Preferred Infrastructure Report

Warragamba Dam Raising

Application Number SSI-8441
EPBC ID Number 2017/7940

Acknowledgement of Country

WaterNSW would like to acknowledge all First Nations people throughout NSW, their connection and legacy to this country is continually shown through their ongoing spiritual, physical and cultural knowledge and practices of the lands and waters.

We pay our respects to all Elders past, present and emerging and acknowledge their ongoing connection and commitment to the waters and lands on which we operate.

We recognise their vast cultural knowledge and management of country and together we will commit to reconciliation and through these partnerships will care for country and waterways on, and all, of our operations and infrastructure areas.

Executive Summary

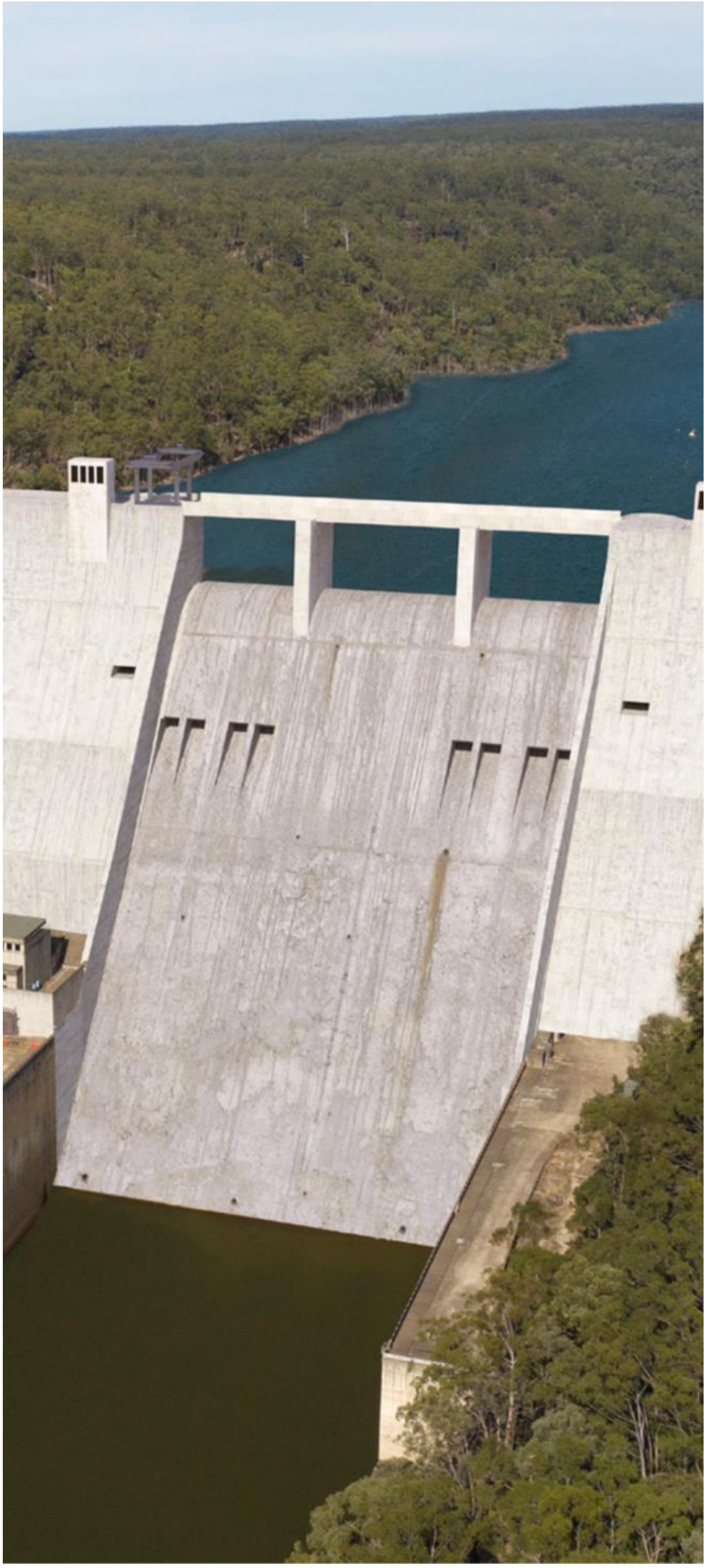
WaterNSW is a New South Wales state-owned corporation and the owner and operator of Warragamba Dam. WaterNSW was requested by the NSW Government to seek planning approvals to raise Warragamba Dam for the purpose of flood mitigation for the Hawkesbury- Nepean valley.

WaterNSW, as the proponent, prepared an Environmental Impact Statement (EIS) which provided a detailed assessment of the Project impacts and the mitigation measures and offset strategies proposed to address the impacts.

The Department of Planning and Environment (DPE) placed the EIS on public exhibition seeking public submissions from 29 September 2021 to 19 December 2021 (82 days). Following the EIS exhibition DPE required that WaterNSW prepare a Preferred Infrastructure Report (PIR) under section 5.17(6)(b) of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

The approval for the Project is sought under Part 5, Division 5.2 of the EP&A Act. The Project was designated as CSSI by way of an Order published on the NSW legislation website on 14 October 2022.

The purpose of this PIR is to describe changes to the CSSI Project since exhibition and in response to submissions. The PIR also contains responses or further information to address key issues raised by DPE.



Warragamba Dam Raising Project

The objective of the Warragamba Dam Raising Project is to reduce risk to life and property damage due to flooding downstream in the Hawkesbury-Nepean Valley.

The raised wall would create an airspace which would provide temporary storage space above the full supply level (FSL) to temporarily hold inflows from the upstream catchment to allow increased evacuation time for affected downstream residents and businesses. When the downstream flood has peaked and river heights are in recession, the stored water would then be released as part of the flood incident management operations for the valley. Providing and operating an airspace or 'flood mitigation zone' contributes to reducing the extent and severity of flooding downstream.

- The Hawkesbury-Nepean Valley has the highest single flood risk exposure in NSW, if not Australia.
- Raising Warragamba Dam would provide flooding mitigation through the temporary storage and controlled release of floodwaters.
- Raising Warragamba Dam would reduce average annual risk to life and reduce flood damages downstream by about 75% on average.
- The dam raising does not change the location of existing floodplain development levels.
- 12m — The new level of the central spillway crest is around 12 metres above the existing FSL.
- Use of the dam for flood mitigation would not change the full supply level or lead to permanent upstream inundation.
- The proposed raising of Warragamba Dam is one of nine outcomes under the NSW Government's Hawkesbury-Nepean Valley Flood Risk Management Strategy.
- Raising Warragamba Dam is the most effective flood mitigation option that would significantly reduce the flood risk across the Hawkesbury-Nepean Valley.
- 14m — The auxiliary spillway crest would be raised to around 14 metres above the existing FSL.
- 17m — The dam side walls (abutments) and roadway would be raised by 17 metres to allow for future climate change.

Warragamba Dam is located within the Wollondilly local government area and is approximately 17 kilometres south-south-west of Penrith and 65 kilometres west of the Sydney CBD. To the west are the Blue Mountains, various national parks and state conservation areas, and the Greater Blue Mountains World Heritage Area (GBMWHA), which make up part of the catchment of Lake Burragorang – the water storage formed by Warragamba Dam.

The Project comprises the following main activities and elements:

- Demolition or removal of parts of the existing Warragamba Dam, including the existing drum and radial gates
- Thickening and raising of the dam abutments
- Thickening and raising of the central spillway
- New gates to control discharge of water from the flood mitigation zone (FMZ)
- Modifications to the auxiliary spillway
- Operation of the dam for flood mitigation
- Installation of environmental flows infrastructure.

The need for the Project was identified through the work of the Hawkesbury–Nepean Valley Flood Management Task Force which was established to investigate feasible flood options to reduce overall flood risks to the valley. The resulting Flood Strategy, adopted by the NSW Government in June 2016, identified nine outcomes, each supported by actions, a number of which are interrelated. The raising of the Warragamba Dam wall to reduce the flood risk downstream was one of the identified outcomes.

The objective of the Project is to provide flood mitigation in order to reduce the significant existing risk to life and property in the Hawkesbury-Nepean Valley downstream of the dam.

A RANGE OF FLOOD MITIGATION OPTIONS ARE INVESTIGATED

2012

MARCH 2012
Warragamba Dam spills for the first time since 1998

DECEMBER 2012
NSW Government accepts the State Infrastructure Strategy 2012-2032 recommendation to review flood mitigation options for the Valley, including raising Warragamba Dam

2013

2013
The Hawkesbury-Nepean Valley Flood Management Review is conducted. It finds there is no single solution to managing the flood risk but that raising Warragamba Dam is the only viable infrastructure solution

2014

2014
The Hawkesbury-Nepean Valley Flood Management Taskforce is formed to advance the work of the 2013 Review, including developing key elements of the Hawkesbury-Nepean Valley Flood Risk Management Strategy

2016

2016
NSW Government adopts the Taskforce's recommendations, including its preferred infrastructure solution of raising Warragamba Dam

2017

MAY 2017
Hawkesbury-Nepean Valley Flood Risk Management Strategy is released, delivering nine outcomes for flood risk mitigation. Outcome 2 is to reduce flood risk in the Valley by raising Warragamba Dam

2017 – 2021
Environmental impact assessment and detailed concept design undertaken for proposal to raise Warragamba Dam

2019

2019
Options Assessment Report produced, detailing investigation of project alternatives

2021

MARCH 2021
Damaging flood event in the Hawkesbury-Nepean Valley

29 SEPTEMBER 2021 – 19 DECEMBER 2021
The Environmental Impact Statement for the proposed Warragamba Dam Raising Project is publicly exhibited

2022

MARCH 2022
Damaging flood event in the Hawkesbury-Nepean Valley

JULY 2022
Damaging flood event in the Hawkesbury-Nepean Valley

NOVEMBER 2022
Submissions Report and Preferred Infrastructure Report submitted to NSW Department of Planning and Environment for assessment

Project delivery

Post-Environment Impact Statement exhibition

Responses to the submissions received have not required a need to change the dam raising configuration to achieve a 14 metre flood mitigation zone being the basis of the Project objective to lower the flood risk downstream. A number of submissions proposed alternative solutions for flood mitigation. The responses to these have outlined their consideration as flood mitigation solutions has already been considered through the extensive options assessment work undertaken by the Taskforce since 2013 and reassessed for the EIS.

Amendments

The Project amendments comprise a design change for a row of concrete baffles in the dissipator floor at the toe of the dam. The function of these baffles is to reduce the energy of the discharged water as it leaves the spillway.

The Project design outlined in the EIS proposed the use of gates or slots to control the release of water. Flood modelling that forms the basis of the design and the flood extents in the EIS was based on the use of gates positioned well below the sill of the central spillway crest. A slot option for discharging the FMZ has been removed from the project description as it was not considered in the flood modelling..

The EIS offset strategy is amended to deliver biodiversity offsets management actions that will deliver a biodiversity benefit on-park equivalent to the biodiversity credits to be retired on National Parks Estate and areas within Greater Blue Mountains World heritage Area or an adjacent or proximate national park or reserve.

Supplementary investigations

As part of preparation of the Submissions Report and PIR, further work has been carried out to build upon the findings of the assessment presented in the EIS and to clarify aspects of the environmental assessment in response to issues raised in submissions. These are summarised in the table on the following page.

Table 1 Supplementary investigations

Aspect	Description	Where provided
Groundwater	Expert technical review of issues raised by DPIE Water	SR: Appendix E
Socioeconomic	Assessment of property buyback options	SR: Appendix F
Geomorphology	Downstream bank stability Downstream erosion and sediment movement Sediment movement through upstream waterways	SR: Appendix G
Contaminated land	Supplementary contaminated land assessment for construction area	SR: Appendix H
Aboriginal heritage	Supplementary assessment to Aboriginal cultural heritage assessment report (Appendix K to the EIS) Includes additional assessment of potential impacts of temporary inundation on the physical values of heritage sites using Longneck Lagoon as a case study	PIR: Appendix F
Flooding and hydrology	Supplementary assessment incorporating additional information including March 2021 flood	PIR: Appendix D
Biodiversity	Additional assessment of potential impacts of temporary inundation on biodiversity values using Longneck Lagoon as a case study	PIR: Appendix E
Non-Aboriginal heritage	Supplementary assessment for State-listed item Megarritys Bridge and for four NPWS section 170 sites in the upstream area	SR: Appendix I PIR: Appendix G
	Archaeological research design	PIR: Appendix H
Sustainability	Revised infrastructure sustainability rating assessment	PIR: Appendix I

Conclusion

There has been an extensive objective, comprehensive, technically robust process for the identification and evaluation of all practicable options and alternatives that has led to the preferred option of raising Warragamba Dam to achieve the objective of reducing risk to life and property in the Hawkesbury-Nepean Valley. This has considered a wide range of factors including socio-economic, environmental and cultural heritage issues which have informed evaluation and refinement of options, and informed decision-making with regard to discarding options and further consideration of options through the evaluation and assessment process.

The principal benefits of the Project are:

- A significant reduction in flood heights and extents for the critical range of major floods events. For example, for the 1 in 100 chance in a year flood, a reduction of flood heights of about 5.2 metres at Penrith, 3.1 metres at Richmond and 4.1 metres at Windsor
- A significant reduction in the number of residential properties impacted by flooding in the critical range of major floods events. For example, for the 1 in 100 chance in a year flood there would an estimated reduction of 5,180 properties (68 percent reduction)
- Flood damage estimates would typically be reduced by approximately 74 to 80 percent for floods up to about the 1 in 200 chance in a year event, reducing to approximately 50 percent for a 1 in 2,000 year chance in a year event
- Increased opportunities for evacuation as evacuation routes would experience less flooding and a longer period before closure due to flooding. For example, for the 1 in 100 chance in a year flood the Windsor Bridge crossing would remain open for an additional 18 hours
- A reduction in the risk to life due to reduced flooding extents and greater evacuation opportunities
- Potentially lower flood insurance premiums for some residential and commercial premises.

The Project is considered to be consistent with the principles of ecologically sustainable development. Additional investigations carried out during preparation of the Submissions Report and the Preferred Infrastructure Report have clarified some aspects of the assessment presented in the EIS. These further investigations suggest the precautionary approach adopted for some aspects of the assessment may have been overly conservative, and that some assumed impacts, such as the total loss of environmental values in the upstream impact area, may not actually be realised. Regardless of this inherent conservatism, the mitigation strategies proposed and offset strategies for biodiversity and protected lands provide a robust framework to safeguard against potential environmental impacts associated with the Project.

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Glossary

Acronym/term	Definition
ACHA	Aboriginal Cultural Heritage Assessment
ACHMP	Aboriginal Cultural Heritage Management Plan
AEP	annual exceedance probability
AHD	Australian Height Datum
AHIMS	Aboriginal Heritage Information Management System
AoS	Assessment(s) of Significance
ARI	Average recurrence interval
BAR	Biodiversity Assessment Report
BCS	Biodiversity, Conservation and Science Directorate (within DPE)
BSA	Biodiversity Stewardship Agreement
CBD	Central business district
CEEC	Critically endangered ecological community
CPW	Cumberland Plains Woodland
CTMP	Construction traffic management plan
DAWE	Department of Agriculture, Water and the Environment (Commonwealth)
DPE	Department of Planning and Environment (previously the DPIE)
DPIE	Department of Planning, Industry and Environment (now the DPE)
EEC	Endangered ecological community
EES	Environment, Energy and Science (now BCS)
EIS	Environmental impact statement
EP&A Act	*Environmental Planning and Assessment Act 1979* (NSW)
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth)
EUIA	Existing Upstream Impact Area
FBA	Framework for Biodiversity Assessment
Flood Strategy	Hawkesbury-Nepean Valley Flood Risk Management Strategy
FMZ	Flood mitigation zone
FSL	Full supply level
GBMWHA	Greater Blue Mountains World Heritage Area
GDEs	Groundwater dependent ecosystems
GSC	Greater Sydney Commission
IBRA	Interim Biogeographic Regionalisation for Australia

Acronym/term	Definition
Infrastructure SEPP	State Environmental Planning Policy (infrastructure) 2007 (repealed on 1 March 2022 with the relevant provisions pertinent to the Project transferred to State Environmental Planning Policy (Transport and Infrastructure) 2021)
ISCA	Infrastructure Sustainability Council of Australia
LOS	Level of Service
mbgl	metres below ground level
MNES	Matter(s) of National Environmental Significance
NPW Act	*National Parks and Wildlife Act 1974* (NSW)
NPWS	National Parks and Wildlife Service
OUV	Outstanding Universal Value
PAD	Potential Archaeological Deposit
PCT	Plant community type
PIR	Preferred Infrastructure Report
PMF	Probable Maximum Flood
POEO Act	*Protection of the Environment Operations Act 1997* (NSW)
the Project	Warragamba Dam Raising Project
PUIA	Project Upstream Impact Area
RAPs	Registered Aboriginal Parties
SEARs	Secretary's Environmental Assessment Requirements
SEPP	State Environmental Planning Policy
SHR	State Heritage Register
SR	Submissions Report
SRD SEPP	State Environmental Planning Policy (State and Regional Development) 2011 (repealed on 1 March 2022 with the relevant provisions pertinent to the Project transferred to State Environmental Planning Policy (Planning Systems) 2021)
SSI	State Significant Infrastructure
TEC	Threatened ecological community
TfNSW	Transport for NSW
VP	viewpoint
WM Act	*Water Management Act 2000* (NSW)
UNESCO	United Nations Educational, Scientific, and Cultural Organization

1

Overview

1 Overview

This section provides a summary of the Warragamba Dam Raising Project as described in the Environmental Impact Statement (EIS). It also outlines the structure of the report and describes the assessment to date and any changes that have been made to the Project since exhibition of the EIS.

1.1 Introduction

The Warragamba Dam Raising Project is one of nine recommended outcomes from the *Hawkesbury-Nepean Valley Flood Risk Management Strategy* (Flood Strategy) (Infrastructure NSW 2017). The Flood Strategy concluded that the significant risks to life and property from flooding in the Hawkesbury-Nepean Valley warranted a comprehensive and coordinated response to reducing impacts and risk. The Project was identified in the Flood Strategy as one of the key outcomes and the preferred infrastructure solution to reduce flooding risk and impacts in the Hawkesbury-Nepean Valley.

The Project as described in Chapter 5 of the EIS includes raising the level of the central spillway crest by around 12 metres and the auxiliary spillway crest by around 14 metres above the existing full supply level (FSL) for temporary storage of inflows once the dam reaches its full supply. The configuration of the spillway crest levels and the gated outlets control the extent and duration of the temporary upstream inundation and downstream releases. There would be no change to the existing FSL or the maximum volume of water stored for water supply.

During the construction period, the opportunity would also be taken to install the physical infrastructure to allow for management of environmental flows as outlined in the NSW Government's 2017 *Metropolitan Water Plan*. However, the actual environmental flow releases do not form part of the Project (and in any case such releases would not occur during flood operations) and are subject to administration under the *Water Management Act 2000* (WM Act).

The Project comprises the following main activities and elements:

- Demolition or removal of parts of the existing Warragamba Dam, including the existing drum and radial gates
- Thickening and raising of the dam abutments
- Thickening and raising of the central spillway
- New gates to control discharge of water from the flood mitigation zone (FMZ)
- Modifications to the auxiliary spillway
- Operation of the dam for flood mitigation
- Environmental flows infrastructure.

All EIS assessments are based on the above design configuration of the spillway crest levels. The flood modelling allows for the controlled release of stored water from the FMZ through eight gated conduits. The outflow modelling that informs the extent of downstream flooding is based on operating rules outlined in Appendix B to the PIR. The discharge would commence after the inflows have peaked and the downstream flood is in recession and vary dependent on the lake level. For the Hawkesbury-Nepean Valley, flood incident management encompasses all sources of flooding including other dam storages and non- regulated rivers. The timing and rate of discharge from Warragamba Dam will be informed by the operating objectives and coordinated under the existing flood incident management protocols, with SES and the Bureau of Meteorology to assist with planning for floods within the Hawkesbury-Nepean Valley.

The proposed works as described in the EIS have not changed apart from the addition of one additional row of concrete baffles blocks on the floor of the dissipator. These are required to further reduce the amount of energy in the discharged water after it is released from the dam but do not influence the amount of water discharged as controlled by the outlet gates. A layout of the proposed works is shown in the detailed concept design drawings provided in Appendix A.

The Secretary's Environmental Assessment Requirements (SEARs), prepared in response to the preliminary environmental assessment (December 2016) directed that the Project consider and be responsive to the implications of projected climate change. Peer reviewed climate change research found that by 2090 it is likely an additional three metres of spillway height could be required to provide similar flood mitigation outcomes to the current proposed flood mitigation proposal if inadequate climate change abatement measures are adopted. Raising the dam side walls and roadway by an additional three metres may, or may not be feasible in the future, both in terms of engineering constraints and cost. As a result, some elements of the design are proposed with a 17 metre height increase to enable adaptation to projected climate change. Any consideration of raising spillway heights above the currently proposed height is unlikely before the mid to late 21st century under current climate change projections, and would be subject to a separate planning approval process at that time.

1.2 Structure of Report

This report is designed to be a stand-alone report which draws on relevant information from the EIS. Where applicable and required by the State Significant Infrastructure Guidelines (DPIE 2021), information from the EIS is replicated in this report and amended if needed.

The following table describes the structure and content of this report.

Table 1-1 Structure of the Preferred Infrastructure Report

Section	Description
1. Overview	Provides an overview of the Project and provides consideration of the key issues raised in Attachment A to the DPE advice to WaterNSW to be addressed in the PIR.
2. Strategic context	Provides an overview of the strategic context of the Project as it currently applies, including an updated description of the Project need, development and alternatives as required by Attachment A to the DPE advice to WaterNSW to be addressed in the PIR.
3. Description of changes	Provides a description of any changes to the Project since the EIS assessment and details of the operating regime.
4. Statutory context	Provides an overview of the strategic context as currently relevant to the Project.
5. Engagement	Describes the engagement activities undertaken by WaterNSW following exhibition of the EIS.

Section	Description
6. Response to DPE key issues	Provides a summary of the supplementary information and additional studies undertaken following exhibition of the EIS.
7. Justification of preferred infrastructure	Provides further justification of the Project with reference to consideration of issues raised in submissions and supplementary information and studies.
8. References	List of references cited in the PIR.
Appendix A	Project design drawings.
Appendix B	Updated mitigation measures table.
Appendices C-I	Supporting supplementary information and studies.

Attachment A to DPE's letter of 17 January 2022 identified specific matters to be addressed in the Submissions Report and/or PIR as appropriate. These are identified in Table 1-2 together with a response to the respective matter.

Table 1-2 DPE requirements for Submissions Report and Preferred Infrastructure Report

DPE requirement	Response
Documentation	
Review for consistency required. Different figures have been used in different sections of the document. For example, inconsistent figures for number of evacuations required in different scenarios.	Clarifications and corrections are provided in Section 7 of the Submissions Report.
Data are marked as being sourced from the Hawkesbury-Nepean Valley Flood Risk Management Strategy (2017), but the figures differ from those presented in the strategy. The source of the data needs to be clarified.	Other key information sources: • *Hawkesbury-Nepean Valley Flood Risk Management Strategy Taskforce Options Assessment Report* (Infrastructure NSW 2019) • *Hawkesbury-Nepean Valley Regional Flood Study Final Report* (WMAwater 2019)
The SR and PIR must assess the upstream and downstream impacts of the proposal equally to provide a clear understanding of the balance between the positive and negative impacts of the proposal for purposes of assessment.	SR: Section 8 PIR: Section 7
Review for accuracy of citations used through the document to ensure citation has occurred where required, and that citations are correct.	Review of citations has been undertaken.
Statements that suggest field surveys, or methodological approaches were not feasible should include a supporting justification stating reasons why.	Clarifications have been provided in responses to relevant issues in the Submissions Report.

DPE requirement	Response
Statutory and Planning Framework	
The SR and PIR must clarify the applicability of clause 125(2)(b) of the State Environmental Planning Policy (Infrastructure) 2011 to the proposal, as the clause refers to water storage facilities, while the proposal relates to flood mitigation.	SR: Section 1.3 PIR: Section 4
Project Need	
Large sections of Chapter 3 of the EIS appear to be copied from the Hawkesbury-Nepean Valley Flood Risk Management Strategy (2017), but this is not attributed in the document. The source of this section should be clarified.	The Flood Strategy is the primary strategic planning document as identified in Section 3.1.1 in Chapter 3 of the EIS and forms the basis of the discussion in this chapter. The Warragamba Dam Raising is one of nine outcomes identified in the Strategy. Other key information sources are: • *Hawkesbury-Nepean Valley Flood Risk Management Strategy Taskforce Options Assessment Report* (Infrastructure NSW 2019) • *Hawkesbury-Nepean Valley Regional Flood Study Final Report* (WMAwater 2019)
Project Development and Alternatives	
The options presented are based on a proposal CIV of approximately $600 million, however the project CIV has been updated in the Department's system to show a CIV of more than $1.3 billion. The complete options analysis presented must be reviewed and updated to reflect the revised project costings.	As described in Chapter 4 of the EIS, the detail of options analysis presented had already been reviewed, reassessed and updated to align with the project costings in the EIS.
Are all possible variables considered and included within the chosen dam option? For example, a 'plunge pool' is identified as potentially being required which would increase spoil to be removed for "Erosion Protection" from 30,000 m^3 to 670,000 m^3. The SR and PIR must address all impacts of the increase of spoil removal if this option is to be progressed.	PIR: Section 3
Project Description	
The Project Description should be reviewed and updated including, where required, relevant figures. For example, Figure 5-4 of the EIS shows a bridge below the lower dissipater slab of the dam. Figure C-5 of Appendix L does not appear to show a bridge in the same location, but further down the river.	PIR: Section 3 and Appendix A.

Attachment A to the DPE advice to WaterNSW identified key issues required to be addressed in the PIR. These issues and where they have been considered in the PIR are listed in Table 1-3.

Table 1-3 Key issues for the PIR

Issue	DPE requirement	Consideration
Project Description and Assessment	Provide a balanced assessment of the upstream and downstream impacts as a result of the proposal, with methodologies applied consistently	Refer Section 7
	Provide details of the proposed operational regime and the impacts of this regime	Refer Appendix B and Section 6.2
	Provide details of the design of the dam wall, including the: • location of any spillways and outlets • maximum design discharge capacity of spillways and outlets	Refer Section 3.2 and Appendix A to this report
Flooding and Hydrology	Provide assessment details about the accuracy of the flooding and hydrology modelling for the proposal, including: • reasons for the difference or uncertainty in the accuracy of modelled flood levels at Wallacia (Appendix H1: Flood and Hydrology Assessment Report - p21)	Refer Section 6.2.2
	• details of data used to calibrate flooding, hydrology and flood behaviour models on floodplain areas that are not from in-channel data.	Refer Section 6.2.3
Heritage	Provide a more comprehensive assessment of Aboriginal cultural heritage values, including: • ongoing consultation with the Aboriginal community which appropriately considers and addresses their comments and concerns • additional work completed in response to issues raised by submissions to identify and assess Aboriginal cultural values likely to be impacted by the proposal, including further field studies • mitigation and management measures for any impacts to Aboriginal heritage, both tangible and intangible.	Refer Section 6.3.1
	Provide a balanced assessment of the upstream and downstream impacts to non-Aboriginal heritage, with methodologies applied consistently.	Refer Section 6.3.2
	Provide a more detailed assessment of the impacts of the proposal on World Heritage including: • consideration of the Aboriginal cultural heritage aspects of World Heritage • consideration of the natural and cultural values • assessment of the impacts of the proposal against the Statement of Outstanding Universal Value for the Greater Blue Mountains World Heritage Area.	Refer Section 6.3.3
	Clear definition is required for the term 'Project Upstream Impact Area (PUIA)' used in analysis for Chapter 18, and across the Aboriginal Cultural Heritage assessment. This definition must clearly state the relevant annual exceedance probability (AEP) or average recurrence interval (ARI) upper and lower bounds for this assessment area.	Refer Section 6.3.4
	The EIS states 'There are also a number of sites within the study area above the EUIA' at page 18-66 of Chapter 18. Details must be	Refer Section 6.3.5

Issue	DPE requirement	Consideration
	provided of the AEP or ARI upper and lower bounds for this assessment area	
Offsetting	Details of the proposed offsetting arrangements for all adverse impacts, including: • updated and proposed offsetting arrangements for upstream and downstream impacts • proposed offsetting arrangements under the Framework for Biodiversity Assessments • proposed offsetting arrangements for impacts to the National Parks estate • proposed offsetting arrangements for impacts to the World Heritage areas • assessment of the effectiveness and feasibility of the proposed offsetting.	Refer Section 6.4
Sustainability and Climate Change	Provide a more detailed technical assessment of how the proposal has considered the impacts of climate change, including: • detailed assessment of risks under future climate scenarios that would affect the proposal • analysis comparing inundation, flooding and hydrology under future climate scenarios with assumptions that have been used to justify the proposal • identification of how climate change risks have been incorporated into project design.	Refer Section 6.5.1
	• identification of how the proposal achieves sustainability outcomes.	Refer Section 6.5.2
Water Quality	Provide a detailed quantitative assessment of impacts and risks to water quality, that: • uses quantitative assessment methods where feasible, and identifies any technical and scientific constraints that justify the use of qualitative methods. • identifies the frequency, extent and duration of water quality impacts from the operation of the Flood Mitigation Zone.	Refer Section 6.6.1
	Identification of models and modelling packages used in the 2017 Metropolitan Water Plan (Metropolitan Water Directorate 2017) where information from that plan has been used by the EIS to analyse or estimate water quality parameters, environmental flow regimes, or future water quality states downstream of the dam.	Refer Section 6.6.2
	The EIS states that 'water quality benefits from environmental flows have been considered in determining future background downstream water quality' at Chapter 27-3. Therefore, assumptions regarding future water quality appear to be contingent on the approval and construction of environmental flows infrastructure that has not yet occurred. Further details of the proposed environmental flows infrastructure and targeted timeframes for approval and operation are required to assess whether it is appropriate to count these benefits.	Refer Section 6.6.3
Biodiversity	Include sufficient additional information, as required by the Commonwealth NSW bilateral assessment agreement, to facilitate	Refer Section 6.7

Issue	DPE requirement	Consideration
	the assessment of the proposal under the requirements of the *Environment Protection and Biodiversity Conservation Act 1999* (Cth).	
Visual Amenity	The PIR must demonstrate what the visual impact would reasonably be from all viewing locations, including areas beyond the project footprint where the works would be readily visible from scenic lookouts or other publicly accessible vantage points.	Refer Section 6.8
Other Matters	Details of road upgrades required and/or maintenance regimes necessary to support heavy vehicle access to the proposal site.	Refer Section 6.9.1
	Changes to the proposal which will minimise its social, environmental and cultural impacts.	Refer Section 6.9.2

2

Strategic Context

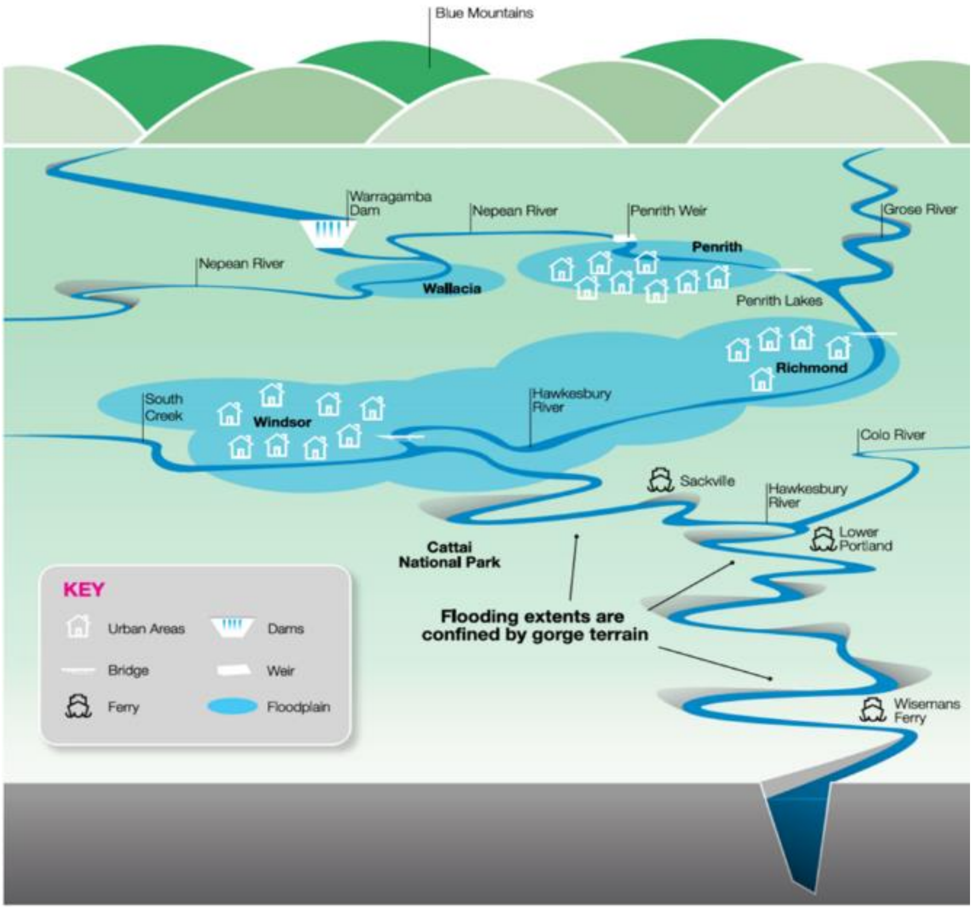
2 Strategic context

The strategic context of the Project has not changed from the position presented in the EIS. The Project was envisaged in the context of the Hawkesbury-Nepean Valley in western Sydney having had a long history of flooding, impacting lives and homes, livelihoods and critical community assets.

2.1 Project need

The Hawkesbury-Nepean Valley is considered to be the most flood-exposed region in NSW if not Australia. It covers around 500 square kilometres in Western Sydney, from Bents Basin near Wallacia to the Brooklyn Bridge. A diverse community of 140,000 live or work on the floodplain, mainly within four local government areas. The valley has a significant flood risk due to its unique geography, constrained road network, historic development in the floodplain and low community awareness of the flood risk. Despite a history of devastating floods, leading up to 2017 there had not been a major flood for over 25 years. Just 33 percent of residents were aware of flood risk, 67 percent had done nothing to prepare (Infrastructure NSW 2018).

Figure 2-1 Topography and features of the Hawkesbury-Nepean Valley



If the worst flood on record were to happen today, around 90,000 people would need to evacuate and over 15,000 homes would be directly impacted. People most at risk are likely to be in geographic flood hot spots and/ or have existing vulnerabilities and complex needs that makes evacuation and recovery more challenging.

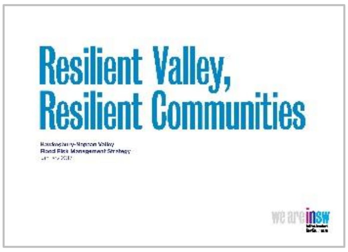
2.2 Project development

A high rainfall event in March 2012 led to the first spill of Warragamba Dam in 14 years. While this caused minor flooding in the Hawkesbury-Nepean Valley, it highlighted the significant flood exposure. The March 2012 event and the Brisbane floods in 2011 led the NSW Government to prioritise investigations into options to mitigate flood risk in the Hawkesbury-Nepean Valley.

As part of developing the State Infrastructure Strategy 2012-2032, Infrastructure NSW commissioned new flood modelling to deliver up-to-date data on flood impacts. The modelling identified that exposure to flooding in the Hawkesbury-Nepean Valley had increased since earlier assessments and was expected to increase further.

The State Infrastructure Strategy 2012-2032 recommended that the NSW Government review all available major flood mitigation options, including raising Warragamba Dam wall, to significantly reduce the potential economic and social impact of flooding in the Hawkesbury-Nepean Valley.

An independently chaired Taskforce was set up in 2014 to investigate feasible flood options to reduce overall flood risk in the valley. The Taskforce's recommendations to the NSW Government were adopted in 2016, and resulted in *Resilient Valley, Resilient Communities Hawkesbury-Nepean Valley Flood Risk Management Strategy* (Infrastructure NSW 2017).



The Flood Strategy, released in mid-2017, aims to reduce the risks to life, property and community impacts from regional floods now and into the future. The Flood Strategy includes an outcome specifically focused on community resilience. Outcome 5 aims to create an 'aware, prepared and responsive community' that is 'better able to respond to flood risk, reducing risk to life and the impact on the community'.

The NSW Government has adopted the Hawkesbury-Nepean Valley Flood Management Taskforce's recommendations, including its finding that raising Warragamba Dam wall is the most effective and efficient infrastructure option to reduce flood impacts and risks. This became the preferred infrastructure solution of the Flood Strategy. Warragamba Dam Raising is one of the nine outcomes designed to get the best flood risk mitigation benefit for the valley and its residents.

The Taskforce found that raising Warragamba Dam to create a flood mitigation zone provided the greatest benefit for reducing flood damages and risk to life compared to the alternatives considered. This is the preferred option used for the environmental assessment.

Importantly, the Project would not change the permanent FSL of the dam and is solely to provide flood mitigation for downstream communities through the creation of a dedicated air space.

2.3 Summary

The objective of the Project is to raise the dam wall to provide flood mitigation downstream. The Project would provide extra storage capacity to temporarily hold floodwaters from the upstream catchment, and then allow release these waters in a controlled manner to reduce downstream flood peak levels and flood extents. The Project is part of a suite of solutions that aim to reduce the significant existing risk to life and property from flooding in the Hawkesbury-Nepean Valley downstream of Warragamba Dam.

3

Description of changes

3 Description of the changes

This section describes the proposed changes to the Project and clarifications in response to issues raised by DPE.

3.1 Design changes

The only change to the design since the EIS was exhibited has been the addition of one row of concrete baffles blocks on the floor of the dissipator. These are required to improve the design and to reduce the amount of energy in the discharged water after it is released from the dam. Amended figures showing the additional row of concrete baffles are included in Appendix A of this report.

This design change will have no additional impact to the EIS assessments as it is of a structural change within the existing dissipator of the dam.

There are no other proposed changes to the proposed infrastructure or the operation outflows rules that inform the EIS flood extents. It should also be noted that the flood modelling extents both upstream and downstream as provided in the EIS have not changed.

3.2 Design clarifications

Issue 1

Are all possible variables considered and included within the chosen dam option? For example, a 'plunge pool' is identified as potentially being required which would increase spoil to be removed for 'Erosion Protection' from 30,000 m^3 to 670,000 m^3. The SR and PIR must address all impacts of the increase of spoil removal if this option is to be progressed.

Response

The detailed concept design (DCD) that informs the EIS was informed by advice from the construction industry participants. The DCD included raising the central and auxiliary spillway levels and the use of gated outlets for discharge of stored water through the spillway. The DCD also provided for erosion protection below the auxiliary spillway with a secant piled contiguous wall as shown on Figure 5-6 of the EIS. The note in Table 5-8 referring to a plunge pool is therefore no longer relevant. Similarly, the reference to consideration of the use of a slot in Chapter 5 *Project description* is also no longer relevant.

Issue 2

The Project description should be reviewed and updated including, where required, relevant figures. For example, Figure 5-4 of the EIS shows a bridge below the lower dissipater slab of the dam. Figure C-5 in Appendix L does not appear to show a bridge in the same location, but further down the river.

Response

The Project description and related figures provided in the EIS describe the permanent changes to the dam structure and appearance. Any temporary works required for construction are not described in detail however may appear on figures such as the indicative location of a temporary bridge in Figure 5-4. Note that the image further down the river in Figure C-5 in Appendix L is the existing Warragamba Weir, not a bridge.

An updated Figure 5-4 is provided in Appendix A (Figure A14) to this report together with additional detailed concept design drawings. These drawings provide more detail and cross sections of the proposed works and have not required to be changed to address any of the submissions received from the EIS exhibition.

4

Statutory context

4 Statutory context

This section summarises the statutory context for the project. Since the original EIS was exhibited the proposed changes or amendments have not changed the statutory context.

WaterNSW is a NSW state-owned corporation and is the owner and operator of Warragamba Dam. WaterNSW was requested by the NSW Government to seek project planning approval for the Warragamba Dam Raising Project (the Project), including the installation of the infrastructure to provide for improved management of environmental flow releases.

The approval for the Project is sought under Part 5, Division 5.2 of the NSW EP&A Act. The Project is designated state significant infrastructure (SSI) and requires approval from the Minister for Planning. Any SSI project may also be declared to be Critical State Significant Infrastructure (CSSI) under section 5.13 of the EP&A Act if it is of a category that, in the opinion of the Minister for Planning, is essential to NSW for economic, environmental or social reasons. The Project was designated as CSSI by way of an Order published on the NSW legislation website on 14 October 2022[1].

The Project was deemed to be a controlled action (ref 2017/7940) as it has the potential to impact on Matters of National Environmental Significance (MNES), and as such requires assessment under the Commonwealth EPBC Act. In accordance with the bilateral agreement reached between the NSW and Commonwealth governments, an EIS under the EP&A Act for SSI can also be used for an EIS under the EPBC Act for a controlled action where directed by the Commonwealth Minister for the Environment. The direction was given for the Project to be assessed under the bilateral agreement on 17 July 2017. The Project will be assessed by relevant NSW agencies in the first instance followed by a decision by the Commonwealth Minister for the Environment.

A preliminary environment assessment was provided to the Secretary of the then Department of Planning, Industry and Environment (DPIE)[2] and Secretary's Environmental Assessment Requirements (SEARs) were issued on 30 June 2017. The SEARs were reissued on 13 March 2018 and included clarifications on assessment requirements including the EPBC Act assessment requirements and detailed downstream assessment requirements. The EIS was placed on public exhibition from 29 September 2021 to 19 December 2021 inclusive.

Provisions within the following NSW State legislation and statutory instruments are also relevant to the Project and are addressed in the EIS:

- *Dams Safety Act 2015*
- *Fisheries Management Act 1994*
- *National Parks and Wildlife Act 1974* (NPW Act)
- *Protection of the Environment Operations Act 1997* (POEO Act)

[1] https://legislation.nsw.gov.au/view/pdf/asmade/sl-2022-617

[2] DPIE was renamed the Department of Planning and Environment (DPE) in December 2021

- *Threatened Species Conservation Act 1995*[3]
- *Water Management Act 2000* (WM Act)
- *Wilderness Act 1987*
- State Environmental Planning Policy (State and Regional Development) 2011 (SRD SEPP)[4]
- State Environmental Planning Policy (infrastructure) 2007[5] (Infrastructure SEPP)
- State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011[6]
- Sydney Regional Environmental Plan No. 20 – Hawkesbury – Nepean River (No. 2 – 1997)[7]
- Wollondilly Local Environmental Plan 2011.

The Commonwealth *Native Title Act 1993* is also relevant to the Project.

The Project would require the following statutory approvals, consents and licences to proceed:

- Assessment and approval by the NSW Minister for Planning under Part 5, Division 5.2 of the EP&A Act
- Assessment and approval by the Commonwealth Environment Minister under the EPBC Act
- An Environment Protection Licence for construction of the Project issued under section 43 of the POEO Act for regulating water pollution
- Changes to the existing water supply works and water use approval under the WM Act for operation of the dam.

Details of these, and the application of State and Commonwealth legislation, are provided in Chapter 2 *Statutory and planning framework* of the EIS.

State Environmental Planning Policy (Infrastructure) 2007

In its advice to WaterNSW, DPE requested that clarification be provided regarding the applicability of clause 125(2)(b) of State Environmental Planning Policy (Infrastructure) 2007 (Infrastructure SEPP) to the Project, as the clause refers to water storage facilities, while the Project relates to flood mitigation.

Chapter 2 *Statutory and planning framework* of the EIS identifies more than one pathway for the Project under the Infrastructure SEPP. Although the primary purpose is for flood mitigation there is modification to the water storage structure to enable the purpose. Chapter 2 identifies that the

3 The TSC Act was repealed when the *Biodiversity Conservation Act 2016* commenced on 25 August 2017. However, the provisions of the Biodiversity Conservation (Savings and Transitional) Regulation 2017 provide for SSI projects to be assessed under the provisions of the TSC Act if the application for the SEARs was made prior to this date. The SEARs for the Project were initially issued on 30 June 2017 meeting this requirement.

4 State Environmental Planning Policy (State and Regional Development) 2011 was repealed on 1 March 2022 with the relevant provisions pertinent to the Project transferred to State Environmental Planning Policy (Planning Systems) 2021.

5 State Environmental Planning Policy (infrastructure) 2007 was repealed on 1 March 2022 with the relevant provisions pertinent to the Project transferred to State Environmental Planning Policy (Transport and Infrastructure) 2021.

6 State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011 was repealed on 1 March 2022 with the relevant provisions pertinent to the Project transferred to State Environmental Planning Policy (Biodiversity and Conservation) 2021.

7 Sydney Regional Environmental Plan No. 20 – Hawkesbury – Nepean River (No. 2 – 1997) was repealed on 1 March 2022 with the relevant provisions pertinent to the Project transferred to State Environmental Planning Policy (Biodiversity and Conservation).

proposal can be characterised as 'development for the purposes of a water storage facility' or for 'flood mitigation' as possible pathways.

Clause 125(2)(b) of the Infrastructure SEPP provides

> *(2) Development for the purpose of water storage facilities may be carried out without consent if it is carried out by or on behalf of—*
>
> > *(b) Water NSW on land within the Sydney catchment area within the meaning of the Water NSW Act 2014.*

Clause 124 of the Infrastructure SEPP provides

> *In this Division—*
>
> ***water storage facility**, **water supply system** and **water treatment facility** have the same meanings as in the Standard Instrument.*

The Standard Instrument provides that a 'water storage facility' is a type of water supply system.

Clause 49 of the Infrastructure SEPP provides that flood mitigation work has the same meaning as it has in the Standard Instrument namely

> *…work designed and constructed for the express purpose of mitigating flood impacts. It involves changing the characteristics of flood behaviour to alter the level, location, volume, speed or timing of flood waters to mitigate flood impacts. Types of works may include excavation, construction or enlargement of any fill, wall or levee that will alter riverine flood behaviour, local overland flooding, or tidal action so as to mitigate flood impacts.*

The Project involves raising the wall of Warragamba Dam to mitigate downstream flooding so more appropriately sits under clause 49. As per clause 50(1), development for the purpose of flood mitigation work may be carried out by or on behalf of a public authority without consent on any land. The equivalent provisions under State Environmental Planning Policy (Transport and Infrastructure) 2021 sit in Part 2.3 Development controls, Division 7 Flood mitigation work.

WaterNSW confirms that clause 49(1) is the more appropriate clause with regard to the Project.

5

Engagement

5 Engagement

This section outlines the consultation and engagement that has occurred during preparation of the Submissions and Preferred Infrastructure Reports.

WaterNSW as the proponent, and Infrastructure NSW as the lead agency for the overall implementation of the Flood Strategy for the valley, have engaged extensively on the Project since 2017. Preparation of the EIS was supported by a comprehensive engagement strategy to ensure the insights of communities, interest groups, government agencies and other stakeholders informed the Project's development.

There are no material changes to the Project that would change the findings of the assessment presented in the EIS. As such, WaterNSW continues to rely on the insights provided by community to date and via the submissions process in late 2021 in considering the effect of the minor design changes described in Section 3.2

5.1 Engagement that informed the PIR

In 2021, the EIS was publicly displayed for 82 days: one of the longest display periods in NSW planning history. At the end of this period, more than 2500 submissions had been received. Of the many submissions made, the most commented areas of interest were biodiversity, United Nations Educational, Scientific, and Cultural Organization (UNESCO) World Heritage, Aboriginal cultural heritage, Project justification and alternatives, and flood impacts and risks (refer following figure).

Figure 5-1 Key issues raised in submissions

In response to these submissions, WaterNSW has worked closely with National Parks and Wildlife Service (NPWS) and the Biodiversity, Conservation and Science (BCS) Directorate of DPE to find further opportunities to strengthen the environmental management approach detailed in this PIR. This multi-agency engagement involved site visits as well as workshops and briefings, leading to a collaborative outcome that addresses the concerns raised during exhibition of the EIS regarding the environmental impact of the Project.

WaterNSW also conducted further engagement activities with a range of groups and stakeholders during the preparation of this PIR, including:

- Meetings and ongoing liaison with DPE Planning, which provided oversight and advice on:
  - responding to submissions

  - planning approval protocols and next steps
- Presentations to DPE Environment and Heritage Group about:
  - changes to upstream flooding and hydrology with the Project
  - terrestrial and aquatic biodiversity EIS submissions
  - World Heritage issues
  - climate change and sustainability
  - biodiversity offset calculations and offset strategy
- Presentations to DPE Water, about further investigations into:
  - potential impacts on groundwater
  - potential downstream geomorphological effects of operation of the FMZ with reference to erosion, bank stability and sediment transport
- Meetings with Heritage NSW to discuss the approach and findings of the Supplementary Assessment to the ACHA report and additional non-Aboriginal heritage assessments
- Consultation with Transport for NSW and the Environment Protection Authority for advice on submissions received
- Communication with Registered Aboriginal Parties to provide Project updates and formal review (including a face to face workshop) of the Supplementary Assessment to the ACHA report
- A presentation to the Gundungurra ILUA explaining current work to prepare the PIR
- Regular updates to the Hawkesbury-Nepean Valley Strategy Communications and Engagement working group, which includes representatives from State Emergency Services, Bureau of Meteorology, Hills, Hawkesbury and Penrith Councils, Transport for NSW, Resilience NSW, DPE, NSW Police, and Infrastructure NSW.

This multi-agency engagement has been critical in understanding feedback received during the EIS exhibition, including how to best consider comments about the Project's approach to managing environmental impact.

5.2 Responding to community

During the preparation of this PIR, WaterNSW has also responded to enquires from the wider community through the Project's dedicated phone line and email address. These contact details are provided on the WaterNSW website and provided in public communications about the Project.

There have been three flood events in the Hawkesbury-Nepean Valley since the end of the EIS exhibition period in December 2021. These events have prompted an increase in the level of community interest and enquiry about the Project. WaterNSW has responded to 75 direct enquiries and, in partnership with Infrastructure NSW, has participated in meetings with flood-affected residents and local councils.

The most common lines of enquiry have been around Project progress, and the feasibility of Project alternatives.

WaterNSW has relied on the EIS documentation to provide well researched and accurate responses to these public enquiries, including information on project alternatives and will continue to do so as the Project moves through the next stage of assessment.

6

Response to key issues

6 Response to DPE key issues

This section provides responses to specific issues raised in Attachment A to DPE's letter of 17 January 2022 that were to be addressed in the PIR.

6.1 Project description and assessment

DPE requirement

Provide a balanced assessment of the upstream and downstream impacts as a result of the proposal, with methodologies applied consistently.

Provide details of the proposed operational regime and the impacts of this regime

Provide details of the design of the dam wall, including the:

- Location of any spillways and outlets
- Maximum design discharge capacity of spillways and outlets.

6.1.1 Assessment of upstream and downstream impacts

The EIS provides a detailed and balanced assessment of the upstream and downstream impacts of the proposed raising of Warragamba Dam. The methodologies applied throughout the EIS were guided by the requirements outlined under the issued Secretary's Environmental Assessment Requirements (SEARs). The SEARs also identified what guidelines or policy frameworks were to be followed by the proponent in each environmental assessment required at the time of the assessment being undertaken. The Submissions Report has addressed all issues raised from the public exhibition supported by further supplementary studies, investigations, or analysis. WaterNSW undertook the necessary engagement with agencies on the various methodologies and approaches to be adopted and implemented in delivering the assessments required to respond to the SEARs and the subsequent further studies and investigations.

6.1.2 Proposed operating regime

Water NSW is a State-owned corporation. It is the owner and operator of Warragamba Dam and the proponent for the environmental planning approvals for the Warragamba Dam Raising Project.

The *Water NSW Act 2014* sets out the framework for WaterNSW activities. The Act lists the key objectives and functions of WaterNSW in sections 6 and 7 respectively, including:

- To capture, store and release water in an efficient, effective, safe and financially responsible manner
- To provide for the planning, design, modelling and construction of water storages and other water management works
- To maintain and operate the works of WaterNSW efficiently and economically and in accordance with sound commercial principles.

WaterNSW carries out these key functions in accordance with its Operating Licence. This sets out terms and conditions under which WaterNSW can carry out these functions. The Operating Licence aims to provide transparent, auditable terms and conditions for WaterNSW to lawfully undertake its activities in accordance with good industry practice. IPART is the regulatory body responsible for WaterNSW compliance with its Operating Licence. WaterNSW functions regulated by the Operating Licence include flood mitigation.

In addition to the Operating Licence, WaterNSW is the holder of a Water Licence and Approvals Package for Greater Sydney issued by DPE (Approvals Package) under the *Water Management Act 2000.* These approvals and water access licences include the requirements for the operation of Warragamba Dam. The works approval for Warragamba Dam is focused on water supply and existing environmental flows at Megarritys Creek. It does not cover flood mitigation. WaterNSW must demonstrate annual compliance against the works approval.

This is in line with the key purpose of the dam for the supply of water to Sydney Water Corporation. This restriction does not prevent WaterNSW operating dams safely in Greater Sydney during flood, however, if the Project is approved, the Operating Licence would need to be amended to reflect the new function of Warragamba Dam for flood mitigation (see discussion below).

In accordance with the WaterNSW Operating Licence and Approvals Package, Warragamba Dam is managed to maintain the lake level at or below FSL. The Approvals Package requires WaterNSW to maximise yield, which is done by ensuring the lake level is full at the beginning and end of a flood event. This also means that pre-releases for flood events are currently precluded from Warragamba Dam operations.

Details of Warragamba Dam operations, both existing and with Project, are provided in Appendix B. The flood operations with Project informed the flood modelling that informs the flood extents upstream and downstream within the assessments of the EIS.

6.1.3 Design details of the proposed dam raising

The proposed works in the EIS have not altered in response to submissions other than the addition of one row of concrete baffles blocks on the floor of the dissipator. This is required to further reduce the amount of energy in the discharged water after it is released from the dam but does not influence the amount of water discharged as controlled by the outlet gates.

Further detailed concept design drawings on the proposed raised dam in addition to those provided in Chapter 5 of the EIS are provided in Appendix A to this report.

6.2 Flooding and hydrology

DPE requirement

Provide assessment details about the accuracy of the flooding and hydrology modelling for the proposal, including:

- Reasons for the difference or uncertainty in the accuracy of modelled flood levels at Wallacia (Appendix H1 *Flooding and Hydrology Assessment Report*, p21)

- Details of data used to calibrate flooding, hydrology and flood behaviour models on floodplain areas that are not from in-channel data.

6.2.1 General overview

Flood modelling of the Hawkesbury-Nepean River has progressed over the past 40 years, which has been the basis for assessing flood risk and options to mitigate the risk. Flood modelling was carried out recently for the *Hawkesbury-Nepean Valley Flood Risk Management Strategy* (Infrastructure NSW 2017*)* and the *Hawkesbury-Nepean Valley Regional Flood Study* (WMAwater 2019). The Regional Flood Study updated the previous flood frequency analysis which was used to verify the probability of different size flood events.

The Regional Flood Study methodology, including modelling approach and calibration, is summarised in Appendix H1 to the EIS. Further clarification is provided in Appendix D to this report. The Regional Flood Study:

- Is a technical document describing the flood behaviour of the main Hawkesbury-Nepean River from Bents Basin near Wallacia downstream to Brooklyn Bridge, and the backwater flooding associated with main river flooding. The study describes regional flood behaviour both for existing conditions and under projected climate change. Local catchments are modelled to have the same duration rainfall event as that which causes the highest flood levels in the main river
- Was undertaken using the most updated modelling tools and information and was done in accordance with the national guidance document for flood estimation (Australian Rainfall and Runoff 2019 (AR&R)). The model also referenced a broad body of work and was extensively peer reviewed by leading academic and industry experts
- Was used to assess various flood mitigation options presented in the Taskforce Options Assessment Report (Infrastructure NSW 2019) and to assess potential Project flood impacts downstream of Warragamba Dam.

6.2.2 Uncertainty in the accuracy of modelled flood levels at Wallacia

As described in the Regional Flood Study (WMAwater 2019), flooding at Wallacia is complex because flood levels there are influenced by Nepean River flows, Warragamba River flows which cause a backwater effect at Wallacia, and a combination of flows from both the Nepean and Warragamba.

Calibration of hydrologic models in the Nepean River is also challenging due to the presence of the four Upper Nepean dams, the limited gauged ratings (measured flow) at high levels at some gauges, and the presence of gorges that act as hydraulic controls (see WMAwater 2018). The Wallacia floodplain has gorges at both its upstream and downstream ends.

For these reasons, the authors of the Regional Flood Study considered that the accuracy of flood levels at Wallacia might be greater than the ±200 mm that applied to the rest of the Hawkesbury-Nepean floodplain.

As part of the process of continuous improvement, the joint probability of Nepean and Warragamba flooding at Wallacia has been further investigated as part of Infrastructure NSW's *Hawkesbury-Nepean River Flood Study*, and is expected to be finalised in 2023.

6.2.3 Model calibration

The Regional Flood Study provides detailed descriptions of model development and calibration. This included development and calibrations for hydrologic and hydraulic models, and Monte Carlo flood estimation.

6.2.3.1 Hydrologic model (RORB) calibration

The hydrologic model was calibrated to streamflow gauges that had sufficient length of record, acceptable data quality, and were on a major tributary of the Hawkesbury River. Model calibration was generally as follows:

- Hydrologic calibration was undertaken at six established hydrographic data stations located on catchments upstream of Warragamba dam and on the Colo River. Calibration and verification was done against seven significant floods: June 1964, June 1975, March 1978, August 1986, April/May 1988, July 1988, and August 1990.
- It was not possible to directly calibrate the model for all catchments (uncalibrated catchments) either because there was no gauging station, no rating curve to produce flows, or the station records were influenced by backwater from the main river. Calibration methodology included analysing storage coefficients (k_c) and rainfall losses. Catchment flows were therefore estimated by comparing and extrapolating catchment characteristics (storage coefficients (k_c) and rainfall losses) between calibrated and uncalibrated catchments.

6.2.3.2 Hydraulic model (RUBICON) calibration

The steps involved in the hydraulic model calibration were:

- Initial calibration to obtain model stability and reasonable fits to the observed data from six floods (November 1961, June 1964, June 1975, March 1978, August 1986, April/May 1988)
- Review by co-author of the RUBICON program
- Calibration of the model using flood events of March 1978, August 1986, April/May 1988 and August 1990
- Fine-tuning around Penrith.

Two types of data were needed to calibrate the hydraulic model:

- Flow characteristics (such as stream flows and ocean conditions)
- Observed heights and, if available, flows within the modelled area that could be compared with the model output.

Table 6-1 summarises the catchment-wide differences between modelled flood levels and gauged or observed level data.

Table 6-1 Calibration and verification of hydraulic model to available flood levels

Event	Purpose	Gauge data difference (m)		Other data difference (m)		Overall difference (m)	
		Mean	Median	Mean	Median	Mean	Median
Nov 1964	Verification	0.05	0.05	0.08	0.08	0.07	0.07
Jun 1964	Verification	-0.03	-0.06	-0.30	-0.22	-0.16	-0.14
Jun 1975	Calibration	0.21	0.30	0.54	0.62	0.37	0.46
Mar 1978	Calibration	-0.01	-0.01	0.13	0.07	0.06	0.04
Aug 1986	Calibration	-0.12	-0.12	0.01	-0.03	-0.05	-0.08
Oct 1987	Verification	NA	NA	-0.02	0.09	-0.02	0.09
May 1988	Calibration	0.14	0.12	0.03	-0.02	0.09	0.05
Jul 1988	Verification	NA	NA	-0.11	-0.10	-0.11	-0.10
Apr 1989	Verification	NA	NA	-0.14	-0.13	-0.14	-0.13
Aug 1990	Calibration	-0.25	-0.23	-0.37	-0.28	-0.31	-0.26

Source: Tables 29 and 30, *Hawkesbury-Nepean Valley Regional Flood Study* (Infrastructure NSW 2019)

An example of model calibration against the 1988 flood event is shown in Figure 6-1 which shows good representations of the observed flood, including at Wallacia.

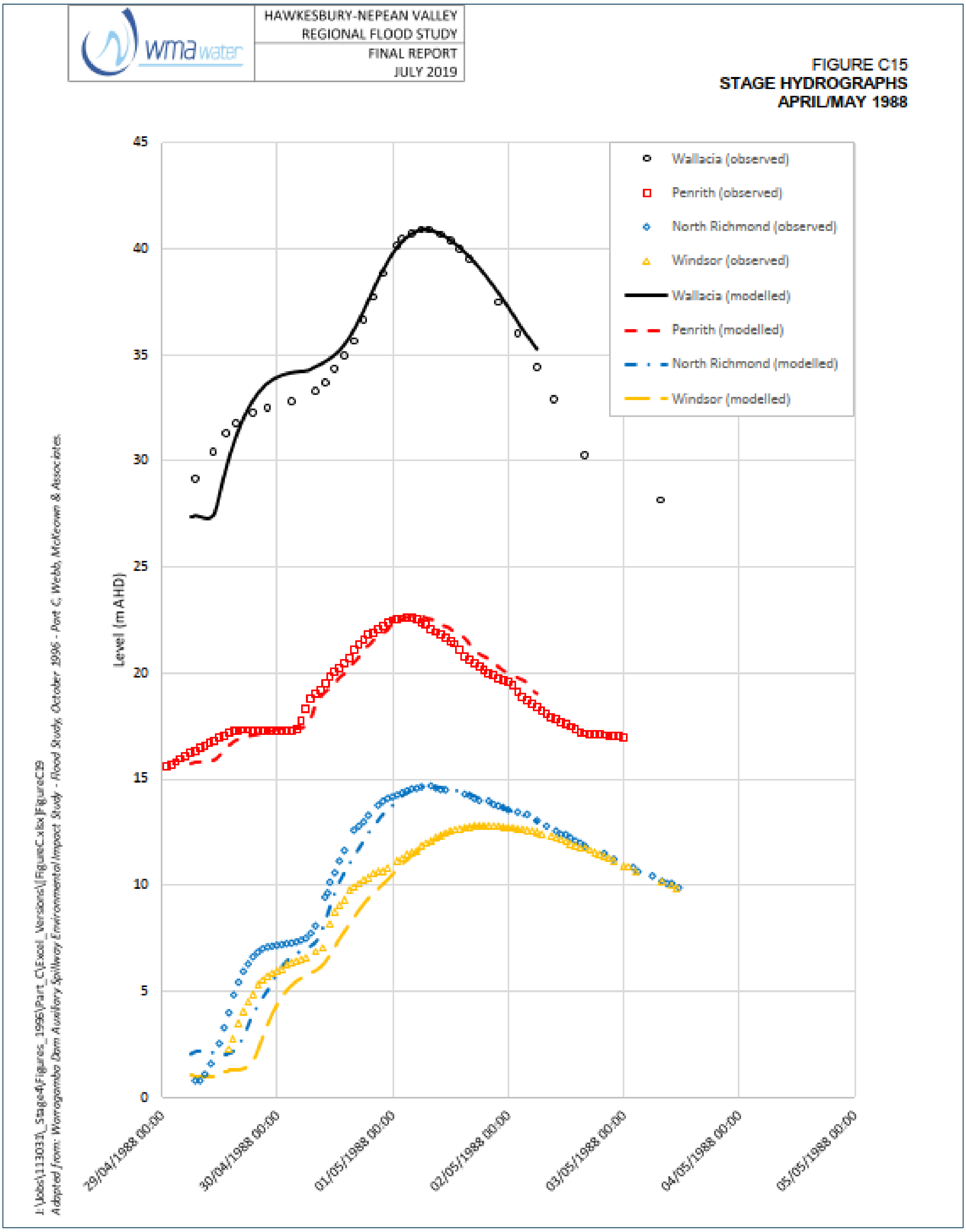
The Regional Flood Study also collected and surveyed flood peak data between gauges and away from the main channel. These also help to verify the modelling when plotted on a long profile (e.g. Figure 6-2).

6.2.3.3 Monte Carlo flood estimation calibration

Some 19,500 model simulations were conducted, which represents the range of floods that could be experienced in about 200,000 years. To verify the Monte Carlo framework, a comparison to flood frequency analysis and a comparison to the long-term flood records was undertaken (Note: all flows were converted to pre-dam flows so that flood frequency analysis was on a comparable basis). Flood frequency analyses are shown on Figure 6-4 (Warragamba), Figure 6-4 (Windsor) and Figure 6-5 (Penrith).

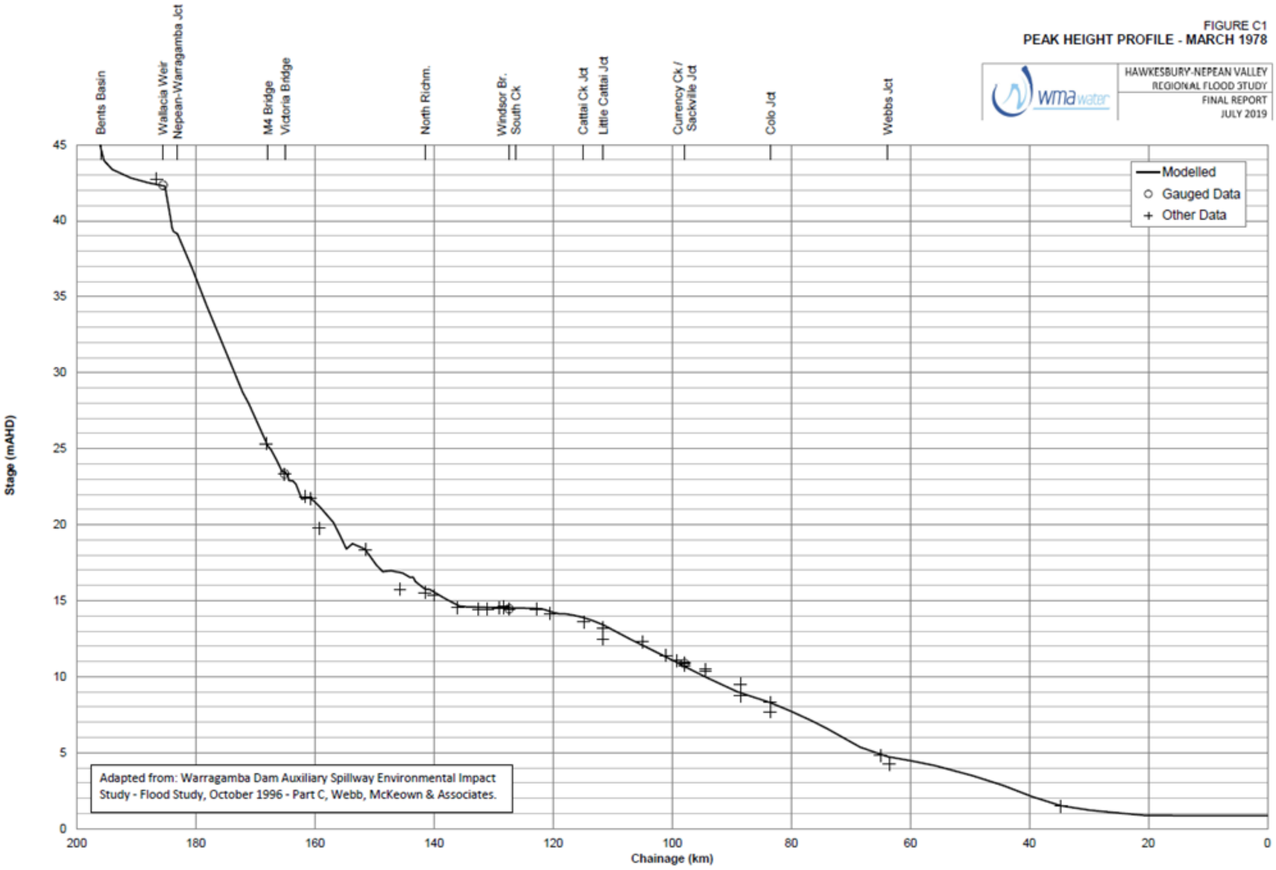
Good matches were achieved for all sites between the 1 in 10 chance in year and 1 in 100 chance in year events. The results varied at the rare end where the Monte Carlo method has fewer data points. However, the Monte Carlo analysis was largely within the confidence limits of the flood frequency analysis.

Figure 6-1 Calibration to observed 1988 flood



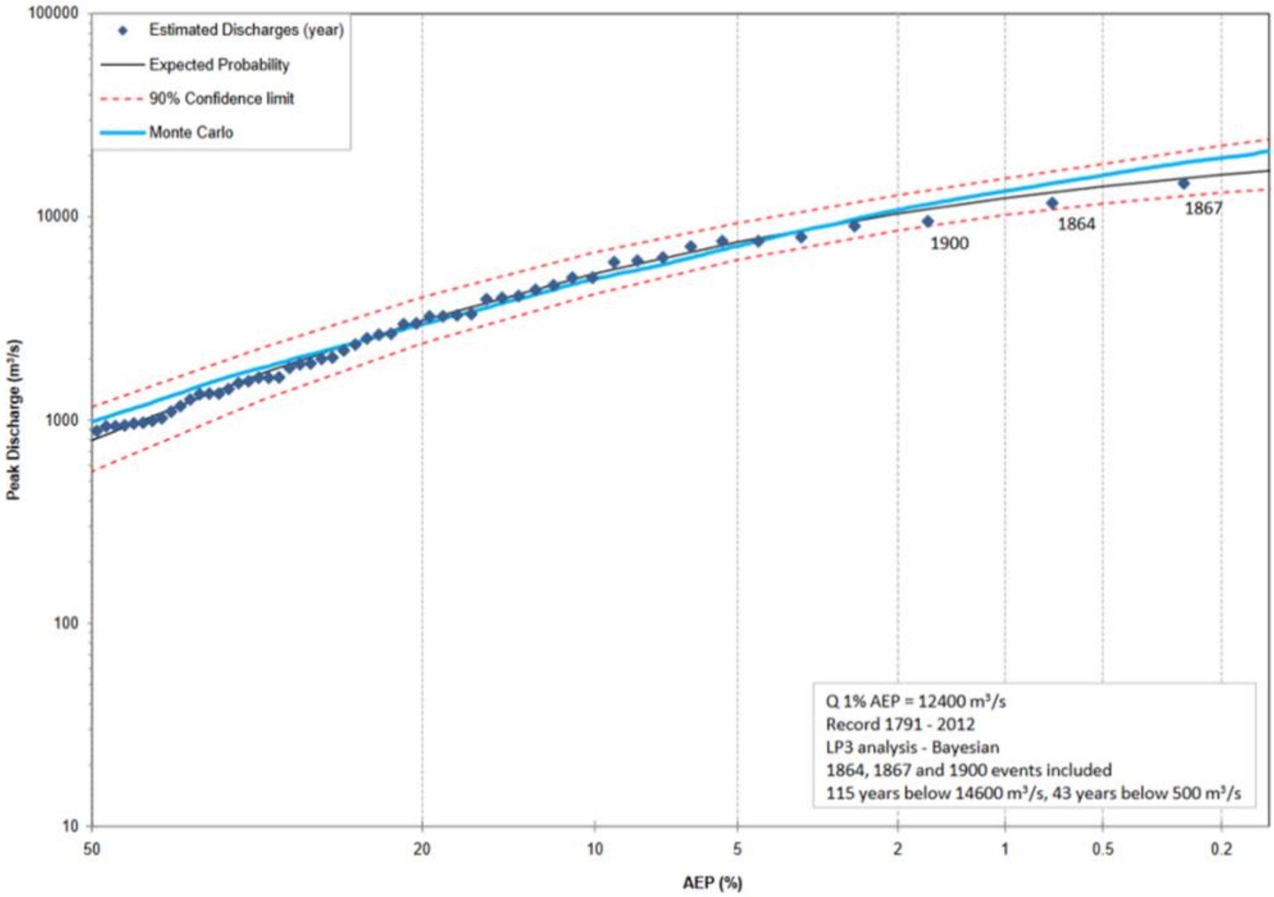
Source: *Hawkesbury-Nepean Valley Regional Flood Study*, Volume 2 (Infrastructure NSW 2019)

Figure 6-2 Calibration to observed 1978 flood



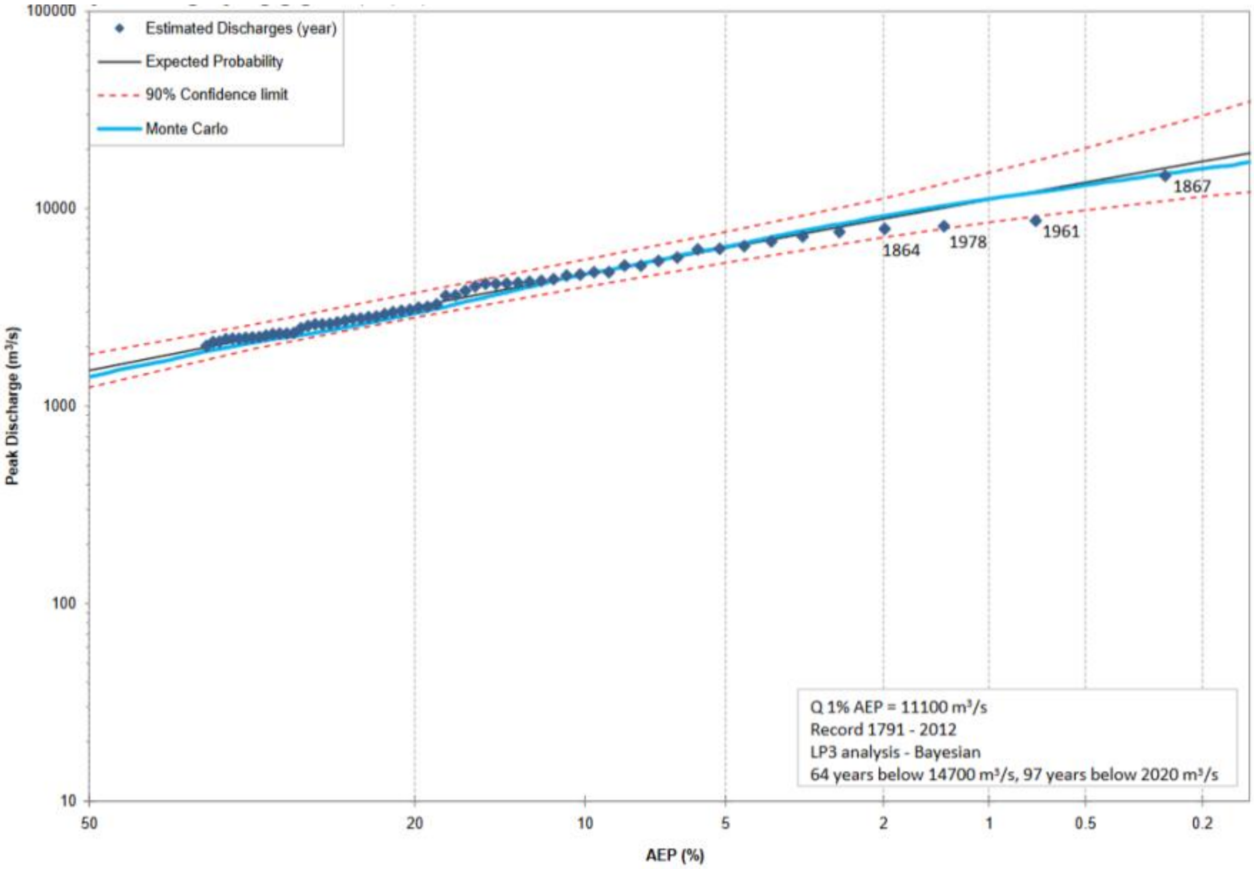
Source: *Hawkesbury-Nepean Valley Regional Flood Study*, Volume 1 (Infrastructure NSW 2019)

Figure 6-3 Pre-dam flood frequency analysis compared to Monte Carlo results – Warragamba



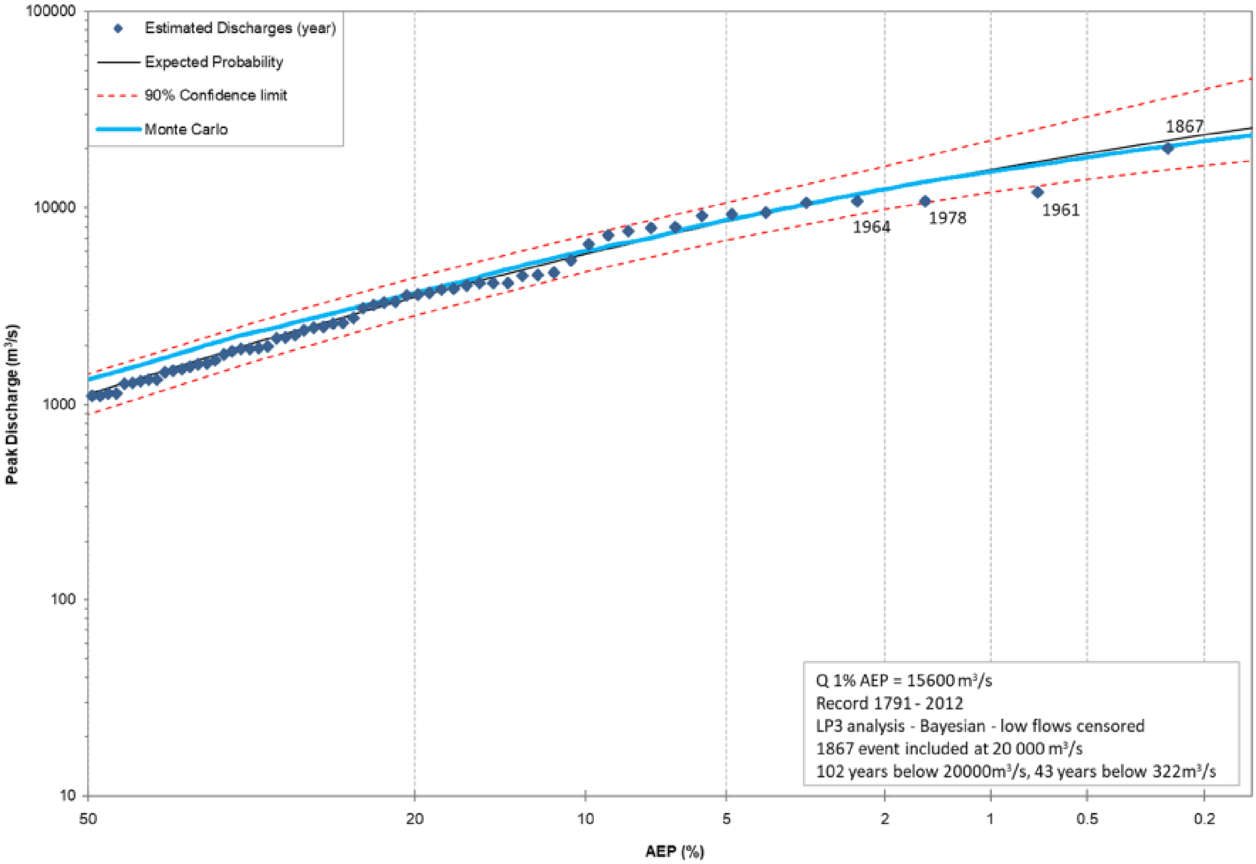
Source: *Hawkesbury-Nepean Valley Regional Flood Study*, Volume 1 (Infrastructure NSW 2019)

Figure 6-4 Pre-dam flood frequency analysis compared to Monte Carlo results – Windsor



Source: *Hawkesbury-Nepean Valley Regional Flood Study*, Volume 1 (Infrastructure NSW 2019)

Figure 6-5 Pre-dam flood frequency analysis compared to Monte Carlo results – Penrith



Source: *Hawkesbury-Nepean Valley Regional Flood Study*, Volume 1 (Infrastructure NSW 2019)

6.3 Heritage

6.3.1 Aboriginal cultural heritage values

DPE requirement

Provide a more comprehensive assessment of Aboriginal cultural heritage values, including:

- Ongoing con8sultation with the Aboriginal community which appropriately considers and addresses their comments and concerns
- Additional work completed in response to issues raised by submissions to identify and assess Aboriginal cultural values likely to be impacted by the proposal, including further field studies
- Mitigation and management measures for any impacts to Aboriginal heritage, both tangible and intangible.

6.3.1.1 Ongoing consultation

All consultation with Aboriginal parties undertaken for the EIS was outlined and documented in Section 6 of the original Aboriginal Cultural Heritage Assessment (ACHA) (Appendix K to the EIS).

Consultation with Aboriginal people about the Aboriginal cultural heritage values (cultural significance) of the Project has continued following the public exhibition of the EIS.

The Registered Aboriginal Parties (RAPs) have been kept informed on the progress of the Project before and after the public exhibition of the EIS. The draft Supplementary Assessment to the ACHA report (refer Appendix F) was provided to RAPs for consultation and feedback including workshops to brief and assist RAPs to navigate the supplementary information.

WaterNSW will continue consultation and engagement with the RAPs for the duration of the Project.

6.3.1.2 Supplementary assessment

Updated AHIMS search

An updated Aboriginal Heritage Management System (AHIMS) search for the Project was undertaken in May 2022. A broader upstream search area than the original ACHA was used to allow for additional site type and feature data to inform the updated predictive model. Based on the updated AHIMS search and the sites identified during the surveys undertaken for the original ACHA, a total of 128 Aboriginal heritage sites are located within the FMZ. Sites with stone artefacts were the most common site type (82 percent).

Based on the AHIMS search undertaken for the original ACHA there are 887 Aboriginal heritage sites in the downstream study area, with sites with stone artefacts being the most common site type (75 percent). In broad terms, there would potentially be a beneficial effect on these sites through a reduction in the frequency of flooding and a reduction in the extent of flooding, with a potential reduction in the number of sites affected by flooding.

Potential Archaeological Deposits (PADs)

Additional consideration of the potential for sub-surface archaeological deposits was undertaken by providing additional information relating to the soils landscapes in the Project area and the results of relevant archaeological studies in the region.

The formation and preservation of archaeological deposits is dependent on a range of interrelated factors relating to soil landscape characteristics including type, depth and limitations of soil, landform and its relative steepness and degree of past disturbance. Additional information relating to these factors for each of the seventeen soil landscapes present within the upstream study area, along with the potential for the soil landscape of preserve archaeological deposits, is provided in Table 34 of the supplementary assessment. In summary, the assessment concluded:

- Alluvial soil landscapes within the Project area (including the Coxs River, Emu Island and Wollondilly River soil landscape units) are all associated with a high potential for preserving PADs due to absence of steep slopes and outcropping, their association with other archaeologically sensitive landforms (alluvial plains and terraces) and waterways (rivers and streams) and the potential for deep alluvium sediments providing the accumulation of archaeological deposits of up to 200 cm.
- Erosional, colluvial, transferal and residual soil landscapes are generally associated with lower potential for PADs variously due shallow soils, steep landforms, outcropping rock and/or

severe sheet erosion, a review of the landscape characteristics and soils identified a number of exceptions where a moderate to high potential for PADs was recognised.

Nine previous archaeological studies in the region were reviewed to make predictions regarding PAD within the Project area including where these are likely to be preserved, at what depths they are likely to occur and what the contents are likely to contain. The results are summarised in Table 35 of the supplementary assessment. In summary the review concluded:

- Several of the shelter sites reviewed fall within Warragamba soil landscape unit which occurs within the current Project area. Although the PAD sensitivity modelling predicts that the Warragamba soil landscape unit is associated with a low PAD sensitivity, the presence of artefacts in these sites suggests that the sensitivity modelling should be used with caution in the context of closed shelter sites.
- In contrast to open context sites, the accumulation and preservation of archaeological deposits in these closed contexts is dependent upon local conditions at the site including for example, the presence of rockfall which may act as a sediment trap preserving deposit. Unfortunately, the limited excavation within open air contexts means that it is not possible to fully test the PAD sensitivity modelling based on this brief literature review at this stage.

Revised rock art analysis

The supplementary assessment expands upon the information contained within the original ACHA and identifies what is known regarding motif and pigment data for rock art associated with the Project area and surrounding region. The additional information was used to inform and support the updated significance assessment of such sites and develop appropriate management measures.

Four existing AHIMS sites and 30 newly identified sites contain rock art. The number, style, form and colour of the motifs at each newly identified site can be summarised as follows:

- Number of motifs present at each site varied from 1 to 14
- Styles were more consistent with a number of line forms, geometric forms, anthropomorphic figures, zoomorphic figures and hand stencils
- Line and engraved forms were commonly recorded in isolation whereas all other forms were typically recorded in combination with line form
- Colours used included black (charcoal) and red, orange and yellow (ochre) and white (clay). Black (charcoal) was commonly recorded in isolation whereas red, white and yellow were more commonly recorded in combination with black.

In comparison to the regional data, the 30 newly identified rock art sites are typical in colour and media and atypical in the number of motifs and motif forms. The 30 art sites contain both typical and atypical motif styles (including common Panaramitee and Simple Figurative motifs) and include some rare sites with significant numbers of motifs and engravings.

Numerous rock art sites are linked to the Gundungara Cultural Landscape which demonstrate the strong connection and inter-connectedness between tangible archaeological sites (such as rock art sites) and the broader cultural landscape with its associated intangible values.

Literature review and case study

A review of information from the broader literature surrounding the impact of flooding on archaeological sites was undertaken including a review of previous studies within the Project area, Australian studies and international studies.

In addition, a survey and assessment of Aboriginal heritage sites adjacent to Longneck Lagoon, a small freshwater wetland situated withing the downstream study area for the Project was undertaken to assess the effects of temporary inundation from previous flood events on previously recorded Aboriginal heritage sites.

Based on the literature review and case study, a synthesis of the potential impacts of flooding on the different archaeological features and site types / features was provided. Archaeological site types included Artefact sites, PADs, rock shelters, burials, rock art (paintings and engravings), axe grinding grooves, scarred trees, stone arrangements, Aboriginal resource, gathering, ceremony and dreaming sites and cultural landscapes.

Predictive model

A review and update of the predictive model was undertaken based on the results from the original ACHA and an analysis and consideration of additional key variables including archaeological features, updated PAD predictions, ethnographic and cultural information, and intangible values.

Following the additional predictive modelling no updates were made to the original archaeological landscape predictions presented in the original ACHA. The predictions in the original ACHA are as follows:

- The PUIA is predicted to contain a total of 174 archaeological sites, comprising 117 open sites with stone artefacts and 51 rockshelter sites and at least 3 other site types.
- The EUIA is predicted to contain 578 archaeological sites, again comprising mostly of open sites, at a predicted 458 open sites and 109 rockshelter sites and at least 11 other sites.
- Outside the EUIA and above the PUIA, in the zone of very low risk from the Project, there are predicted to be 370 archaeological sites.

The supplementary assessment outlines research questions that may be used for the Project in the categories of chronology of past occupation, stone artefact technology, rock art, spatial patterning and activities and regional comparisons. The specific categories and questions would be finalised in consultation with the RAPs during development of the Aboriginal Cultural Heritage Management Plan (ACHMP).

Cultural heritage values and statement of significance

A review and update of the cultural heritage values and statement of significance was undertaken based on the result from the original ACHA and an analysis and consideration of additional key variables. The RAPs have consistently said that all sites have high cultural significance in addition to, and in most cases beyond, what may be expressed using a scientific framework. The significance value relates to the tangible and intangible connections to the cultural landscape. The further values of the archaeological sites were discussed and considered in a more wholistic cultural landscape in the significance assessments in Section 8.3 of the original ACHA.

Archaeological values and significance

A review and update of the original scientific significance assessment of Aboriginal cultural heritage sites in the original ACHA was undertaken based on consideration of:

- Whether the site is likely to contain PAD based on the updated PAD predictions
- Visibility and exposure levels associated with each site and whether or not a site may be associated with additional artefacts and/or features which may contribute to and/or increase its significance
- Number of features associated with a site and/or its association with other sites nearby which may contribute to and/or increase its significance
- Sites potential to contribute to the understandings of past use of the Project area and/or ability to address specific research questions.

Based on the review 43 heritage sites had their scientific significance rating upgrades based on their association with PAD and/or potential to contain extensive artefact assemblage.

The scientific (archaeological) value of the region and the Aboriginal objects contained within it is demonstrated by the 340 known Aboriginal archaeological and cultural heritage sites (this includes sites in the PMF, the EUIA, the PUIA and adjoining lands) which includes:

- 50 sites that have been assessed to be of high archaeological (scientific) significance
- 58 sites that have been assessed to be of moderate archaeological (scientific) significance
- 233 sites that have been assessed to be of low archaeological (scientific) significance.

Full results are provided in Section 7.2 of the supplementary assessment (Appendix F to this report).

Cultural values and significance

The RAPs have consistently advised that all sites have high cultural significance in addition to, and in most cases beyond, what may be expressed using a scientific framework. The significance value relates to the tangible and intangible connections to the cultural landscape. The further values of the archaeological sites were discussed and considered in a more wholistic cultural landscape in the significance assessments in Section 8.3 of the original ACHA.

GBMWHA values and their significance

The GBMWHA is one of the largest and most intact tracts of protected bushland in Australia and was inscribed on the World Heritage List in 2000. While the PUIA contains only 304 hectares of GBMWHA land (0.03 percent of the total GBMWHA area) it contributes overall to the GBMWHA cultural values as it is a cultural landscape with a rare and representative example of the interconnectedness of tangible and intangible values.

Additional information relating to the values and significance of the GBMWHA is provided in Section 7.4 of the supplementary assessment and Section 6.3.3 of this report.

Statement of significance

The statement of significance presented in the original ACHA was updated in an effort to emphasise the importance of intangible values and to include the updated assessment of scientific significance. The statement of significance for the Project area is as follows:

- Very high social and cultural significance to the Aboriginal community
- High aesthetic significance
- High historical significance
- High scientific (archaeological) significance.

Impact assessment approach

A review and update of the impact assessment in the original ACHA was completed for Aboriginal cultural heritage sites and values associated with the Project.

The original ACHA adopted a precautionary approach for the purpose of the impact assessment where it was considered that all Aboriginal sites within the PUIA would be harmed and the degree of harm to these sites would be total. The updated impact assessment presented in the supplementary assessment considers potential impacts in the context of the incremental increase in temporary inundation for the 1 in 5, 1 in 10, 1 in 20, and 1 in 100 chance in a year flood events. The impact assessment also considered the potential effects of temporary inundation on different Aboriginal site types, features and/or cultural resources informed from a review of the literature and the results of additional assessment undertaken for the Longneck Lagoon downstream case study.

While the Project may result in increases in the extent and duration of inundation, the velocity associated with the flow rate would be decreased. Potential impacts would therefore be influenced more by the susceptibility of an area to erosion and/or deposition and the nature of the Aboriginal heritage site feature. Potential effects of the Project are summarised as follows:

- Artefact/s and/or PADs located in high erosion risk areas have the potential to be destroyed by erosional processes which act to remove and/or displace artefacts and any associated features (e.g. PAD) as was observed by Brayshaw (1989: 30) in association with open sites located between the FSL and previous flood level within the Project area. Such potential impacts would result in medium-scale data loss and significantly reduce the integrity and research potential/scientific value of a site.
- Artefact/s, PADs, Engravings, Grinding Grooves and/or Burials located in low-erosion potential areas such as along the valley of the Wollondilly River, may be subject to siltation/depositional effects from backshore runoff which may act to bury the site in alluvial deposits. Little to no impact to the archaeological integrity of these sites is expected. Furthermore, siltation is recognised to enhance preservation in such a context by providing a buffer against biochemical, mechanical and other forms of destructive impacts. Sites, however, may no longer be detectable and/or accessible during surface survey.
- Other site features, such as Axe grinding grooves, Engravings, Rock Art and Burials are most susceptible to biomechanical impacts that may result from increased inundation and wet and dry cycling. Rockshelters sites with art in all areas subject to temporary inundation regardless of duration and extent have the potential to be affected by wet and dry cycling

and related mechanical and biochemical impacts including accelerated weathering, granular loss, exfoliation of painted surfaces, removal and/or degradation of pigments and drawing materials. Changed environmental conditions resulting from the deposition of silts, clay, sand other minerals, for example, can create conditions suitable for the intrusion and growth of destructive micro- or macro-vegetation such as fungi, algae and lichens. Such potential impacts would significantly reduce the integrity and research potential/scientific value of a site (medium-scale data loss).

The key results of the updated impact assessment are summarised as follows:

- A total of 260 known Aboriginal cultural heritage sites would be affected by increased temporary inundation as a result of the Project. These sites include those which would be affected by an increase in frequency of inundation as well as duration of existing inundation events. Of these sites, 30 are above the Project 1 in 100 inundation event level meaning that there is a very low chance of such inundation to be experienced. Nevertheless, as these sites are located within the Project PMF, they still require management and mitigation measures.
- A total of 228 known Aboriginal cultural heritage sites are currently already affected by inundation, this does not include the 49 sites currently below FSL that are already permanently inundated.
- Sites below current FSL or above the Project PMF would not be affected as a result of the Project and are therefore not included in the impact assessment.
- A total of 38 Aboriginal cultural heritage sites previously unaffected by existing inundation would be impacted as a result of the Project. Of these sites, six are considered to have nil to low resilience against inundation.
- The Project would result in cumulative harm to the intangible values of the cultural landscape through extension of previously unmitigated impact on cultural values from the construction of the Warragamba Dam and flooding of the Burragorang Valley and its tributary valleys. The further flooding of the Burragorang Valley would result in irreversible harm to the cultural and spiritual connection that Aboriginal people hold to this part of the Country, their heritage and the cultural landscape and will obscure the tangible aspects of the creation stories associated with the Burragorang such as the Gurrangatch and Mirrigan story.

Further details are provided in Section 8 of the supplementary Aboriginal cultural heritage assessment (Appendix F to this report).

6.3.1.3 Mitigation and management measures

There are no changes to the 17 mitigation and management measures presented in the original ACHA. The recommendations relate to consultation, management, access to Country, site recording, cultural values recording and education.

Further details are provided in Section 9 of the supplementary Aboriginal cultural heritage assessment (Appendix F to this report).

6.3.2 Non-Aboriginal heritage

DPE requirement

Provide a balanced assessment of the upstream and downstream impacts to non-Aboriginal heritage, with methodologies applied consistently.

6.3.2.1 Supplementary assessment

A supplementary assessment has been prepared to provide further information with regard to potential impacts of the Project on non-Aboriginal heritage raised in submissions. This is provided as Appendix G to this report.

The supplementary assessment addresses:

- Upstream: Items on the NPWS Section 170 heritage register in the upstream study area
- Downstream: Megarritys Bridge (SHR no. 01367)
- Construction zone: Preparation of an archaeological design for the construction area (provided as Appendix H to this report).

Downstream heritage items

It is important to note that for the downstream study area, the Project would result in a reduced spatial extent of flooding for all flood events, and therefore would generally reduce the risk of flooding for all identified heritage items. The exceptions to this are items located within the FMZ operation zone which would experience an increased duration of low-level temporary inundation for between one and seven days compared to current conditions. These sites have previously been identified and assessed in Section 7.4 of Appendix I *Non-Aboriginal Heritage Assessment* to the EIS.

6.3.2.2 Heritage items and archaeological potential

Items on the NPWS Section 170 heritage register in the upstream study area potentially affected by the Project are:

- Joorilands Homestead (NPWS s.170 ID3817), of State significance
- Murphys Flat Yards (NPWS s.70 ID 13367), does not fulfil criteria for Local listing
- Stone Hut Ruins (NPWS s.170 ID12804), of Local significance
- Orange Tree Flat House (NPWS s.170 ID12805) does not fulfil criteria for Local listing.

The four identified sites were used for a mix of occupational and agricultural purposes prior to their abandonment in the 20th century. While the Orange Tree Flat House, Murphy's Flat Yards and Jooriland Homestead sites have been assessed as possessing overall nil-to-low potential to possess archaeological resources, the Stone Hut Ruins site possesses low-to-moderate potential for archaeological resources relating to the residential and agricultural usage of the site.

6.3.2.3 Potential impacts

Construction

Neither, the four upstream section 170 sites, nor Megarritys Bridge, would not be subject to any direct or indirect impacts as a result of the construction works.

Flooding

In general terms, the Project would change upstream flooding through an increase in the frequency of floods of a specific magnitude, and the depth, duration and extent of temporary inundation. This would be greatest at the dam wall and in Lake Burragorang, but would lessen moving away from the lake up the tributaries.

Table 6-2 presents the existing duration extents (in days) at each of the four section 170 sites versus the new duration extents for the project, noting some of these locations are not affected by all flood events.

Table 6-2 Changes in temporary inundation (days) for potentially affected section 170 sites

Site	Flood event (1 in x chance in a year)							
	1 in 5		1 in 10		1 in 20		1 in 100	
	E[1]	P[1]	E	P	E	P	E	P
Joorilands Homestead	NA[2]	NA	NA	NA	NA	NA	NA	NA
Murphys Flat Yards	NA	NA	NA	10	NA	13	8	16
Stone Hut Ruins	NA	8	7	10	8	13	8	16
Orange Tree Flat House	NA	8	NA	10	NA	13	NA	16

1. E = existing; P = Project
2. N/A = Not affected by flood event

Operation

The potential operational impacts of the Project on the four upstream sites would relate to additional temporary inundation events during any occurrence when Lake Burragorang is above FSL. The four section 170 listed sites are affected to varying degrees by temporary inundation from the existing dam as previously noted. These existing risks already pose a threat to the conservation values of these sites.

The raising of the dam has the potential to result in extended periods of inundation to the site during flood events. It is noted that the depth and relative velocities of waters backing up and receding during these events would not be very different from the existing situation. Therefore, the primary impacts to these sites would be increased duration of temporary inundation during flooding events. All four of the upstream sites are currently uninhabited and are in poor condition. It is therefore assumed that the potential impact of an extended inundation period would result in some additional deterioration of the structures that remain standing within these sites.

Downstream, flooding in the vicinity of Megarritys Bridge will be reduced with the Project in terms of flood frequency, and flood height and extent. The bridge location is not affected by the 1 in 100 chance in a year flood event with the Project. However, the PMF with the Project would still extend up Megarritys Creek past the location of the bridge.

Archaeological remains

Given the nil-to-low potential for archaeological resources at the Orange Tree Flat House, Murphys Flat Yards and Jooriland Homestead sites, and the low likelihood of impacts to these sites from temporary inundation and continued exposure to flooding, the Project would see a neutral level of impact to potential subsurface historical archaeological resources.

While there is a low-to-moderate potential for archaeological resources at the Stone Hut Ruins site, the Project would not see an increased risk of scouring with velocity of flood waters expected to be low or similar to existing levels. Therefore, the Project would not further impact subsurface historical archaeological resources at the Stone Hut Ruins site.

A summary of the impacts to the sites assessed in the supplementary assessment is provided in the following table.

Table 6-3 Summary of impacts to the five additional sites in the supplementary assessment

Site	Direct (physical) impacts	In-direct (visual and setting impacts)	Archaeological
Megarritys Bridge	Neutral	Neutral	Neutral
Joorilands Homestead	Neutral	Neutral	Neutral
Murphys Flat Yards	Minor-moderate	Neutral	Neutral
Stone Hut Ruins	Minor-moderate	Neutral	Neutral
Orange Tree Flat House	Minor - moderate	Neutral	Neutral

6.3.2.4 Mitigation measures

Details of mitigation measures in relation to the supplementary assessment are provided in the supplementary non-Aboriginal heritage assessment, provided as Appendix G to this report.

6.3.3 World Heritage

DPE requirement

Provide a more detailed assessment of the impacts of the proposal on World Heritage including:

- Consideration of the Aboriginal cultural heritage aspects of World Heritage
- Consideration of the natural and cultural values
- Assessment of the impacts of the proposal against the Statement of Outstanding Universal Value (OUV) for the Greater Blue Mountains World Heritage Area.

6.3.3.1 Overview

The *Matters of National Environmental Significance Significant Impact Assessment Guidelines 1.1* (Impact Guidelines) (DoE 2013) provide the framework for the assessment of various MNES under the EPBC Act. The Impact Guidelines state that

> *Approval under the EPBC Act is required for any action occurring within or outside a declared World Heritage property that has, will have, or is likely to have a significant impact on the World Heritage values of the World Heritage property.*
>
> …
>
> *An action is likely to have a significant impact on the World Heritage values of a declared World Heritage property if there is a real chance or possibility that it will cause:*
>
> - *one or more of the World Heritage values to be lost*
> - *one or more of the World Heritage values to be degraded or damaged, or*
> - *one or more of the World Heritage values to be notably altered, modified, obscured or diminished.*

This section addresses these matters requested by DPE with regard to the Impact Guidelines.

6.3.3.2 Overview of hydrology and flooding

As previously noted, Warragamba Dam was in existence at the time of inscription of the GBMWHA on the World Heritage List in 2000 and the National Heritage List in 2007. Although a heritage item can be listed despite it being subject to risks which are affecting the Outstanding Universal Value, there is an existing flood risk in the upstream catchment associated with the dam that potentially temporarily inundates part of the GBMWHA. The type of flood risk has not changed with the dam raising Project, however, there will be a net incremental increase of around 300 hectares in addition to the existing temporary inundation area within the Project Upstream Impact Area (PUIA). The risk of temporary inundation will remain with both the existing dam and the raised dam.

Flooding in the catchment upstream of Warragamba Dam comprises two components:

- Local catchment inflows – these are independent of the Project, will not be changed by the Project and are determined by local conditions
- Backwater from Lake Burragorang as inflows enter the lake and exceed outflows at the dam.

Local catchment inflows occur above the upstream limit of backwater from Lake Burragorang. Temporary inundation from the backwater effect will change with regard to:

- The lateral extent of temporary inundation
- The depth and duration of temporary inundation
- The frequency of flood events causing temporary inundation.

Further details are provided as follows.

Area of temporary inundation

The additional flooding for flood events up to the 1 in 100 chance in a year event potentially affecting the GBMWHA would occur principally along the Wollondilly River within Lake Burragorang (eastern shoreline) and the main river channel (on the right/eastern bank), and the upper reaches of the Nattai River.

There are no areas of the GBMWHA in proximity to the Coxs River and Kowmung River that would be affected by additional flooding for flood events up to the 1 in 100 chance in a year event.

The size of the upstream study area is 5,280 hectares (defined by the PMF with the Project as per the SEARs). Of this area, 1,360 hectares are within the GBMWHA with 770 hectares already at risk of temporary inundation from the PMF event for the existing dam. The areas of temporary inundation for the existing dam and with the Project for other selected flood events are shown in the following table (Table 4-7 in EIS Appendix J *World Heritage Assessment Report*).

Table 6-4 Existing and with Project temporary inundation

Flood event (1 in x chance in a year)	Existing (ha)	With Project (ha)	Additional area (ha)
5	28	115	87
10	113	279	166
20	153	446	293
100	288	703	415

Depth and duration of temporary inundation

- For the locations approximating the limit of the 1 in 100 chance in a year event, increases in the maximum depth of temporary inundation with the Project for all events would be half a metre or less.
- Increases in the duration of temporary inundation for all events considered for the Nattai River and Wollondilly River would be less than half a day.
- Increases in the duration of temporary inundation for the Kowmung River would be less than half a day up to the 1 in 5 and 1 in 10 chance in a year events, about 1.3 days for the 1 in 20 chance in a year event, and about two days for the 1 in 100 chance in a year event (these would not affect the GBMWHA).
- Increases in the duration of temporary inundation for the Coxs River would be less than half a day for up to the 1 in 20 chance in a year event and then slightly over half a day up to the 1 in 100 chance in a year event (these would not affect the GBMWHA).
- There is an increase in depth and duration of temporary inundation, with locations within Lake Burragorang generally reflecting the pattern of changes in depth and duration of temporary inundation for the same flood events at the dam wall.

Frequency of flood events

- The Project would result in a shift in the flood frequency curves resulting in events of a specified depth occurring more frequently than currently occurs in the upstream catchment; this is most pronounced at the dam wall and in Lake Burragorang, and decreases moving up the tributaries.
- There is no material difference in the existing and with Project flood frequency curves at upstream locations that approximate the extent of the Project PMF (as would be expected).
- The frequency analysis shows that for the Wollondilly River and Nattai River there is effectively no material change in flood frequencies.
- For the Kowmung River, the flood frequency curves start to diverge at about the 1 in 50 chance in a year event. The current 1 in 100 chance in a year event would occur on average about once every 85 years with the Project.
- For the Coxs River, the curves start to diverge between the 1 in 10 chance in a year and the 1 in 20 chance in a year events.
- The current 1 in 100 chance in a year event would occur on average about once every 70 years with the Project. Further details are provided in Section 15.6.4 of the EIS.

Other Lake Burragorang tributaries

There are a number of other tributaries that drain to Lake Burragorang whose upper reaches extend into or are in proximity to the GBMWHA. The catchments for these tributaries represent very minor contributions to Lake Burragorang relative to the overall Warragamba Dam catchment and accordingly were not included in the upstream modelling. As such, information such as depth-duration curves is not available for any of these tributaries.

The following is a summary of characteristics of temporary inundation (existing, with Project) for these tributaries:

- Lacys Creek: about 18 hectares of the GBMWHA lies within the study area (defined by the Project PMF). The existing 1 in 100 chance in a year event does not affect the GBMWHA, the same event for the Project would affect about 11 hectares. Small areas of the 1 in 20 and 1 in 10 chance in a year events (about 2.3 and 0.1 hectares respectively) with the Project also lie within the GBMWHA; none of these events for the existing situation affect the GBMWHA.
- Green Wattle Creek: the existing 1 in 100 chance in a year event does not affect the GBMWHA; the Project would affect about 0.3 hectares.
- Butchers Creek: the existing 1 in 100 chance in a year event affects less than one hectare of the GBMWHA, the Project would affect about an additional 7.7 hectares. None of the other more frequent flood events extend into the GBMWHA in this location.
- Kedumba River: about 1.8 kilometres of the right bank of the Kedumba River is located immediately adjacent to the GBMWHA. This part of the GBMWHA is generally unaffected by the existing 1 in 100 chance in a year event; the Project would affect about 20 hectares of the GBMWHA. None of the other more frequent flood events would affect the GBMWHA.
- Cedar Creek: none of the other existing or Project flood events up to the 1 in 100 chance in a year flood event extend into the GBMWHA in this location.

6.3.3.3 Assessment against OUV of GBMWHA

The assessment against the OUV of the GBMWHA broadly follows that presented in DAWE (2022) with regard to the designation of the components of the OUV for the GBMWHA. This notes that the OUV is composed of multiple and inter-related components that, together, constitute the GBMWHA's exceptional significance.

The assessment presented in DAWE (2022) selected eight high-level components that were considered to represent the two criteria of natural heritage values as presented in the Statement of OUV for the property, i.e.

- (ix) be outstanding examples representing significant on-going ecological and biological processes in the evolution and development of terrestrial, fresh water, coastal and marine ecosystems and communities of plants and animals.
- (x) contain the most important and significant natural habitats for in-situ conservation of biological diversity, including those containing threatened species of Outstanding Universal Value from the point of view of science or conservation.

The selected high-level components and respective descriptions are presented in the following table. These are separated into natural heritage values and integrity. As noted in DAWE (2022), there is considerable overlap among these high-level components, reflecting the interconnectedness of the component values contributing to the OUV of the GBMWHA.

Table 6-5 OUV components

Component	Description
Natural heritage values	
Gondwanan flora	Primitive rainforest species with Gondwanan affinities that have survived in isolated pockets of the GBMWHA (e.g. Wollemi Pine, Blue Mountains Pine, species of *Lomatia, Dracophyllum, Acrophyllum, Podocarpus and Atkinsonia*).
Scleromorphic flora	Plants having hard, short and often spiky leaves that have evolved in response to conditions of low soil fertility and limited water (e.g. Myrtaceae – eucalypts, Fabaceae – acacias, Proteaceae - banksias, grevilleas and hakeas). Scleromorphic flora cover more than 98% of the GBMWHA.
Conservation-significant flora	Plant species and ecological communities that are identified under the EPBC Act and/or BC Act as requiring special environmental protection due to substantial declines in geographic distribution and/or key species, and because of the presence of ongoing pressures that are likely to continue the trend of degradation and loss.
Conservation-significant fauna	Animal species and ecological communities that are identified under the EPBC Act and/or BC Act as requiring special environmental protection for the same reasons as conservation-significant flora.
Integrity	
Water systems	Aquatic features such as streams, springs, swamps, lakes, waterfalls, seeps, groundwater, and associated water-dependent ecosystems that have evolved in tandem with the geomorphic evolution of the landscape. Examples include the Thirlmere Lakes system in Thirlmere Lakes National Park and the Colo,

Component	Description
	Kowmung and Grose river systems, parts of which are declared wild rivers under the NPW Act.
Geodiversity	The diversity of geological structures and landforms such as plateaus, cliffs, escarpments, caves, canyons, gorges and pagoda rocks. These provide the setting for the unique biota and contribute to the GBMWHA's indigenous heritage and natural beauty (Washington and Wray 2011, cited in DAWE 2022).
Boundary integrity	Characteristics of the GBMWHA's boundary (e.g. native vegetation buffers, rocky escarpments) that help protect the GBMWHA's OUV.
Indigenous custodial relationships	Culturally important sites such as caves, shelters, hearths, rock art, grinding grooves, scar trees and landscape features). Species that are important for diet, materials, medicine, cultural identity and spiritual values of the indigenous peoples of the area. Intangible values that reflect the connections and interdependent relationship between Indigenous people and their ancestral lands.

6.3.3.4 Gondwanan flora

Key representatives of the Gondwanan flora in the GBMWHA are the endemic Wollemi Pine (*Wollemia nobilis*), the Blue Mountains Pine (*Pherosphaera fitzgeraldii*) and *Acrophyllum australe* (DAWE 2022).

Wollemi Pine

The Wollemi Pine is restricted to four small patches in a single location in Wollemi National Park (NSW Scientific Committee 2015). The Project would not affect any protected lands falling within Wollemi National Park. Given the intervening distance (>10 kilometres) between the upstream Project area and Wollemi National Park, the potential for indirect impacts is considered remote.

Blue Mountains Pine/Dwarf Mountain Pine,

The Blue Mountains Pine, also known as the Dwarf Mountain Pine, occurs in the upper Blue Mountains between Wentworth Falls and Katoomba. The species is found within the spray zone or associated drip lines and seepage areas of waterfalls on steep, sandstone cliffs and ledges, at altitudes between 680 and 1000 metres above sea level. The sites face south-east to south-west, and being on near-vertical to vertical slopes or under overhangs, are heavily shaded. The degree of shading from other plants varies from none on exposed cliffs and ledges to up to 70 percent from nearby rainforest plants on larger, lower ledges and overhang caves[8].

The biodiversity assessment for the upstream area (Appendix F1 to the EIS) identified that small areas of suitable habitat occur in the upstream study area. The likelihood of occurrence was identified as moderate. Waterfall spray-zone habitat is marginal in the upstream study area. The species was not recorded during field surveys but was assumed to be present for the purposes of the assessment which identified the potential for temporary inundation to adversely impact this species.

8 https://www.environment.nsw.gov.au/threatenedSpeciesApp/profile.aspx?id=10530

All recorded sightings are from the Katoomba and Wentworth Falls areas which are to the north of and outside of the upstream area, and would therefore not be affected by temporary inundation from the Project. The existing upstream PMF level is 131.2 mAHD and would increase to 143.9 mAHD (at Warragamba Dam). This is more than 500 metres below the lower limit of this species as noted above. While the biodiversity assessment adopted a precautionary position with regard to the presence of the species, the likelihood of it being affected by the Project is considered low.

Acrophyllum australe

The biodiversity assessment for the upstream area (Appendix F1) noted that suitable habitat for this species includes sheltered gullies beneath waterfalls and drip zones of rock overhangs and cliff faces, typically where there is a constant source of water. It is generally associated with *Callicoma serratifolia, Dracophyllum secundum, Todea barbata, Alania endlicheri* and *Blechnum ambiguum*. The biodiversity assessment noted that the study area did not contain suitable edaphic or landscape features, or floristic associations for this species. The majority of potential habitat for this species occurs outside of the upstream study area (refer Figure B.7 in Appendix F1) but was included in the assessment through falling within the 500 m buffer used in the biodiversity assessment.

6.3.3.5 Scleromorphic flora

A major component of the OUV for the GBMWHA is the high number of eucalypt species and eucalypt-dominated communities present, some 13 percent of all eucalypt species in the world (Hager and Benson 2010).

Hager and Benson (2010) provide a definitive list of the 96 eucalypts (species of the genera *Eucalyptus*, *Angophora* and *Corymbia* in the family Myrtaceae) that have been recorded in the GBMWHA, together with the distribution of the eucalypts in the eight reserves that make up the GBMWHA. Information on the classification and habitats of the different species is also provided. This paper has been used to inform the following discussion with regard to potential impacts of the Project on eucalyptus with regard to the OUV of the GBMWHA.

The Project potentially affects parts of the following protected lands within the GBMWHA:

- Blue Mountains National Park (upstream area)
- Nattai National Park (upstream area)
- Yengo National Park (downstream area).

These areas are already affected by temporary inundation associated with the existing dam. In general, the risk of temporary inundation will increase in the upstream area and decrease in the downstream area.

Table 1a in Hager and Benson (2010) identifies 55 eucalypt species with relatively widespread distributions in the GBMWHA by individual reserves. Of these, 50 species occur in Blue Mountains National Park, 29 species in Nattai National Park, and 24 species in Yengo National Park. In view of their widespread distribution across the GBMWHA, these species have not been considered in the following discussion.

Table 1b in Hager and Benson (2010) identifies 41 eucalypt species with relatively restricted distributions in the GBMWHA by individual reserves. The following table draws from this table and identifies eucalypt species occurring in one or more of the three national parks noted above. Comment is provided for each species with regard to the potential impact of the Project.

Table 6-6 Eucalypt species with restricted distributions within the GBMWHA potentially affected by the Project

Species	Distribution[1]	Conservation status	Potential impact of Project
Angophora euryphylla	Restricted distribution – sandstone outcrops between the Central Coast and Putty. Occurs in Yengo and Wollemi NPs.	–	Species does not occur within PCTs identified in the Project study area therefore unlikely to be impacted by the Project.
Angophora hispida	Widespread on shallow soils on Hawkesbury sandstone plateaus near the coast. Uncommon in the GBMWHA. Occurs in Yengo and Wollemi NPs.	–	Mid-stratum species in PCT 1083 Red Bloodwood–Grey Gum woodland on the edges of the Cumberland Plain, Sydney Basin Bioregion. Occurs within the Burragorang and Wollemi IBRA subregions which overlap with the Project study area. This PCT occurs on crests, ridges and exposed slopes on coastal sandstone plateaux. These features do not occur in the area of Yengo NP potentially affected by the Project in the downstream study area. This species is therefore unlikely to be impacted by the Project.
Eucalyptus aggregata	Occurs on cold alluvial flats from Wallerawang to Victoria. Suitable climatic and drainage conditions are limited in the GBMWHA. Occurs in Blue Mountains NP.	BC – V EPBC – V	Upstream study area does not contain PCTs, specific species associations, and soil type/edaphics associated with this species, therefore unlikely to be impacted by the Project.
Eucalyptus apiculata	Restricted distribution – scattered populations on skeletal soils between Linden and Berrima. Occurs in Blue Mountains and Nattai NPs.	–	Species does not occur within PCTs identified in the Project study area therefore unlikely to be impacted by the Project.
Eucalyptus baeuerlenii	Restricted distribution – scattered populations at Wentworth Falls, Budawang Range, Wadbilliga NP. Occurs in Blue Mountains NP.	–	Species does not occur within PCTs identified in the Project study area therefore unlikely to be impacted by the Project.

Species	Distribution[1]	Conservation status	Potential impact of Project
Eucalyptus benthamii	Restricted distribution – alluvial soils in the lower Hawkesbury-Nepean catchment Occurs in Blue Mountains and Nattai NPs.	BC – V EPBC – V	Upper stratum species in PCT 553 Mountain Blue Gum–Thin-leaved Stringybark open forest on river flat alluvium in the Sydney Basin Bioregion. Occurs within the Burragorang IBRA subregion which overlaps with the Project study area. This PCT occurs on sheltered valley flats upstream of Lake Burragorang. This species was recorded in the upstream study area. Bush and England (2019) found that *Eucalyptus benthamii* may be tolerant to temporary inundation for up to six weeks duration to a depth of 30 centimetres, suggesting that the species may also possess similar morphological adaptions to enable some level of tolerance to flood stress. Within the upstream study area, the depth of temporary inundation is expected to be more variable and potentially much greater than 30 centimetres. The NSW threatened species profile for the Camden White Gum notes there is a major subpopulation in the Kedumba Valley of the Blue Mountains NP. This occurs primarily along the margins of the Kedumba River and is mostly outside the GBMWHA. The maximum changes in temporary inundation for this area will be in the order of an additional 0.5 m depth and about 0.7 days duration for the 1 in 100 chance in a year flood event and less than 0.5 m and 0.5 days for more frequent events. The Project is therefore unlikely to impact this subpopulation. Areas of this species occurring along other tributaries would experience similar maximum incremental increases of up to half a day and half a metre of temporary inundation.
Eucalyptus burgessiana	A species endemic to the GBMWHA, with scattered populations on skeletal soils at lower elevations. Occurs in Blue Mountains, Nattai and Wollemi NPs.	–	Species does not occur within PCTs identified in the Project study area therefore unlikely to be impacted by the Project.

Species	Distribution[1]	Conservation status	Potential impact of Project
Eucalyptus camphora subsp. camphora	On open swampy flats from Nullo Mountain to the Megalong Valley. Suitable swampy alluvial soils are limited within the GBMWHA. Occurs in Blue Mountains and Wollemi NPs.	–	Species does not occur within PCTs identified in the Project study area therefore unlikely to be impacted by the Project.
Eucalyptus capitellata	Locally frequent on sandy soils on coastal foothills between Karuah and Nerriga. Uncommon in the GBMWHA. Occurs in Yengo NP.	–	Species does not occur within PCTs identified in the Project study area therefore unlikely to be impacted by the Project.
Eucalyptus cunninghamii	A species endemic to the GBMWHA, with localised populations on skeletal soils in the upper Blue Mountains and Wanganderry Tableland. Occurs in Blue Mountains, Nattai and Kanangra-Boyd NPs.	–	Species does not occur within PCTs identified in the Project study area therefore unlikely to be impacted by the Project.
Eucalyptus dendromorpha	Restricted distribution – scattered populations from Mt Tomah to the Budawang Range. Occurs in Blue Mountains NP.	–	Species does not occur within PCTs identified in the Project study area therefore unlikely to be impacted by the Project.
Eucalyptus fergusonii subsp. dorsiventralis	Restricted distribution – Lake Macquarie and northern Yengo NP to Mountain Lagoon Occurs in Yengo and Wollemi NPs.	–	Species does not occur within PCTs identified in the Project study area therefore unlikely to be impacted by the Project.
Eucalyptus fracta	Restricted distribution – sandstone ranges between the Hunter Valley and northern Yengo NP.	BC – V	Species does not occur within PCTs identified in the Project study area therefore unlikely to be impacted by the Project.

Species	Distribution[1]	Conservation status	Potential impact of Project
	Occurs in Yengo NP.		
Eucalyptus hypostomatica	Localised distribution – the lower Hunter Valley to Kangaroo Valley. Occurs in Blue Mountains, Nattai, Yengo and Wollemi NPs.	–	Species does not occur within PCTs identified in the Project study area therefore unlikely to be impacted by the Project.
Eucalyptus ligustrina	Disjunct populations on sandy soils between the Gibraltar Range and Deua NP. Occurs in Blue Mountains and Gardens of Stone NPs.	–	Species does not occur within PCTs identified in the Project study area therefore unlikely to be impacted by the Project.
Eucalyptus michaeliana	Highly disjunct distribution – Broke to St Albans, Enmore to Wollomombi and in Queensland. Occurs in Yengo NP.	–	Species does not occur within PCTs identified in the Project study area therefore unlikely to be impacted by the Project.
Eucalyptus moorei	Disjunct occurrences on sandy soils in the Gibraltar Range, Blue Mountains and the Budawang Range. Occurs in Blue Mountains and Kanangra-Boyd NPs.	–	Species does not occur within PCTs identified in the Project study area therefore unlikely to be impacted by the Project.
Eucalyptus muelleriana	Widespread along the coast and escarpment from Bindook Highlands to Victoria. It reaches its northern limit in the GBMWHA. Occurs in Blue Mountains NP.	–	Component of *Burragorang Valley and Gorges* Mitchell landscape. However, this species does not occur within PCTs identified in the Project study area therefore unlikely to be impacted by the Project.
Eucalyptus prominula	Restricted distribution – skeletal soils from the Watagans to Colo Heights. Occurs in Yengo and Wollemi NPs.	–	Species does not occur within PCTs identified in the Project study area therefore unlikely to be impacted by the Project.

Species	Distribution[1]	Conservation status	Potential impact of Project
Eucalyptus quadrangulata	Disjunct occurrences along the escarpment – Bundanoon to the Bindook Highlands, Barrington Tops to Dorrigo. Occurs in Blue Mountains and Kanangra-Boyd NPs.	–	Species does not occur within PCTs identified in the Project study area therefore unlikely to be impacted by the Project.
Eucalyptus ralla	Restricted distribution – sandstone soils from Lake Burragorang to Yalwal Plateau. Occurs in Blue Mountains NP.	–	Species does not occur within PCTs identified in the Project study area therefore unlikely to be impacted by the Project.
Eucalyptus squamosa	On sandstone from Cessnock to near Picton. Uncommon in the GBMWHA because it mainly occurs on plateaus nearer the coast. Occurs in Yengo and Wollemi NPs.	–	Species does not occur within PCTs identified in the Project study area therefore unlikely to be impacted by the Project.
Eucalyptus stellulata	Widespread on cold flats at higher altitudes from the McPherson Range to Victoria. Sufficiently cold conditions are rare in the GBMWHA. Occurs in Blue Mountains and Kanangra-Boyd NPs.	–	Species does not occur within PCTs identified in the Project study area therefore unlikely to be impacted by the Project.
Eucalyptus expressa ms. (also known as Eucalyptus sp. aff. eugenioides) (Bees Nest Ridge)	Potential additional species. Restricted distribution – sheltered gullies in northern Wollemi and Yengo. Occurs in Yengo and Wollemi NPs.	–	Species does not occur within PCTs identified in the Project study area therefore unlikely to be impacted by the Project.

1. Details as per Table 1b, column 'Why uncommon in GBMWHA', Hager and Benson (2010)

6.3.3.6 Conservation-significant flora

Threatened ecological communities

The biodiversity assessment for the upstream area (Appendix F1) that three of the 18 PCTs potentially impacted by temporary inundation were assessed as conforming to two BC Act-listed TECs. The same PCTs were assessed as an EPBC Act-listed TEC.

PCT 941 (HN553) *Mountain Blue Gum - Thin-leaved Stringybark open forest on river flat alluvium in the Sydney Basin Bioregion* was identified in the study area as a component of River-Flat Eucalypt Forest on Coastal Floodplains, which is listed as an endangered ecological community (EEC) under the BC Act and as a critically endangered ecological community (CEEC) under the EPBC Act. All areas of this PCT mapped in the broader study area were also assessed as the EEC.

Within the study area, River-Flat Eucalypt Forest is distributed in two key locations: along the Kedumba River, and along the Nattai River. The estimated area of the TEC within the upstream impact area is about 107 hectares. The biodiversity assessment identified that temporary inundation could potentially result in loss of and floristic and structural change to this TEC and its values.

PCT 640 (HN527) *Forest Red Gum - Yellow Box woodland of dry gorge slopes, southern Sydney Basin Bioregion and South Eastern Highlands* and PCT 1401 (HN557) *Narrow-leaved Ironbark - Forest Red Gum on rocky slopes of the lower Burragorang Gorge, Sydney Basin Bioregion* were identified within the study area as components of White Box Yellow Box Blakely's Red Gum Woodland which is listed as a CEEC under the BC Act.

These two PCTs have also been identified within the study area as components of White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland, listed as a CEEC under the EPBC Act.

Within the study area, the majority of White Box Yellow Box Blakely's Red Gum Woodland is distributed upstream from Higgins Bay, immediately surrounding Lake Burragorang and along the Wollondilly River. The area of these TECs within the upstream impact area is about 431 hectares. The biodiversity assessment identified that temporary inundation could potentially result in loss of, and floristic and structural change to the TEC and its values.

As part of the supplementary biodiversity assessment presented in the PIR, a desktop analysis of vegetation condition was carried out using survey plots in the upstream study area. This examined vegetation condition for a eucalypt woodland community and a riparian vegetation community, respectively:

- PCT 840 (HN527) *Forest Red Gum-Yellow Box woodland of dry gorge slopes, southern Sydney Basin Bioregion and South Eastern Highlands Bioregion*
- PCT 1105 (HN574) *River Oak open forest of major streams, Sydney Basin Bioregion and South East Corner Bioregion.*

All survey plots used in the analysis were classed as Moderate/good condition.

The analysis benchmarked the number of native species against the Sydney Basin IBRA Region and the South Eastern Highlands IBRA Region. The analysis distinguished between survey plots within the area of existing impact (from the existing dam) and above this area (which would be affected by the Project).

The results for the eucalypt woodland community are shown in Figure 6-6 to Figure 6-9 inclusive. These show that vegetation in the area of existing impact is broadly consistent with the community condition benchmarks suggesting that this community has a degree of resilience to temporary inundation. A similar, but more pronounced pattern was observed for the riparian vegetation community suggesting a stronger degree of resilience to temporary inundation (which would not be unexpected).

Figure 6-6 Native species

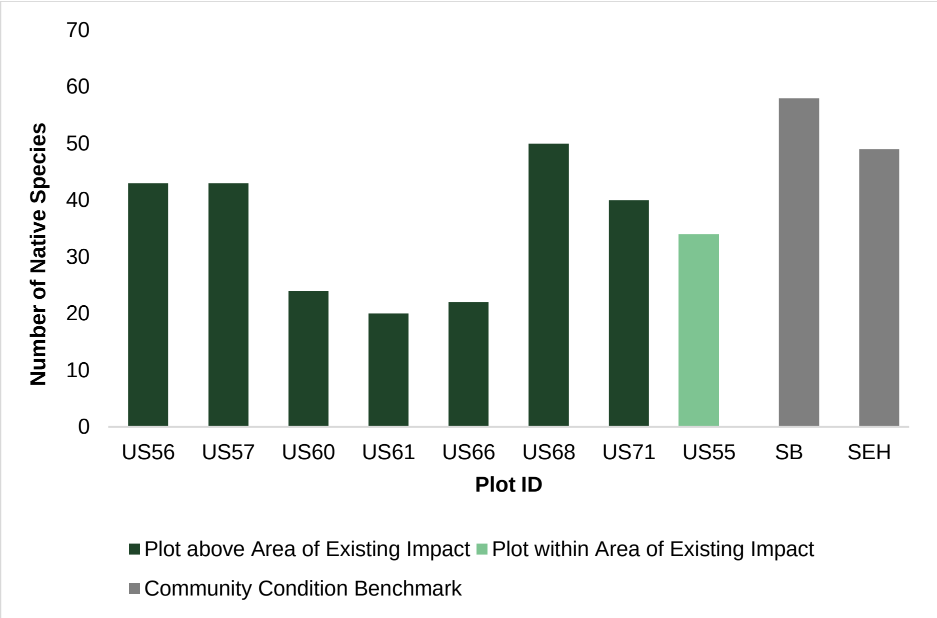


Figure 6-7 Native ground cover – grasses

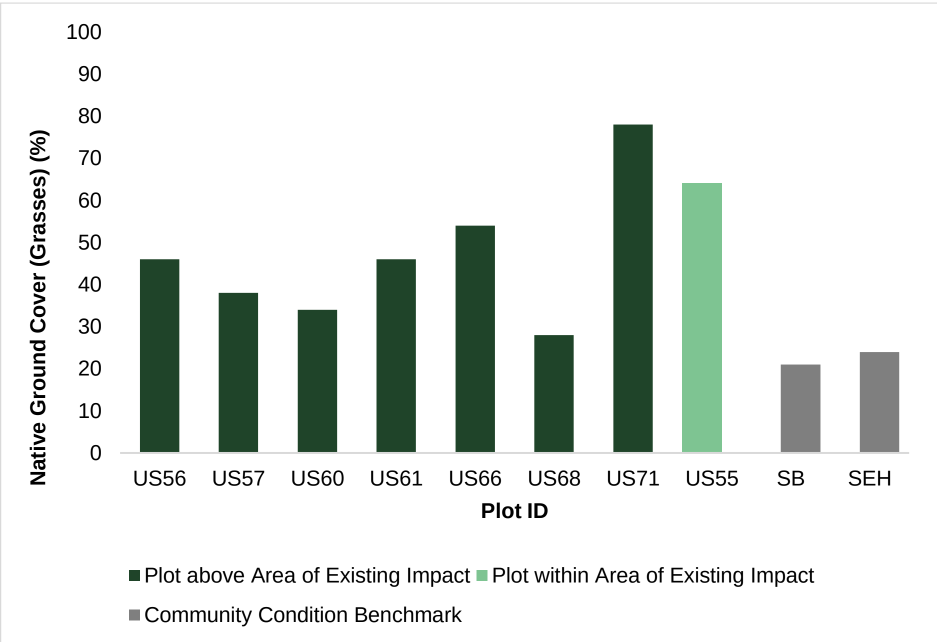


Figure 6-8 Native ground cover – shrubs

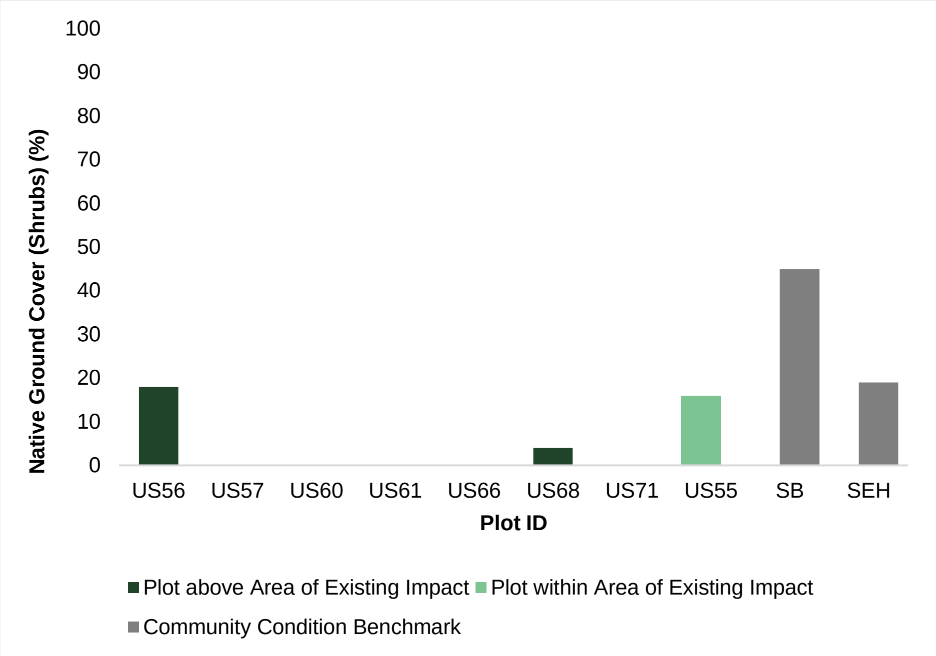
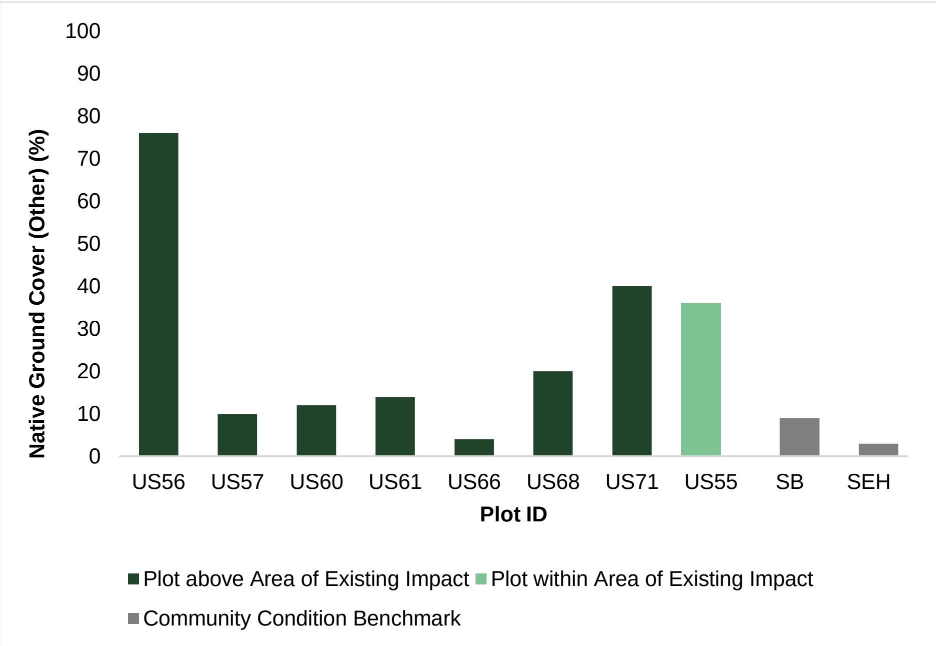


Figure 6-9 Native ground cover – other



Threatened flora

Table 6-7 provides comment with regard to potential impacts on threatened flora potentially impacted by the Project. This is based on Table 7-2 in Appendix F1 *Biodiversity Assessment Report – Upstream* to the EIS incorporating information from additional investigations carried out during preparation of the PIR.

Table 6-7 Threatened flora potentially impacted by the Project

Species name	Common name	BC Act status	EPBC Act status	Description of potential impacts to species
Acacia baueri subsp. aspera	–	V	–	New or additional temporary inundation from the Project may adversely impact this species.
Acacia bynoeana	Bynoe's Wattle	E	V	New or additional temporary inundation from the Project may adversely impact this species.
Acacia clunies-rossiae	Kanangra Wattle	V	–	During surveys for the EIS, this species was recorded upstream of Green Wattle Creek, around the shores of Lake Burragorang and along the main tributaries, including Kedumba, Cox, and Kowmung Rivers. Suitable habitat for the species is found along the western shores of Lake Burragorang from the Wollondilly River to Coxs River. New or additional temporary inundation from the Project may adversely impact this species.
Acacia flocktoniae	Flockton Wattle	V	V	New or additional temporary inundation from the Project may adversely impact this species.
Acacia gordonii	–	E	E	New or additional temporary inundation from the Project may adversely impact this species.
Acacia pubescens	Downy Wattle	V	V	New or additional temporary inundation from the Project may adversely impact this species.
Acrophyllum australe	–	V	V	New or additional temporary inundation from the Project may adversely impact this species.
Ancistrachne maidenii	–	V	–	New or additional temporary inundation from the Project may adversely impact this species.
Asterolasia buxifolia	–	E	–	New or additional temporary inundation from the Project may adversely impact this species.

Species name	Common name	BC Act status	EPBC Act status	Description of potential impacts to species
Asterolasia elegans	–	E	E	New or additional temporary inundation from the Project may adversely impact this species.
Astrotricha crassifolia	Thick-leaf Star-hair	V	V	New or additional temporary inundation from the Project may adversely impact this species.
Baloskion longipes	Dense Cord-rush	V	V	New or additional temporary inundation from the Project may adversely impact this species.
Bossiaea oligosperma	Few-seeded Bossiaea	V	V	During surveys for the EIS, this species was recorded upstream of Murphys Crossing on the Wollondilly River, around the shores of Lake Burragorang to around Higgins Bay. New or additional temporary inundation from the Project may adversely impact this species..
Caesia parviflora var. minor	Small Pale Grass-lily	E	–	New or additional temporary inundation from the Project may adversely impact this species.
Callistemon linearifolius	Netted Bottle Brush	V	–	During the current assessment, the species was recorded in three locations: Little River, Tonalli Cove, and along Green Wattle Creek. New or additional temporary inundation from the Project may adversely impact this species.
Callistemon megalongensis	Megalong Valley Bottlebrush	CE	CE	New or additional temporary inundation from the Project may adversely impact this species.
Calomnion complanatum	–	E	–	New or additional temporary inundation from the Project may adversely impact this species.
Cryptostylis hunteriana	Leafless Tongue Orchid	V	V	New or additional temporary inundation from the Project may adversely impact this species.
Cynanchum elegans	White-flowered Wax Plant	E	E	None – there is no suitable habitat for this species within the upstream study area.

Species name	Common name	BC Act status	EPBC Act status	Description of potential impacts to species
Darwinia biflora	–	V	V	New or additional temporary inundation from the Project may adversely impact this species.
Darwinia peduncularis	–	V	–	New or additional temporary inundation from the Project may adversely impact this species.
Dillwynia tenuifolia	–	V	–	New or additional temporary inundation from the Project may adversely impact this species.
Epacris hamiltonii	–	E	E	New or additional temporary inundation from the Project may adversely impact this species.
Epacris purpurascens subsp. purpurascens	–	V	–	New or additional temporary inundation from the Project may adversely impact this species.
Epacris sparsa	Sparse Heath	V	V	New or additional temporary inundation from the Project may adversely impact this species.
Eucalyptus benthamii	Camden White Gum	V	V	The NSW threatened species profile for the Camden White Gum notes there is a major subpopulation in the Kedumba Valley of the Blue Mountains NP. This occurs primarily along the margins of the Kedumba River and was recorded within the riparian area of the Kedumba River during surveys for the EIS. Stands of 18 year-old *Eucalyptus benthamii* appear to be able to tolerate temporary inundation for up to 6 weeks to a depth of approximately 30 cm (Bush and England (2019). This suggests that the species has some tolerance to temporary inundation, which may be expected given its association with forested wetlands. However, impacts to the species due to temporary inundation to greater depths, are less clear. The maximum changes in temporary inundation for the Kedumba River area will be in the order of an additional 0.5 m depth and about 0.7 days duration for the 1 in 100

Species name	Common name	BC Act status	EPBC Act status	Description of potential impacts to species
				chance in a year flood event and less than 0.5 m and 0.5 days for more frequent events. The Project is therefore unlikely to impact this subpopulation. Areas of this species occurring along other tributaries would experience similar maximum incremental increases of up to half a day and half a metre of temporary inundation.
Eucalyptus glaucina	Slaty Red Gum	V	V	During surveys for the EIS, this species was recorded across much of the upstream study area, around the shores of Lake Burragorang and along the main tributaries, including Wollondilly, Nattai, Kedumba, Cox, and Kowmung Rivers. The species may possess some adaptions to flood stress including temporary water logging, however, the Project may still adversely impact this species.
Eucalyptus pulverulenta	Silver-leafed Gum	V	V	New or additional temporary inundation from the Project may adversely impact this species.
Euphrasia bowdeniae	–	V	V	New or additional temporary inundation from the Project may adversely impact this species.
Genoplesium baueri	Bauer's Midge Orchid	E	E	New or additional temporary inundation from the Project may adversely impact this species.
Genoplesium superbum	Superb Midge Orchid	E	–	New or additional temporary inundation from the Project may adversely impact this species.
Grammitis stenophylla	Narrow-leaf Finger Fern	E	–	During surveys for the EIS, the species was found along West Warragamba Wall, and along Werriberri Creek. New or additional temporary inundation from the Project may adversely impact this species.
Grevillea evansiana	Evans Grevillea	V	V	New or additional temporary inundation from the Project may adversely impact this species.

Species name	Common name	BC Act status	EPBC Act status	Description of potential impacts to species
Grevillea parviflora subsp. parviflora	Small-flower Grevillea	V	V	New or additional temporary inundation from the Project may adversely impact this species.
Gyrostemon thesioides	–	E	–	New or additional temporary inundation from the Project may adversely impact this species.
Hakea dohertyi	Kowmung Hakea	E	E	During surveys for the EIS, this species was recorded in one location (Tonalli Cove). New or additional temporary inundation from the Project may adversely impact this species.
Haloragodendron lucasii	Hal	V	V	New or additional temporary inundation from the Project may adversely impact this species.
Hibbertia puberula	–	E	–	New or additional temporary inundation from the Project may adversely impact this species.
Hygrocybe anomala subsp. ianthinomarginata	–	V	–	New or additional temporary inundation from the Project may adversely impact this species.
Hygrocybe aurantipes	–	V	–	New or additional temporary inundation from the Project may adversely impact this species.
Hygrocybe reesiae	–	V	–	New or additional temporary inundation from the Project may adversely impact this species.
Isopogon fletcheri	Fletcher's Drumsticks	V	V	New or additional temporary inundation from the Project may adversely impact this species.
Kunzea rupestris	–	V	V	New or additional temporary inundation from the Project may adversely impact this species.
Lastreopsis hispida	Bristly Shield Fern	E	–	New or additional temporary inundation from the Project may adversely impact this species.
Leionema lachnaeoides	–	E	E	New or additional temporary inundation from the Project may adversely impact this species.

Species name	Common name	BC Act status	EPBC Act status	Description of potential impacts to species
Lepidosperma evansianum	Evans Sedge	V	E	New or additional temporary inundation from the Project may adversely impact this species.
Leucopogon exolasius	Woronora Beard-heath	V	V	New or additional temporary inundation from the Project may adversely impact this species.
Leucopogon fletcheri subsp. fletcheri	–	E	–	New or additional temporary inundation from the Project may adversely impact this species.
Melaleuca deanei	Deane's Paperbark	V	V	New or additional temporary inundation from the Project may adversely impact this species.
Melaleuca groveana	Grove's Paperbark	V	–	New or additional temporary inundation from the Project may adversely impact this species.
Micromyrtus blakelyi	–	V	V	New or additional temporary inundation from the Project may adversely impact this species.
Olearia cordata	–	V	V	New or additional temporary inundation from the Project may adversely impact this species.
Persicaria elatior	Tall Knotweed	V	V	New or additional temporary inundation from the Project may adversely impact this species.
Persoonia acerosa	Needle Geebung	V	V	New or additional temporary inundation from the Project may adversely impact this species.
Persoonia bargoensis	Bargo Geebung	E	V	New or additional temporary inundation from the Project may adversely impact this species.
Persoonia glaucescens	Mittagong Geebung	E	V	New or additional temporary inundation from the Project may adversely impact this species.
Persoonia hirsuta	Hairy Geebung	E	E	New or additional temporary inundation from the Project may adversely impact this species.

Species name	Common name	BC Act status	EPBC Act status	Description of potential impacts to species
Pherosphaera fitzgeraldii	Dwarf Mountain Pine	E	E	New or additional temporary inundation from the Project may adversely impact this species.
Phyllota humifusa	Dwarf Phyllota	V	V	New or additional temporary inundation from the Project may adversely impact this species.
Pimelea curviflora var. curviflora	–	V	V	New or additional temporary inundation from the Project may adversely impact this species.
Pomaderris brunnea	Brown Pomaderris	E	V	During surveys for the EIS, the species was recorded along the Nattai River, at Tonalli Cove, Higgins Bay, and around Butchers Creek. The local population may have increased as a result of existing temporary inundation. New or additional temporary inundation from the Project may adversely impact this species.
Pterostylis saxicola	Sydney Plains Greenhood	E	E	New or additional temporary inundation from the Project may adversely impact this species.
Pultenaea glabra	Smooth Bush-pea	V	V	New or additional temporary inundation from the Project may adversely impact this species.
Pultenaea parviflora	–	E	V	New or additional temporary inundation from the Project may adversely impact this species.
Pultenaea sp. Olinda	–	E	–	New or additional temporary inundation from the Project may adversely impact this species.
Pultenaea villifera – endangered population	*Pultenaea villifera* population in the Blue Mountains Local Government Area	EP	–	None – there is no suitable habitat for this endangered population within the upstream study area.
Rhizanthella slateri	Eastern Australian Underground Orchid	V	E	New or additional temporary inundation from the Project may adversely impact this species.

Species name	Common name	BC Act status	EPBC Act status	Description of potential impacts to species
Rhodamnia rubescens	Scrub Turpentine	CE	–	New or additional temporary inundation from the Project may adversely impact this species.
Solanum amourense	–	E	–	During surveys for the EIS, this species was recorded upstream of Murphys Crossing on the Wollondilly River, around the shores of Lake Burragorang. New or additional temporary inundation from the Project may adversely impact this species.
Tetratheca glandulosa	–	V	–	New or additional temporary inundation from the Project may adversely impact this species.
Trachymene scapigera	Mountain Trachymene	E	E	New or additional temporary inundation from the Project may adversely impact this species.
Velleia perfoliata	–	V	V	New or additional temporary inundation from the Project may adversely impact this species.
Xanthosia scopulicola	–	V	–	New or additional temporary inundation from the Project may adversely impact this species.
Zieria covenyi	Coveny's Zieria	E	E	New or additional temporary inundation from the Project may adversely impact this species.
Zieria involucrata	–	E	V	New or additional temporary inundation from the Project may adversely impact this species.
Zieria murphyi	Velvet Zieria	V	V	New or additional temporary inundation from the Project may adversely impact this species.

6.3.3.7 Conservation-significant fauna

Table 6-8 provides comment with regard to potential impacts on threatened fauna potentially impacted by the Project. This is based on Table 7-3 in Appendix F1 *Biodiversity Assessment Report – Upstream* to the EIS incorporating information from additional investigations carried out during preparation of the PIR.

Table 6-8 Threatened fauna potentially impacted by the Project

Species name	Common name	BC Act status	EPBC Act status	Description of potential impacts to species
Anthochaera phrygia	Regent Honeyeater	CE	CE	During the surveys for the EIS a large breeding population of Regent Honeyeaters was recorded around Tonalli Cove. Impacts from temporary inundation may include loss of structural components of the vegetation (for example, *Amyema pendula* and *Amyema cambagei*) within areas of suitable breeding habitat, mortality of nestlings should a flood occur during a breeding event, and potential loss of suitable foraging habitat, specifically feed tree species such as *Eucalyptus melliodora, Eucalyptus albens, and Eucalyptus eugenioides.* However, it is noted that these three eucalypt species are relatively widespread across the GBMWHA (Hager and Benson 2010).
Cercartetus nanus	Eastern Pygmy-possum	V	–	Species was not recorded during surveys for the EIS but was assumed to be present. Modification of habitat within the upstream study area may reduce the availability of foraging resources and breeding sites. Impacts may include loss of structural components of the vegetation within areas of suitable breeding habitat, potential mortality of individuals during a flood event, and loss of suitable foraging habitat.
Chalinolobus dwyeri	Large-eared Pied Bat	V	V	During surveys for the EIS, this species was recorded across much of the upstream study area around the shores of Lake Burragorang, along the main tributaries, including Wollondilly, Nattai, Kedumba, Cox, and Kowmung Rivers, and at Warragamba Dam. Temporary inundation may modify the structure and composition of suitable foraging habitat. It is expected that limited roosting and breeding habitat occurs within the upstream study area, however, the surveys for the EIS did not specifically target this type of habitat.

Species name	Common name	BC Act status	EPBC Act status	Description of potential impacts to species
				Impacts may include loss of structural components of the vegetation within areas of suitable breeding habitat, potential mortality of individuals during a flood event, and loss of suitable foraging habitat.
Heleioporus australiacus	Giant Burrowing Frog	V	V	Species was not recorded during surveys for the EIS but was assumed to be present. Modification of habitat within the upstream study area may reduce the availability of foraging resources and breeding sites. Impacts may include loss of structural components of the vegetation within areas of suitable breeding habitat, potential mortality of individuals during a flood event, and loss of suitable foraging habitat.
Hoplocephalus bungaroides	Broad-headed Snake	E	V	Species was not recorded during surveys for the EIS but was assumed to be present. Low quality habitat for this species may be impacted. The affected habitat is confined to the lower reaches of Lake Burragorang and consists of small ledges with few exfoliated rocks and is moderately to well shaded. The most important areas of habitat in the upstream study area occur along the top edges of the sandstone escarpments, where there are more extensive areas of rock shelf and little shading. These areas are well above the proposed temporary inundation area. Impacts may include loss of habitat components such as exfoliated rocks and hollows, and potential mortality during flood events.
Isoodon obesulus subsp. *obesulus*	Southern Brown Bandicoot (eastern)	E	E	Species was not recorded during surveys for the EIS but was assumed to be present. Modification of habitat within the upstream study area may reduce the availability of foraging resources and breeding sites for this species.

Species name	Common name	BC Act status	EPBC Act status	Description of potential impacts to species
				Impacts may include loss of structural components of the vegetation within areas of suitable breeding habitat, potential mortality of individuals during flood events, and loss of suitable foraging habitat.

Species name	Common name	BC Act status	EPBC Act status	Description of potential impacts to species
Ixobrychus flavicollis	Black Bittern	V	–	Species was not recorded during surveys for the EIS but was assumed to be present. Modification of habitat within the upstream study area may reduce the availability of roosting and sheltering sites for this species. Impacts may include loss of structural components of the vegetation within areas of suitable breeding habitat, potential mortality of individuals during flood events, and loss of suitable foraging habitat.
Litoria littlejohni	Littlejohn's Tree Frog	V	V	Species was not recorded during surveys for the EIS but was assumed to be present. Modification of habitat within the upstream study area may reduce the availability of foraging resources and breeding sites. Impacts may include loss of structural components of the vegetation within areas of suitable breeding habitat, potential mortality of individuals during flood events, and loss of suitable foraging habitat.
Macropus parma	Parma Wallaby	V	–	Species was not recorded during surveys for the EIS but was assumed to be present. Modification of habitat within the upstream study area may reduce the availability of foraging resources and shelter sites. Impacts may include loss of structural components of the vegetation within areas of suitable breeding habitat, potential mortality of individuals during flood events, and loss of suitable foraging habitat.
Myotis macropus	Southern Myotis	V	–	Temporary inundation may modify the structure and composition of suitable foraging habitat for this species within the study area. Most of the habitat potentially impacted comprises suitable foraging habitat. It is expected that some roosting and breeding habitat occurs within the upstream study area, however, the surveys for the EIS did not specifically target this type of habitat.

Species name	Common name	BC Act status	EPBC Act status	Description of potential impacts to species
				Impacts may include loss of large areas of the structural components of the vegetation within areas of suitable foraging habitat, loss of suitable breeding and roosting habitat, and potential mortality of individuals during flood events.
Petaurus norfolcensis	Squirrel Glider	V	–	Species was not recorded during surveys for the EIS but was assumed to be present. Modification of habitat within the upstream study area may reduce the availability of foraging resources and nesting sites. Impacts may include loss of structural components of the vegetation within areas of suitable breeding habitat, potential mortality of individuals during flood events, and loss of suitable foraging habitat.
Petrogale penicillata	Brush-tailed Rock-wallaby	E	V	Species was not recorded during surveys for the EIS but was assumed to be present. Modification of habitat within the upstream study area may reduce the availability of foraging resources and shelter sites. Impacts may include loss of structural components of the vegetation within areas of suitable breeding habitat, potential mortality of individuals during flood events, and loss of suitable foraging habitat.
Phascogale tapoatafa	Brush-tailed Phascogale	V	–	Species was not recorded during surveys for the EIS but was assumed to be present. Modification of habitat within the upstream study area may reduce the availability of foraging resources and nesting sites. Impacts may include loss of structural components of the vegetation within areas of suitable breeding habitat, potential mortality of individuals during flood events, and loss of suitable foraging habitat.
Phascolarctos cinereus	Koala	V	V	Species was not recorded during surveys for the EIS but was assumed to be present.

Species name	Common name	BC Act status	EPBC Act status	Description of potential impacts to species
				Modification of habitat within the upstream study area may impact on koalas due to the potential reduction in the availability of foraging resources. Impacts may include loss of structural components of the vegetation within areas of suitable breeding habitat, potential mortality of individuals during flood events, and loss of suitable foraging habitat- specifically suitable feed tree species.
Pseudophryne australis	Red-crowned Toadlet	V	–	Species recorded during EIS surveys, calling from East Warragamba Wall and West Warragamba Wall. Modification of habitat within the upstream study area may reduce the availability of foraging resources and breeding sites. Impacts may include loss of structural components of the vegetation within areas of suitable breeding habitat, potential mortality of individuals during flood events, and loss of suitable foraging habitat.
Varanus rosenbergi	Rosenberg's Goanna	V	–	Species was recorded during EIS surveys near the confluence of the Coxs and Kedumba Rivers. Modification of habitat within the upstream study area may reduce the availability of breeding sites for this species. Impacts may include loss of structural components of the vegetation within areas of suitable breeding habitat, potential mortality of individuals during flood events, and loss of suitable foraging habitat.

6.3.3.8 Water systems

General

The Project would provide for the temporary retention of inflows to Lake Burragorang up to about 1,000 gigalitres in the FMZ. During operation of the FMZ, the water level in Lake Burragorang would increase above FSL. This would also extend up the tributaries that drain to the lake. As noted previously, this pattern of temporary inundation associated with the existing dam already exists and extends into the GBMWHA.

Floodwaters would be retained for a maximum period of 14 days and it is highly unlikely that this would result in permanent changes to upstream surface and groundwater hydrology.

Groundwater

Consideration of potential impacts on groundwater upstream of Warragamba Dam is presented in the expert technical review provided as Appendix E to the Submissions Report. Section 4.2.1 of the technical review provides a description of the existing hydrogeological environment for the Warragamba Dam/Lake Burragorang locality, noting that the Hawkesbury Sandstone geologic unit hosts a major regional aquifer in the area surrounding Lake Burragorang.

Groundwater within the sandstone aquifer is recharged by rainfall across the sandstone outcrop of the lower Blue Mountains west of the Lapstone Structural Complex (LSC) and losses from Lake Burragorang. The groundwater flow direction is consistently west to east from Lake Burragorang, with groundwater flow across the LSC.

An analysis of groundwater levels from a test bore (W7A, located about 1.9 kilometres to the south of Warragamba Dam) for the period mid-2008 to mid-2012 indicated:

- Dam water levels are always higher than sandstone water levels, which confirms that the dam is losing water to the regional sandstone aquifer
- The sandstone water levels do not respond to individual rainfall events and sudden dam level rises; there were two sharp rises in dam storage level (i.e. increases between 4–6 metres) in February and December 2010, with no corresponding sharp increase in groundwater level
- Groundwater levels respond slowly to longer periods of rainfall and increasing dam storage levels with the first noticeable, and very slight, rise in groundwater levels in early 2010
- The groundwater level in August 2010 was 99 metres below ground level (mbgl) (91.5 mAHD) and by August 2012 had risen slowly to 97.6 mbgl (92.9 mAHD) – a very small increase of 1.4 metres. The data confirms lagged and only very slight increases in groundwater levels as the dam fills to FSL.

Work carried out by Parsons Brinckerhoff in 2008 and 2009 completed environmental and radioisotope studies on groundwater samples from Warragamba to Wallacia. This found that groundwater within the Hawkesbury Sandstone aquifer was derived from rainfall with a corrected age of 4,800 years before present (BP) at Warragamba and up to 30,600 years BP at Wallacia. Groundwater ages are significantly older within the LSC and along the groundwater flowpath from west to east. This age data confirms low permeability for the sandstone aquifer and slow natural migration.

Historically there have been no large rises in groundwater levels following sharp increases in dam storage as observed at WaterNSW monitoring bores located close to the dam. Terrestrial vegetation around Lake Burragorang is unlikely to be relying on groundwater in sandstone aquifers due to deep groundwater levels (i.e. typically greater than 50 mbgl) and therefore vegetation fringing the lake is highly unlikely to be groundwater-dependent.

Groundwater levels in the Hawkesbury Sandstone system fluctuate naturally during high and low rainfall periods, and the anticipated changes due to the Project are expected to be within these natural ranges.

Wild rivers

The declared wild river sections for the Grose River and Colo River are located outside of the Project study area and would not be affected by the Project. A small section (about 1,300 metres) of the declared wild river section of the Kowmung River is located in the upstream Project study area. An analysis of depth-duration curves for the closest cross section downstream of the declared wild river catchment showed no material difference between the existing situation and with the Project for all flood events up to the 1 in 100 chance in a year event and a very small difference (less than 0.3 metres) up to the 1 in 1,000 chance in a year event. In real world terms, the Project would not have a material impact on the declared wild river section of the Kowmung River.

6.3.3.9 Geodiversity

The World Heritage nomination report for the Greater Blue Mountains Area (NPWS and Environment Australia 1998) notes that the relief of the area with recognisable features such as steeply dissected plateaus, precipitous cliffs, waterfalls, broad gorges and dark, narrow canyons contribute to its distinctive character.

The Project would provide for the temporary retention of inflows to Lake Burragorang up to about 1,000 gigalitres in the FMZ. Floodwaters would be retained for a maximum period of 10 days. During operation of the FMZ, the water level in Lake Burragorang would increase. This would also extend up the tributaries that drain to the lake. As noted previously, this pattern of temporary inundation associated with the existing dam already exists and extends into the GBMWHA.

The EIS includes an assessment of potential impacts of the Project on upstream geomorphology which takes in part of the GBMWHA. This considered out-of-bank erosion, translocation of sediment features upstream, and in-channel sediment deposition upstream of Lake Burragorang (discussed in Section 5.1 of Appendix N2). The assessment also considered potential impacts in the area immediately adjacent to Lake Burragorang with regard to out-of-shoreline erosion, elevated erosion of shoreline banks, deposition of sediment on sensitive receptors during inundation events, and changes to circulation patterns causing redistribution of sediments (discussed in Section 5.2 of Appendix N2).

The geomorphology assessment identified the potential for some localised changes to geomorphological process in the upstream study area associated with watercourses and with the margins of Lake Burragorang. The area of the GBMWHA along the eastern side of the arm of Lake Burragorang running up to the Wollondilly River may be subject to these changed geomorphological process, however, given these would be localised and considering the small scale relative, any such changes are not regarded as significant. As such, the Project is considered unlikely to have any material effect on geological and geomorphological processes that affect the geo-diversity of the GBMWHA, and accordingly would not result in a material diminishment of this component of the OUV.

6.3.3.10 Boundary integrity

Holland *et al*. (2021, p72) note that

> *Boundary integrity refers to the characteristics of the boundary that protect the natural significance values in the GBMA. The integrity of protected areas in the Greater Blue Mountains could be threatened by developments in areas adjacent to reserves. Impacts may be caused by inadequate environmental protection measures during construction, such as clearing of native vegetation on erodible sandstone soils and poorly designed sedimentation controls. In addition, vegetation communities in the Blue Mountains are adapted to the very infertile, skeletal soils derived from Hawkesbury and Narrabeen Sandstones, which make them susceptible to potentially nutrient rich run-off from adjacent land.*

The GBMWHA was listed without a formal buffer zone, yet an essential part of the conservation strategy of World Heritage properties is the protection of the surroundings of inscribed properties (DAWE 2022). The World Heritage listing[9] notes the GBMWHA has a buffer area of 86,200 hectares.

WaterNSW, jointly with NPWS, proactively manages water quality in the upstream catchment area through the special areas and controlled areas provisions in the *Water NSW Act 2014* and the Water NSW Regulation 2020. The area around Lake Burragorang sits within the *Special Areas – No Entry* special area. This extends over parts of the GBMWHA and adjacent buffer areas such as along the Wollondilly River, Kedumba River and the Coxs River.

These legislative arrangements would not change with the Project. As such, it is considered the Project would not diminish this component of the OUV of the GBMWHA.

6.3.3.11 Indigenous custodial relationships

The Aboriginal cultural heritage assessment for the EIS identified the potential for the Project to affect cultural heritage values. Additional assessment carried out for the Submissions Report and PIR has provided further clarification on the nature of potential impacts of the Project.

The EIS identified the potential for diminishment of Aboriginal cultural heritage values through an increased risk of temporary inundation of identified and potential archaeological sites from the Project. The additional assessment for the Submissions Report and PIR does not change this conclusion.

The revised offset strategy (refer Section C6) provides for the funding of on-park management for the protected lands values offset. This would support maintenance and potential enhancement of Aboriginal cultural heritage values. This would also be consistent with Article 16 of the Burra Charter.

9 https://whc.unesco.org/en/list/917

6.3.3.12 Indirect impacts

Section 527E of the EPBC Act provides that an impact may also be due to indirect consequences of an action. The EPBC Act Policy Statement *'Indirect consequences' of an action: Section 527E of the EPBC Act*[10] notes that

> *The Significant Impact Guidelines Policy Statement 1.1) set out that the 'indirect consequences' of an action may include:*
>
> *(a) off-site impacts including, but not limited to:*
>
> *(i) downstream impacts (such as impacts on wetlands from chemicals discharged into upstream river systems); or*
>
> *(ii) upstream impacts (such as the extraction of raw materials which are used to undertake the action), and*
>
> *(b) actions taken by third parties, where the third party action is facilitated to a major extent by the primary action and the impacts of the third party action were reasonably foreseeable (as set out in sub-section 527E(2) of the EPBC Act).*

The Project involves the raising of Warragamba Dam to provide airspace to temporarily retain inflows and to release them in such a way as to reduce downstream flood levels. This will result in the pattern of upstream flooding changing with regard to:

- The lateral extent of temporary inundation
- The depth and duration of temporary inundation
- The frequency of flood events causing temporary inundation.

The indirect consequences of these changes include:

- Potential changes to vegetation in areas affected by temporary inundation, including threatened ecological communities, threatened flora and habitat for threatened fauna, and potential consequential effects
- Potential diminishment of scientific and cultural heritage values of Aboriginal heritage sites in areas affected by temporary inundation
- Potential diminishment of World Heritage and National Heritage values in areas affected by temporary inundation.

These have been considered in the environmental assessment for the Project and it is therefore considered to accord with section 527E of the EPBC Act.

6.3.3.13 Summary

Table 6-9 summarises the potential of the Project to diminish the OUV of the GBMWHA with regard to the individual components of the OUV, and also noting that these are already potentially affected by the existing dam. Table 6-10 provides a summary assessment of potential impacts of the Project against the MNES World Heritage significant impact criteria.

[10] https://www.dcceew.gov.au/sites/default/files/documents/epbc-act-policy-indirect-consequences.pdf

Table 6-9 Summary of potential diminishment of OUV components due to the Project

Component	Comment
Natural heritage values	
Gondwanan flora	Low potential for diminishment of OUV
Scleromorphic flora	Some potential for diminishment of OUV but not considered to be significant risk
Conservation-significant flora	Some potential for diminishment of OUV but not considered to be significant risk
Conservation-significant fauna	Some potential for diminishment of OUV but not considered to be significant risk
Integrity	
Water systems	Negligible potential for diminishment of OUV
Geodiversity	Negligible potential for diminishment of OUV
Boundary integrity	Negligible potential for diminishment of OUV
Indigenous custodial relationships	Some potential for diminishment of OUV based on potential impacts of temporary inundation on individual sites (as acknowledged in the EIS) but this would be offset through facilitation of proactive management measures to maintain and enhance Aboriginal cultural heritage values.

Table 6-10 Assessment of potential impacts of the Project against MNES World Heritage significant impact criteria

Criterion	Assessment
An action is likely to have a significant impact on the World Heritage values of a declared World Heritage property if there is a real chance or possibility that it will cause:	
One or more of the World Heritage values to be lost	The Project would not result in the loss of one or more World Heritage values. The Project only impacts a small area of the GBMWHA and the considerable diversity of Eucalypts, flora and fauna would remain in other areas not impacted by the Project. While there is potential for an incremental impact on Aboriginal cultural heritage in the GBMWHA, this would be a diminution (as acknowledged below) rather than a loss of value.
One or more of the World Heritage values to be degraded or damaged	The upstream biodiversity assessment identified the potential for the loss of biodiversity values but noted uncertainty around the specific nature and degree of impacts. Additional investigations carried out during preparation of the Submissions Report and PIR suggest that the assessed significance of potential impacts on vegetation may have been conservative and that vegetation may have a greater resilience to temporary inundation than previously concluded. The offset strategy (refer Section C6) and the other mitigation measures detailed in EIS Chapter 29 (EIS synthesis, Project justification and conclusion) would ensure that any degradation or damage to World Heritage values is offset and the overall values of the GBMWHA are maintained in the longer term.

Criterion	Assessment
One or more of the World Heritage values to be notably altered, modified, obscured or diminished	The Project could potentially diminish one or more of the World Heritage values, however, the risk of this is considered low, and noting that there is already an existing risk associated with the current dam. The offset strategy provides for funding of on-park management for the protected lands values offset addressing maintenance and potential enhancement of World Heritage values. The Part 5A EMP would similarly facilitate maintenance and potential enhancement of World Heritage values.

6.3.4 Definition of Project Upstream Impact Area

DPE requirement

Clear definition is required for the term 'Project Upstream Impact Area (PUIA)' used in analysis for Chapter 18, and across the Aboriginal Cultural Heritage assessment. This definition must clearly state the relevant annual exceedance probability (AEP) or average recurrence interval (ARI) upper and lower bounds for this assessment area.

Definition of PUIA

The Aboriginal cultural heritage assessment uses the term 'Project Upstream Impact Area' or PUIA to refer to the area between 2.78 metres above FSL (119.5 mAHD) and 10.25 metres above FSL (126.97 mAHD).

The derivation of this area is explained in detail in the EIS, for example in Section 5 of Appendix J *World Heritage Assessment Report*. As explained, a review of the historical record identified at least one large flood above FSL would occur within a 20-year period. Building on previous hydrological modelling carried out for the Project, further modelling was undertaken to assess the likely level of inundation upstream of the dam. Around 20,000 Monte Carlo simulated events were used to generate a notional 200,000 year flood record. This was then analysed to identify the maximum inundation level in 20-year periods to determine an 'average' or likely inundation level. This was also undertaken for the existing dam scenario so that a comparison of inundation levels could be made.

It is important to note that the upper and lower extents of this area are <u>not</u> linked to flood frequencies in terms of elevations being defined by a flood event of a specified frequency of occurrence.

6.3.5 Flood frequencies for upstream impact area

DPE requirement

The EIS states '*There are also a number of sites within the study area above the EUIA*' at page 18-66 of Chapter 18. Details must be provided of the AEP or ARI upper and lower bounds for this assessment area.

Response

As described in Section 6.3.4, the Aboriginal cultural heritage assessment used the term 'PUIA' to refer to the area between 2.78 metres above FSL (119.5 mAHD) and 10.25 metres above FSL (126.97 mAHD).

The area between FSL (116.7 mAHD) and the lower extent of the PUIA (119.5 mAHD) is referred to as the 'Existing Upstream Impact Area' or EUIA.

As noted in Section 6.3.4, the upper and lower extents of the PUIA are not linked to a flood frequency. Similarly, the FSL is not linked to a flood frequency.

6.4 Offsetting

DPE requirement

Details of the proposed offsetting arrangements for all adverse impacts, including:

- Updated and proposed offsetting arrangements for upstream and downstream impacts
- Proposed offsetting arrangements under the Framework for Biodiversity Assessments
- Proposed offsetting arrangements for impacts to the National Parks estate
- Proposed offsetting arrangements for impacts to the World Heritage areas
- Assessment of the effectiveness and feasibility of the proposed offsetting arrangements.

6.4.1 Revised offset strategy

The offset strategy presented in the EIS comprised two main components:

- A biodiversity offset, as described in in Chapter 13 of the EIS and Appendix F6 to the EIS
- A protected lands values offset, comprising the Warragamba Offset Program, as described in Section 20.7 in Chapter 20 of the EIS.

The protected lands values offset, which included purchasing and managing new lands, was to target offset sites that meet both biodiversity and protected lands offset goals.

This revised offset strategy provides the details of these two components as described in the EIS together with changes to the delivery of offsets arising from submissions and further consultation with DPE and other agencies during preparation of the Submissions Report and PIR.

6.4.1.1 Biodiversity offset

WaterNSW consulted extensively with DPE and relevant agencies to resolve how the FBA can be applied to the upstream area that would be subject to temporary inundation from the Project, particularly as the impacts would be infrequent, cumulative and difficult to measure over time.

For the purposes of completing an FBA assessment and calculation of offsets an upstream impact area has been identified where it is precautionarily assumed a 100 percent loss of biodiversity values within the area.

The calculation of impact to be offset as described in the EIS remains unchanged and is based on the assumed total loss of all biodiversity values from temporary inundation associated with operation of the FMZ within the Project Upstream Impact Area (PUIA). The EIS has described this as the area between 2.8 metres above FSL (RL 119.5 mAHD) and 10.27 metres above FSL (RL 126.97

mAHD), equating to an area of about 1,400 hectares. The rationale for this area is described in Section 3.2 of Appendix F6 *Biodiversity Offset Strategy* to the EIS. This defined area is representative of the likely inundation in a given 20-year period analysed by selecting the peak inundation level for each 20-year period of modelling of around 20,000 flood events. The area is not related to any particular flood frequency which is a common misunderstanding that has been identified in submissions.

The extent of biodiversity loss in the PUIA is quantified through the Framework for Biodiversity Assessment (FBA) as described in Appendix F1 *Biodiversity Assessment Report – Upstream* (Upstream BAR) to the EIS. The Upstream BAR identifies the extent of loss of relevant species and ecosystems and the corresponding number/type of credits required to offset the impact of the Project. In response to comments made by DPE EHG, the number of credits has been updated and a revised credit report will be lodged with DPE.

As described in Section 5 of Appendix F6, the *NSW Biodiversity Offsets Policy for Major Projects* (NSW Government 2014) prescribes four types of strategies that can be used to fulfil the offset requirements:

- Purchasing credits on the open market and retiring these credits
- Offsetting through a site-secured stewardship agreement where a proponent establishes its own Biodiversity Stewardship Agreement (BSA) site(s), generates its own credits and then retires the credits
- A monetary contribution into the Biodiversity Conservation Fund through which the proponent transfers the credit liability to the Biodiversity Conservation Trust, with the amount currently calculated through the Biodiversity Offset Payment Calculator
- Supplementary measures following the rules prescribed in Appendix B to the policy.

Section 6 of Appendix F6 discusses the implementation of the biodiversity offset for the Project for both the construction and operation phases, reflecting the potential need to offset impacts through more than one strategy.

The Warragamba Offset Program approach presented in the EIS was to target the purchase of land suitable for inclusion in the National Park estate and meet both biodiversity and protected land values offset goals.

Change to offset delivery

Further to the biodiversity offset approach in Appendix F6 to the EIS, the priority approach for the delivery of biodiversity offsets to meet the retirement of biodiversity credits would broadly involve Identification and costing of a series of on-park management actions that would deliver a biodiversity benefit on-park equivalent to the biodiversity credits to be retired. The areas that would receive offset actions apply to national park lands and expanded to areas within the GBMWHA or in adjacent or proximate national park or reserve lands. Additionally:

- Management actions will be proposed for each impacted species and ecosystem, i.e. each species/ecosystem that generates a credit liability will be the subject of targeted management actions
- Management actions will be costed and a Net Present Value determined on the basis of delivery/management in perpetuity

- Management actions will be designed, based on the best available science, to deliver a biodiversity benefit on park for the relevant species/ecosystem that is at least equal to the assumed loss in the PUIA.

The following key principles will apply to this component of the offset strategy:

- Management actions will go beyond 'business as usual' in terms of park management and must be based on the best available science
- Management actions will be on the national park estate, ideally on one of the reserves impacted by or adjacent to the Project; however, where it is not possible to generate a biodiversity benefit on the national park estate, or where it relates to an impact that is outside the national park estate, then the offset would be delivered on alternative land.

The Upstream BAR assumed the presence of several threatened species for the purpose of calculating required species credits. This is likely to overstate the magnitude of potential impacts and the required number of species credits. Should the Project be approved, WaterNSW would seek to have the option to conduct further surveys prior to operation of the Project for species where presence has been assumed, and to review the credit calculations for the relevant species accordingly.

As a second-tier priority approach for delivering biodiversity offsets, land purchased for the protected lands values offset would also target offset sites that, where possible, could also meet biodiversity values to contribute to the retirement of biodiversity credits. It is noted that biodiversity values that exist on land acquired for a protected land offset and subject to 'business as usual' park management cannot be counted towards the biodiversity offset requirements as there is no additional biodiversity benefit provided. It is further noted that additional actions on such land over and above 'business as usual' and core park management, and which deliver an increase or uplift in biodiversity values may potentially be counted as a biodiversity offset.

6.4.1.2 Protected lands values offset

As indicated in the EIS, potential impacts on protected lands values were proposed to be addressed through the Warragamba Offset Program. In addition to biodiversity, this encompassed non-biodiversity matters such as:

- Geodiversity
- Water catchment protection
- Cultural heritage
- Landscape, natural beauty and aesthetic values
- Recreation and visitor use
- Social and economic benefits derived from visitation to these areas.

The Warragamba Offset Program will prioritise land suitable for inclusion in the national park estate containing suitable biodiversity, cultural heritage, landscape and park visitor values and opportunities. Any land containing suitable offsets must also be appropriate for the national park estate. The offset would also include on-park management costs for the newly acquired lands to be included in the national parks estate.

The NSW Government's *Revocation, recategorisation and road adjustment policy*[11] states that

18. When negotiating compensation, NPWS will be guided by the following considerations:

- *the proposed revocation and associated compensation must result in an overall public good outcome having regard to all of the conservation, cultural heritage and other values of the land being revoked and the values of any land provided as compensation*
- *compensatory land should preferably be of greater size than the area of land being revoked, and must at least be of equal size*
- *it is desirable to match the area, type and quality of habitat, and cultural heritage values on land being revoked with the area of land proposed as compensation where possible. Exceptions to this may include:*
  - *compensation that includes a higher conservation priority habitat type (e.g. that is poorly reserved) where the habitat to be impacted is commonly represented within the relevant park*
  - *compensation lands that have unique and particularly significant conservation values*
  - *it is desirable that land to be transferred as compensation is close to the area being revoked and preferably adjacent to the affected reserve.*

It is intended that as a minimum the quantum of land required to compensate for impact on national parks (including the affected part of the GBMWHA) will be equivalent to or greater than the affected area of national parks estate in the upstream impact area (1,303 hectares) and containing equivalent or superior values noting that there is 304 hectares of GBMWHA to offset. The protected lands values offset will also provide for separate on-park management costs over a 20-year period with funding secured prior to commencement of Project construction.

With regard to prioritising land that improves or supports the OUV for the GBMWHA (and National Heritage values), this will include consideration of, as appropriate:

- Wilderness areas
- Aboriginal cultural heritage
- Plant communities identified in the OUV statement
- Threatened flora species
- Habitat of threatened fauna species
- Other biodiversity-related matters such as scleromorphic species, ant-adapted plants, diversity and characteristics of the flora as a whole, species diversity, vertebrates and invertebrates identified in the OUV statement
- Visual amenity
- Users of the GBMWHA
- Geological structure, geomorphology and water systems.

6.4.1.3 Summary

The offset strategy is largely as proposed in the EIS except that in delivering biodiversity offsets, the priority to retire credits will involve Identification and costing of a series of on-park management

11 https://www.environment.nsw.gov.au/topics/parks-reserves-and-protected-areas/park-policies/revocation-recategorisation-and-road-adjustment

actions that will deliver an on-park biodiversity benefit equivalent to the biodiversity credits to be retired. The protected lands values offset will prioritise land suitable for inclusion in the national park estate. Should any of these lands also include similar biodiversity values to those being sought for retirement of biodiversity credits then they could be considered for contribution to those offsets as a second priority. The protected lands values offset will also include on park management costs for the new lands for a 20-year period at commencement of operation of the Project.

6.4.2 Effectiveness and feasibility of the proposed offsetting arrangements

An assessment of the effectiveness of the original offset strategy with regard to biodiversity values is presented in Section 7 of Appendix F6 *Biodiversity Offset Strategy* to the EIS with reference to the *NSW Biodiversity Offsets Policy for Major Projects*. These are considered to hold for the revised offset strategy presented in this report, and noting that the commitment to funding provides greater certainty around the implementation of the strategy.

As noted in Section 6.4.1, management actions for the biodiversity would be on the national park estate which is managed under the applicable plan of management, which are subject to ongoing review. This process would assist in informing the effectiveness of offsetting arrangements.

6.5 Sustainability and climate change

DPE requirement

Provide a more detailed technical assessment of how the proposal has considered the impacts of climate change, including:

- Detailed assessment of risks under future climate scenarios that would affect the proposal
- Analysis comparing inundation, flooding and hydrology under future climate scenarios with assumptions that have been used to justify the proposal
- Identification of how climate change risks have been incorporated into project design
- Identification of how the proposal achieves sustainability outcomes.

6.5.1 Climate change

The Project design has been informed by hydrological modelling that allowed for climate change risk and incorporated resilience to climate change as described in Chapter 5 of the EIS. Climate change is addressed in Chapter 14 of the EIS and Appendix G to the EIS including the risks under future climate change scenarios, analysis of future climate scenarios, and consideration of climate risk in the design.

There has been extensive work on consideration of climate risk as part of development of the Project, including for the Project design to incorporate resilience to climate change, as described in Section 5.1 of the EIS. The Project is not vulnerable to climate change, but an essential aim of the Project is to reduce the impact of increased flood risk related to climate change projections.

The scope of the climate change assessment was developed in consultation with climate change experts in the former DPIE. This assessment was then subject to independent peer review facilitated by the Office of the NSW Chief Scientist and Engineer as described in the flood study report (Infrastructure NSW 2019). The peer reviewers were Professor Jason Evans (Climate Change Research Centre, University of NSW) and Professor Seth Westra (School of Civil, Environmental and

Mining Engineering, University of Adelaide). The peer reviewed assessment of climate change was undertaken with extensive consultation with the former DPIE.

If climate change remains as projected, the need for the Project to mitigate the increased flood risk on the downstream communities will only increase as outlined in the EIS. If the impact of climate change on flood risk is below projections, whether due to inaccurate projections or reduced greenhouse emissions, the Project would mitigate less flood events.

The work undertaken is consistent with all identified government climate change objectives and outcomes. This is one of the first major infrastructure projects which has incorporated changes in flood risk due to climate change. Additional information on the extent of climate change consideration can also be found in the report *Climate Change and Flooding Effects on the Hawkesbury-Nepean*[12] (Infrastructure NSW 2021b).

Climate change risks have been assessed based on the scope of the Project and associated components. Table 5-1 in Appendix G shows how the screening of risk was undertaken for the project components. The assessment is high level and provides appropriate assessment of risk based on the level of detail provided by the concept design. Further review and refinement of the risk ratings and treatments would be carried out during detailed design.

Reference should also be made to Section 4.1.7 of the Submissions Report for additional information related to climate change.

6.5.2 Sustainability

Chapter 23 of the EIS presents the results of an assessment of the anticipated sustainability performance of the Project in accordance with SEAR 16.1 as follows:

> *The Proponent must assess the sustainability of the project in accordance with the Infrastructure Sustainability Council of Australia (ISCA) Infrastructure Sustainability Rating Tool and recommend an appropriate target rating for the project.*

The assessment identified that the Project would meet the requirements for a 'Commended' rating.

The assessment has been reviewed as part of preparation of this report. The review identified that the Project could achieve an 'Excellent' rating. Table 6-11 identifies potential credits and levels for a 'Commended' ISCA IS Rating (Potential level EIS), as presented in Chapter 23 of the EIS, and the revised potential credits and levels for an 'Excellent' ISCA IS Rating (Potential level PIR).

A copy of the revised sustainability scorecard credit summary is provided as Appendix I. The revised assessment has been carried out by an accredited ISCA assessor in accordance with ISCA requirements.

A further review of the revised rating would occur during construction planning and detailed design to monitor any potential changes in component credits that could affect the overall score.

12 https://insw.com/media/3233/climate-change-and-flooding-effects-on-the-hnv_2021.pdf

Table 6-11 Potential Project credit achievement

Credit	Description	Potential level EIS	Potential level PIR	General Project comment	Project phase(s)
Man-1	Sustainability Leadership and commitment	1	2	Sustainability objectives and targets were discussed in a working group forum and a Project environmental and sustainability policy and strategy developed. The environmental and sustainability policy and strategy will inform future Project stages. Future commitments to targets may assist in achieving sustainability outcomes.	Planning, concept design, detailed design and construction.
Man-2	Risk and opportunity management	2	2	The environmental and social impacts of the Project have been assessed in the EIS. The assessment of environmental, social and economic risks and opportunities may assist in reducing Project risks and provide benefits to the Project and stakeholders.	Planning, concept design, detailed design and construction.
Man-3	Ongoing organisational structure, roles and responsibilities	0	1	The Project will align with WaterNSW environmental governance structure. Having sustainability responsibilities would enhance sustainability outcomes.	Planning, concept design, detailed design and construction.
Man-4	Inspections and auditing	1	1	The Project will align with WaterNSW environmental governance structure. Regular inspections and auditing assists in identifying issues for rectification.	Detailed design and construction.
Man-5	Reporting and review	2	2	Regular sustainability performance reporting assists in communicating with stakeholders and identifying issues for rectification.	Detailed design and construction.
Man-6	Knowledge sharing	2	2	Corporate sustainability knowledge is increased. Project knowledge is or may be shared with the wider infrastructure industry.	Detailed design and construction.
Man-7	Decision-making	1	2	Evaluating options considering environmental, social and economic assessment provides a structured and consistent process for decision making.	Detailed design and construction.
Pro-1	Commitment to sustainable procurement	2	2	Develop a sustainable procurement policy and sustainability management plan to improve sustainability outcomes.	Detailed design and construction.
Pro-2	Identification of suppliers	2	2	Develop a sustainable procurement policy and sustainability management plan to improve sustainability outcomes.	Detailed design and construction.

Credit	Description	Potential level EIS	Potential level PIR	General Project comment	Project phase(s)
Pro-3	Supplier evaluation and contract award	1	1	Develop a sustainable procurement policy and sustainability management plan to improve sustainability outcomes.	Detailed design and construction.
Pro-4	Managing supplier performance	1	1	Develop a sustainable procurement policy and sustainability management plan to improve sustainability outcomes.	Detailed design and construction.
Cli-1	Climate change risk assessment	3	3	A climate change risk workshop was undertaken as part of the EIS process.	Planning, reference design, detailed design and construction.
Cli-2	Adaptation options	2	2	Extreme, high and medium priority climate change risks were identified and discussed in Chapter 14 of the EIS.	Planning, reference design, detailed design and construction.
Ene-1	Energy and carbon monitoring and reduction	0	1	Monitoring of energy use and greenhouse gas emissions is good practice and may contribute to savings in concrete, steel and transport costs. Modelling can be used to influence design and construction.	Detailed design and construction.
Ene-2	Renewable energy	1	1	Investigate options for renewable energy.	Detailed design and construction.
Wat-1	Water use monitoring and reduction	1	1	Large volumes of water will be required in the concrete batching process. The modelling will assist in identifying areas to target water saving initiatives.	Detailed design and construction.
Wat-2	Replace potable water	2	2	Options for reducing potable water will be investigated.	Detailed design and construction.
Mat-1	Material footprint measurement and reduction	0	1	Reducing the volume of materials will provide Project cost savings and should be considered.	Detailed design and construction.
Mat-2	Environmentally labelled products and supply chains	1	1	Use of environmentally labelled products.	Detailed design and construction.

Credit	Description	Potential level EIS	Potential level PIR	General Project comment	Project phase(s)
Dis-1	Receiving water quality	3	3	Environmental compliance.	Detailed design and construction.
Dis-2	Noise	2	3	Environmental compliance and improved relationship with the surrounding community.	Detailed design and construction.
Dis-3	Vibration	3	3	Environmental compliance and improved relationship with the surrounding community.	Detailed design and construction.
Dis-4	Air quality	1	1	Environmental compliance and improved relationship with the surrounding community.	Detailed design and construction.
Dis-5	Light pollution	Scoped out	Scoped out	The weightings assessment scoped out this credit during design. Measures to prevent light spill during construction may be considered.	Construction
Lan-1	Previous land use	3	3	The land used for the existing asset is used in the previously used land and is being altered through the raising of the dam height.	Detailed design and construction.
Lan-2	Conservation of onsite resources	2	2	Easily incorporated into soil management plans. It is noted that the majority of the Project is on previously disturbed land.	Detailed design and construction.
Lan-3	Contamination and remediation	0	1	Site works should be managed to avoid disturbance of known buried contamination. No known contamination remediation works are proposed. Unexpected finds protocol would apply. Contaminated land is discussed in Chapter 22 of the EIS. A Preliminary Site Investigation Report and Sampling, Analysis and Quality Plan have been prepared as part of the Submissions Report (Appendix H).	Construction-
Lan-4	Flooding design	2	2	The highest Lan-4 credit level has been nominated. Flood mitigation design is the main design criteria for the Project.	Detailed design and construction.
Was-1	Waste management	2	2	The highest Was-1 credit level has been nominated. Reducing waste volumes and maximising reuse and recycling reduces Project costs.	Detailed design and construction.
Was-2	Diversion from landfill	1	1	Reducing waste volumes and maximising reuse and recycling reduces Project costs.	Detailed design and construction.
Was-3	Deconstruction/Disassembly/Adaptability	0	0	The Project did present opportunities for a deconstruction plan. Future stages of the Project may investigate components or pre-fabricated units that can	Detailed design and construction -

Credit	Description	Potential level EIS	Potential level PIR	General Project comment	Project phase(s)
				be easily separate on disassembly / deconstruction into material types for recycling or reuse.	
Eco-1	Ecological value	1	1	Detailed ecological assessments have been carried out as part of the EIS process. Biodiversity is discussed in Chapters 8, 9 and 10 of the EIS. Further work has been carried out and is discussed in Section 6.7 of this PIR.	Planning, reference design, detailed design and construction.
Eco-2	Habitat connectivity	0	0	Detailed ecological assessments have been carried out as part of the EIS process. Biodiversity is discussed in Chapters 8, 9 and 10 of the EIS. Further work has been carried out and is discussed in Section 6.7 of this PIR.	Planning, reference design, detailed design and construction.
Hea-1	Community health and well-being	1	1	Stakeholder engagement is being undertaken as a part of the EIS process. This could be expanded to identify areas for positive contribution to the community health and wellbeing. It is noted that one of the objectives for the Project is reduced flooding risk for the wider Sydney region. Stakeholder engagement is discussed in Chapter 6 *Consultation* of the EIS and Appendix D *Community Consultation Report* to the EIS.	Planning, reference design, detailed design and construction.
Hea-2	Crime prevention	0	0	Future stages of the Project will address crime prevention through environmental design.	Detailed design and construction
Her-1	Heritage assessment and management	2	2	Heritage has been assessed as a part of the EIS process and discussed in Chapters 17 and 18 of the EIS. Recommendations included preparation of interpretation plans which could contribute to improved stakeholder relationships. Further assessment has been carried out and is discussed in Section 6.3 of this PIR.	Planning, reference design, detailed design and construction.
Her-2	Monitoring and management of heritage	1	1	Environmental compliance.	Construction.
Sta-1	Stakeholder engagement strategy	1	1	Stakeholder engagement has been carried out as part of the EIS process and is discussed in Chapter 6 *Consultation* and Appendix D *Community Consultation Report* of the EIS. The strategy is to be further developed and amended during the detailed design and construction stages.	Planning, reference design, detailed design and construction.

Credit	Description	Potential level EIS	Potential level PIR	General Project comment	Project phase(s)
Sta-2	Level of engagement	2	2	Stakeholder engagement is being carried out as part of the EIS process and is discussed in Chapter 6 *Consultation* of the EIS and Appendix D *Community Consultation Report* to the EIS. The strategy is to be further developed and amended during the detailed design and construction stages.	Planning, reference design, detailed design and construction.
Sta-3	Effective communication	1	1	Stakeholder engagement is being carried out as part of the EIS process and is discussed in Chapter 6 *Consultation* of the EIS and Appendix D *Community Consultation Report* to the EIS). The strategy is to be further developed and amended during the detailed design and construction stages.	Planning, reference design, detailed design and construction.
Sta-4	Addressing community concerns	0	0	Stakeholder engagement is being carried out as part of the EIS process and is discussed in Chapter 6 *Consultation* of the EIS and Appendix D *Community Consultation Report* to the EIS). The strategy is to be further developed and amended during the detailed design and construction stages.	Detailed design and construction.
Urb-1	Urban design	2	2	An urban and landscape design plan will be prepared during the detailed design phase. Visual impacts are discussed in Chapter 25 *Visual amenity* of the EIS and Appendix P *Landscape Character and Visual Impact Assessment Report* to the EIS. Additional consideration of potential visual impacts is provided in Section 6.8 of this PIR.	Detailed design and construction.
Urb-2	Implementation	1	1	An urban and landscape design plan will be prepared during the detailed design phase. Visual impacts are discussed in Chapter 25 *Visual amenity* of the EIS and Appendix P *Landscape Character and Visual Impact Assessment Report* to the EIS. Additional consideration of potential visual impacts is provided in Section 6.8 of this PIR.	Detailed design and construction.
Inn-1	Innovation	0	0	Open to the detailed designer and construction contractor to bring sustainability innovation to the Project.	Detailed design, construction.

6.6 Water quality

DPE requirement

Provide a detailed quantitative assessment of impacts and risks to water quality that:

- Uses quantitative assessment methods where feasible, and identifies any technical and scientific constraints that justify the use of qualitative methods
- Identifies the frequency, extent and duration of water quality impacts from the operation of the Flood Mitigation Zone.

Identification of models and modelling packages used in the 2017 Metropolitan Water Plan (Metropolitan Water Directorate 2017) where information from that plan has been used by the EIS to analyse or estimate water quality parameters, environmental flow regimes, or future water quality states downstream of the dam.

The EIS states that 'water quality benefits from environmental flows have been considered in determining future background downstream water quality' at Chapter 27-3. Therefore, assumptions regarding future water quality appear to be contingent on the approval and construction of environmental flows infrastructure that has not yet occurred. Further details of the proposed environmental flows infrastructure and targeted timeframes for approval and operation are required to assess whether it is appropriate to count these benefits.

6.6.1 Quantitative assessment of potential impacts

A detailed quantitative assessment of impacts and risks to water quality from the Project is provided in Chapter 27 of the EIS. This assessment is supported by Appendix Q *Water Quality and Statistical Analysis* to the EIS. The assessment includes a qualitative risk assessment-based approach to identify upstream water quality risks and impacts, and quantitative modelling using the Hawkesbury-Nepean Hydrodynamic Water Quality Model for the downstream assessment.

Potential water quality impacts associated with operation of the FMZ are assessed in Section 27.5.4 of the EIS. It is noted that changes to water quality associated with flood events is an existing risk to downstream receiving areas. The EIS assessment concluded that compared to existing conditions the FMZ discharges would have negligible impact on downstream water quality.

Further clarification on potential water quality impacts is also provided in the Submissions Report; refer to Sections 4.6, 4.7, 5.1.7, 5.5.4, 5.8.22 and 6.9.

6.6.2 Models and modelling packages used in the 2017 Metropolitan Water Plan

The modelling used for the 2017 Metropolitan Water Plan was based on the hydro-economic model, MetroNet, which identifies the optimal solutions (maximum supply at least cost) for securing water for Greater Sydney. The Hawkesbury-Nepean Hydrodynamic Water Quality Model was used in the water quality assessment to determine if the changes in flow regime and discharge water quality from the FMZ have an impact on downstream receiving waters. These are two different types of models which are used for two different purposes.

6.6.3 Water quality benefits from environmental flows

As noted in Section 5.1 of the EIS, the Project would take the opportunity during construction to install the physical infrastructure to allow for management of environmental flows as outlined in the NSW Government's 2017 Metropolitan Water Plan. However, the actual environmental flow releases themselves do not form part of the Project (and in any case such releases would not occur during flood operations) and are subject to separate administration (including assessment) under the *Water Management Act 2000*. The assumed benefit of environmental flows would therefore not form part of the Project.

6.7 Biodiversity

DPE requirement

Include sufficient additional information, as required by the Commonwealth NSW bilateral assessment agreement, to facilitate the assessment of the proposal under the requirements of the *Environment Protection and Biodiversity Conservation Act 1999* (Cth).

6.7.1 General

In accordance with the bilateral agreement reached between the NSW and Commonwealth governments, an EIS under the EP&A Act for SSI can also be used for an EIS under the EPBC Act for a controlled action where directed by the Commonwealth Minister for the Environment. The direction was given for the Project to be assessed under the bilateral agreement on 17 July 2017.

Attachment A to the SEARs contained the EPBC Act assessment requirements for the three controlling provisions triggered by the Project (World Heritage properties, National Heritage places, listed threatened species and communities). The requirements for biodiversity-related MNES in Attachment A to the SEARs are addressed in Appendix F5 *Matters of MNES – Biodiversity* to the EIS.

Additional investigations have been carried out as documented in Section 6 of the PIR and, with regard to World Heritage, in Appendix C to the Submissions Report.

6.7.2 Longneck Lagoon ecology report

Additional work has been carried out to investigate the potential impacts of temporary inundation on an area of Cumberland Plain Woodland (CPW) occurring about 44 kilometres downstream of Warragamba Dam, near Longneck Lagoon.

The investigation included field observations of floristic and environmental attributes across 14 plots (seven affected and seven unaffected by recent temporary inundation) and two transects within areas of CPW near Longneck Lagoon. Field observations included native species richness, exotic cover, length of fallen logs, litter cover, vegetation cover and vegetation assemblages.

Comparison of the field observations at affected and unaffected areas was undertaken to indicate any general differences that occur as a result of temporary inundation. Historical data was also used to provide an indication of any general trends or changes in vegetation condition that have occurred in inundated areas of CPW.

The results of the investigation indicated that, at the time of the assessment the areas of CPW subject to temporary inundation had:

- Lower native species richness and vegetation cover (across all strata)
- Increased cover of exotic species
- Increased debris, including woody debris, leaf litter and anthropogenic litter.

The investigation concluded that as these changes were subtle, longer-term studies would be required to ascertain any consistent directional changes to CPW ecological health as a result of temporary inundation, and recovery after inundation events.

Further details are provided in the report provided as Appendix E to this PIR.

6.7.3 Upstream plant community type (PCT) analysis

Supplementary analysis of vegetation condition has been carried out using survey plots in the upstream study area. This examined vegetation condition for a riparian vegetation community and a eucalypt woodland community, respectively:

- HN574/PCT 1105 River Oak open forest of major streams, Sydney Basin Bioregion and South East Corner Bioregion
- HN527/PCT 840 Forest Red Gum-Yellow Box woodland of dry gorge slopes, southern Sydney Basin Bioregion and South Eastern Highlands Bioregion.

All plots used in the analysis were classed as Moderate/good condition.

The analysis benchmarked the number of native species against the Sydney Basin Interim Biogeographic Regionalisation for Australia (IBRA) Region and the South Eastern Highlands IBRA Region. The analysis distinguished between plots within the area of existing impact (from the existing dam) and above this area (which would be affected by the Project) considering two scenarios:

- The upstream impact area (PUIA)
- The area affected by the existing in 1 in 100 chance in a year flood event.

Additionally, there is an overlap of these two areas so it would be expected that there would be some similarity in the pattern of the results.

It should also be noted that, there has not been a 1 in 100 chance in a year flood in the upstream catchment since the dam was constructed. With the Project, the frequency of this flood level would increase to between 1 in 5 and 1 in 10 chance in a year of occurrent for locations around the perimeter of Lake Burragorang. However, the frequency of occurrence for locations up the tributaries would be largely unchanged.

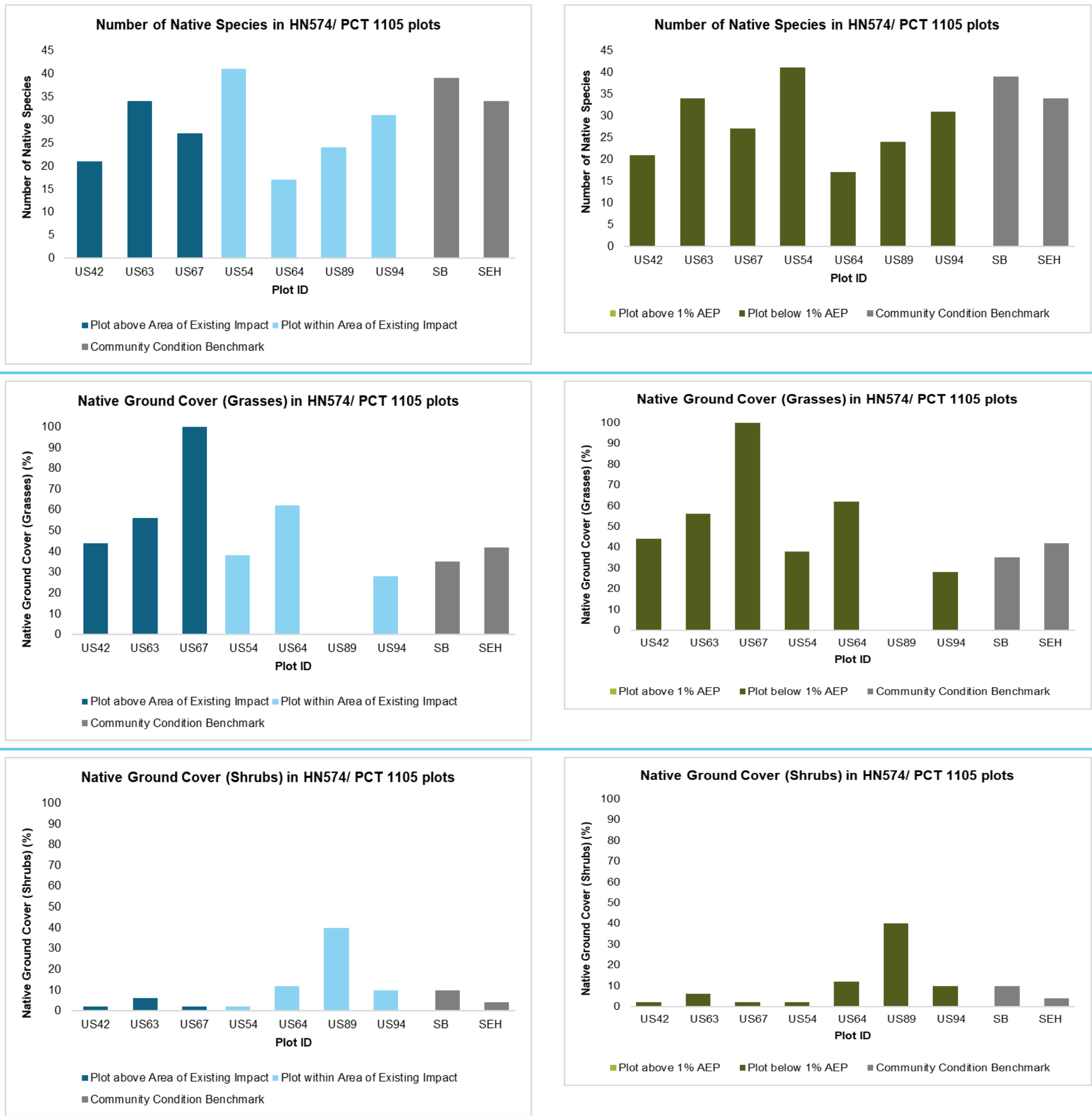
The results for the riparian vegetation community are shown in Figure 6-10. It should be noted that for this community there were no survey plots above the existing 1 in 100 chance in a year flood level which is not unexpected given this is a riparian community. In this case, the interest is simply the comparison between the survey plots in the area of existing temporary inundation for this event and the two benchmarks.

For the upstream impact area scenario, these show that vegetation in the area of existing temporary inundation is broadly consistent with the community condition benchmarks suggesting that this community has a significant degree of resilience to temporary inundation – which would not be unexpected for a riparian vegetation community.

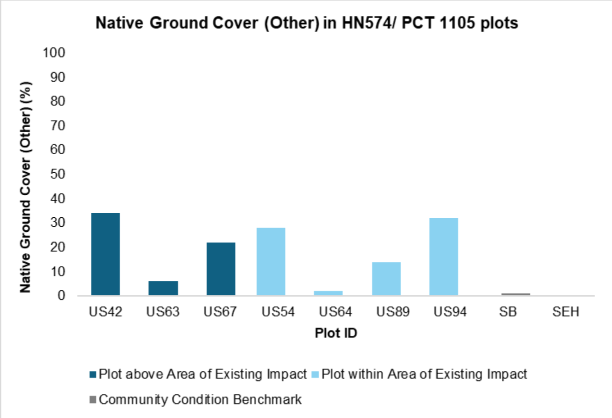
For the second scenario, the results show that the overall number of native species generally align with the two benchmarks but exceed the two benchmarks with regard to ground cover.

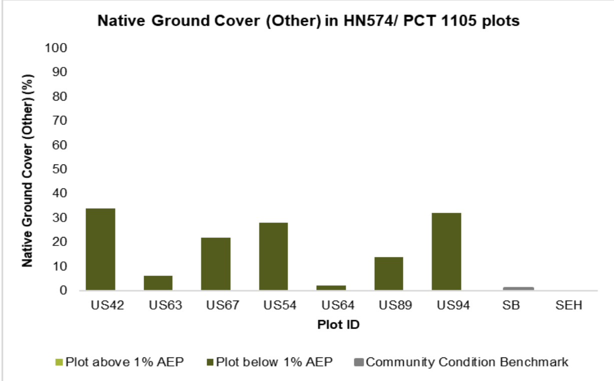
Figure 6-10 HN574/PCT 1105 River Oak open forest of major streams, Sydney Basin Bioregion and South East Corner Bioregion

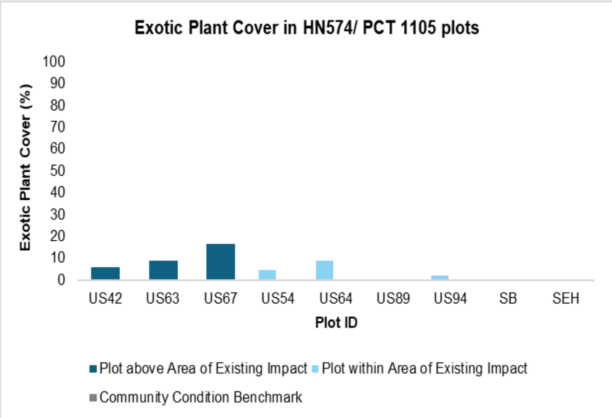
Upstream impact area	1 in 100 chance in a year flood event

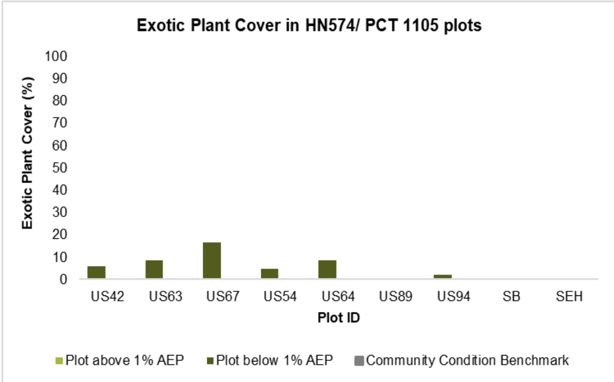


Upstream impact area	1 in 100 chance in a year flood event









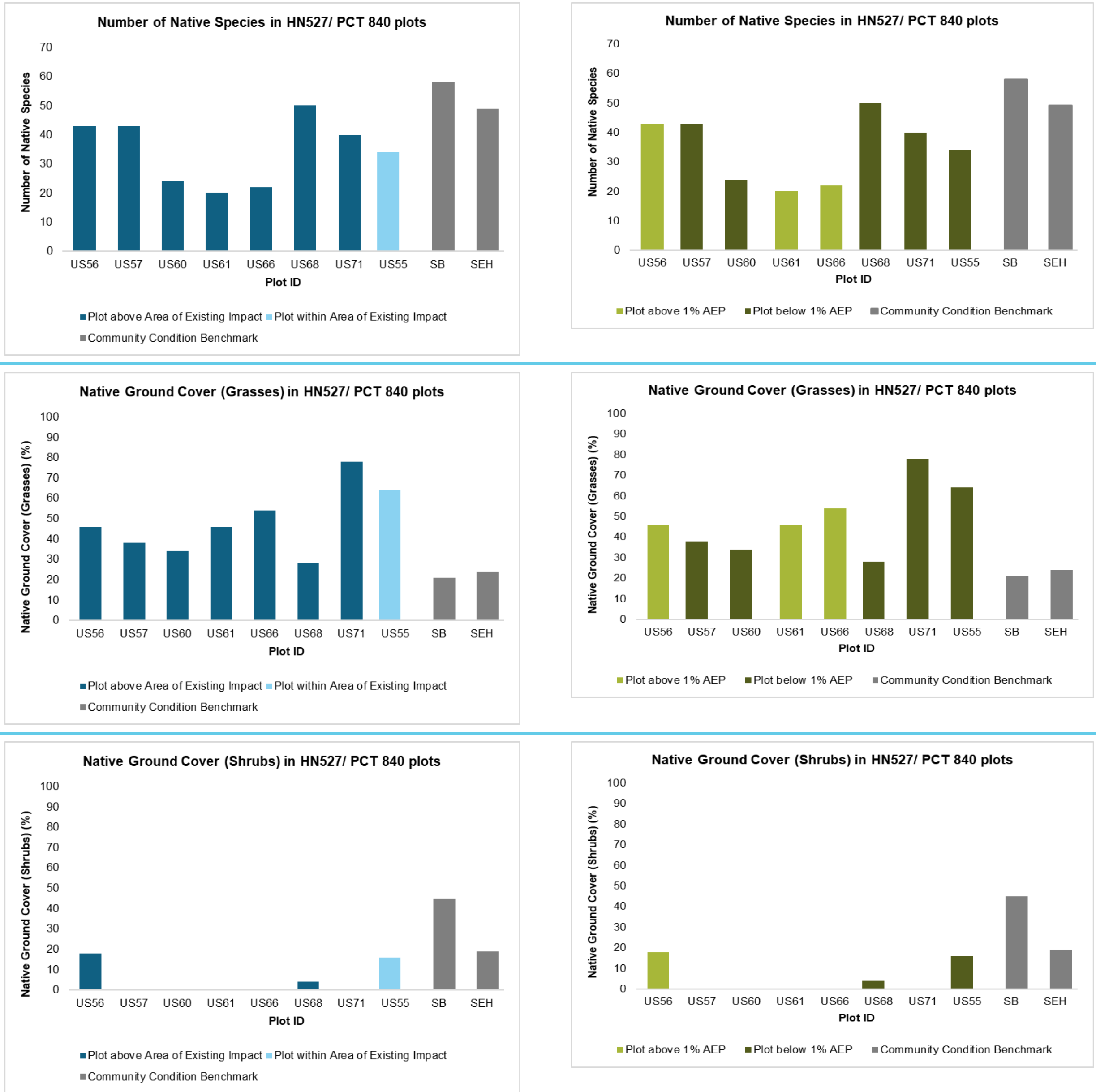
The results for the woodland vegetation community are shown in Figure 6-11.

While some caution is warranted in interpreting the results for the upstream impact area scenario in view of there being only one survey plot in the area of existing temporary inundation, the following is noted:

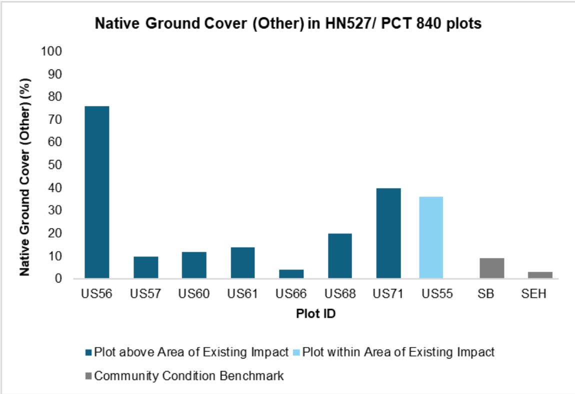
- The percentage of native species in plots above the area of existing temporary inundation ranges from 20 to 50; the percentage of native species in the survey plot in the area of existing temporary inundation is 30; this range/score is less than the Sydney Basin IBRA Region but within the South Eastern Highlands IBRA Region benchmark
- The percentages of native grass species for both temporary inundation areas are higher than both benchmarks
- The percentage of native shrubs species is similar for the plot in the area of existing temporary inundation and one of the two plots in the area above existing temporary inundation but both are lower than the benchmarks
- The percentage for other native ground cover species in the area of existing temporary inundation falls within the range of the survey plots in the area above existing temporary inundation.

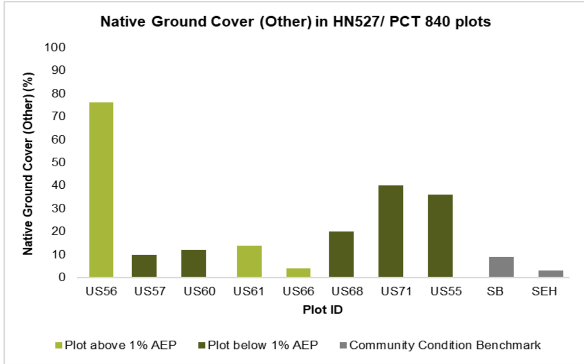
Figure 6-11 HN527/PCT 840 Forest Red Gum-Yellow Box woodland of dry gorge slopes, southern Sydney Basin Bioregion and South Eastern Highlands Bioregion

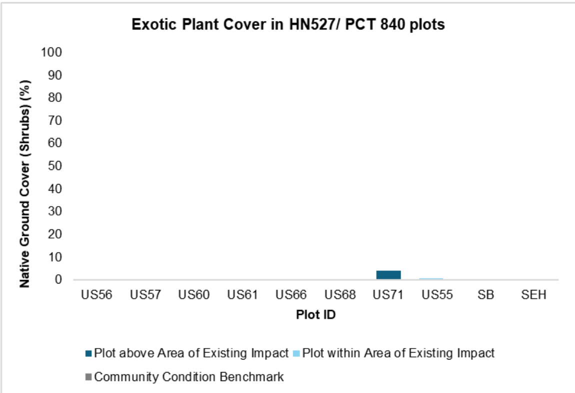
Upstream impact area	1 in 100 chance in a year flood event

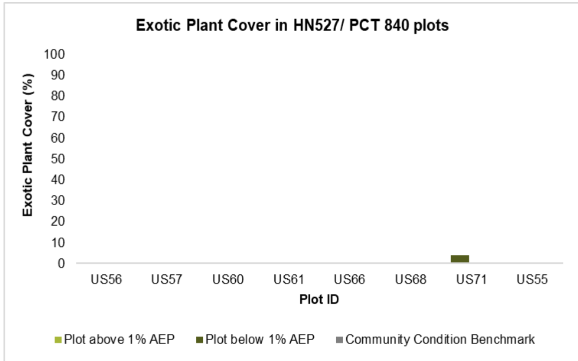


Upstream impact area	1 in 100 chance in a year flood event









As noted, these results need to be interpreted with caution but they broadly show that the survey plot in the area of existing temporary inundation falls within the range of results for the survey plots in the area above existing temporary inundation suggesting that this community has some degree of resilience to temporary inundation.

The existing 1 in 100 chance in a year event scenario shows a broadly similar pattern of results to the upstream impact area scenario. Additionally, the following is noted:

- The percentages of native species overall are generally higher below the existing 1 in 100 chance in a year flood level and a broadly similar pattern occurs for grasses and shrubs
- With the exception of one survey plot, the percentages for other ground cover species is also generally greater for the area below the existing 1 in 100 chance in a year flood level.

As noted, there has not been a 1 in 100 chance in a year flood event in the upstream catchment since the dam was constructed so it is unlikely that temporary inundation is a contributing factor to the observed results. However, considering the results for the upstream impact area, which exhibit a broadly similar pattern, there is a possibility that temporary inundation may not have a significant impact on this community.

6.7.4 Reviews of Assessments of Significance

The downstream Assessments of Significance (AoS) provided in Appendix F2 *Biodiversity Assessment Report – Downstream* to the EIS presented consideration of impacts as concluding they would be unlikely, likely, or potential. The third term was used where a potential impact was not unlikely but, reflecting the probabilistic nature of flooding, it could not be concluded that it was likely. However, subsequent to exhibition of the EIS, WaterNSW was advised that the use of this terminology was not appropriate and that impacts needed to be categorised as either likely or unlikely.

In view of this, a review was conducted of all AoS where it had been concluded that the Project could potentially impact the threatened community or threatened species. This review drew on additional information developed subsequent to the exhibition of the EIS with regard to the effects of temporary inundation on vegetation at Longneck Lagoon, and potential impacts of the Project on groundwater, downstream sediment movement and downstream bank stability.

The review covered:

- Three endangered ecological communities
- Twelve endangered flora species
- Six endangered fauna species.

The review identified two endangered flora species where the Project was likely to have a significant impact based on a precautionary approach. These are listed in Table 6-12 together with comment on the basis for concluding likely impact. The table also identifies proposed management actions for each species.

A second review was then carried out to check for general consistency in the conclusion of significance of impact between the AoS in the first review and AoS in Appendix F5 *Matters of National Environmental Significance – Biodiversity* (and noting that the criteria for the AoS are similar but not identical). This review did not identify any inconsistencies.

Since the MNES AoS were carried out, the flora species *Rhodamnia rubescens* and the vegetation community Coastal Swamp Sclerophyll Forest of New South Wales and South East Queensland have been listed under the EPBC Act. The NSW AoS identified a likely significant and unlikely significant impact respectively.

Table 6-12 NSW-listed threatened species likely to be impacted by the Project

Species	EIS AoS conclusion	Revised AoS conclusion	Proposed management action(s)
Rhodamnia rubescens	The key impacts for this species as a result of the Project is the predicted spread and increase of impacts of disease and pathogens, specifically Myrtle Rust. The reduction of flooding extent and an increased inundation period in the FMZ discharge when flood events occur also are also identified as important impacts. While the hydrological requirements for *Rhodamnia rubescens* are not well-understood, the Project has the potential to increase the susceptibility of *Rhodamnia rubescens* to Myrtle Rust as a result of other stresses. Given the severity of the Myrtle Rust on this species, any individuals that are currently alive are potentially significant to the survival of the species.	Thirty individuals of *Rhodamnia rubescens* were incidentally recorded within the study area. Before its rapid decline as a result of infection from Myrtle Rust, the species was often found in wet sclerophyll associations in rainforest transition zones and creek-side riparian vegetation. DPIE Biodiversity Assessor Update No. 28 advises that given the severity of the Myrtle Rust on this species, any individuals that are currently alive are potentially significant to the survival of the species. This assessor update states that a precautionary approach to assessing potential impacts on these species needs to be undertaken including the assumption that any individuals or populations that remain are potentially viable and that where feasible, these individuals or populations need to be afforded protection to optimise the survival and recovery of this species. As the hydrological requirements of the species are not well understood, a precautionary approach has been taken in assigning a likely significant impact. While the project is not expected to introduce Myrtle Rust into areas not already impacted by this threat, there is a risk that where the disease is already present within a population, individuals may be more susceptible to infection due to increased stress. A precautionary approach has been taken in assigning a likely significant impact to this species.	A targeted strategy for managing *Rhodamnia rubescens* has been developed under the Saving Our Species Program. Proposed actions include (but are not limited to): • Select a series of stratified monitoring sites to monitor on-going Myrtle Rust incidence, severity and symptomology • Complete rapid field surveys across the entire species range to determine rust impact, identify rust-resistant populations, sites or individuals. • Control transformer weeds. It is proposed that these actions are supported by the NSW Government for the potentially affected Maroota population. Actions to be funded could include: • Field survey to identify population within the potentially affected area • Selection of monitoring sites • Identification of rust impacts in accordance with agreed approaches to establish a baseline • Ongoing monitoring of the sites to identify population changes over time. These actions would support the Saving our Species program and enable other management actions to occur should a population impact be identified. Advice would be sought from DPE regarding appropriate actions.

Species	EIS AoS conclusion	Revised AoS conclusion	Proposed management action(s)
Pomaderris brunnea	Potential impacts to the species relate to the predicted reduction of flooding extent and an increased inundation period in the FMZ discharge. Increased periods of inundation may result in temporary damage to individuals or minor modifications to habitat. The species is not known to rely on specific hydrological regimes for its life cycle, however its preferred habitat adjacent to creeklines suggests this may be the case. The habitat within the 10% AEP event and FMZ discharge area is expected to be important for the local population.	*Pomaderris brunnea* occurs in a variety of habitats, often moist woodlands and forests on alluvial floodplains and along creeklines (OEH profile). One occurrence of *Pomaderris brunnea* has been recorded in the project study area. The species is not known to rely on specific hydrological regimes for its life cycle, however its preferred habitat adjacent to creeklines suggests this may be the case. A precautionary approach has been taken in assigning a likely significant impact to this species.	A targeted strategy for managing *Pomaderris brunnea* has been developed under the Saving Our Species Program. Under the Saving Our Species Program, *Pomaderris brunnea* has been assigned to the 'site-managed species' management stream. The following four priority management sites have been identified for this species: • Oakwood property in the Mid-Western Regional LGA. • Gundungurra Reserve/Spring Farm in the Camden LGA. • Wirrimbirra Wildlife Sanctuary in Wollondilly LGA. • Upper Nepean State Conservation Area in the Wingecarribee LGA. It is proposed that these actions are supported by the NSW Government for the potentially affected Colo population. Actions to be funded could include: • Additional survey to better clarify the size and condition of the Pomaderris population in the Colo area. • If appropriate, consider the suitability of including the site as one of the priority sites • Alternatively support actions within the existing priority management sites Advice would be sought from DPE regarding appropriate actions.

6.8 Visual amenity

DPE requirement

The PIR must demonstrate what the visual impact would reasonably be from all viewing locations, including areas beyond the project footprint where the works would be readily visible from scenic lookouts or other publicly accessible vantage points.

Publicly accessible viewpoints

Assessment of potential impacts of the Project on landscape character and visual amenity is addressed in Chapter 25 and Appendix P of the EIS.

Visual impacts typically increase where views are experienced by many people. For this assessment, major publicly accessible viewing areas were selected rather than remote distant locations that only a small portion of the public would visit.

Representative viewpoints (VP) selected within the Warragamba Dam zone for the dam construction and post-completion were:

- VP 2-1: Viewing platform, Warragamba Visitors Centre
- VP 2-2: Valve House Road, Warragamba Dam
- VP 2-3: 18th Street Lookout, Warragamba.

Small sections of the Great Burragorang Valley Walk in proximity to Warragamba Dam may also have visibility of the dam. It is expected that these areas would be closed to the public for safety reasons during construction. The dam is not visible from the Lake Burragorang lookout.

Photomontages were produced for the above three viewpoints to represent the close range views with and with-out the Project. The visual impact assessment for each of these viewpoints considered both the physical infrastructure and the potential change in appearance of vegetation areas in the landscape as a result of temporary inundation.

The assessment of visual amenity related to the raised dam wall concluded there would be a High – Moderate visual impact resulting from the Project with regard to the changed appearance of the dam. The dam is a regionally significant landmark and demonstrates a nationally important engineering achievement. Further consideration of potential impacts on visual amenity following exhibition of the EIS suggests that the impact would more appropriately be Moderate as the dam is an existing feature in the environment and that the Project would be modifying this built feature in a manner consistent with its existing appearance rather than introducing a completely new built feature into the environment.

As described in the EIS, viewing locations beyond the Project footprint upstream were considered with regard to changing water levels in Lake Burragorang associated with operation of the FMZ. However, these are not considered to be a significant influence on visual amenity. Varying water levels below FSL are an existing feature and will not change with the Project. The EIS concluded that there would be negligible impacts resulting from the Project.

It should also be noted that public access to the upstream catchment area during inflow events is currently prohibited due to safety concerns and this would not change with the Project.

Following exhibition of the EIS, a comparative analysis of two upstream vegetation communities was undertaken (refer Section 6.7.3) which suggests that it is unlikely that temporary inundation would result in the loss of a significant portion of the ecological values of the affected land. As total loss of vegetation in the inundated area is unlikely, significant visual impacts as a consequential impact of temporary inundation causing vegetation loss are also considered unlikely.

The EIS also concluded that the viewing locations assessed downstream would have a positive benefit as the extent of flooding for comparative flood events would be reduced.

6.9 Other matters

DPE requirement

- Details of road upgrades required and/or maintenance regimes necessary to support heavy vehicle access to the proposal site.
- Changes to the proposal which will minimise its social, environmental and cultural impacts.

6.9.1 Road upgrades

Potential impacts related to traffic and transport are considered in Chapter 24 and Appendix O to the EIS. Heavy vehicles would use pre-defined fixed routes, namely a northern route and a southern route, to deliver construction materials to the dam site. The northern route includes The Northern Road, Park Road, Silverdale Road, Farnsworth Avenue and Production Avenue, while the southern route includes Silverdale Road, Warradale Road and Production Avenue.

All intersections with and without Project-related traffic would operate at Level of Service (LOS) A in the morning and afternoon peaks, except for The Northern Road/ Park Road intersection which would operate at LOS B. Roads along the northern route have good pavement condition, and roads along the southern route have poor pavement condition. As such additional heavy vehicle movements from construction traffic along the southern route may have detrimental impacts on the surface condition.

Management measure TT1 provides for the preparation of a construction traffic management plan (CTMP) prior to construction. Preparation of the CTMP would include consideration of any required road upgrades and/or maintenance regimes. In addition, WaterNSW commits to:

- Completing the Warradale Road/Production Avenue intersection upgrade works prior to commencement of construction as outlined in Section 4.3.1 of Appendix O to the EIS
- Management measure TT7 which identifies that regular inspection and maintenance would be carried out on Park Road, Silverdale Road, Farnsworth Road, Production Avenue and Warradale Road.

Management measure TT8 identifies that a road dilapidation report will be prepared for Park Road, Silverdale Road, Farnsworth Avenue, Production Avenue and Warradale Road. This will ensure that any deterioration to roads as a result of construction activities is made good by the contractor/ WaterNSW. The need for inclusion of other roads in the dilapidation report will be considered as part of construction planning.

6.9.2 Changes to the Project to minimise impacts

Consideration of environmental factors and mitigation of potential impacts has been an integral part of the option evaluation process (refer Section 7.1) with regard to identification, development, refinement, exclusion of options, and identification of a preferred option.

There are limitations to identification of further practicable changes to mitigate operation-related impacts of the Project due to its location being fixed (and noting that the potential option of other dams upstream was considered back in the 1990s).

There may be further opportunities to mitigate construction-related impacts and these would be pursued during detailed design and construction planning.

7

Justification of preferred infrastructure

7 Justification of preferred infrastructure

7.1 Identification and assessment of alternatives

The decision to progress the Warragamba Dam Raising Project as the preferred infrastructure solution to reducing flood risk in the Hawkesbury-Nepean Valley has not occurred in isolation. Since the 1980s, local and international experts, and interdepartmental committees have undertaken investigations and provided advice to the NSW Government of the day on potential strategies to manage flood risk in the valley. In the decades since, a range of infrastructure and non-infrastructure options have been carefully considered and assessed.

The Hawkesbury-Nepean Floodplain Management Strategy (Hawkesbury-Nepean Flood Management Advisory Committee 1997) identifies the following initiatives to mitigate and manage flood risk in the Hawkesbury-Nepean Valley:

- Improved evacuation routes
- Better flood forecasting and warning
- Enhanced emergency response to floods
- Faster recovery for affected communities
- Increased awareness of flood risks
- Regional approach to flood planning
- Improved understanding of flood hazards
- Development of best practice land development guidelines.

These initiatives informed further work carried out over the period 1998-2004.

In early 2013, the *Hawkesbury-Nepean Valley Flood Management Review* commenced following the Government's adoption of the *State Infrastructure Strategy 2012-2032* and ongoing concerns about flood risk. This found that there was a significant existing and growing flood risk in the valley and concluded there was no simple solution or single infrastructure option that could address all of the flood risk. The 2013 Review identified several priority areas for action:

- Increasing flood awareness and preparedness in the community
- Enhancement of emergency planning, response and recovery
- Better consideration of flood risk in land use planning
- Reviewing governance for effective flood risk management
- Cost-benefit assessment of potential flood mitigation infrastructure options.

Following the recommendations of the 2013 Review, the NSW Government established the Hawkesbury-Nepean Valley Flood Management Taskforce to develop a whole-of-government approach to flood risk management and preparedness in the valley. Through 2014-2016, the Taskforce built on the preliminary investigations of the 2013 Review, to develop a strategy under the disaster risk management framework of 'prevent, prepare, respond and recover'.

