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Environmental Impact Statement – Chapter 13: Biodiversity Offset Strategy

Warragamba Dam Raising

Reference No. 30012078
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13 Biodiversity Offset Strategy

This chapter provides details of a Biodiversity Offset Strategy (BOS) for the Project. The relevant Secretary's Environmental Assessment Requirements (SEARs) are shown in Table 13-1.

Table 13-1. Secretary's Environmental Assessment Requirements: Biodiversity offsets

Desired performance outcome	Secretary's Environmental Assessment Requirements[1]	Where addressed
6. Biodiversity The Project design considers all feasible measures to avoid and minimise impacts on terrestrial and aquatic biodiversity. Offsets and/or supplementary measures are assured which are equivalent to any remaining impacts of Project construction and operation.	1. The Proponent must assess biodiversity impacts in accordance with the current guidelines including the Framework for Biodiversity Assessment (FBA), unless otherwise agreed by OEH, by a person accredited in accordance with s142B(1)(c) of the *Threatened Species Conservation Act 1995*.	This chapter discusses the BOS Appendix F1: Biodiversity Assessment Report – Upstream Appendix F3: Biodiversity Assessment Report – Construction
	2. The proponent must assess the downstream impacts on threatened biodiversity, native vegetation and habitats resulting from any changes to hydrology and environmental flows. This assessment should address the matters in Attachment B.	This chapter discusses the BOS Appendix F2: Downstream ecological assessment
	3. The Proponent must assess impacts on the following: endangered ecological communities (EECs), threatened species and/or populations, and provide the information specified in s9.2 of the FBA. Specific environmental requirements are provided in Attachment C.	This chapter discusses the BOS Appendix F1: Biodiversity Assessment Report – Upstream Appendix F3: Biodiversity Assessment Report – Construction

1. This chapter specifically addresses SEAR 6 in addition to those general requirements of the SEARs applicable to all chapters and as identified as such in Chapter 1 (Section 1.5, Table 1-.1.)

The BOS is supported by detailed investigations, which are documented in the Biodiversity Offset Strategy report (Appendix F6). The assessment of potential biodiversity impacts and mitigation measures is supported by detailed investigations, which have been documented in several working papers and summarised in the Environmental Impact Assessment (EIS). These are:

- Upstream Biodiversity Assessment Report (BAR), (Appendix F1, EIS Chapter 8)
- Downstream Ecological Assessment, (Appendix F2, EIS Chapter 9)
- Construction Biodiversity Assessment Report, (Appendix F3, EIS Chapter 10)
- Aquatic Ecology Assessment Report (Appendix F4, EIS Chapter 11)
- Matters of National Environmental Significance – Biodiversity (Appendix F5, EIS Chapter 12)
- World Heritage assessment report (Appendix J)
- Protected lands (Chapter 20).

The process for identifying, prioritising and meeting project biodiversity credit requirements for construction related impacts would comprise the following activities:

- Assessment of Biodiversity Stewardship Agreement site options
- Purchase of credits from the market
- Supplementary measures (if required)

- Contribution to the Biodiversity Conservation Fund where biodiversity credits could not be sourced from Biodiversity Stewardship Agreement sites on WaterNSW/private land, or on the credit market.

The BOS is the cornerstone of the Warragamba Offset Program (see Section 13.6.2.1) which will provide for no net loss of protected lands values for affected national parks and the Greater Blue Mountains World Heritage Area (GBMWHA). The Warragamba Offset Program will investigate land suitable for offsets and will prioritise land that:

- contains suitable credits
- improves or supports the Outstanding Universal Value for the GBMWHA
- supports the integrity of protected lands
- protects Aboriginal cultural values and heritage.

The Warragamba Offset Program provides for auditing of compliance with these four priorities.

The Warragamba Offset Program also encompasses 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 mitigation measures identified in Section 29.7 of the EIS would contribute to offsetting impacts on protected lands and would support the Warragamba Offset Program.

The Warragamba Offset Program would be supported and complemented by the separate Environmental Management Plan (EMP) that WaterNSW is required to prepare under Part 5A of the *Water NSW Act 2014* before the temporary inundation of any land protected by the *National Parks and Wildlife Act 1974* can occur. The scope and content of the EMP have yet to be defined but would be consistent with the existing management plans for the national parks and the GBMWHA. The EMP would contribute to the maintenance and strengthening of protected lands values.

13.1 Introduction

13.1.1 BOS objective and approach

The objective of the offset strategy is to provide a framework for the delivery of offsets for the potential impacts of the Project and to achieve a long-term conservation gain for the threatened species, populations and communities, national parks and World Heritage values impacted by the Project. It includes the biodiversity offsets required under the Framework for Biodiversity Assessment (FBA) as set out in the SEARs. The BOS is consistent with the potential recategorisation of land under the NSW *Revocation, recategorisation and road adjustment policy* (OEH 2012) and would contribute to national parks and World Heritage values impacted by the Project. It should be noted that the Project does not propose any recategorisation of land under the policy and this reference is included simply to comply with the SEARs.

The varying impacts across the Project study area have necessitated different assessment types across the upstream, construction, and downstream study areas. A variable approach to offsets across each study area has also been adopted for this assessment.

13.1.2 Project impacts

The proposal is to raise the existing Warragamba Dam wall (the Project), which would provide increased temporary capacity (i.e. the flood mitigation zone, FMZ) to retain flood inflows and to manage the release of this to mitigate downstream flooding. The Project would result in potential biodiversity impacts due to disturbance of natural areas during construction, temporary inundation of natural areas upstream of Warragamba dam and changes to the downstream flood regime.

The Secretary's Environmental Assessment Requirements (SEARs) require that:

- impacts associated with the Project within the upstream operational area and construction area must be assessed via the FBA. The FBA does not assess downstream impacts of hydrology on surface vegetation and groundwater dependent ecosystems (GDEs).
- Impacts associated with the Project within the downstream operational area be assessed via Attachment B of the SEARs. It should be noted that the *Threatened Species Conservation Act 1995* (TSC Act) was repealed when the *Biodiversity Conservation Act 2016* (BC Act) commenced on 25 August 2017. However, given the SEARs for the Project were issued prior to 25 August 2017, the Project is being assessed under transitional arrangements that allow the Project to be assessed in accordance with the TSC Act and therefore the FBA applies to the Project.

A summary of potential impacts and the main EIS or report references are provided as follows.

13.1.2.1 Upstream area (Chapter 8, Chapter 11)

The upstream catchment areas of Lake Burragorang already experience temporary inundation during major flood events. The Project would incrementally increase temporary inundation, resulting in changes to depths and durations during operation of the FMZ. The frequency, extent and duration of the increased temporary inundation varies across locations and flood events. The temporary inundation of vegetated areas may impact flora species and plant communities and lead to changes to habitat. The impact may result in temporary and permanent changes in plant community types (PCTs), loss of threatened flora species and loss of habitat for both threatened and non-threatened fauna.

In view of the probabilistic nature of flooding in the upstream study area and the variable extent of land affected by temporary inundation, offsetting of potential biodiversity impacts in the upstream study area is based on the concept of an 'impact area'. Demarcation of this upstream impact area (in terms of elevation) is based on Monte Carlo modelling which was undertaken to assess the likely level of inundation upstream of the dam. Around 20,000 simulated events were used to generate a 200,000 year flood record. This included the full range of possible events based on the latest hydrology analyses. This was then analysed by selecting 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.

Since flood behaviour in the Hawkesbury Nepean Valley has distinct multi-decade wet and dry periods, the inundation assessment period outcomes considered:

- randomly selected periods
- half wet / half dry periods
- wet dominated periods
- dry dominated periods.

The results from all these hypothetical flood sequences were then analysed to determine what the average or likely inundation outcomes would be. In terms of predicted inundation. The average results for the flood/drought sequence were then used to define the upper and lower elevations for the impact area as these were considered to provide the most likely outcome on a statistical basis. These elevations are:

- Lower extent: 2.78 metres above full supply level (FSL) (119.5 mAHD)
- Upper extent: 10.25 metres above FSL (126.97 mAHD).

The size of the upstream impact area is about 1400 hectares with 304 hectares occurring within the GBMWHA. This represents about 0.03 percent of the total area (1,032,649 hectares) of the GBMWHA.

A precautionary approach has been taken to determining offsets in the upstream study area and is based on a total loss of environmental values in the upstream impact area. All biodiversity values occurring in the upstream study area are represented in the upstream impact area and therefore are captured in the BOS. While there is potential for flooding to occur above the upstream impact area, the likelihood is lower than for flooding occurring within the upstream impact area. Additionally, the incremental depth and duration of temporary inundation would be less than for flooding in the upstream impact area.

13.1.2.2 Downstream area (Chapter 9, Chapter 11)

The Project would:

- reduce the extent and duration of flooding downstream. Some plant communities that occur close to the extent of small flood events may experience less flooding from smaller flood events. While these plant communities would still experience flooding, the frequency at which this vegetation is flooded would decrease.
- release temporary stored flood waters in the FMZ after a flood event had peaked. Some vegetation along the main river and in low lying areas may experience increased temporary inundation.

13.1.2.3 Construction area (Chapter 10)

Construction would require clearing of vegetation adjacent to the dam. About 22.4 hectares of native vegetation would be cleared including a small area of one threatened ecological plant community. Native vegetation also provides habitat for some threatened flora and fauna species.

