Hunter Power Project

Hydrology and Flooding Assessment

Rev 0

1 April 2021

Snowy Hydro Limited

Hunter Power Project

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Background

Snowy Hydro Limited (Snowy Hydro) ('the Proponent') proposes to develop a gas fired power station near Kurri Kurri, NSW ('the Proposal'). Snowy Hydro is seeking approval from the NSW Minister for Planning and Public Spaces under the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act) for the Proposal.

The Proposal involves the construction and operation of a power station and electrical switchyard, together with other associated supporting infrastructure. The power station would have a capacity of up to approximately 750 megawatts (MW) which would be generated via two heavy duty gas turbines. Although primarily a gas fired power station, the facility would also be capable of operating on diesel as required.

Construction activities are anticipated to commence early 2022 and the Proposal is intended to be fully operational by the end of 2023.

Purpose of this report

This assessment has been prepared to address the Secretary's Environmental Assessment Requirements (SEARs) (SSI 12590060) relating to water (flooding and hydrology and a detailed water balance). The assessment characterises the existing environment, assesses potential impacts and identifies appropriate mitigation measures to manage any potential impacts.

Potential impacts

The Proposal Site is located on the fringe of the floodplain of a tributary of Black Waterhole's Creek and the Hunter River regional floodplain. The site elevation of the former Kurri Kurri aluminium smelter site and the Proposal's Site levels are above the Probable Maximum Flood (PMF) level. The Proposal would not result in loss of floodplain storage or flow obstruction. Accordingly, there would be no changes to flood behaviour affecting existing developments, infrastructure or flood emergency evacuation routes as a result of the Proposal.

Development of the Proposal Site could potentially increase peak stormwater flows during storm events due to additional impervious surfaces and formalised drainage (in comparison to the current Kurri Kurri aluminium smelter site conditions in early 2021). These potential increased peak flows were modelled for the operational phase of the Proposal to determine the required stormwater detention volume. With the proposed stormwater detention basin, peak flows discharged to the unnamed tributary of Black Waterholes Creek will be maintained or reduced for up to the 1% AEP events. Alternatives to the proposed stormwater detention basin that achieve similar outcomes will be resolved during the detailed design process with the selected design and installation contractors.

Mitigation and management measures

Potential impacts during the construction and operation phase of the Proposal will be mitigated and managed through implementation of the following measure:

- Monitoring of the receiving waterway (tributary of Black Waterholes Creek) downstream of the discharge location(s) to identify any evidence of channel erosion and scour.

1. Introduction

1.1 The Proposal

Snowy Hydro Limited (Snowy Hydro) ('the Proponent') proposes to develop a gas fired power station near Kurri Kurri, NSW ('the Proposal'). Snowy Hydro is seeking approval from the NSW Minister for Planning and Public Spaces under the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act) for the Proposal.

The Proposal involves the construction and operation of a power station and electrical switchyard, together with other associated supporting infrastructure. The power station would have a capacity of up to approximately 750 megawatts (MW) which would be generated via two heavy duty gas turbines. Although primarily a gas fired power station, the facility would also be capable of operating on diesel as required, if there were a constraint or unavailability in the natural gas system and there was a need to supply electricity to the National Electricity Market (NEM).

The proposed power station would operate as a "peak load" generation facility supplying electricity at short notice when there is a requirement in the National Electricity Market. The major supporting infrastructure that is part of the Proposal would be a 132 kV electrical switchyard located within the Proposal Site. The Proposal would connect into existing 132 kV electricity transmission infrastructure located adjacent to the Proposal Site. A new gas lateral pipeline and gas receival station will also be required and this would be developed by a third party and be the subject of a separate environmental assessment and planning approval. Other ancillary elements of the Proposal include:

- Storage tanks and other water management infrastructure;
- Fire water storage and firefighting equipment such as hydrants and pumps;
- Stormwater basin
- Maintenance laydown areas;
- Diesel fuel storage tank(s) and truck unloading facilities;
- Site access roads and car parking; and
- Office/administration, amenities, workshop/storage areas

A detailed layout of the Proposal is shown in Figure 1.1.

Construction activities are anticipated to commence early 2022 and the Proposal is intended to be fully operational by the end of 2023. Further description of the Proposal is provided in Chapter 2 of the Environmental Impact Statement.

1.2 Site location and description

The Proposal Site is located in the small suburb of Loxford in the Hunter Valley region of New South Wales, approximately three km north of the town of Kurri Kurri, approximately 30 km west of Newcastle CBD and 125 km north of Sydney. The Proposal Site is located within the Cessnock City Council local government area (LGA). The location of the Proposal is shown on Figure 1.2.

The Proposal Site forms part of the former Kurri Kurri aluminium smelter site which is owned by Hydro Aluminium Kurri Kurri Pty Ltd (Hydro Aluminium). The aluminium smelter ceased operation in late 2012 and was permanently closed in 2014. Demolition and site remediation works are ongoing but would be completed at the Proposal Site prior to construction of the Proposal.

The Proposal Site's current condition is that of a brownfield site, extensively disturbed by past industrial development. The Proposal would require minimal if any new disturbance of undisturbed land.

The Proposal Site is mostly located within the existing electrical switchyard of the former Kurri Kurri aluminium smelter as shown on Figure 1.3. The existing electrical switchyard will be fully decommissioned and removed prior to the construction of the Proposal. The surrounds are primarily flat, with natural drainage falling gradually towards the north-east towards Black Waterholes Creek. There are two large, shallow artificial ponds located north-east of the Proposal Site, which were constructed to capture stormwater runoff from the Kurri Kurri aluminium smelter site and are integrated with the natural drainage regime. These ephemeral ponds overflow and discharge as irrigation to an adjacent paddock owned by Hydro Aluminium which is north of their site.

The Proposal Site and its surrounds are currently zoned RU2 Rural Landscape under the *Cessnock Local Environmental Plan 2011* (Cessnock LEP), with small pockets of surrounding land zoned E2 Environmental Conservation. However, the Proposal Site and vicinity is currently the subject of a rezoning application. Under this plan, the Proposal Site would be designated as Heavy Industrial. A large proportion of the land surrounding the Proposal Site comprising the former Kurri Kurri aluminium smelter site is still owned by Hydro Aluminium.

Immediately south of the Proposal Site are the remains of the former Kurri Kurri aluminium smelter and the M15 Hunter Expressway. There is some native vegetation adjacent to the Proposal Site in the north, east and west. Land further east and north of the Proposal Site comprises low-lying open rural land, and the waterways of Swamp Creek, Black Waterholes Creek and the Swamp Creek wetlands, which lead to the Wentworth swamps and are part of the extensive Hunter River floodplain. The Hunter River is approximately 9 km north-east of the Proposal Site in Maitland.

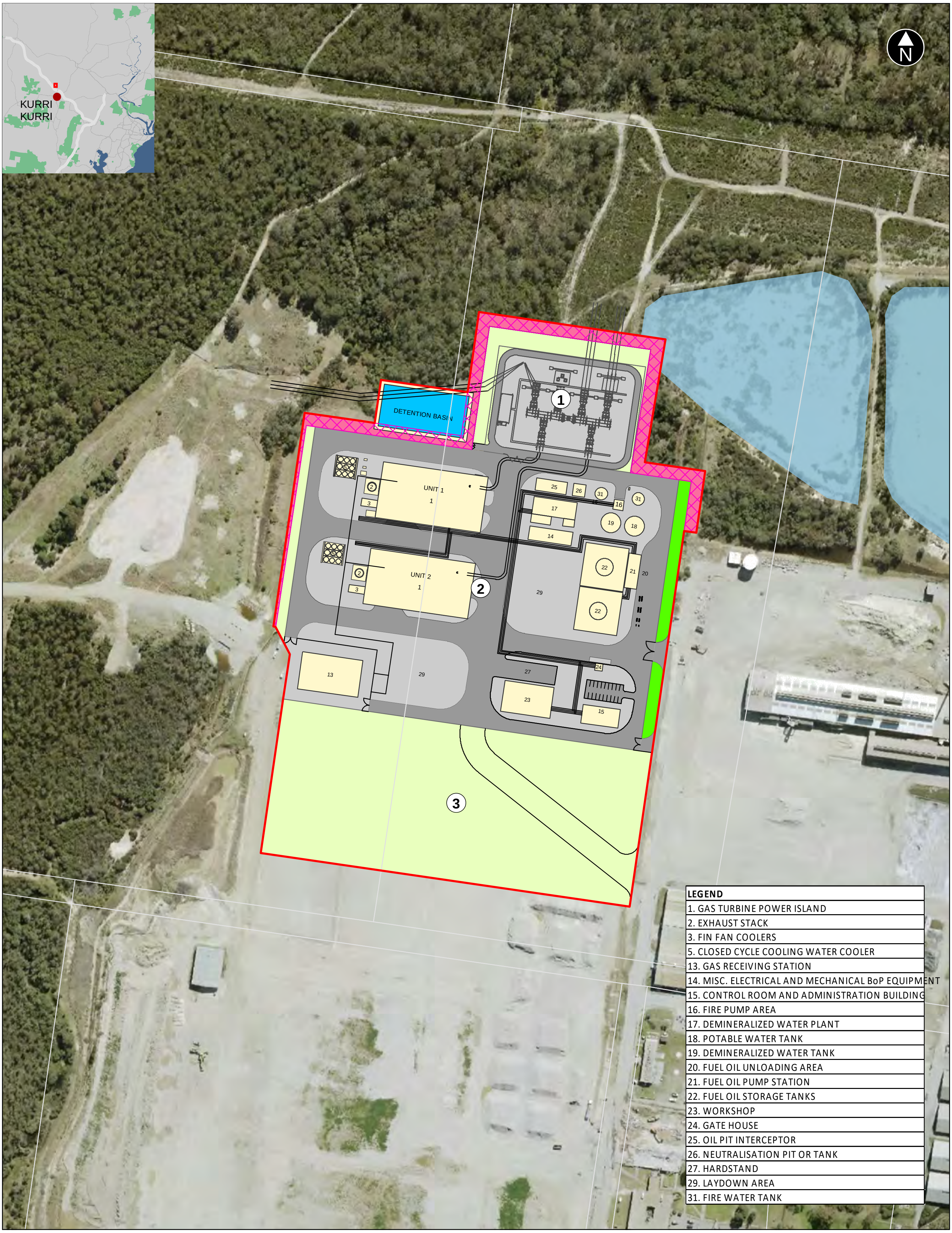
The closest residential zoned land is the suburban areas of Kurri Kurri, located approximately three km south and south-west of the Proposal Site. Further residential areas at Heddon Greta and Cliftleigh are situated approximately 2.5 km to the east. There are some sparse rural residential properties south and south-east of the Proposal Site, the nearest being located on Dawes Avenue, Loxford which is approximately 1.25 km south-east of the Proposal Site. The Kurri Kurri Speedway Club is on Dickson Road, Loxford and is approximately 800 to 850 metres south-east of the Proposal Site.