A key objective of the Taskforce was to identify, develop and assess potential alternatives and options for reducing flood impacts and risks in the valley. This comprised:

- Reviewing previous alternatives and options from the 1997 Hawkesbury-Nepean Floodplain Management Strategy and the 2013 Review

- Identifying new potential alternatives or options
- Developing assessment criteria to enable the comparison of different alternatives and options
- Commissioning studies and design work on feasible alternatives and options to provide suitable information to enable their assessment. This included engineering design of relevant options, flood modelling, evacuation modelling to assess risk to life, flood damages assessment, cost estimation, cost benefit analysis, and preliminary environmental impact assessment
- Using the assessment criteria and information from the additional design and studies to evaluate the alternatives and options to determine which, in single or combination, were the most effective in reducing flood impacts
- Developing the Hawkesbury-Nepean Valley Flood Risk Management Strategy (Flood Strategy) for Government's consideration.

The Taskforce confirmed the findings of the 2013 Review, that there is no simple solution or single infrastructure option that can eliminate the high flood risk to existing communities in the valley. A combination of infrastructure and policy or other initiatives are required to reduce flood risk by:

- Changing the probability and delaying flood events reaching critical levels
- Reducing the exposure of people, property and assets to flood risk
- Increasing the available time to safely evacuate areas exposed to imminent flooding
- Increasing the resilience of communities, property and public assets exposed to floods.

The following criteria were used by the Taskforce to assess alternatives and options for flood risk mitigation:

- Significant regional reduction of flood peak:
  - reduction in downstream peak flood levels for critical flood range for damages of 1 in 50 to 1 in 1,000 chance in a year for damages and risk to life
  - extent of peak flood level reduction in the valley
- Reduced risk to life:
  - reduced exposure to floods
  - flood delay providing a longer window for evacuation
  - average annual vehicles/population unable to evacuate
- Economic costs and benefits:
  - capital and operating costs
  - benefits in terms of avoided flood damages
  - net benefit
- Socio-economic, environmental and cultural heritage impacts
- Other factors.

The assessed alternatives and non-infrastructure measures are detailed in the Taskforce Options Assessment Report (Infrastructure NSW 2019) and comprised:

- Operational alternatives using the existing Warragamba Dam – these primarily modify how the dam is operated but may require some modification to existing infrastructure; these include:
  - opening Warragamba Dam gates more slowly to temporarily hold back inflows ('surcharge' method)
  - pre-releases from Warragamba Dam water supply to create a temporary FMZ in advance of a forecast flood
  - lowering Warragamba Dam's water supply storage to create a dedicated FMZ
  - combined operational alternatives
- New flood mitigation dams – alternatives include new dams built and operated only for flood mitigation:
  - new dams upstream of Warragamba Dam
  - new dam on Nepean River
  - new dams downstream of Warragamba Dam
- Raising Warragamba Dam wall to temporarily store flood waters in a dedicated FMZ – this alternative included detailed consideration of two different heights:
  - raising by 14 metres
  - raising by 20 metres
- Infrastructure upgrades to enhance drainage or protect downstream communities, including:
  - construction of diversion channels to improve the drainage of floodwaters
  - dredging of Hawkesbury River to improve drainage of floodwaters
  - levees to provide localised flood protection to flood prone communities
- Evacuation road upgrades – involving upgrade packages to improve evacuation road network capacity. Two categories of road upgrades were considered:
  - nine evacuation road upgrade packages for major regional evacuation routes
  - local evacuation road upgrades
- Non-infrastructure measures – a wide range of non-infrastructure measures was considered including changes to land use planning controls, improved flood forecasting and response, building community resilience, and better coordination between agencies. Generally, these measures do not result in any reduction in flooding extent or frequency, and so cannot be considered substitutes to flood mitigation infrastructure that would reduce significant existing risk exposure. Nonetheless, these non-infrastructure measures are critical for an integrated and sustainable approach to managing current and future flood risk in the valley.

A phased approach was adopted for the evaluation of potential options and alternatives. Some options were investigated to a pre-feasibility stage, some to a feasibility stage, and others to a detailed feasibility stage. This is consistent with both a project of this size and complexity, as well as best practice frameworks for disaster risk management.

This assessment of alternatives and the phased approach to investigating ways to reduce flood risk in the valley ultimately led to *Resilient Valley, Resilient Communities: Hawkesbury-Nepean Valley Flood Risk Management Strategy* (Infrastructure NSW 2017). This identifies nine outcomes, one of which is to reduce flood risk in the valley by raising the Warragamba Dam wall. This is the infrastructure option that the Taskforce found to have the highest benefit.

In summary, there has been an extensive objective, comprehensive, technically robust process for the identification and evaluation of all practicable options and alternatives that has led to the preferred option of raising Warragamba Dam to achieve the objective of reducing risk to life and property in the Hawkesbury-Nepean Valley. This has considered a wide range of factors including socio-economic, environmental and cultural heritage issues which have informed evaluation and refinement of options, and informed decision-making with regard to discarding options and further consideration of options through the evaluation and assessment process.

7.2 Justification

Justification for the Project is provided in Chapters 3 and 29 of the EIS. As stated in Chapter 3

> *The Warragamba Dam Raising Project is required to reduce flooding impacts on downstream communities and urban development in the Hawkesbury-Nepean Valley. The unique topography of the Hawkesbury-Nepean Valley results in extensive and damaging floods, especially for flood events greater than the 1 in 100 chance in a year flood. The current number of people affected by a 1 in 100 chance in a year flood is 55,000. The risk would increase as the number of people, properties and businesses in the catchment increases over time. Also, because of the limited capacity and flood prone evacuation routes from developed areas of the floodplain, there is a risk of the loss of human life when significant flood events occur. A detailed and comprehensive Hawkesbury-Nepean Valley flood risk management strategy was developed by a multi-agency Taskforce to investigate alternatives and options to reduce the risks and impacts of significant flood events in the Hawkesbury-Nepean Valley. No other infrastructure alternative or option (and their combinations) investigated by the Taskforce was as effective and viable in reducing flood risks as the Project.*

Subsequent to the exhibition of the EIS, a major flood event occurred in the Hawkesbury-Nepean Valley in March 2021 followed by another major flood event in March 2022. The March 2021 flood was the first major flood event (and largest) since 1990 at Windsor and in the lower Hawkesbury River, and the highest flood event since 1925 at Penrith. For both Windsor and Penrith, the March 2021 flood had an estimated frequency of 1 in 20 chance in a year (Infrastructure NSW 2021c).

The analysis of the March 2021 flood (Infrastructure NSW 2021c; page 72) noted

> *About 600 dwellings and 300 commercial/industrial buildings (most on rural land) are estimated to have been impacted by the flood. The many caravan parks between Windsor and Gunderman were severely impacted, with over 1400 manufactured homes flooded.*
>
> *Flooding and riverbank erosion also caused severe damage to local roads, turf farms and vegetable crops.*
>
> *Coming on the heels of drought, bushfire, the February 2020 flood and storm, and COVID-19, the March 2021 flood is known to have compounded psychosocial impacts on affected communities. This includes already socially vulnerable people.*

The analysis also noted (Infrastructure NSW 2021c; page 70)

> *Analysis of the March 2021 flood confirms that dam raising would have provided greater peak level reductions than FSL-lowering or pre-releases. Pre-releases would have brought forward*

closure of downstream river crossings and the onset of minor flooding, making emergency responses before the flood more difficult.

Anecdotal reports after the flood suggest relatively high levels of non-insurance and under-insurance for floods due to the prohibitively high costs quoted. This emphasises the need for measures to reduce the risk.

The experience of the March 2021 flood provides further justification for the Project.

7.3 Key benefits and impacts

The principal benefits of the Project are:

- A significant reduction in flood heights and extents for the critical range of major floods events. For example, for the 1 in 100 chance in a year flood, a reduction of flood heights of about 5.2 metres at Penrith, 3.1 metres at Richmond and 4.1 metres at Windsor
- A significant reduction in the number of residential properties impacted by flooding in the critical range of major floods events. For example, for the 1 in 100 chance in a year flood there would an estimated reduction of 5,180 properties (68 percent reduction)
- Flood damage estimates would typically be reduced by approximately 74 to 80 percent for floods up to about the 1 in 200 chance in a year event, reducing to approximately 50 percent for a 1 in 2,000 year chance in a year event.
- Increased opportunities for evacuation as evacuation routes would experience less flooding and a longer period before closure due to flooding. For example, for the 1 in 100 chance in a year flood the Windsor Bridge crossing would remain open for an additional 18 hours
- A reduction in the risk to life due to reduced flooding extents and greater evacuation opportunities
- Potentially lower flood insurance premiums for some residential and commercial premises.

The principal impacts of the Project are:

- Changes to the upstream flooding regimes through an increase in the frequency of flooding, and in the depth, duration and extent of temporary inundation. This would be most pronounced in and around the perimeter of Lake Burragorang but would drop off rapidly moving upstream away from the lake. These changes have the potential to diminish other environmental values in the upstream area
- An increase in the duration of low-level flooding downstream associated with the emptying of the FMZ
- Potential changes to upstream vegetation communities and fauna habitat associated with differing tolerances and responses to temporary inundation
- Some Aboriginal heritage sites in the upstream area would experience either increased temporary inundation or are in areas that could newly experience temporary inundation due to the Project. While many sites would only experience relatively minor impacts from infrequent temporary inundation, other highly significant sites such as rock art sites may experience more substantial impacts
- A potential diminishment of World Heritage and National Heritage values in the upstream area associated with additional temporary inundation (but noting that the World Heritage and National Heritage listings occurred after construction of the dam and implicitly accept the risk of temporary inundation associated with the dam)

- Potential increased bank erosion downstream associated with discharge of the FMZ, however, the additional analysis carried out during preparation of the Submissions report and PIR has identified that this risk would not be as widespread or unform as assumed in the EIS, with some reaches being at a lower risk while others would have a relatively higher risk.

7.4 Ecologically sustainable development

Clause 192(1)(f) of the NSW Environmental Planning and Assessment Regulation 2021[13] requires an EIS to provide

> *the reasons justifying the carrying out of the development, activity or infrastructure, considering biophysical, economic and social factors, including the principles of ecologically sustainable development set out in section 193.*

This was provided in Table 29-22 in Chapter 29 of the EIS which stated

> *The Project is considered to be consistent with the four principles of ecologically sustainable development:*

- ***Precautionary principle****: This EIS was prepared adopting a conservative approach which includes an assessment of the worst case impacts and scenarios. This includes assuming that the dam was at full supply level when a flood event occurs – and assuming the presence of many threatened species in the upstream catchment, even though they weren't found during field surveys*
- ***Intergenerational equality****: The Project would provide intergenerational equality in terms of flood protection for communities in the Hawkesbury-Nepean Valley as climate change is predicted to increase the future frequency and size and extreme rainfall events*
- ***Conservation of biological diversity and ecological integrity****: The design and assessment of the Project has been undertaken with the aim of identifying, avoiding, minimising and mitigating impacts to biodiversity and ecological integrity. Consistent with the TSC Act/BC Act, EPBC Act and the SEARs, a biodiversity offset strategy has been developed to compensate for the unavoidable total loss of ecological values due to the Project.*
- ***Improved valuation and pricing and incentive mechanisms****: The value placed on avoiding and minimising environmental impacts is reflected in the design features incorporated into the Project. The cost of mitigation measures has been incorporated into the Project cost, as well as the extent of investigations undertaken to inform this EIS.*

The additional investigations carried out during preparation of the Submissions Report and this PIR have clarified some aspects of the assessment presented in the EIS. This suggests the precautionary approach adopted for some aspects of the assessment may have been overly conservative, and that some assumed impacts, such as the total loss of environmental values in the upstream impact area, may not actually be realised.

The revised offset strategy includes a funding component for the protected lands values offset for on-park management which is consistent with the second, third and fourth ESD principles.

[13] The same requirement is in the 2000 Regulation, Schedule 2, Part 3, clause 7.

8

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8 References

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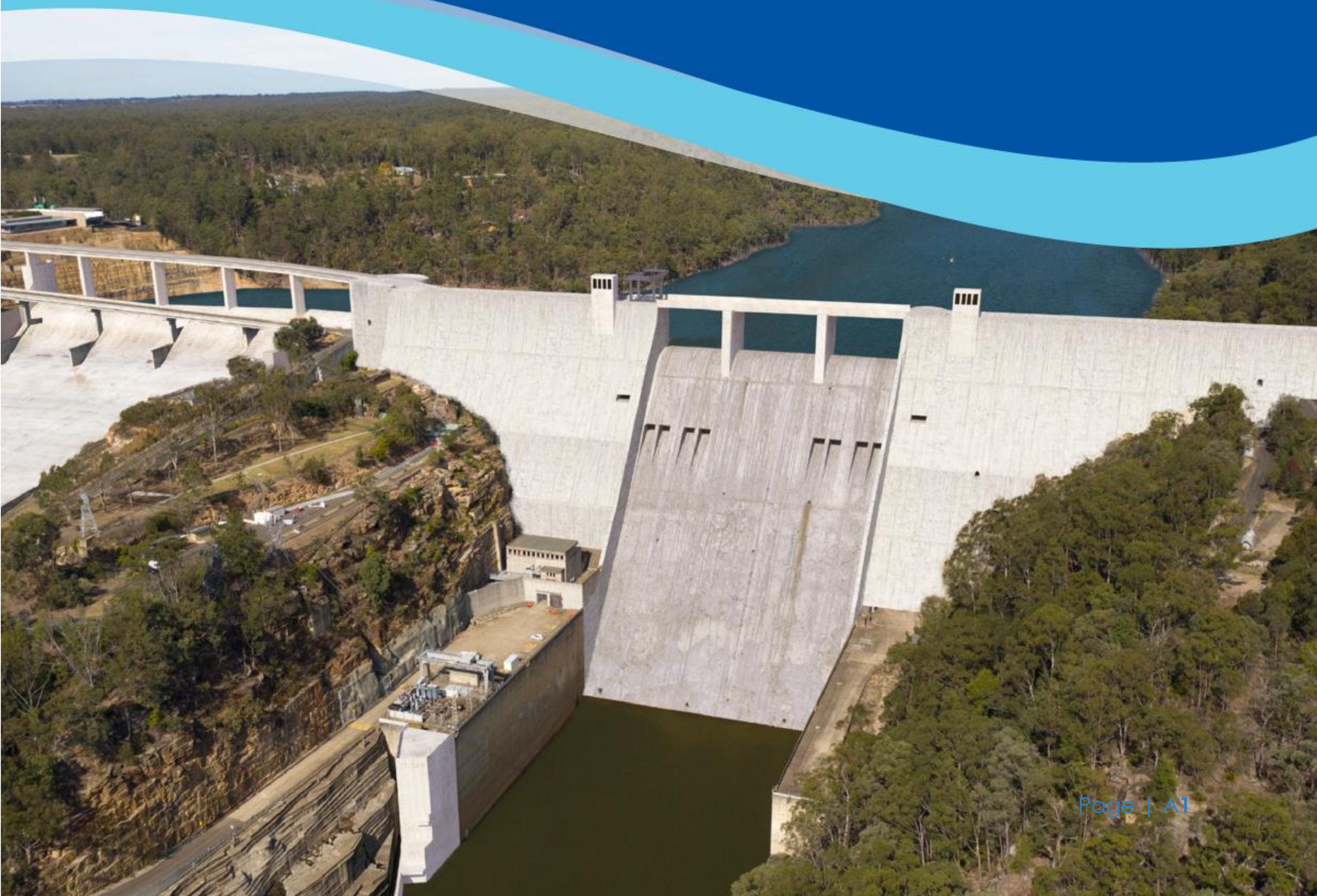
A

Appendices



Appendix A

Project design drawings

The following table lists figures provided in this appendix that provide further design details on the proposed works from those provided in the EIS.

The proposed works in the EIS have not altered in response to submissions other than the addition of one row of concrete baffles blocks on the floor of the dissipator. These are required to further reduce the amount of energy in the discharged water after it is released from the dam but do not influence the amount of water discharged as controlled by the outlet gates.

This minor design change does not alter the assessment or the conclusions reached in the EIS.

Figure #	Description
A1	Plan view of upgraded Warragamba Dam (updated Figure 5-4 in Chapter 5 of the EIS)
A2	Design drawing: General arrangement
A3	Design drawing: Downstream elevation
A4	Design drawing: Upstream elevation
A5	Design drawing: Left abutment (Sections A and B)*
A6	Design drawing: Monolith 17 (Section C)
A7	Design drawing: Monolith 15 (Section D)
A8	Design drawing: Monolith 13 (Section E)
A9	Design drawing: Monolith 11 (Section F)
A10	Design drawing: Central spillway – section through FMZ outlet
A11	Design drawing: Auxiliary spillway crest section
A12	Design drawing: Auxiliary spillway erosion protection plan
A13	Design drawing: Auxiliary spillway erosion protection

* Refer Figure A2 for locations of sections

Figure A1 Plan view of Project

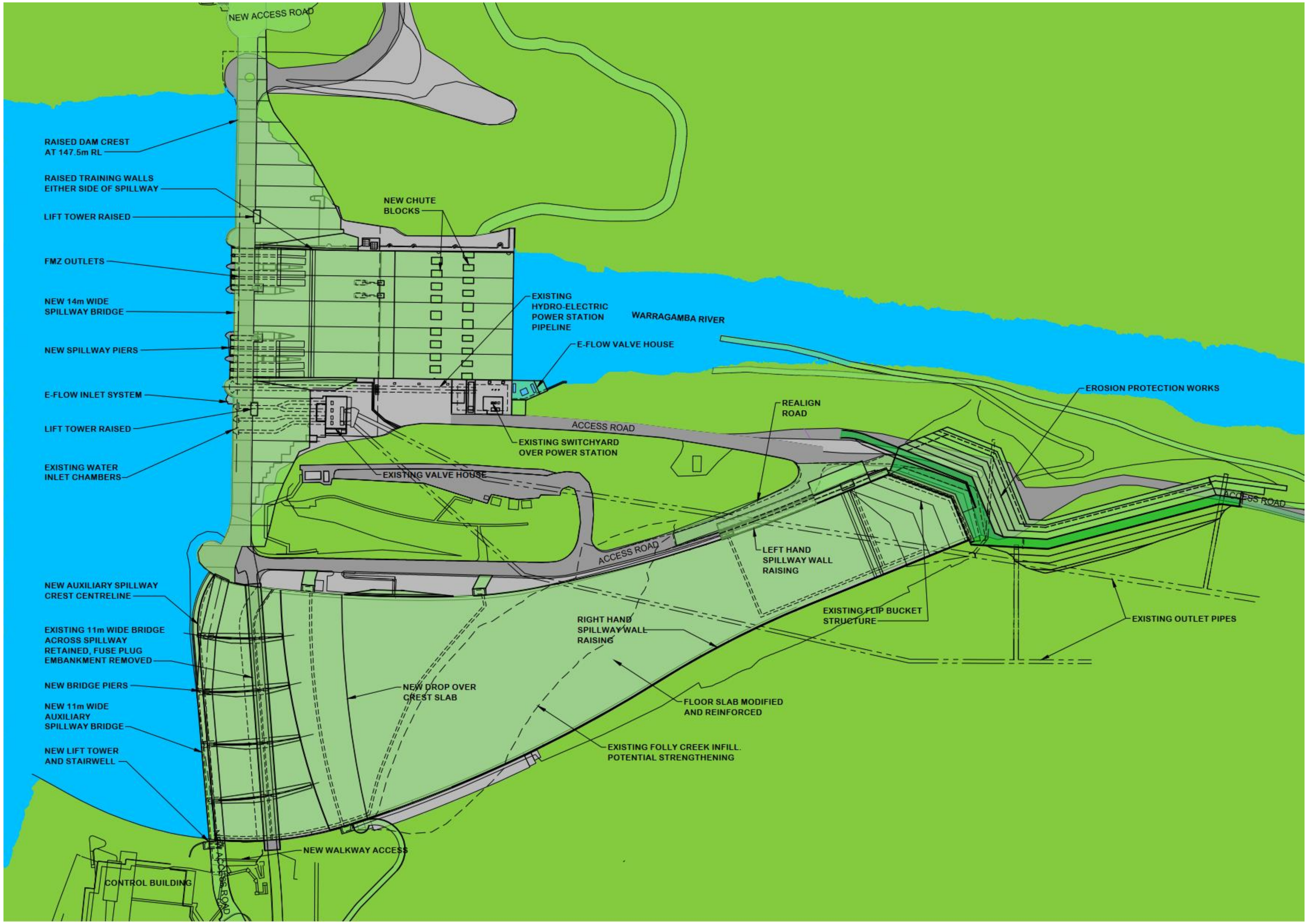


Figure A2 General arrangement

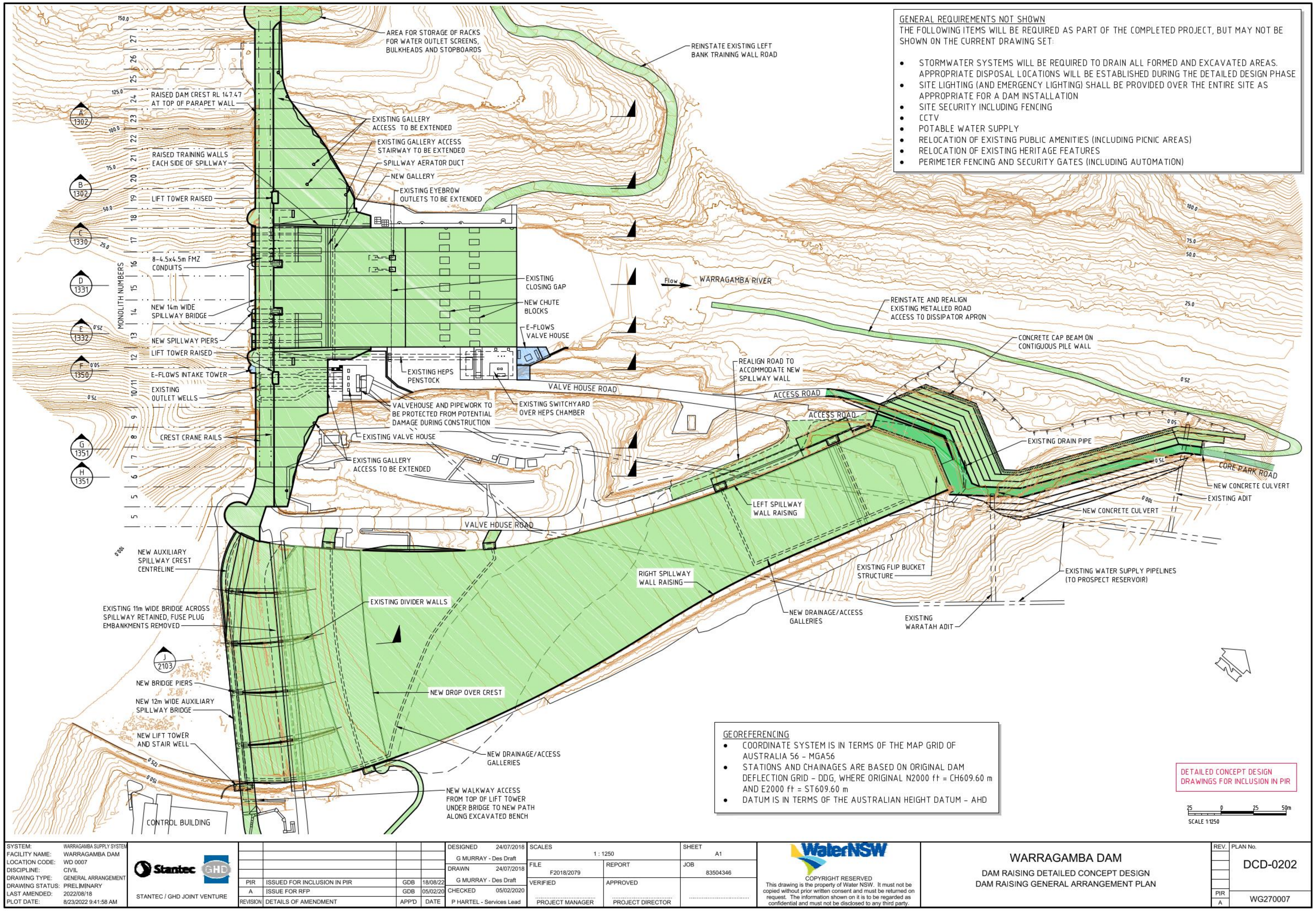


Figure A3 Downstream elevation

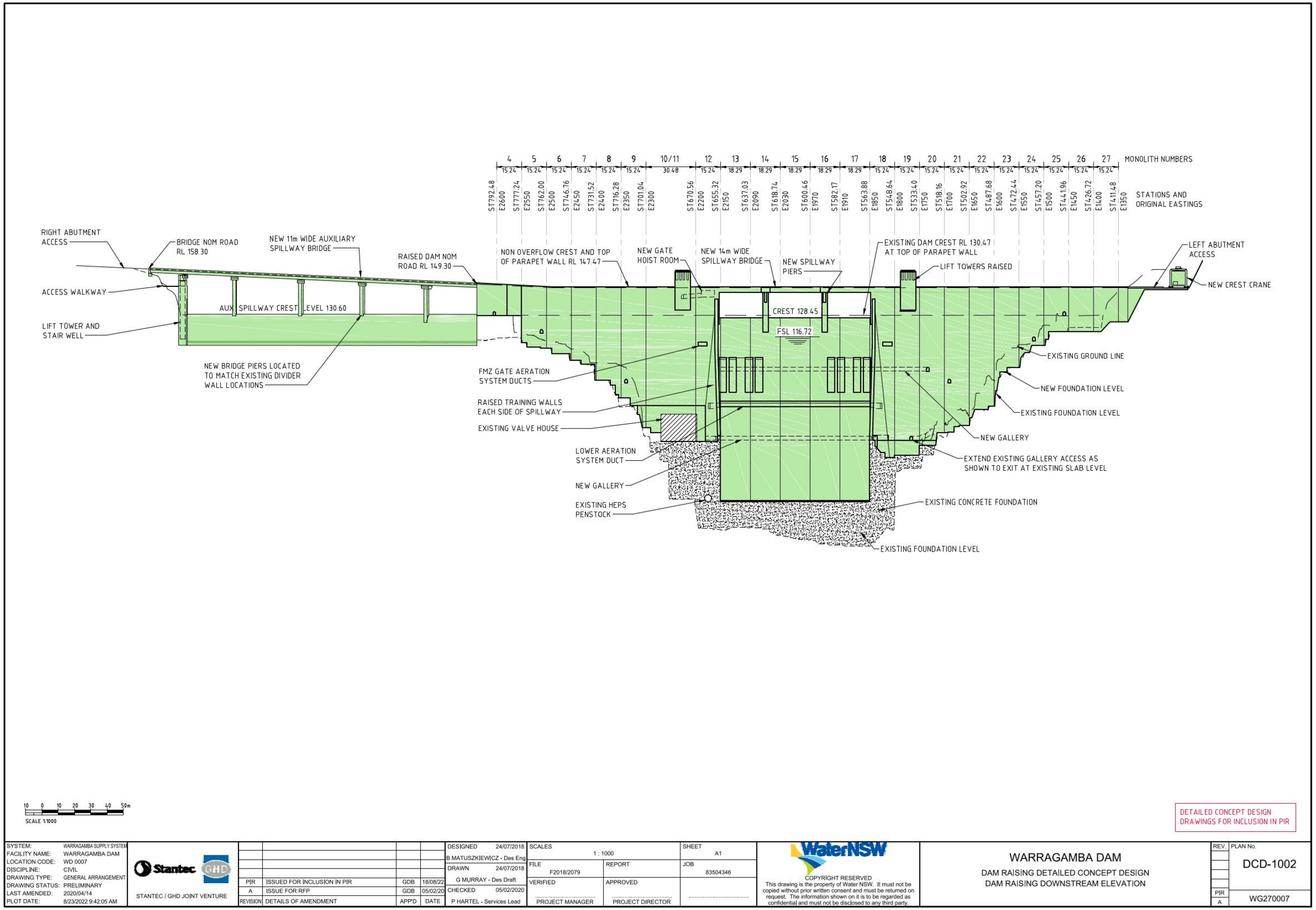


Figure A4 Upstream elevation

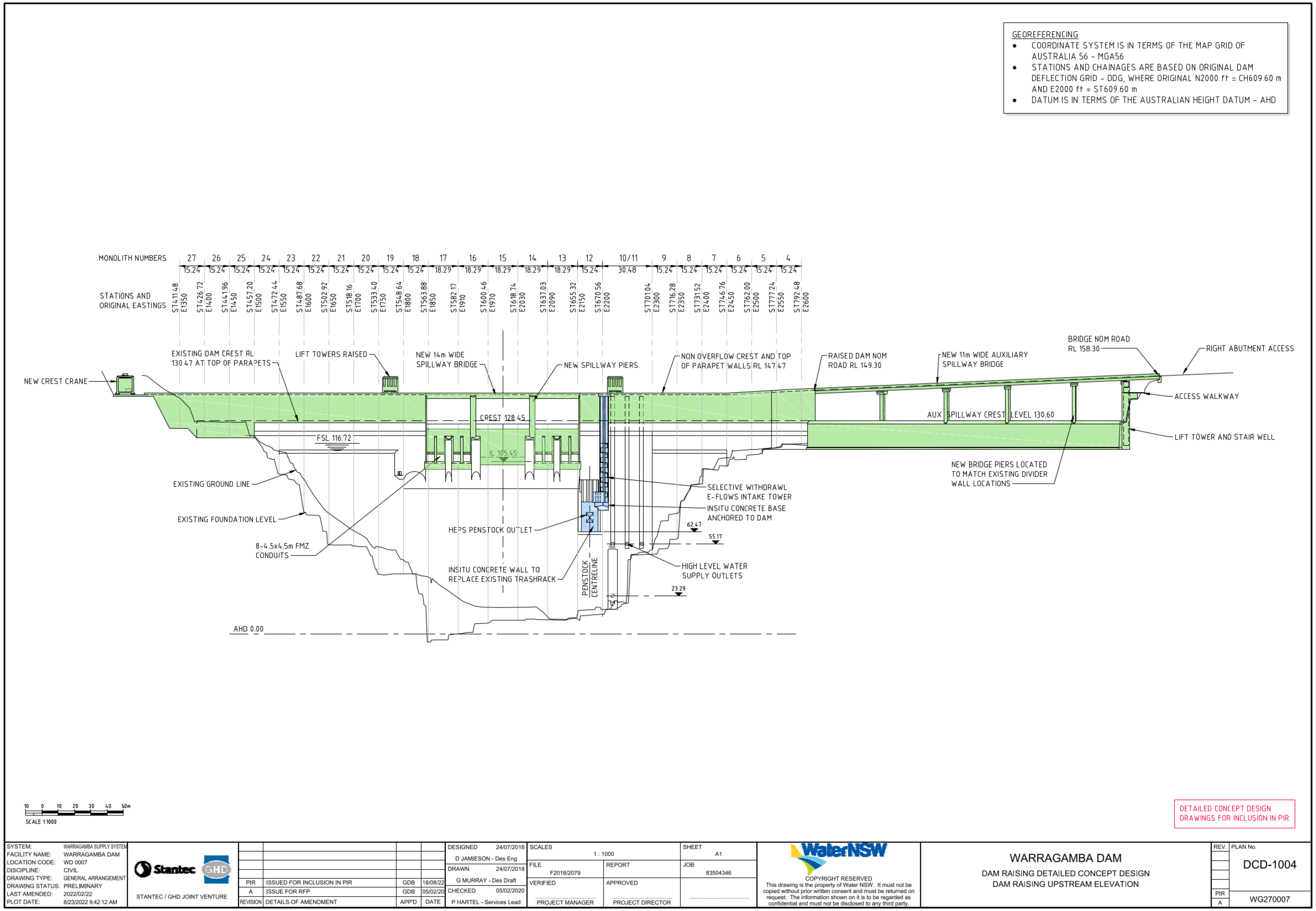


Figure A5 Left abutment (Sections A and B)

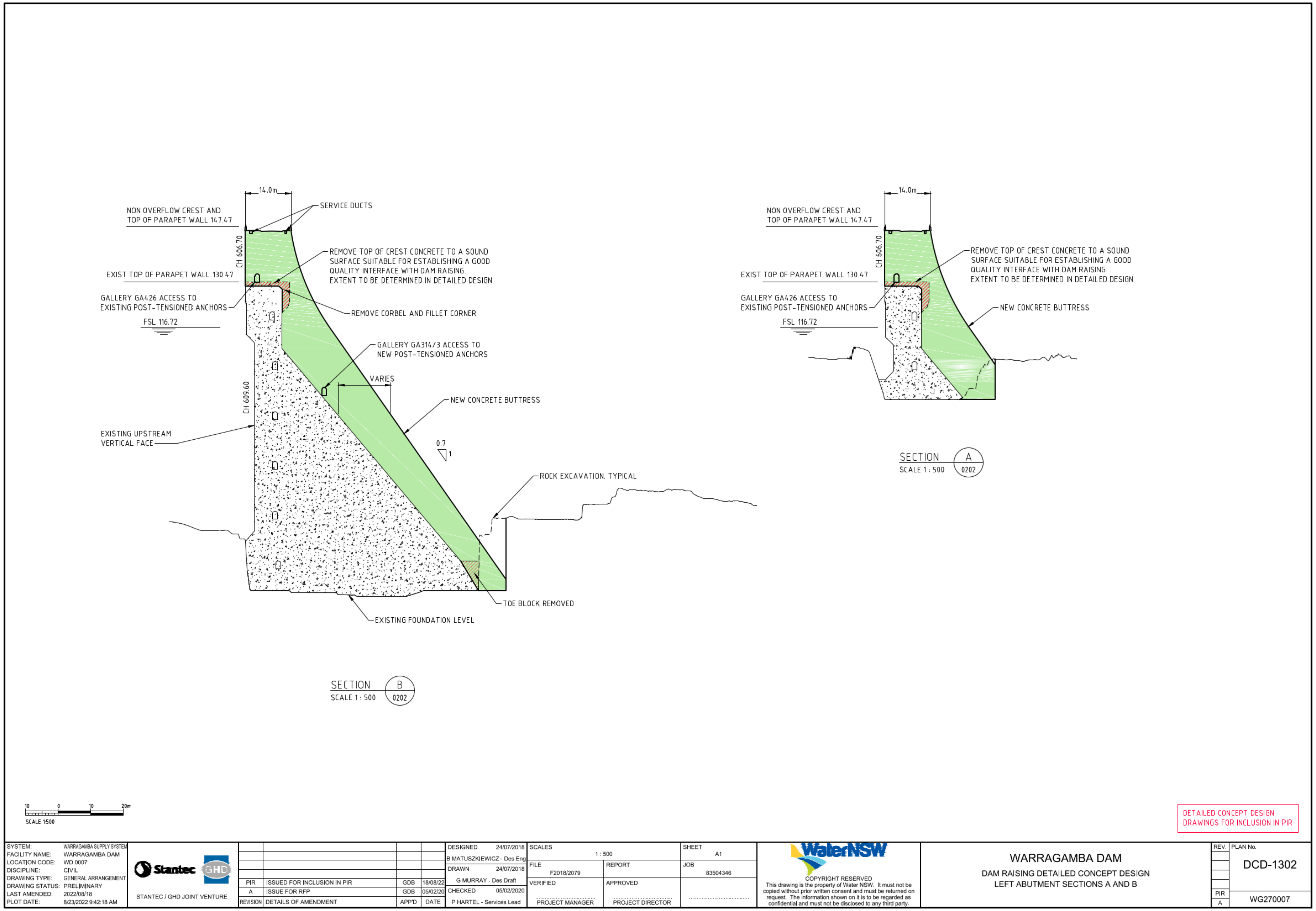


Figure A6 Monolith 17 (Section C)

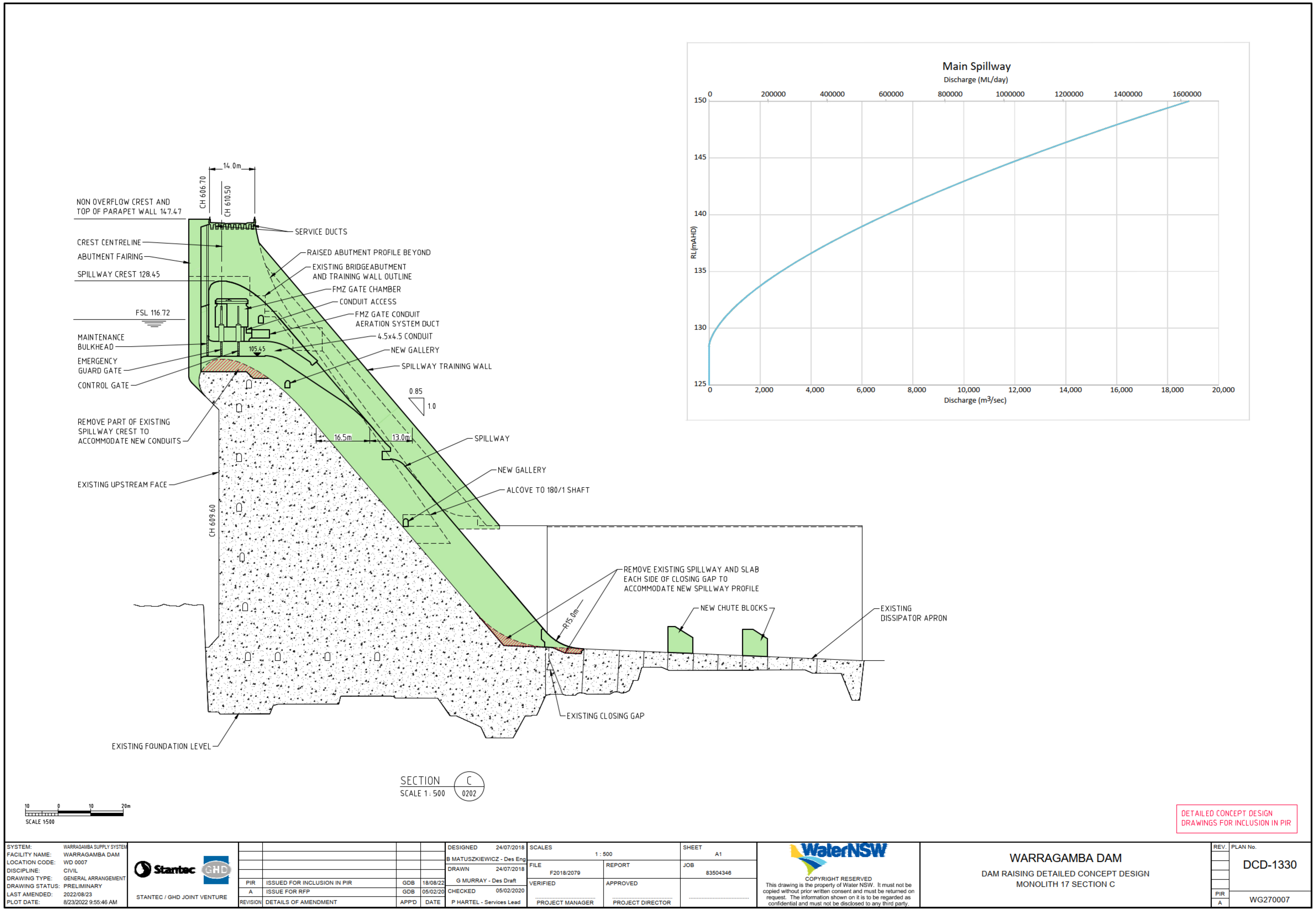


Figure A7 Monolith 15 (Section D)

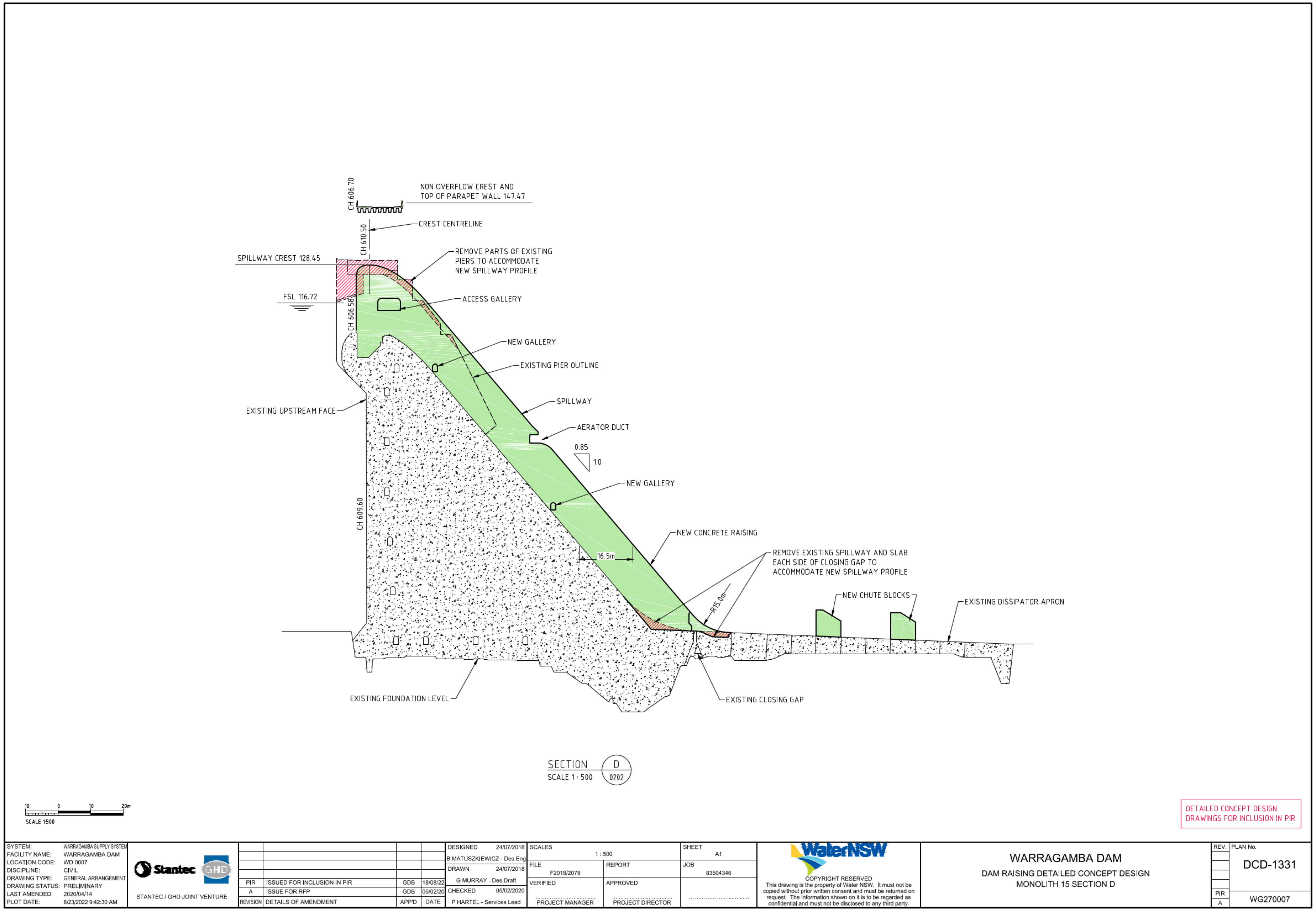


Figure A8 Monolith 13 (Section E)

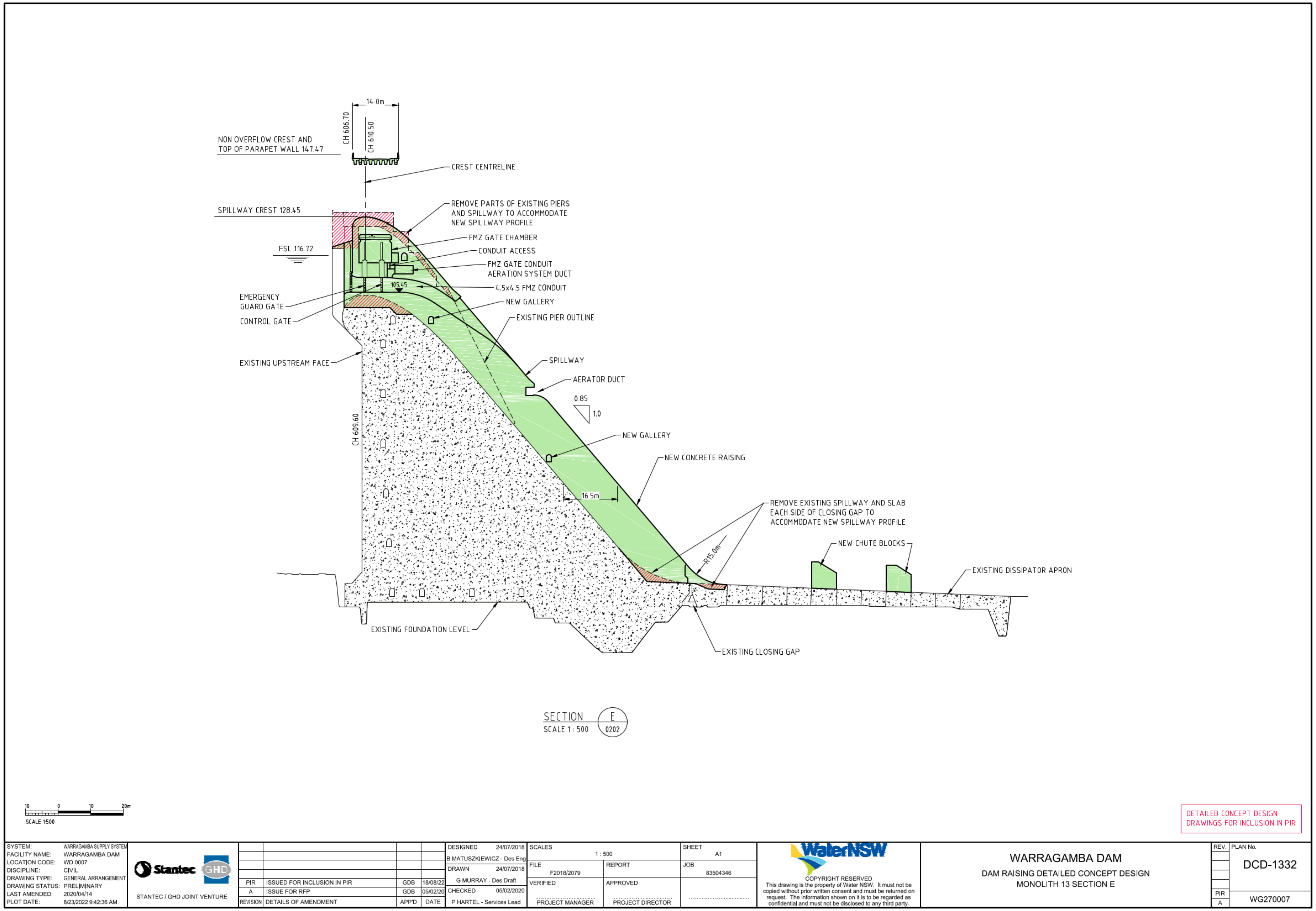
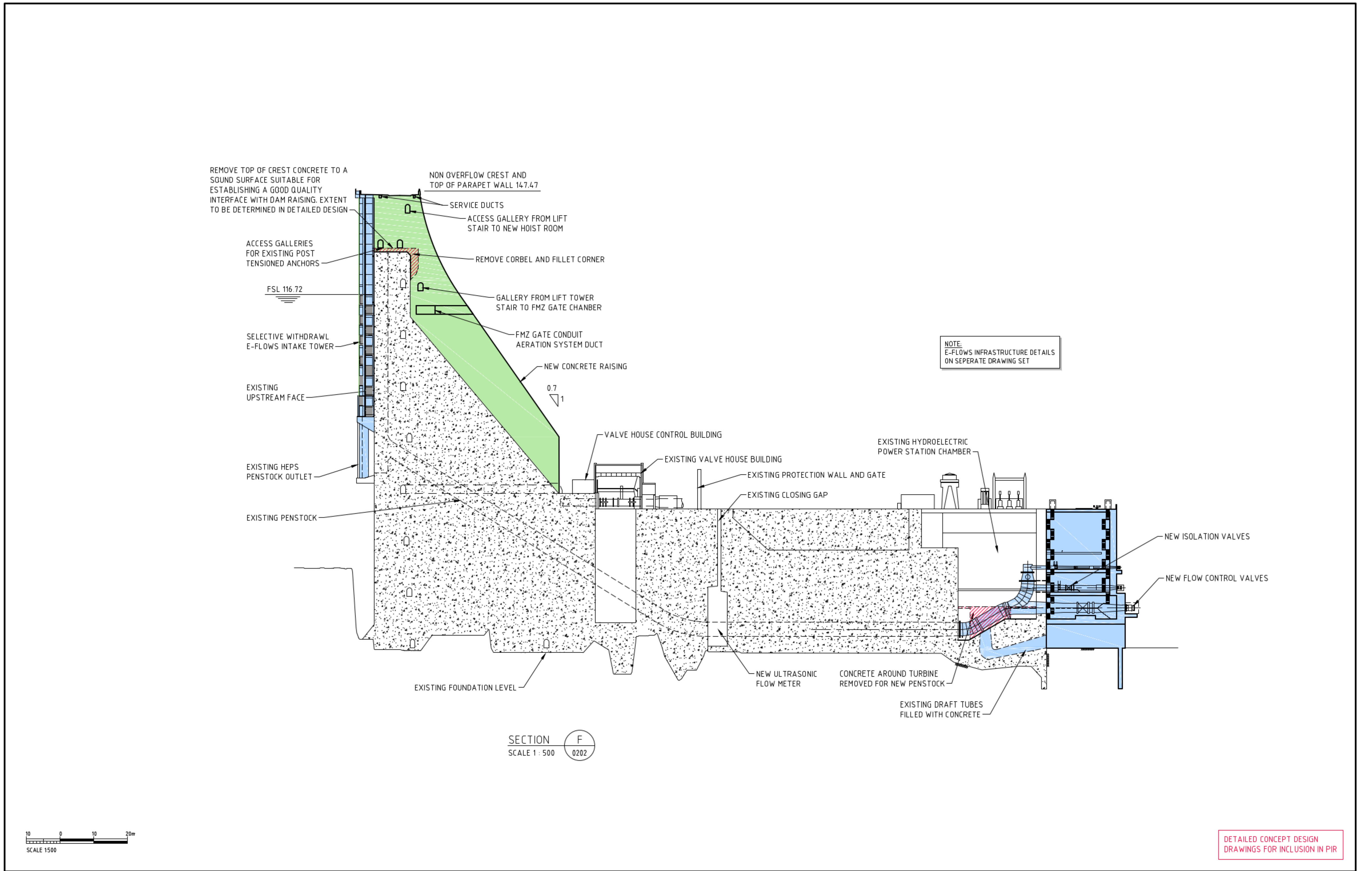


Figure A9 Monolith 11 (Section F)



SYSTEM: WARRAGAMBA SUPPLY SYSTEM					DESIGNED 24/07/2018 D JAMIESON - Des Eng	SCALES 1 : 500	SHEET A1	WaterNSW	REV.
FACILITY NAME: WARRAGAMBA DAM					DRAWN 24/07/2018 G MURRAY - Des Draft	FILE F2018/2079	REPORT	JOB 83504346	PLAN No. DCD-1350
LOCATION CODE: WD 0007	Stantec GHD	PIR	ISSUED FOR INCLUSION IN PIR	GDB 18/08/22	CHECKED 05/02/2020 P HARTEL - Services Lead	VERIFIED	APPROVED	COPYRIGHT RESERVED This drawing is the property of Water NSW. It must not be copied without prior written consent and must be returned on request. The information shown on it is to be regarded as confidential and must not be disclosed to any third party.	WARRAGAMBA DAM DAM RAISING DETAILED CONCEPT DESIGN MONOLITH 11 SECTION F
DISCIPLINE: CIVIL		A	ISSUE FOR RFP	GDB 05/02/20		PROJECT MANAGER	PROJECT DIRECTOR		PIR A
DRAWING TYPE: GENERAL ARRANGEMENT	STANTEC / GHD JOINT VENTURE	REVISION	DETAILS OF AMENDMENT	APP'D DATE					WG270007
DRAWING STATUS: PRELIMINARY									
LAST AMENDED: 2020/04/14									
PLOT DATE: 8/23/2022 9:42:42 AM									

Figure A10 Central spillway – section through FMZ outlet

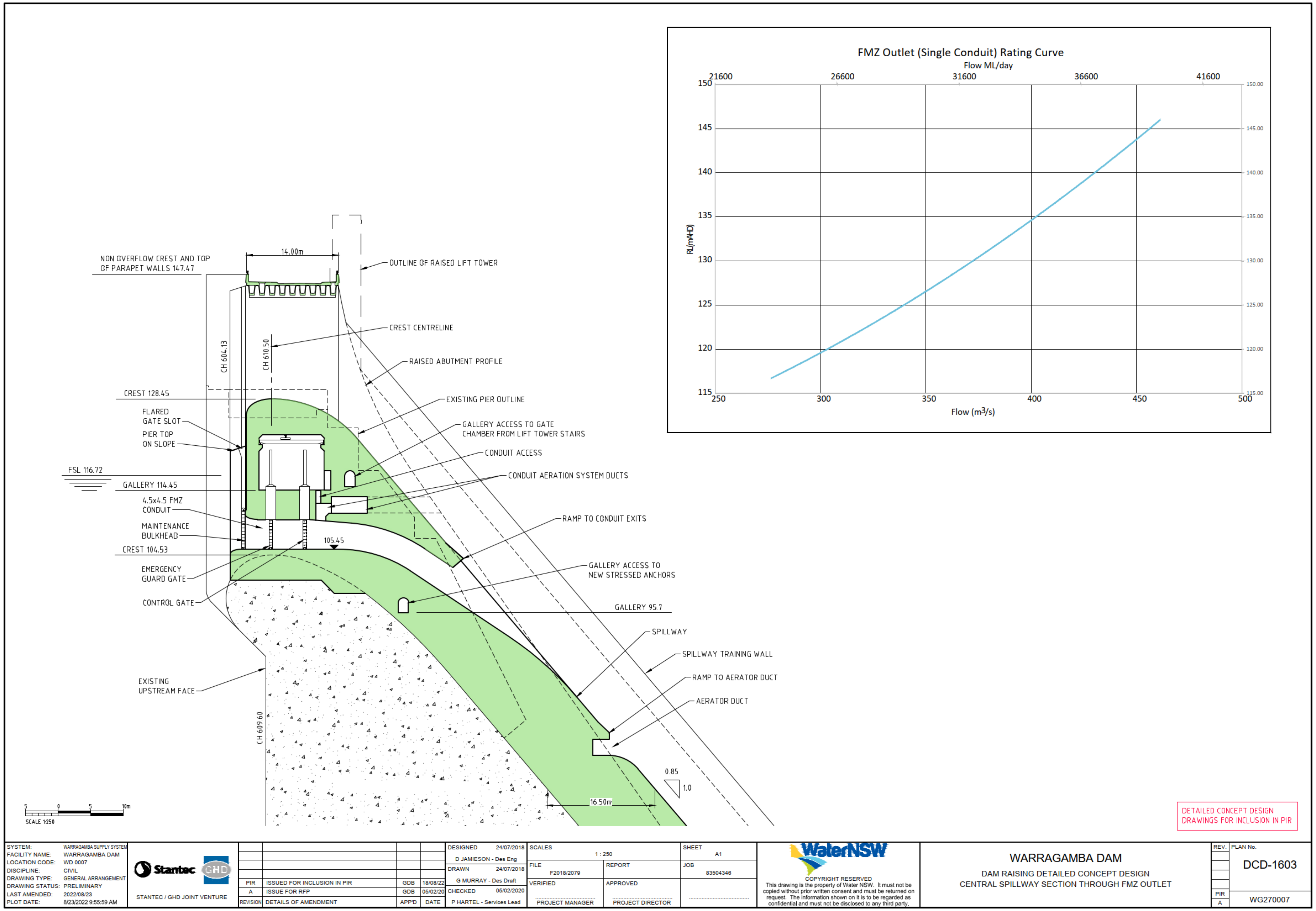


Figure A11 Auxiliary spillway crest section

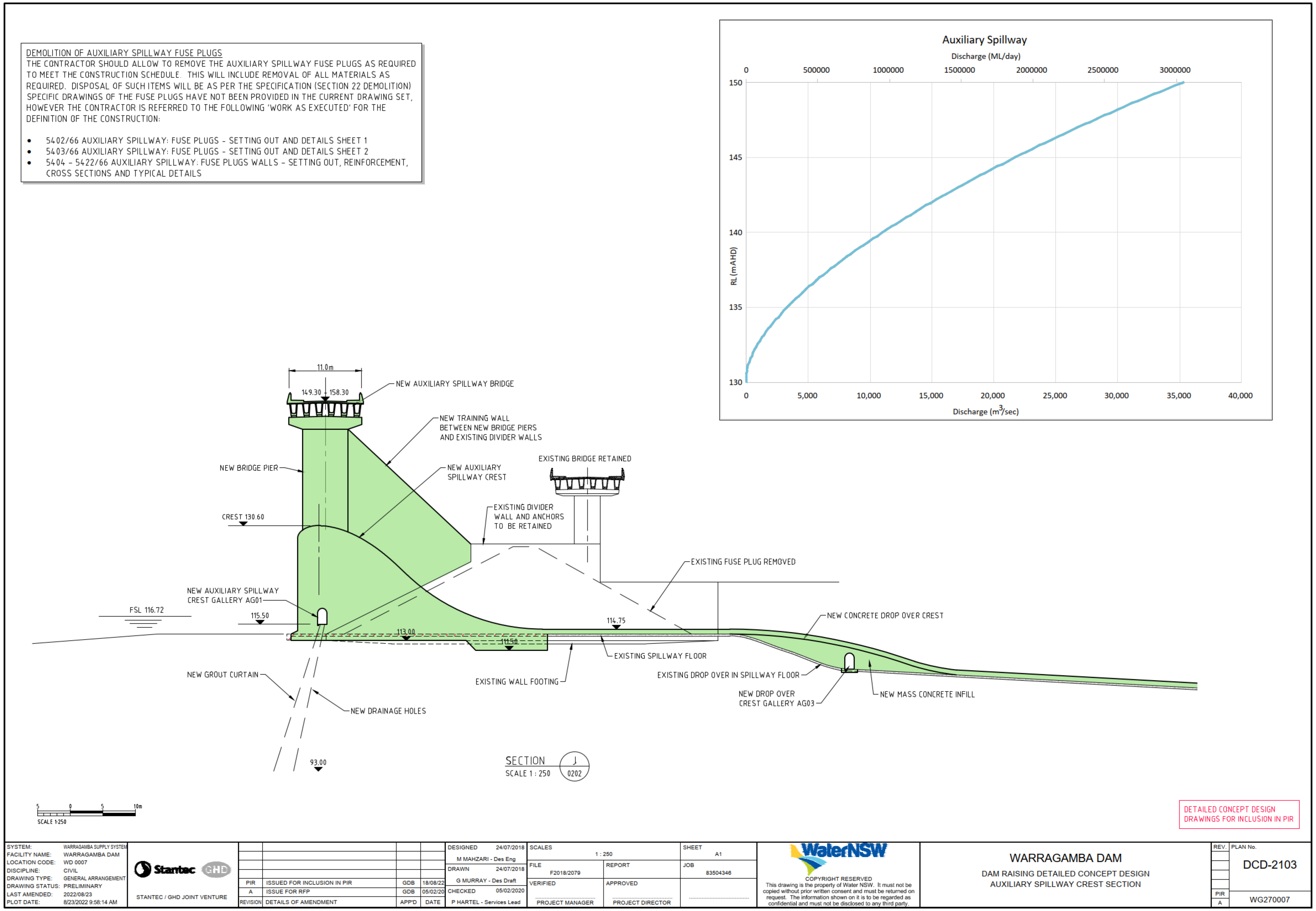
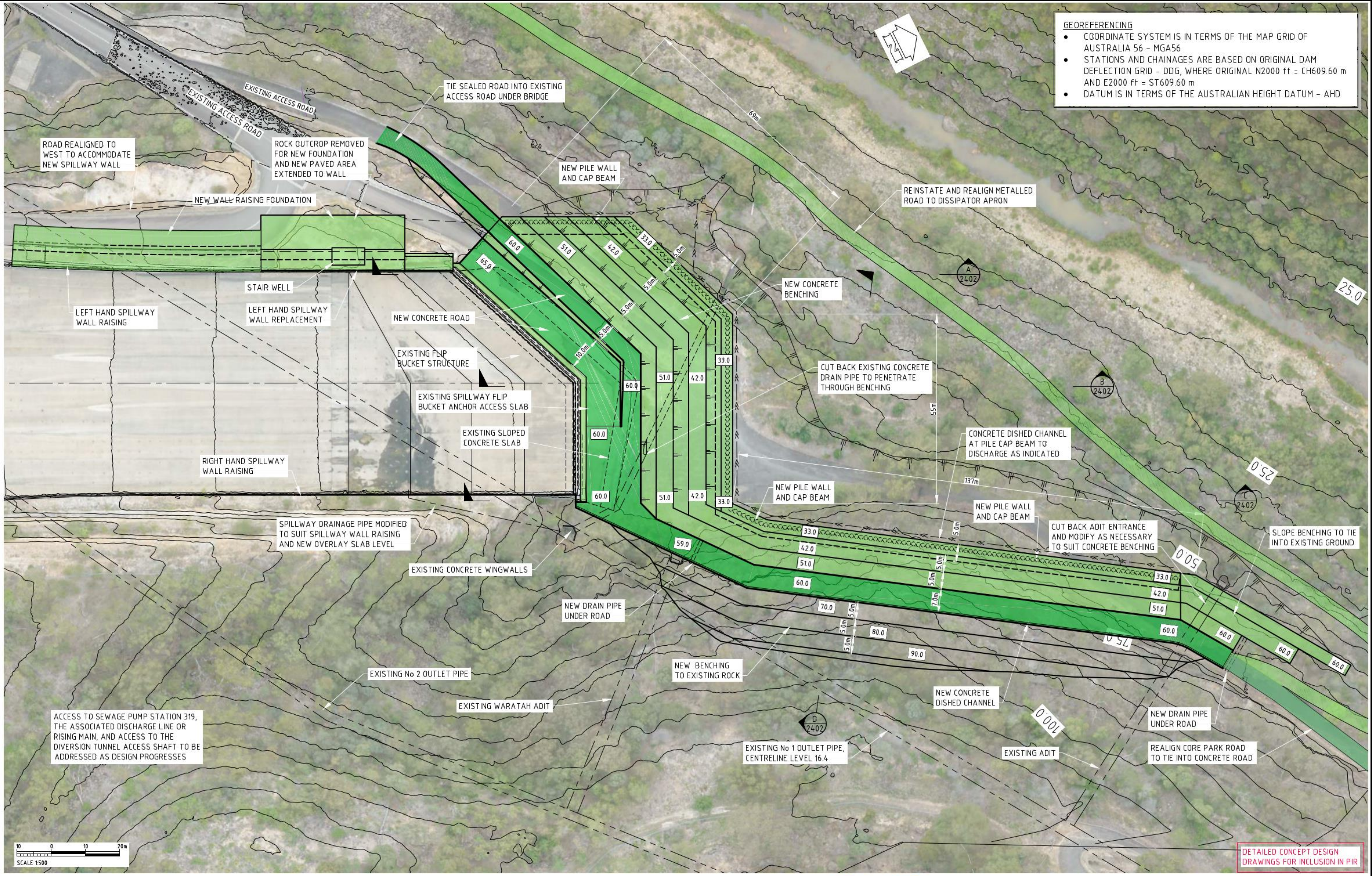


Figure A12 Auxiliary spillway erosion protection plan



SYSTEM: WARRAGAMBA SUPPLY SYSTEM	FACILITY NAME: WARRAGAMBA DAM	LOCATION CODE: WD 0007	DISCIPLINE: CIVIL	DRAWING TYPE: GENERAL ARRANGEMENT	DRAWING STATUS: PRELIMINARY
LAST AMENDED: 2020/04/14	PLOT DATE: 8/23/2022 9:43:10 AM	STANTEC / GHD JOINT VENTURE			
PIR	ISSUED FOR INCLUSION IN PIR	GDB	18/08/22		
A	ISSUE FOR RFP	GDB	05/02/20		
REVISION	DETAILS OF AMENDMENT	APP'D	DATE		
DESIGNED 22/05/2019 M MAHZARI - Des Eng	DRAWN 22/05/2019 G MURRAY - Des Draft	CHECKED 05/02/2020 P HARTEL - Services Lead	SCALES 1:500	FILE F2018/2079	SHEET A1
REPORT	JOB 83504346	VERIFIED	APPROVED	PROJECT MANAGER	PROJECT DIRECTOR

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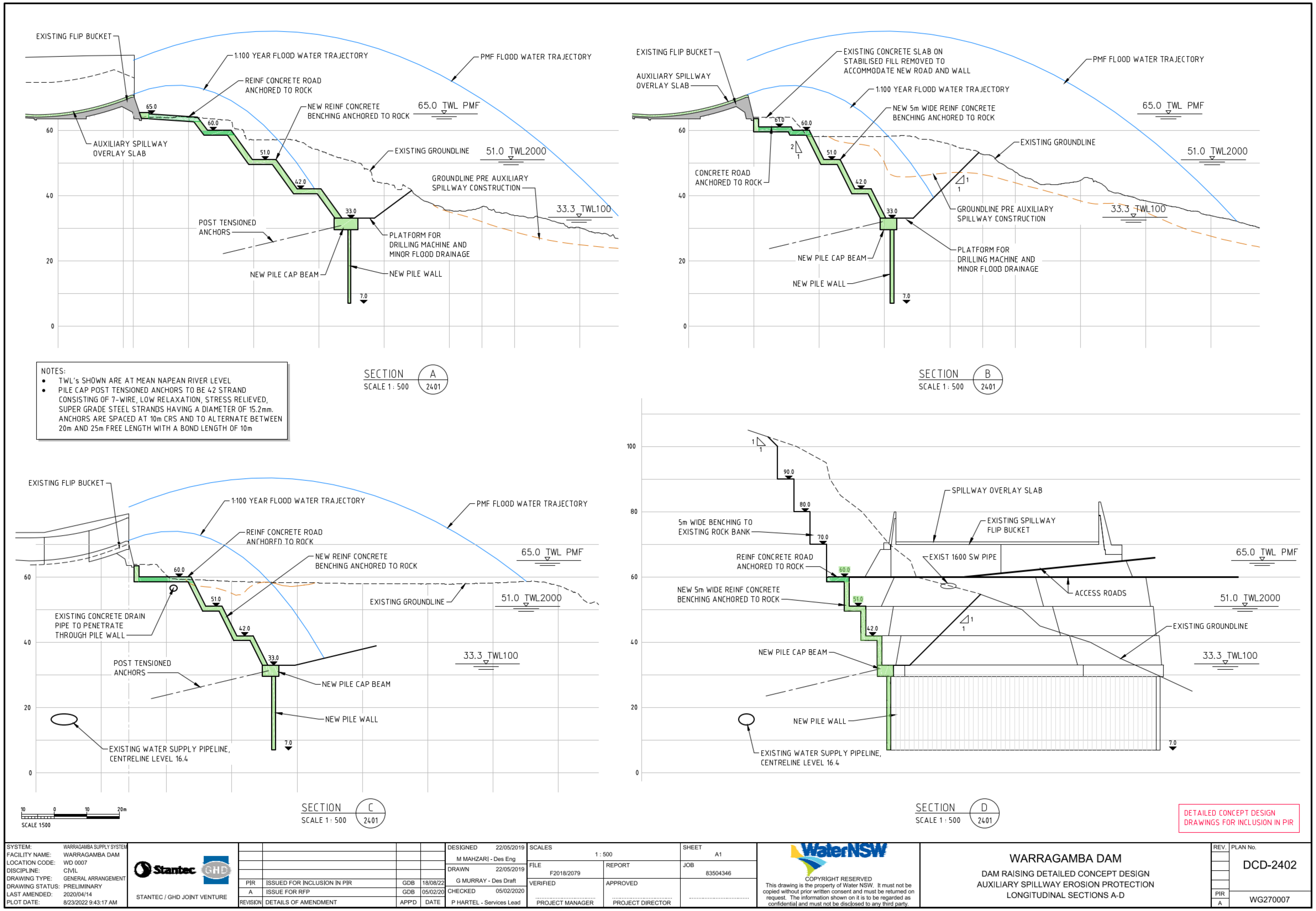
WARRAGAMBA DAM
DAM RAISING DETAILED CONCEPT DESIGN
AUXILIARY SPILLWAY EROSION PROTECTION PLAN

REV. PIR | PLAN No. DCD-2401 | WG270007

Figure A13 Auxiliary spillway erosion protection



Appendix B

Warragamba Dam operations

B1 Overview

B1.1 WaterNSW as owner and operator of Warragamba Dam

The *Water NSW Act 2014* established WaterNSW as a legal entity. The *State Owned Corporations Act 1989* also established WaterNSW as a corporation that is owned by Government. Under the Act, the former State Water Corporation became WaterNSW and the functions from the previous Sydney Catchment Authority were transferred to WaterNSW. As a result, WaterNSW is the responsible authority for, and owner of, Warragamba Dam.

B1.2 Operating Licence and Works Approval

The *Water NSW Act 2014* sets out the framework for WaterNSW activities. The Act lists the key objectives and functions of WaterNSW in sections 6 and 7 respectively, including:

- To capture, store and release water in an efficient, effective, safe and financially responsible manner
- To provide for the planning, design, modelling and construction of water storages and other water management works
- To maintain and operate the works of WaterNSW efficiently and economically and in accordance with sound commercial principles.

WaterNSW carries out these key functions in accordance with its Operating Licence. This sets out terms and conditions under which WaterNSW can carry out those functions. The Operating Licence aims to provide transparent, auditable terms and conditions for WaterNSW to lawfully undertake its activities in accordance with good industry practice. IPART is the regulatory body responsible for WaterNSW compliance with its Operating Licence. WaterNSW functions that are regulated by the Operating Licence include flood mitigation.

The current operating licence specifically excludes flood mitigation as a key function in Greater Sydney and is focused on water supply and environmental flows. This is in line with the key purpose of the dam for the supply of water to Sydney Water Corporation. This restriction does not prevent WaterNSW operating dams safely in Greater Sydney during flood, however, if the Project was to be approved, the Operating Licence would need to be amended to reflect the new function of Warragamba Dam for flood mitigation (see discussion below).

In addition to the Operating Licence, WaterNSW is the holder of a Water Licence and Approvals Package for Greater Sydney issued by DPE (Approvals Package) under the *Water Management Act 2000.* These approvals and water access licences include the requirements for the operation of Warragamba Dam. The works approval for Warragamba Dam is focused on water supply and environmental flows. It does not cover flood mitigation. WaterNSW must demonstrate annual compliance against the works approval.

In addition to the Operating Licence, WaterNSW is the holder of a Water Licence and Approvals Package for Greater Sydney issued by DPE (Approvals Package). These approvals and water access licences are issued under the *Water Management Act 2000*. and include the requirements for the operation of Warragamba Dam. WaterNSW must demonstrate annual compliance against it. The current Approvals Package is focused on water supply and environmental flows. It does not cover flood mitigation.

In line with the WaterNSW Operating Licence and Approvals Package, Warragamba Dam is managed to maintain the lake level at or below FSL. The Approvals Package requires WaterNSW to maximise yield, which is done by ensuring the lake level is full at the beginning and end of a flood event. This also means that pre-releases for flood events are precluded from Warragamba Dam operations.

B1.3 Operating Instruments for a Flood Mitigation Zone

Operation of an FMZ at a raised Warragamba Dam will be an additional function to the current water storage function. The *Water NSW Act 2014* currently allows WaterNSW '*to implement flood mitigation and management*' under section 7(1)(i). Therefore, no changes to the Act are required to implement flood mitigation function at Warragamba Dam.

Clause 1.2 within the current operating licence covers licence authorisations. Clause 1.2.1 authorises all of WaterNSW-listed functions referred to in section 7 of the *Water NSW Act 2014* which includes '*to undertake flood mitigation and management*' with one exception. The exception covered in clause 1.2.1(k) states

> *except for the Sydney catchment area as defined by the Water NSW Act 2014.*

An amendment to the existing operating licence and works approval is required to trigger the flood mitigation function for Warragamba Dam, that exists under the *Water NSW Act 2014*.

Should the Project be approved, WaterNSW will request that the Approvals Package be amended to reflect the changes required for the flood operation mode to include a flood mitigation function.

B1.4 WaterNSW flood operations framework

The principal objectives set out in the *Water NSW Act 2014* relate to managing water infrastructure to improve the availability of water resources that are essential for the people of New South Wales. The principal objectives of the *Water NSW Act 2014* confirm that these operations need to be conducted safely, and this includes operations in extreme events such as floods.

WaterNSW must apply appropriate due diligence in relation to its operations. In relation to the operations of its dams and other structures it must operate the structures to minimise risk to other stakeholders as far as reasonably possible.

The objective of flood operations is therefore to operate the dam:

- To protect the structure from failure
- To leave the storage full at the end of the flood
- Where it does not impede the first two objectives and where feasible and practicable, seek to mitigate the impact of the flood on downstream communities.

WaterNSW has established a flood operations framework in accordance with the NSW State Flood Plan and to meet other key legislative requirements. The purpose of the framework is to outline the WaterNSW roles and responsibilities in relation to flood management, and the process and procedures in place to meet these requirements.

B1.4.1 NSW State Flood Plan

The NSW State Flood Plan (SFP) sets out the state level multi agency arrangements for the emergency management of flooding in NSW. The SFP is a sub plan to the State Emergency Management Plan (EMPLAN).

The SFP establishes the flood emergency management aspects of prevention, preparedness, response, and recovery arrangements and outlines the roles and responsibilities of NSW Government agencies including WaterNSW. The SFP identifies that the lead combat agency in the management of response to floods as the NSW State Emergency Service (SES).

The Hawkesbury-Nepean flood emergency sub plan (HNFESP) sits under the EMPLAN. There are further local council flood plans that are subordinate to the HNFESP. These are outlined below in the discussion of the relationship between plans.

The area covered by the HNFESP is that part of the Hawkesbury-Nepean River system (including its tributaries) from the township of Wallacia downstream to the township of Spencer. It includes:

- Parts of the Wollondilly and Liverpool local government areas, downstream from the southern end of Bents Basin near Wallacia, in the NSW SES Sydney Southern Region
- Parts of the Penrith, Hawkesbury, The Hills and Blacktown local government areas in the NSW SES Sydney Western Region
- Parts of the Hornsby and Gosford local government areas, downstream from Wisemans Ferry to Spencer in the NSW SES Sydney Northern Region.

B1.4.2 Roles of key agencies for the Hawkesbury Nepean flood emergency sub plan

The NSW SES is the designated combat agency for dealing with floods, and to coordinate the evacuation and welfare of affected communities. As the combat agency for flooding, the SES is required to take the lead in planning for the occurrence of floods as detailed within the NSW State Flood Plan.

The Bureau of Meteorology (BOM) maintains, coordinates and delivers operational 24-hour weather warning services as detailed in the NSW State Flood Plan.

WaterNSW, as owner and operator of all the Sydney metropolitan dams, provides information, data and advice to the NSW SES and the BOM in accordance with the NSW State Flood Plan to assist with planning for floods within the Hawkesbury-Nepean Valley. This includes:

- Flow rating charts for river height gauges
- Real-time or near real-time access to river height gauges and height data for the development of official flood warnings
- Real-time or near real-time advice and information from dams and hydrometeorological stations during floods.

WaterNSW operates all metropolitan dams including Warragamba Dam as a system of dams that can contribute to downstream flooding in collaboration with and as directed from time to time by the NSW SES as it manages flood events in the valley, including evacuation requirements.

B1.4.3 Relationship between the plans

The NSW SES and other agencies with responsibilities listed in the HNFESP may prepare supporting plans in accordance with the NSW *State Emergency and Rescue Management Act 1989*. Supporting plans are described in Part 4 *Preparing for Floods* of the HNFESP. The relationship between the various NSW SES flood plans is described as follows.

B1.4.4 State-level plans

The general arrangements for managing floods in NSW are outlined within the NSW State Flood Plan. The special arrangements in the HNFESP augment those described within the respective NSW SES Local Flood Plans.

B1.4.5 Local flood plans

The following plans are subordinate plans to the HNFESP as well as being subordinate plans to the relevant local EMPLANs:

- Hawkesbury City Local Flood Plan (a sub-plan of the Hawkesbury Local EMPLAN)
- Penrith City Local Flood Plan (a sub-plan of the Penrith Local EMPLAN)
- Blacktown City Local Flood Plan (a sub-plan of the Blacktown Local EMPLAN)
- The Hills Shire Local Flood Plan (a sub-plan of The Hills Local EMPLAN)
- Hornsby Shire Local Flood Plan (a sub-plan of the Hornsby Local EMPLAN)
- Gosford City Local Flood Plan (a sub-plan of the Gosford Local EMPLAN).

B1.4.6 Current Flood Operations manual

Each WaterNSW dam has distinct flood operations manuals that document the processes and procedures required to safely operate the dam during a flood event. The manuals contain procedures for responding to large inflows that will likely fill the dam and spill down the spillways including:

- BOM weather forecasting and early warnings
- Preparation for flood operations
- Central spillway crest gate operations
- Monitoring of flows for event through:
  - gauging stations
  - rainfall stations
  - flood model forecast for flood travel times.

B2 Operation of existing Warragamba Dam

B2.1 Normal operation

Warragamba Dam and its reservoir, Lake Burragorang, operate for the supply of water to the Sydney region. The dam provides water to the Prospect water filtration plant, which supplies treated water to approximately 80 percent of Sydney's population. Water from the dam is also supplied to the townships of Warragamba, Penrith, and the Lower Blue Mountains through smaller water filtration plants (WFPs) at Warragamba and Orchard Hills. Water is released into the Warragamba River to provide a secure water supply to the North Richmond WFP and also as minor environmental flows.

Normal operations apply when the storage level is at or below FSL.

B2.2 Flood operation

Warragamba Dam currently does not have a dedicated FMZ. When inflows cause the storage levels to rise above FSL the dam is operated in accordance with what are known as the 'H14 operating rules'. These rules are designed to incrementally open the drum and radial gates in a set sequence to release inflows depending on the lake level to ensure dam safety. This is a fully automated process with oversight from the dam operators.

Currently, during flood events, releases from the dam are managed using the five crest gates. The H14 operating rules define the gates opening and closing sequence when the water level in the dam is above FSL. The central drum gate is the first to be opened and is used to discharge smaller floods, while the four radial gates are only opened for larger floods. The H14 operating rules use a relationship between the lake level and the amount the gates open and release water downstream.

The H14 operating rules have been designed in line with the operational objectives which enable the dam to safely pass flood waters such that:

- Any risk of damage to the gates or dam structure by relatively rapid opening of the gates is minimised
- The peak outflow discharge from the dam is less than the peak inflow to the reservoir, especially during the rising limb and peak of the flood
- The dam does not start spilling until the level has reached FSL. This helps ensure that the dam is full at the end of the flood and delays the flood downstream if the dam was below FSL prior to the flood
- Warning times are maximised by holding flood waters back until the water level is at full storage level
- Operations are automatic requiring monitoring by operators only.

The drum gate operates automatically, lowering continually as the lake level rises above FSL. When flood operations are implemented, it is the first gate to open and the last gate to close. When the lake level reaches 0.3 metres above FSL the drum gate is fully open.

The radial gates operate at defined lake levels in a series of steps for both the opening and closing sequences. When the lake level reaches 1.83 metres above FSL all radial gates are fully open.

The H14 operating rules for both the opening and closing sequences for the drum and radial gates are shown in Table B1 together with lake levels and corresponding gate positions[14].

Table B1 H14 operating rules gate opening and closing sequences

Lake level (m above FSL)	Drum gate	Radial gates 1 & 5	Radial gates 2 & 4
Opening sequence			
+0.08	Commences lowering		
+0.23		Open to 4%	Open to 4%
+0.30	Fully lowered		
+0.46		Open to 9%	Open to 9%
+0.61		Open to 13%	Open to 13%
+0.68	Auxiliary valve opens		
+0.76		Open to 27%	
+0.91			Open to 27%
+1.07		Open to 40%	
+1.22			Open to 40%
+1.37		Open to 56%	
+1.52	Inlet sluice closes		Open to 56%
+1.69		Open to 100%	
+1.83			Open to 100%
Closing sequence			
+1.83		Fully open	Fully open
+1.58			Close to 56%
+1.42		Close to 56%	
+1.27			Close to 40%
+1.22	Inlet sluice opens		
+1.12		Close to 40%	
+0.97			Close to 27%
+0.81		Close to 27%	
+0.66		Close to 13%	Close to 13%
+0.60	Auxiliary valve closes		
+0.51		Close to 9%	Close to 9%
+0.35	Commences raising		

14 A video animation titled ‘How the gates on Warragamba Dam work’ can be found at the following YouTube link: https://www.youtube.com/watch?v=1VFyKsrXKPk

Lake level (m above FSL)	Drum gate	Radial gates 1 & 5	Radial gates 2 & 4
+0.28		Close to 4%	Close to 4%
+0.15		Close to 0%	Close to 0%
+0.08	Fully raised		

B3 Operations with a raised Warragamba Dam

B3.1 Operating objectives for raised dam

WaterNSW has governance, legislative and regulatory requirements for operating dams. The operating objectives for the raised dam established in an order of priority, with guiding principles, are outlined in Table B2.

Table B2 Operating objectives, priority and guiding principles

Operating objectives (in order of priority)	Guiding principle for objective
1. Maintain the structural integrity of the dam	Maintain the dam's structural integrity by ensuring the FMZ airspace is maintained to prevent overtopping of the dam crest from any subsequent floods. Protect the safety of the dam and ensure structural failure and consequential loss of life does not occur.
2. Minimise risk to life	Release of floodwaters at times and rates to maintain reasonable access to evacuation routes or respond to incidents as directed by NSW SES.
3. Maintain Sydney's water supply	Maintain the dam at full capacity and only release water where it is certain the dam will fill.
4. Minimise downstream impact of flooding to properties	Release of floodwaters at times and rates to reduce the flood peak downstream and therefore limit the impact to property.
5. Minimise environmental impact	Release of floodwaters at times and rates to reduce the extent and duration of damaging inundation on the environment.
6. Minimise social impacts	Release of floodwaters at times and rates to have minimal impact on the closure of roads and river activities.

B3.2 Normal operation

The normal operation of the dam is to function as a water storage as outlined in Section B2.1. This will not change with the Project.

B3.3 Flood operation

The dam outflows can contribute to other downstream flood sources when the lake level rises above FSL or top of the drum gate on the central spillway, and commences spilling. The eight new gated conduits, that are set well below the crest level, will remain closed. As the lake level rises above the FSL, water will be captured in the FMZ and either continue to rise and spill over the new spillway crest or be wholly captured within the FMZ.

The FMZ between FSL and the new spillway create level of RL 128.45 mAHD will be used to mitigate and delay the onset of flooding downstream, to maximise the time for downstream evacuation.

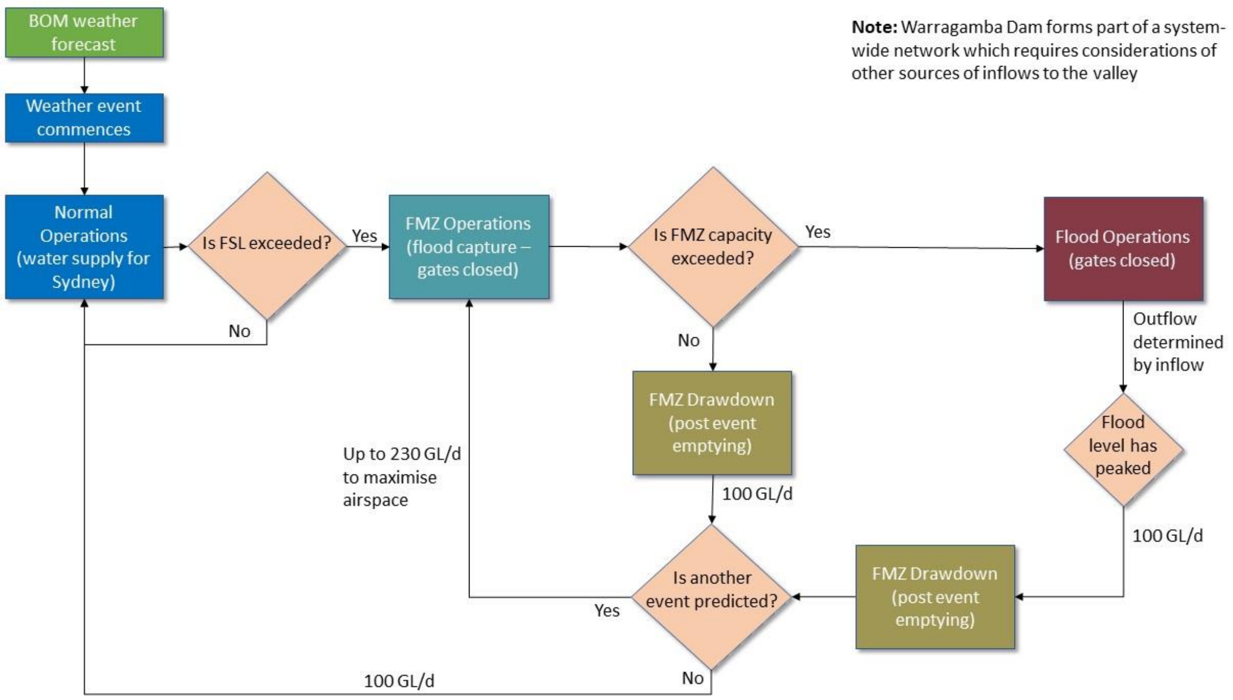
When the flood is in recession as defined by the requirements being met as outlined in Section B3.3.3 then the new gated conduits would commence operation and the temporarily stored water is released in a controlled manner to draw the water level back down to the FSL.

The flood operation of the raised dam will have three distinct modes as follows:

1. FMZ operations mode (flood capture)
2. Flood operations (uncontrolled discharge over spillway)
3. FMZ drawdown mode (post event emptying).

Operation for discharge of the FMZ is outlined in the flow chart in Figure B1. The triggers associated with the diagram are explained further in the following sections.

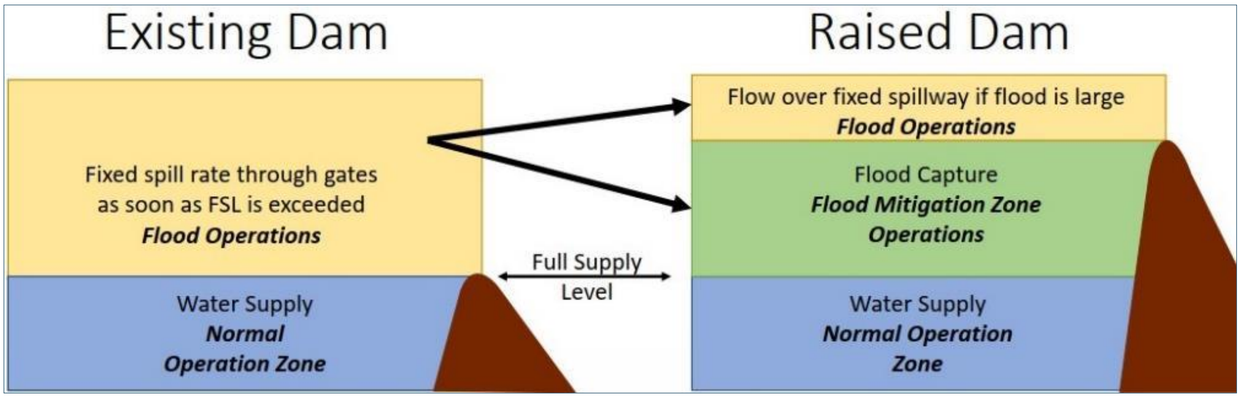
Figure B1 Flood mitigation operations arrangements for raised dam



Note: The discharge volumes shown in the above schematic are the modelled FMZ outflows for the EIS.

The difference in the operating modes for the existing and raised dam are presented in Figure B2.

Figure B2 Difference in operating modes for existing and raised dam



B3.3.1 FMZ operations mode (flood capture)

This mode stores inflows to the lake to maximise downstream warning and evacuation times as required by design requirements for the raised dam and triggers at the commencement of an inflow event that will fill the dam above FSL.

Specifically, the raised dam would provide flood mitigation to temporarily capture around 1,000 gigalitres of water during a flood event to delay any floodwater contribution to a flood incident downstream and allow around 15 hours of additional evacuation time downstream. The eight gated conduits will be closed during this mode.

B3.3.2 Flood operations mode (uncontrolled discharge over spillway)

This mode triggers when the lake level has risen above the spillway crest and the dam is spilling in an uncontrolled manner. During this stage, as the FMZ is full and inflows are continuing, there is no further active flood mitigation measures being undertaken at Warragamba Dam. The eight gated conduits will be closed during this mode.

B3.3.3 Flood drawdown mode (post-event emptying)

The flood modelling that formed the basis of the EIS downstream extents and impact assessment is based on operating the dam in this mode. This mode covers two areas of operations. These being when the dam has spilled and transitions from Flood operations to FMZ drawdown operations to return the lake level to FSL and when a flood event raises the lake level above FSL but does not reach the fixed spillway crests (top level for FMZ operations) and the dam does not spill.

During this mode, discharges are made as per the operating rules outlined below in a controlled manner until the lake level returns to FSL.

This flood drawdown mode occurs when the flood is in recession, defined by the following requirements being met:

- Total Warragamba inflows are in recession, I.e. the peak of the inflow event has been reached and the inflows into the lake are reducing
- Uncontrolled spill is in recession. I.e the volume uncontrolled overflow over the spillway is reducing
- Observed Nepean River at Wallacia Weir flows are receding – the volume of flows (flood levels) at Wallacia Weir from the Nepean River is reducing
- Estimated flows downstream of the Hawkesbury Nepean confluence are all in recession – the volume of flows at from Nepean River at Penrith is reducing
- Total Warragamba inflows are not forecast to exceed the current inflow flood peak within 24 hours (BoM does not predict more rainfall events in the next 24 hours).

Once the requirements have been met, operators at the dam will use the Minimum Discharge Lookup Table (refer Table B3) to identify the release rates based on the maximum lake level (peak level). The table identifies the flow rates that will need to be released.

The FMZ gated outlets have a designed maximum discharge rate of 230 GL/d which can be initiated for about 2-3 days if required if there may be another subsequent flood event due prior to the FMZ being emptied. Thereafter this rate is reduced to 100 GL/d in a constant flow until the FMZ is discharged and the lake level returns to the existing FSL. If there is no forecast subsequent event a lower constant discharge of around 100 GL/d is modelled to draw down the water level to FSL again and limit further downstream flooding.

Therefore, during the constant discharge flow, the FMZ will be released in a controlled manner through the gated outlets and discharged at a rate that does not cause further impacts that exceed the previous flood level peak as the level recedes gradually back to normal river levels.

The constant discharge to drawdown the FMZ can also be varied below the constant rate should the Warragamba contribution be required to ramp down in response to other sources of flooding impacts as part of the current flood incident management operations for the valley.

For those flood events that exceed the FMZ capacity the operator does not initiate the new gates until the flood peak has passed and therefore has no ability to control water discharging over the crests.

The FMZ drawdown as used for design and informing the EIS extents used the Minimum Discharge Lookup Table (Table B3) which identifies the initial flow rate (Flow 1) and if applicable, the level at which it should change to the second flow rate (Flow 2) for each peak level.

Table B3 Minimum Discharge Lookup Table of FMZ outflow model

Peak level (mAHD)	Flow 1 (GL/d)	Minimum days at Flow 1	Change to Flow 2 at (mAHD)	Flow 2 (GL/d)	Minimum days at Flow 2	Minimum total days
117.0	10.0	2.28	117.0			2.28
117.5	20.0	3.06	117.5			3.06
118.0	30.0	3.33	118.0			3.33
119.0	50.0	3.57	119.0			3.57
120.0	60.0	4.32	120.0			4.32
121.0	70.0	4.87	121.0			4.87
122.0	80.0	5.30	122.0			5.30
123.0	90.0	5.65	123.0			5.65
124.0	100.0	5.94	124.0			5.94
125.0	100.0	6.81	125.0			6.81
126.0	100.0	7.70	126.0			7.70
127.0	100.0	8.60	127.0			8.60
128.0	100.0	9.51	127.5			9.51
129.0	100.0	10.45	127.5			10.45
130.0	100.0	11.41	127.5			11.41
131.0	125.0	2.67	127.5	100.0	9.05	11.72
132.0	125.0	3.47	127.5	100.0	9.05	12.53
133.0	150.0	4.12	126.65	100.0	8.23	12.35
134.0	162.5	5.10	125.42	100.0	7.17	12.26
135.0	175.0	5.03	126.02	100.0	7.70	12.73

Peak level (mAHD)	Flow 1 (GL/d)	Minimum days at Flow 1	Change to Flow 2 at (mAHD)	Flow 2 (GL/d)	Minimum days at Flow 2	Minimum total days
136.0	175.0	6.55	124.22	100.0	6.12	12.66
137.0	200.0	6.01	124.82	100.0	6.64	12.65
138.0	200.0	7.04	123.72	100.0	5.69	12.73
139.0	50% rule	5.5	123.02	100.0	4.91	10.41
140.0	50% rule	5.68	122.82	100.0	4.74	10.42
141.0	50% rule	5.85	122.72	100.0	4.66	10.51
142.0	50% rule	6.81	121.22	100.0	3.44	10.25
143.0	50% rule	6.93	120.0	100.0	2.45	9.38
144.0	50% rule	7.06	120.0	100.0	2.49	9.55
145.0	50% rule	7.08	120.0	100.0	2.48	9.56
146.0	50% rule	7.10	120.0	100.0	2.47	9.57
147.0	50% rule	7.12	120.0	100.0	2.46	9.58

Notes to Table B3:

The new central spillway crest level is at RL 128.45 mAHD

How to read the table:

- Identify the maximum lake level (peak level) for the event.
- Lookup Flow 1 rate and open the gated conduits (the lake level determines how many gates and what percentage of the gates need to be opened to achieve the required flow rate) to achieve the flow rate.
- Minimum number of days that the Flow 1 rate needs to be maintained is identified in the Minimum Discharge Lookup Table
- If Flow 2 rate is required, the table identifies the lake level at which the rate should be stepped down to Flow 2 and the minimum duration to return the dam at Flow 2 to reach FSL
- The 50% rule discharge rate is determined by calculating 50% of the peak flow at Penrith gauge minus the current flow at Wallacia gauge.

For example, if the peak flood occurred at 132 mAHD, the gates will be opened to release 125GL/d for approximately 3.47 days or until the lake level reaches 127.5 mAHD and then the gates will be closed to allow a release rate of 100 GL/d for approximately 9.05 days to reach FSL. The table identifies that the total time to release the FMZ as 12.53 days meeting the design requirement to drawdown the FMZ in around 14 days.

A further example can be found in the March 2021 flood report (Infrastructure NSW 2021).

Appendix C

Updated mitigation measures table

The following table provides the full set of revised mitigation measures to avoid, mitigate and/or manage the potential impacts of the Project. Additions to mitigation measures provided in the Environmental Impact Statement are shown in **bold** text, with deletions shown with a ~~strikethrough~~.

Impact	ID	Measure	Timing
Air quality			
Impacts from ambient air quality from dust generation and deposition during construction	AQ1	A construction air quality management plan will be developed and implemented to monitor and manage potential air quality impacts associated with the construction of the Project and activities at construction ancillary facilities. The management plan will identify Project construction activities with the potential to have air quality impacts and the controls required to avoid, minimise and mitigate these impacts. The plan will include measures to: • minimise Project and cumulative dust generation from stockpiles, haulage routes, work activities, exposed ground surfaces and materials handling/storage • minimise generator and vehicle emissions during construction • inspect and address corrective actions • modify or cease dust generating works during unfavourable weather conditions • monitor dust levels • respond to complaints about dust and other air quality issues. The Plan will be implemented for the duration of construction.	Pre-construction and construction
	AQ2	Demolition activities, including removal of hazardous materials will be planned and carried out in a manner that minimises the potential for dust generation. Removal of hazardous materials will be completed prior to the commencement of general demolition works.	Construction
Biodiversity: Upstream			
General flora and fauna impacts	BUS1	Biodiversity offset strategy (See Appendix F6 – Biodiversity offset strategy).	Operation
Biodiversity: Construction area			
General flora and fauna	BC1	A flora and fauna management plan (FFMP) would be prepared as part of the CEMP. Native vegetation clearing would not occur until the FEMP is approved.	Pre-construction and construction

Impact	ID	Measure	Timing
	BC2	The FFMP will be prepared to manage the vegetation retained within the development site. The plan would include details on weed and pest management, nest-boxes and fauna habitat maintenance and monitoring procedures.	Pre-construction, construction and post-construction
Degradation of freshwater wetland habitats	BC3	Install appropriate drainage infrastructure (for example, sediment basins, diversion drains), sediment and erosion controls prior to the commencement of construction.	Pre-construction
	BC4	Clearing of vegetation would be timed to avoid periods when rain is forecast	Pre-construction and construction
	BC5	Dust suppression activities to be undertaken where appropriate.	Pre-construction and construction
	BC6	Stabilisation of disturbed areas, including revegetation in accordance with the FFMP, is to be undertaken as soon as practicable after disturbance.	Pre-construction, construction and post-construction phases
	BC7	Emergency response protocols and procedures for implementation in the event of a contaminant spill or leak to be clearly articulated in the construction and operational environmental management plans.	Pre-construction and construction
	BC8	Spill kits to be located to allow for timely response to uncontained spills. Site inductions are to include a briefing on the use of spill kits.	Pre-construction and construction
	BC9	Bio-retention installed in base of channels and swales to capture and store stormwater consisting of bio-filtration layers, planting and subsoil collection and drainage.	Pre-construction and construction

Impact	ID	Measure	Timing
Vegetation removal or disturbance	BC10	Clearly identifying sensitive areas ('no-go zones') which cannot be impacted by construction and managing clearing such that clearing activities are constrained to these approved areas only.	Pre-construction and construction
	BC11	Site inductions will include a briefing regarding the local threatened species and communities on the site, and protocols to be undertaken if they are encountered.	Construction and post-construction.
Weed invasion and spread	BC12	Management of weeds in and adjacent to cleared areas will occur in accordance with the FFMP and CEMP. The plans will include details relating to the monitoring, management, and where necessary, eradication of weeds, disposal of green waste, and vehicle/plant weed wash down protocols, if required.	Pre-construction, construction, and post-construction.
	BC13	Management of noxious weeds is to be undertaken in accordance with the *Biosecurity Act 2017*.	Pre-construction and construction
	BC14	Equipment used for treating weed infestation will be cleaned prior to moving to a new area within the Project area to minimise the likelihood of transferring any plant material and soil.	Pre-construction and construction
	BC15	Soil stripped and stockpiled from areas containing known weed infestations are to be stored on cleared land at least 40 m from native vegetation.	Construction
Impacts to fauna and flora	BC16	Fauna microhabitat such as hollow logs and dead trees should be removed from areas to be cleared and relocated to adjacent woodland habitat.	Pre-construction and construction
	BC17	A nest box and connectivity management strategy would be prepared prior to clearing of hollow bearing trees and connecting links. The strategy would inform the installation of nest boxes and fauna crossings in and between retained native vegetation adjacent to the site, and the on-going monitoring and maintenance of nest boxes and crossings through the construction and operational phases. This strategy would be included within the FFMP.	Pre-construction and construction
	BC18	High visibility plastic fencing is to be installed to clearly define the limits of the works area.	Construction

Impact	ID	Measure	Timing
	BC19	Undertake a prestart-up check for sheltering native fauna of all infrastructure, plant and equipment and/or during relocation of stored construction materials.	Construction
	BC20	Site inductions are to include a briefing regarding the local fauna of the site and protocols to be undertaken if fauna is encountered.	Construction
	BC21	If any animal is injured, contact the relevant local wildlife rescue agency (for example, WIRES) and/or prequalified veterinary surgery as soon as practical. Until the animal can be cared for by a suitably qualified animal handler, minimise stress to the animal and reduce the risk of further injury by: • handling fauna with care and as little as possible • covering larger animals with a towel or blanket and placing in a large cardboard box • placing smaller animals in a cotton bag or plastic bag (smaller reptiles and frogs), tied at the top • keeping the animal in a quiet, warm and ventilated space.	Pre-construction, construction, and post-construction.
	BC22	If any pits/trenches are to remain open overnight, they are to be securely covered, where reasonable and feasible. Alternatively, fauna ramps (logs or wooden planks) are to be installed to provide an escape for trapped fauna. Pits will be inspected prior to work recommencing and any fauna removed by the project ecologist or designated suitably qualified and licensed representative.	Construction
	BC23	The extent of vegetation clearing is to be clearly identified on construction plans.	Pre-construction
	BC24	In circumstances where native vegetation or mature tree clearing is required outside of the biodiversity development site, the project ecologist will inspect the proposed area and provide advice on the impact to flora and fauna and appropriate management.	Construction
	BC25	Directional lighting will be used where lighting is required in construction areas.	Construction
	BC26	Maintenance of construction machinery and plant will be undertaken to minimise unnecessary noise.	Construction

Impact	ID	Measure	Timing
	BC27	Speed limits will be developed to minimise potential for fauna to be struck by a vehicle within the development site. All vehicles and plant in operation during construction are to adhere to site rules relating to speed limits.	Construction
	BC28	Where suitable for the species, and in line with established conservation programs (such as Saving our Species), threatened species translocation will be carried for species occurring within the development site (Red-crowned Toadlet and *Grevillea parviflora* subsp. *parviflora*). Translocation will be carried out in line with Office of Environment and Heritage Translocation operational policy (OEH 2019) and will involve stakeholders from relevant government agencies, and subject matter experts.	Pre-construction
Bushfire risk connectivity	BC29	Bushfire awareness included in staff induction and in toolbox talks pre-commencement.	Pre-construction and construction
Invasion and spread of pathogens and disease	BC30	Implementation of hygiene protocols to minimise risk of spreading pathogens and disease. Mitigations include vehicle and equipment washdowns, and follow relevant guidelines including: Best Practice Management Guidelines for Phytophthora cinnamomic within the Sydney Metropolitan Catchment Management Authority Area (Suddaby & Liew 2008) Hygiene protocol for the control of disease in frogs (DECC 2008) Management plan for myrtle rust on national parks estate (OEH 2011).	Pre-construction and construction.
Biodiversity: Downstream			
Inundation of native vegetation	BDS1	Development of the operational protocol for the FMZ would seek to minimise potential impacts on downstream vegetation from temporary inundation subject to meeting operational priorities for protection of life and property.	Operation
Aquatic ecology			
Obstruction to fish passage	AE1	Access to the existing eel passageway would be maintained. Should construction activities require modification to the eel passageway, works should be carried outside of the period when likely to be used by juvenile eels.	Pre-construction Construction

Impact	ID	Measure	Timing
Obstruction to fish passage	AE2	Where required, temporary in stream structures would be constructed in accordance with the NSW DPI policy guideline and would be inserted during low-flow periods with management plans being submitted to NSW DPI detailing how high flow events would be managed. Dewatering of temporary in-stream structure would address the following matters: NSW DPI would be notified seven days prior to any dewatering activities to assess the need for potential fish rescue activities and to make appropriate arrangements for this. A separate s37 permit may be required from NSW DPI to relocate fish water is to be pumped a minimum of 30 metres away from the waterway and should preferentially not re-enter the waterway. If water is to re-enter the waterway, water quality would be managed in accordance with the approved water quality criteria for construction of the Project.	Construction
Water quality	AE3	Water quality would be managed in accordance with the approved water quality criteria for construction of the Project.	Construction
Erosion and bank stability	AE4	Scour protection and other bank stability mechanisms would be installed in the Warragamba River below the dam to minimise erosion and destabilisation of streambanks.	Pre-construction Construction
Aquatic habitat impacts	AE5	Aquatic habitat would be protected in accordance with Section 3.3.2 Standard precautions and mitigation measures of the *Policy and guidelines for fish habitat conservation and management (2013 update)* (Fairfull 2013).	Pre-construction Construction
Aquatic habitat impacts	AE6	Existing monitoring programs would be reviewed and revised as required to effectively monitor potential impacts of the Project. The review would include consultation with DPI Fisheries.	Pre-construction Construction Operation
Threatened species	AE7	Relevant safeguards and management measures detailed in the Draft referral guidelines for the endangered Macquarie perch, *Macquaria australasica* (DSEWPaC 2011) would be implemented as required.	Construction
Climate change			
Climate Risk – general	CC1	Development of a Climate Risk Management Sub-Plan. The sub-plan would detail the safeguards and management measures required to be implemented during the construction of the Project. The plan should include monitoring to assess progress on	Pre-construction

Impact	ID	Measure	Timing
		major residual risks and serve as a continuous improvement mechanism to manage climate change risks as they become more robust into the future.	
Climate change – changes in extreme rainfall during construction	CC2	Design of temporary infrastructure, for example, coffer dams, diversions, to accommodate climate projections	Detailed design
Climate change – changes in extreme rainfall during construction	CC3	Implement measures to protect the community from potential impacts associated with climate change during construction of the dam, which may include temporary flood barriers.	Detailed design
Climate change – changes in extreme rainfall during design life	CC4	Detailed design will consider inclusion of design / construction elements to allow the dam to be more readily upgraded in the future to allow for climate change scenarios.	Detailed design
Climate change – more intense extreme weather events during construction	CC5	Construction sequencing for major works to consider peak ECL season.	Pre-construction
Climate change – general	CC6	Climate change will be considered during health and safety management planning.	Pre-construction
Emissions	**CC7**	**Opportunities to further mitigate emissions from energy generation and transportation will be considered during detailed design and construction planning.**	**Detailed design Pre-construction**
Flooding and hydrology			
Impacts during construction	HF1	A Construction Flood Management Plan will be developed to minimise any changes in hydrology up and downstream of the dam and minimise risks to the construction site. Construction activities will be sequenced in accordance with Dams Safety NSW guidelines to ensure dam safety during construction. A Dam Safety Emergency Plan will also be prepared in accordance with the requirements of Dams Safety NSW.	Pre-construction

Impact	ID	Measure	Timing
Impacts from operation of FMZ	HF2	A detailed operational protocol for the operation of the FMZ will be developed in consultation with relevant downstream and upstream stakeholders.	Pre-operation
Monitoring	HF3	Investigate water monitoring systems to reflect Project changes in operational protocols. Investigate additional monitoring station downstream of the Kedumba River	Pre-operation
Health and safety			
Dam failure due to design	HS1	The Project will be designed to meet relevant State, national and international dam safety guidelines and in consultation with the Dams Safety NSW.	Design
Safety risks during construction	HS2	A construction safety management plan will be prepared in consultation with relevant stakeholders and will address safety of the construction workforce and public during general construction, in the event of a flood and for other likely hazards or risks.	Pre-construction and construction
Risks from dangerous goods management	HS3	All dangerous goods and materials will be stored and handled on site in accordance with relevant Australian Standards.	Construction
Transportation of dangerous goods	HS4	Materials will be transported in accordance with the Dangerous Goods (Road and Rail Transport) Act 2008 (NSW), Dangerous Goods (Road and Rail Transport) Regulation 2014 (NSW) and relevant Australian Standards.	Construction
Compromise of dam integrity during construction	HS5	ANZEC Guideline overpressure and ground vibration limits, and WaterNSW dam infrastructure ground vibration limits will be met for all blasting activities.	Construction
Bushfire risk	HS6	Construction activities involving ignition or flammable sources will be managed to minimise fire risks. High risk construction activities relating to bushfire, such as welding and metal work, would not be undertaken on total fire ban days, and will be managed as appropriate.	Construction
Ground contamination	HS7	Ground contamination management measures are provided in Chapter 22 (Soils). These include requirements for additional surveys and a protocol for managing unexpected finds.	Construction
Non-Aboriginal heritage			

Impact	ID	Measure	Timing
Impacts on directly affected heritage items	NAH1	Where possible, consideration will be given to conserve and avoid impact to elements of primary significance and heritage items within the construction zone. Where impact and/or removal is unavoidable, the subsequent measures will be enacted. Photographic archival recording and reporting would be carried out in accordance with the NSW Heritage Office's *How to Prepare Archival Records of Heritage Items* (1998a), and *Photographic Recording of Heritage Items Using Film or Digital Capture* (2006). The record would be prepared by a suitably qualified heritage consultant using archival-quality material. Records for SHR listed items would be held at the NSW Heritage Council and State Library. Records for LEP-listed items would be held by the local Council and local library. A copy of the record would be held by the owner of the asset. Appropriate heritage interpretation would be incorporated into the design for the Project in accordance with the NSW Heritage Office's *NSW Heritage Manual* (1996), *Interpreting Heritage Places and Items Guidelines* (2005b), and *Heritage Interpretation Policy* (2005a).	Pre-construction
	NAH2	A heritage interpretation strategy for the Project will be incorporated into future designs and planning. Opportunities for interpretive displays in appropriate locations would be explored.	Design
	NAH3	An appropriately qualified and experienced heritage architect will provide independent review periodically throughout detailed design.	Design
	NAH4	The Project design will be sympathetic to impacted items (including retained significant elements) and surrounding heritage items by minimising impacts to sight lines, views and setting.	Design
	NAH5	Except for heritage significant elements affected by the Project, direct impact on other heritage significant items elements will be avoided.	Design and Construction
	NAH6	Where heritage significant items or elements are to be retained within the construction zone, detailed design will consider appropriate adaptive reuse or interpretive use to be developed in consultation with a heritage architect.	Design and Construction
	NAH7	A moveable heritage item strategy (including a salvage strategy) will be prepared for the Warragamba Supply Scheme. The strategy will be prepared by a suitably qualified heritage consultant in consultation with WaterNSW and include a comprehensive record of significant elements to be impacted. This will include items, machinery and equipment,	Pre-construction

Impact	ID	Measure	Timing
		and commemorative plaques and memorials contained within curtilage of the Warragamba Dam site. The moveable heritage item strategy will form part of a broader interpretation strategy for the Warragamba Supply Scheme.	
	NAH8	The fabric of primary and contributory significance of items proposed for removal will be identified and catalogued according to the significant fabric strategy prior to design development and will be re-used or salvaged where possible. Where not re-used within the design of the Project, the significant fabric strategy will indicate appropriate storage locations as well as appropriate off-site locations where the salvaged elements may be reused in the future. Where large elements are impacted a sample of fabric may be appropriate.	Pre-construction
	NAH9	Methodologies for the removal of existing structures and construction of new structures and infrastructure will be developed to minimise direct and visual impacts to other elements within the curtilages of the heritage items or to heritage items located near works.	Design and Construction
Impacts on heritage visual values	NAH10	Site remediation measures related to construction sites will be incorporated within the Urban Design and Landscape Plan. The objective of the remediation will be to minimise long-term impacts on the visual amenity of the items by recreating a sympathetic environment. A landscape scheme would be prepared for the SHR listed Haviland Park to re-instate planting and landscaping within and around the item's curtilage. The scheme will consider appropriate plantings. Any boundary wall treatment will be designed in consultation with a heritage architect.	Design and Construction
Impacts on archaeological resources	NAH11	An archaeological research design will be prepared and implemented to identify the need for archaeological testing or monitoring. Archaeological mitigation measures recommended in the archaeological research design will be carried out in accordance with Heritage Council guidelines, and where identified in the archaeological research design, would be supervised by a suitably qualified Excavation Director. An Unexpected Finds Policy will be implemented during the Project to manage and mitigate potential impacts to the potential archaeological resource.	Pre-construction
Impacts from ancillary works	NAH12	Ancillary works required by the Project related to batch plant, laydown areas, power supply, drainage facilities and any other works will be designed and constructed to	Pre-construction

Impact	ID	Measure	Timing
		minimise impacts on heritage items and areas of archaeological potential as much as feasible within the context of the Project.	
Impacts to Haviland Park	NAH13	Design and construction within the SHR curtilage of Haviland Park will consider the recommendations of the Warragamba Supply Scheme CMP 2010 (Graham Brookes and Associates 2010) and the significant fabric strategy.	Design and Construction
Impacts to the Warragamba Supply Scheme	NAH14	Design and construction within the s170 curtilage of the Warragamba Supply Scheme will consider the recommendations of the Warragamba Supply Scheme CMP 2010 (Graham Brooks & Associates 2010) and the significant fabric strategy.	Design and Construction
Impacts to NPWS s170 heritage register items	**NAH15**	**WaterNSW will consult with NPWS on any works and related impacts associated with the Jooriland homestead.**	**Design and Operation**
Aboriginal cultural heritage			
Consultation	ACH 14	WaterNSW would continue consultation and engagement with the Registered Aboriginal Parties for the duration of the Project.	Pre-construction Construction
	ACH 15	An independent facilitator would work with the RAPs and the wider Aboriginal community to develop an Aboriginal advisory group to guide the implementation of Recommendations 8 to 11 in the Cultural Values Assessment Report (Appendix 2 to Appendix K).	Pre-construction Construction Operation
Management of impacts on cultural heritage	ACH 16	An Aboriginal Cultural Heritage Management Plan (ACHMP) would be developed for the Project and implemented as part of the Construction Environmental Management Plan (CEMP). The ACHMP would be developed and managed in consultation with the RAPs, **other relevant stakeholders** and relevant regulatory authorities. The AHMP would provide specific guidance on measures and controls to be undertaken to avoid and mitigate impacts on Aboriginal cultural heritage during construction.	Pre-construction Construction
	ACH 17	Prior to the operation of the Project WaterNSW to review its assessment processes for works within the upstream catchment to include awareness to personnel undertaking an activity on its behalf of any potential Aboriginal cultural heritage values and objects in the area.	Construction Operation

Impact	ID	Measure	Timing
	ACH 18	A cultural heritage awareness and cultural competency training package would be developed and delivered to all WaterNSW staff. The training package would include a site-specific module developed in consultation with the relevant Aboriginal communities and RAPs.	Pre-construction
	ACH 19	The site-specific Aboriginal cultural heritage awareness training package would be delivered as part of the site induction for all employees, contractor(s) and maintenance personnel involved in the construction works and ongoing site management and activities in the catchment of Lake Burragorang.	Construction Operation
	ACH 20	WaterNSW would develop a formal agency-specific process and policy for undertaking cultural heritage assessments and engaging with the Aboriginal community in line with those developed by other state government agencies.	Operation
	ACH 21	WaterNSW would consider engaging an in-house archaeological specialist support in line with other state government agencies.	Operation
Access to Country	ACH 22	WaterNSW would develop and implement a policy to improve access for Aboriginal community members to Country they have cultural connections with that are under WaterNSW management.	Prior to operation
	ACH 23	WaterNSW would facilitate bi-annual on-country visits open to Aboriginal community members with cultural connections to the area.	Ongoing
Site recording	ACH 24	The unsurveyed portion of the PUIA would be surveyed should the Project be approved (survey would include provision for detailed recording of all shelter sites including 3D photogrammetry, planning, detailed photography and scale drawing of any art or other features present).	Prior to operation
	ACH 25	The unsurveyed portion of the area above the PUIA within the upstream study area would be sample surveyed to identify sites and places of high significance should the Project be approved (survey would include provision for detailed recording of all shelter sites including 3D photogrammetry, planning, detailed photography and scale drawing of any art or other features present).	Prior to operation
	ACH 26	Further detailed impact assessment and recording of all Aboriginal cultural heritage sites and places that are located within the PUIA, sites of high significance in the area above the PUIA within the upstream study area, and all art sites within the upstream study area	Prior to operation

Impact	ID	Measure	Timing
		would be carried out. This would include 3D photogrammetry and high resolution digital photographic records and would include the landscape context of sites and site complexes to capture archaeological and cultural values.	
Cultural values recording and education	ACH 27	WaterNSW would consult with the RAPs and the Aboriginal community with regard to carrying out a comprehensive specialist research audit of the holdings of national and international collection institutions to identify cultural materials removed from Country in the Study Area. Subject to proceeding with the audit, WaterNSW would facilitate an access visit for Aboriginal community members to any cultural materials identified in Sydney and Canberra based collection institutions.	Prior to operation
	ACH 28	In consultation with the RAPs and the Aboriginal community, WaterNSW would develop interpretative materials on the Aboriginal cultural values and history of the cultural landscape of the Study Area including: a permanent exhibition at the Warragamba Dam Visitor Centre; interpretative signage and audio posts within the Warragamba Dam grounds; and facilitate the provision of Aboriginal-led cultural events (i.e. tours and talks) through the Warragamba Dam Visitor Centre.	Prior to operation
	ACH 29	In consultation with the RAPs and the Aboriginal community, WaterNSW would develop a cultural values project to record the Gurrangatch-Mirrigan Dreaming Story route through the photographic recording of specific cultural locations within the Study area (prior to any further impacts), oral history recordings with Aboriginal community members, and documentary research.	Prior to operation
	ACH 30	In consultation with the RAPs and the Aboriginal community, WaterNSW would undertake a heritage study of the Aboriginal traditional and historical occupation of the Study area through photographic recording of specific sites (prior to any further impacts), historical documentary research, and oral history interviews.	Prior to operation
Noise and vibration			
Construction noise and vibration	NV1	A construction noise and vibration management plan (CNVMP) will be prepared. The CNVMP will include processes and responsibilities to assess, monitor, minimise and mitigate noise and vibration impacts during construction. The CNVMP will be implemented for the duration of the construction of the Project. The plan will: • identify relevant performance criteria in relation to noise and vibration • identify noise and vibration sensitive receptors and features near the Project	Pre-construction

Impact	ID	Measure	Timing
		• include standard and additional mitigation measures from relevant guidelines and details about when each will be applied • describe the process(es) that will be adopted for carrying out location and activity specific noise and vibration impact assessments to assist with the selection of appropriate mitigation measures • consider cumulative construction noise impacts and construction noise fatigue • include protocols that will be adopted to manage works required outside standard construction hours, in accordance with relevant guidelines including for management of respite periods • detail monitoring that will be carried out to confirm Project performance in relation to noise and vibration performance criteria.	
	NV2	Detailed noise assessments will be carried out for all ancillary facilities required for construction of the Project. The requirement for temporary noise walls within ancillary facilities and adjacent to construction works, and the requirement for other appropriate noise management measures, is to be assessed and implemented prior to the commencement of activities that have the potential to cause noise or vibration impacts.	Pre-construction
	NV3	All residents affected by noise from the construction of the Project and whom may be expected to experience an exceedance of the construction NMLs, will be consulted about the Project prior to the commencement of the activity, with the highest consideration given to those that are predicted to be most affected by the works. The information provided to the residents will include: • general sequencing and locations of construction work • the hours of the Project works • construction noise and vibration impact predictions for the works • construction noise and vibration mitigation measures likely to be implemented on site. Community consultation regarding construction noise and vibration will be detailed in the Community Involvement Plan for the construction of the Project and will include a complaint's handling process. The community will be able to provide feedback via a 24-hour, toll-free Project information and complaints line, a dedicated email address and	Pre-construction

Impact	ID	Measure	Timing
		postal address for the Project. For out of hours works, consultation with affected residents will take place with consideration to Strategy 2 of the ICNG.	
Impacts form out of hours works	NV4	Noisy work and vibration intensive activities (those activities that exceed the vibration criteria) will be scheduled to be undertaken during standard construction hours as far as possible. Works or activities that cannot be undertaken during standard construction hours will be scheduled as early as possible during the evening and/or night-time periods. Where required, respite measures will be implemented for noisy work and vibration intensive activities.	Construction
Construction vehicle noise	NV5	Construction vehicle movements (on and off site) will be managed to avoid or minimise noise impacts. Materials delivery to the construction site would only occur during the day. Mitigation measures for vehicle movements outside of standard construction hours are to be included in the CNVMP.	Construction
Vibration from construction activities	NV6	Vibration generating activities will be managed to minimise the potential for impacts on structures and sensitive receptor(s), including maximising safe working distances where practicable, or use of alternate methods to minimise vibration where safe working distances cannot be achieved. Where alternatives cannot be implemented, vibration monitoring will be undertaken and receptors notified in advance of works.	Construction
Impacts from blasting	NV7	A blast management plan (BMP) will be developed for the Project. This would provide for design and monitoring of trial blasts to confirm site specific conditions and validate local propagation characteristics (develop site specific 'site laws') and confirm the Maximum Instantaneous Charges (MICs) and blast designs to meet vibration and overpressure limits. The BMP would include: • limiting criteria • identified blast sensitive receivers (community and onsite structures) • performance indicators • monitoring protocols • roles and responsibilities • blasting controls • protocols for community consultation, incidents and complaints • contingency protocols	Pre-construction Construction

Impact	ID	Measure	Timing
		• reporting requirements.	
	NV8	The BMP will consider the following with regard to overpressure and ground vibration: • Blast timing: restriction of blasting to between the hours of 9.00 am to 5.00 pm Monday to Saturday with no blasting outside of these times, including on Sundays and Public Holidays. • Blast monitoring and inspection including: monitoring at key sensitive sites and trial blasts to assist in the development of 'site laws' based on monitoring data. • Regular condition surveys and blast monitoring at heritage structures and modification of blast design to meet blast limits at these sites where required.	Pre-construction Construction
	NV9	Mitigation controls will be incorporated into design. A program will be developed for the ongoing monitoring and maintenance of plant and equipment.	Operation
Property and land use			
Construction — Temporary disruption of tourism and recreation uses due to the potential temporary closure of the Warragamba Dam Visitor Centre and Haviland Park.	SE31	Local communities and visitors would be notified about construction activities, the temporary closure of recreation venues, changes in the traffic arrangements and heavy vehicle routes during the construction period. Assess options to continue functions of the Visitor Centre at alternative locations to ensure public safety during construction. Ongoing consultations with relevant NSW Government agencies and local government to identify and implement appropriate solutions to reduce disruption of areas surrounding the Project site. Consult with the local community to select a legacy project to be delivered upon construction completion: • Upgrade the viewing platform on Eighteenth Street with a shelter, interpretive signage and other enhancements. • Develop options to deliver tourism to Warragamba during construction, such as viewpoints, tours or display materials. • Provide alternative BBQ and picnic facilities within the Wollondilly Shire to offset the temporary closure of facilities within the construction area.	Construction

Impact	ID	Measure	Timing
Construction — Delayed travel time in accessing properties due to increased construction traffic.	SE32	Implement the Construction Traffic Management Plan developed as part of the Traffic and Transport Assessment (refer to Chapter 24 and Appendix O of the EIS). Installation of temporary traffic control measures and signage for safe movement of vehicles, pedestrians and cyclists accessing local community facilities, shopping centres and schools. Local communities would be notified about construction activities, the potential temporary closure of recreation venues, changes in the traffic arrangements and heavy vehicle routes during the construction period. Provide support to Wollondilly Council to assist with project-related administration and enquiries.	Construction
Operation Upstream — Community concern regarding effects on World Heritage listed areas	SE33	Regular engagement with local communities (as per a Community and Stakeholder Engagement Plan) to explain actual impacts/benefits, understand concerns and identify mitigation measures. Ensure that environmental impacts are offset, where possible, with a Biodiversity Offset Strategy. Consultation with GBMWHA Advisory Committee and State/Federal government agencies regarding impacts and mitigation measures. Implementation of environmental management plan (EMP) measures which also aid in maintaining the environmental condition of the GBMWHA.	Operation
Operation Upstream — Community concern regarding effects on National Parks	SE34	Regular engagement with local communities (as per a Community and Stakeholder Engagement Plan) to explain actual impacts/benefits, understand concerns and identify mitigation measures. Ensure that environmental impacts are offset, where possible, with a Biodiversity Offset Strategy. Consultation with GBMWHA Advisory Committee, NPWS and State/Federal government agencies regarding impacts and mitigation measures. Implementation of EMP measures which also aid in maintaining the environmental condition of the National Parks.	Operation

Impact	ID	Measure	Timing
Operation Upstream — Two private properties due to temporary and partial inundation of land	SE35	Regular engagement with the two impacted property owners (as per a Community and Stakeholder Engagement Plan) to explain actual impacts and benefits, understand concerns and identify mitigation measures.	Operation
Operation Upstream — Changed access to properties at Yerranderie	SE36	Regular engagement with local communities (as per a Community and Stakeholder Engagement Plan) to explain actual impacts/benefits, understand concerns and identify mitigation measures. Consultation with GBMWHA Advisory Committee, NPWS, and Yerranderie Management Committee and State/Federal government agencies regarding impacts and mitigation measures.	Operation
Operation Downstream — Reduction in the impacts of flooding in the LGAs of Liverpool (primarily limited to Wallacia), Penrith, Blacktown, Hawkesbury, and The Hills (primarily limited to Wisemans Ferry)	SE37	WaterNSW will support the relevant NSW Government agencies and local government to build community awareness on flood risks and specifically the effect which the Project has upon flood risk.	Operation
Operation Downstream — Decreased frequency but increased duration of inhibited access to and from low lying property due to	SE38	Work with relevant agencies to develop and implement updated emergency evacuation plans. Inform stakeholders on the duration of inhibited access to and from properties due to releases from the FMZ.	Operation

Impact	ID	Measure	Timing
longer duration of the FMZ discharge			
Environment			
Construction — Temporary negative visual impacts	SE39	Implement impact mitigation measures as outlined in Appendix P (Landscape and visual impact assessment.) Reduce visual impacts through appropriate landscaping and incorporation of other screening solutions where appropriate. Develop options to deliver tourism to Warragamba during construction, such as viewpoints, tours or display materials.	Construction
Post-Construction — Positive landscape character	SE40	Consult with the local community to select a legacy project to be delivered upon construction completion. Provide information regarding the Project to tourism related agencies to assist them promote the area as a tourism attraction. Rehabilitation and landscaping of the cleared and disturbed areas.	Post construction
Community health and wellbeing			
Construction — Temporary pressure on existing medical and emergency services due to influx of construction workforce	SE41	Engage with medical and emergency service providers as part of ongoing planning and Project development. Provision of appropriate onsite medical response facilities and personnel. Develop and implement safety protocols including an emergency response plan. Provide support to Wollondilly Council to assist with project-related administration and enquiries.	Pre-construction and construction
Operation Upstream — Health effects associated with heightened anxiety	SE42	Regular engagement with local communities (as per a Community and Stakeholder Engagement Plan) to explain actual impacts/benefits, understand concerns and identify mitigation measures.	Operation

Impact	ID	Measure	Timing
Operation Downstream — • Enhanced safety of residential areas due to reduced extent and frequency of floods, including reduced risk of post-flooding infectious disease • Enhanced safety due to improved ability to evacuate communities • Reduced levels of flood risk awareness, reduced (individual) flood disaster planning and increased complacency	SE43	WaterNSW will support the relevant NSW Government agencies and local government to build community awareness on flood risks and specifically the effect which the Project has upon flood risk. Publicly disclose the benefits of the Project to stakeholders via various appropriate communication channels as outlined in the Project's Community and Stakeholder Engagement Plan. WaterNSW will support the relevant NSW Government agencies involved in the *Hawkesbury-Nepean Valley Flood Risk Management Strategy*.	Operation

Impact	ID	Measure	Timing
Improved access to key services, and health facilities			
Operation Downstream — Occasional reduced access to services and health facilities during discharge of water from the FMZ	SE44	Work with relevant NSW Government agencies and local government to build community awareness on flood risks and specifically the effect which the Project has upon flood risk. WaterNSW will support the relevant NSW Government agencies involved in the *Hawkesbury-Nepean Valley Flood Risk Management Strategy*.	Operation
Operation Estuary — Occasional reduced access to services and health facilities	SE45	WaterNSW will support the relevant NSW Government agencies involved in the *Hawkesbury-Nepean Valley Flood Risk Management Strategy*.	Operation
Way of life			
Construction — Temporary generation of employment opportunities	SE46	Provide a clear and efficient process for people to access information about employment and provide an opportunity to register interest in the Project. Liaise with local job network providers to provide information on employment opportunities to local job seekers. Develop a framework to increase the representation of young people, Aboriginal and Torres Strait Islander people and women in the construction industry by providing employment pathways, training and skills development. Provide support to Wollondilly Council to assist with project-related administration and enquiries.	Construction
Construction — Temporary generation of commercial opportunities for businesses	SE47	Develop a local procurement policy to encourage the Project's contactors, where possible, source their workforce and their suppliers for goods and services locally. Provide a process for local businesses to register interest in project-related supplier and service provider opportunities. Work with the local networks and local businesses to organise and plan for how to benefit from the incoming workforce.	Construction

Impact	ID	Measure	Timing
		Work with government stakeholders to build businesses' capacity through business development and mentoring. Work with the local networks and local businesses to organise and plan for how to benefit from the Project. Liaise with local job network providers to provide information on employment opportunities to local job seekers. Provide support to Wollondilly Council to assist with project-related administration and enquiries.	
Construction — Perceived temporary negative effects on Tourism industry	SE48	Local communities and visitors to be notified about construction activities, the potential temporary closure of recreation venues, changes in the traffic arrangements and heavy vehicle routes during the construction period. Assess options to continue functions of the Visitor Centre at alternative location/s while ensuring public safety during construction. Ongoing consultations with relevant NSW Government agencies and local government to identify and implement appropriate solutions to reduce disruption of areas surrounding the Project site. Work with the local networks and local businesses to organise and plan for how to benefit from the Project. Consult with the local community to select a legacy project to be delivered upon construction completion. Upgrade the viewing platform on Eighteenth Street with a shelter, interpretive signage and other enhancements. Develop options to deliver tourism to Warragamba during construction, such as viewpoints, tours or display materials. Provide alternative BBQ and picnic facilities within the Wollondilly Shire to offset the potential temporary closure of facilities within the construction area.	Construction

Impact	ID	Measure	Timing
P-Construction — Increase in visitation numbers to the dam	SE49	Consult with the local community to select a legacy project to be delivered upon construction completion. Provide information regarding the Project to tourism related agencies to assist them promote the area as a tourism attraction. After construction, add project information to the Visitor Centre display.	Post construction
Construction — Temporary impacts on community sentiment, cohesion, and resentment	SE50	Work with the Dam Fest committee to support its ongoing success during the four-year construction phase. Workforce fundraising to contribute to local Warragamba initiatives as voted by the community. Development and implementation of a Code of Conduct for the workforce. Actively engage with local communities to understand concerns and expectations and identify mitigation measures. Provision of regular Project construction updates to the community. Liaise with local job network providers to provide information on employment opportunities to local job seekers. Consult with the local community to select a legacy project to be delivered upon construction completion. Develop options to deliver tourism to Warragamba during construction, such as viewpoints, tours or display materials. Develop and implement a Local Industry Participation Plan for construction. Develop and implement a Construction CSEP which includes a complaints management process and provision of timely information to communities. On-site parking for all construction vehicles.	Construction
Operation Upstream — Reduced tourism visitation due to perceived environmental impacts Reduction in revenue for nature-based recreation businesses	SE51	Implementation of EMP measures which also aid in maintaining the environmental condition of the catchment.	Operation

Impact	ID	Measure	Timing
due to perceived environmental impacts Diminished enjoyment of community values Polarisation of community sentiment resulting in reduced community cohesion			
Operation Downstream — Positive economic effects due to reduced flood related damage to property Reduced risk of people permanently and temporarily losing access to housing and accommodation Improved confidence in housing market and potential reduction in insurance premiums Potential reduction in insurance premiums at individual properties	SE52	WaterNSW will support the relevant NSW Government agencies and local government to build community awareness on flood risks and specifically the effect which the Project has upon flood risk. Publicly disclose the benefits of the Project to stakeholders via various appropriate communication channels as outlined in the Project's Community and Stakeholder Engagement Plan. WaterNSW will support the relevant NSW Government agencies involved in the *Hawkesbury-Nepean Valley Flood Risk Management Strategy*.	Operation

Impact	ID	Measure	Timing
Reduction in flood related economic losses for agricultural and industrial businesses Occasional additional economic losses for agricultural and industrial businesses Reduction in flood related economic losses for tourism and recreation related businesses Occasional additional economic losses for tourism and recreation related businesses Improved community cohesion due to improved ability to control flood related risk and plan communities accordingly			
Operation Estuary — Positive economic effects due to reduced flood related damage to property	SE53	WaterNSW will support the relevant NSW Government agencies to support the *Hawkesbury-Nepean Valley Flood Risk Management Strategy*. WaterNSW will support the relevant NSW Government agencies and local government to build community awareness on flood risks and specifically the effect which the Project has upon flood risk.	Operation

Impact	ID	Measure	Timing
Occasional potential and additional economic losses for fishing and aqua-culture businesses		Publicly disclose the benefits of the Project to stakeholders via various appropriate communication channels as outlined in the Project's Community and Stakeholder Engagement Plan.	
Soils			
Impacts on site workers and/or local community through disturbance of known or potential contaminated land(s) or material.	S1	Prior to ground disturbance, further investigations are recommended to assess and manage potential contamination risk. Any contamination would be managed through implementation of an unexpected finds protocol, as discussed below. Site works should be managed to avoid disturbance of known buried contamination (identified as Site A', which is within the boundary of one of the proposed laydown areas) through implementation of adequate protocols to ensure restrictions on ground disturbance in potentially affected areas. The location of this area will be identified on design drawings. Further investigations and management of potential contamination will be undertaken in accordance with NSW regulatory provisions and NSW Environment Protection Authority (EPA) endorsed guidelines, such as (but not limited to): • National Environment Protection (Assessment of Site Contamination) Measure 1999 (April 2013), EPHC 2013, Canberra • NSW EPA Waste Guidelines • Contaminated Land Guidelines - Consultants Reporting on Contaminated Land (NSW EPA 2020) • Managing Land Contamination: Planning Guidelines SEPP 55 – Remediation of Land (DUAP 1998)	Construction
	S2	Should demolition of existing structures within the construction footprint be required then management of hazardous materials would need to be managed through appropriate controls in accordance NSW regulatory provisions, NSW EPA and SafeWork NSW guidelines such as (but not limited to): • Code of Practice – How to Safely Remove Asbestos (SafeWork NSW 2019) • Code of Practice – How to Manage and Control Asbestos in the Workplace (SafeWork NSW 2019)	Pre-construction

Impact	ID	Measure	Timing
		• Construction and demolition waste: A management toolkit, EPA, 2020 • NSW EPA Waste Guidelines • NSW Health and Safety Act and Regulations • Protection of the Environment and Operations Act 1997 These controls will be detailed in the CEMP. A hazardous materials assessment will be carried out prior to and during the demolition of buildings. Demolition works will be undertaken in accordance with the relevant Australian Standards and relevant NSW WorkCover Codes of Practice, including the Work Health and Safety Regulation 2017 (NSW). Due to the age of the dam and ancillary services, not all hazardous materials may have been assessed during previous surveys. Areas of the dam that are to be disturbed as part of the construction works will be assessed for hazardous building materials prior to commencing works. A protocol for managing unexpected finds of hazardous materials will be included in the CEMP.	
	S3	Areas of contamination, if they were to be uncovered during site works could be managed through implementation of an unexpected finds protocol, otherwise initial intrusive assessments could be carried out to gain a better understanding of the potential for contamination to exist in areas that will be disturbed. Soil contamination if identified is likely to be able to be managed through either offsite disposal or on site capping and management. The protocol will include: cease work in the vicinity initial assessment by an appropriately qualified professional further assessment and management of contamination, if confirmed, in accordance with section 105 of the *Contaminated Land Management Act 1997*.	Pre-construction Construction
	S4	Potentially contaminated areas directly affected by the Project will be investigated and managed in accordance with section 105 of the *Contaminated Land Management Act 1997*.	Pre-construction Construction
	S5	Asbestos handling and management will be undertaken in accordance with an Asbestos Management Plan (as part of the CEMP).	Pre-construction Construction

Impact	ID	Measure	Timing
Unexpected finds	S6	Any unexpected contamination finds will be managed through an unexpected finds protocol which will be detailed in the CEMP.	Pre-construction Construction
Accidental spills during construction	S7	Procedures to address spills, leaks will be developed as part of the CEMP and implemented during construction of the Project.	Pre-construction Construction
Impacts to soil and water quality	S8	Measures will be implemented to appropriately store dangerous goods and reduce the potential for environmental contamination due to spills and leaks.	Pre-construction Construction
	S9	A construction soil and water management plan will be prepared for the Project including procedures to manage potentially contaminated stormwater runoff.	Pre-construction Construction
	S10	Development of an operational protocol that balances the multiple objectives from the FMZ, upstream inundation, environmental flows and downstream riverine requirements. The outcome will be to minimise as much as possible the inundation durations in upstream areas and reduce downstream flooding.	Operation
Traffic and transport			
Impacts from construction traffic	TT1	A construction traffic management plan (CTMP) will be prepared which will detail processes to minimise delays and disruptions and identify and respond to changes in road safety due to Project construction works. **Preparation of the CTMP will include consultation with relevant roads authorities.** The CTMP will be prepared in accordance with applicable guidelines and relevant standards, guides and manuals. The CTMP will: • include a construction contingency plan to manage traffic in the event of emergency road closures due to flood, fire, and/or road accidents, road repair works and bridge load limits • ensure all relevant stakeholders are considered during all stages of the Project • provide safe routes for pedestrians and cyclists during construction • comprehensively communicate changes in traffic conditions on roads or paths to community, emergency services, public transport operators, other road user groups and other affected stakeholders	Pre-construction

Impact	ID	Measure	Timing
		• identify measures to manage the movements of construction-related traffic to minimise traffic and access disruptions in the public road network • minimise the use of local roads by the Project's heavy vehicles and identify haulage routes • propose a car parking strategy for construction staff • consider truck telematics to assist the project managers and road network managers to ensure mass limits are adhere to and to reduce congestion/improve safety during peak construction periods • speed management of construction related vehicles to cross Blaxland Crossing Bridge and continuous monitoring of bridge performance • include relevant details regarding required Road Occupancy Permits.	
Worker vehicle impacts	TT2	Carpooling will be encouraged to minimise number of employee vehicles travelling to the site.	Construction
Off-site queuing of heavy vehicles	TT3	Queueing of heavy vehicles will be permitted only within the site perimeter.	Construction
Access to construction area	TT4	All construction traffic will use Production Avenue to access the site.	Construction
Safety of intersection	TT5	The Warradale Road/Production Avenue intersection will be reviewed against the latest relevant Austroads guidelines (for example, sight distances) and appropriate modifications made in consultation with Wollondilly Shire Council to ensure compliance.	Pre-construction
	TT6	Temporary traffic signals will be installed at Warradale Road/Production Avenue intersection.	Pre-construction
Impacts on road condition	TT7	Regular inspection and maintenance will be carried out on Park Road, Silverdale Road, Farnsworth Avenue, Production Avenue and Warradale Road.	Construction
	TT8	A road dilapidation report will be prepared in consultation with the relevant road authority for the Park Road, Silverdale Road, Farnsworth Avenue, Production Avenue and Warradale Road.	Pre-construction

Impact	ID	Measure	Timing
Out-of-hours heavy vehicle movements	TT9	Heavy vehicle site access will be restricted to the standard working hours only. No heavy vehicle access will be permitted for periods outside standard working hours unless required for an emergency, delivery of oversize plant or for other justifiable reason as detailed in the construction traffic management plan.	Construction
Road safety	TT10	A Stage 1 road safety audit (RSA) will be undertaken at the detailed construction traffic management plan development stage.	Pre-construction
Impacts on visitor parking	TT11	Provision of using existing car park facilities on Farnsworth Avenue for visitor centre and Haviland Park will be considered.	Construction
	TT12	Parking strategy will be developed to understand the demand and supply of parking spaces for the visitor centre and Haviland Park during the construction stage.	Construction
Safety of school buses	TT13	Consideration will be given to ensure that the operation of general construction traffic will be minimised during periods of school bus operations.	Construction
Bridge and road closures during flood mitigation zone discharge	TT14	WaterNSW will keep the Bureau of Meteorology (BoM) informed of the discharge volumes from the FMZ. BoM will then combine these releases with other inflows and rainfall forecasts and tell the SES, TfNSW and Councils what the forecast river levels are at agreed gauge locations according to the NSW Flood Warning Service Level Specification.	Operation
Source of construction materials	TT15	Consideration shall be given for materials recovery and re-use opportunities from nearby construction sites such as Western Sydney Airport (WSA), metro or rail tunnels	Construction
Alternate mode to transfer construction materials	TT16	Consideration shall be given to use alternate modes such as rail, where possible, to transfer the construction materials from long distance to reduce number of constructions related heavy vehicle movements on roads	Construction
Visual amenity			
Construction impacts on visual amenity	VA1	Promote public awareness that the site would be closed and provide signs to direct people to Eighteenth Street Lookout.	Construction
	VA2	The clifftop walkway and dam wall pedestrian access will be reinstated to provide an enhanced visitor/ tourist experience and to continue to provide access to the raised dam crest.	Construction

Impact	ID	Measure	Timing
	VA3	Ensure that a similar level of pedestrian amenity is reinstated after construction of ancillary facilities	Construction Design
	VA4	Enhance the quality of all public domain areas that were closed for the duration of construction	Construction Design
	VA5	Provide signage/ interpretation panels referencing the construction scope and construction program.	Construction
Upstream impacts on visual amenity from potential vegetation loss	VA6	Vegetation management – refer management measures BC1 – BC9	Operation
Downstream impacts on visual amenity from potential vegetation loss	VA7	Vegetation management – refer management measure BDS1	Operation
Downstream impacts on visual amenity from potential vegetation loss	VA8	Vegetation management – refer management measures BC1, BC2	Operation
Waste management			
Generation and disposal of waste	W1	A construction waste management plan (CWMP) will be prepared for the Project prior to construction and will detail appropriate waste management procedures. The CWMP will: • document expected waste types and volumes for the Project • describe procedures for managing office and Project waste materials including separation, treatment, reuse and recycling and disposal in accordance with relevant guidelines • detail waste reporting requirements including the implementation of a waste register • detail the process for identifying waste re-use sites including approval requirements	Construction Operation

Impact	ID	Measure	Timing
		• where practicable, structures would be deconstructed rather than demolished to allow as much material as possible to be re-used or recycled off-site.	
Disposal of spoil	W2	A spoil management plan will be prepared for the Project. The plan will detail spoil management measures including spoil haulage routes and spoil disposal sites.	Construction
Water quality			
General water quality impacts	WQ1	Continuation, monitoring and, where necessary, modification of water quality management measures to address operational impacts of the Project. These include: • monitoring DOC levels in the raw water supply for drinking water purposes to identify any increases in DOC levels so that adaptive management can be implemented via the SCRAMS (Sydney Catchment Aquatic Real-time Management System) • sourcing raw drinking water from other dams when the FMZ at Warragamba Dam is in operation or NOM levels are high. • when NOM levels are high in Lake Burragorang, consider adjusting the blend of water being provided to Prospect WFP so a greater proportion of water is supplied from storages with lower NOM levels. • adjusting treatment processes at WTPs to increase the removals of NOMs – this could include increased doing with ferric chloride, reducing chlorination and increasing chloramination (which does not produce THMs) • implementation of the National Parks EMP – which would have as one its objectives erosion control and revegetation of areas impacted by the operation of the FMZ • continued implementation of other erosion management programs in the upper catchment areas such as WaterNSW Grazing and Erosion Program • sourcing raw water supply for drinking water purposes from other dams when sediment levels are high. • sourcing raw water supply for drinking water purposes from other dams when algal blooms occur • use of the multi-level offtake to withdraw water from less turbid locations in the water column	Existing and ongoing

Impact	ID	Measure	Timing
		• use of the multi-level offtake to withdraw water from lower in the water column as algal blooms only occur in surface layers • use of the multi-level offtake to withdraw water from locations in the water column where pathogen concentrations are low • adjusting processes at Water Filtration Plants to increase the removal of algae in raw water supply for drinking water purposes • adjusting processes at Water Filtration Plants to increase the removal of pathogens in raw water supply for drinking water purposes • adjusting processes at water filtration plants to increase the removal of particulates in raw water supply for drinking water purposes.	
Sedimentation and erosion control, vegetation clearing, management of hazardous material and other water quality risks	WQ2	The construction environmental management plan will include management measures for minimising water quality impacts from (as relevant): • process water management • concrete batching plants • controlled blasting activities • hydro-blasting activities • underwater excavations • dewatering activities (such as the dissipation pool) and any water diversions • use of epoxy resins • discharge of concrete cooling pumping system • use of sediment basins and water treatment plants • road and bridge upgrades (including piling). • material storage areas • demolition and other construction activities. Vegetation clearing: • erosion and sedimentation control measures to be designed, installed, and operated in accordance with Managing Urban Stormwater: Soils and Construction (Landcom 2004)	Construction

Impact	ID	Measure	Timing
		• mulch stockpiles would be managed in accordance with Management of Tannins from Vegetation Mulch (Roads and Maritime Service (RMS) 2012). Other water quality management measures are identified in the following chapters: • Soils (Chapter 22, Section 22.10): S8, S9 • Flooding and hydrology (Chapter 15, Section 15.10): H1.	
Construction water quality impacts	WQ3	A construction water quality monitoring program will be developed	Construction
Water quality impacts on raw water for drinking water purposes	WQ4	While the risks to the quality of raw water supply for drinking water purposes have been assessed to be low, further monitoring is recommended to confirm the risk assessment and enhance adaptive responses to any changes in water quality due to the Project.	Pre-operation
Quality of raw water for drinking water impacts	WQ5	The SCARMS and SCARISS (Sydney Catchment Aquatic Real-time Information Support System) will be updated to include the raised dam, new outlets, and operation of the FMZ.	Pre-operation
Catchment impacts	WQ6	The Catchment to Customer Risk Assessment will be reviewed and updated to reflect any new or changed risks to the quality of raw water supply for drinking water purposes from the operation of the FMZ. Implementation of the EMP as required under the Water NSW Act.	Pre-operation

Appendix D

Flooding and hydrology summary

Flooding and hydrology

Warragamba Dam Raising

Contents

Glossary

Acronym/term	Definition
AEP	annual exceedance probability
AHD	Australian Height Datum
AHIMS	Aboriginal Heritage Information Management System
ARI	Average recurrence interval
DPE	Department of Planning and Environment (previously the DPIE)
DPIE	Department of Planning, Industry and Environment (now the DPE)
EIS	Environmental impact statement
EP&A Act	*Environmental Planning and Assessment Act 1979* (NSW)
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth)
EUIA	Existing Upstream Impact Area
Flood Strategy	Hawkesbury-Nepean Valley Flood Risk Management Strategy
FMZ	Flood mitigation zone
FSL	Full supply level
mgbl	Metres below ground level
PMF	Probable Maximum Flood
PUIA	Project Upstream Impact Area
SSI	State Significant Infrastructure
TfNSW	Transport for NSW

1 Introduction

The purpose of this summary document is to provide clarity on the hydrological and flooding issues, with specific regard to flood modelling and how the Project may affect flood characteristics both upstream and downstream of Warragamba Dam.

During the review of submissions made by stakeholders and the community and agency advice, it was identified that numerous comments reflected an incomplete or partial understanding of hydrology, and the nature of flooding both upstream and downstream of Warragamba Dam.

This summary has been developed to provide additional clarification and technical support for key areas identified in responding to EIS submissions. These are outlined as follows.

Project impact assessment, upstream and downstream

Flooding characteristics vary significantly across the upstream area and downstream floodplain. This summary clarifies how potential upstream changes in inundation are transient, with the primary changes confined mainly to around the dam wall and to a thin margin along the lake perimeter. Potential downstream changes are primarily confined to extended flows in the existing river channel during discharge of the Flood Mitigation Zone (FMZ).

Flood modelling and historic floods

Flood modelling is a complex process and this summary summarises and clarifies key aspects of the modelling undertaken to support the project impact assessment. A brief history of flooding in the Hawkesbury Nepean is summarised, which includes recent flood events in March 2021 and March 2022.

2 Project location and study area

The Hawkesbury-Nepean River drains a catchment of 22,000 square kilometres from the Great Dividing Range to the Pacific Ocean at Broken Bay. Warragamba Dam is located approximately 65 kilometres west of Sydney in a narrow gorge at the start of the Warragamba River, 3.3 kilometres before it joins the Nepean River. The Nepean River then becomes the Hawkesbury River at the junction of the Grose River at Yarramundi. The entire river is called the Hawkesbury-Nepean River. The area downstream of the dam supports several major population centres including the towns of Wallacia, Penrith, Richmond and Windsor.

Lake Burragorang is 52 kilometres long, has 354 kilometres of foreshore and covers a waterway area of approximately 75 square kilometres. Warragamba Dam is situated in a steep, narrow gorge. Before the dam was built the gorge carried the Warragamba River from the junction of the Wollondilly and Coxs Rivers down to the Nepean River below Wallacia. Major tributaries have differing flow characteristics due to variable rainfall across the upstream catchment.

The topography of the Hawkesbury-Nepean Valley varies from rugged and mountainous terrain, which covers nearly half of the area, to floodplains. The latter accounts for only a small percentage of the total area but contains most of the urban development. The catchment is generally aligned south to north, rising to 600 mAHD near the Avon River, 750 mAHD at the head of the Wollondilly River and about 1,200 mAHD on the Great Dividing Range at the head of the Kowmung River.

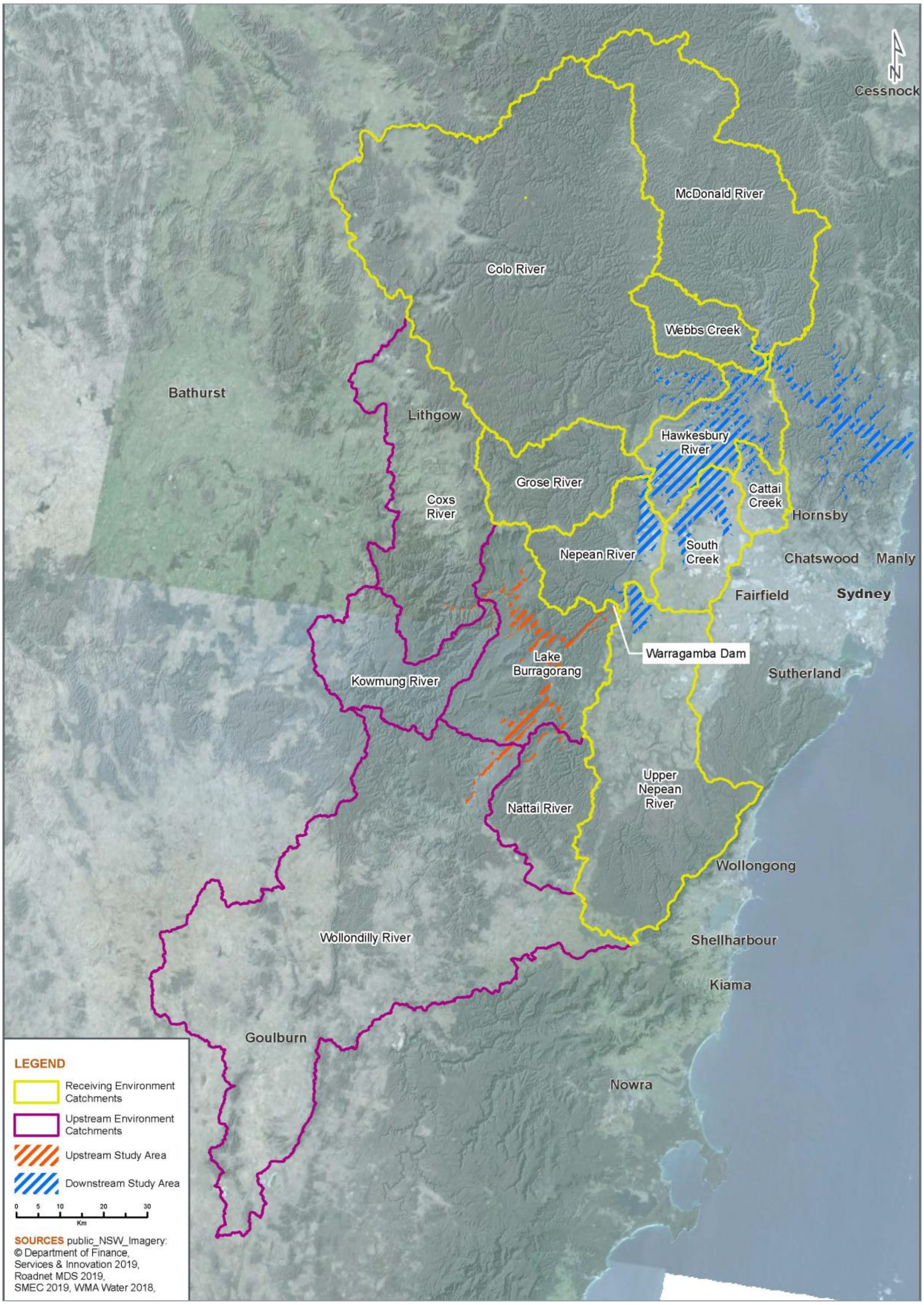
Warragamba Dam can contribute up to around 70 percent of floodwaters in the Hawkesbury-Nepean River catchment. There are four other major dams in the catchment upstream of Sackville on the Nepean River (Nepean, Avon, Cordeaux and Cataract dams). The total area controlled by other dams is a small proportion of the total catchment and has minimal impact on flood behaviour.

The Project study area comprises:

- **Dam surrounds (construction)**: dam construction area and immediate surrounding areas
- **Upstream**: area within the Project PMF extent
- **Downstream**: area within the current PMF (note that the downstream Project PMF area would be less than that for the current PMF).

Regional catchments and the study area are shown are shown on Figure 1.

Figure 1 Hawkesbury Nepean catchment and Project study area



3 Flood terminology and modelling

3.1 Understanding flood probabilities

The annual exceedance probability (AEP) is the probability of an event being equalled or exceeded within a given year. The AEP may be expressed as either a percentage (%) or 1 in 'x' chance in a year event. For example, a one percent AEP event, or 1 in 100 chance in a year event, has a one percent chance of being equalled or exceeded in any given year. Probabilities for various flood events are described in Table 1.

Table 1 Flood probabilities

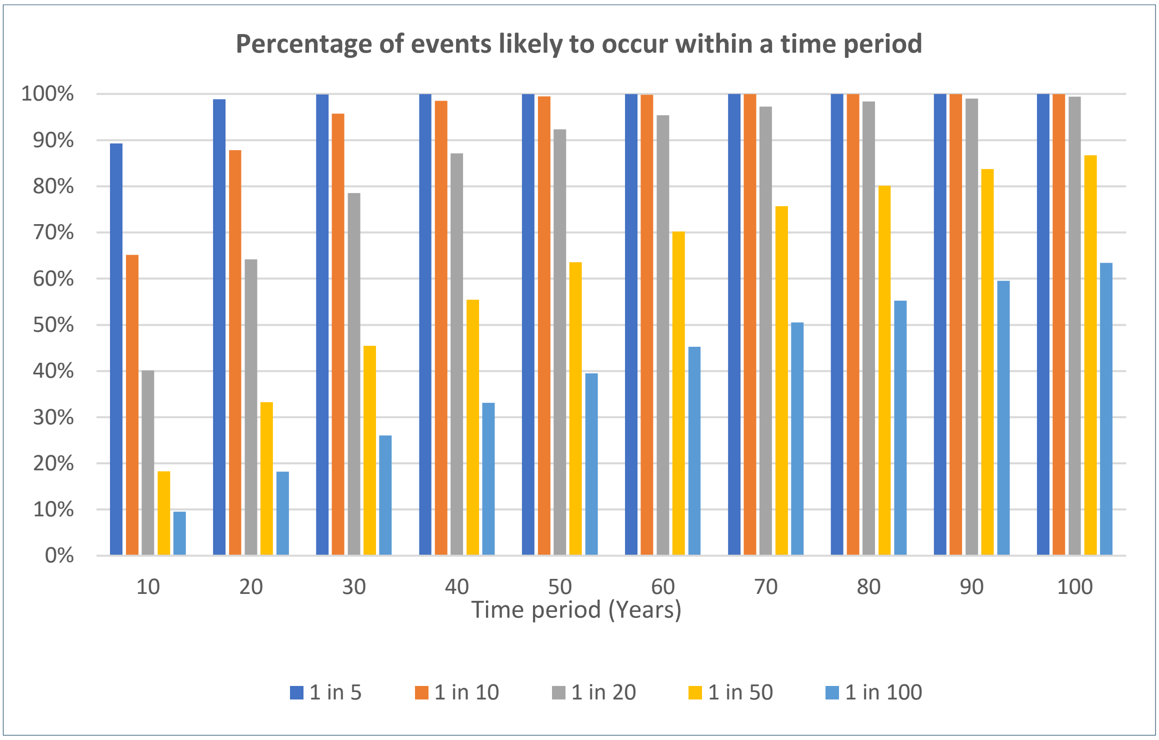
AEP	1 in x chance in a year	Comments
PMF		A hypothetical flood which represent an extreme scenario.
0.2%	500	A flood event with a 0.2% probability of occurring in any given year or likely to occur on average once every 500 years
0.5%	200	A flood event with a 0.5% probability or 200 year return period.
1%	100	A flood event with a 1% probability or 100 year return period.
5%	20	A flood event with a 5% probability or 20 year return period.
10%	10	A flood event with a 10% probability or 10 year return period.
20%	5	A flood event with a 20% probability or 5 year return period.

There can be some ambiguity in interpreting flood probabilities and a 1 in 'x' chance in a year flood event occurring within a specified period can also be described in terms of probability, for example:

- A 1 in 20 chance in a year flood has a 40% chance of occurring within 10 years, a 64% chance in 20 years and a 92% chance in 50 years.
- A 1 in 50 chance in a year flood has an 18% chance of occurring within 10 years, a 33% chance in 20 years and a 64% chance in 50 years.

Probabilities for a range of flood events are shown on Figure 2.

Figure 2 Likelihood of events occurring within a time period



The NSW State Emergency Service (SES) uses this method to describe flooding on its website[1] as shown on Figure 3. This shows the probability of different size floods occurring over a 80-year lifetime.

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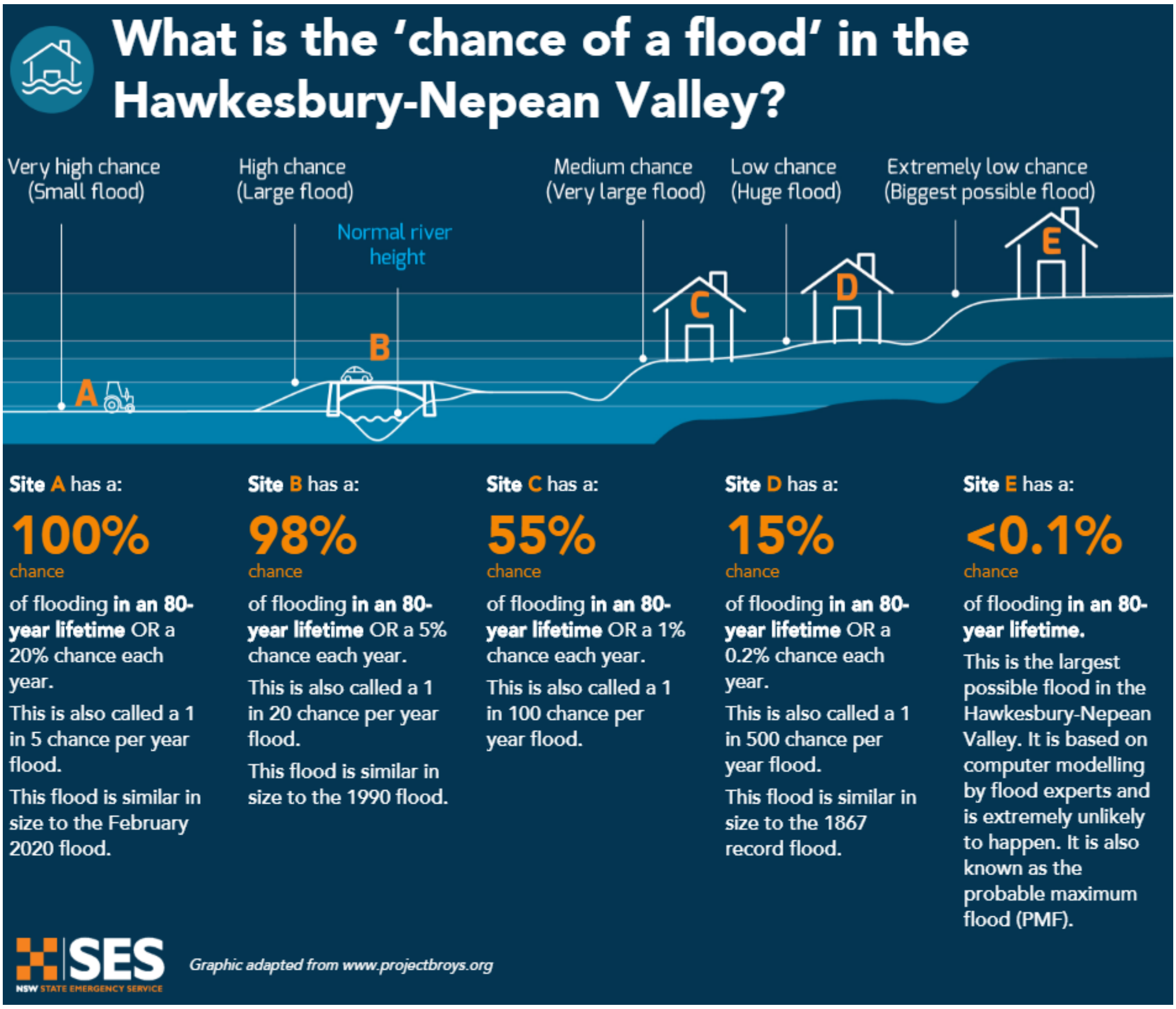
[1] https://www.ses.nsw.gov.au/hawkesbury-nepean-floods

Figure 3 State Emergency Service (SES) – Chance of a flood



Source: State Emergency Service website: *Flood definitions*

3.2 What is the Probable Maximum Flood (PMF)?

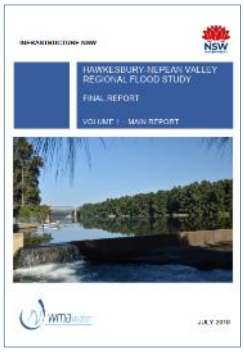
Some submissions refer to the Project PMF as being likely to significantly impact on upstream biodiversity and cultural heritage. This is an erroneous interpretation as the PMF is highly unlikely to ever occur.

The PMF is the largest flood that could conceivably occur at a location. It is estimated from the maximum amount of rainfall that could possibly fall during a flood, coupled with the worst flood-producing catchment conditions. The PMF is a hypothetical flood estimate relevant to a specific catchment whose magnitude is such that there is negligible chance of it being exceeded. It represents a notional upper limit of possible flooding and no attempt is made to assign a probability of exceedance to such an event. The PMF is primarily used for design purposes in ensuring the dam is designed and constructed so as to withstand an event of the size of a PMF.

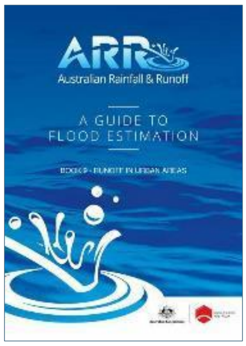
3.3 Flood modelling

3.3.1 Introduction

Flood modelling of the Hawkesbury-Nepean River has progressed over the past 40 years, which has been the basis for assessing flood risk, emergency evacuations and land use planning. Recent flood modelling was carried out for the *Hawkesbury-Nepean Valley Flood Risk Management Strategy 2016-2036 (*Infrastructure NSW 2017*)* and further updated for the *Hawkesbury-Nepean Valley Regional Flood Study* (WMAwater 2019).



The Regional flood study was undertaken using the most updated modelling tools and information. Modelling was done in accordance with Australian Rainfall and Runoff, 2019 (AR&R), which is the national guidance document for flood estimation. The model also referenced a broad body of work and was extensively peer reviewed by leading academic and industry experts.



The Regional Flood Study is a technical document describing the flood behaviour of the main Hawkesbury-Nepean River from Bents Basin near Wallacia downstream to Brooklyn Bridge, and the backwater flooding associated with this main river flooding. It describes regional flood behaviour both for existing conditions and under projected climate change. The model was used to assess various flood mitigation options presented in the *Taskforce Options Assessment Report* (INSW, 2019) and summarised in Chapter 4 of the EIS, and to assess potential Project flood impacts upstream and downstream of Warragamba Dam.

3.3.2 Model development

The Regional Flood Study updates the 1996 flood study (WMA, 1996), which at the time was the most extensive flood study ever carried out in Australia. The study updated the previous flood frequency analysis which was used to verify the probability of different size flood events.

The modelling approach for flooding in the Hawkesbury Nepean considers hydrological and hydraulic factors, outlined as follows.

Hydrology

Hydrology is the study of how rainfall is converted into runoff from a catchment over time. Differing combinations of rainfall (amounts, timing, location) and ground conditions influence flood behaviour.

A rainfall-runoff or hydrologic model (RORB) was developed to model the rainfall-runoff characteristics of the river systems feeding into the Hawkesbury-Nepean Valley. This represents a 22,000 square kilometre area, extending from Goulburn in the south to Wollemi in the north. The model was divided into 121 sub-catchments. A special sub-routine (DAMROU) was added to the RORB program to model flows through Lake Burragorang, which incorporates gate operations at the dam.

The hydrologic model was calibrated and verified by comparing the modelled results to seven actual, recorded historic flood events. Calibration sites included four stream gauging stations located upstream of Warragamba Dam, Warragamba Dam and various stations downstream. The model was used to estimate the flood flows from the various sub-catchments feeding into the Hawkesbury-Nepean River system for a range of rainfall events.

To be resilient to the future impacts of climate change the modelling included climate change predictions for increased rainfall intensity to 2090 as described in Chapter 15 of the EIS.

Hydraulics

Hydraulics is the study of the physical movement of water flow along watercourses and over floodplains. Hydraulic modelling is used to determine flood levels, extents, depths, velocities (speed and direction), hazard and flows.

A quasi two-dimensional RUBICON model was developed to quantify the hydraulic aspects of flood behaviour) and covered a river length of 360 kilometres. The model was calibrated and verified against 10 historical flood events.

3.3.3 Data used for modelling

Data used in the modelling is summarised as follows:

- **Model cross sections:** Model cross sections are generally located approximately one to two kilometres apart and the modelled branches extend up to where gauged inflows are recorded.
- **Rainfall data:** A comprehensive rainfall monitoring network has been installed in the catchment and in 1998 there were 93 pluviographs (real-time rainfall monitoring) and 376 daily rainfall gauges. For each calibration event a spatial pattern was created across the catchment. Temporal rainfall patterns were taken from available pluviographs for each event.
- **Stream flows:** There are over 100 stream gauging stations in the catchment. Ten representative gauging stations were chosen for use as calibration locations or for model verification.
- **Terrain:** A merged digital elevation model (DEM) was created across the catchment and was used to give an overview of the catchment and for calculation of the average slope of sub-catchments.

Dam operations and inflows: WaterNSW supplied a daily time-series of Lake Burragorang lake levels from 1960 to 2017, and hourly time-series of releases for the period covering the calibration events.

Floodplain exposure dataset

In addition to information on flood likelihood and behaviour, the following information was needed for evacuation modelling and flood damages assessment:

- Spatial and temporal distribution of assets (residential, commercial and other infrastructure including roads and utilities)
- Spatial and temporal distribution of population and vehicles based on evacuation subsectors.

Model calibration included:

- Increasing the number of model sub-areas
- Calibrating the model at additional locations within the catchment

- Inclusion of baseflows
- Using the TUFLOW model was used to calibrate the model 10 historical events including a range of representative events.

3.3.4 Monte Carlo modelling

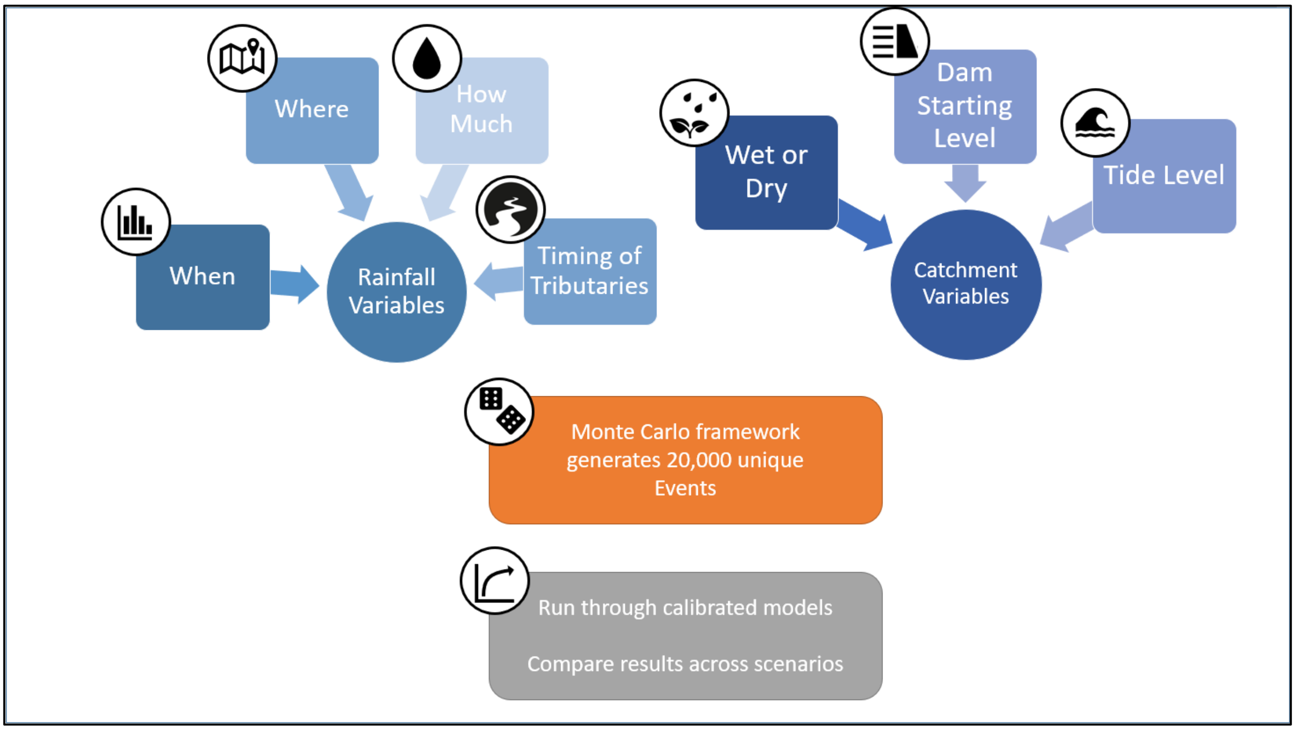
Real flood events exhibit an enormous degree of variability, most of which is determined by where and when rain falls. Flood events are also influenced by how wet the catchment is, and in the case of the Hawkesbury-Nepean floodplain, the levels in Warragamba Dam prior to an event. To address this variability AR&R recommends a Monte Carlo approach for complex systems and major decisions, and requires validation against long flood records that incorporate all the observed variability.

Monte Carlo modelling generates thousands of hypothetical events and by incorporating variability of key input variables:

- *Rainfall intensity and frequency*: the number of times during a specified period of years that rainfall of a certain magnitude or greater occurs
- *Spatial pattern of rainfall*: where in the catchment rain falls
- *Temporal pattern of rainfall*: when, in the event, rain falls
- *Initial loss*: rain 'lost' at the beginning of an event through infiltration into the soil
- *Pre-burst rainfall*: rain that occurs before the most intense storm burst
- *Dam drawdown*: the level of Warragamba Dam before the start of an event
- *Relative timings of dam inflows*: when water flows from rivers and streams to the dam
- *Tides*: tidal influences in the Hawkesbury River.

The process for Monte Carlo modelling is summarised in Figure 4.

Figure 4 Monte Carlo modelling



Source: WMAwater (unpublished) 2022

3.3.5 Flood frequency analysis

Flood frequency analysis, as defined in AR&R, refers to procedures that use recorded and related flood data to identify underlying probability model of flood peaks, at a particular location in the catchment, which can then be used to perform risk-based design and flood risk assessment, while providing input to regional flood estimation methods.

3.3.6 Truncation of flood events

The extent of flooding in the upper reaches of the respective catchments reaches a point where the extent of influence from water backing up as a result of damming reaches a limit where the dominant influence becomes the river inflow. This is referred to as the truncation od a flood event in the EIS.

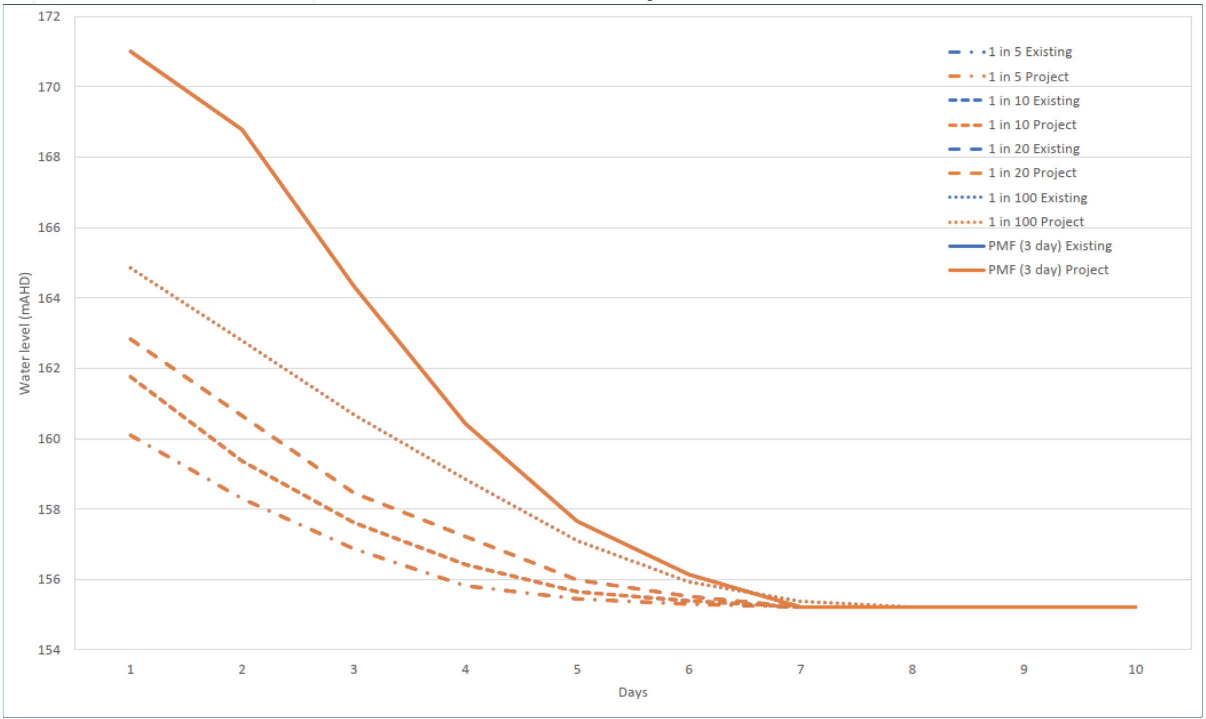
The EIS assessments included an analysis of the truncation effect of flood events between the existing dam and with project. Cross-sections were plotted to determine the location where this truncation effect occurs.

These locations were determined for each of the Lake Burragorang tributaries and became the upper limit for analysis to inform the impact assessment.

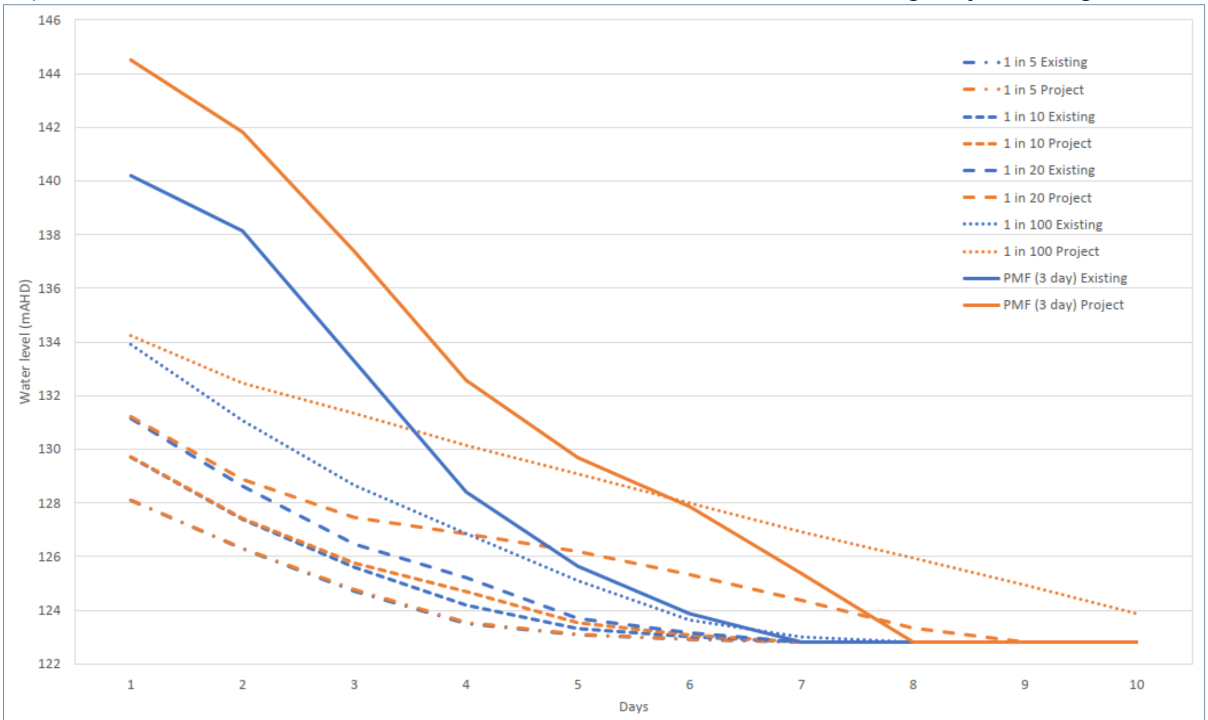
An example is shown in Figure 5, which shows depth-duration curves for the Wollondilly River. At the truncated cross section (top graph) the depth-duration curves show no differences between existing and with Project flooding.

Figure 5 Depth–duration curve examples to show modelling truncation extent of Project influence

Depth-duration curves at upstream location 1: ***No change***



Depth-duration curves at 10 kilometres downstream of above location: **Existing/Project divergence**

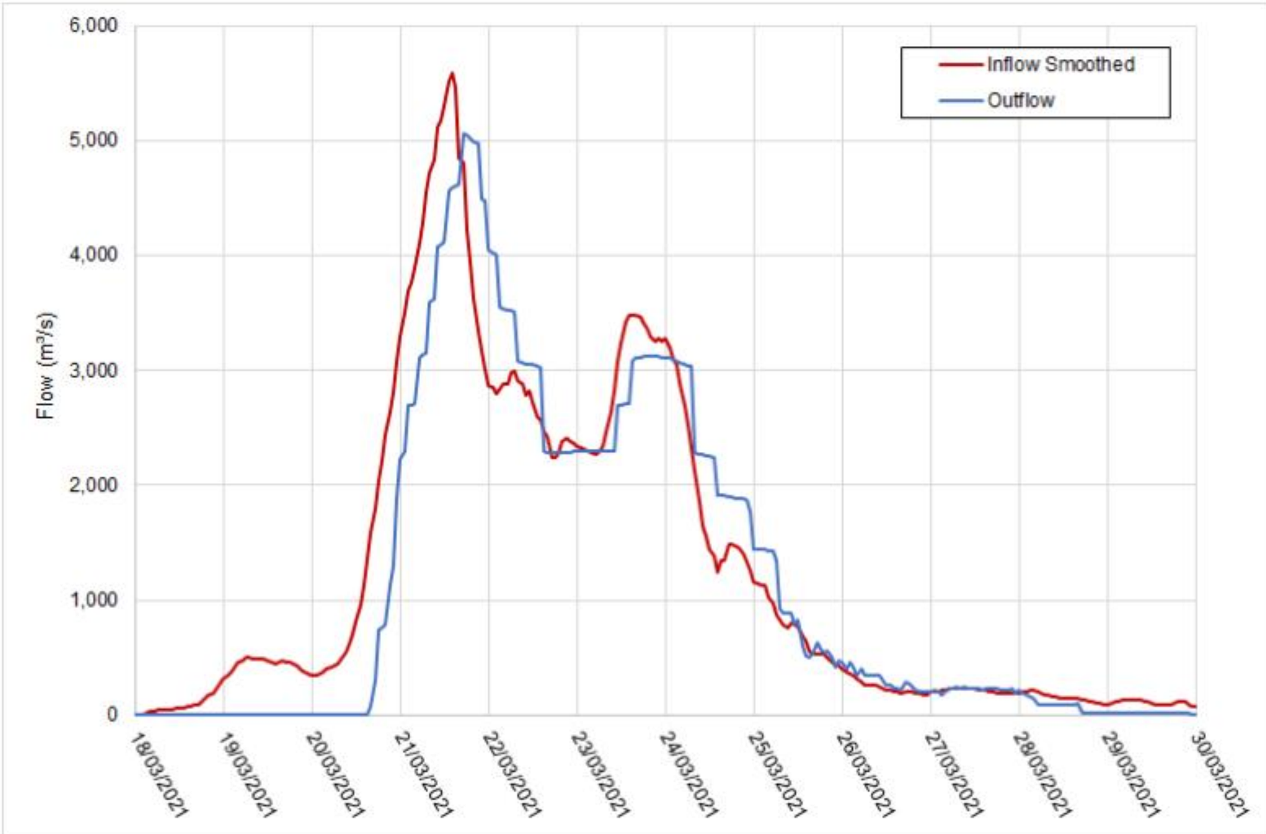


Source: Chapter 15, Warragamba Dam Raising Project EIS)

3.3.7 Model comparison to recent flood events

The hydraulic modelling for the EIS was prepared prior to the finding of reviews of recent flood events of March 2021. Infrastructure NSW has prepared a summary reviewing the March 2021 flood event (Hawkesbury-Nepean River March 2021 Flood Review). As part of the review, Warragamba Dam flood mitigation scenarios were modelled to determine what difference these measures would have made to the height and timing of the March 2021 flood downstream. These scenarios all involve creating air space for the temporary capture of floodwaters.

Figure 6 Warragamba Dam inflow and outflow hydrographs, March 2021 flood



Source: Infrastructure NSW (2021)

Appendix F to that report provides details of the methodology and results of the assessment. In particular Section 2.3 in Appendix F notes that the March 2021 flood was used to validate the TUFLOW hydraulic model developed for the Hawkesbury-Nepean River as part of the Hawkesbury-Nepean River Flood Study and provided the following conclusion below.

The proposed dam raising would have reduced peak flood levels by 5.3 metres at Penrith and 3.4 metres at Windsor. Compared to the option of permanently lowering FSL by 12 metres, the dam raising would have provided additional peak level reductions of 3.0 metres and 1.5 metres for Penrith and Windsor respectively. The raised dam would also have spared the new Windsor Bridge from being overtopped, significantly reducing closure time.

4 Effect of the Project on historic and large floods

4.1 March 2021 - flood mitigation if dam was already raised

The March 2021 flood was estimated to be between a 1 in 10 and 1 in 20 chance in a year event (Infrastructure NSW 2021). It caused devastation amongst some communities, particularly in low-lying areas.

With Warragamba Dam raised as proposed, the March 2021 flood would:

- Reduce the extent of flooding to about a 1 in 5 chance in a year event, which is similar to the 2020 flood
- Reduce the flood peak at lower Windsor by about 3.6 metres and at Penrith by around 5 metres
- Delay the spill from Warragamba Dam by around three to four days, significantly increasing the opportunities to evacuate people and their property from low lying areas
- Delay closing of the new Windsor Bridge by around half a day, and the period of bridge closure by several days.

These changes are shown on Photo 1, Photo 8, Figure 7 and Figure 8.

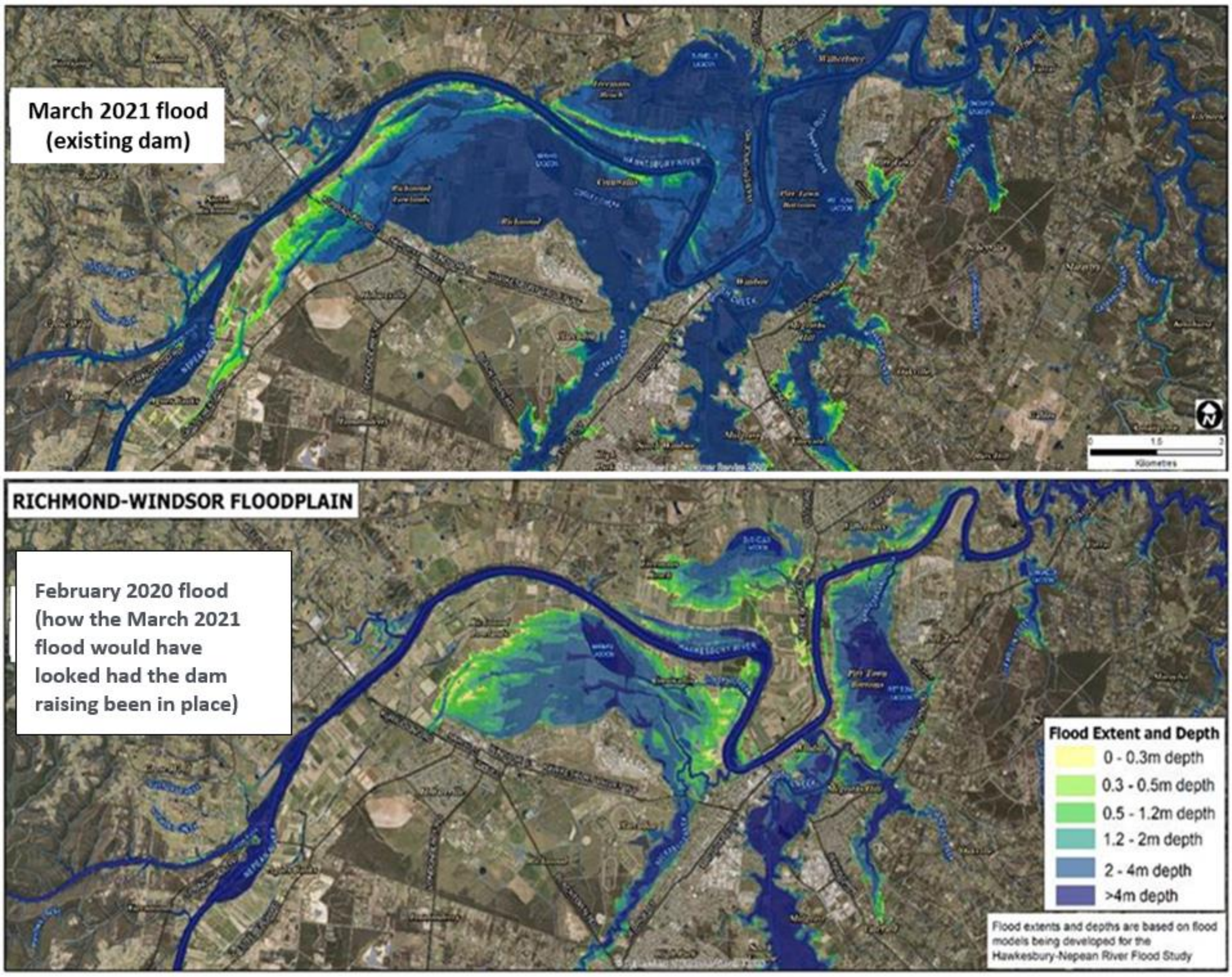
Photo 1 2021 and 2020 (similar to 2021 flood with Project) floods - North Windsor looking north

Source: Infrastructure NSW (2020), Photo: Adam Hollingworth

Photo 8 2021 and 2020 (similar to 2021 flood with Project) floods - North Windsor looking north

Source: Infrastructure NSW (2021), Image: Top Notch video)

Figure 7 Richmond-Windsor floodplain March 2021 and February 2020 floods extent– similar to the difference with a raised dam



Source: Infrastructure NSW (2021

Note: Maps are based on modelling of March 2021 and February 2020 floods by Rhelm/Catchment Simulation Solutions for INSW; modelling of reduction in March 2021 peak flood level by WMAwater for INSW

Figure 8 2021 flood - Victoria Bridge at Penrith near the peak of the March 2021 flood

Photo: Adam Hollingworth

Source: Image adapted from the video 'Snapshot of flooding in Penrith and Emu Plains' (https://www.youtube.com/watch?v=a1HS5JLka9o&t=5s), created by Infrastructure NSW June 2020

Note: Reduction of March 2021 peak flood level based on modelling by WMAwater for Infrastructure NSW

4.2 Mitigating large floods

While the dam raising would have significantly reduced the March 2021 flood, it would have greater benefits for the more dangerous and damaging floods – those with between a 1 in 50 and 1 in 1,000 chance in a year of happening. In a 1 in 100 chance in a year event (Flood Planning Level), the raised dam would:

- Delay the peak and keep evacuation routes open, and significantly reduce risk to life
- Reduce the flood height by around four metres in the Richmond/Windsor floodplain
- Reduce number of people to be evacuated by around 40,000 and impacted homes by around 5,000
- Decrease flood damages by around $3 billion.

Project mitigation is shown on Figure 9and Figure 10.

Figure 9 Jim Anderson Bridge (Windsor) 1 in 100 chance in a year flood – without and with raised dam

Source**:** Image adapted from the video 'Snapshot of flooding in Richmond and Windsor' (https://www.youtube.com/watch?v=adx0nnPzfXs&t=1s), created by Infrastructure NSW June 2020

Note: Modelling of reduction in 1 in 100 chance per year flood level by WMAwater for INSW

Figure 10 Riverstone Station in a 1 in 100 chance in a year flood – without and with raised dam

Source: Image adapted from the video 'Backwater flooding on South and Eastern Creeks' (https://www.youtube.com/watch?v=yEMOh2SujWo&t=8s), created by Infrastructure NSW June 2020

Note: Modelling of reduction in 1 in 100 chance per year flood level by WMAwater for INSW

5 References

Infrastructure NSW 2021, *Hawkesbury-Nepean River March 2021 Flood Review*, INSW, Sydney.

Appendix E

Longneck Lagoon ecology report

Longneck Lagoon Inundation Study

Warragamba Dam

304500690

Prepared for

WaterNSW

6 September 2022

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now

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2	22/08/2022	Final	AM	DW

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Tables

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1 Introduction

Cardno, now Stantec (Stantec) was engaged by Water New South Wales (WaterNSW) to investigate the potential impacts of temporary inundation on Cumberland Plains Woodland (CPW) – listed as critically endangered under the *Biodiversity Conservation Act 2016* (BC Act). As such, Stantec have undertaken a site study to investigate the potential impact of flood inundation on CPW occurring downstream of the Warragamba Dam, near Longneck Lagoon (the Site).

1.1 Site Context

The Site is located within Scheyville National Park, Maralya, NSW in the Hawkesbury City Council LGA (**Table 1-1**). Longneck Lagoon is a popular destination, frequented by visitors year-round for its recreational facilities. The Site is located approximately 44km downstream of the Warragamba Dam and occurs within 650 m of the Hawkesbury River. Vegetation surrounding Longneck Lagoon is subject to inundation during flood events (**Figure 1-2**), with a peak level of 13.27m AHD occurring during a flooding event in March 2022. Other site particulars are presented in **Table 1-1**.

Table 1-1 Site particulars

Attribute	Site Particular
Locality	The Site is located near Windsor, NSW 2756. The Site is located approximately 50 km north-west of Sydney.
LGA	Hawkesbury City Council
Topography	The Site has a gentle sloping terrain towards Longneck Lagoon from approximately 30m ASL to >10m ASL.
Bioregion / Sub-region	Sydney Basin Bioregion / Cumberland
NSW Landscape	Hawkesbury – Nepean Terrace Gravels Hawkesbury – Nepean Channels and Floodplains Blaxlands Ridge Cumberland Plain
Geology	Wianamatta Group Shale Hawkesbury Sandstone Alluvium
Conservation Reserves	The study area is located within Scheyville National Park and is managed by NPWS.
NSW WeedWise Local Areas	Greater Sydney

1.2 Objectives

The following are key objectives for this ecological study:

> Define baseline conditions of CPW within the Site at both affected and unaffected locations.

> Provide additional background into the floristic features of the site and vegetation quality.

> Develop a survey design to be used for future monitoring of CPW at specific locations.

Figure 1-1 Scheyville National Park

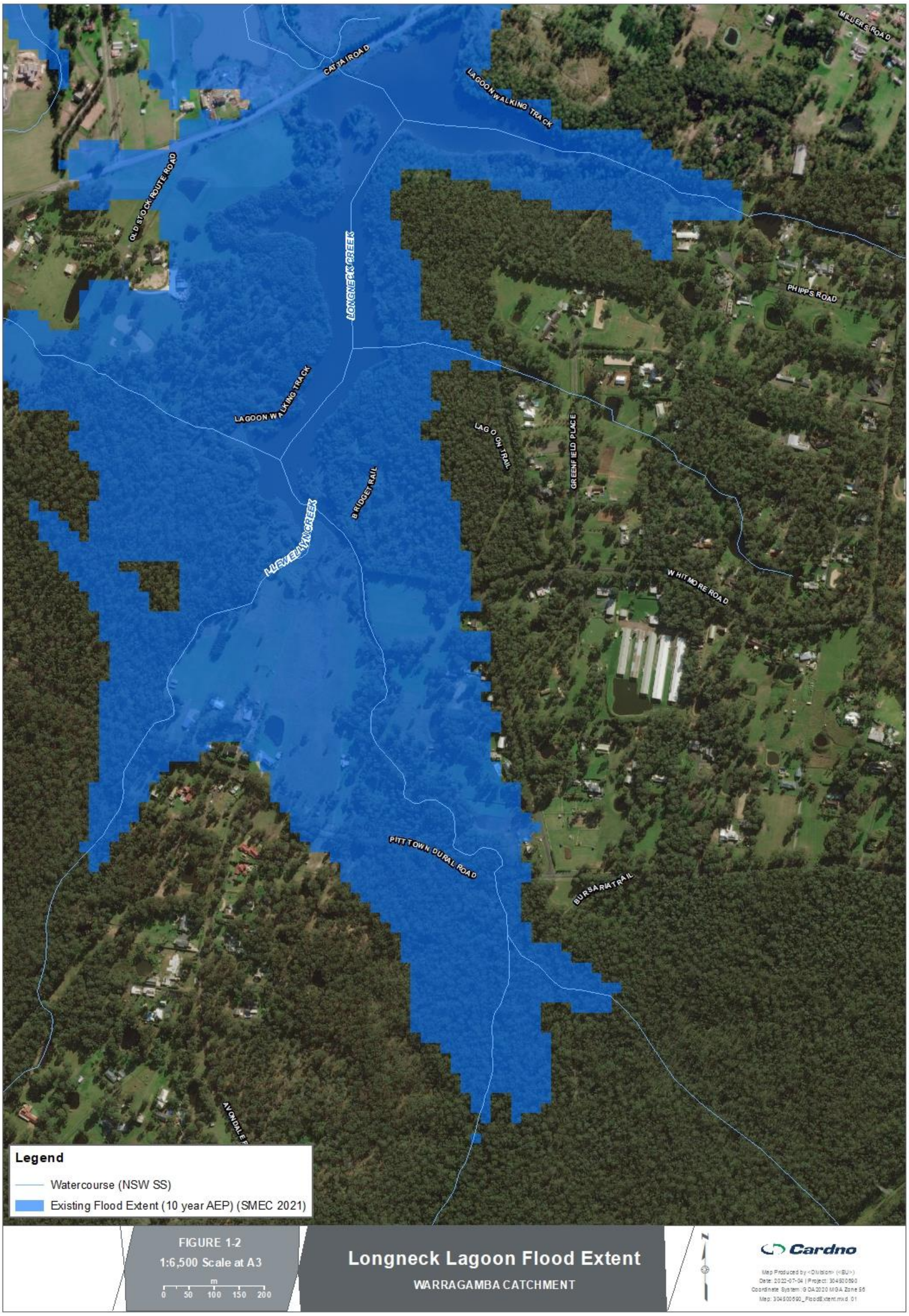


Figure 1-2 Existing Flood Extent of Longneck Lagoon

2 Methodology

2.1 Preliminary Site Inspection

Cardno undertook a preliminary field inspection on 2 March 2022, prior to the March 2022 flooding event, during which visual assessment of vegetation along two transects were undertaken. The first transect (T1) coincided with a transect, monitored by the Longneck Lagoon Environmental Education Centre, located on the southern side of the Education Centre buildings. The second transect (T2) ran adjacent to a tributary of Longneck Creek (**Figure 2-1**). For each transect, an opportunistic flora list and general observations on community type and cover were generated.

2.2 Desktop Review

Prior to further field investigations, Cardno undertook a review of desktop and historical data, including:

> NSW Department of Planning and Environment (DPE), formerly NSW Department of Planning, Industry and Environment (DPIE) – Environment, Energy and Science (EES) branch's BioNet Atlas and Vegetation Classification.

> NSW SEED Spatial Data Portal.

> Previous assessments undertaken within the Site, including:

  - Vegetation mapping undertaken for the Downstream Ecological Assessment of the Warragamba Dam Raising (SMEC 2021).
  - Detailed vegetation integrity plots as per the Biodiversity Assessment Method (BAM; DPIE 2020, BAM plots hereafter) were undertaken for the Downstream Ecological Assessment of the Warragamba Dam Raising (SMEC 2021).

> Historical and modelled flood data relevant to the Site, including flood modelling undertaken by SMEC (2021) and estimated flood extents provided by Infrastructure NSW.

Desktop investigations aimed to:

> Identify Threatened Ecological Communities (TECs) and Plant Community Types (PCTs) occurring in the locality and verify the locations of TECs and/or PCTs that constitute CPW vegetation in the Site and locality.

> Define baseline conditions and typical floristic structures of CPW communities.

> Provide background into the floristic features of the site and vegetation quality.

> Determine the extent and location of historical assessments conducted in CPW within the Site and locality.

> Determine the extent of previous flood inundation across the Site and identify affected (known to have been affected by temporary inundation) and unaffected (not known to have been affected by temporary inundation) areas of CPW within the Site.

2.3 Field Survey

Cardno undertook four days of field investigations across affected and unaffected areas of CPW (Plant Community Type (PCT) 849) across the Site. A total of 14 vegetation integrity plots (BAM plots) and 2 transects were undertaken within areas of PCT 849 across the Site, including:

> 7 plots in affected areas, 6 of which were undertaken in historically survey locations (Plot 1, 5, 6, 7, 8, 11).

> 7 plots in unaffected areas, 1 of which was undertaken in a historical survey location (Plot 2).

> Two transects undertaken in locations previously surveyed by Cardno on 2 March 2022.

A summary of survey effort and environmental conditions during the field investigation is presented in **Table 2-1**. Survey locations are presented in **Figure 2-1**.

Table 2-1 Survey effort and environmental conditions for field investigation (BoM, 2022)

Date	Ecologists	Survey Period	Survey Effort (person hours)	Temperature (°C)		Rainfall (mm)	Other Observations
				Minimum	Maximum		
14/06/2022	Dr. Adriana Corona Mothe (ACM) and Annabelle McTaggart (AM)	8:00 – 15:00	14	-0.2	17.7	0	Nil
15/06/2022		8:00 – 15:00	14	-0.4	21.5	0	Nil
16/06/2022		8:00 – 14:30	13	4.8	22.1	0	Nil
17/06/2022		8:00 – 14:00	12	2.6	19.5	0	Nil

2.3.2 Survey Methods

2.3.2.1 Vegetation Integrity Plots

BAM Plots (**Table 2-1)** were undertaken in accordance with the BAM (DPIE 2020). Assessment of structure and function was completed as per the nested plots, including:

> Litter Cover in 5 x 1m^2 quadrats along a 50m transect.

> Flora composition and structure in a 20m x 20m plot.

> Flora function, including tree classes, logs and hollow bearing trees in a 20m x 50m plot.

The locations of the BAM plots were determined based on the locations of historical plots with available data. Where historical plot data was unavailable, plot locations were selected in areas of PCT 849 with the appropriate history of temporary inundation. Plots were located as close to Longneck Lagoon as possible, in areas of PCT 849 comprising a range of condition types. Due to the characteristics of the Site, it was not feasible to locate plots in areas with similar landform attributes, such as elevation.

Table 2-2 BAM plots

Plot Number	Affected (A) / Unaffected (U)	Source	General Location (within Scheyville National Park)
1	A	Historical plot	Longneck Lagoon Environmental Education Centre
2	U	Historical plot	Longneck Lagoon Environmental Education Centre
3	U	New plot	Longneck Lagoon Environmental Education Centre
4	U	New plot	Longneck Lagoon Environmental Education Centre
5	A	Historical plot	Longneck Lagoon Environmental Education Centre
6	A	Historical plot	South of Pitt Town Dural Road
7	A	Historical plot	South of Pitt Town Dural Road
8	A	Historical plot	South of Pitt Town Dural Road
9	U	New plot	South of Pitt Town Dural Road
10	U	New plot	South of Pitt Town Dural Road
11	A	Historical plot	South of Pitt Town Dural Road
12	U	New plot	South of Pitt Town Dural Road
13	U	New plot	South of Pitt Town Dural Road
14	A	New plot	Longneck Lagoon Environmental Education Centre

At each plot location any additional observations, such as flood debris height and quantity, and the presence of anthropogenic litter, were also noted. A marker was placed at the start of each vegetation plot to assist in ensuring the repeatability of any future investigations. An example is illustrated below.

Plate 2-1: Example marker used for plot identification within the Site

2.3.2.2 Transects

The transects were conducted in locations previously surveyed during the Preliminary Site Inspection in March 2022. During the Preliminary Site Inspection, visual observations were made along each transect. The first transect (T1) coincided with a transect, monitored by the Longneck Lagoon Environmental Education Centre, located on the southern side of the Education Centre buildings. The second transect (T2) ran adjacent to a tributary of Longneck Creek. Both transects were orientated east-west towards the edge of the lagoon to provide an overview of changes in vegetation condition and cover over areas exposed to temporary inundation over varying timeframes.

During the field survey, floristic and environmental attributes, such as floristic structure, exotic species cover and flood inundation evidence, were collected at 10m intervals along each 190m transect. To develop a repeatable survey method for future investigations, these floristic and environmental attributes were collected in a 1x1m quadrat positioned at each 10m interval. Quadrats were set on the northern side of the path in T1 and the southern side of the path in T2. Additional observations of the vegetation adjacent to the transect were also noted.

2.3.3 Survey Limitations

The methodology presented here provides a limitation on describing the biodiversity values of the Site. The biodiversity values of the Site recorded from this field survey should not be seen as a complete/comprehensive inventory. The field survey would have sampled the Site at a point in time (snapshot). A period of several seasons or years is often required to identify all species in an area. Given the short period of time spent on site, the detection of certain species may be affected by:

- Seasonal flowering periods (some species are cryptic and are unlikely to be detected outside of the known flowering period).
- Weather conditions during the survey period (some species may go through cycles of activity related to specific weather conditions).

This report was developed based on available data and the environmental condition of the Site at the time of the field survey and development of this report. Environmental conditions, including the presence of threatened species, can vary with time.

2.4 Analyses

Where historical data was available for a plot location, analyses were also conducted to identify any changes in vegetation condition that have occurred over time. Following the collation of historical data and field surveys, Stantec conducted analyses on contemporary datasets collected from the Site. These analyses aimed to provide an insight into whether any significant differences in floristic structure and community attributes occurred between affected and unaffected sites.

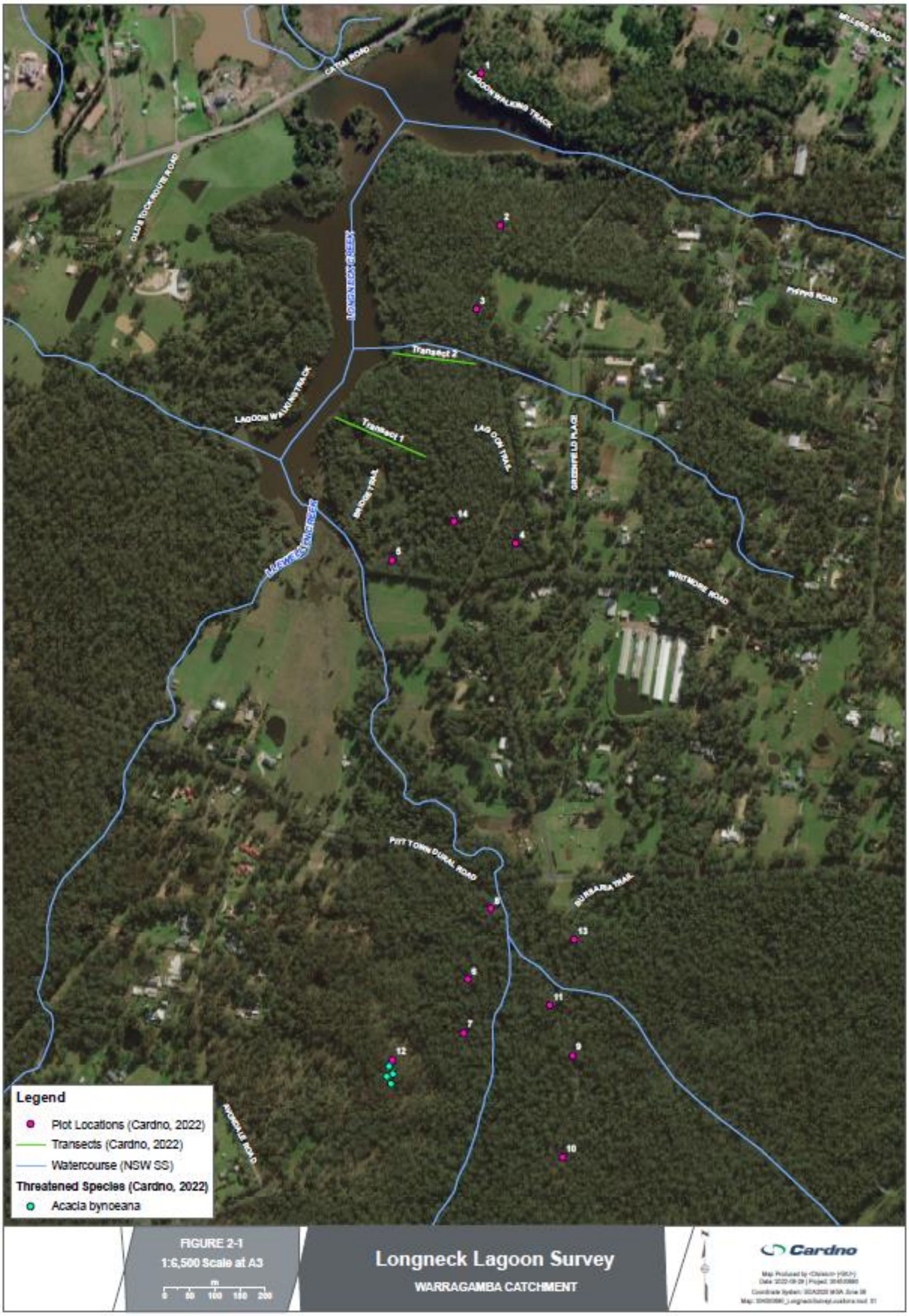


Figure 2-1 Survey Locations

3 Results

3.1 Desktop Results

3.1.1 Local Vegetation Mapping

The Cumberland Plain West (VIS ID 4207) vegetation mapping indicated that there were four PCTs expected to occur within the Site. The PCTs and associated TECs are defined in **Table 3-1** and illustrated in **Figure 3-1.**

Table 3-1 PCTs as per Cumberland Plain West vegetation mapping (VIS ID 4207)

PCT ID	PCT Name	Associated TEC
781	Coastal freshwater lagoons of the Sydney Basin Bioregion and South East Corner Bioregion	▪ Sydney Freshwater Wetlands in the Sydney Basin Bioregion – listed as endangered under the BC Act
835	Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion	▪ River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions – listed as endangered under the BC Act ▪ River-flat eucalypt forest on coastal floodplains southern NSW and eastern Victoria – listed as critically endangered under the EPBC Act
849	Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion	▪ Cumberland Plain Woodland in the Sydney Basin Bioregion – listed as critically endangered under the BC Act. ▪ Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest – listed as critically endangered under the EPBC Act
1395	Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion	▪ Shale Sandstone Transition Forest in the Sydney Basin Bioregion – listed as critically endangered under the BC Act

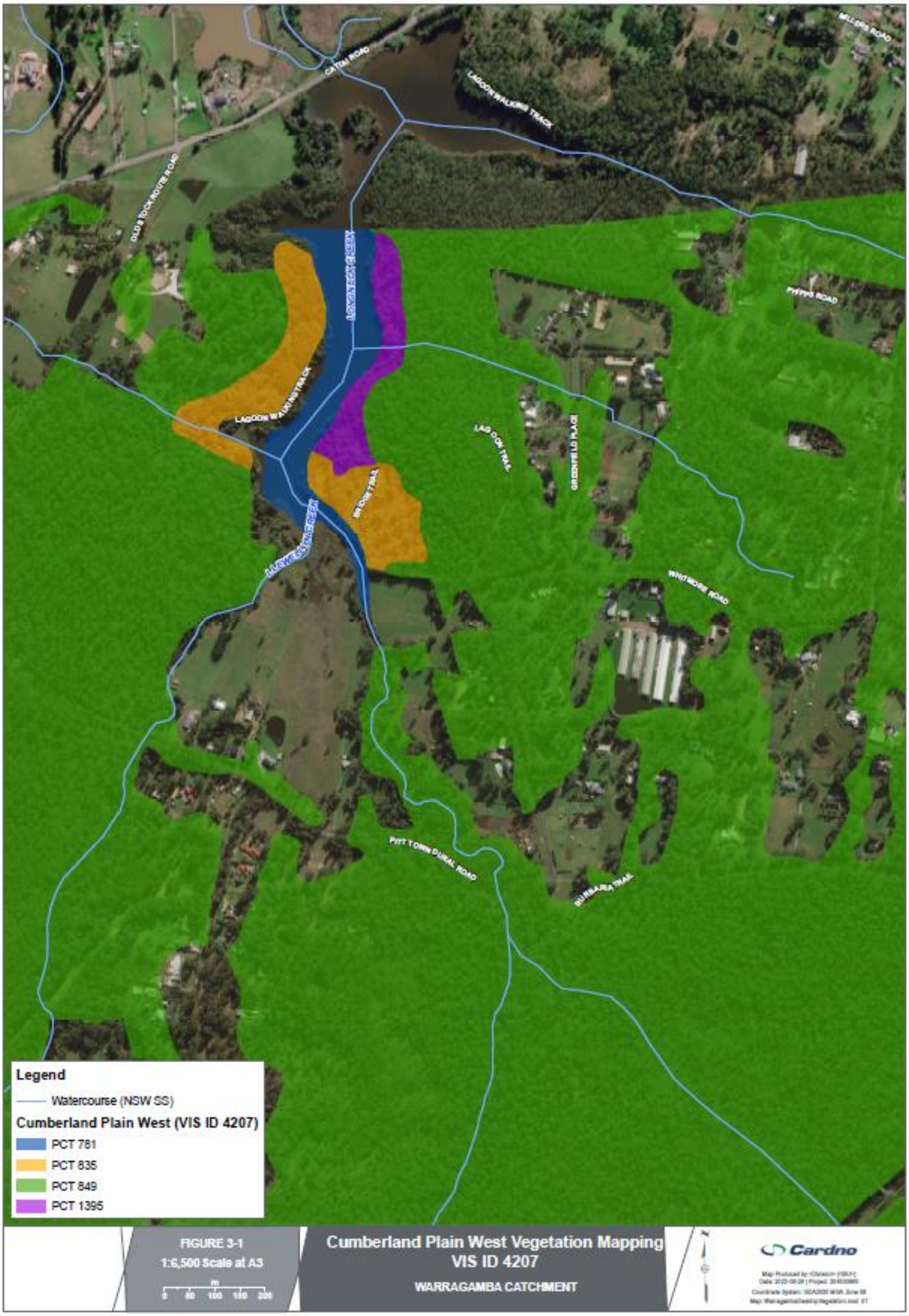


Figure 3-1 Vegetation Mapping – Cumberland Plain West Vegetation Mapping (VIS ID 4207)

3.1.2 BioNet Atlas and Vegetation Classification

For the purposes of this investigation, PCT 849 has been targeted to draw conclusions relating to the potential impacts temporary inundation has on CPW. In order to reach these conclusions, it is important to understand the PCT classification and community benchmarks for PCT 849 as derived from BioNet Atlas. BioNet vegetation classification and key characteristics of PCT 849 are provided below and community benchmark conditions (pristine condition) for PCT 849 is provided in **Table 3-2**.

> **PCT**: Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion (PCT 849).

> **Vegetation formation:** Grassy Woodland.

> **Vegetation class:** Coastal Valley Grassy Woodlands.

> **Conservation status:** Critically endangered under the BC Act and/or EPBC Act.

> **Estimate of percent cleared:** 93%.

> **Description:** Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion (PCT 849) is a grassy woodland occurring on clay/loam soils derived from Wianamatta Shales on the Cumberland Plain. The community is associated with low elevations mainly below 150 metres above sea level (ASL). PCT 849 typically has a canopy dominated by Grey Box (*Eucalyptus mollucana*) and Forest Red Gum (*Eucalyptus tereticornis*). The midstorey is characteristic of Native Blackthorn (*Bursaria spinosa subsp. spinosa*). The ground layer can be diverse and characteristic species include Kidney Weed (*Dichondra repens*), Threeawn Speargrass (*Aristida vagans*), Weeping Grass (*Microlaena stipoides var. stipoides*) and Wattle Mat-rush (*Lomandra filiformis*). Other species can also occur in each stratum.

Table 3-2 Community benchmark conditions for PCT 849

Richness						Cover (%)						Total length of fallen logs (m)	Litter cover (%)
Tree	Shrub	Grass and Grass Like	Forb	Fern	Other	Tree	Shrub	Grass and Grass Like	Forb	Fern	Other		
5	8	12	14	2	5	53	16	58	9	1	4	40	40

3.1.3 Biodiversity Surveys (SMEC 2021)

In 2018 and 2019, SMEC Australia Pty Ltd (SMEC) conducted ecological surveys in downstream areas of Warragamba Dam in support of the proposed Warragamba Dam Raising Project. Ecological investigations were conducted under the Framework for Biodiversity Assessment (FBA) which included plot and transect based floristic data collection as well as ground-truthing of vegetation communities in line with NSW PCT characteristics. A total of 95 plot and transect sites were selected throughout the downstream areas of the Warragamba Dam, including seven plots that occur within areas of CPW within the Longneck Lagoon Site and locality. These plots have been resurveyed by Stantec as part of this Longneck Lagoon study. Data collected from these seven plots as part of the SMEC investigation is presented in **Table 3-3**. It should be noted that not all floristic data and attribute data was available for these plots, and as a result, Plot 2 (DS16) was excluded from analyses of historical data. The SMEC investigation also included ground-truthing of vegetation mapping and the identification of PCTs within the downstream areas of the Warragamba Dam, including the Longneck Lagoon Site. The ground-truthed vegetation mapping is illustrated in **Figure 3-2**.

Table 3-3 Vegetation Plot Data (SMEC, 2021)

SMEC Plot (Plot 2022)	Date	SMEC Condition Class	No. Native species	Native overstorey cover %	Native Midstorey cover %	native ground cover (grasses) %	native ground cover (shrubs) %	Native ground cover (other) %	Exotic plant cover %	total length of fallen logs (m)	bearing (O)	Eastings	northings	zone	Floristic data	Plot attribute data
DS107 (Plot 8)	3/01/2019	HN528_Moderate/good	29	7.7	1.3	66	8	52	13	95	20	304590	6281613	56	N	Y
DS108 (Plot 6)	3/01/2019	HN528_Moderate/good	22	4.6	3.5	44	10	12	2	76	20	304520	6281480	56	N	Y
DS110 (Plot 11)	3/01/2019	HN528_Moderate/good	28	6	20	44	16	6	5	23	20	304688	6281433	56	N	Y
DS111 (Plot 7)	3/01/2019	HN528_Moderate/good	28	8	16	46	2	4	0	22	20	304513	6281365	56	N	Y
DS113 (Plot 5)	14/11/2018	HN528_Moderate/good_low	31	2.6	6	60	6	6	87	1	270	304355	6282317	56	Y	Y
DS14 (Plot 1)	14/11/2018	HN528_Moderate/good_low	21	12	5	46	8	42	74	0	270	304541	6283288	56	Y	Y
DS16 (Plot 2)	N/A	N/A	31	20	0	82.6	0	1.6	0.12	-	-	304587	6282979	56	Y	N

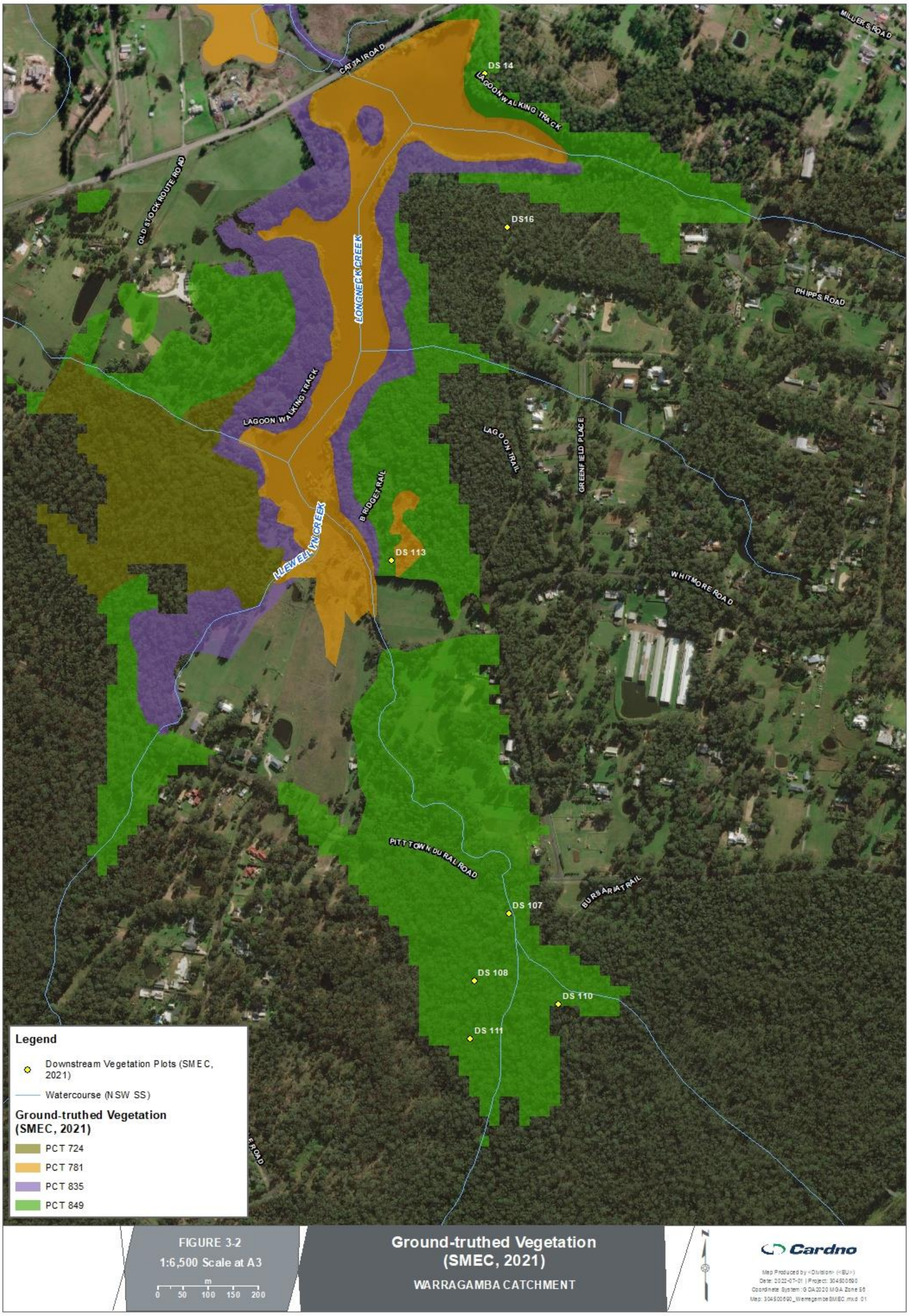


Figure 3-2 Ground-truthed Vegetation (SMEC, 2021)

3.1.4 Historic transect data

Previous assessments of the transects were based on visual observations. During the March 2022 Preliminary Site Visit, it was noted that the vegetation was patchy with a large incursion of weeds, including large patches of *Ligustrum sinense* and *Lantana camara*, and exotic groundcover species. Additionally, the first 50m of T1 was still submerged during this assessment. Native vegetation observed included monospecific stands of *Casuarina glauca* (assigned to PCT 781) and woodland with *Eucalyptus tereticornis* and *Eucalyptus moluccana,* a mid-stratum of *Bursaria spinosa* and ground stratum dominated by exotic species with some *Dichondra repens* and *Cheilanthes sieberi* (assigned to PCT 849). Some patches observed did not have a mid-stratum, with those closer to the woodland areas having a midstory of privet, and occasionally natives such as *Bursaria spinosa*. Groundcover was dominated by exotic grasses and herbs.

3.1.5 Existing Flood Levels

The Site experienced temporary inundation during flooding events in March 2021 (**Figure 3-3**) and March 2022 (**Figure 3-4**). Flood levels peaked at 13.27 m AHD during the March 2022 flooding event. This flooding extent is consistent with the extent of the 10-year AEP (**Figure 3-3**).