13.1.2.4 Greater Blue Mountains World Heritage Area (Appendix J)

Parts of the Greater Blue Mountains World Heritage Area (GBMWHA) within the Lake Burragorang catchment are already impacted by temporary inundation during major flood events. The Project would not significantly impact on the Outstanding Universal Value of the GBMWHA as:

- the area of the GBMWHA within the upstream impact area comprises 0.03 percent of the total area of the GBMWHA; the remaining 99.97 percent would not be affected by the Project
- comprehensive mitigation and offsetting measures have been identified which would ensure that any impacts on the GBMWHA are minimised and which would contribute to the maintenance and enhancement of the Outstanding Universal Value of the GBMWHA such that there would be no net loss.

The Warragamba Offset Program will prioritise land suitable for inclusion in the National Park estate additional offsets may be needed through purchase and retirement of biodiversity credits in order to meet the credit requirements for the project. Any land containing suitable offsets must also be appropriate for the National Park estate and supported by NPWS for this purpose. 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 area impacted (1,400 hectares) and that this would incorporate a minimum area of 304 hectares containing OUV values to offset potential impacts to the GBMWHA.

13.1.2.5 National Parks and State Conservation Areas (Chapter 20)

Parts of national parks and state conservation areas within the Lake Burragorang catchment are already impacted by temporary inundation. These are:

- Blue Mountains National Park
- Burragorang State Conservation Area
- Kanangra-Boyd National Park
- Nattai National Park
- Nattai State Conservation Area
- Yerranderie State Conservation Area.

The Project would result in incremental inundation changes during major flood events.

13.1.3 2019-2020 bushfires

New South Wales, including the catchment of Lake Burragorang, experienced severe bushfires starting in June 2019 and continuing through to early 2020. The bushfires have been described as unprecedented in their extent and intensity affecting at least 5.4 million hectares (seven percent of NSW) including 27 percent of the national park estate, more than 81 percent of the GBMWHA and 54 percent of the NSW components of the Gondwana Rainforests of Australia World Heritage property (DPIE 2020).

The fires affecting the study area began in late October 2019 within remote bushland near Lake Burragorang, near Yerranderie, as well as within the Kanangra-Boyd National Park. Due to the extreme isolation of the area and rugged inaccessible terrain, the fire spread and merged to eventually become the Green Wattle Creek Fire on 27 November 2019. This fire rapidly affected the study area where it burnt out of control for over nine weeks. A total of 278,700 hectares in the Wollondilly area were affected by this fire until it was officially declared 'contained' on 30 January 2020. The fire was declared 'extinguished' by the NSW Rural Fire Service on 10 February 2020 following significant rainfall over the preceding week.

The effects of the 2019-2020 bushfires on the environment, including the ecological consequences, are not yet fully understood. In response, the former Department of the Environment and Energy (DoEE[1]) has released initial advice relating to threatened and migratory species, which have more than 10 percent of their known or predicted distribution in areas affected by bushfires in southern and eastern Australia from 1 August 2019 to 13 January 2020. Regular updates are progressively being provided through the Department's website[2].

In February 2020, the NSW Department of Planning, Industry and Environment (DPIE) released a set of guidelines relating to carrying out biodiversity assessments under the FBA at severely burnt sites (refer to Appendix F1).

13.2 Policy framework for the offset strategy

The policy framework for preparing and implementing the BOS is detailed in Appendix F6 (Section 2) and summarised as follows.

13.2.1 NSW biodiversity offsets policy for major projects

The *NSW Biodiversity Offsets Policy for Major Projects* (NSW Government 2014) provides a standardised approach for assessing impacts of major projects on biodiversity and determining offsetting requirements. The policy is underpinned by the following six principles, which must be considered when assessing offsets for major projects

Principle 1: Before offsets are considered, impacts must first be avoided, and unavoidable impacts minimised through mitigation measures. only then should offsets be considered for the remaining impacts.

Principle 2: Offset requirements should be based on a reliable and transparent assessment of losses and gains.

Principle 3: Offsets must be targeted to the biodiversity values being lost or to higher conservation priorities.

Principle 4: Offsets must be additional to other legal requirements.

Principle 5: Offsets must be enduring, enforceable and auditable.

Principle 6: Supplementary measures can be used in lieu of offsets.

The FBA was used for assessing Project construction and upstream impacts. The FBA provides rules and software (BioBanking Credit Calculator, BBCC) for calculating the number and type of 'credits' that a development site will require to offset its impacts and thus improve or maintain biodiversity values. However, FBA credits are no longer available for purchase and credits would need to be converted into biodiversity assessment method (BAM) credits. WaterNSW would need to seek a 'credit equivalence' statement from the Environment, Energy and Science (EES) group (formerly the Office of Environment and Heritage, OEH) within the Department of Planning, Industry and Environment (DPIE).

Additional assessment is outlined below:

- The FBA does not provide guidance for assessing impacts that are not associated with the clearing of native vegetation. This includes downstream impacts on hydrology and environmental flows on surface vegetation and groundwater dependent ecosystems. Additional assessment requirements are outlined in the Secretary's Environmental Assessment Requirements (SEARs) (Attachment B). This is outlined in Section 13.2.2.
- The FBA applies predominantly to terrestrial biodiversity and additional requirements are provided by the NSW Department of Primary Industries Policy and Guidelines for Fish Habitat Conservation and Management (DPI 2013). Offsets for identified key fish habitats are required once avoidance and mitigation measures have been implemented.

13.2.2 Secretary's environmental assessment requirements

Attachment B to the SEARs identifies additional biodiversity offset requirements for downstream operational impacts as follows:

- meet the principles for the use of biodiversity offsets in NSW (OEH 2018) as follows:
  - *Principle 1*: Impacts must be avoided first by using prevention and mitigation measures.

[1] On 1 February 2020, the Department of Agriculture, Water and the Environment was established, combining the former Department of Agriculture and Department of the Environment and Energy (Environment portfolio). Reference to DoEE has been used in this report in view of the Project commencing when DoEE was in existence.

[2] https://www.environment.gov.au/biodiversity/bushfire-recovery

  - *Principle 2*: All regulatory requirements must be met.
  - *Principle 3:* Offsets must never reward ongoing poor performance.
  - *Principle 4*: Offsets will complement other government programs.
  - *Principle 5:* Offsets must be underpinned by sound ecological principles.
  - Principle 6: Offsets should aim to result in a net improvement in biodiversity over time.
  - *Principle 7*: Offsets must be enduring – they must offset the impact of the development for the period that the impact occurs.
  - *Principle 8*: Offsets should be agreed prior to the impact occurring.
  - *Principle 9*: Offsets must be quantifiable – the impacts and benefits must be reliably estimated.
  - *Principle 10*: Offsets must be targeted.
  - *Principle 11*: Offsets must be located appropriately.
  - *Principle 12*: Offsets must be supplementary.
  - *Principle 13*: Offsets and their actions must be enforceable through development consent conditions, licence conditions, conservation agreements or contracts.
- identify the conservation mechanisms to be used to ensure long-term protection and management of offset sites
- include an appropriate management plan to ensure any proposed compensatory offsets, retained habitat enhancement features and/or impact mitigation measures (including proposed rehabilitation and/or monitoring programs) are appropriately managed and funded.

13.2.3 Environment Protection and Biodiversity Conservation Act 1999 Environmental Offsets Policy

The *Environmental Offsets Policy* (DSEWPaC 2012) outlines the Australian Government's approach to biodiversity offsets under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The policy relates to matters of national environmental significance (MNES), which include:

- world heritage properties
- national heritage places
- listed threatened species and ecological communities.

There are two types of offsets:

- **direct offset**: Actions that provide a measurable conservation gain for an impacted protected matter
- **compensatory measures**: Actions that do not directly offset the impacts on the protected matter but are expected to lead to benefits. Compensatory measures may include research or educational programs.

Suitable offsets must meet the following requirements:

- deliver an overall conservation outcome that improves or maintains the viability of the protected matter
- be built around direct offsets but may include other compensatory measures
- be in proportion to the level of statutory protection that applies to the protected matter
- be of a size and scale proportionate to the residual impacts on the protected matter
- effectively account for and manage the risks of the offset not succeeding
- be additional to what is already required, determined by law or planning regulations, or agreed to under other schemes or programs
- be efficient, effective, timely, transparent, scientifically robust and reasonable
- have transparent governance arrangements including being able to be readily measured, monitored, audited and enforced.

13.2.4 National parks and State conservation areas

There is no formal process to identify offset requirements for any impacts to national parks and state conservation areas. In 2018, an amendment to the *Water NSW Act 2014* (WNSW Act) was enacted that related specifically to the Project and potential impacts of temporary inundation on national parks in the Warragamba Dam catchment.

Under section 64C of the *Water NSW Act 2014*, WaterNSW is required to develop and implement an EMP for the upstream operational area related to the temporary inundation of national park land resulting from the Warragamba

Dam Project. The EMP will be separate to the proposed Warragamba Offset Program but will complement and support the Program. The EMP would need to be consistent with the offset strategy.