1.3 Secretary's Environmental Assessment Requirements (SEARs)

An environmental impact statement (EIS) for the Proposal has been prepared under Division 5.2 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). This Hydrology and Flooding Assessment has been prepared to support the EIS. The purpose of this report is to address the relevant sections of the Secretary's Environmental Assessment Requirements (SEARs) issued on 5 February 2021 (SSI 12590060). The report preparation has also taken cognisance of any applicable agency comments. Table 1.1 outlines the SEARs relevant to this assessment

Table 1.1: SEARs relevant to this assessment

Secretary's requirement
Water – including an assessment of flooding and hydrological impacts of the Proposal.
Water – including a detailed site water balance for the project, including water supply and wastewater disposal arrangements.



Proposal Site
Asset protection zone
Detention basin
Sealed roadway
Crushed rock
Landscaping
Grass / Road base
Existing waterbodies
Existing cadastre
(1) Proposed Switchyard Area
(2) Proposed Plant Area
(3) Proposed Buffer Area

0 100 200 m

1:4,000 at A4
GDA2020 MGA Zone 56

Data sources:
Jacobs
Metromap (Aerometrex) 2020
NSW Spatial Services

Figure 1-1 Proposal Site Layout

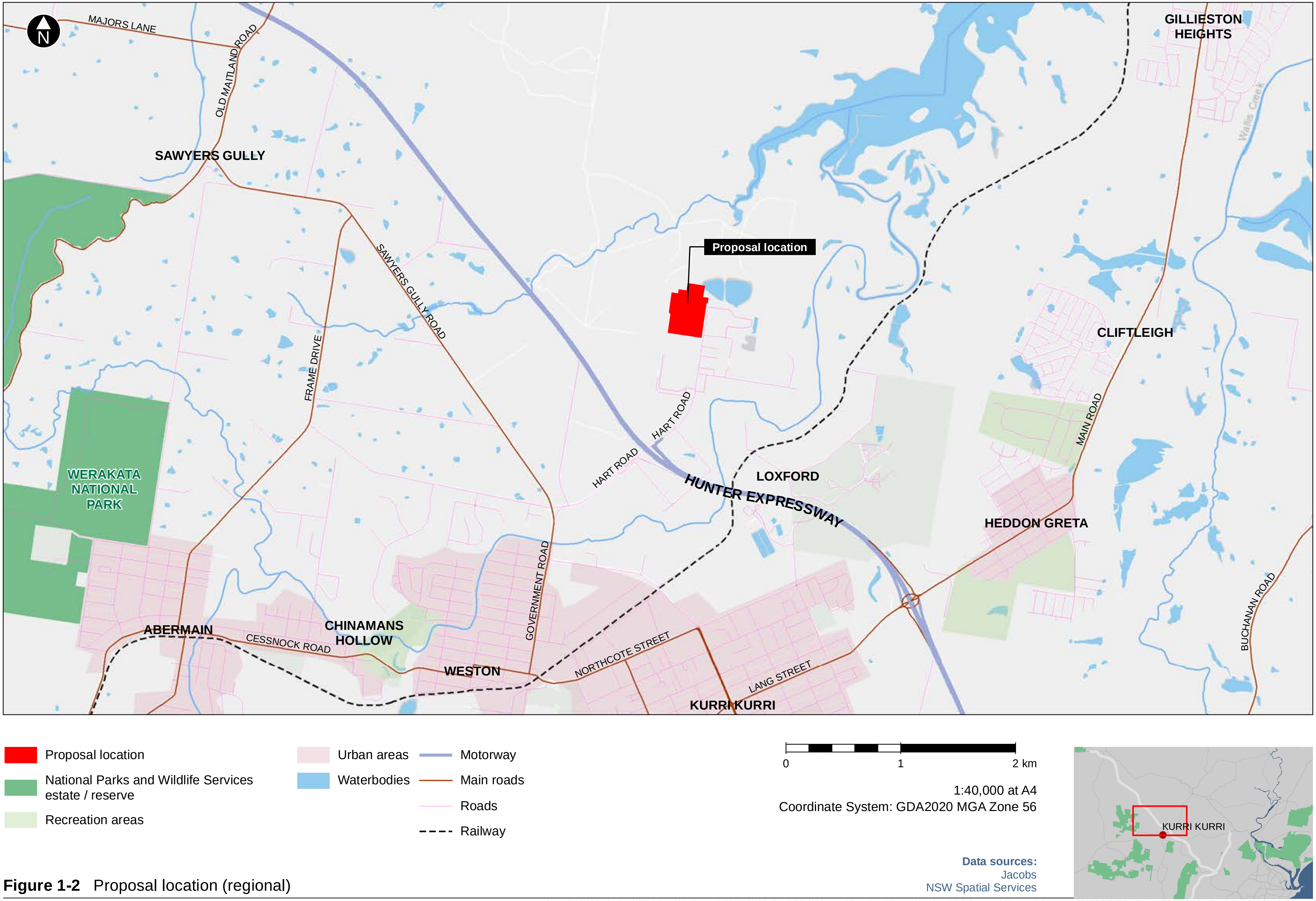
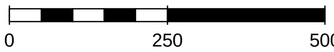


Figure 1-2 Proposal location (regional)

- Proposal Site
- Detention basin
- Existing electrical transmission easement
- Motorway
- Main roads
- Roads
- Railway
- Waterbodies

① Proposed Switchyard Area
② Proposed Plant Area
③ Proposed Buffer Area



1:12,000 at A4
Coordinate System: GDA2020 MGA Zone 56

Data sources:
Jacobs
Metromap (Aerometrex) 2020
NSW Spatial Services

Figure 1-3 Proposal location (local)

snowy hydro renewable energy Jacobs

2. Relevant legislation, guidelines and policies

2.1 Water Management Act 2000

Development on floodplains is managed under the *Water Management Act 2000,* including the provisions of floodplain management plans and ‘flood works’ i.e. works that affect, or are likely to affect, flooding and/or floodplain functions. Given the nature of the Proposal and the location on the fringe of the Hunter River floodplain and that of the unnamed tributary of Black Waterholes Creek adjacent the Proposal Site, the provisions under the *Water Management Act 2000* have been considered.

A controlled activity approval under section 91 of the *Water Management Act 2000* is required for certain types of developments and activities that are carried out in or near waterfront land. However, under the EP&A Act, a controlled activity approval is not required for CSSI, such as this Proposal, and so the NSW Office of Water’s guidelines for controlled activities on waterfront land have not been considered further.

Under Section 256 of the Act approval is required for construction of a building, fence or structure in, on, or adjacent to a levee bank or for the construction of a flood work on the declared Hunter River floodplain (as gazetted under the *Hunter Valley Flood Mitigation Act 1956*). Consultation with the NSW Department Planning, Industry and Environment (DPIE), who administer the *Water Management Act 2000*, confirmed that the Proposal Site is not in the vicinity of registered levee banks or other flood mitigation works, and is outside the declared floodplains as gazetted under the *Hunter Valley Flood Mitigation Act 1956*. As such there is no requirement for the Proponent to seek a Section 256 consent for the Proposal.

2.2 NSW Water Quality and River Flow Objectives

The *NSW Water Quality and River Flow Objectives* (DECCW, 2006) are the environmental values and long-term goals for NSW surface waters. The objectives are in two parts, the NSW water quality objectives and NSW river flow objectives, which are distinct because they relate to different environmental attributes of a waterway that are important for long-term functionality. Potential impacts of the Proposal to NSW river flow objectives nominated for waterways within the surface water study area have been described and addressed in this report. NSW water quality objectives have been described and addressed in the Surface Water Quality chapter 13 of the EIS.

The NSW river flow objectives identify the key elements of the flow regime that protect river health and water quality for ecosystems and human uses. Each objective aims to improve river health by recognising the importance of natural river flow patterns. A set of objectives have been developed specifically for the Hunter River. According to the Objectives, flow patterns in many rivers of NSW have been substantially altered and will not return to natural flow regimes. The NSW Government is not attempting to completely restore natural flow patterns where the community significantly benefits from altered flow patterns. Communities and the Government have identified important areas to maintain or improve river health while continuing to benefit from water use.

There are two key surface water management zones identified along the Hunter River by the Objectives and which are relevant to the Proposal area. These are:

- Estuary: Being dominated by saline conditions, estuaries have hydraulic and water quality characteristics, and potential problems, that are often different from those of freshwater systems. The entire Hunter River estuary, which extends from the ocean up to the Paterson River and includes adjoining mangrove areas and minor tributary inflow channels and waterways, is included in this category.
- Mainly forested areas: Streams in mainly forested areas are often valued for their conservation or recreational values. They often have relatively natural flows and water quality. The Objectives apply to streams running through state forests, national parks and nature reserves and through other forested areas, if any are defined locally (private land or Crown land). The lower reaches of Black Waterholes Creek are included in this category.

In total, there are twelve coastal River Flow Objectives, each dealing with a critical element of natural river flows and estuarine processes. Seven of these are relevant and are used in the impact assessment, refer to Section 6.2.2

2.3 Cessnock City Council Development Control Plan 2010

Chapter 9 of the *Cessnock DCP 2010* outlines the development controls related to development on flood prone land. The management of flood prone land is primarily the responsibility of local governments.

Table 3 in Section 3 categorises land use types into Development Categories according to the sensitivity of each use to flooding, and the relevant development controls which apply to each type of proposed development. Relevant to the development of the Proposal Site (identified as critical infrastructure – utility installations including electricity generating works), Table 3 specifies that critical infrastructure is required to be located outside of the floodplain, i.e. outside and above the PMF extent, and must consider and provide details on the management of floods up to an including the PMF. While CSSI development applications do not need to comply with the requirements of local planning instruments, cognisance has been taken of the intent of the DCP. The Proposal Site is outside the PMF extent.