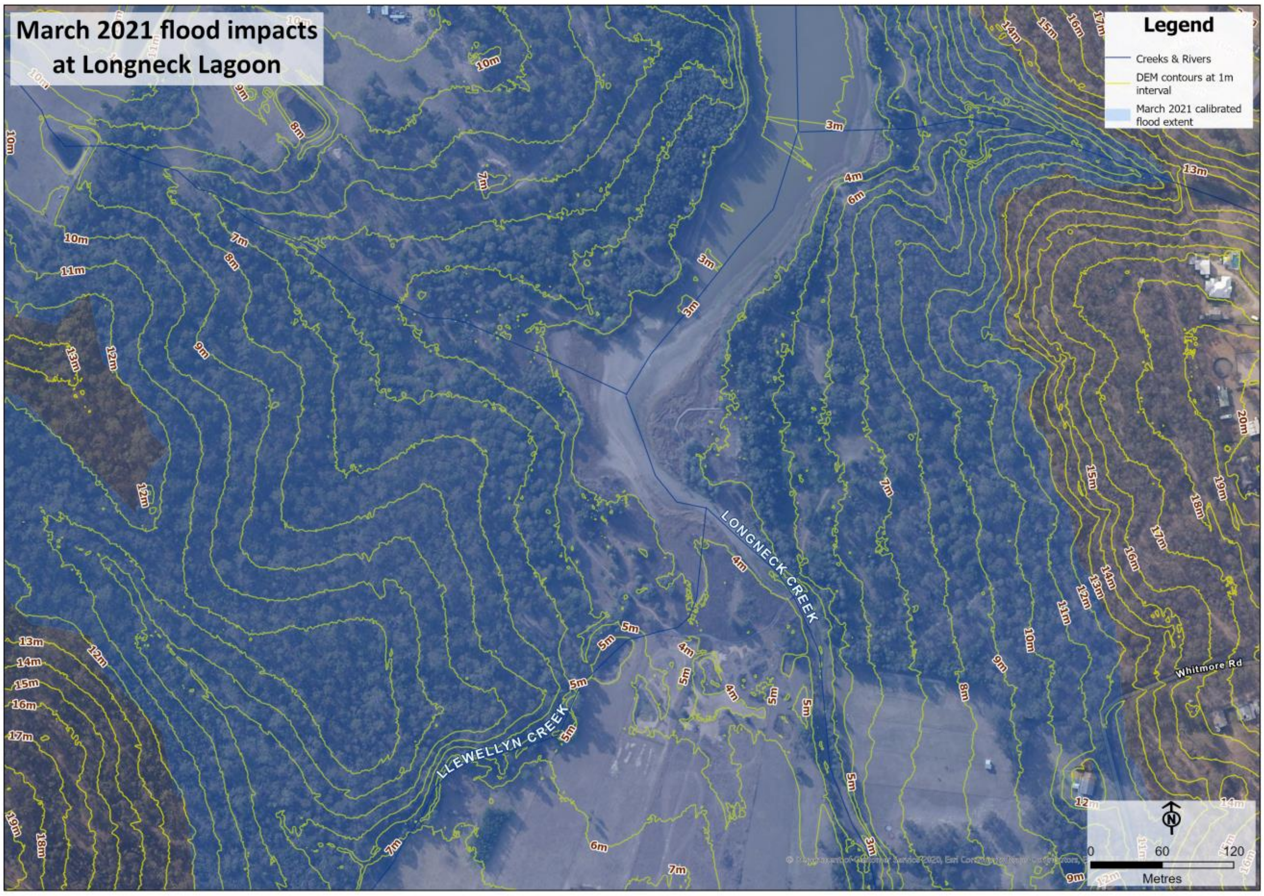


Figure 3-3 Calibrated flood extent of the March 2021 flooding event (figure provided by Infrastructure NSW)

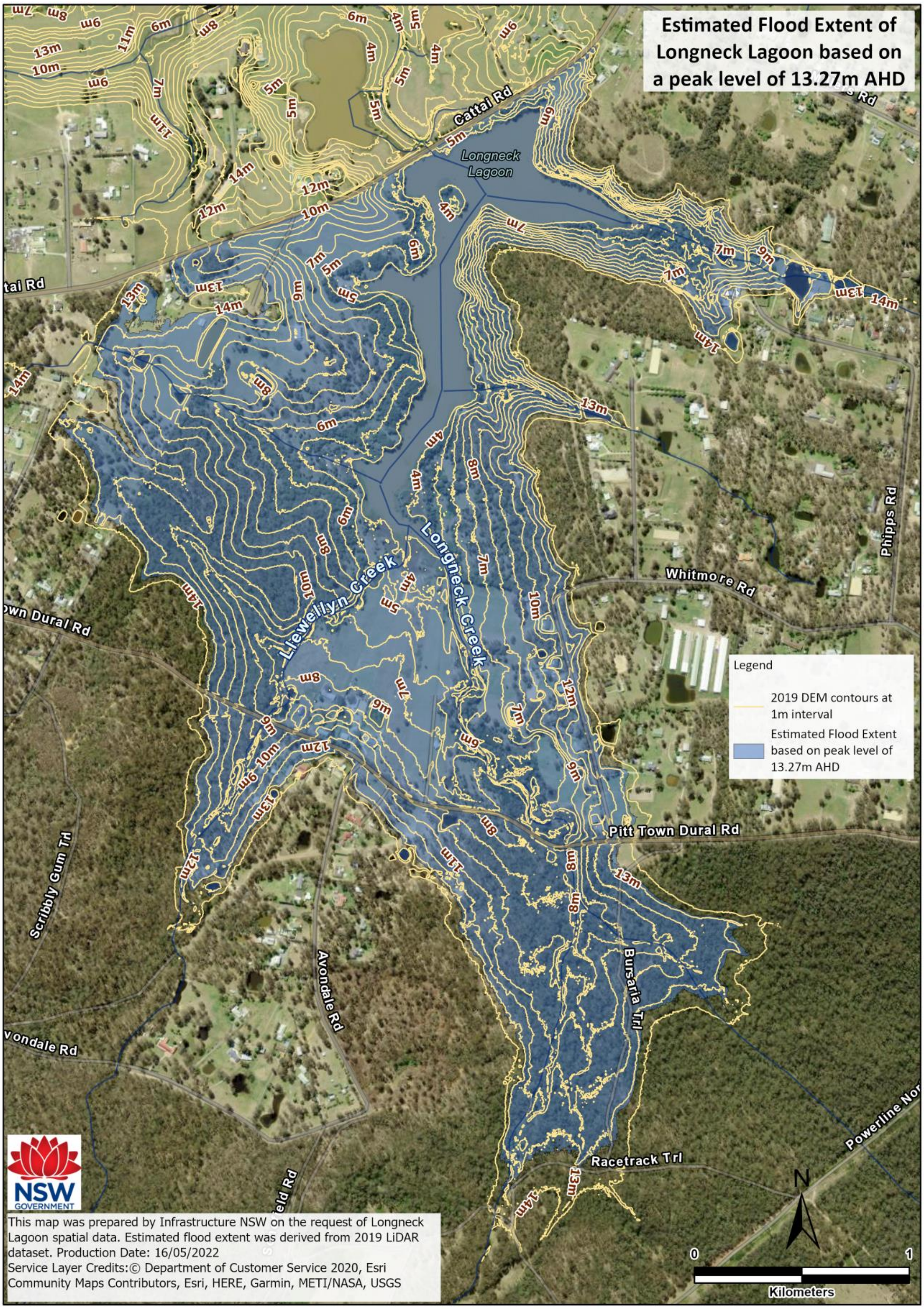


Figure 3-4 Estimated flood extent of the March 2022 flooding event (figure provided by Infrastructure NSW)

3.2 Field Survey

3.2.1 Vegetation Integrity Plots

Vegetation integrity plots were conducted in areas of PCT 849, classified as either affected or unaffected by flooding events, across the Site. Affected and unaffected locations were determined based on the 10-year AEP and the estimated flood extent of the March 2022 flooding event (see **Section 3.1.4)**. Floristic data was collected in accordance with BAM guidelines and is presented in **Table 3-4**. All growth form and high threat weed (HTW) categorisation was informed by the BAM guidelines. A full inventory of flora species encountered during the field investigation is presented in **Appendix A** and photos of each Plot are presented at **Appendix B**.

It should be noted that floristic data collected by SMEC (2021) was in accordance with FBA Guidelines, whereas contemporary data collected as part of this study has been collected using the BAM guidelines. Additionally, the start points of several plots had to be adjusted to account for the presence of creek lines and access tracks (DS113 (Plot 5) and DS107 (Plot 8)). Although there is some overlap with collected data to draw comparisons with, the complete inventory of data collected by SMEC cannot be used to draw conclusions.

It should also be noted that, following on-ground surveys, it was found that Plot 5 is not characteristic of PCT 849 and is instead commensurate with Swamp Oak Floodplain vegetation community. This plot location would need to be changed/addressed for any further survey campaigns.

Analyses of vegetation integrity plot data, including available historical data, is provided in **Section 3.2.2.**

3.2.1.1 General observations

At each plot location any additional observations, such as flood debris height and quantity, and the presence of anthropogenic litter, were also noted. General observations made during the field surveys included:

> An increase in leaf litter moving along the 50m transect towards the lagoon, particularly in Plot 1, where leaf litter cover was observed at 100% in litter plot 5, and Plot 3.

> Abundant flood debris across all affected plots, including woody debris, such as fallen shrubs and branches, and grassy debris accumulated at tree bases.

> Anthropogenic litter, including bottles, cans, and household items, in Plots 1 and 5.

> The detection of a pine cone nearby to Plot 5, where no nearby mature pine tree was noted. This observation highlights the potential for exotic weeds to be introduced or spread during periods of inundation.

> Accumulated debris and silt marks up to 2-3 m in height in Plots 1, 5 and 8.

> An abundance of dead shrubs, particularly in Plots 1 and 5.

Plate 3-1 Accumulation of woody debris in Plot 1

Plate 3-2 Accumulation of woody debris and grasses in Plot 5

Plate 3-3 Accumulation of woody debris and grasses in Plot 8

Table 3-4 Vegetation Integrity Plot data (Stantec, 2022)

Plot Number	Affected (A) / Unaffected (U)	Date	MGA Zone	X Coordinate	Y Coordinate	Midline Bearing	Composition						Structure												
							Tree	Shrub	Grass	Forb	Fern	Other	Tree (%)	Shrub (%)	Grass (%)	Forb (%)	Fern (%)	Other (%)	Large Tree	Hollow-bearing Tree	Litter Cover (%)	Length of Fallen Logs (m)	Regeneration	HTW Cover (%)	Total Exotic Cover (%)
1	A	14/06/2022	56	304549	6283288	270	2	0	4	2	1	0	35	0	60.2	0.2	0.1	0	0	0	86	17	0	20.4	20.6
2	U	14/06/2022	56	304588	6282980	0	2	2	12	5	1	1	35	0.3	42.2	1	0.1	1	0	0	52	4	0	0.6	1.1
3	U	14/06/2022	56	304537	6282807	10	3	2	6	4	1	1	75	5.1	61.6	1.3	0.1	0.1	0	0	45	17	0	0.4	10.5
4	U	14/06/2022	56	304620	6282347	0	2	4	5	3	1	2	75	36.1	40.1	1.1	0.1	0.2	0	0	85.8	18	0	1.7	1.9
5	A	15/06/2022	56	304372	6282321	0	1	0	2	3	0	0	60	0	20.1	0.3	0	0	0	0	94	27	0	30	30.1
6	A	15/06/2022	56	304522	6281478	20	2	1	3	3	0	1	50	0.1	6.1	0.3	0	0.1	0	0	88	130	0	0.3	0.5
7	A	15/06/2022	56	304515	6281371	20	3	2	5	3	0	1	45	10.1	80.3	0.3	0	0.1	0	0	82	88	0	0.6	0.8
8	A	15/06/2022	56	304568	6281619	350	1	0	2	4	0	2	25	0	10.1	0.4	0	0.6	0	0	80	87	0	70.3	70.4
9	U	16/06/2022	56	304731	6281330	145	2	3	11	3	1	1	45	40.2	61.9	0.4	0.1	0.1	0	0	80	52	0	20.3	20.5
10	U	16/06/2022	56	304711	6281124	120	4	1	5	4	1	2	68	40	80.3	0.4	0.1	0.2	0	0	85	43	0	5.1	5.1
11	A	16/06/2022	56	304686	6281427	20	5	1	7	4	0	1	76	5	70.5	0.4	0	0.1	0	0	79	36	0	1.2	1.5
12	U	17/06/2022	56	304372	6281317	150	3	6	11	6	1	1	70	11.3	31.6	3.3	1	0.1	1	0	49	39	1	1.2	1.2
13	U	17/06/2022	56	304733	6281562	30	2	1	8	2	0	1	46	40	71.6	1.1	0	0.1	0	0	83	28	0	5.3	16.3
14	A	17/06/2022	56	304495	6282391	230	2	2	8	2	1	1	30	65	80.7	0.2	1	0.1	0	1	52.8	71	1	1.2	11.2

3.2.2 Transect Data

Species richness was generally low within the quadrats along both transects, ranging from 1 to 8 species in T1 and 1 to 11 species in T2, with a maximum native richness of 5 species along both transects. Additionally, leaf litter cover was high across both transects, with an average of 67% leaf litter cover in T1 and 70% leaf litter cover in T2. Subsequently, groundcover was generally low, with few germinating seedlings, or dominated by exotic species such as grasses (*Ehrharta erecta, Pennisetum clandestinum*) and *Sida rhombifolia.* Where midstory cover was present, this was dominated by *Ligustrum sinense*, although dieback of shrubs was also noted, particularly around the 100-140m mark of T1. Species previously observed in the Preliminary Site Visit, such as *Bursaria spinosa* and *Lantana camara,* were not noted along or adjacent to the transect. Canopy cover was dominated by *Casuarina glauca, Eucalyptus crebra, Eucalyptus moluccana* and *Eucalyptus tereticornis.* Transect data is provided in **Appendix C.**

Observations of flooding evidence were also made along each transect, with flood levels evident with the accumulation of grasses on and around tree trunks and the accumulation of leaf litter. These observations were evident up to the 100m marks of T1 and T2.

Further assessment of the transect data is provided in **Section 3.2.2.** As historic data was based on visual observations, analysis of historical data is not feasible.

4 Analysis

Where historical data was available, analyses were conducted to identify any changes in vegetation condition over time. Following the collation of historical data and field surveys, Stantec also conducted analyses on contemporary datasets collected from the Site. These analyses aimed to provide an insight into whether any significant differences in floristic structure and community attributes occurred between affected and unaffected sites.

4.1 Historic Data Comparisons

Floristic data collected by SMEC (2021) was in accordance with FBA Guidelines, whereas contemporary data collected as part of this study has been collected using the BAM guidelines. A total of six contemporary plot locations overlap with the data collected by SMEC. **Table 4-1** details the contemporary plots with their comparable plots from the SMEC investigation. All six plots fall within areas known to have been affected by temporary inundation.

These comparisons should not be used to draw conclusions, rather provide an indication of any general trends or changes in vegetation condition that have occurred in affected areas of CPW. It is also important to note that surveys undertaken by Stantec were not conducted at the same time of the year as those conducted by SMEC, thus variations may be present due to seasonal changes.

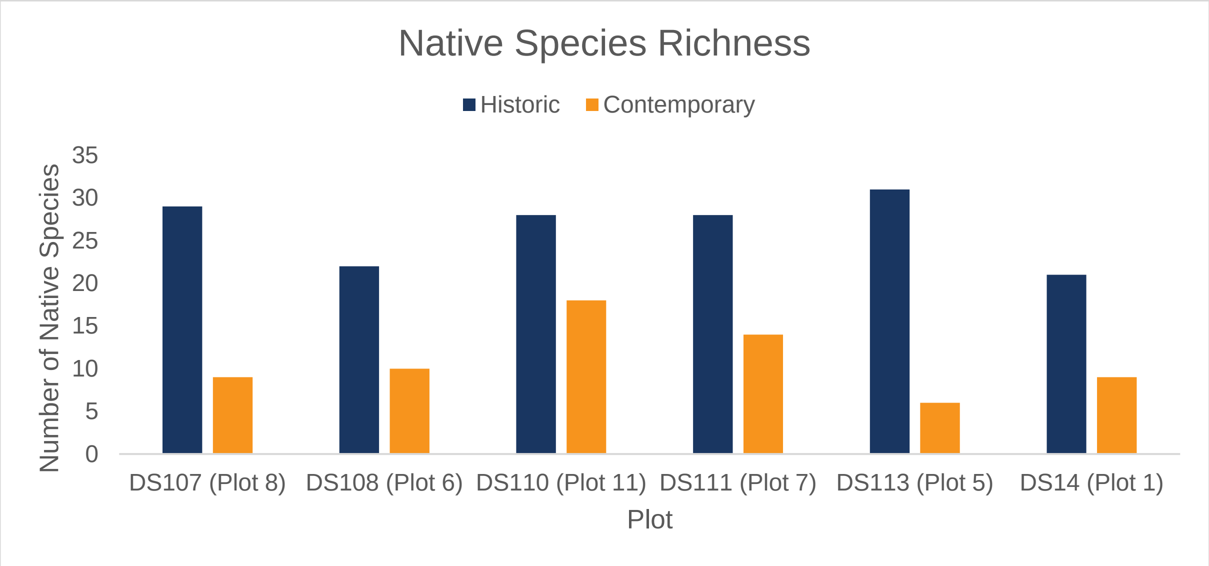
Table 4-1 Comparable vegetation plots

Contemporary Plot Number (Stantec)	Historic Plot Number (SMEC)	Affected/ Unaffected
1	DS14	Affected
5	DS113	Affected
6	DS108	Affected
7	DS111	Affected
8	DS107	Affected
11	DS110	Affected

Although there is some overlap with collected data to draw comparisons with, the complete inventory of data collected by SMEC cannot be used for comparison and conclusions with contemporary data. Notable differences in native species richness, fallen log cover and exotic species coverage are detailed further in the sections below.

4.1.1 Native Species Richness

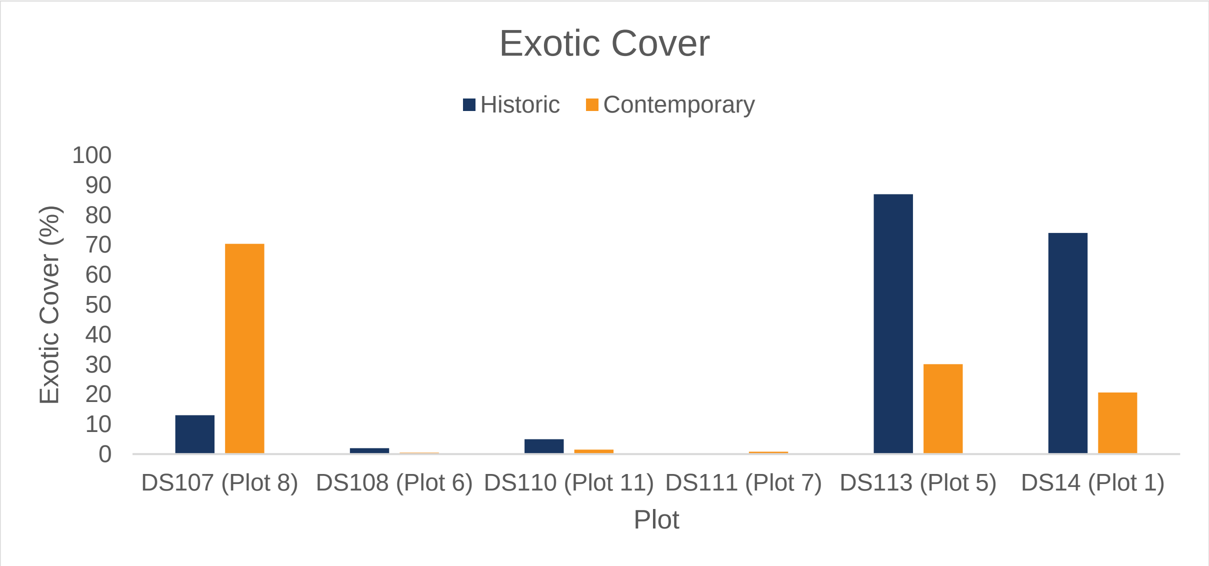
There has been a reduction in native richness (i.e. number of native species) in contemporary surveys across all comparable plot locations compared with species richness in historic surveys. Overall, data shows a reduction of approximately 60% across all comparable plots **(Graph 1).** Decreases in native species richness could be attributed to inundation effects; however, other factors might have influenced the differences in native species richness observed. For example, it is worth noting that historical and contemporary surveys were conducted at different times of the year, thus seasonal changes in plant flowering periods and suitability for detection and/or identification may have occurred.



Graph 1: Native Species Richness within Historic and Contemporary Plots

4.1.2 Exotic Cover

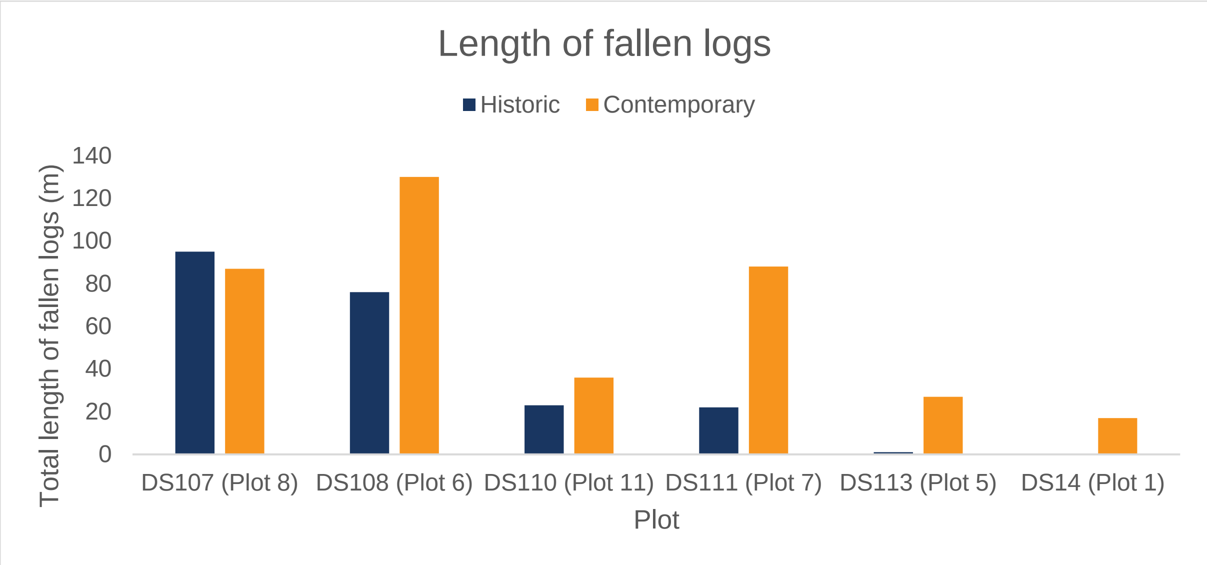
No obvious trend in exotic cover was observed between historic and contemporary plots, however, there has been a significant increase in exotic cover (57.4%) in Plot 8 (DS107) which may be attributed to edge effects due to the proximity of this plot to Pitt Town Dural Road and Longneck Creek. A notable reduction of weed cover was observed in both Plot 5 (DS113) and Plot 1 (DS14). These decreases may be related to the proximity of these plots to the lagoon and thus the increased inundation time experienced. No notable changes were observed for the remaining plots (**Graph 2**).



Graph 2: Cover of Exotic Species within Historic and Contemporary Plots

4.1.3 Length of Fallen Logs

The length of fallen logs within each comparable plot has increased significantly since the collection of the historic data, with the exception of Plot 8 (DS107), where a reduction was observed. Overall, the length of fallen logs within all comparable plots increased by approximately 45% **(Graph 3).**

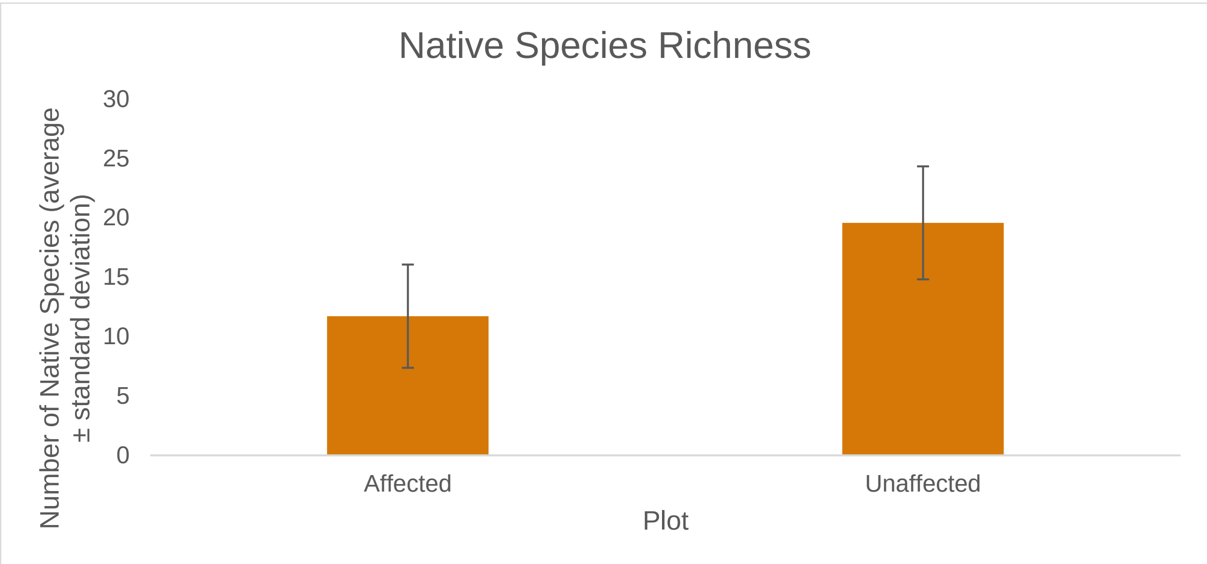


Graph 3: Length of Fallen Logs within Historic and Contemporary Plots

4.2 Affected and Unaffected Plots

4.2.1 Native Species Richness

There was a significant difference between the native species richness of affected and unaffected plots (t=3.226, d.f.=13, P<0.05). Unaffected plots generally had a higher species richness (average ($\bar{x}$) = 19.57 species) than affected plots ($\bar{x}$ =11.71 species) (**Graph 4)**. Native species richness in both affected and unaffected plots was below the community benchmark of 46 species **(**see **Appendix D).**



Graph 4: Average Native Species Richness within Affected and Unaffected Plots (± standard deviation)

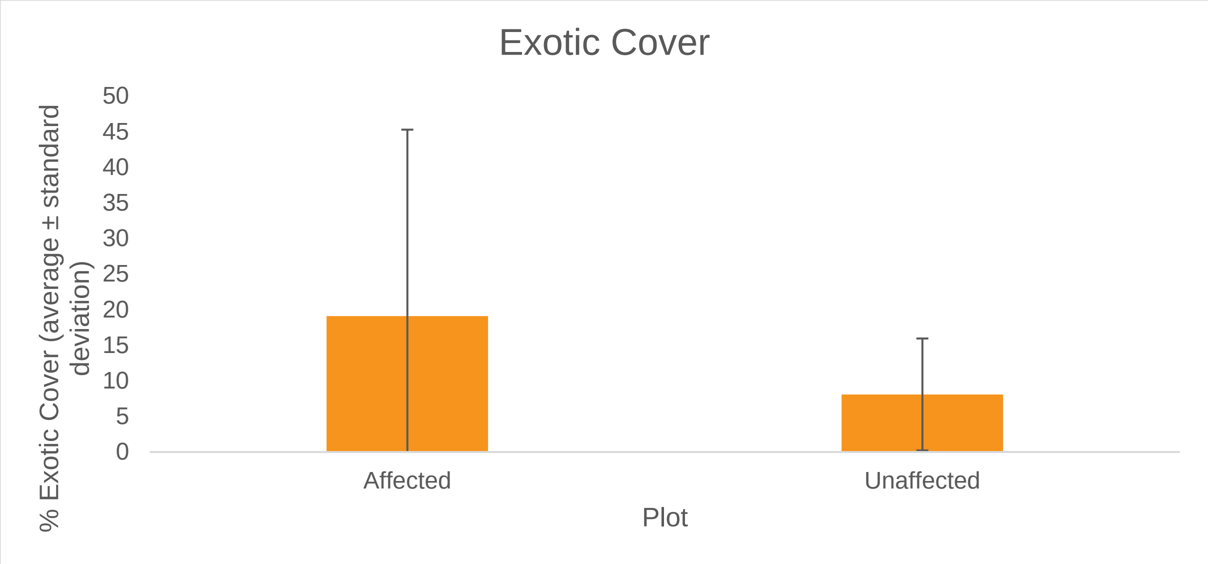
Unaffected plots contained a significantly greater richness of shrubs (t=2.442, d.f.=13, P<0.05), grasses (t=2.648, d.f.=13, P<0.05), and ferns (t=2.449, d.f.=13, P<0.05). On average, unaffected plots contained 1.86 more shrub species and 3.86 more grass species than affected plots. However, there were no significant differences the richness of tree (t=0.476, d.f.=13, P>0.05), forb (t=1.441, d.f.=13, P>0.05), and other species (t=1.342, d.f.=13, P>0.05) between affected and unaffected plots (see **Graphs D2-D7** in **Appendix D)**.

Table 4-2 Species Richness of Growth Forms within Affected and Unaffected Plots

Plot	Affected/ Unaffected	Tree	Shrub	Grass	Forb	Fern	Other
1	Affected	2	0	4	2	1	0
2	Unaffected	2	2	12	5	1	1
3	Unaffected	3	2	6	4	1	1
4	Unaffected	2	4	5	3	1	2
5	Affected	1	0	2	3	0	0
6	Affected	2	1	3	3	0	1
7	Affected	3	2	5	3	0	1
8	Affected	1	0	2	4	0	2
9	Unaffected	2	3	11	3	1	1
10	Unaffected	4	1	5	4	1	2
11	Affected	5	1	7	4	0	1
12	Unaffected	3	6	11	6	1	1
13	Unaffected	2	1	8	2	0	1
14	Affected	2	2	8	2	1	1
Average Affected Plots		2.29	0.86	4.43	3	0.29	0.86
Average Unaffected Plots		2.57	2.71	8.29	3.86	0.86	1.29

4.2.2 Exotic Cover

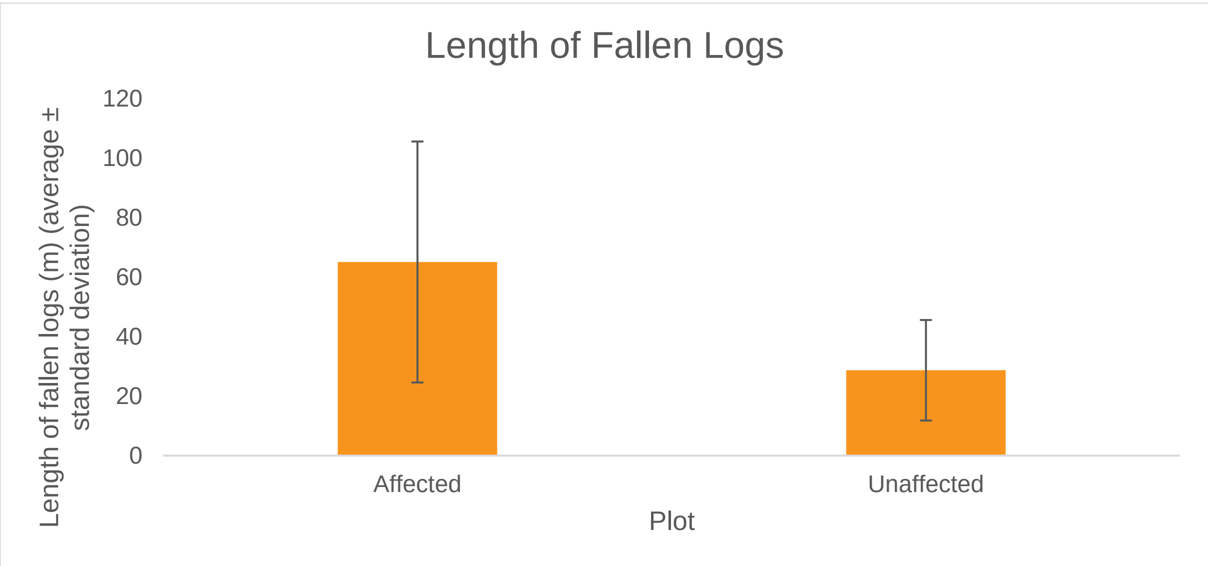
There was no significant difference between the exotic cover of affected and unaffected plots (t=1.0638, d.f.=13, P>0.05). On average, affected plots had a higher cover of exotic species (19%) compared to unaffected plots (8%) (**Graph 5)**. The highest exotic covers occurred in affected plots: 70.4% and 30.1% in Plot 8 and Plot 5, respectively. However, three affected plots also demonstrated exotic cover below 2%. Exotic cover below 2% was also observed in three unaffected plots. Higher exotic cover may be associated with longer periods of inundation, due to the proximity of the plot to the Lagoon (i.e. Plot 1 and 5), or edge effects (i.e. Plot 8).



Graph 5: Average Cover of Exotic Species within Affected and Unaffected Plots (± standard deviation)

4.2.3 Length of Fallen Logs

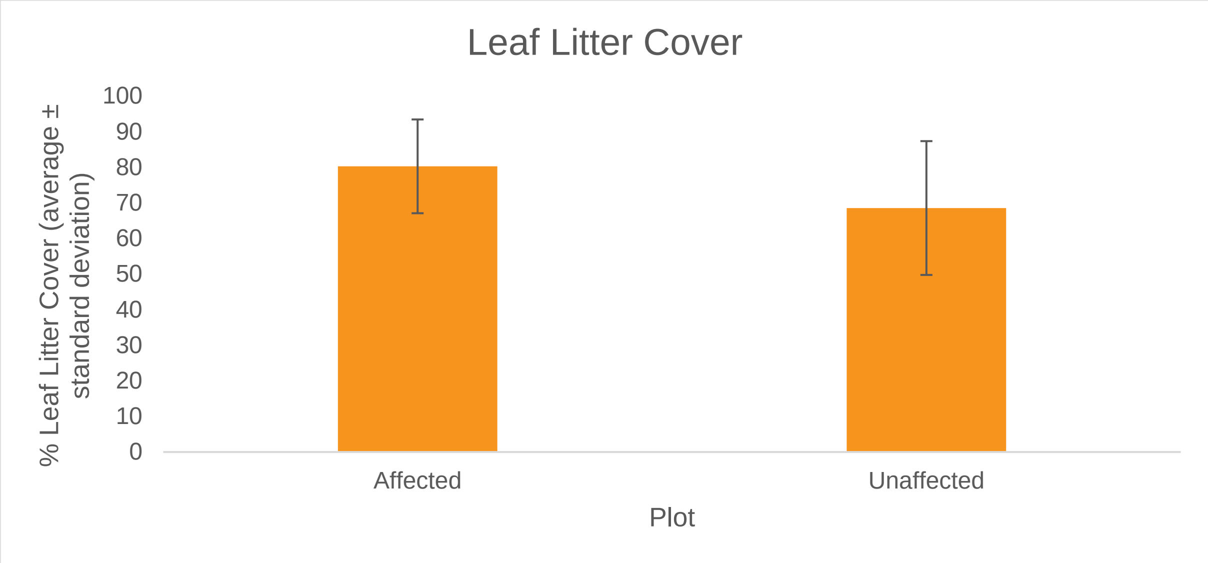
The length of fallen logs within affected plots was significantly higher than that of unaffected plots (t=2.19404, d.f.=13, $P<0.05$). Overall, affected plots contained an average of 65 m of fallen logs, compared to the 29 m average observed within the unaffected plots (**Graph 6)**. The benchmark condition for PCT 849 is 40 m. However, it should also be noted that plots were distributed between land surrounding Longneck Lagoon Environmental Education Centre (3 affected, 3 unaffected) and a section of Scheyville National Park located south of Pitt Town Dural Road (4 affected, 4 unaffected) (**Table 2-1)**, which may be subject to varying degrees of maintenance.



Graph 6: Average Length of Fallen Logs within Affected and Unaffected Plots (± standard deviation)

4.2.4 Litter Cover

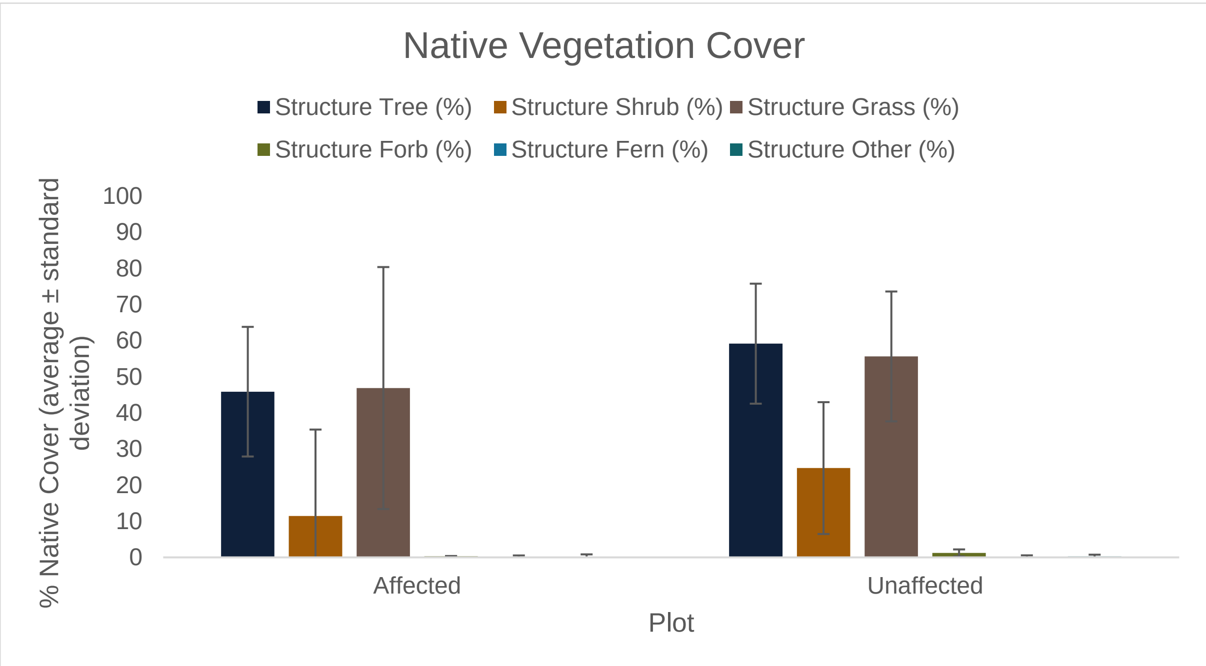
There was no significant difference between the litter cover of affected and unaffected plots (t=1.35069, d.f.=13, $P>0.05$). On average, affected plots had a higher cover of leaf litter (80%) compared to unaffected plots (69%). (**Graph 7**). All affected and unaffected plots had a leaf litter cover higher than the benchmark level of 40% cover for PCT 849.



Graph 7: Average Leaf Litter Cover within Affected and Unaffected Plots (± standard deviation)

4.2.5 Vegetation Cover

Overall, a higher total cover of native vegetation was present in unaffected plots (141%), compared to affected plots (105%). This may be attributed to the effects of inundation on groundcover species not adapted to flooding conditions. Native forb cover, although much lower than benchmark conditions, was significantly higher in unaffected plots than affected plots (t=2.5, d.f.=13, $P<0.05$). However, there were no significant differences in the native vegetation cover of all other growth forms, observed between affected and unaffected plots (**Graph 8).** The presence of cover within each growth form group was more consistently observed in unaffected plots (see **Graphs D8-D13** in **Appendix D)**.



Graph 8: Average Native Vegetation Cover within Affected and Unaffected Plots (± standard deviation)

Table 4-3 Native Cover of Growth Forms within Affected and Unaffected Plots

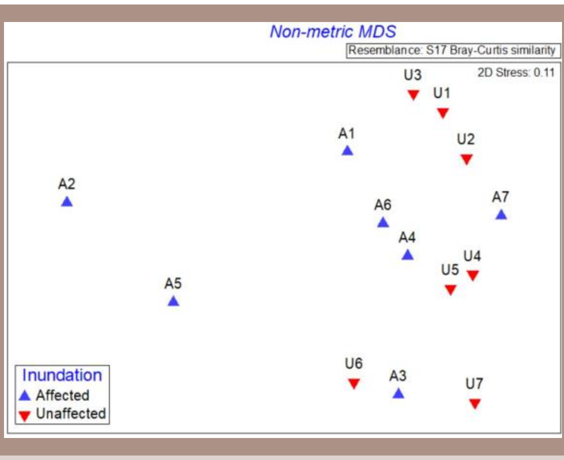
Plot	Affected/ Unaffected	Tree (%)	Shrub (%)	Grass (%)	Forb (%)	Fern (%)	Other (%)
1	Affected	35	0	60.2	0.2	0.1	0
2	Unaffected	35	0.3	42.2	1	0.1	1
3	Unaffected	75	5.1	61.6	1.3	0.1	0.1
4	Unaffected	75	36.1	40.1	1.1	0.1	0.2
5	Affected	60	0	20.1	0.3	0	0
6	Affected	50	0.1	6.1	0.3	0	0.1
7	Affected	45	10.1	80.3	0.3	0	0.1
8	Affected	25	0	10.1	0.4	0	0.6
9	Unaffected	45	40.2	61.9	0.4	0.1	0.1
10	Unaffected	68	40	80.3	0.4	0.1	0.2
11	Affected	76	5	70.5	0.4	0	0.1
12	Unaffected	70	11.3	31.6	3.3	1	0.1
13	Unaffected	46	40	71.6	1.1	0	0.1
14	Affected	30	65	80.7	0.2	1	0.1
Average Affected Plots		45.86	11.46	46.86	0.3	0.16	0.14
Average Unaffected Plots		59.14	24.71	55.61	1.23	0.21	0.26
t		1.437877	1.165869	0.609627	2.5	0.295958	0.774597
P Value		>0.05	>0.05	>0.05	<0.05	>0.05	>0.05

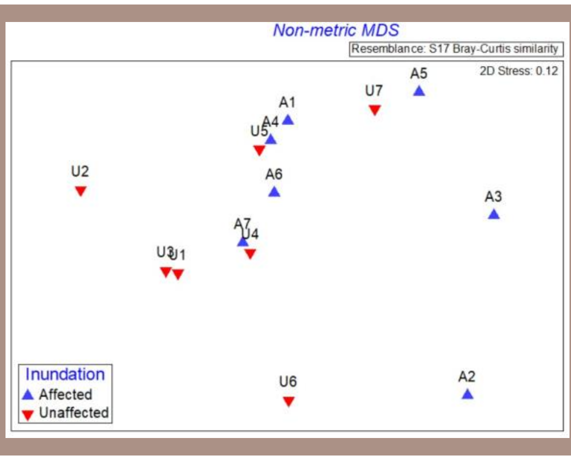
4.2.6 Vegetation Assemblages

Comparison of the vegetation assemblage in affected and unaffected BAM plots were undertaken based on statistical and graphical analysis of data.

A one-way permutational multivariate analysis of variance (PERMANOVA (Anderson 2017[1]) in Primer v7.1 (Anderson *et*. *al*. 2008[2])) was undertaken for measured variables of flora species (cover and abundance). The sole factor was inundation, which included two levels (inundation affected and unaffected vegetation). Replicates consisted of seven BAM plots for each level of inundation. No statistical differences were detected for cover ($t = 1.28$, $P(perm) = 0.134$) and abundance ($t = 1.09$, $P(perm) = 0.279$) of vegetation assemblages in affected and unaffected BAM plots. Dissimilarities in vegetation assemblages were generated in analysis of similarity (ANOSIM, Clarke and Gorley 2015[3]) with Bray-Curtis dissimilarities (Bray and Curtis 1957[4]) and graphically illustrated in non-metric MDS (nMDS). Although there are dissimilarities in the cover (see nMDS 1) and abundance (see nMDS 2) of flora species, those dissimilarities do not result in a clear separation in vegetation assemblages in BAM plots affected *versus* unaffected by inundation.

[1] Anderson M.J. (2017) Permutational Multivariate Analysis of Variance (PERMANOVA). Wiley StatsRef: Statistics Refence Online
[2] Anderson M.J., Gorley R.N. and Clarke K.R. (2008) PERMANOVA+ for PRIMER: Guide to Software and Statistical Methods. PIMER-E Ltd, Devon UK
[3] Clarke K.R. and Gorley R.N. (2015) PRIMER v7: User Manual/Tutorial. PRIMER-E, Plymouth
[4] Bray J.R. and Curtis J.T. (1957) An ordination of the upland forest communities of Southern Wisconsin. Ecological Monographs 27(4):325-349.



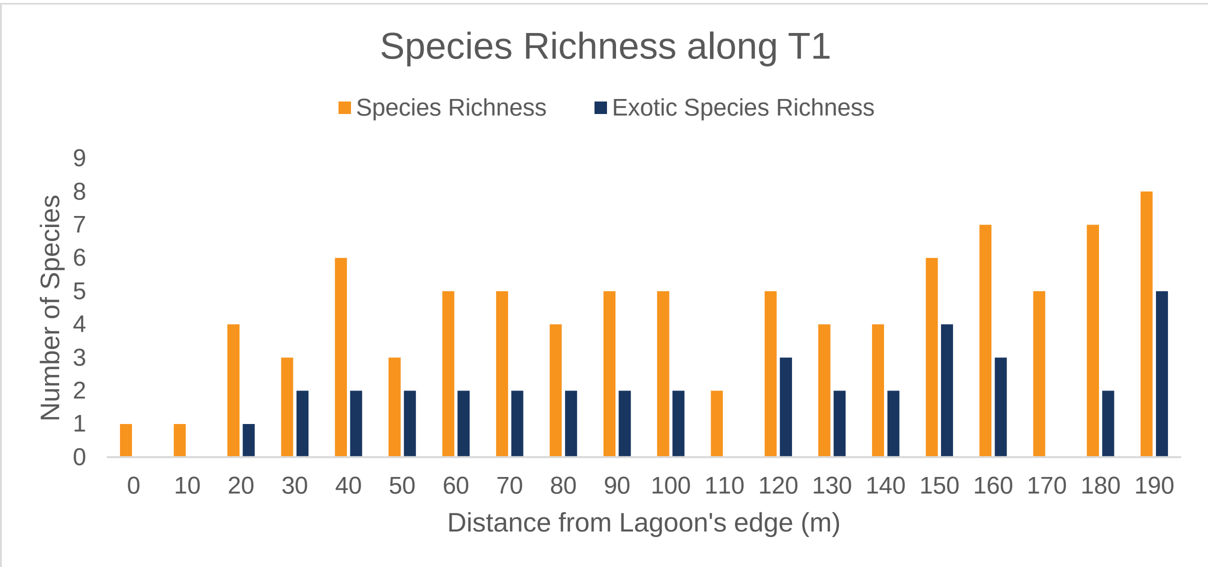


nMDS 1: cover of flora species in affected and unaffected vegetation assemblages	**nMDS 2:** abundance of flora species in affected and unaffected vegetation assemblages

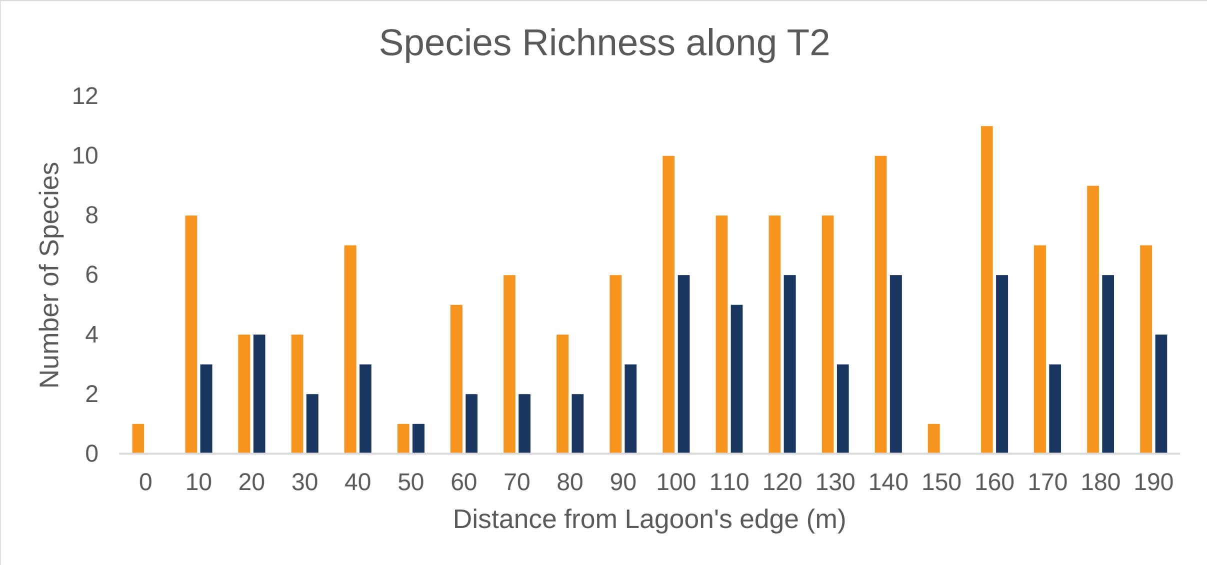
4.3 Transects

4.3.1 Species Richness

Species richness along T1 was generally higher at the furthest points from the lagoon. No obvious trends in exotic species richness were observed along T1 (**Graph 9**). Additionally, no obvious trends in species richness were observed along T2, however the highest richness of all species and exotic species occurred at the furthest points from the lagoon (**Graph 10**). Overall, species richness was low across the transects and generally greater furthest from the lagoon. These patterns may be attributed to the effects of inundation on groundcover species not well adapted to flooding conditions.



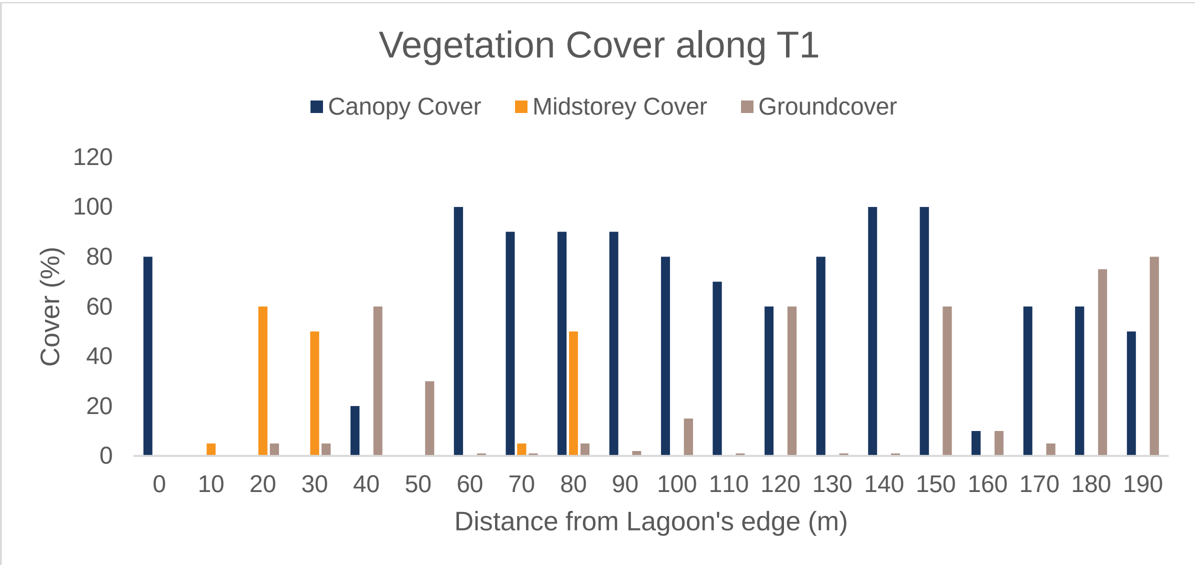
Graph 9: Species Richness along T1



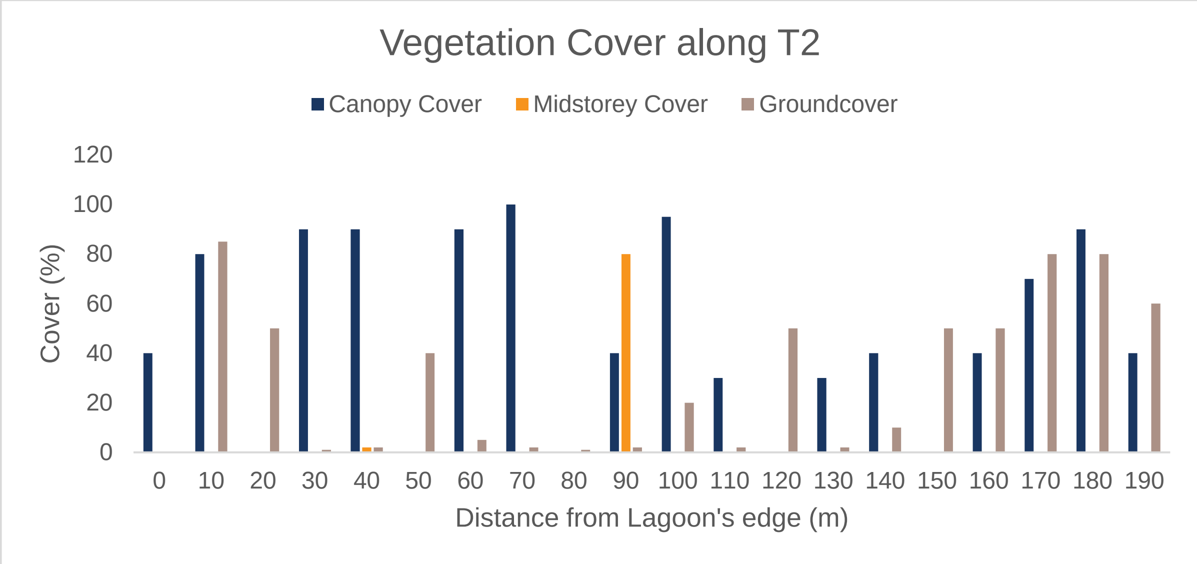
Graph 10: Species Richness along T2

4.3.2 Vegetation Cover

No obvious trends in vegetation cover were observed along T1 (**Graph 11**) or T2 (**Graph 12**).



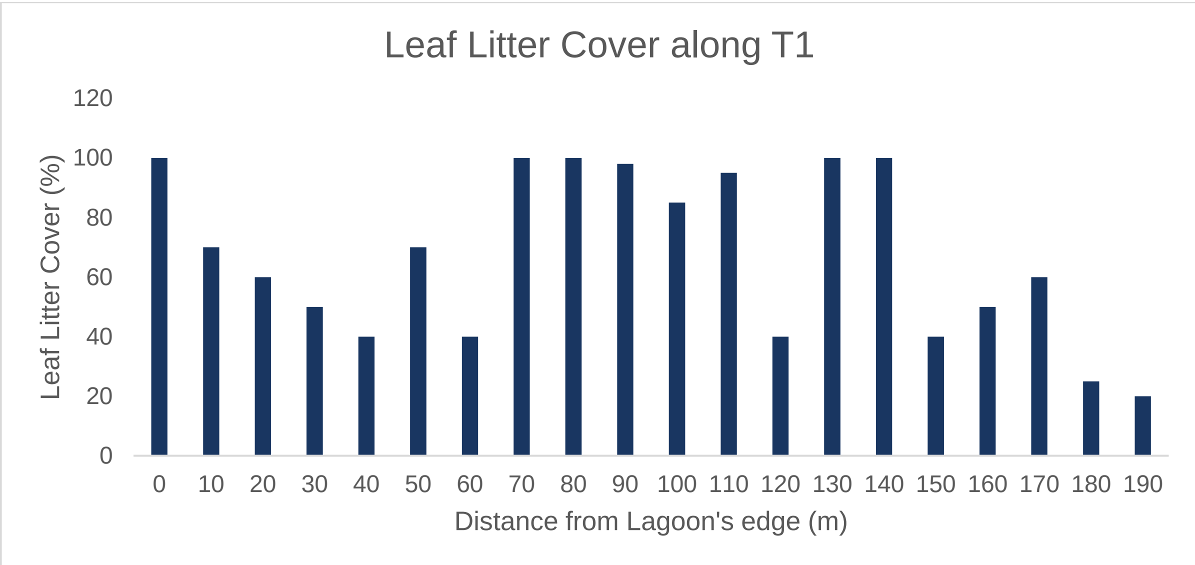
Graph 11: Vegetation Cover along T1



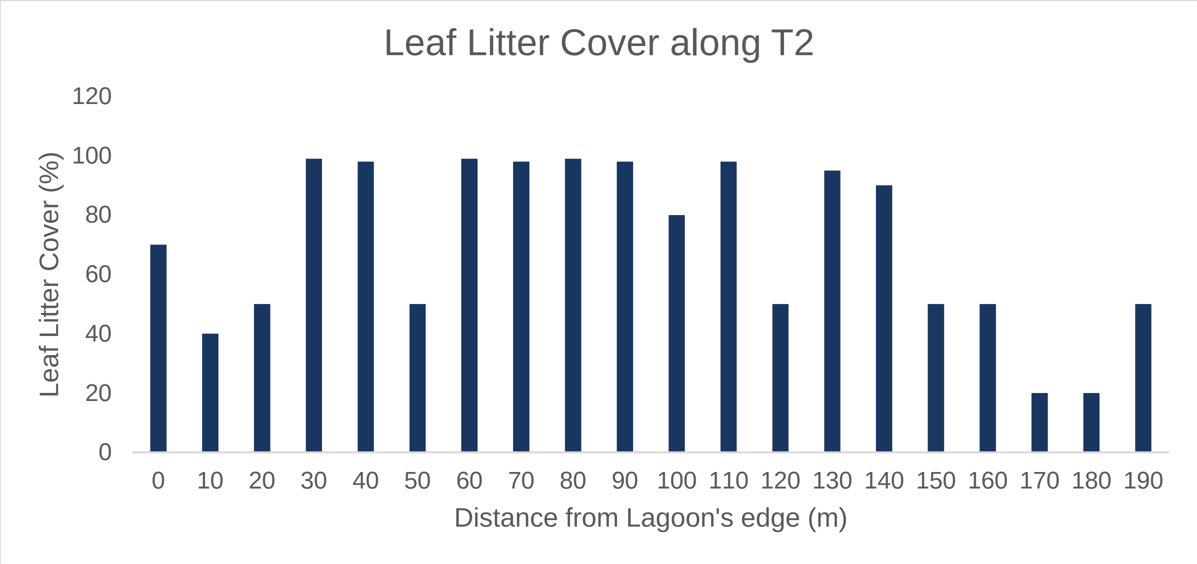
Graph 12: Vegetation Cover along T2

4.3.3 Leaf Litter Cover

No obvious trends in leaf litter cover were observed along T1 (**Graph 13**), however leaf litter cover was generally the greatest along the central quadrats. Leaf litter cover was also the greatest along the central quadrats of T2 (**Graph 14**).



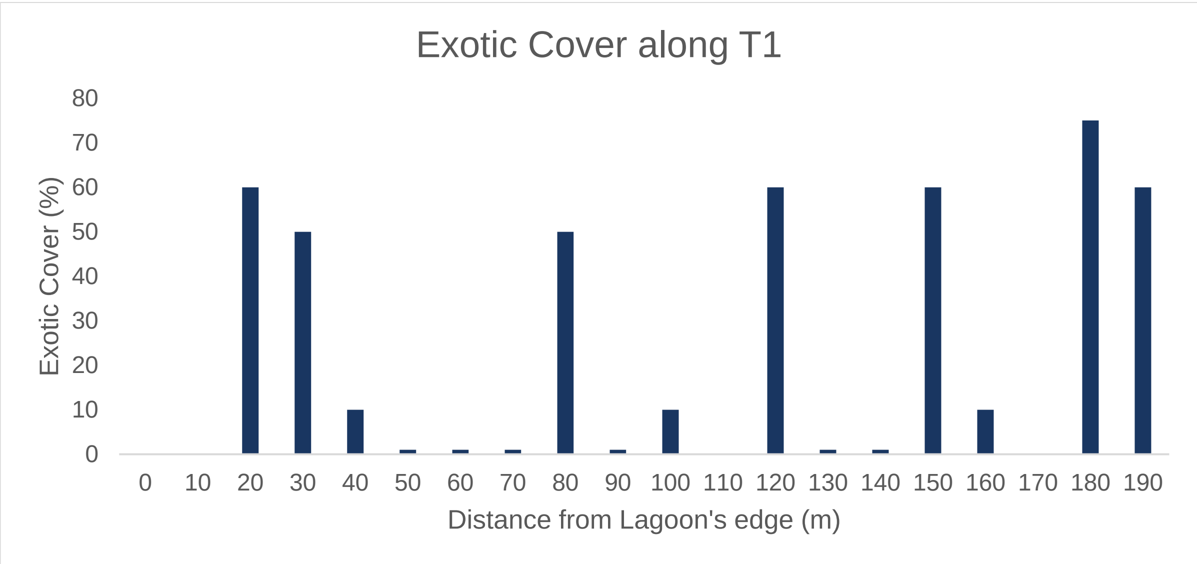
Graph 13: Leaf Litter Cover along T1



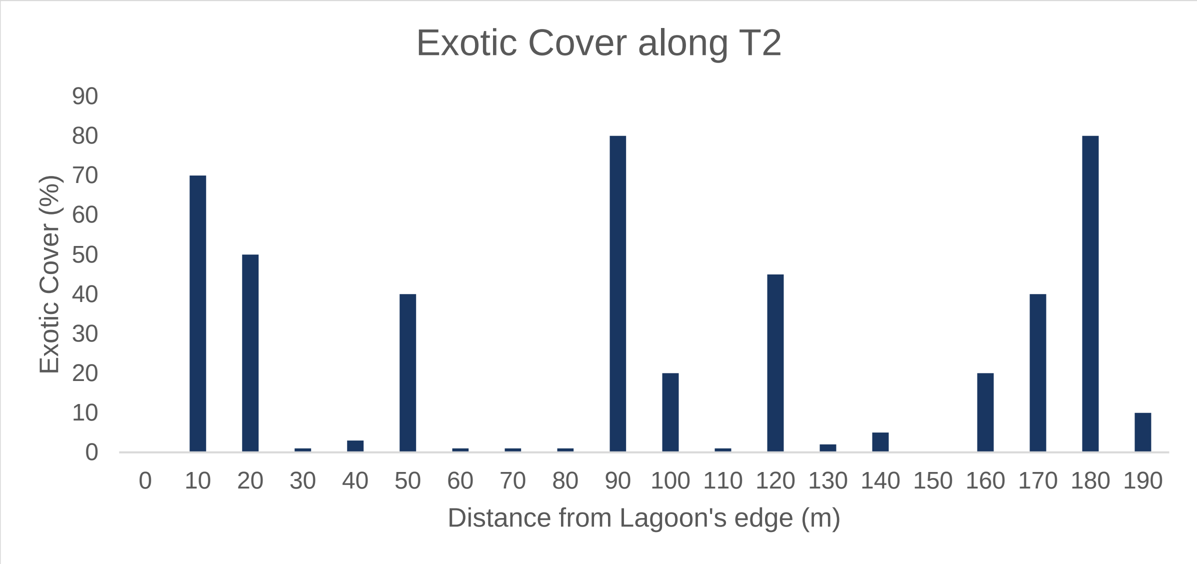
Graph 14: Leaf Litter Cover along T2

4.3.4 Exotic Cover

No obvious trends in exotic cover were observed along T1 (**Graph 15**) or T2 (**Graph 16**).



Graph 15: Exotic Cover along T1



Graph 16: Exotic Cover along T2

5 Summary and Recommendations

This report has been prepared to:

> Define baseline conditions of CPW within the Site at both affected and unaffected locations.

> Provide additional background into the floristic features of the site and vegetation quality.

> Develop a survey design to be used for future monitoring of CPW at specific locations.

Field surveys were undertaken to ensure a repeatable methodology permissive to further investigations or monitoring. As a result, historic data could only be used to provide an indication of any general trends or changes in vegetation condition that have occurred in affected areas of CPW. Additionally, the comparison of affected and unaffected plots has been undertaken to indicate any general differences that occur between these sites.

Historical data on native richness, exotic cover and length of fallen logs was compared to contemporary data to an indication of any general trends or changes in vegetation condition that have occurred in affected areas of CPW. Reductions in native richness were observed across all comparable plots. Some differences may have resulted from seasonal variation between surveys, in addition to impacts of temporary inundation. Additionally, no obvious trends in exotic cover were observed, with differences in magnitude and direction of change occurring between plots. Variation may have resulted from the proximity of plots to the Lagoon and edge effects. With the exception of one plot, the length of fallen logs increased significantly.

Unaffected plots exhibited a higher species richness and forb cover than affected plots, whilst affected plots had a significantly higher length of fallen logs compared to unaffected plots. Exotic cover and leaf litter were generally higher in affected plots, however no significant differences in these attributes occurred between affected and unaffected plots. These general trends may be attributed to inundation effects.

No obvious trends in vegetation cover, exotic cover or leaf litter cover were observed along the transects, however these areas were subject to inundation across their entirety. Species richness was generally low across the transects, increasing at the furthest points from the Lagoon. These patterns may be attributed to the effects of inundation on groundcover species not well adapted to flooding conditions.

A number of limitations were encountered during the surveys and data analyses. These included differences in the season of surveys between historic and contemporary data collection, variation in the sampling methodology, and the omission of historic plots due to inconsistencies in recorded data. As a result, the findings of this study are not directly comparable to those of the Downstream Ecological Assessment of the Warragamba Dam Raising (SMEC 2021). However, SMEC (2021) noted that temporary modifications to CPW, relating to fringing vegetation and erosion impacts, may occur as a result of inundation.

The results of this study indicated that, at the time of the assessment the areas of CPW subject to temporary inundation of CPW had:

> lower native species richness and vegetation cover (across all strata).
> increased cover of exotic species.
> increased debris, including woody debris, leaf litter and anthropogenic litter.

However, it must be noted that this study was a single event, providing a 'snapshot' of the conditions at the time of the assessment. Taking onto account the number of limitations relating to replication and the comparability of data, longer term investigations would be required to ascertain any consistent directional changes to CPW as a result of temporary inundation.

Data generated as a result of this study can be used to provide baseline conditions for further investigations. Further investigation is recommended, following the methodology that has been developed in this study, to monitor changes across individual plots to ensure the validity of conclusions drawn. Further studies could also incorporate relevant information from any future flooding event, such as flood extent, inundation time and time since last flooding event, and assess additional variables for each plot such as species composition and vegetation integrity values. Additionally, floristic changes could be assessed to identify whether flooding events may result in the introduction new exotic species or disproportionate effects on any specific native species or groups.

APPENDIX

A

FLORA INVENTORY

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Family	Scientific Name	Common Name	GF Code	N/E/HTW	BC Act	EPBC Act	1		2		3		4		5		6		7		8		9		10		11		12		13		14	
							Cover	Abundance	Cover	Abundance	Cover	Abundance	Cover	Abundance	Cover	Abundance	Cover	Abundance	Cover	Abundance	Cover	Abundance	Cover	Abundance	Cover	Abundance	Cover	Abundance	Cover	Abundance	Cover	Abundance	Cover	Abundance
Adiantaceae	Cheilanthes sieberi	Rock Fern	Fern	N	-	-	0.1	1	0.1	10	0.1	13	0.1	11									0.1	10	0.1	12			1	51			1	49
Anthericaceae	Dichopogon fimbriatus	Nodding Chocolate Lily	Forb	N	-	-			0.1	1																								
Apiaceae	Centella asiatica	Swamp Pennywort	Forb	N	-	-			0.1	1																								
Apiaceae	Hydrocotyle peduncularis	Pennywort	Forb	N	-	-					0.1	10	0.1	32																				
Apocynaceae	Parsonsia straminea	Common Silkpod	Vine	N	-	-															0.5	7												
Asparagaceae	Asparagus aethiopicus	Asparagus Fern	-	HTW	-	-			0.1	9	0.1	1	0.1	3			0.1	14					0.2	6			1	21	0.1	6	5	24	0.1	6
Asparagaceae	Asparagus asparagoides	Bridal Creeper	-	HTW	-	-	0.2	11											0.5	8	0.1	1			5	34								
Asteraceae	Bidens pilosa	Cobbler's Pegs	-	HTW	-	-															0.1	2												
Asteraceae	Calotis dentex	-	Shrub	N	-	-																							0.1	2				
Asteraceae	Cotula australis	Common Cotula	Forb	N	-	-																											0.1	2
Asteraceae	Lagenophora spp.	-	Forb	N	-	-					0.1	1																						
Asteraceae	Onopordum acanthium subsp. acanthium	Scotch Thistle	-	E	-	-			0.1	1	0.1	1	0.1	1																				
Asteraceae	Ozothamnus diosmifolius	Ball Everlasting	Shrub	N	-	-							30	111																				
Asteraceae	Senecio madagascariensis	Fireweed	-	HTW	-	-	0.1	4	0.2	58	0.2	38	0.5	47									0.1	17	0.1	6			0.1	2	0.1	2		
Asteraceae	Solenogyne bellioides	-	Forb	N	-	-																			0.1	21			1	62				
Asteraceae	Taraxacum officinale	Dandelion	-	E	-	-																	0.1	1										
Basellaceae	Anredera cordifolia	Madeira Vine	-	HTW	-	-																					0.1	1						
Cactaceae	Opuntia monacantha	Drooping Pear	-	HTW	-	-			0.1	1																								
Casuarinaceae	Casuarina glauca	Swamp Oak	Tree	N	-	-									60	54																		
Commelinaceae	Commelina cyanea	Native Wandering Jew	Forb	N	-	-	0.1	3													0.1	1												
Convolvulaceae	Dichondra repens	Kidney Weed	Forb	N	-	-	0.1	15	0.2	81	0.1	11	0.5	120	0.1	8	0.1	2			0.1	3	0.1	23	0.1	24	0.1	56	0.1	15	1	35	0.1	18

Family	Scientific Name	Common Name	GF Code	N/E/HTW	BC Act	EPBC Act	1 Cover	1 Abundance	2 Cover	2 Abundance	3 Cover	3 Abundance	4 Cover	4 Abundance	5 Cover	5 Abundance	6 Cover	6 Abundance	7 Cover	7 Abundance	8 Cover	8 Abundance	9 Cover	9 Abundance	10 Cover	10 Abundance	11 Cover	11 Abundance	12 Cover	12 Abundance	13 Cover	13 Abundance	14 Cover	14 Abundance
Convolvulaceae	Polymeria calycina	Bindweed	Vine	N	-	-																			0.1	2								
Cyperaceae	Cyperus gracilis	Slender Flat Sedge	Grass	N	-	-																							0.1	3				
Cyperaceae	Cyperus spp.	-	Grass	N	-	-			0.1	1			0.1	1					0.1	1			0.1	1										
Cyperaceae	Lepidosperma laterale	Variable Sword-sedge	Grass	N	-	-																							5	27	0.1	1		
Ericaceae	Leucopogon spp.	A Beard-heath	Shrub	N	-	-			0.1	3																								
Euphorbiaceae	Euphorbia hirta	Asthma Plant	-	E	-	-											0.1	15													1	36		
Fabaceae	Acacia falcata	-	Shrub	N	-	-																							0.1	2				
Fabaceae	Acacia parramattensis	Sydney Green Wattle	Tree	N	-	-																			1	3	1	1			1	24		
Fabaceae	Acacia pubescens	Downy Wattle	Shrub	N	V	V																							1	8				
Fabaceae	Acacia spp.	Wattle	Shrub	N	-	-					0.1	3	0.1	2									0.1	1										
Fabaceae	Dillwynia sieberi	Prickly Parrot-pea	Shrub	N	-	-																	0.1	12					5	53				
Fabaceae	Glycine clandestina	Twining Glycine	Vine	N	-	-							0.1	1																				
Fabaceae	Glycine spp.	-	Vine	N	-	-			1	103	0.1	6	0.1	5			0.1	3	0.1	3	0.1	1	0.1	13	0.1	15	0.1	3	0.1	1	0.1	11	0.1	2
Juncaceae	Juncus sp.	-	Grass	N	-	-			0.1	15	0.1	1	0.1	1	0.1	2			0.1	1			0.1	1										
Juncaceae	Juncus usitatus	Common Rush	Grass	N	-	-																					0.1	2	0.1	2				
Lobeliaceae	Lobelia gibbosa	Tall Lobelia	Forb	N	-	-			0.5	122	1	100	0.5	241					0.1	5			0.1	3	0.1	5	0.1	1	1	93			0.1	17
Lomandraceae	Lomandra filiformis	Wattle Matt-rush	Grass	N	-	-																					0.1	1					0.1	1
Lomandraceae	Lomandra multiflora subsp. multiflora	Many-flowered Mat-rush	Grass	N	-	-					0.1	1																	0.1	3				
Malvaceae	Pavonia hastata	Pavonia	-	E	-	-	0.1	43	0.1	9	10	40	0.1	1																			5	31
Malvaceae	Sida rhombifolia	Paddy's Lucerne	-	E	-	-	0.1	3	0.1	1					0.1	1	0.1	19	0.1	5			0.1	32			0.2	91			10	206	5	89
Myrtaceae	Eucalyptus crebra	Narrow-leaved Ironbark	Tree	N	-	-	30	14	30	19	60	25	70	59					5	1							5	1	5	1				

							1		2		3		4		5		6		7		8		9		10		11		12		13		14	
Family	Scientific Name	Common Name	GF Code	N/E/H TW	BC Act	EP BC Act	Cover	Abundance	Cover	Abundance	Cover	Abundance	Cover	Abundance	Cover	Abundance	Cover	Abundance	Cover	Abundance	Cover	Abundance	Cover	Abundance	Cover	Abundance	Cover	Abundance	Cover	Abundance	Cover	Abundance	Cover	Abundance
Myrtaceae	Eucalyptus moluccana	Grey Box	Tree	N	-	-			5	1	10	4					40	5	30	5			40	4	60	16	15	1	50	5	45	10	20	7
Myrtaceae	Eucalyptus sieberi	Silvertop Ash	Tree	N	-	-																			2	1								
Myrtaceae	Eucalyptus tereticornis	Forest Red Gum	Tree	N	-	-	5	2			5	1	5	2			10	3	10	2	25	4	5	2	5	1	50	10	15	6			10	2
Myrtaceae	Melaleuca stypheloides	Prickly-leaved Tea Tree	Shrub	N	-	-							1	2																			60	11
Ochnaceae	Ochna serrulata	Mickey Mouse Plant	-	HTW	-	-											0.1	1																
Oleaceae	Ligustrum sinense	Small-leaved Privet	-	HTW	-	-	15	29	0.1	1					30	69	0.1	1	0.1	2	70	124					0.1	3					1	2
Oxalidaceae	Oxalis perrenans	Yellow-flowered Wood Sorrel	Forb	N	-	-									0.1	23	0.1	1	0.1	1	0.1	10					0.1	1						
Passifloraceae	Passiflora spp.	-	-	E	-	-															0.1	2												
Phormiaceae	Dianella spp.	-	Forb	N	-	-											0.1	3	0.1	1	0.1	9	0.2	21	0.1	3			0.1	2				
Pittosporaceae	Bursaria spinosa	Native Blackthorn	Shrub	N	-	-			0.2	6	5	7	5	18			0.1	1	0.1	2			40	34	40	44	5	6	5	34	40	60	5	5
Plantaginaceae	Plantago lanceolata	Ribwort	-	E	-	-			0.1	1																								
Poaceae	Aristida vagans	Three-awn Speargrass	Grass	N	-	-			1	78	0.1	2											0.1	8					10	43			0.1	1
Poaceae	Bothriochloa macra	Red Grass	Grass	N	-	-																									0.1	2		
Poaceae	Cenchrus echinatus	Mossman River Grass	-	E	-	-													0.1	3														
Poaceae	Chloris truncata	Windmill Grass	Grass	N	-	-			0.1	1																								
Poaceae	Chloris ventricosa	Tall Chloris	Grass	N	-	-																									1	24		
Poaceae	Cymbopogon refractus	Barbwire Grass	Grass	N	-	-			0.2	13	0.1	1											0.1	1					1	36				
Poaceae	Dichanthium spp.	A Bluegrass	Grass	N	-	-			0.1	3																								
Poaceae	Dichelachne spp.	A Plumegrass	Grass	N	-	-	0.1	1	0.2	51	0.2	8	0.1	1					0.1	4			0.1	6	0.1	1							0.1	1
Poaceae	Echinopogon ovatus	Forest Hedgehog Grass	Grass	N	-	-																			0.1	2	0.1	5			0.1	1	0.1	3

							1		2		3		4		5		6		7		8		9		10		11		12		13		14	
Family	**Scientific Name**	**Common Name**	**GF Code**	**N/E/HTW**	**BC Act**	**EPBC Act**	**Cover**	**Abundance**	**Cover**	**Abundance**	**Cover**	**Abundance**	**Cover**	**Abundance**	**Cover**	**Abundance**	**Cover**	**Abundance**	**Cover**	**Abundance**	**Cover**	**Abundance**	**Cover**	**Abundance**	**Cover**	**Abundance**	**Cover**	**Abundance**	**Cover**	**Abundance**	**Cover**	**Abundance**	**Cover**	**Abundance**
Poaceae	Echinopogon spp.	A Hedgehog Grass	Grass	N	-	-																	0.1	1					0.1	6	0.1	2		
Poaceae	Ehrharta erecta	Panic Veldtgrass	-	HTW	-	-																											0.1	10
Poaceae	Entolasia marginata	Bordered Panic	Grass	N	-	-																							10	42			0.1	1
Poaceae	Eragrostis brownii	Brown's Lovegrass	Grass	N	-	-			0.1	5																								
Poaceae	Eragrostis curvula	African Lovegrass	-	HTW	-	-	0.1	1															20	100					1	12	0.1	1		
Poaceae	Microlaena stipoides	Weeping Grass	Grass	N	-	-	30	661	40	2000	61	10000	40	2000					40	1000	0.1	1	60	1000	60	1000	50	1000	0.1	16	0.1	5	80	>1000
Poaceae	Oplismenus aemulus	Basket Grass	Grass	N	-	-	30	1064	0.1	7							5	56	40	1000	10	1000	0.1	15	20	800	20	325			70	>1000	0.1	12
Poaceae	Paspalidium distans	-	Grass	N	-	-			0.1	2			0.1	1	20	1000	0.1	1					1	58	0.1	6	0.1	1	5	28	0.1	2	0.1	1
Poaceae	Paspalum dilatatum	Paspalum	-	HTW	-	-							0.1	3																				
Poaceae	Paspalum distichum	Water Couch	Grass	N	-	-	0.1	10																										
Poaceae	Paspalum spp.	-	Grass	N	-	-																					0.1	1						
Poaceae	Rytidosperma spp.	A Wallaby Grass	Grass	N	-	-			0.1	1	0.1	1																						
Poaceae	Setaria spp.	-	Grass	N	-	-											1	51																
Poaceae	Sporobolus creber	Slender Rat's Tail Grass	Grass	N	-	-																	0.1	11										
Poaceae	Themeda australis	Kangaroo Grass	Grass	N	-	-																	0.1	2					0.1	2				
Polygonaceae	Persicaria spp.	Knotweed	Forb	N	-	-																					0.1	2						
Primulaceae	Anagallis arvensis	Scarlet Pimpernel	-	E	-	-			0.1	1																								
Proteaceae	Grevillea robusta	Silky Oak	Tree	N	-	-																					5	1						
Rubiaceae	Pomax umbellata	Pomax	Forb	N	-	-																							1	107				
Santalaceae	Exocarpos cupressiformis	Native Cherry	Shrub	N	-	-													10	3									0.1	4				
Sapindaceae	Cardiospermum grandiflorum	Balloon Vine	-	HTW	-	-															0.1	3												

							1		2		3		4		5		6		7		8		9		10		11		12		13		14	
Family	**Scientific Name**	**Common Name**	**GF Code**	**N/E/HTW**	**BC Act**	**EPBC Act**	**Cover**	**Abundance**	**Cover**	**Abundance**	**Cover**	**Abundance**	**Cover**	**Abundance**	**Cover**	**Abundance**	**Cover**	**Abundance**	**Cover**	**Abundance**	**Cover**	**Abundance**	**Cover**	**Abundance**	**Cover**	**Abundance**	**Cover**	**Abundance**	**Cover**	**Abundance**	**Cover**	**Abundance**	**Cover**	**Abundance**
Scrophulariaceae	Veronica plebeia	Creeping Speedwell	Forb	N	-	-																							0.1	1				
Solanaceae	Solanum prinophyllum	Forest Nightshade	Forb	N	-	-			0.1	2																								
Solanaceae	Solanum spp.	-	Forb	N	-	-									0.1	6																		
Verbenaceae	Lantana camara	Lantana	-	HTW	-	-	5	4	0.1	3	0.1	1	1	6																	0.1	1		
-	-	Uknown (Dry)			-	-																					40	27						
-	-	Uknown Exotic			-	-																					0.1	1						

APPENDIX

B

PLOT AND TRANSECT PHOTOS

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PLOT AND TRANSECT PHOTOS


Plot 1 Start


Plot 1 End


Plot 2 Start


Plot 2 End


Plot 3 Start


Plot 3 End


Plot 4 Start


Plot 4 End


Plot 5 Start


Plot 5 End


Plot 6 Start


Plot 6 End

 Plot 7 Start	 Plot 7 End
 Plot 8 Start	 Plot 8 End
 Plot 9 Start	 Plot 9 End

 Plot 10 Start	 Plot 10 End
 Plot 11 Start	 Plot 11 End
 Plot 12 Start	 Plot 12 End


Plot 13 Start


Plot 13 End


Plot 14 Start


Plot 14 End

APPENDIX

C

TRANSECT DATA

Transect	Meterage	Easting	Northing	Richness		Dominant species			Cover (%)				
				Species	Native	Canopy	Midstory	Groundcover	Canopy	Midstory	Ground	Leaf Litter	Exotic
T1	190	304261	6282596	1	1	*Casuarina glauca*	-	-	80	0	0	100	0
T1	180	304270	6282586	1	1	-	*Casuarina glauca*	-	0	5	0	70	0
T1	170	304282	6282584	4	3	-	*Ligustrum sinense*	*Dichondra repens*	0	60	5	60	60
T1	160	304288	6282579	3	1	-	*Ligustrum sinense*	Germinating grasses (exotic)	0	50	5	50	50
T1	150	304297	6282576	6	4	*Melaleuca stypheloides*	-	*Dichondra repens, Oxalis perennans*	20	0	60	40	10
T1	140	304310	6282574	3	1	-	-	Germinating grasses (exotic)	0	0	30	70	1
T1	130	304318	6282568	5	3	*Melaleuca stypheloides*	-	-	100	0	1	40	1
T1	120	304324	6282564	5	3	*Casuarina glauca, Melaleuca stypheloides*	*Ligustrum sinense*	-	90	5	1	100	1
T1	110	304334	6282560	4	2	*Casuarina glauca*	*Ligustrum sinense*	-	90	50	5	100	50
T1	100	304343	6282558	5	3	*Casuarina glauca*	-	*Dichondra repens*	90	0	2	98	1
T1	90	304351	6282552	5	3	*Casuarina glauca*	-	Germinating grasses (exotic), *Sida rhombifolia*	80	0	15	85	10

Transect	Meterage	Easting	Northing	Richness		Dominant species			Cover (%)				
				Species	Native	Canopy	Midstory	Groundcover	Canopy	Midstory	Ground	Leaf Litter	Exotic
T1	80	304362	6282549	2	2	*Casuarina glauca*	-	-	70	0	1	95	0
T1	70	304373	6282546	5	2	*Casuarina glauca, Eucalyptus moluccana*	-	Germinating grasses (exotic), *Sida rhombifolia*	60	0	60	40	60
T1	60	304382	6282543	4	2	*Casuarina glauca, Eucalyptus moluccana*	-	*Asparagus asparagoides*	80	0	1	100	1
T1	50	304391	6282540	4	2	*Casuarina glauca, Eucalyptus moluccana*	-	Germinating grasses (exotic), *Sida rhombifolia*	100	0	1	100	1
T1	40	304402	6282538	6	2	*Eucalyptus moluccana*	-	Germinating grasses (exotic), *Glycine clandestina*	100	0	60	40	60
T1	30	304408	6282535	7	4	*Acacia binervia*	-	Germinating grasses (exotic), *Sida rhombifolia*	10	0	10	50	10
T1	20	304420	6282532	5	5	*Eucalyptus crebra, Eucalyptus moluccana*	-	*Lomandra* sp., *Oxalis perannens*	60	0	5	60	0
T1	10	304429	6282527	7	5	*Eucalyptus crebra*	-	Germinating grasses (exotic), *Dichondra repens, Asparagus asparagoides*	60	0	75	25	75
T1	0	304438	6282523	8	3	*Eucalyptus crebra,*	-	Germinating grasses	50	0	80	20	60

Transect	Meterage	Easting	Northing	Richness		Dominant species			Cover (%)				
				Species	Native	Canopy	Midstory	Groundcover	Canopy	Midstory	Ground	Leaf Litter	Exotic
						Eucalyptus moluccana		(exotic), *Sida rhombifolia*					
T2	190	304375	6282724	1	1	*Casuarina glauca*	-	-	40	0	0	70	0
T2	180	304385	6282725	8	5	*Casuarina glauca*	-	Germinating grasses (exotic), *Hydrocotyle sibthorpiodes*	80	0	85	40	70
T2	170	304394	6282722	4	0	-	-	-	0	0	50	50	50
T2	160	304403	6282724	4	2	*Eucalyptus tereticornis*	-	-	90	0	1	99	1
T2	150	304412	6282729	7	4	*Eucalyptus tereticornis*	*Ligustrum sinense*	Seedlings	90	2	2	98	3
T2	140	304425	6282728	1	0	-	-	Germinating grasses (exotic)	0	0	40	50	40
T2	130	304430	6282735	5	3	*Eucalyptus tereticornis*	-	*Dichondra repens*, *Lomandra longifolia*	90	0	5	99	1
T2	120	304441	6282737	6	4	*Melaleuca stypheloides*	-	*Anagallis arvensis*	100	0	2	98	1
T2	110	304445	6282745	4	2	-	-	*Sida rhombifolia*	0	0	1	99	1
T2	100	304458	6282738	6	3	*Eucalyptus crebra*	*Ligustrum sinense*	*Dichondra repens*, *Sida rhombifolia*	40	80	2	98	80
T2	90	304463	6282731	10	4	*Eucalyptus crebra*, *Eucalyptus tereticornis*	-	*Ligustrum sinense* seedlings	95	0	20	80	20

Transect	Meterage	Easting	Northing	Richness		Dominant species			Cover (%)				
				Species	Native	Canopy	Midstory	Groundcover	Canopy	Midstory	Ground	Leaf Litter	Exotic
T2	80	304473	6282730	8	3	*Eucalyptus crebra*, *Eucalyptus tereticornis*	-	*Ligustrum sinense* seedlings, *Sida rhombifolia*	30	0	2	98	1
T2	70	304480	6282733	8	2	-	-	*Sida rhombifolia*, Germinating grasses (exotic)	0	0	50	50	45
T2	60	304494	6282733	8	5	*Eucalyptus crebra*, *Eucalyptus tereticornis*	-	*Glycine clandestina*, *Paspalidium distans*	30	0	2	95	2
T2	50	304501	6282725	10	4	*Eucalyptus crebra*, *Melaleuca stypheloides*	-	*Rumex sp.*, *Oxalis perennans*	40	0	10	90	5
T2	40	304509	6282723	1	1	-	-	*Entolasia marginata*	0	0	50	50	0
T2	30	304518	6282717	11	5	*Eucalyptus crebra*	-	*Paspalidium distans*, Germinating grasses (exotic)	40	0	50	50	20
T2	20	304526	6282716	7	4	*Eucalyptus crebra*	-	*Oplismenus aemulus*, Germinating grasses (exotic)	70	0	80	20	40
T2	10	304533	6282712	9	3	*Eucalyptus crebra*, *Eucalyptus tereticornis*	-	*Sida rhombifolia*, Germinating grasses (exotic)	90	0	80	20	80
T2	0	304537	6282706	7	3	*Casuarina glauca*	-	*Oplismenus aemulus*, Germinating grasses (exotic)	40	0	60	50	10

Transect	Meterage	Easting	Northing	Richness		Dominant species			Cover (%)				
				Species	Native	Canopy	Midstory	Groundcover	Canopy	Midstory	Ground	Leaf Litter	Exotic

APPENDIX D

ADDITIONAL GRAPHS

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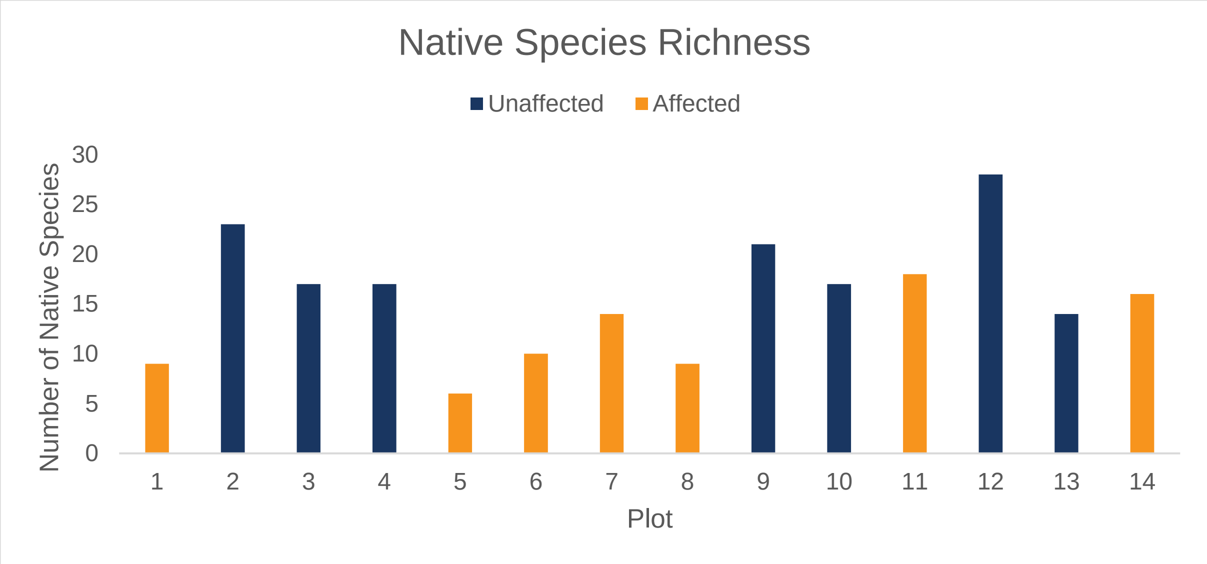
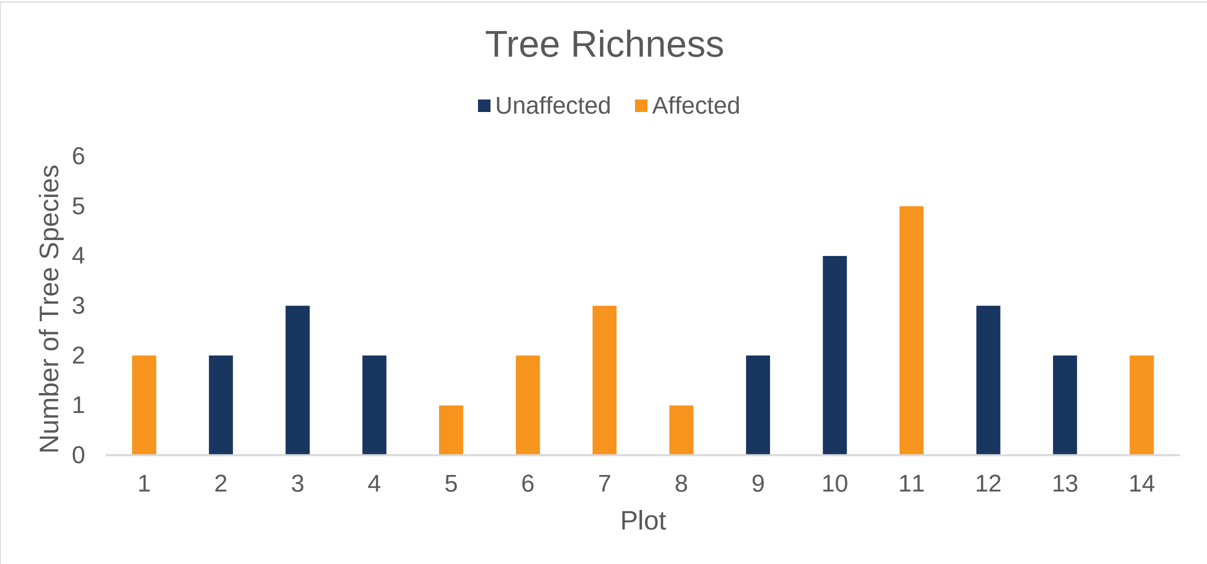
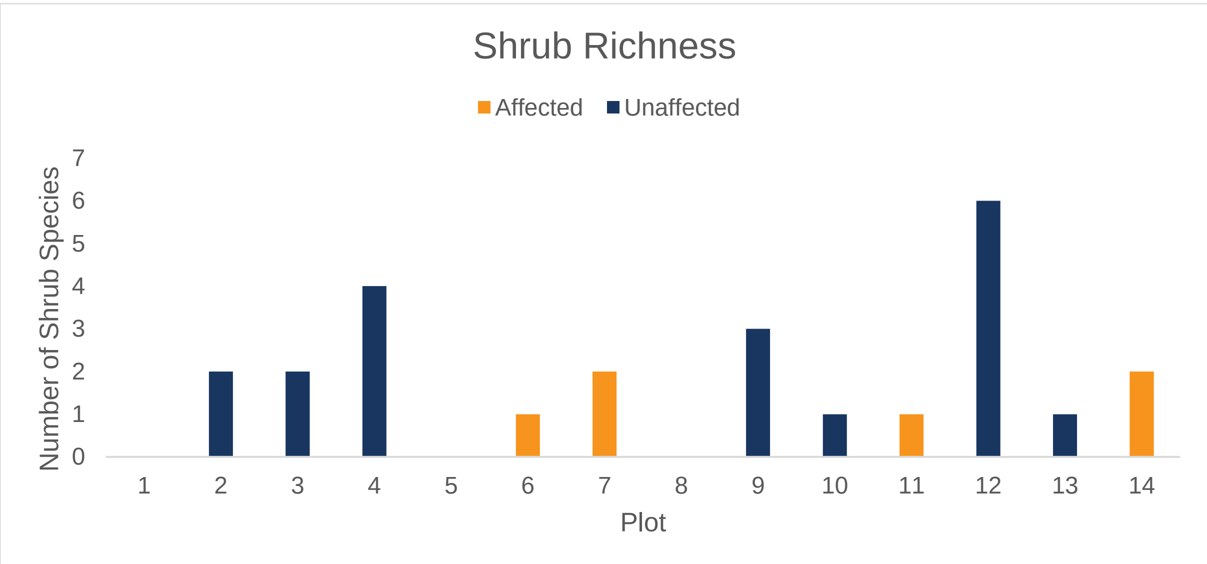
NATIVE SPECIES RICHNESS (BY GROWTH FORM) OF AFFECTED AND UNAFFECTED PLOTS



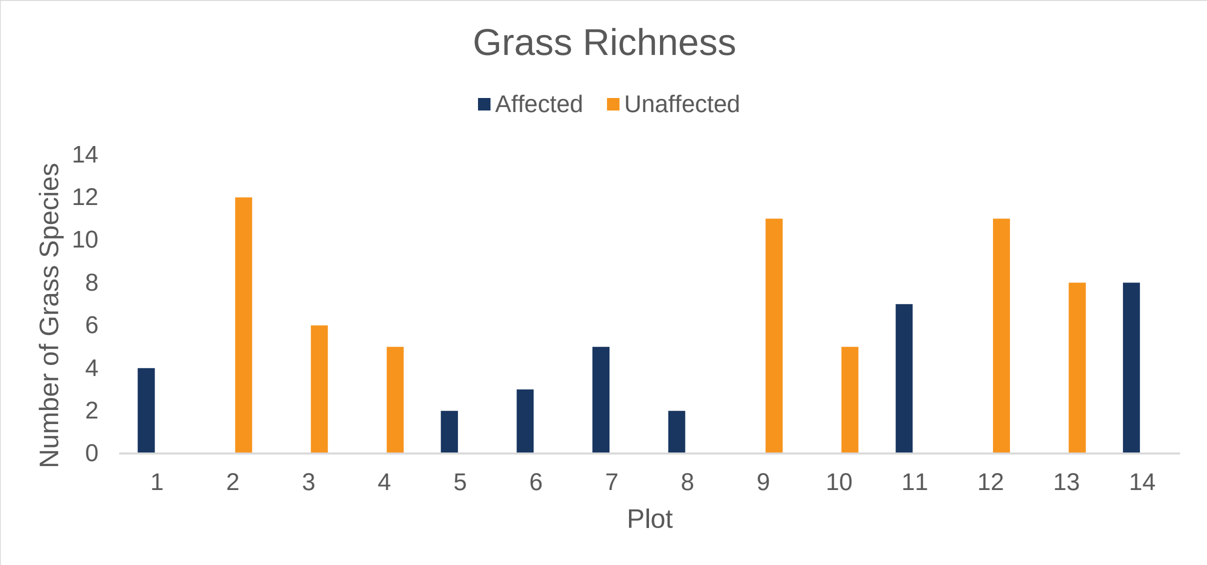
Graph D1: Native Species Richness within Affected and Unaffected Plots. Note Plot 5 is commensurate with PCT 835 and was also below benchmark conditions.



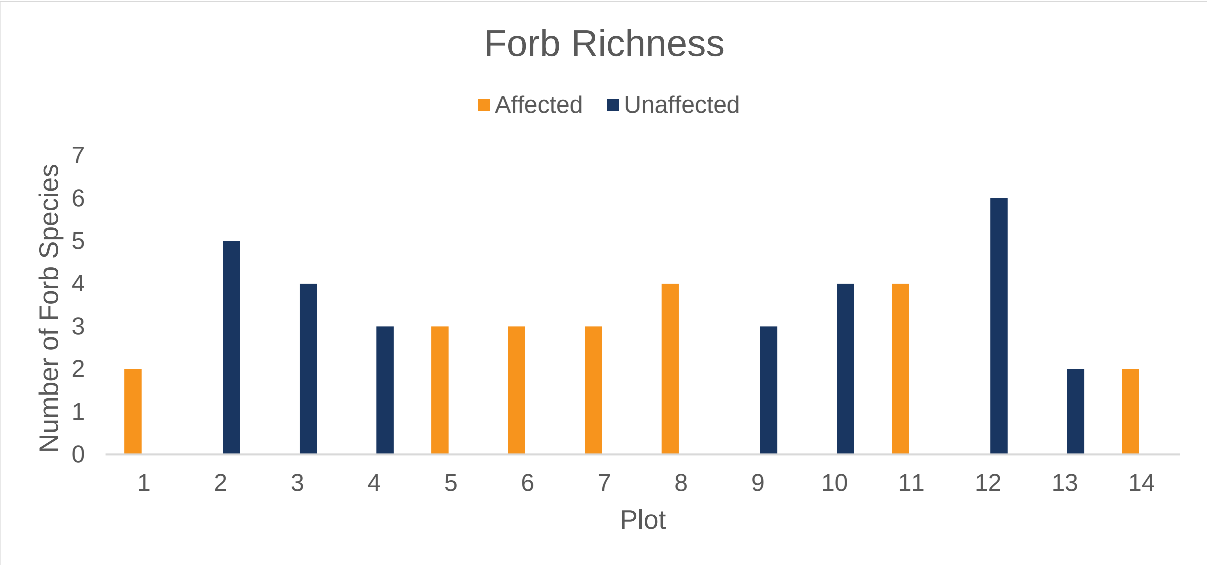
Graph D2: Richness of Tree Species in Affected and Unaffected Plots



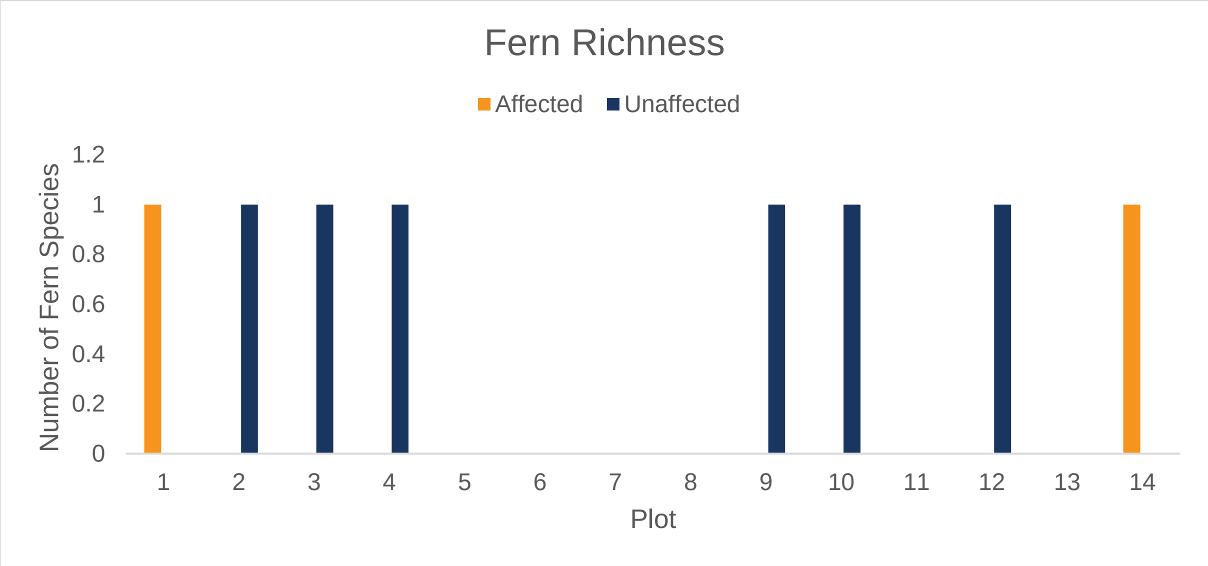
Graph D3: Richness of Shrub Species in Affected and Unaffected Plots



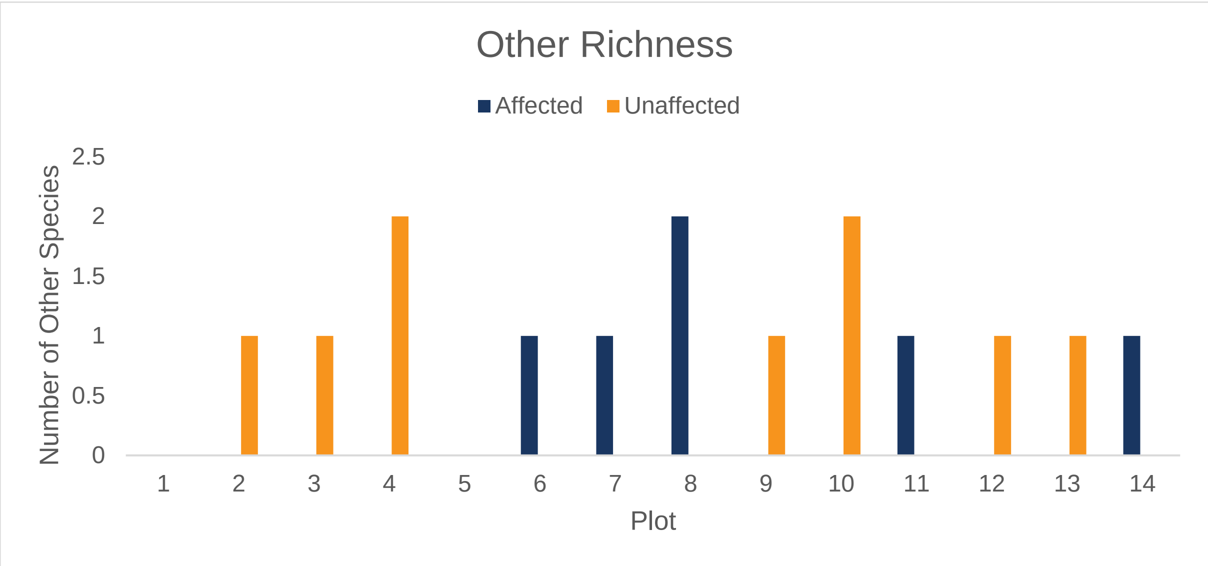
Graph D4: Richness of Grass Species in Affected and Unaffected Plots



Graph D5: Richness of Forb Species in Affected and Unaffected Plots

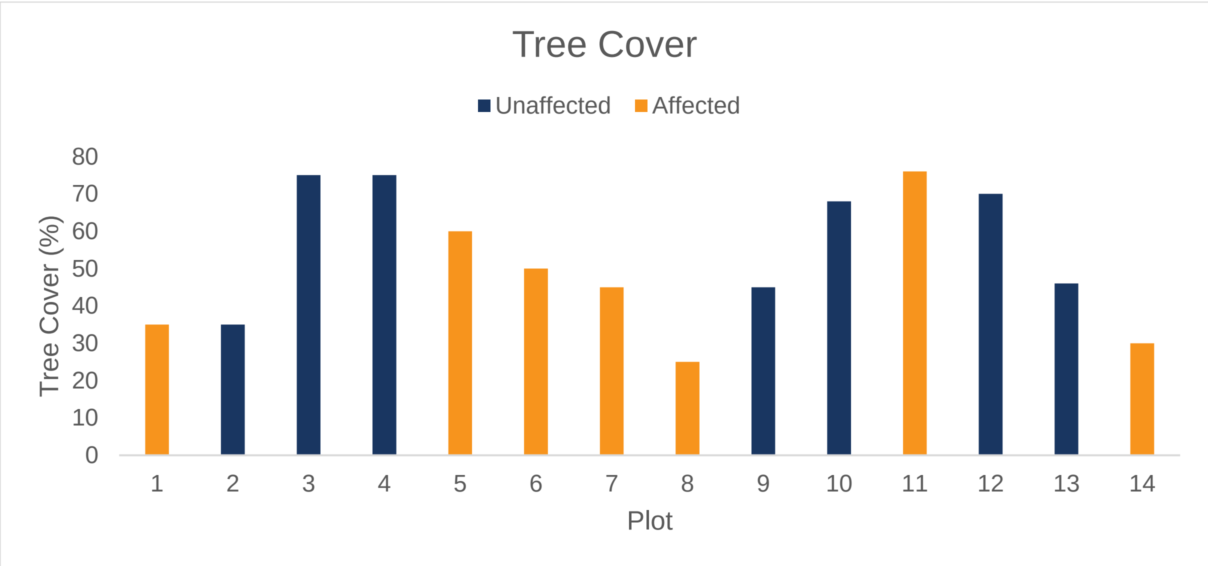


Graph D6: Richness of Fern Species in Affected and Unaffected Plots

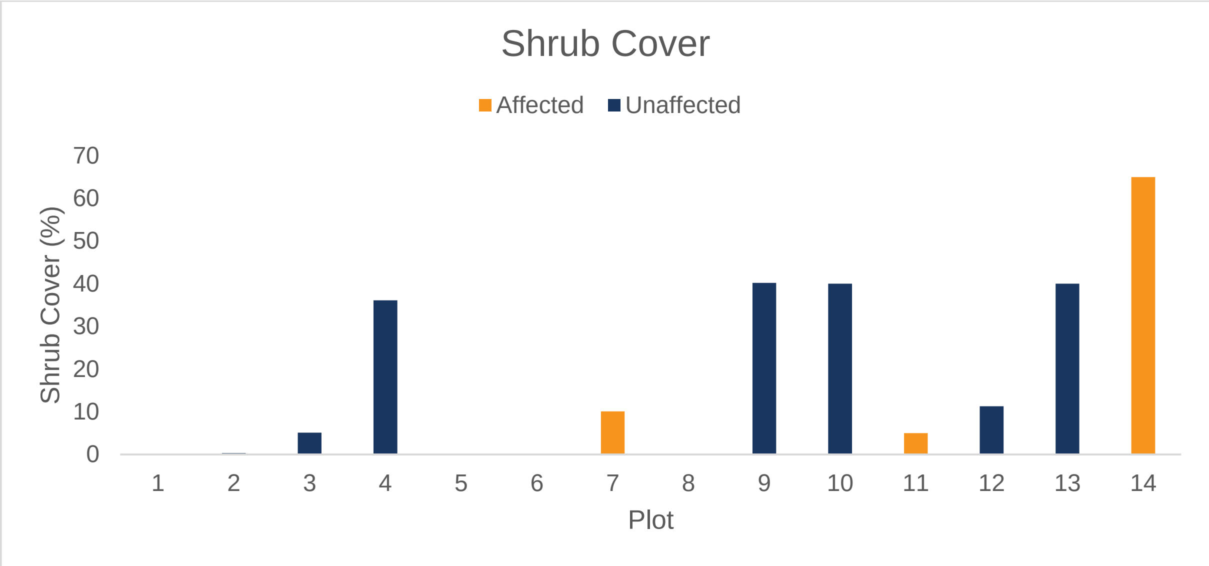


Graph D7: Richness of Other Species in Affected and Unaffected Plots

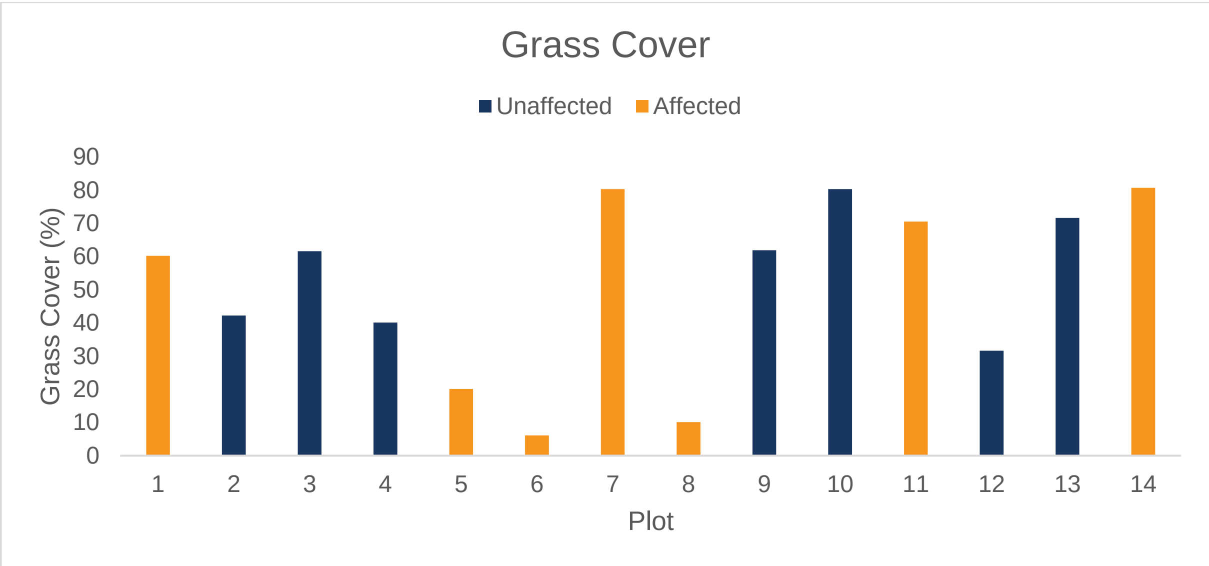
NATIVE VEGETATION COVER (BY GROWTH FORM) OF AFFECTED AND UNAFFECTED PLOTS



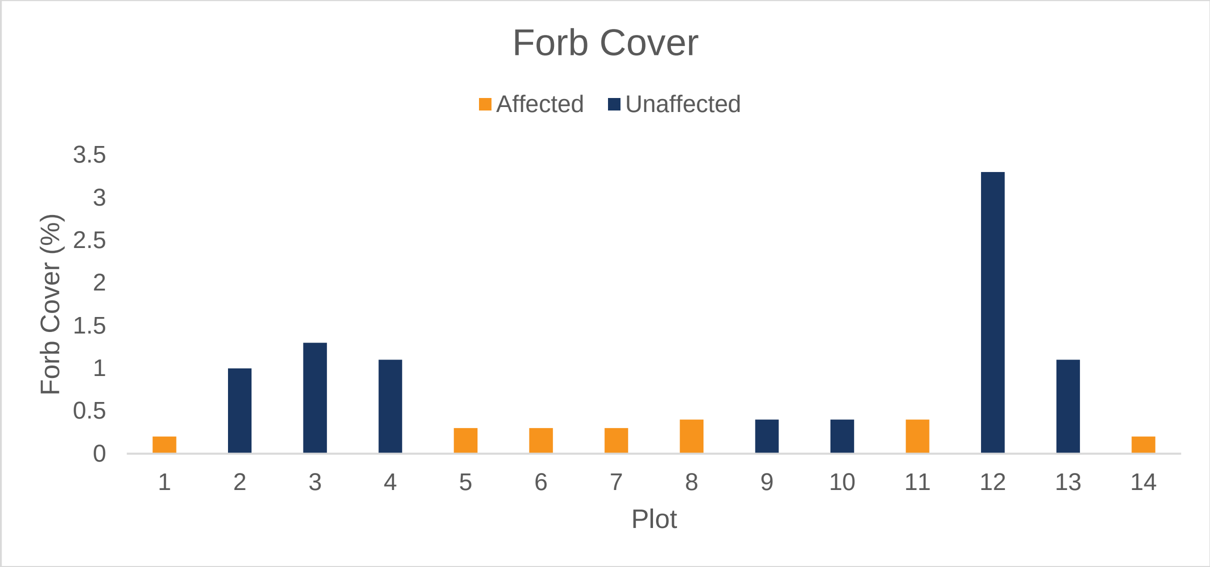
Graph D8: Native Tree Cover in Affected and Unaffected Plots



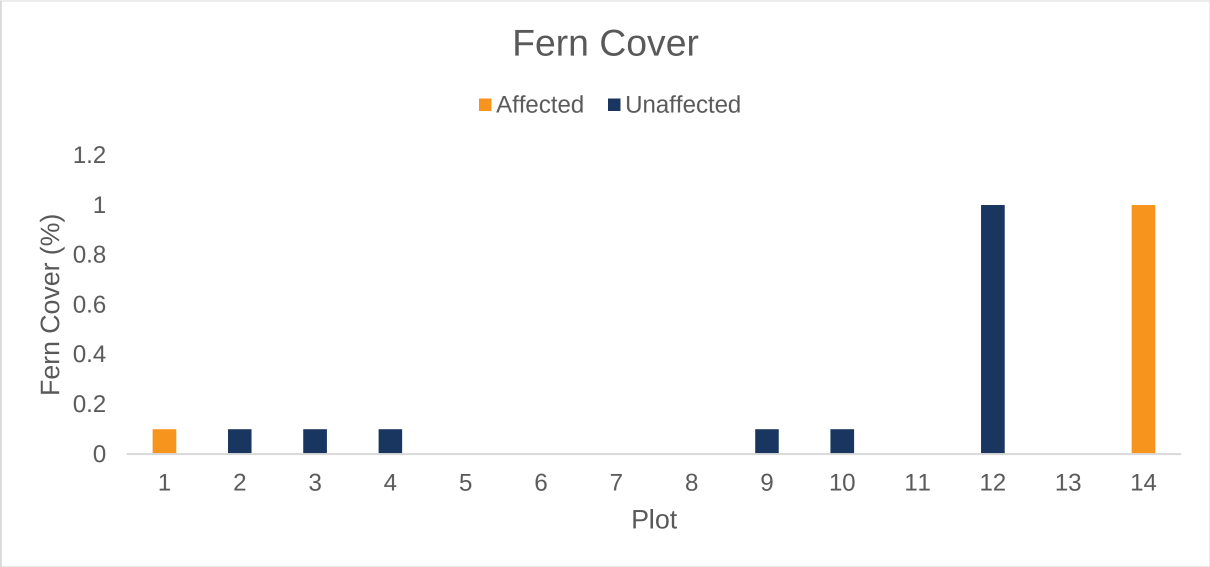
Graph D9: Native Shrub Cover in Affected and Unaffected Plots



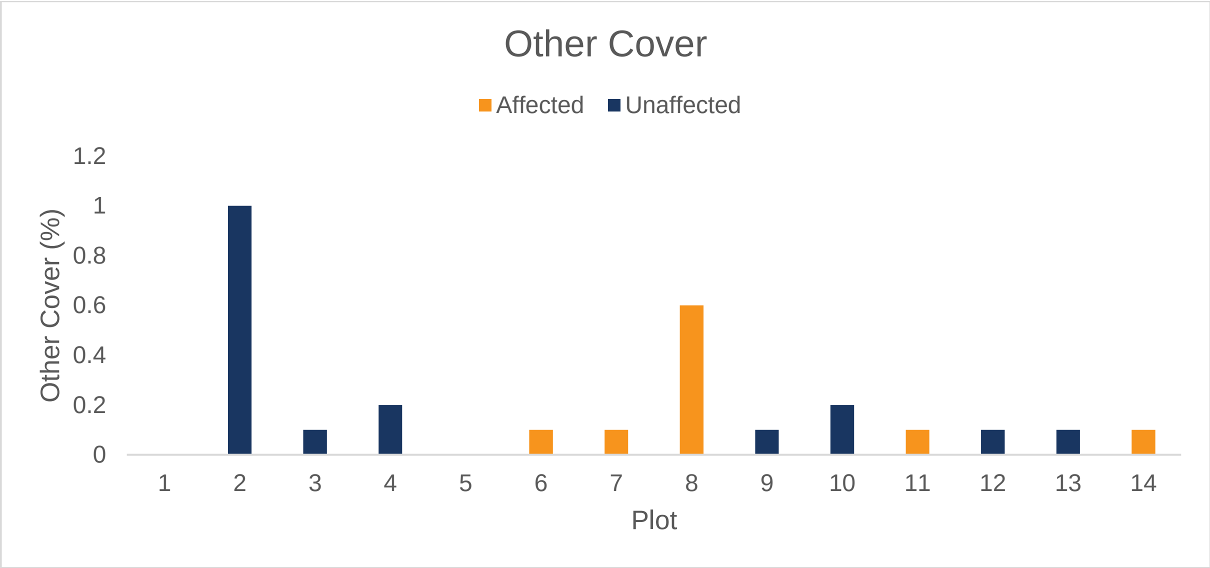
Graph D10: Native Grass Cover in Affected and Unaffected Plots



Graph D11: Native Forb Cover in Affected and Unaffected Plots



Graph D12: Native Fern Cover in Affected and Unaffected Plots



Graph D13: Native Other Cover in Affected and Unaffected Plots

Appendix F

Supplementary Aboriginal cultural heritage assessment

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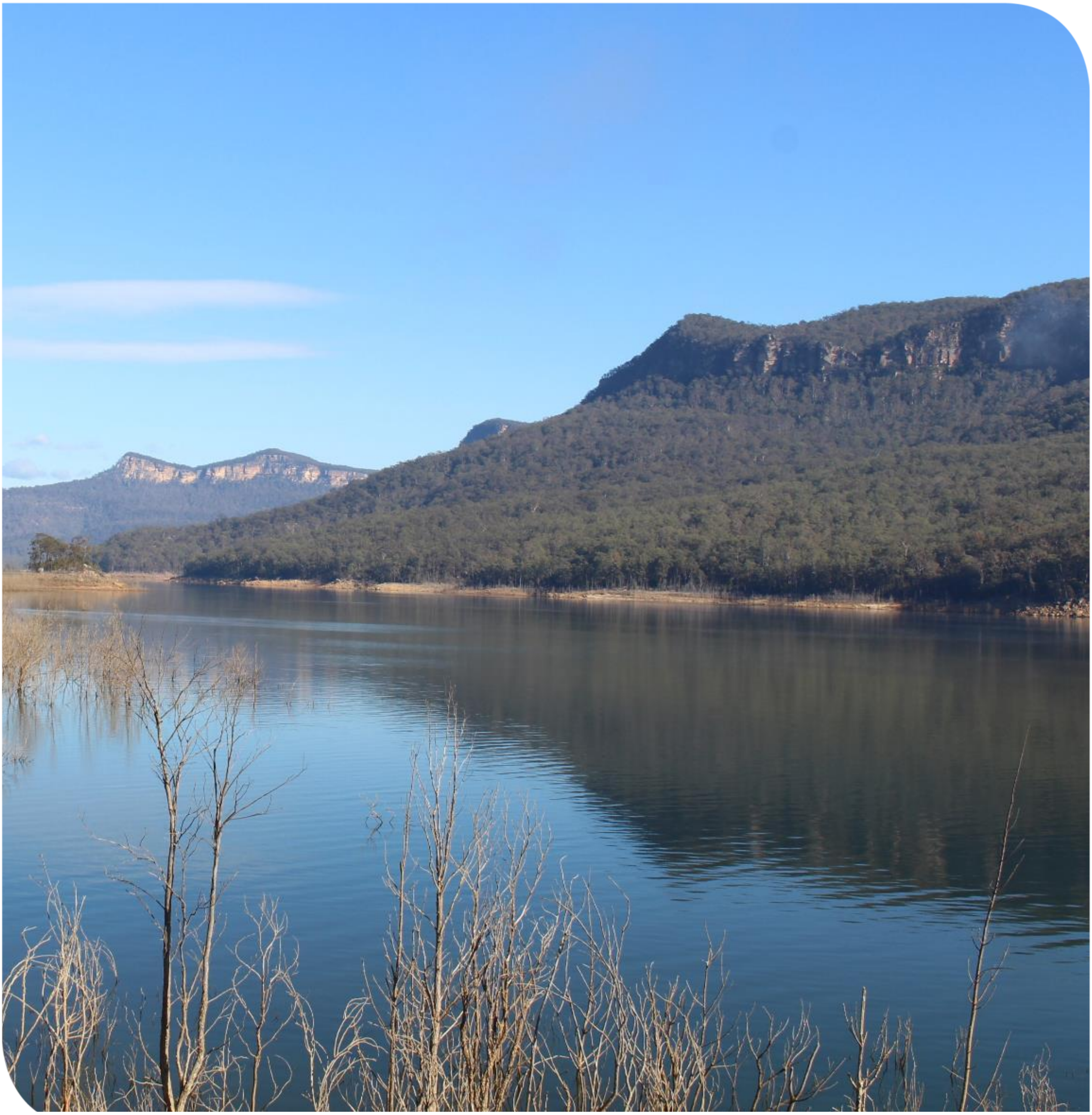
Supplementary Assessment to the Aboriginal Cultural Heritage Assessment Warragamba Dam Raising Warragamba, NSW

Prepared for SMEC Australia Pty Ltd on behalf of WaterNSW

Prepared by Niche Environment and Heritage Pty Ltd 27 October 2022



Executive summary

Background and overview

WaterNSW is seeking environmental planning approvals for the Warragamba Dam Raising Project (the Project) which aims to provide flood storage capacity in the Lake Burragorang catchment (Warragamba Catchment) to facilitate flood mitigation downstream of Warragamba Dam. The potential impact of the Project on Aboriginal cultural heritage was assessed as part of the Environmental Impact Statement (EIS) prepared for the project and is presented in *Appendix K: Aboriginal Cultural Heritage Assessment Report – Warragamba Dam Raising Project,* 10 September 2021, prepared by Niche Environment and Heritage Pty Ltd (Niche) (Aboriginal Cultural Heritage Assessment Report, or ACHA). The ACHA was prepared to address the Secretary's Environmental Assessment Requirements (SEARs) for the Project and to inform the EIS to be assessed under Division 5.2 of Part 5 of the *NSW Environmental Planning and Assessment Act 1979* (EP&A Act) as State Significant Infrastructure (SSI). The ACHA incorporated findings from an Archaeological Report (AR) and a Cultural Values Assessment Report (CVAR) which were completed to inform the assessment.

The EIS, including ACHA, were placed on public exhibition on 29 September 2021 to 19 December 2021 inclusive. During assessment of the EIS, the NSW Department of Planning and Environment (DPE) requested the preparation of a Preferred Infrastructure Report (PIR). With regard to Aboriginal cultural heritage the PIR required:

(1) ongoing consultation with the Aboriginal community which appropriately considers and addresses their comments and concerns,

(2) additional work completed in response to issues raised by submissions to identify and assess Aboriginal cultural values likely to be impacted by the proposal, including further field studies, and

(3) mitigation and management measures for any impacts to Aboriginal heritage, both tangible and intangible.

Niche was engaged by SMEC on behalf of WaterNSW to prepare a supplementary assessment to satisfy the Aboriginal cultural heritage requirements of the PIR and to respond to submissions received during the public exhibition of the Warragamba Dam Raising (WDR) Project EIS. It is not the purpose of this supplementary assessment to replace or supersede the original ACHA, the CVA or the AR tendered with the EIS. Rather this supplementary assessment should be read in conjunction with the original documents and provides additional information, and supplementary assessment to address the submissions made by agencies and other parties in response to the EIS, and to provide a robust foundation on which the PIR can be informed.

The assessment requirements and objectives for the supplementary assessment were developed based on the requirements of PIR and an analysis of the submissions received during the public exhibition of the EIS and therefore include:

- A program of continued Aboriginal community consultation.
- Provision of additional background information, detail and updated register searches.
- A review and update of the predictive model, particularly regarding the assessment of potential archaeological deposits (PADs).
- A review and update of the significance assessment process with particular attention to, and consideration of, PAD and visibility data.
- The presentation of more detailed impact assessment for the Project.

- A review and update of the proposed mitigation measures and recommendations.

Summary of known Aboriginal heritage within Project area and their significance

A total of 340[1] known Aboriginal heritage sites were considered by the assessment (this includes sites in the Probable Maximum Flood level [PMF], the Existing Upstream Impact Area [EUIA], the Project Upstream Impact Area [PUIA] and adjoining lands) associated with a range of archaeological and/or cultural features including Axe Grinding Grooves, Isolated Finds, Open Camp Sites, PADs, Rockshelter sites, Art and Engraving sites, Scarred Trees, Stone Arrangements, Water Hole, Aboriginal Resource and Gathering, and Aboriginal Ceremonial and Dreaming sites. For the purpose of the updated scientific (archaeological) significance assessment, all sites with PAD are treated as being of significance (unless otherwise stated) until proven otherwise. This is consistent with scientific significant assessment approaches where sub-surface testing has not yet occurred.

The scientific (archaeological) significance of a total of forty-three (43) known Aboriginal heritage sites have been revised based on their association with PAD and/or the potential to contain additional artefacts and/or an extensive artefact assemblage. The scientific (archaeological) value of the region and the Aboriginal objects contained within it is demonstrated by the 340 known Aboriginal archaeological and cultural heritage sites (this includes sites in the PMF, the EUIA, the PUIA and adjoining lands) which includes:

- 50 sites that have been assessed to be of high archaeological (scientific) significance.
- 58 sites that have been assessed to be of moderate archaeological (scientific) significance.
- 233 sites that have been assessed to be of low archaeological (scientific) significance.

The fifty (50) known sites within the PUIA include:

- 8 sites that have been assessed to be of high archaeological (scientific) significance.
- 12 sites that have been assessed to be of moderate archaeological (scientific) significance.
- 30 sites that have been assessed to be of low archaeological (scientific) significance.

The Project area has the potential to yield information that would contribute to a further understanding of the cultural history of the local area and region. In particular, the nature of past Aboriginal land-use of the Lake Burragorang valleys, and the relationship between past Aboriginal land use and the available resources including the Lake Burragorang valleys and the surrounding rivers, creeks and tributaries prior to the development of the dam as expressed through archaeological sites and their context.

While individual, site specific assessments of scientific significance are useful for identifying and managing sites with high apparent and contributory values they do not always translate directly to a contribution to the wider cultural landscape. The RAPs for this project have consistently said that all archaeological sites are of high cultural value in addition to, and in most cases beyond, what may be expressed using a scientific framework.

Summary of potential heritage impacts

An updated approach to determining areas of impact from temporary inundation was adopted to describe and assess the potential impacts of the Project on Aboriginal heritage within the Project area to ensure the extent of the impacts were appropriately accounted for and more accurately assessed. The approach taken

[1] Refer to Section 5.2.2.5 for an explanation of discrepancy between the Aboriginal cultural heritage sites totals considered in the original ACHA/EIS compared to the total number considered in this supplementary assessment to the ACHA.

has been to identify an area of impact that takes account of the variability of flood events and their extent over time. While the original ACHA considered potential impacts on Aboriginal heritage in relation to a defined Project Upstream Impact Area (PUIA), the revised impact assessment presented in this supplementary assessment considers potential impacts in the context of the incremental increase in temporary inundation for the 1 in 5, 1 in 10, 1 in 20, and 1 in 100 chance in a year flood events. The impact assessment also considered the potential effects of temporary inundation on different Aboriginal site types, features and/or cultural resources informed from a review of the literature and the results of additional assessment undertaken for the Longneck Lagoon downstream case study.

It is important to note that local catchment run-off represents an existing risk within the Project area that occurs independent of the Project. As recognised in the Longneck Lagoon downstream case study, it is often not possible to differentiate between the effects of temporary inundation (which may be affected by the Project) and those relating to existing local catchment run-off as the types of mechanical processes results in similar affects (e.g. erosion or deposition). Furthermore, not all affects associated with increased inundation are good nor are they all adverse. The anaerobic environment of a deeply buried or deeply submerged site, for example, often proves to be an ideal environment for the preservation of organics and other fragile/perishable cultural materials and/or biological data. Nevertheless, a detailed consideration of the changes in flooding, erosion and sediment movement that will result with the Project, combined with a more comprehensive understanding of the potential impacts of inundation on different types of archaeological sites and/or features means that it is possible to assess and define the likely effects of the Project on Aboriginal heritage resources within the Project area, and the mitigation measures required to off-set these likely effects.

The temporary inundation experienced as a result of the Project is in the form of backwater flow (which is characterised by a low velocity water flow). While the Project may result in increases in the extent and duration of inundation, the velocity associated with the flow rate will be decreased. Potential impacts will therefore be influenced more by the susceptibility of an area to erosion and/or deposition and the nature of the Aboriginal heritage site feature. Potential effects of the Project area are summarised as follows:

- Artefacts and/or PADs located in high erosion risk areas have the potential to be destroyed by erosional processes which act to remove and/or displace artefacts and any associated features (e.g. PAD) as was observed by Brayshaw (1989: 30) in association with open sites located between the FSL and previous flood level within the Project area. Such potential impacts would result in medium-scale data loss and significantly reduce the integrity and research potential/scientific value of a site.
- Artefacts, PADs, Engravings, Grinding Grooves and/or Burials located in low-erosion potential areas such as along the valley of the Wollondilly River, may be subject to siltation/depositional effects from backshore run-off which may act to bury the site in alluvial deposits. Little to no impact to the archaeological integrity of these sites is expected. Furthermore, siltation is recognised to enhance preservation in such a context by providing a buffer against biochemical, mechanical and other forms of destructive impacts. Sites, however, may no longer be detectable and/or accessible during surface survey.
- Other site features, such as Axe grinding grooves, Engravings, Rock Art and Burials are most susceptible to biomechanical impacts that may result from increased inundation and wet and dry cycling. Rockshelters sites with Art in all areas subject to temporary inundation regardless of duration and extent have the potential to be affected by wet and dry cycling and related mechanical and biochemical impacts including accelerated weathering, granular loss, exfoliation of painted surfaces, removal and/or degradation of pigments and drawing materials. Changed environmental conditions resulting from the

deposition of silts, clay, sand other minerals, for example, can create conditions suitable for the intrusion and growth of destructive micro- or macro-vegetation such as fungi, algae and lichens. Such potential impacts would significantly reduce the integrity and research potential/scientific value of a site (medium-scale data loss).

The key results of the revised impact assessment are summarised as follows:

- A total of 260 known Aboriginal cultural heritage sites will be affected by increased temporary inundation as a result of the Project. These sites include those which will be affected by an increase in frequency of inundation as well as duration of existing inundation events. Of these sites, 30 are above the Project 1 in 100 inundation event level meaning that there is a very low chance of such inundation to be experienced. Nevertheless, as these sites are located within the Project PMF, they still require management and mitigation measures as part of this ACHA.
- Approximately 228 known Aboriginal cultural heritage sites are currently already affected by inundation, this does not include the 49 sites currently below Full Supply Level (FSL).
- Sites below current FSL or above the Project PMF will not be affected as a result of the Project. While they are not included in the impact assessment, they will be managed by the recommendations of this report as they fall within the Upstream study area.
- A total of 38 Aboriginal cultural heritage sites previously unaffected by existing inundation will be impacted as a result of the Project. Of these sites, six are considered to have nil to low resilience against inundation.
- The Project will result in cumulative harm to the intangible values of the cultural landscape through extension of previously unmitigated impact on cultural values from the construction of the Warragamba Dam and flooding of the Burragorang Valley and its tributary valleys. The further flooding of the Burragorang Valley will contribute to harm to the cultural and spiritual connection that Aboriginal people hold to this part of the Country, their heritage and the cultural landscape and will obscure the tangible aspects of the creation stories associated with the Burragorang such as the Gurrangatch and Mirrigan story.

Conclusion and recommendations

Consistent with the original ACHA, a total of seventeen recommendations have been made in relation to Aboriginal cultural heritage within the Project area. The recommendations are all indirect mitigation measures. If the Project proceeds the limitations of the proposed activities mean that there is no capacity for directly applied management measures for the avoidance or minimisation of harm. The recommendations relate to consultation, management, access to Country, site recording, cultural values recording and education. While these recommendations were shaped by feedback received from the RAPs during the consultation process, it has been clearly communicated by the RAPs that they do not support the Project. The Project is understood as a continuance of the dispossession and loss of cultural heritage initiated by the original development of the Warragamba Dam in the 1950s.

Impact	Recommended measure	Timing
Consultation	WaterNSW should continue consultation and engagement with the Registered Aboriginal Parties for the duration of the Project.	Pre-construction and Construction
	An independent facilitator would work with the RAPs and the wider Aboriginal community to develop an Aboriginal advisory group to guide	Pre-construction, construction and operation

Impact	Recommended measure	Timing
	the implementation of Recommendations 8 to 11 in the Cultural Values Assessment Report (Appendix 2 to Appendix K).	
Management of impacts on cultural heritage	An Aboriginal Cultural Heritage Management Plan (ACHMP) should be developed for the Project and implemented as part of the Construction Environmental Management Plan (CEMP). The ACHMP should be developed and managed in consultation with the RAPs, other relevant stakeholders and relevant regulatory authorities. The ACHMP should provide specific guidance on measures and controls to be undertaken to avoid and mitigate impacts on Aboriginal cultural heritage during construction.	Pre-construction construction
	Prior to the operation of the Project WaterNSW should review its assessment processes for works within the upstream catchment to include awareness to personnel undertaking an activity on its behalf of any potential Aboriginal cultural heritage values and objects in the area.	Construction and operation
	WaterNSW should continue to provide a cultural heritage awareness and cultural competency training package for all WaterNSW staff. The training package should include a site-specific module developed in consultation with the relevant Aboriginal communities and RAPs.	Pre-construction
	The site-specific Aboriginal cultural heritage awareness training package would be delivered as part of the site induction for all employees, contractor(s) and maintenance personnel involved in the construction works and ongoing site management and activities in the catchment of Lake Burragorang.	Construction and operation
	WaterNSW should develop a formal agency-specific process and policy for undertaking cultural heritage assessments and engaging with the Aboriginal community in line with those developed by other state government agencies.	Operation
	WaterNSW should consider engaging an in-house archaeological specialist support in line with other state government agencies.	Operation
Access to Country	WaterNSW should develop and implement a policy to improve access for Aboriginal community members to Country they have cultural connections with that are under WaterNSW management.	Prior to operation
	WaterNSW should facilitate bi-annual on-country visits open to Aboriginal community members with cultural connections to the area.	Ongoing
Site recording	The unsurveyed portion of the PUIA should be surveyed should the Project be approved (survey should include provision for detailed recording of all shelter sites including 3D photogrammetry, planning, detailed photography and scale drawing of any art or other features present). Additional survey will be guided by the updated predictive modelling presented in this supplementary assessment including consideration of results and predictions generated from the ASDST.	Prior to operation
	The unsurveyed portion of the area above the PUIA within the upstream study area should be sample surveyed to identify sites and places of high significance should the Project be approved (survey should include provision for detailed recording of all shelter sites including 3D photogrammetry, planning, detailed photography and scale drawing of any art or other features present). Additional survey will be guided by the updated predictive modelling presented in this supplementary assessment	Prior to operation

Impact	Recommended measure	Timing
	including consideration of results and predictions generated from the ASDST.	
	Further detailed impact assessment and recording of all Aboriginal cultural heritage sites and places that are located within the PUIA, sites of high significance in the area above the PUIA within the upstream study area, and all art sites within the upstream study area should be carried out. This should include 3D photogrammetry and high resolution digital photographic records and would include the landscape context of sites and site complexes to capture archaeological and cultural values.	Prior to operation
Cultural values recording and education	WaterNSW should consult with the RAPs and the Aboriginal community with regard to carrying out a comprehensive specialist research audit of the holdings of national and international collection institutions to identify cultural materials removed from Country in the Project area. Subject to proceeding with the audit, WaterNSW should facilitate an access visit for Aboriginal community members to any cultural materials identified in Sydney and Canberra based collection institutions.	Prior to operation
	In consultation with the RAPs and the Aboriginal community, WaterNSW should develop interpretative materials on the Aboriginal cultural values and history of the cultural landscape of the Project area including: a permanent exhibition at the Warragamba Dam Visitor Centre; interpretative signage and audio posts within the Warragamba Dam grounds; and facilitate the provision of Aboriginal-led cultural events (i.e., tours and talks) through the Warragamba Dam Visitor Centre.	Prior to operation
	In consultation with the RAPs and the Aboriginal community, WaterNSW should develop a cultural values project to record the Gurrangatch-Mirrigan Dreaming Story route through the photographic recording of specific cultural locations within the Project area (prior to any further impacts), oral history recordings with Aboriginal community members, and documentary research.	Prior to operation
	In consultation with the RAPs and the Aboriginal community, WaterNSW should undertake a heritage study of the Aboriginal traditional and historical occupation of the Project area through photographic recording of specific sites (prior to any further impacts), historical documentary research, and oral history interviews.	Prior to operation

Glossary and list of abbreviations

Term or abbreviation	Definition
Aboriginal cultural heritage	The tangible (objects) and intangible (dreaming stories, legends and places) cultural practices and traditions associated with past and present-day Aboriginal communities.
Aboriginal intangible heritage	NSW National Parks and Wildlife Act 1974 does not provide a definition of intangible heritage. For the purposes of this document and line with the Victorian Heritage Act and *Dhawura Ngilan: A Vision for Aboriginal and Torres Strait Island Heritage in NSW*, the following definition is used "means any knowledge of or expression of Aboriginal tradition, other than Aboriginal cultural heritage and includes oral traditions, performing arts, stories, rituals, festivals, social practices, craft, visual arts, and environmental and ecological knowledge but does not include anything that is widely known to the public.
Aboriginal object(s)	The legal definition for material Aboriginal cultural heritage under the NSW National Parks and Wildlife Act 1974.
Aboriginal stakeholders	Members of a local Aboriginal Land Council, registered holders of Native Title, Aboriginal groups or other Aboriginal people who may have an interest in the Project.
ACHA	Aboriginal Cultural Heritage Assessment.
ACHMP	Aboriginal Cultural Heritage Management Plan.
AHD	Australian height datum. The standard reference level used to express the relative elevation of various features - essentially the height above sea level.
AHIMS	Aboriginal Heritage Information Management System. Aboriginal heritage information management system. A web-available database which contains information and records about Aboriginal objects maintained by the NSW Office of Environment and Heritage.
AHIP	Aboriginal Heritage Impact Permit.
AR	Archaeological Report.
Archaeology	The scientific Subject of material traces of human history, particularly the relics and cultural remains of past human activities.
Archaeological deposit	A layer of soil material containing archaeological objects and/or human remains.
Archaeological investigation	The process of assessing the archaeological potential of an impact area by a qualified archaeologist.
Archaeological potential	The likelihood that an area contains physical remains associated with an earlier phase of occupation, activity or development of that area.
Archaeological site	An area that contains surface or sub-surface material evidence of past human activity in which material evidence (artefacts) of past activity is preserved.
Artefact	An object made by human agency (e.g. stone artefacts).
Assemblage	A group of artefacts found in close association with one another. Any group of items designated for analysis that exist in spatial and/or vertical context – without any assumptions of chronological or spatial relatedness.
Avoidance	A management strategy which protects Aboriginal sites within an impact area by avoiding them totally in development.

Term or abbreviation	Definition
BCD	The Biodiversity and Conservation Division (formerly the Office of Environment and Heritage and now Heritage NSW of the Department of Premier and Cabinet).
BP	BP. Years before the year 1950. This used to describe radiocarbon dates.
Catchment	The area from which a surface watercourse or a groundwater system derives its water.
Chance per year/Chance in a year	Refers to the chance of a certain level of flooding occurring in any one year. The chance that a certain level of flooding occurs in any one year is not related to the timing of other floods. For example, a 1 in 100 chance per year flood refers to a level of flooding with a 1 in 100 (or 1 percent) chance of occurring in any one year, regardless of whether that level or other levels of flooding have occurred in that year (NSW Office of Water 2014).
Code of Practice	Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales.
Construction study area	This area covers approximately 105 ha, of which about 33 ha will be cleared during construction activities.
Cumulative impacts	Combination of individual effects of the same kind due to multiple actions from various sources over time.
CVAR	Cultural Values Assessment Report.
DAWE	The Commonwealth Department of Agriculture, Water and the Environment.
DECCW	The Department of Conservation, Climate Change and Water, replaced by the Biodiversity and Conservation Division (BCD) of the Department of Planning, Industry and Environment (DPIE) and now Heritage NSW of the Department of Premier and Cabinet (DPC).
Development footprint	The area of land that is impacted by a proposed major project that is under the EP&A Act, including access roads, and areas used to store construction materials. For the purposes of this assessment, the development footprint includes areas directly cleared for construction including raised dam spillway, buttress and associated infrastructure.
DG	Director General.
Downstream study area	This area includes flood areas up to the existing PMF. The project will not increase regional inundation levels downstream. Therefore, any previously recorded Aboriginal sites that have been identified do not require impact assessment, noting that those sites in the floodplain will have been subject to inundation from past flood events.
DPC	Department of Premier and Cabinet.
DPIE	The Department of Planning, Industry and Environment.
Drainage	Natural or artificial means for the interception and removal of surface or subsurface water.
EIS	Environmental Impact Statement.
EP&A Act	NSW Environmental Planning and Assessment Act 1979.
EPBC Act	Environmental Protection and Biodiversity Conservation Act 1999.
ESD	Ecologically sustainable development.
eSPADE	Online database of soil and land information provided by the NSW Government.

Term or abbreviation	Definition
EUIA	Refer to definition of Upstream Impact Area.
FGS	Fine Grained Siliceous material. A type of raw material from which stone artefacts were manufactured.
Flake	A piece of stone detached from a core, displaying a bulb of percussion and striking platform.
FMZ	Flood mitigation zone – the zone above the full supply level in lake Burragorang used to capture and temporarily store flood waters.
FSL	Full Supply Level – the current maximum level of water in the dam for Sydney's water supply (RL 116.7 mAHD).
GBMWHA	Greater Blue Mountains World Heritage Area.
GIS	Geographic information system.
Harm	With regard to Aboriginal objects this has the same meaning as the NSW National Parks and Wildlife Act 1974.
Heritage NSW	Aboriginal cultural heritage regulator in the Department of Premier and Cabinet. Responsible for the management of Aboriginal Cultural Heritage (ACH) regulation functions under the National Parks and Wildlife Act 1974. Formerly BCD of DPIE.
ICOMOS	International Council on Monuments and Sites.
ILUA	Indigenous Land Use Agreement.
Impact	Influence or effect exerted by a project or other activity on the natural, built and community environment.
Induration	The process of or condition produced by growing hard.
In situ	Latin words meaning 'on the spot, undisturbed'.
Isolated artefact / find	A single artefact found in an isolated context.
km	Kilometre (1,000 metres).
km^2	Square kilometre(s).
LALC	Local Aboriginal Land Council.
Landscape character	The aggregate of built, natural and cultural aspects that make up an area and provide a sense of place. Includes all aspects of a tract of land – built, planted and natural topographical and ecological features.
Land unit	An area of common landform, and frequently with common geology, soils and vegetation types, occurring repeatedly at similar points in the landscape over a defined region. It is a constituent part of a land system.
Landform	Any one of the various features that make up the surface of the earth.
LEP	Local Environmental Plan.
LGA	Local Government Area.
m	Metre(s).
m^2	Square metre(s).
Mitchell Landscape	Landscapes with relatively homogenous geomorphology, soils and broad vegetation types, mapped at a scale of 1: 250,000.
NNTT	National Native Title Tribunal.
NPW Act	The NSW *National Parks and Wildlife Act* 1974.

Term or abbreviation	Definition
NPW Regulation	National Parks and Wildlife Regulation 2019 (NSW).
NSW	New South Wales.
NTS Corp	Native Title Services Corporation Limited, the Native Title Representative Body in NSW.
OUV	Outstanding Universal Value.
PAD	Potential archaeological deposit. A location considered to have a potential for subsurface archaeological material.
PEAA	Protection of the Environment Administration Act 1991.
PIR	Preferred infrastructure report.
PMF	Probable Maximum Flood level. The PMF is an engineering concept used for dam design and modelling of dam failure; it is not based on realistic weather or flood events that would ever occur. The PMF is a hypothetical flood estimate relevant to a specific catchment whose magnitude is such that there is negligible chance of it being exceeded. It represents a notional upper limit of flood magnitude (i.e. an estimate of the maximum flood magnitude possible in a catchment/ particular location), and no attempt is made to assign a probability of exceedance to such an event (Australian Rainfall and Runoff, Ball et al. 2019). The PMF is unlikely to occur in nature given the size of the Warragamba Dam catchment.
Project area	Refers broadly to all study areas and/or specific areas of investigation associated with the Project and collectively includes key areas such as the upstream study area, the construction study area, the downstream study area, and the FMZ operation area (upstream).
PUIA	Refer to definition of Upstream Impact Area.
RAP	Registered Aboriginal Party.
RL	Reduced level. Refers to metres AHD unless otherwise stated. All levels are reduced from Sea level unless stated otherwise.
The Project	The Warragamba Dam Raising Project.
SEARs	The Secretary's Environmental Assessment Requirements.
UNESCO	United Nations Educational, Scientific and Cultural Organization.
Upstream Impact area	Defined as the area between Full Supply Level (FSL) and the probable maximum flood (PMF) event with the Project. Definitions used in the archaeological study are: **Project Upstream Impact Area (PUIA):** The area between 119.5 mAHD and 126.97 mAHD and covers 1,401 ha (note: the ACHA and Supplementary Assessment to the ACHA uses the terminology 'Subject Area' to represent the PUIA which is consistent with assessment guideline terminology). **Existing Upstream Impact Area (EUIA):** The area below 119.5 mAHD (including below FSL or 116.7 mAHD).
Upstream Study Area	The area between the full supply level and Project PMF that would be affected by temporary inundation during flood mitigation operations.
WD	Warragamba Dam.
WDR	Warragamba Dam Raising.

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1. Introduction

1.1 Background and purpose

WaterNSW is seeking project approval for the Warragamba Dam Raising Project (the Project) which aims to provide flood storage capacity in the Lake Burragorang catchment (Warragamba Catchment) to facilitate flood mitigation downstream of Warragamba Dam. The potential impact of the Project on Aboriginal cultural heritage was assessed in *Appendix K: Aboriginal Cultural Heritage Assessment Report – Warragamba Dam Raising Project,* 10 September 2021, prepared by Niche Environment and Heritage Pty Ltd (Niche) (Aboriginal Cultural Heritage Assessment Report, or ACHA). The ACHA was prepared to address the Secretary's Environmental Assessment Requirements (SEARs) for the Project and to inform the Environmental Impact Statement (EIS) to be assessed under Division 5.2 of Part 5 of the *NSW Environmental Planning and Assessment Act 1979* (EP&A Act) as State Significant Infrastructure (SSI). The ACHA incorporated findings from an Archaeological Report (AR) and a Cultural Values Assessment Report (CVAR) which were completed to inform the assessment.

The EIS, including ACHA, were placed on public exhibition on 29 September 2021 to 19 December 2021 inclusive. During assessment of the EIS, the NSW Department of Planning and Environment (DPE) requested the preparation of a Preferred Infrastructure Report (PIR). With regard to Aboriginal cultural heritage the PIR requires:

- ongoing consultation with the Aboriginal community which appropriately considers and addresses their comments and concerns;
- additional work completed in response to issues raised by submissions to identify and assess Aboriginal cultural values likely to be impacted by the proposal, including further field studies; and,
- mitigation and management measures for any impacts to Aboriginal heritage, both tangible and intangible.

Niche was engaged by SMEC on behalf of WaterNSW to prepare a supplementary assessment to satisfy the Aboriginal cultural heritage requirements of the PIR and to respond to submissions received during the public exhibition of the Warragamba Dam Raising (WDR) Project EIS.

It is not the purpose of this supplementary assessment to replace or supersede the original ACHA, the CVA or the AR tendered with the EIS. Rather this supplementary assessment should be read in conjunction with the original documents and provides additional information, and supplementary assessment to address the submissions made by agencies and other parties in response to the EIS, and to provide a robust foundation on which the PIR can be informed.

1.2 Project Area and key study areas

The Project area is located approximately 65 km west of the Sydney Central Business District in the Wollondilly Local Government Area (LGA). To the west of the Project area are the Blue Mountains and various National Parks and State Conservation Areas which make up the catchment of Lake Burragorang - which is the water storage formed by Warragamba Dam. To the east of the Project area is the Warragamba and Silverdale townships and surrounding rural residential areas (Figure 1).

Details for the Project and proposed activity are outlined in Chapter 1 of the original ACHA and in the EIS. While the extent of the Project area has not changed since the public exhibition of the EIS, a number of revisions have been made to the terminology used to describe and assess key areas associated with the Project. These changes have been made to improve consistency between the EIS and associated technical assessments and assist in the undertaking of a more accurate and detailed impact assessment associated with temporary inundation resulting from the operation of the Project. What follows is a brief overview of these changes and an outline of the terminology used in this supplementary assessment.

The original ACHA considered potential impacts on Aboriginal heritage in relation to the defined Project Upstream Impact Area (PUIA) and the Existing Upstream Impact Area (EUIA). These concepts were developed principally to inform offsetting of biodiversity impacts and for impact assessments of other environmental values such as protected lands in view of the uncertainty around incremental flooding impacts. The adopted approach to offsetting within the PUIA was a precautionary approach to assume total loss. For Aboriginal cultural heritage assessment, a revised approach, that considers potential impacts in the context of the incremental increase in temporary inundation for the 1 in 5, 1 in 10, 1 in 20, and 1 in 100 chance in a year events and mitigation measures in relation to the Flood Mitigation Zone (FMZ) operation area (see below for details), is now preferred for impacts to Aboriginal heritage to ensure a more robust and detailed assessment of impacts is provided. The revised approach to assessing impacts and the changes to the concept of the PUIA and EUIA in the context of the revised impact assessment apply directly to this Supplementary Assessment to the ACHA. The terms, however, are still used throughout the report and in the context of discussing management strategies and recommendation. The approach around biodiversity impacts has not changed. Further explanation of this changed approach as it relate specifically to the impact assessment for Aboriginal heritage is provided in Section 8.1 of this supplementary assessment.

The key areas of investigation (which combine to form the 'Project area') adopted for this supplementary assessment are described in Table 1 below and illustrated in Figure 2 to Figure 4.

Table 1: Definition of key areas for the archaeological assessment

Area	Definition / Comment	Figure
Upstream study area	Defined as the area between Full Supply Level (FSL) and the probable maximum flood (PMF) event with the Project. Definitions used in the archaeological study are: **Project Upstream Impact Area (PUIA):** The area between 119.5 mAHD and 126.97 mAHD and covers 1.401 ha (note: the ACHA and Supplementary Assessment to the ACHA uses the terminology 'Subject Area' to represent the PUIA which is consistent with assessment guideline terminology). **Existing Upstream Impact Area (EUIA):** The area below 119.5 mAHD (including below FSL or 116.7 mAHD).	Figure 2
Construction study area	This area covers approximately 105 ha, of which about 33 ha will be cleared during construction activities.	Figure 3
Downstream study area	This area includes flood areas up to the existing PMF. The project will not increase regional inundation levels downstream. Therefore, any previously recorded Aboriginal sites that have been identified do not require impact assessment, noting that those sites in the floodplain will have been subject to inundation from past flood events.	Figure 4
Flood Mitigation Zone (FMZ)	Flood mitigation zone – the zone above the full supply level in lake Burragorang used to capture and temporarily store flood waters.	NA
Existing Upstream Impact Area (EUIA)	Refer to Upstream study area.	NA
Project Upstream Impact Area (PUIA)	Refer to Upstream study area.	NA

Area	Definition / Comment	Figure
Project area	Refers broadly to all study areas and/or specific areas of investigation associated with the Project and collectively includes key areas such as the upstream study area, the construction study area, the downstream study area, and the FMZ operation area (upstream).	NA

1.3 Report objectives and format

This supplementary assessment has been prepared in accordance with the following regulatory and advisory documents and guidelines:

- *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales* (Department of Environment, Climate Change and Water [DECCW], 2010a)
- *Aboriginal cultural heritage consultation requirements for proponents 2010* (Department of Environment, Climate Change and Water [DECCW], 2010b)
- *Guide to investigating, assessing and reporting Aboriginal cultural heritage in New South Wales* (Office of Environment and Heritage [OEH], 2011a)
- *Draft Guidelines for Aboriginal Cultural Heritage Impact Assessment and Community Consultation* (NSW Department of Environment and Conservation [DEC] 2005a).
- *Due Diligence Code of Practice for the Protection of Aboriginal Objects in New South Wales* (DECCW 2010c).
- *The Burra Charter: The Australia ICOMOS Charter for Places of Cultural Significance* (Australia International Council on Monuments and Sites [ICOMOS] 2013).
- *Engage Early* (Commonwealth Government, 2016),
- *NSW National Parks and Wildlife Regulation, 2019* (NPW Regulation), and

This supplementary assessment is intended to be read in conjunction with the original ACHA prepared for the project by Niche (2021). As much of the project details, background analysis and general discussion detailed in the original ACHA continues to be relevant to the additional analysis undertaken in this supplementary assessment, much of this information is therefore not repeated.

The assessment requirements and objectives for the supplementary assessment have been developed based on an analysis of the submissions received during the public exhibition of the EIS and includes:

- A program of continued Aboriginal community consultation (Section 4)
- Provision of additional background information, detail and updated register searches (Section 5)
- A review and update of the predictive model (Section 6)
- A review and update of the significance assessment process (Section 7)
- A review and update of the impact assessment process (Section 8)
- A review and update of the proposed mitigation measures and recommendations (Section 9)

An overview of the submissions received in relation to Aboriginal cultural heritage is provided in Section 2 and analysed in Section 3 which provides the framework for this supplementary assessment.

Location of the Project Area within a regional context

Aboriginal Cultural Heritage Supplementary Assessment
Warragamba Dam Raising Project

Niche PM: Deirdre Lewis-Cook
Niche Proj. #: 7211
Client: WaterNSW

Figure 1

World Topographic Map: Esri, HERE, Garmin, Foursquare, FAO, METI/NASA, USGS/World_Ocean_Base: NIWA, GeosciencesAustralia, Esri, GEBCO, DeLorme, NaturalVue/World Hillshade: Esri, USGS | Watercourses, Waterbodies, Road and Rail alignments, Protected areas of NSW © Spatial Services 2021. | Niche uses GDA2020 as standard for all project-related data. In order to ensure that data from numerous sources and coordinate systems is aligned, on-the-fly transformation to WGS1984 Web Mercator Auxilliary Sphere is used in the map above. For ease of reference, the grid tick marks and labels shown around the border of the map are presented in GDA2020, using the relevant MGA zone.

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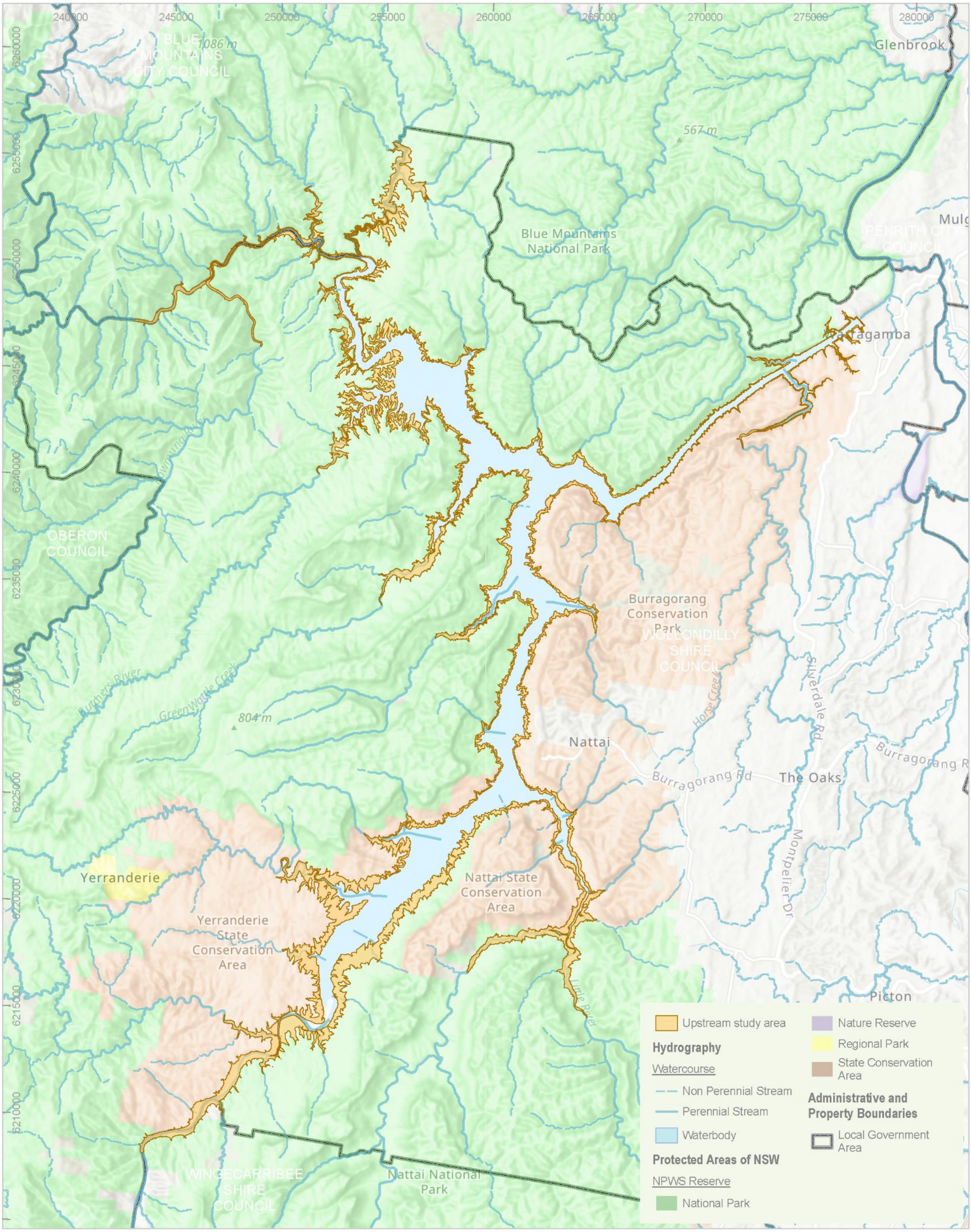

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niche Environment and Heritage

0 5
km
WGS 1984 Web Mercator

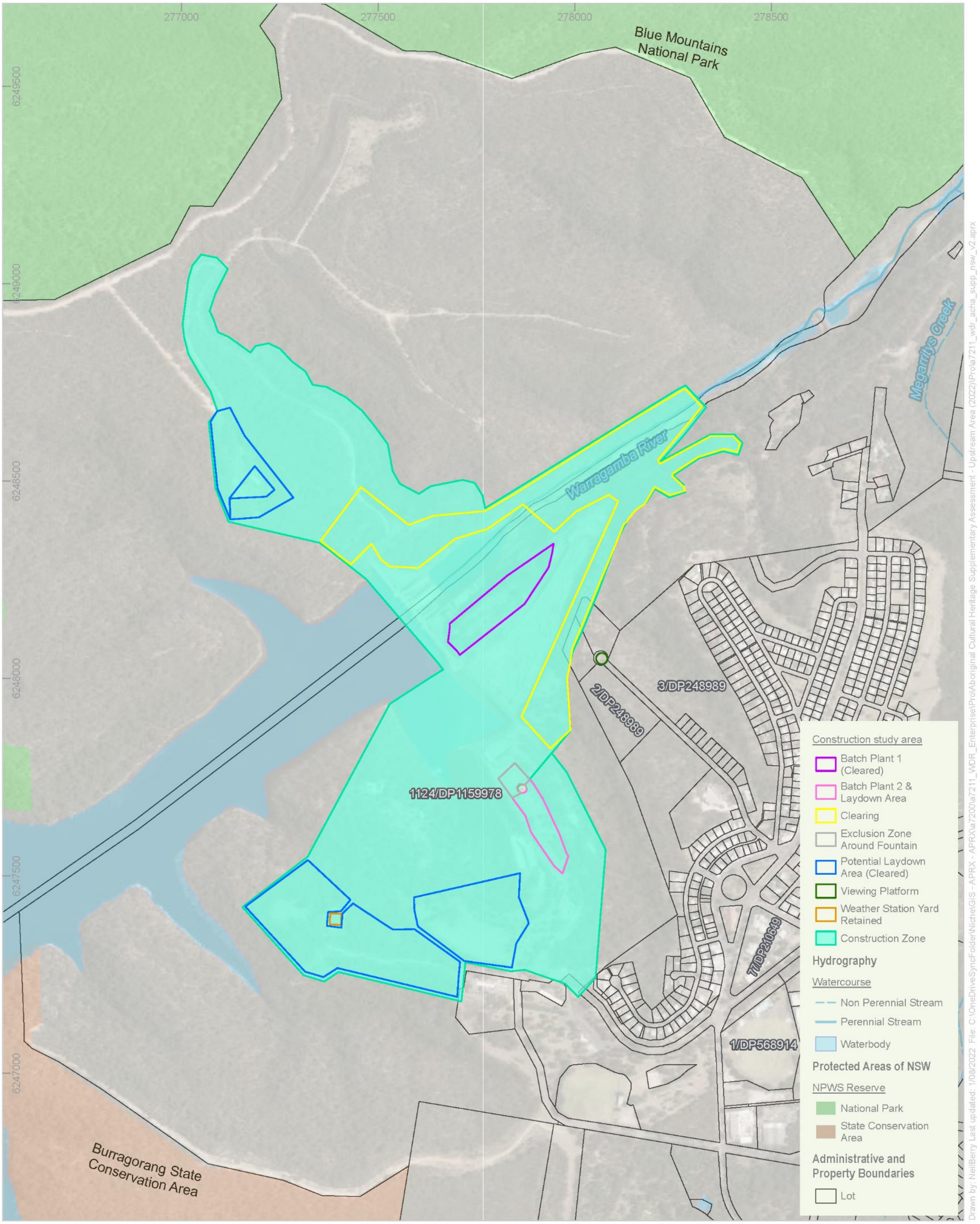
Location of upstream study area

Aboriginal Cultural Heritage Supplementary Assessment
Warragamba Dam Raising Project

Niche PM: Deirdre Lewis-Cook
Niche Proj. #: 7211
Client: WaterNSW

Figure 2

World Topographic Map: Esri, HERE, Garmin, Foursquare, METI/NASA, USGS/World Hillshade: Esri, Geoscience Australia, NASA, NGA, USGS | Watercourses, Waterbodies, Road and Rail alignments, Protected areas of NSW © Spatial Services 2021. | Niche uses GDA2020 as standard for all project-related data. In order to ensure that data from numerous sources and coordinate systems is aligned, on-the-fly transformation to WGS1984 Web Mercator Auxiliary Sphere is used in the map above. For ease of reference, the grid tick marks and labels shown around the border of the map are presented in GDA2020, using the relevant MGA zone.



niche Environment and Heritage

0 200
m
WGS 1984 Web Mercator

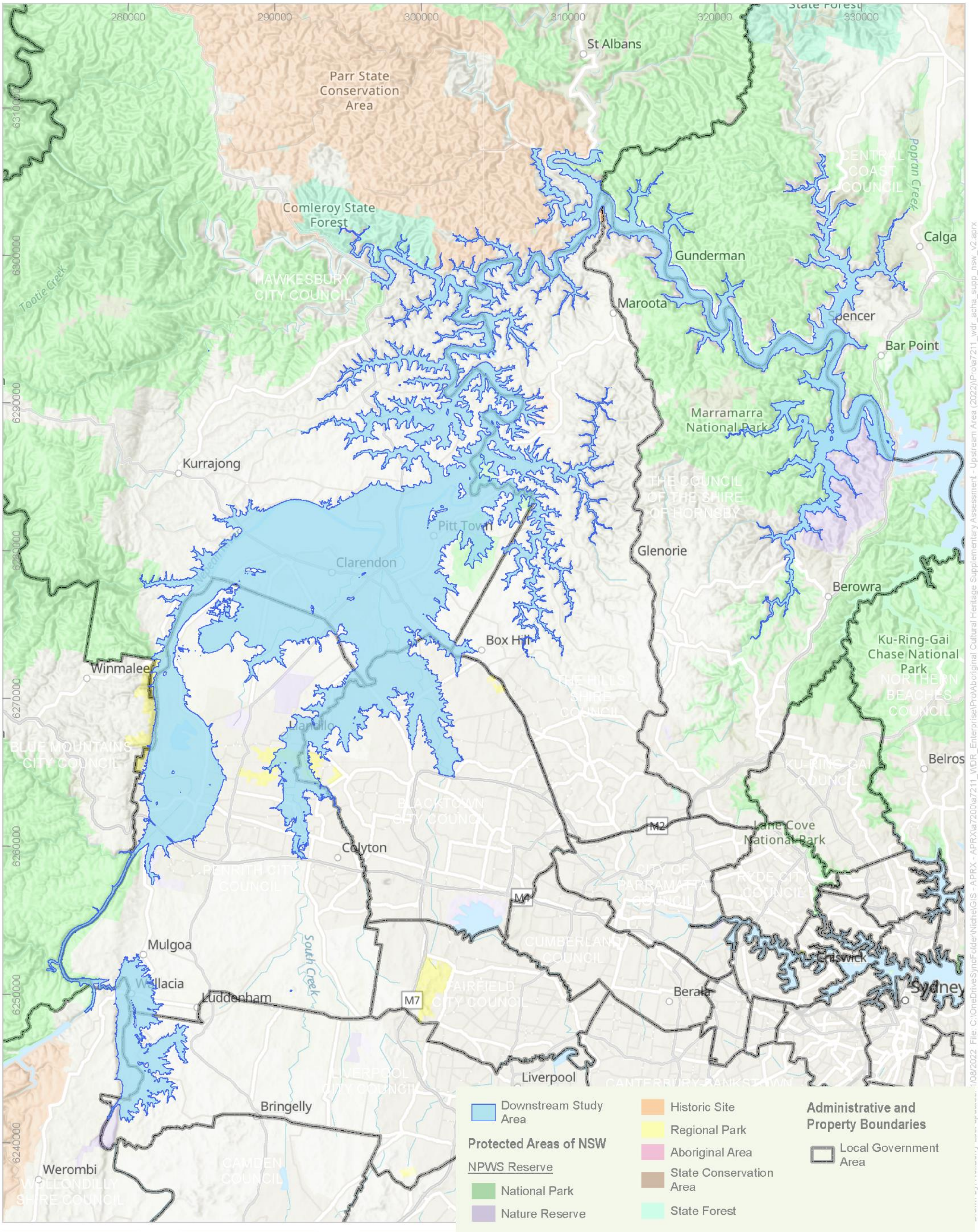
Location of construction study area

Aboriginal Cultural Heritage Supplementary Assessment
Warragamba Dam Raising Project

Niche PM: Deirdre Lewis-Cook
Niche Proj. #: 7211
Client: WaterNSW

Figure 3

public/NSW_Imagery: © Department of Customer Service 2020/World Hillshade: Esri, Geoscience Australia, NASA, NGA, USGS | Watercourses, Waterbodies, Road and Rail alignments, Protected areas of NSW © Spatial Services 2021. | Niche uses GDA2020 as standard for all project-related data. In order to ensure that data from numerous sources and coordinate systems is aligned, on-the-fly transformation to WGS1984 Web Mercator Auxilliary Sphere is used in the map above. For ease of reference, the grid tick marks and labels shown around the border of the map are presented in GDA2020, using the relevant MGA zone.



0 6
km
WGS 1984 Web Mercator

Location of downstream study area

Aboriginal Cultural Heritage Supplementary Assessment
Warragamba Dam Raising Project

Niche PM: Deirdre Lewis-Cook
Niche Proj. #: 7211
Client: WaterNSW

Figure 4

World Hillshade: Esri, CGIAR/World Topographic Map: Esri, HERE, Garmin, Foursquare, FAO, METI/NASA, USGS | Watercourses, Waterbodies, Road and Rail alignments, Protected areas of NSW © Spatial Services 2021. | Niche uses GDA2020 as standard for all project-related data. In order to ensure that data from numerous sources and coordinate systems is aligned, on-the-fly transformation to WGS1984 Web Mercator Auxilliary Sphere is used in the map above. For ease of reference, the grid tick marks and labels shown around the border of the map are presented in GDA2020, using the relevant MGA zone.

2. Overview of submissions

2.1 Preamble

This supplementary assessment addresses submissions raised during the public exhibition of the WDR Project EIS. This section provides a summary of the issues raised by Government agencies, public authorities and other stakeholder groups in relation to Aboriginal cultural heritage and outlines where these are addressed within this supplementary report. In reviewing the advice provided by agencies, it has been noted that where only a statement or comment appears without an "issue" being raised, supporting or clarifying details have not always been provided.

2.2 Submissions from EES

The following outlines the issued raised by the then Environment, Energy and Science (EES) within the Department of Planning, Industry and Environment with regards to Aboriginal heritage.

2.2.1 Hydrology and aquatic biodiversity

One comment in EES's review of the hydrology and aquatic biodiversity and associated impacts of the Project relates to Aboriginal cultural heritage, specifically the impact assessment of Aboriginal cultural values such as those associated with Eel Hole.

Table 2: Hydrology and aquatic biodiversity submissions

Issue	Where previously addressed in EIS/ ACHA	Where addressed in supplementary assessment
EES calls for consideration of potential impacts of the Project on Aboriginal cultural values noting that "the upper end of the PMF appears to coincide with the Eel Hole[2] cited as a resting place of Gurangatch in the Aboriginal creation story of the area.	Appendix 2 of ACHA	Sections 7 and 8

2.2.2 Climate Change and sustainability

Two comments relating to Aboriginal cultural heritage were raised by EES in their consideration of the risk assessment completed in relation to climate change and sustainability.

Table 3: Climate change and sustainability submissions

Issue	Where previously addressed in EIS/ ACHA	Where addressed in supplementary assessment
EES noted that more detailed assessment of risks to Aboriginal cultural assets is required stating "loss of biodiversity has been identified as a risk and assessed with a moderate consequence, however risks to Aboriginal cultural assets do not appear to have been identified."	Section 18.12 of EIS	Sections 7 and 8
ESS call for technical assessment of potential climate change risks stating that "it is unclear how other potential climate	Table 5-1 in Appendix G of EIS	Sections 7 and 8

[2] The Eel Hole' refers to a large waterhole just downstream of the junction of the Nattai River and Whitegum Creek (1905 Parish Map). Eel-holes were associated with the resting places of Gurangatch. Gundungurra Aboriginal Heritage Association 2018. Submission 72 to Inquiry into Water NSW Amendment (Warragamba Dam) Bill 2018 3 October 2018.

Issue	Where previously addressed in EIS/ ACHA	Where addressed in supplementary assessment
change risks have been factored into the Project design and operation, particularly fire, elevated carbon emissions, and the mitigation of risks such as damage and the loss of Aboriginal cultural assets.”		

2.2.3 Protected lands

Several issues relating to Aboriginal cultural heritage are identified within EES’s review of protected lands and the associated impacts of the Project. Identified issues are summarised in the table below and mostly relate to the assessment of cultural heritage values, consideration of RAP views and the cumulative impact of the Project on Aboriginal cultural heritage.

Table 4: Protected lands submissions

Issue	Where previously addressed in EIS/ ACHA	Where addressed in supplementary assessment
World Heritage Committee’s request		
Project impacts on all national park values from temporary inundation of up to 1,303 ha of reserves, including up to 304 ha of the Greater Blue Mountains World Heritage Area (GBMWHA). It is recommended that the EIS address the UNESCO World Heritage Committee’s request that ‘the EIS fully assesses all potential impacts on the OUV [Outstanding Universal Value] and other values including Aboriginal cultural values’.	Section 8.4 of ACHA	Sections 7 and 8
Aboriginal cultural heritage		
It is recommended that the RAPs views are considered in assessing the proposal and if this recommendation is not supported then WaterNSW should provide reasons for that decision.	Section 18.3.1 of the EIS and Section 6 of ACHA (Appendix K)	Section 4
Cumulative impacts on Aboriginal cultural heritage		
It is recommended that the cumulative impacts on Aboriginal cultural heritage (ACH) be assessed in acknowledgement that previous destruction and irreplaceable loss of ACH heightens the need to protect existing heritage.	Section 18.9.5 of the EIS, Section 10 of ACHA and Section 12.5 of Appendix 1 of ACHA	Section 8.7
Assessment of Aboriginal cultural heritage values		
Alternative predictive modelling tools (e.g. the Aboriginal Sites Decision Support Tool) could have improved the survey design and helped to restore the confidence of the RAPs. The ACH assessment report did not assess Potential Archaeological Deposits. This is problematic considering the erosional nature of soils subject to periodic inundation.	NA	Section 6
There was no agreement that the upstream impact area used to quantify biodiversity impacts would also apply to ACH assessment. The area assessed for ACH impacts should have been based on factors relevant to the Aboriginal cultural	NA	Section 8

Issue	Where previously addressed in EIS/ ACHA	Where addressed in supplementary assessment
landscape and the context of Aboriginal heritage and cultural values.		
The Aboriginal cultural heritage assessment report (ACHA) and the Aboriginal heritage chapter both refer to the number of archaeological sites in the World Heritage area and that no cultural values sites are in the upstream impact area within the World Heritage area. This contrasts with the statement in the ACHA that the whole cultural landscape is highly significant.	NA	Sections 7 and 8
The ACHA and Appendix K incorrectly identify that Aboriginal heritage is not part of World Heritage values and note it is included in the GBMWHA strategic management plan. Aboriginal heritage is part of the World Heritage values, as it is part of the integrity of the property.	Section 8.4 of ACHA	Sections 7 and 8
There is a risk that cultural values of high significance have not been identified, resulting in impacts on those values not being assessed.	Completion of ACHA in accordance with relevant legislative requirements and guidelines	Completion of this supplementary assessment in accordance with relevant legislative requirements and guidelines
It is recommended that the RAPs' position of not participating in the cultural values assessment be considered. Even without the in-depth stories or analysis of information, the RAPs have said the cultural values are of high significance.	Executive summary and Section 6 of ACHA	Sections 7 and 8
It is recommended that the significance of the cultural landscape and the upstream impact area within the World Heritage area as part of that significant cultural landscape be acknowledged.	NA	Sections 7 and 8
It is recommended that reference (from the Statement of Outstanding Universal Value) to the Aboriginal cultural values of the World Heritage area and that this is part of the World Heritage values be acknowledged.	NA	Sections 7 and 8
It is recommended that the significance of the cultural landscape and the detailed issues in the ACHA, some of which were not referred to in the main chapters of the EIS be addressed when considering the Project.	NA	Section 7
The outcomes of the Aboriginal cultural heritage assessment have not been recorded in the Aboriginal Heritage Information Management System (AHIMS) as required in the SEARs. It is recommended that the records of archaeological surveys be provided to DPE for recording in the AHIMS.	NA	Appendix 3
Mitigation measures		
ACH assessments would normally include an option for a major project not proceeding as a mitigation measure and, where that is not possible, state other available mitigation	Section 3.4 of the EIS	Section 9

Issue	Where previously addressed in EIS/ ACHA	Where addressed in supplementary assessment
measures. It is recommended that the option of the Project not proceeding as a mitigation measure and, where that is not possible, other available mitigation measures be addressed.		
It does not appear that the proposed mitigation measures have been discussed with the RAPs. An Aboriginal Cultural Heritage Management Plan (ACHMP) has not been developed. Consequently, the RAPs have not agreed to management protocols.	Section 6 of ACHA (Stage 4 of consultation included provision of management recommendations presented in Section 11)	Section 4 and 9
It is recommended that an Aboriginal Cultural Heritage Management Plan be developed.	Management measure ACH3 commits to the preparation of an ACHMP (refer Table 18-27 and Table 29-14 in the EIS)	Section 9
It is recommended that mitigation measures including actions to manage impact to sites prior to harm from inundation be required (for example surface collection of artefacts or salvage). The protocols for these should be developed before any approval with the RAPs and the Gundungurra Consultative Committee and could be developed when preparing the ACHMP.	As per management measure ACH3 of EIS, ACHMP would be developed and managed in consultation with the RAPs and relevant regulatory authorities	Section 9
It is recommended that mitigation measures should consider salvage of deposits either by: • RAPs highlighting which deposits need to be excavated via salvage before the raising of the wall, or • continued monitoring to highlight that the inundation is slowly damaging the sites through erosion.	NA	Section 9
It is recommended that the following additional measures should be considered and discussed with the RAPs and the Gundungurra Consultative Committee: • the ACHMP should be prepared before an approval if the RAPs and Gundungurra Consultative Committee are willing to engage in this process. • the ACHMP should be used to manage those sites not being impacted to ensure their condition is kept to a high standard and cared for, given the loss of other values in the area. The ACHMP should look to manage the wider landscape not just the upstream impact area. • other management or mitigation measures that the RAPs and the Gundungurra Consultative Committee may propose, given they do not appear to have had input on the measures included in the EIS.	NA	Section 9
World Heritage		
It is recommended that Heritage NSW and the Gundungurra Consultative Committee are involved in determining offsets	NA	Section 9

Issue	Where previously addressed in EIS/ ACHA	Where addressed in supplementary assessment
relating to Aboriginal heritage values, including consideration of the outcomes of the Aboriginal cultural heritage management plan and information that is available as a result of the other management measures for Aboriginal heritage.		

2.3 Submissions from Heritage NSW

The following outlines the issued raised by Heritage NSW with regards to Aboriginal heritage.

2.3.1 Archaeological Technical Report

Table 5: Submissions from Heritage NSW

Issue	Where previously addressed in EIS/ ACHA	Where addressed
General		
HNSW considers that the AR does not demonstrate a comprehensive understanding of the scientific values of the proposal area. As a result, the ACHA cannot appropriately integrate these values into the broader significance assessment.	NA	Section 7
Subsurface testing and potential archaeological deposits		
As standard practice, HNSW requires the identification of potential archaeological deposits and the subsurface testing of those deposits to establish their archaeological significance. As part of the background research, the AR clearly articulates the potential for subsurface archaeological deposits to be present within the assessment area. The results of the assessment do not consider the potential for deposit to exist and there has been no exploration of these values.	NA	Sections 6, 7 and 9
Page 29 of the AR states that 'Alluvial deposits have a high significance within the Subject Area, as they have the potential for deep stratified deposits preserving in situ evidence of occupation including repeated occupation over many thousands of years.' There is a relatively small amount of this deposit type remaining in the area, due to the inundation caused by the existing dam. The current proposal will result in the further inundation of what appears to be the remaining alluvial deposits. Without appropriate subsurface testing of these landscapes it is not possible to understand the implications for the potential loss of this deposit and the cumulative impact this would have. Similarly, there are potential archaeological deposits identified in many of the rock shelters that will be impacted. There has not been excavation within these features and, while the report recommends this occurs if the project proceeds, it does not identify which sites will require excavation.	NA	Sections 6 and 7

Issue	Where previously addressed in EIS/ ACHA	Where addressed
Allowing post approval excavation and possible dating of deposit in a rock shelter presents a significant risk that impact will be approved to a site while the significance is unknown. HNSW sees this as a risk, particularly as there is limited potential to influence inundation areas once approval is granted.		
Survey results and predictive model		
Page 33 of the AR states that 'the survey coverage achieved for the Subject Area presents a strong representative sample of the landscape.' HNSW would expect this statement to illustrate why deviating from the standard 100 percent survey coverage is an appropriate approach. While HNSW acknowledges that Brayshaw (1989), as referenced in the AR, has previously suggested 30 percent as an acceptable threshold, HNSW would still anticipate a justification in the context of the current proposal. There is also some ambiguity around the survey coverage. Detailed maps showing survey coverage need to be included in the report.	Section 9 and Figures 16, 17 and 18 in Annex 2 of Appendix 1 of ACHA	Section 6.2.4
HNSW considers that visibility is a limiting factor for the survey and suggests that the identification of features such as artefact scatters, grinding grooves and engravings are strongly linked to visibility of the ground surface. Many of the site photographs provided as appendices depict a landscape with clear visibility restrictions. Additionally, the inability of Niche to relocate previously recorded features, for example stone artefacts within sites, has been directly attributed to visibility restrictions in the site descriptions.	NA	Section 6
It is likely that site numbers have been underestimated and the effective survey coverage is significantly less than the 33 percent survey coverage stated. This calls into question the suitability of the survey and likely means that the numbers of sites predicted to occur across the unsurveyed impact area have been underestimated. By not fully considering the limitations of the survey at this point in the report, the subsequent sections that rely on these results are compromised. Consequently, the updated predictive model is unlikely to be accurate for open sites unless ground surface visibility was 100%. If it is assumed that visibility was on average 50% (the reality, is it is likely to be much lower) this would double the number of predicted open sites within the proposed impact area.	NA	Section 6
The use of 'Soil Landscape hectare (ha) per open site' rather than the conventional number of sites per hectare is misleading and makes comparison of site frequency between soil landscapes challenging. With widely different survey coverage and size of soil landscapes across the assessment area, the number of artefacts per hectare is the clearest way to compare site density. By not clearly stating the density of sites per hectare with full consideration of the impact that	NA	Section 6

Issue	Where previously addressed in EIS/ ACHA	Where addressed
visibility has upon the likelihood of identifying sites, the predictive model cannot be accurately relied upon.		
The predictive model is based on numbers of sites rather than features. One site can be comprised of several features over a large area such as a scarred tree, artefact scatter and grinding grooves. The numbers of features therefore are also likely to be greater than the number of sites predicted. Additionally, by grouping a range of features into the 'open site' classification, a degree of nuance associated with the predictive model is unable to be understood, and several site types are not accounted for, leading to a possible underestimation of the numbers and natures of sites.	NA	Section 6
A basic artefact analysis of artefact types across the assessment area and some research questions have been identified that need to be incorporated into the statement of significance and the scientific value of sites. There has, however, been only limited analysis of other site types such as rock shelters and grinding grooves. Some level of formal analysis such as grinding groove length has been undertaken as several of these traits have informed the updates to the predictive model. They are not, however, clearly articulated in the analysis.	NA	Section 7
The detailed rock art assessment is challenging to follow and many of the charts are not labelled so that they can be easily understood. HNSW considers that a fuller consideration and discussion of the regional motif and pigment data is required to compare to the current assessment area. Full documentation and base line recording are recommended.	NA	Section 5 and 9
Other elements such as the possible cultural markings at Ashtons 1 45-4-0966 and the engraving of the jumping women at Warragamba 74 need further clarification.	NA	Section 5
Significance assessment		
The insufficient consideration of potential archaeological deposits and visibility limitations has resulted in higher significance ratings being placed on sites with higher recorded artefact numbers. HNSW notes that several photographs of artefact scatters identified as high or moderate significance are ex situ and located within denuded landscapes and consequently good visibility. This has resulted in higher numbers of artefacts being recorded. Other sites, with fewer visible artefacts, but significant visibility restrictions and what appears to be potential archaeological deposits have generally been assigned lower significance ratings due to fewer artefacts being recorded.	NA	Section 7
HNSW would anticipate that the eroded artefact scatters have relatively lower potential for scientific investigation. Conversely, if there is potential for artefact scatters within potential archaeological deposits in situ, HNSW would	NA	Sections 6 and 7

Issue	Where previously addressed in EIS/ ACHA	Where addressed
anticipate a greater scientific significance and a recommendation for further testing to establish the nature and extent of the deposit. There has been limited consideration of potential archaeological deposits in open sites, despite the soil landscapes suggesting very good subsurface potential. HNSW requests consideration of these values.		
Rock shelters		
The rock shelters recorded as part of this assessment have been generally assigned a low scientific value. The presence of concentrated, multi-feature occupation sites with evidence of cultural activities and potential for unexplored subsurface deposit, presents an excellent opportunity for scientific investigation. HNSW considers that without further investigation of potential archaeological deposits within each of the rock shelters, the significance of the sites remains unknown.	NA	Section 7
HNSW suggests that by more clearly defining the statement of significance and potential research questions, there would have been a clearer framework of values for Niche to investigate. Additionally, consideration of significance and value at orders of scale, may have provided a comparison with the broader archaeological record of NSW. The presence of such clearly defined cultural values associated with this landscape, presents a rare opportunity to contextualise physical sites and places within a cultural framework. Overall, HNSW considers that there is an underestimation of the significance of the sites in this area.	NA	Section 6.5 and 7
Impact assessment and consideration of Ecologically Sustainable Development		
It is not possible to fully consider the impact caused by the proposal without a full appreciation of the value of this landscape.	Page 62 of ACHA	Section 8
There is limited consideration of the potential impacts of flooding on archaeological sites, and the report does not draw strongly on broader literature to support the assessment. HNSW notes that as part of the survey there were several examples of the impacts of inundation, however images and descriptions of this are unclear.	NA	Section 5.6 and 8
The survey below the full supply level was an excellent opportunity to document the impacts caused by inundation, though this opportunity has been largely overlooked. This evidence could have been used to clearly demonstrate both the known and potential risks to sites as a result of inundation and enable mitigation actions to be developed. This would have enabled more targeted consideration of impacts specific to, for example, the flooding of medicinal springs and impacts to rock art. Site by site consideration of potential impacts,	Section 12.3 of Appendix 1 of ACHA	Section 5.6 and 8

Issue	Where previously addressed in EIS/ ACHA	Where addressed
supported by both survey evidence and the broader literature is recommended.		
The impact assessment needs to consider the predicted sites not identified and engage better with the predicted levels of significance. If the existing significance assessment of known sites is used, it could reasonably expect that a total of 140 low value sites, 10 moderate value and 21 high value sites will be located. It is therefore important to consider the impact to these predicted sites to identify management options and consider whether impact to 21 highly scientifically and culturally significant sites is appropriate. Without further survey of the impact area and potentially subsurface excavation, the presence and scientific values of the predicted sites are unknown and cannot be fully considered.	Section 9 of ACHA	Section 8
HNSW considers that it is difficult to justify the further impact to these values and that it is necessary to explore options to redesign or mitigate impacts. The principles of ESD need to be applied and provide the opportunity for the proponent to argue why the proposal is acceptable. Without this information, HNSW is unclear on the impact assessment or consideration of principles of ESD in the various reports, or the cumulative impact chapter of the EIS.	Chapter 29 of the EIS	Section 8
The report recommendations are not mitigation measures but instead recommendations to undertake the minimum required level of survey, site recording and investigation. A detailed site recording and a management plan cannot offset the loss of these values and no impact should be approved while the significance and number of sites is unknown. If the proposal were to be approved, both intangible and tangible Aboriginal cultural heritage values would be irreversibly impacted. HNSW does not support a proposal where the archaeological values are not understood and where assessment of values is proposed to be deferred to the post approval stage.	NA	Section 7 and 9
Other issues		
Provide evidence that AHIMS site cards have been submitted and the report updated. It is the responsibility of the consultants to submit site recording forms	NA	Appendix 3
Consider indirect impacts such as vibration, dust etc for those sites in proximity to the dam wall construction area. Appropriate management strategies must then be proposed and discussed in the assessment	Section 9.2 of ACHA	Section 8
Undertake a new AHIMS search as the previous search is over 12 months old	NA	Section 5.2
Include consideration of the Aboriginal Place nomination in the report. Please note that there are cross references in the	Section 1.5.2.1 of ACHA	Section 5.3

Issue	Where previously addressed in EIS/ ACHA	Where addressed
text that refer to this subheading that does not appear to exist.		

2.3.2 Aboriginal community consultation

Table 6: Aboriginal Community Consultation submissions

Issue	Where previously addressed in EIS/ ACHA	Where addressed
Aboriginal community knowledge, comments and concerns have not been appropriately or adequately considered and addressed. The aim of the consultation process is to involve the Aboriginal community in decision making and afford opportunities to provide informed comment on the proposal. HNSW notes the Aboriginal community has clearly expressed its concern with this proposal, but it appears the concerns have not been addressed and there has not been a concerted effort to redesign or appropriately mitigate the impacts. HNSW notes that the ACHA and supporting documents placed on EIS exhibition have not been provided to the RAPs for review and therefore, Stage 4 consultation has not been completed. As the current document version is significantly different to the version previously provided to the RAPs for comment, on 29 April 2021, HNSW expects that the RAPs would have been provided an opportunity to comment on the most recent version prior to exhibition. This means that HNSW cannot appropriately consider all feedback provided by the RAPs as part of its review.	NA	Section 4

2.3.3 Environmental impact assessment

Table 7: Environmental impact assessment submissions

Issue	Where previously addressed in EIS/ ACHA	Where addressed
Chapter 18 of the EIS de-emphasises the risks presented by this proposal to Aboriginal cultural heritage. The risk assessment concludes that, without mitigation, impacts will occur which will have medium consequences for Aboriginal cultural heritage. While the EIS considers this a high risk, it is suggested that the consequences of unmitigated impact are higher than reported by the assessment. The assessment concludes that there will be a 'possible contribution to cumulative impacts' (EIS p18-74) because of the proposal. HNSW is of the view that the impact will result in at least a moderate level of cumulative impact causing an increased risk to Aboriginal cultural heritage.	NA	Section 8.7

2.3.4 Mitigation measures and recommendations

Table 8: Mitigation measures and recommendations submissions

Issue	Where previously addressed in EIS/ ACHA	Where addressed
The suggestion that the mitigation measures, as currently presented, are appropriate to mitigate the risk to medium, with only minor consequences for Aboriginal cultural heritage, demonstrates a lack of understanding of the value of Aboriginal cultural heritage and the finite nature of these heritage values. HNSW considers that the mitigation measures proposed are insufficient to adequately reduce the risk to an acceptable level. While the exploration of offset areas that include similar Aboriginal cultural heritage values is desirable, the sites specific to the proposal area, cannot by their nature occur elsewhere and consequently offsetting will not adequately address the impacts.	NA	Section 9

2.4 Other submissions

2.4.1 Australia ICOMOS

The following issues as summarised in the table below were identified by the Australia International Council on Monuments and Sites (ICOMOS) in relation to Aboriginal cultural heritage.

Table 9: Australian ICOMOS submissions

Issue	Where previously addressed in EIS/ ACHA	Where addressed
The EIS does not fully assess all potential impacts because it does not provide adequate identification, investigation or assessment of the potential impacts of the proposed action on the indigenous cultural values of the GBMWHA, which are attributes that contribute to the integrity that underpins the property's OUV.	Chapter 18 of the EIS, Section 6.1.8 of Appendix J *World Heritage Assessment Report*	Section 8.5.2
The discussion of Aboriginal cultural values in the EIS does not adequately consider the implications of the inclusion of some of the affected lands on the National Heritage List nor additional potential National Heritage values. More than 300 hectares of the Project Upstream Impact Area (PUIA) is already on Australia's National Heritage List and other potentially affected areas are currently part of an area that is on the Priority Assessment List which is being evaluated for potential National Heritage values by the Australian Heritage Council. This assessment includes potential Indigenous National Heritage values which have been nominated by the Greater Blue Mountains World Heritage Area Advisory Committee. This consideration is directly responsive to a specific requirement of the Australian Heritage Strategy: *Progressively review existing World Heritage places that have been listed for natural values only to identify*	NA	Section 5.2.3 and 7

Issue	Where previously addressed in EIS/ ACHA	Where addressed
whether the areas may contain internationally significant cultural heritage (Australian Heritage Strategy 2015, Objective 1, Action 8, page 19). As a matter of due process, the Australian Heritage Council should conclude the current Priority Assessment List process and determine whether Indigenous cultural heritage that is within the PUIA has National Heritage value, before any decision is made to proceed with the dam proposal.		
Australia ICOMOS does not agree with the conclusions reached in Appendix J of the EIS that the dam proposal is consistent with the Australian National Heritage Management Principles, which apply to places on the National Heritage List. Specifically, in view of inadequacies in survey and assessment and consultative processes, the ACHAR and the conclusions which flow from it, do not comply with the following principles: *1. The management of National Heritage places should use the best available knowledge, skills and standards for those places, and include ongoing technical and community input to decisions and actions that may have a significant impact on their National Heritage values.* *5. The management of National Heritage places should make timely and appropriate provision for community involvement, especially by people who:* *• have a particular interest in, or associations with, the place, and* *• may be affected by the management of the place.* *6. Indigenous people are the primary source of information on the value of their heritage and the active participation of Indigenous people in identification, assessment and management is integral to the effective protection of Indigenous heritage values.*	NA	Section 4, 8 and 9
The Aboriginal Cultural Heritage Assessment Report (ACHAR), at Appendix K of the EIS, does not provide adequate understanding of the nature, extent and significance of the Aboriginal cultural resources that may be affected by the dam proposal and does not fulfil the SEARs for the EIS. The ACHAR does not meet a fundamental SEARs requirement (3.1) that the: 'level of assessment must be commensurate to the degree of impact and sufficient to ensure that the Department and other government agencies are able to understand and assess impacts'.	NA	Section 7
The EIS is fundamentally flawed because of the inadequate extent of survey undertaken to identify potentially affected Aboriginal sites and the resulting deficiency in assessment and characterisation of predicted impact. It is very concerning that the ACHAR outlines a process for further investigation subsequent to development consent, whereas the further investigation is actually needed to inform consideration as to	Section 8.1, 8.2 and 8.3 of Appendix 1 of ACHA	Section 5, 6, 7 and 8

Issue	Where previously addressed in EIS/ ACHA	Where addressed
whether development consent should be granted. Further investigation of known sites, through recording, comparative study and/or test excavation is needed so that their nature, extent and significance can be comprehensively characterised. This is essential given the nature of the threat posed by the dam proposal.		
Although 43 archaeological sites and 11 other places of cultural significance have been identified, it is estimated that a further 131 sites may be affected. This extrapolation is of questionable validity, and is at best predictive based on the 'normal' and likely to miss any sites that are 'exceptional' to the established pattern. However, without actual information about the actual sites affected, Traditional Owners have effectively been circumvented of the ability to be sufficiently informed about the relevant cultural heritage impacts and therefore the information available to the consent authority is not comprehensive and inadequate.	Section 6.3.3 of ACHA	Section 6
While the ACHAR hypothesises that 'the resilience of the cultural landscape suggest the latest fires have not had an impact that would result in a material effect to this assessment', (ACHAR page 34) the impact of the fires is actually completely unknown because further fieldwork was not undertaken. The extent of field survey and the lack of survey following the 2019-2020 fires is a serious and unacceptable shortcoming.	NA	Section 5.6.3 and Appendix 5
The mitigation and management measures considered in the EIS (Executive Summary page 39) are inappropriate and unacceptable. The EIS proposes 'an Aboriginal cultural heritage management plan to address intergenerational equity including recording of Aboriginal cultural heritage'. Recording is insufficient. The focus should be on avoidance of harm. And yet, the ACHAR concludes, in relation to Aboriginal Cultural Heritage, that if the project proceeds, 'there is no capacity for directly applied management measures for the avoidance or minimisation of harm' (ACHAR page iv).	NA	Section 9
The dam proposal is inconsistent with the principles and processes of *The Burra Charter: the Australia ICOMOS Charter for Places of Cultural Significance 2013*. Best practice heritage practice, including The Burra Charter: The Australia ICOMOS Charter for Places of Cultural Significance 2013 (the Burra Charter), requires that the values of a place of cultural significance should be identified prior to decisions which affect those values, and that, while considering and managing other factors, a primary objective should be conservation of those values. The EIS has not involved adequate consultation nor survey work in relation to the ACHAR. There has been insufficient consideration of alternatives to the proposal to avoid harm. Therefore, the EIS	NA	Section 9

Issue	Where previously addressed in EIS/ ACHA	Where addressed
does not meet Burra Charter standards and is fundamentally flawed.		

2.4.2 International Union for Conservation of Nature (IUCN)

The following issues as summarised in the table below were identified by the International Union for Conservation of Nature (IUCN) in relation to Aboriginal cultural heritage.

Table 10: International Union for Conservation of Nature (IUCN) submissions

Issue	Where previously addressed in EIS/ ACHA	Where addressed
The upstream impact area for the raised dam clearly includes important cultural sites that contribute to the property's integrity. As outlined in the EIS, the project may result in the total loss of a number of known sites with high cultural and scientific significance as a result of their inundation. The inundation of these sites would, therefore, damage attributes of the OUV of the property, and therefore this reported loss is at odds with the conclusion of the EIS that the Project 'would not result in a material loss or degradation of the Outstanding Universal Value of the GBMWHA'.	NA	Section 5.6 and 8
IUCN notes that on 28 August 2020 Traditional Owners formally advised State and National Government consent authorities that they were not properly engaged in the development of the EIS in relation to the cultural values which contribute to the property's integrity, and do not give free, prior and informed consent for the project to proceed.	Section 3 of ACHA, Table 18-5 in Chapter 18 of EIS	Section 4
Consideration of cultural associations relevant to OUV is not rigorous in the EIS. There have been no physical investigations to enable informed assessment of the sites concerned, and the approach to understanding cultural values requires broadening to encompass concepts of place, landscape, contemporary tradition and living heritage, rather than limiting cultural heritage to known individual sites.	Section 8 of Appendix 1 of ACHA	Section 5, 6 and 7

2.4.3 Blue Mountains City Council

The following issues as summarised in the table below were identified by the BMCC in relation to Aboriginal cultural heritage.

Table 11: Blue Mountains City Council submissions

Issue	Where previously addressed in EIS/ ACHA	Where addressed
Unacceptable loss of Aboriginal cultural values of the Gundungurra First Nation		
Council does not support the view of the EIS that the damage from the dam wall raising on the indigenous cultural values of the Gundungurra First Nation are acceptable and instead supports the view of the Gundungurra First Nation RAPs that	Chapter 18 of EIS	Section 8

Issue	Where previously addressed in EIS/ ACHA	Where addressed
the raising of the dam wall and the resultant predicted flood zones, poses a serious and irreparable threat to the significant tangible and intangible Aboriginal cultural values of Gundungurra Country.		
The Warragamba Dam Raising Project will not only result in the loss of a spectacular and extant cultural landscape, now so rare within close proximity to Sydney and as such an important cultural symbol, but that it will also have a profound impact on the health and well-being of Gundungurra people suffering the resultant cultural loss.	Chapter 18 and 21 of EIS	Section 8
Council accepts the views of the Gundungurra people that the cultural heritage assessments done to support the EIS, whether anthropological or archaeological, are inadequate and not proportionate to the context and importance of this rich cultural landscape. Council's ongoing consultation with Gundungurra Traditional Owners on the Aboriginal Cultural Heritage Assessment Report indicates the Traditional Owners' dissatisfaction with the assessment process, the conclusions of the Aboriginal Cultural Heritage Assessment Report and the lack of compensation or redress for damage to loss of cultural sites and Native Title rights.	NA	Section 4
Council strongly urges the NSW Government to undertake a more complete cultural assessment of the impacted area in the final EIS, involving Traditional Owners, as well as providing longer periods for Traditional Owners to comment on subsequent cultural heritage studies.	Section 6.5 of EIS	Section 4
Aboriginal cultural heritage assessment		
The proposed raising of the dam wall will negatively impact the Aboriginal cultural heritage values of the Lake Burragorang area and its tributaries, including hundreds of registered and unregistered Aboriginal cultural heritage sites on AHIMS and an Aboriginal Place nomination. The cultural landscape is assessed in the Archaeological Report to be of very high significance. The potential impacts to the Aboriginal cultural heritage values (both tangible and intangible) of the area are considered unacceptable.	NA	Section 8
The assessment undertaken does not adequately identify, investigate or assess the impacts to Aboriginal cultural heritage. For example, the limited desktop research and small surveyed area. Potential site distribution or predictive modelling reasoning is not adequately provided. Further archaeological field survey is required to appropriately investigate the Aboriginal cultural heritage within the Upstream study area. In addition, the extent of the inundation and its associated impacts to Aboriginal cultural heritage at different water levels is unclear from the EIS documentation.	NA	Section 5.6, 6 and 8
The archaeological assessment of significance is not clearly supported or evidenced, for example, Aboriginal sites are	NA	Section 6 and 7

Issue	Where previously addressed in EIS/ ACHA	Where addressed
identified as having 'low' significance without clear reasoning or explanation. There is very limited archaeological investigation (and no sub-surface test excavation) to truly understand and consider the Aboriginal cultural heritage values of individual sites to be impacted, nor the broader cultural landscape as a whole.		
Consultation with Registered Aboriginal Parties indicates overall objection to the assessment and proposal, which is noted in the report and referenced to confirm that consultation has been undertaken in accordance with the Aboriginal cultural heritage consultation requirements for proponents 2010. However, the proposal does not adequately address the concerns raised throughout the consultation process, rather instead noting that consultation occurred.	NA	Section 4, 7, 8 and 9
The Aboriginal Cultural Values Assessment (CVAR) attempts to identify the cultural values of the areas to be impacted and outlines mitigation measures for the Project, however the appendix identifies that the methodology was limited by Aboriginal cultural knowledge holders who chose not to participate at the time, and the majority of RAPs declined to nominate Aboriginal cultural knowledge holders on the basis that they did not trust the intent of the Proponent or the assessment process. While identifying 45 locations of cultural value in the Upstream study area, the methodology utilised does not sufficiently address the identification and understanding of Aboriginal cultural heritage values of the area, nor do the recommendations adequately address the proposed impacts to Aboriginal cultural heritage.	NA	Section 7, 8 and 9

2.4.4 Hawkesbury City Council

The following issues as summarised in the table below were identified by the Hawkesbury City Council in relation to Aboriginal cultural heritage.

Table 12: Hawksbury City Council submissions

Issue	Where previously addressed in EIS/ ACHA	Where addressed
Mitigation and management measures relating to the impact of flooding on geomorphology, biodiversity and Aboriginal cultural heritage were found to be light on and non-committal.	NA	Section 9
Council considers that the EIS is unsatisfactory in terms of environmental and cultural heritage impact statements, including the lack of acknowledgement of the impacts on the Aboriginal Cultural Heritage of the Gundungurra People and failure to comply with the Burra Charter.	NA	Section 8
It is recommended that:	NA	Section 8 and 4

Issue	Where previously addressed in EIS/ ACHA	Where addressed
• The EIS provide more clarity on the likely contents of dedicated Aboriginal cultural heritage management plan and the potential residual impacts of the Project on cultural assets • The EIS commit to further engage aurally with local Aboriginal communities to gauge local sentiment toward the program, and the establishment and function of the Aboriginal cultural heritage 'keeping place' and the proposed offsets program, and share the results in the EIS • The EIS state the status of support of Aboriginal parties (e.g. RAPs) of the Project • The Project engage cultural advisors to ensure that an Aboriginal voice is present when discussing cultural heritage issues.		

2.4.5 Hornsby Shire Council

The following issues as summarised in the table below were identified by the Hornsby Shire Council in relation to Aboriginal cultural heritage.

Table 13: Hornsby Shire Council submissions

Issue	Where previously addressed in EIS/ ACHA	Where addressed
The heritage impact on Gundungurra land is of great concern to our community. Council understands that a number of submissions are being made which reflect on this issue in detail. Council asks that these submissions be thoroughly considered. As mentioned above, concern is raised that the full impact of the project may be missed in the EIS due to the methodology of assessment. All impacts under all flooding scenarios should be fully assessed. Any amount of inundation (no matter how infrequent) could have permanent consequences on significant cultural items.	NA	Section 8.4

2.4.6 Wingecarribee Shire Council

The following issues as summarised in the table below were identified by the Wingecarribee Shire Council in relation to Aboriginal cultural heritage.

Table 14: Wingecarribee Shire Council submissions

Issue	Where previously addressed in EIS/ ACHA	Where addressed
The Greater Blue Mountains World Heritage Area starts to the south in the Wingecarribee Shire with the Nattai National Park. Council is concerned about the likely impacts on the World Heritage area.	NA	Sections 7 and 8
The heritage impact on Gundungurra land is of great concern to our community. Council understands that a number of submissions are being made which reflect on this issue in detail. Council asks that these submissions be thoroughly	NA	Sections 7 and 8

Issue	Where previously addressed in EIS/ ACHA	Where addressed
considered. As mentioned above, concern is raised that the full impact of the project may be missed in the EIS due to the methodology of assessment. All impacts under all flooding scenarios should be fully assessed. Any amount of inundation (no matter how infrequent) could have permanent consequences on significant cultural items.		

2.4.7 Wollondilly City Council

The following issues as summarised in the table below were identified by the Wollondilly Shire Council in relation to Aboriginal cultural heritage.

Table 15: Wollondilly City Council submissions

Issue	Where previously addressed in EIS/ ACHA	Where addressed
The survey method for used in the EIS for the Aboriginal cultural heritage assessment is inadequate. The survey sampling strategy was not prepared using a stratified random sampling methodology, and it targets areas predicated as being the most archaeologically sensitive. This approach becomes a self-fulfilling prophecy – sites will be found in areas predicted as having sites, and no information is collected about areas where there are no sites predicted.	NA	Section 6.2
Because approximately 30 per cent of the upstream impact area was sampled during the archaeological survey, the Aboriginal heritage impact assessment relies heavily on the predictive model. However, the predictive model is flawed, and only makes predictions about areas already expected to contain sites. Without a rigorously prepared stratified random sample and without any form of null hypothesis testing, the veracity of the predictive model cannot be tested.	NA	Section 6
The results discussion does not provide any information on the effective survey coverage. Limited provision was made in the survey strategy for drawing from ethnographic information or other cultural information relating to intangible values. Part of the survey focussed on creation story as noted by the RAPs but – as noted in the CVAR – no cultural values mapping exercise was undertaken, and consideration of these sites was not included in the ACHA's archaeological survey strategy. The EIS should develop a revised archaeological survey strategy that: • is based on a more rigorous sampling methodology that includes null hypothesis survey locations and greater calculation and reporting of effective survey coverage;	NA	Section 6

Issue	Where previously addressed in EIS/ ACHA	Where addressed
considers and actively includes cultural landscapes and ethnographic information; and covers a greater portion of the Upstream study area.		
The predictive model is flawed due to its limited focus on soil and slope landscape characteristics and its reliance on an inadequate survey methodology. The archaeological survey strategy was not set up to support a testable and verifiable predictive model, so the scientific merit of the predictive model is flawed. A revised predictive model is presented, resulting in the prediction that 174 sites could exist within the Project Upstream impact area (PUIA). The modelling to achieve this prediction is formulated around hectares of soil landscape per site found. However the basis for this is not consistent with the apparent survey method, which largely references slope category rather than soil landscape as the key determinant of which areas were chosen for survey. There is no clear demonstration of how the survey method accounted for the total composition of soil landscapes across this survey area, nor the percentages of each soil landscape covered. The EIS should revise the predictive model to include a broader range of variables, including ethnographic information, the results of an updated sampling strategy, and a consistent set of parameters supported by the survey.	Section 9 and Figures 16, 17 and 18 in Annex 2 of Appendix 1 of ACHA	Section 6
National Heritage values have not been assessed under the EIS Chapter 8 and Appendix K. To update he EIS significance assessment to account for national heritage values which are criteria under the EPBC Act. The significance assessment covers criteria related to the National Parks and Wildlife Act 1974 (NSW) (NPW Act) but overlooks the SEARs requirement that National Heritage values be considered as well. Given the relationship of the site to the Greater Blue Mountains World Heritage Area, the National Heritage List (NHL) criteria under the EPBC Act should be outlined and the identified values assessed against them.	NA	Section 7 and 8
The EIS Aboriginal Cultural Heritage Assessment Report cumulative impact assessment is inadequate; it uses historical impacts as a mitigating measure for current additional impacts, does not account for historical loss, and does not account for the views of RAPs/ Traditional Owners. The concept of cumulative impacts should not use historical impacts as mitigating measure in as a mitigating measure in assessing ongoing and future impact as being negligible. The cumulative impact assessment also fails to address the key issue set out by the Aboriginal community—that the existing dam construction in the 1950s is already a source of significant impact to the cultural values of the area, and that this existing impact is entirely unmitigated. Comments from the Aboriginal community state that the current dam	NA	Section 7 and 8

Issue	Where previously addressed in EIS/ ACHA	Where addressed
represents a historical and inter-generational impact on cultural value. The cumulative impact assessment of the EIS should be revised in light of revised archaeological survey data and in consultation with the Aboriginal community.		
The ACHA acknowledges that there will be harm to all sites within the PUIA, and the degree of harm to those sites is considered to be total. The scientific significance of at last 75 per cent of those sites is broadly unknown (based on the current predictive model) and the cultural significance of all of those sites is high. Despite this position, Section 10 of the ACHA (p 79) states that 'The A[A]R has concluded that considered against the precautionary principle the potential impacts of the Project on archaeological scientific values can be considered relatively minor due to prior or existing impacts'. This conclusion is entirely at odds with the findings of the report. Giving consideration to the precautionary principle, full scientific certainly about the number, nature and extent of sites within the PUIA is not known. Therefore, the conclusion that the impacts from the project would be minor does not take into account the precautionary principle at all. Instead, it is entirely opposed to the fundamental purpose of the precautionary principle. There is also no rationale for the conclusion that the impacts would be minor. This is simply an assertion by the authors that is unsupported by the extent of impacts outlined in Chapter 9.	Section 10 of the ACHA	Section 8 and 9
Within the EIS ACHA, recommendations do not adequately address the impacts, and do not account for Aboriginal cultural values, but are focused only on the archaeological values. The EIS should Revise the recommendations in light of revised predictive modelling, survey strategy and impact assessment, as well as incorporate the views of Aboriginal community.	NA	Section 8 and 9
Impacts on archaeological sites and Aboriginal cultural heritage are downplayed. The assessment acknowledges that there is the potential for other sites to occur but does not propose any mitigation measures, nor really appreciate the significance of such sites. There is an inconsistent approach to the potential impact on sites from water inundation.	Chapter 18 of EIS	Section 7, 8 and 9

2.4.8 Community submissions

The following issues as summarised in the table below were identified community submissions in relation to Aboriginal cultural heritage.

Table 16: Community submissions

Issue	Where previously addressed in EIS/ ACHA	Where addressed
Trish Doyle		
The Project will have a potentially devastating impact on indigenous cultural heritage. Traditional owners oppose this Project. Federal government protection of the area that would be inundated by the Project has been sought. The NSW Government must acknowledge the very real potential of profound loss to indigenous cultural heritage should this Project go ahead.	NA	Section 7 and 8

3. Supplementary assessment framework

3.1 Preamble

Following the public exhibition of the EIS, DPE requested that WaterNSW prepare a Preferred Infrastructure Report (PIR) including a request to address a number of heritage related matters. The approach to the supplementary assessment was therefore designed to address the Aboriginal heritage related matters required for the PIR in addition to the key themes and issues raised during the submission process as presented in the previous section. This supplementary assessment has been prepared to inform both the Submissions Report and PIR.

3.2 PIR: Heritage related matters

The following table provides an overview of the heritage related matters required to be addressed in the PIR and where they have been addressed in this supplementary assessment.

Table 17: Heritage related matters to be addressed in the PIR and where they are addressed in this supplementary assessment

	Heritage matter	Where addressed
1	Provide a more comprehensive assessment of Aboriginal cultural heritage values including: a) Ongoing consultation with the Aboriginal community which appropriately considers and addresses their comments and concerns	Section 4
	b) Additional work completed in response to issues raised by submissions to identify and assess Aboriginal cultural values likely to be impacted by the proposal, including further field studies	Section 5, 6 & 7 See also Section 3.3 below
	c) Mitigation and management measures for any impacts to Aboriginal heritage, both tangible and intangible	Section 9
2	Provide a balanced assessment of the upstream and downstream impacts to non-Aboriginal heritage, with methodologies applied consistently.	Section 6.3.2 of PIR and Appendix G of PIR – Supplementary non-Aboriginal heritage assessment
3	Provide a more detailed assessment of the impacts of the proposal on World Heritage including: a) Consideration of the Aboriginal cultural heritage aspects of World Heritage	Section 8.5.2
	b) Consideration of the natural and cultural values	Section 8.5.2
	c) Assessment of the impacts of the proposal against the Statement of Outstanding Universal Value for the Greater Blue Mountains World Heritage Area.	Section 8.5.2
4	Clear definition is required for the term “Project Upstream Impact Area (PUIA)” used in analysis for Chapter 18, and across the Aboriginal Cultural Heritage Assessment. This definition must clearly state the relevant annual exceedance probability (AEP) or average recurrence interval (ARI) upper and lower bounds for this assessment area.	Section 1.2
5	The EIS states “There are also a number of sites within the Upstream study area above the EUIA.” At 18-66 of Chapter 18. Details must be provided of the AEP and ARI upper and lower bounds for the assessment area.	Section 1.2

3.3 Key themes and issues raised by submissions

Based on a review of the responses received during the submission process a number of key themes and issues have been identified as requiring further consideration and/or assessment. These themes and issues are identified below along with an indication of where they have been addressed within this supplementary assessment. It is noted that there is some overlap with the issues raised in the submissions and those required to be addressed in the PIR as outlined in Section 3.2.

3.3.1 Aboriginal community consultation and RAPs

As an SSI Project that is authorised by a development approval granted under Division 5.2 of Part 5 of the EP&A Act, the Project is exempt from requiring an Aboriginal Heritage Impact Permit (AHIP) under section 90 of the *NSW National Parks and Wildlife Act 1974*. Consequently, it is also exempt from compliance with the consultation process in Clause 80C of the NPW Regulation. As documented in Section 6 of the ACHA, the consultation process nevertheless fulfilled the step-by-step requirements specified in DECCW's *Aboriginal cultural heritage consultation requirements for proponents 2010* in addition to being competed in compliance with the requirements of these and the following guidelines and legislative instruments:

- *Draft Guidelines for Aboriginal Cultural Heritage Impact Assessment and Community Consultation* (DEC 2005).
- *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales* (DECCW 2010b).
- *Guide to investigating, assessing and reporting on Aboriginal cultural heritage in NSW* (OEH 2011).
- *The Burra Charter: The Australia ICOMOS Charter for Places of Cultural Significance* (Australia ICOMOS 2013)
- *NSW National Parks and Wildlife Regulation, 2019* (NPW Regulation).

The consultation process allowed for and encouraged provision of relevant information about aspects of Aboriginal cultural heritage. However, as noted extensively in the ACHA and supporting Annexes, the majority of RAPs declined to nominate Aboriginal cultural knowledge holders on the basis that they did not trust the intent of the Proponent or the assessment process. Those individuals nominated as Aboriginal cultural knowledge holders chose not to participate due to the wider concerns regarding the Proponent and the assessment process.

The lack of active engagement by RAPs was noted as a limitation throughout the assessment process. Nevertheless, the assessment documented and considered concerns and/or issues raised by the RAPs and included any information where provided.

Since the initial review of the draft ACHA report the consultation process has continued throughout the Project. Details of the continued consultation process are provided in Section 4 of this supplementary assessment.

3.3.2 Additional background information and/or detail required

A number of submissions noted that additional background information and/or detail was required to variously inform the validity of the predictive model and/or provide context for the impact and significance assessment components of the Project. Additional information requested included the following:

1. The need for an updated search of the Aboriginal Heritage Information Management System (AHIMS).
2. Consideration of Aboriginal cultural heritage sites downstream of the Project area.
3. More detailed consideration of the Aboriginal Place nomination information.

4. Expanded consideration and discussion of the regional motif and pigment data for rock art.
5. Expanded consideration and discussion of Potential Archaeological Deposits (PADs).
6. More detailed consideration of potential impacts of flooding on Aboriginal archaeological sites based on:
    a) An assessment of broader literature including that which may enable a more targeted consideration of impacts specific to, for example, the flooding of medicinal springs and impacts to rock art.
    b) An assessment of current inundated Aboriginal archaeological sites in the broader Project area.

Additional information and discussion on the above topics is provided in Section 5 of this supplementary assessment in the context of the update and review of the Aboriginal archaeological context.

3.3.3 Issues relating to the predictive model

A number of submissions identified issues relating to the original predictive model that was developed for the Project specifically:

1. A focus on the number of sites rather than archaeological features.
2. The lack of consideration of PADs.
3. The lack of consideration of visibility in general and more specifically in relation to the number of predicted Aboriginal heritage sites.
4. The lack of consideration of intangible values and/or use of ethnographic information or other cultural information relating to intangible values.
5. The lack of clearly defined research questions.

A review and update of the predictive model is provided in Section 6 of this supplementary assessment.

3.3.4 Issues relating to the significance assessment process

A number of submissions identified issues relating to the significance assessment process including:

1. The need to consider PADs in the significance assessment of Aboriginal sites, particularly in relation to open sites.
2. The lack of sub-surface testing and thus unknown nature and extent of sub-surface archaeology associated with sites in the Project area.
3. The need to consider disturbance and visibility in the significance assessment of Aboriginal sites not just the number of visible artefacts recorded at a site (i.e. are more artefacts likely to be present but not currently visible? Thus a site with a low artefact count and low visibility may still have higher significance due to the potential for further artefacts).
4. The need to consider the number of features associated with a site (i.e. potential complexity – more features may equal higher significance) and the association with other sites nearby (i.e. to consider the site's associated with the broader cultural landscape).
5. The need to consider the potential of a site to address the research questions specified in the AR.

With these issues in mind, a review and update of the significance assessment was completed for Aboriginal cultural heritage sites associated with the Project. This is provided in Section 7 of this supplementary assessment.

3.3.5 Issues relating to the impact assessment process

A number of submissions identified issues relating to the impact assessment process including:

1. The use of the PUIA for impact assessments and the assumption of total harm.
2. The assessment of impacts of flooding upstream and downstream.
3. The assessment of potential impacts to Aboriginal cultural values:
    a) Within the Subject Area
    b) Within the World Heritage Area more broadly.
4. The assessment of potential impacts on a site-by-site basis within the Subject Area.
5. The assessment and consideration of Ecological Sustainable development (ESD) principles and cumulative impacts.

With these issues in mind, a review and update of the impact assessment was completed for Aboriginal cultural heritage sites and values associated with the Project. This is provided in Section 8 of this supplementary assessment.

3.3.6 Issues relating to the proposed mitigation measures

A number of submissions identified issues relating to the proposed mitigation measures and recommendations including:

1. The need for full detailed documentation and base line recording of rock shelters, particularly those with art.
2. Factors relating to the timing and development of the Aboriginal Cultural Heritage Management Plan (ACHMP) including issues and recommendations relating to consultation with RAPs (including the Gundungurra Consultative Committee), the timing of the development of the ACHMP (i.e. recommended that this be developed prior to Project approval), the extent of land to which the ACHMP should cover (i.e. recommended to include the wider landscape not just the impact area) and the determination of offsets relating to Aboriginal heritage.
3. The consideration of mitigation measures including actions to manage impact to sites prior to harm from inundation be required (for example protocols for surface collection of artefacts or salvage).
4. The consideration of mitigation measures for the salvage of deposits either via excavation with RAPs and/or continued monitoring of impacts from erosion and inundation.
5. The lack of consideration of and compliance with the Burra Charter and all current guidelines identified in the SEARs.

With these issues in mind, a review and update of the proposed mitigation measures and recommendations for the Project is provided in Section 9 of the supplementary assessment.

4. Continued Aboriginal community consultation

4.1 Preamble

In administering its statutory functions under Part 6 of the NPW Act, Heritage NSW (formerly the Biodiversity and Conservation Division (BCD), which replaced OEH) requires that proponents consult with Aboriginal people about the Aboriginal cultural heritage values (cultural significance) of Aboriginal objects and/or places within any given development area, in accordance with Clause 80c of NSW National Parks and Wildlife Amendment (Aboriginal Objects and Aboriginal Places) Regulation 2019 ('the Regulation'). All consultation undertaken for the original ACHA is clearly outlined and documented in the original report (see Niche 2021). This section outlines the continued consultation that has occurred following the Public Exhibition of the EIS. This consultation has been a continuation of this process and has been undertaken in accordance with *Aboriginal cultural heritage consultation requirements for proponents 2010* (DECCW 2010b).

4.2 Registered Aboriginal Parties

As a result of the Stage 1 process undertaken during the original ACHA (Niche 2021) the following 22 organisations and/or individuals listed in Table 18 are recognised as Registered Aboriginal Parties (RAPs) for the Project based on the registration process completed during the registration period between 6 November 2017 – 25 November 2017.

Table 18: Summary of Registered Aboriginal Parties for the Project

Registered Aboriginal Parties for the Project	
A1 Indigenous Services	Amanda Hickey Cultural Services
Biamanga	Cullendulla
Corroboree Aboriginal Corporation	Cubbitch Barta
Darug Custodian Aboriginal Corporation	Darug Land Observations
Duncan Falk Consultancy	Darug Aboriginal Land Care
Goobah Developments	Gundungurra Aboriginal Heritage Association Inc.
Gundungurra Tribal Council Aboriginal Corporation	Illawarra Local Aboriginal Land Council
Kamilaroi Yankunytjatjara Working Group	Koolkuna Elders
Muragadi Heritage Indigenous Corporation	Murra Bidgee Mullangari Indigenous Corporation
Murramarang	Kazan Brown and Taylor Clarke
Tharawal Local Aboriginal Land Council	Widescope Indigenous Group

Mr Daniel Chalker, having been involved in the Project since it's commencement, has registered Wori Wooilwa as an additional RAP to the above 22 RAPs and will be consulted with moving forward.

4.3 Summary of ongoing consultation

Following the public exhibition of the EIS, WaterNSW has been considering and responding to the 2500+ submissions and preparing a PIR. WaterNSW has undertaken further consultation with the RAPs during the EIS exhibition and will continue consultation and engagement with the RAPs for the duration of the Project. A consultation log of all correspondence relating to the Project during and post the EIS exhibition period is included in Appendix 1 and summarised below.

4.3.1 RAP update letter – Project update

An update was sent to all RAPs on 17 August 2022 to provide an update outlining the progress of the Project as well as its current status. Specifically:

- The EIS was placed on public exhibition from 29 September 2021 to 19 December 2021 inclusive.
- Following on from this, WaterNSW is preparing a Submissions Report, which will document the issues raised in submissions from government agencies, councils, businesses, community groups and individuals, and will provide responses to all issues raised. This will include issues raised in relation to Aboriginal cultural heritage.
- As directed by Department of Planning and Environment (DPE), WaterNSW is also preparing a Preferred Infrastructure Report, which will provide additional information and clarification on specific matters identified in advice provided to WaterNSW in January 2022. This report will address matters relating to Aboriginal cultural heritage.
- During preparation of the above reports, WaterNSW has consulted further with DPE and other government agencies.
- Separate to the above, WaterNSW has also been working to reach an outcome on the knowledge holders to be identified on the AHIMS site cards for sites identified through the Aboriginal cultural heritage assessment for the Project.

4.3.2 RAP update letter – upcoming provision of draft supplementary assessment report

An update was sent to all RAPs on 21 September 2022 indicating the intention to send out the draft supplementary assessment to the ACHA for review by all RAPs. This letter included an invitation to a workshop to be held on either the 10 or 11 October 2022 in order to discuss the information presented in the draft Supplementary assessment to the ACHA and to update RAPs on the Project's progression through the assessment process. Table 19 summarises the responses to the update letter.

Table 19: RAP responses to update letter

Registered Aboriginal Party	Stakeholder	Comment made	Response from Niche
Corroboree Aboriginal Corporation	Marilyn Carroll Johnson	Hi Deirdre We are interested in attending workshop.	Noted. Thanks for the response.
Kazan Brown	Kazan Brown	Taylor and i will attend a workshop if it fits our current schedule, at the moment we don't have rosters. we would also like to request a hard copy of the report each	Noted. Thanks for the response.
Cubbitch Barta	Glenda Chalker	I am available in the morning of the 11th but not the 12th October.	Noted. Thanks for the response.
Kamilaroi-Yankuntjatjara Working Group	Stefeanie Khan	Thank you for the update we will be happy to attend the meeting on the 11th October 2022.	Noted. Thanks for the response.
A1 Indigenous Services	Carolyn Hickey	A1 would be interested in attending the work shop. Kind Regards	Noted. Thanks for the response.

4.3.3 RAP review of draft supplementary information report

A letter was sent to all RAPs on 27 September 2022, accompanied by a copy of the draft Supplementary Assessment to the ACHA, requesting a review of this draft supplementary Assessment to the ACHA. An additional letter was sent to all RAPs on 24 October 2022 thanking those who attended the community consultation meeting and to remind everyone of the closing date for the review period.

4.3.4 Community consultation meeting

An invitation to attend a community consultation meeting to discuss the draft Supplementary Assessment to the ACHA was sent to all RAPs on 4 October 2022. Responses to the meeting invite are provided below in Table 20.