Other specific requirements are as follows:

- the Minister for National Parks and Wildlife to determine the matters that are to be addressed by an EMP (section 64C(2))
- the Minister for National Parks and Wildlife, with the concurrence of the Minister for Water, approve an acceptable EMP (section 64C(4))
- WaterNSW to implement and monitor the EMP (section 64C(5))
- the Minister for National Parks and Wildlife, with the concurrence of the Minister for Water, require an approved EMP to be updated or reviewed (section 64D)
- the Minister for National Parks and Wildlife, with the concurrence of the Minister for Water, may direct WaterNSW to take specified actions in relation to the temporary inundation of national park land resulting from the Warragamba Dam Project, including action relating to the monitoring of risks associated with the temporary inundation and relating to the rehabilitation or remediation of land (section 64E)
- WaterNSW to notify the EES group in DPIE if it is of the opinion that a flood event that may affect national park land in the vicinity of Warragamba Dam is likely to occur (section 64F).

13.2.5 Revocation, recategorisation and road adjustment policy

The *National Parks and Wildlife Act 1974* (the NPW Act) provides that land may be reserved as a national park, nature reserve, historic site, state conservation area, regional park, Aboriginal area or karst conservation reserve. Circumstances may arise that require the revocation of land, a change to the reserve category ('recategorisation'), or an adjustment of boundaries in a reserve. The NSW *Revocation, recategorisation and road adjustment policy* (OEH 2012) provides the policy framework for this process.

The Project is not anticipated to require the revocation of any land reserved under the NPW Act, nor to require any road adjustments that could affect land reserved under the NPW Act. The Warragamba Offset Program (refer Section 13.6.2.1) would provide for the purchase of land suitable for inclusion in the National Park and protected areas system (and potentially including land within the World Heritage area). The policy may be relevant in this regard should any such land already be reserved under the NPW Act, such as a State conservation area (SCA), and require recategorisation.

13.3 Project impacts that require offsetting in accordance with the FBA

13.3.1 Construction impacts

Impacts associated with the construction of the raised dam wall, and offset credits for the construction related impacts, have been calculated using the FBA. However, as FBA credits are no longer available for purchase, the credits required would need to be converted into Biodiversity Assessment Method (BAM) credits for the offsetting of the project to be realised. WaterNSW will need to seek a 'credit equivalence' statement from the OEH before seeking to fulfil the offset requirements.

13.3.1.1 Native vegetation

Impacts resulting from Project construction that fall into the threshold of impacts that require offsetting include are shown in Table 13-2.

Table 13-2. Credit requirements from construction impacts

PCT code	PCT description	Impacted area (ha)
HN564	Red Bloodwood - Grey Gum woodland on the edges of the Cumberland Plain, Sydney Basin Bioregion	2.76
HN566:	Red Bloodwood - Scribbly Gum heathy woodland on sandstone plateaux of the Sydney Basin Bioregion	12.25
HN568:	Red Bloodwood - Sydney Peppermint - Blue-leaved Stringybark heathy forest of the southern Blue Mountains, Sydney Basin Bioregion	5.77

PCT code	PCT description	Impacted area (ha)
HN604:	Turpentine - Grey Ironbark open forest on shale in the lower Blue Mountains, Sydney Basin Bioregion	1.64

The offset requirement for the above PCTs were calculated using the BBCC. A summary of the vegetation zone impacted, threatened species associated with that vegetation zone, loss landscape value, loss in site value, and the number of ecosystem credits required for the impacts is provided in Table 13-3.

Table 13-3. Credit requirements of the proposed construction works

Veg zone	PCT	PCT condition	Area impacted (ha)	Current site value	Future site value	Credit requirement
1	HN564	Moderate/Good	0.31	60.63	0.00	16
2	HN566	Moderate/Good	12.25	77.08	0.00	691
3	HN568	Moderate/Good	5.77	91.06	0.00	430
4	HN604	Moderate/Good	1.64	60.14	0.00	84
5	HN564	Moderate/Good_poor	2.45	30.68	0.00	72

13.3.1.2 Species and populations

Three species credit species were recorded within the development site. However, as outlined in Appendix F3 (Biodiversity Assessment Report - Construction, Section 5.7.2), 54 candidate species credit species are assumed to be present and their habitat offset. The offset requirement for the species credit species were calculated using the BBCC. It is recommended that targeted surveys be carried out in line with relevant guidelines for threatened flora species currently assumed as present within the development site. Targeted surveys should focus on areas that had been subject to recent prescribed burning, as well as within the development footprint. These surveys would likely refine the quantification of impacts and associated credit liability generated by the Project. A summary of the area of habitat or the number in individuals to be impacted and the credit requirements for species credit species are detailed in Table 13-4. Species recorded are identified with an asterisk (*), all other included species have been assumed present based on being predicted to occur.

Table 13-4. Credit requirements of the Project for species credit species

Species credit species name	Common name	BC Act status	EPBC Act status	Area to be removed (ha)	Credit requirement
FLORA					
Acacia baueri subsp. *aspera**	*Acacia baueri* subsp. *aspera*	V	-	12.25	520
Acacia bynoeana	Bynoe's Wattle	E	V	19.96	1,540
Acacia flocktoniae	Flockton's Wattle	V	V	6.11	126
Acacia gordonii	*Acacia gordonii*	E	E	12.25	338
Acacia pubescens	Downy Wattle	V	V	19.66	380
Ancistrachne maidenii	*Ancistrachne maidenii*	V	-	12.55	286
Asterolasia elegans	*Asterolasia elegans*	E	E	12.55	234
Astrotricha crassifolia	Thick-leaf Star-hair	V	V	12.25	1,001
Caesia parviflora subsp. *Parviflora*	Small Pale Grass-lily	E	-	12.55	182
Cryptostylis hunteriana	Leafless Tongue-orchid	V	V	12.25	520
Darwinia biflora	*Darwinia biflora*	V	V	12.55	260
Darwinia peduncularis	*Darwinia peduncularis*	V	-	12.25	234
Dillwynia tenuifolia	*Dillwynia tenuifolia*	V	-	12.55	234
Epacris purpurascens var. purpurascens	*Epacris purpurascens var. purpurascens*	V	-	300[1]	5,100

Species credit species name	Common name	BC Act status	EPBC Act status	Area to be removed (ha)	Credit requirement
Genoplesium baueri	Bauer's Midge Orchid	V	E	12.25	169
*Grammitis stenophylla**	Narrow-leaf Finger Fern	E	-	1.64	26
Grevillea evansiana	Evan's Grevillea	V	V	12.25	195
*Grevillea parviflora subsp. parviflora**	Small-flower Grevillea	E	-	14.19	210
Gyrostemon thesioides	*Gyrostemon thesioides*	E	-	1.95	154
Haloragodendron lucasii	Hal	E	E	12.25	1,001
Hibbertia puberula	*Hibbertia puberula*	E	-	19.96	800
Hygrocybe anomala subsp. *ianthinomarginata*	*Hygrocybe anomala* subsp. *ianthinomarginata*	V	-	13.89	1,078
Kunzea rupestris	*Kunzea rupestris*	V	V	12.55	338
Lastreopsis hispida	Bristly Shield Fern	E	-	5.79	462
Leucopogon exolasius	Woronora Beard-heath	V	V	18.32	266
Leucopogon fletcheri subsp. *fletcheri*	*Leucopogon fletcheri* subsp. *fletcheri*	E	-	12.55	208
Melaleuca deanei	Deane's Paperbark	V	V	12.55	1,001
Melaleuca groveana	Grove's Paperbark	V	-	13[1]	1,560
Micromyrtus blakelyi	*Micromyrtus blakelyi*	V	V	12.55	338
Olearia cordata	*Olearia cordata*	V	V	12.55	169
Persoonia acerosa	Needle Geebung	V	V	18.02	247
Persoonia hirsuta	Hairy Geebung	E	E	19.96	1,540
Pimelea curviflora var. curviflora	*Pimelea curviflora var. curviflora*	V	V	14.19	1,155
*Pomaderris brunnea**	Brown Pomaderris	V	V	0.31	15
Pterostylis saxicola	Sydney Plains Greenhood	E	E	12.55	520
Pultenaea glabra	Smooth Bush-Pea	V	V	18.02	285
Pultenaea parviflora	*Pultenaea parviflora*	E	V	12.25	195
Pultenaea sp. Olinda	*Pultenaea sp.* Olinda	E	-	12.25	520
Rhodamnia rubescens	Scrub Turpentine	CE	-	1[1]	154
Syzygium paniculatum	Magenta Lilly Pilly	E	V	10[1]	130
Tetratheca glandulosa	*Tetratheca glandulosa*	V	-	19.96	320
Velleia perfoliata	*Velleia perfoliata*	V	V	12.55	221
Zieria involucrata	*Zieria involucrata*	E	E	1.70	30
Zieria murphyi	Velvet Zieria	V	V	12.55	195
FAUNA					
*Anthochaera phrygia**	Regent Honeyeater	CE	CE	19.96	1,537
Cercartetus nanus	Eastern Pygmy-possum	V	-	19.32	386
*Chalinolobus dwyeri**	Large-eared Pied Bat	V	V	19.96	259
Heleioporus australiacus	Giant Burrowing Frog	V	V	3.60	47

Species credit species name	Common name	BC Act status	EPBC Act status	Area to be removed (ha)	Credit requirement
Hoplocephalus bungaroides	Broad-headed Snake	E	V	10.24	338
Isoodon obesulus subsp. obesulus	Southern Brown Bandicoot (eastern)	E	E	12.25	318
Meridolum corneovirens	Cumberland Plain Land Snail	E	-	1.64	21
Petaurus norfolcensis	Squirrel Glider	V	-	19.66	433
Petrogale penicillata	Brush-tail Rock-wallaby	E	V	17.38	452
Phascogale tapoatafa	Brush-tailed Phascogale	V	-	13.89	278
Phascolarctos cinereus	Koala	V	V	20.06	522
*Pseudophryne australis**	Red-crowned Toadlet	V	-	8.25	107
*Varanus rosenbergi**	Rosenberg's Goanna	V	-	19.96	659

1 Credit requirement calculated by number of individuals impacted.

13.3.2 Upstream impacts

13.3.2.1 Impact area

The upstream study area comprises the maximum extent of flood prone land estimated from the probable maximum precipitation and resultant inundation. The probabilistic nature of flooding in the upstream study area presents a challenge in identifying appropriate flood events 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.