2.4 Floodplain Development Manual (NSW Government, 2005)

The assessment of potential flooding impacts has been conducted in accordance with the requirements of the *Floodplain Development Manual* (NSW Government, 2005), which incorporates the NSW Government's *Flood Prone Land Policy*. The key objectives of this policy are to identify potential hazards and risks, reduce the impact of flooding and flood liability on owners and occupiers of flood prone property, and to reduce public and private losses resulting from floods. This policy also recognises the benefits of the use, occupation and development of flood prone land.

Given the Proposal Site's location on the fringe of the Hunter River floodplain and that of the unnamed tributary of Black Waterholes Creek adjacent the Proposal Site, the provisions in the *Floodplain Development Manual* have been considered.

2.5 Australian Rainfall and Runoff

Australian Rainfall and Runoff (Ball et al., 2019) is a national guideline for the estimation of design flood characteristics in Australia. The approaches presented in Australian Rainfall and Runoff (ARR) are essential for policy decisions and projects involving:

- Infrastructure such as roads, rail, bridges, dams and stormwater systems
- Floodplain risk management plans for urban and rural communities
- Flood warnings and flood emergency management
- Estimation of extreme flood levels.

This assessment has been undertaken generally in accordance with the key guidelines and design references of ARR.

2.6 Guidelines for Controlled Activities on Waterfront Land

Controlled activities carried out in, on or under waterfront land are regulated by the WM Act (2000). This Act defines waterfront land to include the bed and bank of any river, lake or estuary and all land within 40 m of the highest bank of the river, lake or estuary. The former Department of Industry (Water) (now Department of Planning, Industry and Environment (Water)) prepared guidelines for controlled activities which provide information on the design and construction of a controlled activity, and other ways to protect waterfront land.

However, under section 5.23 of the EP&A Act, an activity approval (including a controlled activity approval) under section 91 of the WM Act is not required for CSSI and so waterfront land has not been considered further in this assessment.

Despite the exemption, the design and construction of the Proposal would take into account the *Guidelines for Controlled Activities on Waterfront Land* (Department of Industry (Water), 2018)).

3. Assessment methodology

3.1 Methodology

The methodology for this hydrology and flooding assessment included the following:

- Desktop review of publicly available flood study reports from local council(s) and other sources to characterise existing flooding conditions at the Proposal Site and the surrounding areas.
- Qualitative assessment of potential impacts to flooding as a result of construction and operation of the Proposal. Given the very low flood risk of the Proposal Site, quantitative modelling assessment of flooding impacts is not warranted.
- Identify the potential impacts from flooding on the Proposal.
- Assessment of potential impacts to surface water hydrology as a result of construction and operation of the Proposal. Further details of the hydrology assessment approach are provided in Section 3.1.1.
- A detailed site water balance for construction and operation of the Proposal, including water supply and wastewater disposal arrangements
- Identify appropriate mitigation and management measures.

3.1.1 Hydrology assessment method

Watercourses relevant to the Proposal are ungauged, and no stream gauge data is available for any representative watercourses within an acceptable distance. A quantitative analysis of stream flow regimes has therefore not been conducted. Potential impacts to receiving waterways in terms of changes to the existing flow regime have therefore been inferred. Potential changes to stormwater discharges from the Proposal Site were estimated using DRAINS hydrological modelling software (version 2020.042). Table 3.1 summarises key assumptions adopted for the stormwater drainage assessment. Section 4.4 provides additional details of the existing and proposed drainage conditions.

A stormwater detention basin forms part of the Proposal Site drainage system and has been conceptually sized to maintain post-development peak flows equal to or less than pre-development peak flows. A stormwater detention basin represents the most common and accepted means of ensuring that peak discharges from a proposed development are no larger than peak discharges from the site prior to development. However, where there is limited space, unsuitable topography, contaminated soils or groundwater, other constraints or owner/operators preferences, it is possible to adopt other alternatives that achieve similar levels of stormwater peak discharge attenuation. These alternatives range from measures to increase stormwater infiltration (porous pavements, swales, infiltration pits) to various forms of storage (oversized pits and pipes, various types of tanks, or shallow ponding over portions of a site such as roads, car parking areas, or undeveloped portions of land). The most suitable method will be resolved during the detailed design process with the selected design and installation contractors.

3.2 Design criteria and performance outcomes

The key design criteria and standards adopted for the Proposal are:

- The Proposal Site would be situated above the probable maximum flood (PMF) or at least 0.5 m above the 1% Annual Exceedance Probability (AEP) flood level, whichever is the greater
- Minimise increases in flood levels due to the Proposal during flood events up to an including 1% AEP event
- Maintain post-development peak flows equal to or less than pre-development peak flows.

3.3 Sources of data

A summary of the information reviewed as a part of the assessment is provided below.

1) Hunter River: Branxton to Green Rocks Flood Study (WMAwater, 2010).

This flood study was prepared for Maitland City Council and defines the Hunter River flooding conditions relevant to the Proposal Site based on TUFLOW hydraulic models developed for the study area. The modelling was calibrated to the 1955, 1971, 1977 and 2007 historic flood events. A range of design floods were estimated, including the 50%, 20%, 10%, 5% , 2%, 1%, 0.5% and 0.2% AEP and PMF events. Climate change impacts on Hunter River flooding are estimated.

Flood mapping from the study is limited in extent to along the Hunter River and minor extension up the tributary waterways. The flood mapping does not extend up to the Proposal Site, however the peak flood levels defined for the 1% AEP and PMF events at the downstream end of Wallis Creek are relevant for the peak flooding conditions at the Proposal Site. Refer to Section 4.5 for discussion on the existing flood conditions at the Proposal Site, based on this and other relevant flood studies.

2) Wallis and Swamp Fishery Creek Flood Study (WMAwater, 2019).

This flood study is the most recent flood study undertaken for Wallis and Swamp Fishery Creek and was prepared for Maitland City Council and Cessnock City Council. Flood modelling was undertaken in a TUFLOW two-dimensional hydraulic model to define flooding conditions due to flooding originating from the Wallis Creek, Swamp Fishery Creek, Black Waterholes Creek and other tributaries in this catchment system. Flooding from the Hunter River was not analysed in the modelling undertaken for this study, but as described in WMAwater (2010) above, the Hunter River flood level at the downstream end of Wallis Creek defines the peak flood level for the 1% AEP and PMF events at the Proposal Site as a result of backwater flooding from the Hunter River.

The Hunter River flood extents are indicated on the flood mapping for this study. The impacts on Wallis and *Swamp Fishery Creek catchment flooding due to climate change is assessed.*

3) Cessnock City Council online flood mapping.

Cessnock City Council provides online flood mapping on their website (https://maps.cessnock.nsw.gov.au/intramaps96/default.htm) but which does not include the peak flood extent mapping for the Hunter River PMF event defined in WMAwater (2010). Only a combined 1% AEP flood extent defined by WMAwater (2010) and WMAwater (2019) is provided at the Proposal Site.

4) Environmental Impact Statement – Former Hydro Aluminium Kurri Kurri Smelter Demolition and Remediation (Ramboll Environ, 2016).

The EIS for the former Kurri Kurri aluminium smelter addresses the main environmental issues for the former smelter site demolition and remediation. It provides an overview of the previous stormwater management system. It describes the former Kurri Kurri aluminium smelter site as being above the 1% AEP flood level.

5) Hydro Aluminium Kurri Kurri Stormwater Management Report - Flood Modelling and Hydrology Review (PCB, 2018).

This report was prepared in response to stormwater runoff issues being identified in relation to the demolition works within the former Kurri Kurri aluminium smelter site. It describes the site as having a number of stormwater detention ponds that collect all stormwater. These ponds are pumped to two large stormwater retention ponds in the north of the Kurri Kurri aluminium smelter site which in turn are discharged by an irrigation system to a licensed discharge area. The report identifies the 1% AEP and PMF levels relevant to the Kurri Kurri aluminium smelter site. Water balance modelling was undertaken to determine cumulative site flows from each of the stormwater detention ponds together with reuse for site dust control and the local catchment areas draining to the two larger existing stormwater retention ponds.

6) LiDAR ground level data.

LiDAR ground level data captured by NSW LPI in 2012 at 1 metre intervals and vertical accuracy of +/- 0.15 m was reviewed for the Proposal Site and surrounds. The data set indicates approximate ground levels at the Proposal Site of between 13.3 m AHD and 14.4 m AHD at the time of data capture. Recent ground survey of the existing Proposal Site indicated that the LiDAR elevations are reasonably accurate with regards to actual levels at the Proposal Site.

Table 3.1: Key Assumptions for Hydrology Assessment

Aspect	Existing Case	Proposed Case
Proposal Site area	Cleared, practically flat, graded former smelter site raised pad 11.83 ha	11.83 ha comprised of three sub areas (refer to Figure 1.1): Switchyard – 1.29 ha Plant (incl. landscaping) – 6.81 ha Buffer – 3.73 ha
Drainage summary	100% of site gravity drainage to unnamed tributary of Black Waterholes Creek to reflect natural site drainage conditions (without the smelter site retention ponds)	100% of site gravity drains to new stormwater detention basin located in the north of the Proposal Site
Slope	Approximately 0.7% based on current LiDAR	Assumed similar 0.7 % is adopted for Proposal Site, but this is subject to detailed design
Landuse surface	Compacted gravel	Switchyard – compacted gravel Proposed Plant – compacted gravel and road base, buildings with roofs, and concrete slabs Buffer – grassed/compacted gravel and grass
Fraction Impervious	Assumed 10%	Switchyard – 20% Proposed Plant – 75% Buffer – 10%
Stormwater detention	Nil	Estimated stormwater detention basin capacity of 2,240 m^3 (nominal 2,000 m^2 at a maximum pond depth of 1.12 m) Estimated 1,200 mm diameter piped outlet (or equivalent) and 15 m long high flow weir

4. Existing environment

4.1 Regional setting

The Proposal Site is situated within the Wallis Creek catchment, a tributary of the Hunter River. The Wallis Creek catchment is approximately 400 km^2 (40,000 ha) (WMAwater, 2019) and has a confluence with the Hunter River approximately 1.5 km east of Maitland (10.5 km northeast of the Proposal Site). Named tributaries of Wallis Creek include Swamp Creek, Deep Creek, Sawyers Creek, Black Waterholes Creek and Bishops Creek (Figure 4.1).