Table 20: Responses to community consultation meeting invite

Registered Aboriginal Party	Stakeholder	Comment made	Response from Niche
Kazan Brown	Gundungurra Traditional Owner	Why is it being held off country in glenbrook	
Sharyn Hall	Gundungurra Aboriginal Heritage Association Inc.	Thank you for your email I'll be attending Regards Sharyn Halls Gundungurra Elder	
Glenda Chalker	Cubbitch Barta	I will be attending, however you certainly haven't made it a reasonably short drive by having it at Glenbrook. I hope that there is some reimbursement of at least travel money, if nothing else. Glenda Chalker	
Sharyn Hall	Gundungurra Aboriginal Heritage Association Inc.	Hi I'm not attending the meeting now Regards Sharyn Halls Gundungurra Elder	
Phil Kahn	Kamilaroi-Yankuntjatjara Working Group	Hi, Thank you for your email, we will be attending the meeting. Kind Regards Phil Khan	
Donna Hickey	Widescope	Hi Steven Hickey confirming his attendance. Time and Date 11:00 am – 12:00 noon Tuesday 11 October 2022 Location Glenbrook NPWS office at 68 Bruce Road, Glenbrook NSW 2773	

Registered Aboriginal Party	Stakeholder	Comment made	Response from Niche
		Regards Donna Hickey	
Carolyn Hickey	A1 Indigenous Services Pty Ltd	Hi, A1 would like to attend the workshop Kind Regards Carolyn Hickey	
Marilyn Carroll-Johnson	Corroboree Aboriginal Corporation.	Hi Deidre Sorry; I am away for survey all week. Apologies. Kind regards Marilyn Carroll-Johnson Director Corroboree Aboriginal Corporation	

The meeting was held on 11 October 2022. A copy of these notes will be provided to all RAP groups.

Table 21: Community consultation meeting attendees

Attendee	Organisation	Attendee	Organisation
Kazan Brown	Gundungurra Traditional Owner	Robert Cawley	WaterNSW
Taylor Clarke	Gundungurra Traditional Owner	Madison Van Der Velde	WaterNSW
Glenda Chalker	Cubbitch Barta	Russell Hill	WaterNSW
Marbuck Kahn	Kamilaroi-Yankuntjatjara Working Group	Jamie Reeves	Niche
Tyron Kahn	Kamilaroi-Yankuntjatjara Working Group	Deirdre Lewis-Cook	Niche
Daniel Chalker	Wori Wooilwa		

4.3.5 RAP review of draft supplementary information report

A letter was sent to all RAPs on 24 October 2022 thanking those who attended the community consultation meeting and to remind everyone of the closing date for the review period.

4.3.6 Responses to Supplementary Assessment to the ACHA

Table 22 summarises the responses to the update letter. An email, included in Appendix 1 of this report, was sent out to all RAPs on 24 October 2022 reiterating the closing date for comments on the Supplementary Assessment to the ACHA.

Table 22: RAP responses to Supplementary Assessment to the ACHA

Registered Aboriginal Party	Stakeholder	Comment made	Response from Niche
Kazan Brown	Kazan Brown	On 27 September 2022 I received a copy of the draft supplementary assessment for comment as a RAP for the Project. The supplementary assessment does not meet DPE requirements. I have resubmitted my original submission because I do not believe our concerns have been addressed adequately in the Draft Supplementary Assessment Document. The following are additional comments on the supplementary Assessment not included in my original submission dated 18 December 2021. This report is in response to the ACHA, yet it contains no submissions or comments by RAPS. Why haven't our concerns been addressed in this document? Where is our voice? Is this an example of how RAPs opinions are being respected? Why is there only 1 submission from Community Members? As previously advised, and reiterated again here, the Traditional Owners and Knowledge Holders of the Burragorang Valley do not give free and informed consent to the project and the destruction of our cultural heritage. **Comments on recommendations** As stated in our original submission, we do not consent to the project. We reject the recommendations- they do not mitigate the harm of the project. The supplementary assessment acknowledges that they are indirect mitigation measures because "If the Project proceeds the limitations of the proposed activities mean that there is no capacity for directly applied management measures for the avoidance or minimisation of harm." The Project must not proceed. In relation to specific recommendations: **Cultural awareness training for WaterNSW staff and others** The recommendation should have been implemented many years ago. Cultural awareness training is something everyone should undertake. It is offensive that the information centre, that has operated as long as it has, has very minimal acknowledgement to the local Gundungurra People. Why is there still little collaboration and information on the local people (we have been here before invasion and **we are still here**). It should not take the destruction of our culture for us to be recognised and acknowledged, this is too little too late. **Access to country** Biannual visits with strangers are neither adequate nor appropriate. We have a right to access our sites in privacy as stated in the **United Nations Declaration on the Rights of Indigenous Peoples** (UNDRIP) (2007). **See below** • **Article 11** "Indigenous peoples have the right to practice and revitalize their cultural traditions and customs. This includes the right to maintain, protect and develop the past, present and future manifestations of their cultures, such as archaeological and historical sites, artefacts, designs, ceremonies, technologies and visual and performing arts and literature" (p. 11). • **Article 12** "Indigenous peoples have the right to manifest, practice, develop and teach their spiritual and religious traditions, customs and ceremonies; the right to maintain, protect, and have access in privacy to their religious and cultural sites; the right to the use and control of their ceremonial objects; and the right to the repatriation of their human remains" (p. 12). • **Article 25** "Indigenous peoples have the right to maintain and strengthen their distinctive spiritual relationship with their traditionally owned or otherwise occupied and used lands, territories, waters and coastal seas and other resources and to uphold their responsibilities to future generations in this regard" (p. 19).	Thanks you for your submission and comments Kazan. Some amendments made to supplementary assessment include:

Registered Aboriginal Party	Stakeholder	Comment made	Response from Niche
		Two days per year is not an adequate amount of time to maintain, develop and pass on our intergenerational knowledge to younger generations. Nor is it appropriate we do this amongst a cast of thousands. Considering the plan is to destroy such a large amount of our cultural heritage **we should be permitted entry now. My children and my grandchildren should have adequate access and time to see and learn about their culture now.** **Water NSW should be facilitating this now rather than talking about making access easier in the future after the project is underway** **Cultural values recording and education** Interpretive material and information should already be a part of the information centre. For the past twenty-five plus years we have been working on recording our cultural values and stories. We are more than capable of doing this ourselves. After participating in this process, I would not trust WaterNSW, or anyone they employed, to carry out a cultural values project in a truthful and respectful manner. These are our stories, and we will tell them how and why we chose to. We will not participate in the cultural values project nor the Mirrigan and Gurrangath songline project. We certainly will not be providing any oral history interviews for the heritage study of the Aboriginal traditional and historical occupation of the project area. The cultural values and recording recommendations are “feel good’ and tokenistic and as a result of this we will not participate nor support them. The “Eel hole” downstream of the junction of the Nattai River and Whitegum Creek (1905 Parish Map). This particular waterhole is not part of the Gurrungatch story, he did not travel that route, the Eel hole was likely named by a local European settler. Page 5 and section 9 recommends Heritage NSW, and the Gundungurra Consultive Committee are involved in determining offset. The ILUA is not inclusive and according to Heritage NSW all relevant parties which have an interest in a particular area, should be consulted. Its important to consider knowledge holders are not always a part of native title claims and land councils. The ILUA was signed over 20 years ago, covers a very large area, and it does not represent all Gundungurra peoples. The report states a number of times that RAP’s were against subsurface testing. This is misleading. One RAP stated subsurface testing harms the integrity of sites. Many of us asked on more then one occasion why testing had not been carried out. We were told it would be part of the management plan and would not occur until after the project was approved. This is a perfect example of why we have lost trust in the project. The statements RAP’s opposed subsurface testing is a perfect example of contractors trying to shift the blame of their own inadequacies onto the RAP’s. See attachment 1, 2 and 3. RAP update letters are just that, updates they are not consultations, there were no discussions and should not be included as such. The rock art study is still only a desk top study and is dangerously inadequate. It ignores the report about Kerswell Hill and information about Waratah rock provided by myself and Dr Jim Smith in my earlier submission and his personal submission. Both these sites are Sacred. This study continues to downplay both the cultural and scientific values of our rock art sites. Page 69 Waratah Rock is still missing reference to footprints and waratah drawing. The importance of this site has been downplayed and as such is highly disrespectful at best and re-writing our stories and dreaming at its worst. As stated in our original submission, the handprint is that of a Burringilling, this is a scared site and must be recorded as such. Information was provided and has been ignored. Page 74 The supplementary assessment says that silt deposits does not necessarily impact a site. This is demonstrably not true. The Bynes Creek carving was excluded from	

Registered Aboriginal Party	Stakeholder	Comment made	Response from Niche
		the first report, not given a significance rating. Moreover, it's been assumed there is no oral history related to the site because 'no one could see it'. Is this an example of how silt does not necessarily impact a site? Is this what will happen in the future to sites covered in silt? Seems to be a blatant re-writing of our stories that existed in this land for millennia (again, as previously as reported in original response to submission). Silt covered sites have an impact on storytelling and the handing down of intergenerational knowledge, it prevents us from seeing, maintaining and connecting to our stories and culture. Sites covered in silt are destroyed and our interconnected knowledge and dreaming is lost. This is on top of the loss that has already been felt by the original dam wall development and compounded by ubiquitous loss across this land as a result of colonisation. Page 83 The supplementary assessment says that not all inundation constitutes adverse impacts. This is disingenuous. The preservation of artifacts organics and other fragile material is rather useless when it's buried under six foot of thick wet cement like silt. Page 14 References bush fire impact to section 5.6.3 and appendix 5. I cannot locate any information on post bush fire surveys. Page 228 Warragamba FMZ what is it? Where is it? How will the approach be different in the future? The words myth and mythology are used throughout the document. These words (not only epistemologically positioned from a while western dominant world view) but are used historically to lessen the importance of our sites and beliefs and has been widely documented as a modern colonisation and subjugation of us as a people's. This document continues to do that with the use of these words. Our stories are no less important than those told by Christians or any other religious group and should be given the same respect and consideration. These words need to be removed. If you are assessing Indigenous peoples and places surely an Indigenous worldview must be employed not a white western world view. Similarly, you can't apply a Western worldview to an Indigenous issue. Indigenous worldviews must be applied to Indigenous issues. This is the heart of self-determination and truth telling. According to UNDRIP (above) "**States** shall consult and cooperate in good faith with the Indigenous peoples concerned through their **own representative** institutions in order to **obtain their free and informed consent prior to the approval of any project affecting their lands** or territories and other resources, particularly in connection with the **development**, utilization or exploitation of mineral, **water** or other resources" (p. 23). As previously advised, and reiterated again here, the Traditional Owners and Knowledge Holders of the Burragorang Valley do not give free and informed consent to the project and the destruction of our cultural heritage. **The supplementary assessment does not meet the DPE's requirements** The supplementary assessment states that its purpose is "to satisfy the Aboriginal cultural heritage requirements of the PIR and to respond to submissions received during the public exhibition". It does not do this. DPE required that the PIR "provide a detailed response to, at a minimum, the key issues raised in Attachment A and a detailed assessment of any changes required to the Proposal to address these issues and any issues raised in submissions or government agency advice". Attachment A required, in relation to heritage: **Heritage** - Provide a more comprehensive assessment of Aboriginal cultural heritage values, including: o ongoing consultation with the Aboriginal community which appropriately considers and addresses their comments and concerns o additional work completed in response to issues raised by submissions to identify and assess Aboriginal cultural values likely to be impacted by the proposal, including further field studies	

Registered Aboriginal Party	Stakeholder	Comment made	Response from Niche
		o mitigation and management measures for any impacts to Aboriginal heritage, both tangible and intangible - Provide a balanced assessment of the upstream and downstream impacts to non-Aboriginal heritage, with methodologies applied consistently. - Provide a more detailed assessment of the impacts of the proposal on World Heritage including: o consideration of the Aboriginal cultural heritage aspects of World Heritage o consideration of the natural and cultural values o assessment of the impacts of the proposal against the Statement of Outstanding Universal Value for the Greater Blue Mountains World Heritage Area. - Clear definition is required for the term "Project Upstream Impact Area (PUIA)" used in analysis for Chapter 18, and across the Aboriginal Cultural Heritage assessment. This definition must clearly state the relevant annual exceedance probability (AEP) or average recurrence interval (ARI) upper and lower bounds for this assessment area. - The EIS states "There are also a number of sites within the Upstream study area above the EUIA." at 18-66 of Chapter 18. Details must be provided of the AEP or ARI upper and lower bounds for this assessment area. Attached to this submission is a peer review of the supplementary assessment against the above requirements [conducted by Dr Paul Irish of Coast History and Heritage]. It is clear from this review and from the following comments, that the supplementary assessment is not the "more comprehensive assessment of Aboriginal Cultural Heritage values" that is required. None of the information provided by me or other knowledge holders has been considered in the supplementary assessment. No further assessment of Aboriginal cultural heritage values is apparent, let alone a "more comprehensive" one. *Requirement 1(a): Provide a more comprehensive assessment of Aboriginal cultural heritage values including [o]ngoing consultation with the Aboriginal community which appropriately considers and addresses their comments and concerns* Crucially, no ongoing consultation with the Aboriginal community occurred as part of the preparation of the draft supplementary assessment. We have been provided with a completed draft, rather than having been actively consulted with and our feedback listened to and incorporated in the scoping and drafting of the document. The supplementary assessment, in its "overview of submissions" at section 2 sets out in detail submissions made by government agencies, public authorities, and heritage bodies. It does not set out any of the submissions made by the people whose cultural heritage will be impacted by the proposal. This is indicative of how genuinely we have been considered in this process- an afterthought, if at all. Section 4 does not address any of the issues that have been previously raised by traditional owners or RAPs. It sets out the inadequate "consultation" (more accurately characterised as notification) that has taken place since DPE's assessment report was released. However, it does not engage with any of the actual issues or concerns or information set out by knowledge holders and the broader Aboriginal community. Where the table at Section 2 lists Section 4 as the location a particular concern raised by government and other public authorities has been addressed, this is inaccurate. For example, Heritage NSW feedback that "Aboriginal community knowledge, comments and concerns have not been appropriately or adequately considered and addressed." is said to be addressed at Section 4 of the Supplementary assessment (p 10).	

Registered Aboriginal Party	Stakeholder	Comment made	Response from Niche
		As above, Section 4 merely lists correspondence and notifications. It does not engage with the substance of our knowledge, comments, and concerns. The implication from Section 4 is that because we did not provide information and concerns directly to Niche at that stage of the Project meant that this (our knowledge, comments and concerns) was not available is unsupportable. Our concerns and comments, and some of our knowledge have been made clear, including in our various submissions on the EIS. These have not been considered. In the context of this disregard for our contribution, it is clear why some did not feel comfortable with continuing to engage with Niche. I have again attached my submission on the EIS, dated 18 December 2021, including attachments to this submission **for your consideration.** I urge you to also consider and address submissions made by other RAPs and knowledge holders on the EIS, as well as academic expert contributions and evidence provided to the NSW Parliamentary Inquiries into the project.3 Section 4 is also said (at page 22) to be the evidence of the supplementary assessment meeting the DPE requirement to: Provide a more comprehensive assessment of Aboriginal cultural heritage values including: a) Ongoing consultation with the Aboriginal community which appropriately considers and addresses their comments and concerns There is **nothing** in Section 4 that could be described as "consultation with the Aboriginal community which appropriately considers and addresses their comments and concerns". To state that it meets this requirement evidently relies on Section 4 not being read. *Requirement 1(b): Provide a more comprehensive assessment of Aboriginal cultural heritage values including [a]dditional work completed in response to issues raised by submissions to identify and assess Aboriginal cultural values likely to be impacted by the proposal, including further field studies* No further field studies have been undertaken in the area that is proposed to be inundated by the proposal, despite being explicitly required. This is also despite the inadequacy of the extent of the original assessment's survey area being an issue raised repeatedly by RAPs, academic experts, and government and other organisations in response to the EIS. As noted in my 2021 submission, my daughter and I are knowledge holders and were excluded from participating in the survey. This meant that sites and cultural knowledge that resides in my family are not recorded or considered as part of the assessment. This is unacceptable and must be rectified for the Minister to have sufficient information to consider the impacts on cultural heritage of the proposal. The supplementary assessment says (at p 221) that "[t]he capacity to map specific elements within the cultural landscape that hold cultural values was limited due to the lack of active engagement of Aboriginal cultural knowledge holders." This is inaccurate and offensive, particularly in light of the exclusion of my family from the only survey that has been undertaken for the proposal. One survey was undertaken of a downstream area. This area is not likely to be impacted by the proposal. *Requirement 1(c): Provide a more comprehensive assessment of Aboriginal cultural heritage values including [m]itigation and management measures for any impacts to Aboriginal heritage, both tangible and intangible*	

[3] The Select Committee on the Proposal to Raise the Warragamba Dam Wall - see https://www.parliament.nsw.gov.au/committees/listofcommittees/Pages/committee-details.aspx?pk=262 and the Standing Committee on State Development Inquiry into the Water NSW Amendment (Warragamba Dam) Bill 2018 – see https://www.parliament.nsw.gov.au/committees/Pages/inquiryprofile/water-nsw-amendment-warragamba-dam-bill-2018.aspx#tab-submissions.

Registered Aboriginal Party	Stakeholder	Comment made	Response from Niche
		Section 8 is said to be "a review and update of the impact assessment was completed for Aboriginal cultural heritage sites and values associated with the Project". My comments on the proposed mitigation measures and recommendations is set out above. I also note the Australia ICOMOS (the body responsible for the Burra Charter) submission on the proposal said that the EIS did not meet Burra Charter standards for a number of reasons, including that it did not sufficiently identify and investigate cultural heritage and that it did not sufficiently consider alternatives to the harm to cultural heritage. For example (emphasis added): "inadequate extent of survey undertaken to identify potentially affected Aboriginal sites and the resulting deficiency in assessment and characterisation of predicted impact. It is very concerning that the ACHAR outlines a process for further investigation subsequent to development consent, **whereas the further investigation is actually needed to inform consideration as to whether development consent should be granted**. Further investigation of known sites, through recording, comparative study and/or test excavation is needed so that their nature, extent and significance can be comprehensively characterised. This is essential given the nature of the threat posed by the dam proposal." "without actual information about the actual sites affected, **Traditional Owners have effectively been circumvented of the ability to be sufficiently informed about the relevant cultural heritage impacts** and therefore the information available to the consent authority is not comprehensive and inadequate." "the impact of the fires is actually completely unknown because further fieldwork was not undertaken. **The extent of field survey and the lack of survey following the 2019-2020 fires is a serious and unacceptable shortcoming**." "**Recording is insufficient. The focus should be on avoidance of harm.**" "**There has been insufficient consideration of alternatives to the proposal to avoid harm**. Therefore, the EIS does not meet Burra Charter standards and is fundamentally flawed." The supplementary assessment does not rectify these errors. The EIS therefore continues not to meet Burra Charter standards. Again, the Traditional Owners and Knowledge Holders of the Burragorang Valley do not give free and informed consent to the project and the destruction of our cultural heritage. Regards, Kazan Brown	
Cubbitch Barta	Glenda Chalker	Thank you for the opportunity of responding to the Draft Supplementary Assessment. 1. I would like to repeat again, the same thing not only I have stated in many submissions is that all of the sites are of high cultural significance. I tire of reading that the majority of the sites in assessments are of low significance. The mere fact that they still exist today, in this destructive world that we all live in should make them even to an archaeologist of high significance. 2. There is a contradiction in one dot point to another on page 3 of the overview, in regards to grinding groove sites. One dot point says that the siltation that will occur is "recognised to enhance preservative affect on", and in the next dot point says they "are most susceptible to biochemical impacts" 3. The cumulative affects go beyond this project. The loss of sites from the initial flooding of the dam is unknown, except for the carved trees that were removed. That loss will never be known, but today there is legislation in place to protect our	Good morning Glenda, Received with thanks. Sincerely, Deirdre

Registered Aboriginal Party	Stakeholder	Comment made	Response from Niche
		places in the landscape, and yet developments are still allowed to destroy our places even when we object. 4. The unsurveyed area should be surveyed , even if the project does not go ahead, not sample surveyed as this assessment suggests 5. Interpretation is irrelevant if the sites within the inundation area are destroyed. I believe it is disrespectful to interpret after destruction of our places. 6. It is important that we are given the opportunity of knowing where all cultural material from the Valley is being kept and to be able to see them 7. Why is the World Heritage Committee making recommendations in regards to mitigation. I would have hoped that they would not support this project in totality. 8. I asked the question in regards to offsets at the last meeting, and never really got an answer. The recommendation that Heritage NSW and the Gundungurra Consultative Committee "include consideration of offsets" This recommendation is insulting to us all that an Aboriginal organisation will be swayed by offsets. What kind of offsets are we talking about? I don't even believe in offsets for trees, let alone Aboriginal Heritage. Once it is destroyed it is gone forever. Are we talking here about dollar offsets? The Heritage of Burragorang Valley belongs to more than one family of Aboriginal people. 9, There is no such thing as "a moderate level of cumulative impact", coming from Heritage NSW, the cumulative impact is complete or whole of level of cumulative impact. Even Heritage NSW says that the mitigation measures are insufficient, and that offsetting Aboriginal Heritage will not adequately address the impacts. 10. Heritage NSW makes the point that the visibility during the survey could skew the numbers of the sites identified, and were not able to be relocated, therefore the actual numbers of the sites present may not reflect the true numbers 11 There would have been more than one community submission, why are they not included in this document. 12. There are 22 Registered Aboriginal Parties to this project and yet less than a handful of RAP's are the same ones that are present at all meetings. Not even a representative of the ILUA is ever present. Where is Appendix 1 in this document in regards to RAP consultation? 13. The original AHIMS search and count is skewed by lack of opportunity of recording sites. Most of these sites were probably recorded by NPWS staff and Sydney Catchment Authority, on an opportunistic level rather than systematic surveying. 14. Initially I was probably one that did not agree with testing PAD's, however if this project proceeds, I may now be more open to the idea. That does not mean at this point in time I agree with it. 15. The statement on page 219, in regards to the dams existence at the time that the GBMWHA was listed, inferring that the listing accepts flood risk is insulting. What we are talking about is that this kind of flooding potentially can destroy some of those values, with much higher levels of inundation than what occurs with the level of the dam today. 16. Page 222, states "the effects of the project WILL NOT result in an overall reduction in the cultural heritage significance of the project area". That statement should I believe be WILL, not WILL NOT. 17. How can a total loss of value be consistent with the precautionary principle be seen as mitigation? 18. Water NSW Warragamba FMZ Management Program will not change the outcome of this project. 19. There is no need for an arborist to determine whether the wounding of scarred trees is of Aboriginal origin. They should all be recorded without an arborist determination. Why do people question and require the so called expert arborist to determine whether they are of Aboriginal origin. Aboriginal people during the survey said they were Aboriginal scarred trees, and that is all anyone should need to know. 20. The last thing that I would like to comment on, even though there is no mention in this document , is that of the list of persons for the site cards. I do not believe that K Khan is a knowledge holder of the area and therefore does not fit any criteria of a knowledge holder. She should not be on the list for the AHIMS site cards for Warragamba Dam. It has now been over two and a half years since the first meeting in regards to this project. It has taken up so much of the time of a handful of Aboriginal persons and organisations. All those meetings have been to the costs of those individuals and organisations. Whilst everyone else in the room is being paid to be there, we sit there and drive to, and have a day off work to be there, for two and a half years	

Registered Aboriginal Party	Stakeholder	Comment made	Response from Niche
		now. Despite this a handful of us still attend, because of the passion we have to protect Burragorang Valley from further destruction. This project should not proceed ever, in order for the State Government of today to allow more homes to be built on the Nepean floodplains. Raising of the Warragamba will not make any difference for those floodplains to be repeatedly flooded forever and a day.	

5. Update and review of Aboriginal archaeological context

5.1 Preamble

The environmental and Aboriginal archaeological contexts for the Project are described in detail in Chapters 4, 5 and 6 of the Archaeological Report (AR) from the original ACHA prepared for the Project (Niche 2021). As the information contained within these Chapters remain relevant to the current Project, the details are not repeated here. However, literature and databases have been reviewed/updated as required to be compliant with regulations and to assist in addressing issues raised during the submission process. This section therefore outlines the results of an updated Aboriginal Heritage Management System (AHIMS) search for the Subject Area and provides additional information to address issues raised during the submissions process.

5.2 Updated Heritage Register searches

5.2.1 Original AHIMS searches

The following provides a summary of the results from Extensive Searches completed for the original ACHA on 27 August 2019. Further details are provided in Section 4.1.1 of Appendix 1 of the original ACHA. A total of 55 Aboriginal cultural heritage sites were identified within the search area which covered the construction study area, PUIA and surrounding area above the PUIA. The results demonstrated that Artefact sites (Open Camp Sites and Isolated Artefacts) represented the dominant site type within the search area accounting for 80% of sites present. Modified trees (Carved or Scarred were the next most common site type forming 11% of sites.

Table 23: Site types based on original AHIMS search for construction study area, PUIA and area above the PUIA within the upstream study area

Site type	Count	Percentage (%)
Aboriginal Resource and Gathering	1	2
Art (Pigment or Engraved)	1	2
Artefact (Open Camp Site or Isolated Artefact)	44	80
Burial	0	0
Grinding Groove	3	5
Modified Tree (Carved or Scarred)	6	11
Shell	0	0
Stone Quarry	0	0
Waterhole	0	0
Total	**55**	**100**

5.2.2 Updated AHIMS searches

5.2.2.1 Upstream study area

Information derived from searches of the AHIMS remain valid for a period of 12 months from search date; therefore, an updated AHIMS search for the Project was conducted in order to ensure currency. The updated AHIMS search for the upstream area (including the upstream study area, construction footprint study area and varying amounts of the surrounding landscape) was undertaken on 17 May 2022 using a shapefile covering the area of interest (Client Service ID: 683454). The results of the updated AHIMS search is provided in Appendix 2 of this supplementary assessment.

The updated AHIMS search yielded a total of 93 Aboriginal sites within the upstream search area for the Project. A summary of the site types/ features present in the upstream study area based on the updated AHIMS search is provided in Table 6 below. The increased number of sites compared to the AHIMS search completed for the original ACHA is due to differences in the search areas, with a larger search area used for the updated 2022 search. The difference in number of Aboriginal heritage sites identified between the original AHIMS search and updated AHIMS search is the result of differences in the search areas used. A broader search area was used for the updated search to allow for additional site type and feature data to inform the updated predictive model in Section 6 of this supplementary assessment.

At the time of completing the updated AHIMS search, the 'newly identified' Aboriginal sites that were located during survey completed for the original ACHA were in the process of being uploaded and submitted to AHIMS. While the site recording forms have been uploaded to the AHIMS, they have not been formally submitted pending resolution of agreement as to the Aboriginal knowledge holders to be identified on the cards with regard to permission to access site details. For this reason, these sites are not reflected in the updated AHIMS search results as presented in Table 24.

Table 24: Site types based on updated AHIMS search for upstream search area

Site type	Count	Percentage (%)
Artefact/s, Aboriginal Resource and Gathering	1	1.1
Axe Grinding Groove	6	6.5
Burial/s	1	1.1
Burial/s, Modified Tree (Carved or Scarred)	4	4.3
Artefact/s	58	62.4
Artefact/s, Art (Pigment or Engraved)	1	1.1
Artefact/s, Modified Tree (Carved or Scarred)	1	1.1
Quarry	1	1.1
Art (Pigment or Engraved)	1	1.1
Modified Tree (Carved or Scarred)	4	4.3
Shell	1	1.1
Shelter with Art	5	5.4
Shelter with Art, Artefact/s, Deposit & Axe Grinding Groove	1	1.1
Shelter with Artefact/s & Deposit	5	5.4
Water Hole/Well	2	2.2
Restricted	1	1.1
Total	**93**	**100.0**

The results include one Restricted site (AHIMS ID#45-4-1025). Based on information obtained regarding this site during the original ACHA (i.e. its location and site type), it has been confirmed that the site is located in an area that will not be impacted by the Project.

Based on the updated search, the results demonstrate that Artefact sites are the most common site type within the search area accounting for 62.4% of sites present. Most sites occur in open-air contexts (n=81; 87.1%) with 11.8% (n=11) occurring in closed sandstone shelter contexts. A total of 103 archaeological features are recorded as being present across the 93 registered sites. Sites are generally associated with a single archaeological feature (n=84, 90.3%). Almost 10% of sites, however, represent multi-component sites being associated with two or more archaeological features (n=9; 9.7%). The frequency of archaeological features is presented in Plate 1. Artefact/s (n=62, 60.2%) represent the most common feature present followed by Modified Tree (Carved or Scarred) (n=10, 9.7%) and Axe Grinding Groves (n=7; 6.8%). Shelters with Art represent the next most common feature accounting for 5.8% (n=6). In contrast all other archaeological features account for less than 5% (n=5 or less). This patterning in the frequency of site type and features is generally consistent with the previous AHIMS search results presented in the original ACHA.

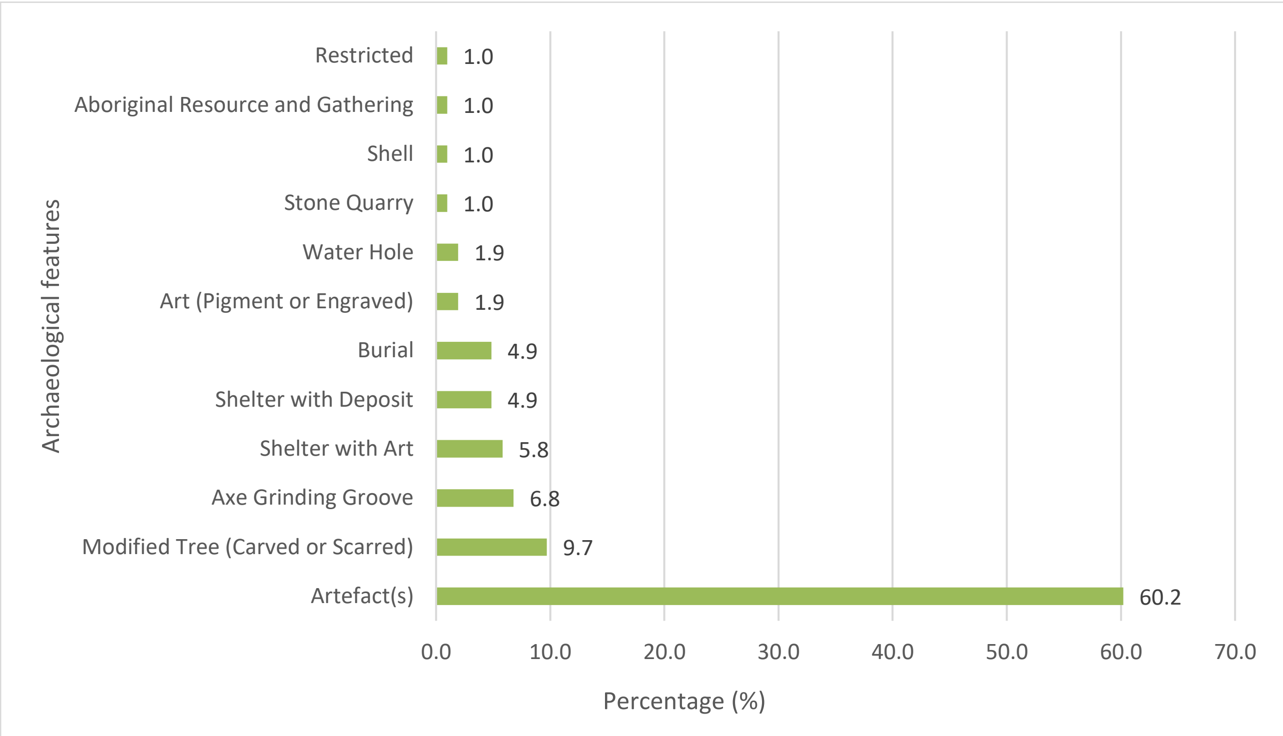


Plate 1: Frequency of archaeological features based on updated AHIMS search for upstream area

5.2.2.2 Additional known Aboriginal heritage sites

In addition to the AHIMS sites just discussed are the known Aboriginal heritage sites that were identified and recorded during the cultural heritage surveys undertaken as part of the original ACHA. These surveys resulted in the identification and recording of 303 new Aboriginal sites within the upstream study area as well as adjoining areas outside of the upstream study area that were subject to survey. The majority of 'newly' recorded sites consisted of Open Camp Sites (n=175). The known site assemblage based on updated AHIMS search, and the known Aboriginal heritage sites recorded during the original ACHA is presented in Table 25 below and their locations provided in Figure 5 and Figure 6.

Table 25: Aboriginal heritage sites identified within the upstream study area during original survey

Site type	Count	Percentage (%)
Artefact/s	196	64.7
Shelter with Deposit and Artefact/s	25	8.3

Site type	Count	Percentage (%)
Shelter with Deposit, Art and Artefact/s	13	4.3
Shelter with Deposit, Art, Artefact/s and Axe Grinding Grooves	9	3.0
Shelter with Deposit and Axe Grinding Grooves	7	2.3
Axe Grinding Grooves	7	2.3
Shelter with Deposit, Artefact/s and Axe Grinding Grooves	6	2.0
Artefacts/s, Modified Tree (Carved or Scarred)	6	2.0
Shelter with Deposit	5	1.7
Aboriginal Resource and Gathering	4	1.3
Modified Tree (Carved or Scarred)	3	1.0
Shelter with Art	3	1.0
Shelter with Art and Axe Grinding Grooves	3	1.0
Artefacts/s, Axe Grinding Groove/s	2	0.7
Shelter with Art and Artefact/s	2	0.7
Shelter with Deposit and Art	2	0.7
Water hole	2	0.7
Stone Arrangement	2	0.7
Shelter with Artefact/s	1	0.3
Shelter with Art, Artefact/s and Axe Grinding Grooves	1[4]	0.3
Shelter with Artefact/s and Axe Grinding Grooves	1	0.3
Shelter with Axe Grinding Grooves	1	0.3
Aboriginal Ceremony and Dreaming	1	0.3
Waterhole and Aboriginal Ceremony and Dreaming	1	0.3
Total	**303**	**100.0**

The patterning of the site types is generally consistent with that based on the updated AHIMS search and the AHIMS search results from the original ACHA with Artefact sites (including Open Camp Sites and Isolated Artefacts) account for over 60% of the sites present. The distribution of sites between open-air and closed rock shelter contexts is similar to that observed in the AHIMS data, albeit with a higher contribution of closed sandstone shelter site type. Similar to the AHIMS patterning, for instance, most sites occur in open-air contexts (n=224; 73.9%) while just over a quarter (n=79, 26.1%) occurring in closed sandstone shelter contexts. Also comparable to the AHIMS patterning, the sites identified during the survey are generally associated with a single archaeological feature (n=225, 74.3%). A higher proportion of sites, however, are multi-component being associated with two (n=49, 16.2%) or more (n=29, 9.6%) archaeological features.

[4] This site was recorded as a new site Warragamba-116 in original ACHA. Further investigation completed during this supplementary assessment has determined that this site is actually a duplicate recording of the previously recorded site 'Warragamba Dam; Bimlow' AHIMS ID#45-4-0026). As such, Warragamba-116 is now discussed as being the updated recording of 'Warragamba Dam; Bimlow' AHIMS ID#45-4-0026.

5.2.2.3 Identification of sites located within the FMZ

Based on the results of the updated AHIMS search (Section 5.2.2.1) and the known Aboriginal heritage sites identified during the survey for the original AHCA (Section 5.2.2.2) a total of 128 Aboriginal heritage sites are located within the Flood Management Zone (FMZ). The breakdown of these sites is provided in Table 26 below. Artefact sites (Open Camp Sites and Isolated Artefacts) are the most common site type within the FMZ comprising 83% of sites. The next most common site type within the FMZ consists of Shelter sites with deposit, artefacts and Axe Grinding Grooves which represent 5.5% of the sites present. Remaining site types form less than 5% of the types present within the FMZ.

Table 26: Identification of site types located within the FMZ

Site type	FMZ	
	Count	**Percentage (%)**
Artefact/s	105	82.0
Axe Grinding Grooves	4	3.1
Aboriginal Resource and Gathering	2	1.6
Artefacts/s, Axe Grinding Groove/s	1	0.8
Artefacts/s, Modified Tree (Carved or Scarred)	3	2.3
Rock Engraving	1	0.8
Shelter with Art	1	0.8
Shelter with Deposit	1	0.8
Shelter with Deposit and Artefact/s	7	5.5
Shelter with Deposit, Artefact/s and Axe Grinding Grooves	2	1.6
Stone Arrangement	1	0.8
Total	**128**	**100%**

5.2.2.4 Identification of sites located within the PUIA

Based on the results of the updated AHIMS search (Section 5.2.2.1) and the known Aboriginal heritage sites identified during the survey for the original AHCA (Section 5.2.2.2) a total of 50 Aboriginal heritage sites are located within the Project Upstream Impact Area (PUIA). The breakdown of these sites is provided in Table 27 below. Artefact sites (Open Camp Sites and Isolated Artefacts) are the most common site type within the PUIA comprising 70% of sites. The next most common site type within the PUIA consists of Axe Grinding Grooves and Shelter with Deposit and Artefact/s which both account for 8% of the sites present. Remaining site types form 2% or less of the types present within the PUIA.

Table 27: Identification of site types located within the PUIA

Site type	PUIA	
	Count	**Percentage (%)**
Artefact/s	35	70
Axe Grinding Grooves	4	8
Aboriginal Resource and Gathering	1	2
Rock Engraving	1	2
Shelter with Art	1	2

Site type	PUIA	
	Count	Percentage (%)
Shelter with Deposit	1	2
Shelter with Deposit and Artefact/s	4	8
Shelter with Deposit, Artefact/s and Axe Grinding Grooves	2	4
Stone Arrangement	1	2
Total	**50**	**100%**

5.2.2.5 Explanation of total site number discrepancy

There is discrepancy between the Aboriginal cultural heritage site totals considered in the original ACHA/EIS compared to the total number considered in this supplementary assessment to the ACHA as outlined in Table 28 below.

The original ACHA/EIS considered all newly recorded sites and only previously recorded AHIMS sites which were revisited during the survey (i.e. location and nature of site confirmed via survey and ground-truthing). The supplementary assessment is based on a combination of a desktop analysis of the updated AHIMS search data which is considered alongside the original ACHA results to allow for the assessment of sites. The supplementary assessment therefore includes a consideration of seven (7) Project Area**.** While the original ACHA/EIS considered a total of 334 sites, with the updated AHIMS data the supplementary assessment considered a total of 340 sites.

Table 28: Aboriginal site discrepancies between original ACHA/EIS and supplementary assessment

Category	Total sites considered		Total sites within PUIA	
	Original ACHA / EIS	Supplementary Assessment	Original ACHA / EIS	Supplementary Assessment
AHIMS registered	31	38	4	11
Newly identified	303	303	39	39
Total	**334**	**340**	**43**	**50**

5.2.2.6 Downstream study area

The Project will result in less frequent and intense flooding downstream of the Warragamba Dam. The FMZ, however, drains water into the downstream study area after the 'natural' flood peak has possessed. While the FMZ is emptied, the duration of low-level flooding experienced downstream of the dam will be extended (refer to Section 8.2.2 of this supplementary assessment for further details).

A series of extensive AHIMS searches were completed for the downstream study area during the original ACHA for the purpose of assisting in understandings of the Aboriginal Objects and sites associated with Lake Burragorang downstream drainage channels. The results of these searches indicated that 887 Aboriginal heritage sites were registered on AHIMS as being located in the downstream study area for the Project. A summary of the site types and features is provided in Table 29. Overall, there will be a net positive effect from the Project for Aboriginal cultural heritage sites, particularly archaeological sites in the downstream study area due to the landscape and sites in this area being subject to less flooding and the fact that floods will be of shorter duration and of less energy. The altered flood regime downstream will also have a small net improvement on the cultural landscape through the reduction in erosion in these downstream areas and better conservation of sites. Considering that the Project will not result in any negative impacts to Aboriginal cultural heritage downstream of Warragamba, no updated AHIMS searches have been undertaken for the downstream study area as part of this supplementary assessment.

Table 29: Summary of AHIMS Aboriginal site types and features within downstream study area based on AHIMS searches completed as part of the original ACHA

Site features	Number	Percentage
Aboriginal Ceremony and Dreaming	1	<1%
Art (Pigment or Engraved)	32	4%
Art (Pigment or Engraved), Artefact	11	1%
Art (Pigment or Engraved), Artefact, Grinding Groove	2	<1%
Art (Pigment or Engraved), Grinding Groove	9	1%
Art (Pigment or Engraved), Potential Archaeological Deposit (PAD)	1	<1%
Artefact (s)	663	75%
Artefact, Modified Tree (Carved or Scarred)	1	<1%
Artefact, Grinding Groove	6	1%
Artefact, Potential Archaeological Deposit (PAD)	2	<1%
Grinding Groove	31	3%
Modified Tree (Carved or Scarred)	6	1%
Potential Archaeological Deposit (PAD)	116	13%
Shell	1	<1%
Stone Quarry	5	1%
Total	**887**	**100**

Figure 5: Known Aboriginal sites within upstream study area - south (Source: Heritage NSW, SMEC, Water NSW and Niche)

Redacted from public version

Figure 6: Known Aboriginal sites within upstream study area - north (Source: Heritage NSW, SMEC, Water NSW and Niche)

Redacted from public version

5.2.3 Updated searches of other registers

The Australian Heritage Database was searched for items and places of Aboriginal cultural heritage and archaeological value on the 20 July 2022 to ensure currency. The results of the search were consistent with the previous search results presented in the original ACHA and are outlined below.

5.2.3.1 World Heritage List

Approximately 304 ha of the upstream study area of the Project area falls within the Greater Blue Mountains World Heritage Area (GBMWHA) which is a declared place on the World Heritage List (WHL; Place ID 105127). This represents about 0.03% of the total 1,032,649 ha area of the GBMWHA.

The boundary of the GBMWHA generally does not correspond with the boundaries of Lake Burragorang and its tributaries or Lake Burragorang's FSL. In most locations around Lake Burragorang there is a strip of land which is not part of the GBMWHA. However, at the southern bank of the Wollondilly River arm of Lake Burragorang the GBMWHA and the Nattai National Park boundary extends down to the FSL of the dam (Figure 5). Other areas where the GBMWHA boundary extends to the FSL or to the bank of a potentially impacted waterway include smaller areas of land at:

- Nattai River near the Little River confluence (Nattai National Park).
- A small reach of the Kedumba River (Blue Mountains National Park).
- Reaches of the Kowmung and Coxs Rivers about 3 km upstream of their confluence (Blue Mountains National Park).
- A number of minor tributaries which flow directly into Lake Burragorang (Blue Mountains National Park).

For the most part the overlap of the upstream study area and GBMWHA occurs in the southern parts of the Project area, on the south-east shore of Lake Burragorang (formerly the lower and midslopes of the valley above the Wollondilly River) and also around the confluence of the Nattai River and Little River.

The GBMWHA is listed under the class natural and under natural heritage criteria on the WHL, but the listing also notes significant contributory values with regard to Aboriginal cultural heritage.

The GBMWHA and Aboriginal cultural heritage values associated with and contributing to its significance are discussed further in Section 7.4 of this supplementary assessment, in the original ACHA, the Cultural Values Assessment Report and in World Heritage Assessment Report (Appendix J of the EIS).

5.2.3.2 National Heritage List

The GBMWHA is also a nominated place on the National Heritage List (NHL; Place ID 105696), the nomination noting that it is "assumed that those values accepted as being universally outstanding are also outstanding at the national level." The nomination to the NHL includes the identification of further contributory values to the WHL listing, including Aboriginal cultural heritage values.

Just over 300 hectares of the upstream study area for the Project is currently listed on the NHL and other parts of the Project area fall within part of an area that is on the Priority Assessment List which is being evaluated for potential National Heritage values by the Australian Heritage Council. This assessment includes potential Indigenous National Heritage values which have been nominated by the GBMWHA Advisory Committee. This consideration is directly responsive to a specific requirement of the Australian Heritage Strategy:

Progressively review existing World Heritage places that have been listed for natural values only to identify whether the areas may contain internationally significant cultural heritage (Australian Heritage Strategy 2015, Objective 1, Action 8, page 19).

It is understood that the values for the additional areas being assessed by the Australian Heritage Council are the same as those for the GBWHA and identified in the National Heritage listing as detailed in Table 30 below.

The GBMWHA and Aboriginal cultural heritage values associated with and contributing to its significance are discussed further in Section 7.4 of this supplementary assessment, in the original ACHA, the Cultural Values Assessment Report and in World Heritage Assessment Report (Appendix J of the EIS).

Table 30: Assessment of values associated with GBMWHA and relation to Aboriginal cultural heritage

Criterion	Relation to Aboriginal cultural heritage
Criterion A: Events and processes *The place has outstanding heritage value to the nation because of the place's importance in the course, or pattern, of Australia's natural or cultural history.*	With regard to Aboriginal cultural heritage, the explanatory notes to this criterion state: *This criterion applies generally to Indigenous environment places, which have figured in defining events resulting in important changes to the political, economic, or social fabric of Indigenous Australia, relate to economic, political or social processes characteristic of Indigenous Australia during different periods of its history, or places that best demonstrate a characteristic way of life in the history of Indigenous Australia.* The indicator of significance relating to Aboriginal cultural heritage states: *The criterion includes places with features that best demonstrate a characteristic way of life in one or more periods of the history of Indigenous Australia.* *The criterion applies to areas with features that relate to a particular way of life important in one or more periods of the history of Indigenous Australia. This aspect of the criterion needs to be handled with considerable sensitivity. It is not meant to cover all areas with a diversity of features that are significant to Indigenous Australians, only those where the features best demonstrate a particular aspect of Indigenous culture or history characteristic of Australia. It encompasses areas important in the history of Indigenous Australia because:* • *the features in the area demonstrate one or more important economic, political or social process in the history of Indigenous Australia.* • *the features in the area best demonstrate aspects of ceremonies practiced, or beliefs held, by Aboriginal people.*
Criterion B: Rarity *The place has outstanding heritage value to the nation because of the place's possession of uncommon, rare or endangered aspects of Australia's natural or cultural history.*	The explanatory notes to this criterion state: *This criterion applies generally to places possessing uncommon, rare, or endangered aspects of Australia's natural or cultural history where these aspects are of national significance to Australia.* *Simple possession of uncommonness, rarity, or endangered aspects is insufficient. A good knowledge of the national context of the particular uncommonness, rarity, or endangered aspects of Australia's natural or cultural history possessed by the place and the degree of the importance of this within Australia's natural or cultural history, is critical to an assessment of whether the place is of such significance that it is of 'outstanding heritage value to the nation'.* The indicator of significance relating to Aboriginal cultural heritage states:

Criterion	Relation to Aboriginal cultural heritage
	The criterion particularly applies to Indigenous ways of life, customs, processes, land-uses, functions or designs that were always few in number, or that are now few in their surviving number due to subsequent destruction. They will demonstrate uncommon aspects of earlier periods of human occupation and activity or a past Indigenous activity that is now rare. *Assessment for this value must be from a position of knowledge about places with similar values in their national context. It is important to know the former distribution and abundance of this type of place in Australia. An extant place that is rare must have sufficient elements to make it a good example of its type. A place with this value is also likely to meet other criteria such as (a) and (d) and it should be used cautiously. Rarity is demonstrated by systematic surveys with comparative assessments.*
Criterion C: Research *The place has outstanding heritage value to the nation because of the place's potential to provide information that makes a contribution of national importance to the understanding of Australia's history, cultures, or the natural world.*	The explanatory notes to this criterion state: *This criterion applies generally to places with a potential to provide information from a variety of sources as a resource for research. This includes natural, Indigenous, historical, social scientific or other information which may be embodied within, be at the place, or be associated with it.* The indicator of significance relating to Aboriginal cultural heritage states: *This criterion applies to sites or areas with potential to contribute to research on Indigenous Australia. The research potential must be demonstrable and must relate to the development of an understanding of Indigenous history and culture.* *This would include any site or area that has demonstrated potential to produce important information that would contribute to our understanding of the following:* • *one or more periods in the history of Indigenous Australians;* • *ways of life or cultures characteristic of Indigenous Australians.*
Criterion D: Principal characteristics of a class of places *The place has outstanding heritage value to the nation because of the place's importance in demonstrating the principal characteristics of:* *(i) a class of Australia's natural or cultural places; or* *(ii) a class of Australia's natural or cultural environments.*	The explanatory notes to this criterion state: *This criterion applies generally to places that represent all or the critical elements characteristic of a class or type, style or design of outstanding importance within Australian natural or cultural places or environments.* The indicator of significance relating to Aboriginal cultural heritage states: *The place should represent all or the principal characteristics characteristic of a particular design or style of importance in the history of Indigenous Australia.* *Most places that could be assessed under this criterion could also be assessed under criterion (a) or (e) and the assessor needs to decide whether an assessment under this criterion will contribute to the conservation of the values at the place. The place should be representative of a design or style. It can include images, built structures or designed landscapes characteristic of Indigenous Australia.*

5.3 Aboriginal Place nomination

Section 84 of the *National Parks and Wildlife Act 1974* allows the Minister for the Environment to declare an area of land to be an Aboriginal Place if this land is or was of special significance with respect to Aboriginal culture (OEH 2017).

As outlined in Section 1.5.2.1 of the original ACAHR, the majority of the Project area has been nominated by the Gundungurra Aboriginal Heritage Association Inc. to be gazetted as an Aboriginal Place. The Aboriginal Place nomination (the Nomination) was submitted to the Office of Environment and Heritage (now Heritage NSW) on 18 July 2018.

As the details contained within the Aboriginal Place nomination form provide clear and articulate reasoning for the high significance of the Project area to the local Aboriginal community and people of NSW more broadly, a copy of the nomination form and its attachments, namely the *Gundungurra Cultural Landscapes* report prepared by archaeologist Michael Jackson at the request and with the assistance of members of the Gundungurra community, is provided in Appendix 4 with a selection of this information reproduced below and in Table 31. Further details and the importance of the story and cultural landscape it creates and describes are discussed in the CVAR (Appendix 2 of the original ACHA).

Table 31: Information from the Gundungurra Cultural Landscape's Coxs to Wollondilly Rivers Aboriginal Place Nomination Form

Aboriginal Place Nomination Details	
Name of proposed Place:	Gundungurra Cultural Landscape's Coxs to Wollondilly Rivers
Former or other names:	Burragorang Valley and may be others
What is the cultural significance of this place for your community?	The Burragorang Valley is recognised by Darug people as a highly significant homeland within the Country of our nearby neighbours the Gundungurra people. Darug people acknowledge that culturally and historically our community held a long and respectful relationship with Burragorang through our kinship and social relationship with the Gundungurra people. Before the loss of the old camps in Burragorang, for countless generations Darug families visited their relatives and extended kin who were part of the Gundungurra community. With the European colonisation of the Burragorang Valley, then the dam a number of generations back, Darug people acknowledge the significant loss felt by the Gundungurra community of their homelands, their Country and their culture which is deeply entwined in this significant place. Darug people also experienced in many instances the loss of those long-standing relationships with the Gundungurra through their dispossession from Burragorang and subsequent disbursement to distant places. Due to the colonisation of the Burragorang Valley and the displacement of the rightful owners, the Country and all that survives in it including cultural heritage is quite well preserved. However, the proposal to raise the Warragamba Dam wall will destroy what remains of the culture in the Valley that has existed since time immemorial. The further flooding of the Burragorang Valley will forever hide under the waters the cultural and spiritual connection that Gundungurra People hold to this important part of the Country, their heritage and a story significant to all people in NSW. Most significantly the further flooding of the Valley through the Warragamba Dam will erase the tangible aspects of the creation story of the Burragorang, the Gurrangatch and Mirrigan story, the knowledge of how the valley and rivers were made handed down over countless generations of Gundungurra People. The Darug People also recognise the importance of this creation story of the Burragorang and the rivers in Gundungurra Country, as it is intertwined with the creation of the Country and rivers therein in Darug Country through the same ancestral beings especially Gurrangatch. To destroy this story through the flooding of the Valley continues to destroy Gundungurra Culture and the spirit of the People, but also all other Aboriginal people in the region that are interconnected to this story, and how it relates to the creation of their own Countries through these ancestral beings.

Aboriginal Place Nomination Details	
	Therefore, the Darug people would also recognise the urgent need to respectfully protect and preserve Burragorang Valley as a highly significant part of Gundungurra Country.

The nomination connects the Coxs' to Wollondilly Rivers, around the current Warragamba Dam, with the Gundungurra creation story or creation Song line, 'The Journey of Gurangatch and Mirrigan' a well-known story documented by Robert Matthews and first published in 1908. The story documents the creation of two of the main rivers in Gundungurra Country, the Wollondilly River and Coxs River, with several of their associated tributaries such as the Kedumba River and Jenolan River and also includes the creation of landscape features along the Great Dividing Range. As described in the *Gundungurra Cultural Landscapes report* (Jackson 2018: 1):

> "*The course of the Wollondilly and Coxs Rivers and some of the features in the surrounding landscape of these rivers were created by the actions of two Ancestors (Burringilling) in the Gundungurra Dreaming (Gunyunggulung). These were Gurangatch – 'like a gigantic eel' (Russell 1914: 23) and Mirrigan, a tiger cat or quoll. The Burringilling had super-human strength and were said to be very clever, to be able to make rivers and other 'natural' features, even cleave mountains. Various special landmarks in the story occur throughout the Wollondilly and Coxs River catchments, as well as along the Great Dividing Range, generally waterholes where the spirit of Gurangatch still resides. A number of these are now under the stored waters of Lake Burragorang, however, areas associated with the fringes of these localities remain intact. Several localities remain outside the Lake Burragorang and Burragorang Valley area. Although there are defined features, localities and sites which are important landmarks in the creation story, the areas linking these places forms an integral and inseparable part of the creation narrative. The story travels for over 170 km and is one of the closest intact Aboriginal creation stories on the doorstep of a major city in Australia.*"

A selection of sites and places of cultural significance associated with the journey taken in the creation story are documented in the *Gundungurra Cultural Landscapes report* (Jackson 2018) and summarised below in Table 32.

Table 32: Sites and places of cultural significance within the Gundungurra Cultural Landscape complied from Jackson 2018 and the sources cited within

#	Site/place	Association	Details
1	Murraural Waterhole	Creation Story	• A deep waterhole called 'Murraural' located at the junction of the Wollondilly and Wingecarribee rivers and one of the many significant landmarks in the creation story. • 'Murraural' also includes the surrounding country. • Murraural was the resting place of one of the Burringilling (Ancestors/ Creation Hero) called Gurangatch. • According to the creation story, Gurangatch tore up the land to allow the waters to flow after him and form the channel of the Wollondilly River thereby creating the course and flow of the river.
2	Birrimbunnungalai Waterhole	Creation Story	• The location of Birrimbunnungalai is on the western side of the Wollondilly River in the vicinity of series of unnamed creek-lines or Dry Creek. • This waterhole was created following the formation of several miles of river channel when Gurangatch emerged from burrowing on a high rocky ridge on one side of the valley.

3	Gunieacor River	Creation Story	• Gurangatch 'went half a mile up Guineacor Creek and made a big hole and turned back' (Mathews unpublished notes: 19) after coming to a "very rocky place which was hard to excavate" (Jackson 2018: 2). • The lower reaches of Guineacor Creek contain an extensive, north-facing river flat area which it is recognised would have been a traditional occupation area with its warm aspect, riverine occupation zones, permanent water and level occupation areas.
4	Toms Island	Creation Story	• The location here Gurangatch had difficulty excavating and therefore created a big bend in the river, almost double-backing upon itself.
5	Wollondilly River/ Jocks Creek Junction	Creation Story	• This stage of Gurangatch's journey resulted in the creation of the Wollondilly River down to the junction of Jocks Creek.
6	Jocks Creek	Creation Story	• Created when Gurangatch made the water flow uphill behind him.
7	Great Dividing Range	Creation Story	• Gurangatch burrowed under the Great Dividing Range upon reaching the source of Jocks Creek where he emerged inside the Wombeyan Caves.
8	Wombeyan Caves	Creation Story	• It is here that Mirrigan caught up to Gurangatch who hid inside the caves. • Mirrigan created a number of features associated with the caves (several weather-worn pot holes/ doline on top of the caves) in his attempt to frighten Gurangatch out from the subterranean passages.
9	Doogalool Waterhole (also spelt Doogoolool)	Creation Story	• One of Gurangatch's Waterholes above the Wollondilly Bridge between Gunggalook Waterhole and Jocks Creek.
10	John Riley's Selection at Burnt Flat	Creation Story & Post-contact	• The location of a post-contact occupation site associated with Gundungurra man John Riley (1859-1929) who acquired and held a Conditional Purchase of a land her between 1890-1904. • The location of a fight between Gurrangatch and Mirrigan which created features of the Wollondilly River.
11	Jumping Woman Story Location	Cultural story	• large cliff which marks the location of a Gundungurra story concerning a 'Jumping Woman'.
12	Gunggalook Waterhole and Gungarlook Farm	Creation Story & Post-contact	• Location of one of Gurangatch's waterholes. • Location of the Riley's farm which was named after the waterhole. The Riley's were the last Gundungurra family to move out of the valley prior to its flooding under the stored waters. • There are several traditional camping sites in the area known by the Riley family, grinding grooves and rock art sites including a site with a large serpent drawing thought to likely represent Gurangatch. • Location for post-contact Aboriginal Reserves 14937 (1891-1954) and 40798 (1906-1954).
13	Belloon Pass (Belanong)	Traditional	• A traditional pass between Gungarlook/ Wollondilly River and the Nattai River valley.
14	Aboriginal Reserve 26 – Nulla Reserve and Aboriginal Reserve 27	Creation Story & Post-contact	• Aboriginal Reserve 26 (1878-1928) was located on the north side of Byrnes Creek and at one time it was the largest Aboriginal camp in the Burragorang Valley area. • The Nulla camp was located close to Burragorang Waterhole, a waterhole created during Gurangatch's journey and used by

			another Ancestor, the 'Giant Kangaroo' (Burru-gorang) who hid there in the Dreaming (Gun-yung-gulung).
15	Burragorang Waterhole and 'The Big Flat'	Creation Story	• Located downstream from the junction of the Wollondilly River and Byrnes Creek towards Tonalli River.
16	'The Big Flat'	Traditional	• Traditional occupation areas adjacent to Burragorang Waterhole. The Big Flat begins above the Byrnes Creek and Wollondilly River junction, extending downstream on the Wollondilly River to just north of the Tonalli River.
17	Summer Hill	Post-contact	• The property was located near the Tonalli and Wollondilly Rivers junction and incorporated part of 'The Big Flat' area. • Members of the Riley Aboriginal family lived at Summer Hill.
18	Woonggaree Waterhole	Creation Story	• Location of a fight between Gurangatch and Mirrigan.
19	Goorit Waterhole	Creation Story & Post-contact	• Location of a waterhole created by Gurangatch situated between Mullindi Waterhole and Woonggaree Waterhole. • Location where a speech was given by Gundungurra man John Riley (1859-1929) to Archbishop John Bede Vaugh (1834-1883) in 1874.
20	The Black Waterhole and Waratah Rock	Creation Story & Cultural Story	• Location of a large waterhole situated along Gurangatch's journey. • Location of a Gundungurra story regarding an Ancestor called Nulla. • The rock, shelter and rock art associated with Waratah Rock feature in a Gundungurra story about the Waratah flower.
21	Gundungurra Burial Sites	Traditional & Post-contact	• Important burial sites with the graves of Burragorang Aboriginal leaders occur near the junction of Nattai and Wollondilly Rivers. • Possibly the largest known concentration of Gundungurra burials with burials continuing upstream on the Wollondilly River to below Mount Kamilaroi.
22	Sheehys Creek	Traditional & Post-contact	• A known traditional route for Aboriginal people between the Cumberland Plain and Burragorang Valley.
23	Nattai River and 'The Eel Hole'	Creation Story	• 'The Eel Hole' refers to a large waterhole located just downstream of the junction of the Nattai River and Whitegum Creeks. Eel-holes are associated with the resting places of Gurangatch.
24	Morle Boc Deposit	Cultural story & Traditional	• A rare mineral deposit with medicinal properties in the form of an extensive outcrop of limestone seeping over sandstone bedrock situated along the western bank of the Little River. • The origins of morle-boc were connected to a Gundungurra Ancestor called Gareem, the 'God' of sickness and health.
25	Burial	Post-contact	• Burials of one of the Gundungurra Riley's and possibly children related to the Darug Lock family on the O'Brien Farm. Exact location requires confirmation from Gundungurra descendants.
26	Kweeoogang Waterhole	Creation Story	• A waterhole created by Gurangatch along the stretch of the Wollondilly between Mullindi Waterhole and the junction between the Nattai and Wollondilly Rovers.
27	Mullindi Waterhole	Creation Story	• A waterhole created by Gurangatch near cave paintings (a shelter site with red hand stencils known by the name of Murrolunggulung) along the stretch of the Wollondilly River.
28	Gunnadarel	Traditional	• The Gundungurra name for Laceys Creek. • A Murrolunggulung shelter (hand stencil site) occurs in lower Gunnadarel Creek.

29	Boonbal Waterhole	Creation Story, Cultural story & traditional	• A waterhole associated with the Gurangatch and Mirrigan story and possibly located near where Brimstone Gully enters the Wollondilly River. • Brimstone Gully was a traditional route out of the Burragorang Valley and is also associated with another Gundungurra story regarding the creation of Waratah flowers. • Brimstone Gully also associated with significant rock art sites.
30	Bullar Mullar	Traditional	• Derives from the Gundungurra placename originally recorded as Bimmillo fronting onto Lacey's Creek and meaning 'a devil place'.
31	Gurrabulla Waterhole	Creation Story	• The location of Gurangatch's last waterhole on the Wollondilly section of his journey and situated in proximity to the junction with the Coxs River.
32	Werriberrii Creek	Traditional	• Derived from the Gundungurra name for tree fern. • Birth location of Gundungurra Elder Billy Russell.
33	Kouroong	Traditional & post-contact	• Gundungurra name for narrow section at western end of the Warragamba gorge meaning 'old skeleton or bones'. • Location of a fierce battle between Coxs River Aboriginal people and 'Wild Blacks of the tops' in 1844.
34	Junba Waterhole	Traditional	• Waterhole located on the Coxs River. • Junba is the Gundungurra word for Long-finned Eel.
35	Gogongolly Creek	Traditional	• Traditional Gundungurra name for a fern species.
36	Muggaroon – Pocket Creek and St Joseph's Farm	Traditional & post-contact	• Gundungurra word for Yabby which occur in Pocket Creek. • Pocket Creek is a major Gundungurra pathway to the Kings Tableland plateau, Erskine Gap and central Blue Mountains plateau area. • Location for Aboriginal farm run by Catholic Church and Aboriginal Reserve 17023 (1892-1924).
37	Gaung Waterhole	Creation Story	• A waterhole created by Gurangatch above Pocket Creek junction.
38	Gudgabung – Green Wattle Creek	Traditional	• The traditional name for the creek.
39	Cooba	Traditional	• Gundungurra name for Stringybark tree.
40	Kerswell Hill Rock Art Site	Traditional & post-contact	• Significant rock art site with red dancing figures – a special type of image occurring across a widespread area of Gundungurra Country – white hand stencils, numerous grinding grooves and stone tools.
41	Cunnark Waterhole	Creation Story	• Gundungurra name for 'Mud or black eel' and possible resting place of Gurangatch.
42	Warrumba	Traditional	• Refers to Pearce's Creek, a traditional route for Gundungurra people to Kings Tableland and the central Blue Mountains plateau.
43	Billagoola Waterhole	Creation Story	• Gurangatch's waterhole formed at or just below the junction of Coxs River and Butchers Creek.
44	Billagoola Creek (Butchers Creek)	Creation Story	• Portion of the Gurangatch journey.
45	Burial site of Tommy Bundle	Post-contact	• Possible location of the grave of Aboriginal man Tommy Bundle (died 1910) based on oral history.
46	Alum Springs	Traditional	• Consists of a shelter site with a medicinal spring.

47	Kedumba Waterhole & Occupation	Creation Story & Traditional	• Gurangatch's waterhole located at the junction of Kedumba River and Coxs River. • Location of a series of sites associated with Gurangatch's journey including three rock art sites, several occupation shelters, at least two grinding groove sites and a possible burial area.
48	Birrigooroo Waterhole	Creation Story & Traditional	• Traditional word for 'reeds growing along creek' and possible name of Gurangatch's waterhole on Reedy Creek, a tributary of Kedumba River. • Rare example of a time when Gurangatch creates a secondary tributary rather than a major side creek.
49	Apple Tree Flat and Cedar Creek	Creation Story & Traditional	• Large open campsite at the junction of Cedar Creek and Coxs River situated along the Gurangatch journey path. • Cedar Creek holds several significant rock art sites and a series of possible medicinal springs. • Apple Tree Flat, opposite Cedar Creek was a major camping location adjacent to Gurangatch's Karrangatta Waterhole. There is a hand stencil (Murrolunggulung) site behind Karrangatta Waterhole.
50	Karrangatta Waterhole	Creation Story	• A waterhole created by Gurangatch at a significant junction in his journey near Little Cedar Creek and Coxs River in the vicinity of the Black Dog Ridge area.
51	Mee-oo-wun Waterhole	Creation Story	• A water hole created when Gurangatch dodged his enemy and burrowed underground from Karrangatta to emerge at Medlow Gap.
52	Kowmung River	Creation Story	• Part of Gurangatch's journey where he passed the junction of Coxs and Kowmung Rivers.
53	Koo-nang-goor-wa, location of a 'Big Fight'	Creation Story	• Location of another fierce encounter between Gurangatch and Mirrigan which created the features at the junction of Coxs River and Kanangra Creek.
54	Jenolan River	Creation Story	• Path of Gurangatch between Coxs River and Harrys Creek (Jenolan River) to Jenolan Caves.
55	Jenolan Caves	Creation Story & Cultural story	• Resting place of Gurangatch and location where he met his friends and relatives. • Also associated with other significant cultural features and associated stories including 'Walga the Sparrowhawk' which explains the split in the rock in the top of the rock known as the Devils Coach House.
56	Wan-dak-ma-lai Walls	Creation Story	• A large sandstone wall (the western side of Mt Bindo) created by Mirrigan to prevent Gurangatch from escaping back over the Great Dividing Range.
57	Joolundoo Waterhole	Creation Story, Traditional & post-contact	• A waterhole over the Great Dividing Range where Gurangatch was taken to by his friends. • The final waterhole and resting/hiding place of Gurangatch and location of the final encounter between Mirrigan and Gurangatch where Mirrigan succeeds in capturing and feasting on part of Gurangatch. • Also a camping location for Aboriginal people as they travelled between the coast and the west and location of a corroboree.

At the time of preparing this supplementary assessment, the nomination of the Aboriginal Place was yet to be determined or declared by the Minster for the Environment. The following key points can be made regarding the information contained within the Aboriginal place nomination:

- The Burragorang Valley, including the current Project area, is recognised as being a highly significant cultural landscape to the Darug and Gundungurra People with traditional, historical and ongoing Aboriginal cultural significance.
- The high significance of the area is in part a result of the long and continuous cultural and spiritual connection to country that the Darug and Gundungurra have which has been strengthened through kinship and social relationships.
- While the whole landscape is considered to be inter-connected and highly significant, certain natural landmarks and/or environmental features in particular are recognised to be associated with intangible values including waterholes where the spirit of Gurangatch still resides and waterways which represent the Creation Story path. Significantly, these environmental features do not necessarily preserve any signs and/or physical evidence of cultural use (i.e. archaeological evidence).
- There is clear overlap between tangible and intangible cultural values within the Gundungurra Cultural landscape with a number of archaeological site types (e.g. open camp sites, rock shelter and art sites, grinding groove sties, burial sites) present along the Creation Story path. Rock art sites in particular serve to animate the landscape, showing mythological beings and their cultural routes or pathways.
- The Creation Story path is bisected by traditional pathways / routes used by past Aboriginal groups to move through the landscape. These areas have the potential to preserve evidence of transient movement through the area.
- The details contained within the nomination and its attachments highlight the inter-connectedness of the environment with Creation Stories, Cultural stories, aspects of traditional culture (including language and cultural activities), and post-contact events and people which all contribute to the significance of the area.
- The details contained within the nomination provide additional context to claims mentioned in the original ACHA relating to the Project being seen by the RAPs as a further accumulation of impacts to Aboriginal cultural heritage that has previously been affected by the original development of the Warragamba Dam and by the impacts of displacement and dispossession which followed colonisation of the Burragorang Valley in the first place.

Figure 7: Sites and places of cultural significance linked to the Journey of Gurangatch and Mirrigan creation story (details derived from Jackson 2018)

Redacted from public version

5.4 Potential archaeological deposits (PADs)

The potential for subsurface archaeological deposits to be present within the Project area was briefly considered within the original ACHA; however, a number of submissions noted the need for an expanded consideration and discussion of Potential Archaeological Deposits (PADs) within the Project area, PAD inclusion within the predictive modelling and consideration of PADs in the assessment of values associated with sites, particularly in relation to site in open air contexts. It is standard practice that, following the identification of PADs, a program of subsurface testing would usually occur to establish their nature, extent and archaeological significance; however, RAPs did not and do not currently support a subsurface-testing regime. The issue of subsurface deposits is therefore currently limited to extrapolating information from the landscape and the results of relevant archaeological studies in the local region.

5.4.1 Soil landscapes and PADs

This section expands upon the concept presented in the original ACHA that soil landscapes, when considered with the levels of past land use, modification and landform characteristics (such as slope), can provide a useful tool in identifying environmental proxies for the likely preservation and burial of Aboriginal objects in a landscape (i.e. PADs). The formation and preservation of archaeological deposits is dependent upon a range of interrelated factors relating to soil landscape characteristics including, but not limited to:

- The type and depth of soils (where deeper well-drained soils have a higher potential for retaining stratified deposits).
- The landform and its relative steepness (where relatively flat and/or gently inclined surfaces have a higher potential to accumulate and preserve deposit).
- The degree of past disturbance associated with an area (where areas not subject to extensive past land use practices such as vegetation clearing, grazing and development have a higher potential for preserving in-situ deposits).
- The qualities and limitations associated with the different soil landscape units including whether an area is subject to severe sheet or water erosion and/or mass movement (where areas less prone to severe sheet and/or water erosion have a higher potential for preserving in-situ deposits).

In the case of rockshelter and overhang contexts, additional localised factors will influence whether or not deposits will accumulate and be preserved. Local factors include:

- The type of surface within a rockshelter or overhang (sediment versus exposed bedrock).
- The size and gradient of the surface within and adjacent to the dripline of the rockshelter or overhang (where relatively flat floors have a higher potential for accumulating deposit).
- The presence of natural sediment traps such as past rock fall outside the dripline of a shelter which acts to trap and preserve sediment within the shelter.
- The degree of disturbance from and/or animal burrowing.

While the above factors largely relate to the formation and preservation of archaeological deposits in open context sites, the obvious exception to this is the case of closed rockshelter and/or overhang sites where the rockshelter itself may be located within a steep landscape context but local conditions favourable to the accumulation and preservation of deposit occur (e.g. rockshelters and/or overhangs with relatively flat sandy floor surfaces and with natural sediment traps resulting from past rock fall).

As outlined in Chapter 5 of the original AR, there are seventeen soil landscapes present within the upstream study area. These soil landscapes are defined by Bannerman et al. (2010), DPIE (2008), Hazelton and Tille (1990) and King (1994) as the Barralier, Cedar Valley, Coxs River, Emu Island, Faulconbridge, Gymea, Hassans Walls, Hawkesbury, Horse Flat, Jooriland Range, Kanangra Gorge, Kedumba, Martins Flat, Martins Flat variant A, Round Mount, Warragamba and Wollondilly River. The location of soil landscape units in relation to the upstream study area and surrounds is presented in Figure 8. Each soil landscape has distinct morphological and topological characteristics, with the result that the occupational history and archaeological potential of the area varies accordingly. The archaeological characteristics of an area are defined through a range of factors, including stability of the soil matrix, surrounding hydrology, underlying geology and land use history. The soil landscapes are categorised as either alluvial, erosional, residual, colluvial or transferral and are described below in Table 33.

Table 33: Description of classifications for the soil landscape units found within the Project area

Classification	Description
Erosional	Erosional soil landscapes are characterised by areas where soil and rock are being removed at a rate greater than they can be transported and deposited from other locations (Hazelton and Tille 1990). Mechanisms for erosion commonly occurring within the Project area include wind and water; both through rain and stream wash. These soil landscapes are considered to have archaeological potential, with older deposits more likely to be retained in-situ in localised areas where erosion levels may be less extreme. Soils of erosional formation within the Project area include the Cedar Valley, Gymea, Jooriland Range, Kedumba, Martins Flat and Martins Flat variant A.
Alluvial	Alluvial soils are soils which consist of earth and sand left behind on land which has been flooded or where a river once flowed. Soil parent material is typically deep, sorted and usually stratified or previously stratified alluvium. Alluvial soil landscapes are therefore formed by deposition along rivers and streams and are often associated with landforms such as current or past floodplains, terraces and alluvial deposits. Site types are likely to include Isolated Artefacts, Open Camp Sites and PADs. Soil of alluvial formation within the Project area include Coxs River, Emu Island and Wollondilly River.
Colluvial	Colluvial deposits are loose, unconsolidated sediments deposited on foot slopes by mechanisms including rain-wash, sheet wash, slow continuous downslope creep, or a combination of these processes. Colluvium is often comprised of a heterogeneous range of sediments ranging from silt to rock fragments. Some colluvial deposits have the potential to be deep due to the nature of their accumulative processes. As a result, thick accumulations of colluvium within some landscape units often contain well-preserved and sometimes deeply buried archaeological deposits. However, colluvial soils are generally associated with shallow stony highly permeable soils (Hazelton and Tille 1990:45, 58). Site types associated with this soil landscape are likely to include Isolated Artefacts and Open Camp Sites, due to the nature of the deposit formation and its associated stability. Colluvial soil landscape units within the Project area include Barralier, Hassan wall, Hawkesbury, Kanangra Gorge, Round Mount and Warragamba.
Transferral	Transferral landform units are generally formed on deep deposits of mostly eroded parent materials washed from areas up slope. Stream channels are often discontinuous, and slopes are generally concave. Transferral landscapes include footslopes, valley flats, fans, bajadas and piedmonts. Site types are likely to include Open Camp Sites, Isolated Artefacts, PADs and Scarred Trees. Transferal soil landscape units within the Project area include Horse Flat.
Residual	Residual soil landscapes are characterised by areas where soils are derived from the long term, in-situ weathering of parent materials. Examples of these types of soil landscapes are flats, plains and plateaus with poorly defined drainage lines (Hazelton and Tille 1990). Site types are likely to include Open Camp Sites, Isolated Artefacts, PADs and Scarred Trees. Residual soil landscapes within the Project area comprise of the Faulconbridge.

Considering, and expanding on, the information provided in the original AR, Table 34: outlines the characteristics of the different soil landscape units. Focus is placed on providing additional information relating to the various factors outlined above that are understood to influence the formation and preservation of archaeological deposits. This information is then used to assess the potential of each soil landscape unit to preserve archaeological deposits. While it is recognised that this assessment is necessarily broad and that a number of additional factors not considered here may influence the formation of archaeological deposits (including site selection and variability in local environmental characteristics), it provides a starting point for forming general predictions relating to PADs within the Project area.

As recognised in the original ACHA, the alluvial soil landscapes within the Project area (including the Coxs River, Emu Island and Wollondilly River soil landscape units) are all associated with a high potential for preserving PADs due to absence of steep slopes and outcropping, their association with other archaeologically sensitive landforms (alluvial plains and terraces) and waterways (rivers and streams) and the potential for deep alluvium sediments providing the accumulation of archaeological deposits of up to 200 cm. While the erosional, colluvial, transferal and residual soil landscapes are generally associated with lower potential for PADs variously due shallow soils, steep landforms, outcropping rock and/or severe sheet erosion, a review of the landscape characteristics and soils identified a number of exceptions where a moderate to high potential for PADs was recognised.

In terms of erosional soil landscapes, the following assessments are made:

- Cedar Valley: Moderate potential for PADs in association with loamy sands (<100 cm depth) on sideslopes of up to 15° and in association with alluvial soils (<50 cm depth) along drainage lines.
- Gymea: Moderate potential for PADs in association with sands on gentle slopes (<100 cm depth) and along drainage lines.
- Jooriland Range: Moderate potential for PADs within slopes from 2-15°.
- Kedumba: Moderate potential for PADs in association with gentle side slopes and crests (<90 cm depth).
- Martin Flat (including Variant A): Moderate potential for PADs within slopes from 5-15° though subject to minor to moderate sheet and gully erosion particularly following bushfires.

In terms of colluvial soil landscapes, the following assessments are made:

- Hassan's Wall: Moderate potential for PADs associated with soils (80-150 cm) on lower slopes and narrow drainage flats.
- Kanangra Gorge: High potential for PADs to occur in association with lower slopes or along drainage lines where moderately deep to deep Alluvial soils (>100 cm) occur.
- Hawkesbury: High potential for PADs to occur in association with overhangs and rock shelters where conditions support accumulation of sediment (i.e. flat floors and sediment traps from past block fall).
- Round Mount: High potential for PADs in association with silicious and earthy sands (<110 cm) on lower side slopes and along drainage depressions.

In terms of transferral soil landscapes, the following assessment was made:

- Horse Flat: High potential for PADs due to low slope angles and potential for deep alluvium.

In terms of residual soil landscapes, the following assessment was made:

- Faulconbridge: Moderate potential for PADs due to low slope angles however deposits are likely to be shallow (<50 cm) and may be subject to localised water erosion.

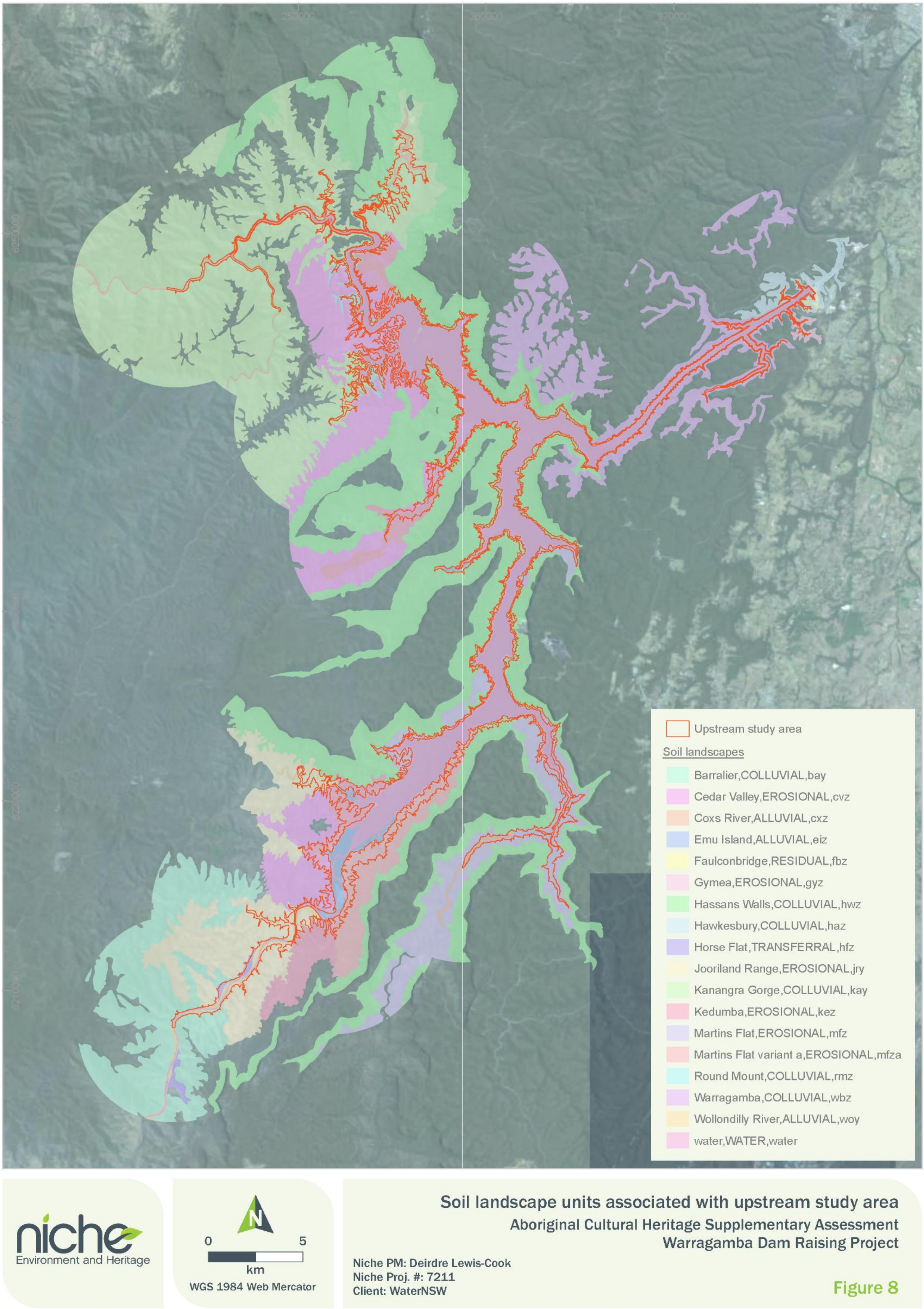
Table 34: Soil landscape units, characteristics and potential to preserve archaeological deposits

Soil landscape unit	Approx. area within PMF with Project	Landforms and slopes	Soils	Potential for PADs
Erosional Soil Landscapes				
Cedar Valley	613.8 ha	• Narrow, deeply incised valleys, convex crests and ridges with moderately to steeply inclined side slopes away from sandstone escarpments. • Slopes from 15 –60°.	• Soils vary from yellow brown loamy sands to medium clays. • Shallow (<30 cm) loam soils on ridges and crests. • Shallow to moderately deep (<100 cm) soils on sideslopes. • Shallow (<50 cm) alluvial soils along narrow drainage lines.	**Low** potential for PADs overall due to generally shallow soils, steep landforms and severe sheet erosion. **Moderate** potential for PADs in association with loamy sands on sideslopes of up to 15° and in association with alluvial soils along drainage lines.
Gymea	4.2 ha	• Undulating to rolling rises and low hills, broad convex crests, moderately inclined side slopes with wide benches, localised rock outcrop. • Slopes between 10-25°.	• Yellow Earths, Earthy Sands, Siliceous Sands, Gleyed Podzolic Soils, Yellow Podzolic Soils and Leached Sands (Hazelton and Tille 1990). • Shallow to moderately deep soils (30-100 cm) on crests and insides of benches. • Shallow (<20 cm) sands on leading edges of benches. • Shallow to moderately deep (<100 cm) sands along drainage lines.	**Low** potential for PADs overall due to generally shallow soils, outcropping rock and high soil erosion. **Moderate** potential for PADs in association with sands on gentle slopes and along drainage lines.
Jooriland Range	303.2 ha	• Low hills. • Slopes from 2-33°.	• Haplic Red Chromosols (Non-Calcic Brown Soils and Red Podzolic Soils) and Bleached-Mottled Red Chromosols (Soloths and some Solodic Soils).	**Low** potential for PADs overall due to widespread minor sheet and gully erosion. **Moderate** potential for PADs within slopes from 2-15°.
Kedumba	605.4 ha	• Broad ridges and valley flats comprised of undulating to rolling rises. • Slopes from 5-15°.	• Soils are generally dark brown loamy sands, bleached sands and blocky clays. • Shallow to moderately deep (<90 cm) soils on crests and sideslopes. • Occasional shallow (<20 cm) soils near cliff edges and associated with rock outcrops.	**Low** potential for PADs in association with cliffs and rock outcrops due to shallow soils and high hazard for water erosion.

Soil landscape unit	Approx. area within PMF with Project	Landforms and slopes	Soils	Potential for PADs
				Moderate potential for PADs in association with gentle side slopes and crests.
Martin Flat	711.1 ha	• Hills. • Slopes from 5-30°.	• Brown Kurosols (Soloths), Red Kurosols and Chromosols (Soloths and Red Podzolic Soils) Yellow Sodosols and Brown Chromosols (Soloths) on lower fans. Also Bleached-Orthic, Bleached-Leptic Tenosols on crests.	**Moderate** potential for PADs within slopes from 5-15° though subject to minor to moderate sheet and gully erosion particularly following bushfires.
Martin Flat Variant A	603.8 ha	• Hillslopes and foot slopes within low hills. • Slopes from 5-25°.		
Alluvial Soil Landscapes				
Coxs River	213.5 ha	• Swamps within alluvial plains and terraces on Quaternary Alluvium (alluvium). • Slopes from 0-5°.	• Soils include brown earths and alluvial soils. • Shallow to moderately deep (<100 cm) alluvial sands and gravels along current stream channels, small terraces and alluvial flats. • Deep (up to 200 cm) alluvial soils within small terraces and floodplains.	**High** potential for PADs due to absence of steep slopes and outcropping, the potential for deep alluvium (up to 200 cm) providing the accumulation of archaeological deposits and the association with other archaeologically sensitive landforms (alluvial plains and terraces) and waterways (rivers and streams).
Emu Island	433.0 ha	• Alluvial plains on Quaternary Alluvium (alluvium and silt). • Slopes from 0-2°.	• Stratic Rudosols (Alluvial Soils) which occur within the Lake Burragorang Special Area Scheduled Lands.	
Wollondilly River	244.9 ha	• Alluvial plains and terraces on Quaternary Alluvium (alluvium). • Slopes from 1-6°.	• Fluvic Clastic Rudosols (Alluvial Soils), Brown Dermosols (Alluvial Soils/Chernozems), Yellow/Brown Kandosols (Yellow Earths/Brown Earths), and Brown Chromosols (Yellow/Brown Podzolic Soils).	
Colluvial Soil Landscapes				
Barralier	17.0 ha	• Abundant rock outcropping and steep slopes. • Slopes from 25-50°.	• Rudosols and Tenosols (Lithosols), Red Chromosols (Red Podzolic Soils) and some Brown Chromosols and Kurosols (Brown Podzolic Soils, Soloths).	**Low** potential for PADs due to steep slopes, extensive outcropping and severe sheet and gully erosion.

Soil landscape unit	Approx. area within PMF with Project	Landforms and slopes	Soils	Potential for PADs
Hassan Wall	1,102.3 ha	• Precipitous sandstone cliffs and steep slopes. • Slopes generally greater than 40° becoming gentler on lower slopes and narrow drainage flats.	• Loamy sands, sands and pedal clays. • Shallow (<30 cm) sands on rocky leges and cliffs. • Moderately deep but stony sands on upper slopes. • Moderately deep (>80 cm) soils on lower slopes and flats. • Shallow (>70 cm) sands along narrow steep, deeply incised drainage lines. • Moderately deep (70-150 cm) sands along drainage flats.	**Low** potential due to steep landforms, outcropping, generally shallow soils and extreme water erosion. **Moderate** potential for PADs (>80-150 cm depth) associated with lower slopes and narrow drainage flats.
Hawkesbury	29.8 ha	• Rugged, rolling to very steep hills with narrow crests and ridges, narrow incised valleys, steep side slopes with narrow rocky benches, broken scarps and boulders. • Slopes generally greater than 25°.	• Lithosols/Siliceous Sands, Earthy Sands, Yellow Earths, Yellow and Red Podzolic Soils and Siliceous Sands. • Shallow (<50 cm) soils associated with rock outcrops. • Some locally deep sands on inside of benches and along joints and fractures.	**Low** potential for PADs overall due to generally shallow soils and severe sheet erosion. **High** potential for PADs to occur in association with overhangs and rock shelters where conditions support accumulation of sediment (flats shelter floors, sediment traps from block fall).
Kanangra Gorge	674.3 ha	• Steep to very steep hills and mountains. Small narrow, convex crests occur above steep to very steep (occasionally precipitous), deeply incised valleys. • Slopes are generally greater than 30°.	• Brown clay loam and reddish-brown clays. • Very shallow (<50 cm) soils on rocky, very steep to precipitous sideslopes, narrow crests and upper slopes. • Moderately deep to deep (>80 cm) soils on lower slopes. • Moderately deep (<100 cm), Alluvial soils along narrow deeply incised drainage lines.	**Low** potential for PADs in areas associated with steep landforms subject to sever sheet erosion. **High** potential for PADs to occur in association with lower slopes or along drainage lines where moderately deep to deep Alluvial soils (>100 cm) occur.
Round Mount	188.9 ha	• Steep to very steep hills and mountains with narrow and convex crests.	• Brownish black loamy sands to bright brown clays. • Shallow (<35 cm) sands associated with rock outcrops.	**Low** potential for PADs due to steep slopes, shallow soils and sever sheet erosion.

Soil landscape unit	Approx. area within PMF with Project	Landforms and slopes	Soils	Potential for PADs
		• Slope gradients are generally greater than 35°.	• Shallow to moderately deep (<110 cm) sands associated with slopes and along drainage depressions.	**High** potential for PADs in association with silicious and earthy sands (<110 cm) on lower side slopes and along drainage depressions.
Warragamba	224.9 ha	• Moderate to very steep slopes, sloping narrow ridges with narrow sandstone and colluvial benches occurring on the slopes which contain sandstone boulders. • Slopes generally greater than 25°.	• Dark brown loamy sand, dark reddish-brown clayey sand and pedal clay. • Localised shallow soils. • Shallow to moderately deep (<50 – <80 cm) soils on crests and ridges. • Moderately dep (<100 cm) on side slopes.	**Low** potential for PADs due to stony soils and localised shallow soils. While moderately deep soils occur along ridges, crests and side slopes these are subject to sever water erosion.
Transferral Soil Landscapes				
Horse Flat	46.1 ha	• Fans on Quaternary Alluvium (alluvium, colluvium and unconsolidated). • Slope gradients are 2-25°.	• Orthic Tenosols (Lithosols, minimal Earths).	**High** potential for PADs due to low slope angles and potential for deep alluvium.
Residual Soil Landscapes				
Faulconbridge	1.2 ha	• Hillcrests within plateaus on Hawkesbury Sandstone. • Slope gradients are 0-5°.	• Loose, brownish black loamy sand, earthy yellow clayey sand and yellow earthy sandy clay loam. • Shallow (<50 cm) soils overlying bedrock of Hawkesbury Sandstone.	**Moderate** potential for PADs due to low slope angles however deposits are likely to be shallow (<50 cm) and may be subject to localised water erosion.



niche Environment and Heritage

Soil landscape units associated with upstream study area

Aboriginal Cultural Heritage Supplementary Assessment
Warragamba Dam Raising Project

Niche PM: Deirdre Lewis-Cook
Niche Proj. #: 7211
Client: WaterNSW

Figure 8

public/NSW_Imagery: © Department of Customer Service 2020/World Hillshade: Esri, Geoscience Australia, NASA, NGA, USGS | Watercourses, Waterbodies, Road and Rail alignments, Protected areas of NSW © Spatial Services 2021. | Niche uses GDA2020 as standard for all project-related data. In order to ensure that data from numerous sources and coordinate systems is aligned, on-the-fly transformation to WGS1984 Web Mercator Auxiliary Sphere is used in the map above. For ease of reference, the grid tick marks and labels shown around the border of the map are presented in GDA2020, using the relevant MGA zone.

5.4.2 Evidence from archaeological studies in the local region

In the absence of a sub-surface testing program, which is not supported by RAPs at this stage, archaeological studies can provide information regarding the nature and extent of subsurface archaeological deposits in the local region. This information can then be used to make predictions regarding PAD within the Project area – where these are likely to be preserved, at what depths they are likely to occur and what the contents likely contain.

A number of archaeological excavations have been conducted to the north and east of the Project area in similar environmental settings (riverbanks, terraces and rockshelters). Sites such as Cranebrook Terrace, Shaws Creek, and Lapstone Creek that were excavated in the early-mid twentieth century have been re-investigated more recently with refined chronologies and investigation of site formation and soil landscapes (Kohen, Stockton and Williams 1984, McCarthy 1948, McCarthy 1978, Nanson, Young and Stockton 1987, Nelson 2007, Williams et al. 2017). Table 16 presents information from such sites.

Most of the regional rockshelter sites were associated with high to very high artefact densities with most artefacts identified >2 m below the surface (Table 35). These rockshelter sites vary in age from 530-13,000 BP, with most dates being generated by radiocarbon dating techniques during the 1960s and 1970s. The two open air creek bank sites vary in artefact density and depth of deposit though both are located on terraces approximately 35 km apart and have been dated using OSL dating techniques within the last 5 years.

The soil landscapes these site types are located within include soil landscapes identified as having moderate potential for PADs (Hassans Walls and Gymea). Shaws Creek KII (Gymea), Lapstone Creek (Gymea) and Lyre Bird Dell (Hassan Walls) are all rockshelter sites with very high artefact densities and deposits <1.5 m (Table 35). Shaws Creek KII is approximately 25 km north of Warragamba Dam, Lapstone Creek is approximately 16 km north and Lyre Bird Dell is approximately 30 km north-west.

This brief review demonstrates that limited excavation has occurred in open air contexts with the majority of archaeological excavations occurring within rock shelter contexts. Several of the shelter sites reviewed fall within soil landscapes that occur within the current Project area including Springwood Creek and Horseshow falls rockshelters which are located within the Warragamba soil landscape unit and Lyre Bird Dell Shelter which falls within the Hassan Wall unit though also borders the Warragamba soil landscape unit. Although the PAD sensitivity modelling predicts that the Warragamba soil landscape unit is associated with a low PAD sensitivity, the presence of artefacts in these sites suggests that the sensitivity modelling should be used with caution in the context of closed shelter sites. In contrast to open context sites, the accumulation and preservation of archaeological deposits in these closed contexts is dependent upon local conditions at the site including for example, the presence of rockfall which may act as a sediment trap preserving deposit. Unfortunately, the limited excavation within open air contexts means that it is not possible to fully test the PAD sensitivity modelling based on this brief literature review at this stage. Limitations of the PAD sensitivity modelling are discussed in more detail in Section 6.3.2 of this report.

Table 35: Regional archaeological studies involving archaeological excavation of PADs

Site name	Site type	Location	Soil landscape	Excavation area	Depth of deposit	Number of stone artefacts	Artefact density	Chronology
Parramatta River Pleistocene Terrace	Open air, Creek bank	Parramatta, NSW (38 km E of Warragamba Dam)	Birrong	35 m² (2021)	0.7-0.9 m	152	High	60 cm – 5.1 kya 80 cm – 11 kya 100 cm – 16.1kya 120 cm – 21 kya 140 cm – 24 kya (OSL 2021)
Cranebrook Terrace	Open air, Creek bank	Peach Tree Creek, Penrith, NSW (17 km NE of Warragamba Dam)	Richmond	12 m² (2017)	3.48-3.73 m	6 (2017)	1 artefact per 23 cm³	3.48m - 4.9kya 3.6m - 9.4kya 3.73m - 9.3kya (OSL 2017)
Shaws Creek KII	Rockshelter on a creek bank	Shaws Creek, Castlereagh, NSW (25 km N of Warragamba Dam)	Predominately Gymea but borders Hawkesbury	Approx. 10 m² (1984)	0-1.5 m	24,495 (1984)	Low	Phase I - <c. 1,500 BP Phase II - 1,500-2,000 BP Phase III - 2,000-4,000 BP Phase VI - > 4,000 BP Phase V - 13,000 BP Phase IV - > 13,000 BP (Radiocarbon 1984)
Lapstone Creek	Rockshelter	Lapstone Creek Cave/Emu Cave, Emu Plains, NSW (16 km N of Warragamba Dam)	Gymea	20.2 m² (1948)	0-1.4 m	1086 recorded "many thousands" (1948)	1 artefact per 460 cm³	50.80 cm - 2,300 BP 91.44 cm - 3,650 BP (Radiocarbon 1966/1978)
Springwood Creek	Rockshelter	Springwood Creek,	Warragamba	2.88m² (1974)	Data not provided	717 (1970)	Very High	20 cm - 615 BP

Site name	Site type	Location	Soil landscape	Excavation area	Depth of deposit	Number of stone artefacts	Artefact density	Chronology
		Springwood, NSW (24 km N of Warragamba Dam)						40 cm - 2,930 BP 70-140 cm - 6,050-8,730 BP (Radiocarbon 1970)
Walls Cave	Rockshelter on a creek bank and terrace	Walls Cave, Blackheath, NSW (37 km NW of Warragamba Dam)	Wollangambe	2 trenches, unknown	0-1.4 m	125	1 artefact per 0.06 cm^3	290 cm above bankfull -3,360 kya 220 cm above bankfull - 12,000 kya (Radiocarbon 1968)
Lyre Bird Dell	Two rockshelters on a creek bank	Gordon Falls Creek, Leura, NSW (30 km NW of Warragamba Dam)	Predominately Hassans Walls but borders Warragamba	unknown	Data not provided	1,285		La: unknown depth -12,550 BP Lb: unknown depth - 530 BP (Radiocarbon 1970)
Kings Table	Rockshelter	Wentworth Falls, NSW (25 km NW of Warragamba Dam)	Wollangambe	unknown	2.2-2.9 m “above bankfull”	3,063	Very High	Phase II - 980 BP Phase VI - 1,075-1,120 BP (Radiocarbon 1973)
Horseshoe Falls	Rockshelter undercut of a waterfall	Hazelbrook, NSW (23 km NW of Warragamba Dam)	Warragamba	unknown	unknown	375	1 artefact per 3 cm^3	Unknown depth – 7,280 BP

(Source: Barry et al. 2021, Kohen, Stockton and Williams 1984, McCarthy 1948, McCarthy 1978, Nanson, Young and Stockton 1987, Stockton and Holland 1974, Williams et al. 2017.)

5.5 Revised rock art analysis

Of the total 334 sites within the Project area, 83 (25%) comprise rockshelter sites with various combinations of site features. Of these 83 sites, 34 (40%) comprise rockshelter with art sites. The 34 rockshelter with art sites form 10% of the total sites across the Project area as a whole. All but one rockshelter with art sites contain multiple site features that indicate numerous activities often occurred at these sites.

Ten Aboriginal cultural heritage sites, containing rock art as a feature, are located within the PUIA and require an impact assessment. These sites include Warragamba 112 (AHIMS ID# pending), Warragamba 113 (AHIMS ID# pending), Warragamba 115 (AHIMS ID# pending), Warragamba 131 (AHIMS ID# pending), Warragamba 144 (AHIMS ID# pending), Warragamba 181 (AHIMS ID# pending), Warragamba 182 (AHIMS ID# pending), Warragamba 300 (AHIMS ID# pending), Bimlow PAD (AHIMS ID#45-4-0997); and Kamilaroi Point (AHIMS ID# 52-1-0142). Kerswell Hill (AHIMS ID#45-4-0026) is located immediately adjacent to the PUIA and is considered a rare site type.

The 10% of sites within the Project area that are rockshelters with art, contribute the significance of the area more broadly. Recorded Aboriginal rock art sites are recognised as contributing to the significance of the GBMWHA and thus also the Project Area. The discussion of Indigenous values associated with the GMWHA in the GBMA Strategic plan, for instance, states that:

> *"Recorded sites of archaeological significance include a widespread sample of the Sydney Region's distinctive Aboriginal rock art, which incorporates two synchronous forms (that is, pigment and engraved forms) on a scale unique in Australia. A number of scientifically important rock art sites with an unusually large number of individual motifs have been recorded within the GBMWHA and continue to be revealed, such as the Eagles Reach site." (DECC 2009: 13).*

Recognising this, a number of submissions requested a fuller consideration and discussion of the regional motif and pigment data, as the discussion provided in the original ACHA was challenging to follow and many of the charts were not labelled so that they can be easily understood. This section therefore considers and expands upon the information contained within the original ACHA to identify what is known regarding motif and pigment data for rock art associated with the Project area and surrounding region which can be used to inform and support the significance assessment of such sites and thus assist in developing appropriate management measures.

Section 10.6 of Appendix 1 of the original ACHA provided a discussion of rock art. It was noted that, while the Project area sample of rock art sites was not large enough to characterise the rock art of the Burragorang, it was possible to make a number of general statements with regard to the broader Sydney and Greater Blue Mountains regions. In order to do so, a comparative desktop analysis of the rock art of the Project area with that of selected samples of rock art sites from the wider region, was undertaken. This was also argued to allow for a regional consideration of archaeological values associated with such sites. The methodology for the desktop assessment was developed in consultation with Heritage NSW and utilised AHIMS data for art and engraving sites from regions that were broadly characterised by landscapes similar to the Project area including Colo River, Grose Valley, Kowmung River, Nattai National Park. The desktop analysis of regional rock art consisted of a total of 206 AHIMS sites consisting of shelters or rock platforms with engravings with either one or a combination of art, deposit, grinding grooves, abrasion patches and/or potential archaeological deposit considered rock art application techniques, material, motif type and frequency.

5.5.1 Analysis

Of the 334 Aboriginal cultural heritage sites identified as part of this assessment, 83 comprise rockshelter sites. Of these 83 rockshelters, 30 newly identified sites contain art. Four existing AHIMS sites (#45-4-0026, #45-4-0997, #45-5-0638, #52-1-0142) are shelters that contain art. Their details are presented in Table 36 below.

Table 36: AHIMS with rock art

AHIMS ID#	Motif/s	Form	Media	Colour	Condition
45-4-0026	100+ anthropomorphic figures, hand stencils, lines and indeterminates	Line, outline, infill and stencil	Charcoal and ochre	Black, red, white and yellow	Good
45-4-0997	Indeterminate	Indeterminate	Ochre	Red	Poor
45-5-0638	1. Left Hand 2. Right Hand 3. Probable hand	1. Stencil 2. Stencil 3. Probable stencil	Not recorded	Not recorded	Not recorded
52-1-0142	1. Anthropomorphic figure 2. Hand and wrist 3. Indeterminate 4. Indeterminate	1. Line 2. Stencil 3. Line 4. Line	1. Ochre 2. Ochre 3. Charcoal 4. Ochre	1. Red 2. Red 3. Black 4. White	Poor

The number, style and form of motifs present at each of the 30 newly identified rockshelter sites with art are summarised below in Table 37 and Plate 2 to Plate 5. The number of motifs present at each site varied from 1 to 14. Styles were more consistent with a number of line forms, geometric forms (including circles, semi-circles, triangles, zigzags, arcs and crescents), anthropomorphic figures (including human figures and/or figure with human characteristics /features), zoomorphic figures (including figures having or representing animal forms or Dreamtime beings of animal form) and hand stencils. Line and geometric motifs occurred in isolation whereas anthropomorphic figures, zoomorphic figures and hand stencils only occurred in combination with other styles. Approximately half of the sites contained a combination of two or more of these motif styles in two or more forms. Specific motifs that fall under combination style include a man, an anthropomorph with radiating lines, a snake, hands, and complex non-figurative. A probable eel, echidna, platypus and moth were also identified and fall under zoomorphic styles.

Line and engraved forms were commonly recorded in isolation whereas all other forms were typically recorded in combination with line form. Colours used included black charcoal and red, orange, yellow and white ochre. Black charcoal was commonly recorded in isolation whereas red, white and yellow were more commonly recorded in combination with black.

Table 37: Key data of the 31 newly identified sites contain art

Key data	
Number of motifs	**Number of sites**
1	9
2	4
3	3

Key data	
4	1
5	6
6	1
7	1
8	2
12	2
14	1
Style of motifs	**Number of sites**
Indeterminate	8
Line	6
Geometric	1
Combination	16
Form of motifs	**Number of sites**
Indeterminate	1
Engraved (pecked)	1
Engraved (scratched)	1
Infill	1
Line	10
Combination	16
Colour of motifs	**Number of sites**
N/A (engraved/abraded)	2
Black	14
Red	4
Orange	2
Combination	8

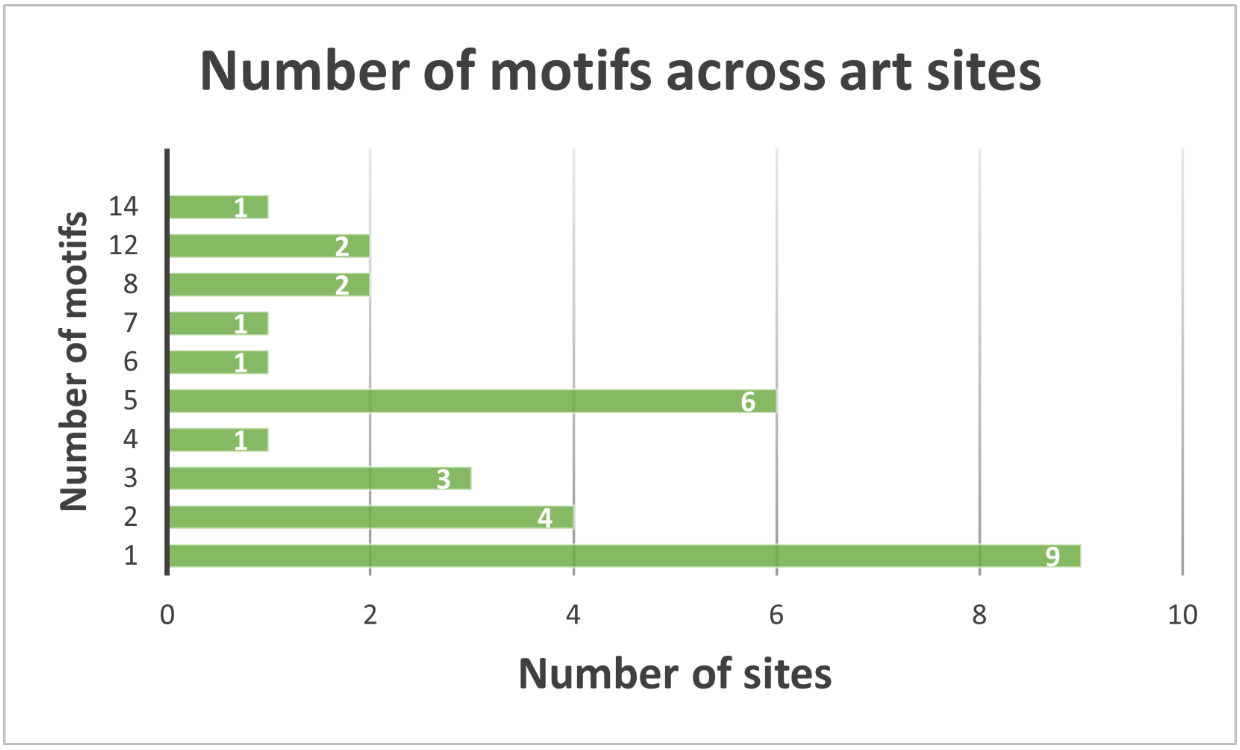


Plate 2: Number of motifs present across newly identified art sites

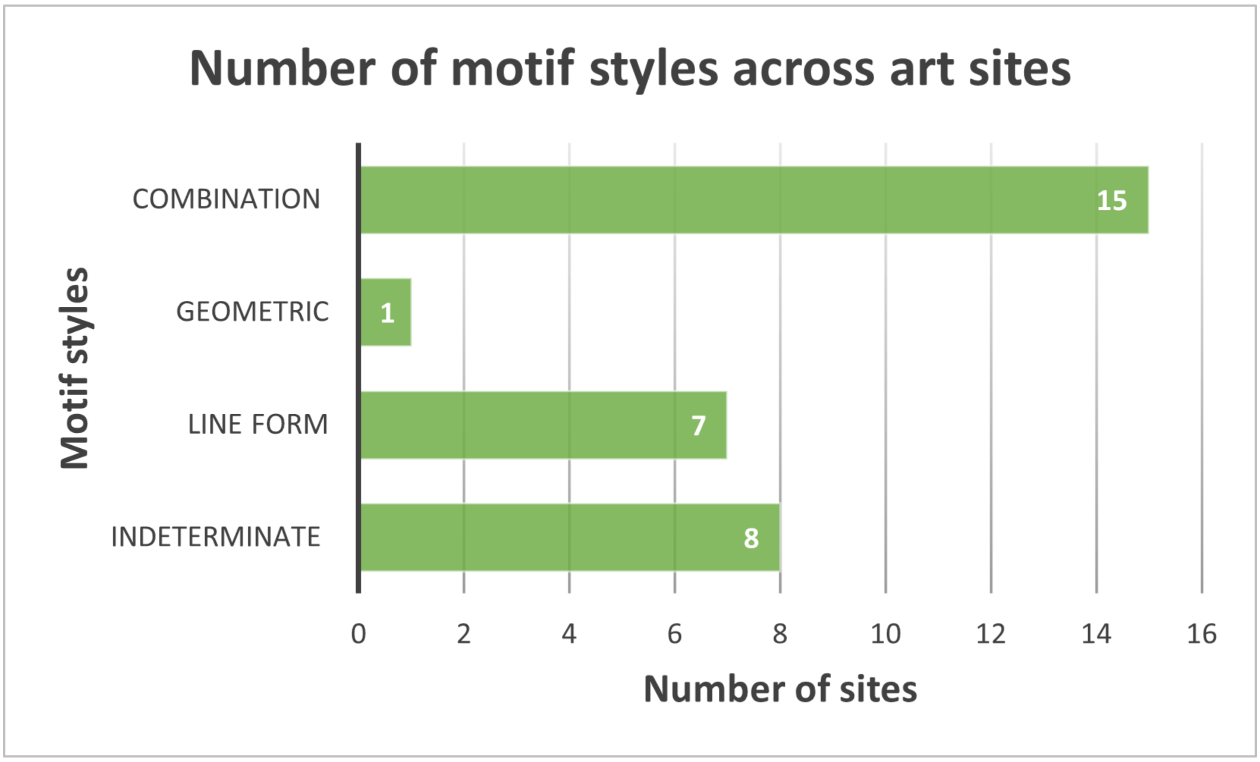


Plate 3: Number of motif styles present across newly identified art sites

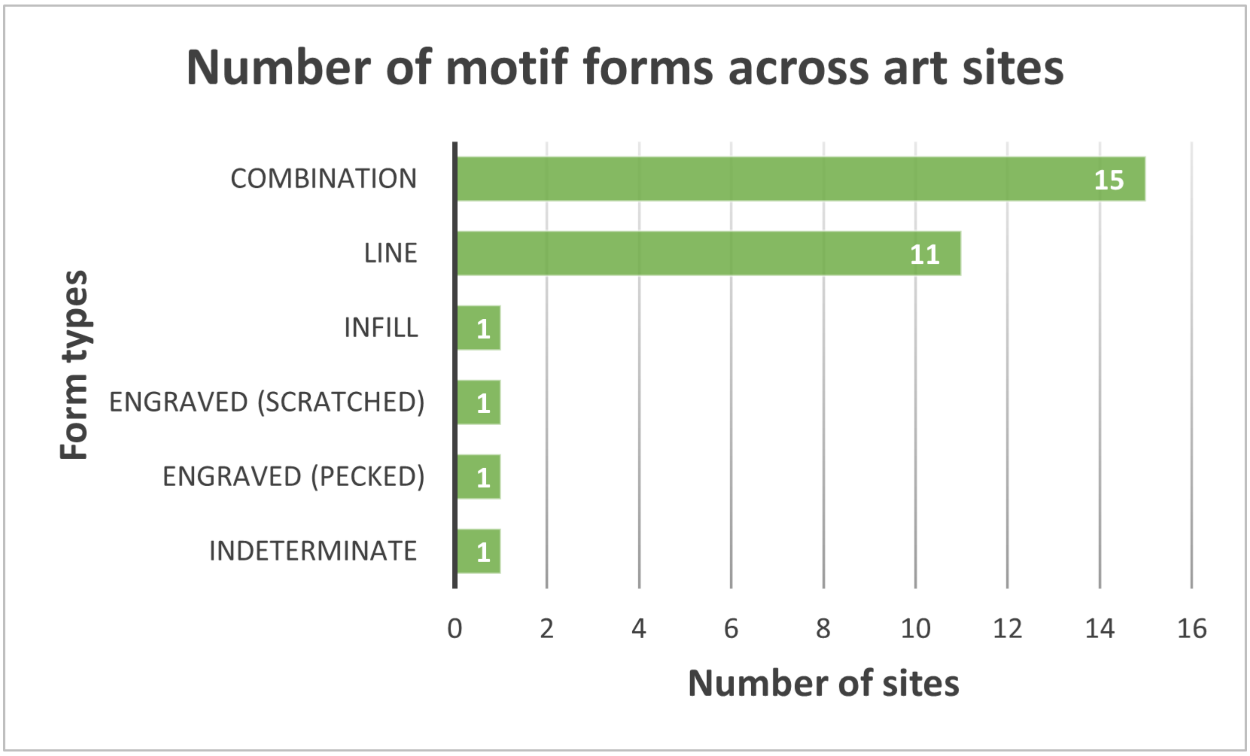


Plate 4: Number of forms present across newly identified art sites

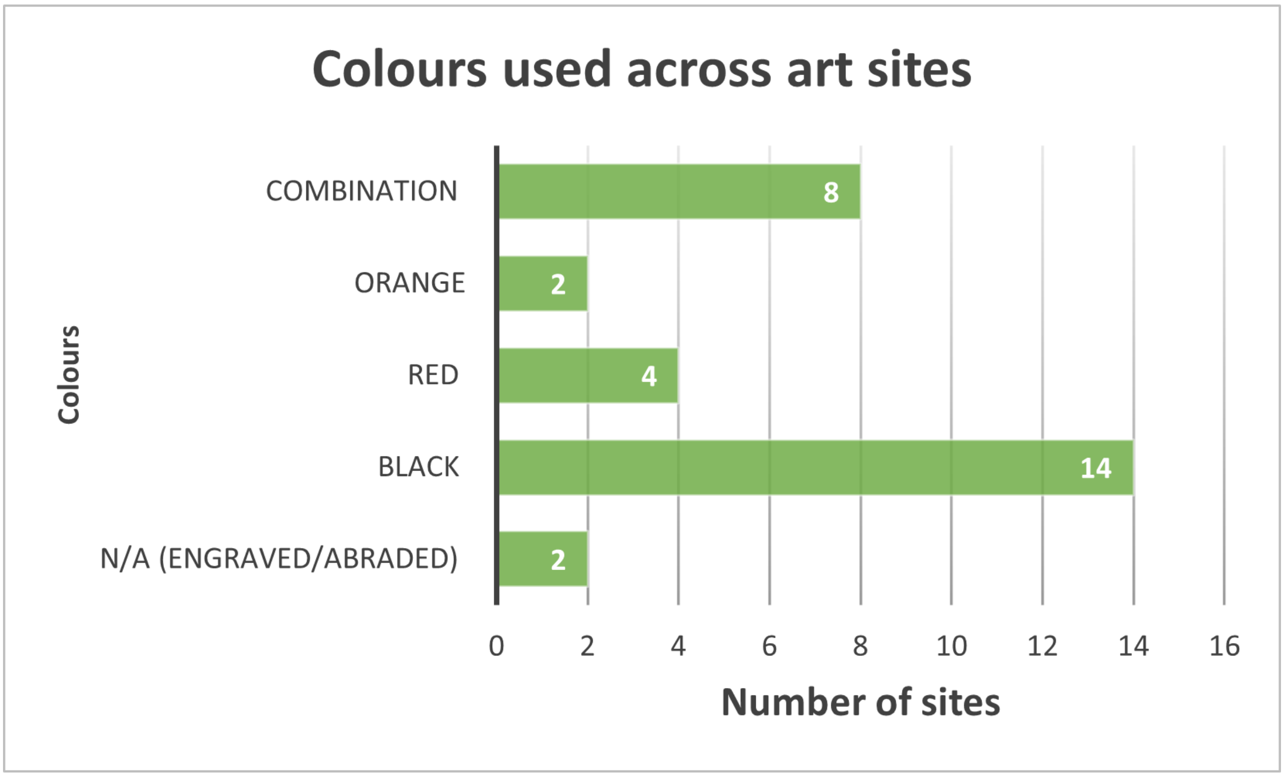


Plate 5: Colours present across newly identified art sites

5.5.2 Regional comparison

5.5.2.1 Number of motifs

Regionally, most pigment art sites contain fewer than 30 motifs. Ten or fewer motifs are the most common number of motifs per site. Compared to the newly identified sites, the regional sites typically contain significantly more motifs. The most common number of motifs per site amongst the newly identified sites is one. Five motifs or fewer is the next most common number of motifs per site amongst the newly identified sites. Two newly identified sites had more than 10 motifs.

Previous research has indicated that sites with over 100 motifs form approximately 5% of all shelter art sites across the Sydney region. Kerswell Hill (AHIMS ID#45-4-0026) has over 100 motifs with several styles, forms, colours and application techniques in addition to extensive layering of indicative of intergenerational use.

The average engraving site in the Blue Mountains region typically contains more than 10 motifs whilst only a fifth of sites contain one motif only (NPWS 1998:164). The three newly identified sites that contain engraved art differ from the regional sites with typically two engravings recorded.

5.5.2.2 Motif style

Within the Greater Blue Mountains, the Panaramitee and Simple Figurative rock art typological styles are present. Panaramitee is an art style found across Australia that has been identified in some instances in the Greater Blue Mountains region. Panaramitee mainly consists of engraved and pigment art styles that depict tracks and circles in a geometric style. The Simple Figurative style is the predominate style found within the Greater Blue Mountains region and mainly consists of tracks and figurative motifs (NPWS 1998:162). Motifs can be in various forms but are typically lines, outlines and some infills. Elements of both the Panaramitee and Simple Figurative are present within the newly identified sites that include geometric (circles) and figurative (anthropomorphic and zoomorphic) motifs in line, outline and infill form. Images depicted within the shelters of the Project area are consistent with a regional pigment art style known to extend across Hawkesbury sandstone landforms of the Sydney and Hunter regions of NSW (Attenbrow 2002:146).

In comparison to specific regional rock art sites recorded from Colo River, Grose Valley, Kowmung River and Nattai National Park, there is seemingly a wider range of motif style/type amongst the regional rock art than the newly identified sites (Plate 6 and Plate 7). However, this is largely due to the specification of the art subject. If the specific animals are listed as zoomorphic styles and the variously specified anthropomorphs are listed as anthropomorphic styles etc, there are only 6 other styles regionally that are not represented within the newly identified sites. The 6 regional motif styles absent from the newly identified sites include food, objects, tracks, human feet, complex non-figurative motifs and contact motifs/graffiti.

Notably, there are motif styles present within the newly identified sites that are not commonly represented regionally. Only one geometric motif, the circle, appears regionally, while the newly identified sites also contain semi-circles, triangles, zigzags, arcs and crescent geometric motifs not common in the region. Disregarding indeterminate styles, which occur most frequently regionally and amongst the newly identified sites., the most common regional styles are anthropomorphic and zoomorphic (combining the specific art subject). The most common style amongst the newly identified sites is a combination of zoomorphic, anthropomorphic, hand stencils, geometric and line motifs. The most common combination is geometric and line. Zoomorphic styles are present at three of the newly identified sites and present in combination with anthropomorphic styles at two of these sites.

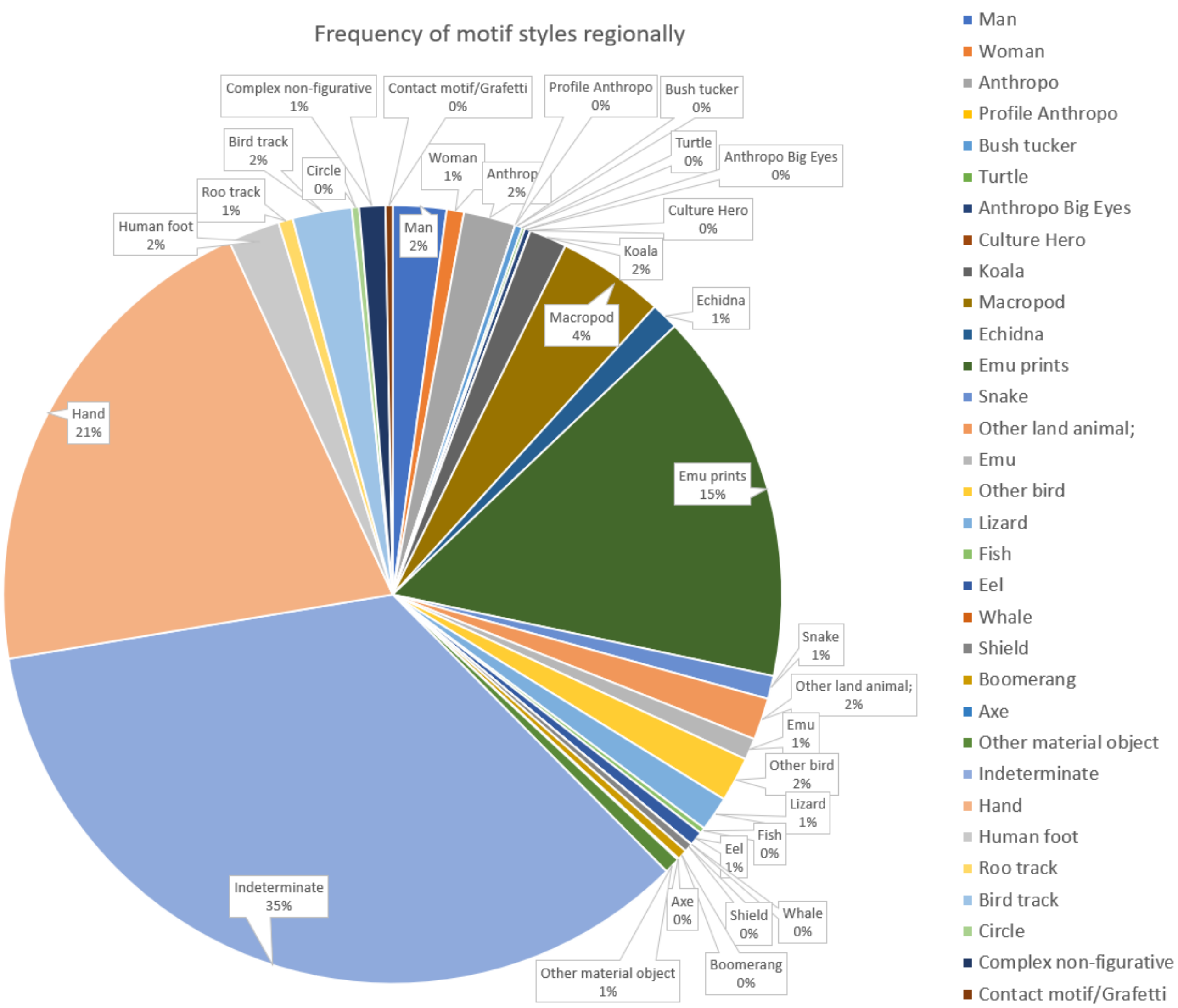


Plate 6: Motif styles present regionally

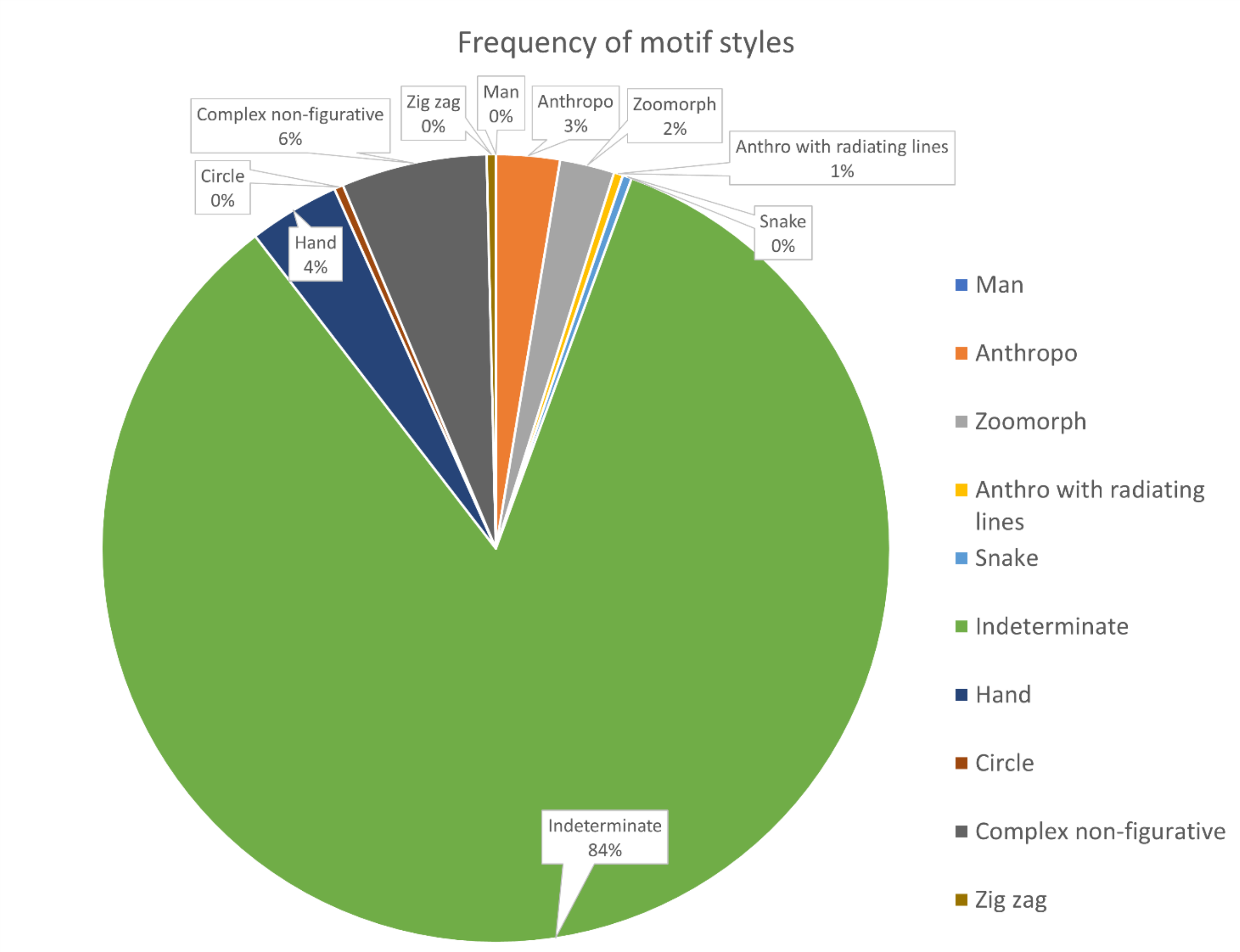


Plate 7: Motif styles present across the newly identified sites

5.5.2.3 Motif colour and form

The most common colour and form of motifs in the greater Sydney region is black charcoal outline/infill. The black charcoal colour recorded as most common amongst the newly identified sites is therefore consistent with the regional colour and media. Regarding form, line forms and a combination of two or more, line, outline, infill, stencil and abraded forms are more common amongst the newly identified sites than outline and infill alone, though both forms are represented. In the Blue Mountains region, outlines and stencilling are the most common forms (NPWS 1998: 166). In the Gundungurra region, hand stencils are one of the common art motifs. Only three of the newly identified sites contain hand stencils (in red and white ochre). Two of the existing AHIMS also contain hand stencils (Table 17 on page 72).

Both wet and dry pigment application was observed in the rock art amongst the newly identified sites including charcoal drawings, ochre paintings and ochre stencilling. In the greater Sydney region, the most common rock art application techniques are painting and drawing. This is consistent with rock art found amongst the newly identified sites. Notably, engravings are typically absent regionally: 'The figurative outline carvings on rock, of animals and people, that are so characteristic of Dharug and Darkingung country, are rare in Gundungurra land with only two sites recorded. These are the Bustard carving at Byrnes Creek in the Burragorang Valley and a Kangaroo head carving at Murruin' (Smith 2009: 152). However, three newly identified sites contain engravings in pecked, scratched and abraded form:

- Warragamba-115
  - One (1) indeterminate motif scratched in line form
  - Two (2) vertical abrasions
- Warragamba-285
  - One (1) abraded anthropomorphic figure
  - Two (2) vertical abrasions
  - Additionally, one (1) left hand stencil, three (3) line motifs in line form, four (4) anthropomorphic figures in outline and infill form and one (1) geometric motif in infill form
- Warragamba-288
  - One (1) geometric pecked engraving
  - One (1) indeterminate engraving
  - One (1) line motif in 'punctures'
  - Five (5) abraded patches
  - Additionally, two (2) geometric motifs in infill form, 2 (2) line motifs in line form

There is oral history recording of a potential fourth engraving site at Warragamba 74, an Aboriginal Ceremony and Dreaming site, but it was unable to identified during the assessment due to the thickness of the vegetation regrowth. According to oral history, Aunty Ivy Brookman, a former resident of the area, describes a macropod engraving at the location of Warragamba 74. Although its precise location could not be verified during the survey, the engraving would comprise the only zoomorphic engraving amongst the newly identified sites.

Possible cultural marking has additionally been reported in association with Ashtons 1 (AHIMS ID# 45-4-0966). This site comprises of an Axe Grinding Groove site located approximately 200 m from the Coxs River that was originally recorded by T. Kondek in 1999 as containing 11 grinding grooves in good condition. The site was re-located during the surveys completed for the ACHA for the current Project in October 2018 resulting in the identification of an additional grinding groove (resulting in a new total of 12 griding grooves at the site) and it was noted that the sandstone surface on which the grooves are located showed evidence of cracking and 'possible cultural markings'. Further details/description of the possible cultural markings were not recorded though from photographic records appear to be in the form of indeterminate curved lines.

5.5.2.4 Summary

Of the 334 Aboriginal cultural heritage sites identified as part of this assessment, 30 sites contain art. Four existing AHIMS sites (#45-4-0026, #45-4-0997, #45-5-0638, #52-1-0142) also contain art. Motifs from both the Panaramitee and the Simple Figurative rock art styles are present within the newly identified sites. Typically, the newly identified sites contain significantly fewer numbers of motifs per site than is found regionally. However, only 5% of all shelter art sites across the Sydney region have over 100 motifs recorded and AHIMS #45-4-0026 has over 100 motifs with several styles, forms, colours and application techniques in addition to extensive layering of indicative of intergenerational use.

Notably, there are motif styles present within the newly identified sites that are not commonly represented regionally. Only one geometric motif, the circle, appears regionally, while the newly identified sites also contain semi-circles, triangles, zigzags, arcs and crescent geometric motifs not common in the region. There are also 6 regional motif styles absent from the newly identified sites including food, objects, tracks, human feet, complex non-figurative motifs and contact motifs/graffiti.

Black charcoal used in the rock art within the newly identified sites is consistent with its regional use. Line forms and a combination of two or more, line, outline, infill, stencil and abraded forms are more common amongst the newly identified sites than outline and infill alone as is typical regionally. Notably, outlines and stencilling are the most common forms in the Blue Mountains region, (NPWS 1998: 166), however, only two of the newly identified sites and three of the existing AHIMS contain hand stencils. Engravings are uncommon regionally, however, three newly identified sites contain engravings in pecked, scratched and abraded form.

In comparison to the regional data, the 30 art sites are therefore typical in colour and media and atypical in number of motifs and motif forms. The 30 art sites contain both typical and atypical motif styles (including common Panaramitee and Simple Figurative motifs) and include some rare sites with significant numbers of motifs and engravings (Warragamba-115, Warragamba-285 and Warragamba-288).

5.5.3 Rock art and the Cultural Landscape

Numerous rock art sites are linked to the Gundungurra Cultural Landscape. Table 38 provides a summary of the Gundungurra Cultural Landscape sites/places that are noted as being associated with significant rock art sites that occur along the passage of the Journey of Gurangatch and Mirrigan creation story (see Section 5.3 of this supplementary assessment for further details). These examples demonstrate the strong connection and inter-connectedness between tangible archaeological sites (such as rock art sites) and the broader cultural landscape with its associated intangible values.

Table 38: Gundungurra Cultural Landscape sites/places noted to be associated with rock art

Site/place #	Site/ place name	Details of the associated rock art
12	Gunggalook Waterhole	Noted as being nearby to the location of a number of locations of rock art sites including a site with a large serpent drawing. This thought to likely be a representation of Gurangatch.
20	Waratah Rock	A large boulder in the hinterland of the Black Waterhole. The rock has a shelter on the western and northern facing sides with rock art consisting of white hand(s) stencils, faint black pigment lines and a possible red anthropomorphic figure ('dancing figure'). The rock, shelter, and rock art feature in a Gundungurra story about the Waratah flower.
29	Boonbal Waterhole	A waterhole located near Brimstone Gully where significant tock art sites with images linking it to paces further north in Gundungurra country (such as Ripple Creek).
40	Kerswell Hill Rock Art Site	Described as: *"a significant rock art site with red dancing figures – a special type of image occurring across a widespread area of Gundungurra Country – white hand stencils, numerous grinding grooves and stone tools. Close to 30 sites across the region are currently known to have examples of the red dancing figures demonstrating that this site is part of a network of related sites, each one forming a significant part of the cultural landscape. There are thousands of stone tools in the area, ochre nodules and axe grinding grooves. It is located adjacent to a known white and yellow ochre deposit which valley residents used in their houses and are likely the source for the white and yellow hand stencils at the site."* (Jackson 2018: 10)
47	Kedumba Waterhole Occupation	Noted as being the location of a series of sites associated with Gurangatch's journey including three rock art sites.

Site/place #	Site/ place name	Details of the associated rock art
49	Apple Tree Flat and Cedar Creek	Large open campsite at the junction of Cedar Creek and Coxs River situated along the Gurangatch journey path. Cedar Creek holds several significant rock art sites. Apple Tree Flat, opposite Cedar Creek was a major camping location adjacent to Gurangatch's Karrangatta Waterhole. There is a hand stencil (Murrolunggulung) site behind Karrangatta Waterhole.

5.6 Flooding and potential impacts to Aboriginal heritage

Management decisions regarding the appropriate mitigation of impacts to cultural resources in inundation zones can only be made in light of increased understandings of the nature of these impacts. A number of submissions identified the need for a more detailed consideration of potential impacts of flooding on Aboriginal archaeological sites and features based on:

(a) an assessment of broader literature including that which may enable a more targeted consideration of impacts specific to, for example, the flooding of medicinal springs and impacts to rock art; and

(b) an assessment of current inundated Aboriginal archaeological sites in the broader Project area.

Prior to addressing the above, it is necessary to set out the character of flooding within the catchment upstream of Warragamba Dam to provide context to the discussion and assist in identifying what may or may not be relevant to the current Project within the broader literature. The following provides a brief overview of the current and potential flooding associated with the Project area. A more detailed discussion of this is provided in Section 8.2 of the supplementary assessment.

Flooding in the catchment upstream of Warragamba Dam comprises two components including local catchment inflows/runoff (which are determined by local conditions and are independent of the Project and will therefore not be changed by the Project) and backwater from Lake Burragorang (which already exists occurring as inflows enter the lake and exceed outflows at the dam and will increase in extent with the Project). Local catchment inflows occur above the upstream limit of backwater from Lake Burragorang. As a result of the Project, temporary inundation from the backwater effect will change with regard to the lateral extent of temporary inundation, the depth and duration of temporary inundation and the frequency of flood events causing temporary inundation. Erosion potential from backwater is very low to negligible being relatively greater with local catchment runoff. Having established the key variables associated with flooding that which will change as a result of the Project (i.e. extent, depth, duration and frequency) a review of results and observations from the original ACHA, a review of information from the broader literature surrounding the impact of flooding on archaeological sites and a case study with results from an additional survey completed within the Project area will now be considered.

5.6.1 Results and observations from original ACHA

Results and observations from the survey completed as part of the original ACHA provide some insights into the potential impacts to archaeological sites from temporary inundation within the Project area. Examples as discussed in the original ACHA and/or recorded during the original surveys completed for the Project are outlined below in Table 39.

Table 39: Examples of impacts from temporary inundation noted in original ACHA

Site name and ID	Site type	Observations & implications
Byrnes Creek (AHIMS ID#52-1-0008)	Sandstone platform with Engraving	• Site unable to be relocated during the survey completed for the original ACHA due to the movement of soils relating to water movement that have covered its registered location (pg. 163 of AR). • Example of how inundation can result in obscuring of sites on sandstone platforms such as engravings and grinding grooves.
Bimlow PAD (AHIMS ID# 45-5-0997)	Shelter with Art, Axe Grinding Grooves and Artefacts	• Site located on a point southwest of Hunt Point next to the stored water at Cox River, Warragamba Dam. The shelter is formed by an isolated boulder and is situated within the stored water at full storage levels. • The art is comprised of red pigment visible on the rear wall of shelter and is very faded. There are multiple grinding groove groupings noticeable on the floor of the shelter, as well as outside on an isolated sandstone platform. There was a total of 43 grinding grooves associated with the shelter. A large artefact scatter is associated with this shelter, and a sample of 25 artefacts were recorded during this assessment. • The site was originally recorded in 2004. During the most recent visit to the site during the ACHA surveys, it was noted that "there is heavy impact from intermittent inundation by the stored water" though specific details of what form this impact took was not provided.
Warragamba-181 (AHIMS ID# pending)	Shelter with Art, Deposit, Artefacts and Axe Grinding Grooves	• During the ACHA surveys it was noted that the shelter showed evidence of periodic inundation in the form of water wash and the presence of a high-water mark visible on rock surfaces. • Art surfaces were noted to be very faded and heavily exfoliated, a result attributed to periodic inundation due visible moisture capture, salt spalling and cryptogrammic weathering. • Associated Grinding Patch were noted to be in average condition, located in front of rock shelter, on a portable sandstone rock. No evidence of impact was noted in relation to this feature suggesting it is less susceptible to inundation.
Warragamba-192 (AHIMS ID# pending)	Shelter with Deposit	• This shelter is located at the base of a ridgeline beside Ripple Creek. The shelter was formed by cavernous weathering. • During the ACHA surveys it was noted that the shelter had evidence of exfoliation and fissuring on back wall and ceiling, block fall on roof, and water weathering, which were attributed to be a result of the periodic inundation of the site from stored waters. • The shelter contained a yellow sandy deposit, but no artefacts were located during this survey. No impacts to the deposit (e.g. erosion) were noted.
Warragamba-200 (AHIMS ID# pending)	Shelter with Deposit and Artefacts	• This site is located beside the stored water at Lake Burragorang. • During the ACHA surveys it was noted that the shelter had evidence of water damage from stored water inundation in the form of water wash and fissuring), as well as block fall.

Site name and ID	Site type	Observations & implications
		• The shelter contained a yellow sandy deposit and a sample of 20 artefacts that were located on the floor of the shelter and the eroding surface of the surrounding landscape. Evidence of fissuring was also recorded on the roof of the shelter. It is not clear whether the erosion was a result of inundation or local catchment run-off or both or other environmental factors such as animals and wind.
Warragamba-206 (AHIMS ID# pending)	Shelter with Deposit and Artefacts	• This site is adjacent to the stored water and is temporarily inundated during periods when the reservoir is at full storage level. • The shelter was formed by cavernous weathering and is still subject to active block fall. Two basalt artefacts were found in the shelter's dripline. • During the ACHA surveys it was noted that the shelter had evidence of fissuring, honey combing, exfoliation and chemical weathering on the back wall and roof with these affects attributed to being the result of and/or influenced by periodic inundation.
Warragamba-207 (AHIMS ID# pending)	Shelter with Axe Grinding Grooves and Deposit	• This site is adjacent to the stored water at Butcher's Creek and is temporarily inundated during periods when the reservoir is at full storage level. • The shelter was formed by cavernous weathering and is associated with five axe grinding grooves located on a boulder at the dripline at the southern end of the shelter. No impacts to these features were noted. • During the ACHA surveys it was noted that the shelter had evidence of water wash, fissuring, honey combing, exfoliation and chemical weathering on the back wall and roof with these affects attributed to being the result of and/or influenced by periodic inundation.
Warragamba-208 (AHIMS ID# pending)	Shelter with Deposit and Artefacts	• This site is adjacent to the stored water at Butcher's Creek and is temporarily inundated during periods when the reservoir is at full storage level. • The shelter was formed by cavernous weathering and is associated with two stone artefacts including a basalt axe. • During the ACHA surveys it was noted that the shelter had evidence of water wash, chemical weathering and erosion of deposit down slope of the shelter with these affects attributed to being the result of and/or influenced by periodic inundation.
Warragamba-211 (AHIMS ID# pending)	Shelter with Art, Deposit and Artefacts	• This site is adjacent to the stored water along Wollondilly River south of Blattmann Point and is temporarily inundated during periods when the reservoir is at full storage level. • The shelter was formed by an isolated boulder and is associated with at least 15 stone artefacts and rock art in the form of three parallel red linear vertical lines. Although the art is covered in silica it is noted to be in poor condition. • During the ACHA surveys it was noted that the shelter had evidence of water wash, fissuring and chemical weathering with these affects attributed to being the result of and/or influenced by periodic inundation.

Site name and ID	Site type	Observations & implications
Warragamba-219 (AHIMS ID# pending)	Shelter with Axe Grinding Grooves, Deposit and Isolated Artefact	• This site is located adjacent to the stored water on the northern side of Bellbird Point and is temporarily inundated during periods when the reservoir is at full storage level. • The shelter was formed by an isolated boulder and is associated with two grinding grooves (one located inside the shelter and the other on a sandstone boulder to the north). No impacts to these features were noted. • During the ACHA surveys it was noted that the shelter had evidence of cavernous weathering, block fall, exfoliation, and spalling with these affects attributed to being the result of and/or influenced by periodic inundation.
Warragamba-239 (AHIMS ID# pending)	Shelter with Deposit and Isolated Artefact	• This site is located adjacent to the stored water on the south side of Warragamba Gorge, north along an unnamed tributary of the Warragamba dam. • The site contained an isolated artefact. • During the ACHA surveys it was noted that the shelter had evidence of water wash which was attributed to periodic inundation though was not described as resulting in any adverse impacts to the site.
Warragamba-258 (AHIMS ID# pending)	Shelter with artefacts and axe grinding grooves	• This site is located beside the stored water of the Cox River in an area subject to temporary inundation from the existing dam and is situated partially below the FSL in Lake Burragorang. • It was noted during the recording of the site that there was mineral formation and weathering patterns evident from the rock surfaces which experience immersion by the stored water, and there was no deposit due to erosion from this process. A large scatter of artefacts was visible at the site, out of which a sample of thirty-eight were recorded and no impacts were noted in association with the artefact scatter. • The site highlights the potential impacts to shelter sites that are subject to submersion. Based on observations made at this site, there was minimal impact from mineral formation weathering however the removal of deposit represents a more pronounced impact.
Warragamba-259 (AHIMS ID# pending)	Shelter with Deposit, Artefacts, Axe Grinding Grooves and Tool Marks	• This site is located adjacent to the stored water of the Cox River is temporarily inundated during periods when the reservoir is at full storage level. • The shelter was formed by an isolated boulder and is associated with a large quantity of artefacts, visible sandy deposit and three axe grinding grooves. • During the ACHA surveys it was noted that the shelter had evidence of fissuring, chemical weathering and micro and macro vegetal growth with these affects attributed to being the result of and/or influenced by periodic inundation. While these affects appear to have modified the condition of the shelter, no impacts to the other features (Artefacts, deposit, grinding grooves) appear to have occurred as a result of previous inundation.
Warragamba-260 (AHIMS ID# pending)	Shelter with Isolated Artefact	• This site is located adjacent to the stored water of the Cox River is temporarily inundated during periods when the reservoir is at full storage level.

Site name and ID	Site type	Observations & implications
		• The site is associated with a single stone artefact. • During the ACHA surveys it was noted that the shelter had evidence of periodic inundation in the form of algal growth, chemical weathering and an absence of deposit.

Based on the above observations, periodic inundation appears to variably affect different archaeological features though it is often difficult to differentiate the effects of temporary inundation from those due to local catchment run-off. Nevertheless, the following key points can be made:

- Where temporary inundation leads to silt deposition, this can obscure the surface artefacts and features associated with a site (e.g. Byrnes Creek, AHIMS ID#52-1-0008). While this does not necessarily impact the site, it results in the site being hidden and affects analytical techniques such as site survey and visibility).
- Where temporary inundation leads to the erosions and transportation of sediment, this can have an adverse effect on sites with PAD/deposit (e.g. Warragamba-258, Warragamba-208).
- Where temporary inundation results in weathering/exfoliation of rock surfaces and mineral formation this may result in adverse effects to rock art (e.g. Warragamba-181). In contrast, where rock art is not present, such processes may be negligible (e.g. Warragamba-258, Warragamba-239).
- Some archaeological features, such as axe grinding grooves, appear to be relatively resistant to the effects of temporary inundation (e.g. Warragamba-181, Warragamba-207, Warragamba-219).

5.6.2 Information from literature review

5.6.2.1 Previous studies within the Project area

The following provides a summary of information regarding the potential impacts of inundation on archaeological sites based on previous assessments which have been undertaken within the Project area, namely those completed in association with the previous Warragamba Flood Protection EIS.

Warragamba Dam – Archaeological study sample investigation of areas upstream to be affected by increased water retention (Brayshaw 1989)

This report presented the results of an archaeological study of the shores of Lake Burragorang with the aim of gaining an understanding of the archaeological resource on the perimeter of the lake and the potential impacts that may occur as a result of increased water retention upstream of the lake. The assessment area covered the land between the full supply level (RL 116.72) and a contour interval of RL 160. Site types identified and assessed within the inundation zone included shelter sites with art and/or archaeological deposits, axe grinding grooves, open camp sites and scarred trees.

It is acknowledged that the impact of flooding within the inundation zone would vary depending upon a range of factors including:

- The elevation of an area or site above FSL
- The period of time it was submerged
- The degree of silt deposition
- Associated weather conditions (e.g. high winds causing destructive wave action).

The backing up of water within smaller streams is also noted as having the potential to damage shelter and other sites above the projected inundation level (Brayshaw 1989: 30).

While the report notes that little research has been done in Australia concerned with understanding the impact of inundation on archaeological sites, it is considered that sufficient is known to indicate broadly the kinds of impact to be anticipated on site types occurring within the inundation area (Brayshaw 1989: 30). A summary of the potential impacts recognised based on site type / feature as informed largely from observations in the field and reported in Bradshaw 1989 is provided in Table 40 below.

Table 40: Potential impact to site types and/or features within Project area (Brayshaw 1989)

Site type / feature	Observations and comments
Archaeological deposits and Artefacts sites	• During the survey for the assessment, Brayshaw (1989: 12) noted that "previous floodings have resulted in scouring visible above the water's edge around most of the perimeter of the dam". • Based on observations of open sites and archaeological deposits identified between the FSL and previous flood level, Brayshaw (1989: 30) noted that "wave action had removed and destroyed the archaeological context of stone artefacts". These site conditions were reported to resemble those previously observed at Lake Glenbawn in the upper Hunter Valley and Lake Jindabyne in the southern highlands of NSW which provide similar examples of flooding that demonstrate the negative effects of water action on the archaeological context of a site. • The most rapid destruction of archaeological stratigraphy in open sites is expected to occur in contexts where artefacts are embedded in easily dispersed clays. • In open contexts where inundation is expected to result in the deposition of silt, such as along the valley of the Wollondilly River, no impact to the archaeological integrity of sites is expected, though due to the heavy sediment load usually carried by the river, such open sites are likely to be covered by alluvial deposits and therefore may no longer be detected by surface survey being hidden from view (Brayshaw 1989: 11).
Rock shelter sites	• Inundation may result in the deposition of silt within a shelter and while this may not affect stone artefacts in the deposit, the changed environmental conditions may impact the preservation of organic materials if present in the deposit. Frequent and/or rapid changes between wet and dry conditions associated with flooding, for instance, may accelerate the decay of plant and animal food remains and other dateable material. • Short term variations between wet and dry conditions can also be destructive to rock art more so than prolonged periods of wetness (Brayshaw 1989: 30). • Additionally, flooding may destabilise the shelters themselves, particularly as a result of severe scouring, and it is the degree and duration of exposure to wave action that is considered to influence their susceptibility to such impacts most significantly (Brayshaw 1989: 30).
Burials	• Burials may occur within deposits in open context or in shelters and would therefore be suspectable to contextual erosion and increased rates of decay as a result of inundation similar to other organic remains (Brayshaw 1989: 30-31).
Rock art – Paintings	• Periodic flow of water is recognised as being the most obvious and most damaging cause of deterioration of art in rock shelters (e.g. Rosenfeld 1985: 52). Variation in the moisture within the rock can accelerate weathering and the exfoliation of painted surfaces while the flow of water across rock surfaces can result in the removal of pigments and/or the deposition of silts, clay sand other minerals which can create conditions suitable for the growth of destructive fungi, algae and lichens (Brayshaw 1989: 31).
Rock art – Engravings	• Engravings typically occur on horizontal rock surfaces and may be susceptible to the deposits of silt. While the deposition of silt itself would result in impact beyond obscuring the site from view, it may result in the creation of an environment where plant growth is promoted, leading to breakdown of the parent rock and eventually the loss of the art as an interpretable design (Brayshaw 1989: 31).

Site type / feature	Observations and comments
Axe grinding grooves	• Axe grinding grooves would be susceptible to the effects of silt deposition as described for engravings.
Scarred trees	• The prolonged presence of water around the base of a scarred tree may drown the tree and/or destabilise it eventually resulting in increased erosion of the base support and felling of the tree itself (Brayshaw 1989: 31).
Stone arrangements	• The principle potential threat to stone arrangements is destabilisation by scouring from wave erosion (Brayshaw 1989: 31).

5.6.2.2 Australian studies

Archaeological survey of the proposed enlargement of Glenbawn Dam (Brayshaw 1981)

Brayshaw describes some observations from Lake Glenbawn which provide evidence of the impact of inundation on open sites. A survey was completed during drought conditions which resulted in a reduced water level at Glenbawn which fell below 20% of capacity. In the areas that were now visible, artefacts which had occurred within alluvium-colluvial deposits were exposed on the surface of the (usually) underlying Pleistocene surface comprised of strongly structured stable red clay soils. The more recent deposits had been removed as a result of wave action though the denser stone artefacts remained. While the stone artefacts may not have moved far laterally, their vertical and contextual context was completely destroyed. This observation demonstrates the resilience of the stone artefacts to inundation though highlights the fragility of the matrix of deposit which contain them which are adversely impacted by inundation.

Aboriginal sites in Kosciusko National Park & Region (Gallard 1980)

Similar to the observations at Glenbawn Dam, stone artefacts and backed clay from hearths were exposed at Lake Jindabyne as a result of wave action between high and low water levels following a period which saw the lake levels reach a record high in 1974. The matrix surrounding these cultural objects had been removed as a result of wave action and the clay hearth-like material had been partially eroded. It was concluded that such impacts would be relatively rapid in contexts where artefacts were embedded within easily dispersed clays. This observation provides another example of the resilience of stone artefacts to inundation and the susceptibility of the deposit to erosion.

Wave action impact on archaeological sites in a freshwater reservoir: The case of Lake Hume, New South Wales (O'Halloran and Spennemann 2002)

This article looks at the types of waves that can be found in inland reservoirs and their specific impacts on Aboriginal archaeological sites and then presents a case study from Bowna, Lake Hume situated on the NSW and Victorian border. The impacts of additional environmental factors including water-level fluctuation, location of sites within the reservoir, the fill rate of the dam, the angle of the basin slope and the stability of sites based on the presence of vegetation are also considered.

Wave action is recognised to influence site preservation in that it causes damage to unconsolidated banks and shorelines resulting in instabilities to sites located in such areas. The nature and degree of impacts is depended upon the type of waves, the type of site and the duration of the effect. Wave types present in reservoirs include shoaling waves, spiling waves, plunging waves and surging waves (O'Halloran and Spennemann 2002: 6). A description of these wave types and their potential impacts to cultural resources is provided in Table 41 ordered from most destructive to least destructive.

Table 41: Wave types and potential impacts (O'Halloran and Spennemann 2002: 7)

Wave type	Description	Potential impacts
Surging waves	Occurs at steep sloping shores. This wave type does not have a breaking crest. Instead, the base of the wave collapses from under the crest and moves quickly towards the shoreline.	The most destructive wave type as such waves are able to lift artefacts and sediment from the bottom of the reservoir and relocate them to the shoreline. This results in damage through sand abrasion and rolling, potentially reduced preservation due to being exposed to differing environmental factors above the shoreline in addition to introducing biases in the composition of the artefact assemblage as a result of size and weight sorting.
Plunging waves	Occur at the shoreline with intermediate slopes. The motion of these waves curls over the crest of the wave causing the wave to plunge forward with high velocity.	Results in severe erosion along the shoreline and sand abrasion to artefacts which are moved about in this shoreline zone.
Shoaling waves	Vary in height and velocity depending upon the depth of the water and the length and consistency of the wave.	May cause some movement and deposition of light artefacts and sediment close to the shore.
Spilling waves	Occur near horizontal shorelines. This wave type breaks gradually.	Generally causes little or no deposition or abrasion of artefacts and is the least destructive to the survival of archaeological sites.

As the above table describes, the type of wave and the resulting degree of impact is dependent upon a range of contextual factors including the character/slope of the shoreline. Generally speaking, the gentler the slope of the shoreline the less destructive the wave type. Other factors such as the presence of vegetation will additionally influence the degree of impact with effects from waves considerably less in contexts where vegetation cover is present. In increasing order of impact on archaeological sites, wave action can cause shoreline erosion through sediment loss, exposure of sites and artefacts, intermingling of site layers and/or artefact transportation in increasing order of impact on archaeological sites (O'Halloran and Spennemann 2002: 7).

The construction of the Hume Reservoir between 1919 to 1936 resulted in the flooding of large tracts of land along the floodplains of the Murray River and Twelve Miles Creek including the town of Bowna which is known to have been inhabited by the Wiradjuri people long before European colonisation of the area in 1835. Wiradjuri cultural sites normally remain inundated by the waters of Lake Hume at the Bowna Waters Reserve and are exposed to fluctuating water levels and wave action. During maintenance and structural reinforcement work at the dam wall between 1998 and 2002, the water levels dropped below 20% capacity, exposing the original creek and river system and a number of archaeological sites and thus provided the opportunity to undertake research on site preservation in this area.

A series of surveys were undertaken between 1999 and 2002 of previously inundated cultural resources associated with Lake Hume reservoir which were exposed and accessible during maintenance and structural reinforcement work at the dam wall. Artefactual material primarily consisted of flakes manufactured from quartz and a very minor quality of chert, silcrete and volcanic pebble. Artefact density of sites ranged from low background scatters to distinct clusters of knapping sites, hearths and open camp sites of varied sizes.

Site 1, an artefact scatter, was surveyed between 1999 and 2000 to investigate the rate at which artefacts were being exposed. During normal periods of full inundation, the site is situated approximately 5 m below the water level. Due to its location within the shoreline fluctuation zone, this site is subject to frequent fluctuating water levels, periods of wave action in near-shore areas and wave-induced currents, causing shoreline erosion, sediment removal and artefact exposure and redeposition (O'Halloran and Spennemann 2002: 10). A total of 74 Aboriginal artefacts were identified during the 1999 survey while 96 were identified when the site was revisited in 2000. In addition to the increased number of artefact exposed, a substantial portion were located in areas where that previously held no artefacts, a result which was interpreted as reflecting the removal of sediment in previously unaffected higher areas of the site through wave action (O'Halloran and Spennemann 2002: 8). A continuation of site erosion was noted during a subsequent site inspection in late March 2022 where the shoreline was recorded to have increased in steepness, root networks of nearby trees had been exposed and rill erosion of some site surfaces had developed (O'Halloran and Spennemann 2002: 8).

Site 2, a small quartz knapping site, was uncovered during the survey work competed in 2000. The removal of sediment from the area during an inundation period resulted in the site being exposed when the water levels dropped from 27% to 25% capacity. Observations over a four-week period revealed that the minimal amount of vegetation growth that occurred during this period were "substantial enough to provide some protection and stabilisation of the soil and archaeological artefacts" despite the site being subjected to maximum impact from waves (O'Halloran and Spennemann 2002: 10). It was concluded that, the introduction of semi-aquatic vegetation, such as *Persicaria hydropiper,* in areas of fluctuating water levels may represent a suitable management strategy for assisting in the stabilisation of shorelines and sites that are prone to sediment erosion (O'Halloran and Spennemann 2002: 11).

The paper is relevant to the current Project as it provides a useful case study for understanding the range of impacts that may occur to artefact scatter sites within the shoreline fluctuation zone of a reservoir. Significantly, it highlights the dynamic nature of the reservoir environment and how changes within this setting can result in changes in the nature and type of impacts. An alteration to the shoreline as a result of wave action (whether through erosion or accretion), for instance, may cause a change in the angle of the shoreline slope and thus the degree of impact (the steeper the shoreline slope the greater the movement and/or transportation of artefacts and deposit). Furthermore, the paper provides support for the positive role that vegetation cover can play in protecting sites and assisting in site stabilisation in such fluctuating environments.

5.6.2.3 International studies

This section looks more broadly at research that has been undertaken into the effects of flooding on the archaeological record. Research discussed below has been undertaken overseas and delineates the effects of large flood events or inundation relating to reservoir contexts on the archaeological resources of a specific region. While the nature of the archaeological sites and the character of the environmental context may therefore differ from that of the current Project, some of the results of these studies nevertheless provide insights into the range and types of impacts that flooding and related stream-flow phenomena have on the archaeological record that are of relevance more broadly. An overview of a selection of international assessments and/or case studies is provided in below.

Floods and Archaeology: West Branch of the Susquehanna River, Williamsport, Pennsylvania, USA (Turnbaugh 1978)

This early paper explores the role of stream flow and flooding as transformers of the archaeological record using observations made in the field following a major inundation event. In 1972, Tropical Storm Agnes resulted in a dumping of 32.5 cm of rain over much of the watershed of the Susquehanna River in Williamsport, Pennsylvania in the United States. The storm resulted in major flooding of the West Branch of the Susquehanna River with run-off leading to a crest of 10.4 m. A flood of this magnitude was estimated to occur less than once in 3 centuries. In the weeks following the flood, the effects of the flood on local archaeological sites were observed and systematically recorded. The project was incorporated into a regional survey and excavation program that had commenced prior to the major flood event. The fieldwork therefore provided an opportunity to analyse the immediate impact of flooding on archaeological resources and to determine and evaluate some general and specific effects of floods on archaeology. The analysis considered a total of 226 archaeological sites (open context sites including artefact scatters and hearth sites) and involved recording site location and environment, orientation to streams, soil types and flood effects (erosion and/or deposition). Some key findings of the study are as follows:

Types of impacts:

- Impact types can be divided into those resulting from erosion and those resulting from deposition; however, these processes always operate in tandem (Turnbaugh 1978: 595).
- The impacts of erosion were highly visible while depositional impacts were somewhat less obvious to the eye but were equally widespread (Turnbaugh 1978: 598).
- Several types of erosion were observed:
  - Channel erosion was perhaps the most severe often associated with a large-scale removal and transport of soil. Channel erosion resulted in cut away along either one of both banks and previously known surface artefact sites directly in the line of such channels were virtually destroyed (Turnbaugh 1978: 595).
  - Slope wash erosion occurred in areas with little or no vegetation. The flow of water over surfaces with minor irregularities resulted in the creation of rills and small gullies which were observed to have dissected the surface of some surface artefact sites and removed colluvium (Turnbaugh 1978: 597).
  - Sheet erosion, caused by stream action, occurred where a wide and unobstructed overbank flood current flowed over flat or gently pitched ground. Where the current was relatively slow and shallow, fine sediment was removed and pebbles and stone artefacts were visible on pedestals of earth. In contrast, swifter and deeper flows were found to result in the removal and redeposition of upper layers of sediment and nearly all resistant objects (such as stone artefacts) (Turnbaugh 1978: 597).
- Mixed silt and clay deposits of vertical accretion were the most prevalent depositional effects on the local archaeological record. Many dozens of sites were partially or wholly blanketed in derived soil to a depth that ranged from 1 to 30 cm and sometimes much more (Turnbaugh 1978: 598).

Patterns of impact on the archaeological record:

- Over half (57.1%) of the archaeological sites received some measure of impact form the flooding (Turnbaugh 1978: 599).
- Sites found to be most susceptible to flood impacts were those located on islands and banks of major streams with reduced impact on hillside and stream terrace sites. The results also found that the damage to sites at stream confluences (areas of intensive stream activity) was much less than anticipated (Turnbaugh 1978: 603).

- Some archaeological sites, however, appeared to have little to no impact. The remnants of fire-cracked stones (a cultural hearth), for example, remained in place after a gentler current had washed the soil from among them while a cluster of seven hearths resisted removal following sheet erosion in the surrounding area (Turnbaugh 1978: 597).
- Fluvial action was found to influence the distribution of stone artefacts in association with surface artefact scatters. Flowing water/ currents, for instance, may sort artefacts according to size and shape (flakes/cores) or according to relative densities of materials (stone/ceramic/bone), or the artefacts may be aligned by the flow (Turnbaugh 1978: 597).

This paper is of relevance to the current Project as it contributes to an understanding of the range of erosional and depositional impacts that may occur to open sites such as artefact scatters following a major flood. In particular, the results are useful in demonstrating that the size of the artefacts/cultural objects, their location and proximity to the margin of the waterbody and the force of the flow will strongly influence the type of impact (erosion or deposition) and the degree of impact/transformation of an archaeological site.

The final Report of the National Reservoir Inundation Study, USA (Lenihan et al. 1982)

The National Reservoir Inundation Study (NRIS) was formed in 1975 as a means to resolve confusion surrounding the question of inundation and its impact on archaeological resources through intensive research. The aim of the multi-agency study was to understand and evaluate the nature of impacts of freshwater inundation on archaeological sites resulting from the construction of reservoirs and how the effects of inundation on archaeological resources can be appropriately mitigated. This extensive report presents the findings of this multi-year research program. The Project involved researching what was already known concerning impacts of flooding on archaeological sites, generating testable hypothesis, conducting assessments of sites that had been inundated, conducting comparative analyses of inundated sites to non-inundated contemporary sites and undertaking experimental studies (constructing artificial sites in areas about to be inundated). The focus of the study was on the extensive impacts that occur in the watershed upstream and downstream from the dam following water impoundment.

In an attempt to cover as many geographic and cultural variables as possible, data was derived from a sample of 40 man-made reservoirs across the USA including from California, Washington, New Mexico, Utah, Texas, Montana, Iowa, Missouri, West Virginia, Arkansas and Tennessee. The study also developed an analytical approach to ensure that the results could be applied more broadly. For analytical purposes, the assessment defined the type and scale of impacts relating to reservoir processes that could occur using the following categories:

- Mechanical processes: considered the most significant set of reservoir processes influencing the preservation of archaeological resources. This category equates to the physical erosion, transport and deposition processes associated with any large body of water. This includes the effects of wave action along vertically fluctuating shorelines, saturation and slumping of shoreline and submerged geologic strata, and siltation from backshore runoff and stream flow. Mechanical impacts result from the fluid forces that are generated by water motion which occurs in the form of waves, current and tides in descending order of force magnitude. Whereas erosion processes predominate in the nearshore areas, deposition is largely associated with the offshore region.
- Biochemical processes: relate to the changed biochemical environment as a result of the reservoir due to the interaction between a terrestrial ecosystem and a riverine aquatic ecosystem within the inundation zone. The biochemical environment, which is regulated by water temperature, dissolved

oxygen concertation and pH, is recognised to have a significant influence over the preservation of archaeological resources.
- Human processes: relating to the actual construction and operation of the dam and the intentional and unintentional impacts form human activity and use of the area (Lenihan et al. 1981: 18-19).

Archaeological / cultural resource categories were also developed for analytical purposes. Instead of using a traditional site type approach, the study took a broad regional perspective, organising archaeological data into a three-level hierarchy of data classes, each associated with certain analytical techniques that may be affected by inundation.

- Large-scale data:

This category of archaeological resources is defined at a regional level and includes physiographic and geomorphic features, regional site distribution patterns and other large scale cultural features such as trails, trade routes and exploitation zones (Lenihan et al. 1982: 20-21).
  - Impact assessment at this level is concerned with the broader impacts that may result from the loss of medium and small-scale archaeological resource data (Lenihan et al. 1982: 77).
- Medium-scale data:
  - This category includes individual sites and thus discrete areas of focussed activity within the landscape. At the site level, this category is not so much concerned with individual artefacts but rather with the context of each artefact in relation to all other artefacts and/or features which combine to form the site (Lenihan et al. 1982: 20-21).
  - Impact assessment at this scale is concerned with disturbances which destroy or alter the spatial and/or stratigraphic contextual relationships within the site, mechanical impacts on cultural entities, biogeochemical alterations of features of the site and compromises to analytical techniques that require an undisturbed site context (Lenihan et al. 1982: 77).
- Small-scale data:
  - This category includes individual artefacts and cultural features and is primarily concerned with the differential preservation of individual artefacts and/or artefact classes. Broad-scale impacts such as inundation have the potential to destroy or preserve entire classes of cultural remains. Some artefact classes such as plant and animal remains, for example, are more fragile, while stone artefacts may be more resilient (Lenihan et al. 1982: 20-21).
  - Impact assessment at this level is concerned with the differential preservation of material, data loss at the attribute level and compromises to analytical techniques (Lenihan et al. 1982: 77).

A hierarchical approach to considering archaeological resources is beneficial in that it recognises that inundation has the potential to adversely affect not only archaeological sites and their contents but also the environmental context of the entire prehistorical settlement system within which they form a part of (Lenihan et al. 1981: 76). Furthermore, it makes clear that cultural values consist of not just discrete sites and artefacts but also the relationships between such entities. Significantly, adverse impacts to any scale of archaeological resource have a flow-on affect to the other scales affects the quality of information obtainable from all other levels of the hierarchy. For example, the loss of sites, medium scale data, may affect larger regional patterns relating to settlement systems and thus affect large-scale data. An impact matrix was developed which considered the scale and types of reservoir processes and the potential impact of these on different scales of archaeological data/ cultural resources. The impact matrix is presented in Table 42 below.

Table 42: NRIS Impact Matrix (Source: adapted from Figure 2.1 in Lenihan et al. 1982: 18)

Impact categories	**Archaeological / cultural resources**		
	Large-scale data: *Regional ecological considerations such as geomorphology, settlement patterns, faunal and floral distributions*	**Medium-scale data:** *Site contextual data, stratigraphic and spatial relationships within a site*	**Small-scale data:** *Differential impacts on common cultural materials including stone artefacts, features, analytical properties etc.*
Mechanical impacts	Mechanical (siltation and erosion) and biogeochemical impacts to the reservoir drainage basin, including gross geomorphological changes; impacts to pre-inundation floral and faunal communities and environments	Near-shore wave action along a vertically fluctuating shoreline, saturation and slumping of shoreline and submerged geologic strata, and erosion and siltation of sites and site deposits from backshore runoff and stream inflow.	Mechanical abrasion, wet/dry impacts to artefacts and other cultural materials.
Biochemical impacts		Biochemical alteration of site soil and contextual relationships.	Differential biochemical deterioration of archaeological material categories.
Human and other impacts	Dam & barrow pit construction, roads, clear-cutting, etc.	Vandalism, recreational use, impacts to shoreline by grazing animals, impacts by invader plant species etc.	

Key results relating to the range of archaeological resources that are affected by inundation and the nature of those effects are provided below.

General key findings:

- The overall effects of reservoir inundation on archaeological resources in any given drainage area are unquestionably detrimental in nature with different archaeological values being differentially affected by inundation (Lenihan et al 1982: 8).
- The nature and degree of impacts are dependent upon the interaction between a range of factors including:
  - The characteristics of the reservoir including its size, depth, orientation, the size and hydrological characteristics of its watershed, regional climatic patterns and the operating characteristics such as fill rate and drawn-down frequency etc.
  - The vertical potion of an archaeological site within the reservoir environment which influences the nature and intensity of hydraulic forces impacting the site with high-energy erosion processes predominating in the shallow beach and near-shore zone and low-energy deposition processes predominating in the off-shore, backshore and downstream zone.
  - The geological and environmental context (e.g. slope, orientation, soils etc.) associated with a site which impacts local site preservation conditions and the ability of a site to withstand erosive water impacts.
  - The nature of the site and/or archaeological feature itself and its ability to withstand mechanical and biochemical impacts (Lenihan et al 1982: 91-92).

- The near-shore zone of a reservoir and areas subject to occasional flooding during high-water periods represent the most critical impact zones. These areas represent high-energy areas that are subjected to shoreline fluctuation of water levels and wet/dry cycling. The vast majority of adverse mechanical processes are concentrated in these areas (Lenihan et al 1982: 6, 18, 98).
- Sediment transport and deposition represent the dominant geological process that occurs within a reservoir. Sediment is derived primarily from stream inflow and secondarily from shoreline degradation which is accompanied by onshore-offshore sediment transport (Lenihan et al 1982: 82).
- Beyond the near-shore fluctuation zone, erosion was in general found to be negligible. In these off-shore areas, depositional processes were found to improve the long-term preservation of sites by providing the site with a 'silt blanket' – an excellent buffer against future biochemical, mechanical and other forms of destructive impacts (Lenihan et al 1982: 97).
- Not all inundation effects constitute "adverse impacts." The anaerobic environment of a deeply buried or deeply submerged site often proves to be an ideal environment for the preservation of organics and other fragile / perishable cultural materials and/or biological data (Lenihan et al. 1982: 19).

Key findings relating to large-scale archaeological / cultural resources:

- Inundation adversely affecting the floral, faunal, palaeobiological and geomorphological environment of the sites would result in loss of significant cultural information which resides in the landscape itself which provide a record of the modern environment as well as of past environmental change (Lenihan et al. 1982: 22, 79).
- Inundation results in the loss of environmental information unique to that particular drainage system due to local differences in soil types, soil depth, slope, topography, moisture and microclimatic conditions. The loss of this data will impact the ability to conduct a broad range of cultural-environmental analyses that rely on fine-grained environmental data (Lenihan et al. 1982: 83).

Key findings relating to medium-scale archaeological / cultural resources:

- Recognising the difficulty of characterising the resistance of a wide variety of archaeological sites to mechanical and biochemical impacts, the study emphasises the importance of considering the kinds of impacts that might be expected to occur to the various categories of information that comprise an archaeological site which consists of entities (e.g. artefacts, cultural objects etc.) and their relationships (spatial, temporal and, by inference, behaviour) (Lenihan et al. 1982: 109).
- Accurate behavioural reconstruction requires an understanding of temporal and spatial relationships between the material deposits within a site. The spatial distribution of artefacts at a site, for instance, can provide insights into the range of activities performed and the location of these different activity areas. The destruction of contextual relationships (spatial and stratigraphic) between artefacts at a site by mechanical erosive forces including wave and current action can have a significant impact on the information content and research potential/scientific value of a site (Lenihan et al. 1982: 88-91).
- The temporal context of past behaviour relies on analytical dating of a small fraction of datable items and the stratigraphic relationships among those items or deposits within a site. Biochemical impacts from inundation may accelerate the breakdown of organic datable materials such as bone, shell and/or charcoal while mechanical impacts may destroy contextual stratigraphic relationships and the potential to date stratigraphic layers using soils (i.e. via optical stimulated luminescence; OSL) (Lenihan et al. 1982: 87-88).
- The lateral displacement of artefacts is influenced by:
  - The magnitude of the erosion process/energy of the flow (the higher the energy the more movement)
  - The slope of the shoreline (the steeper the shoreline the more movement)
  - The erosion resistance of the substrate (the lower the erosion resistance the higher the movement); and

- The size and density of the artefacts on the erosion surface (the smaller the artefact the more the higher the movement) (Lenihan et al. 1982: 114).

- Understandings of the vertical displacement of artefacts as a result of inundation are less developed, though the variables appear to be the same as those influencing spatial distribution (Lenihan et al. 1982: 114-117).
- Consideration of medium-scale archaeological resources emphasises the fact that the categories of information contained within the different relationships between entities are far more susceptible to destruction by mechanical impacts than the entities themselves (Lenihan et al. 1982: 110).

Key findings relating to small-scale archaeological / cultural resources:

- Every level of the archaeological / cultural resource scale is affected by the differential preservation of archaeological materials due to the potential loss of behavioural information.
- Mechanical and biochemical impacts as a result of wet and dry cycling due to increased inundation are understood to affect various archaeological materials differently. The preservation of some archaeological materials such as stone artefacts, for instance, are generally resilient to such affects. In contrast, organic material such as flora and faunal remains (e.g. bone, pollen, seeds, vegetal remains, wood, shell) are typically subject to increased degradation resulting from such cyclical saturation and drying periods and with adverse effects experienced in a relatively short period of time (i.e. within the first few cycles) (Lenihan et al. 1982: 143-5).

Key findings relating to analytical and dating techniques:

- The following analytical and/or dating techniques are generally adversely affected by inundation:
  - Survey techniques in areas affected by siltation are compromised.
  - Access to sites may be compromised by siltation.
  - Soil element analysis compromised.
  - Thermoluminescence (TL) dating techniques compromised (Lenihan et al. 1982: 198).
- The following analytical and/or dating techniques are generally resilient to impacts from inundation:
  - Inundation itself does not appear to impact soil colours, features or stratigraphy.
  - Source identification of different stone material (x-ray fluorescence; XRF techniques) still viable.
  - C-14 archaeomagnetic and fission-track dating techniques generally resilient.
  - Microscopic analysis of use-wear patterns on stone artefacts still viable (Lenihan et al. 1982: 198).

Key findings relation to mitigation and management considerations:

- More attention should be focused on the inter-site environmental database which is the aspect of the human behavioural record that is most susceptible to impact (i.e. not just the loss of a site but the loss of a landscape of sites).
- Archaeologists should devote more attention to the overall susceptibility of impacts to different elements in the archaeological record instead of assuming that inundation affects archaeological values equally (Lenihan et al 1982: 5).
- Should archaeological salvage be required, such programs should be guided by a productive research design to ensure that high-quality data is collected and as much information is obtained from the site as possible in the best possible manner. Decisions regarding the selection of sites, the nature of site testing and excavation, and the collection of specific data elements within sites should be prioritised in response to the ultimate impacts of flooding (Lenihan et al 1982: 198).

This early study represents one of the most comprehensive and detailed research programs that has been undertaken with the aim of developing a more complete understanding of the potential impacts to archaeological resources at a range of scales as a result of freshwater inundation relating to reservoir construction. This report is of relevance to the current Project as it provides a useful framework for considering the types of processes that may affect an archaeological site/feature (including a range of mechanical and/or biochemical processes) and the range of impacts that may result (including various effects on the large, medium and small-scale data levels associated with an archaeological resource). The study is important as it builds upon the traditional site-based approach to considering impacts and provides a framework for considering potential impacts to large-scale /broader archaeological and/or cultural resources such as is required for assessing potential impacts to Aboriginal Ceremony and Dreaming Story routes, Aboriginal resource and gathering zones and the cultural landscape more broadly.

5.6.3 Project case study: Additional survey of Longneck Lagoon

Following the public exhibition of the EIS, Niche was engaged by SMEC Australia Pty Ltd to undertake a survey of Aboriginal heritage sites adjacent to Longneck Lagoon, a small freshwater wetland situated within the downstream study area for the Project. The aim of the survey was to assess the effects of temporary inundation from previous flood events, including the recent significant events of March 2022, on previously recorded Aboriginal heritage sites. In particular, the study looked at the process of erosion and its potential impacts on open camp sites (i.e. artefact scatters and isolated artefacts with or without PAD). The assessment was intended as a case study for the broader Project by considering the potential future impacts to Aboriginal cultural heritage sites that may be subject to flooding within the upstream and downstream study areas and to better determine appropriate management solutions. The following provides an overview of the results of this additional survey. A copy of the full report is provided in Appendix 5.

Longneck Lagoon is a small, permanent freshwater wetland situated in the Hawkesbury Region of north-west Sydney in the suburb of Maraylya, NSW and within the downstream study area for the current Project. The lagoon and its surrounds cover an extent of approximately 21.7 hectares. Longneck Lagoon and surrounding areas have long been subject to intermittent flooding and waterlogging issues. A hydrological study from 1991, for example, suggested that runoff from the Longneck Lagoon catchment occurs once every three months on average with a significant runoff event occurring once a year (Dames and Moore 1991 referenced in Jayawickrema 2000). Longneck Lagoon was selected as an appropriate case study for investigating the potential impacts of temporary inundation on archaeological resources due to the following: (1) the area is known to be subject to periodic flooding events, the most recent of which occurred between February and April 2022, and (2) the area contains eight previously recorded Aboriginal sites, in the form of Open Camp Sites containing artefacts with or without PAD - the most frequent site type found within the current Project area.

The results of an extensive search of AHIMS completed on 6 May 2022 and covering Longneck Lagoon and the immediate surrounds, identified a total of eight (8) previously recorded Aboriginal heritage sites within the area (Table 43). All eight sites were registered as containing stone artefact(s). Five of the Aboriginal sites were recorded in 1988 by the National Parks and Wildlife Service, the site cads for which, identified the potential for archaeological deposits (PADs) despite ‘PADs’ not being formerly registered as a feature at these sites. The Aboriginal sites recorded around Longneck Lagoon tend to be situated on low-lying country in close proximity to natural drainage lines and are subject to intermittent flooding and the effects of local catchment runoff. Their proximity to the lagoon results in seasonal waterlogging, particularly in areas closest to the lagoon and its associated waterways.

Table 43: AHIMS registered sites situated in proximity to Longneck Lagoon

AHIMS ID#	Site name	Site features	Landform	Site card description
45-5-0650	LN12	Artefact(s) & PAD	Creek bank	Sparse open artefact scatter exposed on a cattle track which runs parallel to creek. Site measures 115 m x 20 m. Total of 13 artefacts recorded. Average artefact density 1/177 m². Raw materials include silcrete, indurated mudstone and quartz. High potential for in-situ sub-surface deposits.
45-5-0653	LN15	Artefact(s) & PAD	Creek bank and flats	Relatively dense open artefact scatter (possibly a knapping floor) exposed on a vehicle track near ants nest and identified eroding out of sides of track at a depth of ~5 cm. Site measures 40 m x 5 m. Total of 35 artefacts recorded. Average artefact density 1/3 m². Raw materials include silcrete, indurated mudstone and quartz. High potential for in-situ sub-surface deposits.
45-5-0654	LN16	Artefact(s) & PAD	Creek flats	Very dense open artefact scatter exposed on a vehicle track. At least four discrete concentrations of artefacts within the scatter. Artefacts were also found eroding out of exposed sediment to a depth of 15 cm. Site measures 223 m x 20 m. Total of 110 artefacts recorded though estimated that over 600 artefacts may occur at the site. Average artefact density 1/0.4 m². Raw materials include silcrete, indurated mudstone, chert, quartz and other. High potential for in-situ sub-surface deposits.
45-5-0655	LN17	Artefact(s) & PAD	Lagoon margin flats	Relatively dense open artefact scatter exposed on a cattle track. Site measures 20 m x 10 m. Total of 46 artefacts recorded. Average artefact density 1/4 m². Raw materials include silcrete, indurated mudstone, quartz, basalt and other. High potential for in-situ sub-surface deposits.
45-5-0656	LN18	Artefact(s)	Lagoon banks	Moderately dense open artefact scatter exposed on clay pan. Site measures 20 m x 20 m. Total of 49 artefacts recorded though it was estimated that there was likely up to 70 artefacts at the site. Average artefact density 1/6 m². Raw materials include silcrete and indurated mudstone. The site is noted as being disturbed by flooding which has eroded the bank on which the site is situated. Unlikely to contain any in-situ deposits.
45-5-2738	WD6	Artefact(s)	Hill slope	Small open artefact scatter exposed on dirt road. Contained red silcrete artefacts (flakes and flaked pieces). No further details provided as to the size of the site or potential for in-situ deposits.
45-5-2739	WD7	Artefact(s)	Lagoon flats	Small open artefact scatter located along the edge of the lagoon. Artefacts were observed in an erosion bank. Most artefacts were broken pieces, with some

AHIMS ID#	Site name	Site features	Landform	Site card description
				red silcrete flakes and a quartz flake. The area extended approximately 100 m and was noted to be damaged from flood and fires. Charcoal was embedded in the subsurface layers and some silcrete artefacts had been fire affected. No details provided as to the potential for in-situ deposits.
45-5-3708	LLO1 Coordinates in AMG 66	Artefact(s)	Undulating plain	Small low-density open artefact scatter. Site measures approximately 100 m x 13 m. A total of 39 stone artefacts comprised mainly of silcrete and mudstone and one quartz artefact. Artefact density is 0.03/ m^2. Site noted to be in poor condition due to vehicle damage and erosion resulting in the exposure of archaeological material. No potential for stratified deposits.

It is important to note that flooding at Longneck Lagoon results from runoff from the local catchment upstream of the lagoon and backwater from the Hawkesbury River as the water level in the river increases. This type of backwater flooding effect is a similar effect to the upper tributaries of Lake Burragorang as the lake level rises. The effects of this at a specific location will vary over the duration of the flood event. In the early stages of the flood event, local catchment runoff will likely dominate (with its associated relatively higher flow velocities). As the water level in the main river rises, water will start to back up in tributaries and low-lying areas such as Longneck Lagoon. Temporary inundation (with relatively lower flow velocities) from backwater will then dominate. This will continue until water levels in the main river start to drop, at which point the backwater effect will start to decline and local catchment runoff again becomes dominant.

During flooding events, the close proximity of Aboriginal cultural heritage sites to significant waterways including lagoons, rivers, creek lines and gullies put these areas at risk from various hazards. The potential impact of flooding on Aboriginal cultural heritage can be variable and is influenced by a range of factors including (a) the proximity of sites to waterways, (b) the erodibility of soils present, (c) the presence of vegetation to reduce the force of the inundation, (d) the type of cultural heritage site present (i.e. isolated artefacts or grinding grooves), (e) topographic features of the landscape including slope gradient and length, (f) the pace and energy of the inundation, (g) the duration of the inundation and (g) the water-holding capacity and cohesiveness of soil deposits. The Longneck assessment looked specifically at the types of erosion that can occur, the influence of soil type and composition on the extent of erosion, the effects of slope gradients on erosion and the influence of vegetation cover on extent of erosion. A summary of the key points gleaned from the literature review relating to these factors and their relevance to the Longneck Lagoon assessment is provided in Table 44 below.

Table 44: Summary of types of erosion, key factors influencing erosion and predictions regarding Longneck Lagoon

Factor	Key points from literature review	Relevance to Longneck lagoon
Types of erosion	• Types of erosion: ▪ Sheet erosion = can occur anywhere particularly in areas where vegetation has been removed.	• Within the Longneck Lagoon context, sheet, rill and gully erosion were expected to occur in all areas, while bank erosion would be noted at localities adjacent to the lagoon.

Factor	Key points from literature review	Relevance to Longneck lagoon
	▪ Rill erosion = occurs when runoff water forms small channels as it concentrates down a slope. These rills can be up to 0.3m deep. If they become any deeper than 0.3m they are referred to as gully erosion. ▪ Gully erosion = a severe type of rill erosion. ▪ Bank erosion = occurs immediately adjacent to water body.	
Soil composition	• As floodwaters cannot as easily permeate compacted soils, the level of soil compaction can exacerbate the potential impact of temporary inundations by increasing the risk of runoff in the form of sheet, gully or rill erosion. • If all other factors are controlled, soils with faster infiltration rates, higher levels of organic matter and consolidated structures have greater resistance to erosion. In contrast, fine-textured soils including silt tend to be more readily eroded than loamy soils if soil texture is considered.	• Surface sediments at the Longneck lagoon contain sand and varying proportions of clay. Backwater flooding is recognised to be the cause for this accumulation of fine sediment on the surface, whereas course-textured sediments contained in runoff are known to be deposited on the floodplains where flow rates were slow (Jayawickrema 2000: 41). • The soils associated with Longneck Lagoon are associated with very slow infiltration rates and rates of water transmission and thus high runoff potential. • Where the infiltration rates are slow and sheet wash is a higher risk, surface artefacts are most likely to be affected than sub-surface artefacts as the water does not extensively penetrate through the soils as much during inundation events.
Slope gradient	• The pace and intensity of erosion has been shown to be influenced by the slope gradient present (Liu et al. 2001). • Various forms of erosion will only occur once a certain threshold has been met allowing the transportation of soil to occur (e.g. Renner 1936). If all other factors are held constant, locations with low slope gradients (i.e. relatively flat) have higher propensities to absorb water before sufficient water has collected on the surface for flows to be initiated and erosion to occur.	• The terrain surrounding Longneck Lagoon is generally level to gently inclined, reducing the potential velocity of catchment runoff during significant rainfall and inundation events.
Vegetation cover	• Vegetation can have a number of influences on the passage of water over terrain including by obstructing run off and allowing sediment to settle, preventing accumulations of water to form into streams and by providing greater sub-surface structural integrity to	• The extent of vegetation cover surrounding Longneck Lagoon is variable, however in general the surroundings are well-vegetated with trees, shrubs, grass and leaf litter cover present across the majority of the ground surface. • Along drainage lines and around the perimeter of the lagoon there are defined

Factor	Key points from literature review	Relevance to Longneck lagoon
	soil deposits via the root structure (Renner 1936).	areas of exposure where a lack of vegetation can increase the extent of erosion during periods of inundation. • A number of walking tracks and a small number of clearings are also present within the Subject Area associated with the current public use of the Scheyville National Park.

An archaeological survey of Longneck Lagoon was completed on 15 June 2022 by Carly Todhunter (Heritage Consultant, Niche). The site inspection involved a pedestrian survey over the recorded AHIMS site locations and surrounding area (inclusive of a 20-100 m buffer). During the survey, five of the eight Aboriginal sites were relocated and assessed for evidence of potential impacts from periodic inundation. The three sites that could not be located occurred in environments with thick vegetation and leaf litter, reducing ground surface visibility (GSV) to 0-10%. The condition of the relocated sites were compared to those documented in previous surveys and considered the following: (a) intactness of the sites compared to their existing site records, (b) the level of inundation observed in the surrounding area, and (c) a consideration of the extent of erosion or redeposition of soil that was observed following several major recent flooding events. Any evidence of impact to the sites resulting from the flooding experienced in early 2022 was recorded and photographed. Any artefacts that were identified on the ground surface were photographed, recorded, and their spatial location was logged using the ArcGIS Field Maps program.

Applicability and limitations of the survey results are discussed in detail in the full report provided in Appendix 5. The inability to differentiate between the effects of temporary inundation (which may be affected by the WDR Project) and local catchment run-off (an existing risk which occurs independent of the Project), however, is recognised as a key limitation of the assessment. Nevertheless, the investigation provides some examples of flood-related disturbance to sites which can be used to inform understandings regarding the potential impacts of temporary inundation to Aboriginal archaeological sites in general.

Due to the erodibility of the soils present and the extent of historical inundation, the re-inspected sites at Longneck Lagoon displayed varying levels of disturbance associated with previous flooding. Portions of the assessment area were found to be subject to seasonal or permanent inundation and this dynamic has increased the level of soil compaction in some areas. A detailed description and discussion of the results are provided in the full report in Appendix 5. A summary of the types of impacts observed at each site is provided in Table 45 while a selection of representative photos of the different impacts are provided in Plate 8 to Plate 17.

The site inspection indicated that though extensive inundation was observed in proximity to the Longneck Lagoon and surrounding creeks, low levels of soil redeposition was observed. Where this affect was observed, it was often of a limited nature and/or in isolated areas of the site (see Plate 9 and Plate 11 for examples). Broadly speaking, the sites and their surrounding areas were found to be damp at the time of the site inspection and several indicators of backwater flooding and catchment runoff were observed including leaf litter and branches being caught in tree branches (and upslope of horizontally sitting branches and tree trunks) (Plate 9), moss growth on exposed previously waterlogged soils (Plate 10) and temporary dieback of some grasses likely associated with extended periods of inundation. While some soil intermixing as noted at most sites (Plate 8), impacts appears to have been limited to the upper-most soil horizon due to the slow penetration rates of the soils present, the low slopes of the landscape and the low velocity of the water flow involved. Minor surface cracking was noted at some sites (Plate 13), though this process appears to have had negligible effects on the archaeological sites where it was observed.

The most significant impact to Open Camp Sites, however, was sheet erosion/ sheet wash which was observed to varying extents across 7 of the 8 sites that were inspected (Plate 12 and Plate 14), though some of this may be attributed to local catchment runoff rather than backwater flooding. Rill erosion was observed at most sites particularly in association with areas of exposure where vegetation was sparse (Plate 16 and Plate 17) while sites associated with creek banks demonstrated minor bank erosion (Plate 15). No examples of gully erosion were observed within the assessment area. The background research and site inspection results from Longneck Lagoon demonstrate that the impacts of temporary flooding events on Aboriginal cultural heritage sites can vary significantly. In a hydrologically- sensitive environment such as the lagoon, where multiple creeks feed water from the broader catchment and waterlogging occurs on either a permanent or seasonal basis, the impacts of large flooding events will be amplified. The results demonstrate that, while different forms of erosion occur in different landscape contexts, the potential impacts to Aboriginal sites are essentially comparable, with this process resulting in the removal/transportation of artefacts and deposit and related impacts to the spatial and/or stratigraphic integrity of associated archaeological sites.

This study has shown that the potential impact of temporary flooding events on Aboriginal cultural heritage sites situated in close proximity to waterways can be significant and is affected by several factors including (a) sheet erosion, (b) gully erosion, (c) bank erosion, (d) rill erosion, (e) soil redeposition in runoff, (f) soil mixing resulting from the stationary suspension in water, (g) soil compaction and (h) resorting. The Longneck Lagoon study has demonstrated a protracted history of significant inundation events which have placed a number of registered Aboriginal cultural heritage sites at risk of harm. These issues include sheet, bank and gully erosion, waterlogging issues, soil transportation, soil intermixing and compacting and to a limited extent, the resorting of gravels. Sites situated along drainage lines (e.g. WD 7; AHIMS ID# 45-5-2739, LN 18; AHIMS ID# 45-5-0656, and LN 15; AHIMS ID# 45-5-0653) were observed to have been associated with the most significant impacts, being prone to more prolonged exposure to erosion and the harmful effect of scouring over longer periods of time. The observations made at Longneck Lagoon have applicability to the Aboriginal sites occurring within the upstream and downstream study areas of the Project. The study has shown that site characteristics including landform, soil types (composition and permeability), slope gradient, vegetation cover, the velocity of flow influence the degree of potential impact of temporary inundations and resulting erosion on Aboriginal cultural heritage sites.

Table 45: Summary of impacts observed at the eight Aboriginal sites during the site inspection

AHIMS Site ID	Context	Sheet erosion	Gully erosion	Rill erosion	Bank erosion	Soil compaction	Soil accumulation	Soil inter-mixing	Soil cracking
45-5-0650	Creek bank & flats	Yes, but isolated	No	Yes, but isolated	Yes, but isolated	Moderate	Generally, no	Generally, no	No
45-5-0653	Creek bank & flats	Yes, but isolated	No	Yes, but isolated	Yes, but isolated	Moderate	Yes, but isolated	Yes, but isolated	Yes, but minor
45-5-0654	Creek flats	Yes, but isolated	No	No	No	Moderate	Yes, but limited	No	No
45-5-0655	Lagoon margin flats	Yes, but isolated	No	Yes	No	Low	Generally, no	Yes, but limited	Yes, but minor
45-5-0656	Lagoon bank	Yes, but limited	No	Yes, but isolated	No	Low	Generally, no	Yes	No

AHIMS Site ID	Context	Sheet erosion	Gully erosion	Rill erosion	Bank erosion	Soil compaction	Soil accumulation	Soil inter-mixing	Soil cracking
45-5-2738	Hill slope above lagoon	Yes	No	No	No	Moderate	No	Yes, but very limited	No
45-5-2739	Hill slope & flats above lagoon	Yes	No	Yes, but very isolated	Yes	Moderate	Yes, sediment fan	Yes, but limited	Yes, but minor
45-5-3708	Undulating plain	Yes	No	Yes, but isolated	No	Moderate	Yes, but isolated	Yes, but limited	Yes, but limited

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Plate 8: Example of saturated soils at LN 18 (AHIMS ID# 45-5-0656). Reduced stratigraphic integrity of upper soil horizons due to intermixing of soils during inundation

Plate 9: Example of redeposited soils and organic matter (leaf litter and twigs) accumulating in a trunk cavity and surrounds nearby the location of LN 12 (AHIMS ID# 45-5-0650)

Plate 10: Example of waterlogged soils and algae growth in the vicinity of LN 12 (AHIMS ID# 45-5-0650)

Plate 11: Example of redeposited soils within western portion of LN 15 (AHIMS ID# 45-5-0653). Note the slight slope downwards towards west side of the track

Plate 12: Example of sheet wash in an area of exposure at WD 7 (AHIMS ID# 45-5-2739). Artefacts were firmly embedded within the soil deposit

Plate 13: Example of surface cracking at WD 7 (AHIMS ID# 45-5-2739). The prolonged suspension of the upper soil horizon has resulted in an intermixing of soils. As flood waters receded, cracking has resulted

Plate 14: Example of minor sheet and rill erosion observed along the access track at LN 17 (AHIMS ID# 45-5-0655). No surface runoff of soils was observed at the boundary of the access track in this area

Plate 15: Example of bank erosion on the western side of creek at LN 12 (AHIMS ID# 45-5-0650) likely due to local catchment run-off

Plate 16: Example of rill erosion observed near LL01 (AHIMS ID# 45-5-3708). Larger pebbles have accumulated in distinct areas along the erosion lines

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Plate 17: Example of rill erosion observed at LN 17 (AHIMS ID# 45-5-0655). No accumulation of dirt on the edges of this depression were observed

5.6.4 Synthesis of the potential impacts of flooding on Aboriginal heritage

An accurate prediction of inundation effects is a precondition to effective mitigation of adverse impacts to Aboriginal cultural heritage sites and values. The purpose of this section is to synthesise what is known regarding the potential impacts of inundation on different site types/ features of relevance to the current Project based on:

- The predictions and observations from the original ACHA,
- The additional information discussed from the broader literature, and
- The results of the additional survey and assessment of Aboriginal archaeological sites located at Longneck Lagoon.

An overview of the potential affects and impacts on different archaeological features/ site types as a result of periodic temporary inundation is provided in Table 46. This understanding of the potential impacts on Aboriginal heritage will then be used to inform the revised impact assessment and proposed management strategies and recommendation in the upcoming sections of this supplementary assessment. As indicated in the discussion above and outlined in the table below, not all impacts associated with temporary inundation are good nor are they all adverse. A summary of archaeological / cultural resources that are adversely impacted or resilient to the mechanical and/or biochemical effects of inundation is provided in Table 47 to highlight this variability.

Table 46: Potential impacts of temporary inundation on Aboriginal site types / features

Site type/ feature	Potential impacts to archaeological / cultural resources
Artefact sites	• Artefact sites will be most affected by mechanical processes including erosion, transportation and siltation/deposition. • The degree and type of impact will depend upon: ▪ The size of the artefacts/cultural objects present, and ▪ Their location and proximity to the margin of the waterbody (near-shore versus off-shore/backshore[5]) and thus the force of the flow involved (high-energy versus low-energy). • Artefact sites located in high-energy near-shore areas: ▪ These areas are subject to high-force near-shore wave action. ▪ Sites in these areas have the potential to be destroyed by erosional impacts which act to remove and/or displace artefacts and any associated features (e.g. PAD) as was observed by Brayshaw (1989: 30) in association with open sites located between the FSL and previous flood level within the Project area. ▪ Changed ground conditions may introduce biases in the distribution and/or preservation of surface artefacts. Flow action, for instance, may sort artefacts according to size and shape (flakes/cores) or according to relative densities of materials (stone/charcoal/bone), or the artefacts may be aligned by the flow (e.g. Turnbaugh 1978: 597). This effectively destroys the contextual relationships (spatial and stratigraphic) between artefacts. ▪ Such potential impacts would result in medium-scale data loss and significantly reduce the integrity and research potential/scientific value of a site while at a large-scale, the loss of sites would result in the loss of information relating to settlement patterns. • Artefact sites located in low-energy off-shore areas:

[5] Project specific definitions for these 'near-shore' and 'off-shore' areas and their associated 'high-energy' and 'low-energy' forces are not possible as these areas a dynamic and changing and will depend upon the characteristics of individual flood events. Off-shore areas include backshore and downstream areas.

Site type/ feature	Potential impacts to archaeological / cultural resources
	▪ These areas are subject to lower force stream flows and may be less susceptible to erosional impacts. ▪ Sites in these areas, such as along the valley of the Wollondilly River, may be subject to siltation/depositional effects from backshore run-off which may act to bury the site in alluvial deposits. ▪ No impact to the archaeological integrity of these sites is expected. Furthermore, siltation is recognised to enhance preservation in such a context by providing a buffer against biochemical, mechanical and other forms of destructive impacts (Lenihan et al. 1982: 19). ▪ Sites, however, will no longer be detectable and/or accessible during surface survey.
Potential archaeological deposits (PADs)	• PADs may be associated with Artefact sites or Rock shelter sites. • PADs will be most affected by mechanical processes including erosion, transportation and siltation/deposition while organic cultural materials within the deposit (which may provide information on chronology or subsistence practices) may also be affected by biochemical processes which influence preservation. • The degree and type of impact will depend upon: ▪ The context of the PAD (rockshelter or open air) and characteristics of its surrounding environment (the most rapid destruction of archaeological stratigraphy in open sites is expected to occur in contexts where artefacts are embedded in easily dispersed clays). ▪ The characteristics of the soils (sandstone derived soils on slopes are skeletal and erode readily (Hazelton and Tille (1990)). ▪ The characteristics of and surrounding environment, ▪ Its location and distance from the waterbody and thus the force of the flow and the frequency of inundation. • Biochemical impacts from inundation may accelerate the breakdown of organic datable materials such as bone, shell and/or charcoal (small-scale data loss) while mechanical impacts may destroy contextual stratigraphic relationships and the potential to date stratigraphic layers using soils (i.e. via optical stimulated luminescence; OSL) (Lenihan et al. 1982: 87-88). • Mechanical processes may result in changed ground conditions including: ▪ Translocation of sediments on flat and gentle slopes and the creation of lag deposits. ▪ Erosion above and/or along the shoreline and banks resulting in the destabilisation and removal of sediments that contain Aboriginal artefacts. ▪ Reduction of soil cohesion from water logging. • Such potential mechanical and biochemical impacts would reduce the significance and integrity of any archaeological deposits present in areas of inundation (medium-scale data loss) and the ability to conduct a broad range of cultural-environmental analyses that rely on fine-grained environmental data (large-scale data loss).
Sandstone rock shelter sites	• Sandstone rock shelter sites are typically associated with other archaeological features such as PAD, rock art and/or burials. Specific potential impacts associated with these archaeological features are provided in their relevant sections. • Sandstone rock shelter sites will be affected by a combination of mechanical processes (including erosion, transportation and siltation/deposition) and biochemical processes which influence preservation. • The degree and type of impact will depend upon: ▪ The location of the rock shelter site (near-shore or off-shore) and thus the force of the flow and frequency of inundation.

Site type/ feature	Potential impacts to archaeological / cultural resources
	▪ The nature of its contents (stone artefacts, PAD, bone, etc.). • Rock shelter sites located in high-energy near-shore areas: ▪ These areas are subject to high-force near-shore wave action and more frequent inundation. ▪ Mechanical impacts from flooding may destabilise the shelters themselves, particularly as a result of severe scouring, and it is the degree and duration of exposure to wave action that is considered to influence their susceptibility to such impacts most significantly (Brayshaw 1989: 30). ▪ Mechanical impacts may result in the erosion and/or removal of stone artefacts and/or deposit if present. ▪ Changed environmental conditions resulting from the mechanical processes may result in biochemical impacts associated with the preservation of organic material (e.g. flora and/or faunal material), and/or rock art (if present). • Rock shelter sites located in low-energy off-shore areas: ▪ These areas are subject to lower force stream flows and may be less susceptible to erosional impacts and less frequent inundation. ▪ Mechanical processes may result in the deposition of silt within a shelter. ▪ If the shelter is associated with stone artefacts and/or deposit, no impacts are expected. ▪ Changed environmental conditions, however, may result in biochemical impacts associated with preservation of organic material and/or rock art (if present). Frequent and/or rapid changes between wet and dry conditions associated with flooding, for instance, may accelerate the decay of plant and animal food remains, other dateable material and rock art. • Such potential impacts would significantly reduce the integrity and research potential/scientific value of a site (medium-scale data loss) while at a large-scale, such impacts would result in the loss of information relating to settlement and subsistence patterns.
Burials	• Burials may occur within deposits in open context or in shelters and are susceptible to both mechanical and biochemical effects of inundation. • The nature and degree of impact will depend upon its location (near-shore or off-shore) and thus the force of the flow and frequency of inundation. • The type of mechanical impact (erosion versus siltation) will vary depending upon the location of the burial (near shoreline or off-shore) and thus the force of the flow and frequency of inundation. ▪ Burials in near-shore, high-energy flow areas will be susceptible to erosion and thus displacement or destruction. ▪ Burials in off-shore, low-energy flow areas will be susceptible to siltation. ▪ Regardless of type of mechanical impact, burials are likely to be affected by biochemical processes due to altered environmental conditions similar to other organic remains in rock shelter and/or open-air contexts as discussed previously. Anaerobic environments (oxygen-deprived), for example, support the preservation of organic material/bone while aerobic environments (oxygen-rich) may result in increased rates of decay. • Such potential impacts would significantly reduce the integrity and research potential/scientific value of a site (medium-scale data loss) while at a large-scale, such impacts would result in the loss of information relating to settlement and subsistence patterns, the cultural landscape and its associated values.
Rock art – Paintings	• Rock art in the form of paintings is typically associated with sandstone rock shelter contexts and will be susceptible to a range of mechanical and biochemical processes.

Site type/ feature	Potential impacts to archaeological / cultural resources
	• The nature and degree of impact will depend upon the location of the site (near-shore or off-shore) and thus the force and frequency of inundation and the nature of the materials used to create the paintings (i.e. ochre, charcoal etc.). • Mechanical processes associated with inundation may accelerate weathering, granular loss and the exfoliation of painted surfaces while the flow of water across rock surfaces can result in the removal and/or degradation of pigments and drawing materials. • Mechanical processes resulting from inundation may lead to biochemical impacts on painted rock art as a result of the changed environmental condition of the site. The deposition of silts, clay, sand other minerals, for example, can create conditions suitable for the intrusion and growth of destructive micro- or macro-vegetation such as fungi, algae and lichens (Brayshaw 1989: 31). • Such potential impacts would significantly reduce the integrity and research potential/scientific value of a site (medium-scale data loss) while at a large-scale, such impacts would result in the loss of information relating to settlement and subsistence patterns.
Rock art – Engravings	• Rock art engravings are typically located on horizontal rock surfaces and may be susceptible to mechanical and biochemical processes. • The nature and degree of impact will depend upon the location of the site (near-shore or off-shore) and thus the force and frequency of inundation. • Engraving sites located in high-energy near-shore areas will be more frequently submerged. Mechanical processes may lead to alterations in the nature condition and possibly preservation of this site type (acceleration of granular loss or weathering of the rock surface such as case hardening and delamination of the rind). • Engraving sites located in low-energy off-shore areas will be susceptible to mechanical processes associated with the deposition of silt. While the deposition of silt itself would not result in impact beyond obscuring the site from view and altering accessibility, it may result in the creation of an environment where biochemical impacts in the form of plant growth is promoted, leading to breakdown of the parent rock and eventually the loss of the art as an interpretable design (Brayshaw 1989: 31).
Axe grinding grooves	• Axe grinding grooves will be susceptible to a range of mechanical and biochemical processes as described for rock art- engravings above.
Scarred trees	• Scarred trees may be susceptible to both mechanical and biochemical processes as a result of more frequent flooding. • The nature and degree of impact will depend upon the location of the site (near-shore or off-shore) and thus the force and frequency of inundation. • Mechanical processes associated with the prolonged presence of water around the base of a scarred tree may lead to increased erosion of the base support, destabilisation and eventual felling. • Changed environmental conditions as a result of inundation may lead to biochemical processes affecting preservation of the tree and accelerating destabilisation through rotting and/or drowning of the tree. • Such potential impacts would significantly reduce the integrity and research potential/scientific value of a site (medium-scale data loss) while at a large-scale, such impacts would result in the loss of information relating to settlement and subsistence patterns, the cultural landscape and its associated values.
Stone arrangements	• Stone arrangements may be susceptible to mechanical processes.

Site type/ feature	Potential impacts to archaeological / cultural resources
	• The nature and degree of impact will depend upon the location of the site (near-shore or off-shore) and thus the force and frequency of inundation. • Stone arrangements in high-energy near-shore areas ▪ Sites in these areas will be more frequently submerged. ▪ Mechanical processes in the form of scouring from wave action may lead to the destabilisation of this site type in such a context. ▪ Such potential impacts would significantly reduce the integrity and research potential/scientific value of a site (medium-scale data loss) while at a large-scale, such impacts would result in the loss of information relating to settlement and subsistence patterns, the cultural landscape and its associated values • Stone arrangements in low-energy off-shore areas: ▪ Sites in these areas are expected to be relatively resilient to mechanical impacts. A number of studies, for instance, have demonstrated the resilience of large stone objects to low flow force processes (e.g. Turnbaugh 1978: 597).
Aboriginal resource and gathering sites	• Aboriginal resource and gathering sites may be susceptible to both mechanical and biochemical processes as a result of more frequent flooding as well as altering accessibility. • The nature and degree of impact will depend upon the location of the site (near-shore or off-shore) and thus the force and frequency of inundation. • Mechanical and biochemical processes may result in changes to physical aspects of the sites such as the character of pre-inundation floral and faunal communities and environments. • Such potential impacts would reduce the significance and integrity of any such sites/areas (medium-scale data loss) and the ability to conduct a broad range of cultural-environmental analyses aimed at understanding the role of exploitation zones within the broader settlement system that rely on fine-grained unmodified environmental data (large-scale data loss).
Aboriginal Ceremony and Dreaming sites and Creation story paths	• These site types are often associated with intangible values that are not always easily visible in the landscape and/or defined by a single location. • These site types will be most affected by altered accessibility and changes to physical aspects of the sites as a result of more frequent inundation. • Any impacts and/or modification to the enlivenment within which these 'sites' are intrinsically linked would result in loss of information relating to settlement systems, aspects of dreamtime stories and loss of tangible aspects associated with the intangible values associated with these large-scale resources.
Cultural landscapes	• Potential impacts from more frequent inundation include alteration of existing environmental conditions, loss of tangible aspects of the intangible values (such as archaeological sites and waterholes relating to dreamtime stories) and changes to the ways in which the landscape is interpreted, enjoyed, and maintained by the community. • Loss of sites results in loss of information relating to settlement patterns and aspects that contribute to the overall value of the cultural landscape. • The destruction and/or loss of any of the above site types and/or archaeological features (small and medium-scale resources) will therefore have an adverse effect on the cultural landscape and its values (large-scale resource).

Table 47: Summary of archaeological / cultural resources that are adversely impacted or resilient to the mechanical and/or biochemical effects of inundation

Archaeological / cultural resources category	Adversely impacted	Resilient / un-compromised
Small-scale (i.e., the artefact)	• Preservation and integrity of organic flora and faunal materials compromised due to biochemical impacts. • Preservation and integrity of rock art paintings compromised due to mechanical and biochemical impacts. • Engravings and axe grinding groove sites subject to siltation in downstream areas may be affected by biochemical impacts.	• Preservation and integrity of stone artefacts unaffected. • Deeply buried organic materials (including burials) in anaerobic and alkaline contexts generally resilient. • Engravings and axe grinding groove sites generally resilient to mechanical impacts. • Stone arrangement in off-shore low energy areas generally resilient due to the larger size of the objects and the lower forces of the flow.
Medium-scale (i.e., the site)	• Spatial integrity of artefact sites and PADs located in high-energy near-shore areas compromised.	• Spatial integrity of artefact sites and PADs in low-energy off-shore areas less susceptible to mechanical impacts.
Large-scale (i.e. the environment, settlement system and/or cultural landscape)	• The destruction and/or loss of any of the site types and/or archaeological features (small and medium-scale resources) will have an adverse effect on the cultural landscape and its values (large-scale resource).	• The resilience and thus preservation of any sites/ archaeological features will have a positive effect on the on the cultural landscape and its values (large-scale resource).
Analytical techniques and dating methods	• Survey techniques compromised in areas affected by siltation. • Access to sites may be comprised by siltation. • Soil analysis compromised. • Thermoluminescence (TL) dating techniques compromised.	• Inundation itself does not appear to impact soil colours, features or stratigraphy. • Source identification of different stone material (x-ray fluorescence; XRF techniques) still viable. • C-14 archaeomagnetic and fission-track dating techniques generally resilient. • Microscopic analysis of use-wear patterns on stone artefacts still viable.

6. Update and review of predictive model

6.1 Preamble

The original predictive model for the Project is described in detail in Chapter 7 and re-evaluated in Chapter 10 of the AR of the original ACHA (Niche 2021). The information contained within these original chapters is still relevant to the current Project, however the submissions process highlighted some issues with the predictive model thus required re-consideration and update in this supplementary assessment. This section therefore provides a review and update of the predictive model based on the result from the original ACHA and an analysis and consideration of additional key variables. A number of submissions additionally raised issues with the proposed survey methodology, coverage and/or presentation of results. This section therefore briefly provides some comments and justification relating to these aspects of the original ACHA as well as presenting some additional details/statistics relating to the survey results. This section concludes by providing a review and update of the predictive archaeological landscape model based on further analysis and consideration of updated erosion/flood predictions event data and the provision of clear research questions for the Project.

6.2 Overview of existing predictive model and survey results

6.2.1 Original predictive model

The original predictive model for the Project was developed based on a consideration of environmental data (including landform units, slope data and soil landscape units), along with an assessment of the cultural and archaeological context for the Project area (including the results of previous archaeological investigations in the local region and the known distribution and patterning of previously recorded Aboriginal sites). The original predictive model is presented in Chapter 7 of the AR and summarised below.

The areas below the FSL of Warragamba Dam have been heavily impacted, however areas above FSL have been exposed to limited disturbance or modification, having been protected as either a national park/state conservation area or a water catchment Special Area. This landscape was considered the most likely to contain Open Camp Sites and Isolated Artefacts around the lake's shore and Rock Shelters that were used for occupation shelter and for art. Sandstone platforms located within the rivers, tributaries and adjacent to swamps are most likely to contain Axe Grinding Grooves. Based on an analysis of slope class data, known AHIMS sites within the PUIA were found to cluster on slopes from 0-18 percent but are represented on slopes up to 30 percent with none located on slopes over 35 percent. It was therefore precited that Aboriginal cultural heritage sites within the Project area would likely to be located on slopes from 0-30 percent with higher densities of Aboriginal sites located on slopes from 0-18 percent. In terms of site types, Open Camp Sites, Isolated Artefacts and Scarred Trees were considered most likely to be located on slope classes from 0-18 percent while Sandstone overhangs with archaeological deposits, art, midden and/or artefacts were expected to be located on slope classes from 18-30 percent. Specific expectations based on site type are reproduced in Table 48.

Table 48: Original predictive model

Site type	Predictions
Open Camp Sites and Isolated Artefacts	• The most common class of site type or feature expected to occur within the Project area, accounting for 80% of AHIMS registered sites.

Site type	Predictions
	• Ground surface visibility and exposure will influence the identification of this site type, as site extent and artefact numbers are only visible on the surface and vegetation cover can impede identification and relocation. • Most likely to occur: ▪ on level to gently inclined alluvial plains, floodplains, terraces, foot slopes, simple slopes, ridges and crests, ▪ within 200 m of temporary or permanent water sources, ▪ in association with alluvial and transferral soil landscapes.
Scared Trees	• The next most likely site type expected within the Project area, accounting for 11% of the AHIMS registered sites. • Formed from the removal of bark from a tree for use in the manufacture of canoes, shields, shelters and containers for sorting or carrying items. • The Project area has largely been protected from large scale timber felling operations due to its use as a water catchment area, significantly increasing the likelihood of survival of this site type.
Sandstone shelters, boulder or rock overhangs with	• While not previously recorded in high numbers within the Project area, this site type is expected to be one of the most common site types identified based on the presence of suitable geological characteristics.
Waterholes	• Waterholes were not only a critical resource within the environment but also played a significant role in ceremonies and as a place for the community to meet and pass down stories from one generation to another. • This site type is expected to occur within the Project area.
Rock Engravings	• May be present within the Project area due to the presence of sandstone in close proximity to water. • Rock Engravings may consist of carefully incised images of people, animals, or symbols, in the sandstone.
Burials	• An uncommon site type. • Can occur within soft aeolian and alluvial sediments, caves, or hollow trees in NSW. • Such sites are more commonly located within the sand dunes of the coastal region; however, it is not completely unlikely that this site type will occur within the Project area.
Stone Arrangements	• A rare site type in the local region. • Can include mounds of rocks for burial, or markers, mythological sites, or areas of spiritual connection.
Ceremonial grounds	• Includes locations where initiation ceremonies, marriage alliance ceremonies, tribal meetings, and other important social functions were held. They are places of great significance to Aboriginal people. • None previously recorded on AHIMS within Project Area.
Aboriginal places	• Places of cultural significance to Aboriginal people. An Aboriginal Place nomination covering the Project area is acknowledged to have been submitted but had not yet been declared.

The predictive model took into consideration the various types of Aboriginal heritage site types, the type of landscape / landform these sites are most likely to occur, and the slope of that land. The predictive model is limited by its site-based approach and the limited consideration of visibility and intangible values within the Project area. Nevertheless, the predictive modelling was used to enable targeted and focused field surveys of areas that may or are known to contain Aboriginal heritage items, and so limited surveys were conducted in those areas less likely to contain site items. The following section provides a brief comment and justification on the survey methods utilised during the original ACHA.

6.2.2 Comment on survey methods

As stated in Section 8.1 of the AR, the archaeological survey methodology was developed in accordance with the SEARs and the following guidelines:

- *Aboriginal cultural heritage consultation requirements for proponents 2010* (DECCW 2010b)
- *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales* (DECCW 2010a)
- *Guide to investigating, assessing and reporting on Aboriginal cultural heritage in NSW* (OEH 2011).

Details of the sampling strategy and survey methods are provided in Sections 8.2 and 8.3 respectively of the AR.

The proposed methodology, survey strategy and predictive model was provided to RAPs for review on 5 March 2018. The methodology was also discussed at numerous information sessions (See Section 6.3 and Appendix 3, 5, 7, 8 and 11 of original ACHA for details). Of the RAPs who provided written responses to the Stage 2-3 proposed methodology consultation document, 86.7% (n=13) endorsed, supported and/or had no objections regarding the proposed methodology. One RAP group requested full survey coverage while another requested consideration of creation story sites/locations as part of the survey program. In response to these requests/comments, an additional 45 targeted survey locations were added to the proposed field program with an objective to more fully sample and understand the cultural landscape and increase the survey coverage. The additional survey objectives consisted of sites and areas related to the Gundungurra Dreaming stories, and sites also related to the more recent history of the area such as farming selections. It was considered that the revised approach would allow for the identification and assessment of the highly significant areas of the Burragorang Valley to make sure cultural information is not lost. The additional survey work proposed, resulted in the survey covering a greater sample of the Upstream study area but did not result in a program to survey the entire area.

The survey methodology was therefore developed and informed based on information gathered from various reputable sources including AHIMS, place nominations, previous local and regional archaeological investigations, consultation with RAPs, and field surveys. Specifically, the areas for the field survey were identified and amended based on the results of consultation with RAPs in addition to being informed by Raps during the survey itself. The following section provides a brief overview of survey results and provides clarification of the consideration of visibility and exposure data.

6.2.3 Comment on visibility

A number of submissions raised issues with the limited consideration of visibility throughout the report including:

(a) In the discussion predicting the type and number of Aboriginal heritage sites in unsurveyed areas of the Project area.
(b) In the scientific/archaeological significance assessment process and whether or not a site may be associated with additional artefacts and/or features that have the potential to contribute to and/or increase its significance.
(c) In the presentation and discussion of survey results and effective survey coverage.

The Code of Practice (DECCW 2010a) clearly articulates the difference between visibility (the amount of bare ground (or visibility) on the exposures which might reveal artefacts or other archaeological materials) and exposure (the percentage of land for which erosion and exposure was sufficient to reveal archaeological evidence on the surface of the ground). It is assumed that the issues raised during the submissions process relate to both visibility and exposure, as required by NSW regulation.

This supplementary assessment addresses the issue of 'visibility' in the relevant sections required including in Section 6.2.4 which provides clarification on how visibility was recorded and considered in the presentation of the survey coverage results, Section 6.4 on predicting number and type of Aboriginal sites in unsurveyed areas and Section 7.2 relating to the review and update of scientific significance assessment of sites.

It is important to note that, due to the large size, irregular shape, diverse landscape and culturally sensitive nature of the Project area, the archaeological surveys competed for the original ACHA did not follow the typical formal systematic transect approach to completing the pedestrian surveys. Instead, the survey approach taken was influenced by on-the-ground accessibility/access as well as being informed by the areas of interest identified by RAPs during the survey process. As such, visibility and exposure levels were not reported for individual transects but rather were recorded for site locations which were deemed to be representative of the wider landscape. While many sites were identified in areas of disturbance (and thus high exposure and visibility), the surrounding area of each site was typically also assessed to gain an understanding of adjacent areas with vegetation cover which are on the same landform.

To assist in the process of addressing survey coverage and visibility, data relating to visibility and exposure as documented at each site and adjacent areas at the time of its recording was extracted from the recording forms and summarised in a table for consideration and use in this supplementary assessment. This information is provided in Appendix 6 of this report. Further, while it may not have been explicitly clear in the original ACHA, visibility and exposure levels observed during the survey were considered in assessing whether further artefacts and/or PAD were likely to be present in the surrounding adjacent area despite low visibility. Examples of these considerations are provided in comments extracted from the original recording forms which are also provided in Appendix 6 of this supplementary assessment.

6.2.4 Consideration of survey coverage results

In accordance with the NSW *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales* (DECCW 2010a), the purpose of archaeological survey (sometimes called a field survey) is to record all (or a representative sample of all) the material traces and evidence of Aboriginal land use that are (a) visible at or on the ground surface, or (b) exposed in sections or visible as features (e.g. rock shelters, rock art, scar trees) and to identify those areas where it can be inferred that, although not visible, material traces or evidence of Aboriginal land use have a likelihood of being present under the ground surface (potential archaeological deposits).

Archaeological surveys for the original ACHA were undertaken within the upstream study area, as well as adjoining areas outside of the upstream study area. An area of 2,655 hectares was surveyed on foot as part of the Project. This covered areas below FSL (already impacted by the existing dam), areas subject to existing temporary inundation (FSL to about 2.8 m above FSL), areas potentially affected by temporary inundation from the Project (2.8 m above FSL to 10.2 m above FSL), and areas less likely to be affected by temporary inundation from the Project (10.2 m above FSL). Discussion of survey results in the AR focussed only on the survey data associated with the PUIA. Of the total areas surveyed, approximately 464 ha (33%) of the estimated 1401 ha of the PUIA was assessed.

As noted in the AR, the survey coverage is considered to present a strong representative sample of the landscape and given the types of harm that may potentially affect the Aboriginal cultural heritage sites within the Project area, it is considered adequate for the purpose of this assessment. Brayshaw (1989) also noted that at least 30% of the impact zone would need to be surveyed to accurately determine the extent of Aboriginal cultural heritage sites within the Project. A number of submissions, however, requested clarification regarding survey coverage and/or presentation of site density results. Clarification regarding effective survey coverage and site density results are presented below.

6.2.4.1 Visibility and effective survey coverage

Survey results are influenced by a number of factors including the degree of visibility and/or exposure within a specific context and the obtrusiveness of site types/ archaeological features. The obtrusive nature of sandstone shelter sites and rock platforms suitable for Aboriginal occupation and use, for example, is always high, even in areas as highly vegetated as catchment areas, so these sites are likely to be identified during survey efforts regardless of vegetation coverage. In contrast, other types of materials and sites including open sites with stone artefacts, can be difficult to locate due to thick grass cover, dense vegetation and/or lack of eroded exposures. In these instances, exposure and visibility levels will influence whether a site is identified or not. Recognising this, Requirement 9 of the Code of Practice (DECCW 2010a) necessitates documenting the conditions present during a survey in order to assess the effectiveness of the survey. Survey coverage data allows for an understanding of the obtrusiveness of Aboriginal objects including an assessment of whether objects are readily visible, or buried, or otherwise obscured.

The survey coverage recorded during the original ACHA is reflective of the approach to focusing on areas outlined by the RAPs as being connected to the creation story, ridge and creek lines that have archaeological potential. During this survey, many artefact sites were identified in areas of disturbance. These areas include the eroded shore of the stored water, the dripline of shelters, and other types of disturbance such as wombat holes. These areas were assessed to gain an understanding of adjacent areas with vegetation cover which are on the same landform. Areas of exposure within the Project area included those areas that had been previously eroded through the original construction and operation of the dam (particularly areas below the FSL), or areas that have previously been cleared for agricultural practices and fire trails. Survey below the FSL was made possible due to the low levels of water within the dam and the exposure of Aboriginal objects as a result of this low water level. Visibility was therefore not a limiting factor in some of survey contexts such as the extensive survey conducted below FSL where exposure and visibility were at ~100%.

While the survey results discussed in the original ACHA focussed on data relating only to the PUIA, the supplementary assessment considers all data that was recorded during the surveys undertaken within the upstream study area and adjoining areas which are presented and considered in relation to the Project area. Results are re-presented below in relation to soil landscapes as the selected unit for survey and analysis. Visibility and exposure levels for each soil landscape were calculated as the average % based on data documented on recording forms associated with each site (see Appendix 6). The survey coverage and effective survey coverage is presented in Table 49 relating to the total area surveyed (i.e. including areas within the PUIA, EUIA, Below the FLS and above the PUIA) while data pertaining to the soil landscape summary of surveyed areas is presented in Table 50 as a percentage based on the PMF with the Project. The survey coverage achieved during the original ACHA is illustrated in Figure 9. Where data relating to visibility and /or exposure was not available, for instance, due to the absence of any recording forms within a particular soil landscape unit, this is marked as 'N/A' meaning 'not available'.