For the upstream study area, potential impacts would be principally associated with the effects of temporary inundation from operation of the FMZ, the lower limit of which is the existing FSL. The exact nature of the impacts would be dependent on multiple factors such as:

- 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.

These and other factors contribute to substantial uncertainty with regard to quantifying the potential impacts on World Heritage values, notably biodiversity values and Aboriginal cultural heritage.

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 'impact area' that takes account of the variability of flood events and their extent over time.

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 200,000 year flood record. This included the full range of possible events based on the latest hydrology analyses. This was then analysed by selecting the maximum inundation level in 20 year periods to determine the 'average' or likely inundation level. This was also undertaken for the existing dam scenario so that a comparison of inundation extents could be made.

Since flood behaviour in the Hawkesbury Nepean Valley has distinct multi-decade wet and dry periods, the inundation assessment modelled outcomes considering:

- randomly selected periods
- half wet / half dry periods
- wet dominated periods
- dry dominated periods.

The results from all these hypothetical flood sequences were then analysed to determine what the average or likely inundation outcomes would be.

The average results for the flood/drought sequence were then used to define the upper and lower elevations for the impact area as these were considered to provide the most likely outcome on a statistical basis. These are:

- Lower extent: 2.78 metres above FSL (119.5 mAHD)
- Upper extent: 10.25 metres above FSL (126.97 mAHD).

The likely inundation level for the existing dam is also about the maximum recorded level since construction of Warragamba Dam. For the purposes of the Project, the area between these two levels has been adopted as the upstream impact area. The size of the upstream impact area is about 1400 hectares.

The upstream impact area has been used as a means to offset the potential impacts of the Project. For the purposes of offsetting the potential impacts of the Project, it has been assumed that there would be a complete loss of values in this area. In reality, this is unlikely as sensitive areas/sites would have differing risks of impact depending on their respective locations in terms of elevation. Areas/sites at lower elevations would have a greater risk of temporary inundation than areas/sites at higher elevations within the upstream study area.

13.3.2.2 Biodiversity

The Project's ongoing operation would result in temporary inundation to native vegetation across the study area. The offset impact area has been used to calculate the ecosystem and species credit requirements for the Project. The Project's credit requirements are summarised in Table 13-5, Table 13-6, Table 13-7, Table 13-8, and Table 13-9. Details of the method for calculating the credits are outlined in Appendix F1 (Biodiversity Assessment Report-Upstream).

Table 13-5. Ecosystem credit requirements within the Bungonia IBRA[3] subregion as a result of the Project

Veg Zone	PCT	Condition	Impact area (ha)	Current site value	Future site value	Credit requirement
6	HN553	Moderate/Good	2.58	68.12	0	150
7	HN538	Moderate/Good	0.92	84.44	0	65
13	HN527	Moderate/Good	6.43	72.22	0	392
14	HN527	Moderate/Good_DNGL	18.0	53.38	0	844
17	HN557	Moderate/Good	1.89	73.44	0	117
21	HN574	Moderate/Good	54.29	74.64	0	3,412
Total			**84.10**			**4,980**

[3] IBRA: Interim biogeographic regionalisation of Australia

Table 13-6. Ecosystem credit requirements within the Kanangra IBRA subregion as a result of the Project

Veg Zone	PCT	Condition	Impact area (ha)	Current site value	Future site value	Credit requirement
1	HN564	Moderate/Good	0.59	68.12	0	34
2	HN566	Moderate/Good	22.07	84.44	0	1,549
3	HN568	Moderate/Good	5.49	100.00	0	449
9	HN536	Moderate/Good	1.52	86.28	0	109
11	HN535	Moderate/Good	5.90	100.00	0	483
12	HN532	Moderate/Good	0.62	59.42	0	32
16	HN607	Moderate/Good	3,058.94	76.09	0	3,767
18	HN557	Moderate/Good	0.53	73.44	0	33
19	HN606	Moderate/Good	16.92	74.64	0	1,063
Total			**112.58**			**7,519**

Table 13-7. Ecosystem credit requirements within the Wollemi IBRA subregion as a result of the Project

Veg Zone	PCT	Condition	Impact area (ha)	Current site value	Future site value	Credit requirement
1	HN564	Moderate/Good	1.92	60.63	0	100
2	HN566	Moderate/Good	6.04	77.08	0	343
3	HN568	Moderate/Good	17.84	91.06	0	1,339
9	HN536	Moderate/Good	6.19	82.28	0	442
11	HN533	Moderate/Good	1.28	75.36	0	81
12	HN532	Moderate/Good	3.19	59.42	0	164
16	HN517	Moderate/Good	0.34	78.26	0	22
18	HN607	Moderate/Good	1.84	64.98	0	102
19	HN606	Moderate/Good	20.54	85.99	0	1463
Total			**59.19**			**4,056**

Table 13-8. Ecosystem credit requirements within the Burragorang IBRA subregion as a result of the Project

Veg Zone	PCT	Condition	Impact area (ha)	Current site value	Future site value	Credit requirement
2	HN566	Moderate/Good	0.52	77.08	0	31
3	HN568	Moderate/Good	7.88	91.06	0	590
6	HN553	Moderate/Good	104.51	68.12	0	6,019
7	HN538	Moderate/Good	27.17	84.44	0	1,897
8	HN537	Moderate/Good	0.13	100.00	0	11
9	HN536	Moderate/Good	205.21	82.28	0	14,613
10	HN535	Moderate/Good	16.27	100.0	0	1,326
11	HN533	Moderate/Good	9.69	75.36	0	610
12	HN532	Moderate/Good	222.23	59.42	0	11,348

Veg Zone	PCT	Condition	Impact area (ha)	Current site value	Future site value	Credit requirement
13	HN527	Moderate/Good	64.27	72.22	0	13,899
14	HN527	Moderate/Good_DNGL	39.05	53.38	0	1,818
15	HN525	Moderate/Good	84.20	76.09	0	5,352
16	HN517	Moderate/Good	0.19	78.26	0	11
17	HN557	Moderate/Good	300.39	73.44	0	18,499
18	HN607	Moderate/Good	12.82	64.98	0	710
19	HN606	Moderate/Good	0.27	85.99	0	20
20	HN598	Moderate/Good	9.71	83.51	0	670
21	HN574	Moderate/Good	13.02	74.64	0	813
Total			**1,117.54**			**68,236**

Table 13-9. Species credit species

Species Name	Common Name	BC Act Status	EPBC Act Status	Impact Area(ha)	Credit Requirement
FLORA					
Acacia baueri subsp. *aspera*	*Acacia baueri* subsp. *aspera*	V	-	7.00	280
Acacia bynoeana	Bynoe's Wattle	V	E	35.00	2,695
Acacia clunies-rossiae	Kanangra Wattle	V	-	770.00	10,010
Acacia flocktoniae	Flockton Wattle	V	V	371.00	6,678
Acacia gordonii	*Acacia gordonii*	E	V	8.00	208
Acacia pubescens	Downy Wattle	E	-	35.00	665
Acronychia littoralis	Scented Acronychia	E	E	78.00	3,878
Acrophyllum australe	*Acrophyllum australe*	V	V	13.00	234
Ancistrachne maidenii	*Ancistrachne maidenii*	E	E	29.00	638
Asterolasia buxifolia	*Asterolasia buxifolia*	V	V	14.00	1,078
Asterolasia elegans	*Asterolasia elegans*	V	-	6.00	108
Astrotricha crassifolia	Thick-leaf Star-hair	V	V	8.00	616
Baloskion longipes	Dense Cord-rush	V	-	31.00	558
Bossiaea oligosperma	Few-seeded Bossiaea	V	V	483.00	7,245
Caesia parviflora subsp. minor	Small Pale Grass-lily	E	-	15.00	210
Callistemon linearifolius	Netted Bottle Brush	V	-	1,968.00	13,252
Callistemon megalongensis	Megalong Valley Bottlebrush	V	V	6.00	462
Calomnion complanatum	*Calomnion complanatum*	E	-	1.00	77
Cryptostylis hunteriana	Leafless Tongue Orchid	E	-	7.00	280
Darwinia biflora	*Darwinia biflora*	E	-	8.00	160
Darwinia peduncularis	*Darwinia peduncularis*	E	E	15.00	270
Dillwynia tenuifolia	*Dillwynia tenuifolia*	V	V	2.00	36
Epacris hamiltonii	*Epacris hamiltonii*	V	V	3.00	54