Local receiving waterways for the Proposal Site comprise Swamp Creek to the east and an unnamed tributary of Black Waterholes Creek which flows along the Proposal Site western boundary. Black Waterholes Creek and Swamp Creek converge approximately 2.25 km north-east of the Proposal Site into Wentworth Swamp. Downstream of Wentworth Swamp, Swamp Creek subsequently discharges into Wallis Creek approximately 1.5 km south of South Maitland. While all watercourses and drainage lines within the Wallis Creek catchment are ephemeral, the lower reaches of Wallis Creek are located on the extensive Hunter River floodplain and are subject to tidal influence from the Hunter River (WMAwater, 2019).

A description of the local watercourses in the vicinity of the Proposal Site is provided below. Table 4.1 summarises relevant attributes of watercourses relevant to the Proposal Site.

4.1.1 Swamp Creek

Swamp Creek rises approximately 14 km to the south-west of the Proposal Site in the Broken Back Range. Flowing in a generally north-east direction, it has a confluence with Deep Creek approximately 4 km south-west of the Proposal Site. Continuing to flow north-east, the main channel passes to the east of the Proposal Site before discharging into Wentworth Swamp along with Bishops Creek and Black Waterholes Creek approximately 2.5 km north-east of the Proposal Site. Downstream of Wentworth Swamp, Swamp Creek subsequently discharges into Wallis Creek south of South Maitland (Refer to Figure 4.1).

The catchment area of approximately 23,300 ha is comprised of the moderately steep and dissected hillslopes of the Broken Back Range in the south with elevations of up to 220 mAHD, gently undulating hills though the mid-catchment and a lower catchment comprised of an extensive system of flat, low-elevation floodplains and wetlands where elevations are typically less than 5 mAHD.

In the upper catchment, the main channel traverses through Aberdare State Forest, before passing through the undulating and mostly timbered area of Kearsley and Neath. Downstream of Neath, Swamp Creek passes through generally flat and open terrain along the southern-eastern portion of the Abermain township, before being joined by Deep Creek at Weston. The channel then follows a path through the centre of the urban area of Weston and the western suburbs of Kurri Kurri, before draining to Wentworth Swamp (WMAwater, 2019). The catchment also includes a number of additional urban centres including Cliftleigh, Gillieston Heights and the southern part of Rutherford. Significant industrial developments include the former aluminium smelter site at Loxford and a large commercial/industrial development east of Rutherford.

Adjacent to the Proposal Site, the main channel of Swamp Creek flows in a northerly direction and is comprised of a moderately sinuous (i.e. degree of meanders and bends), well-defined channel traversing an extensively cleared catchment. Riparian vegetation is largely present although at times discontinuous. Downstream of the Proposal Site, the main channel appears increasingly sinuous as it enters an extensively cleared floodplain and discharges into Wentworth Swamp.

4.1.2 Black Waterholes Creek

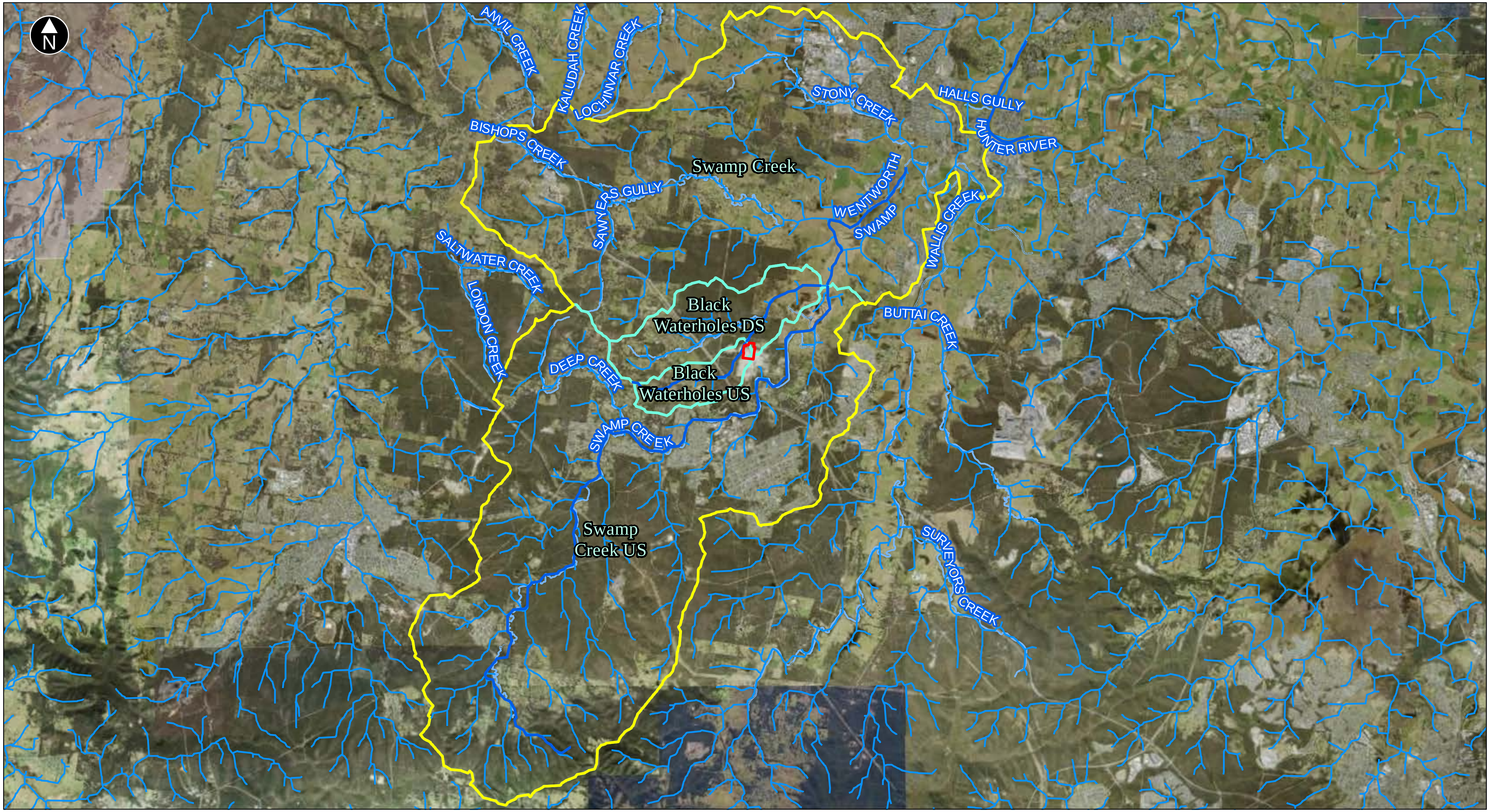
Black Waterholes Creek rises approximately 4 km to the west of the Proposal Site and is predominately located in the Sawyers Gully suburb. The main channel typically flows in an easterly direction before discharging into Wentworth Swamp at the confluence with Swamp Creek. The catchment area of approximately 1,700 ha is typically comprised of gently undulating hills to a maximum elevation of approximately 70 mAHD in the west, falling to less than 5 mAHD at its confluence with Swamp Creek. The catchment is bisected by the M15 motorway (Hunter Expressway) which runs approximately north-south to the east of the Proposal Site.

To the west of the M15 motorway, the catchment is extensively cleared with land use typically consisting of agricultural activities including grazing, intensive animal production and some dryland cropping. The low sinuosity main channel and tributaries appear to be poorly defined, at times discontinuous and subject to frequent impoundment and extraction from online and offline farm dams.

To the east of the M15 motorway, landuse comprises large areas of remnant vegetation which encroach the Proposal Site to the north, east and west. The main channel and tributaries show increasing sinuosity and incision and some natural pools and waterholes are noted. West of the Proposal Site an unnamed tributary of Black Waterholes Creek appears as a low sinuosity, poorly defined drainage line that appears in sections to have been realigned during construction of the smelter site pad. Downstream of the Proposal Site the unnamed tributary traverses through a large area of remnant vegetation before discharging into the main channel of Black Waterholes Creek approximately 1 km north-east of the Proposal Site.

Table 4.1: Watercourse Summary

Watercourse	Description	Details
Swamp Creek	Major tributary of Wallis Creek which subsequently discharges into the Hunter River east of Maitland. Flows along eastern boundary of Proposal Site.	Total catchment area of approximately 23,300 ha of which approximately 1,700 ha is comprised of Black Waterholes Creek catchment. Total catchment upstream of tributary with Black Waterholes Creek is approximately 11,600 ha.
Black Waterholes Creek	Located on western boundary of Proposal Site and a tributary of Swamp Creek which it joins approximately 2.25 km north-east of the Proposal Site. Comprised of an unknown tributary as it passes the Proposal Site.	Total catchment area of approximately 1,700 ha of which approximately 443 ha is upstream of the Proposal Site.



Proposal site
Catchment
Subcatchment
Main stream
Watercourse

0 2 4 km

1:150,000 at A4
Coordinate System: GDA2020 MGA Zone 56

Data sources:
Jacobs 2020
Metromap (Aerometrex) 2020
NSW Spatial Services

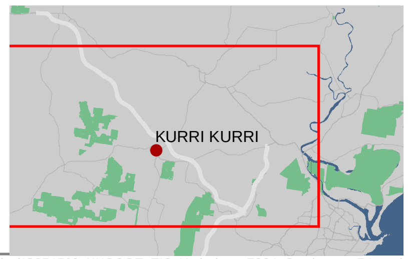


Figure 4-1 Surface Water Features and Catchments

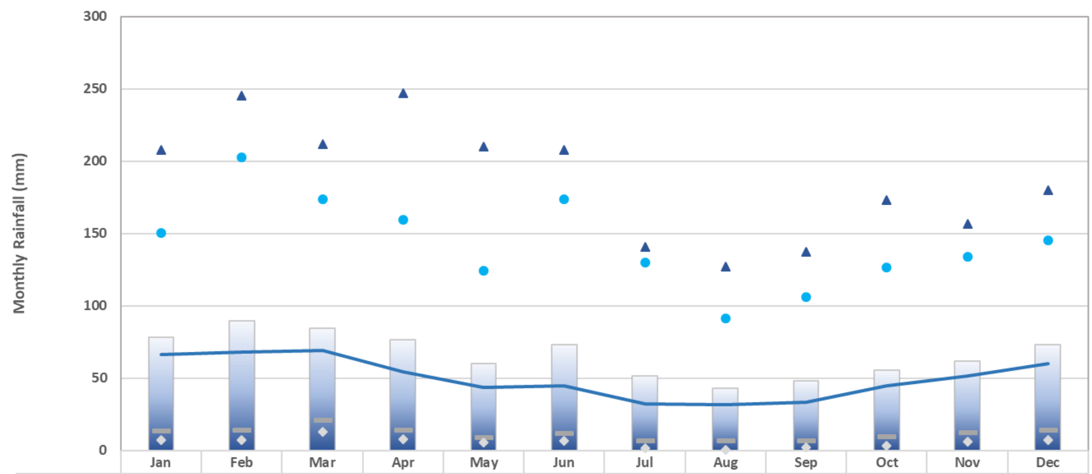
4.2 Climate

The climate at the Proposal Site has a Köppen classification of temperate (no dry season (hot summer)) with a mean maximum summer temperatures of 29.2°C to 30.5°C and a mean maximum winter temperatures of 17.6°C to 19.5°C (Cessnock Airport AWS 061260). Long term climate data from the Proposal Site was obtained from the Bureau of Meteorology (BoM) SILO Data Drill which is derived from the BoMs extensive database of recorded observations taken from its network of weather recording stations. Representative long-term rainfall data for the Proposal Site is presented in Table 4.2 and Figure 4.2 and summarised below:

- Median annual rainfall is approximately 794 mm;
- Annual rainfall variability is relatively low with a standard deviation of 200 mm and coefficient of variation of 0.25;
- Monthly rainfall shows a low to moderate degree of seasonal distribution with a drier period of lower rainfall from July through November and a wetter period from December through April; and
- Median monthly rainfall is lowest in August (31.7 mm) and highest in February (67.8 mm).