Table 49: Survey coverage by soil landscape

Soil landscape category	Soil landscape unit	Total surveyed area (m2)	Average Visibility (%)	Average Exposure (%)	Effective coverage area (m2)	Effective coverage %
Erosional	Cedar Valley	2133896.2	36.5	40.3	313885.462	14.7
	Jooriland Range	1868600.5	20.8	32.9	127872.07	6.8
	Kedumba	2836044.1	22.6	24.4	156390.816	5.5
	Martins Flat	2302806.3	19.8	21.7	94944.7043	4.1
	Martins Flat variant a	3240576.8	47.7	47.3	731142.186	22.6
Alluvial	Coxs River	316099.2	65.0	60.0	113795.708	36.0
	Emu Island	992248.4	50.0	30.0	148837.255	15.0
	Wollondilly River	452627.1	5.0	0.0	0	0.0
Residual	Faulconbridge	42544.5	N/A*	N/A	N/A	N/A
Transferral	Horse Flat	179365.9	N/A	N/A	N/A	N/A
Colluvial	Hassans Walls	3854111.8	57.0	55.8	1225838.8	31.8
	Hawkesbury	381179.9	20.0	8.3	6327.58621	1.7
	Kanangra Gorge	999521.8	19.2	20.6	39533.0848	4.0
	Round Mount	933541.2	44.9	43.7	183172.911	19.6
	Warragamba	517146.5	45.0	45.0	104722.165	20.3
Unknown	Water	5473518.7	48.1	48.8	1266358.76	23.1
Grand Total		**26523828.8**	**40.8**	**41.6**	**4501836.41**	**17.0**

* N/A = data not available

Table 50: Soil landscape summary – sampled areas

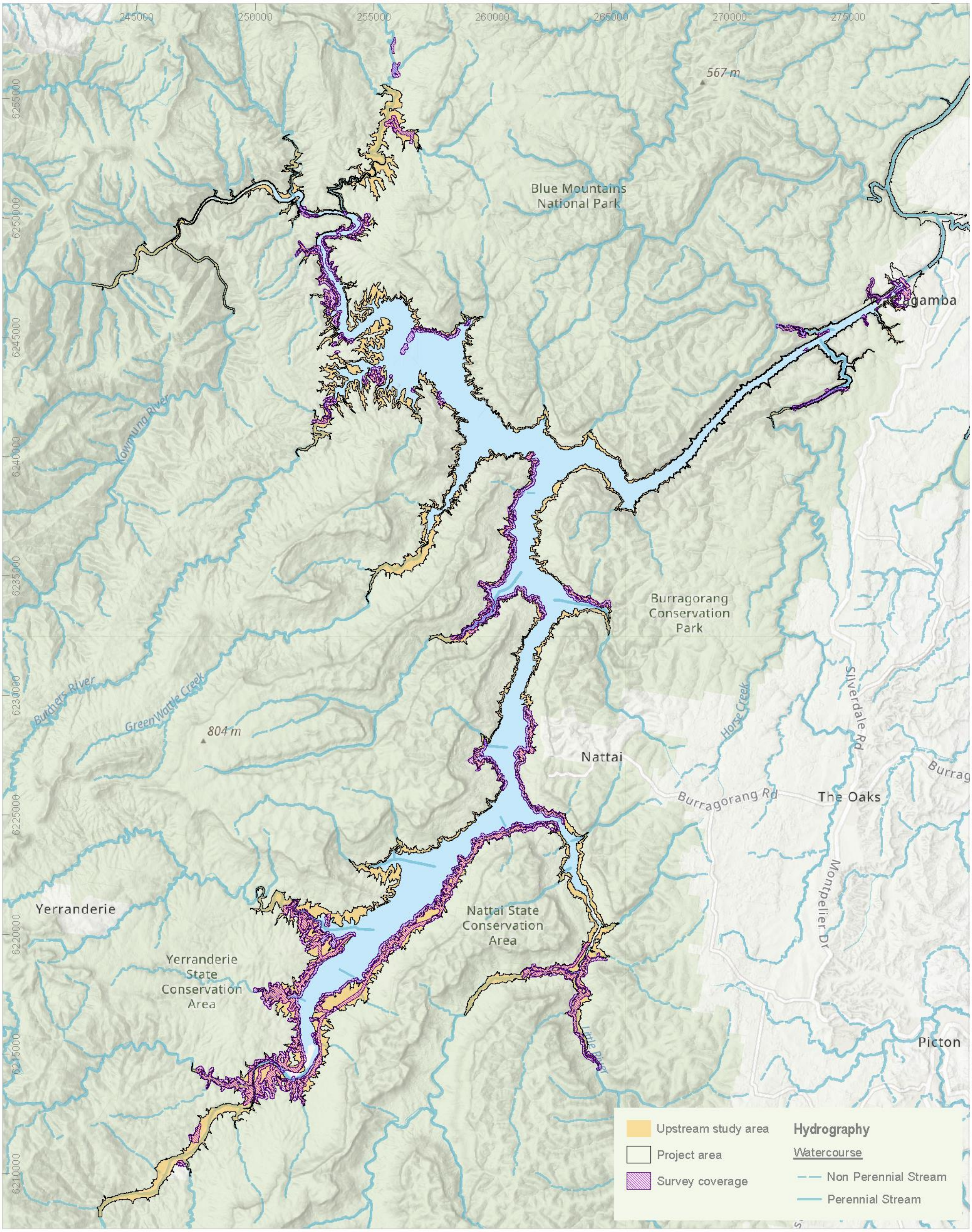
Soil landscape category	Soil landscape unit	Total area within PMF with Project (m2)	Area effectively surveyed (m2)	% of soil landscape effectively surveyed	Number of sites
Erosional	Cedar Valley	6138412.825	313885.4618	5.1	29
	Jooriland Range	3032094.473	127872.0702	4.2	13
	Kedumba	6054427.694	156390.816	2.6	30
	Martins Flat	7110553.064	94944.70434	1.3	21
	Martins Flat variant a	6038247.366	731142.1863	12.1	25
	Gymea	42298.78367	0	0.0	0
Alluvial	Coxs River	2135319.143	113795.7083	5.3	2
	Emu Island	4330459.856	148837.2553	3.4	4
	Wollondilly River	2448692.56	0	0.0	1
Residual	Faulconbridge	11674.73824	N/A	N/A	0
Transferral	Horse Flat	460686.4498	N/A	N/A	4

Soil landscape category	Soil landscape unit	Total area within PMF with Project (m2)	Area effectively surveyed (m2)	% of soil landscape effectively surveyed	Number of sites
Colluvial	Hassans Walls	11022968.52	1225838.796	11.1	67
	Hawkesbury	298402.6506	6327.58621	2.1	3
	Kanangra Gorge	6743278.906	39533.0848	0.6	20
	Round Mount	1888957.012	183172.9108	9.7	37
	Warragamba	2248048.784	104722.1648	4.7	8
	Barralier	169659.9994	0	0.0	0
Unknown	Water	69344486.86	1266358.764	1.8	45
Grand Total		**129518669.7**	**4501836.413**	**3.5**	**309**

* N/A = data not available

6.2.4.2 Site frequency based on soil landscapes

The use of 'Soil Landscape hectare (ha) per open site' rather than the conventional number of sites per hectare was raised as an issue during the submission process as it was argued to be "misleading and makes comparison of site frequency between soil landscapes challenging" (Submission received from Heritage NSW). As the Code of Practice (DECCW 2010a) does not specify a convention for describing site density in predictive models, the original ACHA opted to use landscape area per site, rather than site per landscape area, for the purposes of predictive modelling in order to remove the absurdity of having fractions of sites per hectare.



niche Environment and Heritage

0 4 km

WGS 1984 Web Mercator

Survey coverage within Project area

Aboriginal Cultural Heritage Supplementary Assessment
Warragamba Dam Raising Project

Niche PM: Deirdre Lewis-Cook
Niche Proj. #: 7211
Client: WaterNSW

Figure 10

6.2.5 Summary original updates to predictive model

Following the completion of the survey for the Project, the results were reviewed and discussed in light of the original predictive model. The full analysis and discussion are presented in Section 10 of the original AR. Overall, the results of the survey and distribution of newly identified sites within the Project area was found to be consistent with the patterning outlined in the predictive model. The following provides a summary of the key findings and highlights any updates to the predictive model that were considered necessary based on the survey results.

- Artefact sites as predicted (Open Camp Sites and Isolated Stone artefacts) were the most prevalent number of site type identified during the assessment.
- Shelter sites were more prevalent on very steep slopes, which differed from the predictive model due to the formation of shelters in the Narrabeen sandstone ridgeline formations. Further to this sandstone shelters were the second most common site type, not scarred trees as initially predicted.
- The ratio of scarred trees located was less than expected, and only 1.79% of sites had this feature. Sites consisting of only Scarred Trees accounted for only 1.49% of sites.
- Sites containing only Axe Grinding Grooves accounted for 2.38% of sites surveyed, however as a feature they were more frequent, with 12.50% of sites having related Axe Grinding Groove. Axe grinding grooves were more commonly associated with shelter sites, with only eight sites out of 42 sites containing this feature not associated with a shelter. Some of the Axe Grinding Grooves were on detached sandstone boulders.
- As predicted Axe Grinding Groove and Water Hole sites were difficult to identify due to the water and sediment levels within the Warragamba Dam currently.
- There were no burials identified during the assessment.

6.3 Updates to elements of the predictive model

A number of submissions identified issues relating to the above predictive model specifically relating to the lack of consideration of PADs, the focus on sites rather than archaeological features, the lack of consideration of intangible values and/or use of ethnographic information or other cultural information relating to intangible values and the lack of consideration of visibility in relation to the number of predicted Aboriginal heritage sites in the unsurveyed portions of the Project area. These issues are addressed below.

6.3.1 Archaeological features

Aboriginal site features are present across the whole landscape, though some areas have a greater capacity to contain particular site features or features of different types. Table 51 presents the frequency of known archaeological features located within the Project area based on updated AHIMS search data and known sites recorded during the survey completed for the original ACHA as discussed in Section 5.2 of this supplementary assessment report. The results are visually illustrated in Plate 18. The results demonstrate that Artefact(s), Rockshelters and PADs represent the most common archaeological features present at sites within the Project area.

A number of features included Artefacts, PADs and Axe Grinding Grooves are known to occur in both open-air and closed shelter contexts. Plate 19 illustrates the distribution of the archeologically features between open and closed site contexts. The results demonstrate that Artefacts occur predominantly in open air contexts while PADs and Axe Grinding Grooves occur predominantly in closed shelter contexts. The lack of PADs in open-air contexts, however, is a result of the limited consideration of PADs associated with Open Camp Sites during the survey for the original AHCA (a fact that was raised as an issue in a number of submissions received during the public exhibition of the EIS). This bias/issue is addressed below in Section 6.3.2.

Table 51: Frequency of archaeological features within Project area

Feature	Count	Frequency (%)
Aboriginal Resource	5	0.8
Artefact(s)	324	53.3
Axe Grinding Grooves	44	7.2
Burial	5	0.8
Engravings	2	0.3
Art (Pigment)	37	6.1
Rockshelters	88	14.5
Modified Tree (Carved or Scarred)	21	3.5
Potential Archaeological Deposit (PAD)	71	11.7
Shell	1	0.2
Stone Arrangement	2	0.3
Stone Quarry	1	0.2
Water Hole	5	0.8
Ceremonial / Dreaming	2	0.3
Total	**608**	**100.0**

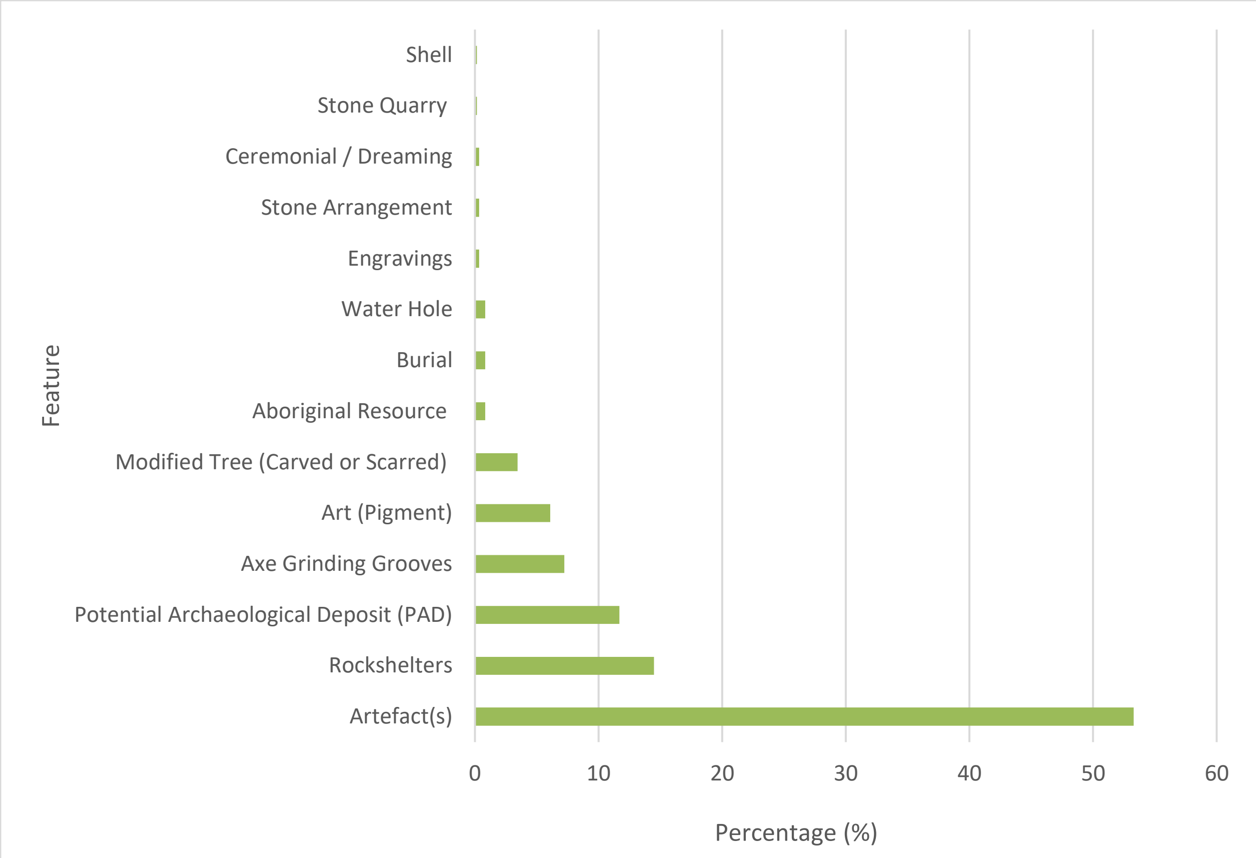


Plate 18: Frequency of archaeological features within the Project area

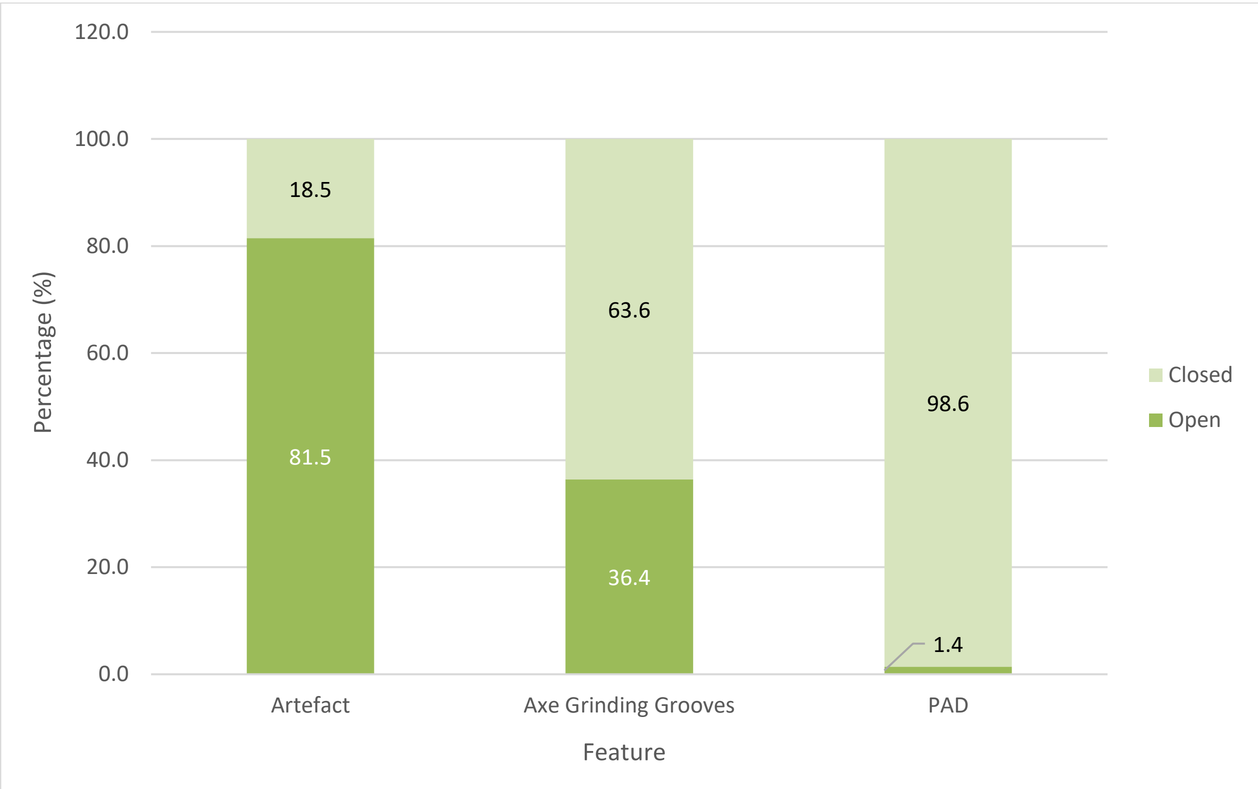


Plate 19: Occurrence of Artefacts, Axe Grinding Grooves and PAD features in open versus closed site contexts

The Department of Planning and Environment have developed an Aboriginal sites decision support tool (ASDST) to support assessments of Aboriginal sites issues in NSW at the landscape-scale. The ASDST uses and extends AHIMS data to illustrate the potential distribution of common Aboriginal site features recorded in the database and can be used as a way of visualising site feature potential and related issues across the whole landscape. The predictive mapping made by the ASDST are based on the application of site predictive modelling which correlates site information in AHIMS with landscape patterns including but not limited to vegetation, soils, terrain, and proximity to water. The predictive mapping is designed to be used at a landscape scale (i.e. scales of 1:100,000 and above) and is associated with a number of important caveats regarding its use a number of which are outlined below.

First of all, the predictive mapping looks at the 'likelihood' of Aboriginal site features occurring within the landscape not the 'probability'. Likelihood refers to how well a sample provides support for particular values of a parameter in a model. In contrast, probability refers to the chance that a particular outcome occurs based on the values of parameters in a model. The models are therefore best considered as "a baseline for site potential in the landscape" which describe the relative elative likelihood as it changes across the landscape (Ridges 2010: 15).

The legend for each predictive map is scaled from white (low likelihood) to back (high likelihood) where the darker an area is the higher likelihood that feature could occur. Importantly, the darkness of an area is a relative quality. "Black does not guarantee that that feature would have been located there or would still be there today. It represents an area where the model predicts a high likelihood of that feature at that location relative to all other areas of the landscape. Similarly, white areas do not indicate an absence of that feature, but the lowest relative likelihood resolved by the model." (Ridges 2010: 15)

Another important caveat concerns the fact that the relative nature of the likelihood measures is not directly comparable between features (Ridges 2010: 15-16). For example, although one area might indicate high modelled likelihood for both stone quarries and artefacts, that does not mean they are both predicted to have an equal probability of occurrence. In this example, the absolute probability of locating quarries is still less because they are generally less frequently observed than stone artefacts. The relative likelihood between different site features is therefore not directly comparable in absolute probability terms

With these caveats and limitations in mind, a series of maps using the ASDST modelling data were created for the current Project for the following Aboriginal site features of relevance to the current Project including stone artefacts (Figure 10), rock art (Figure 11), burials (Figure 12), grinding grooves (Figure 13), stone quarries (Figure 14) and scarred trees (Figure 15). The ASDST mapping produced for this Project utilised the current models which have been modified based on past land-use data to reflect a more realistic likelihood of site features based on the present-day landscape. The current models therefore take into consideration estimated historical impacts on Aboriginal features to describe their potential occurrence in the present-day landscape. The location of known Aboriginal heritage sites containing the relevant archaeological features within the Project area were additionally plotted on the mapping. It is acknowledged that the spatial patterning is inevitably influenced by survey coverage to date, nevertheless, this step allows for initial testing of the predictive modelling, the identification of potential Project-specific pattering in the distribution of site features and identifying expectations for un-surveyed areas. To assist in identifying whether patterning relates to survey extent, the results can be compared to the Figure 9 presented previously which displays the survey coverage achieved during the Project. The key findings of this exercise are presented in Table 52.

At present the ASDST has not developed predictive mapping for PADs. As such, the following Section presents the predictive modelling developed for this Project relating to PAD sensitivity based on additional information presented in Section 5.4 of this report.

Table 52: Key findings from ASDST predictive modelling

Archaeological Feature	Figure	Key findings
Stone artefacts	Figure 10	• The distribution of known Artefact sites within the Project area is widespread and largely consistent with the ASDST predictive mapping with the whole Project area associated with a relatively high likelihood of containing Artefact sites. • Based on the distribution of known Artefact sites, the areas of highest concentration of Artefact sites within the Project area include: ▪ Adjacent to the Cox River Arm and associated tributaries, particularly on the western side of Arm. ▪ Lacys Bay and Bimlow Point area, particularly on the west side of Lake Burragorang. ▪ Adjacent to the Little River (with fewer sites associated with the Nattai River). ▪ Tonalli Point / Wollondilly River area (both sides). • With perhaps the exception of the Nattai River, this spatial patterning is largely reflective of the survey coverage. It is therefore expected that a similar frequency of Artefact sites will be present in unsurveyed areas across the entire Project area.
Rock art	Figure 11	• Based on the ASDST predictive mapping, Rock art sites are most likely to occur in association with: ▪ The Cox River and its tributaries and Butchers Creek Arm in the north western portion of the Project area. ▪ Ripple Creek and Werriberri Creek in the north eastern portion of the Project area. ▪ The southern portion of Lake Burragorang and Wollondilly, Little and Nattai Rivers in the southern portion of the Project area. • The distribution of known Rock art sites within the Project area is relatively disbursed and broadly consistent with the ASDST predictive mapping with notable concentrations of sites with Rock art, for instance, located in association with the Coxs River and its tributaries, and Butchers Creek Arm. • The distribution of Rock art sites appears to be less impacted by survey coverage. The lack of sites with Rock art present in association with the Nattai and Little Rivers, for instance, cannot be attributed to lack of survey coverage as these areas were subject to extensive survey during the original ACHA. • It is likely that additional Rock art sites may be present in unsurveyed areas on the western side of Lake Burragarang between Tonalli River Cove, Higgins Bay and Jerry O'leary Point to the north.
Burials	Figure 12	• The distribution of known Burial sites within the Project area is limited to several sites situated within the now flooded Burragorang Lake. • Based on the ASDST predictive mapping, Burial sites are most likely to occur adjacent to Lake Burragorang and in association with the Cox River and its main tributaries and along the Wollondilly River. • The limited number of known burials sites (n=5) with the Project area, however, means that it is not possible to test the ASDST modelling at this stage nor develop more specific predictions relating to the potential local of previously unknown burial sites.

Archaeological Feature	Figure	Key findings
Grinding grooves	Figure 13	• Based on the ASDST predictive mapping, Grinding groove sites are most likely to occur in association with: ▪ Oakly Creek, Cox River and Kedumba River in the north-western portion of the Project area. ▪ Ripple Creek and Werriberri Creek in the north eastern portion of the Project area. • In contrast, Grinding grooves sites are less likely to occur in the southern portions of the Project area in association with the Wollondilly, Little and Nattai Rivers. • As previously mentioned, high proportion of grinding groove sites within the Project area occur in association with closed shelter contexts (n=28, 63.3%). The distribution of known sites with Axe grinding grooves within the Project area is spatially limited and broadly consistent with the ASDST modelling with a high concentration of this feature at sites on the western side of the Cox River Arm and isolated examples in association with the Wollondilly River. • Patterning in the distribution of known Grinding groove sites does not appear to be a reflection of survey extent, and appears to be less impacted by survey coverage. The lack of sites with Grinding groove sites present in association with the Nattai and Little Rivers, for instance, cannot be attributed to lack of survey coverage as these areas were subject to extensive survey during the original ACHA. • It is likely that additional Grinding groove sites may be present in unsurveyed areas associated with Coxs River Arm and Kedumba River and their tributaries.
Stone quarries	Figure 14	• Based on the ASDST predictive mapping, the distribution of Stone quarries is likely to be very limited within the Project area with this site type/feature most likely to occur in association with Butchers Arm and a small section on the western side of the Coxs River Arm near Fletchers Lookout within the north-western portion of the Project area. In contrast, Stone quarries are unlikely to occur across the remainder of the Project area. • Only one stone quarry site is currently recorded within the Project area and its location adjacent to Butcher Arm is consistent with expectations based on the ASDST predictive mapping. This quarry site (Butchers Arm #1; AHIMS ID# 45-4-0193) consists of a granite outcrop that was associated with the production of granite artefacts. • The absence of Stone quarries in other areas of the Project area does not appear to be the result of a survey coverage. Areas within the Project area associated with the highest likelihood of containing Stone quarries were extensively surveyed during the surveys completed for the ACHA. While additional Stone quarries may be present within the Project area, the likelihood is considered low.
Scarred trees	Figure 15	• Based on the ASDST predictive mapping, Scarred Trees are likely to be widely distributed across the entire Project area similar to Artefact sites. • The distribution of known sites with Scarred trees is largely consistent with the ASDST predictive mapping. • Like Artefact sites, the spatial patterning of Scarred trees is somewhat reflective of the survey coverage. It is therefore expected that additional Scarred tree sites may be present in unsurveyed areas across the entire Project area.

Figure 10: Predicted likelihood of stone artefacts within upstream study area based on ASDST (Source: DPE, Heritage NSW, SMEC, WaterNSW and Niche)

Redacted from public version

Figure 11: Predicted likelihood of rock art within upstream study area based on ASDST (Source: DPE, Heritage NSW, SMEC, WaterNSW and Niche)

Redacted from public version

Figure 12: Predicted likelihood of burials within upstream study area based on ASDST (Source: DPE, Heritage NSW, SMEC, WaterNSW and Niche)

Redacted from public version

Figure 13: Predicted likelihood of grinding grooves within upstream study area based on ASDST (Source: DPE, Heritage NSW, SMEC, WaterNSW and Niche)

Redacted from public version

Figure 14: Predicted likelihood of stone quarries within upstream study area based on ASDST (Source: DPE, Heritage NSW, SMEC, WaterNSW and Niche)

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Figure 15: Predicted likelihood of scarred trees within upstream study area based on ASDST (Source: DPE, Heritage NSW, SMEC, WaterNSW and Niche)

Redacted from public version

6.3.2 Potential archaeological deposits (PADs)

As discussed in Section 5.4 of this supplementary report, soil landscapes provide useful information that can be used to identify environmental proxies for the likely preservation and burial of Aboriginal objects in a landscape. A summary of the results from Section 5.4 is provided in Table 53 below.

Table 53: Summary of soil landscape categories and predictions regarding PADs

Soil Category	Summary and assessed archaeological predictions
Erosional	• Soil landscapes units within the Project Area include Cedar Valley, Gymea, Jooriland Range, Kedumba, Martins Flat and Martins Flat variant A. • Site types would likely include Isolated Artefacts, Open Camp Sites and where suitable geology occurs, Axe Grinding Groove sites and Rockshelters. • **Generally low potential** for PADs due to shallow soils, steep landforms, outcropping rock and/or severe sheet erosion with the following exceptions: - <u>Cedar Valley soil landscape unit</u>: **Moderate potential** for PADs in association with loamy sands (<100 cm depth) on sideslopes of up to 15° and in association with alluvial soils (<50 cm depth) along drainage lines. - <u>Gymea soil landscape unit</u>: **Moderate potential** for PADs in association with sands on gentle slopes (<100 cm depth) and along drainage lines. - <u>Jooriland Range soil landscape unit</u>: **Moderate potential** for PADs within slopes from 2-15°. - <u>Kedumba soil landscape unit</u>: **Moderate potential** for PADs in association with gentle side slopes and crests (<90 cm depth). - <u>Martin Flat (including Variant A)</u>: **Moderate potential** for PADs within slopes from 5-15° though subject to minor to moderate sheet and gully erosion particularly following bushfires.
Alluvial	• Soil landscape units within the Project area include Coxs River, Emu Island and Wollondilly River. • Site types would likely include Isolated Artefacts, Open Camp Sites and PADs. • **High potential** for PADs due to absence of steep slopes and outcropping, the potential for deep alluvium (up to 200 cm) providing the accumulation of archaeological deposits and the association with other archaeologically sensitive landforms (i.e. alluvial plains and terraces) and waterways (i.e. rivers and streams).
Colluvial	• Soil landscape units within the Project area include Barralier, Hassan wall, Hawkesbury, Kanangra Gorge, Round Mount and Warragamba. • Site types would likely include Isolated Artefacts, Open Camp Sites and where suitable geology occurs, Axe Grinding Groove sites and Rockshelters. • **Generally low potential** for PADs due to steep slopes, extensive outcropping and severe sheet and/or water erosion with the following exceptions: <u>Hassan's Wall soil landscape unit</u>: **Moderate** potential for PADs associated with soils (80-150 cm) on lower slopes and narrow drainage flats. <u>Kanangra Gorge soil landscape unit</u>: **High potential** for PADs to occur in association with lower slopes or along drainage lines where moderately deep to deep Alluvial soils (>100 cm) occur. <u>Hawkesbury soil landscape unit</u>: **High potential** for PADs to occur in association with overhangs and rock shelters where conditions support accumulation of sediment (i.e. flats shelter floors, sediment traps from past block fall). <u>Round Mount soil landscape unit</u>: **High potential** for PADs in association with silicious and earthy sands (<110 cm) on lower side slopes and along drainage depressions.
Transferal	• Soil landscape units within the Project area include Horse Flat.

Soil Category	Summary and assessed archaeological predictions
	• Site types include Open Camp Sites, Isolated Artefacts, PADs and Scarred Trees. • Horse Flat soil landscape unit: **High potential** for PADs due to low slope angles and potential for deep alluvium.
Residual	• Soil landscape units within the Project area include Faulconbridge. • Site types are likely to include Open Camp Sites, Isolated Artefacts, PADs and Scarred Trees. • Faulconbridge soil landscape unit: **Moderate potential** for PADs due to low slope angles however deposits are likely to be shallow (<50 cm) and may be subject to localised water erosion.

The qualities and limitations associated with the different soil landscape units, including whether an area is subject to severe sheet or water erosion and/or mass movement, is recognised to influence the accumulation and preservation of in-situ deposits within a certain context. Slope plays a key role in whether an area will be prone to erosion or not and therefore must be integrated into predictions relating to PAD sensitivity. As such, slope data is used to assess risk from water erosion and mass movement which is recognised as a key factor influencing the formation and preservation of deposits. The slope classes defined in the National Committee on Soil and Terrain (Speight 2009: 19) and as used in the original ACHA, were used to assess erosion risk and thus the likelihood of the accumulation and preservation of deposits. An overview of the slope categories and their assessed erosion risk and PAD sensitivity is provided in Table 54. The predicted PAD sensitivity provided in this table only considers the effects of slope on site formation and does not consider or integrate the predictions based on specific characteristics of soil landscape units.

Table 54: Slope categories, erosion risk and PAD sensitivity

Slope category	Definition	Assessed erosion risk	Assessed PAD sensitivity*
Flat or very gently inclined	Gradients between 0^o and 1^o	Low	High
Gently inclined	Gradients between 1^o and 6^o	Low	High
Moderately inclined	Gradients between 6^o and 18^o	Low-moderate	Moderate-to-high
Steep	Gradients between 18^o and 30^o	Moderate-to-high	Moderate-to-low
Very Steep	Gradients between 30^o and 45^o	High	Low
Precipitous	Gradients between 45^o and 72^o	High	Low

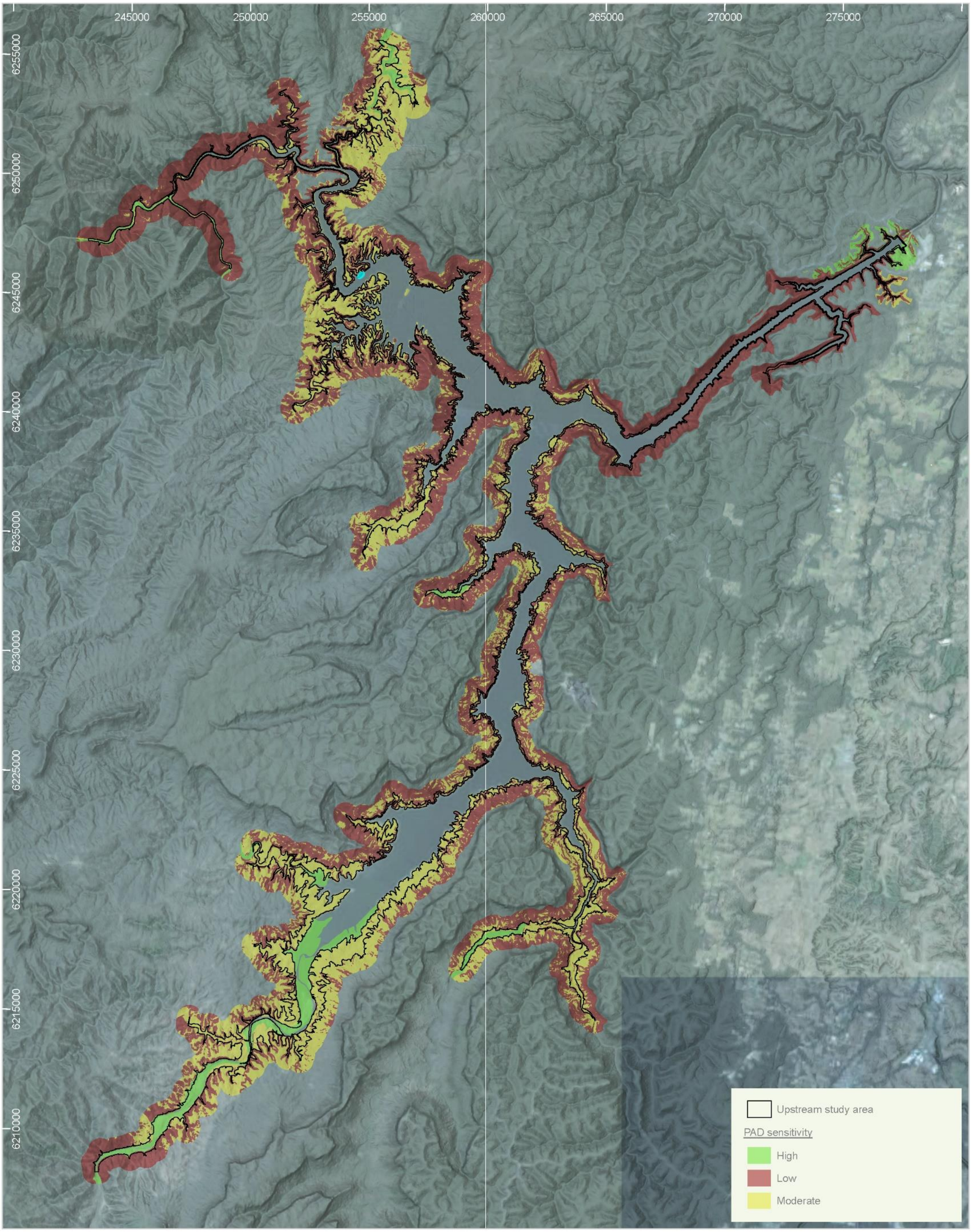
* This is a predicted sensitivity only considers the effects of slope and does not consider or integrate the predictions based on specific characteristics of soil landscape units.

Slope data for the Project area has been considered in conjunction with the additional information presented in Section 5.4 of this supplementary report, to establish predictions regarding the likelihood of PADs within the Project area and to develop PAD sensitivity mapping for the Project area. The assessment of PAD sensitivity is provided in Table 55 and the resulting PAD sensitivity mapping is illustrated in Figure 16. Based on this assessment, PADs are expected to occur in association with gentle - moderately inclined slope classes from 0-18% within alluvial, transferral and residual soil landscape context and to a lesser extent, erosional and colluvial soil landscapes areas. Areas of archaeological potential within the Project area include, but are not limited to, areas around Spring Creek, Fern Creek, Kedumba River, Water Fall Creek, Cedar Creek, Singajjingawell creek, Reedy Creek, Cox River, Kowmung, River, Lake Burragorang, Tollbar Creek, Horse Arm creek, Alum Spring Creek, Oaky Creek, Ripple Creek, Werriberri creek, Butchers

Creek, Green wattle Creek, Fitz's Creek, Black Coola Creek, Bob Higgins Creek, Blossom Lodge Gully, Dunns Gully, Ranger Creek, Tonalli River, Nattai river, Gillians Creek, Little Creek, Jooriland River and Wollondilly River.

Table 55: Soil landscape, slope class and assessed PAD sensitivity

Soil landscape	Code	Slope class	PAD sensitivity
Barralier, COLLUVIAL	bay	All	Low
Cedar Valley, EROSIONAL	cvz	>18°	Low
Cedar Valley, EROSIONAL	cvz	0-18°	Moderate
Coxs River, ALLUVIAL	cxz	All	High
Emu Island, ALLUVIAL	eiz	All	High
Faulconbridge, RESIDUAL	fbz	All	High
Gymea, EROSIONAL	gyz	>18°	Low
Gymea, EROSIONAL	gyz	0-18°	Moderate
Hassans Walls, COLLUVIAL	hwz	>18°	Low
Hassans Walls, COLLUVIAL	hwz	0-18°	Moderate
Hawkesbury, COLLUVIAL	haz	>30°	Low
Hawkesbury, COLLUVIAL	haz	<30°	High
Horse Flat, TRANSFERRAL	hfz	All	High
Jooriland Range, EROSIONAL	jry	>18°	Low
Jooriland Range, EROSIONAL	jry	0-18°	Moderate
Kanangra Gorge, COLLUVIAL	kay	>18°	Low
Kanangra Gorge, COLLUVIAL	kay	0-18°	Moderate
Kedumba, EROSIONAL	kez	>18°	Low
Kedumba, EROSIONAL	kez	0-18°	Moderate
Martins Flat variant a, EROSIONAL	mfza	>18°	Low
Martins Flat variant a, EROSIONAL	mfza	0-18°	Moderate
Martins Flat, EROSIONAL	mfz	>18°	Low
Martins Flat, EROSIONAL	mfz	0-18°	Moderate
Round Mount, COLLUVIAL	rmz	>18°	Low
Round Mount, COLLUVIAL	rmz	0-18°	Moderate
Warragamba, COLLUVIAL	wbz	All	Low
Wollondilly River, ALLUVIAL	woy	All	High



Drawn by: NeilBerry Last updated: 5/09/2022 File: C:\OneDriveSyncFolder\Niche\GIS - APRX - APRX\a7200\a7211_WDR_Enterprise\Pro\Aboriginal Cultural Heritage Supplementary Assessment - Upstream Area (2022)\Pro\a7211_wdr_acha_supp_nsw_v2.aprx

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Environment and Heritage

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WGS 1984 Web Mercator

Predictive sensitivity mapping for PADs within the upstream study area

Aboriginal Cultural Heritage Supplementary Assessment
Warragamba Dam Raising Project

Niche PM: Deirdre Lewis-Cook
Niche Proj. #: 7211
Client: WaterNSW

Figure 16

public/NSW_Imagery: © Department of Customer Service 2020/Terrain: Multi-Directional Hillshade: Airbus,USGS,NGA,NASA,CGIAR,NCEAS,NLS,OS,NMA,Geodatastyrelsen,GSA,GSI and the GIS User Community | Watercourses, Waterbodies, Road and Rail alignments, Protected areas of NSW © Spatial Services 2021. | Niche uses GDA2020 as standard for all project-related data. In order to ensure that data from numerous sources and coordinate systems is aligned, on-the-fly transformation to WGS1984 Web Mercator Auxilliary Sphere is used in the map above. For ease of reference, the grid tick marks and labels shown around the border of the map are presented in GDA2020, using the relevant MGA zone.

v2.0

The PAD sensitivity modelling developed for the Project is associated with a number of important assumptions and limitations in addition to the caveats outlined in the context of the ASDST predictive modelling. The PAD sensitivity modelling, for instance, only considers a limited range of variables of relevance to the preservation and accumulation of archaeological deposits – namely soil landscape unit and slope class. It is recognised that a large number of other variables (including cultural variables relating to decisions made regarding subsistence and settlement strategies) have not been considered. Thus, while a site may be associated with a low PAD sensitivity based on the modelling, it may still be associated with archaeological deposit due to the selection of the location for occupation in the past for cultural reasons unknown to the archaeologist. Such behavioural variables are not readily predictable.

Further, it is recognised that the PAD sensitivity mapping is largely developed for application in open-air site contexts and that rockshelter sites in any soil landscape context has the potential to preserve deposit if the right conditions are present (e.g. sediment trap at dripline, flat shelter floor less prone to slope wash and erosion etc.). Thus, while a rock shelter may be associated with a low PAD sensitivity rating based on the PAD sensitivity model data, it may be that the environmental conditions at the site were favourable to for the accumulation and preservation of deposit and vice versa. Despite these limitations, the PAD sensitivity modelling provides a starting point for assessing the likelihood of whether a site is associated with a PAD. Other characteristics of the site including its nature, extend and location, should also be used to inform the final prediction. Future testing of the predictions may help to refine the model.

To address the lack of consideration of PADs, particularly in open air contexts, newly recorded Aboriginal archaeological sites (specifically Open Camp Sites) within the upstream study area were reconsidered to assess their likelihood of containing PAD in light of the following:

- The associated predicted PAD sensitivity rating.
- The nature and extent of the site (i.e. high-density artefact scatter).
- The visibility and exposure as a site (i.e. whether the extent of the site was considered to likely be larger despite low ground surface visibility).
- Location of site in landscape (e.g. at confluence of two streams, along a ridge).
- The integrity of the site (e.g. in-situ versus disturbed context)
- Any additional comments and data extracted from the original recording form that indicated the likely presence or absence of PAD.

The data compiled for this re-assessment and along with the full results for each site is provided in Appendix 6. The following provides a summary of the main results based on the predictive modelling and re-assessment of newly recorded Aboriginal heritage sites:

- A high proportion of rockshelter sites have already been assessed to be associated with deposit (i.e. PAD).
- A total of thirty-two (32) Artefact sites (Open Camp Sites or Isolated Finds) are now predicted to be associated with PAD. A summary of these sites is provided in Table 56. These results have been considered in the review and update of the significance assessment of sites presented in Section 7.2.

Following the identification of PADs, a program of subsurface testing would usually occur to establish their nature, extent and archaeological significance. However, as RAPs do not support sub-surface-testing regime at this point in time, for the purpose of the significance assessment, all sites with PAD are assessed as being of significance until proven otherwise (see Section 7.2.)

Table 56: Description of Open Camp Sites and Isolated Finds with PAD

Site Name	Site Type	Predicted PAD sensitivity	Description
Warragamba-00	Open Camp Site with PAD	Moderate	Artefact scatter located on a river terrace close to a creek and an unnamed drainage line. The landscape surrounding the area is comprised of tall trees of various species and signs of new growth is evident in the area, most probably from past clearing of the old vegetation. Despite evidence of disturbance, the site's location on a river terrace indicates potential for sub-surface archaeological deposits.
Warragamba-01	Open Camp Site with PAD	Moderate	Artefact scatter located a top of a flat terrace close to Golden Moon Creek. The site comprises of four flakes made from quartz and quartzite. The site's location on a river terrace indicates potential for sub-surface archaeological deposits.
Warragamba-12	Open Camp Site with PAD	Moderate	Site located on an elevated landform within the exposure of an old road. The site is approximately 1.3 km from the junction of the Nattai and Little Rivers. The site comprises of eight stone artefacts made of chert and quartz. It is highly likely that there is subsurface deposit associated with this site.
Warragamba-18	Open Camp Site with PAD	Moderate	Site located on lower slope of a ridge near Gorman Point. Low density but associated with some hearth material and burnt clay scattered on surface indicative of past use of a longer duration (i.e. use involving camping).
Warragamba-27	Open Camp Site with PAD	Moderate	Site positioned at Kamilaroi Point, just above the high-water mark of Lake Burragorang. The site measures 150 m x 250 m and is located nearby a Shelter with Deposit (AHIMS ID 52-1-0142). A sample of six artefacts were recorded at this site. Landscape context and association with another occupation site indicates potential for more frequent use of area and thus sub-surface potential.
Warragamba-39	Open Camp Site with PAD	Moderate	Extensive artefact scatter associated with scattered burnt clay /hearth material indicative of more intensive/focussed use and/or repeated use of the area and thus potential sub-surface deposits. The site is located just off Lake Burragorang foreshore. A sample of twenty-five artefacts were recorded.
Warragamba-40	Open Camp Site with PAD	Moderate	Extensive artefact scatter indicative of more intensive/ focussed use and/or repeated use of the area and thus potential sub-surface deposits. The site is located just off Lake Burragorang foreshore. A sample of twenty-five artefacts were recorded.
Warragamba-48	Open Camp Site with PAD	Moderate	Extensive artefact scatter including numerous cores and six axes indicative of more intensive/ focussed use and/or repeated use of the area and thus potential sub-surface deposits. A sample of twenty-four artefacts were recorded.

Site Name	Site Type	Predicted PAD sensitivity	Description
Warragamba-72	Open Camp Site with PAD	High	Artefact scatter located adjacent to Wollondilly River. Red alluvial deposit recorded as occurring across all of the landform with the possibility for in-situ deep deposits noted despite some disturbance from wombat burrowing in the upper layers.
Warragamba-77	Isolated Artefact with PAD	High	Recorded as an Isolated Artefact located adjacent to Wollondilly River in an area with very low visibility. Potential for additional artefacts. Location in alluvial soil landscape suggests potential for deposits.
Warragamba-94	Open Camp Site with PAD	Moderate	Extensive artefact scatter despite relatively low visibility. The potential for intact sub-surface deposits was noted resulting in its assessment as being of high scientific significance deposits.
Warragamba-96	Open Camp Site with PAD	Moderate	Artefact scatter located on western side of Tonalli Point and extends 250 m x 50 m. Although the site comprised of 2 artefacts, it was noted that there is likely to be subsurface deposit present. It was noted that the site likely extends across the level landform to the west with potential for more extensive occupation evidence towards the ridge to the north.
Warragamba-101	Isolated Artefact with PAD	Moderate	Isolated Artefact located within a valley flat at Tonalli Cove. The artefact consists of a large chert core. Visibility and exposure was low with a high likelihood of more artefacts being present within the area. The position of site within landscape (valley flat at cove) increases archaeological sensitivity of the area and there is potential for sub-surface deposits to also be present.
Warragamba-102	Isolated Artefact with PAD	Moderate	Isolated artefact located within a valley flat at Tonalli Cove Artefact exposed as a result of wombat burrowing indicating its original sub-surface origin. High likelihood of more artefacts across landform including sub-surface archaeological deposits.
Warragamba-109	Open Camp Site with PAD	Moderate	Extensive artefact scatter that likely connects to Warragamba-110 and Warragamba-48 (located on opposite bank of Wollondilly River). "Deposit for excavation" was noted on recording form. A sample of 25 artefacts recorded.
Warragamba-110	Open Camp Site with PAD	Moderate	Extensive artefact scatter that likely connects to Warragamba-109 and Warragamba-48 (located on opposite bank of Wollondilly River). Potential for PAD extrapolated based on association with Warragamba-109 and comments made in association with that site. A sample of 14 artefacts recorded.

Site Name	Site Type	Predicted PAD sensitivity	Description
Warragamba-134	Isolated Artefact with PAD	High	Site consists of a single basalt hatchet in an area with 100% exposure and visibility on the terrace bank of the Cox's River. The site's location within an alluvial soil landscape means that there is a high potential for preserving deep stratified archaeological deposits.
Warragamba-137	Open Camp Site with PAD	High	Open Camp Site with artefacts located on an alluvial terrace 30m from Kedumba River. A sample of 18 artefacts recorded. The site's location within an alluvial soil landscape means that there is a high potential for preserving deep stratified archaeological deposits.
Warragamba-138	Open Camp Site with PAD	Moderate	Two artefacts located on a terrace near the junction of Rocky and Butchers Creek. Terrace landforms are known to often be associated with sub-surface archaeological deposits.
Warragamba-147	Open Camp Site with PAD	Moderate	Open Camp Site situated on terrace adjacent to Burragorang Lake. Recording form noted that the site is situated within an archaeologically sensitive landform with subsurface artefacts considered likely to be present.
Warragamba-148	Open Camp Site with PAD	Low	Open Camp Site located on a lower slope of Houlouhan Point. Recording form noted that artefacts were located within a "highly sensitive landform" with artefacts exposed from erosion by stored water. The exposure of artefacts in this manner indicates a sub-surface origin and thus additional sub-surface potential.
Warragamba-150	Open Camp Site with PAD	Moderate	Open Camp Site located on lower slope near stored water. The site was noted to contain artefacts manufactured from an unusual raw material compared to sites on the other side of the stored water. The recording from noted that the site was within an archaeologically sensitive landform with visible artefacts that were eroding downslope. The exposure of artefacts in this manner indicates a sub-surface origin and thus additional sub-surface potential.
Warragamba-155	Open Camp Site with PAD	Moderate	Open Camp Site located on a point between an unnamed creek and Woodville point. Artefacts included three ground-edge axes. The recording from noted that the site was within an archaeologically sensitive landform with visible artefacts that were eroding downslope. The exposure of artefacts in this manner indicates a sub-surface origin and thus additional sub-surface potential.
Warragamba-156	Open Camp Site with PAD	Moderate	Extensive scatter located alongside the stored water on a large, flat area which comprises Woodville point, and is north of the landform containing Warragamba – 155. An extensive artefact scatter was observed in this region, with a representative sample of 20 artefacts recorded. This point is at the mid-point of the valley it resides in. The position of the site in the landscape (i.e. large flat area in the valley

Site Name	Site Type	Predicted PAD sensitivity	Description
			suitable for camping and thus repeated / focused occupation) increases the potential for archaeological deposits.
Warragamba-199	Open Camp Site with PAD	Moderate	Artefact scatter consisting of 8 artefacts including two basalt cores located directly south of Warragamba-200 a shelter with artefacts and deposit. Sub-surface potential inferred from the site's close association with a shelter /occupation site which indicates the area may have been used repeatedly or more intensively allowing for the accumulation of deposits with evidence of past activities undertaken in the area.
Warragamba-202	Open Camp Site with PAD	Moderate	Extensive artefact scatter located at the junction of Lacy's Creek and the Wollondilly River. Such areas (flat land at the junction of water courses) are known to have been favoured as camp sites and are archaeologically sensitive. Sub-surface archaeological potential was noted in association with the site.
Warragamba-229	Open Camp Site with PAD	Moderate	Long, mostly level saddle with possible quartz artefacts towards edge of FSL. PAD facing 120 degrees south-east.
Warragamba-235	Open Camp Site with PAD	Moderate	Artefact scatter located on a creek terrace near the junction of Alum Springs Creek and Lake Burragorang. Scatter located in a tall forest. Four artefacts including an axe and large basalt cores were recorded. Low visibility (<5%) means that there is a high potential for further artefacts to be present. Location on a creek terrace means that there is a high potential for sub-surface deposits.
Warragamba-247	Open Camp Site with PAD	Moderate	Artefact scatter located on an elevated landform at the junction of Horse Arm Creek and Coxs River. Sample of 12 artefacts recorded during survey including flakes, cores and a ground head axe. Location at the junction of two watercourses indicates high archaeological potential including sub-surface potential.
Warragamba-253	Open Camp Site with PAD	Moderate	Extensive artefact scatter located at the confluence of the Cox River and an unnamed tributary and surrounded by three hills (Commodores, Grundys and Moody's Hills). A sample of 22 artefacts recorded. The site's location in an elevated context at the confluence of two watercourses indicates high archaeological potential including sub-surface potential.
Warragamba-268	Open Camp Site with PAD	Moderate	Artefact scatter located in elevated position at the junction of Oaky Creek and the Cox River. A sample of 8 artefacts recorded including basalt cores, quartz cores and flakes. The site's location in an elevated context at the confluence of two watercourses indicates high archaeological potential including sub-surface potential.

Site Name	Site Type	Predicted PAD sensitivity	Description
Warragamba-271	Open Camp Site with PAD	Moderate	Artefact scatter located on a long flat ridge on a bend in Oaky Creek, a tributary of the Cox River, and within 50 m of this water source. There were several chert and quartz artefacts observed and a basalt axe. The potential for deposits was noted on the recording form for this site.

6.3.3 Ethnographic and cultural information and intangible values

The original predictive model made limited use of ethnographic information or other cultural information relating to intangible values associated with Project Area. As outlined in the Cultural Values Assessment completed as part of the original ACHA, "mythological sites and beings are imprinted in the topography of the landscape and the energy or sentience of the mythological being is understood as remaining in the physical environment. In this sense the mythological beings and their cultural routes or pathways are seen as animating the landscape" (Walters Consultancy Pty Ltd 2021: 22). The traditional and historical patterns of movement of mythical beings and of Aboriginal people create a complex interlinked series of places and cultural routes or pathways linking together nodes in the landscape associated with resource rich areas, mythological movement patterns, and places of ceremonial and spiritual importance.

Information contained within the Aboriginal Place nomination, as outlined in Section 5.3, demonstrates the high cultural significance of the Burragorang Valley within which the Project area is situated and exemplifies the perspective held by Aboriginal people that the landforms and waterways themselves embody culture and hold cultural value. While the whole landscape is considered to be inter-connected and highly significant, certain natural landmarks and/or environmental features are recognised to be associated with intangible values. The existence of such features within the Project area can be predicted to be similarly associated with such intangible values. The table below provides a brief analysis of landforms, landmarks and/or environmental features noted as being of significance within creation stories of relevance to the Project area. While the whole of the Project area is noted to be of high significance to the Aboriginal community as a cultural landscape, these key landforms and/or environmental features are predicted to be of particular intangible value due to their link to specific points within the creation stories.

Table 57: Analysis of creation story/ song line and identification of natural features of significance

Creation story or song line	Landforms, landmarks and/or environmental features noted as being of significance
Gurrangatch-Mirrigan Dreaming Track	• Waterholes and their adjacent areas (where the spirit of Gurangatch still resides) • Caves and cave systems • Cliffs • River valleys • River flats • River junctions • Waterways (the Wollondilly, Nattai, Warragamba, Fish, Wingecarribee, Kanangra and Coxs Rivers and their tributaries)
Buru (Kangaroo) Dreaming Story	• Waterhole (in the Wollondilly River between Byrnes Creek and Tonalli River) • Valleys (Burragorang Valley)

Creation story or song line	Landforms, landmarks and/or environmental features noted as being of significance
Jumping Woman Dream Story	• Cliffs (located on the western banks of the Wollondilly River at Ghungarlook Farm)
Bulluns *gunyunggalung* Story	• Waterhole (Burragorang waterhole in the Wollondilly River) • Valleys (Burragorang Valley) • Waterways (rivers and tributaries)
Gareem *gunyunggalung* Story	• Caves and cave systems (Jenolan, Wombeyan, Abercrombie, Colong, Juanter, Moonshine Creek, and Alum Springs) • Mineral pools and deposits • Springs
The Emu Dreaming Story	• Cliffs

Ethnographic information can provide additional insights into the archaeological potential of certain areas and the likely nature and extent of those sites. The table below provides an analysis of ethnographic information relating to the Project area and an identification of the archaeological implications of this information.

Please note the contents of the ethnographic data contains historical quotes that include inappropriate language, content regarding burial desecration and references to deceased.

Table 58: Analysis of ethnographic information and archaeological implications

Ethnographic information	Archaeological implications
Geologist and amateur ethnologist Robert Etheridge of the Australian Museum noted in 1893: *"The large alluvial flats in this neighbourhood, along the Wollondilly, were, I was informed, great gathering grounds for the various tribes from many miles round, even those of Goulburn and Shoalhaven participating"* (Etheridge 1893:49-50).	• Large alluvial flats of high archaeological potential. • Likely to contain open camp sites with potential archaeological deposits (PADs). • Likely to contain evidence of repeated and concentrated occupation. This evidence may be potentially stratified. • May contain evidence of trade (e.g. diverse raw material types transported over larger distances).
Etheridge also recorded the 'Hands on the Rock' art site in 1893: *"The "rock" consists of a huge mass of Hawkesbury Sandstone (Plate XII) about seventeen feet in breadth and length, hollowed out on the side overlooking the river to the extent of six feet. It is perched on the side of a gentle rise from the Wollondilly, having rolled from the higher ground above, and alongside the track from the Nattai Junction to Cox's River, in the immediate south-west corner of the Parish Werriberri.* […] *On the back wall are depicted a number of red hands, both right and left.* […] *Under the principal hands are four white curved bands, resembling boomerangs or ribs, the whole of the hands being relieved, as is usually the case with these representations, by white splash-work.* […] *Mr. Maurice Hayes, of Queahgong, informed me that he has known*	• Archaeological potential for sites where Hawkesbury Sandstone boulders and outcrops occur. • Archaeological potential on slopes alongside the track from the Nattai Junction to Cox's River. • Likely to contain low density artefacts and isolated finds indicative of short-term travel.

Ethnographic information	Archaeological implications
the rocks for the past fifty years, and that the imprints have not altered in the least. He found it difficult to obtain reliable information from the Aborigines regarding them; they expressed ignorance, but ultimately gave him to understand that the "hands were the imprints of those of their Deity, when on earth." (Etheridge 1893:49-50).	
In 1983, Etheridge excavated the burial site of a senior Aboriginal man, whom he understood to be called Jimmy Ah-re-moy but who may have been known as Tarlo Jack, who died c.1860: "*On a spur overlooking one of these green expanses, known as Gorman's Flat, immediately at the junction of the Wollondilly and Nattai Rivers, in Port B. 171/587, Parish of Wingecarrabee, County Westmoreland, we investigated an interment, thirty years old, indicated by a single carved tree, but the device has, I regret to say, been wantonly destroyed. This grave is known to be that of "Jimmy Aremoy," or "Blackman's Billy," of the local tribe, and called in the Aboriginal dialect Ah-re-moy, and was covered by a small mound at the foot of a small tree, forty-seven feet north of the carved tree, and had been surrounded by a sapling fence*. […]" (Etheridge 1893:50-51). Mr. H. McCooey, a naturalist and resident of the Burragorang Valley, wrote to the Australian Museum recording the objections of Aboriginal people in the area at the disturbance of the grave and the removal of the remains of Jimmy Ah-re-moy or Tarlo Jack. Jimmy Ah-re-moy or Tarlo Jack had only been buried thirty years previously and there were presumably community members who knew him and or were related to him still living at the time his grave was disturbed (McCooeey 1892 in Smith 2017:252; Nepean Times 1902:2). Two other carved burial trees were located at the junction of the Wollondilly and Nattai Rivers, marking the grave of a senior Aboriginal man. Etheridge recorded that in 1896 he had been shown them by T.P. Hayes: *"Two trees at the grave of another headman, pointed out many years before to Mr. Hayes by a blackfellow*" (Etheridge 1918:52). These carved burial trees are recorded as AHIMS Site 52-1-0041 (Brayshaw 1989:8). In 1918 the trees were noted as being in the Australian Museum (Etheridge 1918:52). The trees were identified in 1979 at the Australian Museum as being Eucalyptus trees (Brayshaw 1989:8). Three other carved burial trees were also located at the junction of the Wollondilly and Nattai Rivers, marking the grave of another senior Aboriginal man. Etheridge	• Archaeological potential at river junctions and alluvial flats. • Likely to contain carved trees and burial sites at the junction of the Wollondilly and Nattai Rivers, in the area referred to as Gorman's Flat and Larry Gorman's/ Gannons Flat. • Likely to contain PADs. • Potential for historical artefacts.

Ethnographic information	Archaeological implications
wrote: "Mr. Maurice Gorman subsequently conducted us across the Wollondilly to a slight rise above "*Larry Gorman's F[l]at," Parish of Nattai, on the Nattai side of the Wollondilly, County of Camden, and a little below the junction of the rivers. Here we viewed the burial place of a "Chief" of the late local tribe, the interment having taken place about fifteen years ago. It lies contiguous to one of three marked trees placed in a triangle, the longest side or base of the latter being half a chain in length, and bearing north-west and south-east. The trees are still erect, although the carvings are more or less obliterated by bush fires, but they seem to have been chiefly in zig-zag lines, and of course cut with an iron tomahawk. The heavy rain prevailing at the time deterred us from investigating this burial. It is situated on either Portions C. 98/70 or C.98/105, Parish of Nattai*" (Etheridge 1893:51).	
The Big Flat was the name applied by the senior Gundungurra man William Russell to a major camping area that was in use when he was a young boy in the mid-1800s: "*As a young boobal (boy), I was then camped with my people on the Big Flat, which was then called Burru-ga-rang; there was about 50 or 60 of us camped about through the Valley*" (Russell 1991:16). As Russell noted, the area of the Big Flat was properly called Burra-ga-rang, a name that by the time that Russell was recording his memoirs in the early 1900s was applied to the wider valley. Members of the Riley family were amongst the Gundungurra people who were successful in enrolling to vote in the Burragorang Valley; in the early 1920s the electoral rolls included family members who gave their address as the Big Flat.	• Large alluvial flats of high archaeological potential on the western side of the Wollondilly River, between its junction with Byrnes Creek and the Tonalli River. • Likely to contain open camp sites with PADs. • Likely to contain evidence of repeated and concentrated occupation. This evidence may be potentially stratified.
John Riley (1859-1929) held a conditional purchase lease of Portion 62 in the Parish of Wanganderry, County of Camden, consisting of40 acres on the Wollondilly River. Riley's holding was adjacent to the Burnt Flat Travelling Stock and Camping Reserve, and at some point, an application to form an Aboriginal Reserve adjacent to Portion 62 was made but was unsuccessful (Land Registry Services 2022a). In 1901 the local newspaper published a brief account of a Boxing Day celebration at John Riley's Burnt Flat property that included guests from a number of well-known Aboriginal families in the area: "*On Boxing Day, a very enjoyable day was spent at the residence of Mr. Reilly, of Burnt Flat, near Wanghanderry. Various sports and amusements were gone through, followed by a splendid ball and supper, some 30 couples attending. Dancing*	• Large alluvial flat of high archaeological potential on the eastern side of the Wollondilly River. • Likely to contain PADs. • Likely to contain evidence of contact era and historical occupation.

Ethnographic information	Archaeological implications
was kept up with great spirit until long after daylight, when the merry dancers adjourned to their homes" (Picton Post and Advocate 1901:1).	
A 40-acre conditional purchase lease, Portion 93 in the Parish of Jooriland, County of Westmoreland, was held by Gundungurra man Edward Hilton (1869-1907) (Land Registry Services 2022b). Edward Hilton was the son of Teresa Hilton née Ingram, a Gundungurra woman, and her husband James Hilton, a European farmer. The death of Teresa Hilton was reported in the local newspaper in 1910: "*The death occurred suddenly at about 11 p.m. on Tuesday last of Mrs. Theresa Hilton, wife of Mr. James Hilton, of High Range...* […] *The death of Mrs. Hilton removes from the district the last of the full-blood aborigine* [sic] *tribe. Her husband (a white man) survives her, and also a grown-up family of sons and daughters, one of the latter being married to Mr. John Goodfellow, a sheep farmer at Bullio. Mr. and Mrs. Hilton lived for many years on the river at Bullio, where the former was employed as stockman...*" (Scrutineer and Berrima District Press 1910:2).	• Alluvial flat of high archaeological potential on the western side of the Wollondilly River. • Likely to contain open camp sites with PADs. • Likely to contain evidence of contact era and historical occupation.
Tommy Bundle's Burial was recorded in the late 1980s by the archaeologist Helen Brayshaw who spoke with Lex Maxwell, then caretaker of the Kedumba Pastoral Company. The Maxwell family have a long association with the Burragorang area from a European perspective, having arrived in the area as convicts in the 1830s. Brayshaw recorded from Lex Maxwell: "*The burial of an Aboriginal, Tommy Bundle, who died in about 1910, was marked by a carved tree [Ironbark] at a point 'about 8 miles downstream from the homestead' [near Butchers Creek/Coxs River confluence?]. This site, now flooded, would be one of the most recent examples of tree carving known*" (Brayshaw 1989:8). There are a number of Aboriginal people with the surname Bundle who appear in the documentary records in the first half of the 1800s in the districts; it is uncertain if these are the same or multiple families and which if any of these individuals was the Tommy Bundle who was buried at Black Gooler (Waters Consultancy 2021).	• Archaeological potential at river junctions • Likely to contain carved tree and burials on the north side of the Coxs River opposite its junction with Butcher's Creek, in the area referred to as Black Gooler.
Australian surveyor and self-taught anthropologist Robert Hamilton Mathews (1841–1918) wrote unpublished notes that include ethnographic information. The notebooks of Mathews are recorded as including references to a story involving an Ancestral Being called Nulla, a black spider Ancestral Being called Nyammir, and a dog. Although the details of the Story are unclear it appears to be linked to a reference by A.L.	• Archaeological potential at waterholes and along waterways (as journeys taken by the characters in Dreaming stories often describe the pathways and routes taken by people). • Likely to contain low density artefacts and isolated finds indicative of short-term travel

Ethnographic information	Archaeological implications
Bennett, who had recorded the memoirs of William Russell, to the Black Waterhole as the location where Nulla washed himself. The Black Waterhole/Black Hole is located in the Wollondilly River between Higgins Bay and the Nattai River (Mathews n.d in Smith 2017a:252).	
In 1911, R.H. Mathews described the Byrnes Creek Rock Engraving: *"A bird, perhaps intended for a turkey bustard, measuring 6 feet 2 inches from the top of the head to the end of the tail, is incised on a sandstone rock on the right bank of Byrne's Creek, a tributary of the Wollondilly river, within Portion 5 of 100 acres, Parish of The Peaks, County of Westmoreland. An old blackfellow, about 70 years of age, named "George Riley," a member of the Gundungurra tribe which occupied that part of the country, told me that he first saw this drawing when he was a boy, and even then, the grooving had the appearance of having been done a long time*" (Mathews 1911:405).	• Archaeological potential at river junctions • Likely engraving on the right-hand side of Byrnes Creek near its junction with the Wollondilly River.
Architect, conservationist and dedicated bushwalker in the Blue Mountains region, Myles Dunphy, marked 'Red Hand Cave' on a map in 1933 and journalist, naturalist, and bushwalker Ella McFadyen described the site in 1930: *"In Lower Burragorang Valley a very interesting memorial of the blacks stood in perfect repair as recently as three years ago. It was then my good fortune to examine the Red Hand Rock.... The rock itself is a block of sandstone fallen apparently from the cliffs above, and standing in the open, facing due westward towards the Wollondilly River... The hands were painted in a dark red pigment and outlined in white... They were comparatively small hands, all shown with the thumb on the left side, and a severing line at the wrist. They were broad in the palm, short in the fingers, and corresponded in size to an average hand of a white woman. What was the purpose and significance of these hand paintings is a question not yet decided? That it must have been more than an idle whim is certain from the fact that the preparation of the pigments could have been no simple matter, and instances of red-hand paintings occur in widely scattered places"* (McFayden 1930:18). This site has been conflated with the 'Hands on the Rock' art site previously as they are very similar, however, this site is located on the eastern side of the Wollondilly River just north of the junction with the Nattai River near the Nattai Bluff Trail (Waters Consultancy 2021).	• Archaeological potential at cliff bases and river junctions, potential for sites where sandstone boulders and outcrops occur • Archaeological potential at the Wollondilly River and Nattai River junction • Likely to contain art sites near cliff landforms • Likely to contain PADs.
In April 1895, the minutes of the APB recorded that: *"Mr. J. E. Moore, Glenmore: - Recommdg* [sic] *that ½ ton*	• Archaeological potential at the Byrnes Creek and Wollondilly River junction

Ethnographic information	Archaeological implications
of fencing-wire be purchased for the Aborigines at Burragorang to enable them to enclose Reserve No. 26." The request was "*Approved. Wire will be supplied when posts ready*" (State Archives and Records 2022a).	• Likely to contain PADs and evidence of contact era and historical occupation
In August 1916, the Department of Education contacted the APB to request permission to lease the building [on Gazetted Aboriginal Reserve No. 27]: "*It has been reported by the local Inspector of Schools that a disused building on an Aboriginal Reserve could be made to serve as a school building at Tonalli. I shall be glad, therefore, if you will kindly inform me upon what terms your Board is prepared to grant a lease of the building, which was formerly occupied by the Aboriginal King*" (State Archives and Records 2022b). The APB initially granted permission for the Department of Education to lease the building but then reversed their position, stating: "[…] *I am now in receipt of a report to the effect that the hut said to be disused at Burragorang was until a few months ago occupied by a half caste named A.E. Riley, who vacated it for the purpose of securing work elsewhere during the dry weather recently prevailing. It is understood, however, that Riley intends returning to the place at any time. It appears that he erected portion of it at his own expense and effected various improvements to the Reserve. He also intends wire netting the area. Under the circumstances, it would appear to be an injustice to deprive him of the building*..." (State Archives and Records 2022c).	• Archaeological potential at southern side of Tonalli Cove on the Wollondilly River • Likely to contain PADs and evidence of contact era and historical occupation
In October 1890, regarding Aboriginal Reserve No.10159, the APB noted: "*Situated about 26 miles distant from both Picton & Camden. Frontage to Wollondilly River. Open country but scrubby & mountainous at the back. Well grassed, and most suitable for grazing purposes. Boundary fences of farmers adjoining on both sides, mountains at the back which form a natural fence, front part open on to the Wollondilly. About 6 acres cleared but not fit for cultivation as there are too many rocks. Unoccupied. No buildings on reserve. Aborigines* [sic] *state they object to live on this Reserve on account of the difficulty to get to the river for water, the bank of the river is very steep*" (State Archives and Records 2022d).	• Archaeological potential on the northern side of the Kooloo Creek, Higgins Creek and Wollondilly River junction • Likely to contain evidence of historical occupation • Low potential for PADs given difficulty in river access, rocky soil and terrain
In March 1892, regarding Aboriginal Reserve No. 14937, the APB noted: "*A family of half-castes* [sic] *(Sherritt) intend occupying Reserve. They propose fencing and cultivating a portion, using the remainder for grazing purposes*" (State Archives and Records 2022e).	• Archaeological potential along the Wollondilly River near Colemans Bend • Likely to contain PADs and evidence of historical occupation

Ethnographic information	Archaeological implications
In 1878, regarding St Joseph's School Reserve (St Joseph's Farm), Father Dillon was quoted: *"During the year 1877 the aboriginal* [sic] *tribe of Burragorang, numbering sixty souls, has been settled upon the farm of St. Joseph"* (Australian Town and Country Journal 1878:39).	• Archaeological potential on the north bank of the Coxs River at its junction with Pocket Creek and just above the junction of the Coxs and Wollondilly Rivers • Likely to contain PADs and evidence of historical occupation

Table adapted from information presented in the Aboriginal Cultural Heritage Assessment Report (Waters Consultancy 2021).

6.4 Updated predictions for expected sites within Project area

6.4.1 Understanding of archaeological landscape and expected site types

For a more detailed discussion of the archaeological context see the original AR (Appendix 1: Archaeological Report; Niche 2021). The Project area falls within the Blue Mountains Plateau and the Hawkesbury and Nepean River systems, which include the Coxs River and Wollondilly River systems. This area has been of archaeological focus for some time due to the high frequency of sandstone rockshelters. Over the past few decades there has been a large number of archaeological investigations across the Cumberland Plain generated by the urban development of the area. Past investigations have been aimed at understanding the history and behaviour of past Aboriginal use and occupation in the region. These large data sets have enabled analysis of past spatial and occupational patterns of Aboriginal groups in the region.

While there is early evidence that the Sydney region has been occupied for over 36,000 years (Williams et al. 2014), archaeological research indicates the earliest evidence for occupation in the eastern Blue Mountains is 12,000 years Before Present (BP) from Walls cave, Lyre Bird dell and Kings Table. The earliest date recorded at Kings Table of 22,000 years BP has been rejected due to a lack of clarity on associated taphonomic processes (Johnson 1979). Previous researchers have indicated that the occupation of these shelters is around 12,000 years BP and was consistent with a pattern of earlier but not very intensive occupation. Occupation evidence continues to be sporadic up until about 5000-4500 BP where an increasing and continued use of shelters has been identified (Attenbrow 1981).

The distribution of site types and features is directly related to the bedrock formation and topographic features of a particular environment. Site types and features already known to occur within the Project area include Artefact sites (including Open Camp Sites and Isolated Finds), Axe Grinding Grooves, Rockshelters site (sometimes with multiple features including art, grinding grooves, artefacts, PADs, multiple features) PADs (in open air and closed shelter contexts), Scarred Trees, Engravings, Stone Arrangements, Water Holes, Aboriginal Resource and Gathering and Aboriginal Ceremony and Dreaming.

Based on and analysis of the spatial distribution of known Aboriginal heritage sites / features in relation to the ASDST predictive mapping (refer to Section 6.3.1) the following predictions were made regarding expected site types/ features:

- The spatial patterning of known sites with Artefacts is largely reflective of the survey coverage. It is therefore expected that a similar frequency of Artefact sites will be present in unsurveyed areas across the entire Project area.

* It is likely that additional Rock art sites may be present in unsurveyed areas within the Project area particularly on the western side of the Lake Zone of Lake Burragarang between Tonalli River Cove, Higgins Bay and Jerry O'leary Point to the north.
* The limited number of known burials sites (n=5) with the Project area means that it is not possible to develop specific predictions relating to the potential location of previously unknown burial sites. These site types therefore may occur across the Project area.
* It is likely that additional Grinding groove sites may be present in unsurveyed areas within the Project area particularly in association with the Coxs River Arm and Kedumba River and their tributaries.
* The paucity of Stone quarries within the Project area does not appear to be the result of survey coverage. Areas within the Project area associated with the highest likelihood of containing Stone quarries such as in association with (Butchers Arm and a small section on the western side of the Coxs River Arm near Fletchers Lookout within the north-western portion of the Project area) were extensively surveyed during the ACHA. While additional Stone quarries may be present within the Project area, the likelihood is considered low.
* Like Artefact sites, the spatial patterning of Scarred trees is somewhat reflective of the survey coverage. It is therefore expected that additional Scarred tree sites may be present in unsurveyed areas across the entire Project area.
* Sites may be associated with PAD, and it is expected that the proportion of sites with PAD will be dependent upon the character of the local context including but not limited to slope, soil landscape unit and levels of past disturbance.

These expectations can be used to generate an understanding of expected site types in previously unsurveyed areas and/or areas affected by low visibility as well as guide the development of any future survey strategies/ programs that may be undertaken within the Project area as part of the future management of the area (see Recommendations section of report). Based on the above, it is expected that the unsurveyed area within the Project area is likely to contain a similar level of Aboriginal objects, scientific and cultural significance as those areas that have been surveyed.

6.4.2 Archaeological landscape predictions for Project area

Section 10.10.1 of the original AR presented predictions relating to the expected number of sites to occur within the Project area in unsurveyed areas and areas affected by low-visibility. Survey results were analysed with reference to the soil landscapes to enable a prediction of the total number of sites likely to occur within the EUIA, PUIA and within the PMF with Project. The survey results used for the predictive analysis were the results in their entirety, comprising the results from within and beyond the Project area. The predictive analysis was based on extrapolating the results of the survey across the entirety of the EUIA, PUIA and Above PUIA by defining a ratio of hectares per site. The analysis was constrained to open sites and rockshelter sites only, as there were not enough representative numbers of other sites (such as scarred trees, for example) to make predictions at this landscape level. Nevertheless, the less frequently recorded sites should be expected to occur in proportionate numbers across the Project area.

Based on a predictive archaeological landscape model, the original ACHA made the following predictions regarding archaeological sites: the PUIA is predicted to contain a total of 174 archaeological sites, comprised of 117 open sites with stone artefacts and 51 rockshelter sites and at least 3 other site types. The EUIA is predicted to contain 578 archaeological sites, again comprising mostly of open sites, at a predicted 458 open sites and 109 rockshelter sites and at least 11 other sites. Outside the EUIA and above the PUIA, in the zone of very low risk from the Project, there are predicted to be 370 archaeological sites. Outside the EUIA and above the PUIA, in the zone of very low risk from the project, there are predicted to be 370 archaeological sites.

In addition to the open sites and rockshelters all of the areas may also contain, in similar proportions to their known site occurrence, scarred trees, waterholes, resource and gathering and ceremony and dreaming sites (see also Project CVA; Waters Consultancy 2021).

A number of submissions pointed out that it is likely that site numbers have been underestimated and the effective survey coverage is significantly less than the 33 percent survey coverage stated. It is important to note, that the original ACHA did not state that effective survey coverage was 33% but rather 33% of the PUIA was investigated on foot as part of the surveys completed for the Project. Visibility, exposure, and effective survey coverage data has been provided in Section of this supplementary assessment. The result of this demonstrates that visibility was not a limiting factor in some of survey contexts such as the extensive survey conducted below FSL where exposure and visibility were at ~100%. Nevertheless, the limited visibility in some areas of the Project area suggests that the evidence of Aboriginal occupation within the Project area is likely to be many times that indicated by the survey results.

This supplementary assessment has included additional predictive modelling to assist in developing understandings of areas likely to contain certain archaeological site types and features. However, in the absence of a more accurate approach to generating predictions regarding the site and feature numbers across the Project area in unsurveyed areas and areas affected by poor visibility, the result of the archaeological landscape predictions generated in the original ACHA are considered adequate, even if just to emphasise that evidence of Aboriginal occupation within the Project area is likely to be many times that indicated by the survey results. For this reason, no updates to the original predictions are made in this supplementary assessment, a summary of which is provided in Table 59.

Table 59: Summary of archaeological landscape predictions presented in Original ACHA

Soil Landscape	EUIA[1]		PUIA		Above PUIA	
	Open sites	Rockshelters	Open sites	Rockshelters	Open sites	Rockshelters
Barralier	*0*	*0*	*0*	*0*	*0*	*0*
Cedar Valley	*5*	*3*	*7*	*6*	*20*	*11*
Coxs River	*0*	*0*	*2*	*0*	*13*	*0*
Emu Island	*4*	*0*	*0*	*0*	*0*	*0*
Faulconbridge	*0*	*0*	*0*	*0*	*0*	*0*
Gymea	*0*	*0*	*0*	*0*	*0*	*0*
Hassans Walls	*34*	*3*	*41*	*5*	*89*	*8*
Hawkesbury	*0*	*0*	*0*	*3*	*0*	*1*
Horse Flat	*0*	*0*	*0*	*0*	*0*	*0*
Jooriland Range	*1*	*0*	*3*	*1*	*13*	*1*
Kanangra Gorge	*9*	*4*	*13*	*5*	*47*	*23*
Kedumba	*7*	*2*	*12*	*7*	*24*	*8*
Martins Flat	*7*	*1*	*14*	*3*	*28*	*5*

Soil Landscape	EUIA[1]		PUIA		Above PUIA	
	Open sites	Rockshelters	Open sites	Rockshelters	Open sites	Rockshelters
Martins Flat variant a	*7*	*1*	*13*	*2*	*25*	*2*
Round Mount	*6*	*3*	*8*	*8*	*20*	*9*
Warragamba	*0*	*4*	*0*	*4*	*0*	*9*
Water[2]	*377*	*88*	*2*	*7*	*3*	*1*
Wollondilly River	*1*	*0*	*2*	*0*	*4*	*0*
Summary:	***EUIA***		***PUIA***		***Above PUIA***	
Total (includes known sites)[3]	458	109	117	51	285	80
Other known archaeological site types	11		6		5	
Archaeological site prediction for area (includes known sites)	**578**		**174**		**370**	

[1] This prediction includes the area below FSL, hence the large number of predicted sites
[2] This is because the soil mapping for the area has some areas within the PUIA mapped as "Water"
[3] The model generates decimal numbers and these figures and those above have been rounded from the original results

6.5 Identification of potential research questions

A number of submissions noted that the significance assessment process must consider the potential of a site to contribute to understandings of the archaeology of the region and that this requires an acknowledgment of key research questions. In relation to mitigation and management of Aboriginal heritage, it is further recognised that, should archaeological salvage be required, such programs must be guided by a productive research design to ensure that high-quality data is collected and as much information is obtained from the site as possible. An essential part of this will be the establishment of clear and well-defined research questions to guide the approach to collecting data. The variety of landscapes and associated cultural sites make the Project area ideal for research. As recognised in the GBMA Strategic Plan, large gaps in knowledge remain, especially regarding Aboriginal use and occupation of the area (DECC 2009: 16). Table 60 outlines some specific research questions that may be used for the current Project. While the research questions are framed in relation to specific site/assemblages, the same questions can be expanded to consider the Project area as while. The specific research questions for the Project would be finalised in consultation with RAPs during the developed of the ACHMP.

Table 60: Site specific research questions for the Project area

Category	Questions
Chronology of past occupation	• When was the site, and thus Project area, occupied? • Was the assemblage/site the product of single occupation episode or repeated occupation? • At sites associated with sub-surface deposits, is there evidence of temporal changes in stone technology? • How intensive was the occupation? • Is there potential for the preservation of Pleistocene occupation?
Stone artefact technology (Lithic procurement/ sourcing & stone	• Which raw material resources were used? • What types of raw material sources were used (primary and secondary)? • Does a preference for a raw material occur?

Category	Questions
reduction methods and technology)	• At sites associated with sub-surface deposits, is there evidence of temporal changes raw material type preferences? • Can we infer the distance from the sources based on artefact size, frequency and amount of cortex (i.e. distance-decay)? • How were cores prepared and worked? • Were systematic core reduction strategies employed? • What types of tools were manufactured? • Is there evidence of trade of raw materials? • Can any artefacts be linked back to the known quarry site (Butchers Arm #1; AHIMS ID# 45-4-0193)?
Rock art	• How do the sites with rock art fit within current understanding of regional patterning in Rock Art?
Spatial patterning and activities	• What types of activities occurred on-site/s (i.e. artefact manufacture, maintenance, use, ceremonial activities, axe grinding, art making)? • Do discrete areas of stone working occur (i.e. knapping floors)? • Can artefact distribution be related to environmental factors (i.e. distance to water, slope and environmental context)? • Is there spatially patterning in the types of behaviour/activities (i.e. domestic activities versus ceremonial activities) that occur within the broader landscape of the Project area as has been identified in other areas of eastern NSW (e.g. East Leppington; GML 2016)? • Can the movement of raw material and/or artefact types (such as axes) be tracked across the landscape of the Project area?
Regional comparisons	• How does this site compare with others in the surrounding region?

7. Cultural heritage values and statement of significance

7.1 Introduction

The original cultural heritage values and statement of significance for the Project was presented in Section 8 of the original ACHA while the detailed scientific (archaeological) significance assessment of Aboriginal archaeological site was presented in Annex 5 of the original AR. The information contained within these original chapters, including an outline of the approach taken to assess significance, is still relevant to the current Project and is therefore not repeated below. The submissions process, however, highlighted some issues with significance assessment process specifically relating to the acknowledge of cultural heritage values and/or the assessment of scientific (archaeological) significance thus requiring re-consideration and update in this supplementary assessment. This section therefore provides a review and update of the scientific (archaeological) significance for some sites, cultural heritage values and statement of significance based on the result from the original ACHA, and an analysis and consideration of additional key variables as detailed below.

7.2 Archaeological values and significance of Aboriginal heritage sites

The original scientific (archaeological) significance of Aboriginal sites within the Project area was presented in Annex 5 of the original AR. The AR assessed the scientific significance of each individual site covered by the project, using the principles set out in the Burra Charter and the framework provided in the Aboriginal Cultural Heritage Standards and Guidelines Kit (NSW NPWS 1997). A number of submissions received during the public exhibition of the ACHA identified concerns regarding the significance assessment process. In relation to the assessment of archaeological values and significance, concerns were raised relating to the limited consideration of PADs, visibility, number of features, and potential to contribute to research questions. The following sections provide clarification regarding how these aspects were (or were not) considered in the original assessment process and thus how they have/or have not been considered in the updated significance assessment presented below.

7.2.1 Consideration of PADs and/or visibility

A review of details presented in the original ACHA and/or data contained in the original recording forms associated with each site identified that:

- Visibility and exposure levels associated with each site were considered during the original assessment and comments made regarding whether or not a site may be associated with additional artefacts and/or features despite low visibility at the time of its recording. Thus, a site with a low artefact count and low visibility may still have higher significance rating due to the likely potential for further artefacts and/or features to be present.
- In contrast, while the potential for archaeological deposits was considered during the recording of some sites during the recording process, the presence/absence of this archaeological feature was not explicitly made clear in the original ACHA when describing/classifying site types. It is therefore agreed that the original ACHA included limited consideration of PADs particularly in association with sites in open contexts and that this thus requires consideration.

To address this issue, PAD sensitivity predictive modelling has been developed for the Project and applied to known sites with the result presented in Section 6.3.2 of this supplementary assessment. As a result of this, a total of thirty-two (32) Artefact sites (Open Camp Sites or Isolated Finds) are now predicted to be associated with PAD. This section therefore provides a review and update of this original scientific significance assessment based on a consideration of whether the site likely contains potential archaeological deposits (PAD) based on the updated PAD predictions presented in Section 5.4 and 6.3.2 of this report. It is acknowledged that, without having completed sub-surface testing, the nature and significance of any PADs remains unknown. However, for the purpose of the updated significance assessment, all sites with PADs are treated as being of at least moderate significance until proved otherwise. This is consistent with scientific significant assessment approaches where sub-surface testing has not yet occurred (e.g. Brayshaw 1988).

7.2.2 Number of features and/or potential to address research questions

The number of features associated with a site was considered in the significance assessment process for the original ACHA as described in the AR which stated:

> *"…for the sites identified during this assessment the number of objects/and or art motif type and number and diversity of motifs was considered in the determination of significance for each site.*
>
> *…scientific (archaeological) significance was also determined by evaluating the research potential of each Aboriginal cultural heritage site, and what the artefacts, or Potential Archaeological Deposit (PAD), art assemblage or other archaeological features could potentially indicate to future researchers with regard to how Aboriginal people lived within the landscape of Lake Burragorang.*
>
> *Isolated Artefacts, individual or low numbers of axe grinding grooves and instances where art was charcoal indeterminate and where the artefacts, features or art had no distinctiveness or uniqueness, were given a low scientific (archaeological) significance rating due to the limitation of further scientific information being gleaned from these sites.*
>
> *Aboriginal cultural heritage sites comprising of high numbers of axe grinding grooves, artefacts in high numbers and densities and assemblages of art with high numbers of well-preserved motifs and/or a diversity of motifs, media and application techniques were given a moderate to high scientific (archaeological) significance rating due to the ability of future research to be carried out in regard to artefact development and site use over time. Likewise, sites that comprised of multiple site features (a shelter with art, deposit and grinding grooves, for example) and characteristics such as shelters with undisturbed deposit, high density artefact scatters, axe grinding grooves and art that has been layered indicating extended use of the site over a longer period of time, that has also been well preserved through environmental processes were also given a high (archaeological) significance assessment due to the further understanding they would provide to future researchers. It should be noted that in some cases, such as a hatchet with hafting resin still present, or an artefact with distinctive use-wear, or a particularly unique art motif individual or isolated features can be of high or moderate scientific significance." (AR, pg. 112-113).*

As these aspects were considered in the original scientific (archaeological) significance process, no further consideration is required in terms of the updated significance assessment presented below.

7.2.3 Updates to the scientific (archaeological) significance of sites with PAD

An overview of the scientific significance assessment of all sites is presented in Table 61 below. The scientific significance assessment of sites with PAD / Deposit were reviewed and rating updated where applicable. The review considered the updated predictive modelling and assessment presented in this supplementary assessment as well as a review of information contained on the original recording forms. Sites whose scientific significance rating have been updated based on this review, are shaded in darker grey and a justification for any changes to scientific significance rating provided where applicable. Please note that, for some sites where PAD is now recorded as a feature of the site, the assessed significance rating was unchanged as the original assessment noted the potential for PAD at the site contributing to its significance rating (despite PAD not being acknowledged as a site feature during the original assessment and site classification). Similarly, some Shelter sites with Deposit are still associated with a low scientific significance rating where it has been recorded that the deposit was very shallow, small in spatial extent and, in some instances, highly disturbed. It is important to note that the scientific significance rating for any sites with PAD / Deposit are **provisional only** and may be updated based on the results of any future investigation (i.e. test excavation).

The detailed scientific significance assessments and statements of significance for each updated site are presented in Appendix 7 of this supplementary assessment. For the scientific significance assessments and statements of significance for all other sites (where no updates to the significance assessments were required) are presented in Annex 5 of the original AR.

Table 61: Scientific significance ratings of Aboriginal cultural heritage sites

AHIMS ID	Site Name	Site Type	Scientific significance	Justification for updates (where applicable)
45-4-0186	Policeman's Point	Shelter with Deposit, Artefacts and Axe Grinding Grooves	High	NA
45-4-0187	Kedumba; Kedumba Crossing	Open Camp Site	High	NA
45-4-0191	Grahams Landing	Open Camp Site	High	NA
45-4-0930	CA 1; Warragamba Dam Special Area	Open Camp Site	High	NA
45-4-0931	EH 1; Warragamba Special Area	Open Camp Site	High	NA
45-4-0946	TR 1	Open Camp Site	High	NA
45-4-0948	GW5	Open Camp Site	High	NA
45-4-0966	Ashtons 1	Axe Grinding Grooves	High	NA
45-4-0967	RC1	Open Camp Site	High	NA
45-4-0983	JUNCTION POINT 1	Open Camp Site	High	NA
45-4-0997	Bimlow PAD / Warragamba-190	Shelter with Art, Axe Grinding Grooves, and Artefacts	High	NA
52-1-0045	Jooriland Creek, Upper Burragorang	Axe Grinding Grooves	High	NA
52-1-0126	Little River 1	Open Camp Site	Low	NA
52-1-0127	Little River 2	Open Camp Site	Low	NA
52-1-0128	Little River 3	Open Camp Site	High	NA
52-1-0130	Tonalli Cove 1	Open Camp Site	High	NA
52-1-0131	Tonalli Cove 2	Scarred Tree	Low	NA
52-1-0133	Tonalli Cove 4	Open Camp Site	High	NA
52-1-0136	Green Wattle Point	Open Camp Site	High	NA
52-1-0141	Upper Wollondilly 2	Open Camp Site	High	NA
52-1-0142	Kamilaroi Point	Shelter with Art and Deposit	High	NA

AHIMS ID	Site Name	Site Type	Scientific significance	Justification for updates (where applicable)
52-1-0168	Joorilands Farm 1	Open Camp Site with Scarred Tree	High	NA
52-1-0170	Joorilands Farm 2	Open Camp Site with Axe Grinding Grooves and Scarred Tree	High	NA
52-1-0171	Joorilands Farm 3	Scarred Tree	High	NA
52-1-0178	MF1	Shelter with Deposit	Low	No change as deposit is shallow (10-15 cm)
52-1-0186	W223, Byrnes Creek	Open Camp Site	High	NA
52-1-0236	Burra Lake Flake 1	Open Camp Site	High	NA
52-1-0332	Byrnes Bay OS-1	Open Camp Site	High	NA
52-1-0345	Green Wattle Point OS-1	Open Camp Site	High	NA
52-1-0346	Joorilands OS-1	Open Camp Site	High	NA
52-1-0352	Tonalli OS-1	Open Camp Site	High	NA
45-4-0941	Apple Tree Flat 1	Open Camp Site	High	NA
52-1-0137	Bridge Point 1	Open Camp Site	Low	NA
52-1-0008	Byrnes Creek	Rock Engraving	High	NA
45-4-0944	GW1	Open Camp Site	Low	NA
45-4-0945	Gw2	Open Camp Site	Low	NA
52-1-0175	MF4, Murphy's Flat	Open Camp Site	Low	NA
52-1-0298	Orange Tree Flat - Isolated find 01	Open Camp Site	Low	NA
Pending	Warragamba-00	Open Camp Site with PAD	Moderate	Updated from Low to Moderate due to PAD
Pending	Warragamba-01	Open Camp Site with PAD	Moderate	Updated from Low to Moderate due to PAD
Pending	Warragamba-02	Open Camp Site	Low	NA
Pending	Warragamba-03	Open Camp Site	Low	NA
Pending	Warragamba-05	Aboriginal Resource and Gathering	Low	NA
Pending	Warragamba-06	Open Camp Site	Low	NA
Pending	Warragamba-07	Open Camp Site	Low	NA
Pending	Warragamba-08	Open Camp Site	Low	NA
Pending	Warragamba-09	Open Camp Site	Low	NA
Pending	Warragamba-10	Shelter with Deposit	Moderate	NA
Pending	Warragamba-11	Shelter with Deposit	Low	No change as deposit is shallow and disturbed from wombat activity. Most of the shelter considered to small / shallow for occupation.
Pending	Warragamba-12	Open Camp Site with PAD	Moderate	Updated from Low to Moderate due to PAD
Pending	Warragamba-13	Isolated Artefact	Low	NA
Pending	Warragamba-14	Open Camp Site	Low	NA
Pending	Warragamba-15	Open Camp Site	Moderate	NA

AHIMS ID	Site Name	Site Type	Scientific significance	Justification for updates (where applicable)
Pending	Warragamba-16	Shelter with Art and Artefacts	Low	NA
Pending	Warragamba-17	Open Camp Site	Low	NA
Pending	Warragamba-18	Open Camp Site with PAD	Moderate	Updated from Low to Moderate due to PAD
Pending	Warragamba-19	Open Camp Site	Low	NA
Pending	Warragamba-20	Open Camp Site	Low	NA
Pending	Warragamba-21	Open Camp Site	Low	NA
Pending	Warragamba-22	Open Camp Site	Moderate	NA
Pending	Warragamba-23	Open Camp Site	Low	NA
Pending	Warragamba-24	Open Camp Site	Low	NA
Pending	Warragamba-25	Open Camp Site	Low	NA
Pending	Warragamba-26	Open Camp Site	Low	NA
Pending	Warragamba-27	Open Camp Site with PAD	Moderate	Updated from Low to Moderate due to PAD
Pending	Warragamba-28	Open Camp Site	Low	NA
Pending	Warragamba-29	Open Camp Site	Low	NA
Pending	Warragamba-30	Open Camp Site	Low	NA
Pending	Warragamba-31	Shelter with Deposit and Artefacts	Low	No change as deposit very small and/or shallow
Pending	Warragamba-32	Open Camp Site	Low	NA
Pending	Warragamba-33	Open Camp Site	Low	NA
Pending	Warragamba-34	Open Camp Site	Low	NA
Pending	Warragamba-35	Open Camp Site	Low	NA
Pending	Warragamba-36	Open Camp Site	Low	NA
Pending	Warragamba-37	Open Camp Site	Low	NA
Pending	Warragamba-38	Open Camp Site	Moderate	NA
Pending	Warragamba-39	Open Camp Site with PAD	High	No update required as PAD considered in original assessment
Pending	Warragamba-40	Open Camp Site with PAD	High	No update required as PAD considered in original assessment
Pending	Warragamba-41	Open Camp Site	Low	NA
Pending	Warragamba-42	Open Camp Site	Low	NA
Pending	Warragamba-43	Open Camp Site	Low	NA
Pending	Warragamba-44	Open Camp Site	Low	NA
Pending	Warragamba-45	Open Camp Site	Low	NA
Pending	Warragamba-46	Shelter with Deposit and Artefacts	Low	No change as deposit is small in extent, shallow, eroding and disturbed from wombat activity.
Pending	Warragamba-47	Open Camp Site	Low	NA
Pending	Warragamba-48	Open Camp Site with PAD	High	No update required as PAD considered in original assessment
Pending	Warragamba-49	Open Camp Site	Low	NA
Pending	Warragamba-50	Open Camp Site	Low	NA

AHIMS ID	Site Name	Site Type	Scientific significance	Justification for updates (where applicable)
Pending	Warragamba-51	Open Camp Site	Low	NA
Pending	Warragamba-52	Open Camp Site	Low	NA
Pending	Warragamba-53	Open Camp Site	Low	NA
Pending	Warragamba-54	Open Camp Site	Low	NA
Pending	Warragamba-55	Shelter with Deposit and Artefacts	Low	No change as deposit is eroding out of drip line.
Pending	Warragamba-56	Shelter with Deposit and Artefacts	Low	No change as deposit is eroding, steep at dripline and disturbed from wombat / kangaroo activity.
Pending	Warragamba-57	Shelter with Deposit and Artefacts	Low	No change as deposit has been heavily disturbed by a wombat burrowing and low potential for additional artefacts.
Pending	Warragamba-58	Shelter with Deposit and Artefacts	Low	No change as deposit has been heavily disturbed by a wombat burrowing and low potential for additional artefacts.
Pending	Warragamba-59	Open Camp Site	Low	NA
Pending	Warragamba-60	Shelter with Art and Deposit	Low	No change as the deposit was identified eroding down the slope with minimal deposit remaining in the shelter.
Pending	Warragamba-61	Shelter with Art, Deposit and Artefacts	Low	No change as shelter flood mostly comprises of bedrock. The little deposit was observed eroding downslope from shelter floor.
Pending	Warragamba-62	Shelter with Art and Deposit and Artefacts	Low	No change as the deposit was identified eroding down the slope with minimal deposit remaining in the shelter.
Pending	Warragamba-63	Water hole	Moderate	NA
Pending	Warragamba-64	Isolated Artefact	Low	NA
Pending	Warragamba-65	Open Camp Site	Low	NA
Pending	Warragamba-66	Open Camp Site	Low	NA
Pending	Warragamba-67	Open Camp Site	Low	NA
Pending	Warragamba-68	Open Camp Site	Low	NA
Pending	Warragamba-69	Open Camp Site	Low	NA
Pending	Warragamba-70	Open Camp Site	Low	NA
Pending	Warragamba-71	Open Camp Site	Low	NA
Pending	Warragamba-72	Open Camp Site with PAD	Moderate	Updated from Low to Moderate due to PAD
Pending	Warragamba-73	Isolated Artefact	Low	NA
Pending	Warragamba-74	Water hole and Aboriginal Ceremony and Dreaming	High	NA
Pending	Warragamba-75	Aboriginal Resource and Gathering	High	NA
Pending	Warragamba-76	Scarred Tree	Low	NA

AHIMS ID	Site Name	Site Type	Scientific significance	Justification for updates (where applicable)
Pending	Warragamba-77	Isolated Artefact with PAD	Moderate	Updated from Low to Moderate due to PAD and potential for additional surface artefacts due to low visibility
Pending	Warragamba-78	Isolated Artefact	Low	NA
Pending	Warragamba-79	Open Camp Site with Scarred Tree	Low	NA
Pending	Warragamba-80	Stone Arrangement	Low	NA
Pending	Warragamba-81	Open Camp Site	Low	NA
Pending	Warragamba-82	Open Camp Site	Low	NA
Pending	Warragamba-83	Axe Grinding Grooves	Low	NA
Pending	Warragamba-84	Shelter with Deposit and Artefacts	Low	No change as shelter floor predominantly sandstone (i.e., very little deposit)
Pending	Warragamba-85	Open Camp Site	Low	NA
Pending	Warragamba-86	Open Camp Site	Low	NA
Pending	Warragamba-88	Isolated Artefact	Moderate	NA
Pending	Warragamba-89	Open Camp Site	Low	NA
Pending	Warragamba-90	Isolated Artefact	Low	NA
Pending	Warragamba-91	Scarred Tree	Low	NA
Pending	Warragamba-92	Stone Arrangement	Low	NA
Pending	Warragamba-93	Open Camp Site	Low	NA
Pending	Warragamba-94	Open Camp Site with PAD	High	Updated from Moderate to High due to PAD associated with extensive scatter
Pending	Warragamba-95	Open Camp Site	Low	NA
Pending	Warragamba-96	Open Camp Site with PAD	Moderate	Updated from Low to Moderate due to PAD and potential for additional surface artefacts due to low visibility
Pending	Warragamba-97	Open Camp Site	Low	NA
Pending	Warragamba-98	Open Camp Site	Low	NA
Pending	Warragamba-99	Open Camp Site	Low	NA
Pending	Warragamba-100	Open Camp Site	Low	NA
Pending	Warragamba-101	Isolated Artefact with PAD	Moderate	No update required as PAD and potential for additional surface artefacts due to low visibility considered in original assessment
Pending	Warragamba-102	Isolated Artefact with PAD	Moderate	Updated from Low to Moderate due to PAD and potential for additional surface artefacts due to low visibility
Pending	Warragamba-103	Isolated Artefact	Low	NA
Pending	Warragamba-104	Shelter with Deposit and Artefacts	Low	NA
Pending	Warragamba-105	Open Camp Site	Low	NA
Pending	Warragamba-106	Open Camp Site	Low	NA
Pending	Warragamba-107	Open Camp Site	Moderate	NA

AHIMS ID	Site Name	Site Type	Scientific significance	Justification for updates (where applicable)
Pending	Warragamba-108	Isolated Artefact	Low	NA
Pending	Warragamba-109	Open Camp Site with PAD	High	No update required as PAD considered in original assessment
Pending	Warragamba-110	Open Camp Site with PAD	High	No update required as PAD considered in original assessment
Pending	Warragamba-111	Open Camp Site	Moderate	NA
Pending	Warragamba-112	Shelter with Deposit and Artefacts	Moderate	Updated from Low to Moderate due to good sandy deposit with the potential to contain further evidence of occupation on eastern side of Kedumba waterhole
Pending	Warragamba-113	Shelter with Art, Deposit, Artefacts and Axe Grinding Grooves	Moderate	Updated from Low to Moderate due to flat sandy deposit with the potential to contain further evidence of occupation
Pending	Warragamba-114	Axe Grinding Grooves	Moderate	NA
Pending	Warragamba-115	Shelter with Art, Deposit and Artefacts	Low	No change as deposit eroding downslope.
Pending	Warragamba-117	Open Camp Site	Low	NA
Pending	Warragamba-118	Open Camp Site	Low	NA
Pending	Warragamba-119	Open Camp Site	Low	NA
Pending	Warragamba-121	Isolated Artefact	Low	NA
Pending	Warragamba-122	Open Camp Site	Low	NA
Pending	Warragamba-123	Open Camp Site	Moderate	NA
Pending	Warragamba-124	Open Camp Site	Low	NA
Pending	Warragamba-125	Isolated Artefact	Low	NA
Pending	Warragamba-126	Isolated Artefact	Low	NA
Pending	Warragamba-127	Open Camp Site	Low	NA
Pending	Warragamba-128	Open Camp Site	Low	NA
Pending	Warragamba-129	Open Camp Site	Low	NA
Pending	Warragamba-130	Isolated Artefact	Low	NA
Pending	Warragamba-131	Shelter with Art, Deposit, and Isolated Artefact	Low	No change due to the lack of intact deposit associated with these artefacts.
Pending	Warragamba-132	Shelter with Deposit and Artefacts	High	NA
Pending	Warragamba-133	Water Hole	High	NA
Pending	Warragamba-134	Isolated Artefact with PAD	Moderate	Updated from Low to Moderate due to PAD
Pending	Warragamba-135	Shelter with Deposit and Axe Grinding Grooves	Moderate	Updated from Low to Moderate due to large floor with sandy deposit and hearth material
Pending	Warragamba-136	Shelter with Deposit	Moderate	Updated from Low to Moderate due to large floor with sandy deposit and hearth material

AHIMS ID	Site Name	Site Type	Scientific significance	Justification for updates (where applicable)
Pending	Warragamba-137	Open Camp Site with PAD	High	Updated from Moderate to High due to PAD associated with extensive scatter
Pending	Warragamba-138	Open Camp Site with PAD	Moderate	Updated from Low to Moderate due to PAD
Pending	Warragamba-139	Open Camp Site	Low	
Pending	Warragamba-140	Open Camp Site	Low	
Pending	Warragamba-141	Open Camp Site	Low	
Pending	Warragamba-142	Open Camp Site	Low	
Pending	Warragamba-143	Isolated Artefact	Low	
Pending	Warragamba-144	Shelter with Art	Low	
Pending	Warragamba-145	Shelter with Art, Deposit and Artefacts	Low	No change as deposit is of Morle-Boc
Pending	Warragamba-146	Open Camp Site	Low	
Pending	Warragamba-147	Open Camp Site with PAD	Moderate	Updated from Low to Moderate due to PAD
Pending	Warragamba-148	Open Camp Site with PAD	Moderate	Updated from Low to Moderate due to PAD
Pending	Warragamba-149	Shelter with Deposit and Artefacts	Low	No change as deposit eroding downslope with low potential for additional artefacts.
Pending	Warragamba-150	Open Camp Site with PAD	Moderate	Updated from Low to Moderate due to PAD
Pending	Warragamba-151	Open Camp Site with Scarred Tree	Low	NA
Pending	Warragamba-152	Open Camp Site	Low	NA
Pending	Warragamba-153	Scarred Tree	Low	NA
Pending	Warragamba-154	Open Camp Site	Low	NA
Pending	Warragamba-155	Open Camp Site with PAD	Moderate	Updated from Low to Moderate due to PAD
Pending	Warragamba-156	Open Camp Site with PAD	High	Updated to High due to PAD in association with extensive artefact scatter
Pending	Warragamba-157	Open Camp Site	Moderate	NA
Pending	Warragamba-158	Open Camp Site	Low	NA
Pending	Warragamba-159	Open Camp Site	Low	NA
Pending	Warragamba-160	Open Camp Site	Low	NA
Pending	Warragamba-161	Open Camp Site	Low	NA
Pending	Warragamba-162	Isolated Artefact	Low	NA
Pending	Warragamba-163	Open Camp Site	Low	NA
Pending	Warragamba-164	Open Camp Site	Low	NA
Pending	Warragamba-165	Shelter with Deposit and Artefacts	Moderate	Updated from Low to Moderate due to relatively un-disturbed deposit in dripline and association with at least 11 artefacts
Pending	Warragamba-166	Open Camp Site	Low	NA

AHIMS ID	Site Name	Site Type	Scientific significance	Justification for updates (where applicable)
Pending	Warragamba-167	Open Camp Site	Moderate	NA
Pending	Warragamba-168	Open Camp Site with Scarred Tree	Low	NA
Pending	Warragamba-169	Open Camp Site	Low	NA
Pending	Warragamba-170	Open Camp Site	Low	NA
Pending	Warragamba-171	Open Camp Site	Low	NA
Pending	Warragamba-172	Open Camp Site	Low	NA
Pending	Warragamba-173	Open Camp Site	Low	NA
Pending	Warragamba-174	Open Camp Site	Low	NA
Pending	Warragamba-175	Open Camp Site	Low	NA
Pending	Warragamba-176	Open Camp Site	Low	NA
Pending	Warragamba-177	Open Camp Site	Low	NA
Pending	Warragamba-178	Open Camp Site	Low	NA
Pending	Warragamba-179	Aboriginal Resource and Gathering	Low	NA
Pending	Warragamba-180	Open Camp Site	Low	NA
Pending	Warragamba-181	Shelter with Art, Deposit, Artefacts and Axe Grinding Grooves	Low	No change as deposit and artefacts eroding downslope with low potential for additional artefacts due to disturbance
Pending	Warragamba-182	Shelter with Art, Deposit and Artefacts	Moderate	Updated from Low to Moderate due to deposit, possible in-situ hearth with visible charcoal and artefacts
Pending	Warragamba-183	Isolated Artefact	Low	NA
Pending	Warragamba-184	Open Camp Site	Low	NA
Pending	Warragamba-185	Open Camp Site	Low	NA
Pending	Warragamba-186	Open Camp Site	Low	NA
Pending	Warragamba-187	Shelter with Deposit	Moderate	Updated from Low to Moderate due to yellow-brown sandy deposit, possibly deep
Pending	Warragamba-188	Open Camp Site	Low	NA
Pending	Warragamba-189	Open Camp Site	Low	NA
Pending	Warragamba-191	Open Camp Site with Axe Grinding Grooves and Isolated Artefact	High	NA
Pending	Warragamba-192	Shelter with Deposit	Moderate	Updated from Low to Moderate due to yellow-brown sandy deposit, possibly deep
Pending	Warragamba-193	Shelter with Art	Low	NA
Pending	Warragamba-194	Open Camp Site	Low	NA
Pending	Warragamba-195	Open Camp Site	Low	NA
Pending	Warragamba-196	Open Camp Site with Scarred Tree	Low	NA
Pending	Warragamba-197	Open Camp Site	Low	NA
Pending	Warragamba-198	Isolated Artefact	Low	NA

AHIMS ID	Site Name	Site Type	Scientific significance	Justification for updates (where applicable)
Pending	Warragamba-199	Open Camp Site with PAD	Moderate	Updated from Low to Moderate due to PAD
Pending	Warragamba-200	Shelter with Deposit and Artefacts	High	Updated to High due to relatively un-disturbed yellow sandy deposit associated with an estimated 200+ artefacts
Pending	Warragamba-201	Open Camp Site	Low	NA
Pending	Warragamba-202	Open Camp Site with PAD	Moderate	No update required as PAD considered in original assessment
Pending	Warragamba-203	Open Camp Site	Low	NA
Pending	Warragamba-204	Open Camp Site	Low	NA
Pending	Warragamba-205	Open Camp Site	Low	NA
Pending	Warragamba-206	Shelter with Deposit and Artefacts	Low	No change as shelter floor mostly bedrock, low ceiling with deposit/artefacts eroding downslope
Pending	Warragamba-207	Shelter with Axe Grinding Grooves and Deposit	Low	No change as shelter has sloping rock floor, deposit was eroding downslope
Pending	Warragamba-208	Shelter with Deposit and Artefacts	Low	No change as deposit stripped/eroding down slope due to previous inundation
Pending	Warragamba-209	Shelter with Art, Deposit and Artefacts	Low	No change as yellow sandy deposit eroding downslope
Pending	Warragamba-210	Open Camp Site	Low	NA
Pending	Warragamba-211	Shelter with Art, Deposit and Artefacts	High	Updated to High based on review of info on original site recording. Although shelter floor is largely sandstone bedrock, the area and deposit outside of and surrounding the shelter contains 'hundreds of artefacts'
Pending	Warragamba-212	Open Camp Site	Low	NA
Pending	Warragamba-213	Open Camp Site	Low	NA
Pending	Warragamba-214	Open Camp Site	Low	NA
Pending	Warragamba-215	Open Camp Site	Low	NA
Pending	Warragamba-216	Open Camp Site	Low	NA
Pending	Warragamba-217	Open Camp Site	Low	NA
Pending	Warragamba-218	Open Camp Site with Scarred Tree	Low	NA
Pending	Warragamba-219	Shelter with Axe Grinding Grooves, Deposit, and Isolated Artefact	Low	No change due to poor condition of deposit which has been heavily disturbed
Pending	Warragamba-220	Open Camp Site with Scarred Tree	Low	NA
Pending	Warragamba-221	Open Camp Site	Low	NA
Pending	Warragamba-222	Open Camp Site	Low	NA

AHIMS ID	Site Name	Site Type	Scientific significance	Justification for updates (where applicable)
Pending	Warragamba-223	Shelter with Art and Artefacts	Low	NA
Pending	Warragamba-224	Shelter with Deposit and Isolated Artefact	Low	No change due to poor condition of deposit eroding downslope
Pending	Warragamba-225	Shelter with Deposit and Artefacts	Moderate	Updated from Low to Moderate due to relatively undisturbed yellow deposit at western side of shelter
Pending	Warragamba-226	Aboriginal Ceremony and Dreaming	Low	NA
Pending	Warragamba-227	Open Camp Site	Low	NA
Pending	Warragamba-228	Axe Grinding Grooves	Low	NA
Pending	Warragamba-229	Open Camp Site with PAD	Moderate	Updated from Low to Moderate due to PAD
Pending	Warragamba-230	Open Camp Site	Low	NA
Pending	Warragamba-231	Open Camp Site	Low	NA
Pending	Warragamba-232	Open Camp Site	Moderate	NA
Pending	Warragamba-233	Aboriginal Resource and Gathering	Low	NA
Pending	Warragamba-234	Open Camp Site	Low	NA
Pending	Warragamba-235	Open Camp Site with PAD	Moderate	Updated from Low to Moderate due to PAD
Pending	Warragamba-236	Open Camp Site	Low	NA
Pending	Warragamba-237	Open Camp Site	Low	NA
Pending	Warragamba-238	Shelter with Deposit and Artefacts	Moderate	Updated from Low to Moderate due to good condition of undisturbed yellow sandy deposit
Pending	Warragamba-239	Shelter with Deposit and Isolated Artefact	Moderate	Updated from Low to Moderate due to hearth feature, artefacts and yellow, flat sandy deposit
Pending	Warragamba-240	Shelter with Art, Deposit, and Isolated Artefact	Moderate	Updated from Low to Moderate due to good deposit for excavation
Pending	Warragamba-241	Open Camp Site	Low	
Pending	Warragamba-242	Open Camp Site	Low	
Pending	Warragamba-243	Shelter with Art, Deposit and Artefacts	Moderate	Updated from Low to Moderate due to extensive hearth and deposit
Pending	Warragamba-244	Open Camp Site	Low	
Pending	Warragamba-245	Open Camp Site	Low	
Pending	Warragamba-246	Shelter with Deposit and Artefacts	Low	No change as red sandy deposit in poor condition due to disturbance from animal burrowing
Pending	Warragamba-247	Open Camp Site with PAD	Moderate	No update required as PAD considered in original assessment
Pending	Warragamba-248	Open Camp Site	Low	NA
Pending	Warragamba-249	Open Camp Site	Low	NA
Pending	Warragamba-250	Open Camp Site	Low	NA
Pending	Warragamba-251	Open Camp Site	Low	

AHIMS ID	Site Name	Site Type	Scientific significance	Justification for updates (where applicable)
Pending	Warragamba-252	Open Camp Site	Low	
Pending	Warragamba-253	Open Camp Site with PAD	Moderate	No update required as PAD considered in original assessment
Pending	Warragamba-254	Shelter with Art, Deposit, Artefacts and Axe Grinding Grooves	High	Updated from High due to orange/red sandy deposit and association with 10-100 artefacts
Pending	Warragamba-255	Open Camp Site	Moderate	NA
Pending	Warragamba-256	Open Camp Site	Low	NA
Pending	Warragamba-257	Shelter with Axe Grinding Grooves	Low	NA
Pending	Warragamba-258	Shelter with Artefacts and Axe Grinding Grooves	Low	NA
Pending	Warragamba-259	Shelter with Deposit, Artefacts, Axe Grinding Grooves, and Tool Marks	High	NA
Pending	Warragamba-260	Shelter with Isolated Artefact	Low	NA
Pending	Warragamba-261	Shelter with Deposit, Artefacts and Axe Grinding Grooves	Moderate	Updated from Low to Moderate due to presence of intact red/orange sandy deposit
Pending	Warragamba-262	Open Camp Site	Low	NA
Pending	Warragamba-263	Open Camp Site	Low	NA
Pending	Warragamba-264	Open Camp Site	Moderate	NA
Pending	Warragamba-265	Open Camp Site	Low	NA
Pending	Warragamba-266	Open Camp Site	Low	NA
Pending	Warragamba-267	Open Camp Site with Axe Grinding Grooves	Low	NA
Pending	Warragamba-268	Open Camp Site with PAD	Moderate	Updated from Low to Moderate due to PAD
Pending	Warragamba-269	Isolated Artefact	Low	NA
Pending	Warragamba-271	Open Camp Site with PAD	Moderate	Updated from Low to Moderate due to PAD
Pending	Warragamba-272	Open Camp Site	Low	NA
Pending	Warragamba-273	Shelter with Deposit and Axe Grinding Grooves	Low	No change as considered low potential for sub-surface artefacts
Pending	Warragamba-274	Shelter with Deposit and Axe Grinding Grooves	Low	No change as shelter contains lack of floor space and minimal deposit
Pending	Warragamba-275	Shelter with Art and Axe Grinding Grooves	Low	NA
Pending	Warragamba-276	Shelter with Art and Axe Grinding Grooves	Low	NA
Pending	Warragamba-277	Shelter with Deposit, Art, and Isolated Artefact	Low	NA
Pending	Warragamba-278	Shelter with Deposit, Art, Artefacts and Axe Grinding Grooves	Low	No change as deposit very minimal
Pending	Warragamba-279	Shelter with Art	Low	NA

AHIMS ID	Site Name	Site Type	Scientific significance	Justification for updates (where applicable)
Pending	Warragamba-280	Shelter with Art	Low	NA
Pending	Warragamba-281	Open Camp Site	Low	NA
Pending	Warragamba-282	Shelter with Art, Artefacts and Axe Grinding Grooves	Low	NA
Pending	Warragamba-283	Axe Grinding Grooves	Low	NA
Pending	Warragamba-284	Shelter with Deposit and Axe Grinding Grooves	Moderate	Updated from Low to Moderate due to silty deposit with a depth greater then 400mm.
Pending	Warragamba-285	Shelter with Deposit and Axe Grinding Grooves	High	NA
Pending	Warragamba-286	Shelter with Art and Axe Grinding Grooves	Low	NA
Pending	Warragamba-287	Shelter with Deposit and Axe Grinding Grooves	Low	No change as shelter floor very small and deposit very minimal
Pending	Warragamba-288	Shelter with Deposit, Art, and Artefacts	High	NA
Pending	Warragamba-289	Shelter with Deposit, Art, Artefacts and Axe Grinding Grooves	Low	No change as no interior floor space and minimal deposit
Pending	Warragamba-290	Shelter with Deposit, Art, Artefacts and Axe Grinding Grooves	Low	No change as shelter floor exposed and deposit very minimal
Pending	Warragamba-291	Axe Grinding Grooves	High	NA
Pending	Warragamba-292	Axe Grinding Grooves	Moderate	NA
Pending	Warragamba-293	Shelter with Deposit, Artefacts and Axe Grinding Grooves	Low	No change as shelter floor rocky and deposit is very minimal
Pending	Warragamba-294	Open Camp Site	Low	NA
Pending	Warragamba-295	Shelter with Deposit and Artefacts	Low	No change as deposit very minimal
Pending	Warragamba-296	Shelter with Deposit, Art, and Artefacts	Low	No change as shelter floor rocky and deposit is very minimal
Pending	Warragamba-297	Shelter with Deposit, Art, Artefacts and Axe Grinding Grooves	Low	No change as shelter floor rocky and deposit is very minimal
Pending	Warragamba-298	Shelter with Deposit and Artefacts	Low	No change as deposit mostly consists of eroded termite mount material
Pending	Warragamba-299	Shelter with Deposit, Axe Grinding Grooves, and Isolated Artefact	Low	No change as shelter floor rocky with very minimal shallow deposit
Pending	Warragamba-300	Shelter with Deposit and Artefacts	Low	No change as shelter floor rocky and deposit is very minimal
Pending	Warragamba-301	Shelter with Deposit and Art	Moderate	Updated from Low to Moderate due to relatively undisturbed deposit associated with at least 11 artefacts
Pending	Warragamba-302	Open Camp Site	Low	NA
Pending	Warragamba-303	Open Camp Site	Low	NA

AHIMS ID	Site Name	Site Type	Scientific significance	Justification for updates (where applicable)
Pending	Warragamba-304	Open Camp Site	Low	NA
Pending	Warragamba-305	Axe Grinding Grooves	Low	NA
Pending	Warragamba-306	Shelter with Deposit, Artefacts and Axe Grinding Grooves	Moderate	Updated from Low to Moderate due to relatively undisturbed deposit associated with at least 6 artefacts
Pending	Warragamba-307	Shelter with Deposit and Artefacts	Moderate	Updated from Low to Moderate due to relatively undisturbed deposit associated with at least 11 artefacts

7.2.4 Summary of Scientific (Archaeological) Significance

The scientific (archaeological) significance of a total of forty-three (43) Aboriginal heritage sites have been revised based on their association with PAD and/or the potential to contain an extensive artefact assemblage. As such, updates have included:

- Nineteen (19) Artefact sites whose significance rating has been upgraded from low to moderate significance based on their association with PADs and, in some instances, the potential for additional surface artefacts to be present but not observed due to low visibility.
- Three (3) Artefact sites whose significance rating was upgraded from moderate to high based on the association of a PAD with an extensive artefact scatter.
- Eighteen (18) Shelter sites with Deposit whose significance rating has been upgraded from low to moderate to the presence of PAD which is not shallow or too highly disturbed.
- Three (3) Shelter sites with Deposit whose significance rating has been upgraded to high due to the potential for deep in-situ PAD in association with other features such as in-situ hearth and/or an extensive artefact assemblage.

For the purpose of the updated significance assessment, all sites with PADs are treated as being of significance until proved otherwise. This is consistent with scientific significant assessment approaches where sub-surface testing has not yet occurred (e.g. Brayshaw 1988). As noted previously, however, the exception to this was for Shelter sites with deposit where it was observed that the deposit was very shallow, small in spatial extent and, in some instance, highly disturbed.

The scientific (archaeological) value of the region and the Aboriginal objects contained within it is demonstrated by the 340 known Aboriginal archaeological and cultural heritage sites, including: Aboriginal Resource and Gathering, Axe Grinding Grooves, Isolated Finds, Open Camp Sites, Scarred Trees, Stone Arrangements and Water Hole sites which are predominately of low scientific (archaeological) value (approximately 68.5% of known, and relocated sites), with 58 sites of moderate (archaeological) value (approximately 17.1% of known sites). There are a further 49 sites of high (archaeological) values (approximately 14.4% of known sites).

In summary, for the entire assemblage of 340 known sites considered by the assessment (this includes sites in the PMF, the EUIA, the PUIA and adjoining lands):

- 49 sites were assessed to be of high archaeological (scientific) significance.
- 58 sites were assessed to be of moderate archaeological (scientific) significance.
- 233 sites were assessed to be of low archaeological (scientific) significance.

The known sites within the PUIA are also predominately of low scientific (archaeological) significance (n= 30, 60%), with 12 of moderate (archaeological) significance (24%) and 8 of high (archaeological) significance (12%).

In summary, for the 50 known sites within the PUIA:

- 8 sites were assessed to be of high archaeological (scientific) significance.
- 12 sites were assessed to be of moderate archaeological (scientific) significance.
- 30 sites were assessed to be of low archaeological (scientific) significance.

The Project area has the potential to yield information that would contribute to a further understanding of the cultural history of the local area and region. In particular, the nature of past Aboriginal land-use of the Lake Burragorang valleys, and the relationship between past Aboriginal land use and the available resources including the Lake Burragorang valleys and the surrounding rivers, creeks and tributaries prior to the development of the dam as expressed through archaeological sites and their context.

While individual, site specific assessments of scientific significance are useful for identifying and managing sites with high apparent and contributory values they do not always translate directly to a contribution to the wider cultural landscape (Guilfoyle 2006). The RAPs for this project have consistently said that all archaeological sites hold cultural values in addition to, and in most cases beyond, what may be expressed using a scientific framework. These further values of the archaeological sites are discussed and considered in a more holistic cultural landscape in the significance assessments which have largely been derived from the original AHCA.

7.3 Cultural values and significance

The RAPs have advised throughout the Project, including through the submission process, that all sites have high cultural significance in addition to, and in most cases beyond, what may be expressed using a scientific framework. Further to this the majority of the RAPs consider the proposal to raise the Warragamba Dam wall; for the temporary storage of flood waters; as an unacceptable impact for the future preservation of tangible and intangible connections to their cultural landscape; and have called for an immediate stop to the Project. These further values of the archaeological sites are discussed and considered in a more wholistic cultural landscape in the significance assessments below as reproduced from Section 8.3 of the original ACHA.

The CVAR did not provide individual statements of significance for sites and places identified within the Project area. Rather, in its consideration of both tangible and intangible values the CVAR seeks to assess: "*The cultural landscape, or Dreaming Country… understood as a whole rather than a series of disconnected points*." The cultural values assessment was informed by the principles of the Burra Charter and the five qualities of values identified therein: aesthetic, historic, scientific, social and spiritual, noting that for Aboriginal cultural heritage assessment the key values are the social, spiritual and historic. The identified cultural values were grouped into six strands that include within them multiple specific locations of cultural value as outlined in Table 62 below.

Table 62: Cultural value significance for Project area

Aspect of cultural landscape	Significance	Description and assessment
The Gurrangatch-Mirrigan Dreaming Track	Very High Significance	The Gurrangatch-Mirrigan Dreaming Story tells of the two Ancestral Beings, Gurrangatch and Mirrigan, whose travels created the Wollondilly and Coxs Rivers, as well as creeks, waterholes, and caves in the region. The Gurrangatch-Mirrigan Dreaming Story is an elucidation of the creation of the landscape through which they travelled. The Dreaming Track consists not only of the specific waterholes and locations but of the entirety of the Wollondilly River and Coxs River valleys as the rivers were themselves formed through the actions of Gurrangatch and Mirrigan. The entirety of the current Project is located within the cultural landscape created by the travels of the Ancestral Beings of Gurrangatch and Mirrigan. The Gurrangatch- Mirrigan Dreaming Track maps those elements of the Gurrangatch-Mirrigan Dreaming Story that are located in or adjacent to the Project area. The Gurrangatch-Mirrigan Dreaming Story holds cultural value for contemporary Aboriginal communities across a wide region stretching from the coast through the Blue Mountains and onto the inland plains. The Gurrangatch-Mirrigan Dreaming Story is an exceptional example of a well-documented traditional Dreaming Story with multiple known cultural locations and on-going transmission and active cultural value for the Aboriginal communities of the wider region.
The Buru (Kangaroo) Dreaming Story Places and the associated areas of the Burragorang Valley	Very High Significance	The Buru (Kangaroo) is the source of the Burragorang Valley’s name. The Valley is associated with a Buru (Kangaroo) Dreaming Story that tells of a battle between the Great Kangaroo and two Ancestral Beings and is linked to the Kangaroo Waterhole in the Wollondilly River where the Great Kangaroo hid. There is also a Buru (Kangaroo) Dreaming Story that tells of the creation of the Kangaroo and is linked to the area running west from the Wollondilly River towards Yerranderie and Alum Hill. The Burragorang Valley area is also a place that was known as an important resource area for Kangaroos and associated with the maintenance of the species.
The Living Places	High Significance	The Living Places as a group are of High Significance in illustrating the history of Aboriginal people’s occupation and use of the area. The locations identified as Living Places illustrate aspects of the history of Aboriginal people’s occupation of the Project area. They include an important traditional living place and a number of Aboriginal reserves with distinct histories that contribute to our understanding of the complex patterns of Aboriginal people’s attempts to remain on Country in the face of dispossession and of those communities’ engagement with European communities, religious organisations, and government agencies. Assessment of the varied levels of cultural value and significance that apply to individual Living Place locations cannot be undertaken without input from the Aboriginal community. However, a number of the Living Places can be highlighted for their broader historical significance. Place 1 is amongst the small group of reserves created in the 1870s in New South Wales as a result of Aboriginal people’s active pursuit of rights to land and as the location of an Aboriginal community into the early 1900s. Places 4 and 5 exemplify the successful engagement of Aboriginal families in small-scale farming within their own Country and aspects of the shared Aboriginal-European history of a small agricultural community. Places 6 and 7 provide an insight into an Aboriginal community’s interaction with Catholic officials and community, the

Aspect of cultural landscape	Significance	Description and assessment
		development of a small independent Aboriginal farming community in the late 1800s, and the ongoing fight by Aboriginal people to retain rights to land. Place 8 is an example of a large-scale traditional living place that continued to be utilised in varying residential forms into the 1900s that is also linked to William Russell as a significant historical figure.
The Cultural Places	High Significance	The locations identified as Cultural Places illustrate aspects of the traditional cultural life and activities of Aboriginal people in the region. They include Story or Dreaming places, art sites, and burial sites and illustrate the depth of cultural values that are present within the Project area. They are indicative examples taken from the available documentary record and it is considered that engagement from Aboriginal cultural knowledge holders would identify further Cultural Places. Assessment of the varied levels of cultural value and significance that apply to individual Cultural Place locations cannot be undertaken without input from the Aboriginal community. However, a number of points can be made regarding the cultural values of the mapped locations. Places 1, 2, 3, 4, and 5 are burial sites with traditional ritual features and as such are considered to be of marked cultural value. Place 9 is a shelter site with seventy to one hundred art motifs on its walls and ceilings; these artworks provide a direct visual link with the rich cultural life of the Aboriginal people who created it. Places 10 and 11 are a landform that is rich in the material traces of Aboriginal people's occupation of the area, including multiple art sites, and is likely associated with ritual activities. Place 13 includes six scarred trees, a form of modified cultural object, that hold significant cultural value to contemporary Aboriginal people.
The Archaeological Sites	High Significance	The Archaeological Sites are understood as a group as being of High Significance as a tangible record of traditional Aboriginal occupation and use of the landscape, particularly in the period prior to European invasion and influence on the Gundungurra lands. In a report commissioned over thirty years ago by the NSW Water Board, the agency then responsible for the management of the Warragamba Dam catchment, the archaeologist Helen Brayshaw made a number of management proposals in relation to a potential raising of the Warragamba Dam wall including the, "Appointment to the Water Board of an Archaeological Project Manager and assistant from the local Aboriginal community for 12-18 months to develop, on the basis of further investigation, a Plan of Management. A steering committee should be appointed to oversee its implementation, which is likely to involve a 2–3-year salvage project. Local Aboriginal communities retain strong links with the area and should be represented on the committee." The Archaeological Assessment for this project has documented 334 sites within the immediate area of the project and estimated that over 1,200 archaeological sites would be present in the immediate cultural landscape. The archaeological record of the area includes a diverse assemblage of sites and features, from individual stone artefacts and scarred trees in open country to more 'complex' sites such as rockshelters and open sites with combinations of archaeological and cultural features. All archaeological sites hold some level of cultural value for the Aboriginal people whose Country they are located in. This reflects the cultural understanding of Aboriginal peoples that the archaeological sites are the material traces of their

Aspect of cultural landscape	Significance	Description and assessment
		ancestors' presence and cultural activities. The linking of the archaeological material in the Project area with a history of ongoing Aboriginal occupation and connection to the area, dating back to at least the last ice age, as well as with extant knowledge of cultural routes and Dreaming Stories, acts to increase its cultural value and significance.
The Waterways	Very High Significance	Water and Waterways are central to the cultural values of Country. In an exploration of the role of water in defining complex attachments to place, the anthropologist Sandy Toussaint stated: "That a hydro- and ecological change in how a water source is used can lead to a change in how people relate to it encompasses a range of culturally complex issues, including that water is engendered with a variety of meanings. Identity formation and kinship affiliation can also be determined through research on water, as can knowledge about contested usage, and patterns of migration to and from temporary and permanent water places.… local groups become attached to sources of water beyond water's obvious nourishing, lifegiving force. This is especially the case when water sources are endangered, and cultural ideas, beliefs and activities collide." Successful traditional occupation of this Country required detailed knowledge of waterways, their seasonal and long-term changes, and the flora and fauna associated with and dependent on them. Water and waterways governed Aboriginal people's choice of living places, travel routes, and gathering places for cultural and ceremonial activities. Riverine resources were a vital element of the traditional Aboriginal economy of the region and continued to be utilised throughout the historical period and into the present day. The waterways of the area are central elements of the cultural landscape; the Gurrangatch- Mirrigan Dreaming Story that tells of the creation of this Country is focused on the waterways.

7.4 The GBMWHA values and their significance

The GBMWHA is one of the largest and most intact tracts of protected bushland in Australia and was World Heritage listed in 2000. It is characterised by deeply incised sandstone tablelands which extend over one million hectares incorporating eight adjacent conservation reserves to the west of Sydney and extends almost 250 kilometres from the edge of the Hunter Valley to the Southern Highlands near Mittagong. While the PUIA contains only 304 ha of GBMWHA land (a proportion of 0.03% of the total GBMWHA area) it contributes overall to the GBMWHA cultural values as it is a cultural landscape with a rare and representative example of the interconnectedness of tangible and intangible values.

Section 8.4 of the original ACHA detailed the values and significance of the GBMWHA. The following provides some additional information relating to these values.

The listing for the GBMWHA includes the following brief synthesis:

> *The Greater Blue Mountains Area (GBMA) is a deeply incised sandstone tableland that encompasses 1.03 million hectares of eucalypt-dominated landscape just inland from Sydney, Australia's largest city, in south-eastern Australia. Spread across eight adjacent conservation reserves, it constitutes one of the largest and most intact tracts of protected bushland in Australia. It also supports an exceptional*

representation of the taxonomic, physiognomic and ecological diversity that eucalypts have developed: an outstanding illustration of the evolution of plant life. A number of rare and endemic taxa, including relict flora such as the Wollemi pine, also occur here. Ongoing research continues to reveal the rich scientific value of the area as more species are discovered.

The geology and geomorphology of the property, which includes 300 metre cliffs, slot canyons and waterfalls, provides the physical conditions and visual backdrop to support these outstanding biological values. The property includes large areas of accessible wilderness in close proximity to 4.5 million people. Its exceptional biodiversity values are complemented by numerous others, including indigenous and post-European-settlement cultural values, geodiversity, water production, wilderness, recreation and natural beauty.

The GBMWHA was inscribed onto the World Heritage list for its outstanding universal value (OUV) and against two criteria being:

- Criterion (ix) to be outstanding examples representing significant on-going ecological and biological processes in the evolution and development of terrestrial, fresh water, coastal, and marine ecosystems and communities of plants and animals;
  - In the GBMWHA this criterion is met by the Eucalypt dominate vegetation and habitats and the processes in a eucalypt dominant ecosystem including interactions between eucalypts, understory, fauna, environment, and fire, and the Wollemi pine and Blue mountains pine with linkages to Gondwanan taxa
- Criterion (x) to contain the most important and significant natural habitats for in-situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation.
  - The GBMWHA includes diversity of habitats and plant communities supporting globally significant species and ecosystems, and flora species diversity.

The Statement of OUV prepared for the GBMWHA also provides additional context on other important values such as Aboriginal cultural heritage, particularly within the Statement of Integrity. With regards to Aboriginal cultural heritage the Statement of Integrity states:

An understanding of the cultural context of the GBMA is fundamental to the protection of its integrity. Aboriginal people from six language groups, through ongoing practices that reflect both traditional and contemporary presence, continue to have a custodial relationship with the area. Occupation sites and rock art provide physical evidence of the longevity of the strong Aboriginal cultural connections with the land. The conservation of these associations, together with the elements of the property's natural beauty, contributes to its integrity.

This builds on the recognised Aboriginal cultural heritage values which were included in the nomination which states (Government of Australia 1998; p44):

The rugged upland country of the Greater Blue Mountains is not only of exceptional natural diversity, and of spectacular and ephemeral beauty, but is also closely tied to the lives of people who have occupied, visited, thought about it and cared for it over thousands of years. The property represents, in fact, the combined works of nature and man.

The direct and tangible cultural association with the million hectares of wild country is expressed in two physical forms. First are the widespread Aboriginal occupation sites, rock shelter paintings and rock *platform engravings. Second is the narrower network of historic walking tracks, staircases and lookouts, festooned from the edges of the ridge crossing the Mountains and down to the valley floors.*

Both rock art and tracks are intact and authentic. The texts which follow, on Aboriginal rock art and on pioneering conservation movements in the area, explain the significance of these tangible links with events, traditions, ideas, beliefs, and artistic works of outstanding universal significance.

In relation to Indigenous Values, the GBMA Strategic Plan states the following:

The GBMWHA encompasses the traditional Country of at least six different Aboriginal language groups (see Appendix 6) including several associated with the earliest contact with European settlers in Australia. Although no comprehensive surveys have been undertaken, a widespread and diverse sample of Aboriginal sites has been recorded, preserving a vital record of the social interactions and artistic activities within as well as between these different language groups.

Known sites provide evidence of at least 14,000 (and possibly 22,000) years of Aboriginal occupation of the area, but traditional beliefs connect Aboriginal people with the landscape back as far as the creation stories. Several prominent landscape features with spiritual significance are linked with creation stories, for example Mt Yengo in Yengo National Park and the Coxs and Wollondilly River valleys (Blue Mountains National Park).

Recorded sites of archaeological significance include a widespread sample of the Sydney Region's distinctive Aboriginal rock art, which incorporates two synchronous forms (i.e. pigment and engraved forms) on a scale unique in Australia. A number of scientifically important rock art sites with an unusually large number of individual motifs have been recorded within the GBMWHA and continue to be revealed, such as the Eagles Reach site.

Given the wilderness nature of the area and the limited archaeological surveys to date, there is enormous potential for uncovering further significant sites which will contribute to a better understanding of Aboriginal use of the area over many millennia. The area is important to contemporary Aboriginal groups. (DECC 2009: 13).

7.5 Statement of significance

The following statement of significance is largely consistent with that provided in Section 8.5 of the original ACHA with particular emphasis on the importance of intangible values and some updates based on the updated assessment of archaeological significance of sites as presented in Section 7.2. The statement of significance was prepared following archaeological investigation and analysis carried out according to the *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales* (DECCW 2010b), and utilising assessment criteria that reflect best practice assessment processes as set out in the Burra Charter.

7.5.1 Social and Cultural Significance

The Project area is of **very high social and cultural significance** to the Aboriginal community. There are multiple strands to the social and cultural values of this landscape that include the Dreaming Stories that carry religious and cosmological meaning, the values and meanings of the Waterways and ecology of the region, the long history of traditional occupation and use of Country, and the more recent history of ongoing attempts to maintain connection to Country in the face of dispossession. These aspects weave together to create a broad associative cultural landscape that is of very high significance to the Aboriginal communities of the region and to the wider understanding of Aboriginal cultural heritage and history. As part of the Blue Mountains and Greater Blue Mountains World Heritage Area the Project area also has social significance for non-Aboriginal stakeholders.

7.5.2 Aesthetic Significance

The Project area is associated with **high aesthetic significance**. This significance is demonstrated by the area's environmental intactness, its status as a world-renowned tourist destination and World Heritage Listing. This environmental intactness is due to the ruggedness of the landscape precluding historical development, the protection of the area by surrounding National Parks and other protected lands and the area forming part of the Warragamba Dam catchment area of the greater Sydney region (noting that this protection came at the expense of flooding the Burragorang Valley and tributaries). The Project area's cultural landscape is located within the internationally emblematic and striking natural landscapes of the Blue Mountains: sandstone escarpments, eucalypt forest and wild rivers. This aesthetic landscape is an ever present, unmistakeable and evocative setting when visiting the Upstream study area, contributing a strong sense of natural beauty and place, and forming a distinctive interwoven element of the Aboriginal cultural values of the area.

7.5.3 Historic Significance

The landscape surrounding the Warragamba Dam is of **high historic significance** for Aboriginal and European cultural heritage. The Burragorang Valley demonstrates several representative aspects of historic importance including the history of colonial interactions between Aboriginal peoples and the British. The

deep history of occupation and use of this Country by Aboriginal people is evident in the archaeological record, oral histories, and Dreaming Stories. The Project area provides a rare example of a shared history of Aboriginal and European occupation and community interaction within the intensively settled east coast of Australia in the nineteenth and twentieth centuries. The recent history of ongoing occupation and use of the area by Gundungurra and neighbouring peoples illustrates the continuance and nurturing of culture and connection to Country despite the impacts of dispossession including the original construction of the Warragamba Dam.

7.5.4 Scientific (Archaeological) Significance

The Project area has **high scientific (archaeological) significance**. There were 334 identified Aboriginal archaeological and cultural heritage sites in the Project area and adjoining lands. The assemblage of archaeological sites was diverse, with sites ranging from places with individual features (such as individual artefacts or scarred trees) through to complex sites with multiple features present at places (rockshelters with art, grinding grooves, archaeological deposit). It was estimated that the Project area and surrounds would contain a total of 1,122 archaeological sites, including an estimated 174 within the PUIA. The scientific (archaeological) value of the region and the Aboriginal objects contained within it is demonstrated by the 340 known Aboriginal archaeological and cultural heritage sites considered by the assessment (this includes sites in the PMF, the EUIA, the PUIA and adjoining lands) included 49 sites that have been assessed to be of high archaeological (scientific) significance (14.4%), 58 sites assessed to be of moderate archaeological (scientific) significance (17.1%) and 233 sites assessed to be of low archaeological (scientific) significance (68.5%).

However, the archaeological value of the Project area lies not solely in the potential of the sites to provide information as individual places, but rather as a suite of places and features that are interwoven with the cultural landscape. Unlike some parts of the Blue Mountains the PUIA and surrounds does not contain an extensive or diverse assemblage of rock art. It is rare in south-eastern Australia for such an intact cultural landscape and an extensive archaeological record to co-exist such as exists in the Project area. The Burragorang Valley was a noted area of rich traditional and historical resources, and archaeological places and features may contribute to the picture of land-use of where and how this richness facilitated the social aspects of life in the past. The PUIA and its surrounds has high research potential to yield information that would contribute to a further understanding of both the local area and the region. In particular, the nature of past Aboriginal land-use of the Lake Burragorang valleys, as interpreted through archaeological evidence and the lens of the highly intact cultural landscape.

8. Impact assessment

8.1 Updated approach to impact assessment

The original ACHA considered potential impacts on Aboriginal heritage in relation to the defined Project Upstream Impact Area (PUIA) and the Existing Upstream Impact Area (EUIA). These concepts were developed principally to inform offsetting for impacts with biodiversity and other environmental values in view of the uncertainty around incremental flooding and the potential effects of this on upstream environmental values. The PUIA approach takes a precautionary assumption of assuming total loss of all environmental values in that area. In line with this approach, the ACHA adopted a precautionary approach for the purpose of the impact assessment where it was considered that all Aboriginal sites within the PUIA would be harmed and the degree of harm to these sites would be total. Thus, while the impact assumed total loss and harm, a total loss of value was not certain for all sites so categorised, and some sites may exhibit little change in value as a result of the temporary inundation.

A number of submissions identified issues with this broad approach and/or argued that the PUIA did not represent an appropriate extent for the purpose of completing an accurate impact assessment of Aboriginal cultural values associated with temporary inundation which would result from the Project. An updated approach for the ACH values in determining areas of impact from temporary inundation was therefore required to ensure the extent of the impacts were appropriately accounted for and more accurately assessed.

The upstream study area defined by the extent of the probable maximum flood and resultant inundation. The probabilistic nature of flooding in the upstream study area presents a challenge in identifying appropriate flood events with which can be used to inform an assessment of potential impacts and noting that for a specific flood event of a particular chance of occurrence, there is already an existing potential impact associated with that particular flood event. The exact nature of the impacts would be dependent on multiple factors including:

- the timing and magnitude of the rainfall events
- catchment conditions at the time of the rainfall event
- the existing storage level
- the duration, depth and extent of inundation for an individual flood event
- the potential change in vegetation integrity as a result of the differing responses of individual plant species to different inundation regimes
- the type and condition of Aboriginal cultural heritage items and places.

In view of this, it was determined that a different approach to assessing potential impacts was required in order to provide relative greater certainty around potential impacts and importantly, to provide a more objective basis for identification and development of mitigation measures. The approach taken has been to identify an area of impact that takes account of the variability of flood events and their extent over time.

While the original ACHA considered potential impacts on Aboriginal heritage in relation to a defined PUIA, the following revised impact assessment considers potential impacts in the context of the incremental increase in temporary inundation for the 1 in 5, 1 in 10, 1 in 20, and 1 in 100 chance in a year events. The following section provides an overview of the changes to hydrology and flooding with Project. Section 8.3 then provides an explanation of how these analysis events are used to consider potential impacts to

Aboriginal heritage from new temporary inundation or increased temporary inundation. Following this, an updated detailed impact assessment is presented.

8.2 Summary of changes to hydrology and flooding with the Project

Potential impacts from works (including early works, enabling works and demolition, and main construction works) at the dam wall are described in Section 9.2 of the original ACHA while potential impacts from temporary inundation are detailed in Section 9.2.1 of the original ACHA. This section builds upon the information supplied in the original ACHA by providing a more detailed summary of the changes to hydrology and flooding associated with the Project to assist with understanding the potential impacts to Aboriginal archaeological sites and values upstream and downstream of Warragamba Dam. This information is derived from Appendix J World Heritage Assessment Report.

8.2.1 Upstream

8.2.1.1 Depth and duration of temporary inundation

The upstream environment includes the reservoir formed by Warragamba Dam (Lake Burragorang) and its tributaries. As described in the original ACHA, the Project will cause a temporary increase in the height of the waters of Lake Burragorang and flooding in tributaries of the lake. The extent of inundation is controlled by the peak flood level at the dam wall and the topography across the upstream catchment. Flooding upstream of Lake Burragorang can result from inundation as the lake level rises due to flood inflows, from local catchment runoff, or a combination of the two. Flooding due to inundation is generally restricted to the area around the lake perimeter with flooding due to local catchment runoff being the more dominant cause of flooding further up the catchment. The extent and duration of temporary inundation of additional areas as a result of the Project would depend on the location within the catchment, the size of the event and the high of a particular location above sea level relative to the dam FSL. Modelling assessments of flooding and inundation produced for the Project have explored the likely changes in the duration and depth of inundation events with results for the dam wall summarised below and in Table 63. Graphical representations of these flood event scenarios are provided in Plate 20 to Plate 23 in Section 8.3 below.

Table 63: Changes to temporary inundation levels and durations at dam wall (Source: Appendix J of EIS)

Event (1 in x change in a year)	Existing			Project			
	Level (mAHD)	Depth (m)	Inundation (days)	Level (mAHD)	Depth (m)	Increase in inundation (days)	Total inundation (days)
5	117.4	0.7	2.8	120.3	2.9	4.6	7.4
10	118.0	1.3	3.4	123.1	5.1	6	9.4
20	118.6	1.9	4.0	126.8	8.2	8.6	12.6
100	121.5	4.8	4.0	132.0	10.5	10.8	14.8
PMF	131.2	14.5	4.2	143.9	12.7	7	11.2

The above modelling suggests that the Project would result in changes to the duration of upstream inundation at the dam wall including up to approximately five days for the relatively more frequent 1 in 5 chance in a year flood, and up to about 11 days for a rarer 1 in 100 chance in a year flood event. In relation to depth and duration of temporary inundation as a result of the Project, modelling for the locations approximating the limit of the 1 in 100 chance in a year event in the upstream area indicates that:

- Increases in the depth of temporary inundation for the locations approximating the limit of the 1 in 100 chance in a year event would be in the order of half a metre or less.
- Increases in duration of temporary inundation for all events considered for the Nattai River and Wollondilly River would be less than half a day.
- Increases in temporary inundation for the Kowmung River would be less than half a day up to the 1 in 5 and 1 in 10 chance in a year events, about 1.3 days for the 1 in 20 chance in a year event, and about two days for the 1 in 100 chance in a year event (these would not affect the GBMWHA).
- Increases in temporary inundation for the Coxs River would be less than half a day for up to the 1 in 20 chance in a year event and then slightly over half a day up to the 1 in 100 chance in a year event (these would not affect the GBMWHA).

Overall, the modelling indicates that there is an increasing influence of the Project moving downstream with the increase in temporary depth and duration of temporary inundation, with locations within Lake Burragorang generally reflecting the pattern of changes in depth and duration of temporary inundation for the same flood events at the dam wall.

8.2.1.2 Flood frequencies

An analysis of the modelling relating to the frequency of peak flood levels in the in Lake Burragorang at the dam wall under both existing case and with Project scenarios indicates:

- The Project would result in a shift in the flood frequency curves resulting in events of a specified depth occurring more frequently than currently occurs; this is most pronounced at the dam wall and in Lake Burragorang, and decreases moving up the tributaries.
- There is no material difference in the existing and Project flood frequency curves at upstream locations that approximate the extent of the Project PMF (as would be expected).

8.2.1.3 Flood extents

An analysis of the modelling relating to the extent of additional flooding with Project scenarios indicates:

- The additional flooding for flood events up to the 1 in 100 chance in a year event potentially affecting the GBMWHA would occur principally along the Wollondilly River within Lake Burragorang (eastern shoreline) and the main river channel (on the right/eastern bank), and the upper reaches of the Nattai River.
- There are no areas of the GBMWHA in proximity to the Coxs River and Kowmung River that would be affected by additional flooding for flood events up to the 1 in 100 chance in a year event.

8.2.2 Downstream

Modelling assessments demonstrate that raising the dam wall height for flood mitigation will not increase regional inundation levels downstream. At the time of EIS submission there were 887 Aboriginal heritage sites registered on AHIMS in the Downstream Study Area which will benefit with a lower flood risk with the Project.

8.2.2.1 Flood extents, levels, frequency and duration of temporary inundation

The FMZ is designed to delay and decrease the progression of inflows coming from the upstream Warragamba catchment, which in turn would reduce the severity of regional flood events impacting on the downstream Hawkesbury-Nepean Valley. The Project would significantly reduce flood risk; however, it would not eliminate it completely. Flooding from other catchments such as the Nepean, Grose, Colo and South Creek can also contribute significantly to downstream flooding. The discharge rate of the FMZ predicts that the discharge (outflow) from Warragamba Dam for the 1 in 20 and 1 in 100 chance in a year events for existing and with Project model a substantial reduction in the peak of inundation, but this is offset by an extended period where downstream flows remain above normal until the FMZ is emptied.

The frequency distribution of dam outflows for the existing and Project scenarios downstream shows a reduction in the magnitude and chance of occurrence for an outflow event. As a result, specific outflow events become a relatively less frequent event with the Project. As a result of the Project, the Warragamba/Nepean River area and the Lower Colo area would see a reduction in extent and duration of large food events. The Old Great North Road World Heritage Area is currently unaffected by all flood events and will not be affected by the Project.

As a result of reduced extent, level, frequency and duration of temporary inundation, Aboriginal cultural heritage sites located downstream will be less likely to experience impacts as a result of flood events from the Project compared to existing inundation impacts.

8.2.2.2 Summary

- The area downstream of Warragamba Dam would experience a reduction in the height of flood peaks compared to the existing situation
- Operation of the FMZ would commence after the flood has peaked or is in recession until the FMZ had been emptied back to the FSL; these flows would be controlled to remain within the main channel of the Hawkesbury River and to also not influence any further flooding onto the floodplain
- Downstream flood events would continue to be influenced by inflows from other catchments
- The frequency of flood events of a specific chance of occurrence in a given year would reduce, i.e. they would be less frequent than currently occurs
- The downstream area of the GBMWHA would experience a reduction in the extent of flooding with the Project compared to the existing situation
- The Old Great North Road World Heritage area is currently unaffected by all flood events considered, and this would be unchanged with the Project.

8.3 Analysis events

As outlined above, potential impacts from the Project to Aboriginal heritage are considered in the context of the incremental increase in temporary inundation for the 1 in 5, 1 in 10, 1 in 20, and 1 in 100 chance in a year flood events. This section provides an explanation of how the analysis events are used to consider potential impacts to Aboriginal heritage from new temporary inundation or increased temporary inundation in the upstream study area. A graphical representation of the key flood levels in the upstream study area (see Table 46 in Section 8.2.1.1) are provided in Plate 20 to Plate 23 for the 1 in 5, 1 in 10, 1 in 20, and 1 in 100 chance in a year flood events. A series of hypothetical archaeological sites (Site A to Site I) are represented in these graphs to assist in demonstrating conceptually what sort of impact the Project would have on a specific site for a specific flood event in terms of it causing new temporary inundation or increased temporary inundation. The potential impacts to these hypothetical sites are summarised in Table 64 and show, for example, that:

- Site A will be affected by temporary inundation from the existing dam and the Project during all flood event scenarios. The Project, however, will result in increased temporary inundation (additional depth & duration).
- Site D is not affected by temporary inundation from existing dam or the Project in relation to the 1 in 5 chance in a year flood event. The Project, however, will result in new temporary inundation of the site during the 1 in 10, 1 in 20 and 1 in 100 chance in a year flood event scenarios.
- Site I will not be affected by temporary inundation from the existing dam or the Project during any of the flood event scenarios.

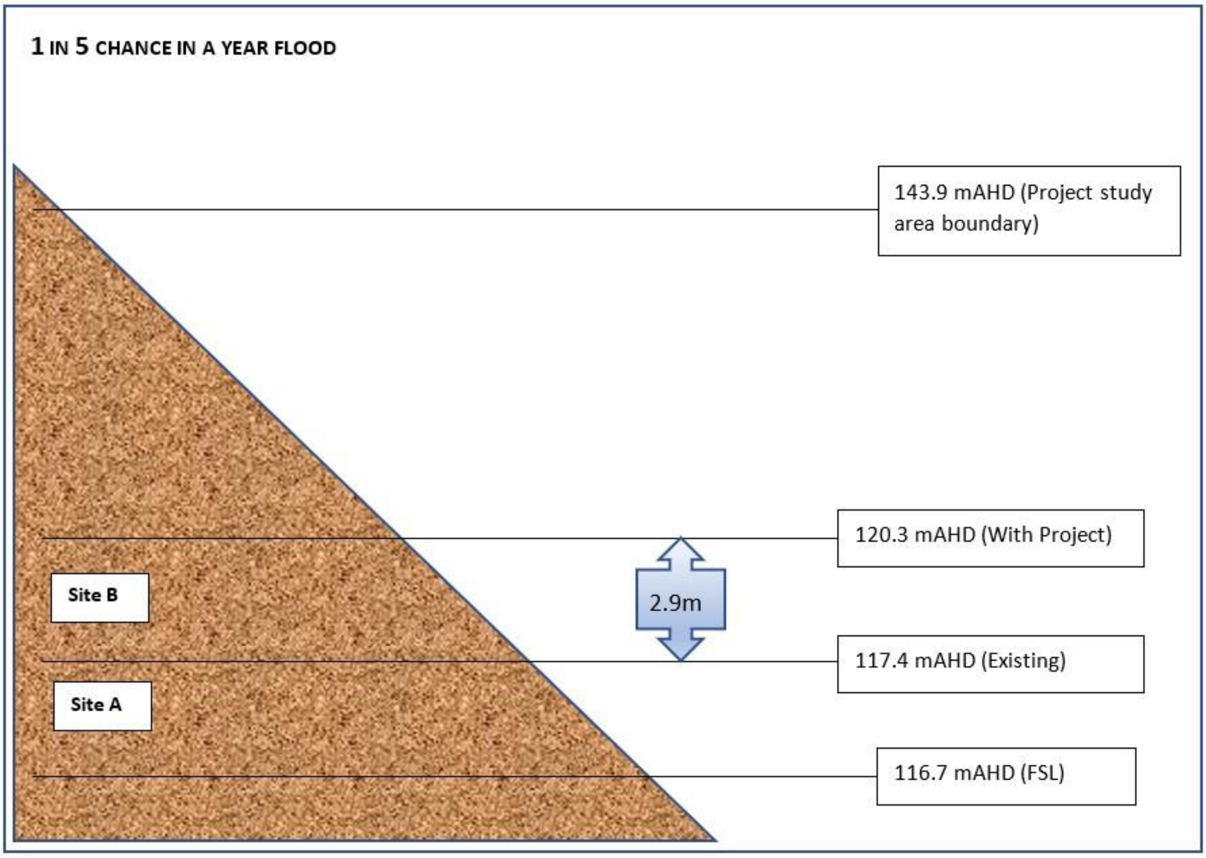

Plate 20: Graphical representation of 1 in 5 chance in a year flood event

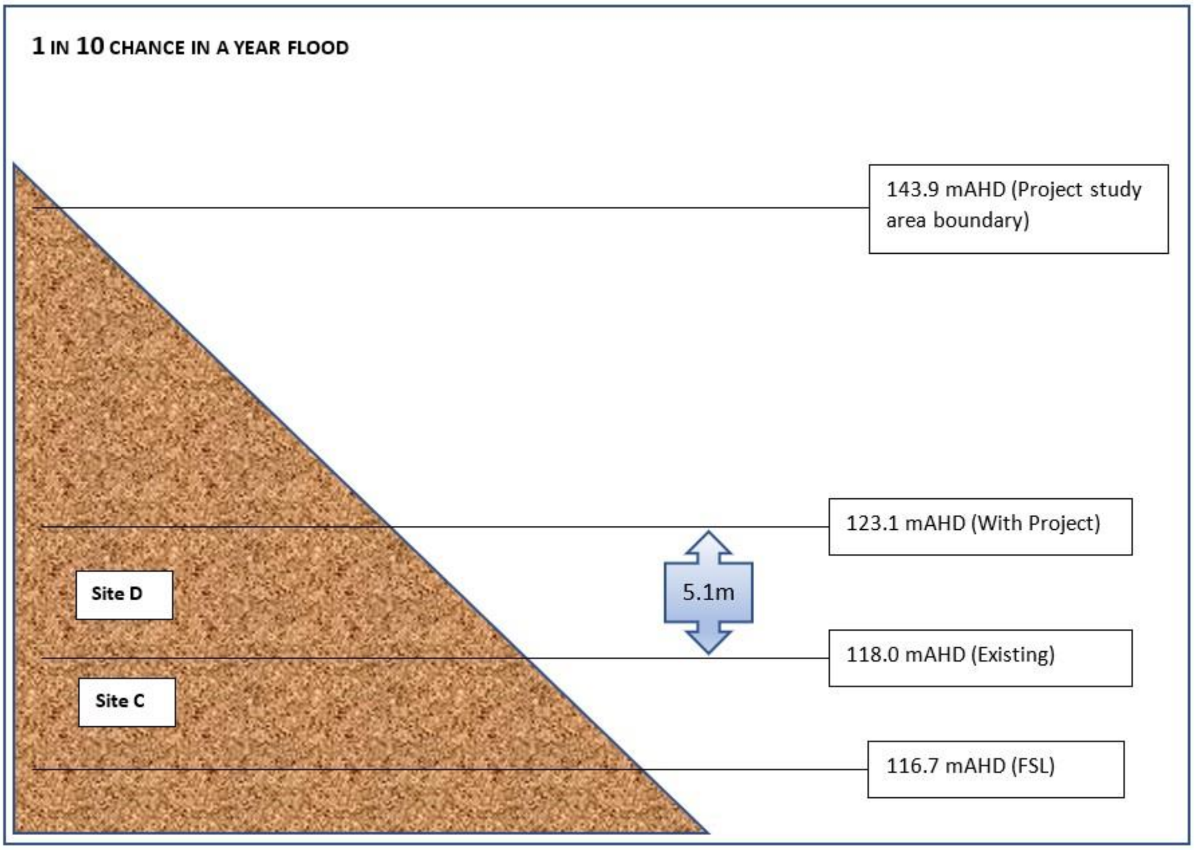

Plate 21: Graphical representation of 1 in 10 chance in a year flood event

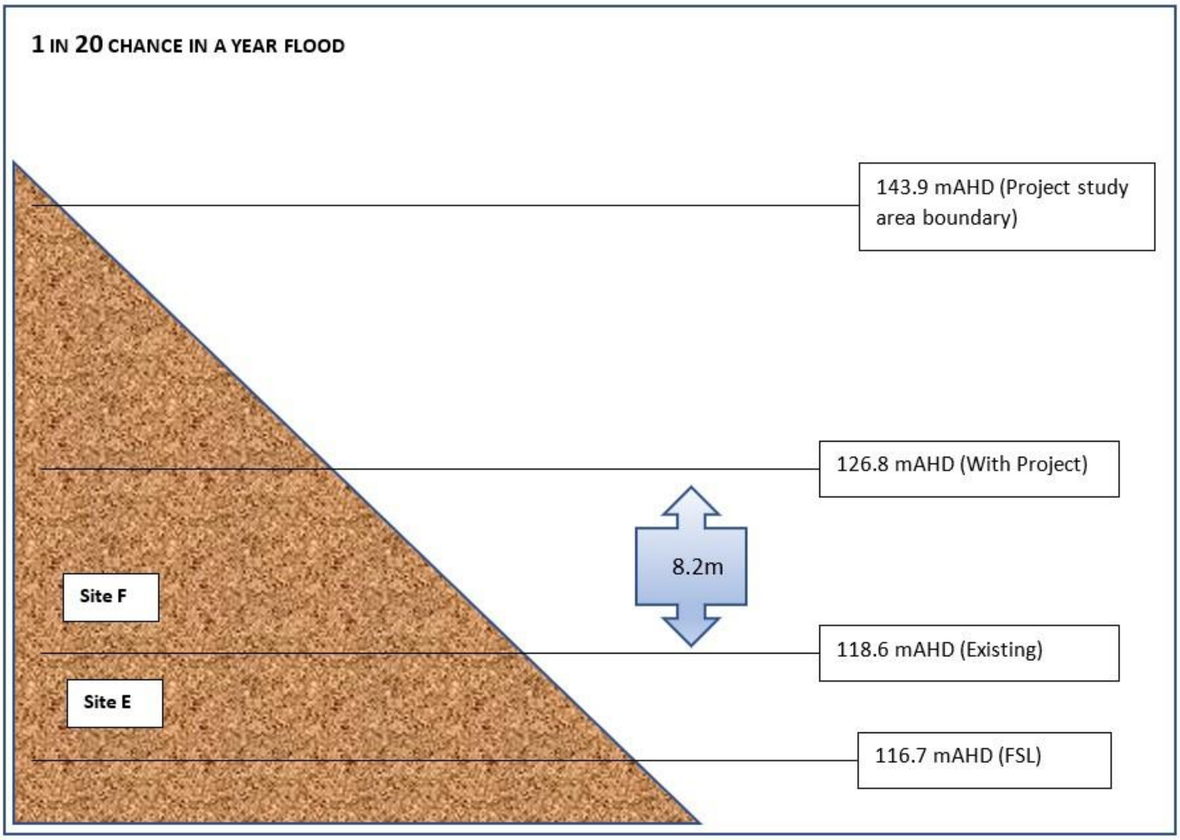

Plate 22: Graphical representation of 1 in 20 chance in a year flood event

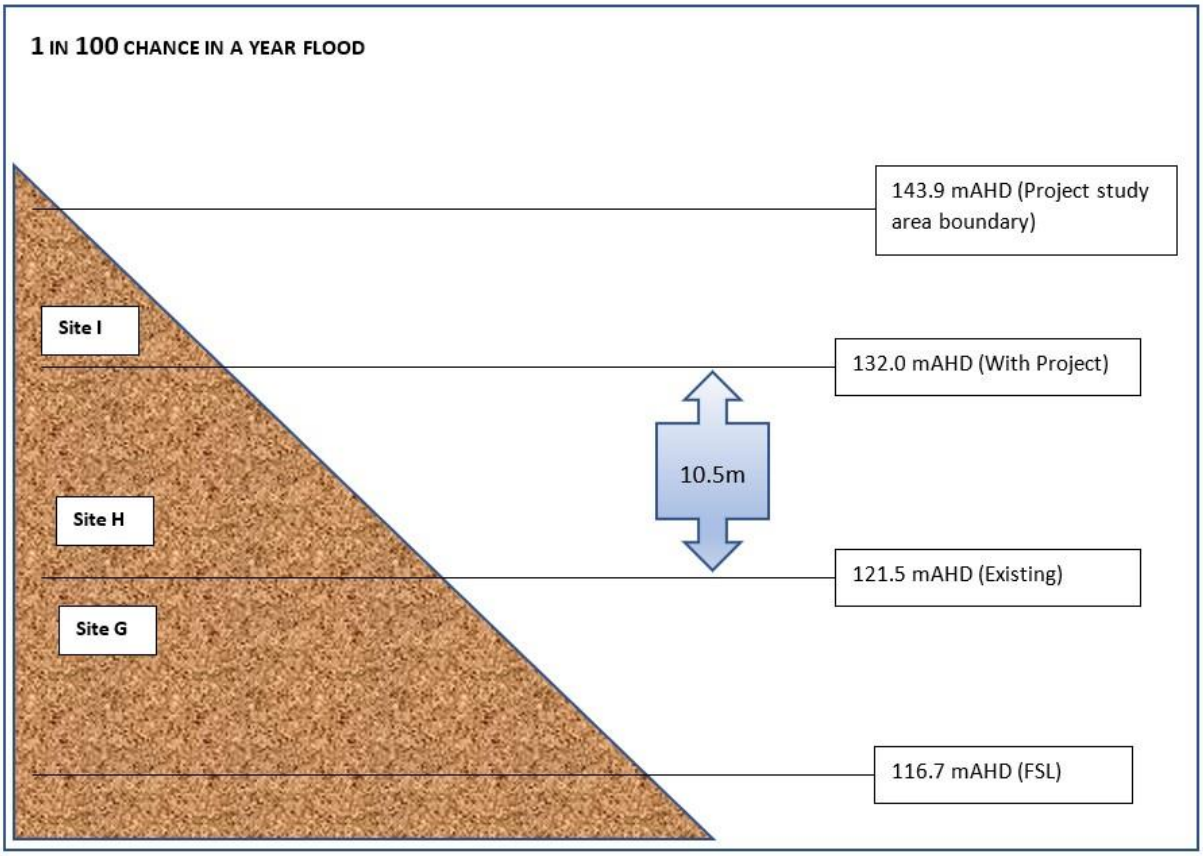

Plate 23: Graphical representation of 1 in 100 chance in a year flood event

Table 64: Summary of potential impacts (existing and from the Project) on hypothetical archaeological sites for a specific flood event. E= existing, P= Project. Key provided below table.

Hypothetical archaeological site	Notional elevation (mAHD)	Flood event (1 in x chance in a year)							
		1 in 5		1 in 10		1 in 20		1 in 100	
		E	P	E	P	E	P	E	P
A	117.0	Y	Y	Y	Y	Y	Y	Y	Y
B	117.6	N	Y	Y	Y	Y	Y	Y	Y
C	117.8	N	Y	Y	Y	Y	Y	Y	Y
D	122.5	N	N	N	Y	N	Y	N	Y
E	118.2	N	Y	N	Y	Y	Y	Y	Y
F	124.5	N	N	N	N	N	Y	N	Y
G	120.0	N	Y	N	Y	N	Y	Y	Y
H	128.5	N	N	N	N	N	N	N	Y
I	133.0	N	N	N	N	N	N	N	N

Key for Table 45	
N	Site not affected by temporary inundation from existing dam or Project
Y	Site affected by temporary inundation from existing dam and/or Project
	Increased temporary inundation from Project (additional depth & duration)
	New temporary inundation from Project

8.4 Summary of changes in fluvial geomorphological processes

A Geomorphological Technical Impact Assessment including Erosion hotspot modelling (Beca 2021) was completed as part of the original EIS to investigate the baseline conditions and impact assessment within the upstream, lake and downstream areas of the Project. The results of these assessments can therefore be used to refine predictions regarding the type of affects expected to occur in the context of the current Project. Table 65 below provides an overview of key fluvial geomorphological processes identified as being relevant to the Project area while Table 66 presents key findings of the likely changes to the nature and extent of such processes effecting different zones of the Project area.

Table 65: Fluvial geomorphological processes relevant to the Project area

Process / impact	Description
Out of bank erosion	Incudes any erosion driven by fluvial processes during events larger than the existing FSL that are not confirmed to the existing river channel. This includes erosion associated with back-up flows in the lower sections of the Upstream Zone (Beca 2021: 95).
Translocation of sediment features upstream	Includes any movement of sediment features up-gradient. May be triggered by the backing up of flows in the existing river mouths which causes a decrease in channel velocity further up the river leading to lower competence to transport sediments but enhanced deposition (Beca 2021: 100).
In-channel and/or floodplain sediment deposition	Results from the settling of sediment particles in the middle section of the channel and/or floodplain. Sediment deposition is responsible for creating alluvial fans and deltas (typically at the mouth of the stream) which represent a lower-energy, more permanent depositional environment that is less susceptible to changes in stream flow. Excessive accumulation of sediment can build up channel plugs and levees.

Table 66: Summary of likely changes to the nature and extent of fluvial geomorphological processes

Area	Key findings
Upstream Zone (including the Coxs, Kedumba, Kowmung, Nattai and Wollondilly Rivers and their tributaries)	• The main risk to the Upstream Zone watercourses is from elevated erosion of terrace deposits during inundation events with a 'medium' residual risk (Beca 2021: 5). • The Project is expected to result in increased out of bank erosion in the west arm upstream zone which includes the Creeks and Rivers to the west such as Laceys Creek, Butchers Creek, Cedar Creek, Cox's River, Kedumba River and Kowmung River (lower). These areas are associated with a higher erosion risk due to the higher land gradients/slopes in this portion of the Project area (Beca 2021: 96-97). • In terms of the south arm upstream zone which includes Creeks flowing into the lake from the east and south such as Brimstone Creek, Green Wattle Creek, Little River, Nattai River, Tonalli Creek, Werriberri River and Wollondilly River, the Project is expected to result in similar erosion classification for the NE arm of the lake with slight-low erosion risk predominating but still associated with some potential for out of bank erosion to occur (Beca 2021: 96).

Area	Key findings
	• Over the last 20 years, sediment deposition across the catchment has been declining likely due to better management of vegetation cover across the catchment compacted to earlier periods (Beca 2021: 97). The Project, however, has the potential to slightly reverse this downward trend by providing conditions favourable for the mobilisation and transport of terrace deposits in some areas such as the transitional zones of the Coxs and Wollondilly Rivers (Beca 2021: 104). • Organic material will be deposited throughout the Upstream Zone during low flow conditions (Beca 2021: 100). • Areas adjacent to the Kedumba and Wollondilly Rivers have the potential to be impacted floodplain sediment deposition. • Sedimentation of terrestrial riparian environments caused by inundation of water were assessed to be a 'negligible' residual risk for the Upstream Zone watercourses and 'low' residual risk for both Lake Burragorang and the Hawkesbury-Nepean. Sediment delivery to the lake will therefore decrease overall as a result of the Project (Beca 2021: 5-6).
Lake Zone (including Lake Burragorang and portions of the North, South and West Arms)	• Lake Zone areas generally have elevated shoreline erosion and out of shore erosion. The results of erosion hot spot modelling indicate that: ▪ Creeks to the west of the lake including Cedars Creek, Cox's River, Kedumba River, Kowmung River are associated with a noticeably higher erosion risk. ▪ The north-east arm of the lake and sheltered inlets throughout the lake are associated with a negligible to low erosion risk range as a result of the Project. ▪ The mid-lake, south-east arm and north-east arm are associated with intermediate erosion risk, partly due to the higher propensity of soils in these areas to erode. ▪ Creeks flowing into the lake from the east and south including the Little River, Nattai River, Wollondilly River and Werriberri Creek are associated with slight to low erosion risk (Beca 2021: 106). • Shoreline bank erosion (separate from the wide-scale erosion of the foreshore / inundated areas summarised above) represents another process that will change as a result of the Project. More frequent water contact time, for example, will result in wave undercutting and dame to berms and banks as well as the transportation of eroded material away from the location (Beca 2021: 110). • Areas most susceptible to increased effects of bank erosion include: ▪ Exposed portions of the bank that protrude out from the shoreline. ▪ Banks that are aligned in a south easterly and westerly direction in line with dominant wind directions. ▪ Large fetch[6] that result in higher energy and wave action. Areas within the Project area that fit within these profiles include the central and southern arms of Lake Burragorang (Beca 2021: 110). • Potential changes to the transport of sediment-laden water and deposition of deposit as floodwater subside represents an additional process that may be affected by the Project. The main area of sediment deposition is likely to be on the Existing foreshore up to the FSL, which is already denuded and contains little vegetation and very little change is expected in terms of the existing circulation patterns causing sediment redistribution as a result of the Project in the Lake Zone portion of the Project area (Beca 2021: 110-111). • Overall, the Project is not expected to result in a change in sediment redistribution compared to existing conditions. Further, it is not expected that there would be any change to the quantity of fine sediment from upstream rivers increasing sedimentation in the lake body. Increased contributions from shoreline erosion are

[6] Fetch is defined as the distance over water that the wind blows in a single direction, and controls wave height along with wind speed and wind duration.

Area	Key findings
	expected to be minor in the context of total influent sediment loads, and it has been concluded that in the long term there will not be a material difference to total sediment deposition in the lake zone (Beca 2021: 111) • Nevertheless, increased wet and dry cycling within the Lake Zone area has the potential to result in biochemical impacts to rock art at sites located within this zone.
Downstream Zone (Hawksbury and Nepean Rivers)	• Downstream, the largest / least frequent inundation events are less likely to cause bank erosion (unlike the Existing Scenario) and instead the intermediate / more frequent 1 in 20-year FMZ discharge will cause greater erosion risks. Tough it is noted that actual bank erosion is caused by a multitude of complex factors that operate independent of any affects relating to the Project (Beca 2021: 114). • Downstream areas generally have lower velocities, which could attribute to the deposition of finer sediments in these reaches (Beca 2021:104-105). • Overall, it is concluded that with the Project in the following effects of relevance to Aboriginal cultural heritage within the Downstream Zone: ▪ Flow peaks will be lower, resulting in reduced extensive inundation. ▪ As FMZ flows are designed to be largely within the banks, the Project would result in a net reduction in out of bank sedimentation risk. ▪ The inundation and sedimentation effects are likely to be limited in location and extent and would occur in areas already subject to flooding under the Existing Scenario (Beca 2021: 117-118).

8.5 Detailed Impact assessment

This section provides an revised impact assessment for known Aboriginal heritage sites within the Project area based on:

- The updated approach which considers potential impacts in the context of the incremental increase in temporary inundation for a range of analysis events including the 1 in 5, 1 in 10, 1 in 20, and 1 in 100 chance in a year events (Section 8.1, 8.2 and 8.3).
- An understanding of the changes to hydrology and flooding with the Project (Section 8.2).
- An understanding of likely changes in fluvial geomorphological processes as a result of the Project (Section 8.4).
- An understanding of the potential effects of temporary inundation on different Aboriginal site types, features and/or cultural resources (Section 5.6 and Table 27).

Impacts are considered in terms of archaeological sites (upstream and downstream), the cultural landscape and the GBMWHA with its OUV.

8.5.1 Impacts to archaeological sites

Local catchment run-off represents an existing risk within the Project area that occurs independent of the Project. As recognised in the Longneck Lagoon downstream case study, it is often not possible to differentiate between the effects of temporary inundation (which may be affected by the Project) and those relating to existing local catchment run-off as the types of mechanical processes results in similar affects (e.g. erosion or deposition). Notwithstanding this, the additional information presented in this supplementary assessment (including a more detailed consideration of the changes in hydrology and fluvial geomorphological processes as a result of the Project and a more comprehensive understanding of the potential impacts of inundation of archaeological sites) means that it is possible to assess and define the likely effects of the Project on Aboriginal heritage resources within the Project area, and the mitigation measures required to off-set these likely effects.

Based on a review of literature and the results of the Longneck Lagoon downstream case study (Section 5.6 of the Supplementary Assessment), it was determined that for Aboriginal site features such as Artefact/s (Open Camp Sites and Isolated Artefacts) and PADs, it was not so much the extent and duration of inundation, but the force of the flow involved and susceptibility of an environment to erosion and/or deposition that influenced the potential degree of impact. The temporary inundation experienced as a result of the Project is in the form of backwater flow (which is characterised by a low velocity water flow). While the Project may result in increases in the extent and duration of inundation, the velocity associated with the flow rate will be decreased. Potential impacts will therefore be influenced more by the susceptibility of an area to erosion and/or deposition.

Artefact/s and/or PADs located in high erosion risk areas have the potential to be destroyed by erosional processes which act to remove and/or displace artefacts and any associated features (e.g. PAD) as was observed by Brayshaw (1989: 30) in association with open sites located between the FSL and previous flood level within the Project area. Such potential impacts would result in medium-scale data loss and significantly reduce the integrity and research potential/scientific value of a site. Artefact/s, PADs, Engravings, Grinding Grooves and/or Burials located in low-erosion potential areas such as along the valley of the Wollondilly River, may be subject to siltation/depositional effects from backshore run-off which may act to bury the site in alluvial deposits. Little to no impact to the archaeological integrity of these sites is expected. Furthermore, siltation is recognised to enhance preservation in such a context by providing a buffer against biochemical, mechanical and other forms of destructive impacts (Lenihan et al. 1982: 19). These buried sites, however, may no longer be detectable and/or accessible during surface survey.

Other site features, such as Axe grinding grooves, Engravings, Rock Art and Burials were most susceptible to biomechanical impacts that may result from increased inundation and wet and dry cycling. Rockshelter sites with Art in all areas subject to temporary inundation regardless of duration and extent have the potential to be affected by wet and dry cycling and related mechanical and biochemical impacts including accelerated weathering, granular loss, exfoliation of painted surfaces, removal and/or degradation of pigments and drawing materials. Changed environmental conditions resulting from the deposition of silts, clay, sand and other minerals, for example, can create conditions suitable for the intrusion and growth of destructive micro- or macro-vegetation such as fungi, algae and lichens (Brayshaw 1989: 31). Such potential impacts would significantly reduce the integrity and research potential/scientific value of a site (medium-scale data loss). A summary of potential impacts to archaeological site types and features specific to the Project is provided in Table 67 below based on a consideration of the results of the flood archaeological literature review (Section 5.6) and the nature and location of fluvial geomorphological processes specific to the Project based on the Geomorphological Technical Impact Assessment and erosion hotspot modelling (Beca 2021) as discussed above.

Table 67: Summary of potential impacts to site types and features

Site type or feature	Condition	Description of potential impacts
Artefact/s and PADs (both open-air and	Areas with increased risk of erosion (regardless of form).	Removal and/or displacement of artefacts and/or features resulting in reduced spatial and/or stratigraphic integrity (medium-scale data loss) and reduced research potential/scientific value.

Site type or feature	Condition	Description of potential impacts
rock shelter contexts)	Areas with increased risk of deposition.	May be subject to siltation/depositional effects from backshore run-off which may act to bury the site in alluvial deposits. Little to no impact to the archaeological integrity of these sites is expected. Sites, however, may no longer be detectable and/or accessible during surface survey and analytical dating techniques such as OSL may be compromised.
Engravings and Grinding Grooves	Areas with increased risk of erosion (regardless of form).	No impacts expected to occur.
	Areas with increased risk of deposition.	May be subject to siltation/depositional effects from backshore run-off which may act to bury the site in alluvial deposits. Little to no impact is expected. Sites, however, may no longer be detectable and/or accessible during surface survey. However, in rare cases where plant growth is promoted, biochemical impacts may lead to the breakdown of the parent rock and eventually the loss of the art or groove as an interpretable design or feature.
Burials	Areas with increased risk of erosion (regardless of form).	Susceptible to erosion and thus displacement or destruction. May be affected by biochemical processes and increased rates of decay resulting in reduced integrity, research potential/scientific value of the site (medium-scale data loss) and the large-scale loss of an aspect contributing to the cultural landscape and its associated values.
	Areas with increased risk of deposition.	Susceptible to siltation. May be affected by biochemical processes and increased rates of decay resulting in reduced integrity, research potential/scientific value of the site (medium-scale data loss) and the large-scale loss of an aspect contributing to the cultural landscape and its associated values.
Rockshelters with Art	All areas subject to increased temporary inundation regardless of extent or frequency.	Subject to impacts resulting from wet-and-dry cycling including accelerated weathering, granular loss, exfoliation of painted surfaces, removal and/or degradation of pigments and drawing materials, and/or the intrusion and growth of destructive micro- or macro-vegetation such as fungi, algae and lichens resulting in reduced integrity and research potential/scientific value of a site (medium-scale data loss).
Scarred Trees	All areas subject to increased temporary inundation regardless of extent or frequency.	Increased erosion of the base support, accelerating destabilisation through rotting and/or drowning of the tree and eventual felling resulting in reduced integrity, research potential/scientific value of the site (medium-scale data loss) and the large-scale loss of an aspect contributing to the cultural landscape and its associated values.
Stone arrangements	All areas subject to increased temporary inundation regardless of extent or frequency.	No impacts expected to occur due to the resilience of large stone objects to low flow force processes (e.g. Turnbaugh 1978: 597).
Aboriginal resource and gathering sites	All areas subject to increased temporary inundation regardless	Changes to physical aspects of the sites (such as the character of pre-inundation floral and faunal communities and environments) and/or changes to accessibility. May result in reduced integrity and significance

Site type or feature	Condition	Description of potential impacts
	of extent or frequency.	and loss of ability to conduct a broad range of cultural-environmental analyses (large-scale data loss).
Aboriginal Ceremony and Dreaming sites and Creation story paths	All areas subject to increased temporary inundation regardless of extent or frequency.	Changes to physical aspects of the sites and/or changes to accessibility. Any impacts and/or modification to the environment within which these 'sites' are intrinsically linked would result in loss of information relating to settlement systems, aspects of dreamtime stories and loss of tangible aspects associated with the intangible values associated with these large-scale resources.

The following section provides an impact assessment for Aboriginal sites within the upstream study area looking at changes to temporary inundation levels and durations and the potential effects of these changes on Aboriginal cultural heritage sites. Duration is considered in 'days' as the unit of measure. The duration with the Project refers to the number of additional days of inundation that would be experienced and should be considered as additional to any existing days of inundation prior to the Project (E).

8.5.1.1 Upstream

The original assessment of impacts of the Project operation on Aboriginal cultural heritage sites was provided in Chapter 9 of the ACHA. Table 68 below provides a more detailed impact assessment for known Aboriginal heritage sites located within the PMF with Project, above the FSL, based on the updated approach outlined above. While the impact assessment presented in Table 68 focusses on impacts relating to the archaeological / scientific value of sites it is acknowledged that RAPs have advised throughout the Project, including through the most recent submission process, that all sites have high cultural significance. Further to this most of the RAPs consider the proposal to raise the Warragamba Dam wall; for the temporary storage of flood waters; as an unacceptable impact for the future preservation of tangible and intangible connections to their cultural landscape; and have called for an immediate stop to the Project.

Table 68: Changes to temporary inundation levels and durations at Aboriginal cultural heritage sites and potential effects. Duration is considered in 'days' as the unit of measure. The duration with the Project (P) refers to the number of additional days of inundation that would be experienced and should be considered as additional to any existing days of inundation prior to the Project (E).

New Site number / AHIMS ID#	Site type	Notional elevation (mAHD)	Flood event (1 in x chance in a year)								Description of potential effects
			1 in 5		1 in 10		1 in 20		1 in 100		
			E	P	E	P	E	P	E	P	
Warragamba -00	Open Camp Site with PAD	118m		2.4	**6.4**	3.8	**6.7**	8	**6.4**	8.3	Located in the South Arm Upstream Zone, this site is already affected by temporary inundation during 1 in 10 year, 1 in 20 year, and 1 in 100 year events. The Project will result in inundation events occurring every 1 in 5 years for a maximum of 2.4 days. The Project will result in an increase in the duration of inundation of approx. 3.8 days during a 1 in 10 year event, 8 days during a 1 in 20 year event, and 8.3 days during a 1 in 100 year event. The site will be subject to slight-low erosion risk and siltation/depositional effects from backshore run-off which may act to bury artefacts in alluvial deposits. Little to no impact to the archaeological integrity of this site is expected; however, the site may no longer be detectable and/or accessible during surface survey. Analytical dating techniques such as OSL may be compromised. The site will also be subject to erosion events may cause removal and/or displacement of artefacts and PAD deposit resulting in reduced spatial and stratigraphic integrity (medium-scale data loss) and reduced research potential and scientific value.
Warragamba -01	Open Camp Site with PAD	128m								<0.5	Located in the South Arm Upstream Zone, this site is not currently affected by existing temporary inundation. The Project will result in inundation of less than half a day during a 1 in 100 year event. The site may potentially be subject to siltation/depositional effects from backshore run-off which may act to bury artefacts in alluvial deposits. Little to no impact to the archaeological integrity of this site is expected; however, the site may no longer be detectable and/or accessible during surface survey. Analytical dating techniques such as OSL may be compromised. The site will also be subject to erosion events may cause removal and/or displacement of artefacts and PAD deposit resulting in reduced spatial and stratigraphic integrity (medium-scale data loss) and reduced research potential and scientific value.
Warragamba -03	Open Camp Site	124m					**6.2**	<0.5	**5.2**	<0.5	Located in the South Arm Upstream Zone, this site is not already affected by existing temporary inundation. The Project may result in inundation events occurring every 1 in 20 years and there will be an increase in the duration of inundation of up to half a day for the 1 in 100 year event. The site will be subject to siltation/depositional effects from backshore run-off which may act to bury artefacts in alluvial deposits. Little to no impact to the archaeological integrity of this site is expected.
Warragamba -05	Aboriginal Resource and Gathering	117m	**6.8**	2.4	**6.4**	3.8	**6.7**	8	**6.4**	8.3	Located in the South Arm Upstream Zone, this site is already affected by existing temporary inundation. The Project will result in an increase in the duration of inundation of approx. 2.4 days during a 1 in 5 year event and up to 8.3 additional days during a 1 in 100 year event. Potential impacts include changes to physical aspects of site (such as floral and faunal communities and environments) and/or changes to accessibility resulting in reduced integrity and significance and loss of ability to conduct a broad range of cultural/environmental analyses (large-scale data loss).
Warragamba -06	Open Camp Site	126m					**6.2**	<0.5	**5.2**	<0.5	This site is located in the South Arm Upstream Zone and is not currently affected by temporary inundation. The Project may result in inundation of approx. half a day during a 1 in 100 year event. The site will be subject to siltation/depositional effects from backwater run-off which may act to bury the site in alluvial deposits. Little to no impact to the archaeological integrity of this site is expected; however, the site may no longer be detectable and/or accessible during surface survey.
Warragamba -11	Shelter with Deposit	132m								6.8	This site is located in the South Arm Upstream Zone and is currently not affected by temporary inundation. The Project will result in an inundation event lasting a maximum of 6.8 days during a 1 in 100 year event. The site will be subject to slight-low erosion which could result in the removal and/or displacement of deposits resulting in reduced spatial and/or stratigraphic integrity and reduced research potential/scientific value. Analytical dating techniques such as OSL may be compromised. The site will also be subject to erosion events may cause removal and/or displacement of artefacts and PAD deposit

New Site number / AHIMS ID#	Site type	Notional elevation (mAHD)	Flood event (1 in x chance in a year)								Description of potential effects
			1 in 5		1 in 10		1 in 20		1 in 100		
			E	P	E	P	E	P	E	P	
											resulting in reduced spatial and stratigraphic integrity (medium-scale data loss) and reduced research potential and scientific value.
Warragamba -12	Open Camp site with PAD	130m	**5.9**	<0.5	**5.4**	<0.5	**6.2**	<0.5	**5.2**	<0.5	The site is located in the South Arm Upstream Zone and is not currently affected by temporary inundation. The Project will result in an inundation event lasting a maximum of half a day during a 1 in 100 year event. The site will be subject to siltation/depositional effects from backwater run-off which may act to bury artefacts in alluvial deposits. Little to no impact to the archaeological integrity of this site is expected; however, the site may no longer be detectable and/or accessible during surface survey.
Warragamba 15	Open Camp Site	120m*		2.4		3.8	**6.7**	8	**6.4**	8.3	The site is located in the Lake Upstream Zone and is already affected by existing temporary inundation during 1 in 100 year events. The Project will result in inundation during 1 in 5 year events (maximum of 2.4 days), 1 in 10 year events (maximum of 3.8 days), and 1 in 20 year events (maximum of 8 days). The Project will result in an increase in the duration of inundation of 8.3 days during a 1 in 100 year event. Due to its location on an 'island' near Gorman Point, the site may be subject to increased effects of erosion resulting in further removal and/or displacement of artefacts and/or features and thus reduced spatial and/or stratigraphic integrity (medium-scale data loss).
Warragamba 17	Open Camp Site	121m*	**6.8**	2.4	**6.4**	3.8	**7.2**	8	**6.8**	8.3	The site is located in the Lake Upstream Zone and is already affected by existing temporary inundation during 1 in 100 year events. The Project will result in inundation during a 1 in 10 year event (maximum of 3.8 days), and a 1 in 20 year event (maximum of 8 days). The Project will result in an increase in the duration of inundation of 8.3 days during a 1 in 100 year event. Due to its location on an 'island' near Gorman Point, the site may be subject to increased effects of erosion resulting in further removal and/or displacement of artefacts and/or features and thus reduced spatial and/or stratigraphic integrity (medium-scale data loss).
Warragamba 18	Open Camp Site with PAD	118m*		2.4	**6.4**	3.8	**7.2**	8	**6.8**	8.3	The site is located in the Lake Upstream Zone and is already affected by existing temporary inundation. The Project will result in inundation during a 1 in 5 year event (maximum of 2.4 days), a 1 in 10 year event (maximum of 3.8 days), and a 1 in 20 year event (maximum of 8 days). The Project will result in an increase in the duration of inundation of 8.3 days during a 1 in 100 year event. Due to its location on an 'island' near Gorman Point, the site may be subject to increased effects of erosion resulting in further removal and/or displacement of artefacts and/or features and thus reduced spatial and/or stratigraphic integrity (medium-scale data loss). Analytical dating techniques such as OSL may be compromised. The site will also be subject to erosion events may cause removal and/or displacement of artefacts and PAD deposit resulting in reduced spatial and stratigraphic integrity (medium-scale data loss) and reduced research potential and scientific value.
Warragamba 19	Open Camp Site	117m*	**6.8**	2.4	**6.4**	3.8	**7.2**	8	**6.8**	8.3	Site already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of 8.3 days for the 1 in 100 year event scenario. Due to its location on an elevated shoreline, there is potential for erosions and out of shoreline erosion which could result in removal and/or displacement of artefacts resulting in reduced spatial and/or stratigraphic integrity (medium-scale data loss) and reduced research potential/scientific value.
Warragamba 20	Open Camp Site	118m*		2.4	**6.4**	3.8	**7.2**	8	**6.4**	8.3	The site is located in the Lake Upstream Zone and is already affected by existing temporary inundation during 1 in 100 year events. The Project will result in inundation during a 1 in 5 year event (maximum of 2.4 days), a 1 in 10 year event (maximum of 3.8 days), and a 1 in 20 year event (maximum of 8 days). The Project will result in an increase in the duration of inundation of 8.3 days during a 1 in 100 year event. Due to its location on an 'island' near Gorman Point, the site may be subject to increased effects of erosion resulting in further removal and/or displacement of artefacts and/or features and thus reduced spatial and/or stratigraphic integrity (medium-scale data loss).
Warragamba 21	Open Camp Site	118m*		2.4	**6.4**	3.8	**7.2**	8	**6.4**	8.3	The site is located in the Lake Upstream Zone and is already affected by existing temporary inundation. The Project will result in inundation during a 1 in 5 year event (maximum of 2.4 days), a 1 in 10 year event

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			1 in 5		1 in 10		1 in 20		1 in 100		
			E	P	E	P	E	P	E	P	
											(maximum of 3.8 days), and a 1 in 20 year event (maximum of 8 days). The Project will result in an increase in the duration of inundation of 8.3 days during a 1 in 100 year event. Due to its location on an 'island' near Gorman Point, the site may be subject to increased effects of erosion resulting in further removal and/or displacement of artefacts and/or features and thus reduced spatial and/or stratigraphic integrity (medium-scale data loss).
Warragamba 22	Open Camp Site	119m		2.4		6.4		7.2	**6.4**	6.4	The site is located in the Lake Upstream Zone and is already affected by existing temporary inundation during 1 in 100 year events. The Project will result in inundation during a 1 in 5 year event (maximum of 2.4 days), a 1 in 10 year event (maximum of 3.8 days), and a 1 in 20 year event (maximum of 8 days). The Project will result in an increase in the duration of inundation of 8.3 days during a 1 in 100 year event. Due to its location on an 'island' near Gorman Point, the site may be subject to increased effects of erosion resulting in further removal and/or displacement of artefacts and/or features and thus reduced spatial and/or stratigraphic integrity (medium-scale data loss).
Warragamba 23	Open Camp Site	118m		2.4	**6.4**	3.8	**7.2**	8	**6.4**	8.3	Site already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of 8.3 days for the 1 in 100 year event scenario. Due to its location on an elevated shoreline, there is potential for erosions and out of shoreline erosion which could result in removal and/or displacement of artefacts resulting in reduced spatial and/or stratigraphic integrity (medium-scale data loss) and reduced research potential/scientific value.
Warragamba 24	Open Camp Site	118m		2.4	**6.4**	3.8	**7.2**	8	**6.4**	8.3	The site is located in the Lake Upstream Zone and is already affected by existing temporary inundation. The Project will result in inundation during a 1 in 5 year event (maximum of 2.4 days), a 1 in 10 year event (maximum of 3.8 days), and a 1 in 20 year event (maximum of 8 days). The Project will result in an increase in the duration of inundation of 8.3 days during a 1 in 100 year event. Due to its location on an 'island' near Gorman Point, the site may be subject to increased effects of erosion resulting in further removal and/or displacement of artefacts.
Warragamba 25	Open Camp Site	118m		2.4	**6.4**	3.8	**7.2**	8	**6.4**	8.3	The site is located in the Lake Upstream Zone and is already affected by existing temporary inundation. The Project will result in inundation during a 1 in 5 year event (maximum of 2.4 days), a 1 in 10 year event (maximum of 3.8 days), and a 1 in 20 year event (maximum of 8 days). The Project will result in an increase in the duration of inundation of 8.3 days during a 1 in 100 year event. Due to its location on an 'island' near Gorman Point, the site may be subject to increased effects of erosion resulting in further removal and/or displacement of artefacts.
Warragamba 26	Open Camp Site	118m		2.4	**6.4**	3.8	**7.2**	8	**6.4**	8.3	The site is located in the Lake Upstream Zone and is already affected by existing temporary inundation. The Project will result in inundation during a 1 in 5 year event (maximum of 2.4 days), a 1 in 10 year event (maximum of 3.8 days), and a 1 in 20 year event (maximum of 8 days). The Project will result in an increase in the duration of inundation of 8.3 days during a 1 in 100 year event. Due to its location on an 'island' near Gorman Point, the site may be subject to increased effects of erosion resulting in further removal and/or displacement of artefacts.
Warragamba 27	Open Camp Site	117m	**6.8**	2.4	**6.4**	3.8	**7.2**	8	**6.4**	8.3	Site already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of 3.8 days for the 1 in 10 year event scenario. The Project will result in an increase in duration of temporary inundation of 8.3 days for the 1 in 100 year event scenario. Due to its location on an elevated shoreline, there is potential for erosions and out of shoreline erosion which could result in removal and/or displacement of artefacts and PAD deposit resulting in reduced spatial and stratigraphic integrity (medium-scale data loss) and reduced research potential and scientific value. Analytical dating techniques such as OSL may be compromised.
Warragamba 28	Open Camp Site	117m	**6.8**	2.4	**6.4**	3.8	**7.2**	8	**6.4**	8.3	The site is located in the Lake Upstream Zone and is already affected by existing temporary inundation. The Project will result in inundation during a 1 in 5 year event (maximum of 2.4 days), a 1 in 10 year event (maximum of 3.8 days), and a 1 in 20 year event (maximum of 8 days). The Project will result in an increase

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			E	P	E	P	E	P	E	P	
											in the duration of inundation of 8.3 days during a 1 in 100 year event. Due to its location on an 'island' near Gorman Point, the site may be subject to increased effects of erosion resulting in further removal and/or displacement of artefacts.
Warragamba 29	Open Camp Site	117m	**6.8**	2.4	**6.4**	3.8	**7.2**	8	**6.4**	8.3	The site is located in the Lake Upstream Zone and is already affected by existing temporary inundation. The Project will result in inundation during a 1 in 5 year event (maximum of 2.4 days), a 1 in 10 year event (maximum of 3.8 days), and a 1 in 20 year event (maximum of 8 days). The Project will result in an increase in the duration of inundation of 8.3 days during a 1 in 100 year event. Due to its location on an 'island' near Gorman Point, the site may be subject to increased effects of erosion resulting in further removal and/or displacement of artefacts.
Warragamba 31	Shelter with Deposit and Artefacts	135m									This site is above the project 1 in 100 temporary inundation event and will not be affected by the project.
Warragamba 32	Open Camp Site	117m	**2.8**	4.6	**3.4**	5	**4**	8.6	**4**	10.8	The site is located in the Lake Upstream Zone and is already affected by existing temporary inundation. The Project will result in inundation during a 1 in 5 year event (maximum of 4.6 days), a 1 in 10 year event (maximum of 5 days), and a 1 in 20 year event (maximum of 8.6 days). The Project will result in an increase in the duration of inundation of 10.8 days during a 1 in 100 year event. Due to its location on an 'island' near Gorman Point, the site may be subject to increased effects of erosion resulting in further removal and/or displacement of artefacts.
Warragamba 33	Open Camp Site	117m	**2.8**	4.6	**3.4**	5	**4**	8.6	**4**	10.8	The site is located in the Lake Upstream Zone and is already affected by existing temporary inundation. The Project will result in inundation during a 1 in 5 year event (maximum of 4.6 days), a 1 in 10 year event (maximum of 5 days), and a 1 in 20 year event (maximum of 8.6 days). The Project will result in an increase in the duration of inundation of 10.8 days during a 1 in 100 year event. Due to its location on an 'island' near Gorman Point, the site may be subject to increased effects of erosion resulting in further removal and/or displacement of artefacts.
Warragamba 34	Open Camp Site	117m	**2.8**	4.6	**3.4**	5	**4**	8.6	**4**	10.8	The site is located in the Lake Upstream Zone and is already affected by existing temporary inundation. The Project will result in inundation during a 1 in 5 year event (maximum of 4.6 days), a 1 in 10 year event (maximum of 5 days), and a 1 in 20 year event (maximum of 8.6 days). The Project will result in an increase in the duration of inundation of 10.8 days during a 1 in 100 year event. Due to its location on an 'island' near Gorman Point, the site may be subject to increased effects of erosion resulting in further removal and/or displacement of artefacts.
Warragamba 35	Open Camp Site	117m	**2.8**	4.6	**3.4**	5	**4**	8.6	**4**	10.8	The site is located in the South Arm Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of 4.6 days during a 1 in 5 year event, 5 days during a 1 in 10 year event, 8.6 days during a 1 in 20 year event, and 10.8 days during a 1 in 100 year event. The site will be subject to slight-low erosion risk and siltation/depositional effects from backwater run-off which may act to bury artefacts in alluvial deposits. Little to no impact to the archaeological integrity of this site is expected; however, the site may no longer be detectable and/or accessible during surface survey.
Warragamba 36	Open Camp Site	117m	**2.8**	4.6	**3.4**	5	**4**	8.6	**4**	10.8	The site is located in the South Arm Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of 4.6 days during a 1 in 5 year event, 5 days during a 1 in 10 year event, 8.6 days during a 1 in 20 year event, and 10.8 days during a 1 in 100 year event. The site will be subject to slight-low erosion risk and siltation/depositional effects from backwater run-off which may act to bury artefacts in alluvial deposits. Little to no impact to the archaeological integrity of this site is expected; however, the site may no longer be detectable and/or accessible during surface survey.

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			1 in 5		1 in 10		1 in 20		1 in 100		
			E	P	E	P	E	P	E	P	
Warragamba 37	Open Camp Site	117m	**2.8**	4.6	**3.4**	5	**4**	8.6	**4**	10.8	The site is located in the South Arm Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of 4.6 days during a 1 in 5 year event, 5 days during a 1 in 10 year event, 8.6 days during a 1 in 20 year event, and 10.8 days during a 1 in 100 year event. The site will be subject to slight-low erosion risk and siltation/depositional effects from backwater run-off which may act to bury artefacts in alluvial deposits. Little to no impact to the archaeological integrity of this site is expected; however, the site may no longer be detectable and/or accessible during surface survey.
Warragamba 38	Open Camp Site	117m	**2.8**	4.6	**3.4**	5	**4**	8.6	**4**	10.8	The site is located in the South Arm Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of 4.6 days during a 1 in 5 year event, 5 days during a 1 in 10 year event, 8.6 days during a 1 in 20 year event, and 10.8 days during a 1 in 100 year event. The site will be subject to slight-low erosion risk and siltation/depositional effects from backwater run-off which may act to bury artefacts in alluvial deposits. Little to no impact to the archaeological integrity of this site is expected; however, the site may no longer be detectable and/or accessible during surface survey.
Warragamba 39	Open Camp Site with PAD	117m	**2.8**	4.6	**3.4**	5	**4**	8.6	**4**	10.8	The site is located in the South Arm Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of 4.6 days during a 1 in 5 year event, 5 days during a 1 in 10 year event, 8.6 days during a 1 in 20 year event, and 10.8 days during a 1 in 100 year event. The site will be subject to slight-low erosion risk and siltation/depositional effects from backshore run-off which may act to bury artefacts in alluvial deposits. Soil deposition will have little to no impact to the archaeological integrity of this site is expected; however, the site may no longer be detectable and/or accessible during surface survey. Analytical dating techniques such as OSL may be compromised. The site will also be subject to erosion events may cause removal and/or displacement of artefacts and PAD deposit resulting in reduced spatial and stratigraphic integrity (medium-scale data loss) and reduced research potential and scientific value.
Warragamba 40	Open Camp Site with PAD	117m	**2.8**	4.6	**3.4**	5	**4**	8.6	**4**	10.8	The site is located in the South Arm Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of 4.6 days during a 1 in 5 year event, 5 days during a 1 in 10 year event, 8.6 days during a 1 in 20 year event, and 10.8 days during a 1 in 100 year event. The site will be subject to slight-low erosion risk and siltation/depositional effects from backshore run-off which may act to bury artefacts in alluvial deposits. Little to no impact to the archaeological integrity of this site is expected; however, the site may no longer be detectable and/or accessible during surface survey. Analytical dating techniques such as OSL may be compromised. The site will also be subject to erosion events may cause removal and/or displacement of artefacts and PAD deposit resulting in reduced spatial and stratigraphic integrity (medium-scale data loss) and reduced research potential and scientific value.
Warragamba 41	Open Camp Site	117m	**2.8**	4.6	**3.4**	5	**4**	8.6	**4**	10.8	The site is located in the South Arm Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of 4.6 days during a 1 in 5 year event, 5 days during a 1 in 10 year event, 8.6 days during a 1 in 20 year event, and 10.8 days during a 1 in 100 year event. The site will be subject to slight-low erosion risk and siltation/depositional effects from backwater run-off which may act to bury artefacts in alluvial deposits. Little to no impact to the archaeological integrity of this site is expected; however, the site may no longer be detectable and/or accessible during surface survey.
Warragamba 42	Open Camp Site	117m	**2.8**	4.6	**3.4**	5	**4**	8.6	**4**	10.8	The site is located in the South Arm Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of 4.6 days during a 1 in 5 year event, 5 days during a 1 in 10 year event, 8.6 days during a 1 in 20 year event, and 10.8 days during a 1 in 100 year event. The site will be subject to slight-low erosion risk and siltation/depositional effects from backwater run-off which may act to bury artefacts in alluvial deposits. Little to no impact to the

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			E	P	E	P	E	P	E	P	
											archaeological integrity of this site is expected; however, the site may no longer be detectable and/or accessible during surface survey.
Warragamba 43	Open Camp Site	117m	**2.8**	4.6	**3.4**	5	**4**	8.6	**4**	10.8	The site is located in the South Arm Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of 4.6 days during a 1 in 5 year event, 5 days during a 1 in 10 year event, 8.6 days during a 1 in 20 year event, and 10.8 days during a 1 in 100 year event. The site will be subject to slight-low erosion risk and siltation/depositional effects from backwater run-off which may act to bury artefacts in alluvial deposits. Little to no impact to the archaeological integrity of this site is expected; however, the site may no longer be detectable and/or accessible during surface survey.
Warragamba 44	Open Camp Site	122m				<0.5		3.2		3.6	This site is located in the south arm upstream zone and is subject to inundation during 1 in 100 year event scenarios. The project will result in the site being affected by 1 in 10 and 1 in 20 year event scenarios, with an increase in the duration of inundation of 3.6 days for the 1 in 100 year event scenario. There is potential for the site to be affected by slight to low erosion risk which could result in removal and/or displacement of artefacts resulting in reduced spatial and/or stratigraphic integrity (medium-scale data loss) and reduced research potential/scientific value.
Warragamba 45	Open Camp Site	117m	**2.8**	4.6	**3.4**	5	**4**	8.6	**4**	10.8	This site is located in the South Arm Upstream Zone and is currently affected by inundation events. The project will result in an increase in the duration of inundation of 4.6 days during a 1 in 5 year event scenario and up to 10.8 days during a 1 in 100 year event scenario. There is potential for the site to be affected by slight to low erosion risk which could result in removal and/or displacement of artefacts resulting in reduced spatial and/or stratigraphic integrity (medium-scale data loss) and reduced research potential/scientific value.
Warragamba 46	Shelter with Deposit and Artefacts	135m									This site is above the project 1 in 100 temporary inundation event and will not be affected by the project.
Warragamba 47	Open Camp Site	117m	2.8	4.6	3.4	5	4	8.6	4	10.8	The site is located in the South Arm Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of 4.6 days during a 1 in 5 year event, 5 days during a 1 in 10 year event, 8.6 days during a 1 in 20 year event, and 10.8 days during a 1 in 100 year event. The site will be subject to slight-low erosion risk and siltation/depositional effects from backwater run-off which may act to bury artefacts in alluvial deposits. Little to no impact to the archaeological integrity of this site is expected; however, the site may no longer be detectable and/or accessible during surface survey.
Warragamba 48	Open Camp Site with PAD	117m	2.8	4.6	3.4	5	4	8.6	4	10.8	The site is located in the South Arm Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of 4.6 days during a 1 in 5 year event, 5 days during a 1 in 10 year event, 8.6 days during a 1 in 20 year event, and 10.8 days during a 1 in 100 year event. The site will be subject to slight-low erosion risk and siltation/depositional effects from backwater run-off which may act to bury artefacts in alluvial deposits. Little to no impact to the archaeological integrity of this site is expected; however, the site may no longer be detectable and/or accessible during surface survey. Analytical dating techniques such as OSL may be compromised. The site will also be subject to erosion events may cause removal and/or displacement of artefacts and PAD deposit resulting in reduced spatial and stratigraphic integrity (medium-scale data loss) and reduced research potential and scientific value.
Warragamba 49	Open Camp Site	117m	2.8	4.6	3.4	5	4	8.6	4	10.8	The site is located in the South Arm Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of 4.6 days during a 1 in 5 year event, 5 days during a 1 in 10 year event, 8.6 days during a 1 in 20 year event, and 10.8 days during a 1 in 100 year event. The site will be subject to slight-low erosion risk and siltation/depositional effects from backwater run-off which may act to bury artefacts in alluvial deposits. Little to no impact to the

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			1 in 5		1 in 10		1 in 20		1 in 100		
			E	P	E	P	E	P	E	P	
											archaeological integrity of this site is expected; however, the site may no longer be detectable and/or accessible during surface survey.
Warragamba 50	Open Camp Site	117m	2.8	4.6	3.4	5	4	8.6	4	10.8	The site is located in the South Arm Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of 2.4 days during a 1 in 5 year event and up to 8.3 days during a 1 in 100 year event. There is potential out of shoreline erosion which could result in removal and/or displacement of artefacts resulting in reduced spatial and/or stratigraphic integrity (medium-scale data loss) and reduced research potential/scientific value.
Warragamba 51	Open Camp Site	122m	5.9	<0.5	5.4	<0.5	6.2	3.2	5.2	3.6	This site is located in the South Arm Upstream Zone and is currently not affected by temporary inundation. The Project will result in the site being affected by 1 in 10, 1 in 20, and 1 in 100 year events. There is potential for the site to be affected by slight-low erosion risk which could result in removal and/or displacement of artefacts resulting in reduced spatial and/or stratigraphic integrity (medium-scale data loss) and reduced research potential/scientific value.
Warragamba 52	Open Camp Site	117m	6.8	2.4	6.4	3.8	7.2	8	6.8	8.3	This site is located in the South Arm Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of 2.4 days during a 1 in 5 year event scenario and up to 8.3 days during a 1 in 100 year event. There is potential for the site to be affected by slight-low erosion risk which could result in removal and/or displacement of artefacts resulting in reduced spatial and/or stratigraphic integrity (medium-scale data loss) and reduced research potential/scientific value
Warragamba 53	Open camp site	132m	5.9	<0.5	5.4	<0.5	6.2	<0.5	5.2	<0.5	This site is located in the South Arm Upstream Zone and is currently not affected by temporary inundation. As a result of the Project, the site will experience temporary inundation for less than half a day in rare 1 in 100 year event scenarios.
Warragamba 54	Open Camp Site	117m	6.8	2.4	6.4	3.8	7.2	8	6.8	8.3	This site is located in the South Arm Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of 8.3 days for the 1 in 100 year event scenario. There is potential for the site to be affected by slight to low erosion risk which could result in removal and/or displacement of artefacts resulting in reduced spatial and/or stratigraphic integrity (medium-scale data loss) and reduced research potential/scientific value
Warragamba 55	Shelter with Deposit and Artefacts	117m	6.8	2.4	6.4	3.8	7.2	8	6.8	8.3	This site is located in the south arm upstream zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of 8.3 days for the 1 in 100 year event scenario. There is potential for the site to be affected by slight to low erosion risk which could result in removal and/or displacement of artefacts and PAD resulting in reduced spatial and/or stratigraphic integrity (medium-scale data loss) and reduced research potential/scientific value
Warragamba 57	Shelter with Deposit and Artefacts	131m								<0.5	This site is South Arm Upstream Zone and is not currently affected by temporary inundation. Project may result in an increase in the duration of inundation of approx. half a day for the infrequent 1 in 100 year event scenario. There is potential for the site to be affected by slight to low erosion risk which could result in removal and/or displacement of artefacts and PAD resulting in reduced spatial and/or stratigraphic integrity (medium-scale data loss) and reduced research potential/scientific value
Warragamba 58	Shelter with Deposit and Artefacts	130m								<0.5	This site is located in the South Arm Upstream Zone and is not currently affected by temporary inundation. Project may result in inundation lasting approx. half a day during a 1 in 100 year event scenario. There is potential for the site to be affected by slight to low erosion risk which could result in removal and/or displacement of artefacts and PAD resulting in reduced spatial and/or stratigraphic integrity (medium-scale data loss) and reduced research potential/scientific value
Warragamba 59	Open Camp Site	130m								<0.5	This site is located in the South Arm Upstream Zone and is not currently affected by temporary inundation. Project may result in inundation lasting approx. half a day during a 1 in 100 year event scenario. There is

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			E	P	E	P	E	P	E	P	
											potential for the site to be affected by slight to low erosion risk which could result in removal and/or displacement of artefacts resulting in reduced spatial and/or stratigraphic integrity (medium-scale data loss) and reduced research potential/scientific value
Warragamba 64	Isolated Artefact	123m				<0.5		3.2	5.2	3.6	This site is located in the South Arm Upstream Zone and is currently not affected by temporary inundation. The project will result in the site being affected by 1 in 10, 1 in 20, and 1 in 100 year event scenarios, lasting a maximum of 3.6 days for the 1 in 100 year event scenario. There is potential for the site to be affected by slight-low erosion risk which could result in removal and/or displacement of the isolated artefact resulting in a low likelihood of relocating the site.
Warragamba 65	Open Camp Site	117m	6.8	2.4	6.4	3.8	7.2	8	6.8	8.3	This site is located in the South Arm Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of 8.3 days for the 1 in 100 year event scenario. There is potential for the site to be affected by slight to low erosion risk which could result in removal and/or displacement of artefacts resulting in reduced spatial integrity (medium-scale data loss).
Warragamba 66	Open Camp Site	138m									This site is above the project 1 in 100 temporary inundation event and will not be affected by the project.
Warragamba 67	Open Camp Site	130m								<0.5	This site is located in the South Arm Upstream Zone and is not currently affected by temporary inundation. Project may result in an inundation event occurring every 1 in 100 years for approx. half a day. There is potential for the site to be affected by slight-low erosion risk which could result in removal and/or displacement of artefacts resulting in reduced spatial integrity (medium-scale data loss).
Warragamba 68	Open Camp Site	117m	6.8	2.4	6.4	3.8	7.2	8	6.8	8.3	This site is located in the South Arm Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of 2.4 days during a 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of 8.3 days during a 1 in 100 year event scenario. There is potential for the site to be affected by slight-low erosion risk which could result in removal and/or displacement of artefacts resulting in reduced spatial integrity (medium-scale data loss).
Warragamba 69	Open Camp Site	135m									This site is above the project 1 in 100 temporary inundation event and will not be affected by the project.
Warragamba 70	Open Camp Site	117m	6.8	2.4	6.4	3.8	7.2	8	6.8	8.3	This site is located in the South Arm Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of 2.4 days during a 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of 8.3 days during a 1 in 100 year event scenario. There is potential for the site to be affected by slight-low erosion risk which could result in removal and/or displacement of artefacts resulting in reduced spatial integrity (medium-scale data loss).
Warragamba 71	Open Camp Site	141m									This site is above the project 1 in 100 temporary inundation event and will not be affected by the project.
Warragamba 72	Open Camp Site with PAD	117m	6.8	2.4	6.4	3.8	7.2	8	6.8	8.3	This site is located in the South Arm Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of 2.4 days during a 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of 8.3 days during a 1 in 100 year event scenario. There is potential for the site to be affected by slight-low erosion risk which could result in removal and/or displacement of artefacts and PAD deposit resulting in reduced spatial and stratigraphic integrity (medium-scale data loss) and reduced research potential and scientific value.
Warragamba 73	Isolated Artefact	132m								<0.5	This site is located in the South Arm Upstream Zone and is not currently affected by temporary inundation. Project may result in an inundation occurring every 1 in 100 years, lasting approx. half a day. The project has a slight-low erosion risk which could result in removal and/or displacement of the isolated artefact reducing the Likelihood of relocating the site.

New Site number / AHIMS ID#	Site type	Notional elevation (mAHD)	Flood event (1 in x chance in a year)								Description of potential effects
			1 in 5		1 in 10		1 in 20		1 in 100		
			E	P	E	P	E	P	E	P	
Warragamba 74	Waterhole and Aboriginal Ceremony and Dreaming	117m	6.8	2.4	6.4	3.8	7.2	8	6.8	8.3	This site is located in the South Arm Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of 8.3 days for the 1 in 100 year event scenario. There is potential for changes to physical aspects of the sites and/or changes to accessibility. Any impacts and/or modification to the environment within which these 'sites' are intrinsically linked would result in loss of information relating to settlement systems, aspects of dreamtime stories and loss of tangible aspects associated with the intangible values associated with these large-scale resources.
Warragamba 75	Aboriginal Resource and Gathering	129m						<0.5	5.2	<0.5	This site located in the South Arm Upstream Zone and is currently affected by temporary inundation. As a result of the Project, the site will experience temporary inundation for less than half a day for 1 in 20 year event scenario as well as in rare 1 in 100 year event scenarios. Here is potential for changes to physical aspects of the site (such as the character of pre-inundation floral and faunal communities and environments) and/or changes to accessibility. May result in reduced integrity and significance and loss of ability to conduct a broad range of cultural-environmental analyses (large-scale data loss).
Warragamba 77	Isolated Artefact with PAD	117m*	6.8	2.4	6.4	3.8	7.2	8	6.8	8.3	This site is located in the South Arm Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of 2.4 days during a 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of 8.3 days during a 1 in 100 year event scenario. There is potential for the site to be affected by slight-low erosion risk which could result in removal and/or displacement of artefacts and PAD deposit resulting in reduced spatial and stratigraphic integrity (medium-scale data loss) and reduced research potential and scientific value.
Warragamba 78	Isolated Artefact	118m	6.8	2.4	6.4	3.8	7.2	8	6.8	8.3	This site is located in the South Arm Upstream Zone and is already affected by existing temporary inundation. Project may result in inundation events occurring every 1 in 5 years. The Project will result in an increase in the duration of inundation of 3.8 days during a 1 in 5 year event, 8 days during a 1 in 20 year event and 8.3 days during a 1 in 100 year event. There is potential for the site to be affected by slight-low erosion risk which could result in removal and/or displacement of the isolated artefact reducing the likelihood of relocating the site.
Warragamba 79	Open Camp Site with Scarred Tree	128m								6	This site is located in the South Arm Upstream Zone and is currently not affected by temporary inundation. The Project will result in temporary inundation for a duration of a maximum of 6 days during a 1 in 100 year event. While artefacts at this site have a higher resilience compared to the scarred tree, they are still at risk of removal and/or displacement by erosion events or burial in alluvial sediments from backshore run-off. The Project will result in increased erosion of the base support of the tree, accelerating destabilisation through rotting and/or drowning of the tree and eventual felling resulting in reduced integrity, research potential/scientific value of the site (medium-scale data loss) and the large-scale loss of an aspect contributing to the cultural landscape and associated values.
Warragamba 80	Stone Arrangement	117*	6.8	2.4	6.4	3.8	7.2	8	6.8	8.3	This site is located in the South Arm Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of 2.4 days for the 1 in 5 year event, 3.8 days for a 1 in 10 year event, 8 days for a 1 in 20 year event, and 8.3 days for the 1 in 100 year event. No impacts are expected to occur due to the resilience of large stone objects to low flow force processes.
Warragamba 81	Open Camp Site	117*	6.8	2.4	6.4	3.8	7.2	8	6.8	8.3	This site is located in the South Arm Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of 8.3 days for the 1 in 100 year event scenario. There is potential for the site to be affected by slight-low erosion risk which could result in removal and/or displacement of artefacts resulting in reduced spatial integrity (medium-scale data loss).

New Site number / AHIMS ID#	Site type	Notional elevation (mAHD)	Flood event (1 in x chance in a year)								Description of potential effects
			1 in 5		1 in 10		1 in 20		1 in 100		
			E	P	E	P	E	P	E	P	
Warragamba 82	Open Camp Site	117*	6.8	2.4	6.4	3.8	7.2	8	6.8	8.3	This site is located in the South Arm Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of 8.3 days for the 1 in 100 year event scenario. There is potential for the site to be affected by slight-low erosion risk which could result in removal and/or displacement of artefacts resulting in reduced spatial integrity (medium-scale data loss).
Warragamba 83	Axe Grinding Grooves	127m								<0.5	This site is located in the South Arm Upstream Zone and is not already affected by existing temporary inundation. Project may result in inundation occurring every 1 in 100 years for a duration of less than half a day. While slight-low erosion risk is expected, the site will not be impacted.
Warragamba 84	Shelter with Deposit and Artefacts	117m*	6.8	2.4	6.4	3.8	7.2	8	6.8	8.3	This site is located in the South Arm Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of 8.3 days for the 1 in 100 year event scenario. There is potential for the site to be affected by slight-low erosion risk which could result in removal and/or displacement of artefacts and PAD resulting in reduced spatial and/or stratigraphic integrity (medium-scale data loss) and reduced research potential/scientific value
Warragamba 85	Open Camp Site	117m*	6.8	2.4	6.4	3.8	7.2	8	6.8	8.3	This site is located in the South Arm Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of 8.3 days for the 1 in 100 year event scenario. There is potential for the site to be affected by slight to low erosion risk which could result in removal and/or displacement of artefacts resulting in reduced spatial integrity (medium-scale data loss).
Warragamba 86	Open Camp Site	117m*	6.8	2.4	6.4	3.8	7.2	8	6.8	8.3	This site is located in the South Arm Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of 8.3 days for the 1 in 100 year event scenario. There is potential for the site to be affected by slight to low erosion risk which could result in removal and/or displacement of artefacts resulting in reduced spatial integrity (medium-scale data loss).
Warragamba 88	Isolated Artefact	123m				<0.5	6.2	3.2	5.2	3.6	This site is located in the South Arm Upstream Zone and is not current affected by existing temporary inundation. Project may result in inundation for less than half a day for the 1 in 10, 3.2 days of inundation for the 1 in 20 event scenario and up to 3.6 days of inundation for the 1 in 100 year event scenarios. There is potential for the site to be affected by slight-low erosion risk which could result in removal and/or displacement of the isolated artefact and a reduced likelihood of relocated the site.
Warragamba 89	Open Camp Site	117*	6.8	2.4	6.4	3.8	7.2	8	6.8	8.3	This site is located in the South Arm Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of 8.3 days for the 1 in 100 year event scenario. There is potential for the site to be affected by slight to low erosion risk which could result in removal and/or displacement of artefacts resulting in reduced spatial integrity (medium-scale data loss).
Warragamba 90	Isolated Artefact	139m									This site is above the project 1 in 100 temporary inundation event and will not be affected by the project.
Warragamba 92	Stone Arrangement	143m									This site is above the project 1 in 100 temporary inundation event and will not be affected by the project.
Warragamba 93	Open Camp Site	124m					6.2	3.2	5.2	3.6	this site is located in the South Arm Upstream Zone and is not current affected by existing temporary inundation. Project may result in inundation for approx. 3.2 days of inundation for the 1 in 20 event scenario and up to 3.6 days of inundation for the 1 in 100 year event scenarios. There is potential for the

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			1 in 5		1 in 10		1 in 20		1 in 100		
			E	P	E	P	E	P	E	P	
											site to be affected by slight-low erosion risk which could result in removal and/or displacement of artefacts resulting in reduced spatial integrity (medium-scale data loss).
Warragamba 94	Open Camp Site with PAD	117m*	2.8	4.6	3.4	6	4	8.6	4	10.8	This site is located in the South Arm Upstream Zone and is currently affected by inundation events. The project will result in an increase in the duration of inundation of 4.6 days for the 1 in 5 year event separate project will see an increase in the duration of inundation of 10.8 days for the 1 in 100 year event scenario. There is potential for the site to be affected by slight-low erosion risk which could result in removal and/or displacement of artefacts and PAD deposit resulting in reduced spatial and stratigraphic integrity (medium-scale data loss) and reduced research potential and scientific value.
Warragamba 95	Open Camp Site	117m*	2.8	4.6	3.4	6	4	8.6	4	10.8	This site is located in the South Arm Upstream Zone and is currently affected by inundation events. The project will result in an increase in the duration of inundation of 4.6 days for the 1 in 5 year event scenario. The project will see an increase in the duration of inundation of 10.8 days for the 1 in 100 year event scenario. There is potential for the site to be affected by slight-low erosion risk which could result in removal and/or displacement of artefacts resulting in reduced spatial integrity (medium-scale data loss).
Warragamba 96	Open Camp Site with PAD	117m*	2.8	4.6	3.4	6	4	8.6	4	10.8	This site is located in the South Arm Upstream Zone and is currently affected by inundation events. The project will result in an increase in the duration of inundation of 4.6 days for the 1 in 5 year event scenario. The project will see an increase in the duration of inundation of 10.8 days for the 1 in 100 year event scenario. There is potential for the site to be affected by slight-low erosion risk which could result in removal and/or displacement of artefacts and PAD deposit resulting in reduced spatial and stratigraphic integrity (medium-scale data loss) and reduced research potential and scientific value.
Warragamba 97	Open Camp Site	140m									This site is above the project 1 in 100 temporary inundation event and will not be affected by the project.
Warragamba 98	Open Camp Site	119m		2.4		3.8		8	6.8	8.3	This site is located in the South Arm Upstream Zone and is already affected by temporary inundation during 1 in 100 year events. Project may result in inundation of 2.4 days for the 1 in 5 year event scenario, 3.8 days for the 1 in 10 year event scenario and 3.8 days for a 1 in 20 year event scenario. The Project will result in an increase in duration of temporary inundation of 8.3 days for the 1 in 100 year event scenario. There is potential for the site to be affected by slight-low erosion risk which could result in removal and/or displacement of artefacts resulting in reduced spatial integrity (medium-scale data loss).
Warragamba 99	Open Camp Site	117m	6.8	2.4	6.4	3.8	7.2	8	6.8	8.3	This site is located in the South Arm Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of 8.3 days for the 1 in 100 year event scenario. There is potential for the site to be affected by slight to low erosion risk which could result in removal and/or displacement of artefacts resulting in reduced spatial integrity (medium-scale data loss).
Warragamba 100	Open Camp Site	138m									This site is above the project 1 in 100 temporary inundation event and will not be affected by the project.
Warragamba 101	Isolated Artefact with PAD	127m								3.6	The site is located in the South Arm Upstream Zone and is not current affected by existing temporary inundation. Project may result in inundation for up to 3.6 days of inundation for the 1 in 100 year event scenarios. There is potential for the site to be affected by slight-low erosion risk which could result in removal and/or displacement of artefacts and PAD deposit resulting in reduced spatial and stratigraphic integrity (medium-scale data loss) and reduced research potential and scientific value.
Warragamba 102	Isolated Artefact with PAD	126m						3.2		3.6	The site is located in the South Arm Upstream Zone and is not current affected by existing temporary inundation. Project may result in inundation for 3.2 days of inundation for the 1 in 20 event scenario and up to 3.6 days of inundation for the 1 in 100 year event scenarios. There is potential for the site to be affected by slight-low erosion risk which could result in removal and/or displacement of artefacts and PAD deposit resulting in reduced spatial and stratigraphic integrity (medium-scale data loss) and reduced research potential and scientific value.

