9.4 Groundwater

This section describes the existing groundwater environment near the project, and the project's potential impacts during construction and operation. It summarises the Groundwater Impact Assessment (Aurecon Arup, 2021c) in Appendix M.

Groundwater impact summary

Groundwater near the project is generally poor quality and moderately to highly saline. It may also be affected by other contaminants associated with activities such as widespread agricultural land use, areas of disturbed terrain and landfilling. For this reason, groundwater near the project has low potential for beneficial use for agricultural and drinking purposes.

The project's construction and operation impacts on groundwater condition will be low, provided appropriate management measures are implemented. There are 12 registered bores in the desktop assessment area used for water supply purposes, including for commercial and industrial, stock and domestic, irrigation, exploration and community water supply use. No impacts to registered water supply bores are expected during construction and operation. Neither construction nor operation are expected to affect the long-term viability of groundwater dependent ecosystems.

During construction, and particularly during excavation, dewatering and the drawdown of groundwater could occur. Dewatering will require a Water Access Licence given that drawdown volumes are likely to be about nine million litres (ML) across the full pipeline construction period, and 57 ML for AWRC construction. Extracted water will be carefully managed to ensure that any contaminated groundwater encountered is appropriately treated and disposed of to prevent impacts to surrounding land or waterways and ensure waterway objectives are protected.

Groundwater drawdown for pipeline construction is likely to be minor and return to normal levels within several days. Groundwater drawdown from AWRC construction will also be temporary and may decrease baseflows to South Creek by about 6% during the first 18 months of construction before returning to normal.

Operational impacts are limited to the AWRC site and relate to reduced groundwater infiltration due to increased impervious services and dewatering during periodic bioreactor maintenance (about every five years). These impacts are minor and further minimised by management measures including stormwater recharge and irrigation, which will partially offset the reduced recharge from the increase in impervious surfaces.

9.4.1 Relevant Secretary's Environmental Assessment Requirements

Table 9-38 shows the Secretary's Environmental Assessment Requirements (SEARs) relevant to groundwater and where in this section they are addressed. This table only references content relating to groundwater. Other chapters address the project's impacts on surface water.

Table 9-38 Project SEARs relating to groundwater impacts

SEARs	EIS section where requirement addressed
1. Describe background conditions for any water resource likely to be affected by the development, including: a) existing surface and groundwater.	Section 9.4.3
c) Water Quality Objectives (as endorsed by the NSW Government (www.environment.nsw.gov.au/ieo/index.htm) including groundwater as appropriate that represent the community's uses and values for the receiving waters.	Section 9.4.2
2. Assess the impacts of the development on water quality, including: a) the nature and degree of impact on receiving waters for both surface and groundwater, demonstrating how the development protects the Water Quality Objectives where they are currently being achieved, and contributes towards achievement of the Water Quality Objectives over time where they are currently not being achieved. This should include an assessment of the mitigating effects of proposed stormwater and wastewater management during and after construction.	Sections 9.4.3, 9.4.5 and 9.4.6
b) identification of proposed monitoring of water quality.	Section 9.4.9
g) identification of proposed monitoring of hydrological attributes.	Section 9.4.9
3. Assess the impact of the development on hydrology, including:	
e) changes to environmental water availability, both regulated/licensed and unregulated/rules-based sources of such water.	Table 9-44 and Table 9-45
4. Map: c) groundwater d) groundwater dependent ecosystems.	Figure 9-14, Figure 9-15, Figure 9-16
7. Consult/coordinate with the Department of Planning, Industry and Environment (and Planning Partnership Office) in respect to environmental impacts on the South Creek catchment and the Wianamatta South Creek program. This includes: c) assess the potential impacts on the quantity and quality of surface and groundwater resources along South Creek, including the implications of dry and wet weather flows from the project.	Section 9.4.5, section 9.4.6 – groundwater impacts to South Creek.
d) details about how the project will be designed, operated and maintained to ensure post-development flows do not exceed pre-development flows into and through the Pipelines Corridor and additional surface and groundwater entering the Pipelines Corridor must be prevented.	Table 9-44 – potential for inflows from groundwater where environmental flows pipeline crosses Pipeline Corridor.

9.4.2 Methodology and assumptions

The groundwater assessment involved the following steps:

- Site walkover and inspection of the AWRC site and environmental flows pipeline.
- Desktop review of relevant datasets and historical investigations. The desktop assessment area for groundwater (shown in Figure 9-14 to Figure 9-16) covered the AWRC site, pipeline alignments and a wider 2 km impact assessment buffer. A 2 km buffer was selected to examine hydrogeological systems at a sub-regional scale and assess a wide extent of potential groundwater impacts.
- Quantitative assessment and modelling of groundwater movement and drawdowns for the trenched pipelines and AWRC. The quantitative assessment involved:
  - Pipeline analytical modelling – the pipelines were divided into discrete sections based on hydrogeological landscapes (HGLs). Construction groundwater inflow rates and drawdowns were estimated using analytical equations developed in accordance with Darcy's law.
  - AWRC numerical modelling – a model was developed to simulate the existing and future behaviour of the groundwater systems at the AWRC site. Construction and operational phase modelling was undertaken.

  The assumptions adopted in the modelling are provided in Appendix M (Chapter 9 and appendices). Key assumptions related to construction periods, as they impact dewatering volumes and duration of drawdowns. Assumptions included:

  - Pipelines will be constructed at a rate of 12-24 m/day per crew. Three crews will be deployed for pipeline construction, working simultaneously.
  - Construction period of 695 days for the pipelines.
  - Construction period of 492 days for the AWRC.

  Results from the modelling were used to assess potential impacts to surrounding groundwater dependent ecosystems and groundwater users. The results were compared against the criteria outlined in the sections below.
- A qualitative assessment was used to assess potential impacts to groundwater quality and impacts from pipeline tunnelling. Tunnelling methods are more sealed from groundwater compared to trenching so a quantitative method was not needed.
- An assessment of the significance of potential groundwater impacts. Results from the quantitative and qualitative assessment, the sensitivity of the environment and the magnitude of the expected change were considered.
- Development of management measures to mitigate potential impacts.

Adopted assessment criteria

Groundwater drawdown

The NSW Aquifer Interference Policy (DPI, 2012) includes minimal impact considerations for impacts to groundwater sources, connected water sources, and their dependent ecosystems, culturally significant sites and water users.

The Aquifer Interference Policy divides groundwater sources into highly productive and less productive. Groundwater sources in the desktop assessment area for the project were identified as less productive, based on the relatively low number of registered supply bores, expected low yields and high salinity. Less productive groundwater sources are further divided by the Aquifer Interference Policy into the categories of alluvial and porous and fractured rock.

The Aquifer Interference Policy specifies two levels of minimal impact considerations. Table 9-39 outlines the applicable Aquifer Interference Policy Level 1 minimal impact considerations for less productive groundwater sources. If the predicted impacts are less than the Level 1 minimal impact considerations, or can be met with additional monitoring and/or mitigation, then these impacts are considered acceptable. Modelled outputs from the AWRC assessment were used to demonstrate that the predicted impacts arising from dewatering activities at the AWRC site can achieve the Level 1 minimal impact considerations.

Table 9-39 Minimal water table impact considerations for aquifer interference activities

Groundwater source	Minimal impact considerations from NSW Aquifer Interference Policy	Drawdown threshold adopted for project
Alluvial water sources Porous and fractured-rock water sources	Less than or equal to 10% cumulative variation in the water table, allowing for typical climatic 'post-water sharing plan' variations of 40 m from any a) high priority GDE, or b) high priority culturally significant site listed in the schedule of the relevant water sharing plan. or A maximum of a 2 m decline cumulatively at any water supply work unless make good provisions should apply. Note: water supply work includes water users such as pumps and bores.	0.1 m (refer to explanation below)

The high priority Groundwater Dependent Ecosystems (GDEs) listed in Schedule 4 Table D of the Water Sharing Plan are not located in the desktop assessment area. However, drawdown has been assessed for other GDEs (as identified in the BOM (2021) GDE Atlas) using the above criteria to meet the SEARs.

There are no high priority culturally significant sites listed in the Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011.

At the time of the groundwater investigation, no long-term groundwater hydrographs were available in the desktop assessment area to determine the cumulative variation of the groundwater table. A conservative natural seasonal cumulative variation in the order of one metre has been assumed for this project. Therefore, the drawdown threshold for predicted impact reporting has been taken as 0.1 m (that is, 10% of one metre) in accordance with the methodology set out in the Aquifer Interference Policy.

Groundwater dewatering

A Water Access Licence under section 56 of the WM Act is required if dewatering volumes are greater than 3 ML/year of groundwater. Dewatering volumes for the project were calculated and compared to the criteria of 3 ML/year.

Groundwater quality

The waterway objectives, outlined in Chapter 8, are also relevant to groundwater.

The minimal water quality impact considerations from the Aquifer Interference Policy are shown in Table 9-40.

Table 9-40 Minimal water quality impact considerations for Aquifer Interference Activities

Groundwater source	Water quality
Alluvial water sources	1 (a) Any change in groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 m of the activity. and 1 (b) No increase of more than 1% per activity in long-term average salinity in a highly connected surface water source at the nearest point to the activity.
Porous and fractured-rock water sources	1 (a) Any change in groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 m of the activity.

The Policy states that if these conditions are not met then appropriate studies will need to demonstrate:

- that the change in groundwater quality will not prevent the long-term viability of the dependent ecosystem, significant site or affected water supply works
- the River Condition Index category of the highly connected surface water source (for alluvial groundwater sources) will not be reduced at the nearest point to the activity.

These studies were not required given modelled outputs demonstrated the project could meet the minimal water quality impact considerations in Table 9-40.

Impact significance

The significance of any potential project impact on the local groundwater systems was determined by considering the sensitivity of the environment related to the assessed criteria and the magnitude

of the expected change. Table 9-41 outlines the impact significance matrix applied to the assessment of potential groundwater impacts.

Table 9-41 Matrix of impact significance

Magnitude of impacts	Sensitivity of environmental values		
	High	Moderate	Low
High	Major	High	Moderate
Moderate	High	Moderate	Low
Low	Moderate	Low	Negligible

The sensitivity of environmental values was based on the following criteria:

- Condition of the environmental value - how far is it understood to have already been changed from its original natural form or state?
- How unique or rare is the condition or value or its dependent ecological receptors?
- How sensitive are the dependent receptors to changes?
- How do the results compare against the identified groundwater level/availability and quality criteria?

The magnitude of impact was based on the following criteria:

- If a qualitative assessment has been conducted, how do the results compare to the pre-development conditions?
- How do the results compare against the identified groundwater level/availability and quality criteria?
- For quantitative assessments the following was considered:
  - Expected duration of impact - temporary or long-lasting/permanent.
  - Expected extent of impact - local or regional/widespread. Estimated degree
  - of change from pre-development conditions.

9.4.3 Existing environment

This section provides an overview of the existing groundwater environment. The review was undertaken within the desktop assessment area, which includes the AWRC site, pipeline alignments and a wider two kilometre impact assessment buffer. The desktop assessment area is shown in Figure 9-14 to Figure 9-16.

Catchment hydrogeology

Groundwater systems

The desktop assessment area includes alluvial and bedrock groundwater systems. Key features of each system are described below.

- Alluvial groundwater systems:
  - Unconfined to semi-confined groundwater systems associated with Quaternary alluvial deposits.
  - Most prevalent in areas surrounding the rivers and streams that intersect the project, including Nepean River, Badgerys Creek, South Creek, Kemps Creek, Cabramatta Creek, Clear Paddock Creek, Georges River and Prospect Creek.
  - Likely to be connected to the associated rivers/streams and responsive to rainfall.
- Bedrock groundwater systems:
  - Unconfined to semi-confined dual porosity (granular and fractured) bedrock systems.
  - Several distinct hydrostratigraphic units are expected to be present, including Bringelly Shale, Minchinbury Sandstone and Ashfield Shale of the Wianamatta Group, overlying Hawkesbury Sandstone.

Hydrogeological Landscape Mapping

A review of HGL mapping (DPIE, 2011e) identified nine main HGLs intersected by the project. Key features of each HGL are summarised in Table 9-42 and shown in Figure 9-14 to Figure 9-16.

The HGL units spatially define and characterise discrete areas of similar features, including salt accumulation, salt stores, saline manifestations and pathways for salt mobilisation. The terms ‘hydrogeological’ and ‘landscapes’ reflect the importance of lithology, bedrock structure, regolith (including soils), landforms, climate and vegetation on recharge, groundwater flow or movement, storage and discharge of a particular hydrological system.

The most prominent HGL in the desktop assessment area is the Upper South Creek (and Upper South Creek Variant A) HGL, which is intersected by the treated water pipeline east of Luddenham, the AWRC and brine pipeline in the vicinity of Kemps Creek and between Cecil Hills and Prospect Creek in Lansdowne. This HGL is characterised by a typical water table depth of 2-6 m below ground level (BGL) and high land and groundwater salinity.

Table 9-42 Summary of hydrogeological landscapes in the desktop assessment area

HGL	Relevant project component(s)	Groundwater flow	Depth to water table	Salinity
Hawkesbury	Environmental flows pipeline, in elevated areas between Warragamba River and Nepean River.	Groundwater flow in the upper systems of this HGL may be intercepted by the project. In the upper systems, groundwater flow is predominantly unconfined along structural features (such as bedding, joints, faults) in the fractured bedrock and through connected pore spaces in the sandstones.	Typically deep (>8 m BGL).	Land salinity is low, groundwater is generally fresh (electrical conductivity (EC) less than 800 µS/cm).
Mid-Nepean River	Environmental flows and treated water pipelines in low-lying areas west of Nepean River.	Groundwater flow is unconfined through unconsolidated alluvial sediments. Localised perching of water tables may occur above clay lenses during wetter periods.	Typically shallow to intermediate (0-8 m BGL) with seasonal variation.	Land salinity is low, groundwater is generally fresh (EC between 800-1600 µS/cm).
Mulgoa	Treated water pipeline in Wallacia, east of Nepean River and again in the vicinity of Elizabeth Dr in Luddenham.	Groundwater flow is unconfined to semi-confined through unconsolidated alluvial/colluvial sediments and along structural features (such as bedding, joints, faults) in the fractured bedrock. Localised perching of water tables may occur above clay lenses during wetter periods. In the fractured rock, groundwater predominantly moves laterally through the shale layers (although vertical movement through fracturing does occur) and vertically through interbedded sandstone and sandstone fracturing.	Intermediate (2-8 m BGL) with seasonal variation.	Land salinity is moderate, groundwater is generally brackish (EC between 1600-4800 µS/cm).

HGL	Relevant project component(s)	Groundwater flow	Depth to water table	Salinity
Greendale	Treated water pipeline between Park Rd in Wallacia and Elizabeth Dr in Luddenham.	Groundwater flow is unconfined to semi-confined through unconsolidated alluvial/colluvial sediments and along structural features (such as bedding, joints, faults) in the fractured bedrock. Localised perching of water tables may occur above clay lenses during wetter periods. In the fractured rock, groundwater predominantly moves laterally through the shale layers (although vertical movement through fracturing does occur) and vertically through interbedded sandstone and sandstone fracturing.	Intermediate (2-8 m BGL) with seasonal variation.	Land salinity is moderate, groundwater is generally brackish (EC between 1600-4800 µS/cm).
Upper South Creek	Treated water pipeline east of Luddenham, the AWRC site and brine pipeline in the vicinity of Kemps Creek.	Groundwater flow is unconfined along structural features (such as bedding, joints, faults) in the fractured bedrock, predominantly moving laterally through the shale layers (although vertical movement through fracturing does occur) and vertically through interbedded sandstone and sandstone fracturing. Lateral flow occurs through alluvial sediments on slopes and plains. Localised perching of water tables may occur above clay lenses during wetter periods.	Intermediate (2-6 m BGL).	Land salinity is high, groundwater is generally saline (EC greater than 4800 µS/cm).
Mount Vernon	Brine pipeline in Cecil Park.	Groundwater flow is unconfined along structural features (such as bedding, joints, faults) in the fractured bedrock, predominantly moving laterally through the shale layers (although vertical movement through fracturing does occur) and vertically through interbedded sandstone and sandstone fracturing. Lateral flow occurs through alluvial sediments on slopes and plains. Localised perching of water tables may occur above clay lenses during wetter periods.	Intermediate (2-6 m BGL).	Land salinity is moderate, groundwater is generally brackish (EC between 800-1600 µS/cm).

HGL	Relevant project component(s)	Groundwater flow	Depth to water table	Salinity
Denham Court	Brine pipeline in Cecil Hills.	Groundwater flow is unconfined along structural features (such as bedding, joints, faults) in the fractured bedrock, predominantly moving laterally through the shale layers (although vertical movement through fracturing does occur) and vertically through interbedded sandstone and sandstone fracturing. Lateral flow occurs through alluvial sediments on slopes and plains.	Intermediate (2-6 m BGL).	Land salinity is moderate, groundwater is generally fresh (EC less than 800 µS/cm).
Upper South Creek variant A	Brine pipeline between Cecil Hills and Prospect Creek in Lansdowne.	Groundwater flow is unconfined along structural features (such as bedding, joints, faults) in the fractured bedrock, predominantly moving laterally through the shale layers (although vertical movement through fracturing does occur) and vertically through interbedded sandstone and sandstone fracturing. Lateral flow occurs through alluvial sediments on slopes and plains.	Intermediate (2-6 m BGL).	Land salinity is high, groundwater is generally brackish to saline (EC between 1600-4800 µS/cm).
Moorebank	Brine pipeline east of Prospect Creek.	Groundwater flow is unconfined through unconsolidated alluvial sediments. Localised perching of water tables may occur above clay lenses during wetter periods. Unconfined to semi-confined flow also occurs along structural features (such as bedding, joints, faults) in the fractured bedrock.	Shallow to intermediate (0-8 m BGL) with seasonal variation.	Land salinity is moderate, groundwater is generally fresh (EC between 800-1600 µS/cm).

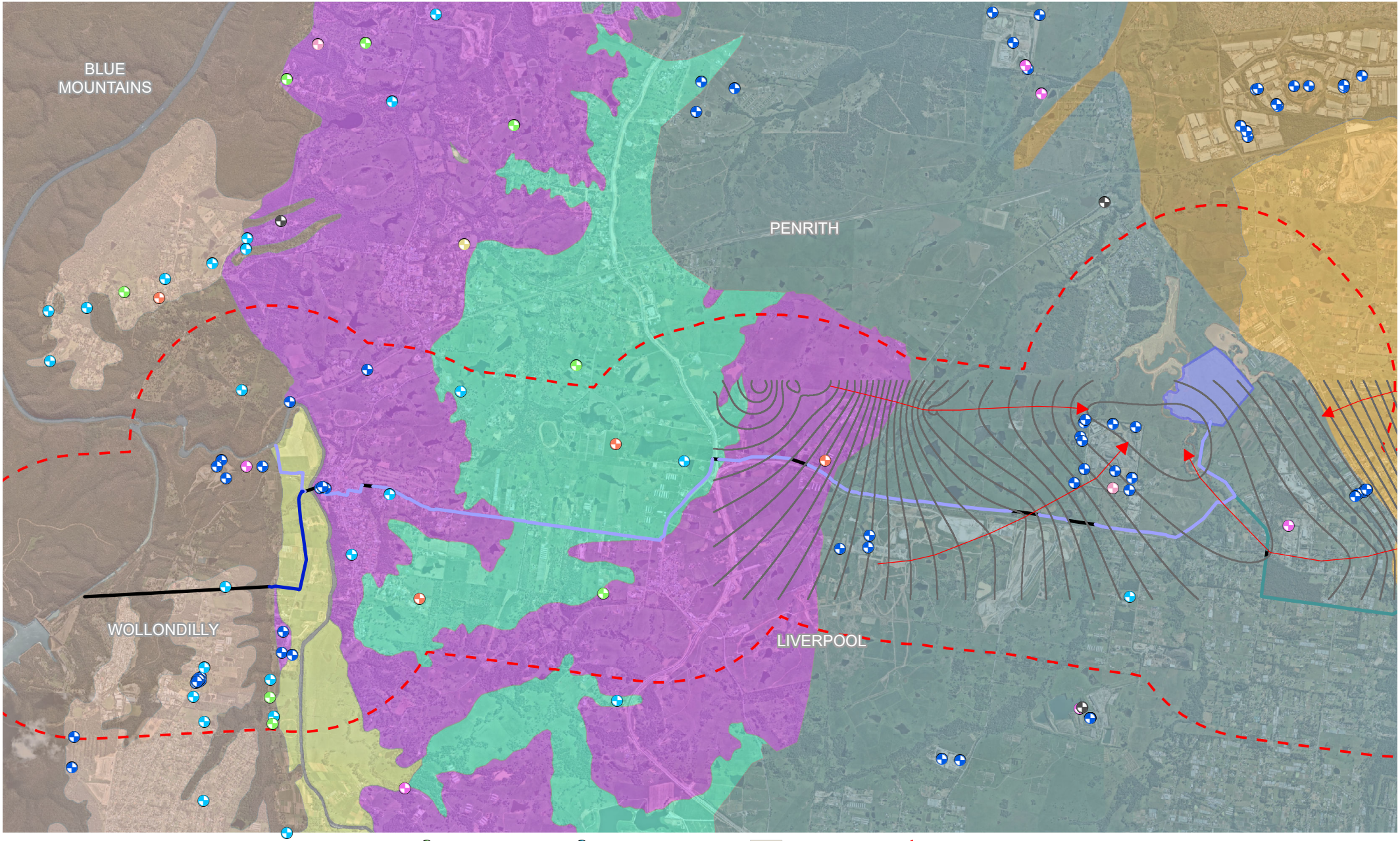


Figure 9-14 Hydrogeological Landscapes

Source: Aurecon, Sydney Water, LPI, Nearmap, ESRI, BOM, DPIE, RMS
Projection: GDA2020 MGA Zone 56