Table 4.2: Annual Rainfall Statistics (SILO Data Drill, 1900-2020)

Statistic	Annual rainfall (mm)
Mean	794
P95	1,154
P90	1,055
P50 (Median)	782
P10	545
P5	498
Standard deviation (mm)	200
Coefficient of variation	0.25



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	78.3	89.7	84.5	76.3	60.1	73.2	51.6	42.9	48.3	55.1	61.9	73.2
95th %ile	207.7	245.0	211.6	246.7	210.1	207.9	140.7	126.8	137.1	173.0	156.5	180.0
90th %ile	150.6	202.6	173.6	159.3	124.1	173.4	129.9	91.3	105.8	126.4	133.7	145.1
Median	66.0	67.8	69.3	54.2	43.6	44.4	32.1	31.7	33.0	44.5	51.4	59.9
10th %ile	13.4	14.1	21.0	13.8	8.7	11.7	6.3	6.4	6.7	9.2	12.4	14.2
5th %ile	7.3	7.1	12.8	7.9	5.4	6.6	1.4	0.4	1.7	3.4	6.0	7.0

Figure 4.2: Monthly Rainfall Statistics (SILO Data Drill, 1900-2020)

4.3 Watercourse hydrology

As described in Section 3.1.1, watercourses relevant to the Proposal are ungauged, and no stream gauge data is available for any representative watercourses within an acceptable distance. Quantitative analysis of stream flow regimes has therefore not been conducted. However, the following qualitative observations are made:

- Watercourses are described as ephemeral (WMAwater, 2019) and, in the instance of the unnamed tributary of Black Waterholes Creek, likely to be largely episodic, subject to flow only during and after significant rainfall events and followed by relatively rapid recession.
- Flows are unlikely to be strongly seasonally distributed although a summer high flow season is expected due to the higher monthly rainfall during the summer (Figure 4.2).
- The low channel gradients and channel geomorphology of the mid to low catchments are likely to result in prolonged storage of standing water within the channel giving rise to a series of ponds and waterholes.

4.4 Drainage conditions

4.4.1 Historical site drainage

The Kurri Kurri aluminium smelter site owned by Hydro Aluminium was originally constructed on a raised pad constructed to approximately 16 mAHD. Grading of the pad was completed to facilitate drainage and stormwater drainage during the operational phase of the smelter comprised of subsurface and open channels throughout the site with flows initially reporting to three dams located within the site (South, Eastern and Western Dams) (Figure 4.3) . These dams served as the initial collection and treatment points for stormwater (Ramboll Environ, 2016).

Two additional large stormwater retention ponds are located in the north-east of the Kurri Kurri aluminium smelter site (known as the North Dam). These were used as part of the water collection and treatment system for the Kurri Kurri aluminium smelter capturing surface water runoff from the site as well as receiving water that had passed through the East and West Dams. Under EPL 1548 Hydro Aluminium was permitted to irrigate an area of Hydro Aluminium land north of the Kurri Kurri aluminium smelter site with water from these dams (Figure 4.4) (Ramboll Environ, 2016).

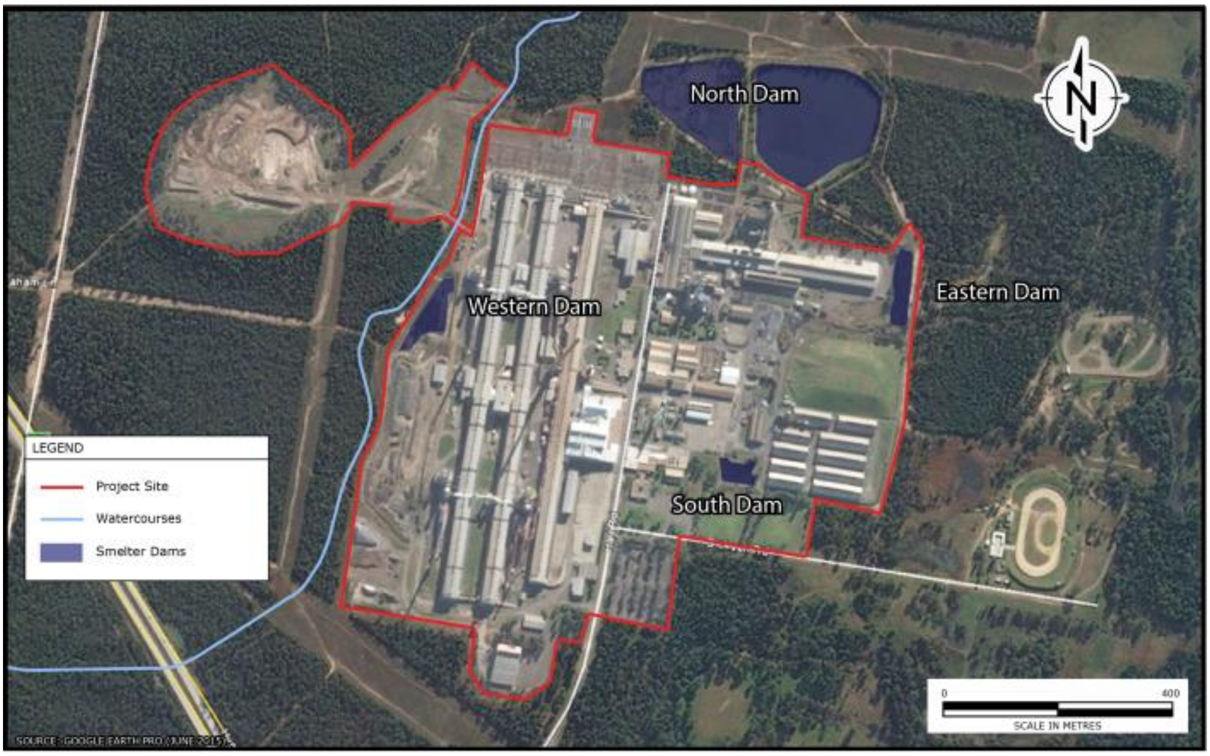


Figure 4.3: Historical Stormwater Management Dams (Ramboll Environ, 2016)

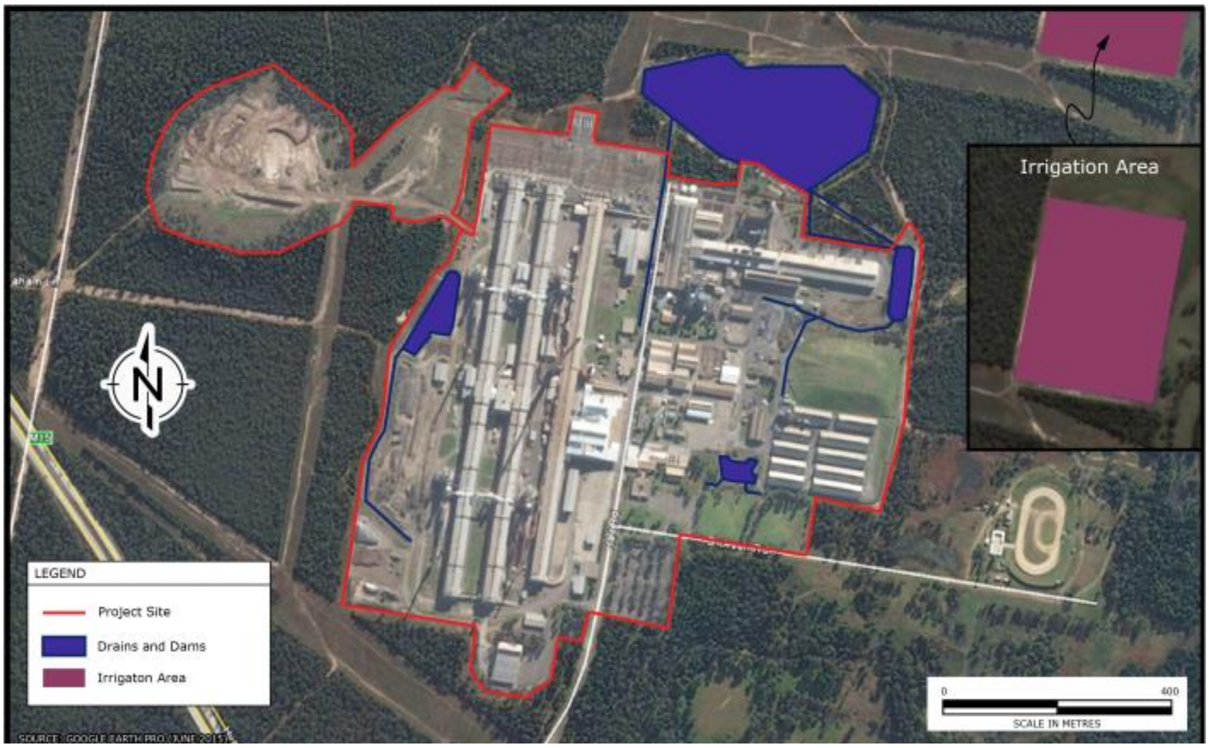


Figure 4.4: Historical Stormwater Management Infrastructure (Ramboll Environ, 2016)

4.4.2 Existing site drainage

The Proposal Site is located at the north-western corner of the former Kurri Kurri aluminium smelter site. Review of LiDAR ground elevations and aerial photography indicates that the eastern half of the site drains to the North Dam, with drainage channels and pipe outlets visible on aerial photography and observed during field visits. The western half of the site drains via overland flow, shallow channels and pipes (again observed during field visits) to the unnamed tributary of Black Waterholes Creek in the west. Open channels along the northern and eastern boundary of the proposed Proposal Site facilitate this drainage to the existing stormwater retention ponds and to the unnamed tributary of Black Waterholes Creek. Refer to Figure 4.5.