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			1 in 5		1 in 10		1 in 20		1 in 100		
			E	P	E	P	E	P	E	P	
Warragamba 104	Shelter with Deposit and Artefacts	126m						3.2		3.6	The site is located in the South Arm Upstream Zone and is not current affected by existing temporary inundation. Project may result in inundation for 3.2 days of inundation for the 1 in 20 event scenario and up to 3.6 days of inundation for the 1 in 100 year event scenarios. There is potential for the site to be affected by slight-low erosion risk which could result in removal and/or displacement of artefacts and PAD resulting in reduced spatial and/or stratigraphic integrity (medium-scale data loss) and reduced research potential/scientific value
Warragamba 105	Open Camp Site	117m	6.8	2.4	6.4	3.8	7.2	8	6.8	8.3	This site is located in the South Arm Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of 8.3 days for the 1 in 100 year event scenario. There is potential for the site to be affected by slight-low erosion risk which could result in removal and/or displacement of artefacts resulting in reduced spatial integrity (medium-scale data loss).
Warragamba 106	Open Camp Site	117*	6.8	2.4	6.4	3.8	7.2	8	6.8	8.3	This site is located in the South Arm Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of 8.3 days for the 1 in 100 year event scenario. There is potential for the site to be affected by slight-low erosion risk which could result in removal and/or displacement of artefacts resulting in reduced spatial integrity (medium-scale data loss).
Warragamba 107	Open Camp Site	117*	6.8	2.4	6.4	3.8	7.2	8	6.8	8.3	This site is located in the South Arm Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of 8.3 days for the 1 in 100 year event scenario. There is potential for the site to be affected by slight-low erosion risk which could result in removal and/or displacement of artefacts resulting in reduced spatial integrity (medium-scale data loss).
Warragamba 108	Isolated Artefact	123m				<0.5		3.2		3.6	The site is located in the South Arm Upstream Zone and is not current affected by existing temporary inundation. Project may result in inundation for less than half a day for a 1 in 10 year event scenario, 3.2 days of inundation for the 1 in 20 event scenario and up to 3.6 days of inundation for the 1 in 100 year event scenarios. There is potential for the site to be affected by slight-low erosion risk which could result in removal and/or displacement of the isolated artefact reducing the likelihood of relocating the site.
Warragamba 109	Open Camp Site with PAD	116m	6.8	2.4	6.4	3.8	7.2	8	6.8	8.3	This site is located in the South Arm Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of 8.3 days for the 1 in 100 year event scenario. There is potential for the site to be affected by slight-low erosion risk which could result in removal and/or displacement of artefacts and PAD deposit resulting in reduced spatial and stratigraphic integrity (medium-scale data loss) and reduced research potential and scientific value.
Warragamba 110	Open Camp Site with PAD	119m				3.8		8	6.8	8.3	This site is located in the South Arm Upstream Zone and is already affected by existing temporary inundation during 1 in 100 year inundation event scenarios. Project may result in inundation of 2.4 days for the 1 in 5 year, 3.8 days for 1 in 10 year, and 8 days for 1 in 20 year event scenarios. The Project will result in an increase in duration of temporary inundation of 8.3 days for the 1 in 100 year event scenario. There is potential for the site to be affected by slight-low erosion risk which could result in removal and/or displacement of artefacts and PAD deposit resulting in reduced spatial and stratigraphic integrity (medium-scale data loss) and reduced research potential and scientific value.
Warragamba 111	Open Camp Site	117m*	6.8	2.4	6.4	3.8	7.2	8	6.8	8.3	This site is located in the South Arm Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of 8.3 days for

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			1 in 5		1 in 10		1 in 20		1 in 100		
			E	P	E	P	E	P	E	P	
											the 1 in 100 year event scenario. There is potential for the site to be affected by slight-low erosion risk which could result in removal and/or displacement of artefacts resulting in reduced spatial integrity (medium-scale data loss).
Warragamba 112	Shelter with Deposit and Artefacts	119m*	6.8	2.4	6.4	3.8	7.2	8	6.8	8.3	This site is located in the West Arm Upstream Zone and is already affected by existing temporary inundation during a 1 in 100 year event scenario. Project may result in an occurrence of inundation every 1 in 5 years for approximately 2.4 days, 1 in 10 years for approx. 3.8 days, 1 in 20 years for approx. 8 days. The Project will result in an increase in duration of temporary inundation of 8.3 days for the 1 in 100 year event. There is potential for the site to be affected by increased out of bank erosion which could result in removal and/or displacement of artefacts and PAD resulting in reduced spatial and/or stratigraphic integrity (medium-scale data loss) and reduced research potential/scientific value.
Warragamba 113	Shelter with Deposit, Art, Artefacts and Axe Grinding Grooves	130m								2	This site is located in the West Arm Upstream Zone and is currently not affected by temporary inundation. Project will result in inundation of 2 days for rare 1 in 100 year events. Art recorded at the site may be subject to impacts resulting from wet-and-dry cycling including accelerated weathering, granular loss, exfoliation of painted surfaces, removal and/or degradation of pigments and drawing materials, and/or the intrusion and growth of destructive micro- or macro- vegetation such as fungi, algae and lichens resulting in reduced integrity and research potential/scientific value of a site (medium-scale data loss). No impact is expected due to resilience of this site type to inundation.
Warragamba 114	Axe Grinding Grooves	122m				<0.5		<0.5		2	This site is located in the West Arm Upstream Zone and is currently not affected by temporary inundation. Project will result in inundation of less than half a day during 1 in 10 and 1 in 20 year event scenarios and up to a maximum of 2 days for the 1 in 100 year event scenario. Due to sites location on eastern bank of Burragorang Lake, the site is not expected to be subject to siltation/deposition. No impact is expected due to resilience of this site type to inundation.
Warragamba 115	Shelter with Deposit, Art and Artefacts	120m		<0.5		<0.5		<0.5	5.3	2	This site is located in the West Arm Upstream Zone and is currently not affected by temporary inundation. Project will result in inundation of less than half a day during 1 in 5, 1 in 10 and 1 in 20 year event scenarios and up to a maximum of 2 days for the 1 in 100 year event scenario. Art recorded at the site may be subject to impacts resulting from wet-and-dry cycling including accelerated weathering, granular loss, exfoliation of painted surfaces, removal and/or degradation of pigments and drawing materials, and/or the intrusion and growth of destructive micro- or macro- vegetation such as fungi, algae and lichens resulting in reduced integrity and research potential/scientific value of a site (medium-scale data loss). Artefacts and PAD may be affected by erosion which could result in removal and/or displacement of material.
Warragamba 117	Open Camp Site	117m	6.8	2.4	6.4	3.8	7.2	8	6.4	8.3	This site is located in the West Arm Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of a maximum of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation a maximum of 8.3 days for the 1 in 100 year event scenario. There is potential for the site to be affected by increased out of bank erosion and siltation/depositional effects from backwater effects.
Warragamba 118	Open Camp Site	118m		2.4	6.4	3.8	7.2	8	6.4	8.3	This site is located in the West Arm Upstream Zone and is already affected by existing temporary inundation. The project will experience 2.4 days of inundation during 1 in 5 Project may result in an increase in the duration of inundation of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of 8.3 days for the 1 in 100 year event scenario. There is potential for the site to be affected by increased out of bank erosion.
Warragamba 119	Open Camp Site	117m*	6.8	2.4	6.4	3.8	7.2	8	6.4	8.3	This site is located in the West Arm Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of a maximum of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation a maximum of 8.3 days for the 1 in 100 year event scenario. There is potential for the site to be affected by increased out of bank erosion and siltation/depositional effects from backwater effects.

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			1 in 5		1 in 10		1 in 20		1 in 100		
			E	P	E	P	E	P	E	P	
Warragamba 124	Open Camp Site	117m*	6.8	2.4	6.4	3.8	7.2	8	6.4	8.3	This site is located in the West Arm Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of a maximum of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of a maximum of 8.3 days for the 1 in 100 year event scenario. There is potential for the site to be affected by increased out of bank erosion and siltation/depositional effects from backwater effects.
Warragamba 125	Isolated Artefact	117m*	6.8	2.4	6.4	3.8	7.2	8	6.4	8.3	This site is located in the West Arm Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of a maximum of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of a maximum of 8.3 days for the 1 in 100 year event scenario. There is potential for the site to be affected by increased out of bank erosion and siltation/depositional effects from backwater effects.
Warragamba 126	Isolated Artefact	117m*	6.8	2.4	6.4	3.8	7.2	8	6.4	8.3	This site is located in the West Arm Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of a maximum of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of a maximum of 8.3 days for the 1 in 100 year event scenario. There is potential for the site to be affected by increased out of bank erosion and siltation/depositional effects from backwater effects.
Warragamba 127	Open Camp Site	117m*	6.8	2.4	6.4	3.8	7.2	8	6.4	8.3	This site is located in the West Arm Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of a maximum of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of a maximum of 8.3 days for the 1 in 100 year event scenario. There is potential for the site to be affected by increased out of bank erosion and siltation/depositional effects from backwater effects.
Warragamba 128	Open Camp Site	117m*	6.8	2.4	6.4	3.8	7.2	8	6.4	8.3	This site is located in the West Arm Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of a maximum of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of a maximum of 8.3 days for the 1 in 100 year event scenario. There is potential for the site to be affected by increased out of bank erosion and siltation/depositional effects from backwater effects.
Warragamba 129	Open Camp Site	117m*	6.8	2.4	6.4	3.8	7.2	8	6.4	8.3	This site is located in the West Arm Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of a maximum of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of a maximum of 8.3 days for the 1 in 100 year event scenario. There is potential for the site to be affected by increased out of bank erosion and siltation/depositional effects from backwater effects.
Warragamba 130	Isolated Artefact	117m*	6.8	2.4	6.4	3.8	7.2	8	6.4	8.3	This site is located in the West Arm Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of a maximum of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of a maximum of 8.3 days for the 1 in 100 year event scenario. There is potential for the site to be affected by increased out of bank erosion and siltation/depositional effects from backwater effects.
Warragamba 131	Shelter with Deposit, Art and Isolated Artefact	117m*	6.8	2.4	6.4	3.8	7.2	8	6.4	8.3	This site is located in the West Arm Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of a maximum of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of a maximum of 8.3 days for the 1 in 100 year event scenario. There is potential for the site to be affected by increased out of bank erosion and siltation/depositional effects from backwater effects. The site may be subject to impacts resulting from wet-and-dry cycling including accelerated weathering, granular loss, exfoliation of painted surfaces, removal and/or degradation of pigments and drawing materials, and/or the intrusion and growth of destructive micro- or macro- vegetation such as fungi, algae and lichens resulting in reduced integrity and research potential/scientific value of the site (medium-scale data loss).

New Site number / AHIMS ID#	Site type	Notional elevation (mAHD)	Flood event (1 in x chance in a year)								Description of potential effects
			1 in 5		1 in 10		1 in 20		1 in 100		
			E	P	E	P	E	P	E	P	
Warragamba 132	Shelter with Deposit and Artefacts	117m*	6.8	2.4	6.4	3.8	7.2	8	6.4	8.3	This site is located in the West Arm Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of a maximum of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of a maximum of 8.3 days for the 1 in 100 year event scenario. There is potential for the site to be affected by increased out of bank erosion and siltation/depositional effects from backwater effects.
Warragamba 135	Shelter with Deposit and Axe Grinding Grooves	129m								<0.5	This site located in the Downstream Zone is currently not already affected by temporary inundation. As a result of the Project, the site will experience temporary inundation for a maximum of less than half a day in rare 1 in 100 year event scenarios. There is potential for an increase in channel fine sediment deposition which may cover/obscure surfaces.
Warragamba 138	Open Camp Site with PAD	127m								2	This site is located in the West Arm Upstream Zone and Site is currently not affected by temporary inundation. Project will result in inundation of a maximum of 2 days for rare 1 in 100 year event scenarios. Deposition of sediments from backwater effects may act to bury recorded Aboriginal objects noted at the site in alluvial deposits. Analytical dating techniques such as OSL may be compromised. The site will also be subject to erosion events may cause removal and/or displacement of artefacts and PAD deposit resulting in reduced spatial and stratigraphic integrity (medium-scale data loss) and reduced research potential and scientific value.
Warragamba 139	Open Camp Site	117m*	6.8	2.4	6.4	3.8	7.2	8	6.4	8.3	Site is located in the West Arm Upstream Zone and is currently subject to existing temporary inundation. The Project will increase the number of days of temporary inundation by a maximum of 8 days for the 1 in 20 year event scenario and up to 8.3 days for the less frequent 1 in 100 year event scenario. Due to its location on within the Coxs Catchment, the site may be subject to the effects of both erosion and deposition. Increased effects of erosion may result in the removal and/or displacement of artefacts and/or features and thus reduced spatial and/or stratigraphic integrity (medium-scale data loss). Increased effects of deposition will result in little to no impact to the archaeological integrity of the site. Though it may no longer be detectable and/or accessible and analytical dating techniques such as OSL may be compromised.
Warragamba 140	Open Camp Site	117m*	6.8	2.4	6.4	3.8	7.2	8	6.4	8.3	Site is located in the West Arm Upstream Zone and is currently subject to existing temporary inundation. The Project will increase the number of days of temporary inundation by a maximum of 8 days for the 1 in 20 year event scenario and up to 8.3 days for the less frequent 1 in 100 year event scenario. Due to its location on within the Coxs Catchment, the site may be subject to the effects of both erosion and deposition. Increased effects of erosion may result in the removal and/or displacement of artefacts and/or features and thus reduced spatial and/or stratigraphic integrity (medium-scale data loss). Increased effects of deposition will result in little to no impact to the archaeological integrity of the site. though it may no longer be detectable and/or accessible and analytical dating techniques such as OSL may be compromised.
Warragamba 141	Open Camp Site	117m*	6.8	2.4	6.4	3.8	7.2	8	6.4	8.3	Site is located in the West Arm Upstream Zone and is currently subject to existing temporary inundation. The Project will increase the number of days of temporary inundation by a maximum of 8 days for the 1 in 20 year event scenario and up to 8.3 days for the less frequent 1 in 100 year event scenario. Due to its location on within the Coxs Catchment, the site may be subject to the effects of both erosion and deposition. Increased effects of erosion may result in the removal and/or displacement of artefacts and/or features and thus reduced spatial and/or stratigraphic integrity (medium-scale data loss). Increased effects of deposition will result in little to no impact to the archaeological integrity of the site. Though it may no longer be detectable and/or accessible and analytical dating techniques such as OSL may be compromised.
Warragamba 142	Open Camp Site	117m*	6.8	2.4	6.4	3.8	7.2	8	6.4	8.3	Site is located in the West Arm Upstream Zone and is currently subject to existing temporary inundation. The Project will increase the number of days of temporary inundation by a maximum of 8 days for the 1 in 20 year event scenario and up to 8.3 days for the less frequent 1 in 100 year event scenario. Due to its location on within the Coxs Catchment, the site may be subject to the effects of both erosion and deposition. Increased effects of erosion may result in the removal and/or displacement of artefacts and/or features and thus reduced spatial and/or stratigraphic integrity (medium-scale data loss). Increased effects

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			1 in 5		1 in 10		1 in 20		1 in 100		
			E	P	E	P	E	P	E	P	
											of deposition will result in little to no impact to the archaeological integrity of the site. though it may no longer be detectable and/or accessible and analytical dating techniques such as OSL may be compromised.
Warragamba 143	Isolated Artefact	125m						3.2		3.6	This site is located in the West Arm Upstream Zone and is not currently subject to existing temporary inundation. As a result of the Project the site will experience temporary inundation for a maximum of 3.2 days for a 1 in 20 year event and 3.6 days for a 1 in 100 year event. These inundation events will not cause damage to the stone artefact; however, erosion activities may cause removal or displacement from its recorded location.
Warragamba 144	Shelter with Art	130m								3.6	Site is located in the South Arm Upstream Zone and will experience inundation for a maximum of 3.6 days during a 1 in 100 year event scenario with the project. In the long term the site may be subject to impacts resulting from wet-and-dry cycling including accelerated weathering, granular loss, exfoliation of painted surfaces, removal and/or degradation of pigments and drawing materials, and/or the intrusion and growth of destructive micro- or macro-vegetation such as fungi, algae and lichens resulting in reduced integrity and research potential/scientific value of a site (medium-scale data loss).
Warragamba 146	Open Camp Site	117m*	6.8	2.4	6.4	3.8	7.2	8	6.4	8.3	Site is located in the lake upstream zone and already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of a maximum of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of a maximum of 8.3 days for the 1 in 100 year event scenario. Potential impacts would include elevated shoreline erosion and out of shoreline erosion resulting in the removal and/or displacement of artefacts.
Warragamba 147	Open Camp Site with PAD	117m*	6.8	2.4	6.4	3.8	7.2	8	6.4	8.3	Site is located in the Lake Upstream Zone and already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of a maximum of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of a maximum of 8.3 days for the 1 in 100 year event scenario. Potential impacts would include elevated shoreline erosion and out of shoreline erosion resulting in the removal and/or displacement of artefacts and PAD deposit resulting in reduced spatial and stratigraphic integrity (medium-scale data loss) and reduced research potential and scientific value.
Warragamba 148	Open Camp Site with PAD	117m*	6.8	2.4	6.4	3.8	7.2	8	6.4	8.3	Site is located in the Lake Upstream Zone and already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of a maximum of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of a maximum of 8.3 days for the 1 in 100 year event scenario. Potential impacts would include elevated shoreline erosion and out of shoreline erosion resulting in the removal and/or displacement of artefacts and PAD deposit resulting in reduced spatial and stratigraphic integrity (medium-scale data loss) and reduced research potential and scientific value.
Warragamba 149	Shelter with Deposit and Artefacts	119m		2.4		3.8		8	6.8	8.3	Site is located in the Lake Upstream Zone and already affected by existing temporary inundation during 1 in 100 year event scenarios. Project may result in inundation lasting a maximum of 2.4 days for 1 in 5, 3.8 days for a 1 in 10 and 8 days for a 1 in 20 year event scenarios. Project may result in an increase in the duration of inundation of a maximum of 8.3 days for the 1 in 100 year event scenario. Potential impacts would include elevated shoreline erosion and out of shoreline erosion resulting in the removal and/or displacement of artefacts.
Warragamba 150	Open Camp Site with PAD	117m*	6.8	2.4	6.4	3.8	7.2	8	6.4	8.3	Site is located in the Lake Upstream Zone and already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of a maximum of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of a maximum of 8.3 days for the 1 in 100 year event scenario. Potential impacts would include elevated shoreline erosion and out of shoreline erosion resulting in the removal and/or displacement of artefacts and PAD deposit resulting in reduced spatial and stratigraphic integrity (medium-scale data loss) and reduced research potential and scientific value.

New Site number / AHIMS ID#	Site type	Notional elevation (mAHD)	Flood event (1 in x chance in a year)								Description of potential effects
			1 in 5		1 in 10		1 in 20		1 in 100		
			E	P	E	P	E	P	E	P	
Warragamba 154	Open Camp Site	118m		2.4	6.4	3.8	7.2	8	6.4	8.3	Site is located in the Lake Upstream Zone and already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of a maximum of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of a maximum of 8.3 days for the 1 in 100 year event scenario. Potential impacts would include elevated shoreline erosion and out of shoreline erosion resulting in the removal and/or displacement of artefacts.
Warragamba 155	Open Camp Site with PAD	117m*	6.8	2.4	6.4	3.8	7.2	8	6.4	8.3	Site is located in the Lake Upstream Zone and already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of a maximum of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of a maximum of 8.3 days for the 1 in 100 year event scenario. Potential impacts would include elevated shoreline erosion and out of shoreline erosion resulting in the removal and/or displacement of artefacts and PAD deposit resulting in reduced spatial and stratigraphic integrity (medium-scale data loss) and reduced research potential and scientific value.
Warragamba 156	Open Camp Site with PAD	117m*	6.8	2.4	6.4	3.8	7.2	8	6.4	8.3	Site is located in the Lake Upstream Zone and already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of a maximum of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of a maximum of 8.3 days for the 1 in 100 year event scenario. Potential impacts would include elevated shoreline erosion and out of shoreline erosion resulting in the removal and/or displacement of artefacts and PAD deposit resulting in reduced spatial and stratigraphic integrity (medium-scale data loss) and reduced research potential and scientific value.
Warragamba 157	Open Camp Site	117m*	6.8	2.4	6.4	3.8	7.2	8	6.4	8.3	Site is located in the Lake Upstream Zone and already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of a maximum of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of a maximum of 8.3 days for the 1 in 100 year event scenario. Potential impacts would include elevated shoreline erosion and out of shoreline erosion resulting in the removal and/or displacement of artefacts.
Warragamba 158	Open Camp Site	117m*	6.8	2.4	6.4	3.8	7.2	8	6.4	8.3	Site is located in the Lake Upstream Zone and already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of a maximum of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of a maximum of 8.3 days for the 1 in 100 year event scenario. Potential impacts would include elevated shoreline erosion and out of shoreline erosion resulting in the removal and/or displacement of artefacts.
Warragamba 159	Open Camp Site	117m*	6.8	2.4	6.4	3.8	7.2	8	6.4	8.3	Site is located in the Lake Upstream Zone and already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of a maximum of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of a maximum of 8.3 days for the 1 in 100 year event scenario. Potential impacts would include elevated shoreline erosion and out of shoreline erosion resulting in the removal and/or displacement of artefacts.
Warragamba 160	Open Camp Site	117m*	6.8	2.4	6.4	3.8	7.2	8	6.4	8.3	Site is located in the Lake Upstream Zone and already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of a maximum of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of a maximum of 8.3 days for the 1 in 100 year event scenario. Potential impacts would include elevated shoreline erosion and out of shoreline erosion resulting in the removal and/or displacement of artefacts.
Warragamba 161	Open Camp Site	117m*	6.8	2.4	6.4	3.8	7.2	8	6.4	8.3	Site is located in the Lake Upstream Zone and already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of a maximum of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of a maximum of 8.3 days for the 1 in 100 year event scenario. Potential impacts would include elevated shoreline erosion and out of shoreline erosion resulting in the removal and/or displacement of artefacts.

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			1 in 5		1 in 10		1 in 20		1 in 100		
			E	P	E	P	E	P	E	P	
Warragamba 162	Isolated Artefact	117m*	6.8	2.4	6.4	3.8	7.2	8	6.4	8.3	Site is located in the Lake Upstream Zone and already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of a maximum of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of a maximum of 8.3 days for the 1 in 100 year event scenario. Potential impacts would include elevated shoreline erosion and out of shoreline erosion resulting in the removal and/or displacement of artefacts.
Warragamba 163	Open Camp Site	117m*	6.8	2.4	6.4	3.8	7.2	8	6.4	8.3	Site is located in the Lake Upstream Zone and already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of a maximum of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of a maximum of 8.3 days for the 1 in 100 year event scenario. Potential impacts would include elevated shoreline erosion and out of shoreline erosion resulting in the removal and/or displacement of artefacts.
Warragamba 164	Open Camp Site	117m*	6.8	2.4	6.4	3.8	7.2	8	6.4	8.3	Site is located in the Lake Upstream Zone and already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of a maximum of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of a maximum of 8.3 days for the 1 in 100 year event scenario. Potential impacts would include elevated shoreline erosion and out of shoreline erosion resulting in the removal and/or displacement of artefacts.
Warragamba 165	Shelter with Deposit and Artefacts	135m									This site is above the project 1 in 100 temporary inundation event and will not be affected by the project.
Warragamba 166	Open Camp Site	117m*	6.8	2.4	6.4	3.8	7.2	8	6.4	8.3	Site is located in the Lake Upstream Zone and already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of a maximum of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of a maximum of 8.3 days for the 1 in 100 year event scenario. Potential impacts would include elevated shoreline erosion and out of shoreline erosion resulting in the removal and/or displacement of artefacts.
Warragamba 167	Open Camp Site	117m*	6.8	2.4	6.4	3.8	7.2	8	6.4	8.3	Site is located in the Lake Upstream Zone and already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of a maximum of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of a maximum of 8.3 days for the 1 in 100 year event scenario. Potential impacts would include elevated shoreline erosion and out of shoreline erosion resulting in the removal and/or displacement of artefacts.
Warragamba 168	Open Camp Site with Scarred Tree	117m*	6.8	2.4	6.4	3.8	7.2	8	6.4	8.3	Site is located in the Lake Upstream Zone and already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of a maximum of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of a maximum of 8.3 days for the 1 in 100 year event scenario. Potential impacts would include elevated shoreline erosion and out of shoreline erosion resulting in the removal and/or displacement of artefacts. Impacts to the scarred tree could potentially involve increased erosion of the base support, accelerating destabilisation through rotting and/or drowning of the tree and eventual felling resulting in reduced integrity, research potential/scientific value of the site (medium-scale loss) and the large-scale loss of an aspect contributing to the cultural landscape and its associated values.
Warragamba 169	Open Camp Site	117m*	6.8	2.4	6.4	3.8	7.2	8	6.4	8.3	Site is located in the Lake Upstream Zone and already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of a maximum of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of a maximum of 8.3 days for the 1 in 100 year event scenario. Potential impacts would include elevated shoreline erosion and out of shoreline erosion resulting in the removal and/or displacement of artefacts.
Warragamba 170	Open Camp Site	117m*	6.8	2.4	6.4	3.8	7.2	8	6.4	8.3	Site is located in the Lake Upstream Zone and already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of a maximum of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of a maximum of 8.3

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			1 in 5		1 in 10		1 in 20		1 in 100		
			E	P	E	P	E	P	E	P	
											days for the 1 in 100 year event scenario. Potential impacts would include elevated shoreline erosion and out of shoreline erosion resulting in the removal and/or displacement of artefacts.
Warragamba 171	Open Camp Site	117m*	6.8	2.4	6.4	3.8	7.2	8	6.4	8.3	Site is located in the Lake Upstream Zone and already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of a maximum of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of a maximum of 8.3 days for the 1 in 100 year event scenario. Potential impacts would include elevated shoreline erosion and out of shoreline erosion resulting in the removal and/or displacement of artefacts.
Warragamba 172	Open Camp Site	117m*	6.8	2.4	6.4	3.8	7.2	8	6.4	8.3	Site is located in the Lake Upstream Zone and already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of a maximum of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of a maximum of 8.3 days for the 1 in 100 year event scenario. Potential impacts would include elevated shoreline erosion and out of shoreline erosion resulting in the removal and/or displacement of artefacts.
Warragamba 173	Open Camp Site	117m*	6.8	2.4	6.4	3.8	7.2	8	6.4	8.3	Site is located in the Lake Upstream Zone and already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of a maximum of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of a maximum of 8.3 days for the 1 in 100 year event scenario. Potential impacts would include elevated shoreline erosion and out of shoreline erosion resulting in the removal and/or displacement of artefacts.
Warragamba 174	Open Camp Site	117m*	6.8	2.4	6.4	3.8	7.2	8	6.4	8.3	Site is located in the Lake Upstream Zone and already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of a maximum of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of a maximum of 8.3 days for the 1 in 100 year event scenario. Potential impacts would include elevated shoreline erosion and out of shoreline erosion resulting in the removal and/or displacement of artefacts.
Warragamba 175	Open Camp Site	117m*	6.8	2.4	6.4	3.8	7.2	8	6.4	8.3	Site is located in the Lake Upstream Zone and already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of a maximum of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of a maximum of 8.3 days for the 1 in 100 year event scenario. Potential impacts would include elevated shoreline erosion and out of shoreline erosion resulting in the removal and/or displacement of artefacts.
Warragamba 176	Open Camp Site	117m*	6.8	2.4	6.4	3.8	7.2	8	6.4	8.3	Site is located in the Lake Upstream Zone and already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of a maximum of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of a maximum of 8.3 days for the 1 in 100 year event scenario. Potential impacts would include elevated shoreline erosion and out of shoreline erosion resulting in the removal and/or displacement of artefacts.
Warragamba 177	Open Camp Site	117m*	6.8	2.4	6.4	3.8	7.2	8	6.4	8.3	Site is located in the Lake Upstream Zone and already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of a maximum of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of a maximum of 8.3 days for the 1 in 100 year event scenario. Potential impacts would include elevated shoreline erosion and out of shoreline erosion resulting in the removal and/or displacement of artefacts.
Warragamba 178	Open Camp Site	117m*	6.8	2.4	6.4	3.8	7.2	8	6.4	8.3	Site is located in the Lake Upstream Zone and already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of a maximum of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of a maximum of 8.3 days for the 1 in 100 year event scenario. Potential impacts would include elevated shoreline erosion and out of shoreline erosion resulting in the removal and/or displacement of artefacts.
Warragamba 179	Aboriginal Resource and Gathering	117m*	6.8	2.4	6.4	3.8	7.2	8	6.4	8.3	Site is located in the Lake Upstream Zone and already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of a maximum of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of a maximum of 8.3

New Site number / AHIMS ID#	Site type	Notional elevation (mAHD)	Flood event (1 in x chance in a year)								Description of potential effects
			1 in 5		1 in 10		1 in 20		1 in 100		
			E	P	E	P	E	P	E	P	
											days for the 1 in 100 year event scenario. Changes to physical aspects of the site (such as character of pre-inundation floral and faunal communities and environments) and/or changes to accessibility may result in reduced integrity and significance and loss of ability to conduct a broad range of cultural/environmental analyses (large-scale data loss).
Warragamba 180	Open Camp Site	117m*	6.8	2.4	6.4	3.8	7.2	8	6.4	8.3	Site is located in the Lake Upstream Zone and already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of a maximum of 2.4 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of a maximum of 8.3 days for the 1 in 100 year event scenario. Potential impacts would include elevated shoreline erosion and out of shoreline erosion resulting in the removal and/or displacement of artefacts.
Warragamba 181	Shelter with Deposit, Art, Artefacts and Axe Grinding Grooves	121m				<0.5		3.2	5.2	3.6	Site is located in the Downstream Zone and is currently affected by existing temporary inundation during 1 in 100 year events. Project may result in inundation for less than half a day for the 1 in 5 and 1 in 10 year events, a maximum of 3.2 days of inundation for 1 in 20 year events and an increased duration of inundation of up to a maximum of 3.6 days for a 1 in 100 year event scenario. Site may be subject to siltation/depositional effects from backwater effects which may act to bury the site in alluvial deposits. Little to no impact to the archaeological integrity of artefacts or deposits is expected. These features: however, may no longer be detectable and/or accessible during surface survey and analytical dating techniques such as OSL may be compromised for any deposit. Griding grooves may be affected in rare cases where a plant growth is promoted; biochemical impacts may lead to the breakdown of the parent rock and eventually the loss of the art or groove as an interpretable design or feature. Art located at the site would be subject to impacts resulting from wet-and-dry cycling including accelerated weathering, granular loss, exfoliation of painted surfaces, removal and/or degradation of pigments and drawing materials, and/or the intrusion and growth of destructive mico- and macro- vegetation such as fungi, algae and lichens resulting in reduced integrity and research potential/scientific value of a site (medium-scale data loss).
Warragamba 183	Isolated Artefact	117m*	2.8	4.6	3.4	6	4	8.6	4	10.8	Site is located in the Lake Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of a maximum of 4.6 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of a maximum of 10.8 days for the 1 in 100 year event scenario. Site may be subject to siltation/depositional effects of backwater run-off which may act to bury the site in alluvial deposits. Little to no impact to the archaeological integrity of this site is expected. The isolated artefact may no longer be detectable and/or accessible during surface survey.
Warragamba 184	Open Camp Site	117m*	2.8	4.6	3.4	6	4	8.6	4	10.8	Site is located in the Lake Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of a maximum of 4.6 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of a maximum of 10.8 days for the 1 in 100 year event scenario. Site may be subject to siltation/depositional effects of backwater run-off which may act to bury the site in alluvial deposits. Little to no impact to the archaeological integrity of this site is expected. There is a chance that artefacts may no longer be detectable and/or accessible during surface survey.
Warragamba 185	Open Camp Site	117m*	2.8	4.6	3.4	6	4	8.6	4	10.8	Site is located in the Lake Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of a maximum of 4.6 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of a maximum of 10.8 days for the 1 in 100 year event scenario. Site may be subject to siltation/depositional effects of backwater run-off which may act to bury the site in alluvial deposits. Little to no impact to the archaeological integrity of this site is expected. There is a chance that artefacts may no longer be detectable and/or accessible during surface survey.

New Site number / AHIMS ID#	Site type	Notional elevation (mAHD)	Flood event (1 in x chance in a year)								Description of potential effects
			1 in 5		1 in 10		1 in 20		1 in 100		
			E	P	E	P	E	P	E	P	
Warragamba 186	Open Camp Site	117m*	2.8	4.6	3.4	6	4	8.6	4	10.8	Site is located in the Lake Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of a maximum of 4.6 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of a maximum of 10.8 days for the 1 in 100 year event scenario. Site may be subject to siltation/depositional effects of backwater run-off which may act to bury the site in alluvial deposits. Little to no impact to the archaeological integrity of this site is expected. There is a chance that artefacts may no longer be detectable and/or accessible during surface survey.
Warragamba 187	Shelter with Deposit	120m		<0.5		<0.5		3.2	5.2	3.6	This site is located in the Lake Upstream Zone and is currently subject to temporary inundation. The project will result in more frequent inundation events occurring during 1 in 5 (maximum duration of <0.5 days), 1 in 10 (maximum duration of <0.5 days), and 1 in 20 (maximum duration 3.2 days) year events. The Project will result in an increase in duration of inundation of 3.6 days during a 1 in 100 year event. Shoreline erosion may result in the removal and/or displacement of deposits resulting in reduced stratigraphic integrity (medium-scale data loss) and reduced research potential/scientific value.
Warragamba 188	Open Camp Site	117m*	2.8	4.6	3.4	6	4	8.6	4	10.8	Site is located in the Lake Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of a maximum of 4.6 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of a maximum of 10.8 days for the 1 in 100 year event scenario. Site may be subject to siltation/depositional effects of backwater run-off which may act to bury the site in alluvial deposits. Little to no impact to the archaeological integrity of this site is expected. There is a chance that artefacts may no longer be detectable and/or accessible during surface survey.
Warragamba 189	Open Camp Site	117m*	2.8	4.6	3.4	6	4	8.6	4	10.8	Site is located in the Lake Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of a maximum of 4.6 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of a maximum of 10.8 days for the 1 in 100 year event scenario. Site may be subject to siltation/depositional effects of backwater run-off which may act to bury the site in alluvial deposits. Little to no impact to the archaeological integrity of this site is expected. There is a chance that artefacts may no longer be detectable and/or accessible during surface survey.
Warragamba 191	Open Camp Site with Axe Grinding Grooves and Isolated Artefact	117m*	2.8	4.6	3.4	6	4	8.6	4	10.8	Site is located in the Downstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of 4.6 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of 10.8 days for the 1 in 100 year event scenario. Site may be subject to siltation/depositional effects of backwater run-off which may act to bury the site in alluvial deposits. Little to no impact is expected; however, sites may no longer be detectable and/or accessible during surface survey. In rare cases, where plant growth is promoted, biochemical impacts may lead to a breakdown of the parent rock and eventually the loss of the groove as a feature.
Warragamba 192	Shelter with Deposit	117m*	2.8	4.6	3.4	6	4	8.6	4	10.8	Site is located in the Downstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of 4.6 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of 10.8 days for the 1 in 100 year event scenario. Site may be subject to siltation/depositional effects of backwater run-off which may act to bury deposits in additional alluvial deposits. Little to no impact to the archaeological integrity of this site is expected. There is a chance that artefacts may no longer be detectable and/or accessible during surface survey and analytical dating techniques such as OSL may be compromised.
Warragamba 193	Shelter with Art	135m									This site is above the project 1 in 100 temporary inundation event and will not be affected by the project.
Warragamba 194	Open Camp Site	117m	2.8	4.6	3.4	6	4	8.6	4	10.8	Site is located in the Lake Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of a maximum of 4.6 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of a maximum of 10.8

New Site number / AHIMS ID#	Site type	Notional elevation (mAHD)	Flood event (1 in x chance in a year)								Description of potential effects
			1 in 5		1 in 10		1 in 20		1 in 100		
			E	P	E	P	E	P	E	P	
											days for the 1 in 100 year event scenario. Site may be subject to siltation/depositional effects of backwater run-off which may act to bury the site in alluvial deposits. Little to no impact to the archaeological integrity of this site is expected. There is a chance that artefacts may no longer be detectable and/or accessible during surface survey.
Warragamba 196	Open Camp Site with Scarred Tree	121m				<0.5		3.2	5.2	3.6	Site is located in the Lake Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of a maximum of <0.5 days for the 1 in10 year event scenario. The Project will result in an increase in duration of temporary inundation of a maximum of 3.6 days for the 1 in 100 year event scenario. Site may be subject to siltation/depositional effects of backwater run-off which may act to bury the site in alluvial deposits. Little to no impact to the archaeological integrity of this site is expected. There is a chance that artefacts may no longer be detectable and/or accessible during surface survey. The scarred tree may be subject to increased erosion of the base support, accelerating destabilisation through rotting and/or drowning of the free and eventual felling resulting in reduced integrity, research potential/scientific value of the site (medium-scale data loss) and the large-scale loss of an aspect contributing to the cultural landscape and its associated values.
Warragamba 198	Isolated Artefact	117m	2.8	4.6	3.4	6	4	8.6	4	10.8	Site is located in the Lake Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of a maximum of 4.6 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of a maximum of 10.8 days for the 1 in 100 year event scenario. Site may be subject to siltation/depositional effects of backwater run-off which may act to bury the site in alluvial deposits. Little to no impact to the archaeological integrity of this site is expected. There is a chance that the isolated artefact may no longer be detectable and/or accessible during surface survey.
Warragamba 199	Open Camp Site with PAD	118m		4.6	3.4	6	4	8.6	4	10.8	Site is located in the Lake Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of a maximum of 4.6 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of a maximum of 10.8 days for the 1 in 100 year event scenario. Site may be subject to siltation/depositional effects of backwater run-off which may act to bury the site in alluvial deposits. Little to no impact to the archaeological integrity of this site is expected. There is a chance that artefacts may no longer be detectable and/or accessible during surface survey. Analytical dating techniques such as OSL may be compromised. The site will also be subject to erosion events may cause removal and/or displacement of artefacts and PAD deposit resulting in reduced spatial and stratigraphic integrity (medium-scale data loss) and reduced research potential and scientific value.
Warragamba 200	Shelter with Deposit and Artefacts	119m		4.6		6		8.6	4	10.8	Site is located in the Lake Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of a maximum of 4.6 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of a maximum of 10.8 days for the 1 in 100 year event scenario. Site may be subject to siltation/depositional effects of backwater run-off which may act to bury the site in alluvial deposits. Little to no impact to the archaeological integrity of this site is expected. There is a chance that artefacts may no longer be detectable and/or accessible during surface survey.
Warragamba 201	Open Camp Site	127m								<0.5	This site is located in the Lake Upstream Zone and is not currently affected by temporary inundation. The project will result in inundation events occurring between every 10 to 100 years during which time the site will be inundated for a maximum of less than half a day during any given inundation event. The site will be subject to elevated shoreline and out of shore erosion resulting in the removal and/or displacement of artefacts and/or features resulting in reduced spatial and/or stratigraphic integrity (medium-scale data loss) and reduced research potential/scientific value.
Warragamba 202	Open Camp Site	123m				<0.5		3.2		3.6	Site is located in the Lake Upstream Zone and is not current affected by existing temporary inundation. Project may result in temporary inundation for less than half a day for the 1 in 10 year event scenario, 3.2

New Site number / AHIMS ID#	Site type	Notional elevation (mAHD)	Flood event (1 in x chance in a year)								Description of potential effects
			1 in 5		1 in 10		1 in 20		1 in 100		
			E	P	E	P	E	P	E	P	
											days of inundation for the 1 in 20 event scenario and up to 3.6 days of inundation for the 1 in 100 year event scenarios. The project will result in elevated shoreline and out of shoreline erosion which could potentially cause the removal and/or displacement of artefacts and PAD deposit resulting in reduced spatial and stratigraphic integrity (medium-scale data loss) and reduced research potential and scientific value.
Warragamba 203	Open Camp Site	120m				<0.5		3.2	5.2	3.6	Site is located in the Lake Upstream Zone and is not current affected by existing temporary inundation. Project may result in temporary inundation for less than half a day for the 1 in 10 year event scenario, 3.2 days of inundation for the 1 in 20 event scenario and up to 3.6 days of inundation for the 1 in 100 year event scenarios. The project will result in elevated shoreline and out of shoreline erosion which could potentially cause the removal and/or displacement of artefacts resulting in reduced spatial and/or stratigraphic integrity (medium-scale data loss) and reduced research potential/scientific value.
Warragamba 205	Open Camp Site	117m	2.8	4.6	3.4	6	4	8.6	4	10.8	Site is located in the Lake Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of a maximum of 4.6 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of a maximum of 10.8 days for the 1 in 100 year event scenario. Site may be subject to siltation/depositional effects of backwater run-off which may act to bury the site in alluvial deposits. Little to no impact to the archaeological integrity of this site is expected. There is a chance that the isolated artefact may no longer be detectable and/or accessible during surface survey.
Warragamba 206	Shelter with Deposit and Artefacts	118m		2.4	6.4	3.8	7.2	8	6.4	8.3	Site is located in the Lake Upstream Zone and already affected by existing temporary inundation. Project will see temporary inundation occurring during 1 in 5 year event scenarios for a maximum of 2.4 days. The Project will result in an increase in duration of temporary inundation of a maximum of 3.8 days during a 1 in 10 year event, 8 days for a 1 in 20 year event, and 8.3 days for the 1 in 100 year event scenario. Potential impacts would include elevated shoreline erosion and out of shoreline erosion resulting in the removal and/or displacement of artefacts and deposits.
Warragamba 207	Shelter with Axe Grinding Grooves and Deposit	117m	6.8	2.4	6.4	3.8	7.2	8	6.4	8.3	Site is located in the West Arm Upstream Zone and is already affected by existing temporary inundation. Project will result in an increase in the duration of inundation of 2.4 days for a 1 in 5 year event, 3.8 days for a 1 in 10 year event, 8 days for a 1 in 20 year event and 8.3 days for the 1 in 100 year event. Increased out of bank erosion may affect deposits at the site.
Warragamba 208	Shelter with Deposit and Artefacts	117m	6.8	2.4	6.4	3.8	7.2	8	6.4	8.3	Site is located in the West Arm Upstream Zone and is already affected by existing temporary inundation. Project will result in an increase in the duration of inundation of 2.4 days for a 1 in 5 year event, 3.8 days for a 1 in 10 year event, 8 days for a 1 in 20 year event and 8.3 days for the 1 in 100 year event. Increased out of bank erosion will result in removal and/or displacement of artefacts resulting in reduced spatial and/or stratigraphic integrity (medium-scale data loss) and reduced research potential/scientific value.
Warragamba 209	Shelter with Deposit, Art and Artefacts	141m	6.8	2.4	6.4	3.8	7.2	8	6.4	8.3	This site is above the project 1 in 100 temporary inundation event and will not be affected by the project.
Warragamba 211	Shelter with Deposit, Art and Artefacts	134m									This site is above the project 1 in 100 temporary inundation event and will not be affected by the project.
Warragamba 212	Open Camp Site	117m	2.8	4.6	3.4	6	4	8.6	4	10.8	Site is located in the Lake Upstream Zone and already affected by existing temporary inundation. Project will see temporary inundation occurring during 1 in 5 year event scenarios for a maximum of 4.6 days. The Project will result in an increase in duration of temporary inundation of a maximum of 6 days during a 1 in 10 year event, 8.6 days for a 1 in 20 year event, and 10.8 days for the 1 in 100 year event scenario. Potential impacts would include elevated shoreline erosion and out of shoreline erosion resulting in the removal and/or displacement of artefacts and deposits.

New Site number / AHIMS ID#	Site type	Notional elevation (mAHD)	Flood event (1 in x chance in a year)								Description of potential effects
			1 in 5		1 in 10		1 in 20		1 in 100		
			E	P	E	P	E	P	E	P	
Warragamba 214	Open Camp Site	119m		2.4		3.8		8	6.8	8.3	This site is located in the Lake Upstream Zone and is already affected by temporary inundation. Project will result in inundation events occurring during 1 in 5 year events (maximum duration 2.4 days), 1 in 10 year events (maximum duration 3.8 days), and 1 in 20 year events (maximum duration 8 days). There will be an increase in duration of inundation for a maximum of 8.3 days during a 1 in 100 year event. Potential impacts would include elevated shoreline erosion and out of shoreline erosion resulting in the removal and/or displacement of artefacts and deposits.
Warragamba 216	Open Camp Site	118m		4.6	3.4	6	4	8.6	4	10.8	Site is located in the Lake Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of 4.6 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of 10.8 days for the 1 in 100 year event scenario. Potential impacts would include elevated shoreline erosion and out of shoreline erosion resulting in the removal and/or displacement of artefacts and deposits.
Warragamba 217	Open Camp Site	117m	2.8	4.6	3.4	6	4	8.6	4	10.8	Site is located in the Lake Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of 4.6 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of 10.8 days for the 1 in 100 year event scenario. Potential impacts would include elevated shoreline erosion and out of shoreline erosion resulting in the removal and/or displacement of artefacts and deposits.
Warragamba 219	Shelter with Deposit, Axe Grinding Grooves and Isolated Artefact	137m									This site is above the project 1 in 100 temporary inundation event and will not be affected by the project.
Warragamba 221	Open Camp Site	117m	2.8	4.6	3.4	6	4	8.6	4	10.8	Site is located in the Lake Upstream Zone and is already affected by existing temporary inundation. Project may result in an increase in the duration of inundation of 4.6 days for the 1 in 5 year event scenario. The Project will result in an increase in duration of temporary inundation of 10.8 days for the 1 in 100 year event scenario. Potential impacts would include elevated shoreline erosion and out of shoreline erosion resulting in the removal and/or displacement of artefacts and deposits.
Warragamba 225	Shelter with Deposit and Artefacts	135m									This site is above the project 1 in 100 temporary inundation event and will not be affected by the project.
Warragamba 228	Axe Grinding Grooves	127m								0.7	This site is located in the West Arm Upstream Zone and is not currently affected by temporary inundation. The project will result in temporary inundation for a duration of less than a day for both a 1 in 20 and 1 in 100 year event. The creeks in this western portion of the Subject Area experience out of bank erosion which is expected to increase as a result of the project. No impacts to the grinding grooves are expected to occur as a result of the Project.
Warragamba 229	Open Camp Site with PAD	121m				<0.5		3.2	5.2	3.6	This site is located in the West Arm Upstream Zone and is currently affected by temporary inundation during a 1 in 100 year event. The project will result in temporary inundation for a duration of less than a day for a 1 in 10 year event and 3.2 days for a 1 in 20 year event. Temporary inundation will increase by a maximum of 3.6 days during a 1 in 100 year event. The creeks in this western portion of the Subject Area experience out of bank erosion which is expected to increase as a result of the project resulting in removal and/or displacement of artefacts and PAD deposit resulting in reduced spatial and stratigraphic integrity (medium-scale data loss) and reduced research potential and scientific value.
Warragamba 230	Open Camp Site	119m		4.6		6		8.6	4	10.8	Site is located in the West Arm Upstream Zone and is already affected by existing temporary inundation during a 1 in 100 year events. Project will result in inundation lasting a maximum of 4.6 days for the 1 in 5 year event scenario, 6 days for a 1 in 10 year event, and 8.6 days for a 1 in 20 year event. The Project will result in an increase in duration of temporary inundation of a maximum of 10.8 days for the 1 in 100 year

New Site number / AHIMS ID#	Site type	Notional elevation (mAHD)	Flood event (1 in x chance in a year)								Description of potential effects
			1 in 5		1 in 10		1 in 20		1 in 100		
			E	P	E	P	E	P	E	P	
											event scenario. The creeks in this western portion of the Subject Area experience out of bank erosion which is expected to increase as a result of the project resulting in removal and/or displacement of artefacts resulting in spatial and/or stratigraphic integrity (medium-scale data loss) and reduced research potential/scientific value and altered accessibility.
Warragamba 232	Open Camp Site	119m		4.6		6		8.6	4	10.8	Site is located in the West Arm Upstream Zone and is already affected by existing temporary inundation during a 1 in 100 year events. Project will result in inundation lasting a maximum of 4.6 days for the 1 in 5 year event scenario, 6 days for a 1 in 10 year event, and 8.6 days for a 1 in 20 year event. The Project will result in an increase in duration of temporary inundation of a maximum of 10.8 days for the 1 in 100 year event scenario. The creeks in this western portion of the Subject Area experience out of bank erosion which is expected to increase as a result of the project resulting in removal and/or displacement of artefacts resulting in spatial and/or stratigraphic integrity (medium-scale data loss) and reduced research potential/scientific value and altered accessibility.
Warragamba 233	Aboriginal Resource and Gathering	129m								<0.5	Site is located in the West Arm Upstream Zone and is not currently affected by temporary inundation. The project will result in temporary inundation of the site for a maximum of less than half a day. Changes to physical aspects of the site (such as character of pre-inundation floral and faunal communities and environments) and/or changes to accessibility may result in reduced integrity and significance and loss of ability to conduct a broad range of cultural/environmental analysis (large-scale data loss).
Warragamba 235	Open Camp Site with PAD	129m								<0.5	Site is located in the West Arm Upstream Zone and is not currently affected by temporary inundation. The project will result in temporary inundation of the site for a maximum of less than half a day. Out of bank erosion may occur resulting in removal and/or displacement of artefacts and PAD deposit resulting in reduced spatial and stratigraphic integrity (medium-scale data loss) and reduced research potential and scientific value.
Warragamba 236	Open Camp Site	130m								<0.5	Site is located in the West Arm Upstream Zone and is not currently affected by temporary inundation. The project will result in temporary inundation of the site for a maximum of less than half a day. Out of bank erosion may occur resulting in removal and/or displacement of artefacts resulting in reduced spatial and/or stratigraphic integrity (medium-scale data loss).
Warragamba 239	Shelter with Deposit and Isolated Artefact	119m		4.6		6		8.6	4	10.8	Site is located in the Downstream Zone and is already affected by existing temporary inundation from 1 in 20 and 1 in 100 year events. Project will result in temporary inundation during 1 in 5 and 1 in 10 year events for a maximum of 4 days. The project will result in an increase in the duration of inundation of 8.6 days for the 1 in 20 year event scenario and 10.8 days for the 1 in 100 year event scenario. Increased in-channel fine sediment deposition occurring at the site as a result of inundation will make it more difficult to relocate the isolated artefact. Overall, little to no impact to the archaeological integrity of the site is expected. The site: however, may no longer be as accessible and analytical dating techniques such as OSL may be compromised.
Warragamba 248	Open Camp Site	117m	6.8	2.4	6.4	3.8	7.2	8	6.4	8.3	Site is located in the West Arm Upstream Zone and is already affected by existing temporary inundation. Project will result in an increase in the duration of inundation of 2.4 days for a 1 in 5 year event, 3.8 days for a 1 in 10 year event, 8 days for a 1 in 20 year event and 8.3 days for the 1 in 100 year event. Increased out of bank erosion will result in removal and/or displacement of artefacts resulting in reduced spatial and/or stratigraphic integrity (medium-scale data loss).
Warragamba 249	Open Camp Site	116m	6.8	2.4	6.4	3.8	7.2	8	6.4	8.3	Site is located in the West Arm Upstream Zone and is already affected by existing temporary inundation. Project will result in an increase in the duration of inundation of 2.4 days for a 1 in 5 year event, 3.8 days for a 1 in 10 year event, 8 days for a 1 in 20 year event and 8.3 days for the 1 in 100 year event. Increased out of bank erosion will result in removal and/or displacement of artefacts resulting in reduced spatial and/or stratigraphic integrity (medium-scale data loss).

New Site number / AHIMS ID#	Site type	Notional elevation (mAHD)	Flood event (1 in x chance in a year)								Description of potential effects
			1 in 5		1 in 10		1 in 20		1 in 100		
			E	P	E	P	E	P	E	P	
Warragamba 251	Open Camp Site	118m	6.8	2.4	6.4	3.8	7.2	8	6.4	8.3	Site is located in the West Arm Upstream Zone and is already affected by existing temporary inundation. Project will result in temporary inundation for 1 in 5 year events, lasting a maximum of 2.4 days. There will be an increase in the duration of inundation of 3.8 days for a 1 in 10 year event, 8 days for a 1 in 20 year event and 8.3 days for the 1 in 100 year event. Increased out of bank erosion will result in removal and/or displacement of artefacts resulting in reduced spatial and/or stratigraphic integrity (medium-scale data loss).
Warragamba 252	Open Camp Site	121m				3.8		8	6.4	8.3	Site is located in the West Arm Upstream Zone and is already affected by existing temporary inundation. Project will result in temporary inundation for 1 in 5 year events, lasting a maximum of 2.4 day. 3.8 days for 1 in 10 year events, and 8 days of 1 in 20 year events. There will be an increase in the duration of inundation of 8.3 days for the 1 in 100 year event. Increased out of bank erosion will result in removal and/or displacement of artefacts resulting in reduced spatial and/or stratigraphic integrity (medium-scale data loss).
Warragamba 256	Open Camp Site	117m	6.8	2.4	6.4	3.8	7.2	8	6.4	8.3	Site is located in the West Arm Upstream Zone and is already affected by existing temporary inundation. Project will result in an increase in the duration of inundation of 2.4 days for 1 in 5 year events, 3.8 says for 1 in 10 year events, 8 days for 1 in 20 year events, and 8.3 days for the 1 in 100 year event. Increased out of bank erosion will result in removal and/or displacement of artefacts resulting in reduced spatial and/or stratigraphic integrity (medium-scale data loss).
Warragamba 262	Open Camp Site	120m		<0.5		<0.5		3.2	5.2	3.6	Site is located in the West Arm Upstream Zone and is already affected by existing temporary inundation during 1 in 100 year events. Project will result in inundation of less than half a day for 1 in 5 and 1 in 10 year events and 3.2 days for 1 in 20 year events. The project will result in an increase in the duration of inundation of a maximum of 3.6 days for the 1 in 100 year event. Increased out of bank erosion will result in removal and/or displacement of artefacts resulting in reduced spatial and/or stratigraphic integrity (medium-scale data loss).
Warragamba 263	Open Camp Site	123m									The project will result in an increase in the duration of inundation of a maximum of 3.6 days for the 1 in 100 year event. Increased out of bank erosion will result in removal and/or displacement of artefacts resulting in reduced spatial and/or stratigraphic integrity (medium-scale data loss).
Warragamba 264	Open Camp Site	118m		2.4	6.4	3.8	7.2	8	6.4	8.3	This site is located in the West Arm Upstream Zone and is currently affected by temporary inundation. Project will result in inundation events happening every 1 in 5 years and an increase in the duration of inundation of 3.8 days for 1 in 10 year events, 8 days for 1 in 20 year events, and 8.3 days for the 1 in 100 year event. Increased out of bank erosion will result in removal and/or displacement of artefacts resulting in reduced spatial and/or stratigraphic integrity (medium-scale data loss).
Warragamba 266	Open Camp Site	119m		2.4		3.8		8	6.4	8.3	This site is located in the West Arm Upstream Zone and is currently affected by temporary inundation. Project will result in inundation events happening every 1 in 5 years and an increase in the duration of inundation of 8.3 days for the 1 in 100 year event. Increased out of bank erosion will result in removal and/or displacement of artefacts resulting in reduced spatial and/or stratigraphic integrity (medium-scale data loss).
Warragamba 268	Open Camp Site with PAD	117m	6.8	2.4	6.4	3.8	7.2	8	6.4	8.3	Site is located in the West Arm Upstream Zone and is already affected by existing temporary inundation. Project will result in an increase in the duration of inundation of 2.4 days for 1 in 5 year events, 3.8 days for 1 in 10 year events, 8 days for 1 in 20 year events, and 8.3 days for the 1 in 100 year event. Increased out of bank erosion will result in removal and/or displacement of artefacts and PAD deposit resulting in reduced spatial and stratigraphic integrity (medium-scale data loss) and reduced research potential and scientific value (medium-scale data loss).
Warragamba 269	Isolated Artefact	117m	6.8	2.4	6.4	3.8	7.2	8	6.4	8.3	Site is located in the West Arm Upstream Zone and is already affected by existing temporary inundation. Project will result in an increase in the duration of inundation of 2.4 days for 1 in 5 year events, 3.8 days for 1 in 10 year events, 8 days for 1 in 20 year events, and 8.3 days for the 1 in 100 year event. Increased

New Site number / AHIMS ID#	Site type	Notional elevation (mAHD)	Flood event (1 in x chance in a year)								Description of potential effects
			1 in 5		1 in 10		1 in 20		1 in 100		
			E	P	E	P	E	P	E	P	
											out of bank erosion will result in removal and/or displacement of the isolated artefact, making it difficult to relocate the site.
Warragamba 271	Open Camp Site	125m						8		8.3	Site is located in the West Arm Upstream Zone and is not currently affected by existing temporary inundation. Project will result in inundation events occurring during 1 in 20 and 1 in 100 year events for a maximum of 8.3 days. Increased out of bank erosion will result in removal and/or displacement of artefacts and PAD deposit resulting in reduced spatial and stratigraphic integrity (medium-scale data loss) and reduced research potential and scientific value.
Warragamba-296	Shelter with Deposit, Art, Artefacts and Axe Grinding Grooves	134m									This site is above the project 1 in 100 temporary inundation event and will not be affected by the project.
Warragamba-297	Shelter with Deposit and Artefacts	136m									This site is above the project 1 in 100 temporary inundation event and will not be affected by the project.
Warragamba-298	Shelter with Deposit, Axe Grinding Grooves and Isolated Artefact	129m								<0.5	This site is located in the Downstream Zone and is currently not affected by temporary inundation. Temporary inundation of less than half a day is expected during 1 in 100 year events. Increased in-channel fine sediment deposition may occur at this site resulting in the site being subject to siltation/deposition effects from backwater run-off which may act to bury the isolated artefact in alluvial deposits. No impacts to the grinding grooves are expected.
Warragamba-299	Shelter with Deposit and Artefacts	129m								<0.5	This site is located in the Downstream Zone and is currently not affected by temporary inundation. Temporary inundation of less than half a day is expected during 1 in 100 year events. Increased in-channel fine sediment t deposition may occur at this site resulting in the site being subject to siltation/deposition effects from backwater run-off which may act to bury artefacts and deposits in alluvial deposits.
Warragamba-300	Shelter with Deposit and Art	118m		2.4	6.4	3.8	7.2	8	6.4	8.3	This site is located in the Downstream Zone and is currently affected by temporary inundation during 1 in 10, 1 in 20 and 1 in 100 year events. The project will see inundation occurring during 1 in 5 year events for a maximum duration of 2.4 days. The project will result in increased duration of inundation of a maximum of 3.8 days during 1 in 10 year events, 8 days during 1 in 20 year events, and 8.3 days during 1 in 100 year events. Increased in-channel fine sediment t deposition may occur at this site resulting in the site being subject to siltation/deposition effects from backwater run-off which may act to bury deposits in alluvial deposits. Art recorded at this site will be subject to impacts resulting from wet-and-dry cycling including accelerated weathering, granular loss, exfoliation of painted surfaces removal and/or degradation of pigments and drawing materials, and/or the intrusion and growth of destructive micro- and marco-vegetation such as fungi, algae and lichens resulting in reduced integrity and research potential/scientific value of a site (medium-scale data loss).
Warragamba-301	Shelter with Deposit and Artefacts	118m		2.4	6.4	3.8	7.2	8	6.4	8.3	This site is located in the Downstream Zone and is currently affected by temporary inundation during 1 in 10, 1 in 20 and 1 in 100 year events. The project will see inundation occurring during 1 in 5 year events for a maximum duration of 2.4 days. The project will result in increased duration of inundation of a maximum of 3.8 days during 1 in 10 year events, 8 days during 1 in 20 year events, and 8.3 days during 1 in 100 year events. Increased in-channel fine sediment t deposition may occur at this site resulting in the site being subject to siltation/deposition effects from backwater run-off which may act to bury artefacts and PADs in alluvial deposits.
Warragamba-302	Open Camp Site	117m	6.8	2.4	6.4	3.8	7.2	8	6.4	8.3	This site is located in the Downstream Zone and is currently affected by temporary inundation during 1 in 5, 1 in 10, 1 in 20 and 1 in 100 year events. The project will result in increased duration of inundation of a maximum of 2.4 days during 1 in 5 year events, 3.8 days during 1 in 10 year events, 8 days during 1 in 20 year events, and 8.3 days during 1 in 100 year events. Increased in-channel fine sediment t deposition may

New Site number / AHIMS ID#	Site type	Notional elevation (mAHD)	Flood event (1 in x chance in a year)								Description of potential effects
			1 in 5		1 in 10		1 in 20		1 in 100		
			E	P	E	P	E	P	E	P	
											occur at this site resulting in the site being subject to siltation/deposition effects from backwater run-off which may act to bury artefacts in alluvial deposits.
Warragamba-303	Open Camp Site	120m		2.4		3.8		8	6.4	8.3	Site is located in the West Arm Upstream Zone and is currently affected by existing temporary inundation during 1 in 100 year events. Project will result in inundation of the site for a maximum of 2.4 days during a 1 in 5 year event and 3.8 days during a 1 in 10 year event. Project will result in increased inundation of 8 days and 8.3 days during the 1 in 20 year and 1 in 100 year events respectively. Increased out of bank erosion will result in removal and/or displacement of artefacts resulting in reduced spatial and/or stratigraphic integrity (medium-scale data loss).
Warragamba-304	Axe Grinding Grooves	119m		2.4		3.8		8	6.4	8.3	Site is located in the West Arm Upstream Zone and is currently affected by existing temporary inundation during 1 in 100 year events. Project will result in inundation of the site for a maximum of 2.4 days during a 1 in 5 year event and 3.8 days during a 1 in 10 year event. Project will result in increased inundation of 8 days and 8.3 days during the 1 in 20 year and 1 in 100 year events respectively. Increased out of bank erosion will result in removal and/or displacement of artefacts resulting in reduced spatial and/or stratigraphic integrity (medium-scale data loss). No impacts to grinding grooves are expected as a result of the project.
Warragamba-305	Shelter with Deposit, Artefacts and Axe Grinding Grooves	119m		2.4		3.8		8	6.4	8.3	
45-4-0186	Policemans Point (Shelter with Deposit, Artefacts and Axe Grinding Grooves)	127m								0.7	Site is located in the West Arm Upstream Zone and is not currently affected by existing temporary inundation. Project will result in inundation of the site for a maximum of less than 1 day during a 1 in 20 and 1 in 100 year events. Increased out of bank erosion will result in removal and/or displacement of artefacts and deposits resulting in reduced spatial and/or stratigraphic integrity (medium-scale data loss). No impacts to grinding grooves are expected as a result of the project.
45-4-0931	EH 1; Warragamba Special Area (Open Camp Site)	119m		2.4	6.4	3.8	7.2	8	6.4	8.3	Site is located in the West Arm Upstream Zone and is currently affected by existing temporary inundation during 1 in 100 year events. Project will result in inundation of the site for a maximum of 2.4 days during a 1 in 5 year event and 3.8 days during a 1 in 10 year event. Project will result in increased inundation of 8 days and 8.3 days during the 1 in 20 year and 1 in 100 year events respectively. Increased out of bank erosion will result in removal and/or displacement of artefacts resulting in reduced spatial and/or stratigraphic integrity (medium-scale data loss).
45-4-0944	GW1	120m		2.4		3.8		8	6.4	8.3	This site is located in the Lake Upstream Zone and is currently affected by temporary inundation during a 1 in 100 year event. The Project will result in inundation events occurring every 1 in 5, 1 in 10 and 1 in 20 years with a maximum duration of 2.4 days, 3.8 days, and 8 days respectively. The Project will result in an increase in inundation duration of 8.3 days for a 1 in 100 year event. The Project will result in elevated shoreline and out of shoreline erosion likely to cause removal and/or displacement of artefacts resulting in reduced spatial integrity (medium-scale data loss).
45-4-0945	Gw2	120m		2.4		3.8		8	6.4	8.3	This site is located in the Lake Upstream Zone and is currently affected by temporary inundation during a 1 in 100 year event. The Project will result in inundation events occurring every 1 in 5, 1 in 10 and 1 in 20 years with a maximum duration of 2.4 days, 3.8 days, and 8 days respectively. The Project will result in an increase in inundation duration of 8.3 days for a 1 in 100 year event. The Project will result in elevated shoreline and out of shoreline erosion likely to cause removal and/or displacement of artefacts resulting in reduced spatial integrity (medium-scale data loss).
45-4-0946	TR1 (Open Camp Site)	122m				<0.5		3.2		3.6	This site is located in the South Arm Upstream Zone and is currently not affected by temporary inundation. The Project will result in temporary inundation occurring during 1 in 5 (maximum 0.5 days), 1 in 10 (maximum 0.5 days), 1 in 20 (maximum 3.2 days), and 1 in 100 (maximum 3.6 days) year events. The site

New Site number / AHIMS ID#	Site type	Notional elevation (mAHD)	Flood event (1 in x chance in a year)								Description of potential effects
			1 in 5		1 in 10		1 in 20		1 in 100		
			E	P	E	P	E	P	E	P	
											will experience slight-slow out of bank erosion risk due to its location on the Wollondilly River. The site may also experience translocation of sediment features upstream and floodplain sediment deposition at various times. As a result of the Project, artefacts may be removed or displaced during erosion events or buried by siltation/deposition due to backwater effects.
45-4-0967	RC1 (Open Camp Site)	122m				<0.5		3.2		3.6	This site is located in the West Arm Upstream Zone along Butchers Creek and is currently not affected by temporary inundation. The Project will result in temporary inundation occurring during 1 in 5 (maximum 0.5 days), 1 in 10 (maximum 0.5 days), 1 in 20 (maximum 3.2 days), and 1 in 100 (maximum 3.6 days) year events. Increased out of bank erosion is expected due to increased land gradients resulting in the removal and/or displacement of artefacts resulting in reduced spatial integrity (medium-scale data loss).
45-4-0983	JUNCTION POINT 1 (Open Camp Site)	147m									
45-4-0997	Bimlow PAD (Shelter with Art, Artefacts and Axe Grinding Grooves) / Warragamba 190	120m		<0.5		<0.5		3.2	5.2	3.6	This site is located in the Lake Upstream Zone and is currently not affected by temporary inundation. The Project will result in temporary inundation occurring during 1 in 5 (maximum 0.5 days), 1 in 10 (maximum 0.5 days), 1 in 20 (maximum 3.2 days), and 1 in 100 (maximum 3.6 days) year events. The Project will result removal and/or displacement of artefacts and PAD caused by potential out of shore erosion resulting in reduced spatial and or stratigraphic integrity (medium-scale data loss) and reduced research potential/scientific value. Art recorded at the site will be subject to impacts resulting from wet-and dry cycling including accelerated weathering, granular loss, exfoliation of painted surfaces, removal and/or degradation of pigments and drawing materials, and/or the intrusion and growth of destructive micro- and macro-vegetation such as fungi, algae and lichens resulting in reduced integrity and research potential/scientific value of a site (medium-scale data loss). No impacts are expected to occur to recorded grinding grooves.
52-1-0008	Byrnes Creek (Engraving)	120m		2.4		3.8		8	6.8	8.3	This site is located in the South Arm upstream Zone and is currently affected by temporary inundation during a 1 in 100 year event. The Project will result in inundation events happening during 1 in 5, 1 in 10 and 1 in 20 years with an increase in inundation duration occurring every 1 in 100 years. Art recorded at the site will be subject to impacts resulting from wet-and-dry cycling including accelerated weathering, granular loss, exfoliation of engraved surfaces, and/or the intrusion and growth of destructive micro- and macro-vegetation such as fungi, algae and lichens resulting in reduced integrity and research potential/scientific value of a site (medium-scale data loss). No impacts are expected to occur to recorded grinding grooves.
52-1-0045	Jooriland Creek, Upper Burragorang (Axe Grinding Grooves)	127m						<0.5		<0.5	This site is located in the South Arm Upstream Zone and is currently not affected by temporary inundation. The Project will result in less than half a day of temporary inundation during a 1 in 20 and a 1 in 100 year event. The Project will result in occurrences of out of bank erosion and sediment deposition as the Wollondilly flows into Lake Burragorang. The grinding grooves may be subject to siltation/deposition effects from backshore run-off which may act to bury the site in alluvial deposits. Little to no impact is expected.
52-1-0127	Little River 2 (Open Camp Site)	124m						<0.5		2	This site is located in the South Arm Upstream Zone where the Little River flows into Lake Burragorang. The site is currently not affected by temporary inundation. The Project will result in a maximum of 2 days inundation during a 1 in 100 year event and less than half a day during a 1 in 20 year event. Shoreline and out of shoreline erosion is expected resulting in the removal and/or displacement of artefacts resulting in reduced spatial integrity (medium-scale data loss).
52-1-0128	Little River 3 (Open Camp Site)	142m									This site is above the project 1 in 100 temporary inundation event and will not be affected by the project.
52-1-0131	Tonalli Cove 2 (Scarred tree)	125m				<0.5	6.2	<0.5	5.2	<0.5	This site is located in the South Arm Upstream Zone along the shores of Lake Burragorang and is currently not affected by temporary inundation. Inundation would likely occur for a maximum of half a day during 1

New Site number / AHIMS ID#	Site type	Notional elevation (mAHD)	Flood event (1 in x chance in a year)								Description of potential effects
			1 in 5		1 in 10		1 in 20		1 in 100		
			E	P	E	P	E	P	E	P	
											in 20 and 1 in 100 year events. The Project would result in increased erosion of the base support of the scarred tree, accelerating destabilisation through rotting and/or drowning of the tree and eventual feeling resulting in reduced integrity, research potential/scientific value of the site (medium scale data loss) and the large scale loss of an aspect contributing to the cultural landscape and its associated values.
52-1-0133	Tonalli Cove 4 (Open Camp Site)	134m									This site is above the project 1 in 100 temporary inundation event and will not be affected by the project.
52-1-0137	Bridge Point 1	130m								<0.5	This site is located in the South Arm Upstream Zone and is currently affected by inundation during 1 in 100 year events.
52-1-0141	Upper Wollondilly 2 (Open Camp Site)	137m									This site is above the project 1 in 100 temporary inundation event and will not be affected by the project.
52-1-0142	Kamilaroi Point (Shelter with Deposit and Art)	129m								<0.5	This site is located in the Lake Upstream Zone and is currently not affected by temporary inundation. The site is expected to experience less than half a day of inundation during a 1 in 100 year event. PAD deposits within the shelter are at risk of removal or displacement during erosion activity resulting in reduced stratigraphic integrity (medium-data loss) and reduced research potential/scientific value. There is also the potential for deposits to be buried during sediment deposition. Art recorded at the site will be subject to impacts resulting from wet-and dry cycling including accelerated weathering, granular loss, exfoliation of painted surfaces, removal and/or degradation of pigments and drawing materials, and/or the intrusion and growth of destructive micro- and macro-vegetation such as fungi, algae and lichens resulting in reduced integrity and research potential/scientific value of a site (medium-scale data loss).
52-1-0168	Joorilands Farm 1 (Open Camp Site with Scarred Tree)	134m									This site is above the project 1 in 100 temporary inundation event and will not be affected by the project.
52-1-0170	Joorilands Farm 2 (Open Camp Site with Axe Grinding Grooves and Scarred Tree)	136m									This site is above the project 1 in 100 temporary inundation event and will not be affected by the project.
52-1-0171	Joorilands Farm 3 (Scarred Tree)	132m							5.2	<0.5	This site is located in the South Arm Upstream Zone along the Wollondilly River and is currently not affected by temporary inundation. The Project will result in less than half a day of inundation during a 1 in 100 year event. The Project would result in increased erosion of the base support of the scarred tree, accelerating destabilisation through rotting and/or drowning of the tree and eventual feeling resulting in reduced integrity, research potential/scientific value of the site (medium scale data loss) and the large scale loss of an aspect contributing to the cultural landscape and its associated values.
52-1-0175	MF4, Murphy's Flat (artefact scatter)	120m									This site is located in the South Arm Upstream Zone and is not currently affected by inundation. Shoreline and out of shoreline erosion is expected resulting in the removal and/or displacement of artefacts resulting in reduced spatial integrity (medium-scale data loss).
52-1-0178	MF1 (Shelter with Deposit)	116m	6.8	2.4	6.4	3.8	7.2	8	6.8	8.3	This site is located in the South Arm Upstream Zone along the Wollondilly River and is currently affected by temporary inundation. The Project will result in an increase in duration of 2.4 days during a 1 in 5 year event to a maximum of 8.3 days during a 1 in 100 year event. Risks of out of bank erosion occurring resulting in PAD removal and/or displacement would cause reduced stratigraphic integrity (medium-scale data loss) and reduced research potential/scientific value. Sediment deposition as a result of inundation may affect analytical dating techniques such as OSL. Inundation may also affect access to the site.

New Site number / AHIMS ID#	Site type	Notional elevation (mAHD)	Flood event (1 in x chance in a year)								Description of potential effects
			1 in 5		1 in 10		1 in 20		1 in 100		
			E	P	E	P	E	P	E	P	
52-1-0186	W223, Byrnes Creek (Open Camp Site)	118m	6.8	2.4	6.4	3.8	7.2	8	6.8	8.3	This site is located in the South Arm Upstream Zone along the Wollondilly River and is currently affected by temporary inundation. The Project will result in inundation occurring during a 1 in 5 year event resulting in 2.4 days of inundation. The project will result in an increase in duration of 3.8 days during a 1 in 10 year event to a maximum of 8.3 days during a 1 in 100 year event. Risks of out of bank erosion occurring resulting in artefact removal and/or displacement would cause reduced spatial integrity (medium-scale data loss) any sediment deposition occurring from inundation could result in the burial of artefacts in alluvial deposits.
52-1-0298	Orange Tree Flat - Isolated find 01	128m									This site is located in the Lake Upstream Zone and is currently not affected by temporary inundation. The site is expected to experience less than half a day of inundation during a 1 in 100 year event. The Project could result in the removal and/or displacement of the isolated artefact, making it difficult to relocate the site.
52-1-0332	Byrnes Bay OS-1 (Open Camp Site)	116m	6.8	2.4	6.4	3.8	7.2	8	6.8	8.3	The site is located in the South Arm Upstream Zone along the shores of Lake Burragorang and is currently affected by temporary inundation. The Project will result in inundation occurring during a 1 in 5 year event resulting in 2.4 days of inundation. The project will result in an increase in duration of 3.8 days during a 1 in 10 year event to a maximum of 8.3 days during a 1 in 100 year event. Risks of out of bank erosion occurring resulting in artefact removal and/or displacement would cause reduced spatial integrity (medium-scale data loss) any sediment deposition occurring from inundation could result in the burial of artefacts in alluvial deposits.
52-1-0346	Joorilands OS-1 (Open Camp Site)	138m									This site is above the project 1 in 100 temporary inundation event and will not be affected by the project.
52-1-0352/45-5-0946	Tonalli OS-1 (Open Camp Site)	123m	5.9	<0.5	5.4	<0.5	6.2	3.2	5.2	3.6	The site is located in the South Arm Upstream Zone where Lake Burragorang meets Tonalli Cove and is currently not affected by temporary inundation. The Project will result in inundation occurring during a 1 in 10 year event resulting in less than half a day of inundation. During a 1 in 100 year event a maximum of 3.6 days is expected. Risks of out of bank erosion occurring resulting in artefact removal and/or displacement would cause reduced spatial integrity (medium-scale data loss) any sediment deposition occurring from inundation could result in the burial of artefacts in alluvial deposits.
52-1-0130	Tonalli Cove 1	118.1		2.4	6.4	3.8	7.2	8	6.8	8.3	This site is located in the South Arm Upstream Zone where lake Burragorang meets Tonalli Cove and is currently by temporary inundation. The Project will result in new inundation occurring every 1 in 5 years for a duration of 2.4 days and increased inundation occurring during a 1 in 10 year event resulting in an addition of 3.8 days of inundation. During a 1 in 100 year event an additional maximum of 8.3 days is expected. Risks of out of bank erosion occurring resulting in artefact removal and/or displacement would cause reduced spatial integrity (medium-scale data loss) any sediment deposition occurring from inundation could result in the burial of artefacts in alluvial deposits.
45-4-0941	Apple Tree Flat 1	123.99		<0.5		<0.5		<0.5		2	This site is located in the West Arm Upstream Zone and is currently not affected by temporary inundation. The Project will result in temporary inundation occurring during 1 in 5 (maximum 0.5 days), 1 in 10 (maximum 0.5 days), 1 in 20 (maximum 0.5 days), and 1 in 100 (maximum 2 days) year events. Increased out of bank erosion is expected due to increased land gradients resulting in the removal and/or displacement of artefacts resulting in reduced spatial integrity (medium-scale data loss).

8.5.1.2 Downstream

As detailed in Section 8.2.2, the Project will result in a reduction in the frequency and extent of flooding within the downstream study area. The discharge of the FMZ after the flood has peaked will be for a longer duration of up to around 14 days until the storage returns to full supply level. The discharge flows will be contained within bank however some low-lying areas may continue to be flooded for a short period while waters recede. In terms of the downstream area, it is expected that, following the implementation of mitigation measures, the residual risk of bank erosion caused by the FMZ discharge release within the downstream area of the Project will be low. This is based on the assumption that the pre-emptive mitigation measures adopted are successful (Beca 2021: 6).

The EIS assessment focused on the impacts to Aboriginal heritage in the upstream areas that would be affected by the temporary inundation. However, recognition should be given to the potential benefits to sites and places downstream of the dam, that would have flood impacts mitigated or avoided as a result of the Project. The EIS Chapter 8 section 18.6.1 identifies a total of 888 sites being recorded within the downstream area of the Hawkesbury-Nepean River catchment that may benefit from the Project.

The EIS Chapter 18 section 18.9.3 presents the impacts of the operation of the Project, that is the temporary inundation of sites and places during flood events. While a full list of impacted sites is presented in the original ACHA, the following summary can be provided:

- 120 sites in the PUIA, comprising 43 known sites and estimated 77 sites, may experience a total loss of value.
- 118 known sites in the EUIA (excluding 66 sites below FSL) may experience partial harm, some of these sites may already be affected by temporary inundation during past flood (high level) events under the current dam operation.

The assumption of a total loss of value is a precautionary position adopted for the Project. Therefore, a total loss of value is not certain for all sites so categorised, and some sites may exhibit little change in value as a result of the temporary inundation as recognised in the revised impact assessment completed for the upstream study area and presented in this supplementary assessment.

Overall, the Project will result in a reduced risk to flooding downstream for most events in turn resulting in reduced impacts to downstream heritage sites.

8.5.2 Impacts to the cultural landscape

The potential impacts of temporary induction on cultural values were covered in Section 9.3.2 of the original ACHA which acknowledged the importance of considering the cultural landscape of Country as a whole rather than as a series of disconnected points.

It is noted that flooding has been part of the landscape prior to the construction of the current dam. Furthermore, the inscription of the Greater Blue Mountains Area (GBMA) onto the World Heritage and National Heritage Lists followed the construction of the original dam wall. Although a heritage item can be listed despite it being subject to risks which are affecting the outstanding universal values there is an existing flood risk in the upstream catchment associated with the dam that potentially temporarily inundates the GBMWHA. It is acknowledged that while the potential impacts are temporary in their physical duration as they relate directly to flooding events, they have the potential to cause permanent harm through physical impacts to the sites and potential alterations to the waterways and ecology of the Project area. Further, these potential impacts are cumulative in nature.

The impact of the Project on the cultural landscape and the cumulative nature of this impact is clearly illustrated in comments received from Gundungurra Aboriginal Heritage Association during the Inquiry into Water NSW Amendment (Warragamba Dam) Bill 2018 and reproduced in part below:

> *"Due to the colonisation of the Burragorang Valley and the displacement of the rightful owners, the Country and all that survives in it including cultural heritage is quite well preserved. However, the proposal to raise the Warragamba Dam wall will destroy what remains of the culture in the Valley that has existed since time immemorial. The further flooding of the Burragorang Valley will forever hide under the waters the cultural and spiritual connection that Gundungurra people hold to this important part of the Country, their heritage and a creation story significant to all people.*
>
> *Most significantly the further flooding of the Valley through the proposal to raise the Warragamba Dam will erase the tangible aspects of the creation story of the Burragorang, the Gurrangatch and Mirrigan story, the knowledge of how the valley and rivers were made handed down over countless generations of Gundungurra people. To destroy the landscape which embodies this dreaming story, through the flooding of the Valley, will continue to destroy Gundungurra culture and the spirit of the people, but also all other Aboriginal people in the region that are interconnected to this story, and how it relates to the creation of their own Countries through these ancestral beings".* (Inquiry into Water NSW Amendment (Warragamba Dam) Bill 2018, Submission No 72, Gundungurra Aboriginal Heritage Association, 3 October 2018).

The following sections look specifically at the potential impacts to several key components of the cultural landscape within the Project area. Consistent with understanding of the cultural landscape, it is acknowledged that any impacts (regardless of duration) to any part of aspect which contributes to the landscape will have a broader effect on the cultural landscape as a whole, with such impacts being cumulative and irreversible.

8.5.2.1 Impacts to Gurrangatch-Mirrigan Dreaming Track cultural landscape

As outlined in Section 9.3.2.1 of the original ACHA, the original construction of the Warragamba Dam in the period from 1948 to 1960 resulted in the flooding of part of the Gurrangatch-Mirrigan Dreaming Track including multiple specific waterholes that are key locations in the Gurrangatch-Mirrigan Dreaming Story. The following provides a more detailed consideration of the potential for increased impacts on the cultural landscape that forms the Gurrangatch-Mirrigan Dreaming Track and for specific locations within it, largely drawing on information contained within the CVA. The CVA plotted features of the Gurrangatch-Mirrigan Dreaming Track Places onto the landscape of the Project area allowing for an assessment of the potential impact on cultural values associated with this creation story because of the Project (Plate 24). A summary of the impact assessment based on the CVA is provided in Table 69 below.

Table 69: Impact assessment on Gurrangatch-Mirrigan Dreaming Track Places based on Waters Consultancy Pty Ltd 2021: 29-41

Places	Location	Impact assessment
Gurrangatch-Mirrigan Dreaming Track Places		
• Place 1: Mur-rau'-ral (aka Murraural) • Place 2: Guineacor Creek Turning Point • Places 3 & 4: Jock's Creek Turning Point & Wam'-bee-ang Caves • Place 5: Doogalool Waterhole or Shauny's Corner	Located on the Wollondilly River from its junction with the Wingecarribee River upstream to its junction with the Jooriland River.	There is no impact on Places 1 to 5 from the PUIA or the EUIA.
• Place 6: Gungga'-look Waterhole • Place 7: Woong'-ga-ree Waterhole • Place 8: Goo-rit Waterhole	Located on the Wollondilly River from its junction with the Jooriland River downstream to its junction with the Nattai River.	Places 6 to 8 are fully impacted by the EUIA. The river flats adjacent to Place 6 are partially impacted by the PUIA.
• Place 9: Kweeoogang Waterhole • Place 10: Mullindee Waterhole • Place 11: Boonbaal Waterhole	Located on the Wollondilly River from below its junction with the Nattai River downstream to its junction with Lacy Creek.	Places 9 to 11 are fully impacted by the EUIA
• Place 12: Gurrabulla Waterhole • Place 13: Gaung-gaung Waterhole • Place 14: Junba Waterhole • Place 15: Billa'goola Waterhole	Located from the junction of the Wollondilly River and Coxs River upstream to the junction of the Coxs River and Butcher's Creek.	Places 12 to 15 are fully impacted by the EUIA
• Place 16: Reedy Creek Waterhole • Place 17: Karrangatta Waterhole • Place 18: Mee'-oo-wun (Mount Mouin) • Place 19: Koo-nang'-goor-wa (Konangaroo)	Places 17 and 19 are located on the Coxs River while Place 16 is located on Reedy Creek upstream from its junction with the Kedumba River and lace 18 is located near Mount Mouin around four kilometres north of the Coxs River.	Place 17 is fully impacted by the EUIA. There is no potential impact on Places 16, 18, or 19 from the EUIA or the PUIA. There is partial impact on the Kedumba River between the Reedy Creek junction and the Coxs River from the PUIA; this extent of Kedumba River holds cultural value as part of the Gurrangatch-Mirrigan Dreaming Track connecting the Coxs River to Gurrangatch-Mirrigan Dreaming Track Place 16. Place 16 falls within the potential impact zone in the Project's 100-year period event modelling.

The above assessment demonstrates that a number of the places associated with the Gurrangatch-Mirrigan Dreaming Track creation story have already been impacted, being located within the current inundation area associated with the exiting dam. The Project will, however, result in additional impacts to the following places along the dreaming track as these places are situated within the PUIA associated with the Project:

- The river flats adjacent to Place 6: Gungga'-look Waterhole will be **partially impacted**.
- The Kedumba River between the Reedy Creek junction and the Coxs River will be **partially impacted** from the PUIA; this extent of Kedumba River holds cultural value as part of the Gurrangatch-Mirrigan Dreaming Track connecting the Coxs River to Gurrangatch-Mirrigan Dreaming Track Place 16.

Conversely, as outlined above, the following places **will not be impacted** by the Project:

- Place 1: Mur-rau'-ral (aka Murraural)
- Place 2: Guineacor Creek Turning Point
- Places 3 & 4: Jock's Creek Turning Point & Wam'-bee-ang Caves
- Place 5: Doogalool Waterhole or Shauny's Corner
- Place 16: Reedy Creek Waterhole
- Place 18: Karrangatta Waterhole
- Place 19: Koo-nang'-goor-wa (Konangaroo)

Redacted from public version

Plate 24: Indicative locations of Places on the Gurrangatch-Mirrigan Dreaming Track (Source: Waters Consultancy Pty Ltd 2021: 28)

8.5.2.2 Impacts to Buru (Kangaroo) Dreaming Story cultural landscape

As outlined in Section 9.3.2.2 of the original ACHA, the Project involves the potential for increased impacts (albeit temporary in nature) on elements of the cultural landscape that are related to the Buru (Kangaroo) Dreaming Story Places. The following provides a more detailed consideration of the potential for increased impacts on the cultural landscape that forms the Buru (Kangaroo) Dreaming Story and for specific locations within it, largely drawing on information contained within the CVA. The CVA plotted features of the Buru (Kangaroo) Dreaming Story Places onto the landscape of the Project area allowing for an assessment of the potential impact on cultural values associated with this creation story as a result of the Project (Plate 25). A summary of the impact assessment based on the CVA is provided in Table 70 below.

Table 70: Impact assessment on Buru (Kangaroo) Dreaming Story Places based on Waters Consultancy Pty Ltd 2021: 42-45

Places	Location	Impact assessment
Buru (Kangaroo) Dreaming Story Places		
• Place A: Tonalli River area • Place B: Kangaroo Waterhole	Includes the Kangaroo Waterhole in the Wollondilly River, indicatively located between Byrnes Creek and the Tonalli River; the lower reaches of the Tonalli River and the surrounding areas; and the area stretching west of the Wollondilly River towards Yerranderie and Alum Hill.	Place B is fully impacted by the EUIA while Place A is partially impacted by the EUIA and the PUIA.

As indicated above, Place B has already been fully impacted, being located within the EUIA while Place A is **partially impacted** by the EUIA and the PUIA.

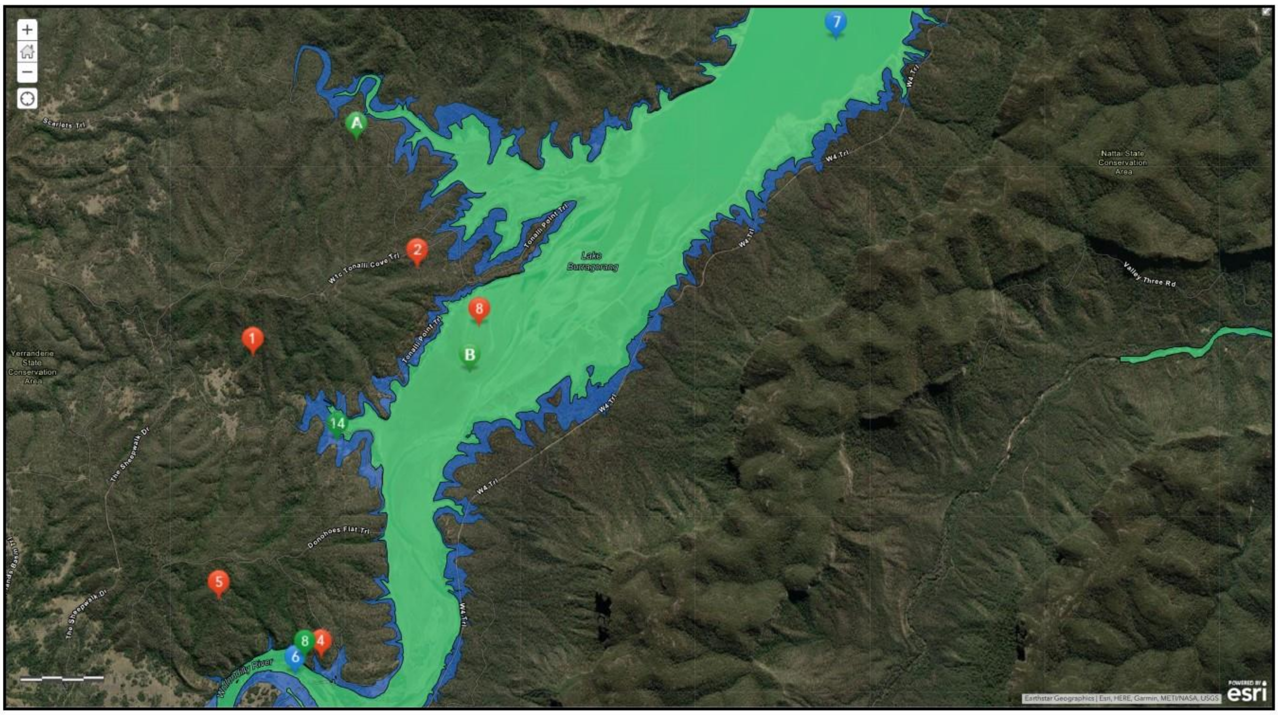

Plate 25: Indicative locations of Places on the Buru (Kangaroo) Dreaming Story (Source: Waters Consultancy Pty Ltd 2021: 45)

8.5.2.3 Living Places (history of occupation and use)

Most of the living places identified are in the lower, richer parts of the valleys and near to waterways and as such are either entirely within or partially within the EUIA. Nevertheless, there is potential for increased impact because of the Project due to longer periods of inundation. The potential impacts are temporary in their physical duration as they relate directly to flooding events. It has not been possible to assess the impacts in consultation with Aboriginal cultural knowledge holders; however, based on the material considered and in line with Aboriginal cultural paradigms it is considered that these potential impacts will be understood as harmful to the identified cultural values.

8.5.2.4 Cultural Places (ritual life)

The Project presents the potential for increased impact through longer flooding events within the EUIA and very short-term rare flooding events above the PUIA. The potential impacts are temporary in their physical duration as they relate directly to flooding events, however, particularly in relation to the artworks at Kerswell Hill, Oaky Creek Site Cluster and the Ripple Creek Site Cluster there is the potential for permanent damage. It has not been possible to assess the impacts in consultation with Aboriginal cultural knowledge holders; however, based on the material considered in-line with Aboriginal cultural paradigms it is considered that these potential impacts will be understood as harmful to the identified cultural values.

8.5.2.5 Archaeological Sites (tangible record of traditional occupation and use)

There are currently 260 Aboriginal cultural heritage sites situated within the PMF, 30 of which are located above the Project 1 in 100 maximum flood event level (132 m) and will not be impacted by the Project.

A summary of Aboriginal cultural heritage sites located within the 1 in 100 maximum flood event level is provided in Table 71.

The assessed impact to these sites is based on the level of resilience an Aboriginal object and/or site has from the effects of water and inundation. Some of these sites will be directly affected by inundation due to low resilience to water while other sites will be vulnerable to diminished archaeological integrity as an indirect result of inundation.

For those sites within or below the Project 1 in 100 year flood event impacts will potentially include the erosion of archaeological deposits at both open sites and rockshelter sites due to the inundation having a deleterious effect on soil cohesion. Changes in local conditions at rock surfaces where there is art are also likely to occur and have unpredictable but negative impacts to the preservation of the art present (either directly through wetting-drying cycles and changed conditions for preservation, or indirectly through changed weathering or deposition of sediment). While the changes predicted to occur within the PUIA are not so dramatic as to result in a denuded landscape like the area below Lake Burragorang's FSL, they will nevertheless result in harm to Aboriginal objects and cultural values.

Thirty eight of the 228 Aboriginal cultural heritage sites that are located within or below the 1 in 100 year flood event level (132 m) are currently unaffected by existing inundation. Of these 38 sites, six are considered to have very low resilience to the effects of inundation and are at risk of significant impacts as a result of the Project.

The impact assessment provided in Table 71 will evaluate and discuss the potential archaeological impacts for known sites and will consider degrees of harm as being either nil, low, moderate or high based on the definitions provided in Table 72 below.

Table 71: Degree and consequence of harm

Degree of harm	Consequence of harm
Nil	Sites not affected by the Project based on flood event scenarios
Low	Sites with high resilience unlikely to be explicitly harmed by inundation. As a result of the Project these sites will not be impacted by implied harm.
Moderate	Sites with high resilience unlikely to be explicitly harmed by inundation. As a result of the Project these sites may be impacted by implied harm resulting in low diminishment of site integrity. These include PADs, engravings, grinding grooves, etc that have the potential to be impacted by secondary harm as a consequence of inundation.
High	Sites that have low to moderate resilience to the effects of water and inundation whereby the effects are a result of primary harm. Site types likely to be affected by a high degree of harm include scarred trees and art sites which are likely to be affected by both primary harm (inundation and water) and secondary harm (biochemical for example).

Table 72: Summary of harm

Site Features	Site features within or below Project 1 in 100	Sites not previously affected by inundation	Summary
Artefact scatter	140	11	• A total of 139 of the 155 artefact scatters are located within or below the 1 in 100 year event maximum level of 132 m. • Of the 139 sites within the 1 in 100 year event maximum flood level, 11 sites are predicted to have not experienced an inundation event previously. • The remaining 128 Aboriginal cultural heritage sites have previously been affected by inundation events. • It is expected that these artefact scatter sites will experience episodes of soil deposition as well as erosion events, during which time the sites will mostly remain unaffected due to their high resilience. At most, these sites will see a continued reduction in spatial integrity or burial.
Open campsite with PAD	22	3	• A total of three artefact scatters is predicted to have not previously been affected by an inundation event. These three sites will likely experience inundation during the 1 in 100 year flood events and as such it is expected that the Project will result in little impact to these sites. • The remaining 19 sites that are currently affected by flood inundation events will, for the majority, see a slight increase in the number of days of inundation. • It is expected that these artefact scatter sites will experience episodes of soil deposition as well as erosion events, during which time the sites will mostly remain unaffected due to their high resilience. • At most, these sites will see a continued reduction in spatial integrity or burial. Soil deposition may potentially impact analytical dating techniques such as OSL.
Isolated artefact	14	4	• Four of the 15 isolated artefact sites are predicted to have never experienced an inundation event previously. • These four sites will experience minimal inundation during the 1 in 10, 1 in 20, and 1 in 100 year events (n=1, the 1 in 20 and 1 in 100 year events (n=1), and the 1 in 100 year events (n=2). • Although the artefact itself is resilient t inundation, their re location during future fieldwork will be made difficult by the effects of soil deposition and erosion as a result of inundation, regardless of whether the site is currently affected by inundation or not.
Isolated artefact with PAD	3	2	• Two of the three isolated artefacts with PAD have not previously been impacted by an inundation event.

Site Features	Site features within or below Project 1 in 100	Sites not previously affected by inundation	Summary
			• Although the artefact itself is resilient to inundation, their re location during future fieldwork will be made difficult by the effects of soil deposition and erosion as a result of inundation, regardless of whether the site is currently affected by inundation or not. • The associated PAD would be at risk of diminished spatial and stratigraphic integrity during erosion events and soil deposition may potentially impact analytical dating techniques such as OSL.
Scarred tree	3	0	• All of these sites are currently affected by existing inundation. • All of these sites will see a maximum increase of less than half a day of inundation during an inundation event with only one site being affected during all flood events. • Scarred trees have little to no resilience from inundation and will continue to be significantly affected by inundation events as they occur.
Scarred tree with artefact/s	3	1	• One of these sites is located outside of the 1 in 100 inundation event and will not be affected by the project. • Of the remaining three sites, one is currently not affected by the project and will experience the effects of inundation during a 1 in 100 year event for a maximum of 6 days. • While the artefacts are resilient to the effects of water, the scarred trees have little to no resilience from inundation and will continue to be significantly affected by inundation events as they occur.
Grinding grooves	4	3	• Three of the four grinding groove sites previously unaffected by inundation will experience inundation. • One site will experience an increase in duration of inundation. Grinding grooves are, for the most part, resilient to erosion that occurs as a result inundation; however these sites may become buried during soil deposition and there is a low risk that biochemical impacts will occur as a result of promoted plant growth.
Grinding grooves with artefact/s	1	0	• This site is currently affected by all predicted flood events and will see an increase in duration of inundation. • These features are resilient to the effects of inundation; however the archaeological integrity of the site could be diminished.
Grinding grooves, shelter, PAD, artefact/s,	4	2	• One of these sites is located above the maximum 1 in 100 year flood event level. • Of the remaining three sites two will be newly affected by inundation during a 1 in 100 year flood event while one will experience an increase in the duration of inundation as well as increased inundation. • These features are resilient to the effects of inundation; however the archaeological integrity of the site could be diminished.
Grinding grooves, shelter, PAD	2	1	• One of these sites is currently unaffected by existing inundation and will be affected by less than half a day of inundation during 1 in 100 year flood events. • The other site will experience an increase in inundation during all flood events.
Grinding grooves, shelter, PAD, artefact/s, art	5	2	• One of these sites is located above the maximum 1 in 100 year flood event level and will not be impacted by the Project. • Two sites are currently unaffected by existing inundation and will experience a maximum duration of 2 days during a 1 in 100 year flood event.

Site Features	Site features within or below Project 1 in 100	Sites not previously affected by inundation	Summary
			• The remaining two sites will be impacted by increased inundation and an increase in duration of inundation. • The art site has low resilience to inundation and will be directly impacted by the Project while the remaining site features have a greater resilience and are predicted to only experience potential indirect impacts and diminished archaeological integrity.
Grinding grooves, scarred tree and artefact/s	1	0	• This site is above the 1 in 100 maximum flood event level and will not be impacted by the project.
Stone arrangements	2	0	• One of these sites is located outside of the 1 in 100 year maximum flood level while the other is already affected by inundation and will see an increase in the duration of inundation during all predicted flood events. • No impacts are expected to occur due to the resilience of large stone objects to low flow force processes.
Shelter with deposit	4	1	• One of these sites is currently unaffected by existing flood events and will be affected by 1 in 100 year flood events. • Two sites will see an increase in duration of inundation during all flood events.
Aboriginal resource and gathering	4	1	• One of these sites is currently unaffected by existing inundation events. Impacts to these sites will be indirect as a result of the project.
Waterhole and Aboriginal ceremony and dreaming	1	0	• This site is already affected by existing inundation and will be impacted by an increase in the duration of inundation events.
Engraving	1	0	• This site will be impacted by inundation from all predicted flood events and an increase in duration of inundation during the 1 in 100 year flood event. • Due to the resilience of this site, impacts resulting from the Project will be indirect
Shelter with deposit and artefact/s	19	4	• Five of these sites are located above the maximum 1 in 100 Project flood levels and will not be impacted by the Project. • Four sites are currently not affected by existing inundation and will experience inundation during a 1 in 100 year flood event. • The remaining 10 sites are currently impacted by inundation and will see an increase in the duration of inundation. • These sites are resilient to inundation and will not be directly impacted by the project; however, the archaeological integrity of the site may be diminished as an indirect result of soil deposition and erosion.
Shelter, PAD, art and artefact/s	4	2	• Two of these sites are located above the maximum 1 in 100 flood event level and will not be impacted by the Project. • The remaining two sites are currently impacted by existing inundation and will be further impacted by an increase in flood events as well as increased duration of inundation. • The art recorded at these sites has very low resilience to inundation and will be directly impacted by the Project.
Shelter, PAD, art	2	1	• One of these sites is currently unaffected by existing inundation. • The remaining site will experience an increase in duration of inundation. • The art recorded at these sites has very low resilience to inundation and will be directly impacted by the Project.
Total	**260**	**38**	

Table 73: Consequence / risk of harm matrix

Degree of resilience	Duration and Frequency/ Likelihood of Inundation		
	Increased frequency and/or duration	Minimal change and/or low frequency (likelihood)	No change / inundation
Low resilience	High	Moderate/High	Nil
Moderate resilience	Moderate/High	Moderate	Nil
High resilience	Low	Low	Nil

To assess the potential effects of the Project on Aboriginal heritage sites within the Project area, a precautionary approach was taken where sites with multiple features (e.g. Shelter with Artefacts, Art, Grinding Grooves and Deposit) were assessed based on their least resilient feature type present (e.g. Rock art). A consequence /risk of harm matrix was developed in an attempt to quantity the potential impact of the Project on known Aboriginal heritage sites within the Project area and to assist in the development of appropriate management and mitigation strategies. This matrix is presented in Table 56 above. Sites were assessed against this matrix and the potential effects of the Project were rated as Nil, Low, Moderate or High based on the degree of resilience of site feature and the duration and frequency (likelihood) of inundation. As a result of the assessment a total of six (6) sites were assessed as having a high consequence of harm; forty-eight (48) sites were assessed as having moderate consequence of harm; 144 were assessed as having moderate/high consequence of harm; twenty-six (26) sites were assessed as having a low consequence of harm; and thirty (30) were assessed as having nil consequence of harm (refer to Appendix 8 for further details).

8.5.2.6 Waterways (the Wollondilly, Nattai, Warragamba, and Coxs Rivers and their tributaries)

The Project involves the potential for increased impacts on Waterways including the Wollondilly River, Nattai River, Warragamba River, Coxs River, Kedumba River, Tonalli River, Jooriland River, Butchers Creek, Ripple Creek, Oaky Creek, Green Wattle Creek, Lacys Creek, Brimstone Creek, Bob Higgins Creek, Byrnes Creek, Colemans Creek, Reedy Creek, and Werriberri Creek. The potential impacts are temporary in their physical duration as they relate directly to flooding events. It has not been possible to assess the impacts in consultation with Aboriginal cultural knowledge holders; however, based on the material considered and in line with Aboriginal cultural paradigms it is considered that these potential impacts will be understood as harmful to the identified cultural values.

8.5.2.7 GBMWHA and OUV

The boundary of the GBMWHA generally does not correspond with the boundaries of Lake Burragorang and its tributaries or Lake Burragorang’s FSL. In most locations around Lake Burragorang there is a strip of land which is not part of the GBMWHA. However, at the southern bank of the Wollondilly River arm of Lake Burragorang the GBMWHA and the Nattai National Park boundary extends down to the FSL of the dam. Other areas where the GBMWHA boundary extends to the Full Supply Level or to the bank of a potentially impacted waterway include smaller areas of land at:

- Nattai River near the Little River confluence (Nattai National Park).
- A small reach of the Kedumba River (Blue Mountains National Park).
- Reaches of the Kowmung and Coxs Rivers about 3 km upstream of their confluence (Blue Mountains National Park).

- A number of minor tributaries which flow directly into Lake Burragorang (Blue Mountains National Park).

There are 304 ha of the GBMWHA within the PUIA, which were relatively well surveyed during the Project assessment. The GBMWHA and PUIA overlap of land contains 8 known cultural heritage sites comprising 7 open sites containing stone artefacts, and one site with axe grinding grooves.

Appendix J of the EIS details the assessment of the Project to the World Heritage areas. Within this document, section 7 outlines the decision made by the World Heritage Committee at its 43rd session in respect of the Project and provides information to address that decision. Section 8 provides a response of how the Project addresses the eight World Heritage impact assessment principles, while a response on the Project against the Strategic Plan including the World Heritage management obligations is provided in section 9.

About 1,675 hectares of GBMWHA in upstream study area. About 351 hectares of GBMWHA in downstream study area. Total area of GBMWHA is 1,032,649 hectares.

The cultural values assessment noted that from the perspective of the Aboriginal cultural knowledge holders, it was understood that the potential impacts of the Project on identified cultural values would be harmful.

The Project has assumed a total loss of values within the upstream impact of which 304 hectares occurs within the GBMWHA. While this scale of impact may not be actually realised, on the assumption of total loss of values, this would result in a diminution of Aboriginal cultural heritage values (loss of 28 sites) and therefore the Project may result in a diminution of this OUV component.

The construction area lies outside of the GBMWHA but is in close proximity to the GBMWHA. At its closest point it is about 50 metres from the GBMWHA, however, construction activities would generally be located at a distance of 300 metres or more from the GBMWHA.

The EIS states that while some impacts of the Project on the GBMWHA would be able to be mitigated or minimised, some impacts would not be able to be mitigated or minimised and therefore offsets are required. The EIS summarised that the impacts to the GBMWHA would not be significant and would not result in a material loss or degradation of the OUV and the Project is not considered to be inconsistent with the management obligation and principles for World Heritage Properties (refer chapter 13 section 13.8).

The Final EIS for the Project will be provided to the Federal Government DAWE to assist with the request of the WHC in order to consider the project at a future meeting.

The current dam was in existence at the time of inscription of the GBMWHA on the World Heritage List in 2000 and on the National Heritage List in 2007. Although a heritage item can be listed despite being subject to risks which are affecting the outstanding universal values there is an existing flood risk in the upstream catchment associated with the dam that potentially temporarily inundates the GBMWHA.

Since the GBMWHA was inscribed on the World Heritage List, the level of Lake Burragorang has been above FSL on 17 occasions (these being between March 2012 and July 2022). In all of these events, temporary inundation occurred to varying degrees in the GBMWHA. No concerns have been expressed about loss of attributes which support OUV in relation to the risk of temporary inundation associated with the existing dam for any of these events.

The upstream impact area for the raised dam clearly includes important cultural sites that contribute to the property's integrity. As outlined in the EIS, the project may result in the total loss of a number of known sites with high cultural and scientific significance as a result of their inundation. The inundation of these sites would, therefore, damage attributes of the OUV of the property.

There are numerous sites potentially affected by temporary inundation from the existing dam, and this risk existed at the time of inscription of the GBMWHA onto the World Heritage list. It is inferred that this risk of temporary inundation was acceptable and would not have a material effect on the OUV of the property.

8.6 Summary of potential impacts

A total of 230 Aboriginal cultural heritage sites will be affected by temporary inundation as a result of the Project (Table 47). These sites include those which will be affected by an increase in frequency of inundation as well as duration of existing inundation events. Of these sites, 30 are above the Project 1 in 100 inundation event level of 132 m; however, because they are located within the Project PMF levels of 143.9 m, they still require management and mitigation as part of this ACHA. Sites excluded from Table 42 are either below FSL or above PMF and to not require an impact assessment. Approximately 38 Aboriginal cultural heritage sites are currently not affected by existing inundation events.

Potential impacts have already been discussed in section 8.5.2. The Project will not cause any new impacts to the majority of sites located within the PUIA; however, it may result in a moderate level of accelerated pre-existing impacts already occurring within the area such as increased erosion and/or deposition.

Approximately 18 previously unaffected sites predicted to become affected by inundation could be considered to have low resilience for two main reasons. These sites consist of site features such as art which would physically deteriorate from cumulative water processes and sites consisting of features such as grinding grooves and PADs that would see a reduction in research potential/scientific value as a result of cumulative water processes.

The Project will result in cumulative harm to the intangible values of the cultural landscape through extension of previously unmitigated impact on cultural values from the construction of the Warragamba Dam and flooding of the Burragorang Valley and its tributary valleys. The further flooding of the Burragorang Valley will result in irreversible harm to the cultural and spiritual connection that Aboriginal people hold to this part of the Country, their heritage and the cultural landscape and will obscure the tangible aspects of the creation stories associated with the Burragorang such as the Gurrangatch and Mirrigan story.

8.7 Ecologically sustainable development and cumulative impacts

Ecologically Sustainable Development (ESD) requires the integration of economic and environmental considerations (including cultural heritage) in decision-making processes. The principles of ESD are defined in Section 6 of the *NSW Protection of the Environment Administration Act 1991* (PEAA). In the context of Aboriginal cultural heritage the two relevant principles are:

- the precautionary principle—namely, that if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.
- inter-generational equity—namely, that the present generation should ensure that the health, diversity and productivity of the environment are maintained or enhanced for the benefit of future generations.

In the context of Aboriginal cultural heritage intergenerational equity can be assessed in terms of cumulative impact to Aboriginal objects, places, and cultural values in a region. Cumulative impacts are the successive, incremental and combined impacts of one or more activities on the environment, including cultural heritage values.

Intergenerational equity is maintained by the continued dissemination of cultural knowledge and the ability to access Country and sites and places of cultural value into the future. It is detrimental to future generations if cultural knowledge and access to Country is lost by the current generation.

While conservation is the best approach when considering Aboriginal cultural heritage, due to the requirements and nature of the proposed activities the avoidance of all Aboriginal archaeological sites within the Project area is not possible if the Project proceeds (see discussion in Section 11 in original ACHA). As a result, the Project would cause cumulative impact and loss of values on the Aboriginal cultural heritage of the region and local area.

The Aboriginal cultural heritage of the area has had significant negative impacts from pastoral and agricultural land use, the original development of the Warragamba Dam and the flooding and water storage of Lake Burragorang. The original development of the Warragamba Dam and the ongoing use of the area as a water catchment for the past 60 years has resulted in:

- sites around Warragamba Dam being impacted by the original construction of the dam due to vegetation clearance and earthworks for the development of the existing dam wall, boat ramp, spillways, and associated infrastructure.
- sites within the FSL of Lake Burragorang (EUIA) being impacted through flooding for long periods of time when lake water levels are high.

The construction works at the dam wall will not harm any known Aboriginal sites. While the Aboriginal archaeological sites located within the existing dam footprint (EUIA) are already impacted they may experience a greater duration of temporary inundation if the Project proceeds. The 43 known Aboriginal cultural heritage sites, and the additional estimated 131 Aboriginal cultural heritage sites, will experience temporary inundation if the Project proceeds. There are a further 29 known Aboriginal archaeological sites above the PUIA but within the Project’s 1 in 100-year flood event modelling and at potential risk. Scientific confidence regarding the condition, nature and extent of the sites has been achieved through archaeological investigations which have included both systematic survey and predictive modelling. The AR concluded that considered against the precautionary principle the potential impacts of the Project on archaeological scientific values can be considered relatively minor due to prior or existing impacts.

The capacity to map specific elements within the cultural landscape that hold cultural values was limited due to the lack of active engagement of Aboriginal cultural knowledge holders. Nonetheless analysis of the available ethnographic and historical sources has identified six key elements or themes that hold cultural value and significance within the Project area. The places of cultural value that have been mapped within each of the six themes are not comprehensive, nonetheless the CVAR mapped 29 known sites and places within the EUIA, 11 sites and places within the PUIA and 3 sites and places above the PUIA. While the places of cultural value located within the existing dam footprint (EUIA) are already impacted they may experience a greater duration of temporary inundation if the Project proceeds. The 11 places of cultural value within the PUIA will experience temporary inundation if the Project proceeds. The 3 places of cultural value above the PUIA are at potential risk of temporary inundation as they lie within the Project’s 1 in 100-year flood event modelling.

Any future proposed impact must be considered as an additional and cumulative impact on what has already been lost under the waters of Lake Burragorang. The reality of dispossession and forced removal from traditional and historical lands, and the loss of heritage values (encompassing tangible and intangible heritage sites and places and harm to the storied landscape) has been communicated by the RAPs in very strong terms during the consultation for the Project. The Project is an incremental addition to a previous project (the dam construction) that has caused cultural trauma and significant loss of cultural heritage values.

As examples of the cultural heritage values that were lost as a result of the original dam construction, the following sites now sit permanently or temporarily under the waters of Lake Burragorang (these are detailed in the CVAR and AR appended to the original ACHA):

- Water holes associated with the Gurrangatch-Mirrigan Dreaming Track.
- Ghungarlook Farm and St Josephs Farm.
- Tommy Bundles burial site, Tarlo Jacks burial site and 'Chiefs' burial site.
- Burial tree sites (carved trees).
- Hands on the Rock archaeological site.
- Byrnes Creek archaeological site (a regionally rare, engraved art site).

As the Project involves construction around the dam wall (an already heavily modified landscape, with no known heritage sites in the footprint) and temporary inundation of the PUIA for less than 11 days there is no significant restriction of access to the cultural landscape, and there is not expected to be significant changes to the tangible heritage sites present in the PUIA (as discussed in Section 6.3.2 of the original ACHA).

The effects of the Project will not result in an overall reduction in the cultural heritage significance of the Project area (it will remain of very high cultural heritage significance) but will nevertheless have a deleterious effect on the cultural heritage values, as described in this Supplementary Assessment. The deleterious effect is via additional loss of sites and places in the PUIA and additional injury to the wounds of previous dispossession and loss.

Through the aggravation of previous harm and by causing the additional loss of values the Project will have a cumulative detrimental effect to quality or benefit that the cultural landscape – and its intangible and tangible contributory values – may provide to the Aboriginal community and will result in a reduction in the inter-generational equity afforded by the cultural landscape of the Project area and its surrounds.

The RAPs have advised through the submission process that the Project area and all sites within and surrounding it have high cultural significance. The Project is seen by the RAPs as a further accumulation of impacts to Aboriginal cultural heritage that has previously been affected by the original development of the Warragamba Dam.

Some RAPs consider the impacts to the cultural heritage values from the Project as acceptable if the management and mitigation measures presented in this ACHA are applied. However, some RAPs consider the proposal to raise the Warragamba Dam wall for the temporary storage of flood waters to be an unacceptable impact to Aboriginal cultural heritage values.

Submissions from the RAPs made the following points:

- The first recommendation would be not to proceed with the proposed project, and hoping that common sense will prevail, and it will not go ahead.
- We do not agree with the raising of the Warragamba Dam. Survey of just 25% of the area has shown that there are many Aboriginal sites throughout the area and that it is very significant to us.
- We would like this record of our history and culture to be protected and not be flooded with water. Many of our sites have already been lost because of the dam and because of development across Western Sydney and there is an opportunity to protect this very significant area for the Darug people and future Australians.
- Many recorded and unrecorded sites would be lost or damaged by raising the dam.
- The project should not go ahead due to the enormous amount of unavoidable destruction to our heritage and environment.
- We would like to record our objection to this development proceeding due to the significant cultural and environmental damage that would occur. We would also like to draw attention to the fact that the Aboriginal community, and I am sure the wider community generally does not believe that the destruction of Aboriginal cultural heritage on such a significant level is in keeping with the expectations and values we hold as a society.
- We would contest that the impact which will be attributed to this project does not align with the cost that will be borne by the Aboriginal community in the loss of such a significant heritage area.

These submissions outline the high level of concern that RAPs have for the future preservation of tangible and intangible connections to their Country and its cultural landscape and the calls from many RAPs for an immediate stop to the Project.

9. Mitigation and Management Measures

9.1 Preamble

A number of submissions identified issues relating to the proposed mitigation measures outlined in the original ACHA. These issues are summarised in Section 3.3.6 of this supplementary assessment. This section builds upon the original management recommendations presented in Chapter 11 of the original ACHA by addressing the issues identified during the submission process. This section includes a detailed consideration of the mitigation and management measures options in the context of relevant guidelines and management documents of relevance to the Project area.

9.2 Conservation Principles and Management Framework

This section provides an outline of the relevant conservation principles and management framework for the current Project.

9.2.1 The Australia ICOMOS Burra Charter (Australia ICOMOS 2013)

The Burra Charter: The Australia ICOMOS Charter for Places of Cultural Significance (Australia ICOMOS Burra Charter, 2013; 'Burra Charter') provides guidance for the conservation and management of places of cultural significance (cultural heritage places). Conservation encompasses the act of archaeological investigation (Articles 1.4, 2 and 28). The Burra Charter defines conservation to mean 'all the processes of looking after a place so as to retain its cultural significance'. Archaeological investigation is commonly an appropriate conservation response, particularly where the place will undergo significant change, or the archaeological evidence may be damaged or destroyed by ground disturbance activities (such as grading or basement excavation) or natural processes (such as erosion or subsidence), and especially where the place's cultural significance is largely embodied in the data that the place may yield.

The Charter sets a standard of practice for those who provide advice, make decisions about, or undertake works to places of cultural significance, including owners, managers and custodians The Charter is divided into a range of interdependent 'Articles' though is designed to be considered as a whole. The Burra Charter Process, or sequence of investigations, decisions and actions, is illustrated below in the flow chart (Table 74) as provided in the Burra Charta. As illustrated in the flowchart and outlined in Article 6: *The cultural significance of a place and other issues affecting its future are best understood by a sequence of collecting and analysing information before making decisions. Understanding cultural significance comes first, then development of policy and finally management of the place in accordance with the policy. This is the Burra Charter Process.*

Based on the Burra Charta Process, the original ACHA and this supplementary assessment have been undertaken to fulfil steps 1 to 3 and to provide recommendations for the undertaking of with steps 4 to 7 of the Charter process. With reference to the seven steps identified in the Burra Charter process flowchart, the following is noted:

6. **Understand the place**: an understanding of the Project area has been developed through the extensive background research, investigation and assessment that has been completed as part of the original ACHA. Furthermore, additional information has been presented in this supplementary assessment which further contributes to developing an understanding of place.
7. **Assess cultural significance**: the cultural significance of the area affected by the Project has been assessed through targeted assessments of Aboriginal and non-Aboriginal cultural heritage assessments

documented in Appendices I and K to the EIS, respectively. This included a detailed Cultural Values Assessment (CVA) report which considered in detail the potential impact of the Project on intangible Aboriginal cultural heritage values within the Project area. This assessment was provided as Appendix 2 of the original ACHA. Further consideration of cultural significance has been made throughout this supplementary report.

8. **Identify all factors and issues**: the original ACHA considered all relevant matters in accordance with the SEARs and further assessment of matters related to Aboriginal heritage has been undertaken as part of this supplementary assessment.
9. **Develop policy**: WaterNSW has an existing environmental policy that addresses conservation (and enhancement) of natural, Aboriginal and non-Aboriginal heritage values.
10. **Prepare a management plan**: Management of identified potential impacts on cultural matters will be addressed through the relevant National Park Plan of Management and through the Part 5A EMP required under the Water NSW Act 2014. The development of an Aboriginal Cultural Heritage Management Plan (ACHMP) for the Project prior to construction was a key recommendation made in the original ACHA and restated in this supplementary assessment.
11. **Implement the management plan**: this step will be undertaken should the Project be approved.
12. **Monitor the results and review the plan**: this step will be undertaken should the Project be approved.

Table 74: The Burra Charter Process: Steps in planning for and managing a place of cultural significance (Source: adapted based on the flowchart presented in Australia ICOMOS 2013: 105F7)

The Burra Charter Process		
Understand significance	**1. UNDERSTAND THE PLACE** Define the place and its extent. Investigate the place: its history, use, associations, fabric (Articles 5-7, 12, 26)	Community and stakeholder engagement should occur throughout the process
	2. ASSESS CULTURAL SIGNIFICANCE Assess all values using relevant criteria. Develop a statement of significance (Article 26)	
Develop policy	**3. IDENTIFY ALL FACTORS AND ISSUES** Identify obligations arising from significance. Identify future needs, resources, opportunities and constraints, and condition (Article 6, 12)	
	4. DEVELOP POLICY Articles 6-13, 26	
	5. PREPARE A MANAGEMENT PLAN Define priorities, resources, responsibilities and timing. Develop implementation actions (Articles 14-28)	
Manage in accordance with policy	**6. IMPLEMENT THE MANAGEMENT PLAN** Articles 26-34	
	7. MONITOR THE RESULTS AND REVIEW THE PLAN Article 26	

[7] https://australia.icomos.org/publications/burra-charter-practice-notes/#flow_chart

9.2.2 Greater Blue Mountains Strategic Plan (DECC 2009)

The GBMA Strategic Plan (DECC 2009) provides the broad management principles for the area, and establishes the framework for the integrated management, protection, interpretation and monitoring of the values of the eight reserves that comprise the GBMWHA. The plan identified a number of key issues and desired outcomes, the following of including some which relate specifically to Aboriginal cultural heritage.

The objectives of the plan in relation to the key issue of Aboriginal cultural heritage include:

- To identify, formally recognise and protect the cultural heritage values of the GBMWHA.
- To manage the GBMWHA jointly with local Indigenous people.

The desired outcomes in relation to Aboriginal culture heritage include:

- The cultural heritage values of the GBMWHA are retained and better understood, and their significance is formally recognised at State, National and World Heritage level as appropriate.
- Management of the GBMWHA is undertaken co-operatively with the Aboriginal people who have traditional connections to the Countries that comprise the GBMWHA.
- The cultural, traditional and social significance of the landscapes within the GBMWHA to Aboriginal people is widely acknowledged and respected.

In consideration of the objective and desired outcomes, the plan outlines a number of management responses in relation to Aboriginal cultural heritage. These are outlined below:

1. Continue and further develop close consultation with local Aboriginal peoples through the Living Country Aboriginal Comanagement Project and the Central Coast / Hunter Range Region Co-management Committee.
2. Through the Mapping Country Project and in partnership with local Aboriginal communities, appropriately document the Indigenous cultural values of the GBMWHA.
3. Ensure valid native title is recognised and Indigenous Land Use Agreements negotiated, consistent with Australia's obligations under the World Heritage Convention and the restrictions on land use imposed by law.
4. Through the Living Country Co-management Project, prepare and implement agreed GBMWHA Indigenous heritage strategies, consistent with government and agency cultural heritage policies (e.g. Cultural Heritage Conservation and Cultural Heritage Community Consultation Policies).
5. Investigate the feasibility of establishing an Aboriginal employment / capacity-building program and develop strategies for working towards Aboriginal co-management of the GBMWHA reserves.
6. Research, record and assess the significance of the cultural heritage values of the GBMWHA against State, National and World Heritage listing criteria and seek formal recognition as appropriate.
7. Encourage cultural heritage research projects which assist with the protection and management of the GBMWHA's cultural heritage values.
8. Emphasise the importance of Indigenous culture and history, by identifying suitable Aboriginal words for naming / co-naming the GBMWHA and its reserves.
9. Ensure recognition of non-Aboriginal heritage values, including art inspired by the landscape, relationships between people and the environment, early conservation campaigns, built heritage, and recreational activities and infrastructure.

9.2.3 Guide to investigating, assessing and reporting on Aboriginal cultural heritage in NSW (OEH 2011)

The two founding principles behind the *Guide to investigating, assessing and reporting on Aboriginal cultural heritage in NSW* (OEH 2011:12) are ecologically sustainable development and intergenerational equity. These principles hold that "the present generation should make every effort to ensure the health, diversity and productivity of the environment – which includes cultural heritage – is available for the benefit of future generations".

The strong emphasis, as in the Burra Charter, is to quantify and understand the heritage values of a place, a site, or an object and exhaust avenues of avoiding harm to those values. If harm cannot be avoided, then there must be consideration and implementation of strategies to minimise harm (OEH 2011:13).

It follows that the hierarchy for consideration in terms of the management strategies available for archaeological sites fall into four general categories, in order of preference from a conservation perspective:

- avoidance and in-situ conservation;
- partial avoidance and partial in-situ conservation (including partial harm);
- harm caused with mitigating circumstances such as collection or salvage; and
- unmitigated harm.

The management and mitigation measures have been prepared in consideration of comments received from the RAPs during the consultation process. However, as noted elsewhere in this report the RAPs have clearly communicated that they do not support the project. The RAPs were not willing to engage in the formal cultural heritage values assessment process for this project due to the legacy of dispossession and contemporary distrust of the Proponent and the broader government apparatus of the consultation, assessment, and planning processes.

There are no Aboriginal cultural heritage sites within the footprint of the construction impact zone around the Warragamba Dam wall. Impacts at the dam wall will include clearing of vegetation and earth disturbance works for construction activities. The remaining impact zone for the Project is the area above the current flooding extent of the existing dam that will be inundated by higher water levels in Lake Burragorang during flood mitigation. For Aboriginal heritage sites and places within the PUIA the Project will result in infrequent temporary inundation for durations of up to 11 days. This temporary inundation is not predicted to cause significant ground disturbance but may result in increased erosion and changes in local conditions that are detrimental to the preservation of sites, places and the features that contribute to their value. Above the PUIA there are sites, places and features that will experience very infrequent inundation for durations of no longer than 11 days.

For the purposes of assessment all sites, places and features within the PUIA were considered by the AR and the CVAR to be at least partially impacted and to have a total loss of value. This is consistent with the precautionary principle (see discussion in Ecologically Sustainable Development and Potential Cumulative Impacts) and the view expressed by Brayshaw McDonald (1989: 31) to "expect the worse" given the significant levels of previous impact and loss of cultural values in the Burragorang Valley.

The harm that will result from the Project sits within an historical and contemporary context of dispossession and loss for the Aboriginal community. Harm to the cultural landscape of the Burragorang Valley caused by the original Warragamba dam project in the mid-twentieth century impacted archaeological sites, historical sites and living places and cultural and story sites related to the Gurrangatch-Mirrigan Dreaming Track and the Buru (Kangaroo) Dreaming Story.

Because the impact zone for the Project is the PUIA there is no feasible alternatives that can implemented at a local level to avoid or directly minimise harm to sites, places and heritage features. For the Project to operate it must capture higher water levels behind the proposed raised dam, temporarily inundating the PUIA. Options and alternatives to the Project are presented in Chapter 4 of the EIS, these include:

- Non-structural strategies: these do not alter flood levels but reduce the effects of downstream flooding.
- Floodplain work: localised physical works in the downstream floodplain to divert floodwaters from properties (levees, for example).
- Drainage strategies: lowering flood levels by assisting floodwaters to escape from the downstream floodplain.
- Flood detention strategies: these temporarily store floodwaters on contributing rivers and thereby lower peak levels downstream.
- Combined strategies: these combine some of the above approaches.

During previous assessment for potential inundation of the PUIA Brayshaw McDonald (1989: 32) considered that a field survey achieving >30% coverage of the impact zone would be a basis on which to develop management strategies for the area. Similarly recognising the limitations for the implementation of direct mitigation measures to avoid harm Brayshaw McDonald envisaged a program of archaeological salvage requirements, supported by a management strategy, a dedicated [WaterNSW] employee to oversee the strategy, and an implementation that would take 12-18 months, resulting in a Plan of Management and salvage program of 2-3 years.

In the absence of directly applied management measures for the avoidance or minimisation of harm, should the Project proceed attempts to mitigate the loss of cultural value must be made through other strategies. As noted above harm or impact with mitigating circumstances is one of the least preferred options for management of cultural heritage values as it does not achieve a conservation outcome, and therefore is not aligned with the principles of inter-generational equity.

The indirect mitigation measures presented in the recommendations below include measures to contribute to intergenerational equity through the recording of Aboriginal cultural knowledge and history of the Burragorang area, an audit of collections institutions to identify cultural materials removed from Country, and improving the Aboriginal community's ability to access, manage and maintain the tangible and intangible aspects of the cultural landscape in the Project area. The mitigation measures will not remove the potential for harm, they may however provide opportunities for improved Aboriginal community access to an area of great cultural value to the community, and in doing so support renewed interaction and engagement with the cultural landscape impacted by the earlier flooding of the valley.

9.3 Options for mitigation

The strong emphasis, as in the Burra Charter, is to quantify and understand the heritage values of a place, a site, or an object and exhaust avenues of avoiding harm to those values. If harm cannot be avoided, then there must be consideration and implementation of strategies to minimise harm (OEH 2011:13). The management and mitigation measures presented in the original ACHA were prepared in consideration of comments received from the RAPs during the consultation process. These comments included those related to cultural considerations surrounding salvage works and the handling of artefactual materials, as well as the cultural significance of all sites. All comments received from the RAPs were considered in the ACHA Report.

This supplementary assessment has included additional work aimed at understanding the resilience of certain Aboriginal heritage site types and features to the effects of inundation. This understanding has been used to present a revised impact assessment for the Project including an assessment of the risk/consequence (i.e. Nil, Low, Moderate and High) of additional inundation that may be experienced as a result of the Project. Such an approach provides the opportunity to adapt management measures according to site types, the features present, their degree of resilience to temporary inundation and the level of risk associated with an increase in temporary inundation. Where a site/feature has a high resilience to the potential effects of temporary inundation (and thus low risk/consequence), for example, management options may include leaving the site in-situ and monitoring for changed conditions. This may include facilitating access to the site for proactive management of cultural heritage sites by traditional owners.

Table 75 provides an example of a potential management matrix that could be implemented for the Project which considers the consequence / risk associated with increased inundation as a result of the Project and the assessed scientific (archaeological) significance of a site. It is acknowledged that all sites are of High cultural value.

Table 75: Potential management option matrix

Consequence / risk associated with increased inundation (i.e., the Project) *	Scientific (archaeological) significance rating		
	Low	Moderate	High
Nil	Conservation	Conservation	Conservation
Low	Conservation	Conservation & Monitoring	Conservation & Monitoring
Moderate	Conservation & Monitoring	Further investigation & potential salvage	Further investigation & potential salvage
High	Conservation & Monitoring	Further investigation & potential salvage	Further investigation & potential salvage

*This considers the likelihood and frequency of temporary inundation as a result of the Project

Options for mitigation were considered in Section 13 of the original AR. These options are described below with consideration of the additional information presented in this supplementary assessment, specifically the management of sites with PAD where avoidance is not possible and/or where the effect of increased temporary inundation has the potential to result in moderate to high consequence risk to cultural resources.

9.3.1 Consideration of alternatives to the Project

Section 4.3 of the EIS provides a detailed discussion regarding the alternatives considered by the Hawkesbury-Nepean Valley Flood Management Taskforce over the period 2014-2016. The Taskforce confirmed the findings of the 2013 Review, concluding that there is no simple solution or single infrastructure option that can eliminate the high flood risk to existing communities in the valley. A combination of infrastructure and policy or other initiatives are required to reduce flood risk by:

- changing the probability and delaying flood events reaching critical levels
- reducing the exposure of people, property and assets to flood risk
- increasing the available time to safely evacuate areas exposed to imminent flooding
- increasing the resilience of communities, property and public assets exposed to floods.

The Taskforce Options Assessment Report (Infrastructure NSW 2019) provides a detailed description of the alternatives and options considered. The proposed raising of Warragamba Dam is one component in a suite of measures to mitigate downstream flood risk as identified in Table 10.1 (Summary of options assessment) of the Taskforce Options Assessment Report. The table also identifies other options considered and the reasons for these not being supported.

9.3.2 Detailed Design to Avoid Harm

Chapter 4 of the EIS discusses the proposed options and alternatives that were considered for flood mitigation in the Hawkesbury-Nepean Valley including:

- Non-structural strategies: these do not alter flood levels but reduce the effects of flooding.
- Floodplain work: localised physical works in the floodplain could be used to divert floodwaters from properties.
- Drainage strategies: these lower flood levels by assisting floodwaters to escape from the floodplain
- Flood detention strategies: these temporarily store floodwaters on contributing rivers and thereby lower peak levels downstream.
- Combined strategies: these combine some of the above approaches.

Criteria used to assess these options were based on reducing flood level peak, reducing risk to life, economic costs, and environmental impacts. Other alternatives and options either did not achieve sufficient flood mitigation or had unacceptable economic or environmental costs. Other measures to avoid harm include:

- Provision of a 14m PUIA rather than a 20m Flood Mitigation Zone. While a 20m Flood Mitigation Zone would provide a greater reduction in flooding downstream compared to a 14m Flood Mitigation Zone, the greater environmental costs from the longer period and extent of upstream temporary inundation were a major factor in discounting this alternative.
- Emptying the PUIA as soon as practical. The one of the objectives of the discharge protocol for the Flood Mitigation Zone will include to minimise the duration and extent of upstream temporary inundation.

During detailed design of the project and the development of the operating protocols for the Project area, it is recommended the proponent consider the known Aboriginal heritage sites and cultural values identified by this study. This process should include a consideration of whether or not the project and the operating protocols can be designed in a way that avoids harm, and if harm cannot be avoided that harm be caused to as few sites as possible, within existing design and operational constraints. Depending on the site type (e.g. artefact scatter or grinding groove) and scientific significance rating, further management measures such as archival recording and fencing may be undertaken prior to harm, in consultation with a suitably qualified archaeologist and representatives of the RAPs.

This approach is consistent with the Heritage NSW requirements of Ecologically Sustainable Development (ESD) and intergenerational equity.

9.3.3 Sites that cannot be avoided

An Aboriginal Cultural Heritage Management Plan (ACHMP) should be developed by a suitably qualified archaeologist in consultation with the RAPs to develop specific management protocols for those Aboriginal cultural heritage sites that will be harmed due to the proposed Project. The Aboriginal cultural heritage sites in the following sections should be included within this ACHMP.

9.3.3.1 Sandstone Shelter sites

All sandstone shelter sites and grinding grooves of moderate or higher significance should have baseline recording to a level which creates a detailed archival record and allows for the monitoring of inundation impacts. The baseline recording should include detailed scale drawing and photography of each site, and in some cases should include consideration of photogrammetry, giga-pixel photography and terrestrial laser scanning. As the Project spans a long operational life, this work should be undertaken progressively and the ACHMP should allow scope for the inclusion of new technologies (for both recording and mitigation) should these become available.

9.3.3.2 Scarred Trees

Scarred Trees account for five of the total number of Aboriginal sites identified during the assessment, none of these trees fall within the Project area and all are considered to be of low scientific significance. Each of these trees should be assessed by a qualified arborist to determine whether the wounding observed at each tree is the result of traditional Aboriginal activities. If these scars are determined to be of Aboriginal origin, then detailed recording (if not already undertaken) and update of their AHIMS registration should be completed.

9.3.3.3 Artefact Sites

The management recommendations made regarding artefact sites that will be impacted by the proposed development is to take no action unless they will be impacted by the proposed surface or ancillary infrastructure. Where impact from increased inundation is considered likely and the consequence is assessed as being moderate to high, artefact sites may be subject to detailed recording and surface salvage.

9.3.3.4 Sites with PAD

The management recommendations made regarding any sites with PAD that will be impacted by the proposed development is to take no action unless they will be impacted by the proposed surface or ancillary infrastructure. Where impact from increased inundation is considered likely and the consequence is assessed as being moderate to high, sites containing PAD may be subject to detailed recording, test excavation and salvage where warranted.

9.3.3.5 Warragamba-288 (AHIMS ID# pending)

Warragamba-288 (AHIMS ID #pending) which comprises of a sandstone shelter with hafted hatchet falls outside of the Project area. Due to its rarity and scientific significance rating of high; it is recommended that this site is included in the ACHMP, and additional recording and archaeological assessment is carried out to provide additional details on the age and mastic type used by the local Aboriginal people for hafting practices.

World heritage and GBMWHA values

The IUCN has advised in its submission that it considers that OUV cannot be offset and therefore the concept of compensation plots for the planned loss of OUV is not appropriate. However, it is noted that the World Heritage Operational Guidelines (Part III.I) provide for modifications to the boundaries of World

Heritage properties. It is presumed that this avenue would be available and could encompass suitable land to support the GBMWHA's OUV should it be required.

As recognised in the GBMA Strategic Plan, the variety of landscapes and associated cultural sites make the GBMWHA ideal for research and educational visits (DECC 2009: 16).

> *"The high scientific value of the GBMWHA therefore reflects not only what has been discovered, but also what remains to be discovered. Large gaps in knowledge remain, especially regarding Aboriginal use and occupation of the area…"* (DECC 2009: 16).

The Project therefore provides an opportunity to positively contribute to the World heritage and GBMWHA research and education values through the increased knowledge and understanding of past Aboriginal land-use. Such information can be generated through research that may be undertaken as part of the management of sites where harm cannot be avoided. It is acknowledged that archaeological research is, by its nature, often destructive (e.g. excavation of a rock shelter or surface salvage of an artefact scatter) and that research/education values are, in certain instances, somewhat in conflict with other values which require avoidance/conservation. The Burra Charta recognises this conflict:

> *"Although archaeological practice has the positive outcome of generating data, it is inevitably destructive of the fabric of the site. Archaeological data are commonly obtained at the expense of some of the physical material that is excavated away. Therefore, options for the in-situ retention of archaeological evidence need to be thought through early in the planning process by an appropriately qualified archaeologist, not as a last resort. In fact, the in-situ retention of archaeological evidence, without physically intrusive archaeological investigation, is often the most appropriate conservation measure (see issue below).*
>
> *Where an archaeological site embodies social or spiritual values in addition to scientific value (as is the case with many places associated with Indigenous cultures) it may be desirable to leave the place undisturbed by archaeological excavation. Archaeologists should not assume that the scientific value that excavation may contribute to is necessarily more important than the social or spiritual values."* (Australian ICOMOS 2013: 4).

This dichotomy can be balanced by implementation a management strategy whereby sites that can be avoided and/or are resilient to the potential effects of temporary inundation may be preserved in-situ while those that have a low resilience to the potential effects of temporary inundation may be subject to salvage to be conducted under a productive research design.

9.3.4 The Gundungurra Indigenous Land Use Agreement (ILUA)

An Indigenous Land Use Agreement (ILUA) exists between the Gundungurra and the NSW Government including WaterNSW. The ILUA covers the area that will be inundated if the proposal to raise Warragamba Dam wall proceeds. The Gundungurra ILUA was signed in 2014 by the Gundungurra people and all relevant Government agencies and NSW Ministers and it was Registered with the Native Title Tribunal in February 2015. The agreement covers about 6942 sq km, approx. 8 km south of Lithgow and approx. 18 km north of Goulburn. The Agreement provides a framework for consultation and participation of the Gundungurra people in the management of the ILUA area which incorporates the Project area.

The Gundungurra ILUA will be considered when implementing management and mitigation measures forthcoming from the Project.

9.3.5 Aboriginal Cultural Heritage Management Plan

An Aboriginal Cultural Heritage Management Plan (ACHMP) should be developed for the Project that details and schedules (for the life of the Project) the mitigation and management measures presented in this report, and any other relevant responsibilities and considerations.

The ACHMP must be developed, managed, and implemented in consultation with the RAPs and relevant regulatory authorities.

The ACHMP should include, but not be limited to the following:

- Protocols for the involvement of the RAPs in cultural heritage works conducted under the ACHMP. A communications protocol that describes clear methods of communication, including expectations of suitable notification and response time, between the proponent and the RAPs.
- Procedures for the management and reporting of previously unknown Aboriginal heritage sites that may be identified during the life of the Project (i.e. an unexpected finds procedure).
- Protocols for the surface collection of artefacts.
- Protocols for the completion of archaeological excavations (including initial testing and triggers for total salvage) of sites with PAD. This would include methodologies for both sites in open contexts (i.e. Open Camp Sites with PAD) and closed shelter sites (Shelters with Deposit).
- Warragamba-288 (AHIMS ID #pending) should be included within the ACHMP.
- A regular review process for the ACHMP (consistent with Step t Article 26 of the Burra Charta).
- Copies of the final ACHMP should be made available to each RAP, the DP&E, WaterNSW, NPWS and the Heritage NSW.

9.3.6 Evaluation of management and mitigation measures

The Project will result in unavoidable harm to sites of Aboriginal heritage, and potential harm to sites that may occur in areas that have not been subject to archaeological survey. The harm involves infrequent temporary inundation with floodwaters for periods of up to 14 days. For these sites and areas that will be temporarily inundated with floodwaters there are no feasible avoidance options that can be implemented by the project. Some direct measures to mitigate harm to these sites has been presented above. To further ameliorate these unavoidable impacts alternative measures that can positively influence ecologically sustainable development and intergenerational equity principles are suggested. These are indirect mitigation measures which include measures to contribute to intergenerational equity through increasing the broader community's knowledge of Aboriginal history in the Warragamba area and improve the Aboriginal community's ability to access and manage the valuable archaeological and cultural resource that exists within and beyond the project's boundary. The indirect mitigation measures are presented in the recommendations.

The mitigation measures developed as part of this assessment will not remove the potential for harm to the Aboriginal sites that they are applied to; but are designed to provide opportunities for additional RAP access and support greater interaction with cultural heritage values that the Aboriginal community have been rendered partially inaccessible due to colonisation and the flooding of the valley.

9.4 Recommendations

Consistent with the original ACHA, a total of seventeen recommendations have been made in relation to Aboriginal cultural heritage within the Project area. The recommendations are all indirect mitigation measures, if the Project proceeds the limitations of the proposed activities mean that there is no capacity for directly applied management measures for the avoidance or minimisation of harm. The recommendations relate to consultation, management, access to Country, site recording, cultural values recording and education. While these recommendations were shaped by feedback received from the RAPs during the consultation process, it has been clearly communicated by the RAPs that they do not support the Project. The Project is understood as a continuance of, and an addition to, the dispossession and loss of cultural heritage initiated by the original development of the Warragamba Dam in the 1950s.

Table 76: Recommendations and timing of management measures

Impact	Recommended measure	Timing
Consultation	WaterNSW should continue consultation and engagement with the Registered Aboriginal Parties for the duration of the Project.	Pre-construction and Construction
	An independent facilitator would work with the RAPs and the wider Aboriginal community to develop an Aboriginal advisory group to guide the implementation of Recommendations 8 to 11 in the Cultural Values Assessment Report (Appendix 2 to Appendix K).	Pre-construction, construction and operation
Management of impacts on cultural heritage	An Aboriginal Cultural Heritage Management Plan (ACHMP) should be developed for the Project and implemented as part of the Construction Environmental Management Plan (CEMP). The ACHMP should be developed and managed in consultation with the RAPs**,** other relevant stakeholders and relevant regulatory authorities. The ACHMP should provide specific guidance on measures and controls to be undertaken to avoid and mitigate impacts on Aboriginal cultural heritage during construction.	Pre-construction construction
	Prior to the operation of the Project WaterNSW should review its assessment processes for works within the upstream catchment to include awareness to personnel undertaking an activity on its behalf of any potential Aboriginal cultural heritage values and objects in the area.	Construction and operation
	WaterNSW should continue to provide a cultural heritage awareness and cultural competency training package for all WaterNSW staff. The training package should include a site-specific module developed in consultation with the relevant Aboriginal communities and RAPs.	Pre-construction
	The site-specific Aboriginal cultural heritage awareness training package would be delivered as part of the site induction for all employees, contractor(s) and maintenance personnel involved in the construction works and ongoing site management and activities in the catchment of Lake Burragorang.	Construction and operation
	WaterNSW should develop a formal agency-specific process and policy for undertaking cultural heritage assessments and engaging with the Aboriginal community in line with those developed by other state government agencies.	Operation
	WaterNSW should consider engaging an in-house archaeological specialist support in line with other state government agencies.	Operation
Access to Country	WaterNSW should develop and implement a policy to improve access for Aboriginal community members to Country they have cultural connections with that are under WaterNSW management.	Prior to operation

Impact	Recommended measure	Timing
	WaterNSW should facilitate bi-annual on-country visits open to Aboriginal community members with cultural connections to the area.	Ongoing
Site recording	The unsurveyed portion of the PUIA should be surveyed should the Project be approved (survey should include provision for detailed recording of all shelter sites including 3D photogrammetry, planning, detailed photography and scale drawing of any art or other features present). Additional survey will be guided by the updated predictive modelling presented in this supplementary assessment including consideration of results and predictions generated from the ASDST.	Prior to operation
	The unsurveyed portion of the area above the PUIA within the upstream study area should be sample surveyed to identify sites and places of high significance should the Project be approved (survey should include provision for detailed recording of all shelter sites including 3D photogrammetry, planning, detailed photography and scale drawing of any art or other features present). Additional survey will be guided by the updated predictive modelling presented in this supplementary assessment including consideration of results and predictions generated from the ASDST.	Prior to operation
	Further detailed impact assessment and recording of all Aboriginal cultural heritage sites and places that are located within the PUIA, sites of high significance in the area above the PUIA within the upstream study area, and all art sites within the upstream study area should be carried out. This should include 3D photogrammetry and high resolution digital photographic records and would include the landscape context of sites and site complexes to capture archaeological and cultural values.	Prior to operation
Cultural values recording and education	WaterNSW should consult with the RAPs and the Aboriginal community with regard to carrying out a comprehensive specialist research audit of the holdings of national and international collection institutions to identify cultural materials removed from Country in the Project area. Subject to proceeding with the audit, WaterNSW should facilitate an access visit for Aboriginal community members to any cultural materials identified in Sydney and Canberra based collection institutions.	Prior to operation
	In consultation with the RAPs and the Aboriginal community, WaterNSW should develop interpretative materials on the Aboriginal cultural values and history of the cultural landscape of the Project area including: a permanent exhibition at the Warragamba Dam Visitor Centre; interpretative signage and audio posts within the Warragamba Dam grounds; and facilitate the provision of Aboriginal-led cultural events (i.e. tours and talks) through the Warragamba Dam Visitor Centre.	Prior to operation
	In consultation with the RAPs and the Aboriginal community, WaterNSW should develop a cultural values project to record the Gurrangatch-Mirrigan Dreaming Story route through the photographic recording of specific cultural locations within the Project area (prior to any further impacts), oral history recordings with Aboriginal community members, and documentary research.	Prior to operation
	In consultation with the RAPs and the Aboriginal community, WaterNSW should undertake a heritage study of the Aboriginal traditional and	Prior to operation

Impact	Recommended measure	Timing
	historical occupation of the Project area through photographic recording of specific sites (prior to any further impacts), historical documentary research, and oral history interviews.	

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Appendix 1: Aboriginal community consultation documents and log

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Appendix 2: Updated AHIMS search results

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Appendix 3: AHIMS site cards (CONFIDENTIAL)

Redacted from public version

PENDING. At the time of preparing this supplementary assessment report, the site cards for the new or updated Aboriginal sites have been drafted but are awaiting the results from consultation with RAPs regarding the name/s of key cultural knowledge holders to be added to the restricted site cards.

Appendix 4: Aboriginal Place Nomination Form

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Appendix 5: Longneck Lagoon Survey Report

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Prepared by Niche Environment and Heritage | 29 August 2022

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Document control

Project number	Client	Project manager	LGA
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F1	Carly Todhunter	WaterNSW	FIN 01	29 August 2022

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1 Executive Summary

Niche has been engaged by SMEC Australia Pty Ltd to conduct an assessment of eight Aboriginal cultural heritage sites adjacent to Longneck Lagoon and to assess the effects of temporary inundation on these sites from previous flood events including the recent significant events of March 2022. This assessment is intended as a case study for the Warragamba Dam Raising Project by considering the potential future impacts to Aboriginal cultural heritage sites that may be subject to flooding within the Upstream and Downstream Study Areas.

The Upstream Study Area for the Warragamba Dam Project is the area between Full Supply Level (FSL) and the probable maximum flood (PMF) event with the Project. The Downstream Study Area is defined as the existing PMF which will reduce in size due to the Project. The bounds of the study areas for the Project were set through the Secretary's Environmental Assessment Requirements (SEARs).

During flooding events, the close proximity of Aboriginal cultural heritage sites to significant waterways including lagoons, rivers, creek lines and gullies put these areas at risk from various hazards. The potential impact of flooding on Aboriginal cultural heritage can be variable and is influenced by (a) the proximity of sites to waterways, (b) the erodibility of soils present, (c) the presence of vegetation to reduce the force of the inundation, (d) the type of cultural heritage site present (i.e. isolated artefacts or grinding grooves), (e) topographic features of the landscape including slope gradient and length, (f) the pace and energy of the inundation, (g) the duration of the inundation and (g) the water-holding capacity and cohesiveness of soil deposits.

On 15 June 2002 an archaeological site inspection was undertaken by Carly Todhunter (Heritage Consultant, Niche) to determine the impact of significant flooding events of April 2022 on eight registered sites in proximity to Longneck Lagoon in Maraylya, NSW (Figure 1, Figure 2, Appendix A, Table 7 and Table 8). All eight sites were Open Camp Sites containing artefacts. Longneck Lagoon is situated within the City of Hawkesbury Local Government Area (LGA) and within the boundaries of the Deerubbin Local Aboriginal Land Council (LALC).

Of the eight registered sites, five were groundtruthed (Figure 3, Figure 6 and Table 7). The three sites that could not be located occurred in environments with thick vegetation and leaf litter, reducing ground surface visibility (GSV) to 0-10%.

The site inspection involved a pedestrian survey over the recorded AHIMS site locations and surrounding area (inclusive of a 20-100 m buffer). The condition of these eight sites were compared to those documented in previous surveys and considered the (a) intactness of the sites compared to their existing site records, (b) the level of inundation observed in the surrounding area, and (c) a consideration of the extent of erosion or redeposition of soil that was observed following several major recent flooding events. Any artefacts that were identified on the ground surface were photographed, recorded, and their spatial location was logged using the ArcGIS Field Maps program.

Any evidence of impact to the sites resulting from the flooding experienced in early 2022 was recorded and photographed for inclusion in this report. All sites were inspected for evidence of (a) sheet erosion, (b) gully erosion, (c) rill erosion, (d) gravel sorting, (e) soil compaction, (f) soil runoff and the redeposition, (f) soil intermixing as soils become saturated and (g) cracking appearing on the surface of reconsolidated soils as they dry. Due to the erodibility of the soils present and the extent of historical inundation, the eight sites at Longneck Lagoon displayed varying levels of previous disturbance associated with flooding.

It is important to note that flooding at Longneck Lagoon results from runoff from the local catchment upstream of the lagoon and backwater from the Hawkesbury River as the water level in the river increases. The effects of this at a specific location will vary over the duration of the flood event. In the early stages of the flood event, local catchment runoff will likely dominate (with its associated relatively higher flow velocities). As the water level in the main river rises, water will start to back up in tributaries and low-lying areas such as Longneck Lagoon. Temporary inundation (with relatively lower flow velocities) from backwater will then dominate. This will continue until water levels in the main river start to drop, at which point the backwater effect will start to decline and local catchment runoff again becomes dominant.

During the site inspection, a number of impacts were observed to the Aboriginal cultural heritage sites that have resulted from temporary inundation events. The most significant impact was sheet erosion which was observed to varying extents across 7 of the 8 sites that were inspected, though some of this may be attributed to local catchment runoff rather than backwater flooding. At 7 of the 8 sites rill erosion was observed, and was most pronounced across areas of disturbance and exposure. Portions of the Study Area were found to be subject to seasonal or permanent inundation and this dynamic has increased the level of soil compaction. As floodwaters cannot as easily permeate compacted soils, the level of soil compaction can exacerbate the potential impact of temporary inundations by increasing the risk of runoff in the form of sheet or rill erosion.

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Figure 6: Survey extent and site inspection results (Source: AHIMS, DPIE and Niche)

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2 Introduction

2.1 The proponent

Niche Environment and Heritage Pty Ltd (Niche) was commissioned by SMEC Australia Pty Ltd on behalf of WaterNSW ('the Proponent') to undertake a site inspection of eight previously recorded Aboriginal cultural heritage sites at Longneck Lagoon, Maraylya, New South Wales (NSW) (Figure 1 and Figure 2) (hereafter referred to as the 'Subject Area').

2.2 Project location

Longneck Lagoon is a small, permanent freshwater wetland situated in the Hawkesbury Region of north-west Sydney in the suburb of Marayla, NSW. The lagoon is situated within the Hawkesbury City Council Local Government Area (LGA) and within the boundaries of the Deerubbin Local Aboriginal Land Council (LALC). It extends for approximately 21.7 hectares (Smith and Smith 1996:30).

2.3 AHIMS site records

An extensive search of the Aboriginal Heritage Information System (AHIMS) was undertaken on 6 May 2022 (AHIMS Client ID: #680898) (see Appendix A and Appendix B). A total of 8 Aboriginal cultural heritage sites were identified within the area: Lat, Long From -33.5854, 150.8761 to Lat, Long To -33.5675, 150.907. All eight Aboriginal cultural heritage sites were registered as containing stone tool artefact(s), as summarised in Table 1. Though the potential for archaeological deposits (PADs) at the five Aboriginal cultural heritage sites recorded in 1988 by the National Parks and Wildlife Service was stated in the site recordings, none of the sites were formally registered as containing PADs.

Table 1: AHIMS registered sites situated in proximity to Longneck Lagoon

Site ID	Site name	Site features	Landform	Hydrologic Soil Group (Figure 4b)	AHIMS Site status
45-5-0650	LN12	Artefact(s)	Creek bank	D- Very slow infiltration	Valid
45-5-0653	LN15	Artefact(s)	Creek bank and flats	C- Slow infiltration	Valid
45-5-0654	LN16	Artefact(s)	Creek flats	D- Very slow infiltration	Valid
45-5-0655	LN17	Artefact(s)	Lagoon margin flats	D- Very slow infiltration	Valid
45-5-0656	LN18	Artefact(s)	Lagoon banks	D- Very slow infiltration	Valid
45-5-2738	WD6	Artefact(s)	Hill slope	D- Very slow infiltration	Valid
45-5-2739	WD7	Artefact(s)	Lagoon flats	D- Very slow infiltration	Valid
45-5-3708	LLO1 Coordinates in AMG 66	Artefact(s)	Undulating plain	D- Very slow infiltration	Partially Destroyed- Community collection took place in December 2010 under AHIP 1121342

2.4 The purpose of the site inspection

This site inspection report has been produced to investigate the impact of temporary inundation events on a group of eight Aboriginal cultural heritage sites that are situated within the Downstream Project Area of the Warragamba Dam Raising Project. This investigation will be used to inform predictions about the potential impact of temporary inundation on Aboriginal cultural heritage sites that may be impacted by the Warragamba Dam Raising Project.

2.5 Applicability and limitations of the survey inspection results

The results of the site inspection provide important context to the impact of temporary flooding events on Aboriginal cultural heritage sites in proximity to waterways and may be used to extrapolate the effects of raising the Warragamba Dam on upstream sites, with some considerations as follows.

Firstly, the slope gradient of sites at Longneck Lagoon will affect the pace and intensity of potential harm caused by rainfall as water flowing down steeper slopes will have greater erosional risks associated with them. The slope gradient will influence the relative impact of local catchment runoff during rainfall events. The Aboriginal cultural heritage sites recorded around Longneck Lagoon tend to be situated on low-lying country in close proximity to natural drainage lines and are subject to intermittent flooding and the effects of local catchment runoff. Their proximity to the lagoon results in seasonal waterlogging, in particular in areas closest to the lagoon and associated waterways.

The original site recordings for the majority of sites at Longneck Lagoon were undertaken in 1998, with the remaining three sites recorded in 2002 and 2004 respectively. No site photographs were available for any of the sites from their site cards and the recording of artefact distribution within each site was either limited or not available. With the limited prior recording, it is not possible to draw absolute conclusions relating to any changes to the distribution or spatial occurrence of specific artefacts. With this said, the spatial extent of LN 15 (AHIMS ID# 45-5-0653) was broader than previously recorded with an occurrence of three artefacts close to Llewellyn Creek having not previously been recorded (Figure 6). It is possible that these artefacts have been exposed during a period of inundation due to their location within a natural drainage line.

The Aboriginal cultural heritage sites present at Longneck Lagoon only represent one site type- Artefact Scatter / Open Camp Sites. The dynamics affecting this specific site type varies from those affecting rock shelters, axe grinding grooves and Aboriginal resource and gathering sites, amongst others (see Table 6). The impacts of flooding observed at sites associated with the Longneck Lagoon has been considered in relation to disturbance to Isolated Finds (artefact), Artefact Scatters (multiple artefacts) and Potential Archaeological deposits (PADs).

The geology and soils present at Longneck Lagoon will influence the extent of harm that results from temporary inundation events. Factors that can affect the level of harm include the level of porosity, water-holding capacity, level of cohesiveness, structural composition and chemical composition of the soils present. These factors can all impact the duration and intensity of harm resulting from temporary flooding.

Numerous exposures are present throughout Longneck Lagoon in the form of tracks and cleared areas for visitors to the park. Vegetation has also previously been cleared and modified for grazing. These modifications can accelerate the potential impact of inundation events.

3 Impacts of temporary inundation on Aboriginal cultural heritage sites

3.1 Introduction

The potential impact of temporary inundation events on Aboriginal cultural heritage sites can take several forms and will vary according to a number of factors. This section will establish a conceptual basis for the study by considering the dynamics that are at play during inundation events.

It is important to note that flooding at Longneck Lagoon results from runoff from the local catchment upstream of the lagoon and backwater from the Hawkesbury River as the water level in the river increases. The effects of this at a specific location will vary over the duration of the flood event. In the early stages of the flood event, local catchment runoff will likely dominate (with its associated relatively higher flow velocities). As the water level in the main river rises, water will start to back up in tributaries and low-lying areas such as Longneck Lagoon. Temporary inundation (with relatively lower flow velocities) from backwater will then dominate. This will continue until water levels in the main river start to drop, at which point the backwater effect will start to decline and local catchment runoff again becomes dominant.

Beyond local catchment runoff, the most significant impacts of heavy rainfall events on isolated artefacts and artefact scatters are erosion, waterlogging and the destabilisation and removal of deposits containing Aboriginal artefacts. The erodibility of soils through bank scour is also of concern, with banks being exposed to undercutting and potentially the exposure of benches and unstable soil during significant flooding events (BECA 2021:86). Bank scour was not observed as a significant issue during the Longneck Lagoon survey, however it was observed at WD 7 (AHIMS ID# 45-5-2739) (Plate 65). In some circumstances, temporary inundation- as noted in a geomorphological assessment of flooding related to the proposed raising of the Warragamba Dam (BECA 2021:114)- can increase waterflow and in turn will temporarily increase stream power resulting in the increased rate of bank erosion.

The potential transportation of artefact-bearing deposits in these stream flows will in turn affect the stratigraphic integrity of potential archaeological deposits and may result in the obscuring or loss of cultural artefacts as they are moved and deposited elsewhere. Both sheet and rill erosion can contribute to the transportation and obscuring of objects under redeposited soils. In particular on relatively rough surfaces, sheet erosion can also result in the formation of a system of enmeshed microchannels or rills as water flows over and exposes embedded rocks. The permeability of soils present at a site will influence the pace of transmission of the water through existing soil horizons during inundation events, with soils associated with slower rates of infiltration being more exposed to the effects of sheet erosion.

3.2 Potential impacts

The potential impacts of temporary inundation on Aboriginal cultural heritage sites can take several forms including (a) sheet erosion, (b) gully erosion, (c) bank erosion, (d) rill erosion, (e) soil redeposition in runoff, (f) soil mixing resulting from the stationary suspension in water, (g) soil compaction and (h) resorting. These impacts are discussed in Table 2.

Table 2: Summary of impacts to Aboriginal cultural heritage sites that can result from temporary episodes of inundation

Impact	Nature of the impact	Potential impact to heritage	Applicability to the Longneck Lagoon locality
Sheet erosion	Sheet erosion occurs when the intensity of rainfall exceeds the infiltration	Depending on whether an alluvial setting is aggrading or degrading, this can either result	The Kurosol soils present in the vicinity of Longneck Lagoon are considered to have very slow

Impact	Nature of the impact	Potential impact to heritage	Applicability to the Longneck Lagoon locality
	capacity of soil. The process generally results in the loss of topsoil, in particular on surfaces with sparse vegetation cover. As soil becomes saturated, its bearing capacity is reduced and this can make it more susceptible to structural damage (Taboada 2003).	in the exposure of archaeological deposits containing artefacts or in the case of aggrading soils, it can result in the obscuring of artefacts under newly deposited soils.	infiltration rates (Section 4.4 and Figure 4) and are therefore relatively more exposed to the impact of sheet erosion during periods of heavy rainfall. Sheet erosion resulting from water catchment runoff is an ongoing issue affecting the integrity of surface deposits.
Rill erosion	Rill erosion can occur during periods of concentrated water flows when the surface runoff forms small channels or rills. Rills are shallow drainage lines less than 30 cm deep. The intensity of rill erosion is largely associated with the local topography as steeper slopes tend to increase the force of the water flow.	Rill erosion can cause artefacts to be transported from their original context or to be obscured under redeposited soil.	Due to the slow infiltration rates of soils surrounding Longneck Lagoon (Section 4.4 and Figure 4), rill erosion can occur across areas of exposures and where sheet erosion is more prolonged. Within exposed areas along walking tracks and clearings, sub-surface gravels that are present on the upper surface can result in rill erosion.
Gully erosion	Gully erosion involves the removal of soil along drainage lines by surface runoff. Gullies are channels that are deeper than 30 cm. Unless remedied, gully erosion will worsen over time as further material is eroded from the unstable banks and this can be worsened by bank slumping. The influence of gully erosion will be most pronounced during periods of high velocity water flows.	Gully erosion can undermine the structural integrity of a soil unit and lead to the exposure and transportation of artefacts.	The flat to gently inclined landscape surrounding the Longneck Lagoon has very few gullies with the majority of channels present being rills less than 30 cm in depth.
Bank erosion / mass failure	Bank erosion can occur adjacent to waterbodies due to the force of flowing water directly abrading a soil deposit (bank scour) or when the integrity of a bank is undermined by material loss and bank collapse occurs (also known as mass failure). Mass failure can cause the root systems of large trees	Aboriginal cultural heritage sites situated close to waterways may become unstable and further exposed to alluvial forces as the bank erodes.	The banks surrounding Longneck Lagoon and the associated creek and drainage lines are exposed to the effects of bank erosion and mass failure during periods of heavy saturation, in particular where the velocity of channel flows are higher. In areas of greatest vegetation clearance or where root systems are only shallow, there is a greater potential

Impact	Nature of the impact	Potential impact to heritage	Applicability to the Longneck Lagoon locality
	situated close to the bank to collapse and cause further damage.		impact on the structural integrity of banks.
Redeposition of soils resulting from sheet, gully or rill erosion	As sheet, gully or rill erosion transports soil from adjoining areas it can become redeposited within depressions. Generally, this redeposition would occur on low-lying ground however as floodwaters raise the water table, water-borne soil can also be deposited on ground higher than the natural water table.	Depending on whether an aggradation of degradation of soils is occurring, this can result in the further exposure or obscuring of archaeological sites.	Soil redeposition associated with water catchment runoff is an issue at Longneck Lagoon, however due to the poor infiltration rates of much of the surrounding landscape, saturation is going to be the most severe along drainage lines and in low-lying terrain. The relatively slow velocity rates of backwater flooding affecting Longneck Lagoon will generally not result in widescale soil reposition.
Soil mixing resulting from temporary suspension in water	Temporary inundations can cause soil particles to become suspended in standing water. Depending on the capacity for water to permeate the soils present, this can extend deeper into the soil profile.	Remixed soils can cause harm to the archaeological integrity of a deposit.	The very slow infiltration rates of soils surrounding Longneck Lagoon (Section 4.4 and Figure 4) generally result in low rates of permeation through the soil profile. In locations along drainage lines and on low-lying terrain where water can more easily permeate, an intermixing of soils in the upper horizon can occur.
Soil compaction	Inundated soils are prone to becoming compacted as suspended soils resettle and harden and this dynamic is worsened in clay-rich soils. In particular, in areas exposed to seasonal inundation cycles, soils are prone to compacting as they swell and shrink.	As compacted soils with reduced porosity are more exposed to erosion during periods of inundation, the further compaction of the soils can increase the extent of harm to sites.	Soils surrounding Longneck Lagoon are generally quite compact due to their prolonged exposure to catchment runoff and backwater flooding.
Resorting	As soils become inundated there is a potential for embedded gravel to be transported and redeposited. The potential for gravel to be transported will be influenced by a range of factors including the size of the gravel and this can result in differential	If small or light artefacts are disproportionately more exposed to being transported during inundation events, this can alter the integrity of an archaeological deposit.	Inundation events at Longneck Lagoon associated with backwater flooding is considered low-velocity and is therefore less likely to result in the transportation and resorting of gravels. In exposed areas where surface runoff can be more severe, resorting can occur to a limited extent.

Impact	Nature of the impact	Potential impact to heritage	Applicability to the Longneck Lagoon locality
	rates of movement for gravel of varying size.		

3.3 Influence of soil composition on the extent of erosion

As previously discussed, a number of factors related to soil composition can have an effect on the extent of erosion that results from significant inundation events. Soil texture (in other words the grain-size of soil particles) has been forwarded by a previous study as the principal characteristic affecting the erodibility of soils, though soil structure, the extent of organic matter and the level of permeability were also identified as important factors (Ritter 2012). If all other factors are controlled, soils with faster infiltration rates, higher levels of organic matter and consolidated structures have greater resistance to erosion. Fine-textured soils including silt tend to be more readily eroded than loamy soils if soil texture is considered.

The erodibility of sandy soils can be affected by a number of characteristics. If considered in terms of soil permeability, soils containing large proportions of sand would be expected to have relatively large pores through which water can drain and therefore the risk of surface runoff would be lessened. The level of cohesiveness of sand, however, is low and this increases the risk of erosion. In contrast, clay-rich soils have smaller pores which reduces the permeability of water and can increase the risk of runoff. A brief summary of the potential risk of erosion to soils with varied compositions of sand, silt, clay and loam is provided in Table 3.

Table 3: Summary of the potential risk of erosion to soils with varied compositions of sand, silt, clay and loam as described in AHDB 2007

Soil composition	Aggregate stability	Potential risk of erosion	Applicability to the Longneck Lagoon locality
Sandy and lightly silty soils	Due to their low levels of clay and organic matter, these soils have low aggregate stability.	Silty soils can become easily dispersed in water and this can result in internal slumping and capping at the surface. If soils are free draining and well structured, they will have a lower risk of runoff. If drainage is impeded by a slowly permeable subsoil or a high water table then these soils are at risk to structural damage and runoff. Where runoff does occur, these soils have a high risk of erosion	The upper horizons of soils present in the landscape surrounding Longneck Lagoon generally contain a fine sand however this component is less than that of clay loam or clay (Section 4.4).
Medium soils featuring clay loam components	The clay component of these soils produced greater aggregate stability than lighter soils.	When these soils contain high concentrations of silt or fine sand they will be prone to capping. If the clay content is low in the subsoil, than these soils can be freely drained with low risk to structural damage. In contrast, if the clay content is high, the	The upper horizons of soils present in the landscape surrounding Longneck Lagoon generally contain a fine sand however this component is less than that of clay loam or clay (Section 4.4).

Soil composition	Aggregate stability	Potential risk of erosion	Applicability to the Longneck Lagoon locality
		soils will be more prone to waterlogging and structural damage. Structural damage or poor drainage can both exacerbate the rates of runoff and soil erosion.	Subsoils in the landscape surrounding Longneck Lagoon generally contain a layer of medium clay overlying a heavy clay and therefore will be more prone to waterlogging in periods of heavy saturation.
Heavy soils comprising clay contents exceeding 35%	The stability of clay-rich soils depends on the type of clay present. The expansion and contraction of clay particles during inundation events can crack the soil mass and break apart aggregates. Some clay soils, however, have a well-developed soil structure.	Heavy, slow draining soils are at a heightened risk of structural damage and runoff. Less stable, acid-rich clays have greater porosity rates and a higher risk of runoff as compared to calcareous clays.	Subsoils in the landscape surrounding Longneck Lagoon generally contain a layer of medium clay overlying a heavy clay and therefore will be more prone to waterlogging in periods of heavy saturation.
Shallow chalk or limestone rich soils	These soils have stable aggregates and form a well-developed structure	These soils are naturally well-drained and have a lower risk of suffering from runoff.	Neither soil category is present in the area surrounding Longneck Lagoon.
Soils with high organic content	These soils have stable aggregates and form a well-developed structure	Organic matter helps to bind soil together and this helps to reduce the impact of erosion from runoff events.	Surface soils present in the surrounding landscape to Longneck Lagoon can have high organic components which help to improve their structural integrity, however much of these topsoils have also been adversely affected by historical vegetation clearance.

The level of compaction will also influence the extent of erosion, due to its influence on the propensity of soil to absorb water. Clay-rich soils have the highest tendency to be compacted and therefore sheet and rill erosion is a significant risk.

The chemical content of soil and the percentage of organic matter that it contains can both affect the level of erosion experienced during temporary inundation. For instance, calcium and iron compounds in the soil can help to bind the soil together into structural units, aggregates or peds (AHDB 2007). Well-structured soils allow water to penetrate further during inundation events and prevent the extent of runoff.

The surface roughness of soils will also influence the potential extent of runoff that can occur during temporary inundation events. All other factors being controlled, rough surfaces can help to reduce runoff by allowing the water to collect and be absorbed.

3.4 Influence of slope gradient on the extent of erosion

The potential impact of temporary inundation on Aboriginal cultural heritage sites will be influenced by the slope gradient present. Sites situated on gently included slopes in close vicinity to waterways are most likely to have broader areas of impact resulting from backwater flooding as groundwater levels rise and affect larger areas of the surrounding landscape. In particular, sites including artefact scatters and grinding grooves situated within flood impact areas can be covered in transported sediment. As stated in Section 3.3, the type of soil present in the environment will influence the capacity of the soil to transmit and absorb these additional waterflows. Where sites occur on moderate to high slope gradients, the spatial extent of backwater flooding will be constrained as floodwaters permeate across the lowest lying areas first before proceeding to higher points in the landscape. Where temporary waterflow does occur within areas of moderate to high slope gradient, the stream power will generally increase due to gravity.

The pace and intensity of erosion has been shown in previous experimental studies to be influenced by the slope gradient present (see Table 4). These experiments have shown that some forms of erosion will only occur once a certain threshold has been met allowing the transportation of soil to occur. This critical slope gradient will vary according to factors such as the infiltration rates, flow velocity, soil particle size, extent of rainfall, vegetation cover and surface roughness (ibid.). Previous estimates of the critical slope gradient (i.e. the slope that a given discharge will be sustained at a uniform critical depth in a given channel) have been made with varied results, as summarised in Table 4. The length of a slope has also been recognised as influencing the extent of erosion, with longer slope lengths associated with higher rates of erosion due to their greater accumulation of runoff and greater velocities (Ritter 2012).

Table 4: Critical slope gradients for sustaining soil erosion as obtained by previous studies and summarised in Liu et al. 2001

Author(s)	Study	Estimated critical slope gradient
Renner (1936)	Conditions influencing erosion of the Boise River watershed	40.5°
Chen (1985)	The experiments of the effects of the sloe on soil erosion	25°
Horton (1945)	Erosional development of streams and their drainage basins, hydro-physical approach to quantitative morphology	57°
Cao (1993)	On the study of the critical slope of soil erosion	41°
Liu et al. (2001)	Influences of soil gradient on soil erosion	41.5 - 50°

In the Renner (1936) study, the proportion of gully, sheet or no erosion within areas with varying slope gradients was recorded (Plate 1). The study determined that if all other factors were held constant, locations with low slope gradients (i.e. relatively flat) have higher propensities to absorb water before sufficient water has collected on the surface for flows to be initiated and erosion to occur. For locations having a 0-5° slope, 79% of the studied land experienced no erosion and only 21% experienced sheet erosion. A slope gradient between 6-15°, however, resulted in 46% of the studied land being affected by sheet erosion and 4% being affected by gully erosion. The highest percentage impacts by gully erosion the results were varied due to other factors including grazing activities, however the highest percentage impacts were observed on average between 26 - 75°. Plate 1 provides a summary of the study's findings.

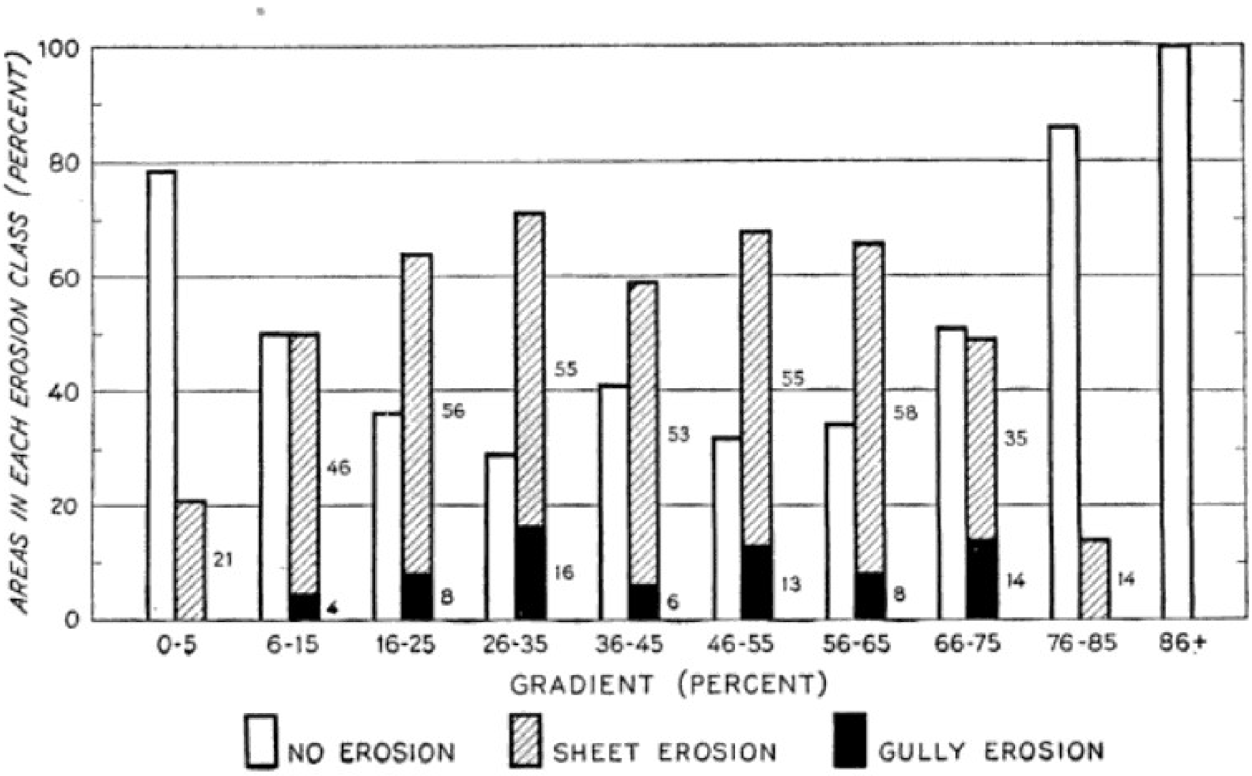

Plate 1: Percentage of land affected by sheet, gully or no erosion based on their slope gradient, as observed in the Renner (1936) study of the Boise River watershed, page 21

The terrain surrounding Longneck Lagoon is generally flat to gently inclined, reducing the potential velocity of catchment runoff during significant rainfall events. It should be noted, however, that the level topography of land adjoining Longneck Lagoon also results in broader areas of the surrounding landscape being impacted by backwater flooding as floodwaters can more easily submerge flat to gently inclined landscapes adjoining existing waterways. The slope present at the eight Aboriginal cultural heritage sites present at Longneck Lagoon are detailed in Table 5.

Table 5: Slope gradients at the eight Aboriginal cultural heritage sites present at Longneck Lagoon

AHIMS ID #	Site name	Slope gradient	Slope category
45-5-0650	LN12	1-6°	Gently Inclined
45-5-0653	LN15	0-1°	Flat or Very Gently Inclined
45-5-0654	LN16	1-6°	Gently Inclined
45-5-0655	LN17	1-6°	Gently Inclined
45-5-0656	LN18	0-1°	Flat or Very Gently Inclined
45-5-2738	WD6	1-6°	Gently Inclined
45-5-2739	WD7	1-6°	Gently Inclined
45-5-3708	LLO1	0-1°	Flat or Very Gently Inclined

3.5 Influence of vegetation cover on the extent of erosion

The extent of erosion that can result from temporary flooding events is influenced by the extent of vegetation cover that is present. Vegetation can have a number of influences on the passage of water over terrain including by obstructing run off and allowing sediment to settle, preventing accumulations of water to form into streams and by providing greater sub-surface structural integrity to soil deposits via the root structure (Renner 1936). For the most severe instances of sheet erosion observed in Renner's study, vegetation cover was between 5 and 30%.

The extent of vegetation cover surrounding Longneck Lagoon is variable, however in general the surroundings are well-vegetated with trees, shrubs, grass and leaf litter cover present across the majority of the ground surface. Along drainage lines and around the perimeter of the lagoon there are defined areas of exposure where a lack of vegetation can increase the extent of erosion during periods of inundation. A number of walking tracks and a small number of clearings are also present within the Subject Area associated with the current public use of the Scheyville National Park.

3.6 Potential consequences for Aboriginal cultural heritage sites according to site type

The impact of temporary flooding on Aboriginal cultural heritage sites and archaeological deposits present have previously been considered by Niche (2021a and 2021b) and Brayshaw McDonald (1989: 30-31). These studies have demonstrated that the potential impact of temporary inundation events can vary according to the site features present. A summary of the potential impacts due to temporary inundation on various Aboriginal cultural heritage site types is provided in Table 6.

Table 6: Summary of predicted impacts of temporary flooding inundations to at-risk Aboriginal cultural heritage sites

Site Type	Potential impacts
Archaeological deposits and Artefacts sites	- Waterlogging and potential slumping of underlying soils - Sheet or rill erosion resulting in the transportation of surface objects - Sheet or rill erosion resulting in the redeposition of eroded soils over surface artefacts - Changes to the spatial distribution of artefacts within an artefact scatter due to differential rates of erosion for artefacts of varying sizes - Loss in stratigraphic integrity with soil horizons intermixing - Bank erosion resulting in the collapse and loss of artefact-bearing soil deposits
Sandstone rock shelters	- Disturbance to and potential loss of potential archaeological deposits (PAD) due to erosion - Transportation of surface artefacts from their original context - Acceleration of weathering to art surfaces - Acceleration of granular loss - Intrusion of micro- and macro- vegetation
Scarred trees	- Risk of damage or death to the tree resulting from prolonged periods of inundation - Undermined soils causing damage to the root system
Axe grinding grooves and engravings	- Acceleration of granular loss - Weathering of the rock surface due to case-hardening and the delamination of the rind
Aboriginal ceremonial and dreaming sites	- Accessibility will be altered so places might not be able to be visited and maintained until conditions improve - Potential loss or damage to significant features - Alteration to the natural environment including erosion and vegetation cover loss

Site Type	Potential impacts
Aboriginal resource and gathering sites	- Loss and damage to vegetation - Loss in biodiversity - Altered creek and gully flows resulting in potentially prolonged periods of inaccessibility

4 Background to Longneck Lagoon

4.1 Introduction

Forming part of the Cattai National Park, Longneck Lagoon is an important reserve for the research and conservation of a rich diversity of native flora and fauna. Historically, the lake was a shallow marshland of mudflats and reeds and was fringed by wide expanses of native grasses growing within the floodplains (Ridgeway 2022). Beyond shellfish and freshwater species the lagoon would have offered inhabitants a range of other important foods including freshwater tubers from native sedges, rushes, and waterlilies. Raw materials for tool production including silcrete and sandstone are known to occur locally and were widely exploited by resident groups. A number of Aboriginal campsites are known to exist around the lagoon, and the area was traditionally occupied by the Dharug people.

4.2 Hydrological setting

Longneck Lagoon is situated within the Hawkesbury River floodplain and is primarily fed by two creek systems commencing from the south (Figure 4). Longneck Creek, the larger of the two creek systems, extends for approximately 5 km through the Cattai National Park extending northwards before draining north-west into the lagoon on its eastern side. Llewellyn Creek also commences within the Cattai National Park and extends for 3 km north-east before draining into Longneck Lagoon from the south-west. Along the course of Llewellyn Creek, a number of Aboriginal cultural heritage sites have been identified (Figure 3) containing stone tool artefacts. Additional creeks approaching from the east and west also feed into the lagoon and have the potential to cause harm to Aboriginal cultural heritage sites present during significant inundation events.

A small creek to the north of Longneck Lagoon connects the lagoon to the Hawkesbury River. The lagoon is impacted by runoff from its catchment as well as backwater flooding from the Hawkesbury River. The Longneck Lagoon catchment area extends over an area of 1,700 hectares (Jayawickrema 2000) and takes in much of the Cattai National Park and surrounds. Backwater flooding can affect the surrounding landscape of Longneck Lagoon as waters back up on the advance to the Hawkesbury River due to the installation of an artificial weir in 1972. This can result in flooding over low-lying areas in proximity to waterways and drainage lines (see Plate 5 to Plate 18). Backwater flooding at Longneck Lagoon has been shown in previous hydrological studies to have occurred once per year on average (Jayawickrema 2000: 40).

4.3 Flooding events

Longneck Lagoon and surrounding areas have long been subject to intermittent flooding and waterlogging issues. A hydrological study from 1991 suggested that runoff from the Longneck Lagoon catchment occurs once every three months on average with a significant runoff event occurring once a year (Dames and Moore 1991 referenced in Jayawickrema 2000). Below-average rains experienced during subsequent years reduced the risk of flooding within the Longneck Lagoon catchment and the broader region. Between 1991 and 2020, the occurrence of moderate to major flooding along the Hawkesbury River reduced significantly as the region experienced a drought-dominated cycle with fewer and less severe flooding events (SES 2021) (see Plate 2).

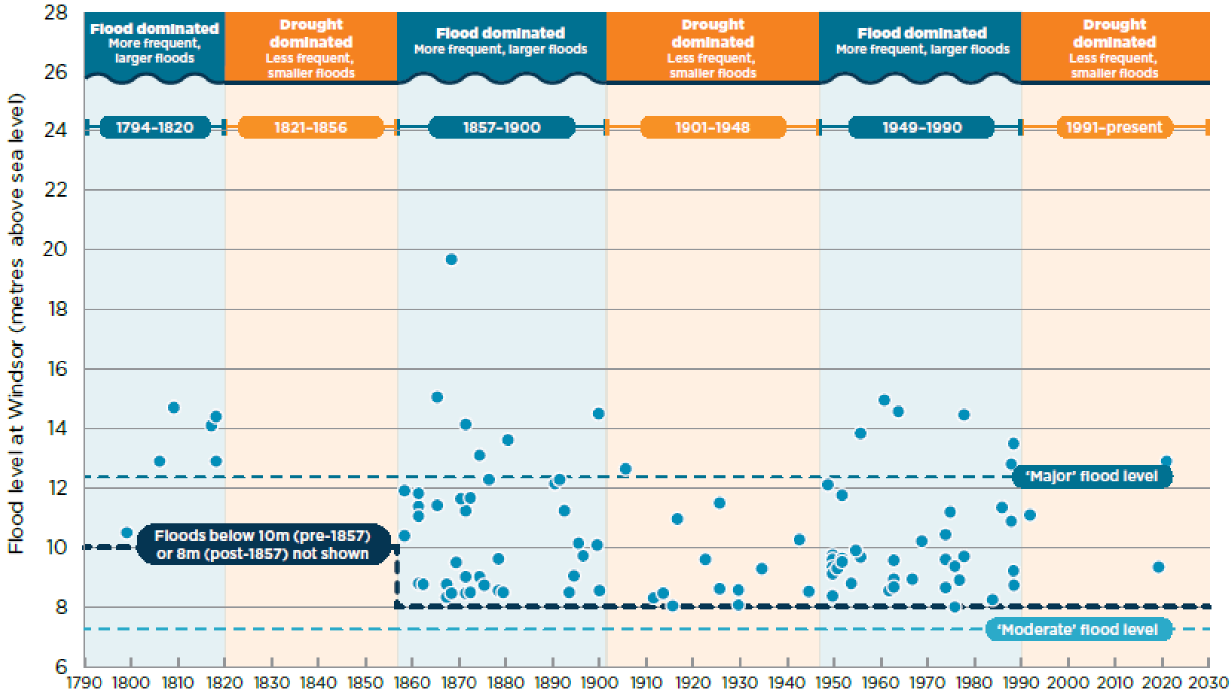

Plate 2: Flood levels recorded at Windsor on the Hawkesbury River over the period 1790 to present day (from SES 2021)

Since 2019, a number of major and prolonged flood events have impacted the area significantly, with the banks and flats surrounding the lagoon having remained periodically inundated for extended periods. Commencing in September 2020, a La Niña event caused widespread rainfall and led to periodic flooding along major river systems in Greater Sydney. During February and April 2022, widespread flooding of the Nepean and Hawkesbury floodplains was experienced. Heavy and prolonged rainfall fell during this period due to the combined effects of the La Niña cycle as well as a significant East Coast Low system that brought heavy rains. By 2 March 2022, widespread evacuations of communities living along the Hawkesbury River and surrounds was deemed necessary. By this time, Warragamba Dam was spilling at a rate of in excess of 70 gigalitres a day (Hannam 2022) and floodwaters continued to build up downstream along the connected Nepean and Hawkesbury River systems. The impacts of flooding events on catchment areas in the region have been accelerated by historical land use, most notably by cattle grazing and the use of pesticides, the formation of dams and irrigation to direct water use for agricultural production and grazing and extensive vegetation clearance.

Throughout the 20th and 21st centuries, the expansion of grazing, farming and quarrying activities in the local catchment area have contributed to a contamination of the catchment runoff and resulting algae blooms have threatened various aquatic plant and animal species at the lagoon. Nearby vegetation clearance has accelerated the frequency and intensity of sheet erosion during heavy periods of rainfall and this has adversely affected water quality at the lagoon. Natural drainage patterns in the immediate surrounds of the lagoon have been altered as a result of various interventions to contain stormwater and sewage flows as well as through historical cattle grazing activities, sand and gravel extraction and vegetation clearance (see Use and Disturbance below).

An artificial weir built in 1972 at the northern end of Longneck Lagoon contributes to the prolonged suspension of sediment within floodwaters at the lagoon and the trapping of these sediments from flowing into the Hawkesbury River further to the north (Dufty 1990). This intervention has been claimed to increase the level of turbidity within the waters at Longneck Lagoon, though this is also known to have been adversely influenced by runoff within the catchment as well as the wind-driven resuspension of dispersive sediments inhibiting plant growth (Jayawickrema, 2000:45).

4.4 Soil and geology

At a broad regional scale, the floodplains surrounding Longneck Lagoon comprise alluvial deposits of gravel, sand, silt and clay associated with the underlying Wianamatta Shale and Hawkesbury Sandstone geological units (Figure 4). In their ground water sampling study of Longneck Lagoon, Dames and Moore found that surface sediments at the lagoon contained sand and varying proportions of clay. Backwater flooding was found to be the cause for this accumulation of fine sediment on the surface, whereas course-textured sediments contained in runoff were found to be deposited on the floodplains where flow rates were slow (Jayawickrema 2000: 41). Underlying this layer was an unconsolidated Londonberry Clay with a texture comprising fine to coarse sand that is stiff to hard in consistency. Underlying this was Rickabys Creek Gravels comprising sand, gravel and cobbles within a fine matrix of silt and clay. Underlying this gravel was Bringelly Shale comprising siltstone and claystone and finally a deposit of sandstones and shales of the Hawkesbury Sandstone group.

According to the Australian soil classification system, the eight registered Aboriginal cultural heritage sites at Longneck Lagoon predominately comprise Kurosols- natric (KUn), with only WD 6 (AHIMS ID# 45-5-2738) and WD 7 (AHIMS ID# 45-5-2739) occurring within the Hydrosols (HY) soil unit. Kurosols- natric (KUn) are characterised by soils displaying strong texture contrasts between A- horizon and strongly acidic B-horizon soils. The natric suborder occurs where the upper B2-horizon has a higher proportional salt content. Broadly speaking, kurosols commonly have low water-holding capacity and thus can be more subject to surface wash during heavy inundations. Hydrosols, in contrast, tend to be seasonally or perennially inundated due to their proximity to waterways. Particles within hydrosols can become dispersed and surface wash and soil accumulation can result. Throughout the Subject Area, soils were found during the site inspection to be very fine and be fairly compact and these factors both have the potential to magnify the impact of flooding inundation as water is not able to adequately permeate into the soil.

The impact of flooding events on the soils present at Longneck Lagoon vary according to their proximity to the edge of the main body of water with soils present in the immediate vicinity considered to have slower rates of infiltration than those in the hinterland. According to the hydrologic groups of soils in NSW classification system, the land immediately adjoining the lagoon on which all eight Aboriginal heritage sites are located is considered to have very slow infiltration rates (Figure 4b). Land that falls within this classification generally has very slow rates of water transmission and high runoff potential (NSRCS 2007). Areas in which the water table occurs within 60 cm of the ground surface generally fall into this group. Further back from the lagoon, the land is considered to have slow infiltration rates with soils having slow rates of water transmission and moderately high runoff potential when thoroughly wet (Figure 4b and in NRCS 2007). The rate of water infiltration for soils present at Aboriginal cultural heritage sites can affect the level of impact to underlying soils and any deposits which may be present. In cases where the infiltration rates are slow and sheet wash is a higher risk, surface artefacts are most likely to be affected than sub-surface artefacts as the water does not extensively penetrate through the soils as much during inundation events. Nonetheless, the impact of the increased height of the ground water during temporary inundation events and the potential inundation of sites by rising groundwater levels can be significant in particular contents, in particular in disturbed contexts where water can penetrate more rapidly.

Broadly speaking, the upper slopes of the Longneck Lagoon catchment consist of Ashfield Shale of the Wianamatta Group and the lower slopes comprise Tertiary alluvials (LLFSC 1991). In the surrounding region of the Cumberland Plains, a range of stone raw material sources are known to occur. Red and yellow silcrete occurs abundantly in the local area and has been widely observed in excavations undertaken at Pitt Town and surrounds.

Radiometric dating completed on core samples collected at Longneck Lagoon have been used to establish an estimate of the rate of sedimentation that has occurred over the twentieth century (Jayawickrema 2000:84). The samples were obtained from three locations at the approximately centre of the lagoon's main body of water. The sedimentation rates showed an average increase of 2.1 cm per year, and was found to have increased following the installation of the weir.

A soil profile recorded within the north-western portion of the Subject Area provides a general stratigraphy for the surrounding landscape to Longneck Lagoon (OEH 1988) (Figure 4). The upper horizon of the profile comprised a dark brown coarse sandy loam (7.5 YR 3/3) extending for 30 cm. Underlying this was a 40 cm-deep unit of strong brown (7.5 YR 5/6) sandy clay. Both of these upper horizons had no evident cracks or macropores. The lower two horizons comprised a brownish yellow (10YR 6/6) medium clay (extending between 70 and 120 cm) and lastly, a light yellowish brown (10 YR 6/4) heavy clay (extending between 120 and 200 cm).

4.5 Flora and Fauna

Longneck Lagoon is an important wetland environment for a range of flora and fauna species. In the past, the area would have offered shelter and habitat for a range of species including eels, turtles, fish, birds, kangaroos and wallabies.

Macrofossil remains identified at Longneck Lagoon can provide some insight into the historic environment that existed at the lagoon (Jayawickrema 2000: 92-3). Four species were found to be the most prevalent, comprising a freshwater algae species (from the family Characeae), a free-floating aquatic plant (*Ceratophyllum demersum L.),* a rush grass (lax twig rush) and a species of saw sedge (Gahnia forst). Their relative prevalence within the core samples that were taken enabled Jayawickrema to formulate a profile of environmental change at the lagoon over time. In simple terms, there is an ecological phase (extending approximately 0-48cm) which represents a phase of comparatively stable water levels from approximately 1978 onwards. Phase 2 (occurring between 48 and 96 cm) represented a wetland phase with seasonal wet and dry periods and with greater water level fluctuations than in the present day (Jayawickrema 2000: 100-1).

4.6 Aboriginal use of the lagoon and surrounds

The plant communities evident within the floodplains of the Hawkesbury River at the time of contact were created through a combination of Aboriginal firing practices (Hope 1983) and the relatively stable climate (Young 1986) of the last few thousand years. Resource availability throughout the region has directly influenced the patterns of Aboriginal occupation and consequently, the spatial distribution of Aboriginal archaeological sites. In order to properly consider the potential use of the lagoon by Aboriginal communities it is important to understand both how Aboriginal people were using natural resources as well as how the distribution of these resources varied across and between landscapes.

Kohen (1986) presents an excellent summary of the vegetation communities in the area at the time of European contact. The Nepean and Hawkesbury Rivers and associated floodplains supported a tall open-forest dominated by the Forest red gum (*Eucalyptus tereticornis*). She-oaks (*Casuarina cunninghamiana*) is noted as occurring in direct contact with creek banks, while the common reed (*Phragmites australis*) was associated with the smaller streams (Kohen 1986:35). She-oaks were used for a range of purposes including to make shields, spear-throwers and the gum can be used as a sealant for canoes. More sheltered portions of the landscape supported stands of Blackbutt (*Eucalyptus pilularis*), often associated with edible climbing vines such as the wombat berry (*Eustrephus latifolius)*. Freshwater swamps in the area were dominated by the Tall Spike Rush (*Eleocharis sphacelata)* (Kohen 1986:35) which served multiple uses including as foliage for shelter construction and for medicine (the stems were broken up in water and let to rest in order to produce an antiseptic).

Early ethnographic evidence from the Sydney region suggested that there were two distinct economies in operation at the time of contact: that along the coast and that of the plains. The plains economy was dominated by small animals and the consumption of roots such as wild yam (Tench 1793:230). Berries, yam and fern roots, banksia flowers and honey were also described at the time (Collins 1802:462). William Dawes (1791), while undertaking a study of the Dharug language, identified that there were likely three classes of food consumed by the woodland groups: berries, honey-bearing flowers (Banksia, Grevillia etc) and roots. One of the words used for the final group was *djarug*, strongly suggesting that the Aboriginal people of the Cumberland Plains (Dharug) strongly relied on tuberous plants in their diet (Kohen 1986).

Plant resources were also utilised for tools, including spears and coolamons, as well as for medicine. Various tree species typically used to produce tools, weapons and coolamons occur locally. Based on this information, the landscape surrounding the lagoon would have contained numerous plant resources to support Aboriginal communities, both on the alluvial plain and closer towards the Hawkesbury River itself.

An accurate estimate of the faunal resources in the area at the time of contact is problematic, as many of them suffered heavy losses associated with initial clearing for farming. Larger macropods, including grey kangaroos and wallabies, were most likely common, as were emus (Tench 1793; Collins 1802; Best 1843). Echidnas and platypuses are known prey species to be found in the area, as well as marsupials including kangaroos, wallabies, wombats, koalas, possums, and bandicoots (Kohn 1986). Eels, freshwater mussels, and turtles are also known faunal resources that would have been available to people living in the area.

Large numbers of lithic resources are also found within the broader region, chief among them is a fine-grained silcrete which was widely abundant. Outcrops of the Hawkesbury Sandstone were used for grinding hatchet heads (Dickson 1981). Isolated quartz and conglomerate pebbles were also available from the sandstone, and could be used as raw materials for flaking. Deposits within the Hawkesbury River contain chert, quartz, quartzite and basalt, while gravels associated with Rickabys Creek and the St Marys Formation contain granite, porphyries, silcrete and shales.

A record of traditional Aboriginal place names for Longneck Lagoon and surrounding areas has the potential to reveal information related to the environments which once occurred there and the type of resources that particular areas were known for. The Real Secret River: Dyarubbin project explored a list of traditional place names along the Hawkesbury River and surrounds compiled by the Reverend John McGarvie in 1829 and contextualised these names with the assistance of Darug knowledge-holders (Karskens et. al. 2020). The project identified a traditional place name for the Lagoon, Kanogilba or Ganigulba, which refers to the area being used for collecting wood to make clubs (Karskens et. al. 2020). Their research suggested that several place names in the local area were connected with forests, trees and wooden implements. Another local placename is Murramatta or Mara-mada which refers to a place with tracks and may refer to the Pitt Town Common.

In Pitt Town to the north-west there is an area known as Mekoorabon or Mii-gurabang which likely refers to a bee hole in a bloodwood tree. Further north in a portion of present-day Cattai National Park there is an area close to the river, which was referred to as Booldoorra or Buulbura, referring to soft corkwood which is a tree species that no longer grows in the area but may have been prominent in the past. The species is known to have been used by Aboriginal people to poison fish as well as for medicinal purposes and for carving. Further north-east of the Activity Area in present-day Cattai a number of place names also suggest that the local area was rich with plant resources. Berambo or Birambu (meaning waddy or war club), Karrowerry or Garuwari (meaning native plum tree) and Boolo or Bula (meaning coachwood) are all names associated with the nearby Cattai Creek. These place names emphasise the importance of various plant species in the region.

4.7 Use and Disturbance

The contemporary history of Longneck Lagoon can be traced back to government policies in the early 19th century to provide common grazing land to landholders settling the Hawkesbury region. In 1804, the NSW colonial government established three commons around the Hawkesbury region. Amongst them, an area of 2,285 hectares was set aside as the Nelson Common (later referred to as Pitt Town Common) to be used as a public common for stock grazing. Longneck Lagoon occurs within this Common. Unlike other adjoining areas that were set aside as private grants, the lagoon and adjoining area were considered slightly less fertile and were therefore deemed suitable for stock grazing by registered local landowners (Ridgeway 2022: 19). Each landowner paid a small licence fee for use of the land and was entitled to graze cattle and collect timber within the Common. The extent of vegetation clearance that occurred during this phase of the lagoon's history is not clear, however it is highly likely that Aboriginal cultural heritage sites were disturbed during this time and in proceeding periods as a result of the clearing of tracks and grazing land through the common.

Sand and gravel quarries were established in the Hawkesbury Region in the ninetieth and twentieth centuries to supply building materials for the expanding settlement. By the end of the nineteenth century, extraction had commenced at Windsor, Richmond, Wiseman's Ferry and at Upper Castlereagh as well as at various smaller quarries (Howard Tanner and Associates Pty Ltd 1984:116). A large sandstone quarry was in operation from the mid-19th century and continued operating until the 1930s at the end of Phipps Road, Cattai Road and the Longneck Lagoon Field Studies Centre. In broad terms, the extraction method used at the time involved excavating sand and gravel below the level of the main alluvial flats and the conveyance of this material to washing stations where sand and clay would be flushed out (Howard Tanner and Associates Pty Ltd 1984:117). The impact of this activity on the surrounding environment was likely significant due to the length of time that the quarry remained in operation.

On 4 August 1894, the Lands Department reserved two large areas adjoining Longneck Lagoon for the provision of sand and gravel. One parcel was situated to the south of the lagoon and the other to the west. Reserve 21,140 encompassed an area of 170 acres south of the Pitt Town Dural Road and north of Gravel Pits Road and contained by the Llewellyn Creek on the west and Longneck Creek on the east (Plate 3). One previously identified Aboriginal cultural heritage site is situated within this area of disturbance (AHIMS ID# 45-4-0650). Reserve 21,411 encompassed an area of 120 acres to the west of the lagoon (Plate 4). Two previously recorded Aboriginal cultural heritage sites are situated within this area of disturbance (AHIMS ID# 45-5-3708 and 45-5-2738) (Figure 3).

Plate 3: Close- up of Reserve 21140 situated south of Longneck Lagoon as depicted in the 1894 Parish map of Pitt Town, County of Cumberland accessed online 6 June 2022 https://hlrv.nswlrs.com.au/

Plate 4: Close- up of Reserve 21141 situated east of Longneck Lagoon as depicted in the 1894 Parish map of Pitt Town, County of Cumberland accessed online 6 June 2022 https://hlrv.nswlrs.com.au/

Beyond these impacts, Illegal turf cutting was also identified as an issue in the first half of the twentieth century at Longneck Lagoon. A report from November 1934 of a case of two individuals who came in the night to illegally cut and remove 500 blocks of turf at the lagoon provide some historical context to this disturbance (Windsor and Richmond Gazette, 2 November 1934, page 5). In earlier times, individuals could apply for a permit from the Local Lands Office to harvest the turf however the newspaper account in 1934 confirms that the Local Lands Office were no longer issuing permits. According to a police constable asked to provide testimony regarding the criminal act, the illegal extraction was a widespread problem in the area (ibid.). Later that month, Alderman Mitchell of the Windsor Council reported that a camp had recently been established at the lagoon by a group of five men who were digging turf illegally and "ruining the property" (Windsor and Richmond Gazette, 24 November 1933, page 1). The precise location of the turf gathering cannot be established due to the extent of disturbance to the natural environment in subsequent decades and the lack of direct evidence.

Over the course of the twentieth century, Longneck Lagoon experienced varying levels of inundation as shown in Plate 5 to Plate 18. These changes can be attributed both to natural causes as well as some interventions which altered aspects of the local topography and altered natural water flows. As mentioned previously, the impact of quarrying, grazing and the harvesting of turf and timber have all impacted the environment surrounding the lagoon. In some ways, these have altered the extent of inundation and the ability of the soils to contain heavy rainfall and manage surface wash. As previously stated, the soils present also have very slow infiltration rates and are prone to surface wash. To reduce local flooding, the local council installed a number of culverts and bridges that have altered the natural course of the creeks.

In the 1980s, a regional program to improve flood evacuation routes resulted in the raising of Cattai Road by 1.2 m along the outflow of the Longneck Lagoon wetland to the north. The natural outlet to the north of the lagoon was thus blocked and a culvert constructed to carry water from the southwestern edge of the lagoon. During peak flooding events, this alteration to the natural water flows northwards out of the lagoon has resulted in greater accumulations of floodwaters and the broader inundations of the lagoon banks and flats (compare the extent of the lagoon in Plate 9 to Plate 10 for further context).

In 1971, Longneck Lagoon and the adjacent woodlands were declared a wildlife refuge. Later in 1987, the area was set aside as a Crown Reserve for the study and conservation of native flora and fauna (National Parks and Wildlife Service 2000). Under the *Fauna Protection Act (NSW)* 1971, the lagoon was protected as a wildlife refuge and became the first official conservation reserve on the Cumberland Plain (Ridgeway 2022: 23). Commercial grazing leases over the lagoon were soon ended and the management of the site handed over to a Crown Trust. Between 1974 and 1977, the land around the lagoon was enclosed and fences which were erected to keep out free-roaming cattle from neighbouring properties. At this time, the woodlands around the lagoon were considered to have been impacted by overgrazing and vegetation clearance (Ridgeway 2022:23). In 1983 the Crown Trust implemented an order to ban all net fishing at the lagoon. In the same year, bushland around the lagoon was protected under an Interim Conservation Order under the Heritage Act. In the contemporary period the lagoon is still used as a public recreation and nature reserve and is open to the public.

Plate 5: Longneck Lagoon in 1955 Source: DPIE

Plate 6: Longneck Lagoon in 1961 Source: DPIE

Plate 7: Longneck Lagoon in 1965. Source: DPIE

Plate 8: Longneck Lagoon in 1966 Source: DPIE

Plate 9: Longneck Lagoon in 1970 Source: DPIE

Plate 10: Longneck Lagoon in 1975 Source: DPIE

Plate 11: Longneck Lagoon in 1978 Source: DPIE

Plate 12: Longneck Lagoon in 1984 Source: DPIE

Plate 13: Longneck Lagoon in 1986 Source: DPIE

Plate 14: Longneck Lagoon in 1991 Source: DPIE

Plate 15: Longneck Lagoon in 1994 Source: DPIE

Plate 16: Longneck Lagoon in 1998 Source: DPIE

Plate 17: Longneck Lagoon in 2002 Source: DPIE

Plate 18: Longneck Lagoon in 2004 Source: DPIE

5 Site inspection results

5.1 Site inspection overview

On 15 June 2022 an archaeological site inspection was undertaken by Carly Todhunter (Heritage Consultant, Niche) to determine the impact of significant flooding events that occurred of April 2022 on eight registered sites in proximity to Longneck Lagoon.

5.2 Assessment of impacts

The site inspection indicated that though extensive inundation was observed in proximity to the Longneck Lagoon and surrounding creeks, low levels of soil redeposition was observed. Broadly speaking, the sites and their surrounding areas were found to be damp at the time of the site inspection and several indicators of backwater flooding and catchment runoff were observed including leaf litter and branches being caught in tree branches (and upslope of horizontally sitting branches and tree trunks), moss growth on exposed soil and temporary dieback of some grasses likely associated with extended periods of inundation. The majority of sites occur on existing tracks, and these were found to have suffered some minor sheet and rill erosion (in particular where the sand and silt content was higher) though the low permeability of the soils have limited their transmission. The accumulation of exposed soil and gravels in areas situated lower topographically in the landscape was observed only in limited contexts and it is clear that erosion resulting from major flooding events have had a protracted history at the lagoon.

Rill erosion was observed in confined areas during the site inspection and has resulted in sub-surface gravels being exposed and potentially transported from their original depositional context. Accumulations of soil in low-lying areas below gully or creek banks was also observed, however this dynamic was found to be confined to specific areas rather than being a broad pattern affecting the eight sites and may be more of an outcome of catchment runoff. All eight Aboriginal cultural heritage sites displayed some evidence of erosion associated with flooding.

The three sites which were found to be most heavily impacted by the inundation in terms of their stratigraphic integrity were WD 7 (AHIMS ID# 45-5-2739), LN 18 (AHIMS ID# 45-5-0656) and LN 15 (AHIMS ID# 45-5-0653). At the time of the survey, LN 18 (AHIMS ID# 45-5-0656) was found to be heavily saturated with an area extending approximately 300 m^2 across the marshland still covered by water (Plate 46 to Plate 50). Artefacts previously recorded at this site could not be groundtruthed due to the inundation.

WD 7 (AHIMS ID# 45-5-2739) is situated on the eastern bank of the Longneck Lagoon and was found to have been heavily inundated with evidence of sheet erosion apparent in the exposure of underlying shale gravels and the deposition of a sediment fan at the base of the slope. Some cracking was present on the ground surface due to receding groundwater levels (Plate 62 and Plate 63). It was not possible to determine whether this cracking has resulted from the most recent flooding events, but it is most likely to have been formed over several flooding events. The banks of the lagoon were also found to be eroded along the lagoon's edge (Plate 64 and Plate 65).

LN 15 (AHIMS ID# 45-5-0653) displayed compelling evidence for the deposit being impacted by previous inundation events, however it was unclear over what timespan and to what intensity this erosion has occurred. The occurrence of artefacts within defined areas of disturbance that likely act as drainage lines during heavy inundations suggests that these artefacts have likely either been exposed from, or transported to their present location by sheet and rill erosion (Plate 32, Plate 33 and Plate 36). Clear indicators for intermixed upper soil horizons associated with heavy saturations and the accumulation of soils on the edges of disturbed areas subject to sheet or rill erosion was observed.

For a more detailed discussion of the impacts observed during the site inspection see Table 7.

Table 7: Summary of sites forming part of the site inspection at Longneck Lagoon

AHIMS Site ID	Groundtruthed	Evidence of inundation observed
45-5-0650	No- Due to vegetation cover and leaf litter which reduced ground surface visibility (GSV) to 0-10% across most of the site.	Leaf litter and branches were strewn across the site and surrounding area due to backwater flooding and catchment runoff (Plate 19 and Plate 22). The area surrounding the creek was still very wet at the time of the site inspection and recent algae growth has appeared across exposed surfaces (Plate 25 and Plate 30). Sheet and rill erosion were observed in locations close to the creek (Plate 26, Plate 27, Plate 28 and Plate 29). This contributed to some isolated areas of bank collapse (Plate 27 and Plate 30). Further back from the creek's edge, rill and sheet erosion were observed in isolated areas (Plate 22, Plate 23, Plate 24 and Plate 25), though the majority of the surrounding landscape had no observable signs on the ground surface. Soil redeposition associated with rill and sheet erosion appears to have been constrained by the thick vegetation cover and leaf litter which have helped to slow the passage of water and improve water retention (Plate 20 and Plate 21). The surrounding soil is moderately compacted suggesting intermittent flooding and heavy saturations associated with catchment runoff have occurred over extended time periods. The western banks of the creek were found to be eroded in some areas (Plate 27 and Plate 30), however this was fairly limited and suggests that the water velocity associated with backwater flooding in the area was slow.
45-5-0653	Yes- fewer artefacts observed on track compared to the 1988 recording. 16 artefacts observed compared to 35 artefacts previously recorded.	Only limited signs of erosion associated with recent flooding events were observed at the site though impacts occurring over extended periods due to temporary flooding events were apparent (Plate 31, Plate 32, Plate 34 and Plate 36). The site predominately occurs on an access track, however nearby to the recorded location a group of three mudstone artefacts occurring in a disturbed context closer to Llewellyn Creek (Plate 36, Plate 37 and Plate 38) were identified as being an exposed deposit belonging to the same artefact scatter. Further surface and sub-surface artefacts are highly likely to occur within and between these two areas however are obscured by leaf litter (Plate 35 and Plate 38). As the access track contains large proportions of sand, the floodwaters have likely contributed to the further exposure and possible concealment of surface artefacts as sediment sheds off the hardened path. Minor surface evidence of sheet and rill erosion resulting in the redeposition of soil adjoining the tracks was observed and may be responsible for the observed spatial distribution of the artefacts in the western portion of the site adjoining the track (Figure 6, Plate 32 and Plate 33). Moss growth was present throughout (Plate 34, Plate 36, Plate 37 and Plate 38)

AHIMS Site ID	Groundtruthed	Evidence of inundation observed
		suggesting waterlogging in this area and the ground was still quite wet overall. No obvious sorting of stone pebbles was observed on the surface of the track, however given the abundance of exposed shale pebbles it is clear that sheet erosion has occurred (Plate 34).
45-5-0654	No- the site could not be relocated due to vegetation and leaf litter reducing GSV to 5%. An area of 100 x 80 m around the recorded location was inspected. Site was recorded as containing more than 600 artefacts previously and may still be intact under the leaf litter.	Thick vegetation and leaf litter was observed across the ground surface (Plate 39, Plate 40 and Plate 41) and the ground was wet at the time of the site inspection. Thick moss growth was observed across some large exposures and the soil was found to have been moderately compacted. It is likely that the thick moss growth and leaf litter is obscuring some of the previously recorded artefacts, however this could not be confirmed without impacting the site. Due to the extent of thick vegetation and leaf litter, the potential extent of sheet erosion could not be determined however only very limited redeposited soil accumulations could be observed on the ground surface.
45-5-0655	Yes- fewer artefacts observed on track compared to the 1988 site recording. 8 artefacts were identified during the site inspection compared to the 46 that were originally recorded.	The area was found to have been saturated with surrounding soils still very wet at the time of the site inspection (Plate 42). Limited evidence of sheet and rill erosion was observed on the surface of the track (Plate 42, Plate 43, Plate 44 and Plate 45) and large numbers of previously recorded artefacts present on the track could not be relocated. Recent bike tyre and shoe tracks along track suggesting that some disturbance related to the public's use of the tracks following flooding have occurred (Plate 43). A narrow depression running lengthways along the track was also observed as evidence of rill erosion within the site's extent (Plate 43 and Plate 45). Though redeposited soils were limited along the length of the track, some isolated areas of redeposition were observed (Plate 44).
45-5-0656	Yes- however no artefacts were observed due to extensive inundation in the area. The artefacts are likely under the standing water and are in a highly-disturbed context.	This was the most heavily impacted site during the survey (Plate 46, Plate 47, Plate 51 and Plate 52). Floodwaters saturated this entire marshland area due to its low-lying location and propensity to hold water. A large area within the site was completely covered with water at the time of the survey (Plate 46). Surrounding soils were heavily waterlogged and soil appears to have been redeposited or intermixed in some areas (Plate 44, Plate 50 and Plate 57). Nonetheless, large areas of the site were not affected by soil redeposition (Plate 49 and Plate 56). A drainage line extending in a north-easterly direction has experienced some rill erosion (Plate 53, Plate 54 and Plate 55). The soil is a dark black humic topsoil with thick leaf litter inclusions. In some areas due to the extent of saturation it is likely that soil intermixing has occurred (Plate 50 and Plate 57).

AHIMS Site ID	Groundtruthed	Evidence of inundation observed
45-5-2738	No- Artefacts were not present on ground surface of track as described. Adjoining area is heavily vegetated, and visibility was 0% in areas beyond the track.	No eroded or redeposited soil were observed on the ground surface related to recent flooding however there has been some gravel accumulation on the western side of the track (situated downslope) (Plate 58 and Plate 59). Sheet erosion can be expected to have occurred in this area due to the slope of the track and the slow absorption rates of the soils present. Moss growth covering exposed areas of the track was also observed and may be responsible for the obscuring of previously identified surface artefacts. Introduced fill material including brick fragments was observed along the length of the track. Floodwaters have nonetheless flooded the area and are identifiable by the presence of leaf litter caught in branches several metres high. Some standing pools of water were present in the surrounding area (in depressions upslope from the access track and within the surrounding vegetation). Long grass present adjoining the track also appears to have been affected by the prolonged inundation (Plate 58).
45-5-2739	Yes- 9 surface artefacts were identified however this number cannot be compared to the original site recording as the number of artefacts originally identified in 2002 was not recorded in the site card.	Feedback from a NPWS employee on site confirmed that floodwaters rose 6 m in this area and therefore the entire site was inundated. The soil was found to be moderately compacted, and several cracks were visible on the surface (Plate 62 and Plate 63) due to receding floodwaters. None of these disturbed areas displayed discernible soil horizons and it is likely that the deposit has been disturbed over extended periods of time by intermittent flooding events and inundations. Evidence of sheet erosion along the track was present across the exposed area (Plate 60, Plate 61, Plate 62, Plate 63 and Plate 64), most notably in the formation of a sediment fan with sediment transported along the drainage line leading north-west into the lagoon (and cutting through the site). The banks of the lagoon to the north-west of the site were found to be eroded (Plate 64 and Plate 65).
45-5-3708	Yes, however the site has already been subject to community collection of all surface artefacts in the past. No previously unrecorded artefacts were identified during the current site inspection (following a 20-minute walkover of the site and surrounds).	Site occurs on a track in proximity to the Longneck Lagoon Education Centre. Floodwaters were reported by workers from NPWS as having inundated the low-lying areas at the southern boundary of the site. Limited evidence of sheet and rill erosion were observed along the surface and edges of the access track (Plate 66, Plate 67 and Plate 68) and gravel resorting was observed adjacent to the track (Plate 67 and Plate 68), likely associated with catchment runoff. Very limited areas of redeposited soils adjacent to the track were observed (Plate 69 and Plate 70) and the track was observed to have been recently cleared of leaf litter.

Table 8: Summary of impacts observed at the eight Aboriginal cultural heritage sites during the site inspection at Longneck Lagoon on 15 June 2022

AHIMS Site ID	Context	Soil landscape	Evidence of sheet erosion	Evidence of gully erosion	Evidence of rill erosion	Evidence of bank erosion	Evidence of soil compaction	Evidence of surface runoff and soil accumulation at edges of exposed areas	Soil intermixing observed on exposed areas of the ground surface	Soil cracking observed within exposed areas of the ground surface
45-5-0650	Creek bank and creek flats	Lucas Heights – Residual. Associated with minor gully and sheet erosion along exposed ground.	Yes, in isolated areas.	No	Yes, in isolated areas	Yes, in isolated areas	Moderate	Generally no, however some isolated areas of surface runoff were observed	Generally no, however some isolated areas of soil intermixing were observed	No
45-5-0653	Creek bank and creek flats	Berkshire Park- Alluvial. Gully, sheet and rill erosion possible. Soils are prone to localised seasonal waterlogging and flooding.	Yes, in isolated areas.	No	Yes, in isolated areas	Yes, only in eastern portion	Moderate	Yes, in isolated areas	Yes, in isolated areas	Yes, though minor
45-5-0654	Creek flats	Berkshire Park- Alluvial. Gully, sheet and rill erosion possible. Soils are prone to localised seasonal waterlogging and flooding.	Yes, in isolated areas	No	No	No	Moderate	Yes, in limited areas	No	No
45-5-0655	Lagoon margin flats	Berkshire Park- Alluvial. Gully, sheet and rill erosion possible. Soils are prone to localised	Yes, in isolated areas.	No	Yes	No	Low	Generally no, however there were some isolated areas	Yes, however it was limited	Yes, some minor cracking was observed

AHIMS Site ID	Context	Soil landscape	Evidence of sheet erosion	Evidence of gully erosion	Evidence of rill erosion	Evidence of bank erosion	Evidence of soil compaction	Evidence of surface runoff and soil accumulation at edges of exposed areas	Soil intermixing observed on exposed areas of the ground surface	Soil cracking observed within exposed areas of the ground surface
		seasonal waterlogging and flooding.						of soil redeposition		
45-5-0656	Lagoon bank	Berkshire Park- Alluvial (western side). Gully, sheet and rill erosion possible. Soils are prone to localised seasonal waterlogging and flooding. Bakers Lagoon- Swamp (eastern side). Flood hazard, waterlogging and permanently high water tables can occur. The erosion hazard for concentrated flooding is moderate. Topsoils comprise sand, silt and organic matter and are moderately dispersible. Subsoils contain lower organic matter and are highly erodible. Large dish-shaped swampy depressions can become permanently or	Generally the ground appeared to have been heavily saturated, though evidence of sheet erosion was limited	No	Yes, along some isolated drainage lines	No	Low	Generally no, however there were some isolated areas of soil redeposition	Yes	No

AHIMS Site ID	Context	Soil landscape	Evidence of sheet erosion	Evidence of gully erosion	Evidence of rill erosion	Evidence of bank erosion	Evidence of soil compaction	Evidence of surface runoff and soil accumulation at edges of exposed areas	Soil intermixing observed on exposed areas of the ground surface	Soil cracking observed within exposed areas of the ground surface
		periodically waterlogged.								
45-5-2738	Hill slope directly above the lagoon	Bakers Lagoon- Swamp (eastern side). Flood hazard, waterlogging and permanently high water tables can occur. The erosion hazard for concentrated flooding is moderate. Topsoils comprise sand, silt and organic matter and are moderately dispersible. Subsoils contain lower organic matter and are highly erodible. Large dish-shaped swampy depressions can become permanently or periodically waterlogged.	Yes	No	No	No	Moderate	No, however some gravel sorting was observed on the western side of the track (situated lower topographically)	Yes, but very limited given the extent of gravel present	No
45-5-2739	Hill slope and flats directly above the lagoon	Bakers Lagoon- Swamp (eastern side). Flood hazard, waterlogging and permanently high-water tables can occur. The erosion hazard for	Yes, and this has likely contributed to the obscuring of artefacts previously	No	Yes, in very isolated areas	Yes	Moderate	Yes, a sediment fan has been deposited over the site with sediment	Yes, though limited by the slow penetration rates of the soils present	Yes, some are hairline cracks and others are slightly wider.

AHIMS Site ID	Context	Soil landscape	Evidence of sheet erosion	Evidence of gully erosion	Evidence of rill erosion	Evidence of bank erosion	Evidence of soil compaction	Evidence of surface runoff and soil accumulation at edges of exposed areas	Soil intermixing observed on exposed areas of the ground surface	Soil cracking observed within exposed areas of the ground surface
		concentrated flooding is moderate. Topsoils comprise sand, silt and organic matter and are moderately dispersible. Subsoils contain lower organic matter and are highly erodible. Large dish-shaped swampy depressions can become permanently or periodically waterlogged.	recorded at the location					transported from upslope.		
45-5-3708	Undulating plain	Lucas Heights- Residual. Minor gully and sheet erosion can occur in disturbed areas. The erosion hazard for non-concentrated flows is generally moderate but can range from slight to extreme. The erosion hazard for concentrated flows is high.	Yes, however is contained by the presence of gravel on the ground surface	No	Yes, along the edges of the access track	No	Moderate	Yes, in isolated areas though the majority of the site was unaffected	Yes, though limited by the slow penetration rates of the soils present	Yes, though very limited

6 Photographic record

6.1 LN 12 (AHIMS ID# 45-5-0650)

Redacted from public version

Plate 19: Inundated creek banks on the western side of Llewellyn Creek in proximity to LN 12 (AHIMS ID# 45-5-0650). Ground surface visibility was poor along the creek banks due to vegetation cover and leaf litter (GSV- 10%). Catchment runoff and backwater flooding has resulted in limited erosion throughout the surrounding landscape with the soils present over 20m from the creek's edge still very wet at the time of the site inspection.

Plate 20: Photographed approximately 35m back from the creek's edge, this area to the south of LN 12 (AHIMS ID# 45-5-0650) had dried significantly by the time of the site inspection. Evidence of sheet or rill erosion could not be observed on the ground surface in this area.

Plate 21: Well vegetated areas further back from the creek's edge appear less flood affected. Very few exposures with eroded soils were observed in proximity to LN 12 (AHIMS ID# 45-5-0650).

Plate 22: In the vicinity of fallen timber laying horizontally on the ground surface, redeposited soils accumulating in a trunk cavity and surrounds was observed. Given the orientation of the trunk cavity (facing the sloped area to the west) and the distance back from the creek's edge (approximately 100 m) it is more likely that this erosion is associated with catchment runoff rather than backwater flooding.

Plate 23: Evidence of erosion associated with catchment runoff was observed in the vicinity of LN 12 (AHIMS ID# 45-5-0650) including redeposited and intermixed soils on the ground surface. This soil has covered leaf litter present in the surrounding area.

Plate 24: Close-up of redeposited soils in the vicinity of LN 12 (AHIMS ID# 45-5-0650). Algae had begun to develop on the water-logged soils. Some isolated areas with little to no vegetation cover have been affected, in particular along pronounced rills or along steeper creek banks.

Plate 25: Minor rill erosion present in the vicinity of LN 12 (AHIMS ID# 45-5-0650) showing the effects of local catchment runoff resulting in the exposure of sub-surface gravels. Waterlogged soils in adjacent areas have also started to experience algae growth.

Plate 26: Vegetation present across the creek banks and flats in the vicinity of LN 12 (AHIMS ID# 45-5-0650) have likely reduced the impact of rising floodwaters by helping to decelerate the force of backwater flooding. In general, it may expected that backwater flooding in this area would only have a low water velocity.

Plate 27: Eroded location on the upper bank on the western side of the creek at LN 12 (AHIMS ID# 45-5-0650) showing the effects of slumping and subsequent undermining of exposed creek banks in isolated areas within 20 m of the creekline. Temporary backwater flooding have likely saturated the surrounding area, acting to reduce the soil cohesive strength and undermine the bank’s structure. Minor volumes of redeposited soils can be observed below this erosion.

Plate 28: Rill erosion present in the vicinity of LN 12 (AHIMS ID# 45-5-0650) in an area of mid-slope on the western side of the creek line.

Plate 29: Vegetated areas along the western bank of the creek line at LN 12 (AHIMS ID# 45-5-0650) have helped to reduce the impact of rising floodwaters on the stratigraphic integrity of adjacent creek banks.

Plate 30: Minor bank erosion observed on the western banks of creek line at LN 12 (AHIMS ID# 45-5-0650).

6.2 LN 15 (AHIMS ID# 45-5-0653)

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Plate 31: Western exposure of artefacts at LN 15 (AHIMS ID# 45-5-0653) along existing track. The location of surface artefacts has been identified with pink flags. The artefacts have potentially been impacted by sheet and rill erosion across the exposed track, with artefacts redeposited further downslope. As this occurrence has not been previously mapped out in detail, it is not possible to compare the distribution and spatial occurrence of specific artefacts to their pre-flooding arrangement. The presence of exposures associated with the walking track and previous grazing in the area as well as the high sand and silt content present in the surrounding soils has likely accelerated the rate of erosion observed.

Plate 32: The spatial distribution of surface artefacts within the western portion of LN 15 (AHIMS ID# 45-5-0653) along a defined path within a clearing of vegetation and slight slope change provide evidence of rill erosion along a natural drainage line cutting across the walking track. On the surface, some redeposited soils have accumulated on the western side of the track (left of the track in the picture) in the vicinity of the identified artefacts. Other artefacts previously identified at the location have likely been covered by the redeposition. Nonetheless, it should be noted that this portion of the site occurs within an area of previous disturbance related to vegetation clearance, track construction/ use and grazing activities and is generally exposed to catchment runoff.

Plate 33: Close-up of redeposited soils associated with rill and sheet erosion within the western portion of LN 15 (AHIMS ID# 45-5-0653). There is a slight slope leading from the western side towards the track.

Plate 34: Ground surface within western portion of LN 15 (AHIMS ID# 45-5-0653) showing the occurrence of sheet and rill erosion in the local area. The high sand and silt content present has increased the erodibility of the deposit, with surface gravels being highly exposed in this area. The artefacts were identified sitting above this deposit and have potentially either been exposed at or transported to this location. Previous moss growth at this location has been inundated by the redeposited soils.

Plate 35: Ground surface visibility was 0% away from exposures in the western extent of LN 15 due to the presence of thick vegetation cover and leaf litter. It is likely that further surface and sub-surface artefacts are situated within and between the western and eastern portions of this site.

Plate 36: Three previously unrecorded mudstone artefacts were identified during the site inspection sitting loosely on the ground surface in proximity to the recorded location for LN 15 (AHIMS ID# 45-5-0653). These three artefacts were therefore treated as occurring within the eastern extent of a broader site extent for LN 15 (AHIMS ID# 45-5-0653). The three artefacts are situated only a few metres above the creek level and this has resulted in some localised evidence of inundation and erosion. Due to their exposed context (within 15m of the creek line), they are unlikely to occur in-situ. No eroded soils were found to have built up in the immediate surroundings, nor was any sorting of gravels observed. The ground surface of the soil displayed evidence of intermixing and small cracks and moss growth were observed.

Plate 37: An isolated area of sheet erosion observed east of LN 15 (AHIMS ID# 45-5-0653). Small cracks in the ground surface were observed during the site inspection, likely associated with the fall in the groundwater level after heavy inundation events.

Plate 38: Thick vegetation and leaf litter cover at eastern boundary of LN 15 (AHIMS ID# 45-5-0653) reduced the ground surface visibility to approximately 0%. Further surface and sub-surface artefacts may occur at the site.

6.3 LN 16 (AHIMS ID# 45-5-0654)

Plate 39: The impact of flooding at the recorded location of LN 16 (AHIMS ID# 45-5-0654) has been relatively limited, though no artefacts could be identified during the present site inspection. The site is situated on an old vehicle track. The soil present is a brown sandy loamy silt and was compact and wet at the time of the site inspection. Thick moss growth potentially predating the most recent floods covers large parts of the surrounding area suggesting that soils present are frequently waterlogged. Ground surface visibility was 5%.

Plate 40: Ground surface visibility at LN 16 (AHIMS ID# 45-5-0654) was generally 5% due to extensive leaf litter and vegetation cover.