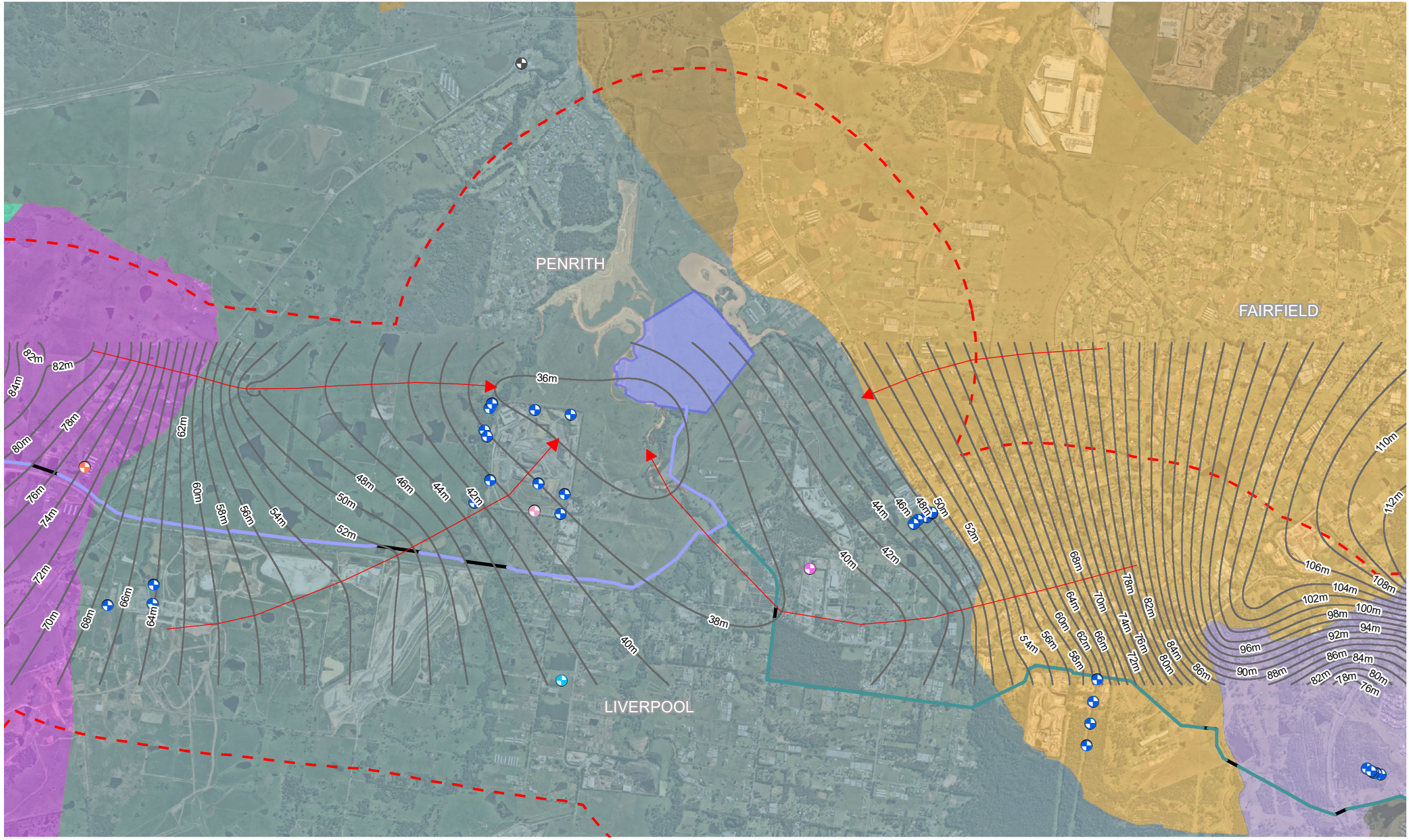


Figure 9-15 Hydrogeological Landscapes

Source: Aurecon, Sydney Water, LPI, Nearmap, ESRI, BOM, DPIE, RMS
Projection: GDA2020 MGA Zone 56

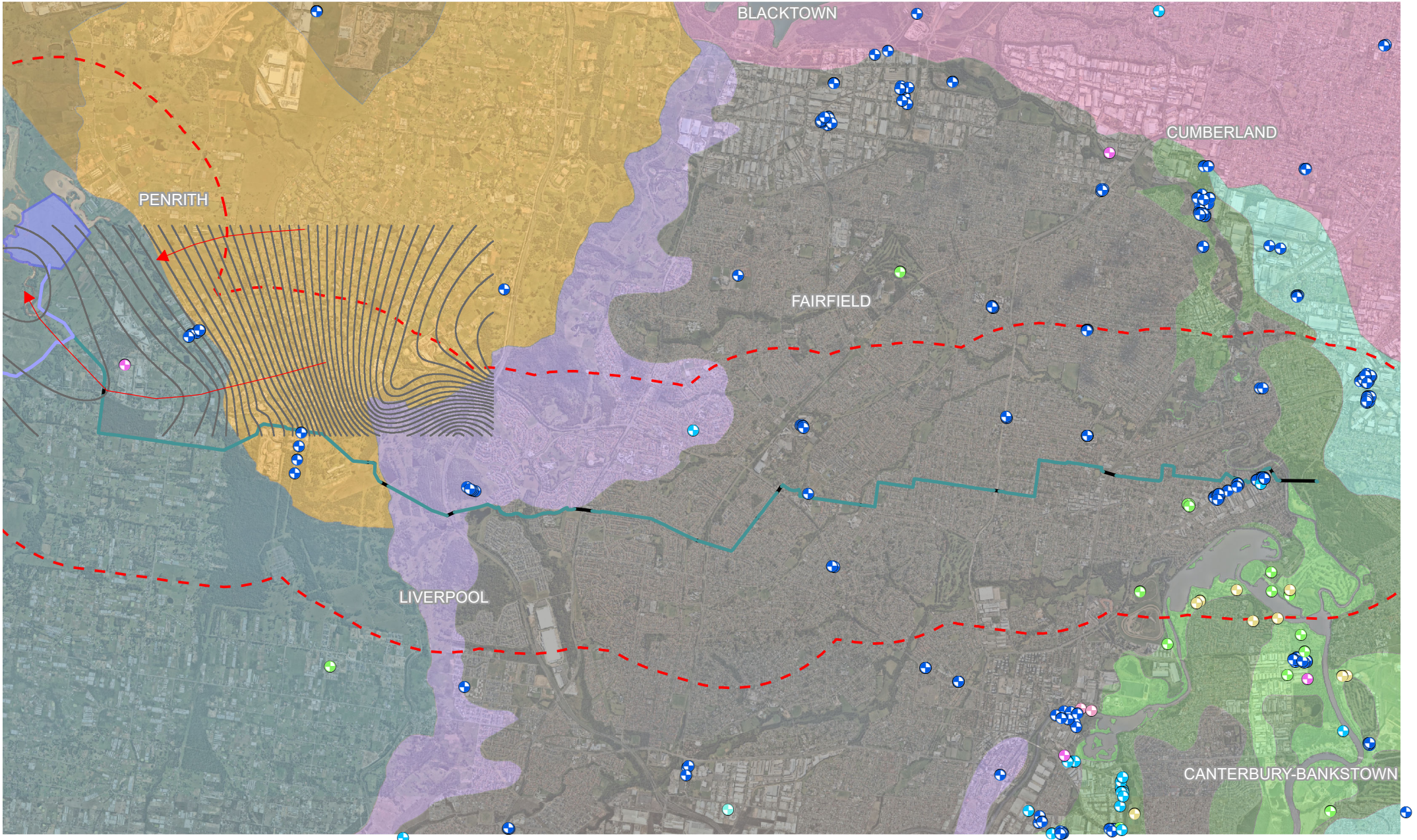


Figure 9-16 Hydrogeological Landscapes

Source: Aurecon, Sydney Water, LPI, Nearmap, ESRI, BOM, DPIE, RMS
Projection: GDA2020 MGA Zone 56

Groundwater quality

The groundwater across most of the desktop assessment area is of relatively poor quality and has low potential for beneficial use for agricultural and drinking purposes.

Groundwater contamination

The potential presence of contamination is described in detail in section 9.5 and the Soils and Contamination Impact Assessment report in Appendix N. Groundwater toxicants may be present in the desktop assessment area, associated with activities such as widespread agricultural land use, areas of disturbed terrain and landfilling. Elevated concentrations of heavy metals and nutrients within groundwater, above waterway objectives, have been identified in previous investigations in the region (RMS, 2019).

An active landfill (SUEZ Kemps Creek Resource Recovery Park) is located about 800 m south-west of the AWRC site. Contaminants of concern associated with landfill sites include ground gases (such as methane, carbon dioxide, hydrogen sulfide) and leachate (such as acidic water, nitrogen, phosphorus and heavy metals).

Groundwater salinity

Groundwater salinity is expected to vary across the desktop assessment area. Groundwater is expected to be brackish to saline across a significant portion of the desktop assessment area (for example in the Upper South Creek HGL), with some small areas of fresh water (for example in the Hawkesbury and Mid-Nepean HGL). An overview of the varying groundwater salinity for each HGL is included in Table 9-42. Electrical conductivity ranges for Mulgoa, Greendale, Upper South Creek and Upper South Creek Variant A HGLs have maximum values that exceed the waterway objectives criteria of 125-2200 µS/m.

Similarly, a review of the Map of Salinity Potential in Western Sydney (DIPNR, 2002) indicates a variable salinity risk across the desktop assessment area. Areas to the west around Warragamba and Wallacia have a very low to moderate salinity risk, while all other areas are within moderate to high salinity risk areas, with some areas of known salinity. Areas with high salinity potential include the low-lying areas around Cosgrove Creek and Kemps Creek.

Acid sulfate soils and rock

Acid sulfate soils (ASS) risk mapping indicates that most of the desktop assessment area is not located within an area of potential acid sulfate soils (potential ASS) (DPIE, 1998). The exception is some potential ASS risk areas around Georges River and Prospect Creek in the eastern portion of the desktop assessment area. More information on ASS is provided in section 9.5.

Groundwater levels and flows

The direction of local groundwater flow is likely to be controlled by the proximity to local surface water bodies and areas of higher permeability soils. Shallow groundwater movement through alluvial groundwater systems tends to be much faster relative to consolidated rocks in the Wianamatta Group.

Intermediate and regional flow directions in the underlying bedrock aquifers (Wianamatta Group formations and Hawkesbury Sandstone) are expected to be generally consistent with the topography.

Groundwater elevation data taken across the central portion of the desktop assessment area in August 2018 as part of the M12 Motorway EIS indicate the following intermediate/regional groundwater levels and flow directions (RMS, 2019):

- From west to east, groundwater elevations range from 90 m AHD in Luddenham to 35 m AHD in the vicinity of the AWRC site, indicating intermediate/regional groundwater flow is in an easterly direction between these areas.
- Continuing from west to east, groundwater elevations range from 35 m AHD in the vicinity of the AWRC to 112 m AHD in Cecil Park, indicating intermediate/regional groundwater flow is in a westerly direction between these areas.
- Groundwater levels and flow appear to converge towards the low-lying areas in the vicinity of Badgerys Creek, South Creek, Kemps Creek and the AWRC site, which is consistent with local topographical observations.

Beyond the extents of the M12 Motorway EIS groundwater elevation data, the following intermediate/regional groundwater flow directions are expected, consistent with local topographic observations:

- Flows are likely to be generally east to west between Luddenham and Nepean River.
- Flows are likely to be generally west to east between Cecil Park and Cabramatta, tending south-east towards Georges River.

Attempts were made to measure groundwater levels in registered water supply bores in the vicinity of the proposed environmental flows pipeline alignment. Registered bores are shown in Figure 9-14 to Figure 9-16. Direct measurements were unable to be collected. Interviews with landowners about the registered bores indicate that there is no significant aquifer present at the depth and location of the proposed tunnelling alignment and groundwater is unlikely to be encountered.

Groundwater dependent ecosystems

Groundwater dependent ecosystems (GDEs) are ecological communities that rely on groundwater, either entirely or in part, for their health or survival.

A review of the Bureau of Meteorology's GDE Atlas (BOM, 2021) indicates that several GDEs are present in the desktop assessment area. The Atlas divides GDEs into high, moderate or low potential for groundwater interaction (BOM, 2021). These areas are illustrated in Figure 9-17 to Figure 9-19.

GDEs can be characterised as terrestrial, aquatic or subterranean. Aquatic ecosystems rely on the surface expression of groundwater, including surface water ecosystems which may have a groundwater component, such as rivers, wetlands and springs. Terrestrial ecosystems rely on the subsurface presence of groundwater, this includes all vegetation ecosystems. Subterranean ecosystems include cave and aquifer ecosystems. There are no known subterranean GDEs in the project area. Aquatic and terrestrial GDEs are mapped in more detail in Chapter 8 and section 9.1.

Schedule 4 Table D of the Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011 lists high priority GDEs. There are no high priority GDEs located in the desktop assessment area.

Regional groundwater users

A review of the Bureau of Meteorology (BoM) National Groundwater Information System (NGIS) indicates several registered groundwater bores in the desktop assessment area. No groundwater level information is available for these bores. The locations of the registered groundwater bores are illustrated in Figure 9-14 to Figure 9-16. Table 9-43 summarises the number and type of registered bores in the desktop assessment area (BOM, 2020).

Table 9-43 Summary of registered bores in the desktop assessment area

Groundwater Bore Type	AWRC	Brine pipeline	Treated water pipeline and environmental flows
Commercial and industrial	1	1	1
Stock and domestic	0	0	1
Monitoring	19	67	5
Irrigation	0	4	0
Exploration	1	0	0
Community water supply	0	1	2
Total	**21**	**73**	**9**

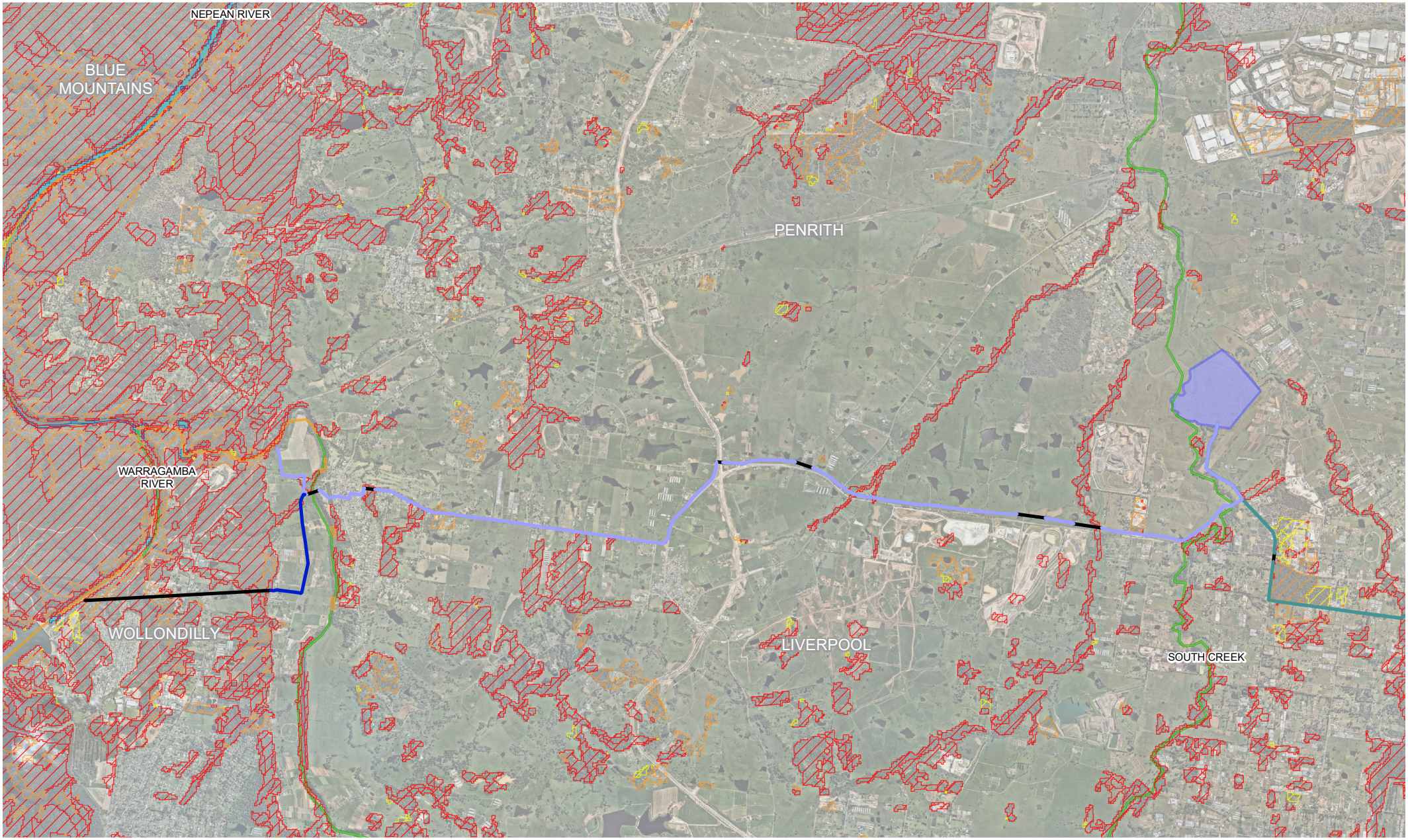


Figure 9-17 Groundwater Dependant Ecosystems

Source: Aurecon, Sydney Water, LPI, Nearmap, ESRI, BOM, DPIE
Projection: GDA2020 MGA Zone 56

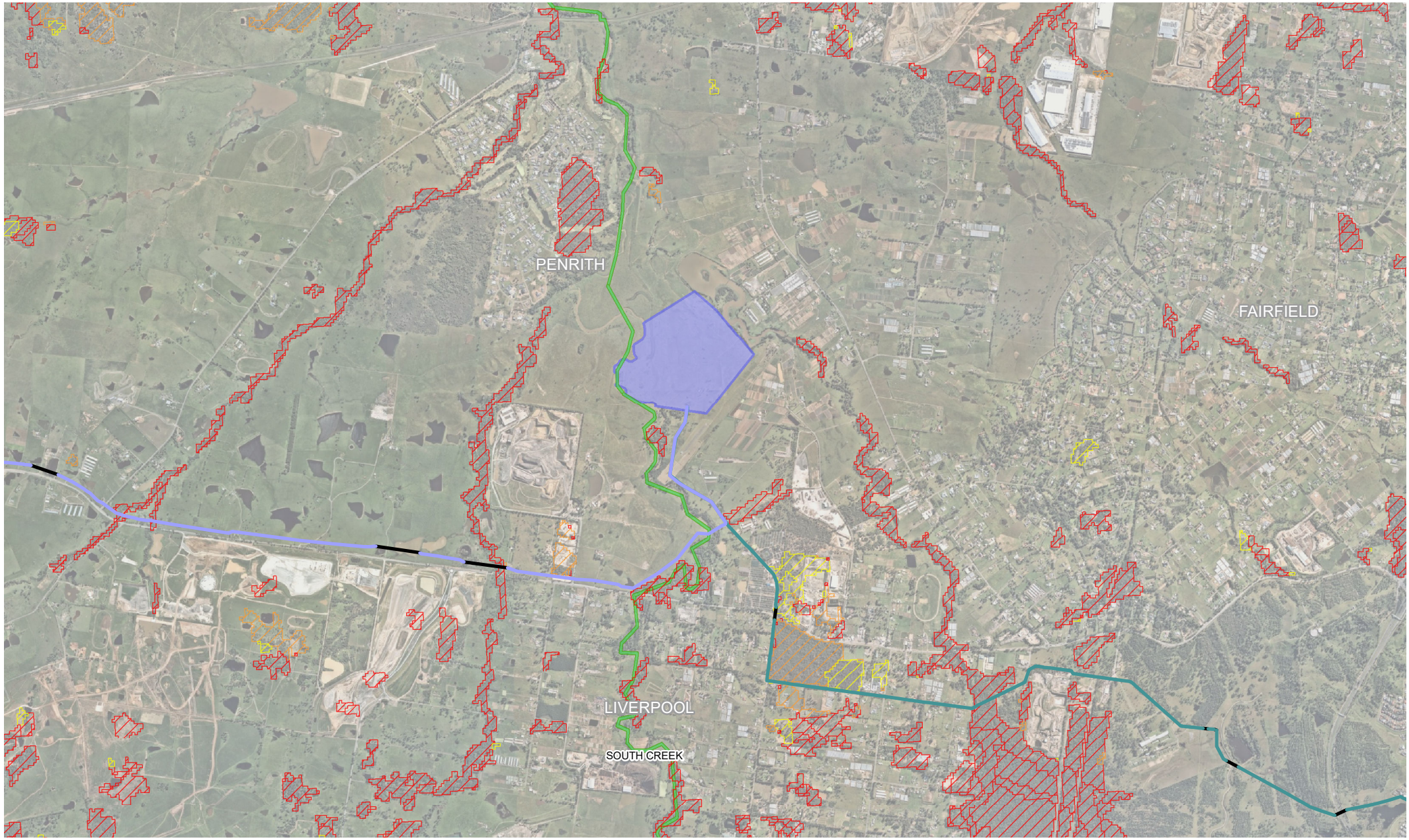


Figure 9-18 Groundwater Dependant Ecosystems

Source: Aurecon, Sydney Water, LPI, Nearmap, ESRI, BOM, DPIE
Projection: GDA2020 MGA Zone 56