However, for the purposes of the hydrology assessment it has been assumed that 100% of the Proposal Site will gravity drain to the unnamed tributary of Black Waterholes Creek. This is to reflect natural site drainage conditions (without the Kurri Kurri aluminium smelter site retention ponds). Table 3.1 provides a summary of key assumptions adopted for the hydrology assessment.

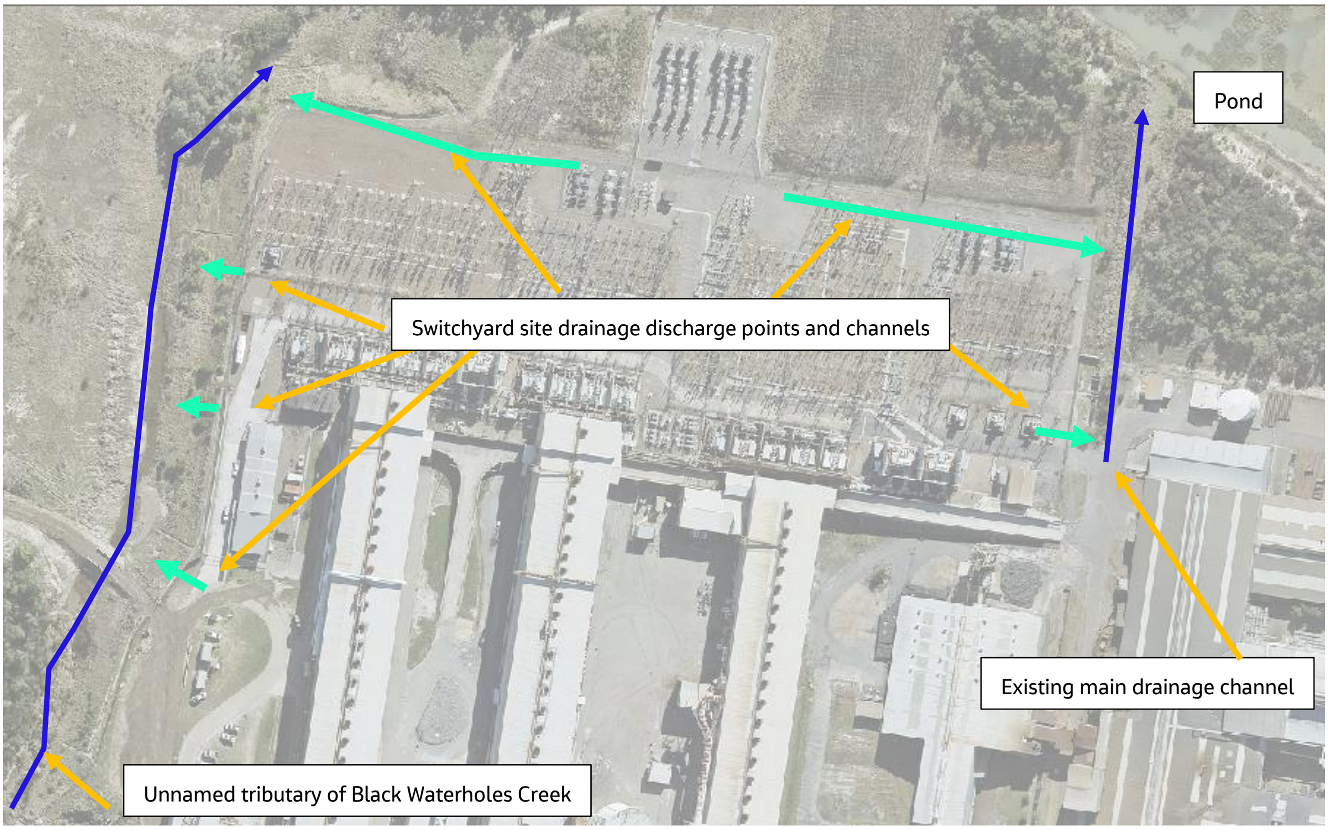
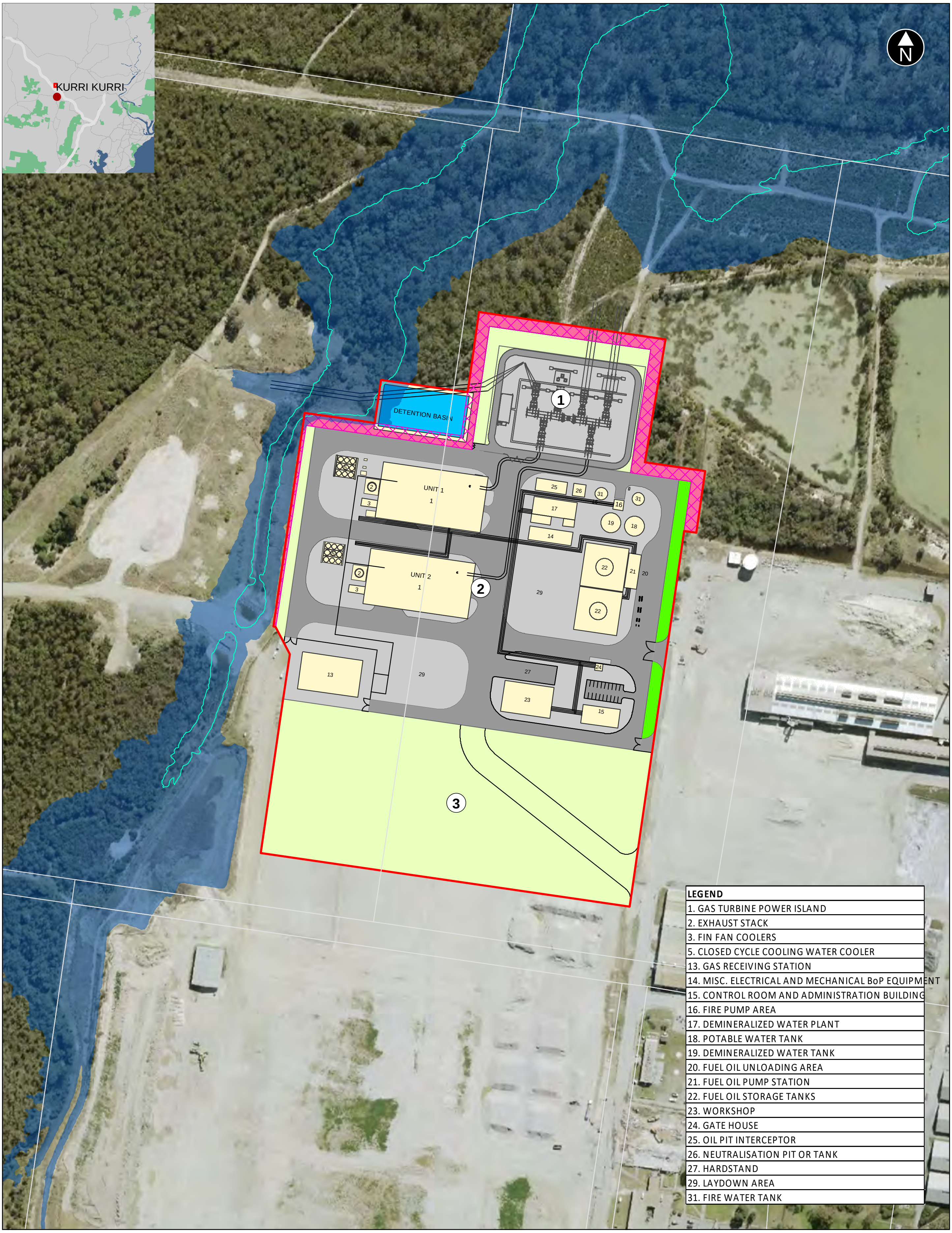


Figure 4.5: Existing switchyard site drainage arrangement (Aerial photography circa 2018)

4.5 Existing flood conditions

Flooding at the Proposal Site occurs as a result of both local catchment flooding in the unnamed tributary of Black Waterholes Creek in addition to backwater flooding from the Hunter River. For flood events up to and including the 2% AEP event, local catchment flooding in the unnamed tributary of Black Waterholes Creek dominate peak flooding at the site. Peak flood levels and depths at the Proposal Site in the 1% AEP event and larger are dictated by Hunter River backwater flooding, rather than flooding from local watercourses (WMAwater, 2019). The 1% AEP flood level is 9.73 mAHD and the PMF level is 11.71 mAHD (WMAwater, 2010) for the current climate (no climate change). The flood extents are mapped in Figure 4.6 based on the reported peak flood levels and LiDAR data. The Proposal Site is entirely above PMF level.



Proposal Site
Asset protection zone
1% AEP flood extent
Possible maximum flood extenet
1 Proposed Switchyard Area
2 Proposed Plant Area
3 Proposed Buffer Area

0 100 200 m

1:4,000 at A4
GDA2020 MGA Zone 56

Data sources:
Jacobs
Metromap (Aerometrex) 2020
NSW Spatial Services

Figure 4-6 Regional flood extents

5. Site water balance

Indicative water demands, water sources, discharges and wastewater disposal for the Proposal, during both construction and operation, are presented in the following sections.

5.1 Construction

5.1.1 Proposal water demands and source

During construction, some of the key water demands are anticipated as follows:

- Earthworks – conditioning of bulk fill materials and pavement foundations
- Dust suppression – access tracks and work areas
- Concrete curing
- Irrigation for revegetation and landscaping
- Potable water for use at site offices, crib rooms and ablutions.

Indicative estimates of water demands are provided in Table 5.1 and are based on preliminary construction material estimates.