Plate 41: Thick moss growth observed across some large areas of exposed dirt in proximity to the recorded location for LN 16 (AHIMS ID# 45-5-0654). This moss growth has potentially obscured the identification of artefacts previously recorded on the ground surface.

6.4 LN 17 (AHIMS ID# 45-5-0655)

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Plate 42: Artefact scatter identified on track surface at LN 17 (AHIMS ID# 45-5-0655). Eight (8) artefacts were identified during the present site inspection (marked with pink flags). The artefacts were situated along the track from approximately 40 m to 75 m back from the lagoon's edge. The soils present at the site were found to be very wet during the survey, however evidence of sheet and rill erosion was limited. The soil present is a brown silty clay and some intermixing in the upper horizon was observed (likely extending only to a shallow depth).

Plate 43: Minor sheet and rill erosion observed along the access track at LN 17 (AHIMS ID# 45-5-0655) with some intermixing observed. A few footprints and bike tracks were observed during the site inspection and have formed whilst the track was wet. No surface runoff of soils was observed at the boundary of the access track in this area.

Plate 44: Redeposited soil along access track at LN 17 (AHIMS ID# 45-5-0655) showing the extent of intermixing and some limited cracking. Overall, the level of erosion observed was not extensive.

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Plate 45: A narrow depression running lengthways along the access track at LN 17 (AHIMS ID# 45-5-0655) was observed as evidence of rill erosion within the site's extent. No accumulation of dirt on the edges of this depression were observed.

6.5 LN 18 (AHIMS ID# 45-5-0656)

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Plate 46: Extent of inundation (red polygon) at LN 18 (AHIMS ID# 45-5-0656). This broad, low-lying terrain was covered by a large body of water at the time of the survey and surrounding areas were heavily inundated. This standing water had not receded due to saturated soils resulting from the heavy rain events of April 2022. Artefacts previously identified at the site could not be relocated.

Plate 47: Saturated soils at LN 18 (AHIMS ID# 45-5-0656) showing the temporary impact on vegetation following prolonged submersion. Very few debris from fallen trees have been transported into this area despite the large inundations, suggesting the inundation event has been more gradual.

Plate 48: Thinly vegetated areas covered by fallen pine needles and grass in areas adjacent to the standing water at LN 18 (AHIMS ID# 45-5-0656) appear to have fared better. These grass-covered areas were heavily saturated at the time of the survey and were wet underfoot. No channelling or bank scouring was observed in the surrounding area.

Plate 49: Inundated soils at LN 18 (AHIMS ID# 45-5-0656) showing the impact of rising groundwater in this flood-prone area. At the time of the survey and in spite of broad-scale saturation, redeposited soils associated with rill or sheet erosion could be observed on the ground surface at this location.

Plate 50: Saturated soils at LN 18 (AHIMS ID# 45-5-0656) showing the prolonged impact of floodwaters in low-lying areas in proximity to the lagoon. The stratigraphic integrity of this area has been impacted by the prolonged presence of standing water, with upper soil horizons likely experiencing some intermixing.

Plate 51: Saturated soils at LN 18 (AHIMS ID# 45-5-0656) showing the prolonged impact of the heavy rainfall event in low-lying areas in proximity to the lagoon.

Plate 52: Saturated soils at LN 18 (AHIMS ID# 45-5-0656) showing the prolonged impact of the heavy rainfall event in low-lying areas in proximity to the lagoon.

Plate 53: Saturated soils at LN 18 (AHIMS ID# 45-5-0656) showing the prolonged impact of heavy rainfall in low-lying areas in proximity to the lagoon. A narrow channel has formed along a shallow drainage line.

Plate 54: Saturated soils at LN 18 (AHIMS ID# 45-5-0656) showing the prolonged impact of heavy rainfall in low-lying areas in proximity to the lagoon. A narrow channel formed along a drainage line stemming out from the area of saturation has likely experienced rill erosion. Soil appears to have been deposited along the left bank though the extent of this rill erosion and redeposition could not be readily ascertained.

Plate 55: Saturated soils at LN 18 (AHIMS ID# 45-5-0656) showing the prolonged impact of heavy rainfall in low-lying areas in proximity to the lagoon. Rill erosion is present in this sensitive area (situated further north-east along the same channel as Plate 54.

Plate 56: Upstream of this channel the surrounding area has been heavily saturated. No accumulation of soil that has been transported by the floodwaters was observed at the base of the large tree suggesting low velocity flows through this area. Limited sheet and gully erosion were observed at this location.

Plate 57: As the groundwaters have receded they have left a mark on the soils present on the ground surface of the surrounding area to LN 18 (AHIMS ID# 45-5-0656). The upper soil horizon appears to have been intermixed.

6.6 WD 6 (AHIMS ID# 45-5-2738)

Plate 58: Moss growth on track at WD 6 (AHIMS ID# 45-5-2738) and grass dieback in adjoining areas. Surface gravels have accumulated on the western side of the track (situated lower on the slope). Some isolated, low-lying areas within the vegetated area adjoining the access track were covered by standing water at the time of the survey. Sheet erosion in a southerly and westerly direction across the exposed track may be expected in this area. The small scatter of red silcrete artefacts which have been recorded at the site in February 1995 could not be relocated during the present site inspection. It is unclear whether the artefacts have been transported elsewhere due to erosion or obscured by sheet erosion as the level of ground surface visibility (GSV) in the area adjacent and downslope to the track was 0%.

Plate 59: Eroded access track situated in the north-eastern corner of the lagoon at the approximate location of WD 6 (AHIMS ID# 45-5-2738). Gravel has accumulated on the westernmost side of the track (sitting lower topographically) confirming sheet erosion has occurred in the area. The track surface contains a combination of natural gravels as well as introduced fill material (crushed brick). Ground surface visibility was poor across the exposed track, with moss cover obscuring some of the surface. The soil is a compact sandy clay loam and no exposures with visible stratigraphy were observed during the site inspection.

6.7 WD 7 (AHIMS ID# 45-5-2739)

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Plate 60: Area of exposure within site extent of WD 7 (AHIMS ID# 45-5-2739) with several artefacts identified on the ground surface (marked by pink flags). Photographed facing west. Though sheet erosion is likely to have occurred in this area, the distribution of the artefacts throughout the site was not found to be concentrated during the site inspection. Erosion to the lagoon banks was observed, however this dynamic has occurred over a prolonged time period. The inundation has likely caused soils within the site extent to be suspended and intermixed within the upper horizon however the depth to which this dynamic has occurred has been limited by the poor transmission rates of the soils present. Surface runoff on the edges of the soil exposure were not observed during the present site inspection however the formation of a sediment fan at the base of the slope is indicative of surface runoff of soils downslope.

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Plate 61: Southern extent of WD 7 (AHIMS ID# 45-5-2739) showing the location of surface artefacts (marked by pink flags). Artefacts were identified almost exclusively on exposed ground within areas of good ground surface visibility (access tracks and the broader exposure at the centre of the site).

Plate 62: Close-up of impacted soils within the exposure at WD 7 (AHIMS ID# 45-5-2739). Artefacts that were identified on the surface in the vicinity of this location were firmly embedded within the soil deposit. This aggrading soil has built up with sediments transported downslope to form a sediment fan.

Plate 63: Cracking present on ground surface at WD 7 (AHIMS ID# 45-5-2739) associated with intermittent flooding events. The prolonged suspension of the upper soil horizon has resulted in an intermixing of soils, though the depth of this impact could not be verified in the field. After the surge and as flood waters receded, cracking has resulted. The inundation has also likely contributed to some minor slumping of the bank and the subsequent hardening of reconsolidated soils. The absence of vegetation in this area has made the site more susceptible to bank scouring.

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Plate 64: Area of exposure within the site extent for WD 7 (AHIMS ID# 45-5-2739) showing the extent of sheet and bank erosion.

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Plate 65: Eroded banks adjoining Longneck Lagoon at WD 7 (AHIMS ID# 45-5-2739) showing the effects of bank scouring and slumping /collapse. The grass cover present in this area was only slowly recovering at the time of the site inspection with growth still very sparse following the effects of sheet erosion and soil redeposition.

6.8 LL01 Coordinates in AMG 66 (AHIMS ID# 45-5-3708)

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Plate 66: Condition of road surface at LL01 Coordinates in AMG 66 (AHIMS ID# 45-5-3708) following the impact of extensive flooding that occurred in early March 2022. Evidence of soil transportation across and along the exposed track was only observed in isolated locations during the site inspection.

Plate 67: At the edges of the track in the vicinity of LL01 Coordinates in AMG 66 (AHIMS ID# 45-5-3708) evidence of rill erosion was observed in a limited capacity during the site inspection. Rill erosion has likely exposed sub-surface gravels present.

Plate 68: Limited rill erosion was observed along the edges of the track at LL01 Coordinates in AMG 66 (AHIMS ID# 45-5-3708) with infilled sand having covered some of the surface gravels. Larger pebbles have accumulated in distinct areas along the erosion lines. No artefacts were observed on the ground surface during the site inspection following community collection in 2010 (AHIP # 1121342).

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Plate 69: Redeposited soils observed on the ground surface of access tracks leading to the Longneck Lagoon Environmental Centre and in the vicinity of LL01 Coordinates in AMG 66 (AHIMS ID# 45-5-3708). Surface gravels have been obscured by the redeposited soil.

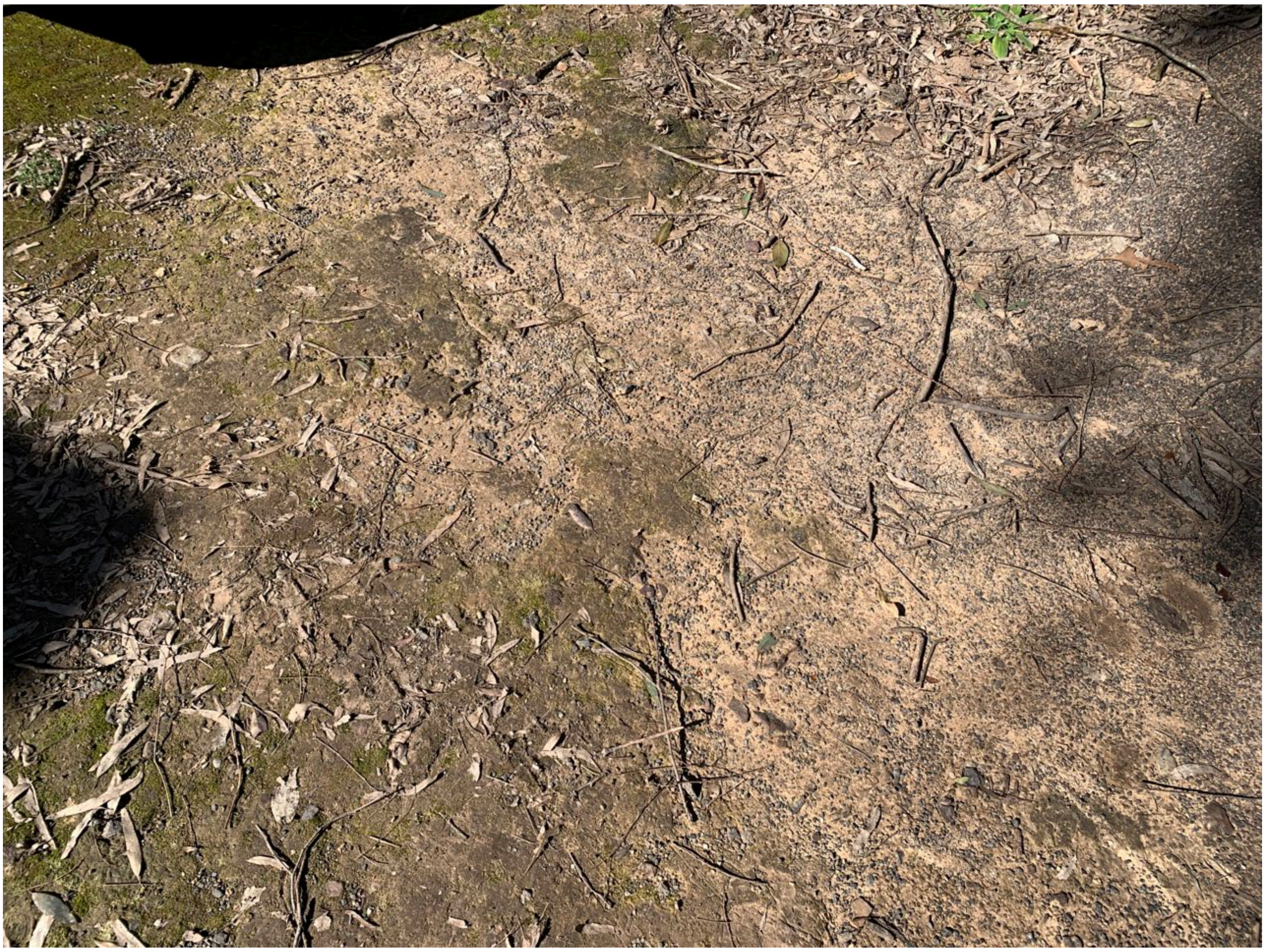

Plate 70: Close-up of redeposited soils present in the vicinity of LL01 Coordinates in AMG 66 (AHIMS ID# 45-5-3708) on the north-eastern perimeter of the track. This was the most heavily impacted area along the track in terms of redeposited soils, however this area is situated further east than the previously recorded location of surface artefacts.

7 Consolidation of results

The background research and site inspection results from Longneck Lagoon demonstrate that the impacts of temporary flooding events on Aboriginal cultural heritage sites can vary significantly. In a hydrologically-sensitive environment such as the lagoon, where multiple creeks feed water from the broader catchment and waterlogging occurs on either a permanent or seasonal basis, the impacts of large flooding events will be amplified.

This study has explored a range of impacts to Aboriginal cultural heritage sites at Longneck Lagoon that can result both from catchment runoff and backwater flooding, as outlined in Table 9.

Table 9: Summary of impacts to Aboriginal cultural heritage sites that can result from temporary episodes of inundation as observed during the site inspection at Longneck Lagoon

Impact	Nature of the impact	Evidence observed at Longneck Lagoon
Sheet erosion	Sheet erosion occurs when the intensity of rainfall exceeds the infiltration capacity of soil. The process generally results in the loss of topsoil, in particular on surfaces with sparse vegetation cover. As soil becomes saturated, its bearing capacity is reduced and this can make it more susceptible to structural damage (Taboada 2003).	Evidence of sheet erosion was observed at 7 of the 8 sites, though the extent of this erosion varied. As many of the sites were situated on compacted tracks with gravel inclusions and comprising relatively impermeable parent soils, the impact of the sheet erosion was fairly limited for isolated flooding events and significant when considered over extended timespans.
Rill erosion	Rill erosion can occur during periods of concentrated water flows when the surface runoff forms small channels or rills. The intensity of rill erosion is largely associated with the local topography as steeper slopes tend to increase the force of the water flow.	Evidence of rill erosion was observed during the site inspection was most common within exposed areas such as walking tracks. In total, six of the eight sites had observable impacts from rill erosion though due to the relatively level topography of the eight sites, the extent of rill erosion was not significant.
Gully erosion	Gully erosion involves the removal of soil along drainage lines by surface runoff. Unless remedied, gully erosion will worsen over time as further material is eroded from the unstable banks and this can be worsened by bank slumping.	Gully erosion was not observed at any of the Aboriginal cultural heritage sites due to the absence of gully features at these sites.
Bank erosion and mass failure	Bank erosion can occur adjacent to waterbodies due to the force of flowing water directly abrading a soil deposit (bank scour) or when the integrity of a bank is undermined by material loss and bank collapse occurs (also known as mass failure). Mass failure can cause the root systems of large trees situated close to the bank to collapse and cause further damage.	Bank erosion was observed at three of the eight Aboriginal cultural heritage sites. The impact was most severe where vegetation was bare or non-existent. The impact of bank erosion will be most severe when sites occur in close proximity to waterways.
Redeposition of soils resulting from sheet, gully or rill erosion	As sheet, gully or rill erosion transports soil from adjoining areas it can become redeposited within depressions. Generally, this redeposition would occur on low-lying ground however as	As most of the Aboriginal cultural heritage sites occur on tracks, surface runoff being deposited in adjacent areas had been expected, however only limited evidence was observed during the site inspection. Only four

Impact	Nature of the impact	Evidence observed at Longneck Lagoon
	floodwaters raise the water table, water-borne soil can also be deposited on ground higher than the natural water table.	sites had clear evidence for redeposited soils resulting from sheet and rill erosion, with three additional four sites having very isolated examples of surface runoff.
Remixed soils resulting from temporary suspension in water	Temporary inundations can cause soil particles to become suspended in standing water. Depending on the capacity for water to permeate the soils present, this can extend deeper into the soil profile.	Evidence for surface intermixing resulting from the temporary saturation of soils or surface runoff was observed at seven of the eight sites, though only in limited contexts and only to a shallow depth.
Soil compaction	Inundated soils are prone to becoming compacted as suspended soils resettle and harden and this dynamic is worsened in clay-rich soils. In particular, in areas exposed to seasonal inundation cycles, soils are prone to compacting as they swell and shrink.	Soils present at the eight sites observed during the site inspection were found to be have low to moderate compaction. Sites situated closest to the lagoon or drainage lines subject to seasonal inundations were found to be the most heavily compacted.
Resorting	As soils become inundated there is a potential for embedded gravel to be transported and redeposited. The potential for gravel to be transported will be influenced by a range of factors including the size of the gravel and this can result in differential rates of movement for gravel of varying size.	The potential impact of this dynamic on the archaeological integrity of a deposit containing artefacts is clear, however at Longneck Lagoon the exposed surfaces of the sites did not show any significant resorting of embedded gravels.

8 Conclusion

This study has shown that the potential impact of temporary flooding events on Aboriginal cultural heritage sites situated in close proximity to waterways can be significant and is affected by several factors including (a) sheet erosion, (b) gully erosion, (c) bank erosion, (d) rill erosion, (e) soil redeposition in runoff, (f) soil mixing resulting from the stationary suspension in water, (g) soil compaction and (h) resorting.

The potential influence of these dynamics in varied environments will be influenced by a range of factors including soil composition and its permeability level, the grain-size of particles, the extent of vegetation and leaf litter present, the slope gradient and length, surface texture and the extent of previous disturbance. These characteristics will influence the extent of harm caused by temporary inundation events and have been considered in the supplementary information prepared for the Warragamba Dam Raising Project.

The study has demonstrated that Longneck Lagoon has had a varied hydrological regime over time and has been impacted by disturbance including vegetation clearance, turf removal, timber clearing and quarrying activities. Prior to the construction of a weir in 1972, the spatial extent of the lagoon was far smaller, and the surrounding landscape was prone to more varied periods of wet and dry. After 1972, water levels at the lagoon rose and broader sections of the surrounding landscape become more severely inundated.

The Longneck Lagoon study has demonstrated a protracted history of significant inundation events which have placed a number of registered Aboriginal cultural heritage sites at risk of harm. These issues include sheet, bank and gully erosion, waterlogging issues, soil transportation, soil intermixing and compacting and to a limited extent, the resorting of gravels. Sites situated along drainage lines were shown to have the most significant impact and were prone to more prolonged exposure to erosion and the harmful effect of scouring over longer periods of time.

The observations made at Longneck Lagoon have applicability to the Aboriginal cultural heritage sites occurring within the upstream and downstream project areas of the project and may be used to formulate more inclusive predictive models of harm. This study has shown that site characteristics including soil landscapes, hydrologic soil groups and slope gradient can be used to predict the potential impact of temporary inundations on Aboriginal cultural heritage sites.

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10 Appendix A– AHIMS Site Cards

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11 Appendix B– AHIMS extensive search results

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Appendix 6: PAD sensitivity, visibility & exposure data

Site Name	AHIMS ID	Confirmed Site Type	Soil landscape unit	Approx. recorded site extent (m)	Visibility	Exposure	PAD clearly Identified in original recording Y/N	Suspected PAD based on recorded description and/or location	Predicted PAD sensitivity rating	Overall PAD evaluation	Notes / comments
Warragamba-00	Pending	Open Camp Site with PAD	Martins Flat	20 x 20	<5%	<5%	No	Yes	Moderate	Yes	River terrace
Warragamba-01	Pending	Open Camp Site with PAD	Martins Flat	20 x 20	<5%	<5%	No	Yes	Moderate	Yes	River terrace
Warragamba-02	Pending	Open Camp Site	Martins Flat	20 x 20	<10%	<10%	No	No	Low	No	
Warragamba-03	Pending	Open Camp Site	Martins Flat	20 x 20	<5%	<5%	No	No	Low	No	
Warragamba-05	Pending	Aboriginal Resource and Gathering	Martins Flat	250 x 20	<5%	<5%	No	No	Low	No	
Warragamba-06	Pending	Open Camp Site	Martins Flat	20 x 20	<10%	<20%	No	No	Low	No	
Warragamba-07	Pending	Open Camp Site	Martins Flat	20 x 20	<10%	<5%	No	No	Moderate	No	2 artefacts in disturbed context near old track / road
Warragamba-08	Pending	Open Camp Site	Martins Flat	20 x 20	0%	<80% on road, <5% off road	No	No	Moderate	No	3 artefacts in disturbed context near old track / road
Warragamba-09	Pending	Open Camp Site	Martins Flat	20 x 20	<5%	<5%	No	No	Low	No	
Warragamba-10	Pending	Shelter with Deposit	Martins Flat	6.7 x 3.4	<20%	<10%	Yes	Yes	Moderate	Yes	
Warragamba-11	Pending	Shelter with Deposit	Martins Flat	7.5 x 1.2	<10%	<15%	Yes	Yes	Moderate	Yes	
Warragamba-12	Pending	Open Camp Site with PAD	Martins Flat	20 x 20	<50%	<50%	Yes	Yes	Moderate	Yes	8 stone artefacts located near junction of Nattai and Little Rivers
Warragamba-13	Pending	Isolated Artefact	Martins Flat	20 x 20	<10%	<10%	No	No	Moderate	No	
Warragamba-14	Pending	Open Camp Site	Martins Flat	100 x 20	<20%	<30%	No	No	Moderate	No	Disturbed context
Warragamba-15	Pending	Open Camp Site	water	200 m length	<30%	<30%	No	No	NA	No	
Warragamba-16	Pending	Shelter with Art and Artefacts	water	7 x 2.8	70%	70%	No	No	NA	No	
Warragamba-17	Pending	Open Camp Site	Hassans Walls	20 x 20	<80%	100% below high water, 2% above	No	No	Moderate	No	Disturbed context
Warragamba-18	Pending	Open Camp Site with PAD	Hassans Walls	150 x 20	<10% above HW mark	<10% above HW mark	No	Yes	Moderate	Yes	Low artefact density but burnt clay and hearth feature noted.
Warragamba-19	Pending	Open Camp Site	water	20 x 20	<50%	80%	No	No	NA	No	
Warragamba-20	Pending	Open Camp Site	Martins Flat	20 x 20	<20%	<10%	No	No	Moderate	No	Disturbed context
Warragamba-21	Pending	Open Camp Site	water	20 x 20	<10%	<10%	No	No	NA	No	
Warragamba-22	Pending	Open Camp Site	Hassans Walls	100 x 20	>50% below HW mark and 10% above	100% below HW mark and 10% above	No	No	Moderate	No	Artefact scatter of varying density on spur of ridge, no evidence of sub-surface potential

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Warragamba-23	Pending	Open Camp Site	Hassans Walls	180 x 120	90% below HW mark and 10% above	70% below HW mark and 10% above	No	No	Moderate	No	Low density scatter with 6 artefacts on a broad ridge & no evidence of sub-surface potential
Warragamba-24	Pending	Open Camp Site	Hassans Walls	80 x 20	90% below HW mark and 10% above	70% below HW mark and 10% above	No	No	Moderate	No	Low density scatter with 6 artefacts on a broad ridge & no evidence of sub-surface potential
Warragamba-25	Pending	Open Camp Site	Hassans Walls	200 m length	80% below HW mark and 10% above	80% below HW mark and 10% above	No	No	Moderate	No	Low density scatter with 12 artefacts on a broad ridge & no evidence of sub-surface potential
Warragamba-26	Pending	Open Camp Site	Martins Flat variant a	150 x 100	<80%	<80%	No	No	Moderate	No	Low density scatter with 10 artefacts on a broad ridge & no evidence of sub-surface potential
Warragamba-27	Pending	Open Camp Site with PAD	Martins Flat variant a	150 x 250	50% below HW mark and 10% above	70-80% below HW mark and 10% above	No	No	Moderate	Yes	Artefact scatter at Kamilaroi Point nearby a Shelter with Deposit (AHIMS ID# 52-1-0142)
Warragamba-28	Pending	Open Camp Site	Martins Flat variant a	50 x 50	80% below HW mark and 10% above	>50% above HW mark	No	No	Moderate	No	Located on spur in a disturbed context
Warragamba-29	Pending	Open Camp Site	Martins Flat variant a	60 m length	70% below HW mark and <10% above	80% below HW mark	No	No	Moderate	No	Three artefacts located in an area associated with extensive vegetation clearing.
Warragamba-30	Pending	Open Camp Site	water	150 m length	70-80% below HW mark and 10% above	70-80% below HW mark and 10% above	No	No	NA	No	
Warragamba-31	Pending	Shelter with Deposit and Artefacts	Martins Flat variant a	17.1 x 3.4	<10%	<10%	No	Yes	Low	Yes	Eroding deposit on shelter floor with 3-4 visible artefacts
Warragamba-32	Pending	Open Camp Site	water	200 x 40	<40	<40	No	No	NA	No	
Warragamba-33	Pending	Open Camp Site	Martins Flat variant a	20 x 20	>70% below HW mark, <20% above	>70% below HW mark, <20% above	No	No	Moderate	No	Located just off an access track / disturbed context
Warragamba-34	Pending	Open Camp Site	Martins Flat variant a	250 x 100	70% below HW mark and <10% above	50% below HW mark, <20% above HW mark	No	No	Moderate	No	highly disbursed artefact scatter associated with glass and building rubble
Warragamba-35	Pending	Open Camp Site	Martins Flat variant a	200 m length	60-80%	60-80%	No	No	Moderate	No	Five artefacts highly disbursed and located on a ridge

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Warragamba-36	Pending	Open Camp Site	Martins Flat variant a	20 x 20	80% below HW mark and 10% above	80% below HW mark and 10% above	No	No	Moderate	No	located on a spur a landform typically associated with sporadic and/or transient use
Warragamba-37	Pending	Open Camp Site	Martins Flat variant a	20 x 20	80% below HW mark and 10% above	80% below HW mark and 10% above	No	No	Moderate	No	Five artefacts located near bank of Burragorang, no sub-surface potential noted
Warragamba-38	Pending	Open Camp Site	Martins Flat variant a	20 x 20	80% below HW mark and 10% above	80% below HW mark and 10% above	No	No	Moderate	No	Low density scatter located on spur/ridge
Warragamba-39	Pending	Open Camp Site with PAD	Martins Flat variant a	300 x 300	80-90% below HW mark	80-90% below HW mark	No	Yes	Moderate	Yes	Extensive artefact scatter with burnt clay located on foreshore of Lake Burragorang
Warragamba-40	Pending	Open Camp Site with PAD	Martins Flat variant a	200 x 200	50% below HW mark and <10% above	50% below HW mark and <10% above	No	Yes	Moderate	Yes	Extensive artefact scatter located on foreshore of Lake Burragorang
Warragamba-41	Pending	Open Camp Site	Martins Flat variant a	200 x 200	>50% below HW mark, <5% above	>50% below HW mark, <5% above	No	No	Moderate	No	Located on a ridge, a landform typically associated with sporadic and/or transient use
Warragamba-42	Pending	Open Camp Site	Martins Flat variant a	20 x 20	50% below HW mark and <10% above	50% below HW mark and <10% above	No	No	Moderate	No	11 artefacts located on shoreline
Warragamba-43	Pending	Open Camp Site	Martins Flat variant a	20 x 20	80-90% below HW mark, <20 above	80-90% below HW mark, <20 above	No	No	Moderate	No	6 artefacts located on shoreline
Warragamba-44	Pending	Open Camp Site	Martins Flat variant a	20 x 20	<60% below HW mark, <10% above	<60% below HW mark, <10% above	No	No	Moderate	No	5 artefacts located on shoreline
Warragamba-45	Pending	Open Camp Site	Martins Flat variant a	20 x 20	<40% below HW mark, <10% above	<40% below HW mark, <10% above	No	No	Moderate	No	8 artefacts located on shoreline
Warragamba-46	Pending	Shelter with Deposit and Artefacts	Martins Flat variant a	3 x 2.1	<20%	<20%	Yes	Yes	Moderate	Yes	Eroding deposit on shelter floor with 3 visible artefacts
Warragamba-47	Pending	Open Camp Site	Martins Flat variant a	20 x 20	40% below HW mark, <10% above HW mark	40% below HW mark, <10% above HW mark	No	No	Moderate	No	9 artefacts located on shoreline

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Warragamba-48	Pending	Open Camp Site with PAD	Martins Flat variant a	220 x 250	<50% below HW mark, <10% above HW mark	<50% below HW mark, <10% above HW mark	No	No	Moderate	Yes	Extensive artefact scatter including numerous cores and six axes.
Warragamba-49	Pending	Open Camp Site	Martins Flat variant a	200 x 300	<20% below HW mark, <10% above HW mark	<20% below HW mark, <10% above HW mark	No	No	Moderate	No	3 artefacts, no sub-surface potential noted
Warragamba-50	Pending	Open Camp Site	Martins Flat variant a	20 x 20	20% below HW mark, <10% above	20% below HW mark, <10% above	No	No	Moderate	No	4 artefacts, no sub-surface potential noted
Warragamba-51	Pending	Open Camp Site	Martins Flat variant a	20 x 20	30%	30%	No	No	Moderate	No	6 artefacts located in flood corridor of Wollondilly River. Likely not in-situ
Warragamba-52	Pending	Open Camp Site	Martins Flat variant a	150 m length	<10%	<5%	No	No	Moderate	No	2 artefacts in disturbed context near access road
Warragamba-53	Pending	Open Camp Site	Martins Flat variant a	20 x 20	40%	40%	No	No	Moderate	No	3 artefacts in disturbed context near access road
Warragamba-54	Pending	Open Camp Site	Kedumba	20 x 20	<10%	<10%	No	No	Moderate	No	3 artefacts in disturbed context near access road
Warragamba-55	Pending	Shelter with Deposit and Artefacts	Kedumba	21.5 x 4.9	10%	10%	Yes	Yes	Low	Yes	Eroding deposit on shelter floor with 4 visible artefacts
Warragamba-56	Pending	Shelter with Deposit and Artefacts	Kedumba	5.5 x 2.1	<10%	<10%	Yes	Yes	Low	Yes	Eroding deposit under dripline with 2 visible artefacts
Warragamba-57	Pending	Shelter with Deposit and Artefacts	Kedumba	19.1 x 5.7	<10%	<10%	Yes	Yes	Moderate	Yes	Eroding deposit on edge of floor under drip line with 2 visible artefacts
Warragamba-58	Pending	Shelter with Deposit and Artefacts	Kedumba	11.4 x 3.8	<20%	<20%	Yes	Yes	Moderate	Yes	Highly disturbed from flooding, deposit is present in leaf litter with 1 visible artefact. Hearth material also observed.
Warragamba-59	Pending	Open Camp Site	Kedumba	100 m length	10%	<5%	No	No	Moderate	No	1 artefact in disturbed context near access road
Warragamba-60	Pending	Shelter with Deposit and Art	Kedumba	7.4 x 4	<10%	20%	Yes	Yes	Low	Yes	Eroded deposit extending 10m downslope with 6 visible artefacts.
Warragamba-61	Pending	Shelter with Deposit, Art and Artefacts	Jooriland Range	9.5 x 4.3	60%	90%	Yes	Yes	Low	Yes	Eroded deposit continuing downslope with 7 visible artefacts.

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Warragamba-62	Pending	Shelter with Deposit, Art and Artefacts	Kedumba	4.3 x 4.2	10%	20-30%	Yes	Yes	Low	Yes	Eroded deposit continuing downslope 10 m with 2 visible artefacts.
Warragamba-63	Pending	Water Hole	water	180 x 60	0	0	No	No	NA	No	
Warragamba-64	Pending	Isolated Artefact	Kedumba	20 x 20	<10%	<10%	No	No	Moderate	No	
Warragamba-65	Pending	Open Camp Site	Jooriland Range	90 x 80	<20%	<20%	No	No	Moderate	No	
Warragamba-66	Pending	Open Camp Site	Jooriland Range	190m length	<10%	<10%	No	No	Moderate	No	
Warragamba-67	Pending	Open Camp Site	Jooriland Range	20 x 20	<10%	<10%	No	No	Moderate	No	
Warragamba-68	Pending	Open Camp Site	Jooriland Range	300 x 50	60%	70%	No	No	Moderate	No	
Warragamba-69	Pending	Open Camp Site	Jooriland Range	GPS point	<30%	50%	No	No	Moderate	No	Disturbed context just off access track
Warragamba-70	Pending	Open Camp Site	Jooriland Range	100 x 150	10%	100%	No	No	Moderate	No	Five artefacts in disturbed context just off access track
Warragamba-71	Pending	Open Camp Site	Jooriland Range	20 x 20	2%	2%	No	No	Moderate	No	Two artefacts in disturbed context just off access track
Warragamba-72	Pending	Open Camp Site with PAD	Wollondilly River	100 x 150	1%	0%	Yes	Yes	High	Yes	Red alluvial deposit across all of the landform with a possibility of in-situ deep deposits
Warragamba-73	Pending	Isolated Artefact	Jooriland Range	20 x 10	<20%	<20%	No	No	Moderate	No	
Warragamba-74	Pending	Water hole and Aboriginal Ceremony and Dreaming	Cedar Valley	410 x 100	<30%	<30%	No	No	Low	No	
Warragamba-75	Pending	Aboriginal Resource and Gathering	Cedar Valley	20 x 20	<5%	<5%	No	No	Moderate	No	
Warragamba-76	Pending	Scarred Tree	Cedar Valley	GPS point	<5%	<10%	No	No	Moderate	No	
Warragamba-77	Pending	Isolated Artefact with PAD	Emu Island	20 x 20	<50% below HW mark and <10% above HW mark	30% below HW mark, <10% above HW mark	No	No	High	Yes	Low visibility but alluvial soil landscape
Warragamba-78	Pending	Isolated Artefact	Cedar Valley	20 x 20	5%	10%	No	No	Moderate	No	Isolated artefact but potential to extend NE along spur/ridge
Warragamba-79	Pending	Open Camp Site with Scarred Tree	Cedar Valley	GPS point	<10%	<10%	No	No	Moderate	No	Located in a valley flat, a landform suitable for camping, though no potential for sub-surface deposits noted
Warragamba-80	Pending	Stone Arrangement	Cedar Valley	20 x 20	5%	5%	No	No	Moderate	No	

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Warragamba-81	Pending	Open Camp Site	Cedar Valley	20 x 20	40%	50% below HW mark, <10% above HW mark	No	No	Moderate	No	
Warragamba-82	Pending	Open Camp Site	Cedar Valley	20 x 20	20-30% below HW mark and <10% above	20-30% below HW mark and <10% above	No	No	Moderate	No	
Warragamba-83	Pending	Axe Grinding Grooves	Cedar Valley	6 x 1.8	90%	100%	No	No	Moderate	No	
Warragamba-84	Pending	Shelter with Deposit and Artefacts	Cedar Valley	16 x 3.4	60%	100%	Yes	Yes	Low	Yes	Intact sandy deposit on the shell floor with 2 visible artefacts.
Warragamba-85	Pending	Open Camp Site	Cedar Valley	50 x 30	20%	30% below HW mark, <5% above HW mark	No		Moderate		3 artefacts located on a spur; a landform typically associated with ephemeral / transient use
Warragamba-86	Pending	Open Camp Site	Cedar Valley	50 x 50	30%	40% below HW mark, <10% above	No	No	Moderate	No	
Warragamba-88	Pending	Isolated Artefact	Kedumba	200 x 250	<10%	<10%	No	No	Moderate	No	
Warragamba-89	Pending	Open Camp Site	Kedumba	300 x 70	<5%	<5%	No	No	Moderate	No	
Warragamba-90	Pending	Isolated Artefact	Cedar Valley	250 x 90	<5%	<5%	No	No	Moderate	No	
Warragamba-91	Pending	Scarred Tree	Cedar Valley	GPS point	<5%	<5%	No	No	Moderate	No	
Warragamba-92	Pending	Stone Arrangement	Jooriland Range	50 x 5	<10%	<5%	No	No	Moderate	No	
Warragamba-93	Pending	Open Camp Site	Kedumba	300 x 100	<10%	<10%	No	No	Moderate	No	Site likely extends 300 m to south west and 100 m to north east.
Warragamba-94	Pending	Open Camp Site with PAD	Kedumba	300 x 180	20% below HW, <5% above	20% below HW, <5% above	Yes	Yes	Moderate	Yes	Large number of artefacts and potential for intact subsurface deposits The site potentially extends further inland SW up to 1km along ridge.
Warragamba-95	Pending	Open Camp Site	Kedumba	120 X 150	<5% above HW mark, 20% below	Not recorded	No	No	Moderate	No	Moderate level of disturbance has removed potential for intact sub-surface deposits.

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Warragamba-96	Pending	Open Camp Site with PAD	Kedumba	250 X 50	<10% above HW mark	<10% above HW mark	No	Yes	Moderate	Yes	While only associated with 2 artefacts site potentially extends across the level landform with potential for more extensive occupation evidence towards the ridge to the north. Potential for sub-surface deposits also noted.
Warragamba-97	Pending	Open Camp Site	Kedumba	250m length	<20%	<10%	No	No	Moderate	No	3 highly dispersed artefacts located on a ridgeline, a landform typically associated with transient use
Warragamba-98	Pending	Open Camp Site	Kedumba	300 x 50	<20% below HW mark	<50% below HW mark, <10% above HW mark	No	No	Moderate	No	
Warragamba-99	Pending	Open Camp Site	Kedumba	200m length	<5% above HW mark, <30% below HW mark	<5% above HW mark, <30% below HW mark	No	No	Moderate	No	
Warragamba-100	Pending	Open Camp Site	Cedar Valley	200 x 20	<30% below HW mark, 10% above HW mark	<30% below HW mark, 10% above HW mark	No	No	Low	No	
Warragamba-101	Pending	Isolated Artefact with PAD	Jooriland Range	300 m length	<10%	<10%	No	Yes	Moderate	Yes	Large chert core located at Tonalli Cove. Low visibility but high potential for more artefacts to be present including potential sub-surface deposits
Warragamba-102	Pending	Isolated Artefact with PAD	Jooriland Range	100 x 100	<5%	<5%	No	Yes	Moderate	Yes	Located in valley flat. Artefact exposed as a result of wombat burrowing. High likelihood of more artefacts across landform 100 m e/w and 100 m n/s including sub-surface deposits
Warragamba-103	Pending	Isolated Artefact	Kedumba	20 x 20	<5%	<5%	No	No	Moderate	No	Low visibility but likely on ephemeral use of landform and thus low potential for sub-surface deposits
Warragamba-104	Pending	Shelter with Deposit and Artefacts	Kedumba	4.2 x 2.1	<40%	50%	Yes	Yes	Low	Yes	Sandy deposit inside shelter with 2 visible artefacts.

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Warragamba-105	Pending	Open Camp Site	Kedumba	20 x 20	<20% above HW mark, <40% below HW mark	<20% above HW mark, <40% below HW mark	No	No	Moderate	No	2 artefacts located on a spur; a landform typically associated with sporadic / transient use
Warragamba-106	Pending	Open Camp Site	Kedumba	100 x100	<10% above HW mark, <50% below HW mark	<10% above HW mark, <50% below HW mark	No	No	Moderate	No	Highly dispersed artefacts
Warragamba-107	Pending	Open Camp Site	Kedumba	100 x 20	<30% above HW mark, <80% below HW mark	<30% above HW mark, <80% below HW mark	No	No	Moderate	No	Highly dispersed artefacts
Warragamba-108	Pending	Isolated Artefact	Kedumba	20 x 20	<20% above HW mark	<10%	No	No	Moderate	No	
Warragamba-109	Pending	Open Camp Site with PAD	Kedumba	1000 m in length	<5% above HW mark, <50% below HW mark	<5% above HW mark, <50% below HW mark	Yes	Yes	Moderate	Yes	Extensive artefact scatter that likely connects to Warragamba-110 and 48. "Deposit for excavation" was noted on recording form
Warragamba-110	Pending	Open Camp Site with PAD	Kedumba	200 x 70	<10% above HW mark, <50% below HW mark	<10% above HW mark, <50% below HW mark	No	Yes	Moderate	Yes	Potential based on its association with Warragamba-109
Warragamba-111	Pending	Open Camp Site	Kedumba	100 x 50	<30% below HW mark, <10% above HW mark	<30% below HW mark, <10% above HW mark	No	No	Moderate	No	Highly dispersed artefacts (n=3)
Warragamba-112	Pending	Shelter with Deposit and Artefacts	Kanangra Gorge	15 x 5	<10%	<10%	Yes	Yes	Low	Yes	Sandy deposit inside shelter with 2 visible artefacts.
Warragamba-113	Pending	Shelter with Deposit, Art, Artefacts and Axe Grinding Grooves	Kanangra Gorge	19 x 7	<20%	<20%	Yes	Yes	Moderate	Yes	
Warragamba-114	Pending	Axe Grinding Grooves	Kanangra Gorge	13 x 12	<30%	<30%	No	No	Moderate	No	
Warragamba-115	Pending	Shelter with Deposit, Art and Artefacts	Kanangra Gorge	39 x 4.5	<20%	<20%	Yes	Yes	Low	Yes	Eroding deposit down slope within dripline and containing 2 visible artefacts.
Warragamba-116 / Warragamba; Bimlow	45-4-0026	Shelter with Deposit, Art, Artefacts and Axe Grinding Grooves	Hassans Walls	10.5 x 10	<5%	<5%	Yes	Yes	Low	Yes	Deposit present in shelter and eroding downslope on shelter floor and under dripline. 200+ visible artefacts

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Warragamba-117	Pending	Open Camp Site	Hassans Walls	100 x 50	<60% below HW mark, <10% above HW mark	<60% below HW mark, <10% above HW mark	No	No	Moderate	No	11 artefacts highly dispersed on a spur, a landform typically associated with transient / sporadic use
Warragamba-118	Pending	Open Camp Site	Hassans Walls	50 x 50	<60% below HW mark, <10% above HW mark	<60% below HW mark, <10% above HW mark	No	No	Low	No	6 artefacts highly dispersed on a spur, a landform typically associated with transient / sporadic use
Warragamba-119	Pending	Open Camp Site	Hassans Walls	130 x 50	<70% below HW mark, <5% above HW mark	<70% below HW mark, <5% above HW mark	No	No	Moderate	No	2 artefacts highly dispersed on a spur, a landform typically associated with transient / sporadic use
Warragamba-121	Pending	Isolated Artefact	Hassans Walls	100 x 50	<50% below HW mark and <20% above HW mark	<50% below HW mark and <20% above HW mark	No	No	Low	No	
Warragamba-122	Pending	Open Camp Site	Hassans Walls	60 x 50	<50% below HW mark and <10% above HW mark	<50% below HW mark and <10% above HW mark	No	No	Low	No	
Warragamba-123	Pending	Open Camp Site	water	200 x 50	<50% below HW mark and <10% above HW mark	<50% below HW mark and <10% above HW mark	No	No	NA	No	
Warragamba-124	Pending	Open Camp Site	Hassans Walls	200 x 100	<70% below HW mark and <10% above HW mark	<70% below HW mark and <10% above HW mark	No	No	Moderate	No	High dispersed low-density scatter, no potential for sub-surface deposits noted
Warragamba-125	Pending	Isolated Artefact	water	80 x 50	50% below HW mark, <10% above HW mark	50% below HW mark, <10% above HW mark	No	No	NA	No	
Warragamba-126	Pending	Isolated Artefact	Hassans Walls	20 x 20	100%	100%	No	No	Low	No	
Warragamba-127	Pending	Open Camp Site	Hassans Walls	100 x 200	50% below HW mark, <20% above HW mark	50% below HW mark, <20% above HW mark	No	No	Moderate	No	High dispersed low-density scatter, no potential for sub-surface deposits noted
Warragamba-128	Pending	Open Camp Site	Hassans Walls	150 x 20	50% above HW mark, <10% below	50% above HW mark, <10% below	No	No	Moderate	No	High dispersed low-density scatter, no potential for sub-surface deposits noted
Warragamba-129	Pending	Open Camp Site	Hassans Walls	150 x 20	<60% below HW mark, <20% above HW mark	<60% below HW mark, <20% above HW mark	No	No	Moderate	No	High dispersed low-density scatter, no potential for sub-surface deposits noted

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Warragamba-130	Pending	Isolated Artefact	Hassans Walls	20 x 20	<60% below HW mark, <10% above HW mark	<60% below HW mark, <10% above HW mark	No	No	Moderate	No	
Warragamba-131	Pending	Shelter with Deposit, Art and Isolated Artefact	Round Mount	36 x 4.5	<30%	<30%	Yes	Yes	Low	Yes	Eroding down slope 1 m from drip line with 1 visible artefact.
Warragamba-132	Pending	Shelter with Deposit and Artefacts	Round Mount	55 x 3.5	<90	<90	Yes	Yes	Low	Yes	Eroding deposit of creamy sandy loam with more than 100 visible artefacts. Potential at drip line of shelter.
Warragamba-133	Pending	Water Hole	Kanangra Gorge	GPS point	<5%	<5%	No	No	Moderate	No	
Warragamba-134	Pending	Isolated Artefact with PAD	Coxs River	20 x 20	100	100	No	Yes	High	Yes	Alluvial soil landscape
Warragamba-135	Pending	Shelter with Deposit and Axe Grinding Grooves	Hawkesbury	22 x 5.5	10%	<5%	Yes	Yes	High	Yes	Up to 18 x 4 m sandy deposit with hearth material and wallaby scats. "Likely to have sub-surface archaeological material"
Warragamba-136	Pending	Shelter with Deposit	Hawkesbury	11.8 x 3	<40%	10%	Yes	Yes	Low	Yes	Grey-brown sandy loam with no visible artefacts. "Deposit has a high potential to hold cultural material"
Warragamba-137	Pending	Open Camp Site with PAD	Coxs River	150 x 120	30%	20%	No	Yes	High	Yes	Alluvial soil landscape
Warragamba-138	Pending	Open Camp Site with PAD	Kanangra Gorge	20 x 20	<5%	<5%	No	Yes	Moderate	Yes	Two artefacts located on a terrace near the junction of Rocky and Butchers Creek.
Warragamba-139	Pending	Open Camp Site	Kanangra Gorge	130 x 70	<20%	<20%	No	No	Moderate	No	Highly dispersed low-density scatter located on a ridge, a landform typically associated with transient / ephemeral use
Warragamba-140	Pending	Open Camp Site	Kanangra Gorge	130 x 130	<20%	<10%	No	No	Moderate	No	Highly dispersed very low-density scatter located on a ridge, a landform typically associated with transient / ephemeral use

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Warragamba-141	Pending	Open Camp Site	Kanangra Gorge	200 x 70	<5%	<5%	No	No	Moderate	No	Highly dispersed low-density scatter located on a ridge, a landform typically associated with transient / ephemeral use
Warragamba-142	Pending	Open Camp Site	Kanangra Gorge	90 x 70	<10%	<10%	No	No	Moderate	No	Highly dispersed low-density scatter located on a ridge, a landform typically associated with transient / ephemeral use
Warragamba-143	Pending	Isolated Artefact	Cedar Valley	Not recorded	<80%	<80%	No	No	Low	No	
Warragamba-144	Pending	Shelter with Art	Cedar Valley	5.1 x 1.8	<30%	<50%	Small amount of deposit but not PAD	No	Low	No	Very small deposit described as occurring on level floor, but steep slope of shelter noted.
Warragamba-145	Pending	Shelter with Deposit, Art and Artefacts	water	30 x 3.4	<50%	<20%	Yes	Yes	NA	Yes	Yellow soil at dripline with 11 visible artefacts. Also, note that the cave as a Morle-Boc deposit.
Warragamba-146	Pending	Open Camp Site	Hassans Walls	200 x 10	100%	100%	No	No	Low	No	
Warragamba-147	Pending	Open Camp Site with PAD	Hassans Walls	300 x 200	100%	100%	Yes	Yes	Moderate	Yes	Archaeologically sensitive landform with subsurface artefacts predicted
Warragamba-148	Pending	Open Camp Site with PAD	Hassans Walls	100 x 100	<80%	<80%	Yes	Yes	Low	Yes	"Highly sensitive landform" with artefacts exposed by stored water erosion.
Warragamba-149	Pending	Shelter with Deposit and Artefacts	Hassans Walls	9.7 x 3.6	<20%	<20%	Yes	Yes	Low	Yes	Soils present at dripline and eroding downslope.
Warragamba-150	Pending	Open Camp Site with PAD	Hassans Walls	300 x 70	<80%	<80%	Yes	Yes	Moderate	Yes	Archaeologically sensitive landform with visible artefacts that are eroding downslope.
Warragamba-151	Pending	Open Camp Site with Scarred Tree	Hassans Walls	Not recorded	<20%	<20%	No	No	Low	No	Artefact extent is across the erosion footprint
Warragamba-152	Pending	Open Camp Site	Hassans Walls	60 x 100	<10%	<10%	No	No	Moderate	No	Disturbed context near access track and likely not in-situ
Warragamba-153	Pending	Scarred Tree	Hassans Walls	Not recorded	10%	10%	No	No	Low	No	
Warragamba-154	Pending	Open Camp Site	Hassans Walls	70 x 100	<80%	<80%	No	No	Low	No	
Warragamba-155	Pending	Open Camp Site with PAD	Hassans Walls	200 x 70	<60%	<60%	Yes	Yes	Moderate	Yes	Archaeologically sensitive landform with visible artefacts that are eroding downslope

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Warragamba-156	Pending	Open Camp Site with PAD	Hassans Walls	360 x 300	<20%	<20%	No	Yes	Moderate	Yes	Extensive scatter located in a large flat area in the valley suitable for camping and thus repeated / focused occupation.
Warragamba-157	Pending	Open Camp Site	Hassans Walls	240 x 70	<5%	<5%	No	No	Moderate	No	
Warragamba-158	Pending	Open Camp Site	Hassans Walls	200 x 170	<80	<80	No	No	Moderate	No	
Warragamba-159	Pending	Open Camp Site	Hassans Walls	150 x 100	<10%	<10%	No	No	Moderate	No	
Warragamba-160	Pending	Open Camp Site	Hassans Walls	120 x 80	<80%	<80%	No	No	Moderate	No	Moderate density but not noted to be associated with any sub-surface potential
Warragamba-161	Pending	Open Camp Site	Hassans Walls	80 x 70	<30%	<30%	No	No	Moderate	No	Low-density scatter located on lower-slope but associated with large rock-fall caused by collapse of a section of the cliff line which forms the valley
Warragamba-162	Pending	Isolated Artefact	Martins Flat	70 x 150	<10%	<10%	No	No	Moderate	No	
Warragamba-163	Pending	Open Camp Site	Martins Flat	100 x 50	<10% above HW mark, <80% below HW mark	<10% above HW mark, <80% below HW mark	No	No	Moderate	No	
Warragamba-164	Pending	Open Camp Site	Martins Flat	50 x 50	>80% below HW mark, <10% above HW mark	>80% below HW mark, <10% above HW mark	No	No	Moderate	No	
Warragamba-165	Pending	Shelter with Deposit and Artefacts	Martins Flat	14 x 2	50%	10%	Yes	Yes	Moderate	Yes	Eroded deposit on shelter floor with 11 visible artefacts.
Warragamba-166	Pending	Open Camp Site	Martins Flat	120 x 40	<10%	<5%	No	No	Low	No	
Warragamba-167	Pending	Open Camp Site	Hassans Walls	100 x 40	>50% below HW mark	>50% below HW mark	No	No	Moderate	No	Highly dispersed low-density scatter located on a spur, a landform typically associated with transient / ephemeral use
Warragamba-168	Pending	Open Camp Site with Scarred Tree	water	100 x 100	>50% below HW mark, <10% above HW mark	>50% below HW mark, <10% above HW mark	No	No	NA	No	
Warragamba-169	Pending	Open Camp Site	Hassans Walls	200 x 70	>50% below HW mark, <10% above HW mark	>50% below HW mark, <10% above HW mark	No	No	Moderate	No	

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Warragamba-170	Pending	Open Camp Site	water	300 x 50	>50% below HW mark, <10% above HW mark	>50% below HW mark, <10% above HW mark	No	No	NA	No	
Warragamba-171	Pending	Open Camp Site	water	220 x 30	>50% below HW mark, <10% above HW mark	>50% below HW mark, <10% above HW mark	No	No	NA	No	
Warragamba-172	Pending	Open Camp Site	Hassans Walls	200 x 130	<10%	<5%	No	No	Moderate	No	
Warragamba-173	Pending	Open Camp Site	water	200 x 50	<50% below FSL, <5% above FSL	<50% below FSL, <10% above FSL	No	No	NA	No	
Warragamba-174	Pending	Open Camp Site	water	170 x 50	50% below FSL, <5% above FSL	50% below FSL, <5% above FSL	No	No	NA	No	
Warragamba-175	Pending	Open Camp Site	water	180 x 70	<70% below FSL, <10% above FSL	<70% below FSL, <10% above FSL	No	No	NA	No	
Warragamba-176	Pending	Open Camp Site	water	130 x 130	<70% below FSL, <10% above FSL	<70% below FSL, <10% above FSL	No	No	NA	No	
Warragamba-177	Pending	Open Camp Site	Hassans Walls	100 x 50	<50% below FSL, <5% above FSL	<50% below FSL, <5% above FSL	No	No	Moderate	No	
Warragamba-178	Pending	Open Camp Site	water	50 x 50	<50% below FSL, <5% above FSL	<50% below FSL, <5% above FSL	No	No	NA	No	
Warragamba-179	Pending	Aboriginal Resource and Gathering	Hassans Walls	20 x 4	<80%	<80%	No	No	Low	No	
Warragamba-180	Pending	Open Camp Site	water	Not recorded	<50% below FSL, <5% above FSL	<50% below FSL, <5% above FSL	No	No	NA	No	
Warragamba-181	Pending	Shelter with Deposit, Art, Artefacts and Axe Grinding Grooves	Warragamba	38 x 5	<60%	<60%	Yes	Yes	Low	Yes	Eroding downslope with two visible artefacts. Deposit is usually inundated below the high-water mark.
Warragamba-182	Pending	Shelter with Deposit, Art and Artefacts	water	20 x 6	<80%	<80%	Yes	Yes	NA	Yes	In-situ hearth with associated wood, charcoal and 2 visible stone artefacts on floor of shelter
Warragamba-183	Pending	Isolated Artefact	water	80 x 30	<50% below FSL, <10% above FSL	<50% below FSL, <10% above FSL	No	No	NA	No	Low visibility but potential for additional surface artefacts
Warragamba-184	Pending	Open Camp Site	Hassans Walls	350 x 100	<70% below FSL, <10% above FSL	<70% below FSL, <10% above FSL	No	No	Moderate	No	Highly dispersed low-density scatter located on a spur, a landform typically associated with transient / ephemeral use

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Warragamba-185	Pending	Open Camp Site	Hassans Walls	150 x 70	<70% below FSL, <10% above FSL	<70% below FSL, <10% above FSL	No	No	Moderate	No	Highly dispersed low-density scatter located on a spur, a landform typically associated with transient / ephemeral use
Warragamba-186	Pending	Open Camp Site	Hassans Walls	100 x 40	<60% below FSL, <10% above FSL	<60% below FSL, <10% above FSL	No	No	Moderate	No	Highly dispersed low-density scatter located on a spur, a landform typically associated with transient / ephemeral use
Warragamba-187	Pending	Shelter with Deposit	Hassans Walls	10 x 1.2	<10%	<10%	Yes	Yes	Moderate	Yes	PAD mentioned in description. Yellow brown sandy deposit.
Warragamba-188	Pending	Open Camp Site	water	50 x 50	<60% below FSL, <10% above FSL	<60% below FSL, <10% above FSL	No	No	NA	No	
Warragamba-189	Pending	Open Camp Site	water	Not recorded	<40% below FSL, <5% above FSL	<40% below FSL, <5% above FSL	No	No	NA	No	
Warragamba-190 / Bimlow PAD	45-4-0097	Shelter with Art and Deposit, Grinding Grooves	water	Not provided	N/A	N/A	Yes	Yes	Unknown	Yes	Sandy deposit eroding down slope with several hundred artefacts
Warragamba-191	Pending	Open Camp Site with Axe Grinding Grooves and Isolated Artefact	water	300 x 30	<80% below FSL, <5% above FSL	<80% below FSL, <5% above FSL	No	No	NA	No	
Warragamba-192	Pending	Shelter with Deposit	Warragamba	60 x 2.7	<40%	<30%	Yes	Yes	Low	Yes	Yellow sandy deposit would be fully submerged under FSL, shelter wall 1/3 submerged.
Warragamba-193	Pending	Shelter with Art	Warragamba	70 x 6.2	0%	0%	No	No	Low	No	
Warragamba-194	Pending	Open Camp Site	Hassans Walls	100 x 75	<50% below FSL, <5% above FSL	<50% below FSL, <5% above FSL	No	No	Moderate	No	
Warragamba-195	Pending	Open Camp Site	Hassans Walls	115 x 55	<70%	<5%	No	No	Moderate	No	Highly dispersed low-density scatter located on a spur, a landform typically associated with transient / ephemeral use
Warragamba-196	Pending	Open Camp Site with Scarred Tree	Hassans Walls	200 x 70	<50% below FSL, <5% above FSL	<50% below FSL, <5% above FSL	No	No	Moderate	No	
Warragamba-197	Pending	Open Camp Site	Hassans Walls	60 x 50	<50% below FSL, <5% above FSL	<50% below FSL, <5% above FSL	No	No	Moderate	No	
Warragamba-198	Pending	Isolated Artefact	Hassans Walls	50 x 40	<80% below FSL, <5% above FSL	<80% below FSL, <5% above FSL	No	No	Moderate	No	Isolated artefact located on a spur; a landform typically

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											associated with transient / sporadic use
Warragamba-199	Pending	Open Camp Site with PAD	Hassans Walls	100 x 50	<60% below FSL, <5% above FSL	<60% below FSL, <5% above FSL	No	Yes	Moderate	Yes	Artefact scatter consisting of 8 artefacts including two basalt cores located directly south of Warragamba-200 a shelter with artefacts and deposit. Sub-surface potential inferred from the site's close association with a shelter /occupation site.
Warragamba-200	Pending	Shelter with Deposit and Artefacts	Hassans Walls	6.8 x 1.7	70%	20-30%	Yes	Yes	Moderate	Yes	Yellow sandy deposit on shelter floor with 200+ artefacts
Warragamba-201	Pending	Open Camp Site	Hassans Walls	100 x 30	<70% below FSL, <5% above FSL	<70% below FSL, <5% above FSL	No	No	Moderate	No	
Warragamba-202	Pending	Open Camp Site with PAD	Hassans Walls	120 x 50	70-90% below FSL, <5% above	70-90% below FSL, <5% above	Yes	Yes	Moderate	Yes	Extensive artefact scatter located at the junction of Lacy's Creek and the Wollondilly River. Sub-surface potential noted.
Warragamba-203	Pending	Open Camp Site	Hassans Walls	200 x 100	<70% below FSL, <10% above FSL	<70% below FSL, <10% above FSL	No	No	Moderate	No	
Warragamba-204	Pending	Open Camp Site	Hassans Walls	100 x 80	>60% below FSL, <10% above FSL	>60% below FSL, <10% above FSL	No	No	Moderate	No	
Warragamba-205	Pending	Open Camp Site	Hassans Walls	100 x 50	<60% below FSL, <10% above FSL	<60% below FSL, <10% above FSL	No	No	Moderate	No	
Warragamba-206	Pending	Shelter with Deposit and Artefacts	Cedar Valley	12.5 x 7.7	60%	90%	Yes	Yes	Moderate	Yes	Eroding deposit in dripline and eroding down slope with 2 visible artefacts.
Warragamba-207	Pending	Shelter with Deposit and Axe Grinding Grooves	Cedar Valley	19.5 x 4.4	100%	100%	Yes	yes	Moderate	Yes	Eroding deposit in dripline and shelter floor with 4 visible artefacts.
Warragamba-208	Pending	Shelter with Deposit and Artefacts	Cedar Valley	9.3 x 2.6	100%	100%	Yes	Yes	Moderate	Yes	Eroding deposit down slope from shelter with 2 visible artefacts.
Warragamba-209	Pending	Shelter with Deposit, Art and Artefacts	Round Mount	12.5 x 7.2	<10%	<10%	Yes	Yes	Moderate	Yes	Yellow sandy deposit eroding down slope and containing 10+ visible artefacts.

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Warragamba-210	Pending	Open Camp Site	Hassans Walls	100 x 50	<80% below FSL, <5% above FSL	<80% below FSL, <5% above FSL	No	No	Moderate	No	
Warragamba-211	Pending	Shelter with Deposit, Art and Artefacts	water	8 x 9 estimated from site plan	<40%	50%	Yes	Yes	N/A	Yes	Several hundred artefacts on sandstone bedrock floor and eroding down slope.
Warragamba-212	Pending	Open Camp Site	Hassans Walls	100 x 75	<50% below FSL, <10% above FSL	<50% below FSL, <10% above FSL	No	No	Moderate	No	
Warragamba-213	Pending	Open Camp Site	water	Not recorded	<80% below FSL, <5% above FSL	<80% below FSL, <5% above FSL	No	No	NA	No	
Warragamba-214	Pending	Open Camp Site	water	Not recorded	<50% below FSL, <10% above FSL	<50% below FSL, <10% above FSL	No	No	NA	No	
Warragamba-215	Pending	Open Camp Site	Hassans Walls	Not recorded	<50% below FSL, <10% above FSL	<50% below FSL, <10% above FSL	No	No	Moderate	No	
Warragamba-216	Pending	Open Camp Site	Hassans Walls	100 x 60	<60% below FSL, <10% above FSL	<60% below FSL, <10% above FSL	No	No	Moderate	No	
Warragamba-217	Pending	Open Camp Site	Hassans Walls	100 x 70	<80% below FSL, <5% above FSL	<80 below FSL, <5% above FSL	No	No	Moderate	No	
Warragamba-218	Pending	Open Camp Site with Scarred Tree	Hassans Walls	350 x 200	<80% below FSL, <20% above FSL	<80% below FSL, <20% above FSL	No	No	Moderate	No	
Warragamba-219	Pending	Shelter with Deposit, Axe Grinding Grooves and Isolated Artefact	Hassans Walls	10.8 x 3.6	60%	60%	Yes	Yes	Low	Yes	Yellow sandy deposit in dripline with 1 visible artefact
Warragamba-220	Pending	Open Camp Site with Scarred Tree	Hassans Walls	250 x 130	<60%	<60%	No	No	Moderate	No	
Warragamba-221	Pending	Open Camp Site	Hassans Walls	80 x 60	<50% below FSL and <10% above FSL	<50% below FSL and <10% above FSL	No	No	Moderate	No	
Warragamba-222	Pending	Open Camp Site	water	-	<80% below FSL and <5% above	<80% below FSL and <5% above	No	No	NA	No	No
Warragamba-223	Pending	Shelter with Art and Artefacts	water	13 x 5.5	<80%	<80%	No	No	NA	No	No
Warragamba-224	Pending	Shelter with Deposit and Isolated Artefact	Kanangra Gorge	10 x 2.2	30%	20%	Yes	Yes	Low	Yes	Deposit eroding downslope in wombat hole with 1 visible artefact.
Warragamba-225	Pending	Shelter with Deposit and Artefacts	Kanangra Gorge	9.5 x 4.3	60% below FSL, 20% above FSL	80% below FSL, 10% above FSL	Yes	Yes	Low	Yes	Eroding sandy deposit on western side of shelter with 3 visible artefacts.

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Warragamba-226	Pending	Aboriginal Ceremony and Dreaming	water	Not recorded	80% below FSL, 10% above FSL	80% below FSL, 10% above FSL	No	No	NA	No	
Warragamba-227	Pending	Open Camp Site	Kanangra Gorge	100 x 30	<10%	<10%	No	No	Moderate	No	
Warragamba-228	Pending	Axe Grinding Grooves	water	3.4 x 2.5	<20%	<20%	No	No	NA	No	
Warragamba-229	Pending	Open Camp Site with PAD	Kanangra Gorge	120 x 60	<5%	<40%	Yes	Yes	Moderate	Yes	Long, mostly level saddle with possible quartz artefacts towards edge of FSL. PAD facing 120 degrees south-east.
Warragamba-230	Pending	Open Camp Site	water	200 x 100	30% below FSL, <10% above FSL	30% below FSL, <10% above FSL	No	No	NA	No	
Warragamba-231	Pending	Open Camp Site	water	-	<50% below FSL	<50% below FSL	No	No	NA	No	
Warragamba-232	Pending	Open Camp Site	water	200 x 100	40% below FSL, 10% above FSL	40% below FSL, 10% above FSL	No	No	NA	No	
Warragamba-233	Pending	Aboriginal Resource and Gathering	Kanangra Gorge	1.7 x 1.65	<10%	<10%	No	No	Moderate	No	
Warragamba-234	Pending	Open Camp Site	Kanangra Gorge	10 x 10	<10%	<10%	No	No	Moderate	No	
Warragamba-235	Pending	Open Camp Site with PAD	Kanangra Gorge	140 x 50	<5%	<5%	No	Yes	Moderate	Yes	Located on a creek terrace. Low visibility means potential for more artefacts
Warragamba-236	Pending	Open Camp Site	Round Mount	200 x 150	40%	10%	No	No	Moderate	No	Highly dispersed low-density scatter located on a spur, a landform typically associated with transient / sporadic use
Warragamba-237	Pending	Open Camp Site	water	120 x 50	<10%	<10%	No	No	NA	No	
Warragamba-238	Pending	Shelter with Deposit and Artefacts	Warragamba	11.8 x 1.9	<10%	<10%	Yes	Yes	Low	Yes	Yellow sandy deposit in dripline with 3 visible artefacts.
Warragamba-239	Pending	Shelter with Deposit and Isolated Artefact	water	29 x 6.5	<10%	<10%	Yes	Yes	NA	Yes	Yellow sandy deposit eroding down slope with 1 silcrete artefact and some discolouration from charcoal (hearth present).
Warragamba-240	Pending	Shelter with Deposit, Art and Isolated Artefact	Hawkesbury	12 x 3	<10%	<10%	Yes	Yes	High	Yes	PAD described- grey sandy deposit with 1 visible chert flake. Permanent waterhole occurs nearby on creek with faint art observed on shelter.

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Warragamba-241	Pending	Open Camp Site	water	80 x 80	<30% below FSL, <10% above FSL	<30% below FSL, <10% above FSL	No	No	NA	No	
Warragamba-242	Pending	Open Camp Site	Round Mount	150 x 80	<20% below FSL, <10% above FSL	<20% below FSL, <10% above FSL	No	No	Moderate	No	
Warragamba-243	Pending	Shelter with Deposit, Art and Artefacts	Cedar Valley	9 x 4.9	20%	20%	Yes	Yes	Low	Yes	
Warragamba-244	Pending	Open Camp Site	Cedar Valley	70 x 100	20% below FSL, 5% above FSL	20% below FSL, 5% above FSL	No	No	Low	No	
Warragamba-245	Pending	Open Camp Site	Cedar Valley	100 x 100	<40% below FSL, <10% above FSL	<40% below FSL, <10% above FSL	No	No	Moderate	No	
Warragamba-246	Pending	Shelter with Deposit and Artefacts	Cedar Valley	5.2 x 1.8	<10%	<10%	Yes	Yes	Low	Yes	Red sandy deposit eroding down slope with >12 visible artefacts.
Warragamba-247	Pending	Open Camp Site with PAD	Kanangra Gorge	100 x 100	70% below FSL, <10% above FSL	50% below FSL, <10% above FSL	No	Yes	Moderate	Yes	Artefact scatter located on elevated landform at the junction of Horse Arm Creek and Coxs River
Warragamba-248	Pending	Open Camp Site	Round Mount	80 x 50	<60%	<60%	No	No	Low	No	
Warragamba-249	Pending	Open Camp Site	water	115 x 50	40% below FSL, <5% above FSL	40% below FSL, <5% above FSL	No	No	NA	No	
Warragamba-250	Pending	Open Camp Site	Round Mount	170 x 130	<30% below FSL, <20% above FSL	<30% below FSL, <20% above FSL	No	No	Moderate	No	
Warragamba-251	Pending	Open Camp Site	Round Mount	130 x 140	30% below FSL, <20% above FSL	30% below FSL, <20% above FSL	No	No	Moderate	No	
Warragamba-252	Pending	Open Camp Site	Round Mount	100 x 120	40% below FSL, <10% above FSL	40% below FSL, <10% above FSL	No	No	Moderate	No	
Warragamba-253	Pending	Open Camp Site with PAD	Round Mount	100 x 70	60% below FSL, <20% above FSL	60% below FSL, <20% above FSL	No	Yes	Moderate	Yes	Extensive scatter located at the confluence of the Cox River and an unnamed tributary
Warragamba-254	Pending	Shelter with Deposit, Art, Artefacts and Axe Grinding Grooves	Round Mount	5 x 2	<20%	<20%	Yes	Yes	Yes	Yes	Orange/red sandy deposit in shelter and 100 m down slope with 10 - 100 visible artefacts.
Warragamba-255	Pending	Open Camp Site	Round Mount	140 x 70	<20%	<20%	No	No	Low	No	
Warragamba-256	Pending	Open Camp Site	Round Mount	70 x 50	<20%	<20%	No	No	Moderate	No	
Warragamba-257	Pending	Shelter with Axe Grinding Grooves	Round Mount	6 x 4.5	<10%	<10%	No	No	Low	No	

Site Name	AHIMS ID	Confirmed Site Type	Soil landscape unit	Approx. recorded site extent (m)	Visibility	Exposure	PAD clearly Identified in original recording Y/N	Suspected PAD based on recorded description and/or location	Predicted PAD sensitivity rating	Overall PAD evaluation	Notes / comments
Warragamba-258	Pending	Shelter with Artefacts and Axe Grinding Grooves	Round Mount	4 x 5.5	<20%	<20%	No	No	Moderate	No	No deposit noted
Warragamba-259	Pending	Shelter with Deposit, Artefacts, Axe Grinding Grooves and Tool Marks	Round Mount	10.6 x 3.8	<20%	<20%	Yes	Yes	Low	Yes	Red / orange sandy deposit eroding down slope and over the shelter floor with 100 + visible artefacts.
Warragamba-260	Pending	Shelter with Isolated Artefact	water	9.2 X 1.2	<20%	<20%	No	No	NA	No	
Warragamba-261	Pending	Shelter with Deposit, Artefacts and Axe Grinding Grooves	Round Mount	10. 5 x 4.6	<40%	<40%	Yes	Yes	Low	Yes	Red/ orange intact sandy deposit on shelter flood with 4 visible artefacts.
Warragamba-262	Pending	Open Camp Site	Round Mount	120 X 140	<50% below FSL, <10% above FSL	<50% below FSL, <10% above FSL	No	No	Low	No	
Warragamba-263	Pending	Open Camp Site	Round Mount	Not recorded	<70% below FSL, <10% above FSL	<70% below FSL, <10% above FSL	No	No	Moderate	No	
Warragamba-264	Pending	Open Camp Site	Round Mount	125 X 120	80% below FSL, 10% above FSL	80% below FSL, 10% above FSL	No	No	Moderate	No	
Warragamba-265	Pending	Open Camp Site	Round Mount	110 X 60	80% below FSL, <10% above FSL	80% below FSL, <10% above FSL	No	No	Moderate	No	
Warragamba-266	Pending	Open Camp Site	Round Mount	130 X 60	<70% below FSL, <10% above FSL	<70% below FSL, <10% above FSL	No	No	Moderate	No	
Warragamba-267	Pending	Open Camp Site with Axe Grinding Grooves	water	100 X 50	60% below FSL, <10% above FSL	60% below FSL, <10% above FSL	No	No	NA	No	
Warragamba-268	Pending	Open Camp Site with PAD	Round Mount	70 X 50	<70% below FSL, <10% above FSL	<70% below FSL, <10% above FSL	No	Yes	Moderate	Yes	Located in an elevated position at the junction of Oaky Creek and the Cox River
Warragamba-269	Pending	Isolated Artefact	Round Mount	120 X 100	50% below FSL, <10% above FSL	50% below FSL, <10% above FSL	No	No	Moderate	No	
Warragamba-271	Pending	Open Camp Site with PAD	Round Mount	180 X 30	20%	5%	Yes	Yes	Moderate	Yes	PAD noted as possible in photo log.
Warragamba-272	Pending	Shelter with Deposit and Axe Grinding Grooves	Round Mount	4.6 X 3.8	<80%	<80%	Yes	Yes	Low	Yes	Yellow sandy deposit with no visible artefacts.
Warragamba-273	Pending	Shelter with Deposit and Axe Grinding Grooves	Round Mount	5.5 X 2.7	<80%	<80%	Yes	Yes	Low	Yes	Sandy deposit with no visible artefacts.

Site Name	AHIMS ID	Confirmed Site Type	Soil landscape unit	Approx. recorded site extent (m)	Visibility	Exposure	PAD clearly Identified in original recording Y/N	Suspected PAD based on recorded description and/or location	Predicted PAD sensitivity rating	Overall PAD evaluation	Notes / comments
Warragamba-274	Pending	Shelter with Art and Axe Grinding Grooves	Round Mount	Not recorded	<20%	<20%	No	No	Low	No	
Warragamba-275	Pending	Shelter with Art and Axe Grinding Grooves	Round Mount	0.5 X 1	<20%	<20%	No	No	Moderate	No	No deposit noted
Warragamba-276	Pending	Shelter with Deposit, Art and Isolated Artefact	Round Mount	5 X 2	<80%	<80%	No	No	Low	No	
Warragamba-277	Pending	Shelter with Deposit, Art, Artefacts and Axe Grinding Grooves	Round Mount	Not recorded	<80%	<80%	Yes	Yes	Moderate	Yes	
Warragamba-278	Pending	Open Camp Site	Round Mount	Not recorded	<30%	<30%	No	No	Moderate	No	Surface of site noted to be shallow and associated with evidence of erosion
Warragamba-279	Pending	Shelter with Art	Round Mount	Not recorded	<20%	<20%	No	No	Low	No	
Warragamba-280	Pending	Open Camp Site	Round Mount	Not recorded	<10%	<10%	No	No	Moderate	No	
Warragamba-281	Pending	Shelter with Art, Artefacts and Axe Grinding Grooves	Round Mount	5.2 X 2.8	<60%	<60%	No	No	Low	No	No deposit noted
Warragamba-282	Pending	Axe Grinding Grooves	water	5 X 3.5	100%	100%	No	No	NA	No	
Warragamba-283	Pending	Shelter with Deposit and Axe Grinding Grooves	Round Mount	10 X 1	<80%	<80%	Yes	Yes	Low	Yes	
Warragamba-284	Pending	Shelter with Deposit and Axe Grinding Grooves	Cedar Valley	Not recorded	<40%	<40%	Yes	Yes	Low	Yes	
Warragamba-285	Pending	Shelter with Art and Axe Grinding Grooves	Cedar Valley	10 X 4.5	<20%	<20%	No	No	Low	No	No deposit noted
Warragamba-286	Pending	Shelter with Deposit and Axe Grinding Grooves	Cedar Valley	5 X 3	<20%	<20%	Yes	Yes	Low	Yes	Yes, though minimal
Warragamba-287	Pending	Shelter with Deposit, Art and Artefacts	Cedar Valley	5.8 X 2.2	<40%	<40%	Yes	Yes	Low	Yes	Yes, though minimal
Warragamba-288	Pending	Shelter with Deposit, Art, Artefacts and Axe Grinding Grooves	Cedar Valley	Not recorded	<40%	<40%	Yes	Yes	Low	Yes	Yes, though minimal

Site Name	AHIMS ID	Confirmed Site Type	Soil landscape unit	Approx. recorded site extent (m)	Visibility	Exposure	PAD clearly Identified in original recording Y/N	Suspected PAD based on recorded description and/or location	Predicted PAD sensitivity rating	Overall PAD evaluation	Notes / comments
Warragamba-289	Pending	Shelter with Deposit, Art, Artefacts and Axe Grinding Grooves	Cedar Valley	15 X 5.4	<20%	<20%	Yes	Yes	Low	Yes	Rocky loose deposit more than 50 cm in depth in west of shelter with 2 visible artefacts/
Warragamba-290	Pending	Axe Grinding Grooves	water	2 X 1.8	<20%	<20%	No	No	NA	No	
Warragamba-291	Pending	Open Camp Site with Axe Grinding Grooves	Cedar Valley	17 X 7.5	<40%	<40%	No	No	Low	No	
Warragamba-292	Pending	Shelter with Deposit, Artefacts and Axe Grinding Grooves	Cedar Valley	8.6 X 44	<80%	<80%	Yes	Yes	Low	Yes	
Warragamba-293	Pending	Open Camp Site	Cedar Valley	8 X 0.5	<40%	<40%	No	No	Low	No	
Warragamba-294	Pending	Shelter with Deposit and Artefacts	Cedar Valley	6 X 4.2	<20%	<20%	Yes	Yes	Low	Yes	
Warragamba-295	Pending	Shelter with Deposit, Art and Artefacts	Cedar Valley	10 X 10	<60%	<60%	Yes	Yes	Low	Yes	
Warragamba-296	Pending	Shelter with Deposit, Art, Artefacts and Axe Grinding Grooves	Warragamba	36 X 10	<20%	<20%	Yes	Yes	Low	Yes	
Warragamba-297	Pending	Shelter with Deposit and Artefacts	Warragamba	27 X 7.2	<50%	<50%	Yes	Yes	Low	Yes	
Warragamba-298	Pending	Shelter with Deposit, Axe Grinding Grooves and Isolated Artefact	Warragamba	13 X 3.2	<60%	<60%	Yes	Yes	Low	Yes	
Warragamba-299	Pending	Shelter with Deposit and Artefacts	Warragamba	30 X 8.2	<80%	<80%	Yes	Yes	Low	Yes	
Warragamba-300	Pending	Shelter with Deposit and Art	Warragamba	16 X 5.7	<40%	<40%	Yes	Yes	Low	Yes	
Warragamba-301	Pending	Shelter with Deposit and Artefacts	Warragamba	12 X 12	<90%	<90%	Yes	Yes	Low	Yes	
Warragamba-302	Pending	Open Camp Site	water	10 X 80	<20%	<20%	No	No	NA	No	
Warragamba-303	Pending	Open Camp Site	Round Mount	60 X 100	<20%	<20%	No	No	Moderate	No	
Warragamba-304	Pending	Axe Grinding Grooves	Round Mount	10 X 10	<40%	<40%	No	No	Moderate	No	
Warragamba-305	Pending	Shelter with Deposit, Artefacts and Axe Grinding Grooves	Round Mount	Not recorded	<80%	<80%	Yes	Yes	Moderate	Yes	
Warragamba-306	Pending	Shelter with Deposit and Artefacts	Cedar Valley	10 X 3	<10%	<10%	Yes	Yes	Low	Yes	

Site Name	AHIMS ID	Confirmed Site Type	Soil landscape unit	Approx. recorded site extent (m)	Visibility	Exposure	PAD clearly Identified in original recording Y/N	Suspected PAD based on recorded description and/or location	Predicted PAD sensitivity rating	Overall PAD evaluation	Notes / comments
Warragamba-307	Pending	Shelter with Deposit, Artefacts and Axe Grinding Grooves	Cedar Valley	10 X 7.2	<90%	<90%	Yes	Yes	Low	Yes	

Appendix 7: Updated Scientific significance assessment for sites with PAD

Scientific Significance of Artefact Sites (Open Camp Sites & Isolated Artefacts) where PAD is now listed as an archaeological feature

AHIMS ID	Site Name	Site Type	Significance Statement	Research Potential	Representativeness	Rarity	Scientific Significance Rating
Pending	Warragamba-00	Open Camp Site with PAD	Warragamba-00 comprises an artefact scatter located on a river terrace close to a creek and unnamed drainage line. The landscape surrounding the area is comprised of tall trees of various species and signs of new growth is evident in the area, most probably from past clearing of the old vegetation. Despite evidence of disturbance, the site's location on a river terrace indicates potential for sub-surface archaeological deposits. The site is given an overall scientific significance rating of moderate, due to the potential for intact subsurface archaeological deposits at the site.	Moderate- There is potential for subsurface deposit to be associated with the artefacts located at this site.	Low- As there are 195 open camp sites within the Subject Area, it does not impact the representative class of Open Camp Sites in the Subject Area.	Low- Due to high number of Open Camp Sites within the Subject Area and its surrounds.	Moderate- There is potential for subsurface deposit to be located within this site.
Pending	Warragamba-01	Open Camp Site with PAD	Warragamba-01 comprises an artefact scatter located a top of a flat terrace close to Golden Moon Creek. The site contains at least four flakes made from quartz and quartzite. The site's location on a river terrace indicates potential for sub-surface archaeological deposits. The site is given an overall scientific significance rating of moderate, due to the potential for intact subsurface archaeological deposits at the site.	Moderate- There is potential for subsurface deposit to be associated with the artefacts located at this site.	Low- As there are 195 open camp sites within the Subject Area, it does not impact the representative class of Open Camp Sites in the Subject Area.	Low- Due to high number of Open Camp Sites within the Subject Area and its surrounds.	Moderate- There is potential for subsurface deposit to be located within this site.
Pending	Warragamba-12	Open Camp Site with PAD	Warragamba-12 comprises an artefact scatter located on an elevated landform within the exposure of an old road. The site is approximately 1.3 km from the junction of the Nattai and Little Rivers. The site comprises of eight stone artefacts made of chert and quartz. It is highly likely that there is subsurface deposit associated with this site. The site is given an overall scientific significance rating of moderate, due to the potential for intact subsurface archaeological deposits at the site.	Moderate- There is potential for subsurface deposit to be associated with the artefacts located at this site.	Low- As there are 195 open camp sites within the Subject Area, it does not impact the representative class of Open Camp Sites in the Subject Area.	Low- Due to high number of Open Camp Sites within the Subject Area and its surrounds.	Moderate- There is potential for subsurface deposit to be located within this site.
Pending	Warragamba-18	Open Camp Site with PAD	Warragamba-18 comprises an artefact scatter located on lower slope of a ridge near Gorman Point. Low density but associated with some hearth material and burnt clay scattered on surface indicative of past use of a longer duration (i.e. use involving camping) and the accumulation of sub-surface deposits. The site is given an overall scientific significance rating of moderate, due to the potential for intact subsurface archaeological deposits at the site.	Moderate- There is potential for subsurface deposit to be associated with the artefacts located at this site.	Low- As there are 195 open camp sites within the Subject Area, it does not impact the representative class of Open Camp Sites in the Subject Area.	Low- Due to high number of Open Camp Sites within the Subject Area and its surrounds.	Moderate- There is potential for subsurface deposit to be located within this site.
Pending	Warragamba-27	Open Camp Site with PAD	Warragamba-27 comprises an artefact scatter positioned at Kamilaroi Point, just above the high-water mark of Lake Burragorang. The site measures 150 m x 250 m and is located nearby a Shelter with Deposit (AHIMS ID 52-1-0142). A sample of six artefacts were recorded at this site. Landscape context and association with another occupation site indicates potential for more frequent use of area and sub-surface potential. The site is given an overall scientific significance rating of moderate, due to the potential for intact subsurface archaeological deposits at the site.	Moderate- There is potential for subsurface deposit to be associated with the artefacts located at this site.	Low- As there are 195 open camp sites within the Subject Area, it does not impact the representative class of Open Camp Sites in the Subject Area.	Low- Due to high number of Open Camp Sites within the Subject Area and its surrounds.	Moderate- There is potential for subsurface deposit to be located within this site.
Pending	Warragamba-39	Open Camp Site with PAD	Warragamba-39 comprises of over 258 stone artefacts and burnt clay along the foreshore of Lake Burragorang. The site is given an overall scientific significance rating of high, due to the large number of artefacts and the potential for intact subsurface archaeological deposits at the site.	High- There is potential for subsurface deposit to be associated with the artefacts located at this site.	High	High- There are a low number of Open Camp Sites of more than 250 artefacts located on the shore of Lake Burragorang.	High- There is potential for subsurface deposit to be present in association with an extensive artefact scatter.

AHIMS ID	Site Name	Site Type	Significance Statement	Research Potential	Representativeness	Rarity	Scientific Significance Rating
Pending	Warragamba-40	Open Camp Site with PAD	Warragamba-40 comprises of over 18 stone artefacts along the foreshore of Lake Burragorang, the site measures 200 m x 200m... The site is given an overall scientific significance rating of high, due to the large number of artefacts and the potential for intact subsurface archaeological deposits at the site.	High- There is potential for subsurface deposit to be associated with the artefacts located at this site.	High	High- There are a low number of Open Camp Sites of more than 18 artefacts located on the shore of Lake Burragorang.	High- There is potential for subsurface deposit to be present in association with an extensive artefact scatter.
Pending	Warragamba-48	Open Camp Site with PAD	Warragamba-48 comprises of over 24 stone artefacts, including six axes along the foreshore of Lake Burragorang and measure 250 m x 250 m. The site is given an overall scientific significance rating of high, due to the large number of artefacts and the potential for intact subsurface archaeological deposits at the site.	High- There is potential for subsurface deposit to be associated with the artefacts located at this site.	High	High- There are a low number of Open Camp Sites of more than 24 artefacts located on the shore of Lake Burragorang.	High- There is potential for subsurface deposit to be present in association with an extensive artefact scatter.
Pending	Warragamba-72	Open Camp Site with PAD	Warragamba-72 comprises an artefact scatter located adjacent to Wollondilly River. Red alluvial deposit recorded as occurring across all of the landform with the possibility for in-situ deep deposits noted despite some disturbance from wombat burrowing in the upper layers. The site is given an overall scientific significance rating of high, due to the large number of artefacts and the potential for intact subsurface archaeological deposits below the upper levels of surface disturbance at the site.	Moderate- There is potential for subsurface deposit to be associated with the artefacts located at this site.	Low- As there are 195 open camp sites within the Subject Area, it does not impact the representative class of Open Camp Sites in the Subject Area.	Low- Due to high number of Open Camp Sites within the Subject Area and its surrounds.	Moderate- There is potential for subsurface deposit to be located within this site.
Pending	Warragamba-77	Isolated Artefact with PAD	Warragamba-77 comprises an isolated artefact located adjacent to Wollondilly River. The artefact is located in an area with very low visibility with a high potential for additional artefacts to be present in the area. The sites location in an alluvial soil landscape suggests potential for deep intact subsurface archaeological deposits. The site is given an overall scientific significance rating of moderate, due to the potential for additional artefacts and intact subsurface archaeological deposits to be present at the site.	Moderate- There is potential for subsurface deposit to be associated with the artefacts located at this site.	Low- There are 21 isolated artefact sites recorded within the Subject Area	Low- Due to low number of artefacts present and the high number of other artefacts found within the Subject Area.	Moderate- There is potential for subsurface deposit to be located within this site.
Pending	Warragamba-94	Open Camp Site with PAD	Warragamba-94 comprises of over 10 stone artefacts on the foreshore of the Wollondilly River. The site measures 180 m x 350 m. The site is given an overall scientific significance rating of high, due to the large number of artefacts and the potential for intact subsurface archaeological deposits at the site.	High- There is a large number of artefacts located at this site. A sample of 10 were recorded for the purpose of this assessment but the scatter was noted as being extensive.	High	High- There are a low number of Open Camp Sites of more than 10 artefacts located on the shore of Wollondilly River.	High- There is potential for subsurface deposit to be present in association with an extensive artefact scatter.
Pending	Warragamba-96	Open Camp Site with PAD	Warragamba-96 comprises an artefact scatter with potential for subsurface deposit located on western side of Tonalli Point and extends 250 m x 50 m. Low visibility at the site means that there is a high potential for additional surface artefacts to be present across the level landform to the west with potential for more extensive occupation evidence towards the ridge to the north. The site is given an overall scientific significance rating of moderate, due to the potential for additional artefacts and intact subsurface archaeological deposits to be present at the site.	Moderate- There is potential for subsurface deposit to be associated with the artefacts located at this site.	Low- As there are 195 open camp sites within the Subject Area, it does not impact the representative class of Open Camp Sites in the Subject Area.	Low- Due to high number of Open Camp Sites within the Subject Area and its surrounds.	Moderate- There is potential for subsurface deposit to be located within this site.
Pending	Warragamba-101	Isolated Artefact with PAD	Warragamba-101 comprises an isolated artefact located within a valley flat at Tonalli Cove. The artefact consists of a large chert core. Visibility and exposure was low with a high likelihood of more artefacts being present within the area. The position of site within landscape (valley flat at cove) increases archaeological sensitivity of the area and there is potential for sub-surface deposits to also be present. The site is given an overall scientific significance rating of	Moderate- There is potential for subsurface deposit to be associated with the artefacts located at this site.	Low- There are 21 isolated artefact sites recorded within the Subject Area	Low- Due to low number of artefacts present and the high number of other artefacts found within the Subject Area.	Moderate- There is potential for subsurface deposit to be located within this site.

AHIMS ID	Site Name	Site Type	Significance Statement	Research Potential	Representativeness	Rarity	Scientific Significance Rating
			moderate, due to the potential for additional artefacts and intact subsurface archaeological deposits to be present at the site.				
Pending	Warragamba-102	Isolated Artefact with PAD	Warragamba-102 comprises an isolated artefact located within a valley flat at Tonalli Cove. The artefact was exposed as a result of wombat burrowing indicating its original sub-surface origin. Visibility and exposure was low with a high likelihood of more artefacts being present within the area including sub-surface archaeological deposits. The site is given an overall scientific significance rating of moderate, due to the potential for additional artefacts and intact subsurface archaeological deposits to be present below the upper levels of disturbance at the site.	Moderate- There is potential for subsurface deposit to be associated with the artefacts located at this site.	Low- There are 21 isolated artefact sites recorded within the Subject Area	Low- Due to low number of artefacts present and the high number of other artefacts found within the Subject Area.	Moderate- There is potential for subsurface deposit to be located within this site.
Pending	Warragamba-109	Open Camp Site with PAD	Warragamba-109 comprises of over 25 stone artefacts on the foreshore of the Wollondilly River. Warragamba 48 and Warragamba 110, located on the opposite river bank are associated with this site The site is given an overall scientific significance rating of high, due to the large number of artefacts and the potential for intact subsurface archaeological deposits at the site.	High- There is a large number of artefacts located at this site. A sample of 25 were recorded for the purpose of this assessment	High	High- There are a low number of Open Camp Sites of more than 25 artefacts located on the shore of Lake Burragorang.	High- There is potential for subsurface deposit to be present in association with an extensive artefact scatter.
Pending	Warragamba-110	Open Camp Site with PAD	Warragamba-110 comprises of over 14 stone artefacts on the foreshore of the Wollondilly River and measures 100 m x 100m. Warragamba 109, located on the opposite river bank are associated with this site The site is given an overall scientific significance rating of high, due to the large number of artefacts and the potential for intact subsurface archaeological deposits at the site.	High- There is potential for subsurface deposit to be associated with the artefacts located at this site.	High	High- There are a low number of Open Camp Sites of more than 14 artefacts located on the shore of Lake Burragorang.	High- There is potential for subsurface deposit to be present in association with an extensive artefact scatter.
Pending	Warragamba-134	Isolated Artefact with PAD	Warragamba-134 consists of a single basalt hatchet in an area with 100% exposure and visibility on the terrace bank of the Cox's River. The site's location within an alluvial soil landscape means that there is a high potential for preserving deep stratified archaeological deposits. The site is given an overall scientific significance rating of moderate, due to the potential for additional artefacts and intact subsurface archaeological deposits to be present below the upper levels of disturbance at the site.	Moderate- There is potential for subsurface deposit to be associated with the artefacts located at this site.	Low- There are 21 isolated artefact sites recorded within the Subject Area	Low- Due to low number of artefacts present and the high number of other artefacts found within the Subject Area.	Moderate- There is potential for subsurface deposit to be located within this site.
Pending	Warragamba-137	Open Camp Site with PAD	Warragamba-137 comprises an extensive artefact scatter located on an alluvial terrace 30m from Kedumba River. A sample of 18 artefacts recorded. The site's location within an alluvial soil landscape means that there is a high potential for preserving deep stratified archaeological deposits. The site is given an overall scientific significance rating of high, due to the large number of artefacts and the potential for intact subsurface archaeological deposits at the site.	High- There is a large number of artefacts located at this site. A sample of 18 were recorded for the purpose of this assessment	High	High- There are a low number of Open Camp Sites of more than 18 artefacts located on an alluvial terrace of Kedumba River.	High- There is potential for subsurface deposit to be present in association with an extensive artefact scatter.
Pending	Warragamba-138	Open Camp Site with PAD	Warragamba-138 comprises a low-density artefact scatter located on a terrace near the junction of Rocky and Butchers Creek with a high potential for sub-surface archaeological deposits. The site is given an overall scientific significance rating of moderate, due to the potential for additional artefacts and intact subsurface archaeological deposits to be present at the site.	Moderate- There is potential for subsurface deposit to be associated with the artefacts located at this site.	Low- As there are 195 open camp sites within the Subject Area, it does not impact the representative class of Open Camp Sites in the Subject Area.	Low- Due to high number of Open Camp Sites within the Subject Area and its surrounds.	Moderate- There is potential for subsurface deposit to be located within this site.
Pending	Warragamba-147	Open Camp Site with PAD	Warragamba-147 comprises an artefact scatter located on a terrace adjacent to Burragorang Lake. The site is situated within an archaeologically sensitive landform with subsurface artefacts	Moderate- There is potential for subsurface deposit to be	Low- As there are 195 open camp sites within the Subject Area, it does not impact the	Low- Due to high number of Open Camp Sites within the Subject Area and its surrounds.	Moderate- There is potential for subsurface deposit to be located within this site.

AHIMS ID	Site Name	Site Type	Significance Statement	Research Potential	Representativeness	Rarity	Scientific Significance Rating
			considered likely to be present. The site is given an overall scientific significance rating of moderate, due to the potential for additional artefacts and intact subsurface archaeological deposits to be present at the site.	associated with the artefacts located at this site.	representative class of Open Camp Sites in the Subject Area.		
Pending	Warragamba-148	Open Camp Site with PAD	Warragamba-148 comprises an artefact scatter located on a lower slope of Houlouhan Point. Artefacts were exposed from erosion by stored water. The exposure of artefacts in this manner indicates a sub-surface origin and thus additional sub-surface potential. The site is given an overall scientific significance rating of moderate, due to the potential for intact subsurface archaeological deposits to be present below the upper levels of disturbance at the site.	Moderate- There is potential for subsurface deposit to be associated with the artefacts located at this site.	Low- As there are 195 open camp sites within the Subject Area, it does not impact the representative class of Open Camp Sites in the Subject Area.	Low- Due to high number of Open Camp Sites within the Subject Area and its surrounds.	Moderate- There is potential for subsurface deposit to be located within this site.
Pending	Warragamba-150	Open Camp Site with PAD	Warragamba-150 comprises an artefact scatter located on a lower slope near the foreshore of Lake Burragorang. The site contains artefacts manufactured from an unusual unknown raw material compared to sites on the other side of the stored water. The site is located within an archaeologically sensitive landform with visible artefacts that were eroding downslope. The exposure of artefacts in this manner indicates a sub-surface origin and thus additional sub-surface potential. The site is given an overall scientific significance rating of moderate, due to the potential for intact subsurface archaeological deposits to be present below the upper levels of disturbance at the site.	Moderate- There is potential for subsurface deposit to be associated with the artefacts located at this site.	Low- As there are 195 open camp sites within the Subject Area, it does not impact the representative class of Open Camp Sites in the Subject Area.	Low- Due to high number of Open Camp Sites within the Subject Area and its surrounds.	Moderate- There is potential for subsurface deposit to be located within this site.
Pending	Warragamba-155	Open Camp Site with PAD	Warragamba-155 comprises an artefact scatter located on a point between an unnamed creek and Woodville point. Artefacts included three ground-edge axes. The recording from noted that the site was within an archaeologically sensitive landform with visible artefacts that were eroding downslope. The exposure of artefacts in this manner indicates a sub-surface origin and thus additional sub-surface potential. The site is given an overall scientific significance rating of moderate, due to the potential for intact subsurface archaeological deposits to be present below the upper levels of disturbance at the site.	Moderate- There is potential for subsurface deposit to be associated with the artefacts located at this site.	Low- As there are 195 open camp sites within the Subject Area, it does not impact the representative class of Open Camp Sites in the Subject Area.	Low- Due to high number of Open Camp Sites within the Subject Area and its surrounds.	Moderate- There is potential for subsurface deposit to be located within this site.
Pending	Warragamba-156	Open Camp Site with PAD	Warragamba-156 comprises an extensive artefact scatter located alongside the stored water on a large, flat area which comprises Woodville point, and is north of the landform containing Warragamba – 155. An extensive artefact scatter was observed in this region, with a representative sample of 20 artefacts recorded. This point is at the mid-point of the valley it resides in. The position of the site in the landscape (i.e. large flat area in the valley suitable for camping and thus repeated / focused occupation) increases the potential for archaeological deposits. The site is given an overall scientific significance rating of high, due to the large number of artefacts and the potential for intact subsurface archaeological deposits at the site.	High- There is a large number of artefacts located at this site. A sample of 20 were recorded for the purpose of this assessment	High	High- There are a low number of Open Camp Sites of more than 20 artefacts located within a open valley.	High- There is potential for subsurface deposit to be present in association with an extensive artefact scatter.
Pending	Warragamba-199	Open Camp Site with PAD	Warragamba-199 comprises an artefact scatter containing 8 artefacts including two basalt cores located directly south of Warragamba-200 a shelter with artefacts and deposit. Sub-surface potential inferred from the site's close association with a shelter /occupation site which indicates the area may have been used repeatedly or more intensively allowing for the accumulation of	Moderate- There is potential for subsurface deposit to be associated with the artefacts located at this site.	Low- As there are 195 open camp sites within the Subject Area, it does not impact the representative class of Open Camp Sites in the Subject Area.	Low- Due to high number of Open Camp Sites within the Subject Area and its surrounds.	Moderate- There is potential for subsurface deposit to be located within this site.

AHIMS ID	Site Name	Site Type	Significance Statement	Research Potential	Representativeness	Rarity	Scientific Significance Rating
			deposits with evidence of past activities undertaken in the area. The site is given an overall scientific significance rating of moderate, due to the potential for intact subsurface archaeological deposits to be present at the site.				
Pending	Warragamba-202	Open Camp Site with PAD	Warragamba-202 comprises of over 15 stone artefacts. The site is given an overall scientific significance rating of moderate, due to the large number of artefacts and the potential for intact subsurface archaeological deposits at the site.	Moderate- There is potential for subsurface deposit to be associated with the artefacts located at this site.	Low- As there are 195 open camp sites within the Subject Area, it does not impact the representative class of Open Camp Sites in the Subject Area.	Low- Due to high number of Open Camp Sites within the Subject Area and its surrounds.	Moderate- There is potential for subsurface deposit to be located within this site.
Pending	Warragamba-229	Open Camp Site with PAD	Warragamba-229 comprises an artefact scatter located along a long mostly level saddle near the foreshore of Lake Burragorang. Potential archaeological deposits is recorded as being present in the south-eastern portion of the site. The site is given an overall scientific significance rating of moderate, due to the potential for intact subsurface archaeological deposits to be present at the site.	Moderate- There is potential for subsurface deposit to be associated with the artefacts located at this site.	Low- As there are 195 open camp sites within the Subject Area, it does not impact the representative class of Open Camp Sites in the Subject Area.	Low- Due to high number of Open Camp Sites within the Subject Area and its surrounds.	Moderate- There is potential for subsurface deposit to be located within this site.
Pending	Warragamba-235	Open Camp Site with PAD	Warragamba-235 comprises an artefact scatter located on a creek terrace near the junction of Alum Springs Creek and Lake Burragorang. Scatter located in a tall forest. Four artefacts including an axe and large basalt cores were recorded. Low visibility (<5%) means that there is a high potential for further artefacts to be present. Location on a creek terrace means that there is a high potential for sub-surface deposits. The site is given an overall scientific significance rating of moderate, due to the potential for additional artefacts and intact subsurface archaeological deposits to be present at the site.	Moderate- There is potential for subsurface deposit to be associated with the artefacts located at this site.	Low- As there are 195 open camp sites within the Subject Area, it does not impact the representative class of Open Camp Sites in the Subject Area.	Low- Due to high number of Open Camp Sites within the Subject Area and its surrounds.	Moderate- There is potential for subsurface deposit to be located within this site.
Pending	Warragamba-247	Open Camp Site with PAD	Warragamba-247 comprises of over 15 stone artefacts. The site is given an overall scientific significance rating of moderate, due to the large number of artefacts and the potential for intact subsurface archaeological deposits at the site.	Moderate- There is potential for subsurface deposit to be associated with the artefacts located at this site.	Low- As there are 195 open camp sites within the Subject Area, it does not impact the representative class of Open Camp Sites in the Subject Area.	Low- Due to high number of Open Camp Sites within the Subject Area and its surrounds.	Moderate- There is potential for subsurface deposit to be located within this site.
Pending	Warragamba-253	Open Camp Site with PAD	Warragamba-253 comprises of over 15 stone artefacts. The site is given an overall scientific significance rating of moderate, due to the large number of artefacts and the potential for intact subsurface archaeological deposits at the site.	Moderate- There is potential for subsurface deposit to be associated with the artefacts located at this site.	Low- As there are 195 open camp sites within the Subject Area, it does not impact the representative class of Open Camp Sites in the Subject Area.	Low- Due to high number of Open Camp Sites within the Subject Area and its surrounds.	Moderate- There is potential for subsurface deposit to be located within this site.
Pending	Warragamba-268	Open Camp Site with PAD	Warragamba-268 comprises an artefact scatter located in elevated position at the junction of Oaky Creek and the Cox River. A sample of 8 artefacts recorded including basalt cores, quartz cores and flakes. The site's location in an elevated context at the confluence of two watercourses indicates high archaeological potential including sub-surface potential. The site is given an overall scientific significance rating of moderate, due to the potential for intact subsurface archaeological deposits to be present at the site.	Moderate- There is potential for subsurface deposit to be associated with the artefacts located at this site.	Low- As there are 195 open camp sites within the Subject Area, it does not impact the representative class of Open Camp Sites in the Subject Area.	Low- Due to high number of Open Camp Sites within the Subject Area and its surrounds.	Moderate- There is potential for subsurface deposit to be located within this site.
Pending	Warragamba-271	Open Camp Site with PAD	Warragamba-271 comprises an artefact scatter located on a long flat ridge on a bend in Oaky Creek, a tributary of the Cox River, and within 50 m of this water source. There were several chert and quartz artefacts observed and a basalt axe. The site is considered to have a high potential for sub-surface archaeological deposits. The	Moderate- There is potential for subsurface deposit to be associated with the artefacts located at this site.	Low- As there are 195 open camp sites within the Subject Area, it does not impact the representative class of Open Camp Sites in the Subject Area.	Low- Due to high number of Open Camp Sites within the Subject Area and its surrounds.	Moderate- There is potential for subsurface deposit to be located within this site.

AHIMS ID	Site Name	Site Type	Significance Statement	Research Potential	Representativeness	Rarity	Scientific Significance Rating
			site is given an overall scientific significance rating of moderate, due to the potential for intact subsurface archaeological deposits to be present at the site.				

Shelter sites with Deposit whose scientific significance ratings and statements have been updated

AHIMS ID	Site Name	Site Type	Significance Statement	Research Potential	Representativeness	Rarity	Scientific Significance Rating
Pending	Warragamba-112	Shelter with Deposit and Artefacts	Warragamba 112 comprises of a sandstone shelter formed through cavernous weathering and block fall in antiquity. This shelter is located on the mid slope of a ridgeline. The artefacts within this shelter are located within the floor deposit. The site type, shelter with deposit is common within the region but due to the presence of sandy deposit in good condition and the potential to contain further evidence of occupation on the eastern side of Kedumba waterhole the site is provisionally assessed as being of moderate scientific significance.	Moderate- Due to good sandy deposit with the potential to contain further evidence of occupation on eastern side of Kedumba waterhole.	Low- Due to low number of features which are unable to act as an exemplar representative sample as well as previous disturbance.	Low- Due to high number of shelters within the Subject Area and the surrounding landscape, numbering 83 in total.	Moderate
Pending	Warragamba-113	Shelter with Deposit, Art, Artefacts and Axe Grinding Grooves	Warragamba 113 comprises of a sandstone shelter formed through cavernous weathering and block fall in antiquity. This shelter is located on the mid slope of a ridgeline. The site contains art, deposit and five axe grinding grooves. All of the art depictions are indeterminate in form and drawn in charcoal. However, due to the presence of flat sandy deposit with the potential to contain further evidence of occupation the site is provisionally assessed as being of moderate scientific significance.	Moderate- Due to flat sandy deposit with potential to contain further evidence of occupation.	Low- Due to the condition and nature of most features which are unable to act as an exemplar representative sample as well as previous disturbance.	Low- Due to high number of shelters within the Subject Area and the surrounding landscape, numbering 83 in total.	Moderate
Pending	Warragamba-135	Shelter with Deposit and Axe Grinding Grooves	Warragamba 135 is a shelter with abrasion patches situated mid-slope of a gully formed by cavernous weathering and block fall in antiquity and is located an unnamed creek. However, due to the presence of a large floor with sandy deposit and hearth material with potential to contain further evidence of occupation the site is provisionally assessed as being of moderate scientific significance.	Moderate- Due to large floor with sandy deposit and hearth material with potential to contain further evidence of occupation.	Low- Due to the condition and nature of most features which are unable to act as an exemplar representative sample as well as previous disturbance.	Low- Due to high number of shelters within the Subject Area and the surrounding landscape, numbering 83 in total.	Moderate
Pending	Warragamba-136	Shelter with Deposit	Warragamba – 136 is a shelter with deposit with a high potential to contain cultural material. This shelter is affected by fissuring, block fall and exfoliation on the back wall. Evidence of wombats was present on the site. The site type, shelter with deposit is common within the region. However, due to the presence of a large floor space with sandy deposit and hearth material with potential to contain further evidence of occupation the site is provisionally assessed as being of moderate scientific significance.	Moderate- Due to large floor with sandy deposit and hearth material with potential to contain further evidence of occupation.	Low- Due to the condition and nature of most features which are unable to act as an exemplar representative sample as well as previous disturbance.	Low- Due to high number of shelters within the Subject Area and the surrounding landscape, numbering 83 in total.	Moderate
Pending	Warragamba-165	Shelter with Deposit and Artefacts	Warragamba – 165 is a shelter with deposit located on a bench on the lower slopes of a ridgeline, the shelter is within 50m of the stored water. Warragamba – 166 extends north to the end of the point on which this site is located. There was an archaeological deposit located at this shelter and 11 artefacts were located, mostly at the shelter's dripline. The site type, shelter with deposit is common within the region. However, due to the presence of relatively un-disturbed deposit in dripline in association with at least 11 artefacts and the potential for additional sub-surface evidence of occupation the site is provisionally assessed as being of moderate scientific significance.	Moderate- Due to relatively un-disturbed deposit in dripline in association with at least 11 artefacts and the potential for additional sub-surface evidence of occupation.	Low- Due to low number of features which are unable to act as an exemplar representative sample as well as previous disturbance.	Low- Due to high number of shelters within the Subject Area and the surrounding landscape, numbering 83 in total.	Moderate

AHIMS ID	Site Name	Site Type	Significance Statement	Research Potential	Representativeness	Rarity	Scientific Significance Rating
Pending	Warragamba-182	Shelter with Deposit, Art and Artefacts	Warragamba-182 is a Shelter with Art, Deposit and Artefacts that is located 50m east of an unnamed tributary of Ripple Creek. The shelter was formed by cavernous weathering and block fall and shows evidence of exfoliation, fissuring and block fall. There were eight motifs recorded at this shelter, with one humanoid figure and several motifs consisting of lines and is in poor condition. There were five artefacts located as part of this survey. However, due to the presence of deposit, possible in-situ hearth with visible charcoal and artefacts and the potential to contain additional sub-surface evidence of occupation the site is provisionally assessed as being of moderate scientific significance.	Low- Due to the presence of deposit, possible in-situ hearth with visible charcoal and artefacts and the potential to contain additional sub-surface evidence of occupation despite the poor condition and low number of art panels.	Low- Due to low number of features which are unable to act as an exemplar representative sample as well as previous disturbance.	Low- Due to high number of shelters within the Subject Area and the surrounding landscape, numbering 83 in total.	Moderate
Pending	Warragamba-187	Shelter with Deposit	Warragamba-187 is a Shelter with Deposit located on a creek bank beside the stored water in Lacy's Creek. The shelter is formed by an isolated boulder, and shows signs of chemical weathering, water wash and salt and granular loss. There is a yellow sandy deposit located in the shelter. The site type, shelter with deposit is common within the region. However, due to the presence of potentially deep yellow-brown sandy deposit with the potential to contain stratified evidence of past occupation the site is provisionally assessed as being of moderate scientific significance.	Moderate-Due to the presence of potentially deep yellow-brown sandy deposit with the potential to contain stratified evidence of past occupation.	Low- Due to low number of features which are unable to act as an exemplar representative sample as well as previous disturbance.	Low- Due to high number of shelters within the Subject Area and the surrounding landscape, numbering 83 in total.	Moderate
Pending	Warragamba-192	Shelter with Deposit	Warragamba-192 is a Shelter with Deposit located at the base of a ridgeline beside Ripple Creek. The shelter was formed by cavernous weathering and has evidence of exfoliation on back wall and ceiling, block fall on roof, and is subject from water weathering from the stored water, which inundates the site. There is a yellow sandy deposit, but no artefacts were located during this survey. The site type, shelter with deposit is common within the region. However, due to the presence of potentially deep yellow-brown sandy deposit with the potential to contain stratified evidence of past occupation the site is provisionally assessed as being of moderate scientific significance.	Moderate-Due to the presence of potentially deep yellow-brown sandy deposit with the potential to contain stratified evidence of past occupation.	Low- Due to low number of features which are unable to act as an exemplar representative sample as well as previous disturbance.	Low- Due to high number of shelters within the Subject Area and the surrounding landscape, numbering 83 in total.	Moderate
Pending	Warragamba-200	Shelter with Deposit and Artefacts	Warragamba-200 is a Shelter with Deposit and Artefacts located directly north of Warragamba-199, beside the stored water at Lake Burragorang. The shelter was formed by an isolated boulder and shows evidence of water damage from stored water inundation, as well as block fall. There was a yellow sandy deposit in the floor of the shelter, and a sample of 20 artefacts was located in the shelter and the eroding surface of the surrounding landscape. Evidence of fissuring was also recorded on the roof of the shelter. The site type, shelter with deposit is common within the region though the high number of artefacts associated with such site type is uncommon. However, due to relatively un-disturbed nature of the yellow sandy deposit associated with an estimated 200+ artefacts the site is provisionally assessed as being of high scientific significance.	High- Due to relatively un-disturbed yellow sandy deposit associated with an estimated 200+ artefacts	Moderate – Due to the low number of such site types with such a high density of artefacts	Moderate – Due to the low number of such site types with such a high density of artefacts	High
Pending	Warragamba-211	Shelter with Deposit, Art and Artefacts	Warragamba-211 is a Shelter with Art, Deposit and Artefacts located beside the stored water along the Wollondilly River, south of Blattmann Point and north of Warragamba-210. The shelter was formed by an isolated boulder and is impacted by flooding as it is below the FSL. There is also evidence of fissuring and exfoliation on the roof and black fall and chemical weathering also impacts the site. The art present is 3 parallel red linear vertical lines, and the art surface is in poor condition. A sample of 15 artefacts were recorded during this assessment with a potential for hundreds of artefacts considered likely. Several volcanic artefacts were present as part of this sample. Although shelter floor is largely sandstone bedrock, the area and deposit immediately outside of and surrounding the shelter contains 'hundreds of artefacts'. Due to the large number of artefacts and	High- Due to the large number of artefacts and potential for additional stratified evidence of occupation.	Moderate – Due to the low number of such site types with such a high density of artefacts	Moderate – Due to the low number of such site types with such a high density of artefacts	High

AHIMS ID	Site Name	Site Type	Significance Statement	Research Potential	Representativeness	Rarity	Scientific Significance Rating
			potential for additional stratified evidence of occupation, the site is provisionally assessed as being of high scientific significance.				
Pending	Warragamba-225	Shelter with Deposit and Artefacts	Warragamba-225 is a Shelter with Deposit and Artefacts located 340m North West of Warragamba-225, alongside the stored water. There were three artefacts located during this survey. The site type, shelter with deposit is common within the region. However, due to the presence of relatively undisturbed yellow deposit at western side of shelter with the potential to contain additional evidence of occupation, the site is provisionally assessed as being of moderate scientific significance.	Moderate- Due to undisturbed yellow deposit at western side of shelter with the potential to contain additional evidence of occupation.	Low- Due to low number of features which are unable to act as an exemplar representative sample as well as previous disturbance.	Low- Due to high number of shelters within the Subject Area and the surrounding landscape, numbering 83 in total.	Moderate
Pending	Warragamba-238	Shelter with Deposit and Artefacts	Warragamba-238 is a Shelter with Deposit and Artefacts located beside the stored water on the South side of Warragamba Gorge, next to an unnamed tributary of the Warragamba River. There were three artefacts located at this site. The site type, shelter with deposit is common within the region. However, due to good condition of undisturbed yellow sandy deposit with the potential to contain additional evidence of the site is provisionally assessed as being of moderate scientific significance.	Moderate- Due to good condition of undisturbed yellow sandy deposit with the potential to contain additional evidence of occupation.	Low- Due to low number of features which are unable to act as an exemplar representative sample as well as previous disturbance.	Low- Due to high number of shelters within the Subject Area and the surrounding landscape, numbering 83 in total.	Moderate
Pending	Warragamba-239	Shelter with Deposit and Isolated Artefact	Warragamba-239 is a Shelter with Deposit and Isolated Artefact located beside the stored water on the South side of Warragamba Gorge, north along the unnamed tributary of the Warragamba River from Warragamba-238. A single flake was located at this site in association with a potential hearth feature. The site type, shelter with deposit is common within the region. However, due to the presence of a hearth feature, artefact and yellow, flat sandy deposit with the potential to contain additional evidence of occupation the site is provisionally assessed as being of moderate scientific significance.	Moderate- Due to hearth feature, artefact and yellow, flat sandy deposit with the potential to contain additional evidence of occupation.	Low- Due to low number of features which are unable to act as an exemplar representative sample as well as previous disturbance.	Low- Due to high number of shelters within the Subject Area and the surrounding landscape, numbering 83 in total.	Moderate
Pending	Warragamba-240	Shelter with Deposit, Art and Isolated Artefact	Warragamba-240 is a Shelter with Art, Deposit and Artefacts located beside an intermittent creek line that has permanent waterholes occurring along it. There were five art motifs comprising of charcoal indeterminate lines and one chert flake found at this site. The site type is common within the region. However, due to the good condition of the deposit within the shelter and its potential to contain in-situ stratified evidence of occupation the site is provisionally assessed as being of moderate scientific significance.	Moderate- Due to good condition of the deposit within the shelter and its potential to contain in-situ stratified evidence of occupation.	Low- Due to low number of features which are unable to act as an exemplar representative sample as well as previous disturbance.	Low- Due to high number of shelters within the Subject Area and the surrounding landscape, numbering 83 in total.	Moderate
Pending	Warragamba-243	Shelter with Deposit and Artefacts	Warragamba-243 is a Shelter with Art, Deposit and Artefacts that is located South East of the Cox's River and Horse Arm Creek junction. The shelter was formed by cavernous weathering and block fall. There were five motifs recorded at this shelter, with one animalistic figure and several motifs consisting of lines and is in poor condition. There were seven artefacts located as part of this survey along with an extensive hearth feature. The site type, shelter with deposit is common within the region. However, due to the presence of an extensive hearth and deposit with the potential to contain additional evidence of occupation the site is provisionally assessed as being of moderate scientific significance.	Moderate- Due to extensive hearth and deposit with the potential to contain additional evidence of occupation.	Low- Due to low number of features which are unable to act as an exemplar representative sample as well as previous disturbance.	Low- Due to high number of shelters within the Subject Area and the surrounding landscape, numbering 83 in total.	Moderate
Pending	Warragamba-254	Shelter with Deposit, Art, Artefacts and Axe Grinding Grooves	Warragamba-254 is a Shelter with Art, Deposit, Artefacts and Axe Grinding Grooves located alongside an unnamed tributary of the Cox River, and west of both Warragamba-255 and Warragamba-256, and south west of Warragamba-253. The shelter was formed from an isolated boulder, and is mid-slope on the gully formed by the creek. The art surfaces are impacted by graffiti, and weathering processes. Three artefacts were located, along with three groupings of abrasion patches, and two art panels though it was estimated that the site may contain up to 100 artefacts. Due to the large number of artefacts and the presence of	High- Due to the large number of artefacts and the presence of orange/red sandy deposit with potential for additional stratified evidence of occupation.	Moderate – Due to the low number of such site types with such a high density of artefacts	Moderate – Due to the low number of such site types with such a high density of artefacts	High

AHIMS ID	Site Name	Site Type	Significance Statement	Research Potential	Representativeness	Rarity	Scientific Significance Rating
			orange/red sandy deposit with potential for additional stratified evidence of occupation the site is provisionally assessed as being of moderate scientific significance.				
Pending	Warragamba-261	Shelter with Deposit, Artefacts and Axe Grinding Grooves	Warragamba-261 is a Shelter with Deposit, Artefacts and Axe Grinding Grooves located mid-slope beside the stored water of the Cox River, south of Warragamba-257, and south west of Warragabma-259. The shelter was formed from an isolated boulder, and shows evidence of chemical weathering, water wash, wombat disturbance, fissuring and salt and granular losses. There was four artefacts located during this survey, and two axe grinding grooves. Due to the presence of intact red/orange sandy deposit with potential for additional stratified evidence of occupation the site is provisionally assessed as being of moderate scientific significance.	Moderate- Due to presence of intact red/orange sandy deposit with potential for additional stratified evidence of occupation.	Low- Due to low number of features which are unable to act as an exemplar representative sample as well as previous disturbance.	Low- Due to high number of shelters within the Subject Area and the surrounding landscape, numbering 83 in total.	Moderate
Pending	Warragamba-284	Shelter with Deposit and Axe Grinding Grooves	Warragamba-284 is a Shelter with Deposit and Axe Grinding Grooves. The shelter is located along a ridgeline situated north of Warragamba-280. There were four grinding grooves found in close proximity to each other. On the left side of the shelter is a cavity containing silty deposit which has a greater depth than 400mm. There were no visible artefacts found associated with the deposit. However, due to the presence of silty deposit with a depth greater then 400mm and the potential for additional stratified evidence of occupation the site is provisionally assessed as being of moderate scientific significance.	Moderate- Due to presence of silty deposit with a depth greater then 400mm and the potential for additional stratified evidence of occupation.	Low- Due to low number of features which are unable to act as an exemplar representative sample as well as previous disturbance.	Low- Due to high number of shelters within the Subject Area and the surrounding landscape, numbering 83 in total.	Moderate
Pending	Warragamba-301	Shelter with Deposit and Artefacts	Warragamba-301 is a Shelter with Deposit and Artefacts. The shelter is located near Warragamba-300 at Werriberri Creek. The shelter is in close proximity to the stored water. There were eleven artefacts recorded as part of this survey. The site type, shelter with deposit is common within the region. However, due to the presence of relatively undisturbed deposit associated with at least 11 artefacts and the potential for additional stratified evidence of occupation the site is provisionally assessed as being of moderate scientific significance.	Moderate- Due to presence of relatively undisturbed deposit associated with at least 11 artefacts and the potential for additional stratified evidence of occupation.	Low- Due to low number of features which are unable to act as an exemplar representative sample as well as previous disturbance.	Low- Due to high number of shelters within the Subject Area and the surrounding landscape, numbering 83 in total.	Moderate
Pending	Warragamba-306	Shelter with Deposit and Artefacts	Warragamba-306 is a Shelter with Deposit and Artefacts. The shelter is located on the southern slope above Oaky Creek in a sandstone formation. There were six artefacts found along the drip line. The site type, shelter with deposit is common within the region. However, due to the presence of relatively undisturbed deposit associated with at least 6 artefacts and the potential for additional stratified evidence of occupation the site is provisionally assessed as being of moderate scientific significance.	Moderate- Due to presence of relatively undisturbed deposit associated with at least 6 artefacts and the potential for additional stratified evidence of occupation.	Low- Due to low number of features which are unable to act as an exemplar representative sample as well as previous disturbance.	Low- Due to high number of shelters within the Subject Area and the surrounding landscape, numbering 83 in total.	Moderate
Pending	Warragamba-307	Shelter with Deposit, Artefacts and Axe Grinding Grooves	Warragamba-307 is a Shelter with Deposit, Artefacts and Axe Grinding Grooves. The shelter is located above Cox River on the western side. There was an area of grinding grooves on a rock just within the drip line. As well as the abrasion patches present on the rock there were parallel abrasion patches at the northern and southern ends of the shelter, just inside the drip line. There were eleven artefacts found in the interior of the shelter and along the drip line. The site type is common within the region. However, due to the presence of relatively undisturbed deposit associated with at least 11 artefacts and the potential for additional stratified evidence of occupation the site is provisionally assessed as being of moderate scientific significance.	Moderate- Due to presence of relatively undisturbed deposit associated with at least 11 artefacts and the potential for additional stratified evidence of occupation.	Low- Due to low number of features which are unable to act as an exemplar representative sample as well as previous disturbance.	Low- Due to high number of shelters within the Subject Area and the surrounding landscape, numbering 83 in total.	Moderate

Appendix 8: Consequence/ Risk of Harm Assessment

Site	Site type	Consequence of harm	Summary
Warragamba -00	Open Camp Site with PAD	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a low risk of implied harm to the in-situ context of artefacts and archaeological integrity of the PAD as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. Site will experience an increase in duration to existing inundation events.
Warragamba -01	Open Camp Site with PAD	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts and archaeological integrity of the PAD as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will only experience inundation during a 1 in 100 flood event.
Warragamba -03	Open Camp Site	Moderate	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. Site will experience an increase in duration to existing inundation events.
Warragamba -05	Aboriginal Resource and Gathering	Moderate	Site will experience an increase in duration to existing inundation events; however, these inundation events are frequent and will potentially cause an increased risk of implied harm. Effects of inundation will result in diminished site integrity.
Warragamba -06	Open Camp Site	Moderate	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. Site will experience an increase in duration to existing rare inundation events (1 in 20 and 1 in 100).
Warragamba -11	Shelter with Deposit	Moderate	There is nil risk of explicit harm; however, there is a risk of implied harm to the archaeological integrity of the PAD as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. The Project will result in the site experiencing inundation during a 1 in 100 year flood event.
Warragamba -12	Open Camp site with PAD	Moderate	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a low risk of implied harm to the in-situ context of artefacts and archaeological integrity of the PAD as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. Site will experience an increase in duration to existing inundation events.
Warragamba 15	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. Site will experience an increase in duration to existing inundation events.
Warragamba 17	Open Camp Site	Moderate	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. Site will experience an increase in duration to existing inundation events.
Warragamba 18	Open Camp Site with PAD	Moderate	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts and archaeological integrity of the PAD as a consequence of inundation as a

Site	Site type	Consequence of harm	Summary
			result of secondary activity such as erosion or soil deposition. Site will experience an increase in duration to existing inundation events.
Warragamba 19	Open Camp Site	Moderate	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. Site will experience an increase in duration to existing inundation events.
Warragamba 20	Open Camp Site	Moderate	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency and duration of inundation.
Warragamba 21	Open Camp Site	Moderate	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency and duration of inundation.
Warragamba 22	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience a significant increase in frequency of inundation and an increase in duration of inundation.
Warragamba 23	Open Camp Site	Moderate	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency and duration of inundation.
Warragamba 24	Open Camp Site	Moderate	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency and duration of inundation.
Warragamba 25	Open Camp Site	Moderate	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency and duration of inundation.
Warragamba 26	Open Camp Site	Moderate	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency and duration of inundation.
Warragamba 27	Open Camp Site	Moderate	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency and duration of inundation.
Warragamba 28	Open Camp Site	Moderate	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency and duration of inundation.
Warragamba 29	Open Camp Site	Moderate	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency and duration of inundation.

Site	Site type	Consequence of harm	Summary
Warragamba 31	Shelter with Deposit and Artefacts	Nil	This site is above the project 1 in 100 temporary inundation event and will not be affected by the project.
Warragamba 32	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency and duration of inundation.
Warragamba 33	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency and duration of inundation.
Warragamba 34	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency and duration of inundation.
Warragamba 35	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency and duration of inundation.
Warragamba 36	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency and duration of inundation.
Warragamba 37	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency and duration of inundation.
Warragamba 38	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency and duration of inundation.
Warragamba 39	Open Camp Site with PAD	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency and duration of inundation.
Warragamba 40	Open Camp Site with PAD	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency and duration of inundation.
Warragamba 41	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency and duration of inundation.
Warragamba 42	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency and duration of inundation.

Site	Site type	Consequence of harm	Summary
Warragamba 43	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency and duration of inundation.
Warragamba 44	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency and duration of inundation.
Warragamba 45	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 46	Shelter with Deposit and Artefacts	Nil	This site is above the project 1 in 100 temporary inundation event and will not be affected by the project.
Warragamba 47	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 48	Open Camp Site with PAD	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts and archaeological integrity of the PAD as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 49	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 50	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 51	Open Camp Site	Moderate	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 52	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 53	Open camp site	Moderate	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 54	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.

Site	Site type	Consequence of harm	Summary
Warragamba 55	Shelter with Deposit and Artefacts	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts and archaeological integrity of the PAD as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 57	Shelter with Deposit and Artefacts	Low	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts and archaeological integrity of the PAD as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency of inundation that will occur for less than half a day during a 1 in 100 year inundation event
Warragamba 58	Shelter with Deposit and Artefacts	Low	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts and archaeological integrity of the PAD as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency of inundation that will occur for less than half a day during a 1 in 100 year inundation event
Warragamba 59	Open Camp Site	Low	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts and archaeological integrity of the PAD as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency of inundation that will occur for less than half a day during a 1 in 100 year inundation event
Warragamba 64	Isolated Artefact	Moderate	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase frequency of inundation as well as an increase in duration of inundation. Although the artefact itself may be resilient, there is a risk that the site will not be located again.
Warragamba 65	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 66	Open Camp Site	Nil	This site is above the project 1 in 100 temporary inundation event and will not be affected by the project.
Warragamba 67	Open Camp Site	Low	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency of inundation that will occur for less than half a day during a 1 in 100 year inundation event
Warragamba 68	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 69	Open Camp Site	Nil	This site is above the project 1 in 100 temporary inundation event and will not be affected by the project.
Warragamba 70	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.

Site	Site type	Consequence of harm	Summary
Warragamba 71	Open Camp Site	Nil	This site is above the project 1 in 100 temporary inundation event and will not be affected by the project.
Warragamba 72	Open Camp Site with PAD	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts and archaeological integrity of the PAD as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 73	Isolated Artefact	Moderate	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation. Although the artefact itself may be resilient, there is a risk that the site will not be located again.
Warragamba 74	Waterhole and Aboriginal Ceremony and Dreaming	Low	There is nil risk of explicit harm to the features of this site. There is a risk of implied harm to the physical aspects of and/or access to the site. This site will experience an increase in duration of inundation.
Warragamba 75	Aboriginal Resource and Gathering	Moderate	Site will experience an increase in frequency and duration of existing inundation events; however, these inundation events are infrequent. Effects of inundation will result in diminished site integrity.
Warragamba 77	Isolated Artefact with PAD	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of the artefact and archaeological integrity of the PAD as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation. Although the artefact itself may be resilient, there is a risk that the site will not be located again.
Warragamba 78	Isolated Artefact	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation. Although the artefact itself may be resilient, there is a risk that the site will not be located again.
Warragamba 79	Open Camp Site with Scarred Tree	Moderate/High	The resilience of the scarred tree is low and any inundation event will likely have significant effects. Although the consequence of harm is evaluated as high, it is worthwhile noting that the temporary inundation event will likely occur during 1 in 100 year flood events only.
Warragamba 80	Stone Arrangement	Low	No impacts are expected to occur due to the resilience of large stone objects to low flow force processes. This site will experience an increase in inundation duration.
Warragamba 81	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 82	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 83	Axe Grinding Grooves	Low	This site will experience an increase in frequency of inundation from a 1 in 100 year flood event. No impacts are expected to occur from erosion; however, implied harm could potentially occur as a result of biochemical effects.

Site	Site type	Consequence of harm	Summary
Warragamba 84	Shelter with Deposit and Artefacts	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts and archaeological integrity of the PAD as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 85	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 86	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 88	Isolated Artefact	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation less frequent flood events. Although the artefact itself may be resilient, there is a risk that the site will not be located again.
Warragamba 89	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 90	Isolated Artefact	Nil	This site is above the project 1 in 100 temporary inundation event and will not be affected by the project.
Warragamba 92	Stone Arrangement	Nil	This site is above the project 1 in 100 temporary inundation event and will not be affected by the project.
Warragamba 93	Open Camp Site	Moderate	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation during less frequent flood events.
Warragamba 94	Open Camp Site with PAD	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts and archaeological integrity of the PAD as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 95	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 96	Open Camp Site with PAD	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts and archaeological integrity of the PAD as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 97	Open Camp Site	Nil	This site is above the project 1 in 100 temporary inundation event and will not be affected by the project.

Site	Site type	Consequence of harm	Summary
Warragamba 98	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency of inundation as well as an increase in duration of inundation.
Warragamba 99	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 100	Open Camp Site	Nil	This site is above the project 1 in 100 temporary inundation event and will not be affected by the project.
Warragamba 101	Isolated Artefact with PAD	Moderate	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of the artefact and archaeological integrity of the PAD as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency of inundation during a 1 in 100 year event. Although the artefact itself may be resilient, there is a risk that the site will not be located again.
Warragamba 102	Isolated Artefact with PAD	Moderate	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of the artefact and archaeological integrity of the PAD as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency of inundation during a 1 in 100 year event. Although the artefact itself may be resilient, there is a risk that the site will not be located again.
Warragamba 104	Shelter with Deposit and Artefacts	Moderate	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts and archaeological integrity of the PAD as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency of inundation.
Warragamba 105	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 106	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 107	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 108	Isolated Artefact	Moderate	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency of flood events. Although the artefact itself may be resilient, there is a risk that the site will not be located again.

Site	Site type	Consequence of harm	Summary
Warragamba 109	Open Camp Site with PAD	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts and archaeological integrity of the PAD as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 110	Open Camp Site with PAD	Moderate	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts and archaeological integrity of the PAD as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency and duration of inundation.
Warragamba 111	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 112	Shelter with Deposit and Artefacts	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts and archaeological integrity of the PAD as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency of inundation.
Warragamba 113	Shelter with Deposit, Art, Artefacts and Axe Grinding Grooves	Low	Stone artefacts and grinding grooves are materially resilient to water/inundation, therefore there is nil to low risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts and archaeological integrity of the PAD as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. The art at this site has low resilience to water. This site will experience an increase in frequency of inundation that will occur for a maximum of 2 days during a 1 in 100 year inundation event
Warragamba 114	Axe Grinding Grooves	Low	Grinding grooves are materially resilient to water/inundation, therefore there is nil to low risk of explicit harm. There is a risk of implied harm to the archaeological integrity of the grooves as a consequence of inundation as a result of secondary activity such biochemical activity. This site, previously unaffected by existing inundation, will experience an increase in frequency of inundation for short periods of time.
Warragamba 115	Shelter with Deposit, Art and Artefacts	High	Stone artefacts and grinding grooves are materially resilient to water/inundation, therefore there is nil to low risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts and archaeological integrity of the PAD as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. The art at this site has low resilience to water. This site will experience an increase in frequency and duration of inundation.
Warragamba 116	Shelter with Deposit, Art, Artefacts and Axe Grinding Grooves	Moderate/High	Stone artefacts and grinding grooves are materially resilient to water/inundation, therefore there is nil to low risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts and archaeological integrity of the PAD as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. The art at this site has low resilience to water. This site will experience an increase in frequency of inundation during a 1 in 100 year flood event for a maximum duration of less than a day.
Warragamba 117	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 118	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.

Site	Site type	Consequence of harm	Summary
Warragamba 119	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 124	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 125	Isolated Artefact	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase induration of inundation. Although the artefact itself may be resilient, there is a risk that the site will not be located again.
Warragamba 126	Isolated Artefact	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation. Although the artefact itself may be resilient, there is a risk that the site will not be located again.
Warragamba 127	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 128	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 129	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 130	Isolated Artefact	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation. Although the artefact itself may be resilient, there is a risk that the site will not be located again.
Warragamba 131	Shelter with Deposit, Art and Isolated Artefact	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 132	Shelter with Deposit and Artefacts	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 135	Shelter with Deposit and Axe Grinding Grooves	Low	Grinding grooves are materially resilient to water/inundation, therefore there is nil to low risk of explicit harm. There is a risk of implied harm to the archaeological integrity of the PAD as a consequence of inundation as a result of secondary activity

Site	Site type	Consequence of harm	Summary
			such as erosion or soil deposition. This site will experience an increase infrequency of inundation for less than half a day during a 1 in 100 flood event.
Warragamba 138	Open Camp Site with PAD	Low	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts and archaeological integrity of the PAD as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency of inundation for a maximum of 2 days during a 1 in 100 food event.
Warragamba 139	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 140	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 141	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 142	Open Camp Site	Moderate	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 143	Isolated Artefact	Moderate	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency of inundation during 1 in 20 and 1 in 100 year floods. Although the artefact itself may be resilient, there is a risk that the site will not be located again.
Warragamba 144	Shelter with Art	Moderate/High	There is a risk of explicit and implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as biochemical impacts. This previously unaffected site will experience an increase in frequency of temporary inundation for a maximum of 3.6 days during a 1 in 100 year flood.
Warragamba 146	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 147	Open Camp Site with PAD	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts and archaeological integrity of the PAD as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 148	Open Camp Site with PAD	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts and archaeological integrity of the PAD as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.

Site	Site type	Consequence of harm	Summary
Warragamba 149	Shelter with Deposit and Artefacts	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts and archaeological integrity of the PAD as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency and duration of temporary inundation.
Warragamba 150	Open Camp Site with PAD	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts and archaeological integrity of the PAD as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 154	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 155	Open Camp Site with PAD	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts and archaeological integrity of the PAD as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 156	Open Camp Site with PAD	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts and archaeological integrity of the PAD as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 157	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 158	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 159	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 160	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 161	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 162	Isolated Artefact	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.

Site	Site type	Consequence of harm	Summary
Warragamba 163	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 164	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 165	Shelter with Deposit and Artefacts	Nil	This site is above the project 1 in 100 temporary inundation event and will not be affected by the project.
Warragamba 166	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 167	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 168	Open Camp Site with Scarred Tree	High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. There is a risk of explicit and implied harm to the scarred tree This site will experience an increase in duration of inundation.
Warragamba 169	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 170	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 171	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 172	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 173	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.

Site	Site type	Consequence of harm	Summary
Warragamba 174	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 175	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 176	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 177	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 178	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 179	Aboriginal Resource and Gathering	High	Site will experience an increase in frequency and duration of existing inundation events; however, these inundation events are infrequent. Effects of inundation will result in diminished site integrity. This site will experience an increase in duration of temporary inundation.
Warragamba 180	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 181	Shelter with Deposit, Art, Artefacts and Axe Grinding Grooves	Moderate/High	Stone artefacts and grinding grooves are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. The art at the site is at risk of explicit and implied harm from exposure to water as well as secondary effects caused by biochemical impacts. This site will experience an increase in frequency and duration of temporary inundation.
Warragamba 183	Isolated Artefact	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 184	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 185	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.

Site	Site type	Consequence of harm	Summary
Warragamba 186	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 187	Shelter with Deposit	Moderate	There is nil risk of explicit harm; however, there is a risk of implied harm to the archaeological integrity of the PAD as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. The Project will result in an increase in frequency and duration. It should be noted that while the consequence of harm is high for this site, the increase in frequency will see the site being affected for less than half a day during inundation events.
Warragamba 188	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of temporary inundation.
Warragamba 189	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of temporary inundation.
Warragamba 191	Open Camp Site with Axe Grinding Grooves and Isolated Artefact	Moderate/High	Stone artefacts and grinding grooves are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts and archaeological integrity of the PAD as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency and duration of temporary inundation.
Warragamba 192	Shelter with Deposit	Moderate/High	There is nil risk of explicit harm; however, there is a risk of implied harm to the archaeological integrity of the PAD as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. The Project will result in an increase in frequency and duration. It should be noted that while the consequence of harm is high for this site, the increase in frequency will see the site being affected for less than half a day during inundation events.
Warragamba 193	Shelter with Art	Nil	This site is above the project 1 in 100 temporary inundation event and will not be affected by the project.
Warragamba 194	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of temporary inundation.
Warragamba 196	Open Camp Site with Scarred Tree	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. There is a risk of explicit and implied harm to the scarred tree This site will experience an increase in frequency and duration of temporary inundation.
Warragamba 198	Isolated Artefact	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of temporary inundation.
Warragamba 199	Open Camp Site with PAD	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts and archaeological integrity of the PAD as a consequence of inundation as a

Site	Site type	Consequence of harm	Summary
			result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency and duration of temporary inundation.
Warragamba 200	Shelter with Deposit and Artefacts	High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency and duration of temporary inundation.
Warragamba 201	Open Camp Site	Low	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of temporary inundation of less than half a day during a 1 in 100 year flood event.
Warragamba 202	Open Camp Site	Moderate	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency and duration of temporary inundation.
Warragamba 203	Open Camp Site	Moderate	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency and duration of temporary inundation.
Warragamba 205	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of temporary inundation.
Warragamba 206	Shelter with Deposit and Artefacts	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency and duration of temporary inundation.
Warragamba 207	Shelter with Axe Grinding Grooves and Deposit	Moderate/High	Grinding grooves are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. The art at the site is at risk of explicit and implied harm from exposure to water as well as secondary effects caused by biochemical impacts. This site will experience an increase in frequency and duration of temporary inundation.
Warragamba 208	Shelter with Deposit and Artefacts	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of temporary inundation.
Warragamba 209	Shelter with Deposit, Art and Artefacts	Nil	This site is above the project 1 in 100 temporary inundation event and will not be affected by the project.
Warragamba 211	Shelter with Deposit, Art and Artefacts	Nil	This site is above the project 1 in 100 temporary inundation event and will not be affected by the project.

Site	Site type	Consequence of harm	Summary
Warragamba 212	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency and duration of temporary inundation.
Warragamba 214	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency and duration of temporary inundation.
Warragamba 216	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency and duration of temporary inundation.
Warragamba 217	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency and duration of temporary inundation.
Warragamba 219	Shelter with Deposit, Axe Grinding Grooves and Isolated Artefact	Nil	This site is above the project 1 in 100 temporary inundation event and will not be affected by the project.
Warragamba 221	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of temporary inundation.
Warragamba 225	Shelter with Deposit and Artefacts	Nil	This site is above the project 1 in 100 temporary inundation event and will not be affected by the project.
Warragamba 228	Axe Grinding Grooves	Low	Grinding grooves are materially resilient to water/inundation, therefore there is nil risk of explicit harm. This site will experience an increase in frequency of temporary inundation during a 1 in 100 year flood for a maximum of less than one day.
Warragamba 229	Open Camp Site with PAD	Moderate	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts and archaeological integrity of the PAD as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency and duration of temporary inundation.
Warragamba 230	Open Camp Site	Moderate	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency and duration of temporary inundation.
Warragamba 232	Open Camp Site	Moderate	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency and duration of temporary inundation.
Warragamba 233	Aboriginal Resource and Gathering	Low	Site will experience an increase in duration to existing inundation events for a maximum of less than half a day during a 1 in 100 year flood event.

Site	Site type	Consequence of harm	Summary
Warragamba 235	Open Camp Site with PAD	Low	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts and archaeological integrity of the PAD as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency of temporary inundation for a maximum of half a day during a 1 in 100 year flood.
Warragamba 236	Open Camp Site	Low	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency of temporary inundation for a maximum of half a day during a 1 in 100 year flood.
Warragamba 239	Shelter with Deposit and Isolated Artefact	Moderate	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts and archaeological integrity of the PAD as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency and duration of temporary inundation.
Warragamba 248	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of temporary inundation.
Warragamba 249	Open Camp Site	Moderate	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of temporary inundation.
Warragamba 251	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of temporary inundation.
Warragamba 252	Open Camp Site	Moderate	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency and duration of temporary inundation.
Warragamba 256	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of temporary inundation.
Warragamba 262	Open Camp Site	Moderate	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency and duration of temporary inundation.
Warragamba 263	Open Camp Site	Low	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency temporary inundation for a maximum of 3.6 days during a 1 in 100 year flood.

Site	Site type	Consequence of harm	Summary
Warragamba 264	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency and duration of temporary inundation.
Warragamba 266	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency and duration of temporary inundation.
Warragamba 268	Open Camp Site with PAD	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts and archaeological integrity of the PAD as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of temporary inundation.
Warragamba 269	Isolated Artefact	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of inundation.
Warragamba 271	Open Camp Site	Moderate	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency of inundation during a 1 in 20 and 1 in 100 year flood event.
Warragamba-296	Shelter with Deposit, Art, Artefacts and Axe Grinding Grooves	Nil	This site is above the project 1 in 100 temporary inundation event and will not be affected by the project.
Warragamba-297	Shelter with Deposit and Artefacts	Nil	This site is above the project 1 in 100 temporary inundation event and will not be affected by the project.
Warragamba-298	Shelter with Deposit, Axe Grinding Grooves and Isolated Artefact	Low	Stone artefacts and grinding grooves are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts and PAD as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency of temporary inundation for a maximum of less than half a day during a 1 in 100 year flood event..
Warragamba-299	Shelter with Deposit and Artefacts	Low	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts and PAD as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency of temporary inundation for a maximum of less than half a day during a 1 in 100 year flood event..
Warragamba-300	Shelter with Deposit and Art	High	There is a risk of implied harm to the in-situ context of PAD as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. The art at the site is at risk of explicit and implied harm from exposure to water as well as secondary effects caused by biochemical impacts. This site will experience an increase in duration of temporary inundation.
Warragamba-301	Shelter with Deposit and Artefacts	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts and archaeological integrity of the PAD as a consequence of inundation as a

Site	Site type	Consequence of harm	Summary
			result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency and duration of temporary inundation.
Warragamba-302	Open Camp Site	Moderate	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of temporary inundation.
Warragamba-303	Open Camp Site	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency and duration of temporary inundation.
Warragamba-304	Axe Grinding Grooves	Low	Grinding grooves are materially resilient to water/inundation, therefore there is nil to low risk of explicit harm. There is a risk of implied harm to the archaeological integrity of the grooves as a consequence of inundation as a result of secondary activity such biochemical activity. This site will experience an increase in frequency and duration of inundation.
Warragamba-305	Shelter with Deposit, Artefacts and Axe Grinding Grooves	Moderate	Stone artefacts and grinding grooves are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts and archaeological integrity of the PAD as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency and duration of temporary inundation.
45-4-0186	Policemans Point (Shelter with Deposit, Artefacts and Axe Grinding Grooves)	Low	Stone artefacts and grinding grooves are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts and archaeological integrity of the PAD as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency of temporary inundation for a maximum of less than one day during a 1 in 100 year flood event.
45-4-0188	Butchers Creek 1	Nil	This site is above the project 1 in 100 temporary inundation event and will not be affected by the project.
45-4-0931	EH 1; Warragamba Special Area (Open Camp Site)	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency and duration of temporary inundation.
45-4-0943	GW3 – artefact scatter	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency and duration of temporary inundation.
45-4-0944	GW1 - Open Campsite	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency and duration of temporary inundation.
45-4-0945	Gw2 - Open Campsite	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency and duration of temporary inundation.

Site	Site type	Consequence of harm	Summary
45-4-0946	TR1 (Open Camp Site)	High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency and duration of temporary inundation.
45-4-0967	RC1 (Open Camp Site)	Moderate	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency and duration of temporary inundation.
45-4-0968	Butchers 2	Nil	This site is above the project 1 in 100 temporary inundation event and will not be affected by the project.
45-4-0997	Bimlow PAD (Shelter with Art, Artefacts and Axe Grinding Grooves)	Moderate/High	Stone artefacts and grinding grooves are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. The art at the site is at risk of explicit and implied harm from exposure to water as well as secondary effects caused by biochemical impacts. This site will experience an increase in frequency and duration of temporary inundation.
52-1-0008	Byrnes Creek (Engraving)	Moderate/High	Engravings are resilient to water/inundation, therefore there is nil risk of explicit harm. The engravings are at risk of implied harm from secondary effects caused by biochemical impacts. This site will experience an increase in frequency and duration of temporary inundation.
52-1-0019	Nattai River 1 - Shelter with Art	Moderate/High	There is a risk of explicit and implied harm to the art at the site from exposure to water as well as secondary effects caused by biochemical impacts. This site will experience an increase in frequency of temporary inundation.
52-1-0020	Nattai River 2	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of temporary inundation.
52-1-0045	Jooriland Creek, Upper Burragorang (Axe Grinding Grooves)	Low	Grinding grooves are materially resilient to water/inundation, therefore there is nil to low risk of explicit harm. There is a risk of implied harm to the archaeological integrity of the grooves as a consequence of inundation as a result of secondary activity such biochemical activity. This site will experience an increase in frequency and duration of inundation.
52-1-0127	Little River 2 (Open Camp Site)	Moderate	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of temporary inundation.
52-1-0128	Little River 3 (Open Camp Site)	Nil	This site is above the project 1 in 100 temporary inundation event and will not be affected by the project.
52-1-0131	Tonalli Cove 2 (Scarred tree)	Moderate/high	There is a risk of explicit and implied harm to the scarred tree. This site will experience an increase in duration of temporary inundation.
52-1-0132	Tonalli Cove 3	Nil	This site is above the project 1 in 100 temporary inundation event and will not be affected by the project.

Site	Site type	Consequence of harm	Summary
52-1-0133	Tonalli Cove 4 (Open Camp Site)	Nil	This site is above the project 1 in 100 temporary inundation event and will not be affected by the project.
52-1-0134	Byrnes Bay 1	Nil	This site is above the project 1 in 100 temporary inundation event and will not be affected by the project.
52-1-0137	Bridge Point 1 - open campsite	Low	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase infrequency of temporary inundation of less than half a day during a 1 in 100 year flood event.
52-1-0138	Bridge Point 2 - open campsite	Nil	This site is above the project 1 in 100 temporary inundation event and will not be affected by the project.
52-1-0139	Bridge Point 3	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency and duration of temporary inundation.
52-1-0141	Upper Wollondilly 2 (Open Camp Site)	Nil	This site is above the project 1 in 100 temporary inundation event and will not be affected by the project.
52-1-0142	Kamilaroi Point (Shelter with Deposit and Art)	Moderate/High	There is a risk of implied harm to the in-situ context of PAD as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. The art at the site is at risk of explicit and implied harm from exposure to water as well as secondary effects caused by biochemical impacts. This site will experience an increase in frequency of temporary inundation during a 1 in 100 year flood for a maximum of less than half a day.
52-1-0168	Joorilands Farm 1 (Open Camp Site with Scarred Tree)	Nil	This site is above the project 1 in 100 temporary inundation event and will not be affected by the project.
52-1-0170	Joorilands Farm 2 (Open Camp Site with Axe Grinding Grooves and Scarred Tree)	Nil	This site is above the project 1 in 100 temporary inundation event and will not be affected by the project.
52-1-0171	Joorilands Farm 3 (Scarred Tree)	Moderate/High	The resilience of the scarred tree is low and any inundation event will likely have significant effects. This site will see an increase in duration of temporary inundation.
52-1-0173	W104, scarred tree	Moderate/High	The resilience of the scarred tree is low and any inundation event will likely have significant effects. This site will see an increase in duration of temporary inundation.
52-1-0175	MF4, Murphy's Flat (artefact scatter)	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of temporary inundation.

Site	Site type	Consequence of harm	Summary
52-1-0178	MF1 (Shelter with Deposit)	Moderate/High	There is a risk of implied harm to the in-situ context of artefacts and PAD as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency of temporary inundation for a maximum of less than half a day during a 1 in 100 year flood event..
52-1-0180	MF3, Murphy's Flat - Warragamba Special Area	Low	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase infrequency of temporary inundation of less than half a day during a 1 in 100 year flood event.
52-1-0186	W223, Byrnes Creek (Open Camp Site)	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of temporary inundation.
52-1-0248	Joorilands Farm 6	Low	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase infrequency of temporary inundation of less than half a day during a 1 in 100 year flood event.
52-1-0298	Orange Tree Flat - Isolated find 01	Low	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase infrequency of temporary inundation of less than half a day during a 1 in 100 year flood event.
52-1-0332	Byrnes Bay OS-1 (Open Camp Site)	Moderate/High	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in duration of temporary inundation.
52-1-0352/45-5-0946	Tonalli OS-1 (Open Camp Site with PAD)	Moderate	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts and archaeological integrity of the PAD as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency and duration of temporary inundation.
52-1-0130	Tonalli Cove 1 Open campsite with PAD	Moderate	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts and archaeological integrity of the PAD as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This site will experience an increase in frequency and duration of temporary inundation.
45-4-0941	Apple Tree Flat 1	Moderate	Stone artefacts are materially resilient to water/inundation, therefore there is nil risk of explicit harm. There is a risk of implied harm to the in-situ context of artefacts and archaeological integrity of the PAD as a consequence of inundation as a result of secondary activity such as erosion or soil deposition. This previously unaffected site will experience an increase in frequency of temporary inundation.
52-1-0125	Nattai River 9 Open campsite with PAD	Nil	This site is above the project 1 in 100 temporary inundation event and will not be affected by the project.

Site	Site type	Consequence of harm	Summary
52-1-0247	Joorilands Farm 5 Open campsite with PAD	Nil	This site is above the project 1 in 100 temporary inundation event and will not be affected by the project.
52-1-0246	Joorilands Farm 4 Open campsite with PAD	Nil	This site is above the project 1 in 100 temporary inundation event and will not be affected by the project.

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Wildlife Schools and training

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Aboriginal heritage
Historical heritage
Conservation management
Community consultation
Archaeological, built and landscape values

Environmental management and approvals
Impact assessments
Development and activity approvals
Rehabilitation
Stakeholder consultation and facilitation
Project management

Environmental offsetting
Offset strategy and assessment (NSW, QLD, Commonwealth)
Accredited BAM assessors (NSW)
Biodiversity Stewardship Site Agreements (NSW)
Offset site establishment and management
Offset brokerage
Advanced Offset establishment (QLD)

Appendix G

Supplementary non-Aboriginal heritage assessment

Warragamba Dam Wall Raising Project

Non-Aboriginal Heritage
Supplementary Report to the
Environmental Impact Statement

Final Report to SMEC for WaterNSW
August 2022

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EXECUTIVE SUMMARY

WaterNSW, a New South Wales (NSW) state owned corporation, is seeking environmental planning approval for the Warragamba Dam Raising Project (the project). The Project requires approval from the NSW Minister for Planning under Division 5.2 of the *Environmental Planning and Assessment Act 1979* (NSW) (EP&A Act). To support the project approval application, an Environmental Impact Statement (EIS) was prepared for public exhibition in 2021. This report is a Supplementary Report as part of the next stage in the assessment process for the Response to Submissions Report. This report has been prepared to assess the project's impact on four non-Aboriginal sites listed on the National Parks and Wildlife Service (NPWS) Section 170 Heritage and Conservation Register (S170 Register) and a separate assessment for the State Heritage Register (SHR) listed Megarittys Bridge (ID #01367).

The project is also a controlled action under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and therefore requires concurrent assessment under the EPBC Act. In accordance with the Bilateral Agreement reached between the NSW and Commonwealth Governments, an EIS under the EP&A Act for State Significant Infrastructure (SSI) can also be used for an EIS under the EPBC Act for a controlled action, where directed by the Federal Minister. The direction was given for the project to be assessed under the Bilateral Agreement on 17 July 2017.

This Supplementary Report has assessed the four S170 heritage sites as being in poor condition and that the project would result in a continued disintegration of their condition or a complete loss of fabric due to the increased duration of temporary inundation at each of the sites for the 1 in 5 chance in a year event and larger flood events.

The separate assessment for the State Heritage Register listed Megarritys Bridge builds on the findings within the impact assessment supporting the EIS and has concluded that no impacts are expected to the State heritage values of the item.

Overview of findings

The findings of this Supplementary Report are summarised in the below table.

Summary of significance and impacts to the four Section 170 sites and the SHR listed Megarritys Bridge

Site name	Listing	Significance grading	Impacts
Megarritys Bridge	State Heritage Register ID 01367	**State**	**Neutral** impacts
Orange Tree Flat House	National Parks and Wildlife Services Section 170 ID 12805	Does not fulfil criteria for a Local listing	**Minor - moderate** physical impacts **Neutral** visual and setting impacts **Neutral** archaeological impacts

Site name	Listing	Significance grading	Impacts
Stone Hut Ruins	National Parks and Wildlife Services Section 170 ID 12804	**Local**	**Minor - moderate** physical impacts **Neutral** visual and setting impacts **Neutral** archaeological impacts
Murphy's Flat Yards	National Parks and Wildlife Services Section 170 ID 13367	Does not fulfil criteria for a Local listing	**Minor-moderate** physical impacts **Neutral** visual and setting impacts **Neutral** archaeological impacts
Managers Cottage Group Joorilands	National Parks and Wildlife Services Section 170 ID 3817	**State**	**Neutral** physical impacts **Neutral** visual and setting impacts **Neutral** archaeological impacts

Changes to temporary inundation duration (days) for potentially affected S170 sites

Location	Flood event (1 in x chance in a year)							
	1 in 5		1 in 10		1 in 20		1 in 100	
	Existing	Project	Existing	Project	Existing	Project	Existing	Project
Jooriland	NA*	NA	NA	NA	NA	NA	NA	NA
Murphy's Flat Yards	NA	NA	NA	10	NA	13	8	16
Stone Hut Ruins	NA	8	7	10	8	13	8	16
Orange Tree Flat House	NA	8	NA	10	NA	13	NA	16

* Not affected by flood event

Mitigation measures

The following mitigations apply to the project in relation to the four heritage items assessed in this Supplementary Report.

- WaterNSW should conduct an Archival Recording of the four S170 sites prior to the operation of this project. The archival recording should be conducted by an appropriately qualified heritage specialist and must be conducted in accordance with Heritage Office guidelines (see *How to Prepare Archives Records of Heritage Items and Guidelines for Photographic Recording of Heritage Sites, Buildings and Structures*) and should lodge the record with the State Library and the local Council library. The report should be shared with National Parks and Wildlife Service and Heritage NSW for their records. A copy could also be shared with the Wollondilly Heritage Centre & Museum out of courtesy.
- WaterNSW should conduct inspections of these four S170 sites following any major flood event where one or more sites is affected by backwater flooding attributable to the Project, and shall consult with NPWS with regard to any required measures relating to additional temporary inundation from the Project.
- No specific mitigations are required for the State Heritage listed Megarritys Bridge as no heritage impacts are expected.
- WaterNSW to prepare a Management Plan for the locally significant Stone Hut Ruins in consultation with NPWS. This Management Plan would focus on fabric management post-inundation, general conservation post-inundation and opportunities for heritage interpretation, such as through digital archival recording to enable public engagement with the heritage values of the item offsite. This plan should be produced by a suitably qualified heritage specialist with heritage architect and engineer input. The plan can be produced post approval but should be implemented prior to completion of construction.
- WaterNSW to prepare a condition assessment in consultation with NPWS and provide advice on stabilisation and minimisation of moisture ingress and damage to the Stone Hut Ruins. This should be provided to the project prior to construction by a suitably qualified engineer with heritage experience. Findings and recommendations from this reporting must be implemented and considered prior to completion of construction of the project.

CONTENTS

FIGURES

TABLES

1.0 INTRODUCTION

WaterNSW, a New South Wales (NSW) state owned corporation, is seeking environmental planning approval for the Warragamba Dam Raising Project (the project). The Project requires approval from the NSW Minister for Planning under Division 5.2 of the *Environmental Planning and Assessment Act 1979* (NSW) (EP&A Act). Under the project approval application, an Environmental Impact Statement (EIS) was prepared for public exhibition in 2021. This report is a Supplementary Report as part of the next stage in the assessment process for the Response to Submissions Report. The agency advice from the Environment, Energy and Science Group (EES) within the Department of Planning and Environment (DPE) noted that impacts to some sites on the National Parks and Wildlife Service (NPWS) Section 170 Heritage and Conservation Register (S170 Register) had not been addressed in the EIS. Advice provided by Heritage NSW included a general comment that additional information is required to assessment of impacts to Megarittys Bridge. This report has been prepared to assess the project's impact on four non-Aboriginal sites listed on the NPWS Section 170 Register and a separate assessment for the State Heritage Register (SHR) listed Megarittys Bridge (ID #01367).

The project is also a controlled action under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and therefore requires concurrent assessment under the EPBC Act. In accordance with the Bilateral Agreement reached between the NSW and Commonwealth Governments, an EIS under the EP&A Act for State Significant Infrastructure (SSI) can also be used for an EIS under the EPBC Act for a controlled action, where directed by the Federal Minister. The direction was given for the project to be assessed under the Bilateral Agreement on 17 July 2017.

Artefact Heritage has been engaged by SMEC Australia Pty Ltd (SMEC) to undertake further investigations into the potential impacts associated with the proposed flood mitigation works at Warragamba Dam (the project) to four Section 170 (S170) listed sites and to provide a separate assessment for the SHR listed Megarittys Bridge, building off the assessment previously provided in the EIS. The raised dam would provide an airspace (called a Flood Mitigation Zone) to temporarily capture up to around 1,000 gigalitres of water during a rainfall or inflow event. The aim of this Supplementary Report is to identify the five listed heritage items and any potential archaeological remains which may be impacted by the project, determine the level of heritage significance of each item, assess the potential impacts to those items, recommend mitigation measures to reduce or avoid heritage impacts and identify other management or statutory obligations.

Artefact Heritage note that impact assessment of the World and National heritage listed Greater Blue Mountains World Heritage Area (GBMWHA), including the Greater Blue Mountains Area – Additional Values, has been assessed in a separate report provided as Appendix J to the EIS with additional information provided in the Submissions Report. Artefact Heritage also note that the Managers Cottage Group Joorilands (item #3817) listed on the NPWS S170 Register and the SHR listed Megarritys Bridge (item #01367) were assessed as part of the Non-Aboriginal Heritage Impact Assessment for the EIS however this report offers further information about the impact assessment.

1.1 Project location

The overall project area is located approximately 65 km west of the Sydney Central Business District in the Wollondilly Local Government Area (LGA). To the west of the project area are the Blue Mountains, various National Parks and State Conservation Areas and the GBMWHA which make up part of the catchment of Lake Burragorang – the water storage formed by Warragamba Dam. To the east of the project area is the Warragamba and Silverdale townships and surrounding rural residential areas.

1.1.1 Study area

The study area has been separated from the overall project area for targeted assessment of the project on the S170 sites in question (see Figure 1-1). Megarritys Bridge is located within the vicinity of the Construction Footprint for the project and has been illustrated in Figure 1-1 although it is noted that this assessment largely focuses on the S170 sites.

The study area comprises an area along the tributaries of Lake Burragorang, specifically Wollondilly River and the Little River. Two of the S170 listed sites are along the Wollondilly River at Colemans Bend, roughly 1.5 km from Smiths Lagoon. One of the S170 sites is further upstream along the Wollondilly, roughly 6 km from Smiths Lagoon. The other S170 listed site is along the Little River, roughly 4 km from Lake Burragorang and 500 m from where the Little River and the Nattai River meet. To the west of this study area is the Yerranderie State Conservation Area, to the north is the Nattai State Conservation Area, and to the east/south is the Nattai National Park.

See Figure 1-2 to Figure 1-5 for the locations of the four S170 sites.

Megarritys Bridge is located approximately 2 km east of Warragamba Dam. The bridge site is located at the base of the Warragamba Chlorine Dosing Plant in Wallacia, and crosses over Megarritys Creek, a tributary of Warragamba River. The bridge can also be accessed off Weir Road in Warragamba.

See Figure 1-6 for the location of the SHR listed Megarritys Bridge.

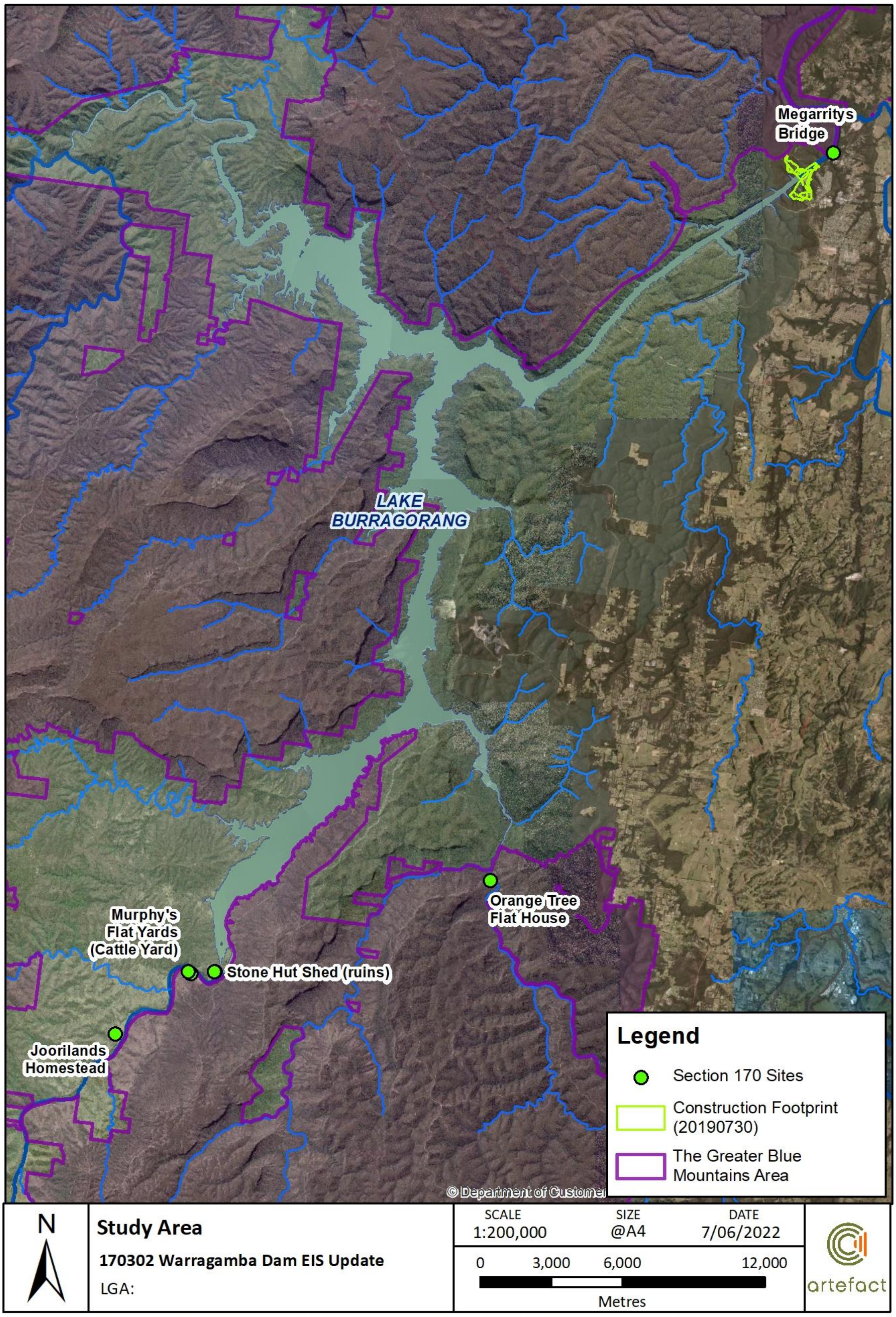

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Figure 1-1: Regional location of the S170 sites in relation to the World Heritage area and the construction footprint

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Figure 1-2: Location of the Orange Tree Flat House site

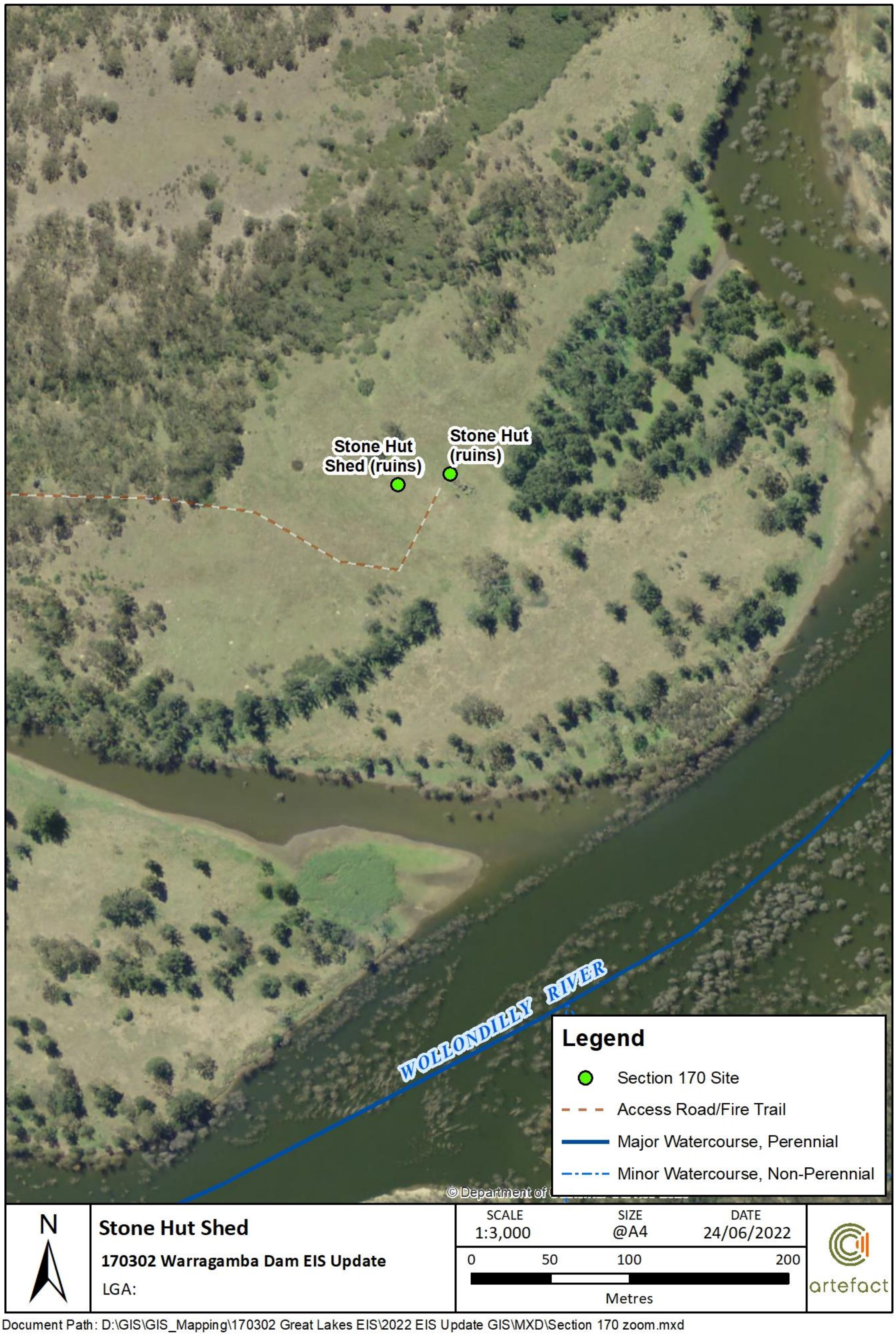

Figure 1-3: Location of the Stone Hut Ruins site

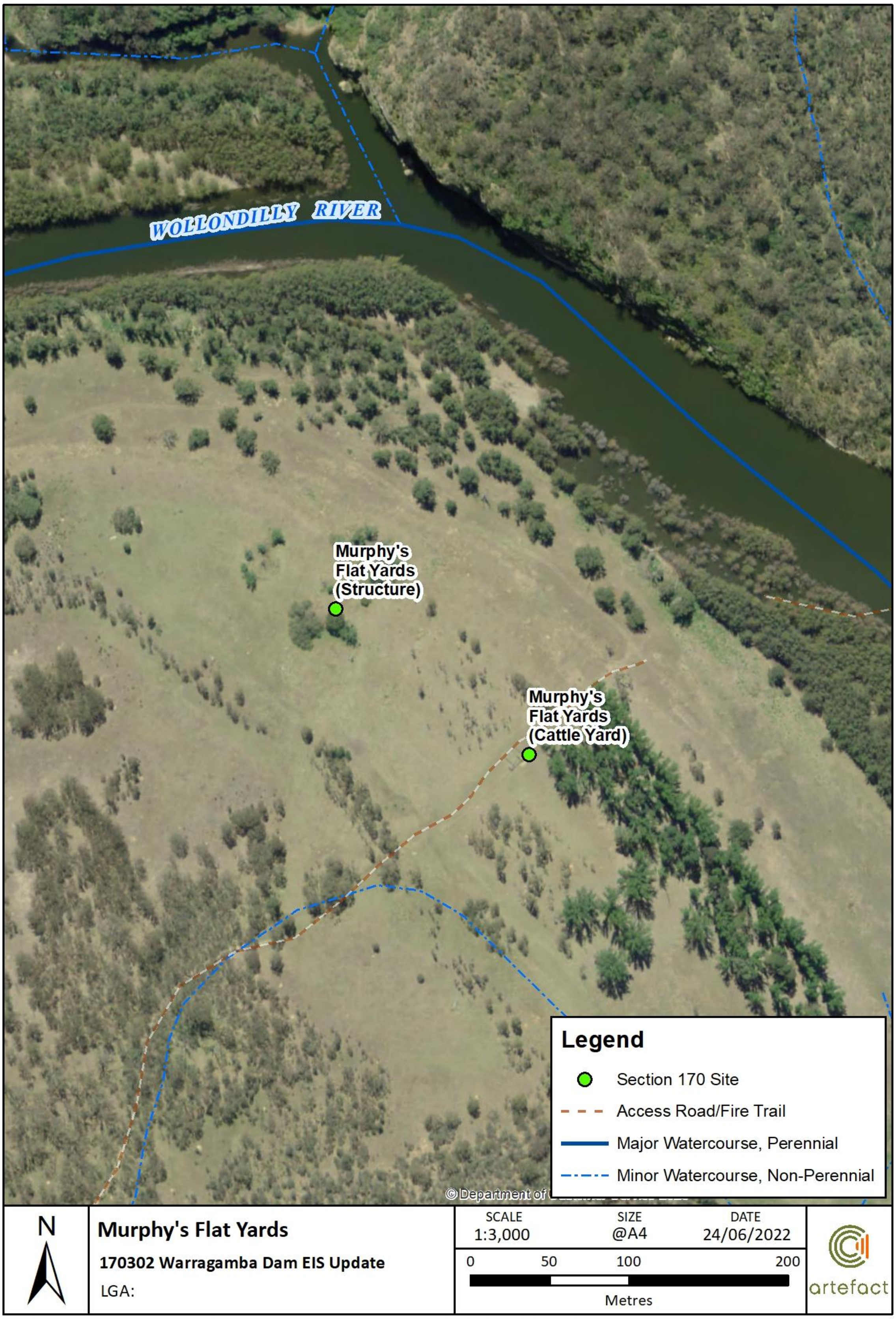

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Figure 1-4: Location of the Murphy's Flat Yards site

Figure 1-5: Location of the Joorilands Homestead site

Figure 1-6: Location of the Megarritys Bridge site

Figure 1-7: Location of the Megarritys Bridge site in relation to the construction footprint

1.2 Methodology

The scope of this Supplementary Report is to prepare a non-Aboriginal heritage assessment for the project in accordance with the EPBC Act and the *Heritage Act 1977* (Heritage Act). This report contains targeted assessment of five heritage items as part of the Submissions Report stage of the EIS for the project. The heritage impact assessment is consistent with the methodology used in the EIS report (refer Appendix I *Non-Aboriginal Heritage Assessment Report*, Section 7.1).

Construction impacts associated with raising the dam wall to create a Flood Mitigation Zone, and impacts from the operation of the project will be assessed. The Supplementary Report will assess the site areas as shown in Figure 1-2 to Figure 1-6.

This Supplementary Report has been informed by the *NSW Heritage Manual* (NSW Heritage Office and NSW Department of Urban Affairs and Planning 1996) and the *Australia ICOMOS Charter for Places of Cultural Significance, The Burra Charter*, 2013 (Burra Charter). In addition, this report has been prepared in accordance with the following heritage guideline and policy documents:

- Heritage Council of NSW *Statements of Heritage Impact* (updated 2002)
- Heritage Council of NSW *Assessing Heritage Significance: NSW Heritage Manual* (updated 2002)
- Heritage Branch, Department of Planning, *Assessing Significance for Archaeological Sites and 'Relics'* (2009)

1.3 Limitations

Overall, the following limitations apply to the assessment:

- No Aboriginal heritage values were assessed in this report.
- No sub-surface investigations were undertaken. The assessment of archaeological potential is based on knowledge of similar sites and site formation processes, the historical background and predicted robustness of potential archaeological remains
- This assessment relies on publicly available digital mapping data. No additional mapping has been carried out to map the curtilage of items that do not have publicly available digital mapping data (i.e. items on Section 170 Heritage and Conservation Registers)
- No identification or assessment of unlisted items of potential heritage significance not included on statutory registers or lists was undertaken due to the extensive potential study area. The identification of unlisted heritage items was therefore beyond the scope of this assessment.
- Site inspection of the Jooriland Homestead S170 item and the Megarritys Bridge SHR item were not completed as part of this assessment. All information related to the significance, historical context and impact assessment for this site has been extracted from previous assessments.
- No community consultation was undertaken in the production of this assessment. Social and associative significance assessments for heritage listed items and potential archaeological resources were based predominantly on existing studies and data included on the State Heritage Inventory (SHI) for individual items.

1.4 Authorship

This assessment was prepared by Jess Mauger (Senior Heritage Consultant). Section 5.0 was prepared by Sam Sammut (Heritage Consultant) and reviewed by Jenny Winnett (Principal). Dr Sandra Wallace (Managing Director) provided management input and review.

2.0 HERITAGE LISTINGS

2.1 Legislative context

The legislative context of the planning approval and listings is discussed in detail in the EIS assessment, see Section 2 of Appendix I Non-Aboriginal Heritage Assessment. The below legislative context relates to the additional items assessed for this supplementary report.

2.1.1 State Heritage Register

The State Heritage Register listed Megarritys Bridge (ID #01367) has been included in this assessment and the curtilage is shown below in Figure 2-1.

Figure 2-1: State Heritage curtilage of Megarritys Bridge #01367

2.1.2 Section 170 Heritage and Conservation Registers

The Heritage Act requires all NSW government agencies to identify and manage heritage assets under their ownership and control. Under Section 170(3) of the Heritage Act, government instrumentalities must establish and keep a register which includes all places of environmental heritage listed on the SHR, environmental planning instruments, or which may be subject to an interim heritage order that are owned, occupied, or managed by that government body. Government agencies must also ensure that all places entered on its register are maintained with due diligence in accordance with State Owned Heritage Management Principles approved by the Minister on advice of the NSW Heritage Council. These principles serve to protect and conserve the heritage significance of identified sites, places and objects and are based on relevant NSW heritage legislation and statutory guidelines.

There are **four** places listed on State Agency Section 170 Heritage and Conservation Registers located within the study area. As mapped, Section 170 Heritage and Conservation Registers curtilages are not available for many items on the State Heritage Inventory (SHI) database and the items within the study area have not been mapped in this Supplementary Report.

Of the four sites, the Managers Cottage Group Joorilands has a Conservation Management Plan (prepared by Christo Aitken & Associates for National Parks and Wildlife Services, August 2006) but it is understood that there are no existing management plans for the other three sites.

Table 2-1: Section 170 Heritage and Conservation Register listings within the study area

Heritage Item	Section 170 Heritage and Conservation Registers No.	Location
Orange Tree Flat House	National Parks and Wildlife Services Section 170 ID 12805	Zone: GDA 56 Easting: 264612 Northing: 6218580
Murphy's Flat Yards	National Parks and Wildlife Services Section 170 ID 12804	Zone: GDA 56 Easting: 251979 Northing: 6214619
Stone Hut Ruins	National Parks and Wildlife Services Section 170 ID 13367	Zone: GDA 56 Easting: 253016 Northing: 6214729
Managers Cottage Group Joorilands	National Parks and Wildlife Services Section 170 ID 3817	Zone: GDA 56 Easting: 248805 Northing: 66212090

3.0 HISTORICAL CONTEXT

This chapter provides additional historical information relating to the items assessed in this Supplementary Report. The history of the broader study area has not been reproduced as it is included in the EIS assessment.

3.1 Orange Tree Flat House

The Orange Tree Flat House is located just off the Orange Tree Flat Trail, close to the bend of Little River and in the basin of a steep valley formed by the Nattai Tablelands. Early European settlement in the Wollondilly region was predominantly rural. The rich soil of the riverside land was ideal for crop cultivation, and the tall native forests provided plenty of work for timber-getters.

The subject site is located on a 100-acre (40-hectare) lot of land in the Parish of Burragorang that belonged to James O'Brien prior to 1900, according to the earliest available Parish maps (Figure 3-2). James O'Brien was born in Menangle, Wollondilly, in September 1842 and died in 1900, although the estate appears to have remained in his name into the 1930's.[1] The year of O'Brien's land grant is unknown, however, it was likely allotted at a similar time to neighbouring grants. The lot of land immediately north of the subject site was owned by ex-convict Thomas Maxwell, who died by drowning in the Wollondilly River in 1843.[2] It can be assumed that the land in and around the subject site was granted to O'Brien sometime before Maxwell's death.[3]

Early parish maps indicate that the large "Mount Burragorang" estate immediately to the east of the O'Brien estate was set aside for the "preservation and growth of timber," (Figure 3-2) and it is likely that O'Brien's estate was used for the same purpose. A 1933 tourist map of the Burragorang Valley (Figure 3-1) places an 'old farm' and 'sawmill and camp' at the subject site. The map notes that ex-convict and local constable James Reilly (who served in the area from 1828) named Orange Tree Flat as the point at which the first white man – Francis Louis Barrallier in 1802 – entered the Burragorang Valley. The Orange Tree Flat property was one of the earliest settled areas in the Burragorang Valley, and likely consisted of a homestead, timber-getter's campsite, and sawmill. It is probable that the Orange Tree Flat House used purely for the purposes of timber cultivation, and is a representation of the early timber-getting industry in Wollondilly.

Significant clearing along the north and western edge of the property is evident on aerial images from 1962, which also indicates that the property was primarily a timber-getting site (Figure 3-3). Tree and bush regrowth are apparent in aerial photography from 1977 (Figure 3-4) and 1990 (Figure 3-5). A road through the subject site that accommodated a single vehicle is marked on parish maps from 1900 and now forms the Orange Tree Flat trail. The house is not visible on the earliest available aerial maps (from 1962) to present (see Figure 3-3 to Figure 3-5), and the exact date of its construction is unknown, however, it probably pre-dates O'Brien's death in 1900.

1 Find a Grave, "James O'Brien, 1842-1900," accessed 10 May 2022 via: <https://www.findagrave.com/memorial/145158709/james-o'brien>.
2 NSW State Archives, Convict Index. "MAXWELL, Thomas: 4/4303; Reel 986" accessed on 10 May 2022 via: <https://www.records.nsw.gov.au/archives/collections-and-research/guides-and-indexes/node/1616/browse>.
3 Ibid.

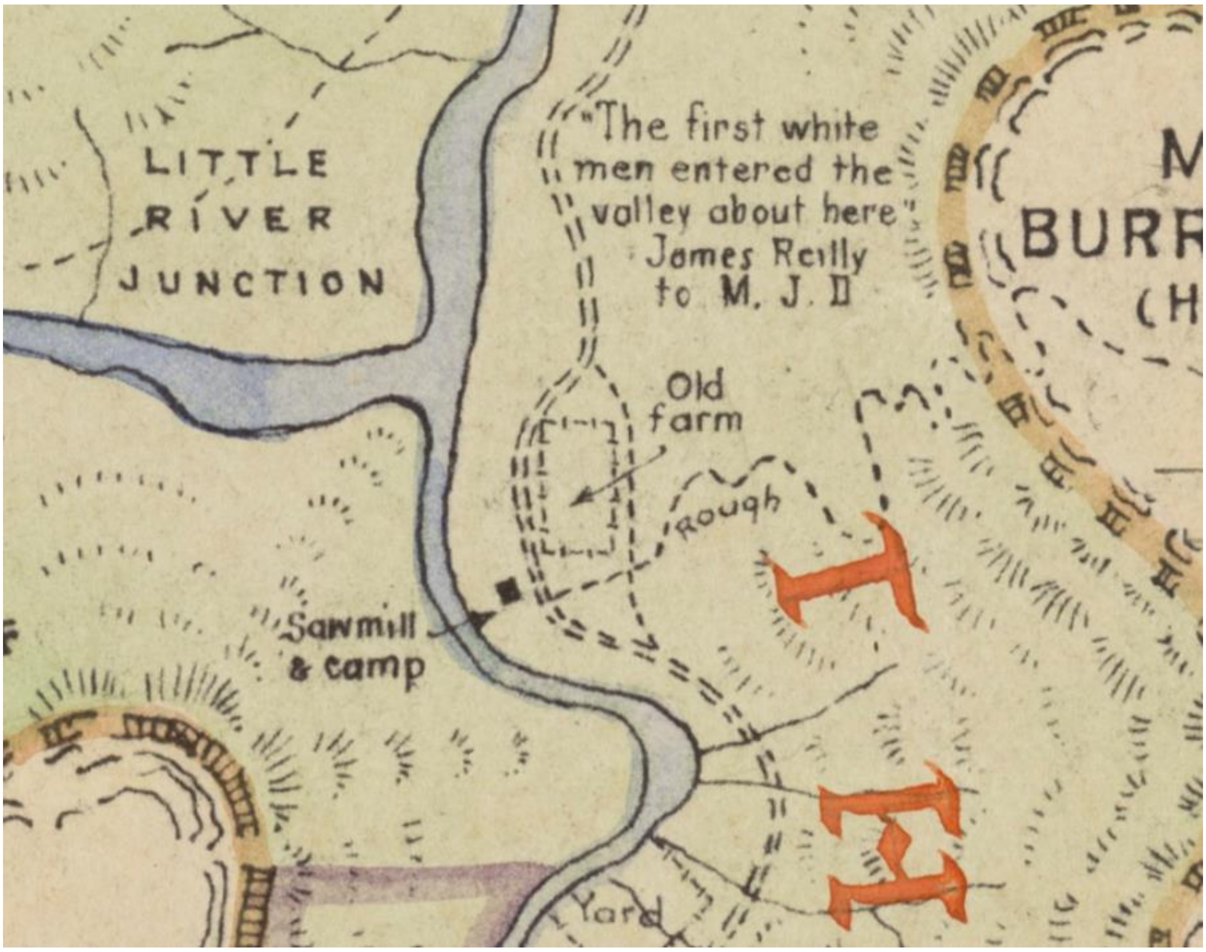

Figure 3-1. 1933 Map of the Picton Lakes, Blue Gum & Little River Canyons, lower Nattai Valley and central Burragorang, including the country between Buxton, Picton and The Oaks. (Source: State Library of NSW, 74VvVVEZgXvA)

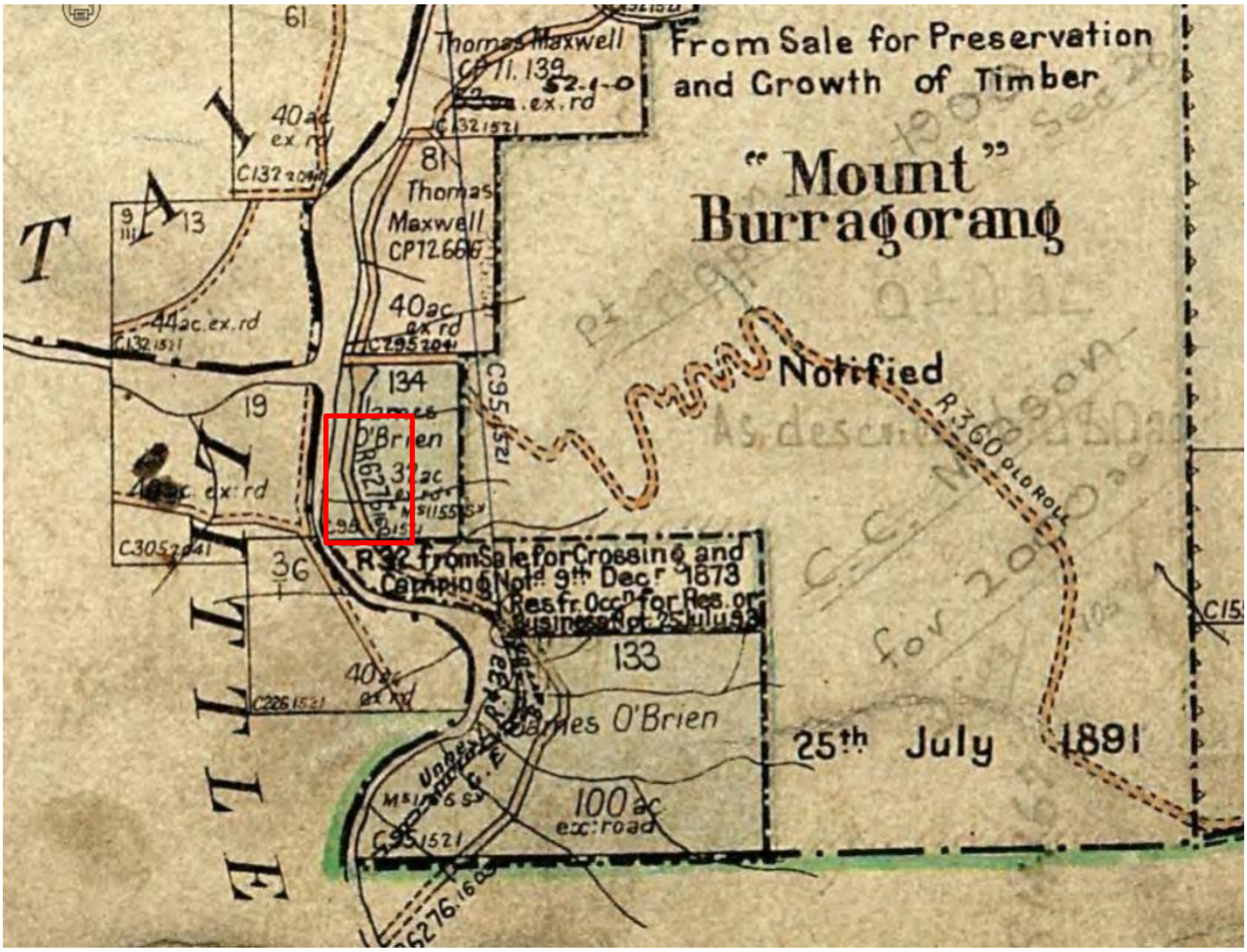

Figure 3-2. 1900 Parish of Wollondilly map, approximate subject site marked in red (Source: Historic Land Records Viewer)

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Figure 3-3. 1962 Aerial image, approximate site location (Source: NSW Spatial Services)

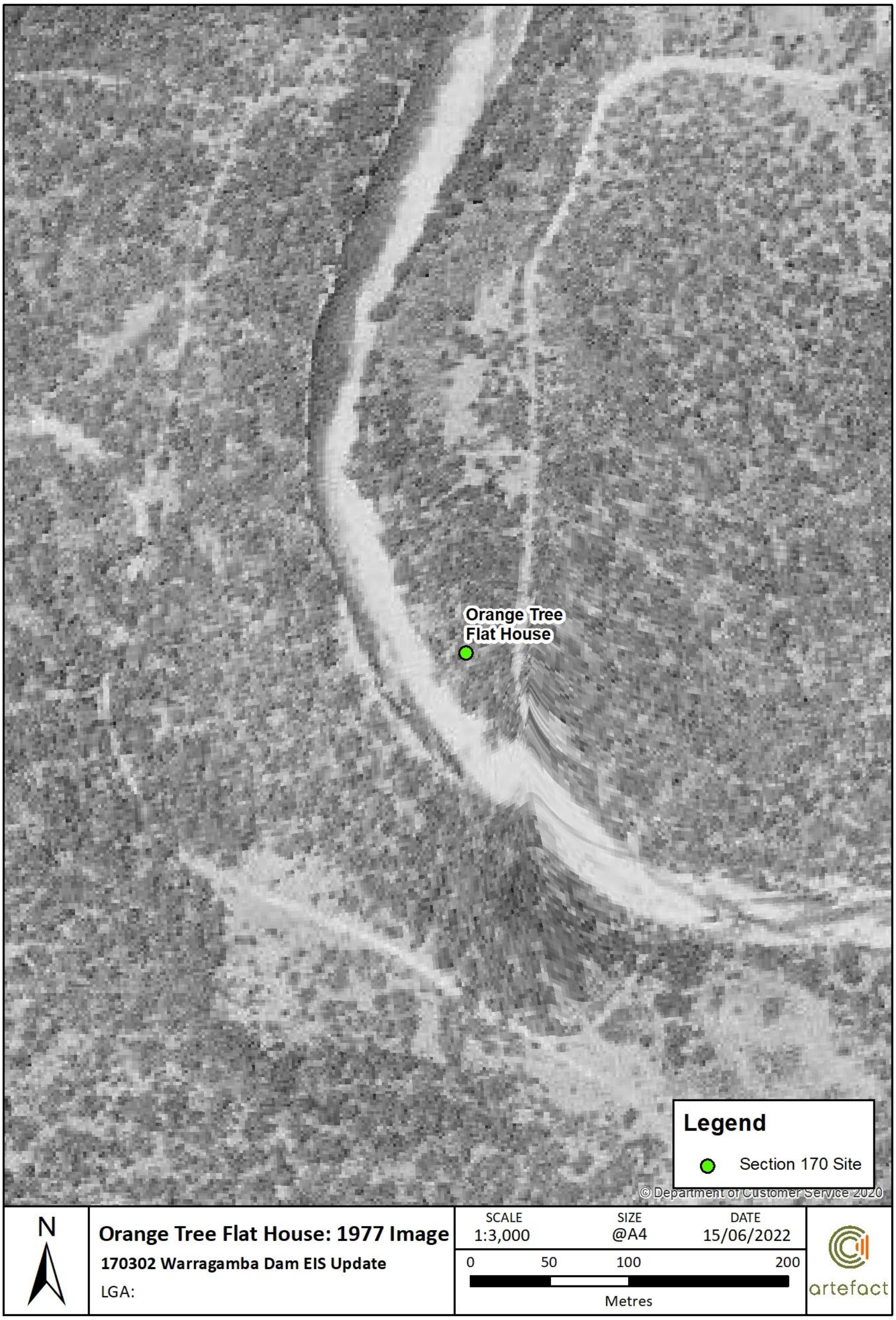

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Figure 3-4. 1977 Aerial image, approximate site location (Source: NSW Spatial Services)

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Figure 3-5. 1990 Aerial image, approximate site location (Source: NSW Spatial Services).

3.2 Stone Hut Ruins

The stone hut ruins are located on a 100-acre lot of land at Colemens Bend on the Wollondilly River. The land was purchased in 1838 by Richard Hunt and Samuel Barber, who jointly owned 1,000 acres of land in Burragorang.[4] Like many early settlers to the region, Hunt and Barber probably used their land for grazing cattle and sheep, a popular industry in the area west of the Wollondilly River.[5] Unlike fellow pastoralists residing in the valley at the time, in 1877 Samuel Barber protested the proposed flooding of Burragorang, writing in the Sydney Morning Herald "the only source from whence the city of Sydney and suburbs can be supplied with pure water is from the Nepean."[6] Hunt's descendants lived in the Burragorang Valley until 1933, leaving a decade before the valley was flooded.[7] A small amount of land immediately to the west of the subject site was "put aside for the use of Aborigines" in 1891 according to parish maps. The local Catholic priest, Father John Dillon, had established two Aboriginal reserves in 1878 at Toonali River and Byrnes Creek, and it has been noted that the property west of the ruins was a third reserve.

An image of the house (Figure 3-7) that probably dates to 1900-1910 – prior to the flooding of the Burragorang Valley – indicates that it was likely used as a homestead into the early 20th century; the property is cleared and fenced, and a woman is pictured doing laundry on the veranda. By the 1980s, Hunt and Barber's land had been resumed by the state as a conservation area, and the house was abandoned and in poor condition by 1990. An image from the 1990s shows that much of the structure had crumbled away and the house was overgrown with trees and scrubs (Figure 3-8).

Aerial images from 1977 (Figure 3-10) and 1990 (Figure 3-11) show that the land was largely cleared, with the exception of a line of trees close to the hut and some dispersed trees to the north. This may be the result of human intervention or could be a natural geographical occurrence or self-seeded trees.

4 *New South Wales Government Gazette No. 331*, 2 May 1838. 'Title Deeds,' pg. 341.

5 Steven Ring and Christo Aitken & Associates, et al. for Sydney Catchment Authority and National Parks and Wildlife Services, June 2001, *Jooriland Sheep Station: Yerranderie State Conservation Area – Draft Conservation Management Plan. Part 3*, pg. 14.

6 *Sydney Morning Herald*, 24 Mar 1877. 'To the editor of the Sydney Morning Herald,' pg. 8.

7 Part 3, pg. 14.

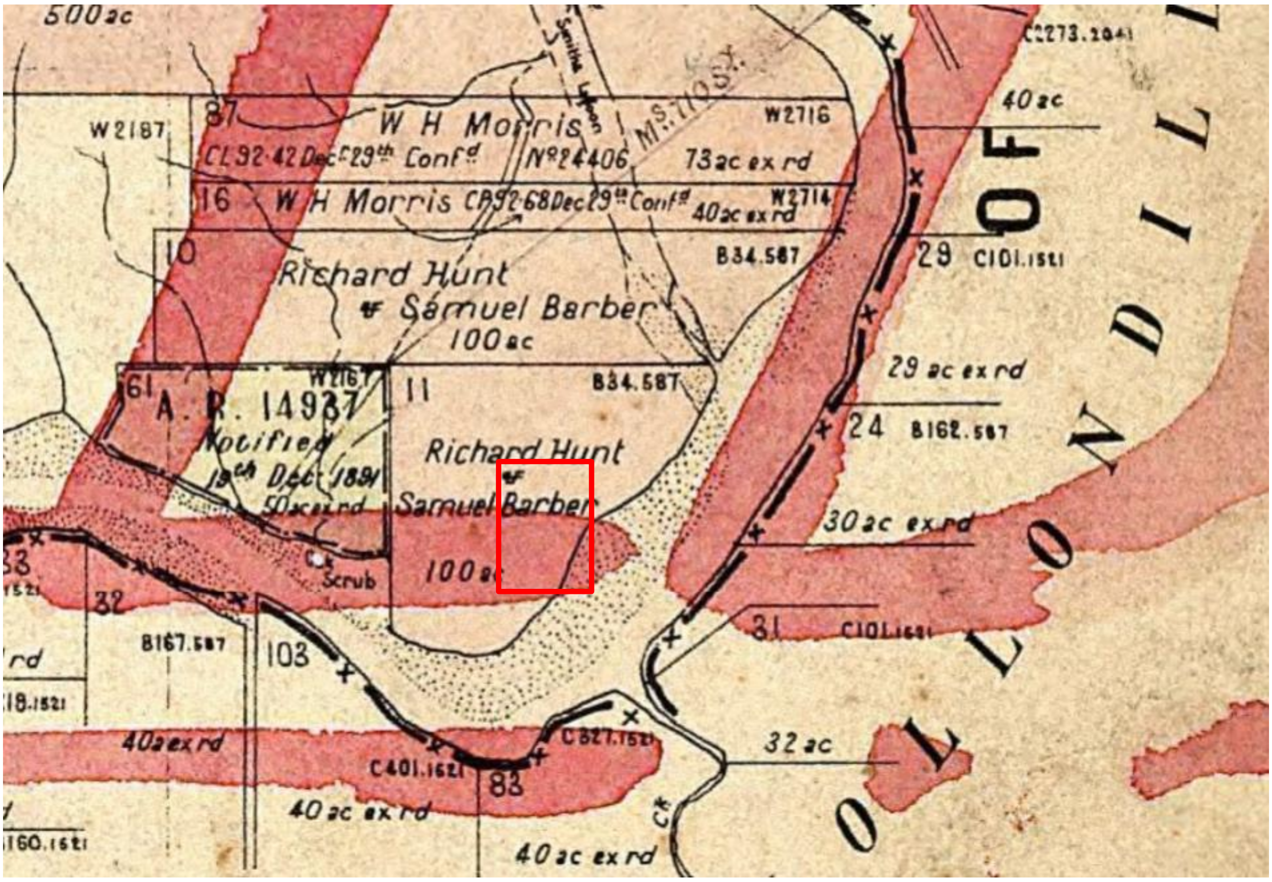

Figure 3-6. 1895 Parish of The Peaks map, subject site in red (Source: Historic Land Records Viewer).

Figure 3-7. Stone Hut Ruins, pre-flooding, date unknown but likely the late 1920s or early 1930s (Source: Trish Hill, Wollondilly Heritage Centre & Museum)

Figure 3-8. Stone hut ruins, c. 1990 (Source: Trish Hill, Wollondilly Heritage Centre & Museum)

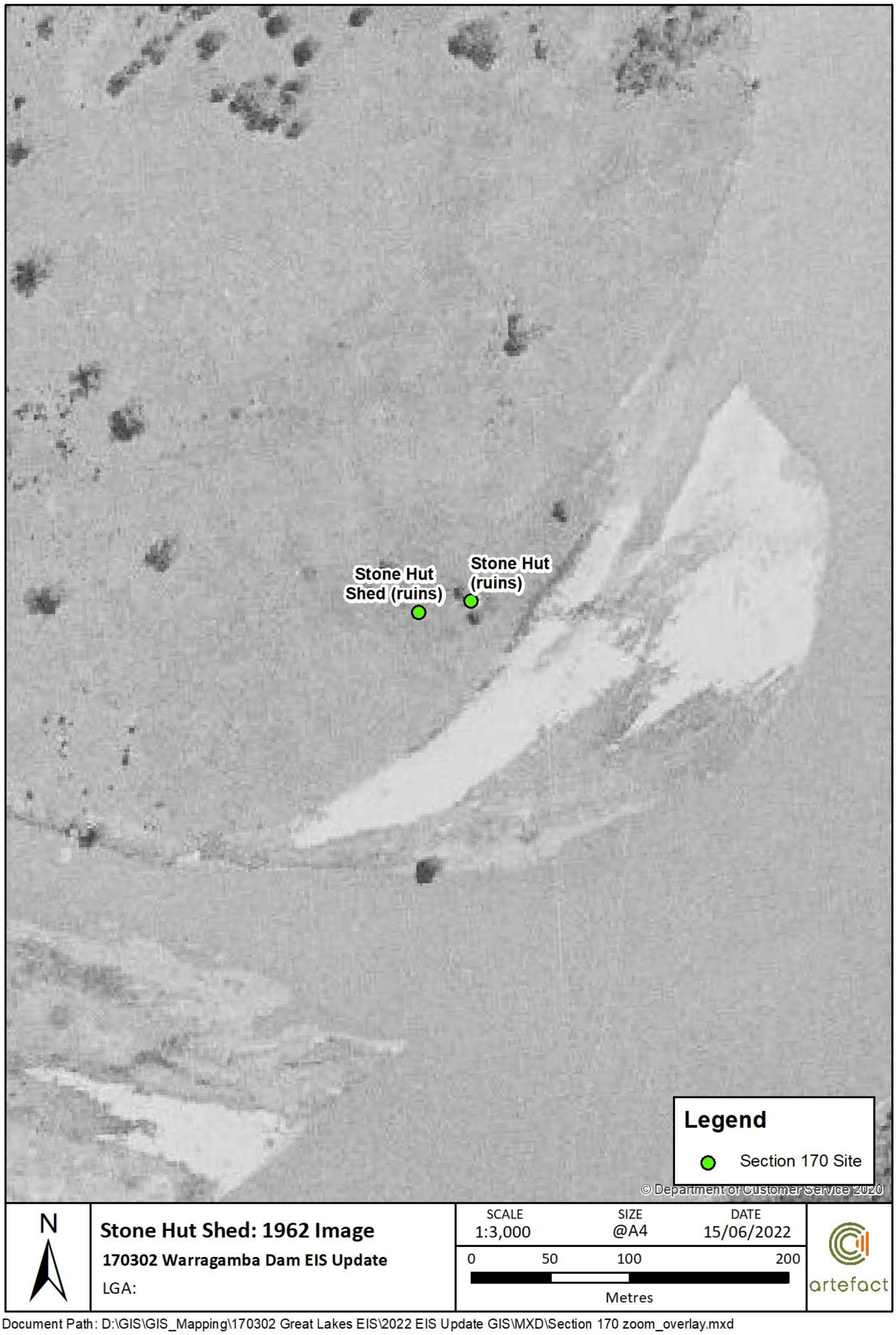

Figure 3-9. 1962 Aerial image, overlayed with approximate site location (Source: NSW Spatial Service)

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Figure 3-10. 1977 Aerial image, overlayed with approximate site location (Source: NSW Spatial Service)

Figure 3-11. 1990 Aerial image, overlayed with approximate site location (Source: NSW Spatial Service)

3.3 Murphy's Flat Yards

The subject site – known the "Murphy's Flat Yards" – is located on a 40-acre lot of land (Figure 3-12) that was owned by Edward Murphy from around 1854.[8] Murphy lived in Burragorang with his wife, Mary, and four daughters.[9] Like most others in the region, the Murphy family was Irish-Catholic and appears to have been highly involved in the local church community – in 1865, the Murphy's hosted the 25-year anniversary celebration of the construction of Burragorang's Catholic church.[10]

Despite the Murphy family's proximity to the coal mines of Yerranderie, their property appears to have been used as a homestead. Upon his death in 1880, Murphy's land was put up for sale, with the notice of sale recording that he owned over 250 acres of cleared, fenced, and cultivated land along the Wollondilly River.[11] The exact nature of the 'cultivation' is not stated, however, nearby properties appeared to have been used for orchards, timber-getting, or grazing. As per Figure 3-13, the notice of sale records a 40-acre lot of land on the Wollondilly that was "partly fenced and ring-barked" and with a "Bush Hut and Stock-yard on this lot" – it is on this lot of land that the subject site is located.[12] The existence of a stockyard indicates that the land was used for grazing for a period in the 19th century and existing stone, brick and concrete remains on the site suggest the "Bush Hut" was upgraded to a more substantial building with surrounding sheds and structures perhaps in the late 19th or early 20th centuries.

There are no further records of sale following this 1881 notice, and Edward Murphy continues to be listed as the land's owner in 1973 parish maps. Aerial photography from 1962 (Figure 3-14) shows that the subject site was almost entirely cleared. The former structures are not visible on aerials until 1977 (Figure 3-15), when the ruins become apparent – this is likely due to advancements in photography rather than an indicator of its construction date. The aerials also show a neat row of trees appearing to the east, which indicates they were possibly planted sometime between 1962 and 1977. It is possible there were occupants of the land up until at least the mid-1960s.

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8 *New South Wales Government Gazette No. 78*, 1 Jul 1854. 'Country Lots,' pg. 1351.
9 *Freeman's Journal*, 6 Apr 1878. 'Death,' pg. 12.
10 *Freeman's Journal*, 23 Dec 1865. 'The Jubilee at Camden,' pg. 807.
11 *Freeman's Journal*, 2 Jul 1881. 'To Farmers and Others – 7 Blocks of Rich Land,' pg. 20.
12 Ibid.

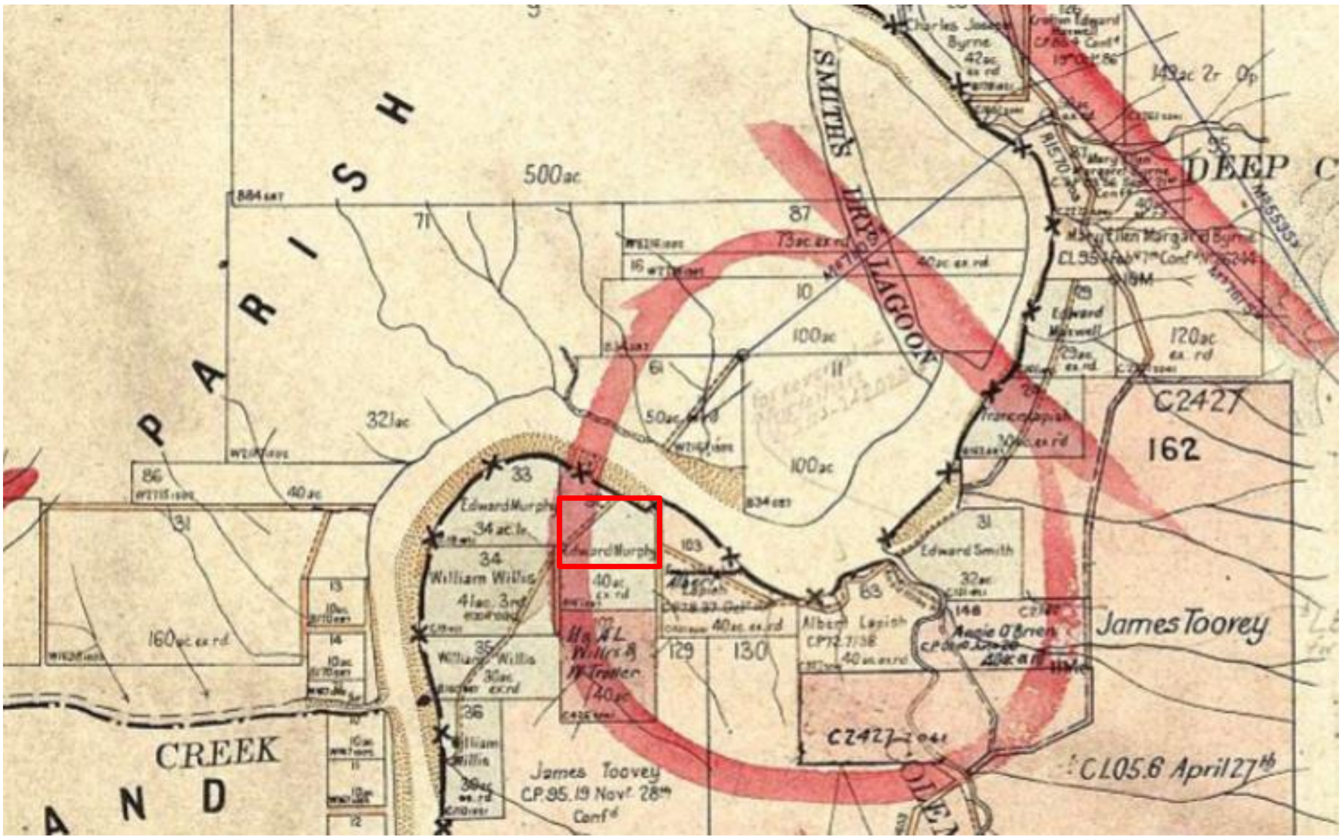
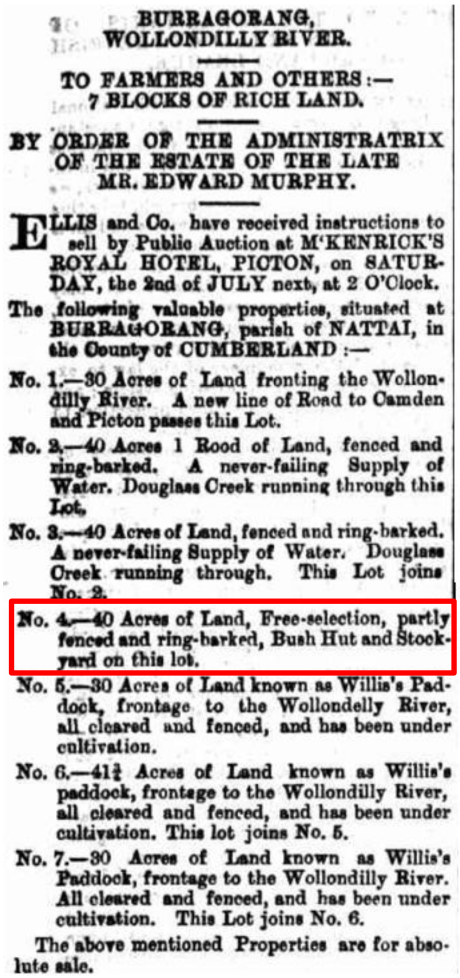


Figure 3-12. 1899 Parish of Nattai map, subject site in red box (Source: Historic Land Records Viewer).



BURRAGORANG,
WOLLONDILLY RIVER.

TO FARMERS AND OTHERS:—
7 BLOCKS OF RICH LAND.

BY ORDER OF THE ADMINISTRATRIX OF THE ESTATE OF THE LATE MR. EDWARD MURPHY.

ELLIS and Co. have received instructions to sell by Public Auction at M'KENRICK'S ROYAL HOTEL, PICTON, on SATURDAY, the 2nd of JULY next, at 2 O'Clock.

The following valuable properties, situated at BURRAGORANG, parish of NATTAI, in the County of CUMBERLAND:—

No. 1.—30 Acres of Land fronting the Wollondilly River. A new line of Road to Camden and Picton passes this Lot.

No. 2.—40 Acres 1 Rood of Land, fenced and ring-barked. A never-failing Supply of Water. Douglass Creek running through this Lot.

No. 3.—40 Acres of Land, fenced and ring-barked. A never-failing Supply of Water. Douglass Creek running through. This Lot joins No. 2.

No. 4.—40 Acres of Land, Free-selection, partly fenced and ring-barked, Bush Hut and Stockyard on this lot.

No. 5.—30 Acres of Land known as Willis's Paddock, frontage to the Wollondelly River, all cleared and fenced, and has been under cultivation.

No. 6.—41½ Acres of Land known as Willis's paddock, frontage to the Wollondilly River, all cleared and fenced, and has been under cultivation. This lot joins No. 5.

No. 7.—30 Acres of Land known as Willis's Paddock, frontage to the Wollondilly River. All cleared and fenced, and has been under cultivation. This Lot joins No. 6.

The above mentioned Properties are for absolute sale.

Figure 3-13. Notice of Sale, 1881 (Source: Freeman's Journal).

Figure 3-14. 1962 Aerial image, overlayed with approximate site location (Source: NSW Spatial Service).

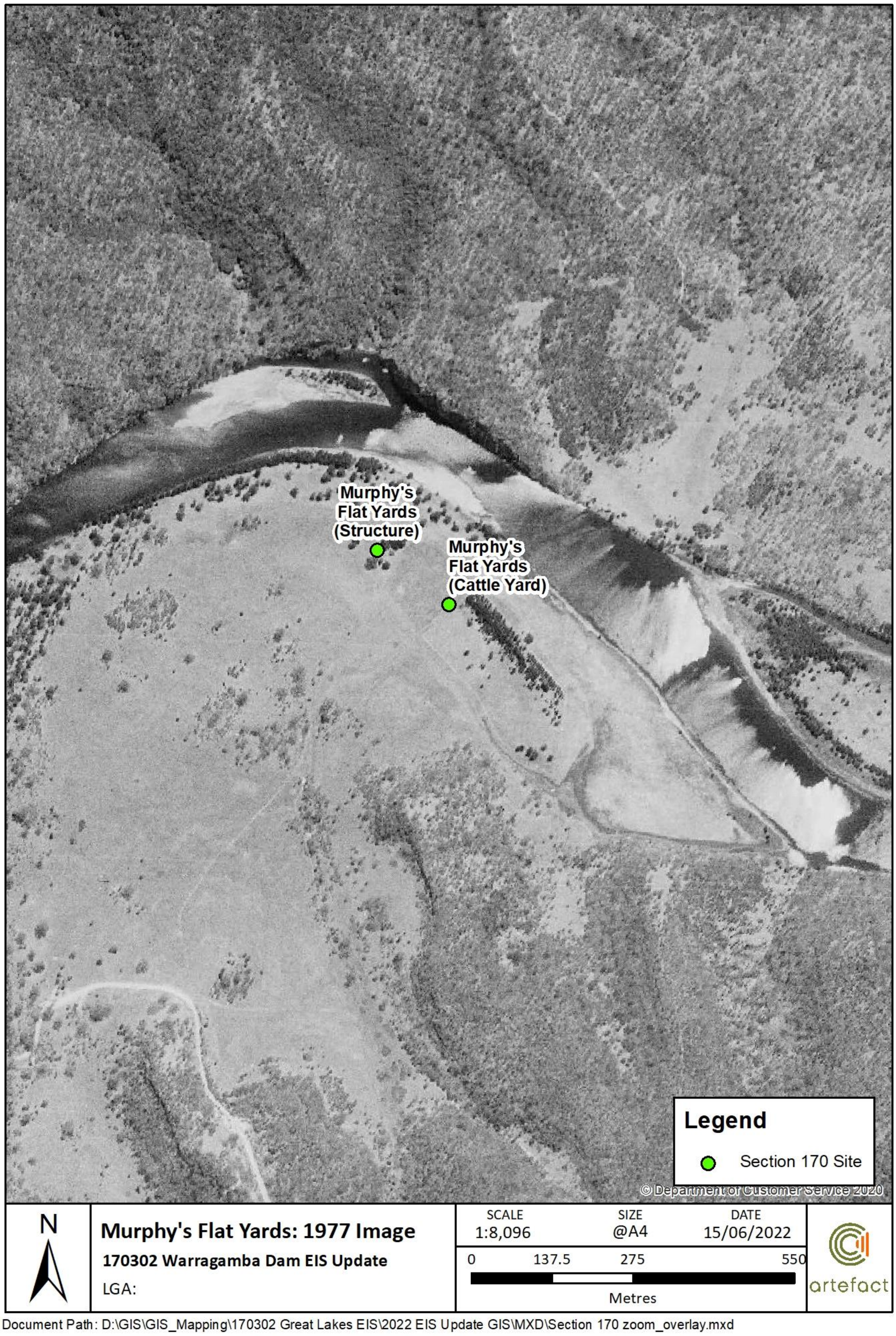


Figure 3-15. 1977 Aerial image, overlayed with approximate site location (Source: NSW Spatial Service).

Figure 3-16. 1990 Aerial image, overlayed with approximate site location (Source: NSW Spatial Service)

3.4 Jooriland Homestead

The following history of Jooriland has been extracted from previous reporting including the Non-Aboriginal Heritage Impact Assessment prepared by Artefact for the EIS, the *Jooriland Sheep Station: Yerranderie State Conservation Area – Draft Conservation Management Plan* (draft CMP) prepared by Steven Ring and Christo Aitken & Associates, et al. for the Sydney Catchment Authority and NPWS (June 2001) and the *Jooriland Sheep Station Conservation Management Strategy* (CMS) prepared by Christo Aitken & Associates for NPWS (2006).[13] The extent of the structures on the homestead are shown in red on Figure 3-19 and Figure 3-20. The Jooriland Old Homestead building as well as examples of pastoral activities in Burragorang are shown in Figure 3-17.

John Wild – a former government cattle herdsman at Camden – and his wife Emmeline Susannah Wild were granted the land that would become "Jooriland" in 1852. Between 1852 and 1870 the road to Camden is constructed through the station, and the hut and sheepyard are also erected during this time. Following Wild's death in 1857 the 12 ha riverside block was held by his family until 1875, when it was bought by Edward Moore from Oran Park. Moore obtained additional grants to build "Jooriland" to its final size and erected the timber homestead that still stands, before selling in 1902 to George and Amelia Egan, who held the property until 1925. The Egan's expanded the Old Homestead and re-constructed the roof. They also established a slab cottage, a woolshed and a new homestead on the property.

Then ensued the first of the property's two tenures by prominent pastoral families, when it was acquired by Denzil (later Sir Denzil) Macarthur-Onslow – a descendant of Merino pioneer John Macarthur – in 1925 and later sold it to the family-controlled Camden Park Estates in 1932. Camden Park Estates held "Jooriland", which they ran primarily as a sheep station in conjunction with their Camden dairy interests, until 1936 when it was bought by a Sydney property dealer, Frank Thurech, an investor from Double Bay. In 1936 the property again changed hands, this time to a sibling partnership of the Pye pastoral family. Richard and Henry Pye were both graziers from Sydney. It is between 1936 and 1945 that modifications to the bathroom and kitchen in the Old Homestead occur, electricity was introduced, and a former timber and fibro cottage adjacent to the Old Homestead was likely constructed.

In 1945 Henry and Richard Pye sold "Jooriland" to another brother, Walter Pye, a prominent Sydney businessman and philanthropist (who later donated his historic home, "Lindesay" at Darling Point, to the National Trust). A new shearers quarters was constructed during this time before the land was sold to Frederick Pye in 1948, another relative of the grazier family.

From 1955 the land was purchased by the NSW Water Board (now WaterNSW and Sydney Water) and access became restricted. The area was gazetted as part of the Yerranderie State Recreation Area in the late 20th century and was partially leased to Langs of Bindook Station until 1993. The Old Homestead was not used by Langs from 1972 onwards. Some of the buildings were used by the Water Board and NPWS as a base camp for joint management project, with some burning down in the 1980s. Remnants of these structures were buried on site by the Water Board.

In 2001, Steven Ring and Christo Aitken & Associates were commissioned to draft a Conservation Management Plan for the site, which based some of their assessment on the Australian Water Technologies study conducted by James Stephany for the Water Board in 1994.

[13] Refer to: Artefact Heritage, 2021. 'Warragamba Dam Raising Environmental Impact Statement, Appendix I,' report to Water NSW, pg. 73.; Steven Ring and Christo Aitken & Associates, et al. for Sydney Catchment Authority and National Parks and Wildlife Services, June 2001, *Jooriland Sheep Station: Yerranderie State Conservation Area – Draft Conservation Management Plan*. Part 1, pg. 18.

Figure 3-17. Historic images of pastoral activities in Burragorang and the Jooriland Old Homestead (Source: Source: "How 'Jooriland' joined pastoral pyes' stable", *The Land*, 2018)

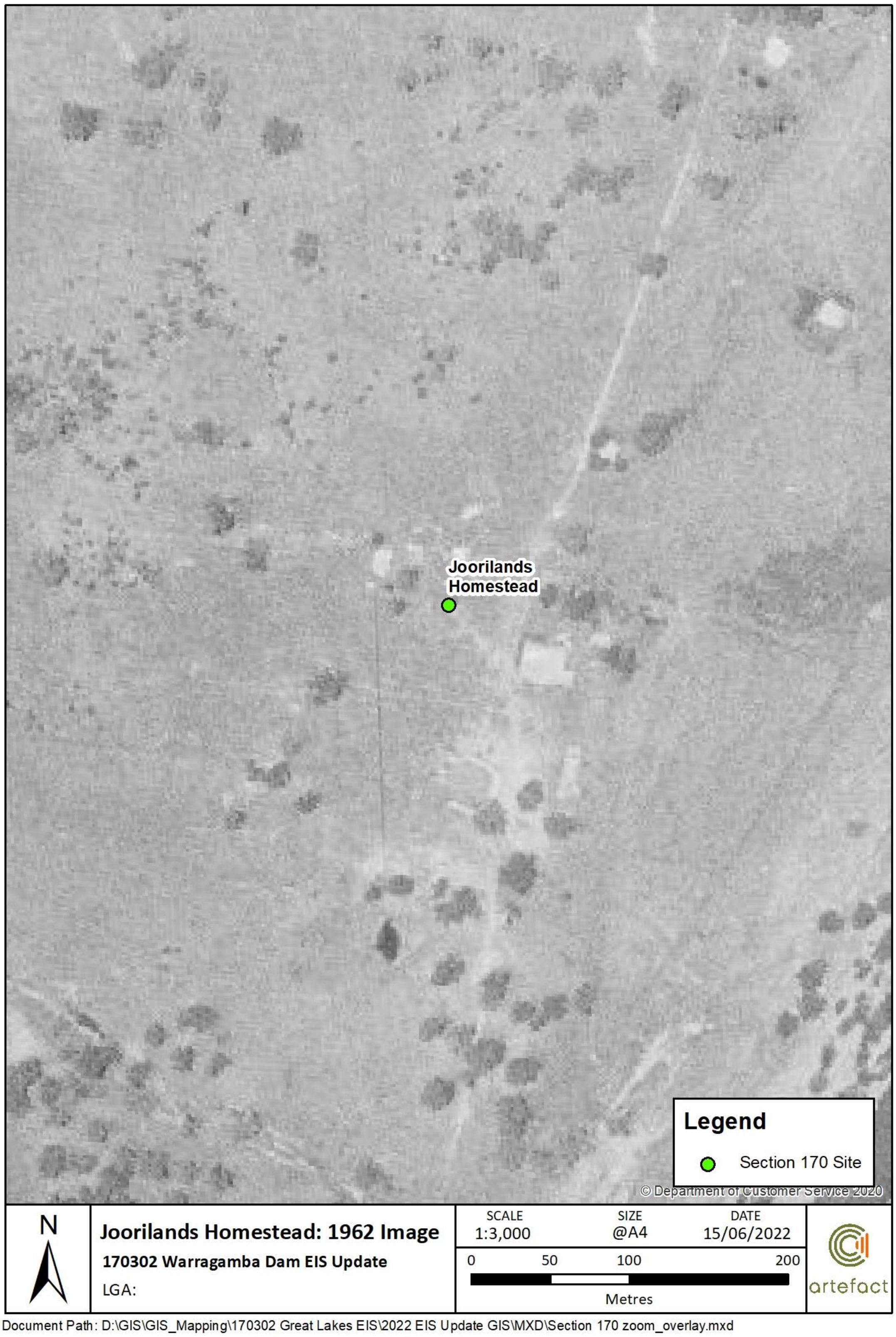
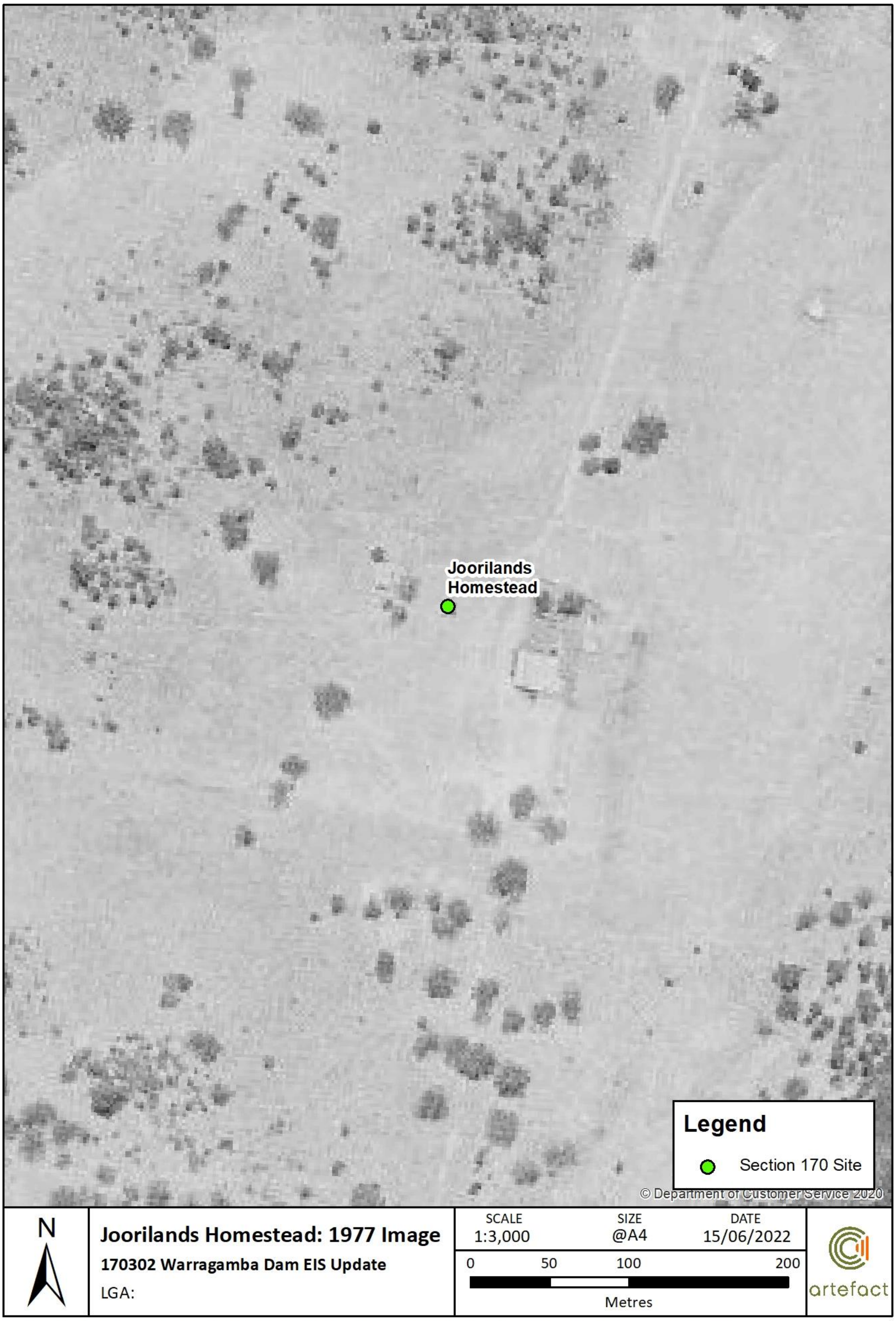


Figure 3-18. 1962 Aerial image, Jooriland Homestead approximate location (Source: NSW Spatial Service)



Document Path: D:\GIS\GIS_Mapping\170302 Great Lakes EIS\2022 EIS Update GIS\MXD\Section 170 zoom_overlay.mxd

Figure 3-19. 1977 Aerial image, Jooriland Homestead approximate location (Source: NSW Spatial Service)

Figure 3-20. 1990 Aerial image, Jooriland Homestead approximate location (Source: NSW Spatial Service)

3.5 Megarritys Bridge

The following history is extracted from the State Heritage Inventory (SHI) form for Megarrity's bridge. For detailed historical context for the Upper Nepean Scheme and Warragamba Dam, refer to Chapter 3 of the Non-Aboriginal Heritage Report for the EIS (Appendix I).