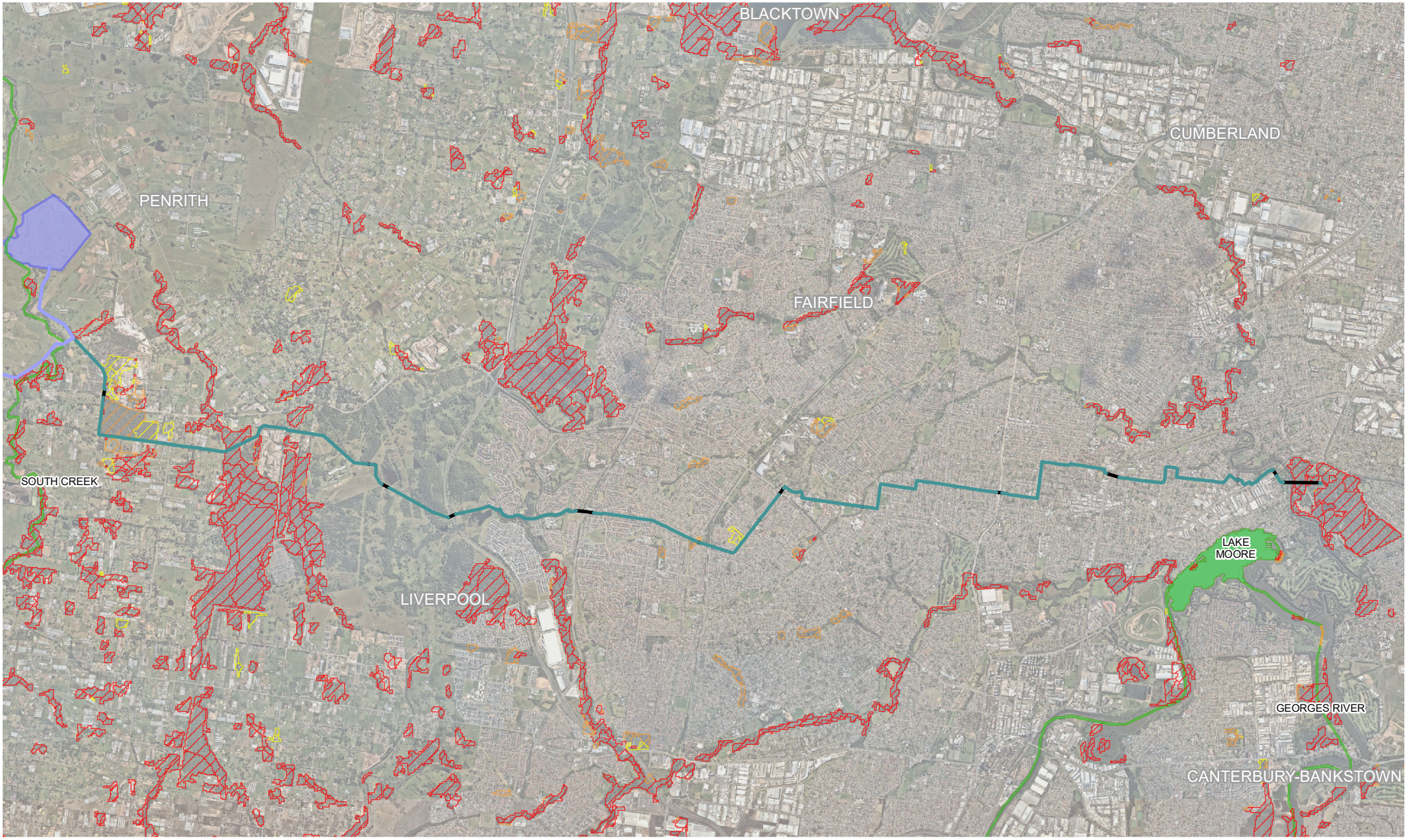


Figure 9-19 Groundwater Dependant Ecosystems

Source: Aurecon, Sydney Water, LPI, Nearmap, ESRI, BOM, DPIE
Projection: GDA2020 MGA Zone 56

9.4.4 Legislation and guidelines

The groundwater impact assessment has been undertaken in accordance with the following legislation, regulation, plans and policies. A summary of each, plus an analysis of their relevance and application to the assessment is included in Appendix M.

- *Environmental Planning and Assessment Act 1979* (EP&A Act).
- *Water Act 1912*.
- *Water Management Act 2000* (WM Act).
- *Protection of the Environment Operations Act 1997* (POEO Act).
- Water Management Regulation 2018.
- Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011.
- NSW Aquifer Interference Policy (DPI, 2012).
- NSW State Groundwater Policy Framework (Department of Land & Water Conservation (DLWC), 1998a).
- NSW Groundwater Quality Protection Policy (DLWC, 1998b).
- NSW Groundwater Dependent Ecosystems Policy (Department of Land & Water Conservation, 2002a).
- National Water Quality Management Strategy (Australian Government, 2018).
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018).
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2000).
- National Environment Protection (Assessment of Site Contamination) Measure (2013).

The key legislation and guidelines that require approvals or include assessment criteria are outlined in more detail below.

Water Management Act 2000 and Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011

The objects of the WM Act are to provide for the sustainable and integrated management of the water sources of the state for the benefit of both present and future generations. Water sharing plans are the main tools in the WM Act for managing water sources. They define the rules for sharing water within a particular water source. The project is located in the area covered by the Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011 and in the 'Sydney Basin Central' groundwater source.

Section 5.23(1) of the EP&A Act states that the following approvals are not required for approved State significant infrastructure:

- Water use approval under section 89 of the WM Act.

- Water management work approval under section 90 of the WM Act.
- Activity approval (other than an aquifer interference approval) under section 91 of the WM Act.

A Water Access Licence under section 56 of the WM Act is required if dewatering volumes are greater than 3 ML/year of groundwater. This volume also triggers the need for an aquifer interference approval under section 91. However, at the time of time of writing this EIS, these provisions are yet to commence.

Protection of the Environment Operations Act 1997

Environment Protection Licences (EPLs) will be required for scheduled development work and the scheduled activity. The scheduled development work EPL may include requirements relating to groundwater management, including the management of dewatering volumes.

NSW Aquifer Interference Policy

The NSW Aquifer Interference Policy (DPI, 2012) includes minimal impact considerations for impacts to groundwater sources, connected water sources, and their dependent ecosystems, culturally significant sites and water users. Section 9.4.2 discusses application of this policy.

9.4.5 Construction impact assessment

During construction, groundwater impacts are mainly associated with dewatering groundwater within excavations and groundwater drawdown (lowering of the groundwater table). Groundwater drawdown can reduce the availability of groundwater for GDEs and surrounding water users. Table 9-44 summarises construction impacts, their location and significance (without any mitigation). Impacts identified in Table 9-44 have been estimated based on the modelling and methodology as described in section 9.4.2.

Management measures to address the impacts are included in section 9.4.9. The implementation of the management measures reduces the impact rating for all impacts to low. Any residual groundwater impacts are expected to meet the criteria provided in section 9.4.2.

Table 9-44 Potential impacts to groundwater during construction

Impact	Location	Impact significance
Dewatering Groundwater is likely to be encountered where excavations intersect the groundwater table. Where this occurs, construction dewatering will be required to provide safe ground conditions to enable construction activities to take place. During construction of the trenched pipelines, the groundwater inflow rates vary across the different HGLs. Estimates range from 0.0008 ML/day to 0.017 ML/day. Estimated pumped volumes vary for each HGL, ranging from 0.025 ML to 2.04ML. Higher amounts of dewatering will be required in low lying areas adjacent to waterways where groundwater is closer to the surface compared to topographically higher areas away from waterways. The total pumped volume that could be expected during construction is about 9 ML over a period of 695 days (refer to Table 9-13 in Appendix M for full details). During construction of the AWRC, high initial inflow is expected to occur, stabilising at about 0.115 ML/day. The construction period comprises 492 days. Total pumped volume over the construction period has been estimated to be about 57 ML, with about 50 ML pumped within the first 365 days of the construction. A Water Access Licence under the WM Act will therefore be required as the total dewatering volume for the project exceeds 3 ML/year.	AWRC and trenched pipelines	Moderate
Drawdowns from dewatering activities Dewatering activities can result in groundwater drawdowns (lowering of the water table). This may reduce the availability of groundwater for GDEs and surrounding groundwater users. During construction of the pipelines, estimated drawdowns at GDEs vary for each HGL, ranging from 0.2 to 3.2 m. During construction of the AWRC, the drawdown is estimated to be 0.2 m at South Creek, resulting in a 6% reduction in the creek's baseflow, potentially impacting aquatic ecosystems. Water supply bores have not been identified within the extent of the drawdowns, so these groundwater users will not be impacted. The estimated drawdowns for the pipelines and AWRC exceed the criteria outlined in Table 9-39. However, the drawdowns will be temporary. For the pipelines, excavations are progressive and typically at the rate of 12-24 m/day per crew. It is expected that once backfilled, groundwater levels will return to	AWRC and trenched pipelines	Moderate

Impact	Location	Impact significance
normal within a few days. At the AWRC, the duration of excavation and drawdown could be up to 18 months, based on the reference design construction schedule. Appropriate monitoring and management measures will be implemented. Given the short-term nature of construction, the drawdowns are not expected to prevent the long-term viability of the affected GDEs. Refer to Chapter 8 and section 9.1 for a more detailed assessment of impacts to GDEs.		
Increased hydraulic connection between aquifers The interception of aquifers during excavation may lead to increased hydraulic connection between otherwise disconnected aquifers and/or lateral migration of groundwater along pipeline backfill material. The local groundwater systems are generally highly saline and relatively shallow. By increasing the vertical hydraulic connection between the local groundwater systems and the underlying regional systems through excavations, or by increasing the lateral hydraulic connection through the pipeline backfill material, preferential migration pathways may be formed affecting water qualities, hydraulic gradients and flow regimes in the groundwater systems. Increased hydraulic connection between aquifers may occur at the following areas: • At the interface of alluvial systems with Bringelly Shale. This may occur horizontally at interface of different geologies shown on the geology maps in Appendix M and vertically where excavation transects or cuts through different geological units. • At the AWRC site. Due to the long construction period at the AWRC, dewatering will induce an upward flow field which will potentially cause deeper low-quality water to be mobilised into the upper alluvial system as illustrated in the conceptual model in Figure 6-3 in Appendix M. • At the shafts for the trenchless sections depending on the backfill material used. • At localised perched aquifers in the following HGLs: – Mid-Nepean River HGL. – Mulgoa HGL. – Greendale HGL. – Upper South Creek HGL. – Mount Vernon HGL.	AWRC and pipelines.	High

Impact	Location	Impact significance
– Upper South Creek Variant A HGL. – Moorebank HGL. These HGLs are prevalent across the project and the proposed mitigation measures will manage this risk. These measures include the installation of permanent vertical cut-offs in areas where increased connectivity may occur such as in alluvial soils. Horizontal trench cut-offs may also be used where perched aquifers are encountered.		
Mobilisation and migration of saline or contaminated groundwater As identified in section 9.4.3, toxicants may be present in the groundwater. Alterations to the groundwater systems, through construction dewatering and the construction of underground structures, could form hydraulic gradients with the potential to induce contaminant migration. Migration of contaminants would be consistent with the direction of induced groundwater flows. Mitigation measures to reduce the amount of dewatering and drawdowns and appropriate management of extracted groundwater will assist in minimising the mobilisation and migration of contaminated groundwater. Such measures include, where feasible, the use of sheet piling to minimise groundwater interaction, the use of trenchless construction techniques and adopting a stage dewatering approach. In addition, additional measures such as recharge trenches in high risk areas can prevent migration of contaminants. Provided mitigation measures are implemented, the predicted minor changes in groundwater quality will not prevent the long-term viability of GDEs. Registered bores relating to beneficial groundwater use categories (for example, irrigation, stock drinking water and raw drinking water) in the vicinity of the project are not expected to be impacted as they are outside of the impacted area. The criteria identified in **Table 9-38** will be met. Any minor change in groundwater quality would not lower the beneficial use category of the groundwater source.	AWRC and pipelines	Moderate
Disposal of saline or contaminated groundwater Groundwater volumes will vary depending on a variety of factors such as the depth, duration and location of the work in addition to seasonal and weather-related fluctuations in groundwater level. Conservative estimates of dewatering volumes are: • Treated water pipeline – 3.8 ML over 219 days.	AWRC and pipelines	Moderate

Impact	Location	Impact significance
• Environmental flows pipeline – 1.3 ML over 26 days. • Brine pipeline – 3.8 ML over 450 days. • AWRC site – 50 ML for the first year. Extracted groundwater in some areas is likely to exceed project waterway objectives, particularly for salinity. Disposal to land, stormwater or nearby waterways could potentially impact soils, water quality and aquatic ecosystems. The water will be tested and compared against relevant criteria in the project waterway objectives and WAL. If criteria are met, or can be met with treatment, the groundwater will be appropriately discharged to suitable land, stormwater or a nearby waterway. If relevant water quality criteria cannot be met, groundwater will be tankered off site for disposal to a nearby wastewater system or treatment plant. These measures will ensure waterway objectives are protected.		
Acid sulfate soils Potential ASS risk areas are present around Georges River and Prospect Creek in the eastern portion of the desktop assessment area. If saturated materials in these areas were exposed to oxygen (for example, through drawdown of the groundwater table from construction dewatering), sulfuric acid and iron can be released from the ASS. This potentially results in impacts including: • leaching/mobilisation of metals from otherwise stable soil matrices, increasing the concentration of heavy metals in the groundwater to potentially toxic levels • reduced durability of underground structures, such as steel and concrete, through corrosion • degradation of soil quality in affected areas, preventing vegetation growth. The mitigation measures identified in section 9.5 will adequately manage this potential impact.	Brine pipeline. ASS risk areas are present around Georges River and Prospect Creek in the eastern portion of the desktop assessment area.	Moderate

Impact	Location	Impact significance
Groundwater seepage When tunnelling in aquifers, there is a possibility of groundwater seepage occurring through the borehole, particularly in areas with elevated water pressures (such as semi-confined aquifers). Groundwater seepage will occur when hydraulic heads in the aquifer exceed the static pressures of the drilling fluid. In addition, if excavations associated with the entry and exit points for the HDD intersect the saturated material, seepage into the open excavations will occur and dewatering will be required (as with trenched pipeline construction).	Pipelines constructed via tunnelling.	Moderate
Frac-outs Another potential impact from tunnelling construction is the unintentional return of drilling fluid to the surface. This occurs when the pressures in the drilling fluid exceed the overburden pressure or if preferential pathways (such as fault lines, fractures or loose materials) are present. These are called frac-outs and can lead to environmental impacts, such as sedimentation in watercourses, groundwater and surface water quality impacts and harm to ecological communities (particularly in aquatic environments).	Pipelines constructed via tunnelling.	Moderate
Discharge of hydrostatic test water The discharge of hydrostatic test water (used for pressure testing of pipelines) from tunnelling activities may also impact receiving land, surface water and groundwater.	Pipelines constructed via tunnelling.	Moderate
Tunnelling beneath Warragamba Pipelines No significant groundwater inflow is expected because the aquifer is expected to be deep based on anecdotal information. Additional groundwater inflows to the Pipelines Corridor are not anticipated.	Environmental flows pipeline.	Low
Contaminated runoff There is potential for groundwater quality impacts to occur from contaminated runoff from the operation of vehicles and machinery, chemical spills and alkaline concrete wash water. This may cause localised soil, surface water or groundwater contamination and possible downstream ecological impacts. The mitigation measures identified in section 9.2 will adequately manage this potential impact.	AWRC and pipelines.	Low

Impact	Location	Impact significance
Tunnelling beneath waterways Tunnelling beneath waterways may lead to the disruption of surface water and groundwater connectivity. Any disruption in connectivity would be very localised.	Tunnelling beneath watercourses.	Low

9.4.6 Operational impact assessment

The key potential impacts during operation are associated with dewatering during maintenance procedures, an increase in impervious surfaces and proposed irrigation. Table 9-45 summarises operational impacts, their location and significance (without any mitigation).

Management measures to address the operational impacts are included in section 9.4.9. The implementation of these measures reduces the impact rating for all impacts to low. Any residual groundwater impacts are expected to meet the criteria outlined in section 9.4.2.

Table 9-45 Potential impacts to groundwater during operation

Impact	Location	Impact significance
Dewatering and drawdown during maintenance activities The proposed secondary treatment process at the AWRC includes a bioreactor, which may be constructed partially underground. The bioreactor will need to be emptied for maintenance about every five years, causing a reduction in the weight of the structure. Management measures may be required to reduce buoyancy and negate potential floatation forces on the structure. One option is to temporarily dewater the groundwater local to the structure, via a subsoil drainage system. This process may induce drawdown and locally lower the groundwater table. Predictive numerical modelling estimated an average inflow rate of 3 m^3/hr into the space otherwise occupied by the bioreactor with groundwater trying to displace the empty bioreactor. For a five-day maintenance period, the total volume is estimated to be around 0.4 ML. A Water Access Licence or aquifer interference approval will not be required. When the bioreactor is emptied, dewatering will lower the water table to 35.6 m AHD, just below the base of the structure. The expected drawdown will be about 0.6 m below current average groundwater level. The extent of the drawdown is expected to be localised and not extend to nearby GDEs. Impacts are unlikely to exceed the criteria listed in Table 9-39. Groundwater at the AWRC is expected to be high in salinity. An approach to manage the extracted groundwater will need to be developed and implemented through an appropriate dewatering management procedure. Given the high salinity, the extracted groundwater will likely be transferred to the AWRC for treatment.	AWRC	Moderate
Increase in impervious surfaces and impact to groundwater levels and creek baseflow There is potential for a long-term reduction in groundwater levels at the AWRC site occurring due to an increase in impervious surfaces and a localised reduction in groundwater recharge. Groundwater recharge in considered to be low in this area and numerical modelling has predicted a long term local depression of the groundwater table of 0.9 m at the centre of the AWRC site and a reduction (about 1%) of baseflow in the creek reaches adjacent to the site. Drawdown reduces to zero before intersecting South Creek. Therefore the predicted change in groundwater levels does not exceed the criteria identified in Table 9-39.	AWRC	Moderate

Page 617

Impact	Location	Impact significance
The reduction in baseflow to South Creek will be offset by stormwater management at the AWRC site. The aim of the strategy is to re-create the pre-development environmental water balance by offsetting the lost recharge. This will be done through increasing post-construction recharge via leaky wetlands and detention basins, as well as local irrigation. The long-term impact on the local water balance will be minimal as will any reduction in the environmental water availability of both groundwater and South Creek. More details about Sydney Water's approach to managing stormwater on the AWRC site is provided in section 9.2. No additional management measures are required. Climate change influences during future stages are not expected to exacerbate the impact, as the reduction in baseflow will be negligible in comparison to the predicted increase in surface water runoff.		
Irrigation As outlined in section 9.2, stormwater from the AWRC site will be harvested for irrigation of the green space area as a means of contributing to the regional waterway health (flow) targets. The underlying groundwater at the AWRC site is expected to be saline. Over irrigation may result in the groundwater level rising, mobilising high salinity groundwater to shallow depths. This could lead to increased salinity in the landscape and degradation of the local fauna and flora as well as the surface water resources on a permanent basis. The irrigation rate proposed will strike a balance between retaining stormwater in the catchment, providing for a quality green space area, and preventing salinification of groundwater by avoiding excessive infiltration of water into soils. The proposed controlled irrigation rate on low saline soils is considered to have a combined low risk of salinity impacts on soils and the underlying groundwater table. With this approach it is expected that pre-development groundwater levels will be maintained and the risk of increasing salinity is considered low. The criteria relating to salinity in Table 9-43 (no more than 1% increase) is expected to be met. The management measures included in section 9.2 effectively mitigate this potential impact.	Irrigation at AWRC	Moderate

Impact	Location	Impact significance
Groundwater seepage There is potential for groundwater seepage to occur after construction of the tunnelled sections of pipelines. Once installed, drilling fluids will solidify. Therefore, groundwater seepage through the pipeline annulus is expected to be negligible. However, there will be a relatively short period after construction where the drilling fluid will still be in a liquid condition. If damage to the pipeline and leakage occurs during this period, upward groundwater seepage can be induced.	Pipelines constructed via tunnelling	Low
Pipe bursts/leakage Water leaking from the pipelines during operation may cause localised increases to groundwater levels and potentially induce groundwater contamination. Water transmitted through the treated water and environmental flows pipelines will be of high quality and unlikely to cause significant impacts to groundwater quality. Water transmitted through the brine pipeline will have much higher total dissolved solids and leaks/bursts occurring across this pipeline is likely to cause a localised decline degradation in groundwater quality. Sydney Water designs its pipelines to a high standard to minimise the risk of leaks as described in section 4.4.4. In addition, design measures taken to prevent leaks and failures from the brine pipeline are documented in section 4.6.2. Sydney Water's standard procedures include regular inspections and incident response procedures which will also manage this potential risk and impact. No additional management measures are required.	Pipelines	Moderate

Impact	Location	Impact significance
Groundwater quality impacts from infiltrating contaminated runoff There is potential for groundwater quality impacts to occur from contaminated runoff from the operation of vehicles and machinery, chemical spills and overflow/leakages of untreated or partially treated wastewater infiltrating the groundwater systems. Chemical storage tanks will be installed in dedicated concrete bunds to contain any spills and covered with protective coatings to prevent concrete corrosion. All chemical storage facilities will meet the relevant codes for safe storage and handling. A first flush system will also be installed at the AWRC. Sydney Water's standard operating procedures, including spills and incident response procedures, will also manage this potential risk. These measures will ensure that waterway objectives are protected. No additional management measures are needed.	AWRC	Low

9.4.7 Impact of future stages

The modelling and assessment focused on the Stage 1 footprint.