Species Name	Common Name	BC Act Status	EPBC Act Status	Impact Area(ha)	Credit Requirement
Epacris purpurascens subsp. purpurascens	*Epacris purpurascens* subsp. *purpurascens*	V	V	300.00	5,100
Eucalyptus benthamii	Camden White Gum	V	V	44.00	616
Eucalyptus glaucina	Slaty Red Gum	V	V	10,970.00	23,505
Eucalyptus pulverulenta	Silver-leafed Gum	V	V	170.44	30
Euphrasia bowdeniae	*Euphrasia bowdeniae*	V	V	3.00	231
Genoplesium baueri	Bauer's Midge Orchid	V	V	223.00	2,899
Genoplesium superbum	Superb Midge Orchid	E	-	10.00	770
Grammitis stenophylla	Narrow-leaf Finger Fern	E	-	41.00	533
Grevillea evansiana	Evans Grevillea	E	E	7.00	105
Grevillea parviflora subsp. parviflora	Small-flower Grevillea	V	V	9.00	126
Gyrostemon thesioides	*Gyrostemon thesioides*	CE	-	886.00	68,222
Hakea dohertyi	Kowmung Hakea	V	V	199.00	3,781
Haloragodendron lucasii	*Haloragodendron lucasii*	V	-	8.00	616
Heleioporus australiacus	Giant Burrowing Frog	E	V	883.64	11,487
Hibbertia puberula	*Hibbertia puberula*	V	V	35.00	1,400
Hibbertia superans	*Hibbertia superans*	E	E	8.00	208
Isopogon fletcheri	Fletcher's Drumsticks	E	E	3.00	69
Kunzea rupestris	*Kunzea rupestris*	E	V	8.00	208
Lastreopsis hispida	Bristly Shield Fern	V	V	23.00	1,771
Leionema lachnaeoides	*Leionema lachnaeoides*	V	-	1.00	77
Lepidosperma evansianum	Evans Sedge	V	V	1.00	77
Leucopogon exolasius	Woronora Beard-heath	V	V	50.00	392
Leucopogon fletcheri subsp. *fletcheri*	*Leucopogon fletcheri* subsp. *fletcheri*	E	V	8.00	128
Melaleuca deanei	Deane's Paperbark	E	-	9.00	693
Melaleuca groveana	Grove's Paperbark	E	-	6.00	84
Micromyrtus blakelyi	*Micromyrtus blakelyi*	V	-	8.00	208
Olearia cordata	*Olearia cordata*	V	V	8.00	104
Persicaria elatior	Tall Knotweed	V	V	896.00	11,648
Persoonia acerosa	Needle Geebung	V	V	33.00	429
Persoonia bargoensis	Bargo Geebung	E	E	22.00	1,694
Persoonia glaucescens	Mittagong Geebung	V	-	9.00	693
Persoonia hirsuta	Hairy Geebung	E	V	35.00	2,695
Pherosphaera fitzgeraldii	Dwarf Mountain Pine	V	V	1.00	26
Phyllota humifusa	Dwarf Phyllota	E	-	8.00	144
Pimelea curviflora subsp. *curviflora*	*Pimelea curviflora* subsp. *curviflora*	V	V	8.00	616

Species Name	Common Name	BC Act Status	EPBC Act Status	Impact Area(ha)	Credit Requirement
Pomaderris brunnea	Brown Pomaderris	V	-	1,146.00	17,190
Pterostylis saxicola	Sydney Plains Greenhood	E	E	111.00	4,440
Pultenaea glabra	Smooth Bush-Pea	V	V	33.00	495
Pultenaea parviflora	*Pultenaea parviflora*	E	V	7.00	105
Pultenaea sp. Olinda	*Pultenaea sp. Olinda*	E	-	7.00	280
Rhizanthella slateri	Eastern Australian Underground Orchid	V	V	23.00	1,771
Solanum amourense	*Solanum amourense*	E	-	470.00	6,110
Tetratheca glandulosa	*Tetratheca glandulosa*	V	-	305.00	4,880
Trachymene scapigera	Mountain Trachymene	E	E	19.00	760
Velleia perfoliata	*Velleia perfoliata*	V	V	18.00	306
Xanthosia scopulicola	*Xanthosia scopulicola*	V	-	21.00	315
Zieria covenyi	Coveny's Zieria	E	-	11.00	1,100
Zieria involucrata	*Zieria involucrata*	E	E	21.00	315
Zieria murphyi	Velvet Zieria	E	V	7.00	105
FAUNA					
Anthochaera phrygia	Regent Honeyeater	CE	CE	4	97,370
Cercartetus nanus	Eastern Pygmy-possum	V	-	1,296.12	25,923
Chalinolobus dwyeri	Large-eared Pied Bat	E	E	1,203.02	15,640
Epacris sparsa	Sparse Heath	V	V	2.00	36
Hoplocephalus bungaroides	Broad-Headed Snake	V	V	124.71	4,116
Isoodon obesulus subsp. obesulus	Southern Brown Bandicoot (Eastern)	E	E	1,167.29	30,348
Ixobrychus flavicollis	Black Bittern	E	-	1.84	24
Litoria littlejohnii	Littlejohn's Tree Frog	V	-	420.32	10,935
Macropus parma	Parma Wallaby	V	-	1.84	48
Myotis macropus	Southern Myotis	V	-	863.79	19,004
Petaurus norfolcensis	Squirrel Glider	V	-	1,238.37	27,244
Petrogale penicillata	Brush-tailed Rock-wallaby	V	-	411.70	10,706
Phascogale tapoatafa	Brush-tailed Phascogale	V	-	32.98	660
Phascolarctos cinereus	Koala	V	V	1,380.35	35,890
Pseudophryne australis	Red-crowned Toadlet	V	-	760.31	9,874
Varanus rosenbergi	Rosenbergs Goanna	V	-	1,111.39	36,676
FUNGI					
Hygrocybe anomala subsp. *ianthinomarginata*	*Hygrocybe anomala* subsp. *ianthinomarginata*	V	V	267.00	20,559
Hygrocybe aurantipes	*Hygrocybe aurantipes*	V	-	35.00	1,400
Hygrocybe reesiae	*Hygrocybe reesiae*	CE	CE	35.00	1,400

13.3.3 Downstream

Assessment of potential impacts on downstream biodiversity has been carried out with reference to the matters specified in requirement 6.2 and Attachment B to the SEARs. A risk assessment framework was used to determine the key likely impacts of the Project and the biodiversity features likely to be most sensitive to the predicted changes in hydrological conditions. This involved carrying out a risk assessment on the key impacts relevant for biodiversity and cross-referenced with threatened species and communities with potential to occur within the downstream survey area. Threatened entities that had a moderate or higher potential to occur and were subject to 'Medium' or greater impact risk were further assessed through an Assessment of Significance under the TSC Act.

Downstream of the Project there are numerous land uses and activities that have an existing impact on the environment. For example, water quality in the downstream catchment would include inflows from downstream catchments (such as the Nepean River, Grose River, Macdonald River, and Colo River), runoff from rural and urban land uses, and discharges from sewage treatment plants. These would, to greater or lesser degrees, be occurring concurrent with Project impacts and present practicable constraints to accurately apportioning impacts to the Project and to other sources. This uncertainty is likely to increase with increasing distance downstream, which presents challenges to practical management and offsetting of impacts associated with the Project.

Potential impacts on downstream biodiversity have not been assessed under the FBA and therefore do not require offsetting under the FBA. This notwithstanding, measures considered to minimise, mitigate and offset impacts to biodiversity for the downstream area are addressed in Chapter 9 and Section 13.4 below.

13.4 Avoid, minimise and mitigate

Principle 1 of the *NSW Biodiversity Offsets Policy for Major Projects* (NSW Government 2014) requires that project proposals consider all reasonable measures to avoided and minimise impacts in biodiversity. The following chapter outlines how the project has avoided and minimised impacts to biodiversity in line with the policy.

13.4.1 Construction impacts

13.4.1.1 Avoidance of direct impacts

Under the FBA, a proponent must seek to avoid direct impacts of a major project on biodiversity values, including:

- endangered ecological communities (EECs) and critically endangered ecological communities (CEECs)
- PCTs that contain threatened species habitat
- areas that contain habitat for vulnerable, endangered or critically endangered threatened species or populations
- an area of land that the Minister for Environment has declared as critical habitat in accordance with section 47 of the TSC Act (now referred to as 'areas of outstanding biodiversity value' under Part 3 of the *Biodiversity Conservation Act 2016*, BC Act)
- the riparian areas of 4th order or higher streams and rivers, important wetlands and estuaries
- State significant biodiversity links.

The scale and nature of the development means that options to avoid impacts to biodiversity within the development site are limited. The development site is necessarily tied to the dam wall location and direct impacts resulting from the footprint of any newly built section of dam wall, including abutments and spillway, cannot be avoided. However, where feasible, ancillaries such as batch plants, laydowns, and worker amenities have been located within areas that do not contain native vegetation or threatened species habitat.

13.4.1.2 Measures to minimise and mitigate impacts

The measures proposed to minimise and mitigate impacts to biodiversity during construction of the raised dam wall are outlined in Table 13-10.