Over the duration of construction (anticipated to be approximately two years), approximately 8.5 ML of water is estimated to be required, nominally 4.25 ML per year. This is equivalent to an average daily demand of approximately 11.6 kL or 0.28 L/s for a 12 hour working day.

It is expected that all construction water demands would be supplied to the Proposal Site by Hunter Water via a connection into their existing potable water network available in the vicinity of the Hart Road and Dickson Road junction. There may be the potential to use rainwater collected from temporary site offices and stored in on-site tanks.

There may also be potential to opportunistically utilise water within the proposed sediment basin for uses such as dust suppression and fill conditioning. However, water availability from the basin is not guaranteed as there is an environmental requirement to empty the basin within five days following a storm event.

Table 5.1: Estimate of total construction water demands

Water Use	Requirement (ML)	Assumption
Earthworks	0.10	Allowance to increase antecedent soil moisture content by 5% to reach optimum moisture content. 2,000 m3 fill requirement
Dust suppression	3.65	Allowance of two 10,000 L tankers per day for summer months for duration of construction (assumed 2 years)
Concrete batching	Nil	Assume procured offsite and imported
Concrete curing	0.25	Allowance of 5% of concrete volume (20 L per tonne) 12,000 tonnes of concrete (approx. 5,000m3) assumed
Irrigation	0.12	Allowance 2,000 L per day for last two months of construction
Potable	4.38	Allowance of 50 L per day per person for duration of construction Estimated average workforce per day of 120 personnel
Total	**8.5**	

5.1.2 Proposal discharge locations

Discharge of stormwater from the Proposal Site will only occur via the proposed sediment basin. Discharge will be monitored and managed in accordance with a Construction Environmental Management Plan (CEMP) and any relevant regulatory conditions.

Any wastewater produced during construction will be collected and disposed of off-site at an approved facility or discharged to Hunter Water's existing sewer system which is located within the existing Kurri Kurri aluminium smelter site.

5.2 Operation

5.2.1 Operational water demands and supply

During operation of the Proposal, the main water demands are expected to include:

- Input to the demineralised water treatment plant for the production of demineralised water for wet compression/fogging and NO_x emission control when operating on diesel
- Inlet air / evaporative cooling for the gas turbines
- Supply to workshops, amenities and administration buildings, including kitchens, safety showers, eyewash facilities, etc.
- Make-up supply for the firefighting and emergency facilities
- Plant wash down
- Landscaping irrigation.

Operational water demands will vary depending on the fuel used, with natural gas having lower water consumption demands compared to operating on diesel fuel. Annual water usage is also highly dependent on the ambient temperature during operation and at what rate and when the evaporative coolers and/or wet compression/fogging are utilised.

Indicative water demands based on the largest expected F Class gas turbine are summarised on Table 5.2. This will be dependent on the eventual gas turbine selected for the Proposal and will be refined during the detailed design process.

The estimated potable water demand, emanating from the potable water tank on the Proposal Site, is expected to be up to approximately 133 kL/hr. This does not correspond to the instantaneous water demand on the Hunter Water supply connection due to the presence of the potable and demineralised water tanks on the Proposal Site which help buffer out the instantaneous demands.

Increased demands of demineralised water for nitrous oxide control are required for operation on diesel. The indicative total annual water demand for operation of the Proposal is approximately 80 ML based on a 10 per cent Capacity Factor[1] on natural gas and two per cent Capacity Factor on diesel (total of 1,051 hours per year, comprising approximately 876 hours on gas 175 hours on diesel fuel) which the Proposal is seeking approval for. The expected Capacity Factor is more likely to be two per cent per year which would result in considerably less water demand volumes.

All operational water demands can be supplied to the Proposal by Hunter Water via a new connection to their existing potable water network. Demineralised water would be produced on site via a demineralised water plant which will be fed from the potable water supply.

[1] The Capacity Factor is the proportion of actual energy generated per year (expressed as MWh) compared with the total energy that could have been produced if operating at full load for every hour of the year (expressed as MWh).

Table 5.2: Estimated operational water demands for main plant components

Water Demand	**Fuel type**	
	Natural Gas (kL/hr)	**Diesel (kL/hr)**
Evaporative cooler make-up	67.7	67.7[2]
Demineralised Water Plant Supply	65.3	65.3
Domestic Use	0.075	0.075
POTABLE WATER TOTAL	**133.1**	**133.1**
Wet compression / fogging	57.6	0.0
NOx emission control	0.0	144.0
Compressor washing (as required)	7.2	7.2
DEMINERALISED WATER TOTAL	**64.8**	**151.2**

5.2.2 Proposal discharge locations

Discharge of stormwater from the Proposal Site would occur via a proposed stormwater detention basin (subject to detailed design). Discharge will be monitored and managed in accordance with an Operational Environmental Management Plan (OEMP) and any relevant regulatory conditions.

Process wastewater and sewage will be collected and disposed of to an existing Hunter Water sewer under a trade waste agreement.

The indicative total annual wastewater volume for operation of the Proposal is approximately 16.2 ML, again based on a 10 per cent Capacity Factor on natural gas and two per cent Capacity Factor on diesel. Again, the expected Capacity Factor is more likely to be two per cent per year which would result in considerably less wastewater disposal volumes.

[2] The same estimate has been used for diesel operation. However, it is expected that the evaporative cooler make-up flow when operating on diesel will be slightly less than when operating on gas due to lower expected power outputs.

6. Assessment of potential impacts

6.1 Flooding

The Proposal Site is located on the fringe of the floodplain of a tributary of Black Waterhole's Creek and the Hunter River regional floodplain. The site elevation of the former Kurri Kurri aluminium smelter site and the Proposal's Site levels are above the PMF level . The Proposal would not result in loss of floodplain storage or flow obstruction. Accordingly, there would be no changes to flood behaviour affecting existing developments, infrastructure or flood emergency evacuation routes. From review of flood mapping in WMAwater (2019) and topographic data, local road access from the Proposal Site to the M15 Hunter Expressway is maintained during and up to the 1% AEP storm event at a minimum.

The PMF is more than 0.5 m higher than the 1% AEP flood level (refer Section 4.5) and the Proposal Site is above the PMF. This meets the adopted design criteria and performance outcomes for the Proposal.

6.1.1 Consideration of climate change impacts on flooding

The Proposal is expected to have an operational life of approximately 30 years. Based on the information presented in WMAwater (2010), the 1% AEP flood level is estimated to increase from year 2021 levels by approximately 0.2 m for every 10 per cent increase in rainfall as a result of climate change.

Interim climate change factors for the year 2050 for an upper range projection scenario of anthropogenic greenhouse gas emissions are available from *Australian Rainfall and Runoff 2019*. This source suggests a nine per cent increase in storm rainfall intensities in the Hunter Region between 2021 and 2050. Hence, the 1% AEP Hunter River flood level could increase by 0.2 m by the year 2050. This level remains below the current low point of the Proposal Site.

Based on current climate change guidance relating to storm rainfall intensity and flooding, the PMF level is not expected to increase as a result of climate change in this timeframe. Hence, the Proposal is expected to remain above the PMF level during its design life under the climate change conditions.

6.2 Hydrology

Construction of the Proposal could potentially affect hydrology (frequency, volume, rate, duration and velocity) and increase peak stormwater flows during storm events as a result of the following activities:

- Vegetation clearance and reduced rates of stormwater infiltration associated with further soil compaction and introduction of impervious layers
- Temporary alteration or restriction of existing drainage paths and catchments
- Additional impervious surfaces and formalised drainage
- Discharge of flow from the proposed stormwater detention basin, designed to capture all runoff from an 85th percentile five-day rainfall event
- Implementation of a stormwater detention basin

Development of the Proposal Site could potentially increase peak stormwater flows during storm events due to additional impervious surfaces and formalised drainage. These potential increased peak flows were modelled for the operational phase of the Proposal.

However, the stormwater detention basin will maintain or reduce peak flows discharged to the unnamed tributary of Black Waterholes Creek up to the 1% AEP event. A preliminary calculation of the required detention volume is 2,240 m^3.

A stormwater detention basin represents the most common and accepted means of ensuring that peak discharges from a proposed development are no larger than peak discharges from the site prior to development. However, where there is limited space, unsuitable topography, contaminated soils or groundwater, other constraints or owner/ operators preferences, it is possible to adopt other alternatives that achieve similar levels of stormwater peak discharge attenuation. These alternatives range from measures to increase stormwater infiltration (porous pavements, swales, infiltration pits) to various forms of storage (oversized pits and pipes, various types of tanks, or shallow ponding over portions of a site such as roads, car parking areas, or undeveloped portions of land). The most suitable method will be resolved during the detailed design process with the selected design and installation contractors.

6.2.1 Stormwater modelling (DRAINS) results

Table 6.1 below summarises the stormwater discharge modelling results, showing peak discharge rates from the Proposal Site for the existing and proposed case. Results are shown for a range of design storm events from 63% AEP (one exceedance per year) to 1% AEP.

There is a reduction in peak discharge rates to the receiving environment (unnamed tributary of Black Waterholes Creek) for all storm events.

Table 6.1: Stormwater Drainage Assessment Results Summary

Event	Existing Case Peak Discharge (m3/s)	Proposed Case Peak Discharge (m3/s)	Change in Total Peak Discharge	
			Absolute (m3/s)	Relative (%)
63% AEP	0.87	0.77	-0.10	-11.7%
50% AEP	1.21	1.05	-0.16	-13.2%
20% AEP	1.72	1.43	-0.29	-16.9%
10% AEP	2.30	2.03	-0.27	-11.7%
5% AEP	2.87	2.52	-0.35	-12.2%
2% AEP	3.73	3.27	-0.46	-12.3%
1% AEP	4.48	4.42	-0.06	-1.3%

6.2.2 NSW River Flows Objectives

As outlined in Table 6.2, the Proposal is not expected to have a material impact on any of the relevant NSW River Flow Objectives.

Table 6.2: River Flow Objectives Relevant to Proposal

NSW river flow objective	Description	Hunter River sub-catchment type		Proposal impacts
		Mainly forested areas	Estuary	
	Maintain wetland and floodplain inundation	×	✓	The Proposal would not result in loss of floodplain storage or flow obstruction.
	Protect pools in dry times	✓	×	The Proposal Site area is a relatively small portion of the total catchment of the receiving waterway and stormwater discharges from the Proposal Site would be consistent with that for the total catchment in terms of the timing, frequency and duration.
	Protect natural low flows	✓	×	
	Maintain natural flow variability	✓	✓	A stormwater detention basin will maintain or reduce peak flows discharged to the unnamed tributary of Black Waterholes Creek for up to the 1% AEP event. No extraction of surface water from local creeks is proposed during either construction or operation.
	Manage groundwater for ecosystems	✓	✓	
	Minimise effects of weirs and other structures	✓	✓	The Proposal would not result in loss of floodplain storage or flow obstruction.
	Maintain or rehabilitate estuarine processes and habitats	×	✓	The Proposal would not result in loss of floodplain storage or flow obstruction.