The extent of influence on groundwater drawdown associated with future stages of the AWRC has been qualitatively assessed based on the modelling results for Stage 1. Due to similar size and design, it is expected that impacts during construction and operation will be similar in extent to Stage 1. The impact of construction dewatering for future stages is expected to be of local extent, which will be contained within the extent of the proposed AWRC site boundary. Beyond this extent, the impacts to groundwater flow pattern is expected to be negligible.

Impacts from maintenance and irrigation associated with future stages are also expected to be similar to Stage 1. A similar drawdown of around 0.6 m is expected during maintenance regimes. Any additional irrigation would continue to be operated in a controlled manner to minimise the risk of salinity.

Given the pipelines will be built to their ultimate capacity in Stage 1, no additional impacts are expected in future stages.

9.4.8 Cumulative impacts

Potential cumulative impacts to groundwater have been assessed with consideration of other major projects also being constructed or proposed in the region, including:

- Western Sydney International Airport
- M12 Motorway
- Sydney Metro – Western Sydney Airport
- Northern Road Upgrade – Glenmore Road to Bringelly
- Warragamba Dam Raising.

These proposed major projects along with the general expected future urban development in the area have the potential to alter the groundwater conditions. Construction and operation of the AWRC and pipelines could contribute to these cumulative groundwater impacts.

Generally major projects are designed and delivered in accordance with current environmental legislation and incorporate sufficient control measures to mitigate associated impacts. Given the widespread expected urbanisation of the local environment, which would include numerous small-scale developments, the cumulative impacts from these smaller developments could become a more likely source of compounded impacts.

Most groundwater impacts associated with the project are expected to be minor and short-term (during construction). The project is not expected to generate significant groundwater impacts during operation. If the proposed mitigation measures are incorporated, the project will have a minor contribution to any cumulative groundwater impacts from other development in the region.

9.4.9 Management measures

Table 9-46 details the management measures Sydney Water will implement to manage groundwater impacts during construction and operation.

Table 9-46 Groundwater management measures

ID	Potential impact	Management measure	Timing
GW01	Drawdown of groundwater from dewatering activities - general	Identify appropriate trench/shaft support systems (for example sheet piling) in areas with higher hydraulic conductivity and storage properties to minimise groundwater drawdown. This includes all areas mapped as Quarternary alluvial sediments/deposits (Mid-Nepean hydrogeological landscape (HGL), Mulgoa HGL, Upper South Creek HGL, Upper South Creek (Variant A) HGL and Moorebank HGL).	Detailed design During construction
GW2	Drawdown of groundwater - AWRC	Monitor baseline groundwater levels at the AWRC site and levels in South Creek, by: • installing two additional groundwater monitoring wells mid-way between the South Creek and the north western boundary of the site. These will be a shallow and a deep well targeting the upper alluvial aquifer and the residual soil profile. • installing a level gauge at South Creek. Continuous loggers will be installed to monitor water levels. Results will be used to establish baseline conditions, verify the existing surface water and groundwater connectivity and assist in developing a risk-based approach to managing groundwater impacts at the site.	Prior to construction During construction
GW03	Drawdown of groundwater and impact to South Creek - AWRC	Develop a risk-based approach to managing drawdowns and impacts to South Creek during construction at the AWRC. This approach should include: • Monitoring the difference in elevation between South Creek and groundwater levels. • Identify trigger values and associated management measures to take should groundwater levels fall below the water level in South Creek. Management measures should be commensurate with the potential risk of impact to South Creek and nearby GDEs.	Prior to construction During construction

ID	Potential impact	Management measure	Timing
GW04	Drawdown of groundwater from tunnelling construction	Determine the most appropriate trenchless construction techniques to minimise groundwater drawdown, for example 'key' the launch and reception shafts into underlying material with relatively low permeability (eg competent bedrock) to reduce the amount of groundwater entering through the floor and inadvertently scouring the stream bed to the depth of the pipe.	Detailed design
GW05	Increased hydraulic connection between aquifers	Develop options to minimise the potential of increased hydraulic connection between aquifers during pipeline trenching. This will include consideration of the following: • Installation of permanent vertical cut-offs within the trench to prevent the lateral migration of groundwater along the alignment of the pipelines. • Horizontal trench cut-offs where perched aquifers are encountered, to prevent lateral migration and dewatering of the system. Maintenance of the perched layers may also be achieved through backfilling to prevent vertical migration.	Detailed design
GW06	Mobilisation and migration of saline or contaminated groundwater	Adopt a staged approach to dewatering by dewatering in discrete, smaller areas that align with the construction schedule.	During construction
GW07	Mobilisation and migration of saline or contaminated groundwater	Construct adjacent recharge trenches to maintain saturation in high risk areas. If the extent of the drawdown is likely to include an area with existing contamination, consider constructing recharge trenches to limit the cone of depression and create a hydraulic barrier that could prevent the migration of contaminants.	During construction

ID	Potential impact	Management measure	Timing
GW08	Disposal of saline or contaminated groundwater. Disposal of contaminated hydrostatic test water.	Develop and implement a dewatering procedure that identifies how extracted groundwater will be managed. Including requirements for storage, transport, testing and disposal. Disposal options to be considered include: • discharge to land • discharge to stormwater or waterway in accordance with Sydney Water's Water Quality Management During Operational Activities (D0001667) • discharge to the wastewater system in accordance with Sydney Water discharge criteria • tanker by a licensed waste contractor and dispose off-site to an appropriately licensed facility.	Prior to construction During construction
GW09	Frac-outs and groundwater seepage during tunnelling construction	Undertake a risk assessment at trenchless crossings to determine the likelihood of 'frac-outs' and need for any design changes or additional management measures, including consideration of: • refining the design to intersect more competent rock and avoid any preferential pathways such as fault lines, fractures, unconsolidated material • casing at the entry / exit points where there are unconsolidated materials, reduced ground cover and reduced bearing pressure • the need for and location of drill pressure relief wells to provide a pathway for controlled release of drilling fluid pressures • geotechnical conditions at each tunnelling site and the maximum allowable drilling fluid pressures.	Detailed design

ID	Potential impact	Management measure	Timing
GW10	Frac-outs and groundwater seepage during tunnelling construction	Develop a Drilling Fluid Management procedure to avoid impacts, including: • potential risk for 'frac-outs' at tunnelled crossings • approach to identify and manage frac-outs • contain and monitor drilling fluid at entry/exit points until it can be transported to a licensed waste facility • reuse and/or disposal of drilling fluids by appropriately qualified personnel to a licensed facility • prioritising the use of fluids that reduce the risk of seepage into groundwater from boreholes.	Prior to construction During construction
GW11	Tunnelling beneath Warragamba Pipelines and waterways	As part of geotechnical program, investigate: • groundwater levels along tunnelled section of environmental flows pipeline. Identify any additional measures required to prevent groundwater seepage into the Warragamba Pipelines Corridor. • potential surface water - groundwater linkages around watercourses. If needed, consider options to avoid disrupting the connectivity.	Detailed design
GW12	Dewatering and drawdowns during maintenance activities at AWRC site	Consider the inclusion of vertical and horizontal drainage layers and 'chimneys' with coarse filter material to achieve desired drawdowns against the underground structures more quickly and reduce the amount of dewatering required.	Detailed design
GW13	Dewatering and drawdowns during maintenance activities at AWRC site	Adopt a staged approach to dewatering by dewatering in discrete, smaller areas that align more closely to the maintenance schedule.	During operation

9.5 Soils and contamination

This section describes the existing contaminated land and soils environment near the project and the potential impacts during project construction and operation. This section provides an overview of the key findings of the detailed Soils and Contaminated Land Impact Assessment (Aurecon Arup, 2021f) included in Appendix N.

Soils and contamination impact summary

With appropriate management, the significance of project impacts on soil and contamination are expected to be low. The greatest potential for impact is during construction, when soils are disturbed to build the AWRC, pipelines and release structures. Operational impacts are expected to be low given that limited soil disturbance will be required, apart from during infrequent maintenance activities.

Sydney Water has not identified any widespread contamination near the project but has identified 16 areas of environmental concern (AEC) based on desktop investigations and soil sampling. The main contaminant of concern is asbestos, which has been found in localised areas on the AWRC site (around current and former structures), at the Warragamba viewing platform, at Eighteenth Street near Warragamba River and in several other locations near the pipeline alignments. Other sources of potential contaminants near project infrastructure include landfills and service stations. However, the interaction between these and the project is limited or non-existent. It is also possible that other unexpected contamination could be found during construction.

Saline and sodic soils are expected across the project area, which means the potential risk of saline runoff into waterways and of sodic soil erosion will need to be managed. Disturbance of acid sulfate soils (ASS) can result in acidic runoff into the environment, and although there is some potential for brine pipeline construction to encounter ASS close to Prospect Creek, this is considered unlikely.

Sydney Water will adopt a range of management measures to manage the project's potential soil and contamination impacts, including further investigation of AECs as design progresses, plans to appropriately manage any contamination found (including asbestos) and standard soil and erosion management measures.

9.5.1 Relevant Secretary's Environmental Assessment Requirements

Table 9-47 summarises the Secretary's Environmental Assessment Requirements (SEARs) relevant to contaminated land and soils and where in this section they are addressed.

Table 9-47 Project SEARs relating to contaminated land and soils impacts

SEARs	EIS section where requirement addressed
26. An assessment of the impacts of the project on soils and land capability of the site and surrounds, including:	
a) verifying the risk of acid sulfate soils (Class 1, 2, 3 or 4 on the Acid Sulfate Soil Risk Map) within, and in the area likely to be impacted by, the project.	Section 9.5.3
b) assessing the impact of the project on acid sulfate soils (including impacts of acidic runoff offsite) in accordance with the current guidelines.	Section 9.5.5
c) assess whether the land is likely to be contaminated and identify if remediation of the land is required, having regard to the ecological and human health risks posed by the contamination in the context of past, existing and future land uses. Where assessment and/or remediation is required, the Proponent must document how the assessment and/or remediation would be undertaken in accordance with current guidelines.	Sections 9.5.3, 9.5.5, 9.5.9
d) assess whether salinity is likely to be an issue and if so, determine the presence, extent and severity of soil salinity within the project area.	Sections 9.5.3, 9.5.5, 9.5.6
e) assess the impacts of the project on soil salinity and how it may affect groundwater resources and hydrology.	Sections 9.5.5 and 9.5.6. Sections 9.2.6 and 9.4.6 – irrigation impacts on saline soils and groundwater resources.
f) assess the impacts on soil and land resources (including erosion risk or hazard). Particular attention must be given to soil erosion and sediment transport consistent with the practices and principles in the current guidelines.	Sections 9.5.5, 9.5.6 and 9.5.9. Sections 9.2.5 and 9.2.9 for surface water construction impacts and sediment and erosion control management measures
g) assess the potential for asbestos contamination around the Core Park area, Megarritys Creek, Warragamba Viewing Platform and Eighteenth Street, and long-term monitoring requirements and potential for remediation works.	Sections 9.5.3, 9.5.5, 9.5.9 Figure 9-20

9.5.2 Methodology and assumptions

The key steps undertaken for the assessment included:

- desktop review of relevant datasets and historical investigations. The desktop assessment area covered the AWRC site, pipeline alignments and a wider two kilometre impact assessment buffer. The two kilometre impact assessment buffer was based on iterative reference design planning for the project that included pipeline options over a broader area
- a site walkover in April 2020 to confirm the findings of the desktop assessment, to look for potential signs and sources of land contamination and inform the intrusive investigation
- an intrusive investigation taking soil samples from representative areas across the AWRC site, the brine pipeline and treated water pipeline. The soil samples were analysed for chemicals of potential concern (COPC), salinity (salt content in soils), sodicity (a high sodium content in soils indicating increased erosion risk) and acid sulfate soils (soils containing iron sulfides). Across the pipeline alignments, 405 samples were collected, with 326 samples then analysed for a suite of COPC based on field observations and screening for contamination indicators. At the AWRC site, 259 samples were collected with 214 samples then analysed for the same suite of COPC based on field observations and screening for contamination indicators. Selected samples were tested for salinity, sodicity and ASS based on landscape conditions and indicators
- a hazardous materials survey of existing structures and ground surfaces, at the AWRC site, to identify hazardous building materials. This survey, conducted in July 2020, was observational and no analysis of samples was undertaken
- comparing data from the desktop review, intrusive investigations findings and hazardous materials survey against the Tier 1 screening criteria from guidelines in section 9.5.4 (principally ASC NEPM, 2013). This was used to identify and map Areas of Environmental Concern (AEC). AECs are areas which may present contamination-related hazards to human health or to environmental receptors, if ground disturbance occurs without management or mitigation measures
- analysis of potential risks to human health or environmental receptors was undertaken. This was done by identifying the likelihood of each 'source, pathway, receptor' linkage occurring between the AECs and human or environmental receptors and the potential consequence of the exposure. Each of these linkages was given a risk rating. As there is no prescriptive method for undertaking a risk assessment for contaminated land, the risk assessment matrix in Table 9-48 was developed from the contaminated land guidelines in section 9.5.4
- undertaking an impact assessment and identifying management measures to mitigate potential impacts.

Table 9-48 Risk assessment matrix for contaminated land

Consequence	Likelihood					
		Rare	**Unlikely**	**Possible**	**Likely**	**Almost certain**
	Severe	Low	Low to moderate	Moderate to high	Very high	Very high
	Moderate	Negligible to low	Low	Moderate	Moderate to high	High
	Mild	Negligible	Low	Low	Low to moderate	Moderate
	Negligible	Negligible	Negligible	Negligible to low	Low	Low

9.5.3 Existing environment

Soil characteristics

Appendix N includes a comprehensive desktop consideration of soil resources and characteristics including soil landscapes, soil erodibility, acid sulfate soils (ASS), salinity and land capability, including where they occur in relation to the AWRC and pipeline components of the project.

AWRC

Soil landscape mapping (Chapman et al, 2009) shows the AWRC site is located on South Creek and Blacktown soil landscapes. A summary of erodibility hazard for each soil landscape is provided below:

- South Creek soil landscapes are highly susceptible to water erosion due to the active floodplain nature of the landscape. Streambank and gully erosion are common results of concentrated flow.
- Blacktown soil landscapes are susceptible to localised water erosion hazards with localised moderately reactive plastic subsoils. Gully, sheet and rill erosion may occur on cleared areas where vegetation is not maintained.

The Department of Planning, Industry and Environment (DPIE) ASS risk map (accessed from eSPADE online soil mapping) shows that the AWRC site is outside areas mapped as having potential ASS (DPIE, 1998). ASS risk mapping is not available from Penrith City Council.

The land and soil capability class system has eight classes which represent a decreasing capability of the land to sustain landuse. eSPADE (DPIE, 2013b) online mapping shows soil capability classes for the AWRC site as being classes 4, 5 and 6. Classes 4 and 5 are generally described as land capable of a variety of land uses with moderate to high limitations for high impact land uses such as cropping, high intensity grazing and horticulture. Class 6 is described as land capable of a limited set of land uses with severe limitations for high impact land uses. Land use is restricted to low impact uses such as grazing, forestry and nature conservation.

Salinity mapping (DPIE, 2011e) indicates the AWRC site is located in an area with moderate salinity potential with no known areas of salinity mapped on the site.

Analysis of soil samples taken from the AWRC site for the project provided the following information about soil characteristics:

- Non saline soils are present near the surface (up to one metre below ground level), and saline to moderately saline soils are one to three metres below ground level.
- Soils across the AWRC site are generally highly sodic, indicating a high potential for erosion if soils are exposed and vegetation removed. Samples indicated non to moderately sodic surface soils, moderately sodic soils at depths of about 0.4 metres and highly sodic soils at depths of about one metre.
- Soil sampling did not indicate the presence of ASS. ASS are considered highly unlikely to be present in soils across the AWRC site.

Pipelines and water release infrastructure

Soil landscape mapping (Chapman et al, 2009) shows most of the treated water pipeline is located in the Blacktown and Luddenham soil landscapes, with the South Creek soil landscape found along the creek corridors. The Nepean release location is located on the Richmond soil landscape, and the environmental flows pipeline including the Warragamba release location is located on the Hawkesbury and Hazelwood soil landscapes. The brine pipeline is located on Blacktown, Luddenham, South Creek and Berkshire Park soil landscapes.

A summary of soil erodibility hazard for each landscape is provided below.

- Blacktown soil landscapes are susceptible to localised water erosion hazards with localised moderately reactive plastic subsoils. Gully, sheet and rill erosion may occur on cleared areas where vegetation is not maintained.
- Berkshire Park soil landscapes are susceptible to wind erosion hazard on cleared land. Gully, sheet and rill erosion may occur on dissected areas.
- Hawkesbury soil landscapes suffer from severe sheet erosion, often during storms and after ground cover is destroyed by bushfires.
- Hazelwood soil landscapes are susceptible to water erosion on localised slopes.
- Luddenham soil landscapes are erosional landscapes and disturbed land and can suffer sheet erosion.
- Richmond soil landscapes can suffer water erosion on localised terrace edges.

- South Creek soil landscapes are highly susceptible to water erosion due to the active floodplain nature of the landscape. Streambank and gully erosion are common results of concentrated flow.

The DPIE ASS risk map (accessed from eSPADE online mapping) indicates that most of the desktop assessment area for the treated water pipeline, environmental flows pipeline and brine pipeline is outside areas mapped as having potential ASS. Some potential ASS risk areas are present around Prospect Creek in the eastern portion of the desktop assessment area, indicating potential risk from disturbance and excavation associated with brine pipeline construction in these areas. This is consistent with mapping in the Bankstown Local Environmental Plan (2015) and Fairfield Local Environmental Plan (2013). Sydney Water's soil sampling indicated that ASS would unlikely be encountered with the exception of the Prospect Creek area.

DPIE salinity mapping (DPIE, 2011e) indicates the areas with high salinity potential across the treated water pipeline and brine pipeline include low lying areas around Cosgrove Creek, Kemps Creek and the South Creek alluvial plain. There are no known areas of salinity that intersect the pipeline alignments. The same mapping also indicates areas around Warragamba River and Nepean River release locations have a low to moderate salinity risk with no known areas of salinity mapped for these locations. Sydney Water soil samples analysed for the brine pipeline were typically non saline with the exception of some locations around Clear Paddock Creek. Soil samples analysed for the treated water pipeline indicate generally non saline conditions. Moderately saline soils were detected at one sample location about 50 m west of South Creek. Salinity concentrations generally increase with depths to the water table across the treated water and pipeline alignments.

eSPADE online mapping shows soil capability for the desktop assessment area along the treated water pipeline, environmental flows pipeline and brine pipeline includes soil capability classes 3, 4, 5, 6 and 7. Class 3 is high capability land which is only found in the rural lots close to Nepean River. Classes 4, 5 are generally described as land capable of a variety of land uses with moderate to high limitations for high impact land uses (cropping, high intensity grazing and horticulture) and are found in Warragamba and scattered sections of the alignment from Nepean River to the M7 Motorway through to Lansdowne. Class 6 is described as land capable of a limited set of land uses with severe limitations and land use is restricted to low impact uses such as grazing, forestry and nature conservation and found on the plateaus close to Warragamba River and scattered from Nepean River to the M7 Motorway. Class 7 is land classed as incapable of supporting agriculture and is found near on the steep banks of Warragamba River near the release location.

Sydney Water soil sampling found that soils across the treated water pipeline and brine pipeline alignments ranged from non-sodic to highly sodic, with surface soils (up to 0.4 m below ground surface) being non to moderately sodic. Deeper soils (greater than 0.4 m below the ground surface) indicated highly sodic conditions.

Intrusive investigations indicated two potential areas of slope instability along the brine pipeline alignment due to historical landslides to the west and east of the M7 Motorway and the area between Prospect Creek and Henry Lawson Drive. Slope instability is also likely on the steep slopes of the Warragamba valley downstream of the dam.

Contamination

Table 9-49 summarises potentially contaminated areas across the desktop assessment area and these are also shown as areas of environmental concern (AEC) on Figure 9-20 and Figure 9-21. Appendix N includes a full summary of previous investigations and reports reviewed to understand the existing environment.

In addition to undertaking reviews of previous studies, Sydney Water also completed contamination analysis of soil samples across the project. The findings consolidated from these studies are summarised here, with more detail included in Appendix N.

AWRC

At the AWRC site, a study by JBS&G (2018) identified the main source of contamination as localised asbestos containing materials (ACM) in surface soils. Some near surface soil samples showed minor exceedances of heavy metals and Total Recoverable Hydrocarbon (TRH) for ecological screening levels.

Sydney Water's contamination analysis of soil samples at the AWRC site in 2020 identified the following:

- The site typically has natural soils from the surface with minimal filling present. Fill materials were observed at one location from the surface to 0.1 m below ground level.
- All the samples analysed for COPCs (non-asbestos) were below the adopted Tier 1 screening guideline investigation criteria for human health with several minor exceedances of ecological criteria. The presence of minor exceedances of ecological criteria for heavy metals and TRH is not considered a constraint due the site being filled and landscaped with topsoil suitable to support plant growth.
- ACMs were detected in localised areas of soils (typically sourced from former nearby structures now removed) and existing buildings such as sheds and derelict buildings on the site.

Concentrations of all other COPCs assessed did not exceed adopted human health criteria. Polyfluoroalkyl substances (PFAS) were not reported in any soil samples analysed across the site.