Table 13-10. Construction mitigation measures

Impact	Mitigation measure	Outcome	Timing	Responsibility
General flora and fauna	A flora and fauna management plan (FFMP) would be prepared as part of the construction environmental management plan (CEMP). Native vegetation clearing would not occur until the FFMP is approved.	Flora and fauna would be managed in accordance with the requirements of the FFMP	Pre-construction and construction	WaterNSW and Construction Contractor
	The FFMP would 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.	The vegetation within the development site surrounding the storage area would be managed in accordance with the FFMP	Pre-construction, construction and post-construction phases	WaterNSW and Construction Contractor
Degradation of freshwater wetland habitats	Install appropriate drainage infrastructure (e.g. sediment basins, diversion drains), sediment and erosion controls prior to the commencement of construction.	Prevention of sedimentation and erosion leading to a reduction in water quality and degradation of aquatic habitats	Pre-construction	WaterNSW and Construction Contractor
	Clearing of vegetation would be timed to avoid periods when rain is forecast	Prevention of sedimentation and erosion leading to a reduction in water quality and degradation of aquatic habitats	Pre-construction and construction	WaterNSW and Construction Contractor
	Dust suppression activities to be undertaken where appropriate.	Prevents sedimentation and erosion leading to a reduction in water quality and degradation of aquatic habitats	Pre-construction and construction	WaterNSW and Construction Contractor
	Stabilisation of disturbed areas, including revegetation in accordance with the FFMP, is to be undertaken as soon as practicable after disturbance.	Prevents sedimentation and erosion leading to a reduction in water quality and degradation of aquatic habitats	Pre-construction, construction and post-construction phases	WaterNSW and Construction Contractor
	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.	Prevents pollution of waterways.	Pre-construction and construction	WaterNSW and Construction Contractor
	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.	Prevents pollution of waterways.	Pre-construction and construction	WaterNSW and Construction Contractor

Impact	Mitigation measure	Outcome	Timing	Responsibility
	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.	Reduces impacts from altered hydrological regimes leading to an increase in impervious surface such as changes in runoff and infiltration, redirection of flows.	Pre-construction and construction	WaterNSW and Construction Contractor
Vegetation removal or disturbance	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.	Prevention of over clearing of vegetation.	Pre-construction and construction	Construction Contractor
	Site inductions are to include a briefing regarding the local threatened species and communities on the site, and protocols to be undertaken if they are encountered.	Prevention of impacts to threatened species and communities.	Construction and post-construction.	WaterNSW and Construction Contractor
Weed invasion and spread	Management of weeds in and adjacent to cleared areas will occur in accordance with the FFMP, CEMP, and operational environmental management plan (OEMP). The plan would 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.	Prevention of weed establishment and weed invasion.	Pre-construction, construction, and post-construction.	WaterNSW and Construction Contractor
	Management of noxious weeds is to be undertaken in accordance with the Biosecurity Act 2015.	Prevention of weed establishment and weed invasion	Pre-construction and construction	WaterNSW and Construction Contractor
	Equipment used for treating weed infestation will be cleaned prior to moving to a new area within the development site to minimise the likelihood of transferring any plant material and soil.	Prevention of weed spread	Pre-construction and construction	WaterNSW and Construction Contractor
	Soil stripped and stockpiled from areas containing known weed infestations are to be stored on cleared land at least 40 m from native vegetation.	Prevention of weed establishment and weed invasion	Construction	Construction Contractor
Impacts to fauna and flora	Fauna microhabitat such as hollow logs and dead trees should be removed from areas to be cleared and relocated to adjacent woodland habitat.	Retaining fauna habitat resources	Pre-construction and construction	Construction Contractor
	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	Replaces lost hollow resources in the landscape	Pre-construction and construction	Construction Contractor

Impact	Mitigation measure	Outcome	Timing	Responsibility
	nest boxes and crossings through the construction and operational phases. This strategy would be included within the FFMP.			
	High visibility plastic fencing is to be installed to clearly define the limits of the works area.	Prevents disturbance or over clearing of fauna habitat and native vegetation outside the construction area	Construction	Construction Contractor
	Undertake a prestart-up check for sheltering native fauna of all infrastructure, plant and equipment and/or during relocation of stored construction materials.	Prevents fauna injury/mortality	Construction	Construction Contractor
	Site inductions are to include a briefing regarding the site's local fauna and protocols to be undertaken if fauna is encountered.	Prevents fauna injury/mortality	Construction	Construction Contractor
	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.	Prevents fauna injury/mortality	Pre-construction, construction, and post-construction.	WaterNSW and Construction Contractor
	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.	Prevents fauna injury/mortality	Construction	Construction Contractor
	The extent of vegetation clearing is to be clearly identified on construction plans.	Prevents impacts to fauna habitat and native vegetation outside the development footprint	Pre-construction	WaterNSW and Construction Contractor
	In circumstances where native vegetation or mature tree clearing is required outside of the biodiversity development site, the project ecologist will inspect	Prevents impacts to fauna habitat and native vegetation outside the development footprint	Construction	WaterNSW, Construction Contractor, and

Impact	Mitigation measure	Outcome	Timing	Responsibility
	the proposed area and provide advice on the impact to flora and fauna and appropriate management.			appointed project ecologist
	Directional lighting will be used where lighting is required in construction areas.	Minimises disruption to fauna foraging, nesting or roosting behaviours	Construction	Construction Contractor
	Maintenance of construction machinery and plant will be undertaken to minimise unnecessary noise.	Prevents fauna injury/mortality	Construction	Construction Contractor
	Speed limits will be developed to minimise the 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.	Prevents fauna injury/mortality	Construction	Construction Contractor
Bushfire risk connectivity	Bushfire awareness included in staff induction and in toolbox talks pre-commencement.	Reduces risk of possible bushfire events impacting on biodiversity values	Pre-construction and construction	Construction Contractor
Invasion and spread of pathogens and disease	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 cinnamomi *within the Sydney Metropolitan Catchment Management Authority Area* (Botanic Gardens Trust 2008) ▪ *Hygiene protocol for the control of disease in frogs* (NPWS 2008) ▪ *Management plan for myrtle rust on national parks estate* (OEH 2011)	Prevents the spread and establishment of disease and pathogens	Pre-construction and construction	Construction Contractor

13.4.2 Upstream and downstream impacts

13.4.2.1 Avoidance of impacts

Chapter 4 of the EIS discusses the proposed options and alternatives that were considered for flood mitigation in the Hawkesbury-Nepean Valley. These are:

- infrastructure upgrades to enhance drainage or protect downstream communities
- new flood mitigation dams, including new dams built and operated only for flood mitigation
- operational alternatives using existing infrastructure
- evacuation road upgrades
- non-infrastructure alternatives, such as changes to planning controls, improved flood monitoring and response and better coordination between agencies.
- strategies combining two or more of the above alternatives

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 impacts include:

- provision of a 14-metre flood mitigation zone rather than a 20-metre flood mitigation zone; while the latter would provide a greater reduction in flooding downstream compared to a 14-metre 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 flood mitigation zone as soon as practicable; a key objective of the discharge protocol for the flood mitigation zone would be to minimise the duration and extent of upstream temporary inundation.

The scale and nature of the Project means that options to avoid impacts to threatened entities within the upstream study area are limited to the above.

13.4.2.2 Measures to minimise and mitigate impacts

The BOS is the principal mechanism to minimise and mitigate biodiversity impacts in the upstream impact area. The BOS would be complemented and supported by the separate National Parks EMP required to be prepared by WaterNSW under section 64C of the *Water NSW Act 2014*.

The proposed mitigation measure for the downstream area is listed in Table 13-11.

Table 13-11. Downstream mitigation measures

Impact	Mitigation measure	Outcome	Timing	Responsibility
Inundation of native vegetation	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.	Balancing impacts of operations within the upstream and downstream areas	Operation	WaterNSW

13.5 Offsetting options

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:

- offsetting through a site secured stewardship (formerly known as biobanking) agreement
- purchasing credits
- supplementary measures following the rules prescribed in Appendix B the policy
- monetary contribution into the Biodiversity Conservation Fund.

Given the scale and uncertainty of the impacts and associated offsets, a more bespoke approach is proposed in Section 13.6, which includes elements of the four strategies detailed below.

13.5.1 Offsetting through a site secured stewardship agreement

Offset sites will generally be secured using a conservation covenant, and an appropriate biodiversity management framework would then be implemented. The NSW Biodiversity Offset Scheme and Biodiversity Assessment Method (BAM) (formerly known as BioBanking) provides a mechanism for biodiversity offset sites to be securely titled under a legally binding conservation covenant known as a Biodiversity Stewardship Agreement (BSA) (formerly known as a BioBanking Agreement). This system expresses the conservation gain delivered through conservation and management of the offset site in terms of biodiversity credits and provides rules for the like-for-like trading of credits to offset the impacts of a development.

If the offset sites are secured under a BSA then the number and type of biodiversity credits that are linked to the offset areas for the affected threatened biota would be purchased and retired. This outcome will be achieved either through identification of suitable offset areas and completion of a BSA assessment to secure a new offset site, or purchase of biodiversity credits from existing BSA sites that contain habitat for the affected threatened biota. The biodiversity credits must be retired to offset the impact of a development on biodiversity values.

There are three key areas for a potential biodiversity stewardship agreement as part of the Warragamba Dam Raising Project:

- protecting land owned by WaterNSW under a BSA
- purchase of land and protection of land under a BSA
- purchase of land and protection of land through inclusion in a national park under a Plan of Management.

13.5.2 Purchase credits

The Environment, Energy and Science (EES) Group within DPIE maintains several BioBanking public registers, including:

- **biobanking agreement register**: Provides the location of each biobank site, the number and type of credits generated, and a copy of the biobanking agreement.
- **biodiversity credits register**: Provides ownership information in relation to each credit, and their status.
- **biobank site expressions of interest (EOI) register**: Landowners who are interested in establishing biobank sites but have not entered a biobanking agreement.

There is an opportunity to purchase credits from landowners selling appropriate credits on the market, should they be available. Once purchased, the biodiversity credits must be retired to offset the impact of a development on biodiversity values. Purchased credits would need to be consistent with the like for like offset rules set out in the FBA.