6.3 Cumulative impacts

6.3.1 Demolition and remediation of the Hydro Aluminium aluminium smelter

The Proposal Site forms part of the decommissioned Kurri Kurri aluminium smelter site, which is owned by Hydro Aluminium, and which ceased operation in late 2012 and was permanently closed in 2014. Demolition of the former Kurri Kurri aluminium smelter and remediation of the land is an approved State Significant Development and was the subject of an Environmental Impact Statement that was publicly exhibited in 2016. The extensive works are ongoing but would be completed within the Proposal Site prior to construction of the Proposal. Demolition and remediation of former Kurri Kurri aluminium smelter land outside of, but adjacent to, the Proposal Site is estimated to be ongoing to late 2023 and therefore concurrent with construction of the Proposal.

It is expected that the demolition and remediation project would maintain stormwater discharges from that site in accordance with industry standards for construction sites. Given the negligible hydrology impacts estimated for the Proposal, no cumulative hydrology impacts are expected to occur during the construction phase of both projects.

6.3.2 ReGrowth Kurri Kurri Rezoning, subdivision and industrial development

The rezoning, subdivision and industrial development of the Hydro Aluminium land is a major planning proposal by Regrowth Kurri Kurri to rezone approximately 329 hectares of land at and around the former Kurri Kurri aluminium smelter from Rural Landscape (RU2) to residential and public recreation, business, heavy and general industrial, infrastructure and environmental conservation (B1, B5, IN1, IN3, R2, RE1 and SP2 (in part)), to reduce the minimum lot size from 40 ha to 450 m^2 (in part) and to identify the site as an urban release area. The rezoning proposal affects land in both the Cessnock and Maitland local government areas. Under this plan, the Proposal Site would be designated Heavy Industrial. On 1 December 2020, the NSW Department of Planning, Industry and Environment issued a Gateway Determination enabling Cessnock City Council to place the Hydro Kurri Kurri Planning Proposal on public exhibition for a minimum of 28 days. Submissions closed on 1 February 2021.

The rezoning proposal is subject to further approval and physical works would be subject to lodgement and approval of separate development applications. Development applications for development of the land following rezoning and subdivision are not expected until 2023, by which time the Proposal is anticipated to be under construction and in operation by late 2023. There are not currently any development applications, nor any further detail around the type of future development that might occur adjacent to the Proposal Site. Therefore, potential cumulative impacts from the ReGrowth Kurri Kurri rezoning, subdivision and industrial development have not been assessed.

7. Mitigation and management measures

Potential impacts during the construction and operation phase of the Proposal will be mitigated and managed through implementation of the following measure:

- Monitoring of the receiving waterway (tributary of Black Waterholes Creek) downstream of the discharge location(s) to identify any evidence of channel erosion and scour.

8. References

Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I, (Editors) (2019). *Australian Rainfall and Runoff: A Guide to Flood Estimation*, Commonwealth of Australia.

Cessnock City Council (2010). *Cessnock Development Control Plan 2010*.

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Ramboll Environ. (2016). *Environmental Impact Statement Former Hydro Aluminium Kurri Kurri Smelter Demolition and Remediation.* Ramboll Environ Australia Pty Ltd .

WMAwater. (2019). *Wallis and Swamp Fishery Creek Flood Study.* Maitland and Cessnock City Councils.

Appendix A. Glossary of terms and abbreviations

<table>
<tr><th>Term</th><th>Meaning</th></tr>
<tr><td>AHD</td><td>Australian Height Datum. A common national surface level datum approximately corresponding to mean sea level.</td></tr>
<tr><td>Annual Exceedance Probability (AEP)</td><td>The chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage. In this study AEP has been used consistently to define the probability of occurrence of flooding. The following relationships between AEP and ARI applies to this study (ARR, 2019).
<table>
<tr><th>Frequency Descriptor</th><th>EY</th><th>AEP (%)</th><th>AEP (1 in x)</th><th>ARI</th></tr>
<tr><td rowspan="6">Very frequent</td><td>12</td><td></td><td></td><td></td></tr>
<tr><td>6</td><td>99.75</td><td>1.002</td><td>0.17</td></tr>
<tr><td>4</td><td>98.17</td><td>1.02</td><td>0.25</td></tr>
<tr><td>3</td><td>95.02</td><td>1.05</td><td>0.33</td></tr>
<tr><td>2</td><td>86.47</td><td>1.16</td><td>0.50</td></tr>
<tr><td>1</td><td>63.2</td><td>1.58</td><td>1.00</td></tr>
<tr><td rowspan="4">Frequent</td><td>0.69</td><td>50.00</td><td>2</td><td>1.44</td></tr>
<tr><td>0.5</td><td>39.35</td><td>2.54</td><td>2.00</td></tr>
<tr><td>0.22</td><td>20.00</td><td>5</td><td>4.48</td></tr>
<tr><td>0.2</td><td>18.13</td><td>5.52</td><td>5.00</td></tr>
<tr><td rowspan="4">Infrequent</td><td>0.11</td><td>10.00</td><td>10.00</td><td>9.49</td></tr>
<tr><td>0.05</td><td>5.00</td><td>20</td><td>20.0</td></tr>
<tr><td>0.02</td><td>2.00</td><td>50</td><td>50.0</td></tr>
<tr><td>0.01</td><td>1.00</td><td>100</td><td>100</td></tr>
<tr><td rowspan="3">Rare</td><td>0.005</td><td>0.50</td><td>200</td><td>200</td></tr>
<tr><td>0.002</td><td>0.20</td><td>500</td><td>500</td></tr>
<tr><td>0.001</td><td>0.10</td><td>1000</td><td>1000</td></tr>
<tr><td rowspan="6">Extremely Rare</td><td>0.0005</td><td>0.05</td><td>2000</td><td>2000</td></tr>
<tr><td>0.0002</td><td>0.02</td><td>5000</td><td>5000</td></tr>
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<tr><td>Extreme</td><td></td><td></td><td>PMP</td><td></td></tr>
</table>
</td></tr>
<tr><td>ARR</td><td>Australian Rainfall and Runoff. Guidelines prepared by the Institute of Engineers Australia for the estimation of design floods. Reference is made to the 1987 or the 2016 versions of ARR, as specified.</td></tr>
</table>

Term	Meaning
Average Recurrence Interval (ARI)	The long-term average number of years between the occurrences of a flood as big as or larger than the selected event. For example, floods with a discharge as great as or greater than the 20 year ARI flood event will occur on average once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event. Also refer to Average Exceedance Probability (AEP), which is the industry standard terminology for definition of design flood events.
catchment	The land area draining through the main stream, as well as tributary streams, to a particular site. It always relates to an area above a specific location.
DECCW	NSW Government Department on Environment, Climate Change and Water. Now the Department of Planning Industry and Environment (DPIE)
DIPNR	Former NSW Government Department of Infrastructure, Planning and Natural Resources. Now the Department of Planning Industry and Environment (DPIE).
discharge	The rate of flow of water measured in terms of volume per unit time, for example, cubic metres per second (m^3/s). Discharge is different from speed or velocity of flow, which is a measure of how fast the water is moving for example, metres per second (m/s).
DPIE	NSW Government Department of Planning Industry and Environment
exceedances per year (EY)	The number of times an event is likely to occur or be exceeded within any given year.
flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with major drainage before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunami.
flood liable land /flood prone land	Is synonymous with flood prone land (i.e.) land susceptibility to flooding by the probable maximum flood event. Note that the term flooding liable land covers the whole floodplain, not just that part below the FPL (see flood planning area)
floodplain	Area of land which is subject to inundation by floods up to and including the probable maximum flood event, that is flood prone land.
flood risk	Potential danger to personal safety and potential damage to property resulting from flooding. The degree of risk varies with circumstances across the full range of floods. Flood risk in this manual is divided into 3 types, existing, future and continuing risks. They are described below. Existing flood risk: the risk a community is exposed to as a result of its location on the floodplain. Future flood risk: the risk a community may be exposed to as a result of new development on the floodplain. Continuing flood risk: the risk a community is exposed to after floodplain risk management measures have been implemented. For a town protected by levees, the continuing flood risk is the consequences of the levees being overtopped. For an area without any floodplain risk management measures, the continuing flood risk is simply the existence of its flood exposure.

Term	Meaning
flood storage areas	Those parts of the floodplain that are important for the temporary storage of floodwaters during passage of a flood. The extent and behaviour of flood storage areas may change with flood severity, and loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation. Hence, it is necessary to investigate a range of flood sizes before defining flood storage areas.
hazard	A source of potential harm or situation with a potential to cause loss. In relation to this technical paper the hazard is flooding which has the potential to cause damage to the community.
hydrology	The study of the rainfall and runoff process; in particular, the evaluation of peak flows, flow volumes and the derivation of hydrographs for a range of floods.
LEP	Local Environmental Plan
local overland flooding	Inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.
LPI	Land and Property Information
m AHD	metres Australian Height Datum (AHD)
m/s	metres per second. Unit used to describe the velocity of floodwaters.
m^3/s	Cubic metres per second or "cumecs". A unit of measurement of creek or river flows or discharges. It is the rate of flow of water measured in terms of volume per unit time.
probable maximum flood (PMF)	The largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation coupled with the worst flood producing catchment conditions. Generally, it is not physically or economically possible to provide complete protection against this event. The probable maximum flood defines the extent of flood prone land, that is, the floodplain.
risk	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of this technical paper it is the likelihood of consequences arising from the interaction of floods, communities and the environment.
runoff	The amount of rainfall which ends up as a streamflow, also known as rainfall excess.
scour	Erosion by mechanical action of water, typically of soil.
SEARs	Secretary's Environmental Assessment Requirements
TUFLOW	TUFLOW is a computer program which is used to simulate free-surface flow for flood and tidal wave propagation. It provides coupled 1D and 2D hydraulic solutions using a powerful and robust computation. The engine has seamless interfacing with GIS and is widely used across Australia.