Pipelines

In general, for the pipelines, previous investigations found little or low risk of contamination from existing sources across the desktop area. Contamination was found at specific locations along the environmental flows pipeline, where the main sources of contamination were found to be from ACM. Notable locations include:

- Core Park Road (ACM areas about 100 m south of the environmental flows pipeline)
- Megarritys Creek (ACM areas about 250 m to the south of the environmental flows pipeline)
- Warragamba Dam viewing platform (ACM areas about 500 m to the south of the environmental flows pipeline).

Sydney Water's contamination analysis of soil samples along the brine pipeline alignment identified:

- Fill material down to a maximum depth of 2.1 m was present at various locations along the brine pipeline. During site works volatile vapours were noted at one sample location on Cabramatta Road, potentially originating from an adjacent service station at Bonnyrigg.
- Most samples taken along the brine pipeline did not exceed any guideline investigation criteria (NEPM 2013). No asbestos fragments were detected.
- An exception was one sample found Total Recoverable Hydrocarbons (TRH) exceeding the Health Screening Levels for commercial or industrial land use guidelines (ASC NEPM, 2013). This is associated with the service station located close to the alignment near Bonnyrigg.

Sydney Water's contamination analysis of soil samples along the treated water pipeline alignment identified:

- Fill material down to a maximum depth of 2.1 m was present at various locations.
- There were no exceedances of the guideline investigation criteria (ASC NEPM 2013) for COPCs (non-asbestos).
- Asbestos fragments were detected in two sample locations along the treated water pipeline alignment. However, analysis results did not report any free or respirable fibres, and all samples were from a depth greater than 100 mm from the surface and within fill material.

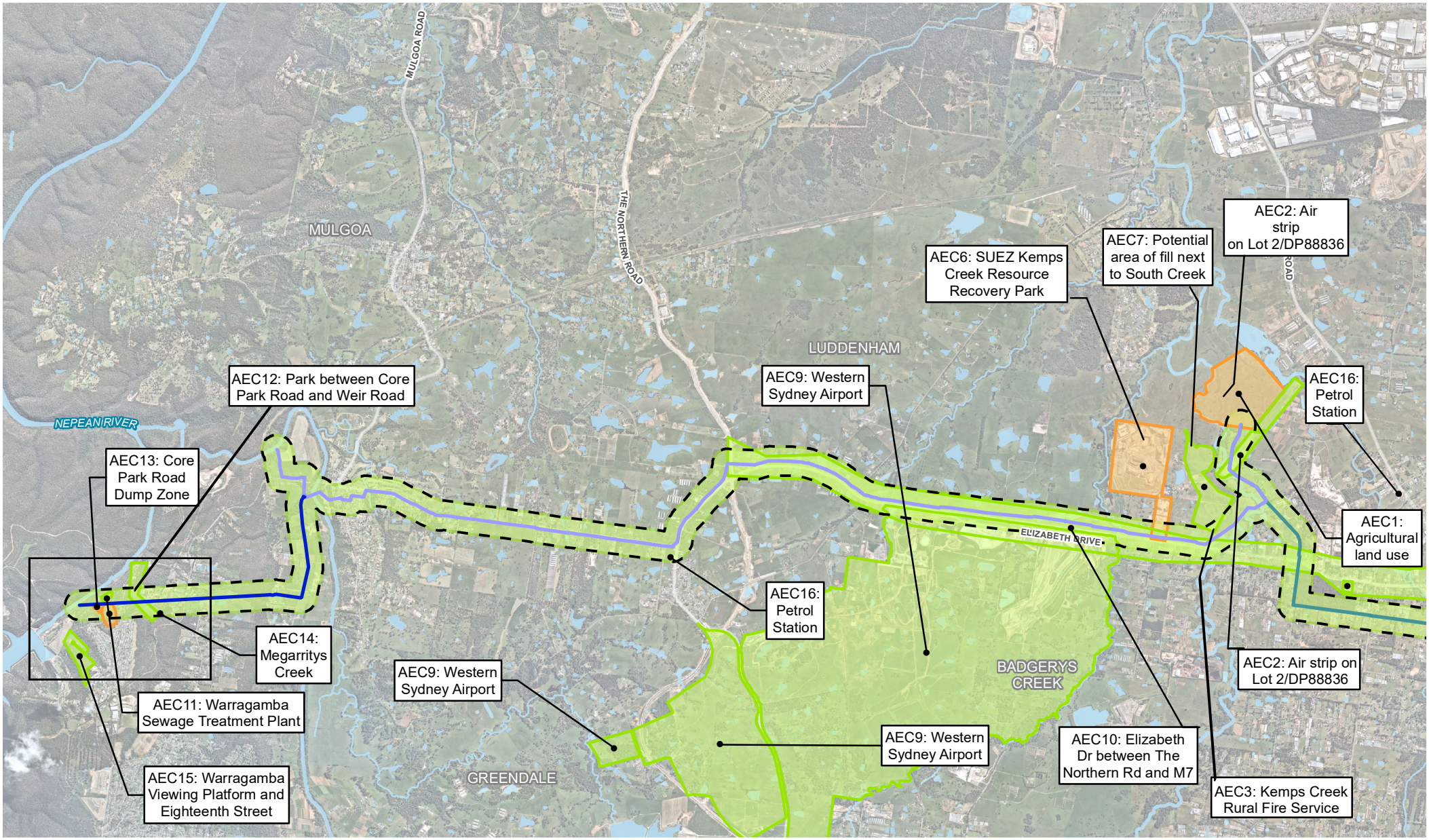
Table 9-49 Summary of historical contamination in the project's desktop assessment area

AEC ID	Location	Historical activities	Potential COPCs present	Historical contamination summary
1	AWRC site	Former and current agricultural land usage Pesticide and herbicide use Chemical/fuel use and storage Structures containing hazardous building materials (HBM) including asbestos and heavy metals Historical filling and stockpiles on site	ACM Heavy metals	ACM fragments were present in soils and in buildings on site across the AWRC site. Areas of ACM are located and limited to former structures and surrounding current structures across the AWRC site. Zinc and copper had minor and localised exceedances of adopted Tier 1 screening criteria for ecological receptors (ASC NEPM 2013) (JBS&G, 2018).

AEC ID	Location	Historical activities	Potential COPCs present	Historical contamination summary
2	AWRC Air strip on Lot 2/DP88836	Potential use of historical fire-fighting foams containing PFAS for airfield activities.	PFAS	Small air strip with limited use and no known fire training adjacent to the AWRC site to the immediate south-east. No exceedances of adopted guidelines (PFAS NEMP 2.0, 2020) for PFAS from Sydney Water analysis (2020) and JBS&G (2018) previous site investigations.
3	Kemps Creek Rural Fire Service	Use of historical fire-fighting foams containing PFAS	PFAS	No exceedances for PFAS (AAJV, 2019b).
4	Western Rd to Brandown Quarry	Historical filling	Heavy metals	Ecological exceedances (ASC NEPM, 2013) for zinc, copper and nickel in soil. Copper and zinc exceedance in groundwater. Metal concentrations noted to be natural and at background concentrations (Aurecon Arup, 2021f).
5	Former Kari & Ghossayn Pty Ltd (solid waste landfill)	Former landfilling activities	TRH, Benzene, Toluene, ethylbenzene and xylene (BTEX), ammonia, Polycyclic Aromatic Hydrocarbons (PAH), heavy metals, Organochlorine pesticides (OCP), Orthophenylphenol (OPP), Polychlorinated Biphenol (PCB), nutrients, ACM	Results from soil sampling near the site found no exceedances of adopted Tier 1 screening criteria. However, no samples were collected within the site. Possible contamination within the site (RMS, 2019).

AEC ID	Location	Historical activities	Potential COPCs present	Historical contamination summary
6	SUEZ Kemps Creek Resource Recovery Park	Historical and current landfilling activities	TRH, BTEX, ammonia, PAH, heavy metals, OCP, OPP, PCB, nutrients, ACM	Groundwater containing elevated copper, zinc, ammonia, nitrogen and nickel levels, and gas containing methane and carbon dioxide exceedances above adopted guidelines (ASC NEPM, 2013 and NSW EPA guideline Assessment and management of hazardous ground gases, 2020c) were found adjacent to the site (RMS, 2019).
7	Potential area of fill next to South Creek	Historical filling	Heavy metals	Exceedances of adopted Tier 1 screening criteria (ASC NEPM, 2013) for copper and zinc in groundwater (RMS, 2019).
8	Corner of Elizabeth Drive and Range Road, Kemps Creek	Illegal dumping of building materials	ACM	ACM present within the soil to the north of Range Road (RMS, 2019).
9	Western Sydney Airport	Contaminants from construction activities	TRH, BTEX, PAH, heavy metals, PCB, nutrients, ACM	No exceedances of adopted Tier 1 screening criteria (ASC NEPM, 2013) (AAJV, 2019b).
10	Elizabeth Drive between the Northern Road and M7	Dumped domestic and C&D waste Suspected ACM Historical filling	TRH, BTEX, PAH, heavy metals, PCB, ACM	No exceedances in soil of adopted Tier 1 screening criteria (ASC NEPM 2013) (AAJV, 2019b). Asbestos cement sheeting present in waste piles along roadway and at surface of piles.
11	Warragamba Wastewater treatment plant	Historical filling	ACM Heavy metals E. Coli	Heavy metals and E.coli in soil samples. ACM present on site (Parsons Brinckerhoff, 2008).

AEC ID	Location	Historical activities	Potential COPCs present	Historical contamination summary
12	Park Road between Core Park Road and Weir Road	Historical filling	ACM	ACM present in soils. Area has since been remediated (CH2M, 2017a, 2017b, 2017c).
13	Core Park Road Dump Zone	Illegal dumping	ACM, PCBs	Asbestos cement sheeting, friable asbestos wiring and a fluorescent light fitting present (IE, 2016).
14	Megarritys Creek	Illegal dumping	ACM	ACM present on surface (WSP, 2015, ADE, 2017, 2019a, 2019b).
15	Warragamba viewing platform and Eighteenth Street	Historical filling	TRH, BTEX, PAH, heavy metals, PCB, ACM	ACM in soils and on surface exceeded the adopted Tier 1 screening criteria (ASC NEPM, 2013). TRH, benzo(a)pyrene and naphthalene exceedances of adopted Tier 1 screening criteria (ASC NEPM, 2013) in localised areas. The area has been remediated but residual ACM is still present on site in sub soils and likely deeper due to legacy issues and former Warragamba Dam construction housing made from asbestos sheeting and asbestos products.
16	Petrol stations across project area	Petrol Storage, dispensing and spills	TRH, ACM	TRH C6-C10 and TRH C6-C10 exceeded the adopted Tier 1 screening criteria (ASC NEPM, 2013) in one sample along the brine pipeline (Aurecon Arup, 2021f).



Treated water pipeline
Brine pipeline
Environmental flows pipeline

Areas of Environmental Concern

Risk Rating

Low
Moderate

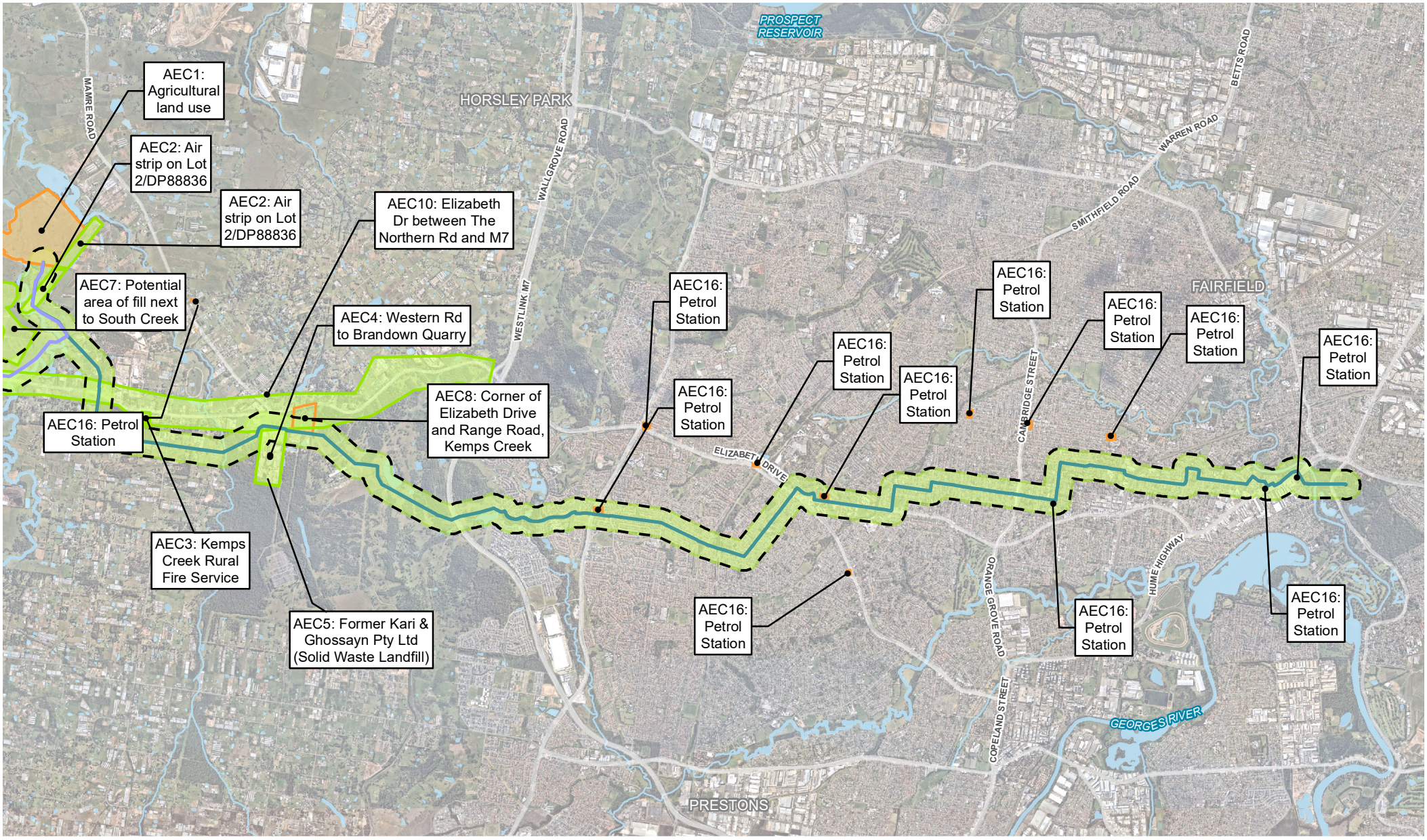
Base Data

Watercourse
Waterbody

1:70,000
0 0.5 1km

Figure 9-20 Areas of Environmental Concern AWRC and Treated water pipeline

Source: Aurecon, Sydney Water, LPI, Nearmap, ESRI
Projection: GDA2020 MGA Zone 56



Treated water pipeline
Brine pipeline

Areas of Environmental Concern

Risk Rating

Low
Moderate

Base Data

Watercourse
Waterbody

1:73,000
0 0.5 1km

Figure 9-21 Areas of Environmental Concern Brine pipeline

Source: Aurecon, Sydney Water, LPI, Nearmap, ESRI
Projection: GDA2020 MGA Zone 56

9.5.4 Legislation and guidelines

Table 9-50 summarises legislation relevant to the project.

Table 9-50 Legislation relevant to the project

Legislation	Relevance to project
Contaminated Land Management Act 1997 (NSW) (CLM Act)	The general object of this act is to establish a process for investigating and (where appropriate) remediating land that the Environment Protection Authority (EPA) considers to be contaminated significantly enough to require regulation. Several clauses in the Act relate to responsibility for contaminated land (clause 6) and duty to report contamination (clause 60) to the EPA. These clauses will be adhered to when construction and operation of the project is undertaken. The Act and clauses are relevant because they establish a process for investigating contaminated land and provide a framework for reporting to the EPA contamination risks that warrant regulation or involvement of an accredited site auditor for reportable contamination.
Protection of the Environment Operations Act 1997 (NSW) (POEO Act)	The POEO Act is the key piece of environment protection legislation administered by the EPA. The objects of this act include to protect, restore and enhance the quality of the environment in NSW, having regard to the need to maintain ecologically sustainable development. The following are key clauses, parts and chapters relevant to the construction and operation of the project: • Chapter 3 – Environment Protection Licences will be required for construction and operation of the project. • Part 5.7 – Duty to notify of pollution incidents for construction and operation of the project.

The following guidelines have been used to develop the methodology for the assessment of land contamination hazards and to guide management measures:

- Sampling Design Guidelines for Contaminated Land (Draft) (NSW EPA 2020a).
- Guidelines for the Assessment and Management of Groundwater Contamination (NSW EPA 2007).
- Guidelines for Consultants Reporting on Contaminated Land (NSW EPA 2020b).
- Guidelines for the Assessment and Management of Sites Impacted by Hazardous Ground Gases (NSW EPA 2012).
- Waste Classification Guidelines – Part 1 to Part 4 (NSW EPA 2014a).
- Guidelines on the Duty to Report Contamination under the *Contaminated Land Management Act 1997* (NSW EPA 2015).

- Guidelines for the NSW Site Auditor Scheme (Third Edition)(NSW EPA 2017a).
- National Environment Protection (Assessment of Site Contamination) Measure 1999 (as amended 2013).

The following guidelines have been used to develop the methodology for the assessment of erosion and salinity hazards, interpretation of soil analytical results and to guide management measures.

- Managing Urban Stormwater: Soils and Construction Volume 1 and Volume 2 (A. Installation of Services; B. Waste Landfills; C. Unsealed Roads; D. Main Roads; E. Mines and Quarries), (Landcom, 2004)
- Guidelines for developments adjoining land and water managed by the Department of Environment, Climate Change and Water (DECCW 2010c).
- The land and soil capability assessment scheme: Second approximation (OEH 2012).
- Guidelines for Surveying Soil and Land Resources (McKenzie et al, 2008).
- Australian Soil and Land Survey Handbook (CSIRO 2009).
- Soil and Landscape Issues in Environmental Impact Assessment (DLWC 2002b).
- Site investigations for Urban Salinity (DLWC 2002c).
- Australian Geomechanics Society (2007) *Landslide risk management guidelines* presented in Australian Geomechanics Society (Australian Geomechanics Society, 2007).

Collected intrusive investigation soil sample results were screened against Tier 1 screening levels for commercial and industrial land use investigation levels that are established within the National Environmental Protection Measure guidelines (ASC NEPM, 2013). Exceedances indicate where more remediation, management or risk assessment could be necessary for COPCs. The following criteria were used:

- Health Investigation Level (HIL) for (D) (ASC NEPM 2013).
- Health Screening Level (HSL) (D) (ASC NEPM 2013).
- Health Screening Level (HSL) (D) for commercial/industrial land use for direct contact with petroleum hydrocarbon compound contaminants in soil, particularly for onsite workers during construction (CRC CARE 2011).
- Health Screening Levels (HSL) (D) for asbestos (ASC NEPM 2013).
- Ecological Investigation Levels (EILs) (ASC NEPM 2013).
- Ecological Screening Levels (ESLs) (ASC NEPM 2013).
- Waste Classification Guidelines- Part 1: Classification of waste and annexures (NSW EPA 2014).
- Acid Sulfate Soils Management Manual (ASSMM) (NSW ASSMAC 1998).

9.5.5 Construction impact assessment

The following is a summary of the key findings from the contaminated land and soils construction impact assessment. Appendix N includes the full assessment.

Contamination impacts

Table 9-51 summarises the project's potential impacts on contamination, focused on AECs. These impacts are primarily due to the demolition of structures and the disturbance, mobilisation and handling (including stockpile management) of contaminated soil from construction activities. Key contamination sources are associated with ACMs found in surface soils and fill materials at depth. Key receptors for asbestos contamination are construction workers and the public. Impacts are considered low where AECs are unlikely to intersect with the project.

Where impacts are moderate, provided the management measures in section 9.5.9 are implemented, overall construction impacts associated with contaminated land for the project are expected to reduce to low.