> *Megarritys Creek Bridge is a concrete arch bridge spanning Megarritys Creek. The construction of the bridge provided a vital link across the Creek for the operation of the Warragamba Emergency Scheme. While it was designed eventually to carry the No. 1 106" outlet main from Warragamba Dam, for the Emergency Scheme it carried the 48" main from the weir to Prospect Reservoir.*[14]

Figure 3-21: Photograph of Megarittys Bridge, c. 1941. (Source: NLA, PIC/8732/17 LOC Album 562)

[14] State Heritage Inventory form for 'Megarritys Bridge'. Retrieved from: https://www.hms.heritage.nsw.gov.au/App/Item/ViewItem?itemId=5051476

4.0 EXISTING ENVIRONMENT

4.1 Site inspection

Site inspection was undertaken on 16 May 2022 by two of Artefact's consultants Jess Mauger (Senior Consultant – Built Heritage) and Sam Sammut (Heritage Consultant – Historical Archaeology). Due to the targeted nature of this assessment, site inspections were limited to the general area of the four S170 listed items. Jooriland and Megarritys Bridge were not inspected as part of this site inspection. Information for Jooriland and Megarritys Bridge is extracted from previous assessments or the State Heritage Inventory (SHI).

Results of the site inspection are included under the heading for each listed item. The exact locations of each of these items are shown in Figure 1-2 to Figure 1-6.

4.1.1 Orange Tree Flat House

4.1.1.1 Description

The remains of the Orange Tree Flat House primarily consist of an extant, free-standing bluestone chimney and fireplace (see Figure 4-1). The chimney is about 2.5 metres in height with the opening of the fireplace measuring 0.8 metres in height (see Figure 4-6 and Figure 4-9). The structure is located roughly 5 metres west of the Orange Tree Flat trail, and about 10 metres from the water's edge of Little River, up on a steep embankment. The structure is situated in a clearing within relatively thick vegetation and has impeded views towards the Little River and the Orange Tree Flat trail.

The structure is constructed of bluestone with a lime mortar aggregate. It is a typical chimney design, with a wide fire base which narrows to a chimney flue. There is some vegetation growing over the structure but there is no evidence of the vines compromising the chimney (see Figure 4-8). The internal structure of the chimney is clear of vegetation and there is no evidence of collapse. There are areas at the back of the structure which are experiencing cracking or breaking of the lime mortar.

The fireplace is intact with no evidence of obstructions. Within the fireplace there are two iron elements, one steel plate is used as a lintel for the top of the opening to the fireplace and one flat bar which appears to be attached internally to the structure and is aligned vertically inside the chimney (see Figure 4-10 and Figure 4-14). It is possible this was used as a stove hook to hold billies or pots over a fire. Externally there are two steel bolts inserted through the structure on either side, perhaps as a stabilising element or attached to the vertical steel bar within the chimney itself (see Figure 4-11).

Externally on the chimney structure, on both sides, is evidence of the affixing of former walls with lime, which suggests the fireplace and chimney were formally attached to a structure (see Figure 4-12).

Surrounding the chimney structure there are limited scattered remnants of stone, with no evidence of other materials associated with former structures. The thick undergrowth and vegetation did not allow for a thorough survey of any other possible above ground structural remains however in the relatively cleared area surrounding the chimney there is no obvious evidence of a former building or structure.

4.1.1.2 Site survey

Below is a table of site images of the Orange Tree Flat House site taken by Artefact's consultants:

Figure 4-1: Frontal view of the extant stone chimney and fireplace, facing north-east.

Figure 4-2: Side view of the stone chimney, facing north.

Figure 4-3: View of chimney showing surrounding setting.

Figure 4-4: View showing surrounding clearing and vegetation.

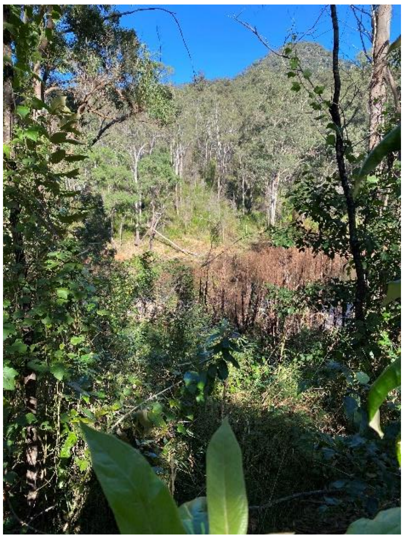


Figure 4-5: View from the clearing towards Little River

Figure 4-6: The chimney structure with scale (1.3 m).

Figure 4-7: Little River, about 10m west of the chimney, facing downstream.

Figure 4-8: View of the chimney showing vegetation growing over the structure.

Figure 4-9: View of the fireplace with scale.

Figure 4-10: Image of the iron lintel above the fireplace.

Figure 4-11: Image of one of the steel bolts protruding from the side of the chimney.

Figure 4-12: Image of one of the external sides of the chimney, showing possible former joint or wall.

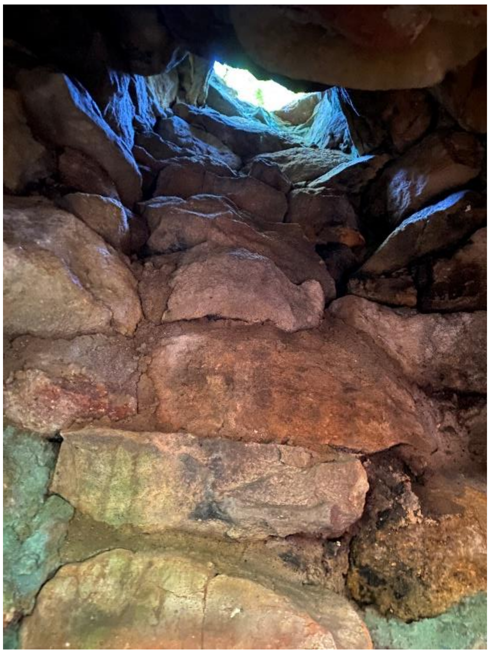


Figure 4-13: View inside the chimney flue.

Figure 4-14: Closer image of the iron bar vertically hanging within the fireplace.

4.1.2 Stone Hut Ruins

4.1.2.1 Description

The Stone Hut Ruins primarily consist of an extant, partially collapsed sandstone house, a corrugated iron water tank, remnant fencing and timber posts, and scattered remains of other stone structures nearby (see Figure 4-15 to Figure 4-38). The ruins are situated on a soft slope, about 240 metres from the Wollondilly River. The ruins are visible from the river however they are partially hidden by overgrown grasses and mature trees lining the banks of the river.

The stone house is constructed of sandstone with a lime aggregate, with larger blocks used as lintels and doorsteps (see Figure 4-18). It is very likely this house is an example of the continuation of the Old Colonial Georgian style into the Victorian era, which is characterised by symmetrical facades, simple rectangular shapes, and general orderliness. This is evidenced in a historic image found of the stone house (see Figure 3-7), which is likely dated to the late 1920s to early 1930s based on the woman's attire on the veranda. This would be before the Hunt family vacated the property in 1933. In this image the house's corrugated iron roof is well intact with a modest veranda held up by timber posts and smaller fencing in the foreground. In the background a structure is held up by four tall timber posts, which may have been a shelter or a platform. What is also illustrated in this photograph is that the room on the righthand side of the image is possibly a later extension to the main house, likely the smallest room on the most westerly side (see Figure 4-22). The image also shows evidence of a timber door and possibly 6-paned glazed windows. On the left hand side of the picture there appears to be a mature tree and possible fencing in the form of a small paddock adjacent to the house. This tree is perhaps the snag shown leaning towards the house, surrounded by younger trees growing inside and around the house, in an image of the site taken in 1990 (see Figure 3-7).

There is evidence of shaped stone around the doorways where former door jams would have been inserted (see Figure 4-20). The house consists of four rooms in a traditional linear layout. The most westerly room is the smallest (see Figure 4-22), which adjoins two moderate sized rooms (see Figure 4-23) which lead into the largest room to the east (see Figure 4-26). The walls of the largest room on the eastern side of the house have collapsed, mostly in a uniform fall (see Figure 4-17). On the northern face of the house, there is evidence of a former veranda, with a mixed stone foundation and possibly concrete surface (see Figure 4-19). This has all subsided inwards. Extant sections of lime are evident on the internal walls of the structure, indicating the internal rooms were finished with a wash (see Figure 4-25, Figure 4-33 and Figure 4-34).

Timber lintels line all six windows, and four external and one internal doorway, which all appear in poor condition (see Figure 4-27). One of the internal timber lintels between the second room and the third room is on the ground having likely fallen when the internal wall collapsed (see Figure 4-23).

The entire house is currently exposed with the roof no longer extant. There is some evidence of the former corrugated iron roof with some metal brackets still nailed (with handcrafted nails) to timber lintels framing the most western doorway (see Figure 4-27, Figure 4-35 and Figure 4-36).

There is no longer evidence of the former flooring in the house with the subfloor completely exposed however there is a clear differentiation between the structure's foundations and where the former flooring would have been located (see Figure 4-30). Internally and externally the ground is experiencing a moderate level of visible moisture in the lower stones and foundations of the walls (see Figure 4-39).

To the west of the stone house is an extant corrugated iron water tank (see Figure 4-32). This appears to be in fair condition. To the west of the tank are remnant timber fence posts, which were found to run along the extent of the property around the house. Separate from the fencing is a larger timber post which has a metal nail or bolt protruding from the top (see Figure 4-37). In the general vicinity of these structures are scattered sandstone blocks completely covered by ground cover and grasses (Figure 4-38). These were likely from smaller stone structures associated with the main house.

4.1.2.2 Site survey

Below is a table of site images of the Stone Hut Ruins site taken by Artefact's consultants:

Figure 4-15: View of the northern façade of the stone hut ruins, showing the collapsed veranda and eastern wall.

Figure 4-16: View of the collapse eastern wall.

Figure 4-17: View of the collapsed easterly wall.

Figure 4-18: Example of a window with timber and sandstone lintels.

Figure 4-19: View of the subsided veranda.

Figure 4-20: Example of a doorway with sandstone and timber lintels.

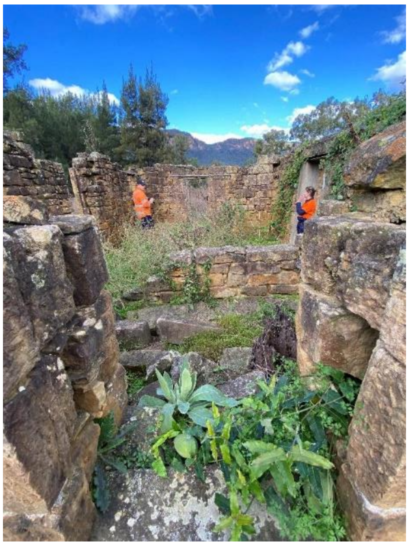


Figure 4-21: View of all four rooms, facing east.

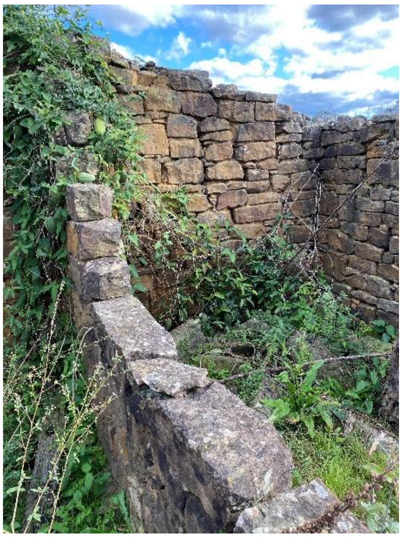


Figure 4-22: View of the first, smallest room, facing south west.

Figure 4-23: View of the two middle rooms, facing south.

Figure 4-24: View from middle rooms facing west towards the smallest room.

Figure 4-25: Example of lime wash on the interior walls and doorways.

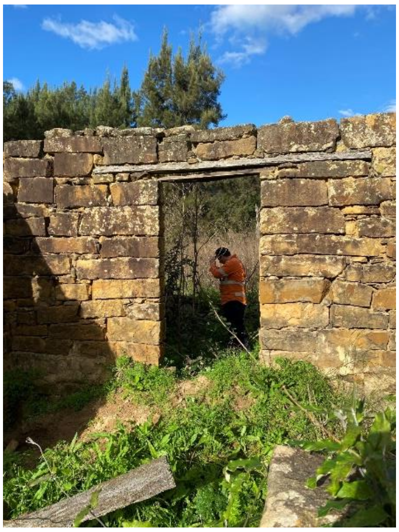


Figure 4-26: View of the doorway from the third room into the fourth room, facing east.

Figure 4-27: Example of timber lintel and timber framing to former roof with evidence of metal bracket nailed to the beam.

Figure 4-28: View of the southerly wall, facing north east.

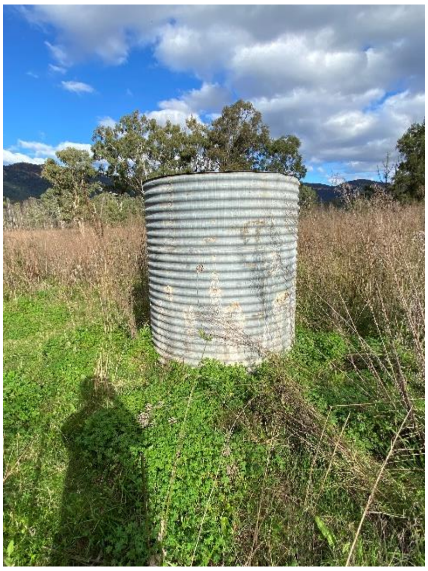


Figure 4-29: Extant corrugated iron water tank.

Figure 4-30: View of the third room showing the former floor level and the subfloor level, shown through colour differentiation in the sandstone.

Figure 4-31: Example of the condition of timber lintels.

Figure 4-32: View of the tank and southern wall, facing north.

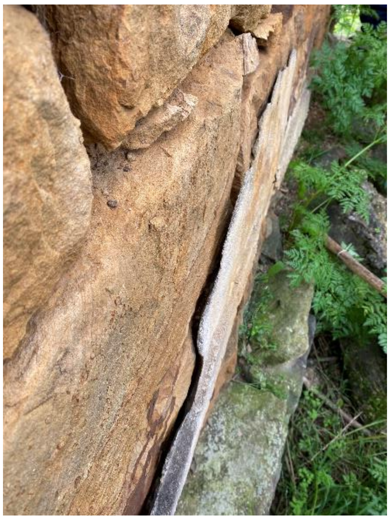


Figure 4-33: Another example of lime wash on the interior walls.

Figure 4-34: Flaked lime wash from the walls, showing sand aggregate.

Figure 4-35: Example of metal bracket from timber beams with a long, handmade nail.

Figure 4-36: Metal bracket nailed into a timber beam.

Figure 4-37: Large timber post and remnant fencing, a few metres beyond the water tank.

Figure 4-38: Example of scattered sandstones in the grass nearby to the stone house.

Figure 4-39: Example of damp ground beneath the foundations.

4.1.3 Murphy's Flat Yards

4.1.3.1 Description

Murphy's Flat Yards is a scattering of timber fencing, a cattle ramp, and former structure footings (see Figure 4-42 to Figure 4-65). The yards and former structures are situated about 210 metres from the Wollondilly River, on a flat plain largely cleared of mature trees but overgrown with grasses. The distance between the livestock ramp and the former structures is roughly 140 metres, with the structures positioned on the top of a minor slope overlooking the yards and the river. A number of different non-native tree species such as peppercorn trees are evident close to the former structures and yards.

The former cattle or sheep ramp, yard and remnant fencing are in poor condition but are largely legible as a sorting and holding yard (see Figure 4-42 and Figure 4-43). The construction is primarily a timber post and rail arrangement with rails tied to the posts with high tensile wire or bolted to the end posts (see Figure 4-47 and Figure 4-48). Some of the fencing also consists of timber posts with belly wire fencing, suggesting rabbit or kangaroo proof fencing was used on the property (see Figure 4-50). There is evidence of both kinds of fencing throughout the general area of these structures, which suggest majority of the property was fenced into paddocks.

An extant corrugated water tank is situated between the former yard and the former structures, a little over halfway between the former structures (see Figure 4-54). The tank is empty and is lined with possibly concrete.

The former structures are in a largely cleared area surrounded by possibly self-seeded non-native trees (see Figure 4-56). More remnant fencing is present which suggests there was fencing around the possible former homestead or sheds in this area. The area has several scattered materials such as red bricks, stone, stone footings with concrete capped foundations as well as fragments of corrugated metal sheeting and other discarded materials (see Figure 4-61). Some of the structure foundations could have been footings for tanks or sheds, with a rounded stone and concrete structure possibly being a septic tank (see Figure 4-58, Figure 4-62 and Figure 4-63). The larger structures have bluestone or concrete foundations and are capped with concrete slabs. It is unknown what these former structures were due to the lack of extant structural elements such as a roof or walls, and their narrowness in size, however some of the foundations were concealed by grasses and were not completely comprehensible. Nearby to these foundations are five tall timber posts standing upright in a circle, which may have previously been a shelter (like the one seen at the stone house) or possibly held a water tank on top or a windmill (see Figure 4-65).

4.1.3.2 Site survey

Below is a table of site images of the Murphy's Flat Yards site taken by Artefact's consultants:

Figure 4-40: View towards Murphy's Flat from the Wollondilly River, facing west.

Figure 4-41: Another view towards Murphy's Flat from the Wollondilly River, facing west.

Figure 4-42:Former livestock ramp and yard, with extant fencing, facing west.

Figure 4-43: View of the livestock ramp and yard, with extant fencing, facing south.

Figure 4-44: View of cleared area looking towards the livestock ramp and yard, facing south-east.

Figure 4-45: Former sorting yard fencing.

Figure 4-46: Former livestock ramp.

Figure 4-47: Example of the high tensile fencing wire used to tie the rails to the posts at the yard.

Figure 4-48: Example of bolted rails to end posts at the yard.

Figure 4-49: Example of remnant timber fencing near to the yard, with fragments of metal sheeting.

Figure 4-50: Example of remnant fencing north of the yard with rabbit proof wire.

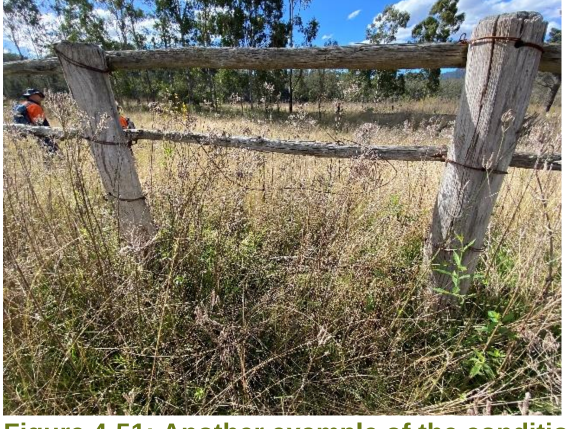


Figure 4-51: Another example of the condition of the timber fencing at the yard.

Figure 4-52: Remnant fencing facing the yard, facing south.

Figure 4-53: Remnant fencing facing the yard, facing north.

Figure 4-54: Extant water tank between the yard and former structures.

Figure 4-55: Example of timber posts nearby to the former structures.

Figure 4-56: Setting of the former structures with non-native trees present in the background.

Figure 4-57: Looking back towards the tank and yard from the area of the former structures, facing east.


Figure 4-58: View of former structure foundations, facing west.


Figure 4-59: View of former structure foundations, facing north.


Figure 4-60: Another view of former structure foundations, facing west.


Figure 4-61: Example of rubbish materials around the former structures such as brick.


Figure 4-62: Example of a former structure, possible former septic tank.


Figure 4-63: Example of former structures, one with stone foundations and one with concrete foundations.

Figure 4-64: Example of remnant intact brickwork close to the former structures.

Figure 4-65: Five tall timber posts extant to the west of the former structures, facing west.

4.1.4 Jooriland Homestead

4.1.4.1 Description

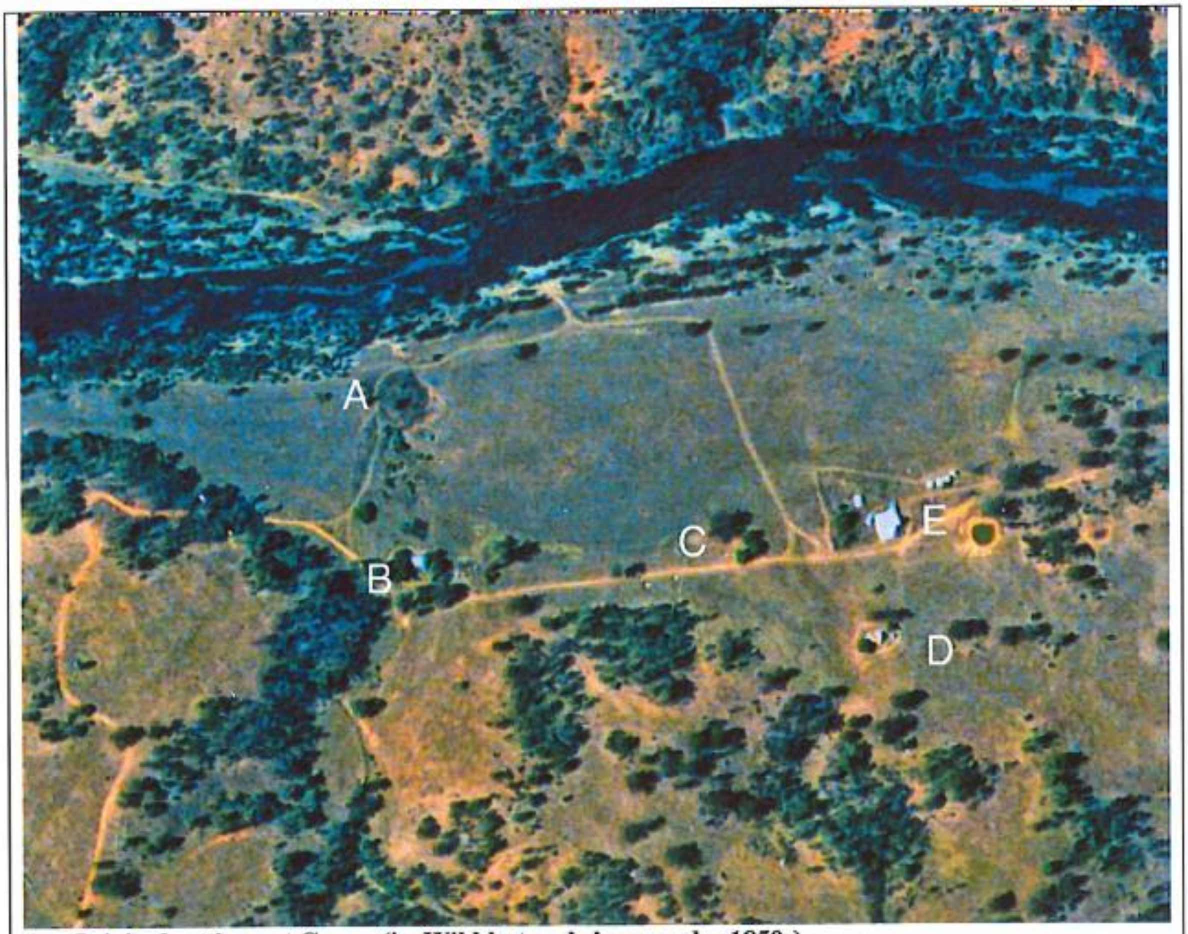
Jooriland was not inspected as part of the site inspection conducted by Artefact Heritage on 16 May 2022 as information on the site was available in the existing draft Conservation Management Strategy (CMS). The following description of Jooriland has been summarised from the draft CMS for the site (Christo Aitken & Associates, 2006).[15]

Jooriland is situated on the Wollondilly River, with the junction of Jooriland Creek and the River lying north of the property. The property was formally accessed from Camden until the flooding of Warragamba Dam in the 1950s. It formerly compromised approximately 250 acres of freehold land and was managed as a predominantly pastoral property for over 100 years. Forest regrowth triggered by extensive wildfires which began when the property was abandoned in the 1970s has seen the landscape start to shift back to a natural state on the upper slopes but generally it remains cleared of mature vegetation. Majority of the property is fenced, with a large amount still extant.

Jooriland is typical of many medium sized pastoral working properties in NSW with a number of buildings, sheds, yards, outbuildings and other structures or elements remaining from a range of periods of occupation (Figure 4-66). There is a distinct group of precincts consisting of a shearing group (see Figure 4-67), a slab cottage group, an old homestead (see Figure 4-68) and new homestead group. Some buildings have been demolished and relocated over time or have been burnt in bushfires.

The property once ran 6000 to 7000 sheep together with some cattle and has been surveyed as the largest and most intact of the properties in Burragorang. The homestead retains the range of farming elements including the homestead buildings, managers cottages, a woolshed (Figure 4-69), shearers cottages and associated outbuildings, and infrastructure such as yards, paddocks, water tanks, a generator, overhead lines, a septic tank, and irrigation lines. There has been little change since it was abandoned apart from general issues associated with lack of maintenance such as decay, deterioration and vandalism.

[15] Refer to: Jooriland Sheep Station Conservation Management Strategy (CMS) prepared by Christo Aitken & Associates for National Parks and Wildlife Services (2006), pp. 7 – 15 for more detailed descriptions of the buildings, their condition and further commentary on the site.



A – Original settlement Group (ie Wild hut and sheepyards c1850s)
B – Main Homestead Group (ie homestead, orchard, garage, generator shed, site of wb cottage)
C- Slab Cottage Group (ie slab cottage and site of former outbuildings etc))
D – Managers Cottage Group (ie weatherboard cottage, garage, fibro hut etc)
E – Woolshed Group (ie woolshed, yards, shearers cottages, shower block, site of classers hut etc)

Figure 4-66: A map of the homestead structures (Source: Jooriland Sheep Station CMS, pg 30)

Figure 4-67: Image of the shearer's quarters. (Source: "How 'Jooriland' joined pastoral pyes' stable", *The Land*, 2018).

Figure 4-68: Image of the Jooriland Old Homestead building. (Jooriland Sheep Station CMS, pg 32)

Figure 4-69: Image of the Jooriland woolshed building. (Jooriland Sheep Station CMS, pg 43)

4.1.5 Megarritys Bridge

The following physical description is extracted from the State Heritage Inventory (SHI) form for Megarrity's Bridge. A site inspection was not conducted for this site as part of this assessment. However a site inspection was completed for the inspection of Warragamba Emergency Scheme (SHR No. 01376, LEP No. I270) as the bridge is located within its curtilage. For the information on this site survey refer to Section 4.5 of Appendix I *Non-Aboriginal Heritage Report* supporting the EIS.

> *The construction incorporated an arch formwork design using tubular steel scaffolding. It is believed that this was the first instance in NSW of the use of this material for such load carrying purposes.*
>
> *Substantially as designed, but with an increase in height of the crest of 5.1m with post tensioning anchors undertaken in 1989 as part of interim flood mitigation works.*[16]

4.2 Significance Assessments

The following significance assessments have been prepared in accordance with the following heritage guideline and policy documents:

- Heritage Council of NSW *Statements of Heritage Impact* (updated 2002)
- Heritage Council of NSW *Assessing Heritage Significance: NSW Heritage Manual* (updated 2002)
- Heritage Branch, Department of Planning, *Assessing Significance for Archaeological Sites and 'Relics'* (2009)

In NSW assessments of heritage significance are conducted in accordance with the Heritage Council of NSW guideline document *Assessing Heritage Significance: NSW Heritage Manual* (updated 2002). Assessments and management recommendations should also be made with consideration for the Burra Charter.[17] Both guidelines stipulate that the NSW Heritage Assessment criteria should guide the level of significance assigned to heritage items.

The criteria are as follows:

- Research potential or archaeological research potential (NSW Heritage Assessment Criterion E). Note: archaeological potential and significance is not dealt with in this report or heritage assessment, only research potential of built heritage items.
- Associations with individuals, events or groups of historical importance (NSW Heritage Assessment Criteria A, B & D)
- Aesthetic or technical significance (NSW Heritage Assessment Criterion C)
- Ability to demonstrate the past through archaeological remains (NSW Heritage Criteria A, C, F & G)

[16] State Heritage Inventory form for 'Megarritys Bridge'. Retrieved from: https://www.hms.heritage.nsw.gov.au/App/Item/ViewItem?itemId=5051476
17 NSW Heritage Office 2001; NSW Heritage Branch, Department of Planning 2009; Australia ICOMOS 2013

4.2.1 Orange Tree Flat House significance assessment

The following table outlines the significance assessment for the Orange Tree Flat House remains.

Table 4-1: Orange Tree Flat House significance assessment

Criteria	Discussion
A – Historical Significance	The Orange Tree Flat House remains are an example of mid-to-late-19th century construction techniques of stone chimneys and is indicative of a typical bush-style dwelling of that era. Whilst it is the last extant feature of the former structure which was located at this site, and it represents the era of development in Burragorang prior to the flooding of the valley, it is not of particular importance to the history of the area.
B – Associative Significance	The remains of the Orange Tree Flat House may be associated with the former owners of the land, i.e. James O'Brien and family, however generally this item does not qualify for significance under this criterion.
C – Aesthetic or Technical Significance	The chimney and fireplace structure at the Orange Tree Flat House site is an isolated element within the larger surrounds along the Little River. It is not an exceptional example of its type (particularly as the adjoining structure is no longer present) nor is it easily viewed from any vantage points along the Little River or nearby track. This item does not qualify for significance under this criterion.
D – Social Significance	The house may have some social value to the descendants of the O'Brien family however this item does not qualify for significance under this criterion.
E – Research Potential	The Orange Tree Flat House does illustrate typical housing materiality used by the community along the Little River, utilising local materials and hardier construction techniques compared to a bark or timber dwelling. The remains also assist in the understanding of the dwelling types used in the Burragorang Valley prior to the flooding. Whilst this information is useful, it does not necessarily contribute to the broader understanding of the local area or the wider history of rural development outside of the Sydney area. This item does not qualify for significance under this criterion.
F – Rarity	The remains at the site do demonstrate a masonry construction technique that is slowly becoming lost throughout regional NSW, particularly so close to the Sydney metropolitan area. Also the Burragorang Valley, which was flooded during the creation of Warragamba Dam, lost many of its former homesteads and dwellings so Orange Tree Flat House is one of few which remain above water level. However, it is unlikely to be the only example of its type and it not of exceptional interest as the chimney is the only fabric extant of the former structure. This item does not qualify for significance under this criterion.
G – Representativeness	Orange Tree Flat House may have some representative value for its pristine rural setting and its integrity as an original element to the former dwelling at the site however it does not represent exceptional characteristics of a bluestone chimney and is in poor condition. This item does not qualify for significance under this criterion.

Based on the above heritage assessment, the Orange Tree Flat House has some historic value as early example of a mid-to-late 19th century rural stone chimney and fireplace, but it is not of exceptional value as an individual heritage feature.

The Orange Tree Flat House would not fulfil the criteria to be listed at Local Level.

4.2.2 Stone Hut Ruins significance assessment

The following table outlines the significance assessment for the Stone Hut Ruins.

Table 4-2: Stone Hut Ruins significance assessment

Criteria	Discussion
A – Historical Significance	The land has been identified as belonging to Richard Hunt and Samuel Barber, who jointly purchased the property in 1838. It is believed that Hunt's descendants lived on the property up until 1933. It is likely this house was constructed in the early part of their 95-year history on the land. Being made of sandstone, which has evidently been cut and dressed by an experienced mason, the house demonstrates the skill taken to construct a dwelling of this nature and highlights the moderate wealth of the former occupants. Whilst currently in poor condition, the house and its surrounding remnants are evidence of continued and successful settlement of the land by European families during the 19th and 20th centuries, prior to the flooding of the valley. The house is also a good example of a sandstone dwelling in a rural setting, close to the Sydney metropolitan area. The site fulfils the criteria for local significance.
B – Associative Significance	The remains of the Stone Hut Ruins may be associated with the former owners of the land, i.e. Samuel Barber, Richard Hunt and family, however this item does not qualify for significance under this criterion.
C – Aesthetic or Technical Significance	The Stone Hut Ruins are a good example of a partially intact sandstone house, used as the primary homestead on a rural property in the Burragorang area. The house is an example of the continuation of the Old Colonial Georgian style into the Victorian era, which is characterised by symmetrical facades, simple rectangular shapes, and general orderliness. The Stone Hut Ruins is typical of this style, and this is further evidenced in the photograph of the house intact and in use (see Figure 3-7). The stone house and its surrounds are situated in a picturesque rural setting. The landscape of the house is very pastoral and isolated, with the locality allowing for water and mountain views as well as vantage points across the property. Whilst the house does not exhibit landmark qualities and it is not aesthetically distinctive from others of its type, the Stone Hut Ruins exemplify the orderly nature of an Old Colonial Georgian sandstone dwelling and has positive visual appeal. The site fulfils the criteria for local significance.
D – Social Significance	The house may have some social value to the descendants of the Hunt family however largely this item does not qualify for significance under this criterion.

Criteria	Discussion
E – Research Potential	The stone house does illustrate an atypical housing materiality used along the Wollondilly River, with sandstone uncommonly used for houses in this district (which appear to be mainly constructed of timber). The house therefore assists in the understanding the varying tastes and resources of different agriculturalists in the Burragorang Valley prior to the flooding. Whilst this information is useful, it does not necessarily contribute to the broader understanding of the local area or the wider history of rural development outside of the Sydney area. This item does not qualify for significance under this criterion.
F – Rarity	The ruins are an example of a house completely constructed from sandstone in the Old Colonial Georgian style, which is becoming less common to find in a completely rural setting so close to the Sydney metropolitan area. Also, the Burragorang Valley, which was flooded in the mid-20th century during the creation of Warragamba Dam, lost many of its former homesteads and dwellings, so the Stone Huts Ruins is one of few which remain above water level. However, the house is not the only example of its type and it not of exceptional interest with much of the structure experiencing complete or partial failure, rot, and rising damp. This item does not qualify for significance under this criterion.
G – Representativeness	The Stone Hut Ruins has some representative value as an extant but partially collapsed Old Colonial Georgian or Victorian Georgia stone dwelling. Through its form and the lack of a formal entry, the building hints at the pastoral way of life of the first European settlers of the district. It also has some representative value as one of the few, or perhaps only, sandstone homesteads in the wider Burragorang district.

Based on the above heritage assessment, the Stone Hut Ruins site has historic and aesthetic values, as an early example of an early-to-mid 19th century sandstone homestead. Whilst it is not of extraordinary value as an individual heritage feature, within the context of the Burragorang district, this site does contribute to the course of the local area's cultural history and provides positive aesthetic characteristics to the local area.

The heritage significance of the Stone Hut Ruins would fulfil the criteria to be listed at Local Level.

4.2.3 Murphy's Flat Yards significance assessment

The following table outlines the significance assessment for the Murphy's Flat Yards remains.

Table 4-3: Murphy's Flat Yards significance assessment

Criteria	Discussion
A – Historical Significance	Murphy's Flat Yard has some historic value as the remnant livestock ramp and sorting yard, the different fencing types and former structure foundations do illustrate that Murphy's Flat was predominantly a sheep or cattle grazing farm, being one of the common agricultural practices in this district. However generally this item does not qualify for significance under this criterion.
B – Associative Significance	The remains of the Murphy's Flat Yard may be associated with the former owners of the land, i.e. Edward Murphy and family, however largely this item does not qualify for significance under this criterion.
C – Aesthetic or Technical Significance	Whilst idyllically situated on a flat plain along the Wollondilly River, the remains are not of particular visual or sensory appeal, so the site does not qualify for significance under this criterion.
D – Social Significance	This item does not qualify for significance under this criterion.
E – Research Potential	The site does not offer any outstanding or extraordinary information which is not readily known about the local district or wider regional development in the Sydney area. This item does not qualify for significance under this criterion.
F – Rarity	This item does not qualify for significance under this criterion.
G – Representativeness	The site is not easily legible as a former homestead with all of the former structures no longer extant. The purpose of existing foundations of former structures are not definitively known. The timber livestock ramp and yard are comprehensible however they are in poor condition and are not completely intact to qualify for representative value.

Based on the above heritage assessment, the Murphy's Flat Yards site has some historic value as an example of an early grazing farm in the Burragorang distract, but it is not of particular interest.

The item would not fulfil the criteria to be listed at Local Level.

4.2.4 Jooriland Homestead significance

The CMP assessed Jooriland as having **Local** significance for Criteria A, B, D and E, and as having **State** significance for Criteria C and G.

The following is the Statement of Significance for Jooriland Homestead as extracted from the CMP for the site:

> *Jooriland is the last intact large pastoral property within the Upper Burragorang Valley north west of Camden. It is located in a dramatic natural setting on the river flats of the Wollondilly River at the foot of the impressive cliffs of the Jooriland escarpment. The property was originally part of an 1852 land grant but the rugged area is likely to have been used as sheep grazing from as early as the 1830s.*
>
> *Subsequent owners (including the Macarthurs and Camden Park Estate) increased the landholding and leased adjoining lands to develop the property's pastoral industry. There are a number of intact buildings including a weatherboard homestead c1890s, a smaller weatherboard and fibro residence c1920s, a larger timber and galvanised iron woolshed c1900 with later Shearer's accommodation c1940s and a number of rustic slab outbuildings that appear to have recycled materials from 19th Century slab buildings. The relative physical intactness of not only the building group but also the individual buildings is rare in the locality although the buildings are only typically representative in form and design.*
>
> *It is the overall rural vista that is unique at Jooriland. The contrast in topography and the contrast between the European buildings and the surrounding bushland is a theme that has been well represented in Australian Art since the 1890s (eg Frederick McCubbin, Tom Roberts, Arthur Streeton) and is now rare. The farm and its setting encapsulates an image of Australia which is an important part of 20th Century Australian culture.*
>
> *It is a rare cultural landscape within the NSW context and as such has state significance due to this aspect. There have been no major changes to the fabric of the place, its landscape or its setting since the mid 1950s with the development of Warragamba Dam. It is an environment trapped in time with little opportunity for alterations to the landscape such as subdivision, new construction, roads, powerlines etc. The incidental statutory protection to the place afforded through its Section 1 Land status provides the unique opportunity for its current cultural landscape to remain unaltered in perpetuity unlike any other place in NSW. The place and its setting can not* (sic) *be further developed.*
>
> *The layering of various improvements to either the fabric of the overall landholding or the fabric of the buildings provides an ability to understand pressures for change in a rural property particularly for the period 1890 to 1950. The site has high archaeological potential as it has been little altered. There are a wide range of research and educational opportunities which could include the study of both its cultural and its natural aspects.*
>
> *It has local social significance as it is the last intact farm on the Upper Burragorang Valley, but it may also develop a social importance from within the broader Australian community, as its existences becomes more widely known; Jooriland has the potential to stimulate the imagination as a result of the mystique surrounding such a place, locked into the past, but which cannot be viewed or visited.*[18]

4.2.5 Megarritys Bridge

The following Statement of Significance is extracted from the SHI for Megarrity's Bridge:

> *Megarritys Bridge is considered to be of high significance as it serves the function of carrying the major Warragamba pipeline across Megarritys Creek. It is historically associated with the Warragamba Emergency Scheme, and at the time of construction, was one of the largest*

[18] Steven Ring and Christo Aitken & Associates, et al. for Sydney Catchment Authority and National Parks and Wildlife Services, June 2001, *Jooriland Sheep Station: Yerranderie State Conservation Area – Draft Conservation Management Plan*. Part 1, pp. 132 – 133.

> *concrete arch bridges to be built in NSW. It is a unique item of engineering heritage as its design is based on an innovative 'bow string' arch design rather than the more common 'decked' arch design.*[19]

The bridge is listed as fulfilling Criterion (F) Rarity at a State level.

> *This item is assessed as historically rare statewide. This item is assessed as scientifically rare statewide.* [20]

[19] State Heritage Inventory form for 'Megarritys Bridge'. Retrieved from: https://www.hms.heritage.nsw.gov.au/App/Item/ViewItem?itemId=5051476
[20] State Heritage Inventory form for 'Megarritys Bridge'. Retrieved from: https://www.hms.heritage.nsw.gov.au/App/Item/ViewItem?itemId=5051476

5.0 ARCHAEOLOGICAL ASSESSMENT

5.1 Archaeological potential

This section discusses the potential of the study area to contain historical archaeological resources. The potential for the survival of archaeological remains is significantly affected by activities which may have caused ground disturbance. This assessment is therefore based on consideration of current ground conditions, and analysis of the historical development of the study area.

'Archaeological potential' refers to the likelihood that an area contains physical remains associated with an earlier phase of occupation, activity or development of that area. This is distinct from 'archaeological significance' and 'archaeological research potential'. These designations refer to the cultural value of potential archaeological remains and are the primary basis of the recommended management actions included in this document.

Excavation works associated with the project are confined to the construction zone only, which was the focus of the archaeological assessment in the EIS. This assessment will focus on the identified S170 sites which will be impacted by the temporary inundation resulting from the works.

5.1.1 Summary of historic land-use

A summary of the historical development of the identified sites is contained with Section 3.0 of this report.

5.1.2 Discussion of archaeological potential

The following section will discuss the potential for the study area to contain archaeological remains associated with the identified sites.

Orange Tree Flat House

The Orange Tree Flat House site appeared significantly dilapidated and overgrown during the site inspection. The site consisted of a stone chimney believed to be part of the homestead, as well as stones that likely formed part of the structure's walls. No alignment for the structure was conclusively determined, although the chimney likely formed part of the structure's easternmost wall. The site has been significantly impacted by environmental processes since its abandonment. During the site inspection, it was noted that the land to the west of the visible remnants of the structure sloped down steeply towards the nearby riverbank. Although the land around the site was heavily vegetated, it was apparent that the river has eroded the land west of the site during flooding events or high tides. Given the position of the structure's remnants, it is predicted that the homestead on the property would have continued westward towards the water. Consequently, it is believed that archaeological resources associated with the site have been displaced or destroyed by fluvial movement. As such, there is **low potential** for archaeological resources associated with the homestead to be present at the Orange Tree Flat House site.

The sawmill and camp associated with the homestead were not identified during the site inspection. However, as they are located west of the homestead on the 1933 Map (Figure 3-1) they are likely to have been impacted by the fluvial movement evidenced in the areas around the river. Their assumed location was also shown to be heavily vegetated, with numerous trees and shrubs whose roots are certain to have disrupted the integrity of any present subsurface deposits. Consequently, there is **nil-to-low potential** for archaeological resources associated with the sawmill and camp to be present.

Stone Hut Ruins

Due to the dilapidation of the Stone Hut structure, it was not possible to accurately assess ground surface conditions within the building. Elements of the structure had collapsed inwards, with numerous stone blocks obstructing the ground surface beneath. Moreover, much of the unobstructed ground surface within the structure was vegetated or showed signs of disturbance caused by wombat burrows. The site visit indicated that any previous flooring treatment was no longer present, having potentially been removed after the site was abandoned. No artefacts were observed during the site inspection, and it is likely that any which may have been present were impacted by the collapse of the structure and exposure to the elements. The site has limited potential to contain intact occupation deposits. Due to impacts caused by bioturbation, there is **low-to-moderate potential** for archaeological resources to be present within the structure and in its vicinity. Extant remains may include the remnants of ancillary structures, such as outhouses or sheds, in-ground cisterns or underground storage, or potential artefact bearing deposits including refuse scatters or rubbish pits. However, there is little information available surrounding the site's layout to indicate the form or location of any such structures or features.

Evidence of a structure, assumed to be the shed seen in Figure 3-7, was observed approximately 30 m southwest of the Stone Hut. However, as the structure was likely a general use shed associated with the property's usage for livestock grazing it is expected that archaeological resources associated with this feature will be limited to minor, subsurface structural elements. No artefact deposits are expected to be associated with this structure, although there is **low-to-moderate potential** for structural elements of the shed to be present beneath the ground surface.

Murphy's Flat Yards

The cattle yard at Murphy's Flat featured extant truncated fence posts around its boundary. While it is possible that postholes from former fenceposts on this alignment are present, it is considered unlikely that any other archaeological resources or artefact deposits associated with the cattle yard will be present at the site. Therefore, there is **nil-to-low potential** for additional archaeological resources related to the cattle yard.

Remains of a structure or structures were identified approximately 100 m west of the cattle yards. These are likely the remnants of the 'Bush Hut' identified within the historical context established in this report. However, the presence of concrete elements suggests that these features were likely installed during the twentieth century and represent a modification to or replacement of the original structure on the site. The construction of these features is likely to have disturbed any evidence of the previous structure. Moreover, the concentrated presence of wooden posts and bricks in certain locations across the site, as well as a small set of stairs could indicate that the structure was built on supports off the ground surface. If so, this would limit the potential for archaeological resources associated with the 'Bush Hut' to be present. Given the site's usage as a temporary residence, there is some potential for artefact bearing rubbish pits to be present. However, as occupation at the site would have been sporadic it is likely that any artefacts would limited to isolated finds rather than substantial deposits. Therefore, it is ultimately considered that there is **low potential** for archaeological resources associated with the 'Bush Hut' to be present at the site.

Joorilands

The Jooriland Homestead features extant pastoral and vernacular structures with truncated fence posts around its boundary, and remnant historic and agricultural elements scattered around the site. While it is possible that slabs from former 19th century structures and postholes from former fenceposts are present, it is considered unlikely that any other archaeological resources or artefact deposits associated with the early colonial development of the site will be present at the site.

Therefore, there is **nil-to-low potential** for additional archaeological resources related to the early phase of development on the site.

The site has seen a number of different phases of development, with extensive upgrades to existing structures and former structures in the early 20th century, with the provision of new amenities such as electricity, water reticulation and sewerage systems. Remains of any earlier structures, such as footings or slabs, were reused to support newer structures. A number of new residential structures were erected during these later phases of development, some of which were burnt down in the 1990s. The construction of these features is likely to have disturbed any evidence of previous structures or earlier farming activity. If so, this would limit the potential for archaeological resources to be present. However given the site's usage as a moderate sized agricultural homestead there is some potential for artefact bearing deposits associated with farming activities but these are likely to be limited to isolated finds rather than substantial deposits. Also it is noted in the draft CMP that many of the known rubbish pits on the site were cleared by the Water Board and the NPWS in the late 20th century. Therefore, it is ultimately considered that there is **low potential** for archaeological resources to be present at the site.

A summary of the archaeological potential for the identified sites is included in Table 5-1.

Table 5-1: Summary of archaeological potential

Phase	Potential archaeological remains	Level of disturbance	Archaeological potential
Orange Tree Flat House	Structural remnants of homestead, remnant of the sawmill and campsite, artefact bearing deposits	High level of disturbance through extensive growth of vegetation and landform erosion caused by flooding events	Nil-to-low
Stone Hut Ruins	Structural remnants of the Stone Hut, artefact bearing deposits, ancillary structures	Disturbance to site through dilapidation of structure, as well as extensive vegetation growth and bioturbation	Low-to-moderate
Murphy's Flat Yards	Fenceposts for cattle yard Structural remnants of the 'Bush Hut', ancillary structures, artefact bearing deposits	Localised disturbance through demolition and later construction activities, extensive vegetation growth and bioturbation	Nil-to-low
Joorilands	Structural remnants, artefact bearing deposits, rubbish pits, ancillary structures	Disturbance to site through dilapidation of structures, as well as extensive bushfires, vegetation growth and bioturbation	Nil-to-low

5.2 Archaeological significance

Archaeological significance refers to the heritage significance of known or potential archaeological remains. As with other types of heritage items, archaeological remains should be managed in accordance with their significance. In situations where development is proposed, this can influence the degree of impact that may be acceptable or the level of investigation and recording that may be required.

While archaeological remains often form an integral component of the overall significance of a heritage place, it is necessary to assess them independently from above ground and other historic elements. Assessing the heritage value of archaeological remains is made more difficult by the fact that their extent and nature is often unknown. It becomes necessary for judgement to be made based on expected or potential attributes. The NSW Heritage Branch document *Assessing Significance for Historical Archaeological Sites and 'Relics'*[21] provides the framework for the following significance assessment. A summary of the criteria is included in Table 5-2.

Table 5-2: Overview of NSW Heritage Branch archaeological significance criteria

Heritage Branch archaeological significance criteria	Meaning
Archaeological Research Potential (NSW Heritage Criterion E)	Archaeological research potential is the ability of the archaeological evidence, through analysis and interpretation, to provide information about a site that could not be derived from any other source, written or otherwise, and which contributes to the archaeological significance of the site and its 'relics'. The integrity of a site, the state of preservation of archaeological material and deposits will also be relevant.
Association with individuals or groups of historical importance (NSW Heritage Criteria A, B and D)	Archaeological remains may have associations with individuals, groups and events which may transform mundane places or objects into significant items through the association with important historical occurrences.
Aesthetic or technical significance (NSW Heritage Criterion C)	Whilst the technical value of archaeology is usually considered as 'research potential' aesthetic values are not usually considered to be relevant to archaeological sites. This is often because until a site has been excavated, its actual features and attributes may remain unknown. It is also because aesthetic is often interpreted to mean attractive, as opposed to the broader send is sensory perception or 'feeling' as expressed in the *Burra Charter*. Nevertheless, archaeological excavations which reveal highly intact and legible remains in the form of aesthetically attractive artefacts, aged and worn fabric ad remnant structures, may allow both professionals and the community to connect with the past through tangible physical evidence.
Ability to demonstrate the past through archaeological remains (NSW Heritage Criteria A, C, F and G)	Archaeological remains have an ability to demonstrate how a site was used, what processes occurred, how work was undertaken and the scale of an industrial practice of other historic occupation. They can demonstrate the principal characteristics of a place or process that may be rare or common. A site may best demonstrate these aspects at the time of excavation. It may also be possible to explain the nature of the site and demonstrate past practises via public interpretation with before, during, or after excavation.

5.2.1 Assessment against the NSW heritage assessment guidelines

The Orange Trail Flat House, Murphy's Flat Yards and Jooriland Homestead sites have been identified as having **nil-to-low** potential, whereas the Stone Hut Ruins site has been assessed as possessing **low-to-moderate** potential to contain archaeological resources.

[21] Heritage NSW, *Assessing Significance for Historical Archaeological Sites and 'Relics'* December 2009 p11-14. Accessed online at: https://www.environment.nsw.gov.au/-/media/OEH/Corporate-Site/Documents/Heritage/assess-significance-historical-archaeological-sites-relics.pdf.

The assessment of the significance of the potential archaeological resources contained within the identified sites against the NSW heritage assessment criteria is outlined in Table 5-3.

Table 5-3: Consideration against NSW heritage assessment criteria

Criterion	Discussion
A – Historical Significance An item is important in the course or pattern of the local area's cultural or natural history.	Intact subsurface structural elements or artefact bearing deposits located at the Stone Hut Ruins, Joorilands Homestead or Murphy's Flat Yards sites may be able to inform us about the development of the area and yield information about their occupation which is absent in the historical record. **Archaeological resources present at the identified sites, if found to be significantly intact and legible, may meet the threshold for local significance under this criterion.**
B – Associative Significance An item has strong or special associations with the life or works of a person, or group of persons, of importance in the local area's cultural or natural history	The historical context established in this report has not indicated that the identified sites possess any known associative significance. **Archaeological resources located within the identified sites are unlikely to reach the threshold for local significance under this criterion.**
C – Aesthetic Significance An item is important in demonstrating aesthetic characteristics and/or a high degree of creative or technical achievement in the local area.	The potential archaeological remains within the identified sites have little potential for aesthetic significance. Although it is recognised that exposed *in situ* archaeological remains may have distinctive/attractive visual qualities and have visual characteristics with the ability to connect communities and individuals to the past through tangible remains, any potential archaeological remains at the identified sites are likely to be ephemeral. **Archaeological resources present at the identified sites are unlikely meet the threshold for local significance under this criterion.**
D – Social Significance An item has strong or special association with a community or cultural group in the local area for social, cultural or spiritual reasons	The historical context established in this report has not indicated that the identified sites possess any known social significance. **Archaeological resources located within the identified sites are unlikely to reach the threshold for local significance under this criterion.**
E – Research Potential An item has potential to yield information that will contribute to an understanding of the local area's cultural or natural history	Archaeological remains associated with the identified sites could potentially yield information regarding the development of each site; however, they are unlikely to possess significant research potential on a broader scale. It is necessary to reaffirm that there is a general lack of potential for intact artefact bearing deposits within the sites, which could indicate an inability to respond to research questions or to meaningfully contribute to our knowledge of the previous occupants of the sites. **Archaeological resources located within the identified sites are unlikely to reach the threshold for local significance under this criterion.**

Criterion	Discussion
F – Rarity An item possesses uncommon, rare or endangered aspects of the local area's cultural or natural history	The Orange Tree Flat House and Murphy's Flat Yards sites would not be considered rare, as mixed-use residential and agricultural properties were common in the Burragorang Valley area during the nineteenth and twentieth centuries. However, the Stone Hut Ruins and Jooriland Homestead may be considered rare within the local area due to the structure's relatively intact condition. **Archaeological resources present at the identified sites, if found to be significantly intact and legible, may meet the threshold for local significance under this criterion.**
G – Representative An item is important in demonstrating the principal characteristics of a class of NSW's cultural or natural places of cultural or natural environments (or the cultural or natural history of the local area).	The potential archaeological resources present at the identified sites are unlikely to be important in demonstrating the principal characteristics of their previous occupation or usage, and are unlikely to convey information that is not already available from historical sources. **Archaeological resources located within the identified sites are unlikely to reach the threshold for local significance under this criterion.**

5.2.2 Statement of archaeological significance

The four identified sites were used for a mix of occupational and agricultural purposes prior to their abandonment in the twentieth century. While the Orange Tree Flat House, Murphy's Flat Yards and Jooriland Homestead sites have been assessed as possessing overall nil-to-low potential to possess archaeological resources, the Stone Hut Ruins site possesses low-to-moderate potential for archaeological resources relating to the residential and agricultural usage of the site. If found to be substantially intact, archaeological resources from these sites may reach the local significance threshold for their ability to contribute to our knowledge of the history and development of the site (Criteria A and E) and for their rarity (Criterion F). However, the previous human and environmental processes which have impacted the site are likely to have disturbed any archaeological remains present and, as such, there is little potential for relics here as defined by the *Heritage Act*.

6.0 HERITAGE IMPACT ASSESSMENT

6.1 Methodology

This assessment has been prepared using the Statements of Heritage Impact 2002,[22] prepared by the NSW Heritage Office, contained within the NSW Heritage Manual, as a guideline. A detailed assessment is provided for direct, potential direct, indirect and archaeological impacts. Impact terminology and grading systems are consistent with those used in the Non-Aboriginal Heritage report in the EIS for the project.

6.1.1 Assessing flooding impacts

In any consideration of potential impacts associated with the project, it is important to remember that there is already a potential flooding impact associated with the existing reservoir. The focus of this assessment is on the potential incremental impact associated with the project. Floods are all uniquely different depending on the conditions in place when the event occurs. For example, if a flood occurs during a drought when a dam is half empty, upstream inundation levels would be lower than if the dam had been full. Conversely, if a flood occurs soon after previous rain then greater inflows would occur and with the dam being already quite full, more upstream inundation would result.[23]

6.1.1.1 Existing flooding

Flooding in the upstream catchment is a combination of backwater inundation from Lake Burragorang and local catchment inflows. The latter will not change with the project. The water level in Lake Burragorang increases until the outflow exceeds the inflow, at which time the water level recedes to the full supply level (FSL) which is the maximum operational level of Warragamba Dam. The FSL will not change with the project. The extent and duration of temporary inundation is dependent upon the magnitude of the flood-producing rainfall event, the water level in the dam storage at the time of the inflow event and the rate of release of water from the dam. The extent of inundation is controlled by the peak flood level at the dam wall and the topography across the upstream catchment. Steep terrain extends upstream from the dam wall for at least 20 kilometres, so that the extent of land inundated changes at a relatively small rate with increasing magnitude floods. However, the rate of change and inundated area increases as terrain flattens about where the Wollondilly River and Coxs River enter Lake Burragorang.[24]

For the existing dam, water levels in Lake Burragorang remain elevated for a period of about three to four days up to the 1 in 100 chance in a year flood event. Although lake levels remain elevated for a period of days, the period of inundation for specific locations would vary depending on where they are in the catchment, with depth and duration decreasing with elevation.[25]

The nature of existing flooding for the four S170 sites is summarised as follows:

- Jooriland
  - All structures sit above the 1 in 100 chance in a year flood level
  - The group of three structures within the Woolshed Group (location E in Figure 4-66) nearest the river sit on the existing PMF boundary; all other structures sit above the existing PMF (and

22 NSW Heritage Office 2002
23 *Environmental Impact Assessment – Appendix J: World Heritage Assessment Report Warragamba Dam Raising*. Prepared for WaterNSW by SMEC. 2021. Pg. 61.
24 *Environmental Impact Assessment – Appendix J: World Heritage Assessment Report Warragamba Dam Raising*. Prepared for WaterNSW by SMEC. 2021. Pp. 34 – 36.
25 *World Heritage Assessment Report Warragamba Dam Raising*. Prepared for WaterNSW by SMEC. 2021. Pp. 36 – 37.

it should be noted that the PMF is a very rare event with a less than 0.001 percent chance of it occurring in any given year)

- The duration of temporary inundation for the PMF event is about six days

- Murphy's Flat Yards
  - The structure and the cattle yard are affected by the 1 in 100 chance in a year flood event but not by more frequent flood events
  - The duration of temporary inundation for the 1 in 100 chance in a year flood event is about seven days

- Stone Hut Ruins
  - Possibly affected by the 1 in 20 chance in a year event; affected by the 1 in 100 chance in a year flood event
  - The duration of temporary inundation for the 1 in 20 chance in a year flood event is about seven days and the same for the 1 in 100 chance in a year flood event

- Orange Tree Flat House
  - Possibly affected by the 1 in 100 chance in a year flood event and larger events; not affected by more frequent flood events
  - The duration of temporary inundation for the 1 in 100 chance in a year flood event is about seven days.

Temporary inundation at these four S170 sites is due principally to backwater from Lake Burragorang with local catchment runoff likely only having a very minor contribution. As such, water velocities at these sites would be generally very low.

6.1.1.2 Project flooding

In general terms, the project would change upstream flooding through an increase in the frequency of floods of a specific magnitude, and the depth, duration and extent of temporary inundation. This will be greatest at the dam wall and in Lake Burragorang but will lessen moving away from the lake up the tributaries.

The nature of flooding with the Project for the four S170 sites is summarised as follows:

- Jooriland
  - All structures sit above the 1 in 100 chance in a year flood level
  - All structures apart from the Manager's Cottage (location D in Figure 4-66) are within the project PMF
  - The duration of temporary inundation for the PMF event is about seven days

- Murphy's Flat Yards
  - The structure and the cattle yard are affected by the 1 in 10 chance in a year flood event and larger (relatively less frequent) flood events
  - The duration of temporary inundation for the 1 in 10, 1 in 20 and 1 in 100 chance in a year flood events is about 10 days

- Stone Hut Ruins
  - The Stone Hut Ruins (but not the Stone Hut Shed ruins) are affected by the 1 in 5 chance in a year flood, while both are affected by the 1 in 10 chance in a year flood event and larger events
  - The duration of temporary inundation for the 1 in 5 chance in a year flood event is about seven days and about 10 days for the 1 in 10 chance in a year flood event

- Orange Tree Flat House
  - Possibly affected by the 1 in 10 chance in a year flood event and affected by larger events
  - The duration of temporary inundation for the 1 in 10 chance in a year flood event is about 10 days.

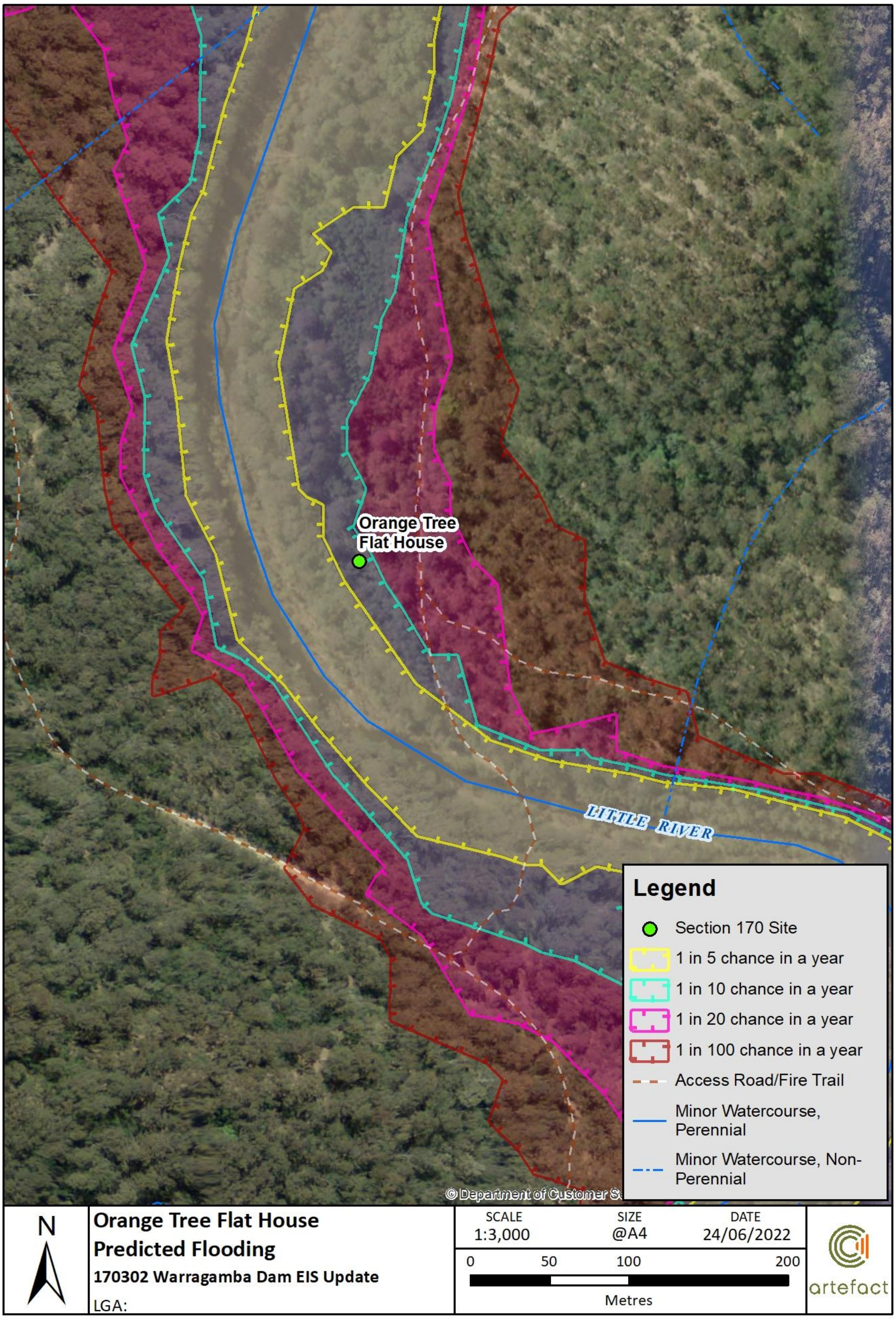
The additional duration of temporary inundation is the primary impact for the project. The following table illustrates the existing duration extents (in days) at each of the three S170 sites versus the new duration extents for the project As noted previously, some of these locations are not affected by all flood events. Additionally, the PMF event has not been considered in view of its extreme rarity and that incremental impacts would be associated with more frequent flood events.

Table 6-1: Changes to temporary inundation duration (days) for potentially affected S170 sites

Location	Flood event (1 in x chance in a year)							
	1 in 5		1 in 10		1 in 20		1 in 100	
	Existing	Project	Existing	Project	Existing	Project	Existing	Project
Jooriland	NA*	NA	NA	NA	NA	NA	NA	NA
Murphy's Flat Yards	NA	NA	NA	10	NA	13	8	16
Stone Hut Ruins	NA	8	7	10	8	13	8	16
Orange Tree Flat House	NA	8	NA	10	NA	13	NA	16

* Not affected by flood event

Predicted flooding with the project for the four flood events up to the 1 in 100 chance in a year flood event has been overlayed with the locations of the sites to show the extent of temporary inundation on the targeted areas (see Figure 6-1 to Figure 6-5)



Document Path: D:\GIS\GIS_Mapping\170302 Great Lakes EIS\2022 EIS Update GIS\MXD\Section 170 zoom innundation.mxd

Figure 6-1: Chance in a year flooding events with the project for the Orange Tree Flat House site (Artefact 2022).

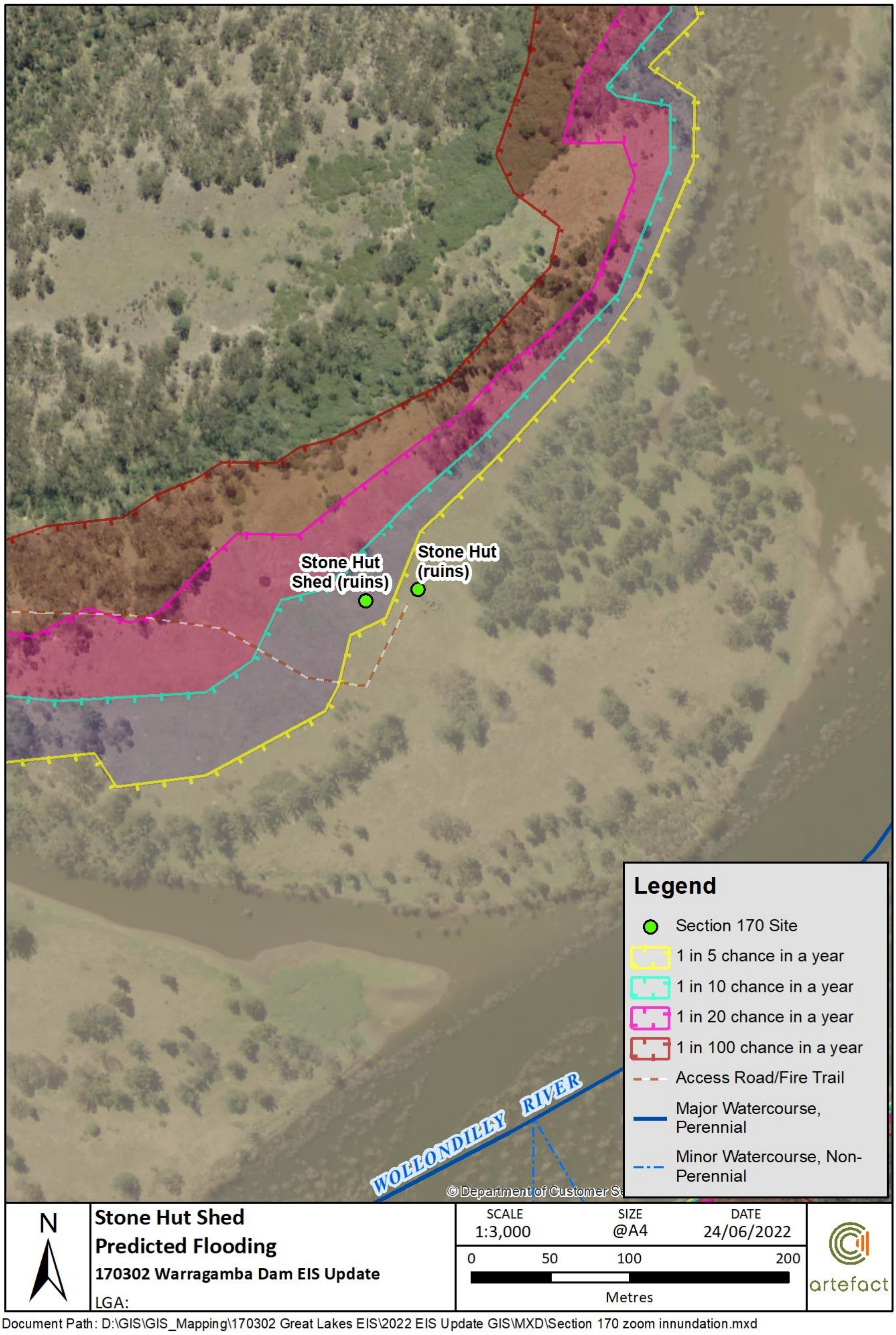


Figure 6-2: Chance in a year flooding events (in years) for the Stone Hut Ruins site (Artefact 2022).

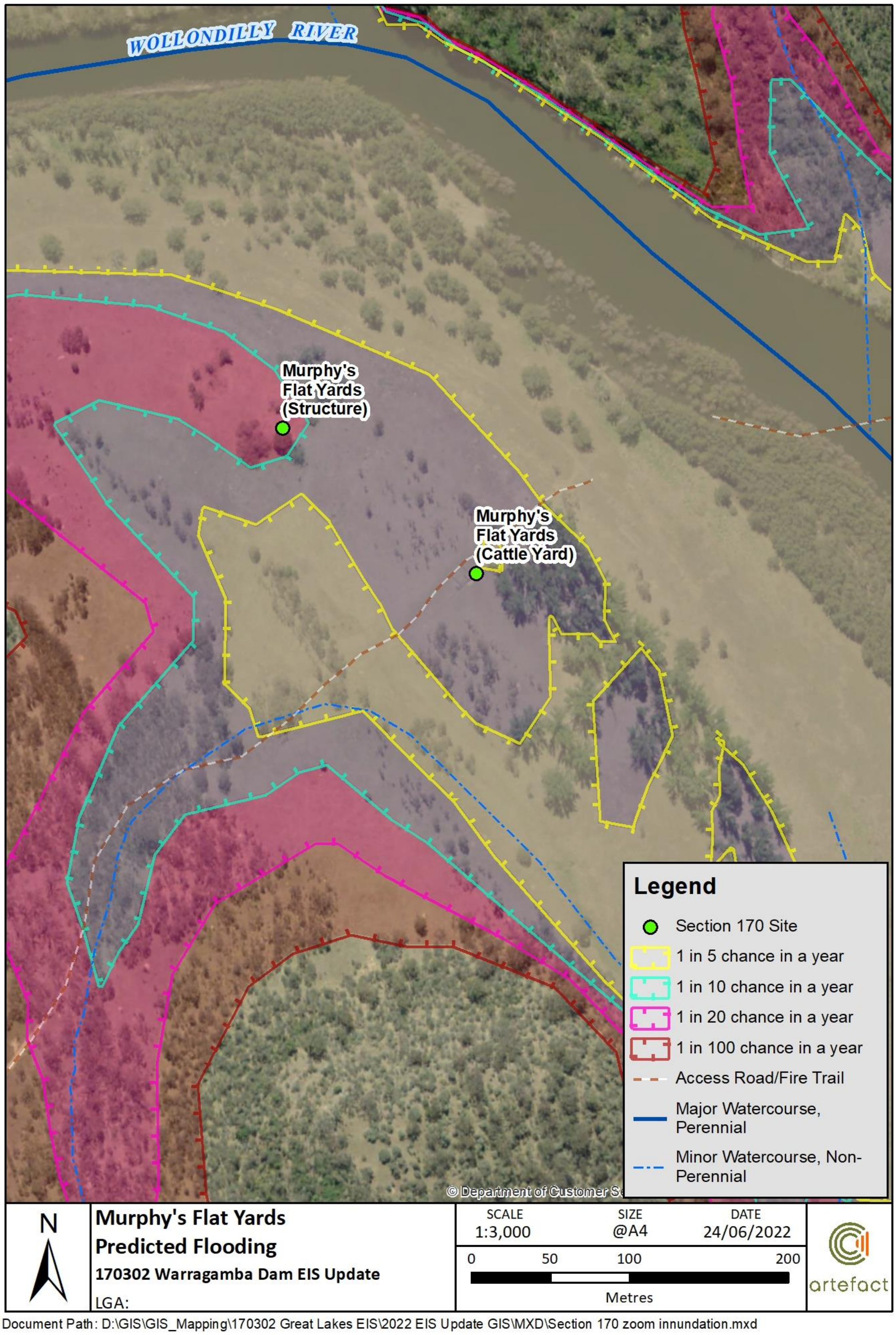


Figure 6-3: Chance in a year flooding events (in years) for the Murphy's Flat Yards site (Artefact 2022).

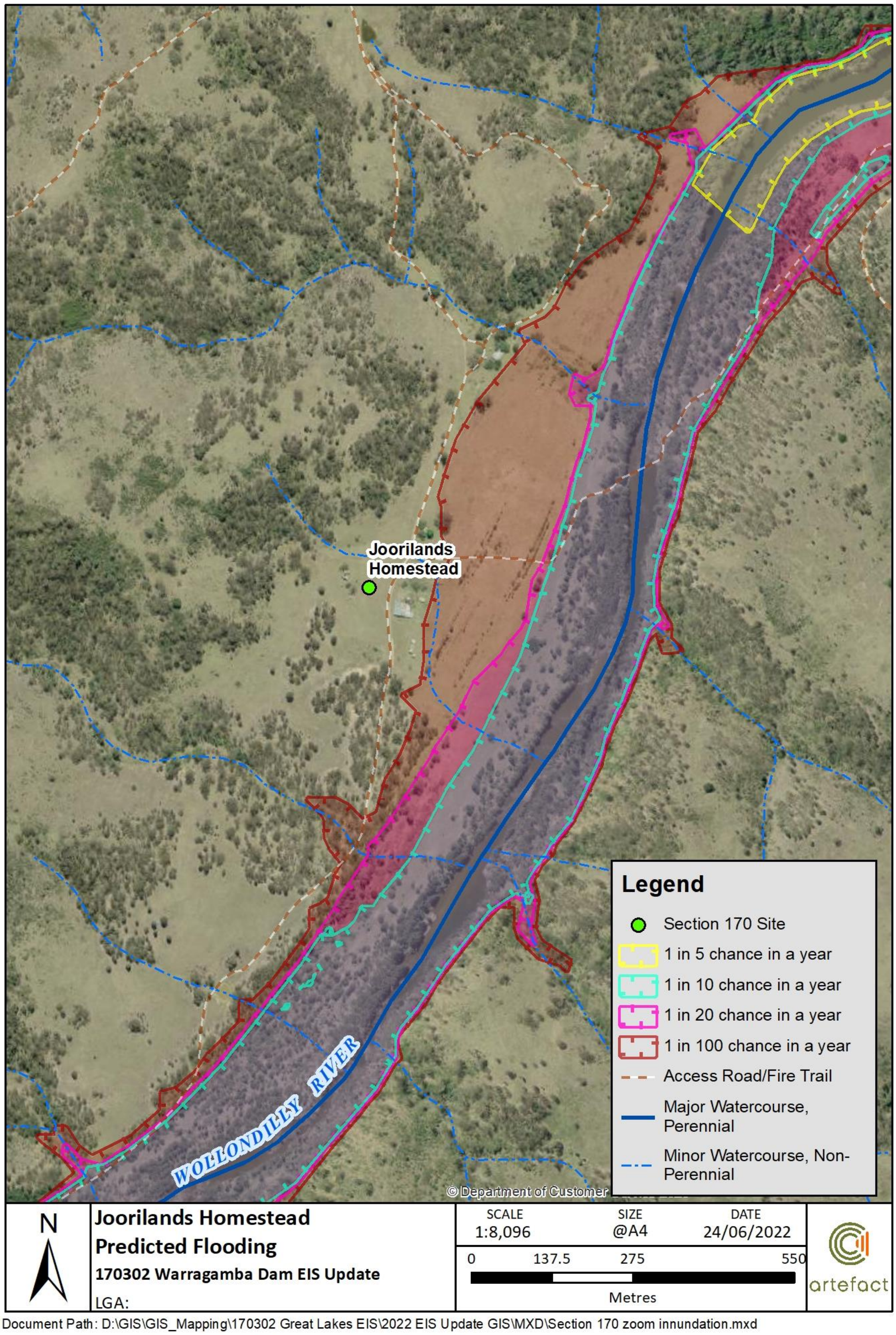


Figure 6-4: Chance in a year flooding events (in years) for the Jooriland Homestead site (Artefact 2022).

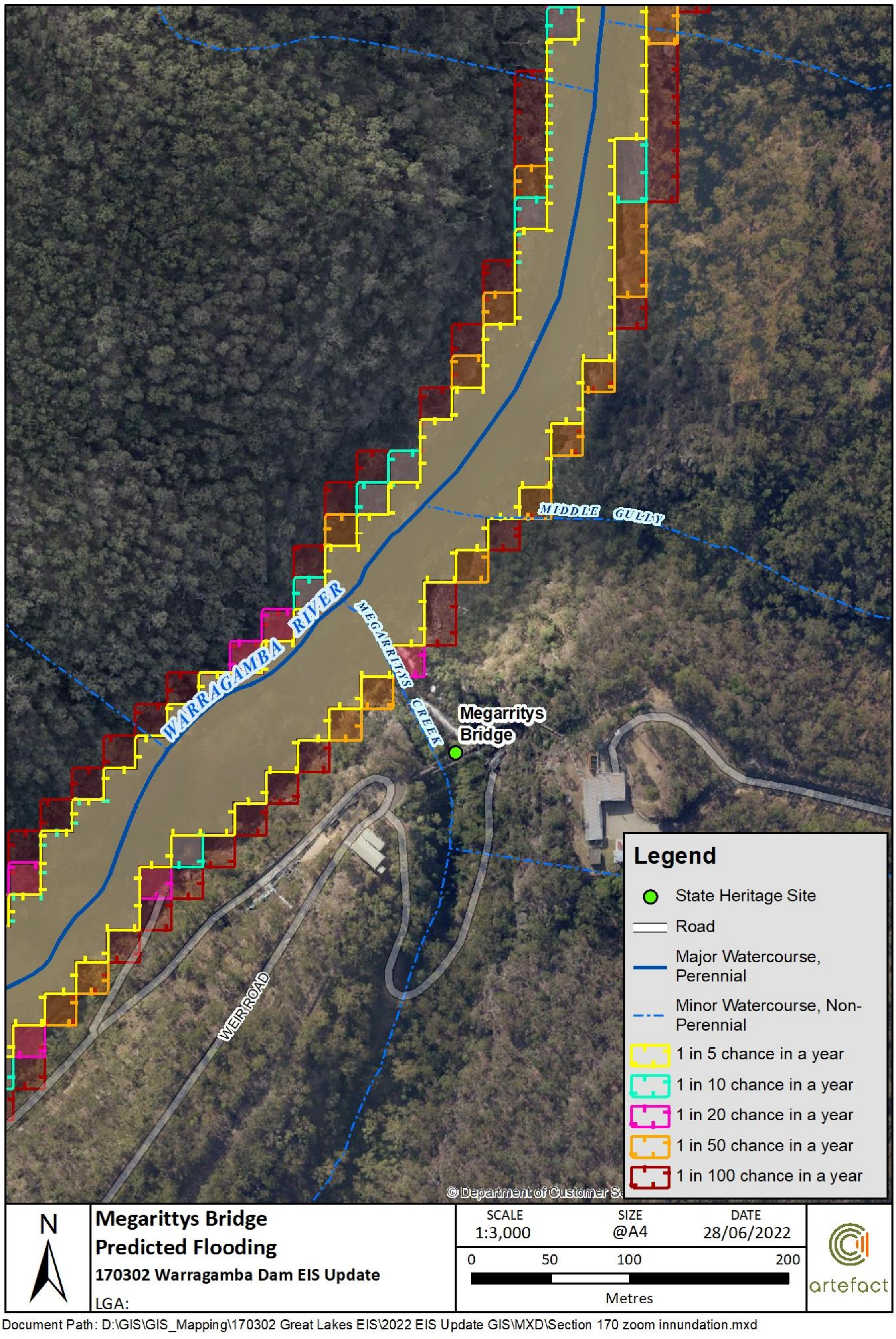


Figure 6-5: Chance in a year flooding events (in years) for the Megarritys Bridge site (Artefact 2022).

6.2 Potential impacts

This section provides an assessment of impact for the four S170 listed sites and the SHR listed Megarritys Bridge, subject to this Supplementary Report. It provides an overview of the project construction and operational impacts on the five sites.

A detailed impact assessment for the Stone Hut Ruins, the Jooriland Homestead and the Megarritys Bridge site are provided below. Given the Orange Tree Flat House and Murphy's Flat Yards were assessed not meeting the criteria for Local listing no detailed impact assessment was provided.

Potential archaeological impacts as well as direct and indirect cumulative impacts for all four S170 sites are also provided in this section.

The exact locations of the heritage items are shown in Figure 6-1 to Figure 6-5.

6.2.1 Construction impacts

The four S170 sites are over 42 kilometres south-west from the construction footprint of the project. These sites would not be subject to any direct or indirect impacts as a result of the construction works.

Megarritys Bridge is located 853 metres downstream of the construction footprint of the project. It is not expected that any direct or indirect physical or visual impacts would occur to the State heritage values of Megarritys Bridge during the construction of this project.

6.2.2 Operation impacts

The operational impacts of the project on the four upstream sites would involve additional temporary inundation events during any occurrence when Lake Burragorang is above FSL.

The four S170 listed sites are affected to varying degrees by temporary inundation from the existing dam as noted in Section 6.1.1. Three of the four sites are affected by the existing PMF. These existing risks already pose a threat to the conservation of these sites. The raising of the dam has the potential to result in additional periods of inundation to these sites during certain flood events i.e. sites that would not be impacted under an existing 1 in 10 year event would see up to an additional 10 days of temporary inundation whilst some would remain unaffected. These increases are illustrated in Table 6-1. It is noted that the depth and relative velocities of waters backing up and receding during these events would not be very different from the existing situation. Therefore, the primary impacts to these sites would be increased duration of temporary inundation during flooding events. All four of the sites are currently uninhabited and are in poor condition. It is therefore assumed that the potential impact of an extended inundation period would result in some additional deterioration of the structures that remain standing within these sites.

Megarritys Bridge is unlikely to experience physical impacts associated with flood events as the height of water discharged into Warragamba River by the dam would not change as a result of this project. For all events, there would be a reduction in the peak flow discharged by the dam which would lessen any risk of damage to the heritage item. The Bridge is also elevated over a gorge, with Megarritys Creek far below the structure. This height also mitigates any risk for direct or indirect physical impacts to the heritage item.

6.2.3 Impact assessment for the Stone Hut Ruins site

The following table summarises the targeted impact assessment for the Stone Hut Ruins site.

Table 6-2: Impact assessment for the Stone Hut Ruins site

Impact type	Discussion
Physical (direct) impacts	**Minor -moderate** Whilst currently in poor condition, the Stone Hut Ruins site and its surrounding remnants are evidence of continued and successful settlement of the land by European families during the 19th and 20th centuries, prior to the flooding of the valley. The project would see an increase to the duration of temporarily inundation at the site during flood events and additional discharge from the Flood Mitigation Zone. The site already experiences physical impacts from the existing temporary inundation levels of the dam. These consist of periods of up to 7 days of temporary inundation during the 1 in 10 year event and 8 days in a 1 in 50 and 1 in 100 year event but it is currently not effected by a 1 in 5 year event. The relative depth and velocity of flood waters is low at this site during existing flooding events. Direct physical impacts of the existing temporary inundation timeframes have seen the site experience general structural failure. It is noted that the existing condition of the site could be a result of a number of factors, such as lack of occupation and maintenance, weather events, bushfire, as well as vandalism but temporary inundation from flooding events does contribute the site's overall dilapidation. The project's direct physical impacts to this site would consist of an increase in the duration of temporary inundation already experienced at the site (see Table 6-1). The structural integrity of the building has been compromised by the existing flooding, and any lingering flood waters may see additional deterioration of the stonework, timber rot, as well as general structural displacement from rising damp and shifting sediment. It is noted that the site is already exhibiting elements of structural failure as it is no longer occupied and maintained. Given the site is already compromised and has been neglected for a number of decades, it is likely the building would continue to deteriorate which would be contributed to by extended inundation.
Visual and setting (indirect) impacts	**Neutral impact** The site is located on a modestly flat plain, on a soft rise, surrounded by overgrown grasses and ground covering vegetation. It is lined with mature native vegetation to the rear of the property and a mix of potentially non-native and native mature trees closer to the rivers edge. The site overlooks the Wollondilly River to the east as well as the tall escarpments of the Nattai State Conservation Area. The setting of the Stone Hut Ruins is predominantly rural and isolated. However, it has positive visual appeal and is ideally situated for a homestead. The project would not see a change to this pastoral landscape. The surrounding setting would largely remain rural, picturesque and somewhat untouched.
Summary	The Stone Hut Ruins site has been assessed in this report as having significance at a Local level. Overall, the project would have a potential **minor -moderate** impact on the fabric of the Stone Hut Ruins site as an early example of an early-to-mid 19th century sandstone homestead.

6.2.4 Impact assessment for the Managers Cottage Group Joorilands site

The following table summarises the targeted impact assessment for the Joorilands Homestead site.

Table 6-3: Impact assessment for the Managers Cottage Group Joorilands site

Impact type	Discussion
Physical (direct) impacts	**Neutral impact** Whilst currently in fair to poor condition, the Managers Cottage Group Joorilands (Jooriland) site and its surrounding remnants are evidence of continued and successful settlement of the land by European families during the 19th and 20th centuries, prior to the flooding of the valley. It is noted that the site has exhibited elements of structural failure as it is no longer occupied and maintained.[26] Given the site is already seeing elements of termite damage, decay and dilapidation, and has been neglected for a number of decades, it is likely the buildings and remaining elements would continue to deteriorate. This deterioration would not be accelerated by the project as the site is above the 1 in 100 flood level with the project, so inundation is unlikely.
Visual and setting (indirect) impacts	**Neutral impact** The site is located on a wide flat plain and is surrounded by overgrown grasses and ground covering vegetation. It is lined with mature native vegetation to the rear of the property and a mix of potentially non-native and native mature trees closer to the river's edge. The site overlooks the Wollondilly River to the east as well as the tall escarpments of the Nattai and Yerranderie State Conservation Areas. The setting of the homestead is predominantly rural and isolated. However, it has positive visual appeal and encapsulates an image of rural NSW which is often seen as representative of a by-gone era. The project would not see a change to this pastoral landscape. The surrounding setting would largely remain rural and picturesque.
Summary	The Managers Cottage Group Joorilands site has been assessed as having significance at a Local and State level. Overall, the project would see a **Neutral** impact on the historic, aesthetic, research, representative and rarity values assessed for the Managers Cottage Group Joorilands site as an early example of a mid-19th century homestead.

[26] The Managers Cottage Group Joorilands site was not inspected by Artefact for this report. All information pertaining to its current condition have been assumed and based on details contained in the CMP (draft, 1994) and CMS (2006) for the site. Detailed structural and condition assessments are provided in the CMP (see Section 4) and CMS (see Section 1.2) for the site.

6.2.5 Impact assessment for the Megarritys Bridge site

The following table summarises the targeted impact assessment for the SHR listed Megarritys Bridge.

Table 6-4: Impact assessment for Megarritys Bridge

Impact type	Discussion
Physical impacts	**Neutral impact** Megarritys Bridge is located 853 metres downstream of the construction footprint of the project. It is not expected that any direct or indirect physical would occur to the State Heritage values of Megarritys Bridge during the construction or operation of this project. The item is not expected to experience any additional impact as the height of water discharged into Warragamba River by the dam would not change as a result of this project. For most events, there would be a reduction in the peak flow discharged by the dam which would lessen any risk of damage to the heritage item. The bridge is also raised above the gorge of Megarritys Creek so the clearance from the river below also mitigates any risk for direct or indirect physical impacts to the heritage item.
Historic impacts	**Neutral impact** Megarritys Bridge is historically associated with the Warragamba Emergency Scheme, and at the time of construction, was one of the largest concrete arch bridges to be built in NSW. It is a unique item of engineering heritage as its design is based on an innovative 'bow string' arch design rather than the more common 'decked' arch design. The project is not expected to result in any direct or indirect impacts which would jeopardise the State Heritage values of Megarritys Bridge as a rare concrete bow string arch bridge or affect its association to the Warragamba Emergency Scheme.
Visual and setting impacts	**Neutral impact** Megarritys Bridge is located 853 metres downstream of the construction footprint of the project. It is not expected that any direct or indirect visual impacts would occur to the State Heritage values of Megarritys Bridge during the construction or operation of this project.
Summary	Megarritys Bridge is located downstream of the construction footprint of the project, elevated above Megarritys Creek. It is not expected that any direct or indirect would occur to the State Heritage values of Megarritys Bridge.

6.3 Assessment of impact to archaeological remains

The four S170 sites were used for a mix of occupational and agricultural purposes prior to their abandonment in the 20th century. While the Orange Tree Flat House, Murphy's Flat Yards and Joorilands Homestead sites have been assessed as having nil-to-low potential for significant archaeological resources, the Stone Hut Ruins site has a low-to-moderate potential for archaeological resources relating to the residential and agricultural usage of the site. If found to be substantially intact, archaeological resources from these sites may reach the local significance threshold for their ability to contribute to our knowledge of the history and development of the site (Criteria A and E) and for their rarity (Criterion F). However, the previous human and environmental processes which have impacted the site are likely to have disturbed any archaeological remains present and, as such, there is little potential for relics here as defined by the *Heritage Act*.

Given the nil-to-low potential for archaeological resources at the Orange Tree Flat House, Murphy's Flat Yards and Jooriland Homestead sites, and the low likelihood of impacts to these sites from temporary inundation and continued exposure to flooding, the project would see a Neutral level of impact to potential subsurface historical archaeological resources. Whilst there is a low-to-moderate potential for archaeological resources at the Stone Hut Ruins site, the project would not see an increased risk of scouring with velocity of flood waters expected to be low or similar to existing levels. Therefore, the project would not impact subsurface historical archaeological resources at the Stone Hut Ruins site.

6.4 Cumulative impact

The EIS assessment identified that the overall impact of the project across a most flood events would largely be considered positive in most cases downstream from the dam, including SHR listed Megarritys Bridge. However, the four S170 sites which are situated upstream from the project construction area would likely see minor-moderate direct impacts due to the increased duration of temporary inundation at each of the sites and additional discharge from the Flood Mitigation Zone. These impacts would occur for potentially longer extended periods of time across more uncommon flood events.

Each of the sites have been assessed to be in poor to fair condition and are currently experiencing different types of structural failure such as collapse, cracking, and rot. All the sites are overgrown with vegetation which is also compromising the structural integrity of the extant built fabric. Specifically at the Stone Hut Ruins site there is currently evidence of rising damp and possible rising ground water or evidence of standing water following rainfall, which may be exacerbated by the additional days of temporary inundation during any flood event. The cumulative impacts of being inundated for extended periods of time would see the structures continue to experience disintegration, although this would likely occur over a longer period, without project impacts as a result of existing environmental factors.

The visual and archaeological impacts for all five sites assessed in this report have been found to be Neutral therefore no cumulative impacts would occur.

7.0 RECOMMENDATIONS AND MITIGATION

This Supplementary Report has assessed the four S170 heritage sites as being in poor condition and that the project would minor-moderate direct impacts due to increased duration of temporary inundation during all flooding events.

The separate assessment for the SHR listed Megarritys Bridge builds off the findings within the impact assessment supporting the EIS and has concluded that no impacts are expected to the State heritage values of the item.

7.1 Overview of findings

The findings of this Supplementary Report are summarised in the below table.

Table 7-1: Summary of significance and impacts to the four Section 170 sites and the SHR listed Megarritys Bridge

Site name	Listing	Significance grading	Impacts
Megarritys Bridge	State Heritage Register ID 01367	**State**	**Neutral** impacts
Orange Tree Flat House	National Parks and Wildlife Services Section 170 ID 12805	Does not fulfil criteria for a Local listing	**Minor - moderate** physical impacts **Neutral** visual and setting impacts **Neutral** archaeological impacts
Stone Hut Ruins	National Parks and Wildlife Services Section 170 ID 12804	**Local**	**Minor - moderate** physical impacts **Neutral** visual and setting impacts **Neutral** archaeological impacts
Murphy's Flat Yards	National Parks and Wildlife Services Section 170 ID 13367	Does not fulfil criteria for a Local listing	**Minor-moderate** physical impacts **Neutral** visual and setting impacts **Neutral** archaeological impacts
Managers Cottage Group Joorilands	National Parks and Wildlife Services Section 170 ID 3817	**State**	**Neutral** physical impacts **Neutral** visual and setting impacts **Neutral** archaeological impacts

7.2 Mitigation measures

National Parks and Wildlife Services (NPWS) are the asset owner for the listed sites discussed in this report and under the statutory obligations of Section 170 of the NSW *Heritage Act 1977* NPWS are responsible for the ongoing maintenance and conservation of these heritage places. However it is industry best practise to provide standard mitigations for any potential impacts which may occur to these sites attributable to the project. The following mitigation measures have been recommended for WaterNSW to conduct in consultation with NPWS, which would provide standard protection.. WaterNSW will consult with NPWS on any recommendations which result from these mitigation measures that require an action to be considered and implemented for a site by NPWS as the asset owner..

The following mitigations apply to the project in relation to the four heritage items assessed in this Supplementary Report:

- WaterNSW should conduct an Archival Recording of the four S170 sites prior to the operation of this project. The archival recording should be conducted by an appropriately qualified heritage specialist and must be conducted in accordance with Heritage Office guidelines (see *How to Prepare Archives Records of Heritage Items and Guidelines for Photographic Recording of Heritage Sites, Buildings and Structures*) and should lodge the record with the State Library and the local Council library. The report should be shared with National Parks and Wildlife Service and Heritage NSW for their records. A copy could also be shared with the Wollondilly Heritage Centre & Museum out of courtesy.
- WaterNSW should conduct inspections of these four S170 sites following any major flood event where one or more sites is affected by backwater flooding attributable to the Project, and shall consult with NPWS with regard to any required measures relating to additional temporary inundation from the Project.
- No specific mitigations are required for the State Heritage listed Megarritys Bridge as no heritage impacts are expected.
- WaterNSW to prepare a Management Plan for the locally significant Stone Hut Ruins in consultation with NPWS. This Management Plan would focus on fabric management post-inundation, general conservation post-inundation and opportunities for heritage interpretation, such as through digital archival recording to enable public engagement with the heritage values of the item offsite. This plan should be produced by a suitably qualified heritage specialist with heritage architect and engineer input. The plan can be produced post approval but should be implemented prior to completion of construction.
- WaterNSW to prepare a condition assessment in consultation with NPWS and provide advice on stabilisation and minimisation of moisture ingress and damage to the Stone Hut Ruins. This should be provided to the project prior to construction by a suitably qualified engineer with heritage experience. Findings and recommendations from this reporting must be implemented and considered prior to completion of construction of the project.

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Appendix H

Archaeological research design

Warragamba Dam Raising

Non-Aboriginal Archaeological Research Design

Report on behalf of WaterNSW

August 2022

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Author:	Sammuel Sammut
Project manager:	Jenny Winnett
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1.0 INTRODUCTION

1.1 Introduction

Artefact Heritage (Artefact) has been engaged by SMEC on behalf of WaterNSW, a New South Wales (NSW) state owned corporation, to prepare a Non-Aboriginal Archaeological Research Design (ARD) as part of the Warragamba Dam Raising Project (the project). The project involves raising the current height of the Warragamba Dam to counteract the effect of possible future flood events and will include demolition and upgrading works to specific parts of the structure and its surrounds. The objective of the project is to reduce risk to life and property damage downstream in the Hawkesbury-Nepean Valley by raising Warragamba dam.

Artefact prepared a Non-Aboriginal Heritage Impact Assessment (HIA) as part of the Environmental Impact Statement (EIS) for the project. The HIA was subsequently adapted into a chapter of the EIS by SMEC. [1] The assessment determined that portions of the construction study area (the study area), which is the only location where excavation works for the project will occur, possessed moderate to high potential to contain locally significant archaeological resources associated with the construction and operation of the Warragamba Dam. Consequently, several mitigation and management measures were recommended in the HIA. Management measure NAH11 stated that an ARD will be prepared and implemented to identify the need for archaeological testing or monitoring within the areas of archaeological potential prior to construction commencing. [2]

Consequently, this ARD has been prepared to guide archaeological management of the proposed works. It provides a detailed assessment of the potential and significance of archaeological remains in the study area, outlines an archaeological research design for the works and provides an archaeological methodology for managing these remains encountered within the study area.

1.2 Study area

The Project site is located approximately 65km west of the Sydney Central Business District in the Wollondilly Local Government Area (LGA). To the west of the Project site are the Blue Mountains, various National Parks and State Conservation Areas, as well as the Greater Blue Mountains World Heritage Area (GBMWHA), which make up part of the catchment of Lake Burragorang – the water storage formed by Warragamba Dam. To the east of the Project site is the Warragamba and Silverdale townships and surrounding rural residential areas.

The HIA for the project assessed a larger area, comprising three zones covering the construction and operational impacts (upstream and downstream) of the project.

The wider study area comprised:

- **Construction study area:** The construction study area includes Warragamba Dam elements and facilities, immediate surrounds and construction compounds
- **Upstream operational study area:** The upstream operational study area comprises the maximum extent of flood prone land estimated from the probable maximum precipitation.

[1] Artefact, 2020. *Environmental Impact Statement – Appendix I: Non-Aboriginal Heritage Assessment Report: Warragamba Dam Raising*. Report to SMEC for WaterNSW; SMEC, 2021. *Environmental Impact Statement – Chapter 17: Non-Aboriginal heritage: Warragamba Dam Raising*. Prepared for WaterNSW.
[2] SMEC, 2021. p.66.

Upstream operational impacts of the Project include the area of the Lake Burragorang catchment and tributaries that flow into Lake Burragorang.

- **Downstream operational study area:** The downstream operational impacts of the Project include the maximum extent of flood prone land estimated from the probable maximum precipitation affecting the Warragamba River, the Hawkesbury-Nepean River and its floodplain, and some of the tributaries of the Hawkesbury-Nepean.

This ARD focuses on the construction study area (the study area) only, as this location was determined to possess moderate to high potential to contain archaeological remains related to the construction and operation of the Warragamba Dam (Figure 1).

1.3 Limitations and constraints

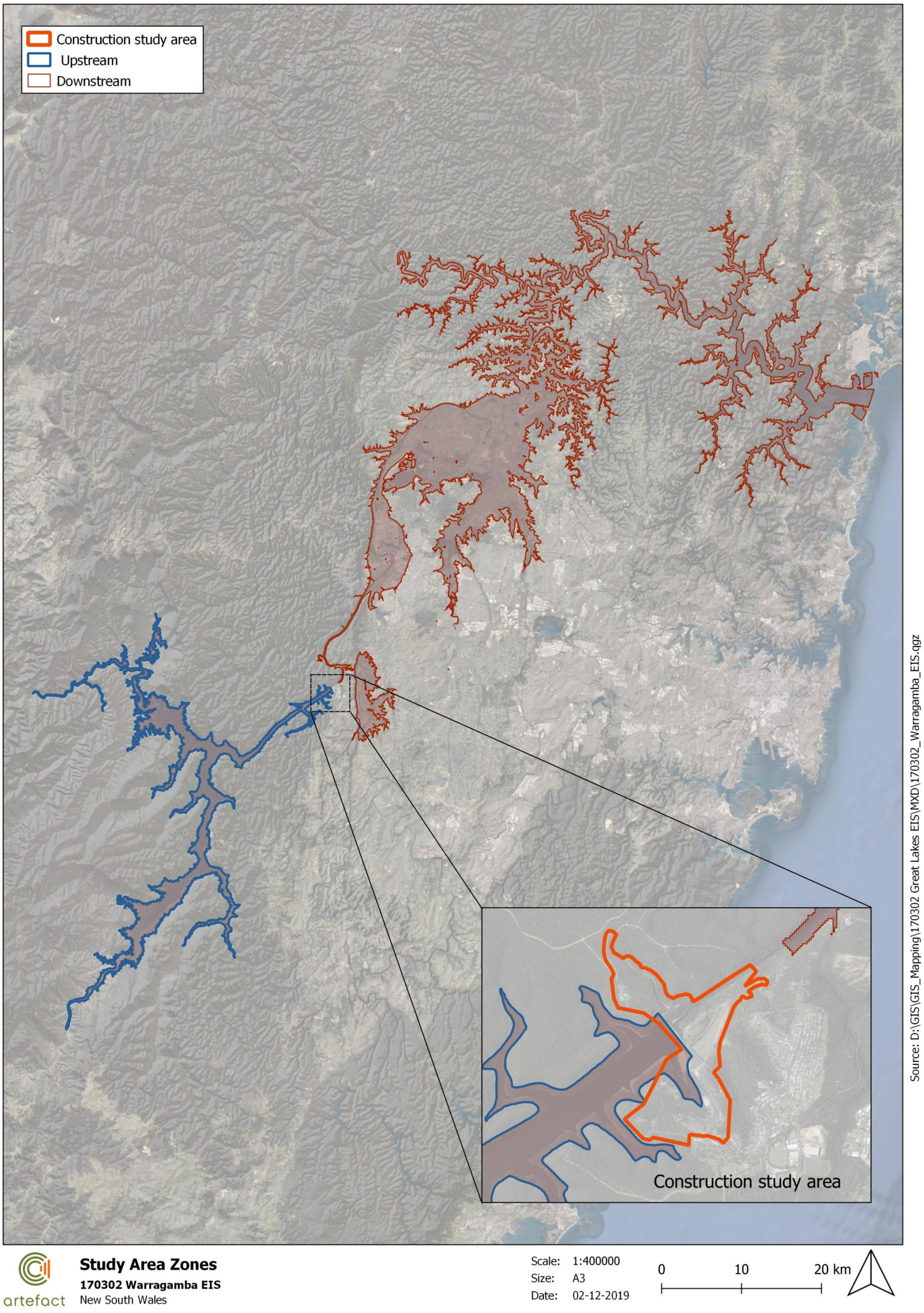
This report provides an assessment of Non-Aboriginal heritage and potential archaeological resources only and does not assess Aboriginal cultural heritage.

This document does not include management of potential archaeological resources outside the construction study area.

1.4 Authorship

This report was prepared by Sammuel Sammut (Heritage Consultant). Management input and review was provided by Sandra Wallace (Managing Director) and Jenny Winnett (Principal).

Figure 1. Study area zones (upstream operational study area, construction study area, downstream operational study area)



2.0 STATUTORY CONTEXT

2.1 Introduction

The following legislation applies to the study area in respect to the management of cultural heritage. A complete list of heritage items within the larger study area is not included here. Heritage items relevant to the construction study area, the focus of this ARD, are included below.

2.2 The World Heritage Convention

The *Convention Concerning the Protection of World Cultural and Natural Heritage 1972* (the Convention), also referred to as the World Heritage Convention, provides State Parties (i.e. Countries) with guidance on how to identify potential sites for inscription on the World Heritage List, and what is required of each State Party in the protection and preservation of such sites. Signatories of the Convention pledge to conserve World Heritage sites situated on their territory, and to take active measures to protect their national heritage. The Convention aims to promote international cooperation to protect heritage that is of such outstanding universal value that its conservation is important for current and future generations. The Convention also sets out the criteria that a site must meet to be inscribed on the World Heritage List.

Encouragement is provided to each of the State Parties to ensure that the protection of world and national heritage is integrated into relevant planning process and programs, and provide sufficient resourcing to protect, conserve, and communicate the significant values of each place.

The United Nations Educational, Scientific and Cultural Organisation (UNESCO), summarises the importance of the Convention by stating:

> *“The most significant feature of the 1972 World Heritage Convention is that it links together in a single document the concepts of nature conservation and the preservation of cultural properties. The Convention recognizes the way in which people interact with nature, and the fundamental need to preserve the balance between the two.”*

2.3 Environment Protection and Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) provides a legislative framework for the protection and management of matters of national environmental significance, that is, flora, fauna, ecological communities and heritage places of national and international importance. Heritage places are protected through their inscription on the World Heritage List (WHL), Commonwealth Heritage List (CHL) or the National Heritage List (NHL).

Under Part 9 of the EPBC Act, approval under the EPBC Act is required for any action occurring within, or outside, a Heritage place that has, will have, or is likely to have a ‘significant impact’ on the heritage values of a World, National or Commonwealth heritage listed property (referred to as a ‘controlled action’ under the Act). A ‘significant impact’ is defined as:

> *“an impact which is important, notable, or of consequence, having regard to its context or intensity. Whether or not an action is likely to have a significant impact depends upon the sensitivity, value, and quality of the environment which is*

> *impacted, and upon the intensity, duration, magnitude and geographic extent of the impacts."*

The EPBC Act stipulates that a person who has proposed an action that will, or is likely to, have a significant impact on a site that is listed on the World Heritage List, National Heritage List, or Commonwealth Heritage List, must refer the action to the relevant Minister (hereafter the Commonwealth Minister). The Commonwealth Minister will then determine if the action requires approval under the EPBC Act. If approval is required, an environmental assessment would need to be prepared. The Minister would approve or decline the action based on this assessment.

The significance of the action is based on the sensitivity, value and quality of the environment that is to be impacted, and the duration, magnitude and geographic extent of the impact. If the action is to be undertaken in accordance with an accredited management plan, approval is not needed, and the matter does not need be referred to the Minister.

Impacts to places listed on the World and National heritage lists are assessed under the guidance of the DoEE publication *Matters of National Environmental Significance Significant Impact Assessment Guidelines 1.1*.

2.3.1 Bilateral agreement made under Section 45 of the EPBC Act

The Project was referred to the then Commonwealth Department of the Environment and Energy (DoEE) by WaterNSW and was determined to be a controlled action under the EPBC Act.

The referral was accompanied by a preliminary consideration of relevant Matters of National Environmental Significance (MNES), principally those relating to biodiversity and heritage. This includes the areas of the Greater Blue Mountains World Heritage Area (GBMWHA) which would be impacted by temporary increased inundation during significant flood events due to the operation of the Project.

Subsequent to the referral, the NSW *Biodiversity Conservation Act 2016* (BC Act) came into effect on 25 August 2017, repealing the *Threatened Species Conservation Act 1995* (TSC Act). One effect of this was to remove the legislative basis for the bilateral assessment agreement between the Commonwealth and NSW governments which provided for an EIS prepared under the EP&A Act for SSI to be also used for an EIS under the EPBC Act for a controlled action, where directed by the Commonwealth Minister for the Environment. This was rectified on 24 March 2020 when the NSW Government and the Australian Government finalised amendments to the NSW Bilateral Agreement under the EPBC Act, to respond to the introduction of the NSW BC Act.

However, under Part 7 of the Biodiversity Conservation (Savings and Transitional) Regulation 2017, the Project is regarded as a 'pending Part 5 assessment', and therefore the TSC Act and the bilateral assessment agreement are still in place for the Project. The matters specified in clause 6 of the former bilateral assessment agreement have been addressed in preparing the EIS. Appropriate consideration has also been given to relevant Commonwealth guidelines for the EIS information requirements.

Revised SEARs were issued by DPIE on 13 March 2018 which contained the EPBC Act assessment requirements provided by DoEE.

2.3.2 Matters of National Environmental Significance Significant Impact Assessment Guidelines 1.1.

The *Matters of National Environmental Significance Significant Impact Assessment Guidelines 1.1* (Impact Guidelines) guides the process for the assessment of various matters under the EPBC Act, including the assessment of impacts to such matters as:

- Listed threatened species and ecological communities
- Listed migratory species
- World Heritage properties
- National Heritage places.

The Impact Guidelines state that:

> *"Approval under the EPBC Act is required for any action occurring within or outside a declared World Heritage property that has, will have, or is likely to have a significant impact on the World Heritage values of the World Heritage property.*
>
> *An action is likely to have a significant impact on the World Heritage values of a declared World Heritage property if there is a real chance or possibility that it will cause:*
>
> - *one or more of the World Heritage values to be lost*
> - *one or more of the World Heritage values to be degraded or damaged, or*
> - *one or more of the World Heritage values to be notably altered, modified, obscured or diminished."*[3]

The approach above is also used in assessing impacts to places of National Heritage significance.

2.3.3 World, National, and Commonwealth Heritage Principles

Under the EPBC Act, actions that have, will have, or are likely to have a significant impact on the values of a World, National, or Commonwealth heritage property must be in line with the Heritage Principles, as presented in Schedules 5, 5B, and 7B of the EPBC Regulations respectively. These principles are reproduced in Appendix 2.

The three sets of principles guiding statement is to *"…to identify, protect, conserve, present and transmit, to all generations…"*[4] the values of the places on each list, and in the case of the WHL, to "…*if appropriate, rehabilitate the World Heritage values of the property*."[5]

[3] Commonwealth Department of the Environment, 2013. *Matters of National Environmental Significance Significant Impact Assessment Guidelines 1.1.* pp.15-16
[4] National Heritage Management Principles. Accessed at http://www.austlii.edu.au/cgi-bin/viewdoc/au/legis/cth/consol_reg/epabcr2000697/sch5b.html on 23/10/2017
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2.4 NSW Heritage Act 1977

The NSW *Heritage Act 1977* (Heritage Act) provides protection for items of 'environmental heritage' in NSW. 'Environmental heritage' includes places, buildings, works, relics, movable objects or precincts considered significant based on historical, scientific, cultural, social, archaeological, architectural, natural or aesthetic values. Items considered to be significant to the State are listed on the State Heritage Register (SHR) and cannot be demolished, altered, moved or damaged, or their significance altered without approval from the Heritage Council of NSW.

2.4.1 The 2009 'Relics provisions'

The Heritage Act also provides protection for 'relics', which includes archaeological material or deposits. According to Section 139 (Division 9: Section 139, 140-146) of the *Heritage Act 1977*:

(1) A person must not disturb or excavate any land knowingly or having reasonable cause to suspect that the disturbance or excavation will or is likely to result in a relic being discovered, exposed, damaged or destroyed unless the disturbance is carried out in accordance with an excavation permit.

(2) A person must not disturb or excavate any land on which the person has discovered or exposed a relic except in accordance with an excavation permit.

(3) This section does not apply to a relic that is subject to an interim heritage order made by the Minister or a listing on the State Heritage Register.

(4) The Heritage Council may by order published in the Gazette create exceptions to this section, either unconditionally or subject to conditions, in respect of any of the following:

   a. Any relic of a specified kind or description,
   b. Any disturbance of excavation of a specified kind or description,
   c. Any disturbance or excavation of land in a specified location or having specified features or attributes,
   d. Any disturbance or excavation of land in respect of which an archaeological assessment approved by the Heritage Council indicates that there is little likelihood of there being any relics in the land.

Section 4(1) of the Heritage Act (as amended in 2009) defines a relic as:

> *...any deposit, artefact, object or material evidence that:*
>
> *relates to the settlement of the area that comprises New South Wales, not being Aboriginal settlement, and is of State or local heritage significance*

A relic has been further defined as:

> *Relevant case law and the general principles of statutory interpretation strongly indicate that a 'relic' is properly regarded as an object or chattel. A relic can, in some circumstances, become part of the land be regarded as a fixture (a chattel that becomes permanently affixed to land).*[6]

[6] *Assessing Significance for Archaeological Sites and 'Relics'*, Heritage Branch, Department of Planning, 2009:7.

Excavation permits are issued by the Heritage Council of NSW, or its Delegate, under Section 140 of the Heritage Act for relics not listed on the SHR or under Section 60 for relics listed on the SHR. An application for an excavation permit must be supported by an Archaeological Research Design and Archaeological Assessment prepared in accordance with the NSW Heritage Division archaeological guidelines. Minor works that will have a minimal impact on archaeological relics may be granted an exception under Section 139 (4) or an exemption under Section 57 (2) of the Heritage Act.

2.4.1.1 *Works*

'Works' refer to past evidence of infrastructure. 'Works' may be buried, and therefore archaeological in nature; however, exposure of a 'work' does not trigger reporting obligations under the Heritage Act. 'Works', as places of environmental heritage, have the potential to provide information that contributes to our knowledge of past practices, and good environmental practice recognises this. Transport for NSW, for example, uses its *Standard Management Procedure: Unexpected Heritage Places* to manage the discovery of such works[7].

2.4.2 Works

The Heritage Act places 'works' in a separate category to archaeological 'relics'. 'Works' refer to remnants of historical structures which are not associated with artefactual material that may possess research value. 'Works' may be buried, and therefore archaeological in nature, however, exposure of a 'work' does not require approved archaeological excavation permits under the Act.

The following examples of remnant structures have been considered to be 'works' by the NSW Heritage Council:

- Evidence of former infrastructure, where there are no historical artefacts in association with the item
- Historical building footings where there are no historical artefacts in association with the item.

Where buried remnants of historical structures are located in association with historical artefacts in controlled stratigraphic contexts (such as intact historic glass, ceramic or bone artefacts), which have the potential to inform research questions regarding the history of a site, the above items may not be characterised as 'works' and may be considered to be 'relics'. The classification of archaeological remains as a 'work' therefore is contingent on the predicted remains being associated with historical structures as well as there being no prediction of the recovery of intact artefactual deposits which may be of research interest.

2.4.3 State Heritage Register

The SHR was established under Section 22 of the Heritage Act and is a list of places and objects of importance to the people of NSW, including archaeological sites. The SHR is administered by the Heritage New South Wales, Department of Premier and Cabinet (Heritage NSW) and includes a diverse range of over 1,500 items, in both private and public ownership. To be listed, an item must be deemed to be of heritage significance for the whole of NSW.

There is one SHR item located within the Construction study area, comprising Warragamba Dam - Haviland Park (SHR No. 01375).

[7] Roads and Maritime, 2015

2.4.4 Section 170 Heritage and Conservation Registers

The Heritage Act requires all government agencies to identify and manage heritage assets under their ownership and control. Under Section 170(3) of the Heritage Act, government instrumentalities must establish and keep a register which includes all places of environmental heritage listed on the SHR, environmental planning instruments, or which may be subject to an interim heritage order that are owned, occupied, or managed by that government body. Government agencies must also ensure that all places entered on its register are maintained with due diligence in accordance with State Owned Heritage Management Principles approved by the Minister on advice of the NSW Heritage Council. These principles serve to protect and conserve the heritage significance of identified sites, places and objects and are based on relevant NSW heritage legislation and statutory guidelines.

There is a single Section 170 Heritage and Conservation Register listed place within the construction study area: the Warragamba Supply Scheme (WaterNSW No. 4580161).

2.5 Environmental Planning and Assessment Act 1979 (NSW)

The EP&A Act establishes the framework for cultural heritage values to be formally assessed in the land use planning and development consent process. The EP&A Act requires that environmental impacts are considered prior to land development. This includes impacts on cultural heritage places and places as well as archaeological sites and deposits. The project is subject to assessment pursuant to Division 5.2 (s5.12) (State Significant Infrastructure) of the EP&A Act.

The EP&A Act also requires that local governments prepare planning instruments, such as Local Environmental Plans (LEPs) and Development Control Plans (DCPs) in accordance with the EP&A Act, to provide guidance on the level of environmental assessment required.

Each LEP controls actions that may impact places within each instrument's Schedule 5 Registers, and each of these lists, and the places listed on them within the study area are detailed below.

2.5.1 State Environmental Planning Policy (Infrastructure) [ISEPP] 2007

In 2007, the *State Environmental Planning Policy (Infrastructure) 2007* (ISEPP) was introduced to streamline the development of infrastructure projects undertaken by state agencies, including WaterNSW. Generally, where there is conflict between the provisions of the ISEPP and other environmental planning instruments, the ISEPP prevails. It is noted that the ISEPP has been repealed and replaced by State Environmental Planning Policy (Transport and Infrastructure) 2021 (which commenced on 1 March 2022), and the transitional provisions are contained in Schedule 9.

Under clause 50 of the ISEPP, development for the purpose of flood mitigation may be carried out by a public authority without consent on any land. The ISEPP overrides the controls included in the LEPs an DCPs, and WaterNSW would be required to consult with the council only when development "*is likely to have an impact that is not minor or inconsequential on a local heritage place (other than a local heritage place that is also a State heritage place) or a heritage conservation area*". When this is the case, WaterNSW must not carry out such development until it has:

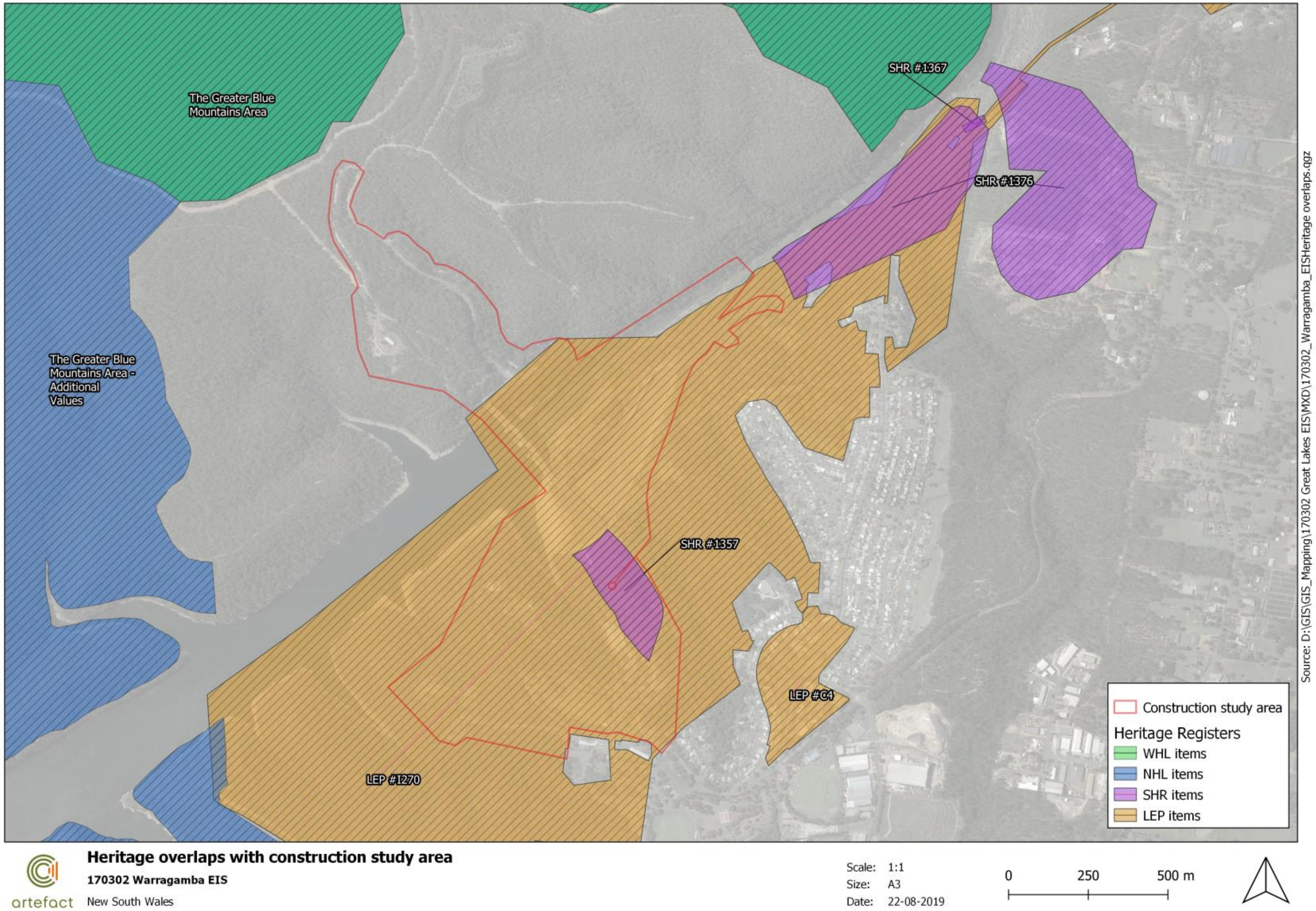
- Had an assessment of the impact prepared
- Given written notice of the intention to carry out the development, with a copy of the assessment, to the council for the area in which the heritage place or heritage conservation area (or the relevant part of such an area) is located
- Taken into consideration any response to the notice that is received from the council within 21 days after the notice is given (ISEPP Clause 14).

2.5.2 Local Environment Plans

The study area falls within the boundaries of the Blacktown, Central Coast, Hawkesbury, Hornsby, Pittwater, Gosford, Liverpool, Penrith, The Hills, and Wollondilly LEPs, all of which pre-date the recent council mergers. Schedule 5 Registers of each LEP includes a list of places/sites of heritage significance within the relevant LGA.

There is one LEP heritage item within the Construction study area, comprising the Warragamba Supply Scheme and Warragamba Emergency Scheme (LEP No. I270).

Figure 2: Heritage items within the construction study area



3.0 HISTORICAL CONTEXT

This chapter provides an overview of the Non-Aboriginal history of the study area. Aboriginal history and context are discussed in the separate Aboriginal heritage report for the project (Appendix K of the EIS). This encompasses the history of Western Sydney and the Hawkesbury, an overview of Sydney's water supplies, development of Warragamba Dam and history of the conservation of the World and National heritage items within the study area.

3.1 Non-Aboriginal history

3.1.1 Early colonial history

Following European settlement in 1788, the most pressing need for the colony was a stable food source to alleviate potential famine and reduce the reliance on ships bringing supplies from England. Exploration to the west of Sydney Cove had begun soon after initial colonisation, as it was found that the sandstone soils of coastal Sydney were unsuited for intensive farming.[8] Exploration up the river in 1788 located better land at an area originally named Rose Hill and later Parramatta, and settlement soon commenced in the locality during the 1790s. Shortly after, a third settlement was established at Toongabbie in 1792. These settlements were at the centre of the agricultural occupation of the surrounding land.

Further north, the first Europeans visited the Hawkesbury River in 1788 a few months after arriving in the colony with the First Fleet. Governor Arthur Phillip and his party travelled to Prospect Hill, via Broken Bay. It was in Broken Bay that Phillip first saw the mouth of the Hawkesbury River.[9] In 1789, Phillip successfully travelled the length of the River, naming it after Lord Hawkesbury, the First Earl of Liverpool. Shortly after Phillip's exploration, surveyors began marking out the land along the Hawkesbury with land grants and roads, and several Crown Grants were also included. The early settlers of the lower Hawkesbury were remote from major settlements, and access remained difficult. This meant that the area did not become heavily occupied until the late 19th century when rail and ferry infrastructure was developed in the area.[10]

The Cumberland Plain, with its gently undulating landscape and rich alluvial soils, offered better conditions for farming and land was cleared in the Cumberland Plain as early as the 1790s.[11] Settlement around the Cumberland Plains initially focused on the well-watered areas around the Hawkesbury and Georges Rivers, but soon began to spread further west and south. The heavily dissected sandstone plateau and deep valleys characteristic of the Blue Mountains, which provided a physical barrier to the inland, meant that for 25 years between 1788 and 1813, the European colony's expansion was restricted to the coastal strip around Sydney.

Convict labour was largely responsible for the development of Western Sydney into productive land. During the early years of settlement in the late 18th century and early 19th century, the absence of machinery and the shortage of bullocks meant that convicts cleared land, erected public buildings, private buildings, and provided labour for jobs small and large.[12] The County of Cumberland and the County of Camden, are largely associated with convict era development. A range of assets constructed by convicts survive within the study area including the Great North Road. In 1840, transportation of convicts to the colony ceased.[13]

[8] FORM 2006 in Austral 2011.
[9] Nichols, M. 2004. Pictorial History Hawkesbury Shire, Kingsclear Books Pty Ltd, Hawkesbury, NSW, p. 8.
[10] Rowland, J. 2008. Brooklyn, Dictionary of Sydney.
[11] FORM 2006 in Austral 2011.
[12] Kass, T. 'Western Sydney Thematic History'. 2005:9.
[13] Kass, T. 2005:11.

Figure 3: Historical painting depicting a view of the Nepean River at the Cow Pastures, 1825 (Source: State Library Victoria)

3.1.2 Rural development

Rural development and settlement within much of the study area was driven by the availability of fertile soil and accessible water sources such as creeks and riverbeds. By end of the 18th century, fertile alluvial soils along the Nepean River, Hawkesbury River and South Creek, and the area of Prospect Hill, comprised early land grants and were being farmed for wheat and maize.[14] The floodplains of the Nepean River provided the most fertile soil in the region and occupation and farming took place along its banks and alluvial soils from 1789 onwards.

Following exploration of the area during the late 18th century, the colonial gentry soon regarded it as rich, fertile and suitable land for livestock grazing and pastoral pursuits, and the acquisition of land in the district was being sought by private colonists. The newly appointed Governor Lachlan Macquarie soon had the land surveyed and began granting land allotments to the colonial elite. The establishment of key towns including Campbelltown, Camden, Windsor and Richmond resulted in continued development and consolidated agricultural pursuits in the area.

In May 1813, an exploratory expedition led by immigrants Gregory Blaxland, William Charles Wentworth and William Lawson set out from Emu Plains to find a way to cross the Blue Mountains, to secure a passage west. After 21 days navigating an established Aboriginal trading route, the party reached the summit of what is now Mount Blaxland. Although Blaxland, Wentworth and Lawson did not complete a crossing of the Great Dividing Range, a trail across the Blue Mountains by white settlers had been blazed, enabling access to the western pastoral lands beyond.

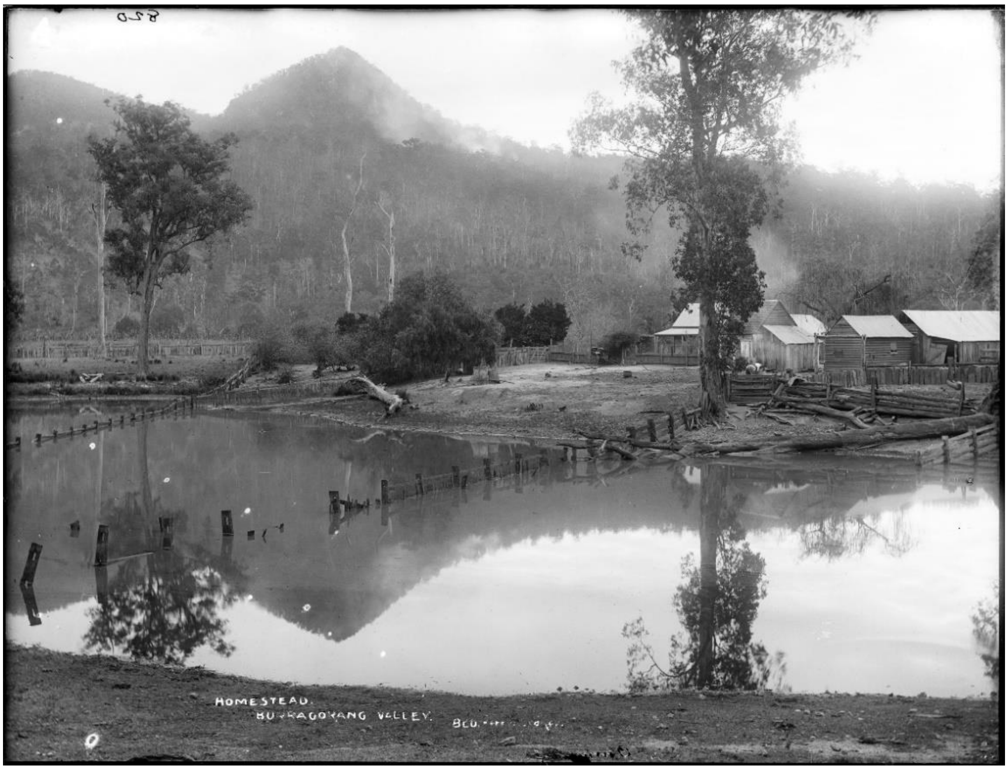
During the early to mid-19th century, areas surrounding the Blue Mountains, encompassing Burragorang Valley and the Cumberland Plains beyond, were expropriated from local Aboriginal groups and used for the mining of coal, lead and silver, for farming and for recreational activities.

[14] NSW Department of Commerce, State Records 2007:1.

Established in 1827 as a mining town, Burragorang developed into a small township that comprised houses, farms, churches, cemeteries and several guesthouses.

Figure 4: Historical painting by George William Evans depicting a view along the Nepean River at connection with Grose River, 1809
(Source: State Library NSW, call no. SV/123)

Figure 5: A homestead in the Burragorang Valley prior to flooding of the township to establish Warragamba Dam, c1884-1917 (Source: Museum of Applied Arts & Sciences. Object No. 85/1284-435)



3.1.3 Consolidated settlement and development

With the development of links with Bathurst following completion of a road between Sydney and Bathurst in 1815, and the opening of agricultural land further west following the crossing of the Blue Mountains, the importance of the Western Sydney agricultural region diminished. The character of the area also shifted as the new road to Parramatta was constructed, making the area more attractive to settlers. Drought followed by wheat leaf rust in the 1870s necessitated a change in crop types and by the 1890s the area was a major producer of citrus and dairying. During the last decades of the nineteenth century and throughout the twentieth century, portions of the Cumberland Plain region were used for quarrying, gravel and sand extraction.

3.2 Overview of Sydney's water supplies

The following section provides a context of Sydney's water supplies over time and the background to the development of Warragamba Dam. It is noted the Warragamba Supply Scheme Conservation Management Plan (CMP) prepared by Graham Brooks & Associates in 2010 (Warragamba Supply Scheme CMP 2010) provides a detailed history of Warragamba Dam and the evolution of Sydney's water supplies.

3.2.1 Early water sources, the Upper Nepean Scheme & additional catchment areas

In January 1788, the European colony was founded on the first water supply system, a 'spring of water' that flowed into Sydney Cove, which became known as the Tank Stream. Although it was never satisfactory for the requirements of the colony and subject to variations of the weather, the Tank Stream continued to serve the fledgling colony until the mid-1820s.[15] From 1827, Sydney's second water supply was developed as a series of reservoirs on the Lachlan Swamps, which are now part of the Centennial Park lakes system. The Lachlan Swamps continued to supply Sydney with water until 1860, when it was replaced by the development of the Botany Swamps located to the south.[16]

Residential and industrial growth in Sydney resulted in increasing water consumption. By 1867, the Botany Swamps supply was considered to be over-taxed, and a Special Commission was appointed by the Governor of NSW to recommend a scheme that could provide a reliable and plentiful water supply to meet the city's future growth, harvesting water on river catchment areas far removed from the city and transferred by means of canals and pipelines.[17] The Upper Nepean Scheme was proposed, based on the provision of water from the Nepean River and its tributaries of the Avon, Cataract, and Cordeaux Rivers.

The Upper Nepean Scheme was envisaged as a 'run of the river scheme' involving the diversion of the natural flow of waters without regulation in storage reservoirs by the construction of weirs, tunnels and reservoirs.[18] The scheme was built between 1879 and 1887, and was commissioned in 1888. The Prospect Reservoir, which was constructed as part of the scheme, was completed in 1888 as the first earth-fill embankment dam in Australia.[19]

During the remaining portion of the nineteenth century, Sydney's water supplies were obtained by amplifying the existing supplies and progressively developing the Botany water reserve, Prospect Reservoir, and by the construction of Cataract Dam by 1907, which was developed to maximise the

[15] Graham Brooks & Associates. 'Conservation Management Plan: Warragamba Supply Scheme'. 2010:16.
[16] Graham Brooks & Associates. 2010:16.
[17] Graham Brooks & Associates. 2010:19.
[18] Graham Brooks & Associates. 2010:19.
[19] Sydney Catchment Authority, 2013. Prospect Reservoir. Site accessed on 26/03/2015 at: http://www.sca.nsw.gov.au/water/supply/dams/prospect-dam

potential of the Upper Nepean Scheme. However, to provide adequate water supply for the growing population in the metropolitan area, the Public Works Department continued investigations to determine other feasible water supply schemes.

Figure 6: Historic photograph of Prospect Reservoir at the time of completion, 1888 (Source: Reproduced in Besley, M. 'The Sweat of their Brows' Water Board, 1988)

The Public Works Department, through engineers such as Ernest M. de Burgh and Leslie A.B. Wade, proposed the damming of the Warragamba River. In 1908, E.M. de Burgh, Chief Engineer of the Water Supply and Sewerage Branch, recommended to the Minister that an investigation be made into the proposal for a dam on the Warragamba River for irrigation and water supply purposes. E.M. de Burgh's report outlined the improvements to engineering that would make the construction of a high masonry dam, using 'waste weirs' to safely manage the escape for flood waters, possible.

During the drought of 1915/1916, planning was undertaken by the Public Works Department to increase Sydney's water supply by the construction of a dam on the Warragamba River,[20] although the financial stringency brought about by the First World War delayed any action.

Separate to investigations surrounding Warragamba, an additional report prepared by E.M. de Burgh outlined the need to extend the storage in the Upper Nepean and additional catchment areas. In November 1918, upon cessation of the First World War, a Special Board of Experts was appointed to examine the findings of E.M. de Burgh's report. The Special Board recommended the immediate construction of Avon Dam and construction of the Nepean Dam to supply about two years' worth of water to metropolitan Sydney and raising the height of the recently commenced Cordeaux Dam. In 1923, the Nepean Dam was constructed.

3.3 Development of Warragamba Dam

3.3.1 Early consideration

In 1810, Macquarie visited the area, and noted the immense body of water that poured into a circular basin connecting with the Nepean to form a large river.[21] The name "Warragamba" is derived from

[20] Graham Brooks & Associates. 2010:32.
[21] Graham Brooks & Associates. 2010:35.

Macquarie, based on the “real and proper Native name” of the river “Warragombie”. The first use of the word “Warragamba” appears to have been used in 1825 by Surveyor General Oxley. The native words “warra” meaning swamp and “gamba” meaning ti-tree.[22]

3.3.2 Exploration

In 1845, explorer Count PE de Strzelecki suggested the use of the Warragamba River, among other rivers, for agricultural irrigation.[23] In a Special Commission in 1867-1869, a member of the Commission Lieut. Thomas Woore strongly urged the construction of a dam in the gorge of the Warragamba, and for works to convey water through Mulgoa and Prospect for the supply of Sydney. Woore outlined the advantages of locating a water supply at Warragamba, the collecting area of which would be within reach of the city and could be tapped at its lowest point to feed the water by gravity to Sydney.[24]

3.3.3 Woore’s proposed design

To enable the construction, Woore proposed the use of a coffer dam and shifting of sluice-gates fitted on the inner face of the wall. The work would be gradually raised by alternate shifts and gradually proceed in horizontal layers until complete. Woore’s proposed conveyance of water into Sydney was by a tunnel and inverted syphon cut into the rock to take the water through adjacent gorges. An aqueduct would then transport the water along the ridges to a reservoir located at Petersham, then considered the highest land near Sydney. Due to perceived engineering difficulties associated with construction of a dam in a flood-prone river, Woore’s colleagues instead recommended the construction of what is now known as the Upper Nepean Scheme.[25]

3.3.4 Change in governance

In 1925, the provision of future water supplies for Sydney was transferred to the Metropolitan Water Sewerage and Drainage Board (MWS&DB). Despite the vital role of the Upper Nepean Scheme, the pressing need to supply adequate water supplies to the metropolitan area persisted. In June 1925, the Board appointed an expert committee to report on the utilisation of Warragamba or other catchment area as the next to be developed following completion of the dams on the Cordeaux, Avon and Nepean Rivers. In September 1925, the committee recommended that a dam 91.5 metres high with top water level of 94.5 metres above sea level be constructed on the Warragamba with a capacity of 181,000 million gallons.[26]

In 1929, the Metropolitan Water Sewerage and Drainage Board took over from the Department of Public Works to complete the Nepean Dam, which had just been commenced, to be followed by the construction of the Woronora Dam. While these two dams increased quantity of water for Sydney’s growing population, the effects of the severe drought from 1934 to1942 drought necessitated the commencement of the Warragamba project by the construction, as an emergency, of the Warragamba Emergency Scheme to pump river flow to Prospect. In July 1938, the project to obtain water from Warragamba River was formally approved by the Sydney Water Board, with work to proceed in four stages.[27]

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[22] Aird, WV. ‘The Water Supply, Sewerage and Drainage of Sydney’. 1961:108, as in Graham Brooks & Associates. 2010:35.
[23] Graham Brooks & Associates. 2010:35.
[24] Graham Brooks & Associates. 2010:35.
[25] Graham Brooks & Associates. 2010:36.
[26] Graham Brooks & Associates. 2010:39.
[27] Graham Brooks & Associates. 2010:40.

3.3.5 Warragamba Emergency Supply Scheme

Stage One of the Warragamba development involved construction of the Warragamba Emergency Supply Scheme, just downstream of the current dam. A 50ft high overshot weir was constructed, along with a pumping station and pipeline to deliver 40 million gallons per day to Prospect Reservoir. Twin 72 inch diameter steel pipes were laid through the weir, to service pumps supplying the 25 kilometre-long, 48 inch diameter cement lined steel pipeline to Prospect Reservoir. The pipeline also included a concrete arch bridge over Megarrity's Creek, a dam of 9 million gallons capacity to act as a balance reservoir on the line and to provide emergency supply, and a chlorination and alum plant for water treatment.[28]

Construction of the Warragamba Emergency Supply Scheme commenced in April 1937, involving establishment of the office and work camps. The office site was located on the east bank of the Warragamba River, with access along what is now known as Weir Road. Construction elements included a 10-tonne cableway, shed, batching plants, electrical substations, staff facilities and accommodation. The project was completed within three years and played a key part in avoiding the failure of Sydney's water supply.[29] Upon completion of the Warragamba Emergency Supply Scheme, efforts were diverted to completing the major dam and pipelines of the Warragamba development.

3.3.6 Warragamba to Prospect Reservoir pipeline

In 1937, a temporary 48 inch pipeline had been constructed to take water from the weir associated with the Warragamba Emergency Supply Scheme to Prospect Reservoir. The second stage of the Warragamba development was the replacement of this pipeline with a larger 84 inch pipeline to provide more water to Prospect Reservoir.

It was originally planned to construct three pipelines, each 84 inches in diameter and 23 kilometres in length from the connection on the eastern side of the Nepean River to Prospect Reservoir.[30] These would connect to the two pipes in tunnel and concrete extending between the dam and the northern bank of the Nepean River. To minimise costs, however, a second pipeline was eventually constructed between 1965 and 1969 as a single 106-inch diameter pipeline, equivalent to two 84-inch pipelines.[31]

3.3.7 Construction of Warragamba Dam

In 1943, the Metropolitan Water, Sewerage and Drainage Board engaged geologist William Browne to investigate a proposed site for the Warragamba Dam. Upon finding a weakness in this initial site, comprising a bed of shale at a critical level of the foundation area, the present site further upstream was deemed most suitable, and was formally accepted by the Metropolitan Water, Sewerage and Drainage Board on 2 October 1946.

The topography and geological features of the site influenced the adoption of a straight gravity wall with central spillway design for the dam.[32] The dam's planning, design and construction was directed by three distinguished Engineers-in-Chief to the Board including Mr S.T. Farnsworth, Sir William Hudson and Mr T.B. Nicol.

In 1948, construction works commenced. To provide a dry area for excavation of the site and initial concreting work, coffer dams were constructed across the river upstream and downstream of the site. Diversion of the river around the construction site between the two coffer dams was achieved by way

[28] Graham Brooks & Associates. 2010:41.
[29] Graham Brooks & Associates. 2010:41.
[30] Graham Brooks & Associates. 2010:43.
[31] Graham Brooks & Associates. 2010:43.
[32] Graham Brooks & Associates. 2010:45.

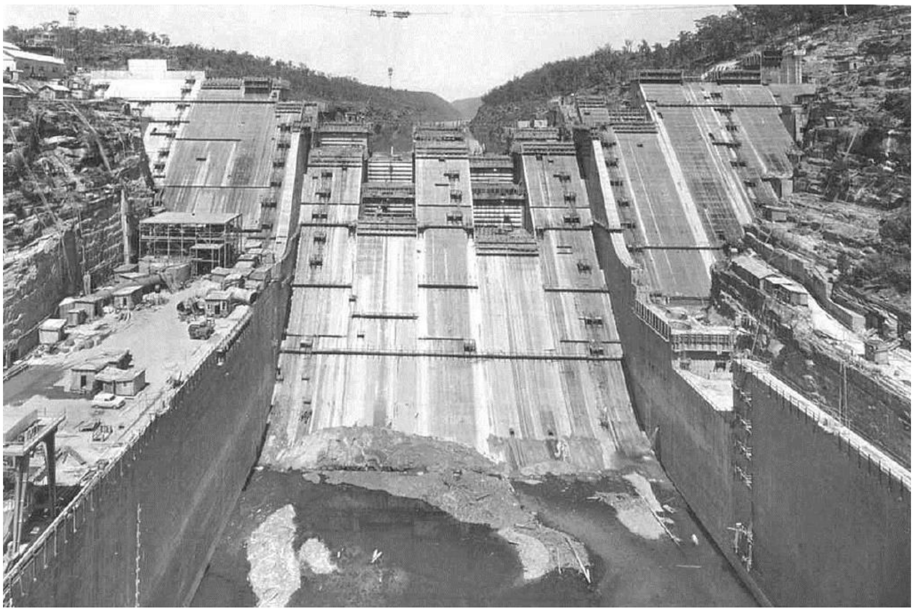
of establishing a 5.5 metre x 4.3 metre concrete lined diversion tunnel approximately 550 metres long under the eastern riverbank. Other initial works comprised the construction of 47 workers cottages and employee barracks, reconstruction of access roads, and excavation (and levelling of areas) for equipment including the 10-tonne cableway tower.[33] In 1953, concreting works commenced.

All civil engineering work was carried out by the Sydney Water Board's own day labour work force. The work force totalled between 1,600 to 1,700 men for most of the project's duration. The Warragamba township that was established during construction comprised approximately 500 cottages, barracks, shops, town hall, schools, churches, sports facilities and a medical centre. Upon completion of the dam in 1960, the township area was transferred to the local Shire Council.[34]

During construction of the dam, frequent complications and challenges led to many innovations and advancements in construction and engineering methods. Model studies and investigations were undertaken to increase the efficiency of the scheme.[35] The general spillway dimensions were determined by studying the history of floods on the Warragamba and passing flood waters over the dam, while the length of the concrete apron and height of the containing walls were determined by information gained from model studies combined with observations from precedent spillway systems. Water from the dam, surplus to supply requirements, was used for electricity generation via the Hydroelectric station constructed on the eastern side of the spillway.[36]

By 1960, the main body of the dam had been completed, with a total of 43,372 cubic yards of concrete in place, and the crest roadway, bridge spans, crest gates, crest crane and roadway approaches nearing completion.[37] On 14 October 1960, the dam, which had been completed at a cost of £35,500,000, was officially opened by the then Premier of NSW, the Hon. R.J. Heffron. About 4,000 people attended the opening ceremony, including the workers and their families and government representatives.[38]

Figure 7: Historical photograph of works progress at the dam, 1958 (Source: KW 581107 – 1, SWC/SCAHR&AF)



[33] Graham Brooks & Associates. 2010:46.
[34] Graham Brooks & Associates. 2010:48.
[35] Graham Brooks & Associates. 2010:51-52.
[36] Graham Brooks & Associates. 2010:57.
[37] Graham Brooks & Associates. 2010:53.
[38] Graham Brooks & Associates. 2010:53.

3.3.8 Modifications and development at Warragamba Dam

In November 1961, heavy flood flows resulted in damage to the dam and particularly the abutments downstream of the dam that necessitated a series of repairs. Upon completion of works and selling of surplus equipment, the works area, which comprised several bare, excavated platforms and open areas, required rehabilitation. During the 1960s, works were focused around the beautification programme, and completion of park and picnic areas and former works areas associated with the dam. These landscaped areas comprised two picnic areas and a terraced garden immediately above the eastern bank, to accommodate visitors and organised conducted tour groups of the dam.[39]

Developments in rainfall and flood estimation during the early 1980s indicated that Warragamba Dam could experience floods much larger than previously estimated. In December 1985, the Warragamba Dam flood protection program was announced by the Government.[40]

With several model studies demonstrating the dam would fail after a 1 in 750 chance in a year flood event, a two-stage program was formulated. Between 1987 and 1990, the first stage involved the crest of the dam being raised by five metres to cater for a 1 in 1,500 chance in a year flood, and the dam wall itself was strengthened using post-tensioned steel cables. The second stage involved the construction of an auxiliary spillway located on the eastern bank of the dam to divert excess flood waters around the dam and reduce the pressure on the wall. [41]

Preliminary site works for the auxiliary spillway commenced in 1998, and in 1999 construction of the large structure began. Works involved modification to the existing structure of the dam and surrounding area. Large amounts of rock and soil were removed from the site (effectively the western end of Haviland Park) and were relocated to the western bank to create the rehabilitated Left Bank Spoil embankment. Concurrently, a public platform and lookout overlooking the dam and spillway works site with access from Eighteenth Street, was constructed.[42] The construction of the auxiliary spillway resulted in the removal of a significant part of the Haviland Park's original area and exotic plantings, along with the loss of other features including a children's playground and picnic shelter located at the western end of the park.

Bushfires in December 2001 caused considerable damage to the area surrounding the dam and spillway construction site. Growth and planting on the Left Bank Spoil embankment were affected, while archaeological sites and remains of elements relating to the Emergency Scheme, the former Community Relations building and works depot area and sheds, were lost. The fire also caused further damage to the deteriorating timber suspension bridge crossing the gorge.[43] Elements of Haviland Park were also impacted.

In 2008-2009, the Sydney Catchment Authority (SCA) constructed a new Warragamba Visitor and Operations Centre at the western end of Haviland Park, with views over the dam and auxiliary spillway. A new maintenance shed and other auxiliary structures have also been built adjacent to the picnic areas. The former SCA Operations office, now the only extant building dating to the initial construction phase of the dam, has been adaptively reused as a Moveable Heritage store.[44]

[39] Graham Brooks & Associates. 2010:57.
[40] Graham Brooks & Associates. 2010:58-59.
[41] Graham Brooks & Associates. 2010:59-60.
[42] Graham Brooks & Associates. 2010:60.
[43] Graham Brooks & Associates. 2010:60.
[44] Graham Brooks & Associates. 2010:60.

4.0 ARCHAEOLOGICAL CONTEXT

4.1 Introduction

This section discusses the study area's potential to contain historical archaeological resources. The potential for the survival of archaeological remains is significantly affected by activities which may have caused ground disturbance. This assessment is therefore based on consideration of current ground conditions, and analysis of the historical development of the study area.

'Archaeological potential' refers to the likelihood that an area contains physical remains associated with an earlier phase of occupation, activity or development of that area. This is distinct from 'archaeological significance' and 'archaeological research potential'. These designations refer to the cultural value of potential archaeological remains and are the primary basis of the recommended management actions included in this document.

4.2 Summary historical land use

Based on the historical development of the study area established in Section 3.0 of this report and in the HIA prepared by Artefact, the use of the study area and surrounds has been divided into the following phases outlined in Table 1.

Table 1. Historical phases of land use in the study area and surrounds

Phase	Date	Historical activities
1	c.1800 – c.1900	**Early land grants and rural development**
2	c.1900 – 1940	Urban expansion/Warragamba Dam.

4.2.1 Phase 1: Early land grants and rural development (c. 1800 – 1900)

There is **nil to low potential** that archaeological evidence of land clearance, and modification for agricultural or pasturing purposes, pre-dating the construction of the Warragamba Dam, would be located within the study area. Evidence for these types of activities are typically ephemeral and are therefore likely to have been disturbed by ongoing modification of the landscape through construction. Archaeological remains may include the following:

- Evidence of tree clearance (tree boles, etc.)
- Evidence of cultivation (postholes, plough marks in subsoils, etc)
- Evidence of the formalisation of agricultural precinct boundaries, such as postholes associated with early fence lines.

4.2.2 Phase 2: Urban expansion/Warragamba Dam (1900 – 1940)

The Warragamba Supply Scheme CMP 2010 identified several locations with the potential to contain an archaeological resource. The following potential archaeological resources are located within the construction footprint of the proposed works:[45]

[45] Graham Brooks and Associates Pty Ltd, June 2010 p.278

- The original construction township from the Warragamba Emergency Scheme and early years of site testing and establishment for Warragamba Dam – this was originally located on the ridge to the east of the river and is now mostly outside the ownership boundaries of the dam site
- Evidence of the construction and operation of the Warragamba Emergency Scheme including the power station, chlorination and alum plant, batching plant and support sheds, which remain on the eastern back of the river
- The single men's quarters and site of the wet canteen from the Warragamba Dam construction township on either side of the road to the Dam lookout
- Staff barracks on the eastern side of the entrance road adjacent to Haviland Park
- Junior staff quarters on the northern side of the road to the conference centre
- The aggregate bins, aerial ropeway and depot in the area now occupied by Haviland Park
- Evidence of former roads and stores area to the east of the auxiliary spillway
- Evidence associated with the 10-tonne cableway in the Terraced Gardens
- Evidence associated with the 18-tonne cableway on the eastern side of the dam[46] and the upper and lower tail tower foundations on the western side of the dam.

4.3 Archaeological potential

4.3.1 Discussion of previous land disturbance

While the history of the study area could have produced a range of archaeological evidence related to former activities and phases, the likelihood of such evidence surviving to the present is influenced by various factors. These factors include the durability of the material evidence and subsequent impacts such as demolition and construction.

The landscape surrounding the Warragamba Dam has undergone substantial modification throughout the decades since its construction. Various development and upgrade works have resulted in significant ground disturbance that is likely to have impacted archaeological evidence relation to the construction of the original Warragamba Emergency Scheme and construction areas.

Moreover, the construction of the auxiliary spillway in the late 1990s removed the construction terraces that formerly held the ice making plant, concrete mixing plant, mechanical workshop and cement silos.[47] Following this, construction of the Warragamba Deep-Water Storage Access infrastructure in the early 2000s directly impacted the site of the former chlorination plant, WSP009 and part of the former substation. [48]

Based on the history of these events, a number of these activities would have resulted in ground disturbance. These types of activities have the potential to remove evidence of previous structures and other archaeological remains relating to nineteenth to early twentieth century use of the study area.

[46] Ibid
[47] Graham Brooks and Associates Pty Ltd, June 2010, p.279.
[48] Graham Brooks and Associates Pty Ltd, June 2010, p.279.

4.3.2 Assessment

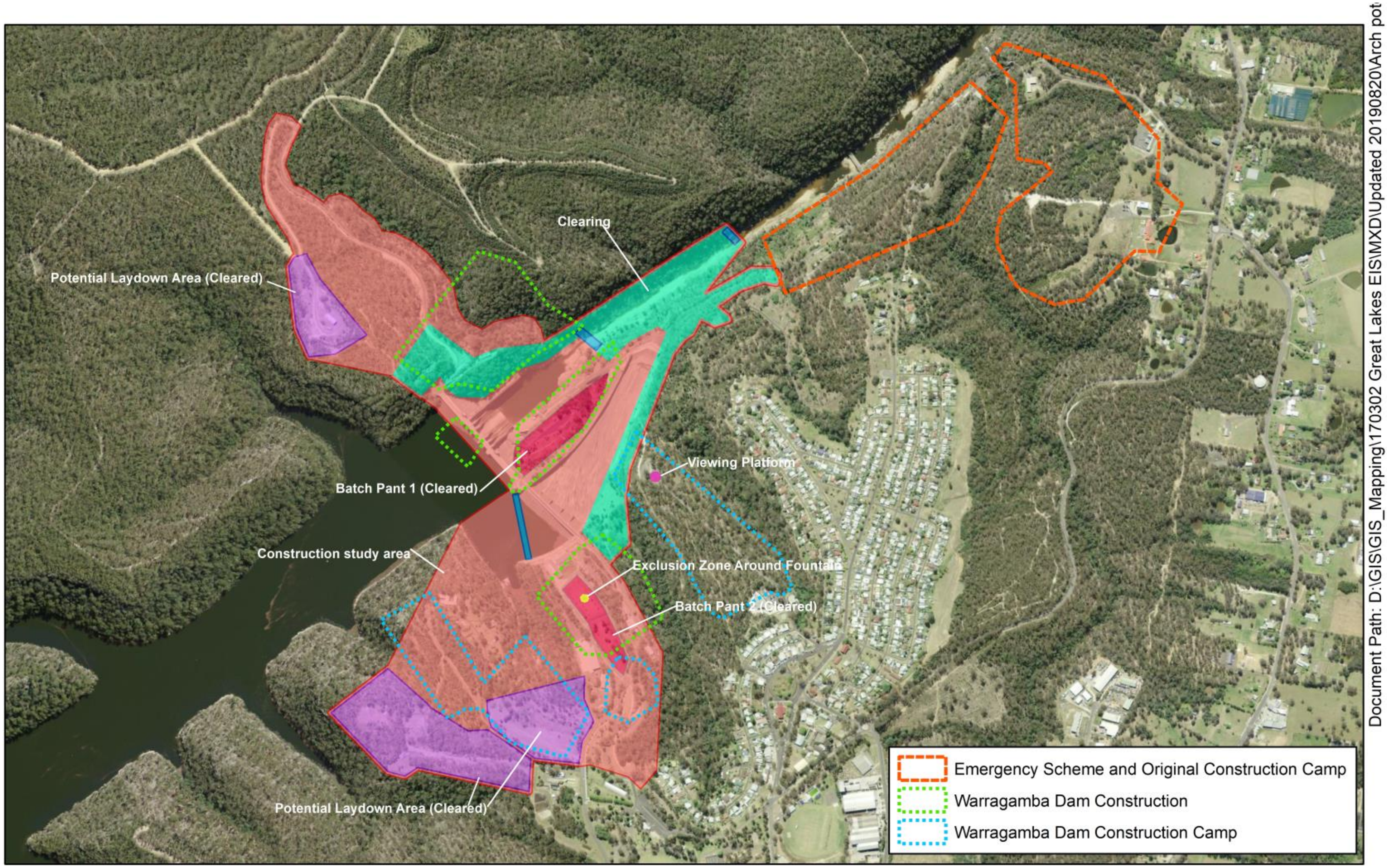
Table 2 below provides a summary of the potential for identifying intact, legible archaeological remains related to former structures and historical land use described in Section 4.3 above. Figure 8 provides an overview of archaeological potential within the study area.

Table 2. Summary of potential archaeological remains within the study area

Phase	Potential archaeological remains	Level of disturbance	Archaeological potential of the study area
1: Early land grants and rural development	Evidence of land clearance and modification for agricultural or pasturing purposes, including tree boles, plough marks and fence lines	High level of disturbance through 20th century construction activity	**Nil to low**
2: Warragamba Dam	Evidence of the original emergency scheme (power station, chlorination and alum plant, batching plant and support sheds) and construction camp. Remains may include: • Building platforms, retaining walls, guttering and drainage, artefact deposits and potential building footings • Concrete slabs and plinths, disused services and pipelines, former roadways (some with bitumen or gravel surfaces), concrete pathways and steps, dry packed retaining walls, artefact deposits and evidence of rock cuttings	Localised disturbance through demolition and later construction activities	**Moderate to high**
2: Warragamba Dam	Remains of the Warragamba Dam construction camp, including: • Evidence of the single men's barracks including footings, roads, paths, disused services and artefact deposits • Evidence of former anchor tunnel, tail tower footings and pathways • Evidence of junior and senior staff barracks including footings, services, artefact deposits and landscaping features	Localised disturbance through demolition and later construction activities	**Moderate to high**

Phase	Potential archaeological remains	Level of disturbance	Archaeological potential of the study area
2: Warragamba Dam	Evidence of the construction of Warragamba Dam including: • The carpenter's stores and Folly Creek suspension bridge including concrete slabs and footings, pits, services and the concrete slab and anchor tunnel for the suspension bridge • Former roads and road surfaces • Footings and disused services associated with the former offices • Evidence of the 18 and 10 tonne cableways including concrete slab footings, tracks and buffer stops of the 18 tonne cableway travelling tail tower, footings of the former electricity substation, the west-bank block anchor for the Warragamba Gorge suspension bridge, and the slab footing of the former compressor house • The current terraced gardens contain the space formerly occupied by the travelling 10 tonne cableway tower and its tracks and may also contain footing slabs from the former compressors, pumps and coolers • Evidence of the original upstream coffer dam	Heavy localised impact through construction of the auxiliary spillway in the 1990s Construction of the Warragamba Deep-Water Storage Access Infrastructure in the early 2000s impacted on the site of the former chlorination plant and substation.	**Moderate to high**

Figure 8. Summary of the areas of archaeological potential of the study area.



artefact

Archaeological potential

170302 Warragamba EIS
New South Wales

SCALE 1:13,000
SIZE A4
DATE 3/09/2019

0 0.125 0.25 0.5 Kilometers

N

4.4 Archaeological Significance

4.4.1 Introduction

This section assesses the heritage significance of the known or potential archaeological remains outlined in Section 4.0. Similar to other types of heritage items, archaeological remains should be managed in accordance with their significance. Assessing the heritage value of archaeological remains is complicated by the fact that their extent and nature is often unknown. Judgement must therefore be based on expected or potential attributes.

The *NSW Heritage Manual* provides the framework for the following significance assessment of the study area. These guidelines incorporate the aspects of cultural heritage value identified in the *Burra Charter* (Australia ICOMOS 2013). The Heritage Branch (now HNSW) has also issued the 2009 *Assessing Significance for Historical Archaeological Sites and 'Relics.*[49] and the 1996 *Archaeological Assessment Guidelines*.[50] The assessment of historical archaeological sites requires a specialised framework in order to consider the range of values of an archaeological site.

The most widely used framework is that developed by Bickford and Sullivan and comprises three key questions which can be used as a guide for assessing the significance of an archaeological site:

- *Can the site contribute knowledge that no other resource can?*
- *Can the site contribute knowledge that no other site can?*
- *Is this knowledge relevant to general question about human history or other substantive questions relating to Australian history, or does it contribute to other major research questions?*

The emphasis in these three questions is on the need for archaeological research to add to the knowledge of the past in an important way, rather than merely duplicating known information or information that might be more readily available from other sources such as documentary records or oral history. As a result, archaeological significance has usually been addressed in terms of Criterion (e) of the NSW Heritage assessment criteria that is '*the potential to yield information*…'.

The following assessment of archaeological significance for the study area responds to both the Heritage Branch and the Bickford and Sullivan questions.

4.4.1 Assessment against the NSW heritage assessment guidelines

The significance of the potential archaeological resource, defined as being all potential archaeological remains within a site as identified in Section 4.0, has been assessed using the NSW heritage assessment criteria and described in Table 3.

Further detail on the possible significance of potential archaeological remains is then discussed in relation to the specific predicted archaeological remains within the study area in Table 3.

[49] Heritage Branch, 2009.
[50] NSW Heritage Office 1996, 25 – 27.

Table 3. Assessment of Archaeological Significance against the NSW Heritage Act criteria

Criterion	Discussion
A - Historical Significance An item is important in the course or pattern of the local area's cultural or natural history	The Warragamba Supply Scheme has played a fundamental role in providing water to metropolitan Sydney from 1940, through the Emergency Scheme at a time of great need. Through its construction, the Warragamba Dam ensured the security of Sydney's water supply in a period of protracted and record-breaking drought. The construction of the Emergency Scheme narrowly averted the failure of Sydney's water supply and was constructed in record time using the majority of the Water Board's available resources and manpower. The construction of the Warragamba Dam was irrefutably the primary reason behind the establishment of Warragamba township. Archaeological evidence associated with the Emergency Scheme, construction of Warragamba Dam, and the individuals who were involved in the construction works would contribute to our knowledge of the cultural history of the area. **If found to be intact, archaeological remains associated with the Emergency Supply Scheme have the potential to reach the local significance threshold under this criterion.**
B - Associative Significance An item has strong or special associations with the life or works of a person, or group of persons, of importance in the local area's cultural or natural history	The construction of the Warragamba Supply Scheme between the years 1937 and 1961 necessitated the employment of a large body of labourers and tradesmen whop lived at the construction sites with their families. The number of employees at the Emergency Scheme was up to 2,000 and up to 1,700 for Warragamba Dam, numbers which represent a significant increase in the population of the local area during this period. The township that emerged during the construction of the Dam, and the workers and their descendants, continue to have strong associations with the site. **If found to be intact, archaeological remains associated with the Warragamba Dam construction camp have the potential to reach the local significance threshold under this criterion.**
C – Aesthetic Significance An item is important in demonstrating aesthetic characteristics and/or a high degree of creative or technical achievement in the local area	The potential archaeological remains within the study area have little potential for aesthetic significance. Although it is recognised that exposed *in situ* archaeological remains may have distinctive/attractive visual qualities and have visual characteristics with the ability to connect communities and individuals to the past through tangible remains, the potential archaeological remains at the study area are likely to be ephemeral. **Archaeological resources associated with the Warragamba Dam are unlikely to reach the threshold for local or State significance under this criterion.**
D – Social Significance An item has strong or special association with a particular community or cultural group in the local area for social, cultural or spiritual reasons	Warragamba Dam is a recognised and significant part of the historic built environment of the local area. The Dam and surrounding area have strong links and continued association with Warragamba township, with some residents having direct association with its construction and ongoing operations. Archaeological evidence associated with former workers and inhabitants of the construction camps and Warragamba township may have resonance with the descendants of these individuals. **If found to be intact, archaeological remains associated with the Warragamba Dam have the potential to reach the local significance threshold under this criterion.**
E – Research Potential An item has potential to yield information that will contribute to an understanding of the local area's cultural or natural history	Archaeological remains associated with the construction of the Supply Scheme between 1937 and 1961 have the potential to demonstrate aspects of its planning and construction. Remains may include remnant structures and/or modified landscapes associated with the provision of plant and equipment, employee accommodation and camp services, and routes of access for the supply of stores and materials. Remains may include: • Remnant road alignments – the principal means of access to the dam construction site for transporting workers, equipment, supplies and materials • Remains of the Emergency Scheme camp and barracks • Remains of the substation and other infrastructure • Evidence of the travelling tail towers and cableway – remnant features of these include the broad, sweeping, cleared platform, upper tail towers and rails/tracks

Criterion	Discussion
	Potential archaeological evidence contained within the subject site is likely to contribute knowledge on several recognised key research themes, which are relevant to broader research questions relating to NSW history, namely: • Developing local, regional and national economies – Environment; cultural landscape – Activities associated with the interactions between humans, human societies and the shaping of their physical surroundings **Potential intact archaeological remains associated with the construction and functioning of the Warragamba Dam and the construction camp may reach the local significance threshold under this criterion.**
F – Rarity An item possesses uncommon, rare or endangered aspects of the local area's cultural or natural history	The study area has the potential to contain evidence of a significant 20th century engineering achievement, and the development of a landscape created for the specific purpose of managing the water supply of Sydney. Should archaeological resources associated with Phase 2 of the study area's development be present and intact, they may be relatively rare. **If found to be intact, archaeological remains associated with the Warragamba Dam have the potential to reach the local significance threshold under this criterion.**
G – Representative An item is important in demonstrating the principal characteristics of a class of NSW's cultural or natural places of cultural or natural environments (or the cultural or natural history of the local area)	The construction technologies used at Warragamba represent a culmination of technology and experience associated with dams constructed in NSW through to this period. Key representative attributes include the use of rope and cableways, the building of camps an township to house labourers and tradesmen, building of cottages to house salaried staff, the construction of terraced platforms for plant and machinery, mechanisation of concrete production, the construction of purpose built access roads to transport workers, materials and supplies to the site, the construction of permanent infrastructure such as water supply and the use of electricity to power plant, equipment and township. **If found to be intact, archaeological remains associated with the Warragamba Dam have the potential to reach the local significance threshold under this criterion.**

4.4.2 Statement of Archaeological Significance

A statement of significance for the study area was recorded within the HIA presented as part of the EIS. The statement of significance is as follows:

> *Prior to the construction of the Warragamba Emergency Scheme in the 1940s the study area was occupied by agricultural land. It is unlikely that archaeological remains pre-dating early 20th century development have been retained.*
>
> *The construction study area has moderate to high potential to contain an archaeological resource associated with the construction of the Warragamba Emergency Scheme, including earlier structures, evidence of former technologies, and the workers construction camp and township which developed throughout the 1930s to 1960s. There is potential that archaeological remains associated with these developments are retained within the study area. This resources, if found to be substantially intact, would reach the local significance threshold primarily for its historical, social and technological values.*

5.0 ARCHAEOLOGICAL IMPACT ASSESSMENT

5.1 Proposed works

Warragamba Dam Raising is a project to provide flood mitigation to reduce significant existing risk to life and property in the Hawkesbury-Nepean Valley downstream of the dam. This would be achieved through raising the level of the central spillway crest by around 12m and the auxiliary spillway crest by around 14m above the existing full supply level (FSL) for temporary storage of inflows. The spillway crest levels and outlets control the extent and duration of the temporary upstream inundation. There would be no change to the existing maximum volume of water stored for water supply.

Peer-reviewed climate change research found that by 2090 it is likely that an additional three metres of spillway height would be required to provide similar flood mitigation outcomes as the current flood mitigation proposal. Raising the dam side walls and roadway by an additional three metres may not be feasible in the future, both in terms of engineering constraints and cost. The current design includes raising the dam side walls and roadway by 17m now to enable adaptation to projected climate change. Any consideration of raising spillway heights is unlikely before the mid to late 21st century and would be subject to a separate planning approval process.

The Project would include the following main activities and elements:

- Demolition and removal of parts of the existing Warragamba Dam, including the existing drum and radial gates
- Thickening and raising of the dam abutments
- Thickening and raising of the central spillway
- New gates or slots to control discharge of water from the Flood Mitigation Zone (FMZ)
- Modifications to the auxiliary spillway
- Operation of the dam for flood mitigation
- Installation of environmental flow infrastructure.

Construction is anticipated to be completed within four to five years.

The Project would delay downstream flooding, which would reduce current downstream flood peaks and increase the time taken for downstream water levels to recede. The dam would be subject to the following operational regimes, depending on the water level.

5.1.1 Normal operations

Normal operations would apply when the reservoir is at or lower than the FSL.

5.1.2 Flood operations

Flood operations would apply when the water level is higher than the FSL. The FMZ would have sufficient storage to accommodate up to a 1 in 40 chance in a year flood. For larger floods, the FMZ would be filled and uncontrolled discharge would occur over the central spillway, and potentially, auxiliary spillway of the dam. Operational objectives are to:

- Maintain the structural integrity of the dam
- Minimise risk to life

Figure 9: Proposed works

- Minimise downstream impact of flooding to properties
- Minimise environmental impact
- Minimise social impact

5.2 Archaeological impact assessment

The proposed works include several activities with the potential to impact on archaeological remains, including vegetation clearance, demolition, levelling and construction works. See Figure 10 for an overview.

Project activities within areas identified as having potential to contain archaeological remains associated with the Warragamba Dam construction camp include:

- Vegetation clearance for potential materials storage and handling area

Vegetation clearance on the north-westernmost edge of the area of archaeological potential. Excavation works associated with the construction study area may result in impact to archaeological remains associated with the Warragamba Dam construction camp through vegetation removal associated with the establishment of material storage areas. It is not anticipated that these works would result in a substantial impact to potential remains.

Excavation works associated with the construction study area identified as having potential to impact archaeological remains associated with construction of the Warragamba Dam include:

- The establishment of two concrete batch plants and areas for materials storage and handling
- Vegetation clearance north of the river
- Construction of the raised dam wall and spillway.

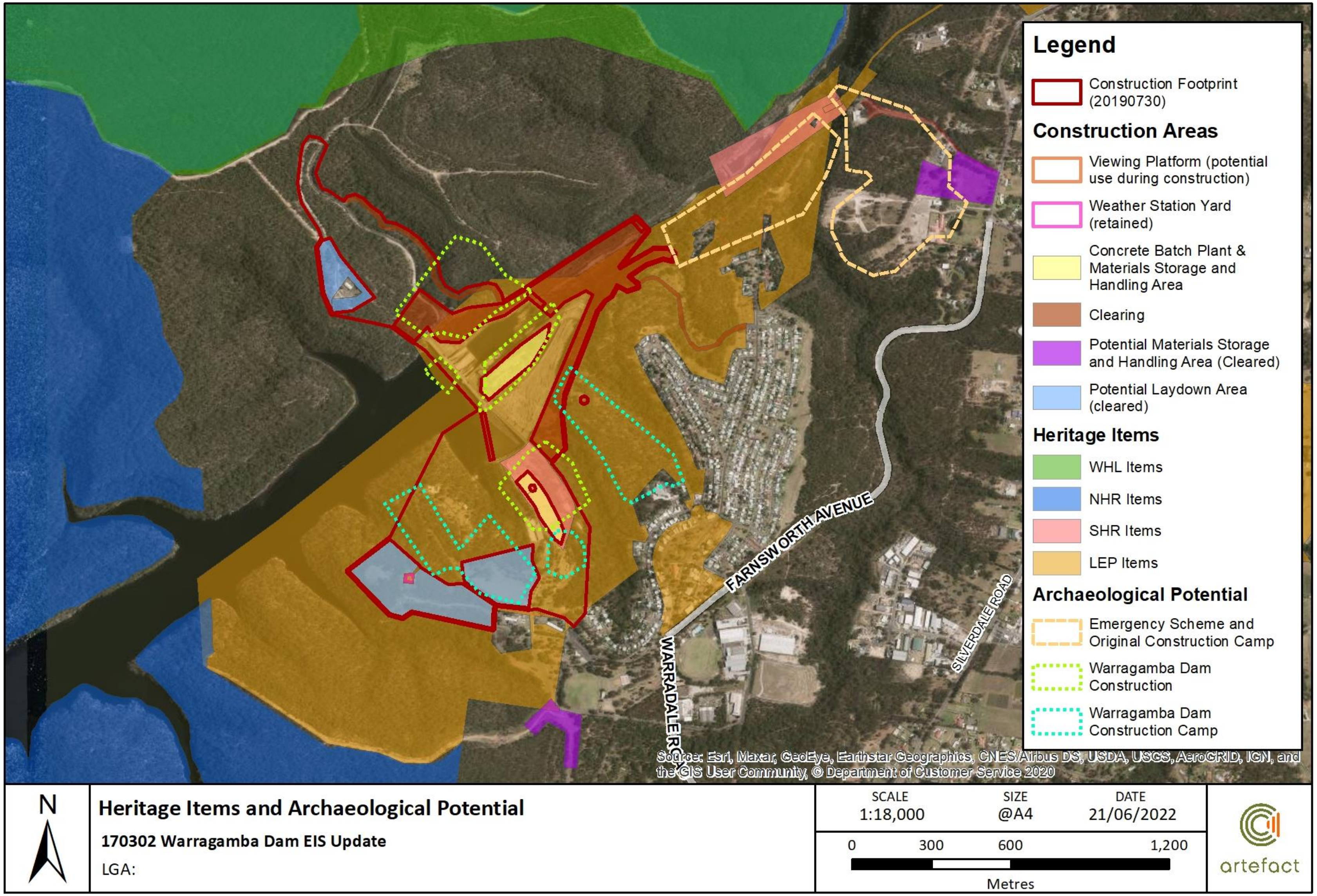
Much of the archaeological evidence associated with the construction of the Warragamba Dam was removed in the 1990s during construction of the ancillary spillway, although there are portions of the study area which retain archaeological potential. It is considered that construction works and vegetation removal near the dam would result in a moderate impact to archaeological remains.

Table 4: Summary archaeological impact assessment

Phase	Potential archaeological remains	Archaeological potential	Proposed works	Recommended management
2: Warragamba Dam	Evidence of the original emergency scheme (power station, chlorination and alum plant, batching plant and support sheds) and construction camp. Remains may include: • building platforms, retaining walls, guttering and drainage, artefact deposits and possibly some building footings • concrete slabs and plinths, disused services and pipelines, former roadways (some with bitumen or gravel surfaces), concrete pathways and steps, dry packed retaining walls, artefact deposits and evidence of rock cuttings.[51]	**Moderate to high**	Clearing	Archaeological monitoring
2: Warragamba Dam	Remains of the Warragamba Dam construction camp, including: • Evidence of the single men's barracks including footings, roads, paths, disused services and artefact deposits • Evidence of former anchor tunnel, tail tower footings and pathways • Evidence of junior and senior staff barracks including footings, services, artefact deposits and landscaping features	**Moderate to high**	Clearing Concrete batch plant with associated materials storage and handling	Archaeological monitoring Archaeological testing
2: Warragamba Dam	Evidence of the construction of Warragamba Dam including: • The carpenter's stores and Folly Creek suspension bridge including concrete slabs and footings, pits, services and the concrete slab and anchor tunnel for the suspension bridge • Former roads and road surfaces • Footings and disused services associated with the former offices • Evidence of the 18 and 10 tonne cableways including concrete slab footings, tracks and buffer stops of the 18 tonne cableway travelling tail tower, footings of the former electricity substation, the west-bank block anchor for the Warragamba Gorge suspension bridge, and the slab footing of the former compressor house • The current terraced gardens contain the space formerly occupied by the travelling 10 tonne cableway tower and its tracks and may also contain footing slabs from the former compressors, pumps and coolers • Evidence of the original upstream coffer dam	**Moderate to high**	Clearing Two concrete batch plants with associated materials storage and handling	Archaeological monitoring Archaeological testing

[51] Graham Brooks and Associates Pty Ltd, June 2010 p.278

Figure 10: Overview of areas of archaeological potential and proposed works.



6.0 ARCHAEOLOGICAL RESEARCH DESIGN

6.1 Introduction

Contextual analysis is undertaken to place the history of a particular site within relevant historical contexts, in order to gauge how typical or unique the history of a particular site actually is. This is usually ascertained by gaining an understanding of the history of a site in relation to the broad historical themes characterising Australia at the time. Such themes have been established by the Australian Heritage Commission and the NSW Heritage Office and are outlined in synoptic form in New South Wales Historical Themes, issued by the NSW Heritage Office.

6.2 Historic themes

6.2.1 Summary of relevant themes

After considering the history of the study area, five relevant historical themes were identified. This is presented in Table 5. Each theme will be discussed in turn to contextualise the site history and identify potential archaeological evidence. Historic themes and their descriptions have been derived from the Heritage Council of NSW Historical themes guidelines.[52]

Table 5: Historic themes for potential archaeological resources

Australian Theme	NSW Theme
Developing local, regional and national economies	Environment - cultural landscape
Developing local, regional and national economies	Commerce
Developing local, regional and national economies	Industry
Developing local, regional and national economies	Environment – cultural landscape
Developing local, regional and national economies	Pastoralism
Building settlements, towns and cities	Towns, suburbs and villages
Building settlements, towns and cities	Utilities
Working	Labour
Developing local, regional and national economies	Transport

6.3 Research questions

The significance of a potential archaeological resource lies in its ability to respond to research agendas in a meaningful way, rather than duplicating known information, or information that might be more readily available from other sources such as documentary records or oral history. Therefore, the aim of the following research questions is to ensure that the proposed archaeological investigation is focused on genuine research needs and will contribute meaningfully to the project and archaeological

[52] Heritage Council of NSW 2001. *New South Wales Historical Themes*. Heritage Office guidelines. Accessed online 20 September 2021: https://www.heritage.nsw.gov.au/assets/Uploads/a-z-publications/g-i/Historical-Themes.pdf

practise more broadly. In framing the Research Design, it is useful to consider the following three lines of enquiry: general, analytical and interpretative. The site investigation may answer these descriptive questions about the nature and extent of the existing archaeological resource, and the type of questions that might be asked of the potential remains follow below.[53]

6.3.1.1 General – Descriptive Questions

- What physical evidence of former activities survives within the site?
- What is the integrity of the remains? Have they been truncated by later development or excavation work within the study area?
- What contexts, phases, and activity areas are evident?
- What natural and cultural formation processes have contributed to the development of the archaeological site and its associated deposits/features?
- Does the site contain in situ artefact bearing deposits?
- Does the site contain significant archaeological 'relics'?

6.3.1.2 Analytical Questions

- Is there evidence of modification of the landscape to better suit industrial uses of the site?
- Do any remains of the former dam site provide us with previously unknown information regarding the functioning of the site?
- Is there evidence for workers housing at the site, and what can remains tell us about workers and their families, and life on a large industrial complex in the early to mid 20th century?

6.3.1.3 Interpretive questions

- Is there evidence of modification of the landscape to better suit industrial uses of the site? Is there evidence of modification of the Dam or additional remains associated with water management in the area?
- Is there artefactual or architectural evidence of the practising of trades or professions within the construction camp?
- What does the material culture reveal about the daily lives of the site occupants, specifically relating to:
  - diet (include reference to faunal and botanical material)
  - hygiene, sanitation and rubbish disposal
  - consumerism, status, respectability, ethnicity, household structure, etc.
  - work practices?
- Can the status/class of the site occupants be discerned?
- How does the project fit into broader, regional frameworks and theoretical models?

Additional research questions may be posed (and existing questions modified) as the archaeological excavation progresses and the extant and condition of the archaeological resource is revealed.

[53] Adapted from Heritage Victoria 2014. *Guidelines for Investigating Historical Archaeological Artefacts and Sites*. Department of Transport, Planning and Local Infrastructure.

7.0 ARCHAEOLOGICAL METHODOLOGY

7.1 Introduction

Proposed excavation works associated with construction of the concrete batch plants have the potential to impact on locally significant archaeological resources associated with earlier phases of the development of Warragamba Dam. The clearance of vegetation where ground disturbance is required i.e. for the removal of larger trees etc, has the potential to impact on archaeological evince of the Warragamba Dam construction Camp and resources associated with earlier phases of the development of Warragamba Dam.

7.2 Archaeological management overview

It is therefore recommended that a program of archaeological monitoring and salvage be implemented in areas where in-ground excavation is required for the removal of vegetation, and that archaeological testing be undertaken prior to works for the construction of the concrete batch plants.

It is proposed that management of the potential archaeological resource include the following processes.

- Heritage induction (Section 7.3)
- Archaeological Monitoring and salvage (Section 7.6)
- Historical archaeological test excavation (Section 7.4)
- Reporting of the test excavation program, re-assessment of significance and production of updated management and design recommendations (Sections 7.9).

Table 6: Definition of archaeological methodologies

Methodology	Definition
Monitoring	Archaeological monitoring is where an archaeologist is in attendance and supervising construction excavation work with potential to expose or impact archaeological remains. Monitoring is generally undertaken where there is lower potential for significant archaeological remains and/or where minor excavation work is in an area of archaeological sensitivity. If archaeological remains are identified during monitoring, they would be excavated and recorded by the site archaeologist
Salvage excavation	Archaeological salvage refers to open-area archaeological excavation under the control of the Excavation Director undertaken prior to impact. Salvage includes the horizontal excavation of the entire historical archaeological site. Manual excavation would be undertaken using hand tools, by a qualified archaeological team.

7.3 Role of the archaeological team

An essential requirement of archaeological investigation is that they are undertaken and managed by suitably qualified and experienced people, known as Excavation Directors (ED) and Site Directors (SD).

ED's are people who have professional training and extensive fieldwork experience in the investigation of relics within historical archaeological sites. ED's must have completed tertiary training in archaeology, prehistory or a closely related field (such as classical/near eastern archaeology, geosciences or heritage studies, with an archaeological component). A complete overview of the requirements for ED's are outlined in the *Heritage Council of NSW Criteria for assessing Excavation Directors.* [54]

The *Heritage Council of NSW Criteria for assessing Excavation Directors* defines an ED as follows:

Primary Excavation Director – usually has prepared the archaeological assessment and is the best person to actively supervise the standards in the archaeological proposal and the approved research design. This person has primary responsibility for all aspects of the archaeological project including fieldwork and post-excavation research. Fieldwork includes selection of the methods and strategies appropriate for a particular site, and aspects such as facilitating public access if required by the Conditions of the approved permit. The Primary Excavation Director always retains full and ultimate responsibility for the final excavation report.

A SD is similarly qualified, although may be at an earlier stage of their career. In order to be nominated as an ED in instances where excavation approvals from the Heritage Council of NSW are required, nominated ED's must demonstrate that they have had experience as an SD on at least three sites prior. An SD supports the nominated ED during the process of archaeological investigation through undertaking fieldwork and providing logistical support. The project SD must have experience working on similar sites and under similar methodologies, to those proposed in this document.

The *Heritage Council of NSW Criteria for assessing Excavation Directors* defines an SD as follows:

The site director or site supervisor supports the Excavation Director in managing the archaeological investigation of the site. That person provides direction to archaeologists and to trench or area supervisors, records the site under excavation in accordance with the research design and assists in general site management. The Site Director is the intermediary between the Excavation Director and the field archaeologists and supports both. The requirements are further explained in the above criteria for large scale/complex excavation where they refer to skills already demonstrated for testing and monitoring.

7.4 Heritage induction

Archaeological heritage should be included in the general project induction for all personnel. This included an overview of the project and employee obligations, archaeological management and the role of the archaeological team.

Toolbox meetings should also be undertaken as and when required. Records of all training should be filed in accordance with the project filing system.

[54] *Heritage Council of NSW Criteria for assessing Excavation Directors*, September 2019. Accessed via: https://www.heritage.nsw.gov.au/assets/Uploads/files/Excavation-Directors-Assessment-Criteria.pdf

7.5 Contractor responsibilities

The contractor would set up site and then operate under the direction of the archaeologists during any archaeological investigation. This would include but not be limited to:

- Provide a heritage site induction to contractors
- Set out and secure the work area for the construction and archaeological team
- Provide Dial Before You Dig or similar current service plans for the area/clear the area of live services
- Provide machine plant to assist the removal of fill where required under the supervision of the archaeological team
- Provide shoring, if required
- Provide pressurised water and a sieving area, if required
- Provide spoil/stockpile management
- Have suitable processes in place to manage contaminated material, including asbestos containing materials and contaminated soils.

7.6 Archaeological monitoring methodology

Archaeological monitoring is where an archaeologist is in attendance and supervising construction excavation work with the potential to expose or impact archaeological remains. Monitoring is generally undertaken where there is lower potential for significant archaeological remains and/or where minor excavation work is in an area of archaeological sensitivity. Archaeological monitoring would be conducted by on site archaeologists who would be coordinated by the Site Director and Excavation Director.

The on-site archaeologist would supervise excavation but would also be able to direct machine excavation contractors in consultation with contractor supervisors, to excavate areas of interest under their direction, so long as excavation does not exceed the approved impact area for the scope of work. Should construction excavation work endanger potential archaeological deposits, the machine excavation contractor must cease excavation if advised by the monitoring archaeologist.

If archaeological remains are identified during archaeological monitoring, they would be recorded and assessed to determine if further investigation is required. Localised stoppages in the excavation work may be required to facilitate this process. Works would not recommence until the monitoring archaeologist has completed the recording and the Excavation Director is satisfied that further investigation is not required.

If significant and intact archaeological remains are identified, then further investigation such as salvage would be required prior to construction impacts occurring to the item. Assessments of significance of all finds would be supervised and confirmed by the Excavation Director.

7.6.1 Archaeological salvage (if required)

Archaeological salvage generally refers to open area archaeological excavation under the control of the Excavation Director. Open area salvage excavation is a method of archaeological investigation in which the full horizontal extent of an area of site is investigated and cleared, whilst preserving the stratigraphic record. Salvage excavation would only be proposed where significant archaeological remains have been identified during archaeological monitoring or test excavation programs.

A Work Method Statement (WMS) would be prepared if salvage excavation is required in order to guide the detailed investigation of the remains in the relevant location.

Salvage would involve removal of modern fills and disturbance to the top of archaeological layers of interest by machine under archaeological supervision. On the identification of any historical/archaeological fills, salvage excavation would commence. This investigation would be undertaken using hand tools, by a qualified archaeological team. The archaeological remains would then cleaned by hand, investigated (excavated) and recorded in detail by the archaeological team. In urban archaeological sites, careful machine excavation may also be employed to assist the detailed archaeological excavation process.

Construction works would not proceed until the salvage excavation is completed and the Excavation Director has provided clearance for the area in question. It is noted that due to the relatively deep archaeological deposits at the construction site, clearance can only be given to an area for a specific scope of work.

Salvage excavation may also be triggered upon encountering archaeological material during works. Should this occur, mechanical excavation would cease and excavation using hand tools would be undertaken by archaeologists trained in on-site historical excavation methods, under the guidance of the Excavation Director. Where contaminated deposits are identified, remote recording techniques may be utilised to minimise exposure to harmful materials.

7.6.2 Artefact collection and recording methodology

Artefacts may be uncovered during archaeological monitoring and salvage. Artefacts from secure or *in situ* contexts would be collected and recorded. Retrieval of artefacts would focus on diagnostic pieces and other items whose analysis would contribute to the research questions for this site. Specific methodologies have been outlined below.

Artefacts recovered from the archaeological investigations would be the property of WaterNSW and would be securely stored by them following completion of post-excavation analysis. Where possible artefacts would be incorporated into interpretive displays.

An artefact retention policy for the archaeological program is shown in Figure 11.

7.6.2.1 Modern deposits

Artefacts from modern (post-1960) deposits would be sample collected to demonstrate the nature and context of the remains.

7.6.2.2 Historic fills and secondary deposits

Similarly, artefacts collected from historic fills and other bulk deposits that lack stratigraphic integrity will be recorded and a representative sample collected.

7.6.2.3 Primary deposits

All artefacts from primary deposits would be collected by context and bagged. Diagnostic or unique/fragile artefacts would be bagged separately under their corresponding context.

7.6.2.4 Building materials

Building and structural materials would be collected by type and sampled. For example, one full brick and one partial brick of the same type, two samples of mortar, stone, timber and plaster (bagged by context). All collected samples would be noted on their corresponding context sheet and recorded in a building material sample register.

7.6.2.5 Organic or fragile materials

Metal and fabric or organic materials such as timber, leather, bone or shell would be stored in plastic bags for conservation purposes under their corresponding context. If significant and diagnostic fabric or leather items are found, these would be submitted to a conservation specialist with two months of collection.

7.6.2.6 Hazardous materials

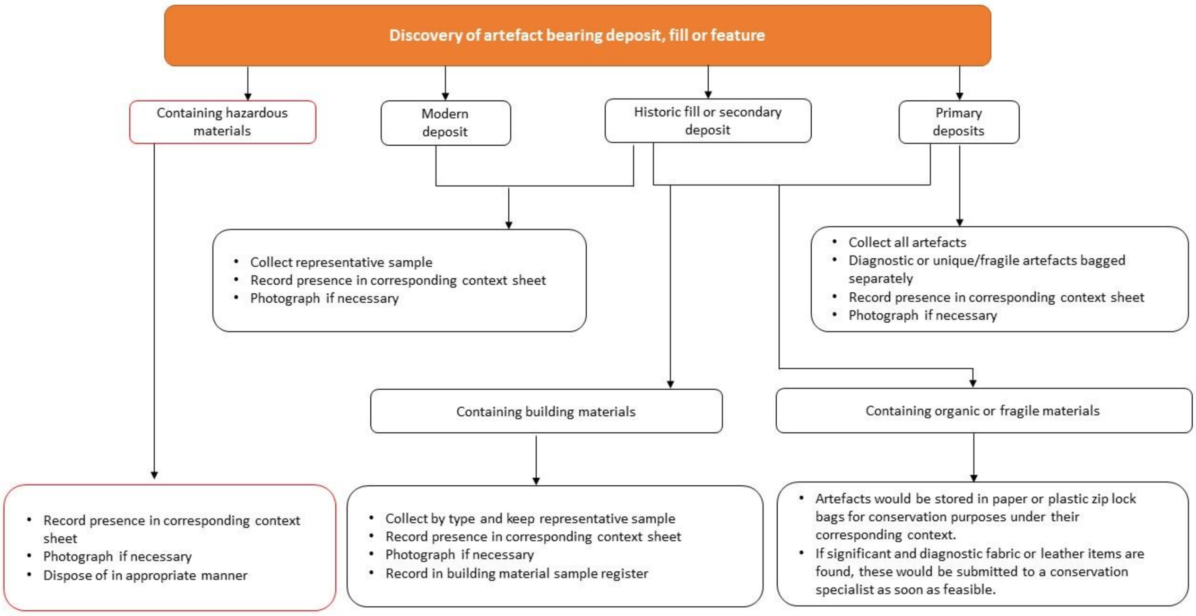
Artefacts manufactured from hazardous material such as asbestos or found within a contaminated deposit would not be collected, although their presence within the context would be recorded in their corresponding context sheet. Such artefacts be disposed of in an appropriate manner according to guidelines for dealing with hazardous waste.

7.6.2.7 Artefact discard guidelines

Non artefactual material is not to be collected from sieves or the field unless in response to a targeted research question such as retention of soil samples. In the event that non artefactual material has erroneously entered artefact collections this may be disposed of at any stage without further recording. Non artefactual material includes:

- Hazardous material
- Modern material resulting from the demolition and excavation process (includes items such as dynabolts, geofab, food wrappers and containers, construction PVC)
- Fragments of construction material including ballast, broken bricks, pipes and tiles
- Unmodified stones and rocks
- Metal items that have rusted to an unrecognisable form
- Items such as ceramic or glass that are smaller than 1cm x 1cm and which show no diagnostic features (visible pattern, decoration or makers mark)
- Pieces of wood that are not identifiable in form &/ are too small for species identification (5cm x 3cm)
- Items with no contextual ID
- Degraded items that cannot be identified.

Figure 11. Proposed artefact retention policy for the project



7.7 Test excavation methodology

7.7.1 Work Method Statement

As detailed excavation impacts are not yet known, a WMS would be prepared ahead of ground disturbing works to guide the test excavation. This would include:

- An overview of potential impacts due to excavation impacts
- Mapping of test trench locations to correspond with excavation impacts.

7.7.2 Pre-excavation

Coordinates and plans showing locations of proposed test trenches would be provided to the client and relevant contractors prior to excavation commencing.

This would allow the area to be inspected by service locator contractors to ensure that existing services would not be impacted by works.

Should existing or unknown services be located within proposed trenching areas, the locations of test trenches may require modification. It is proposed that test trenches be moved within 5 m of their original location in these circumstances.

7.7.3 Test excavation methodology

Initial investigation of each test trench would involve the machine excavation of test trenches under the supervision of an archaeological team under the oversight of an Excavation Director with commensurate excavation experience.

Machine excavation would use a 5- to 10-tonne excavator with a 1.2 m to 1.6 m flat bucket. Machine excavation would remove existing ground surfaces in shallow layers. Removed soils would be stockpiled for backfill on finalisation of each testing location.

On identification of potential historical archaeological deposits or remains, investigation would be undertaken using hand tools. Archaeological remains would be cleaned by hand to allow archaeologists to understand the nature of the potential archaeological resource within the trench.

Should non-significant archaeological remains be identified, these would be recorded and removed.

Excavation of each trench area would continue until significant archaeological remains or natural subsurface culturally sterile soil layers have been identified.

The following would be taken into consideration during the test excavation program:

- It is not proposed that State significant remains or 'relics' be impacted or removed from site during the testing program. Should potentially State significant remains be identified, manual cleaning would continue to identify the extent of the resource only. All structural and associated artefact bearing deposits would remain in place during excavation
- During the test excavation program, any intact structural remains and/or deposits would be exposed, cleaned and archaeologically recorded
- In situ artefactual remains would not be impacted by the test excavation. Should de-contextualised artefacts be identified within non-significant deposits these would be recorded and collected
- Remains would be archaeologically recorded by context, photographed and their location precisely planned. Once recording had been completed, the remains would be protected by a layer of geofabric and backfilled with soil removed from the trench under archaeological supervision to ensure their preservation
- Archaeological test excavation cannot exceed a safe depth. Maximum depth of excavation without shoring or increasing pit size is 1.5 m, however, the maximum safe depth in contexts with loose or unstable sediments will be less.

7.7.4 Artefact analysis

In situ artefact bearing deposits would not be excavated during test excavation. Detailed artefact analysis will not be required. However, in the event that a significant artefact is identified within non-significant fills, i.e. topsoil, these would be recorded and the artefact bagged and collected in accordance with archaeological best practice.

Any significant out of context artefacts would be catalogued by a specialist and the results included in the final results report.

7.8 Archaeological recording and documentation procedures

7.8.1 Introduction

Archaeological recording would be undertaken by allocating each stratigraphic unit a context number and completing a record of each context on a context sheet.

Mapping, planning and recording would be coordinated through a GIS system that would combine data from varying sources and present it in the form of maps.

The Excavation Director and the Site Director need to complete a daily journal outlining the aims for the work to be done each day, what is achieved and what the next task is. In this way, the progress of the excavation and the day-to-day work and decisions are captured.

7.8.2 Survey Control

A survey control for the site would be established, tied to the Geocentric Datum of Australia (GDA) 2020.

Within archaeological excavation areas, the archaeological team would set out a grid where possible for ease of recording and, where required, and establish main and subsidiary datums based on survey information. Further datums for vertical control will be established to allow all excavation areas to be surveyed into a nearby datum. These will be tied back to Australian Height Datum and the survey grid.

Where electronic surveying equipment is not available to the archaeological team, horizontal measurements and detailed scaled plans of excavation areas and features would be prepared. Vertical relative elevations would be taken with dumpy level. These plans and levels would be tied to a previously surveyed main or subsidiary datum. Every level taken is assigned a number and is recorded on a level sheet.

Where dateable or otherwise special artefacts are located they would be recorded in three dimensions with surveying equipment if available.

7.8.3 Recording of Contexts

All soil deposits and significant features would be given a unique context number without duplication. Context numbers will be recorded in a register of context numbers to ensure context numbers are not duplicated. Each context is numbered sequentially.

Rubble deposits would be recorded only where it provides specific information regarding masonry and construction (i.e., wall finishes, material etc.). Fills need to be described in detail as there are varying types of fills (e.g., demolition, levelling).

Contexts would be related to each other through the use of a Harris Matrix. The relationships between each of the contexts are recorded on the context sheet and these are also recorded in Stratify, a computer program used for producing Harris Matrices.

7.8.4 Recording of Archaeological Features

Archaeological features would be recorded through the preparation of plans and sections. Structural elements, such as brick walls or timber posts, would be recorded in situ to observe phases in construction, and then removed in stratigraphic sequence.

Plans and sections will be labelled with details of what is being recorded, context numbers and details of the recorder. Each plan, map or section will be catalogued and receive a number which is put on the plan and in the catalogue. The plan, map or section will be placed flat in an artist portfolio.

Plans need four control points on each plan that can then be surveyed in to georeference the plan. All records of vertical sections would include elevation data to ensure accurate measurement of stratigraphic layers at the site. Excavation open areas of significant features would include elevation levels throughout site, recorded either with a DGPS or total station, or with a dumpy level measured off surveyed datum control points for the site. The surface level and end of excavation elevation levels for all test excavation trenches, and all salvage excavation areas, would be recorded.

In addition, were suitable and relevant archaeological features would be photogrammetrically recorded to produce orthophotographic plans and 3D models

7.8.5 Photography

In photographically recording archaeological features, recommended practice would be to shoot to the requirements for photogrammetry, which includes accurate scale bars, overlapping of images and recording with a colour card where required. Photographs would be recorded in a register identifying the shot number, direction and a description of the scene.

All photographic recording would be carried out in accordance with *Photographic Recording of Heritage Items Using Film or Digital Capture* (Heritage Office 2006), accepting that parts of these guidelines are technically obsolete. The engaged archaeologist would use a digital SLR camera and shoot in raw format to capture the maximum amount of information from the camera sensors. The photograph number and direction would be recorded, and a description provided for all photographs and the locations from which each image was taken would be recorded on a site base plan.

Where possible, photogrammetry would be conducted to record significant archaeological features *in situ*.

7.9 Heritage NSW notification

Should state significant historical archaeological 'relics,' or other significant remains **not** predicted by the HIA or this ARD be identified during the excavation program, there is a requirement to notify Heritage NSW as delegate of the NSW Heritage Council under s146 of the Heritage Act.

Additional consultation with Heritage NSW may be required and additional archaeological management undertaken prior to works being able to proceed. Additional approvals may be required should the project works require impact to significant 'relics' not identified in this ARD.

7.10 Post-excavation analysis

7.10.1 Preliminary results reporting

An interim or preliminary archaeological findings report would be prepared following completion the test excavation program and submitted to HNSW within a month. This report would outline the main archaeological findings, post-excavation and analysis requirements, and would also include any further archaeological investigation requirements for the project.

7.10.2 Artefact analysis

Any historical artefacts recovered during monitoring and/or salvage excavation would be catalogued and recorded for inclusion in the final excavation report and any relevant interpretive strategy. Processing would include the following:

- The cleaning and drying of artefacts
- Initial sorting and division of remains into artefact categories
- Cataloguing of artefacts in an appropriate database
- Labelling and preparation of artefacts for storage in a suitable artefact repository.

7.10.3 Archaeological excavation report

Following the completion of archaeological testing, post-excavation analysis of the findings would be undertaken. An archaeological excavation report will be produced that will comprehensively describe and interpret the findings of the investigation within the context of the research design and research questions.

The document would be issued as a single report incorporating the findings of the archaeological program. This would include stratigraphic reporting, production of illustrations, detailed site plans, photographs, analysis of significant out-of-context artefactual finds and provide responses to the research questions. The report would include a reassessment of archaeological significance based on the investigation results and recommend future actions required to manage historical archaeology at the site.

7.11 Contaminated materials

Due to the potential for contaminants across the study area, the controlled archaeological excavation would also be undertaken in accordance with the specified work health and safety protocols established for the site, prior to the commencement of works on site. Should the discovery of contaminants on site likely result in the potential harm to archaeological staff working on site, there may be a requirement to deviate from the proposed archaeological methodology, in order to ensure the health and safety of onsite staff. This may include the use of protective clothing, face masks, and specified gloves, additional washing protocols, through to the need to cease hand excavation on site.

Should the requirement to employ mechanical excavation rather than hand excavation arise, archival recording of archaeological material would need to be taken in the form of photographic, and possibly 3D scanning, from a safe distance (as specified in the work health and safety requirements of the remediation specialists).

7.12 Site clearance

A written clearance confirmation would be provided by the Excavation Director to the contractor once archaeological management has been completed in each area. This should be signed off by WaterNSW before project works can commence.

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Appendix I

Revised IS rating assessment

Infrastructure Sustainability Scorecard

Category	Credit	Title	Level	Criteria	Materiality Score	Points per level	Score possible	Target level	Target score	General notes	Level assessed	Score assessed	Rulings used	Evidence	Notes on evidence
					Assessor progress tracking						**Assessment – Round One**				
	Man-1	Sustainability leadership and commitment	1	There are commitments to mitigating negative environmental, social and economic impacts	2	0.30	0.90	1	0.30		2	0.60			
				These commitments are embedded into sustainability objectives and/or targets											
			2	The requirements for Level 1 are achieved											
				The sustainability objectives and/or targets are reflected in project contracts											Easily Achievable through inclusion of sustainability objectives and targets (for key sustainability focus areas) in design and construction contracts.
			3	The requirements for Level 2 are achieved											
				The sustainability commitments go beyond mitigating negative impacts to restorative actions (i.e. net positive benefits for society and the environment)											
				The sustainability commitments are publicly stated											
	Man-2	Risk and opportunity management	1	Environmental, social and economic risks are assessed	2	0.45	0.90	2	0.90		2	0.90			
				The risk assessment is updated at least annually											
			2	The requirements for Level 1 are achieved											
				Environmental, social and economic opportunities are also assessed											
	Man-3	Organisational structure, roles and responsibilities	1	A member(s) of the senior management team has central responsibility for managing sustainability	2	0.45	0.90	0	0.00		1	0.45			Easily achivable if the IS Rating is continued into design and construction
				A principal participant in the team is an IS Accredited Professional whose role is to provide sustainability advice											
			2	The requirements for Level 1 are achieved											
				An independent sustainability professional is engaged to monitor and review sustainability performance											
	Man-4	Inspection and auditing	1	Internal environmental inspections of site management are undertaken at least weekly during construction	2	0.45	0.90	1	0.45		1	0.45			
				Environmental audits of the management system are conducted. At least one external review or audit is conducted during design.											
				During construction at least four environmental audits are conducted per year where at least one is external.											
				Internal sustainability inspections of site management are undertaken at least weekly during construction											

Management Systems			2	Sustainability audits of the management system are conducted. At least one external review or audit is conducted during design.								
				During construction at least four sustainability audits are conducted per year where at least one is external.								
	Man-5	Reporting and review	1	Sustainability performance is reported at least annually to senior management	2	0.30	0.90	2	0.60	2	0.60	
				The sustainability report includes sustainability objectives and/or targets and identifies areas for improvement								
				Sustainability performance is reviewed formally at least annually by senior management								
			2	The requirements for Level 1 are achieved								
				Sustainability performance is reported at least quarterly to senior management								
			3	The requirements for Level 2 are achieved								
				Sustainability performance is reported annually publicly								
				Management review incorporates stakeholder participation								
	Man-6	Knowledge sharing	1	Sustainability knowledge is shared within the project.	2	0.67	2.02	2	1.35	2	1.35	
			2	The requirements for Level 1 are achieved								
				Sustainability knowledge is shared beyond project boundaries to parent organisations and/or other key stakeholders.								
				Sustainability knowledge is shared from outside the project/asset onto the project.								
			3	The requirements for Level 2 are achieved								
				Sustainability knowledge is shared beyond project and key stakeholder boundaries to the wider industry.								
				Sustainability knowledge sharing includes 'lessons learnt' (that had negative consequences) as well as 'good practices'.								
	Man-7	Decision-making	1	For significant issues, decision making is characterised by: Considering options including business as usual and proven approaches taken in comparable situations	2	0.97	2.92	1	0.97	2	1.95	
				And evaluating options primarily on the basis of financial aspects but considering environmental, social and economic aspects qualitatively through risk assessment, constraint analysis or other non-scored means								
				And evaluating options based on the forecast useful life of infrastructure asset								
			2	For significant issues, decision making is characterised by: Considering options including business as usual and proven approaches taken in comparable situations								
				And evaluating options by considering environmental, social and economic aspects through the use of multi-criteria analysis or other scored means;								This can be achieved using MCA documenta tion from the business case and optioneering phases.
				And evaluating options based on the forecast useful life of infrastructure asset								

			3	For significant issues, decision making is characterised by: Considering options including business as usual, non-asset, technical limits and an option that specifically aim to address sustainability aspects;								
				And evaluating options by considering environmental, social and economic aspects through incorporating their value into cost-benefit analysis or other quantified means;								
				And evaluating options based on the forecast useful life of infrastructure asset and using social rates of return for discounting								
Procurement and Purchasing	Pro-1	Commitment to sustainable procurement	1	There is a commitment to require environmental aspects to be considered in the procurement process	2	0.37	1.12	2	0.75	2	0.75
			2	There is a commitment to require sustainability aspects to be considered in the procurement process							
			3	Requirements of Level 2 are achieved							
				The sustainable procurement commitments are publicly stated							
				Sustainable procurement commitments are embedded into sustainability objectives and/or targets							
	Pro-2	Identification of suppliers	1	Potential suppliers requested to provide details of their environmental policy and its implementation	2	0.37	1.12	2	0.75	2	0.75
			2	Potential suppliers requested to provide details of their sustainability policy and its implementation							
			3	Requirements for Level 2 are achieved							
				Engagement with potential suppliers is undertaken to explain sustainability requirements and expectations, and to help stimulate innovation in relation to sustainability through the procurement process.							
	Pro-3	Supplier evaluation and contract award	1	Supplier evaluation considers environmental aspects through use of qualitative criteria	2	0.37	1.12	1	0.37	1	0.37
			2	Supplier evaluation considers sustainability aspects through use of qualitative criteria.							
				Supplier contracts incorporate sustainability objectives and/or targets							
			3	Requirements for Level 2 are achieved							
				Supplier evaluation considers sustainability aspects through use of multi-criteria analysis or other scored means.							
	Pro-4	Managing supplier performance	1	Suppliers have environmental objectives and/or targets	2	0.37	1.12	1	0.37	1	0.37
				Supplier environmental performance is monitored for the duration of contracts, against the objectives and/or targets.							
			2	Requirements for Level 1 are achieved							
				Suppliers have sustainability objectives and/or targets.							
				Poor sustainability performance or non-compliance is actively managed							
			3	Requirements for Level 2 are achieved							
				Contract managers work with suppliers to identify any emerging or new sustainability opportunities							
				Success is encouraged and rewarded							
			1	A readily available climate change projection is identified and adopted for the asset region over the forecast useful life of the asset	4	1.50	4.49	3	4.49	3	4.49

Climate Change Adaptation	Cli-1	Climate change risk assessment		Direct climate change risks to the asset over the forecast useful life are identified and assessed									
			2	The requirements of Level 1 are achieved									
				A number of readily available climate change projections are identified and adopted for the asset region over the forecast useful life of the asset									
				The climate change risk assessment also considered indirect climate change risks to the asset									
				A multi-disciplinary team participated in identifying climate change risks and issues									
			3	The requirements of Level 2 are achieved									
				Modelling is undertaken to characterise the likely impacts of the projected climate change for all High and Extreme priority climate change risks									
				A comprehensive set of affected external stakeholders participated in identifying climate change risks and issues									
	Cli-2	Adaptation options	1	Adaptation options to treat all extreme and high priority climate change risks are identified, assessed and appropriate measures implemented	4	1.50	4.49	2	2.99	2	2.99		
				After treatment there are no extreme priority residual climate change risks									
			2	The requirements of Level 1 are achieved									
				Adaptation options to treat 25-50% of all medium priority climate change risks are identified, assessed and appropriate measures implemented									
			3	The requirements of Level 2 are achieved									
				The optimal scale and timing of options is addressed (which may be triggered by when a specific climate threshold is likely to be achieved)									
				Adaptation options to treat at least 50% of all medium priority climate change risks are identified, assessed and appropriate measures implemented									
				After treatment there are no high priority residual climate change risks									
Energy and Carbon	Ene-1	Energy and carbon monitoring and reduction	1	Monitoring and modelling of energy use and GHG emissions, and actions taken to reduce them is undertaken, covering at least Scope 1, Scope 2 and land clearing across the infrastructure lifecycle	2	2.70	8.09	0	0.00	1	2.70		Level 1 is generally achievable by the construction contractors. Also, there is very limited energy use in the operational phase, but what is designed can be calculated.
			1-3 scaled	The requirements for Level 1 are achieved									
				Monitoring and modelling demonstrates a reduction in GHG emissions compared to a base case footprint. For every reduction up to 30% for Level 3, fractions of Levels may be achieved on a sliding scale.									
	Ene-2	Use of renewable energy	1	Opportunities for use of renewable energy are fully investigated	2	0.45	1.35	1	0.45	1	0.45		Level 1 is easily acievable by designers and contractors as they can undertake simple cost benefit calculations to determine if any renewable opportunities are feasible for the operation or construction of the project.
			1-3	The requirements for Level 1 are achieved									
				For every substitution of energy from renewable sources up to 40% for Level 3, fractions of Levels may be achieved on a sliding scale.									

Water	Wat-1	Water use monitoring and reduction	1	Monitoring and modelling of water use, is undertaken	1	0.67	2.02	1	0.67		1	0.67	Level 1 is generally achievable by the construction contractors. Also, there is very limited water use in the operational phases
			1-3 scaled	The requirements for Level 1 are achieved									
				Monitoring and modelling demonstrates a reduction in water use compared to a base case footprint. For every reduction up to 20% for Level 3, fractions of Levels may be achieved on a sliding scale.									
	Wat-2	Replace potable water	0-3 scaled	Monitoring and modelling demonstrates that some proportion of total water use is from non-potable sources (substituting for potable). Fractions of Levels may be achieved on a sliding scale up to 100% for Level 3.	1	0.37	1.12	2	0.75		2	0.75	
Materials	Mat-1	Materials footprint measurement and reduction	1	Monitoring and modelling of materials lifecycle impacts is undertaken using the Materials Calculator (or other suitable Lifecycle Assessment technique) across the infrastructure lifecycle	3	2.70	8.09	0	0.00		1	2.70	Level 1 is generally achievable by the design and construction contractors. Also, there is very limited materials use in the operational phases
			1-3 scaled	The requirements for Level 1 are achieved									
				Monitoring and modelling demonstrates a reduction in materials lifecycle impacts compared to a base case footprint. For every reduction up to 30% for Level 3, fractions of Levels may be achieved on a sliding scale.									
	Mat-2	Environmentally labelled products and supply chains	1	One material/product has an ISCA approved environmental label.	3	0.45	1.35	1	0.45		1	0.45	
			2	3-9% of materials/products by value have an ISCA approved environmental label.									
			3	>9% of materials/products by value have an ISCA approved environmental label.									
	Dis-1	Receiving water quality	1	Measures to minimise adverse impacts to receiving water environmental values during construction and operation have been identified and implemented.	3	1.07	3.20	3	3.20		3	3.20	
				Monitoring of water discharges and receiving waters is undertaken at appropriate intervals and at times of discharge during construction and operation									
			2	The requirements for Level 1 are achieved									
				Monitoring and modelling of water discharges and receiving waters demonstrates no adverse impact on local receiving water environmental values.									
				The infrastructure does not increase peak stormwater flows for rainfall events of up to a 1.5 year ARI event discharge									
			3	The requirements for Level 2 are achieved									
				Opportunities to improve local receiving water quality and/or provide environmental flows have been identified and implemented									
				Monitoring and modelling demonstrates improvement of local receiving water environmental values									
			1	Measures to mitigate noise during construction and operation have been identified and implemented	1	0.36	1.07	2	0.71		2	0.71	
				Monitoring of noise is undertaken at appropriate intervals and in response to complaints during construction and operation									
				The requirements for Level 1 are achieved									

Discharges to Air, Land and Water	Dis-2	Noise	2	For construction, modelling and monitoring demonstrates no recurring or major divergences from the noise management process in ISCA approved noise guidelines							
				For operation, modelling and monitoring and monitoring demonstrates no recurring or major exceedances of noise goals							
			3	The requirements for Level 2 are achieved							
				For construction, modelling and monitoring demonstrates no divergence from the noise management process in ISCA approved noise guidelines							
				For operation, modelling demonstrates no exceedances of noise goals.							
	Dis-3	Vibration	1	Measures to mitigate vibration during construction and operation have been identified and implemented	1	0.36	1.07	3	1.07	3	1.07
				Monitoring of vibration is undertaken at appropriate intervals and in response to complaints during construction and operation							
			2	The requirements for Level 1 are achieved							
				For construction, modelling and monitoring demonstrates no exceedances of vibration goals for structural damage to buildings and structures.							
				For operation, modelling and monitoring demonstrates no recurring or major exceedances of vibration goals for human comfort criteria							
				No physical damage has been caused to any buildings or structures by vibration caused by construction or operation							
			3	The requirements for Level 2 are achieved							
				For operation, modelling demonstrates no exceedances of vibration goals for human comfort criteria							
	Dis-4	Air quality	1	Measures to minimise adverse impacts to local air quality during construction and operation have been identified and implemented	2	0.71	2.13	1	0.71	1	0.71
				Monitoring of air emissions and/or air quality is undertaken at appropriate intervals and in response to complaints during construction and operation							
			2	The requirements for Level 1 are achieved							
				Monitoring and modelling demonstrates no recurring or major exceedances of air emission or air quality goals							
			3	The requirements for Level 2 are achieved							
				Monitoring and modelling demonstrates no exceedances of air emission or air quality goals							
				Measures to prevent light spill during construction have been identified and implemented	0	0.00	0.00	0	0.00	0	0.00
				The lighting design for operation prevents horizontal light spill through compliance with the numerical limits for obtrusive light in Tables 2.1 and 2.2 of AS4282.							

Land	Dis-5	Light pollution	1	The lighting design for operation prevents upward light spill by ensuring that, relative to its particular mounting orientation, 95% (by number) of external public lighting luminaires within the project boundary have an Upward Light Ratio less than 5% (for roads and public spaces this must be less than 3% in accordance with AS1158).								
	Lan-1	Previous land use	0-3 Scaled	0 to >75% of the land used for the project is previously disturbed. Fractions of Levels may be achieved on a sliding scale up to >75% use of previously disturbed land for Level 3.	2	0.75	2.25	3	2.25	3	2.25	
	Lan-2	Conservation of on site resources	1	Conservation of topsoils and subsoil has been considered	2	0.30	0.90	2	0.60	2	0.60	
			2	The requirements for Level 1 are achieved								
				All subsoil and topsoil impacted by the project is separated and protected from degradation, erosion or mixing with fill or waste								
				95% of all topsoil (by volume) retains its productivity and is beneficially re-used on or nearby to the project								
			3	The requirements for Level 2 are achieved								
				Opportunities to improve topsoil productivity of previously disturbed areas have been identified and incorporated into the project								
	Lan-3	Contamination and remediation	1	Site assessment follows the recommended approach in Schedule A 'Recommended general process for assessment of site contamination' of National Environment Protection (Assessment of Site Contamination) Measure 1999	2	0.60	1.80	0	0.00	1	0.60	Level one aligns mostly with NEPM and is easily achievable.
				Remediation options are identified and selected using a sustainability hierarchy								
			2	The requirements for Level 1 are achieved								
				Sustainability appraisal of remediation options is undertaken against the sustainability indicators in Table 1 of 'A Framework for Assessing the Sustainability of Soil and Groundwater Remediation'								
			3	The requirements for Level 2 are achieved								
				The effectiveness and durability of the remedial solution, and maintenance and monitoring, have been considered over the lifetime of the infrastructure and beyond								
	Lan-4	Flooding design	1	The run-off, flood risk, and potential increased flood risk elsewhere as a result of the project have all been assessed over their expected working life, in line with the requirements of 'Flood plain management in Australia: best practice principles and guidelines' and appropriate flood resilience measures have been included in the design so that there is no increase in flood risk	3	1.01	2.02	2	2.02	2	2.02	
			2	The run-off, flood risk, and potential increased flood risk elsewhere as a result of the project have all been assessed over their expected working life, in line with the requirements of 'Flood plain management in Australia: best practice principles and guidelines' and appropriate flood resilience measures have been included in the design so that there is a significant decrease in flood risk								
				Predictions for waste quantities and types have been developed for construction and operation	3	1.35	2.70	2	2.70	2	2.70	

Waste	Was-1	Waste management	1	Measures to minimise waste during construction and operation have been identified and implemented											
				Monitoring of all wastes is undertaken during construction and operation											
			2	The requirements for Level 1 are achieved											
				Waste monitoring and management has been managed, reviewed or audited by a suitably qualified professional											
				Waste handling and disposal/recycling all the way to final destination has been audited at appropriate intervals											
	Was-2	Diversion from landfill	1	All of the following targets for landfill diversion have been achieved or bettered: 70 to <80% by volume of spoil	3	1.57	4.72	1	1.57		1	1.57			
				25 to <50% by volume of inert and non-hazardous waste											
				25 to <40% by volume of office waste											
			2	All of the following targets for landfill diversion have been achieved or bettered: 80 to 100% by volume of spoil											
				50 to 90% by volume of inert and non-hazardous waste											
				40 to 60% by volume of office waste											
			3	All of the following targets for landfill diversion have been achieved or bettered: 100% by volume of spoil											
				>90% by volume of inert and non-hazardous waste											
				>60% by volume of office waste material											
	Was-3	Deconstruction/ Disassembly/ Adaptability	1	A deconstruction plan is developed based on good practice	2	0.45	1.35	0	0.00		0	0.00			
			1-3 scaled	The requirements for Level 1 are achieved											
				The deconstruction plan is reviewed and updated. Reviews should consider changes to technology and infrastructure planning											
				0 to 50% by value of components or pre-fabricated units used can be easily separated on disassembly/ deconstruction into material types suitable for recycling or reuse. For every increment of deconstructability up to 50% for Level 3, fractions of Levels may be achieved on a sliding scale.											
	Eco-1	Ecological value	1	The ecological value of the infrastructure site is maintained	2	2.25	6.74	1	2.25		1	2.25			
			1-3 scaled	The ecological value of infrastructure site is enhanced by 0 to 20%. Fractions of Levels may be achieved on a sliding scale up to 20% for Level 3.											
...ogy			1	There is a low or moderate degree of existing habitat connectivity identified and this is maintained	2	0.90	2.70	0	0.00		0	0.00			It is likely that this credit would be scoped out

Ecolo	Eco-2	Habitat connectivity	2	There is a low or moderate degree of existing habitat connectivity identified and this is enhanced OR There is a high degree of existing habitat connectivity identified and this is maintained								
			3	There is a low or moderate degree of existing habitat connectivity identified and this is enhanced (no offsetting) OR There is a high degree of existing habitat connectivity identified and this is maintained (no offsetting)								
Community Health, Well-being and Safety	Hea-1	Community health and well-being	1	Measures to positively contribute to community health and wellbeing for one priority issues have been identified and implemented	2	0.75	2.25	1	0.75	1	0.75	
			2	Measures to positively contribute to community health and wellbeing for two priority issues have been identified and implemented								
				Monitoring of community health and wellbeing indicators related to the priority issues is undertaken at appropriate intervals during construction and operation of the asset.								
			3	Measures to positively contribute to community health and wellbeing for three priority issues have been identified and implemented.								
				Monitoring of community health and wellbeing indicators related to the priority issues is undertaken at appropriate intervals during construction and operation of the asset and demonstrates improvement of relevant indicators.								
	Hea-2	Crime prevention	1	The likelihood of crime has been reduced through implementing appropriate CPTED guidelines in design, construction and operation	0	0.00	0.00	0	0.00	0	0.00	It is likely that this credit would be scoped out given the project type and location.
				All tunnels or underpasses have end-to-end visibility								
			2	The requirements for level 1 are achieved								
				Temporary construction diversions and lighting are designed to meet CPTED guidance								
Heritage	Her-1	Heritage assessment and management	1	Community heritage values have been identified through consultation and integrated into studies	4	1.50	4.49	2	2.99	2	2.99	
				Measures to minimise adverse impacts to heritage during construction and operation have been identified and implemented								
			2	The requirements for Level 1 are achieved								
				Community and key stakeholders have participated in the heritage studies								
				Heritage values beyond those listed in government registers have been identified, considered and addressed								
				Heritage has been interpreted to promote local heritage values								
			3	The requirements for Level 2 are achieved								
				Opportunities have been identified and implemented to enhance heritage values.								
	Her-2	Monitoring and management of heritage	1	Monitoring of heritage is undertaken at appropriate intervals during construction and operation	4	1.50	4.49	1	1.50	1	1.50	
			2	The requirements for Level 1 are achieved								
				Monitoring and modelling demonstrates maintenance of heritage values								
				The requirements for Level 2 are achieved								

Stakeholder Participation

		3	Monitoring and modelling demonstrates enhancements to heritage values								
Sta-1	Stakeholder engagement strategy	1	A comprehensive stakeholder engagement strategy is developed	3	0.56	1.68	1	0.56		1	0.56
		2	The requirements for Level 1 are achieved								
			The strategy is implemented and formal monitoring, evaluation and corrective action is undertaken								
			The community is informed of the draft strategy and provided an opportunity to give feedback. Community feedback is documented and used to guide completion of the final strategy								
		3	The requirements for Level 2 are achieved								
			Stakeholders, including the community, have input to the strategy by way of a facilitated workshop(s) OR The strategy is independently reviewed.								
Sta-2	Level of engagement	1	Negotiable issues are identified and the level of participation on these issues is at least 'consult' or higher on the IAP2 spectrum	3	0.56	1.68	2	1.12		2	1.12
			Stakeholders are informed about non-negotiable issues								
		2	Negotiable issues are identified and the level of participation on these issues is at least 'involve' or higher on the IAP2 spectrum								
			Stakeholders are informed about non-negotiable issues								
		3	Negotiable issues are identified and the level of participation on these issues is at least 'collaborate' or higher on the IAP2 spectrum								
			Stakeholders are informed about non-negotiable issues								
Sta-3	Effective communication	1	The community has been provided with information that: - was provided in a timely manner - supported community participation - was meaningful and relevant - was accessible	3	0.84	1.68	1	0.84		1	0.84
			This has been verified by: - internal management/reviews/audits OR - community feedback with 65-80% support								
		2	The community has been provided with information that: - was provided in a timely manner - supported community participation - was meaningful and relevant - was accessible								
			This has been verified by: - independent reviews/audits OR - community feedback with >80% support								
Sta-4	Addressing community concerns	1	The community believe their concerns have been considered and addressed	3	0.84	1.68	0	0.00		0	0.00
			This has been verified by: - internal management/reviews/audits OR - community feedback with 65-80% support.								
			The community believe their concerns have been considered and addressed								

			2	This has been verified by: - independent reviews/audits OR - community feedback with >80% support.									
Urban and Landscape Design	Urb-1	Urban design	1	An urban and landscape design plan is developed and implemented that includes the following: 1. Site analysis; 2. Vision and objectives for the infrastructure; 3. Site planning; and 4. Strategies that respond to: a. the relevant People and Place principles outlined in the Australian Urban Design Protocol (AUDP) or b. other ISCA approved guidelines	2	1.20	3.59	2	2.40		2	2.40	
			2	The requirements for Level 1 are achieved The urban and landscape design plan has been internally reviewed									
			3	The requirements for Level 1 are achieved The urban and landscape design plan has been independently reviewed									
	Urb-2	Implementation	1	Urban and landscape designs are constructed and ongoing management is incorporated into urban design and landscape management plans	2	0.45	0.90	1	0.45		1	0.45	
			2	The requirements for Level 1 are achieved The infrastructure is managed in accordance with the urban and landscape design plan and achieves a high degree of compliance.									
Innovation	Inn-1	Innovation	1	An innovation submission can be awarded up to 10 points as follows: - Up to 10 initiatives can be submitted. - Each verified initiative will be awarded one point unless it is an Australian 1st (3 pts), World 1st (5 pts), or indicated otherwise elsewhere. - Each initiative must meet one or more of the following five criteria: 1 innovative technology or process 2 market transformation 3 improving on credit benchmarks 4 innovation challenge 5 global sustainability	2	1.00	10.00	0	0.00		0	0.00	

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