13.5.3 Supplementary measures

Where biodiversity credits are not available, or where better conservation outcomes would be achieved through measures directly related to particular species, supplementary measures may be considered as an appropriate offset. Before supplementary measures can be considered as an offset, the proponent must demonstrate that all reasonable steps have been taken to secure an offset site or biodiversity credits. Given the difficulty in sourcing biodiversity credits for all Plant Community Types and species credit species impacted by the Project, the use of supplementary measures may be needed for this project. Use of supplementary measures, if used, would be consistent with the requirements set out in Section 10 of the FBA.

Proponents must follow the four-tier decision hierarchy when identifying supplementary measures. The four tiers are described as follows:

Tier 1: Actions directed to the entity impacted: Tier 1 actions are those which directly benefit the threatened species, community, or population impacted. Offsets for EPBC protected matters cannot move past Tier 1 of the hierarchy.

Tier 2: Actions directed to similar entities in the locality: Tier 2 actions are those directed to similar entities to those impacted in line with the variation rules.

Tier 3: Actions to benefit broader threatened species: Tier 3 actions are those directed to any threatened species, communities, and populations within the same IBRA subregion within which the impact occurs.

Tier 4: Actions to benefit broader threatened species: Tier 3 actions are those directed to any threatened species, communities, and populations anywhere in NSW.

13.5.4 Biodiversity Conservation Fund

Proponents may deposit into the Biodiversity Conservation Fund as an alternative to retiring biodiversity credits. By doing this, the responsibility of finding an offset is transferred to the Biodiversity Conservation Trust. The financial contribution required for a proponent to meet their offset obligation is calculated by the Biodiversity Offset Payment Calculator, which uses three modules to calculate the costs of paying into the fund based on previous credit trades made, market fluctuation risk, and administrative costs.

13.6 Offset strategy implementation

13.6.1 Construction area offset strategy

The process for identifying, prioritising and meeting project biodiversity credit requirements for construction related impacts would comprise the following activities:

13.6.1.1 Assessment of BSA site options

WaterNSW would carry out an assessment of suitability of potential BSA sites on WaterNSW owned, or privately owned land via the BioBank site expressions of interest public register. This process is described in Section 13.5.1 and would involve:

- initial desktop assessment to identify land which potentially contain plant community types, and species credit species habitat which meet the requirements of like-for-like, or allowable under the variation rules, in order to identify potential BSA sites.
- Ground truth the identified potential BSA sites for suitable PCTs and species credit species habitat. Targeted surveys may be required to determine presence of species credit species within the potential BSA sites.
- Select BSA sites and carry out necessary assessment and reporting to establish a BSA.
- Retiring credits into the biodiversity conservation fund to meet offset requirements.

Works associated with this option will be carried out by an accredited person under the BC Act.

13.6.1.2 Purchase of credits from the market

The potential for purchasing credits from landowners selling appropriate credits on the market is described in Section 13.5.2. This will be investigated as part of the offset strategy implementation and will involve searches of the Biodiversity credits register and following up responses from potential landowners/credit brokers to the Warragamba Dam Raising 'credits wanted' expression of interest. Should suitable biodiversity credits be identified, WaterNSW would commence negotiations to purchase available credits. Purchased credits would be retired into the biodiversity conservation fund to meet offset requirements.

13.6.1.3 Supplementary measures

Should supplementary measures be required in the event that suitable biodiversity credits are not available, WaterNSW would follow the process outlined in Section 13.5.3.

13.6.1.4 Biodiversity Conservation Fund

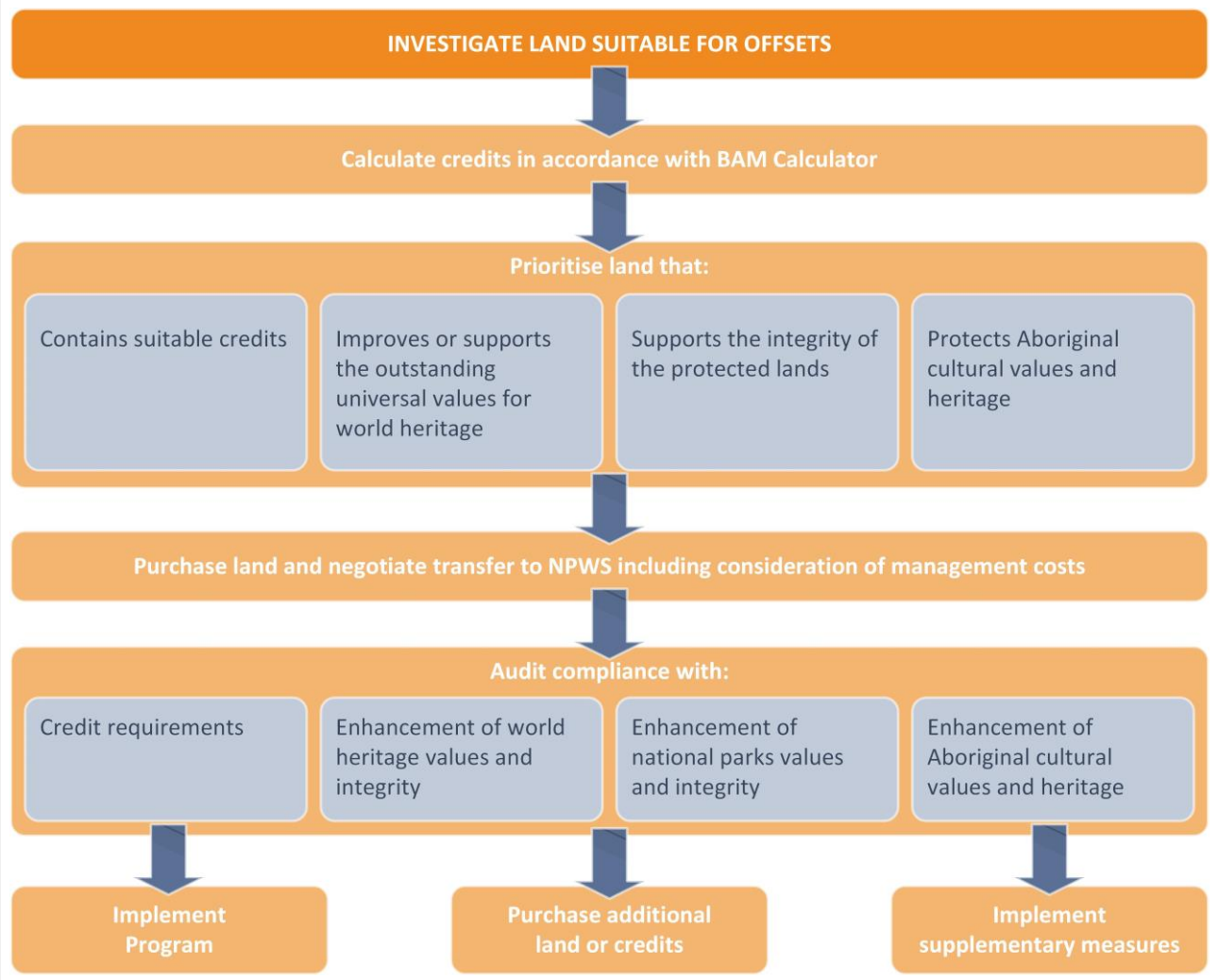
In the instance where biodiversity credits could not be sourced from BSA sites on WaterNSW/private land, or on the credit market, WaterNSW would deposit the balance of credits into the Biodiversity Conservation Fund to meet their offset obligations.

13.6.2 Upstream area offset strategy

13.6.2.1 Warragamba Offset Program

The process of identifying, prioritising and meeting project biodiversity credit requirements for the upstream operational impacts will be via a project-specific Warragamba Offset Program, which is summarised in Figure 13-1. The program will include specific actions which, when implemented, will offset for the potential impacts of the Project within the upstream study area. The program will be implemented prior to Project operation.

Figure 13-1. Summary of the proposed approach to implementing the Warragamba Offset Program



It should be noted that while the Warragamba Offset Program will prioritise land suitable for inclusion in the National Park estate, additional offsets may be needed through purchase and retirement of biodiversity credits in order to meet the credit requirements for the Project. Any land containing suitable offsets must also be appropriate for the National Park estate and supported by NPWS for this purpose. 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 area impacted (1,400 hectares) and that this would incorporate a minimum area of 304 hectares containing constituent values for the OUV of the GBMWHA to offset potential impacts to the GBMWHA.

With regard to prioritising land that improves or supports the OUV for the GBMWHA, this would 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
- Eucalyptus species
- other biodiversity related matters:
  - 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.

This would be informed by the detailed assessment provided in Appendix J (World Heritage Assessment Report).

The Warragamba Offset Program will include the establishment of an advisory committee which would comprise a group of core representatives from DAWE, DPIE, NPWS, Local Land Services, Biodiversity Conservation Trust, Greater Blue Mountains World Heritage Area Management Committee, WaterNSW, and Infrastructure NSW, and would involve other parties such as local council and relevant subject matter experts where required. The advisory committee would be overseen by an independent chairperson.

The advisory committee would provide input into:

- consideration of compensatory options for both downstream and upstream that adhere to the NSW Biodiversity Offsets Policy for Major Projects, EPBC Environmental Offsets Policy, and OEH's Principles for the use of biodiversity offsets in NSW
- identification and prioritisation of potential compensatory options
- selection of final suite of biodiversity compensation package
- determining allocation of compensation funds to each action
- an annual Implementation Report to be issued to NSW and Commonwealth Governments outlining the actions taken and how compensatory obligations are being fulfilled.