Table 9-51 Summary of construction impacts to areas of environmental concern

AEC ID	Location	Potential COPCs present	Impact summary	Impact significance
1	AWRC – current and former structures such as farm sheds and radio towers containing asbestos and heavy metals	ACM Heavy metals	Demolition, excavation and stockpiling of soils containing ACM have potential to create exposure scenarios to construction workers and spread contaminated soil across the site. Because ACM fragments were present in soils and in buildings across the site, the impact significance is moderate. Zinc and copper ecological screening criteria exceedances (ASC NEPM, 2013) were previously identified across the site. The impact significance is considered low because rehabilitation will include the use of suitable soils for landscaping.	Moderate
2	AWRC Air strip on Lot 2/DP88836	PFAS	If present, PFAS can migrate through surface water and groundwater pathways. Because there are no exceedances for PFAS and the air strip is small with no previous known fire training occurring, the impact significance is low.	Low
3	Kemps Creek Rural Fire Service	PFAS	Because there are no known exceedances from investigations undertaken for the project and AEC 3 is about 500 m from the project brine pipeline alignment, the impact significance is low.	Low

AEC ID	Location	Potential COPCs present	Impact summary	Impact significance
4	Western Rd to Brandown Quarry	Heavy metals	Because ecological exceedances (ASC NEPM, 2013) for zinc, copper and nickel in soil are noted concentrations at background levels, the impact significance is low.	Low
5	Former Kari & Ghossayn Pty Ltd (Solid Waste Landfill)	TRH, BTEX, ammonia, PAH, heavy metals, OCP, OPP, PCB, nutrients, ACM	Because soil sampling near the site found no exceedances of adopted Tier 1 criteria (ASC NEPM, 2013) and AEC 5 is 1.7 km from the brine pipeline the impact significance is low.	Low
6	SUEZ Kemps Creek Resource Recovery Park	TRH, BTEX, ammonia, PAH, heavy metals, OCP, OPP, PCB, nutrients, ACM	There is potential for contaminated groundwater to migrate to the AWRC site as topography indicates that groundwater is expected to flow from west to east. However, the presence of South Creek between the two sites will act as a barrier or hydrogeological divide to the migration of groundwater and landfill gas. The impact significance for migration of contaminated groundwater is moderate. Landfill gas is deemed to have a low impact significance to the project due to the distance between the two sites (400 m).	Moderate
7	Potential area of fill next to South Creek	Heavy metals	Because exceedances for copper and zinc in groundwater are expected to be from background levels the impact significance is low.	Low
8	Corner of Elizabeth Drive and Range Road, Kemps Creek	ACM	Because of ACM present within the soil to the north of Range Road and parts of AEC 8 are within the impact area for the project and will be disturbed during construction, the impact significance is moderate.	Moderate
9	Western Sydney Airport	TRH, BTEX, PAH, heavy metals, PCB, nutrients, ACM	Because there are no adopted Tier 1 screening criteria (ASC NEPM, 2013) exceedances and the treated water pipeline does not intersect with AEC 9 the impact significance is low.	Low

AEC ID	Location	Potential COPCs present	Impact summary	Impact significance
10	Elizabeth Drive between the Northern Road and M7	TRH, BTEX, PAH, heavy metals, PCB, ACM	Because there are no adopted Tier 1 screening criteria (ASC NEPM, 2013) exceedances in soil, and asbestos cement sheeting present in waste piles is unlikely to be disturbed by construction of the treated water pipeline, the impact significance is low.	Low
11	Warragamba wastewater treatment plant	ACM Heavy metals E. Coli	AEC 11 is 500 m from the environmental flows pipeline. Soil disturbance from construction is not expected, therefore the impact significance is low.	Low
12	Park Road between Core Park Road and Weir Road	ACM	Whilst ACM is present in surface soils, AEC 12 is next to the environmental flows pipeline which will be tunnelled beneath surface soils. This means disturbance of surface soils is not expected at this location, therefore the impact significance is low.	Low
13	Core Park Road Dump Zone	PCBs ACM	Whilst ACM is present in surface soils, AEC 13 is next to the environmental flows pipeline which will be tunnelled beneath surface soils. This means disturbance of surface soils is not expected at this location, therefore the impact significance is low.	Low
14	Megarritys Creek	ACM	Whilst ACM is present in surface soils AEC 14 is next to the environmental flows pipeline, which will be tunnelled beneath surface soils. This means disturbance of surface soils is not expected at this location, therefore the impact significance is low.	Low
15	Warragamba viewing platform and eighteenth street	TRH, BTEX, PAH, heavy metals, PCB, ACM	Given the historical presence of ACM within AEC 15 and because part of AEC 15 may be disturbed by activities (including the drill site) within the Warragamba compound, the impact significance is moderate.	Moderate

AEC ID	Location	Potential COPCs present	Impact summary	Impact significance
16	Petrol stations	TRH, ACM	Given the TRH exceedance in the soil sample associated with the service station near Cabramatta Rd, West Bonnyrigg and that AEC 16 may be subject to disturbance at this location for pipeline construction, the impact significance is moderate. Whilst other AECs are unlikely to be impacted by disturbance during construction, COPCs can migrate so the impact significance is moderate.	Moderate

Soil impacts

Table 9-52 summarises potential construction impacts associated with soil resources for the project. The key impacts are associated with the disturbance and exposure of soil resources including saline and sodic soils across the project area. This could lead to increased risk of erosion and mobilisation of sediments and discharge of saline runoff to waterways. Provided the management measures in section 9.5.9 are implemented, moderate impacts associated with exposure of saline and sodic soils, clearing and excavation are expected to reduce to low.

Table 9-52 Summary of potential construction impacts on soils

Location	Potential soil hazard	Impact summary	Impact significance
Disturbance and deeper excavations (for example, AWRC site) and tunnelling and trenching works near creeks	Highly saline soils	Because disturbance and excavation is required at depths greater than two metres below the ground surface and close to creeks, the project will likely encounter soils with high salinity, resulting in potential for saline sediment to enter waterways. The impact significance is moderate.	Moderate
Disturbance and shallower excavations across the project impact areas	Moderately saline soils	Because disturbance and excavation will likely encounter soils with moderate salinity across the project area, resulting in potential for saline sediment to enter waterways, the impact significance is moderate.	Moderate

Location	Potential soil hazard	Impact summary	Impact significance
AWRC and pipeline excavations	Sodic soils	Exposure of sodic soils causes wetting and clay dispersal increasing the potential risk of erosion and sedimentation of waterways. Because sodic soils are likely to be encountered at variable depths and concentrations across the project impact area, with moderate to high sodicity present in soils at depths greater than 0.5 m the impact significance is moderate.	Moderate
Rehabilitation at the AWRC and across the pipelines	Sodic soils	The reuse of sodic soils at the ground surface (for example, in rehabilitation) may increase the potential risk of erosion at these locations. As sodic soils are likely to be encountered and brought to the surface during excavation the impact significance is moderate.	Moderate
Brine pipeline near Prospect Creek and Henry Lawson Drive and to the east and west of the M7 Motorway	Slope stability	Destabilisation of soil profiles due to excavations may occur in these areas, however as cuts associated with pipeline construction are not expected to be large scale or excessively deep, the impact significance is low.	Low
Brine pipeline near Prospect Creek and Georges River	ASS	The disturbance, exposure and wetting of ASS from excavations and dewatering may generate sulfuric acid which will cause leaching of metals from soils, and degradation of soil quality preventing vegetation growth. ASS are not generally expected within most of project impact area, but there is low potential in these locations, therefore the impact significance is low.	Low

9.5.6 Operational impact assessment

Key impacts in the operational phase are associated with salt mobilisation in soils due to excessive irrigation at the AWRC site, soil erosion impacts associated with scouring at release locations and sodic soils used for landscaping at the AWRC. Provided the management measures described in section 9.5.9 are in place, all operational impacts associated with soil salinity and ongoing erosion are expected to remain low.

9.5.7 Impact of future stages

Impacts from future stages during construction are not expected to be significant. This is because the impacts resulting from contaminated land at the AWRC site are expected to be similar to the impacts identified for Stage 1 and will likely be mitigated by management measures similar to those identified in section 9.5.9. During operation, further land disturbance is not expected and provided the construction management measures are implemented, the impacts associated with future stages are not expected to be significant.

9.5.8 Cumulative impacts

The following projects have been considered for the assessment of cumulative impacts:

- Western Sydney International Airport.
- M12 Motorway.
- Western Sydney Aerotropolis Growth Area (WSAGA).
- Sydney Metro Western Sydney Airport.
- Northern Road upgrade.
- Warragamba Dam wall raising.

Cumulative impacts for contaminated land, soil salinity and erosion could occur during concurrent construction of the above projects. The M12 Motorway project reported areas of potential contamination within the construction boundary, demolition of buildings with potentially hazardous materials but negligible impacts associated with soil salinity and ASS. The Western Sydney International Airport reported key impacts associated with soil erosion, salinity and use of water for irrigation. Both projects will implement remedial and soil management measures, therefore cumulative impacts associated with contamination and soil salinity are not expected to be significant.

Future development of WSAGA precincts will be controlled by the State Environmental Planning Policy (Western Sydney Aerotropolis) 2020 and Development Control Plan (a Phase 1 draft at time of writing) which include objectives and benchmarks for soil and contamination management that will seek to manage impacts caused by rapid urbanisation. Cumulative impacts associated with the project are not expected to be significant.

Interaction and therefore cumulative impacts between the Sydney Metro Western Sydney Airport project and the Northern Road Upgrade and the AWRC is not expected.

There are no cumulative impacts expected from the Warragamba Dam wall raising project.

9.5.9 Management measures

Table 9-53 summarises contaminated land and soil management measures for construction and operation of the project. Monitoring requirements would be consistent with the remedial action plan indicated in Table 9-53 below.

Table 9-53 Management measures for contamination and soil

ID	Potential impact	Description of management measure	Timing
CLS01	Disturbance of saline soils, acid sulfate soils (ASS), contamination and sodic soils	Develop and implement a soil sampling program to assess excavated soils for salinity, acid sulfate soils (ASS), contamination and sodicity. If identified: • Saline soils will be managed in accordance with NSW Department of Primary Industries (2014) Salinity Training Handbook and NSW guidelines for salinity management. • Develop an ASS management plan (ASSMP) in accordance with the NSW ASSMAC (1998) guidelines and consideration of the Department of Agriculture and Water Resources '*National Acid Sulfate Soils guidance: National acid sulfate soils sampling and identification methods manual*' (Sullivan et al., 2018), that includes: – identification of ASS locations – handling and storage procedure to avoid and minimise exposure of stockpiles – where stockpiles are exposed, treat exposed areas with lime • Excavation of sodic soils will be avoided if possible. If not possible to avoid excavation, they will not be reused within the project for landscaping or surface rehabilitation Undertake soil sampling investigations in accordance with ASC NEPM (2013), Sampling Design Guidelines (NSW EPA, 1995), Consultants Reporting on Contaminated Land, (NSW EPA, 2020) and Assessment and Management of Hazardous Ground Gases (NSW EPA, 2020).	Detailed design Prior to construction During construction
CLS02	Demolition of structures that may contain asbestos containing material	Undertake a pre-demolition destructive hazardous material survey of any buildings and structures within the AWRC site to confirm hazardous materials and estimate types and volumes.	Prior to construction During construction

ID	Potential impact	Description of management measure	Timing
CLS03	Disturbance of contaminated soils during construction	Develop and implement a remedial action plan for AECs, if the soil sampling program or pre-demolition destructive hazardous material survey identifies this is required. Prepare this in accordance with the ASC NEPM (2013) and Consultants Reporting on Contaminated Land, (NSW EPA, 2020).	Prior to construction During construction
CLS04	Disturbance and excavation of unexpected contaminated soils	Develop and implement an unexpected finds procedure that will include: • stop work in area suspected of contamination • inspection and verification of the area by a contaminated lands practitioner • collection of soil samples and analysis for chemicals of potential concern (COPC) identified by the inspection • management, risk assessment or remedial action based on the type, extent, waste implications and significance of the COPC • requirement to notify the NSW EPA under section 60 of the CLM Act • remediation in accordance with remedial action plan	Prior to construction During construction
	Contaminated runoff from the operation of vehicles, machinery, spills and leaks entering waterways	This impact is appropriately managed by measures in section 9.2 (Surface water).	During construction
	Salt mobilisation in soils from excessive irrigation at the AWRC	This impact is appropriately managed by measures in section 9.2 (Surface water).	During operation
	Erosion of soils from operational releases	This impact is appropriately managed by measures in section 9.2 (Surface water).	During operation
	Generation of contaminated waste streams	This impact is appropriately managed by measures in section 12.2 (Waste management).	During construction During operation
	Use of saline groundwater from dewatering operations	This impact is appropriately managed by measures in section 9.4 (Groundwater).	During construction

ID	Potential impact	Description of management measure	Timing
	Increased erosion and sedimentation of waterways from vegetation removal	This impact is appropriately managed by measures in section 9.2 (Surface water).	Prior to construction During construction

10 Heritage impacts

This chapter assesses the project's heritage impacts, including Aboriginal heritage, non-Aboriginal heritage, World heritage and National heritage.

10.1 Aboriginal heritage

This section describes Aboriginal heritage items and Potential Archaeological Deposits (PADs) near the project, and the project's potential impacts on those during construction and operation. It provides an overview of the key findings of the detailed Aboriginal Cultural Heritage Assessment Report (ACHAR) (Kelleher Nightingale Consulting, 2021) included in Appendix O.

Aboriginal heritage impact summary

The project will impact on some Aboriginal heritage items during construction but further impacts are unlikely during operation.

During construction, Sydney Water cannot totally avoid impacts to Aboriginal archaeological items given landuse and engineering constraints and the large size of the impact area. However, Sydney Water has refined the design to avoid all items considered to have high significance. Fifteen archaeological sites including one area of potential archaeological deposit (PAD) will be partially impacted by the project. Of the 15 sites, three are in areas for which existing Aboriginal Heritage Impact Permits (AHIPs) apply or have been submitted. Of those sites impacted all are of low to moderate archaeological significance.

During detailed design, Sydney Water will consider further opportunities to refine the project to reduce impacts to sites and PADs where practical. Where impacts cannot be avoided a program of test excavations and artefact salvage will be undertaken. Sydney Water will also implement other measures to manage Aboriginal heritage impacts during construction, including procedures for managing any unexpected heritage finds.

The Aboriginal heritage impact assessment was undertaken in consultation with 26 Registered Aboriginal Parties (RAPs) who registered their interest in the project. Sydney Water consulted the RAPs on a range of matters including methodology review, cultural values, and review of the draft Aboriginal Cultural Heritage Assessment Report (ACHAR). Some groups were also involved in field surveys. RAPs were generally supportive of the findings of the ACHAR, with the exception of one group who raised concerns about participants in the archaeological survey, the scale of maps, and the destruction of cultural values.

Sydney Water is also completing an Aboriginal Cultural Values Study in consultation with local Aboriginal communities to better understand intangible Aboriginal cultural values of water in the South Creek catchment and parts of Nepean River. This study is separate to the project but its outcomes may help inform ongoing management and design of the project, including design of the green space area on the AWRC site and heritage interpretation.

10.1.1 Relevant Secretary's Environmental Assessment Requirements

Table 10-1 summarises the Secretary's Environmental Assessment Requirements (SEARs) relevant to Aboriginal heritage and where in this section they are addressed.

Table 10-1 Project SEARs relating to Aboriginal heritage impacts

SEARs	EIS section where requirement addressed
20. Identifying and describing the Aboriginal cultural heritage values that exist across the whole area that will be affected by the project and document these in an Aboriginal Cultural Heritage Assessment Report (ACHAR). This may include the need for surface survey and test excavation. The identification of cultural heritage values must be conducted in accordance with the Code of Practice for Archaeological Investigations of Aboriginal Objects in NSW (OEH 2010), and be guided by the Guide to investigating, assessing and reporting on Aboriginal Cultural Heritage in NSW (DECCW, 2011) and consultation with Heritage NSW.	Section 10.1.3 and Appendix O. Chapter 6 addresses consultation with Heritage NSW
21. Consulting with Aboriginal people must be undertaken and documented in accordance with the Aboriginal cultural heritage consultation requirements for proponents 2010 (DECCW). The significance of cultural heritage values for Aboriginal people who have a cultural association with the land must be documented in the ACHAR.	Sections 10.1.2 and 10.1.3 and Appendix O. Chapter 6 addresses consultation with Heritage NSW
22. Assessing and documenting impacts to Aboriginal cultural heritage values in an ACHAR. The ACHAR must demonstrate attempts to avoid impact upon cultural heritage values and identify any conservation outcomes. Where impacts are unavoidable, the ACHAR must outline measures proposed to mitigate impacts. Any objects recorded as part of the assessment must be documented and notified to Heritage NSW.	Sections 10.1.5, 10.1.6, 10.1.9 and Appendix O.
23. The ACHAR must outline procedures to be followed if Aboriginal objects are found at any stage of the life of the [development/project] to formulate appropriate measures to manage unforeseen impacts.	Section 10.1.9 and Appendix O.

10.1.2 Methodology and assumptions

The ACHAR was undertaken in accordance with the guidelines listed in section 10.1.4 and included:

- reviewing available background information from previous assessments, reports and the Aboriginal Heritage Information Management System (AHIMS) database to establish the archaeological, ethnohistorical, landscape and Aboriginal cultural values of the impact assessment area

- archaeological survey of the impact assessment area to verify Aboriginal heritage values identified in the desktop review and identify additional areas of potential archaeological value not previously identified. For clarity, the impact area and impact assessment area are defined as:
  - Impact area: The area to be directly impacted by construction and operation of the project, including identified compound areas and access tracks. The impact area is generally 12.5 metres each side of the pipeline alignments but is wider or narrower in certain areas. For the AWRC site, this impact area comprises the entire 78 hectares (ha) site.
  - Impact assessment area: A wider area, generally 12.5 metres each side of the impact area to allow for design flexibility after the EIS is approved.
- reviewing project impact area in the context of identified Aboriginal archaeological sites and potential archaeological deposits (PADs), including identifying opportunities to amend the impact area to avoid or minimise impacts
- assessing impacts where they cannot be practically avoided in accordance with significance assessment criteria described below
- developing management measures where impacts could not be avoided
- consulting with the Aboriginal community at key steps in the assessment process in accordance with *Aboriginal Cultural Heritage Consultation Requirements for Proponents* (DECCW 2010b). Aboriginal community consultation undertaken for the project is summarised below.

Significance assessment criteria

The Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales (DECCW, 2010a) requires significance assessment using criteria established in the Burra Charter (Australia International Council on Monuments and Sites ICOMOS, 2013). The Burra Charter and its accompanying guidelines are considered best practice standard for cultural heritage management in Australia. Guidelines to the Burra Charter set out four criteria for the assessment of cultural significance:

- Aesthetic value is the sense of the beauty of a place, object, site or item.
- Historic value is the association of a place, object, site or item with historical events, people, activities or periods.
- Scientific value is the importance of the data available for a place, object, site or item, based on its rarity, quality or representativeness, as well as on the degree to which the place (object, site or item) may contribute further substantial information.

- Social value is the qualities for which a place, object, site or item has become a focus of spiritual, political, national or other cultural sentiment to a group of people. In accordance with the Guide to investigating, assessing and reporting on Aboriginal cultural heritage in NSW (OEH, 2011), the social or cultural value of a place (object, site or item) may be related to spiritual, traditional, historical or contemporary associations. According to the former Office of Environment and Heritage (OEH), 'social or cultural value can only be identified though consultation with Aboriginal people' (OEH, 2011:8).

Aboriginal stakeholder consultation

The ACHAR has been prepared in consultation with the Aboriginal community in accordance with the Aboriginal Cultural Heritage Consultation Requirements for Proponents 2010 (DECCW, 2010b) and the requirements of clause 61 of the National Parks and Wildlife Regulation 2019.

Table 10-2 summarises Aboriginal community engagement activities undertaken for the project. Table 10-3 lists the Registered Aboriginal Parties (RAPs) who registered for the project. Appendix O describes this consultation in full and includes details of comments and submissions from the Aboriginal community and how they have been addressed.

Table 10-2 Summary of Aboriginal community engagement

Activity	Details
Government agency notification letters	Letters were sent to relevant local government and NSW Government agencies on 1 April 2020. Copies of the letters are included in Appendix O.
Advertising for registered stakeholders in local media	Advertising in The Sydney Morning Herald on 16 April 2020.
Notification of closing date for registration	Notification indicated a final closing date for registration of 30 April 2020. Twenty-six Aboriginal community individuals and groups registered their interest in being a Registered Aboriginal Party (RAP) for the project.
Provision of project information and proposed cultural heritage assessment methodology	Project information and a draft methodology was provided to registered parties and allowance made for a 28-day review period which ended on 29 May 2020. Comments received were considered in finalising the methodology for preparation of the ACHAR.
Provision of draft ACHAR for review	Draft ACHAR issued to RAPs on 5 May 2021 (a minimum 28-day review period was provided and submissions were accepted beyond the 28-day period). Submissions were received from five RAPs and were considered in finalising the ACHAR.
Ongoing consultation with the local Aboriginal community	Sydney Water has sought to maintain an ongoing dialogue with the Aboriginal community through both the formal ACHAR consultation process, and through existing stakeholder interactions which occur independently of the project.

Table 10-3 Registered Aboriginal Parties

Registered Aboriginal stakeholder	
Deerubbin Local Aboriginal Land Council	Galamaay Cultural Consultants
Gandangara Local Aboriginal Land Council	Ginninderra Aboriginal Corporation
Tharawal Local Aboriginal Land Council	Goodradigbee Cultural & Heritage Aboriginal Corporation
A1 Indigenous Services	Kamilaroi Yankuntjatjara Working Group
Aragung Aboriginal Cultural Heritage Site Assessments	Merrigarn
Aunty Fran Bodkin	Muragadi Heritage Indigenous Corporation
Barking Owl Aboriginal Corporation	Murra Bidgee Mullangari Aboriginal Corporation
Barraby Cultural Services	Widescope Indigenous Group
Butucarbin Aboriginal Corporation	Yulay Cultural Services
Cubbitch Barta	Yurrandaali
Darug Custodian Aboriginal Corporation	Waawaar Awaa Aboriginal Corporation
Dhinawan Culture and Heritage	Two Aboriginal stakeholders who requested their details be withheld
Didge Ngunawal Clan	-

Assumptions

The ACHAR was undertaken based on the information available in the AHIMS database, previous Aboriginal heritage reporting, field survey, targeted test excavations and with the involvement of RAPs. Existing information sources provide an indication of the Aboriginal archaeology of an area but do not represent the entire potential archaeology of that area. Similarly, involvement of the RAPs provides a comprehensive consultation process but does not include input from indigenous stakeholders who did not register to be involved in the project. Despite this, the assessment has been undertaken based on the most relevant information available at the time of preparation. Measures have been included in section 10.1.9 to manage any previously unidentified Aboriginal archaeology identified during construction works.

10.1.3 Existing environment

Consideration of the existing environment for the project is based on the impact assessment area shown in Figure 4-16 and

Figure 4-17. Appendix O includes a detailed description of the existing environment of the region within which the project is located.

When reading this section it should be noted that an artefact is an item of Aboriginal heritage origin. A PAD is an area which has been assessed as having the potential to contain Aboriginal objects.

Ethnohistorical context

Aboriginal people have a long history of inhabiting the greater Sydney region from the coastal areas in the east to the Blue Mountains in the west. Prior to the British invasion, Aboriginal people living in the region transferred knowledge of history and culture through oral and artistic means.

Individuals generally lived in groups of one or more extended families that were associated with particular areas. These groups were interconnected through marriage and large gatherings of several groups occurred for specific purposes such as communal participation in subsistence gathering activities, initiations, funerals and ritual combat. Aboriginal customary law and practices, while varying across Australia, included responsibilities of various kinds for land and for objects and ideas associated with land, complex structures of kinship and family groupings, patterns and rules of marriage and child care, and procedures for the conduct and resolution of disputes.

Aboriginal people living in the region during the late eighteenth and nineteenth centuries made a range of items including canoes, huts, containers, nets, spears, womera, clubs and shields. Most of the items made by Aboriginal people during the late eighteenth and nineteenth centuries were made from perishable materials and the small number that have survived are generally kept in museum collections. Ochres of red, yellow and white were used on items and as personal decoration while body piercings and scarification were also practiced. Rock art was created as pictographs (drawings) using ochres and charcoal or petroglyphs (rock engravings). Motifs (dendroglyphs) were also carved into the hardwood of trees of the south-western Cumberland plain as cultural markers.

Aboriginal people living inland in the Sydney region relied on small animals and plant foods in addition to seasonally available fish and eels. Animals such as kangaroos, possums and gliders were hunted and traps were built along waterways to catch birds and small animals. Wild yams and other roots were harvested in considerable quantities along the alluvial flats and terraces of Nepean River and Hawkesbury River while berries, Banksia flowers and wild honey were also recorded as foods of the local inhabitants.

The history of Aboriginal people who lived in Australia during the eighteenth and nineteenth centuries is disproportionately reliant on contemporary documents created by a small number of individuals from Europe or of European descent. As a result, the Aboriginal people who were involved in these events and the history of the eighteen and nineteenth centuries incorrectly appear “invisible, unrelated to important local historical events, or passive victims of colonisation” (Heritage NSW, 2011: 6). As part of consultation for this project Darug Custodian Aboriginal Corporation during consultation for the current project, noted that:

‘It has been discussed by our group and with many consultants and researches that our history is generic and is usually from an early colonists perspective or solely based on archaeology and sites. These histories are adequate but they lack the people’s stories and parts of important events and connections of the Darug people and also other Aboriginal people that now call this area home and have done so for numerous generations (Darug Custodian Aboriginal Corporation, letter dated 24/05/2020).’

Early British accounts described the Sydney region as a mosaic of Aboriginal family groups that were associated with particular areas of land. However, the organisation of territory and groups was likely to have been more complex than understood by the British. Several groups were identified during the late eighteenth and nineteenth centuries in the vicinity of the impact assessment area including the Burra-ga-rang, Cubbitch Barta, Gahbrogal, Gomerrigal and the Mulgowy. The Burra-ga-rang were associated with an area in south-western Sydney that included the Burragorang Valley (now Lake Burragorang) and the catchments of the Warragamba, Wollondilly and Coxs Rivers. The Cubbitch Barta were associated with the area around of Camden. The Gomerrigal (Gomerigal or Gomerrigal-Tongarra) who were possibly the later named ‘South Creek Tribe’ associated with Wianamatta/South Creek to the confluence of the creek with the Hawkesbury River. The Gahbrogal (Cah-bro-gal or Cobrakall) were associated with the area around Cabramatta. The Mulgowy (also referred to as the ‘Mulgoa Tribe’) were associated with the Mulgoa Valley.

The late eighteenth and early nineteenth centuries included periods of intense conflict between British and Aboriginal people and complex relationships and interactions which are described in detail in Appendix O. Appendix O also includes the range of references from which the above information has been sourced.

Landscape context

The impact assessment area is in the catchment areas of Nepean River and Wianamatta/South Creek in the west and Georges River in the east. The catchment areas are divided by two ridgelines that extend from the Woronora Plateau at Menangle Sugarloaf in the south and separate at Badgery Hill, with one ridgeline extending to the northeast towards Prospect Hill and the other to the north west towards Luddenham. The impact assessment area contains a range of distinct landforms from the foothills of the Blue Mountains in the west, the terraces, paleochannels and active channel of Nepean River, the undulating, low lying ridges and alluvial flats of the Wianamatta/South Creek catchment area and wide low lying terraces and floodplains of Georges River catchment area in the east.

The active floodplains of the major rivers and creeks contain alluvial South Creek soils while some adjacent areas of older Berkshire Park and Richmond alluvial soils occur on the terraces of Nepean River and Georges River. The alluvial South Creek soil landscape is characterised by flat landforms with incised channels that are subject to frequent episodes of inundation, erosion and aggradation. The landscape contains deep structured loams and clays overlying bedrock or relict soils. The South Creek soil landscape may retain archaeological deposits but due to its location on active floodplains the integrity may be compromised due to repeated episodes of erosion and deposition caused by fluvial activity.

A detailed description of the vegetation and biodiversity of the landscape is provided in section 9.1.

Archaeological context

The current scientific understanding of the human occupation of the Australian continent is that Aboriginal people have lived in Australia for at least the last 40,000-60,000 years. Archaeological evidence shows that the Sydney Region has been occupied since at least 18,000 years ago. Archaeological investigation is reliant on the artefacts or physical evidence of human activities which have survived anywhere from centuries to thousands of years. The oldest of these artefacts are likely to represent a small fraction of the objects that were used by Aboriginal people with even the most robust organic materials unlikely to survive in contexts older than 6,500 years.

The most numerous artefacts at Aboriginal archaeological sites in the Sydney Region are made from stone and were discarded in either open landscape settings or within closed landscape settings, primarily rock shelters. The accumulation of stone artefacts in both contexts may have occurred over a long period of time and subject to a range of natural processes and human activities. Previous archaeological investigations of Aboriginal archaeology in the Sydney region have shown that significant changes have occurred within the types of artefacts used, artefact raw materials and the spatial distribution and density of Aboriginal archaeological sites while Aboriginal people adapted to an ever-changing landscape and environment. Appendix O provides a brief overview of the artefacts and objects that have been found throughout Western Sydney over the time of occupation by Aboriginal people.

Desktop assessment

A search of AHIMS identified that 493 Aboriginal archaeological sites and 25 areas of PAD have been previously registered within or in the vicinity of the impact assessment area. The search area included a broad area covering the full length of all pipelines and including all suburbs in which the project is located. The previously recorded Aboriginal archaeological sites generally correlate to the intensity of previous archaeological investigations with 403 sites recorded in the central and eastern portions of the impact assessment area with relatively few in the west where land use remains predominantly agricultural. The spatial distribution of previously recorded Aboriginal archaeological sites is unlikely to be an accurate representation of archaeological sites across the impact assessment area. Despite this, the distribution helps determine general spatial patterns and identify areas where Aboriginal archaeological sites may occur due to similarities of landform, geology and land use practices.

Most of the previously recorded Aboriginal archaeological sites (429) were surface stone artefact scatters or isolated stone artefacts. However, other feature types were also recorded including art (pigment or engraved), modified tree (carved or scarred) and grinding groove. The surface stone artefact scatters and isolated stone artefacts were almost exclusively found close to water with 339 of the 429 registered sites with surface artefacts located within 250 metres of a river, creek or drainage line. Of these, 212 were located within 100 metres.

Previous studies generally found higher stone artefact densities within artefact scatters on relatively elevated landforms along the margins of creeks (especially those offering permanent water) and rivers, potentially reflecting repeated or more intensive use.

Archaeological survey

During the middle of 2020, Kelleher Nightingale Consulting carried out an archaeological field survey of the impact assessment area with representatives from Deerubbin Local Aboriginal Land Council (DLALC), Gandangara Local Aboriginal Land Council (GLALC) and Tharawal Local Aboriginal Land Council (TLALC). The survey focused on establishing a detailed appreciation of archaeologically sensitive landforms to assist in identifying the full spatial extent of identified archaeological sites. Assessment of archaeological potential was based on topographic location and visible disturbance. The survey inspected areas of exposed ground (such as eroded surfaces) for stone artefacts or evidence of intact soils. Sandstone outcrops were inspected for grinding grooves, rock shelters and engravings while mature trees were inspected for evidence of Aboriginal bark removal or carving.

Ground surface visibility varied greatly across the survey areas at the time of survey and was generally higher in areas where natural processes, such as erosion, or land use practices had removed vegetation or restricted its growth. The survey noted that areas where low intensity agriculture or native vegetation were present had generally been subject to low levels of visible disturbance while areas where structures, roads and utilities had been constructed had localised high levels of visible surface disturbance.

The archaeological survey included location and validation of sites identified from the desktop assessment as well as recording and newly identified artefacts, scatters or PADs. Table 10-4 summarises the items identified in the impact assessment area as part of the archaeological desktop and field survey.

Aboriginal test excavation – AWRC site

In 2018, consultants for Transport for NSW (TfNSW) completed an archaeological test excavation in the proposed M12 Motorway corridor immediately south of the proposed AWRC site and west of the Fleurs Aerodrome. A total of 333 artefacts were recovered during this test excavation program. This nearby high density of artefacts and the landform characteristics of the AWRC site, suggested a high potential for subsurface archaeological deposits on the AWRC site.

Kelleher Nightingale Consulting completed an archaeological test excavation program on the AWRC site to determine the nature and extent of any archaeological deposits present. Undertaking this excavation program during the preparation of the EIS allows a better understanding of archaeological constraints and therefore the opportunity for improved outcomes for Aboriginal heritage. Appendix O provides full details of the test excavation methodology for the AWRC site.

A total of 309 artefacts were recovered during the AWRC test excavation. The results demonstrated that the crest and upper slope landforms within the impact area for the AWRC contained a subsurface archaeological deposit. However, the spatial distribution of artefacts was irregular. Slightly shallower depth of deposit and surface artefacts indicated that removal of some of the upper deposit may have occurred in the past. Visible subsurface disturbance was low and artefact density did not appear to be connected to historical land use within the property.

Summary of archaeology in the impact assessment area

Review of background database information, test excavation of the AWRC site, and the archaeological survey has identified 19 Aboriginal archaeological sites including two areas of PAD within the impact assessment area. These sites and PADs generally fall within four localities which for the purposes of this assessment are described as:

- Wallacia
- Luddenham
- Badgerys Creek / Kemps Creek
- Cecil Hills/ Cecil Park/ Elizabeth Hills.

Table 10-4 outlines the Aboriginal archaeological sites and areas of PAD identified in the impact assessment area. These are shown in Figure 10-1 to Figure 10-4.

Table 10-4 Aboriginal archaeological values within the impact assessment area

Locality	Site name	AHIMS No.	Site features	Status	Assessed significance
Wallacia	Baines Creek Wallacia AFT 1	TBC	Artefact	Valid	Moderate
Wallacia	Bents Basin Road Wallacia AFT 1	TBC	Artefact	Valid	Moderate
Wallacia	Silverdale Road 11	45-5-3103	Modified Tree (Carved or Scarred)	Not a site	NA
Wallacia	Wallacia Weir AFT 1	TBC	Artefact	Valid	Moderate
Luddenham	Elizabeth Drive/Adams Road AFT 1	45-5-5105	Artefact	Valid	Moderate
Luddenham	TNR AFT 15	45-5-4788	Artefact	Valid	Moderate
Luddenham	TNR AFT 16	45-5-4783	Artefact	Within SSI 7127	Moderate

Locality	Site name	AHIMS No.	Site features	Status	Assessed significance
Badgerys Creek / Kemps Creek	Badgerys Creek West B (BWB)	45-5-5298	Artefact	Valid	Low
Badgerys Creek / Kemps Creek	Elizabeth Drive AFT 1 (including Elizabeth Precinct PAD 01, Elizabeth Precinct PAD 03, Elizabeth Precinct Isolated Find 04 and Elizabeth Precinct Isolated Find 05)	45-5-5259 (including 45-5-5234, 45-5-5236, 45-5-5330 and 45-5-5331)	Artefact	Valid	Moderate
Badgerys Creek / Kemps Creek	Elizabeth Precinct PAD 02	45-5-5235	PAD	Valid	NA
Badgerys Creek / Kemps Creek	Fleurs1 Fleurs Radio Telescope (including duplicate recordings M12 A4 and South Creek East (SCE))	45-5-0496 (including 45-5-4749 and 45-5-5306	Artefact	Valid	Moderate
Cecil Hills/ Cecil Park/ Elizabeth Hills	IFSC 7 Cecil Park	45-5-2430	Artefact	Within AHIP C0005620	NA
Cecil Hills/ Cecil Park/ Elizabeth Hills	GLC1 (including Artefact Scatter PAD 2023-846)	45-5-2561 (including 45-5-4022)	Artefact	Partially within AHIP C0005620 and Cecil Park Reservoir AHIP application area	NA
Cecil Hills/ Cecil Park/ Elizabeth Hills	P-CP7	45-5-2306	Artefact	Valid	Low
Cecil Hills/ Cecil Park/ Elizabeth Hills	P-CP12	45-5-2378	Artefact	Valid	Moderate

Locality	Site name	AHIMS No.	Site features	Status	Assessed significance
Cecil Hills/ Cecil Park/ Elizabeth Hills	PAD-OS-5	45-5-2723	Artefact	Valid	Moderate
Cecil Hills/ Cecil Park/ Elizabeth Hills	PP-F3	45-5-3298	Artefact	Valid	Low
Cecil Hills/ Cecil Park/ Elizabeth Hills	Wylde MTB PAD2	45-5-5261	PAD	Valid	Moderate
Cecil Hills/ Cecil Park/ Elizabeth Hills	CH05 (Mirvac)1	45-5-3557	Artefact	Destroyed	NA

1 - Two sites were registered in the AHIMS as being located in the impact assessment area were determined to no longer be archaeological sites:

- Silverdale Road 1 was not located at the registered coordinates and the location was determined to not be an Aboriginal archaeological site.
- CH05 (Mirvac) had been destroyed by residential development and was no longer extant.

2 - Significance does not apply to PAD sites as archaeology has not yet been identified and significance cannot be determined. Significance is also not relevant to sites covered by an AHIP, given the permit exists to harm the sites.

A detailed description of each of the Aboriginal archaeological items identified in Table 10-4 is provided in Appendix O.

Aboriginal cultural values

During the consultation process described in section 10.1.2 some of the stakeholders identified Aboriginal cultural heritage values in relation to the wider impact assessment area. These include:

- strong association with the land
- responsibility to look after the land, including the heritage sites, plants and animals, rivers, creeks and the land itself
- Aboriginal culturally modified trees
- artefact sites and landscape features
- waterways, particularly Nepean River, Georges River, Wianamatta/ South Creek and tributaries
- indigenous plants and animals
- general concern for burials, as their locations are not always known and they can be found anywhere.

Sydney Water is also completing an Aboriginal Cultural Values Study in consultation with local Aboriginal communities to better understand intangible Aboriginal cultural values of the Western Sydney region, focused on the cultural values of water in the South Creek catchment and parts of Nepean River. This study is separate to the project but its outcomes may help inform ongoing management and design of the project, including design of the green space area on the AWRC site and heritage interpretation. The cultural values study is in the early stages and at the time of writing has not identified any specific cultural values in addition to those identified above. The cultural values study will be reviewed once complete and relevant recommendations considered in the context of the project.

10.1.4 Legislation and guidelines

The *National Parks and Wildlife Act 1974* (NP&W Act) administered by the Heritage Division, Department of Premier and Cabinet (DPC), is the primary legislation for the protection of Aboriginal cultural heritage in NSW. The NP&W Act gives the Secretary of DPC responsibility for the proper care, preservation and protection of 'Aboriginal objects' and 'Aboriginal places'. Section 86 of the NP&W Act identifies offences relating to the harm of Aboriginal objects or places.

The project is being assessed as State significant infrastructure (SSI) under the *Environmental Planning and Assessment Act 1979* (EP&A Act). Under section 5.23 of the EP&A Act, projects classified as SSI do not need to obtain an Aboriginal Heritage Impact Permit (AHIP) under section 90 of the NP&W Act but the SSI approval typically captures equivalent conditions for managing Aboriginal heritage.

The ACHAR was undertaken in accordance with the following guidelines:

- Department of Environment, Climate Change and Water NSW (DECCW) (now Heritage NSW), 2010a. *Code of Practice for the Archaeological Investigation of Aboriginal Objects in New South Wales*. Department of Environment, Climate Change and Water NSW, Sydney
- DECCW (now Heritage NSW), 2010b. *Aboriginal Cultural Heritage Consultation Requirements for Proponents* 2010: Part 6 National Parks and Wildlife Act 1974. Department of Environment, Climate Change and Water NSW, Sydney.
- Office of Environment and Heritage (OEH) (now Heritage NSW), 2011. *Guide to investigating, assessing and reporting on Aboriginal cultural heritage in NSW*. Office of Environment and Heritage, Sydney.

The project is also a controlled action under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Although the project is not a controlled action as a result of Aboriginal heritage impacts, the following guidelines have been considered in consulting with the Aboriginal community:

- *Engage Early: Guidance for proponents on best practice Indigenous engagement for environmental assessments under the Environment Protection and Biodiversity Conservation Act 1999* (DoE, 2016). Sydney Water has aligned with these guidelines by:
  - identifying and acknowledging all relevant affected Aboriginal people and
  - communities committing to early engagement at the pre-referral stage

  - building trust through early and ongoing communication for the duration of the project, including approvals, implementation and future management
  - setting appropriate timeframes for consultation, and
  - demonstrating cultural awareness.
- *Ask First: A guide to respecting Indigenous heritage places and values* (Australian Heritage Commission, 2002). Sydney Water has aligned with these guidelines by:
  - engaging in initial and ongoing consultation with the community
  - identifying Aboriginal heritage places and values
  - managing the identified places and values through ongoing consultation and engagement with the community.

Section 10.1.2 summarises consultation undertaken with the Aboriginal community for the project, including the processes followed to identify relevant members of the Aboriginal community and engage with them from early in the project.

10.1.5 Construction impact assessment

Fifteen Aboriginal archaeological sites and PADs have been identified within the impact area. Figure 10-1 to Figure 10-4 show the identified sites and PADs, where they intersect with the impact area and where impacts may occur as a result of the project.

Impact avoidance and minimisation

Following the identification of Aboriginal constraints (as outlined in section 10.1.3) the project's impact area was modified to avoid Aboriginal sites and PADs where practical. Priority was given to avoiding sites and PADs of moderate to high significance. Residual impacts are of moderate to low significance as shown in Table 10-5. Of the items identified in the impact area, the design will avoid or minimise impacts to the following:

- TNR AFT 16 – the project was modified so the impact area will avoid this site.
- Wylde MTB PAD2 – the impact area was modified to avoid this PAD.
- PP-F3 and GLC1 (including Artefact Scatter PAD 2023-846) – impacts have been limited to those portions of the artefact scatter with low significance based on the visibly disturbed nature of the areas while the portions assessed as having moderate significance have been avoided. The non-impacted portions of these sites are located in the Western Sydney Parklands where future development is restricted.
- IFSC 7 Cecil Park and GLC1 (including Artefact Scatter PAD 2023-846) – impacts are located wholly or partially within Sydney Water's existing Prospect to Macarthur Drinking Water Link AHIP area (AHIP C0005620). The project will not result in further impact to these sites provided that work is undertaken in accordance with the conditions of these existing AHIPs. The remaining portion of GLC1 (including Artefact Scatter PAD 2023-846), within the impact area and outside the Prospect to Macarthur Drinking Water Link AHIP area, is located in a disturbed access track junction with low archaeological significance.

- Elizabeth Precinct PAD 02 – impact to a portion of this site is restricted to a less archaeologically significant slope where there is likely to be more subsurface disturbance.

Impacts to sites and PADs

Table 10-5 shows the 15 Aboriginal archaeological sites and PADs identified in the impact area and the level of impact they will experience as a result of the project. Three of these sites have been identified as having pre-existing or approved impacts under an AHIP or SSI approval for another project. Therefore, the project will result in partial impact to 11 archaeological sites and one PAD, with the level of significance ranging from low to moderate.

Table 10-5 Potential impacts to Aboriginal heritage

Name	AHIMS ID	Type of harm	Degree of harm	Consequence of harm	Significance of harm
Badgerys Creek West B (BWB)	45-5-5298	Direct	Partial	Partial loss of value	Low (impacted portion)
Baines Creek Wallacia AFT 1	TBC	Direct	Partial	Partial loss of value	Moderate
Bents Basin Road Wallacia AFT 1	TBC	Direct	Partial	Partial loss of value	Moderate
Elizabeth Drive/Adams Road AFT 1	45-5-5105	Direct	Partial	Partial loss of value	Moderate
Elizabeth Drive AFT 1 (including Elizabeth Precinct PAD 01, Elizabeth Precinct PAD 03, Elizabeth Precinct Isolated Find 04 and Elizabeth Precinct Isolated Find 05)	45-5-5259 (including 45-5-5234, 45-5-5236, 45-5-5330 and 45-5-5331)	Direct	Partial	Partial loss of value	Moderate
Fleurs1 Fleurs Radio Telescope (including M12 A4 and South Creek East (SCE))	45-5-0496 (including 45-5-4749 and 45-5-5306	Direct	Partial	Partial loss of value	Moderate
GLC1 (including Artefact Scatter PAD 2023-846)[1]	45-5-2561 (including 45-5-4022)	None	None	No loss of value	None
IFSC 7 Cecil Park[1]	45-5-2430	None	None	No loss of value	None

Name	AHIMS ID	Type of harm	Degree of harm	Consequence of harm	Significance of harm
P-CP7	45-5-2306	Direct	Partial	Partial loss of value	Low (impacted portion)
P-CP12	45-5-2378	Direct	Partial	Partial loss of value	Moderate
PAD-OS-5	45-5-2723	Direct	Partial	Partial loss of value	Moderate
PP-F3	45-5-3298	Direct	Partial	Partial loss of value	Low (impacted portion)
TNR AFT 15	45-5-4788	Direct	Partial	Partial loss of value	Moderate
TNR AFT 16[1]	45-5-4783	None	None	No loss of value	None
Wallacia Weir AFT 1	TBC	Direct	Partial	Partial loss of value	Moderate

Notes on table:

1 – Denotes site with pre-existing or approved impacts under an AHIP/ SSI / other approach

RAP responses to construction impacts

Following preparation of the draft ACHAR, RAPs were provided a copy of the draft report to allow them to review and provide comment on the draft findings and conclusions. Five formal responses were received in total. This included responses from Cubbitch Barta Native Title Claimants, Kamilaroi Yankuntjatjara Working Group, Waawaar Awaa Aboriginal Corporation. Two responses were received from RAPs wishing to have their name withheld.