13.6.2.2 Assessment of offset site options

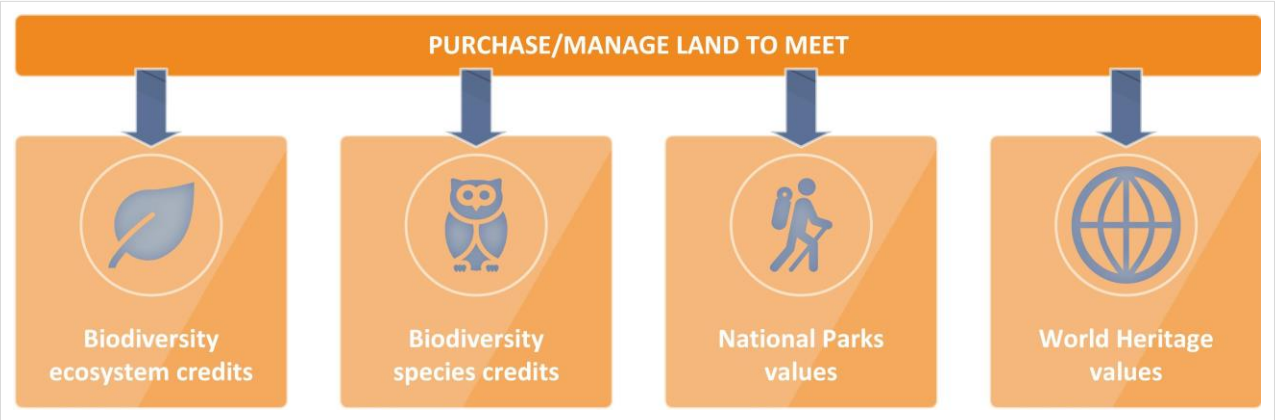
The Warragamba Offset Program would investigate the suitability of potential offset sites. This process would involve:

- initial desktop assessment to identify land which potentially contain plant community types, and species credit species habitat which meet the requirements of like-for-like, or allowable under the variation rules, in order to identify potential offset sites.
- Ground truth the identified potential offset sites for suitable PCTs and species credit species habitat. Targeted surveys may be required to determine presence of species credit species within the potential offset sites.
- Determine if areas of selected land are suitable for inclusion into national parks and World Heritage estate and add to the integrity of the world heritage area or protected land estate. Suitable lands may include freehold lands and properties within or immediately adjacent to the national parks and world heritage areas. Figure 13-2 illustrates the goal of the Warragamba Offset Program to target offset sites that meet both biodiversity and protected lands goals.
- Select offset sites and carry out necessary assessment and reporting consistent with establishing a Biodiversity Stewardship Agreement.
- Assessment will be carried out by an accredited person under the BC Act.

13.6.2.3 Establishment of offsets

It is proposed that the priority for the Warragamba Offset Program would be purchase of land suitable for inclusion in the National Park and protected areas system potentially included within the World Heritage area. This is consistent with the potential impacts of the Project occurring within the National Park system. WaterNSW will work with the National Parks and Wildlife Service to ensure that the land is suitable for inclusion and that costs of management of the lands to ensure the offset is delivered is appropriately considered in the Warragamba Offset Program. This is illustrated in Figure 13-2.

Figure 13-2. Targeting of offsets



Implementation of the Warragamba Offset Program would be audited to measure progress towards providing the required biodiversity credits and improvements to the protected lands system and world heritage values. Should additional offsets be required the following actions would be considered:

- purchase of additional land
- purchase and retirement of credits from the credit market
- implementation of supplementary measures that achieve benefits for species and communities potentially impacted by the project or benefit the management of the protected lands system or the integrity of world heritage values. The final suite of supplementary measures would meet the 18 rules governing the use of supplementary measures under the *NSW Biodiversity Offsets Policy for Major Projects*
- potential supplementary measures may include species specific actions recommended within the NSW saving our species program and commonwealth recovery plans; actions that contribute to threat abatement programs; biodiversity research and survey programs; actions that promote protection of world heritage values within the regional community.

13.6.2.4 Development and implementation of environmental management plan

The regulatory requirements for developing an environmental management plan (EMP) for the upstream operational area are discussed in Section 13.2.4. The EMP would be separate to the proposed Warragamba Offset Program but would complement and support the Program.

The scope and content of the EMP has yet to be defined but would need to be consistent with the existing management plans for the national parks and GBMWHA.

13.6.3 Offset strategy for downstream operational impacts

Offsets for potential impacts within the downstream area are not proposed as outlined in Appendix F2 (Downstream ecological assessment).

13.7 Evaluation of the proposed offset strategy against offset criteria

13.7.1 NSW offsetting principles

The *NSW Biodiversity Offsets Policy for Major Projects* is discussed in Section 13.2.1. Details of how the Project's offsets have been applied are summarised in Table 13-12.

Table 13-12. Consideration of NSW biodiversity offset policy principles

Principle	Application to the Project
1. Before offsets are considered, impacts must first be avoided, and unavoidable impacts minimised through mitigation measures. only then should offsets be considered for the remaining impacts.	The Project has applied the hierarchy of 'avoid-minimise-offset': ▪ *Avoid*: Options for avoidance are limited given the scale and nature of the development types. Alternatives to the Project have been considered as outlined in Chapter 4 of the EIS. ▪ *Minimise*: Mitigation measures to be employed as part of the construction and operational phases are outlined in Section 13.4.
2. Offset requirements should be based on a reliable and transparent assessment of losses and gains.	The impacts of the Project have been assessed following a transparent assessment methodology, the FBA. There are three key stages involved with the framework including: ▪ Stage 1 – Biodiversity Assessment ▪ Stage 2 – Impact Assessment of Biodiversity Values ▪ Stage 3 – Biodiversity Offset Strategy. The Biodiversity Assessment Reports prepared for the Project are consistent with the methods outlined in the FBA to assess biodiversity in relation to the project impacts. The impact assessment on biodiversity values is provided in: ▪ Appendix F1 (Biodiversity assessment report - upstream). ▪ Appendix F3 (Biodiversity assessment report - construction). Appendix F2 to the EIS (Downstream environmental assessment is compliant with Appendix B of the SEARs. This document addresses the requirements of Stage 3 of the FBA.
3. Offsets must be targeted to the biodiversity values being lost or to higher conservation priorities.	The proposed offset strategy targets the biodiversity values being potentially impacted and these are quantified through the FBA calculator.
4. Offsets must be additional to other legal requirements.	Offsets proposed in the BOS are additional to other legal requirements.
5. Offsets must be enduring, enforceable and auditable.	The Warragamba Offset Program would oversee the delivery of offsets to be made through either addition to the protected lands estate or through Biodiversity Stewardship Agreements. Any offsets made through these mechanisms would be enduring, enforceable, and auditable.
6. Supplementary measures can be used in lieu of offsets.	While efforts would be made to source biodiversity credits through land based offsets mechanisms, the use of supplementary measures may be required and be appropriate to meet offset requirements.

13.7.2 Commonwealth offsetting principles

The EPBC Act Environmental Offsets Policy is discussed in Section 13.2.3. Comment on how the Project is considered to address these requirements with regard to listed threatened species and ecological communities is provided in Table 13-13.

Table 13-13. Assessment against Environmental Offsets Policy requirements

Requirement	Assessment of the Project
Suitable offsets must deliver an overall conservation outcome that improves or maintains the viability of the protected matter.	The proposed approach to offsetting potential impacts of the Project prioritises identification and investigation of suitable land for offsets, and prioritises land that contains suitable credits, improves or supports the OUV for World Heritage, supports the integrity of protected lands, and protects Aboriginal cultural heritage and values. The BOS would be implemented through the Warragamba Offset Program.
Suitable offsets must be built around direct offsets but may include other compensatory measures.	The priority for the Warragamba Offset Program is on securing direct offsets. The use of other compensatory measures may be required to meet offset requirements.
Suitable offsets must be in proportion to the level of statutory protection that applies to the protected matter.	This is inherent in the proposed approach to implementation of the Warragamba Offset Program (refer also above comment for first requirement).
Suitable offsets must be of a size and scale proportionate to the residual impacts on the protected matter.	Suitable offsets would be determined through the use of the FBA to ensure they are proportionate to the residual risks.
Suitable offsets must effectively account for and manage the risks of the offset not succeeding.	The Warragamba Offset Program is being guided by the FBA which builds risk into the credit calculations. Offsets sites would be protected through either protected land status or Biodiversity Stewardship Agreements that provide long term legal protection to the sites.
Suitable offsets must be additional to what is already required, determined by law or planning regulations, or agreed to under other schemes or programs.	The Warragamba Offset Program will be additional to any existing statutory requirements.
Suitable offsets must be efficient, effective, timely, transparent, scientifically robust and reasonable.	The Warragamba Offset Program would be based on the FBA processes accredited under the EPBC Act that represent best practice in offset calculation. Any offsets made through these mechanisms would be efficient, effective, transparent, scientifically robust and reasonable.
Suitable offsets must have transparent governance arrangements including being able to be readily measured, monitored, audited and enforced.	The Warragamba Offset Program would provide a transparent process to audit and enforce implementation. An appropriate reporting program outlining progress towards meeting offset requirements will be included.

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