Most submissions provided support for the findings in the ACHAR. One submission raised concerns about participants in the archaeological survey, the scale of maps, and the destruction of cultural values. These matters have been considered in the finalisation of the ACHAR. Some submissions also included a desire to be involved in any future archaeological surveys of investigations required as part of the project.

Table 10-6 identifies measures to manage and minimise impacts which cannot be avoided.

FIGURE REDACTED FOR PUBLIC EXHIBITION DUE TO SENSITIVITY OF IMAGE

Figure 10-1 Potential impacts to Aboriginal heritage – Wallacia

FIGURE REDACTED FOR PUBLIC EXHIBITION DUE TO SENSITIVITY OF IMAGE

Figure 10-2 Potential impacts to Aboriginal heritage – Luddenham

FIGURE REDACTED FOR PUBLIC EXHIBITION DUE TO SENSITIVITY OF IMAGE

Figure 10-3 Potential impacts to Aboriginal heritage – Badgerys Creek and Kemps Creek

FIGURE REDACTED FOR PUBLIC EXHIBITION DUE TO SENSITIVITY OF IMAGE

Figure 10-4 Potential impacts to Aboriginal heritage – Cecil Hills and Cecil Park

10.1.6 Operational impact assessment

The full extent of ground disturbance works will occur during the construction phase so impacts to Aboriginal archaeology are unlikely during operation.

10.1.7 Impact of future stages

The ACHAR has assessed the full impact area for the AWRC site and associated pipelines for Stage 1 and future stages. No additional Aboriginal heritage impacts are expected in future stages.

10.1.8 Cumulative impacts

Redevelopment and infrastructure projects in Western Sydney over the last 40 years have identified and subsequently impacted Aboriginal archaeological sites. The project is one of several major projects currently underway in the area, including the Western Sydney International Airport, Sydney Metro – Western Sydney Airport, M12 Motorway, Northern Road Upgrade and the Warragamba Dam Wall Raising. Collectively, these projects also have an impact on Aboriginal heritage.

The project will impact on Aboriginal sites. Where practical, project design has sought to avoid or minimise impacts to Aboriginal archaeological sites as outlined in section 10.1.5. Where possible, the impact area of the project has been designed to overlap with other projects AHIPs, to limit impacts to areas previously approved for disturbance.

Where impact has the potential to occur, management measures have been recommended to ensure non-impacted portions of sites are avoided. Test excavations undertaken during the EIS and preliminary design phase have helped define areas of higher archaeological significance within the AWRC site. This will provide opportunity to minimise impacts in this location during the detailed design phase and therefore cumulative impact that may occur when considering the AWRC site and M12 Motorway collectively.

10.1.9 Management measures

Table 10-6 outlines management measures Sydney Water proposes to manage Aboriginal heritage impacts. Sydney Water has avoided highly significant Aboriginal sites and minimised impacts to low and moderately significant sites where possible. In light of this and the management measures proposed below, the project is considered to have an acceptable level of residual impacts.

Table 10-6 Aboriginal heritage management measures

ID	Impact	Management measure	Timing
AH01	Impact to Aboriginal sites / Potential Archaeological Deposits (PADs)	Explore opportunities to avoid or further reduce the identified potential impacts to Aboriginal items where practical.	Detailed design
AH02	Impacts to Aboriginal heritage, including unexpected finds	Develop and implement a Heritage Management Plan as part of the CEMP. This will include: • roles and responsibilities • construction phase Aboriginal heritage and non-Aboriginal heritage measures from this table • an unexpected finds procedure for managing any items of potential Aboriginal archaeological, cultural heritage, or non-Aboriginal heritage significance identified during construction • inducting all construction site staff (before they start work) on known Aboriginal and non-Aboriginal heritage items in the impact area and measures to be implemented during construction to avoid impacts. Inductions will include: – briefing on the heritage sensitivity of the site – management measures – guidance on identifying unexpected finds – obligations under the *Heritage Act 1977*.	Prior to construction During construction
AH3	Impact to Aboriginal sites / PADs of moderate Aboriginal heritage significance	Undertake archaeological salvage in accordance with an approved Salvage Excavation Methodology, where ground disturbance is proposed within the following sites: • Baines Creek Wallacia PAD 1 • Bents Basin Road Wallacia PAD 1 • Wallacia Weir PAD 1 • Oaky Creek Elizabeth Drive PAD 1 • Elizabeth Drive/Adams Road AFT 1 • TNR AFT 15 • Elizabeth Drive AFT 1 • Elizabeth Drive AFT 3 • Elizabeth Precinct PAD 03	Prior to construction

ID	Impact	Management measure	Timing
		• Fleurs1 Fleurs Radio Telescope (including duplicate recordings M12 A4 and South Creek East (SCE)) • P-CP7 • P-CP12 • PAD-OS-5 Coordinate this program with non-Aboriginal heritage salvage excavation, in locations where salvage is required for both.	
AH04	Impacts to sites with existing AHIPs	Construction activities undertaken in the following sites will be in accordance with the existing AHIP conditions: • GLC1 (including Artefact Scatter PAD 2023-846) • IFSC 7 Cecil Park	During construction
AH05	Unexpected finds – Human skeletal remains	In the event that construction activity reveals possible human skeletal material (remains) an unexpected finds human skeletal remains procedure will be implemented in accordance with the Skeletal Remains – Guidelines for the Management of Human Skeletal Remains under the *Heritage Act 1977* (NSW Heritage Office 1998) and the Aboriginal Cultural Heritage Standards and Guidelines Kit (NPWS 1997).	During construction

10.2 Non-Aboriginal heritage

This section describes non-Aboriginal heritage items and landscapes near the project and the project's potential impacts on them, during construction and operation. It provides an overview of the key findings of the detailed Statement of Heritage Impact (SOHI) (Extent Heritage, 2021) included in Appendix P.

Non-Aboriginal heritage impact summary

The project has the potential to impact on non-Aboriginal heritage items during construction, but there is minimal potential for impacts during operation.

The main potential project impacts during construction include damage to items through ground disturbance during excavation, vibration from activities such as tunnelling, and building infrastructure in scenic landscapes. Through these activities, the project will potentially impact 17 items with archaeological or built heritage value. Seven of these are not listed on any heritage registers. One item (the Upper Canal) is on the State Heritage Register and the remainder are on State authority or local council heritage registers.

During construction, the significance of the impacts on most listed heritage items is considered negligible. However, moderate to major impacts are expected to:

- built heritage at Fleurs Radio Telescope site at the AWRC site
- archaeological heritage at Blaxlands Farm, at the treated water release location to Nepean River
- South, Kemps and Badgerys Creek Confluence Weirs Scenic Landscape near the AWRC.

During operation, once the AWRC is built, it will change the visual landscape of the Fleurs Radio Telescope site, which is considered a moderate impact.No impacts to non-Aboriginal heritage are expected during pipeline operation.

Sydney Water will implement a range of measures to manage the project's heritage impacts. These include archival recording and further archaeological testing in several locations, measures to avoid accidental damage to heritage items and stop work provisions if unexpected heritage items are found. In addition, Sydney Water will prepare a heritage interpretation framework for the AWRC site to celebrate the site's heritage.

10.2.1 Relevant Secretary's Environmental Assessment Requirements

Table 10-7 summarises the Secretary's Environmental Assessment Requirements (SEARs) relevant to non-Aboriginal heritage and where in this section they are addressed.

Table 10-7 Project SEARs relating to non-Aboriginal heritage impacts

SEARs	EIS section where requirement addressed
24. A Statement of Heritage Impact (SOHI) should be prepared for the project by a suitably qualified heritage consultant in accordance with the guidelines in the NSW Heritage Manual. The SOHI is to address the impacts of the project on the heritage significance of the site and adjacent areas and is to identify the following:	This section and Appendix P
a) All heritage items (state and local) within and near the site, including built heritage, landscapes and archaeology, and includes detailed mapping of these items, and assessment of why the items and site(s) are of heritage significance.	Section 10.2.3 and Appendix P
b) Assesses the project's impact on the heritage significance of heritage items or potential heritage items on, and near the development site. Documentary evidence should also be provided by an appropriately qualified Structural Engineer, with experience in heritage buildings, confirming that any affected heritage item is capable of withstanding the proposed works.	Sections 10.2.5, 10.2.6 and Section 10.2.8 Structural engineering is only considered relevant to the Upper Canal and addressed in Table 10-15
c) Addresses the project's compliance with policies of relevant Conservation Management Plans for the affected sites;	Sections 10.2.4 and 10.2.5
d) The impacts of the proposal on heritage item(s) including visual impacts, along with photomontages; and	Sections 10.2.5, 10.2.6 and section 10.2.7. Photomontages included in section 11.3
e) Any attempts to avoid and/or mitigate the impact on the heritage significance or cultural heritage values of the site and the surrounding heritage items; and	Sections 10.2.2 and 10.2.9 and Table 10-15
f) Justification for any changes to the heritage fabric or landscape elements including any options analysis.	Section 10.2.5 (applies to Fleurs Radio Telescope only) Section 3 includes options analysis.

SEARs	EIS section where requirement addressed
25. A historical archaeological assessment prepared by a suitably qualified historical archaeologist in accordance with the guidelines Archaeological Assessment (1996) and Assessing Significance for Historical Archaeological Sites and Relics (2009). This assessment should identify what relics, if any, are likely to be present, assess their significance and consider the impacts from the project on this potential archaeological resource. Where impact is likely to occur, it is recommended that the significance of the relics be considered in determining appropriate mitigation strategy. If harm cannot be avoided in whole or part, an appropriate Research Design and Excavation Methodology should also be prepared to guide any proposed excavations or salvage programme.	Appendix P
38. An assessment of construction and operational noise and vibration impacts in accordance with relevant NSW noise and vibration guidelines. The assessment must include consideration of impacts to sensitive receivers, infrastructure, heritage and include, as relevant, the characteristics of noise and vibration (for example, low frequency noise).	Sections 10.2.5 and 11.2
46. An assessment of the visual impact of the project and any ancillary infrastructure during construction and operation on: a) views and vistas; b) key sites and buildings; c) heritage items including Aboriginal places and non-Aboriginal heritage; and d) the local community.	Sections 10.2.6 and 11.3

10.2.2 Methodology and assumptions

The assessment of the project's non-Aboriginal heritage impacts involved:

- a preliminary heritage assessment to help inform options assessment and reference design
- survey of the study area including targeted fieldwork to investigate areas of non-Aboriginal heritage and historical archaeological potential located in the impact assessment area
- review of historical archaeological potential
- assessment of potential impacts from the project on the identified non-Aboriginal heritage and potential archaeology of the impact area
- where impacts could not be avoided during the iterative design process, development of management measures to minimise, mitigate and manage remaining impacts to non-Aboriginal heritage.

Preliminary heritage assessment

A preliminary heritage assessment was undertaken to identify potential risks to known heritage items within the impact assessment area and to inform the project's design. Design development was iterative and involved consultation between project engineers and environmental specialists (including heritage specialists) to refine the design with the aim of avoiding direct project impact to non-Aboriginal heritage items where practical. Any impacts which could not be wholly or partially avoided would then be subject to further impact assessment as part of the SOHI.

The assessment also included desktop review of all applicable legislation and policies including review of all applicable statutory heritage lists and review of previous reports including previous heritage assessments for projects such as the M12 Motorway. Appendix P provides more detail on the reports reviewed.

Survey of the study area

The study area for the SOHI encompasses the wider Western Sydney area which provides context of the historical land use and settlement patterns applicable to the impact assessment area. For clarity, the impact area and impact assessment area are defined as:

- Impact area: The area to be directly impacted by construction and operation of the project, including identified compound areas and access tracks. The impact area is generally 12.5 metres each side of the pipeline alignments but is wider or narrower in certain areas. For the AWRC site, this impact area comprises the entire 78 hectares (ha) site.
- Impact assessment area: A wider area, generally 12.5 metres each side of the impact area to allow for design flexibility after the EIS is approved.

A program of targeted fieldwork was undertaken between July and November 2020 to investigate built heritage and historical archaeological potential in the impact assessment area.

Review of historical archaeological potential

The following steps were taken to assess the study area's potential for significant historical archaeological remains or relics:

- Review of previous heritage studies and assessments relevant to the study area to locate previously identified archaeological sites.
- Assessment of historical maps and aerial photography extending across the impact assessment area to identify new areas, not captured in previous studies, with evidence of historical development/disturbance.
- Preparation of site development histories for identified Potential Archaeological Sites (PAS).
- Use of site histories, historical maps and aerial photography to develop assessments of historical archaeological potential and significance for each PAS.

Impact assessment approach

The assessment of impacts on the built and historical archaeological significance of heritage (and potential heritage) items within the project was modelled from the International Council on Monuments and Sites (ICOMOS) *Guidance on Heritage Impact Assessments* (ICOMOS, 2011). A similar approach was used for assessing historical archaeological impacts.

Table 10-8 defines the levels of impact used in this assessment, derived from these ICOMOS guidelines. The impact definitions emphasise the degree of change in terms of materiality and setting.

Table 10-8 Non-Aboriginal heritage impact definitions

Impact level	Built heritage, historical urban landscape attributes
Major	Change to key historic building elements that contribute to Outstanding Universal Value (OUV), such that the resource is totally altered. Comprehensive changes to the setting.
Moderate	Changes to many key historic building elements, such that the resource is significantly modified. Changes to the setting of an historic building, such that it is significantly modified.
Minor	Change to key historic building elements, such that the asset is slightly different. Change to setting of an historic building, such that it is noticeably changed.
Negligible	Slight changes to historic building elements or setting that hardly affect it.
No change	No change to fabric or setting.

Table 10-9 outlines the additional impact levels for items of State heritage significance in accordance with ICOMOS (2011).

Table 10-9 Impact levels for State heritage items

Impact level	Definition
Total loss of significance	Major adverse impact to the extent where the place would no longer meet the criteria for listing on the State Heritage Register.
Major adverse impact	Major (that is, more than minor or moderate) adverse impacts to State heritage significance.
Moderate adverse impact	Moderate adverse impacts to State heritage significance.
Minor adverse impact	Minor adverse impacts to State heritage significance.

Impact level	Definition
Little to no impact (negligible)	An alteration to State heritage significance that is so minor that it is considered negligible. Little to no impact (as opposed to no impact) acknowledges that any change will result in some level of impact/alteration to State heritage significance.
Positive impact	Alterations that enhance the ability to demonstrate the State heritage significance of a State heritage-listed place.

Assumptions

The impact assessment area was inspected and photographed by the non-Aboriginal heritage specialist team between July and November 2020. Physical inspections were undertaken as a visual study only and involved no physical ground disturbance, excavation or testing. This field inspection coupled with the background desktop review was not intended as an exhaustive history of the area. However, an assessment of potential impacts has been undertaken on the available information. There is potentially unidentified archaeology within the impact assessment area and measures have been included in section 10.2.9 to manage this risk.

10.2.3 Existing environment

The Hawkesbury Nepean River system and its many tributaries was a source of much interest for the early settlers and frequently referred to in personal narratives of the day. The presence of these watercourses and the rich alluvial soils of the river floodplain were major factors in attracting permanent settlement to the area by the early settlers who were keen to make their fortune from agricultural and pastoral pursuits.

The historical content of a range of small settlements, such as Wallacia and Luddenham is evident throughout the impact assessment area and associated with this early settlement and subsequent development of the available land resource for agricultural pursuits. The eastern portion of the impact assessment area was equally associated with the early growth of agricultural pursuits west of Sydney although these suburbs have since experienced more rapid urban development. Appendix P provides a detailed description of the non-Aboriginal heritage context of the impact assessment area. This section summarises the:

- listed non-Aboriginal heritage items located in the impact assessment area
- potential (unlisted) non-Aboriginal heritage items located in the impact assessment area
- listed non-Aboriginal heritage items located adjacent to the project outside the impact assessment area
- areas of Potential Archaeological Sites (PAS) located in the impact assessment area.

Each of these items is identified on Figure 10-5 and described in the sections below.

Listed non-Aboriginal heritage items in the impact assessment area

Table 10-10 identifies heritage items in the impact assessment area listed on statutory World, National, Commonwealth, State heritage lists and local environmental plans (LEPs). Several items are captured in more than one list. A detailed description of each of the items is included in Appendix P, with the exception of the Greater Blue Mountains which is addressed in section 10.3 and Appendix Q.

Table 10-10 Listed non-Aboriginal heritage items in the impact assessment area

Register / Listing	Item Name	Item Number	Significance
National Heritage List and World Heritage List	Greater Blue Mountains	105999	World
Commonwealth Heritage List	-	-	-
State Heritage Register	Upper Canal System (Pheasants Nest Weir to Prospect Reservoir)	01373	State
State Agency Heritage and Conservation Register (WaterNSW)	Upper Canal System (Pheasants Nest Weir to Prospect Reservoir)	NA	State
State Agency Heritage and Conservation Register (WaterNSW)	Warragamba Supply System	-	State
State Environmental Planning Policy (Western Sydney Aerotropolis) 2020	McGarvie-Smith Farm	I1	Local
State Environmental Planning Policy (Western Sydney Aerotropolis) 2020	The Fleurs Radio Telescope site	I5	Local
State Environmental Planning Policy (Western Sydney Aerotropolis) 2020	Luddenham Road alignment	I8	Local
State Environmental Planning Policy (Western Sydney Aerotropolis) 2020	Luddenham Showground	I15	Local
State Environmental Planning Policy (Western Sydney Parklands) 2009	Upper Canal System (Pheasants Nest Weir to Prospect Reservoir)	7	State
State Environmental Planning Policy (Western Sydney Parklands) 2009	Liverpool Offtake Reservoir	12	Local
Fairfield LEP 2010	Bandstand in Cabravale Park	I17	Local
Liverpool LEP 2008	Sydney Water Supply Upper Canal	15	State
Penrith LEP 2014	Luddenham Road Alignment	843	Local

Register / Listing	Item Name	Item Number	Significance
Penrith LEP 2014	The Fleurs Radio Telescope Site	832	Local
Penrith LEP 2014	McGarvie-Smith Farm	857	Local
Penrith LEP 2014	Luddenham Homestead Site	A849	Local
Penrith LEP 2014	Luddenham Showground	679	Local
Wollondilly LEP 2011	Blaxland's Farm	I269	State
Wollondilly LEP 2011	Blaxland's Crossing	I289	Local
Wollondilly LEP 2011	Warragamba Supply Scheme and Warragamba Emergency Scheme	I270	State

Potential non-Aboriginal heritage items in the impact assessment area

Table 10-11 lists the potential non-Aboriginal heritage items identified in the impact assessment area from a field survey and review of previous reports. These items are not registered on statutory heritage lists but have been identified to have potential heritage significance. Appendix P includes a detailed description of each of the items.

Table 10-11 Potential non-Aboriginal heritage items in the impact assessment area

Name	Address	Potential heritage significance
Blaxland's Garden	2595 Silverdale Road, Wallacia	Local/ State
Exeter House	1669-1723 Elizabeth Drive, Badgerys Creek	State
Exeter Farm Archaeological Site	885A Mamre Road, Kemps Creek	State
Fleurs Aerodrome	949A Mamre Road, Kemps Creek	Local
McMaster Field Station	1853-2109 Elizabeth Drive, Badgerys Creek	Local
South, Kemps and Badgerys Creek Confluence Weirs Scenic Landscape	Badgerys Creek	Local
South Creek Bridge	885A Mamre Road, Kemps Creek	Local
Lennox Reserve	Hume Highway, Canley Vale	Local
Lansvale Park	Hume Highway, Lansvale	Local

Listed non-Aboriginal heritage items in the vicinity of the impact assessment area

Table 10-12 lists non-Aboriginal heritage items on statutory heritage lists that have been identified close to, but not in the impact assessment area. Appendix P includes a detailed description of each of the items.

Table 10-12 Non-Aboriginal heritage items in the vicinity of the project

Name	Address	Significance	Item Number	Approximate distance from project
Lansdowne Bridge	Hume Highway, Lansvale	State	01472 (State Heritage Register)	100 m
'House', Lansdowne	7 Henry Lawson Drive, Lansdown	Local	I27 (Bankstown LEP)	40 m
St. Andrews Anglican Church (Former)	25 Park Road, Wallacia	Local	326 (Penrith LEP)	10 m
'Bayly Park' - house	919-929 Mamre Road, Kemps Creek	Local	104 (Penrith LEP)	500 m
Park Road Conservation Area	Park Road, Wallacia	Local	HCA6 (Penrith LEP)	20 m
Blaxland Crossing	Nepean River, Wallacia	Local	I289 (Wollondilly LEP)	50 m
Wallacia Hotel	1590–1594 Mulgoa Road, Wallacia	Local	325 (Penrith LEP)	200 m
Wallacia Weir	Nepean River, Wallacia	-	No ID provided (Sydney Regional Environmental Plan No 20 - Hawkesbury-Nepean River (No 2-1997)	100 m

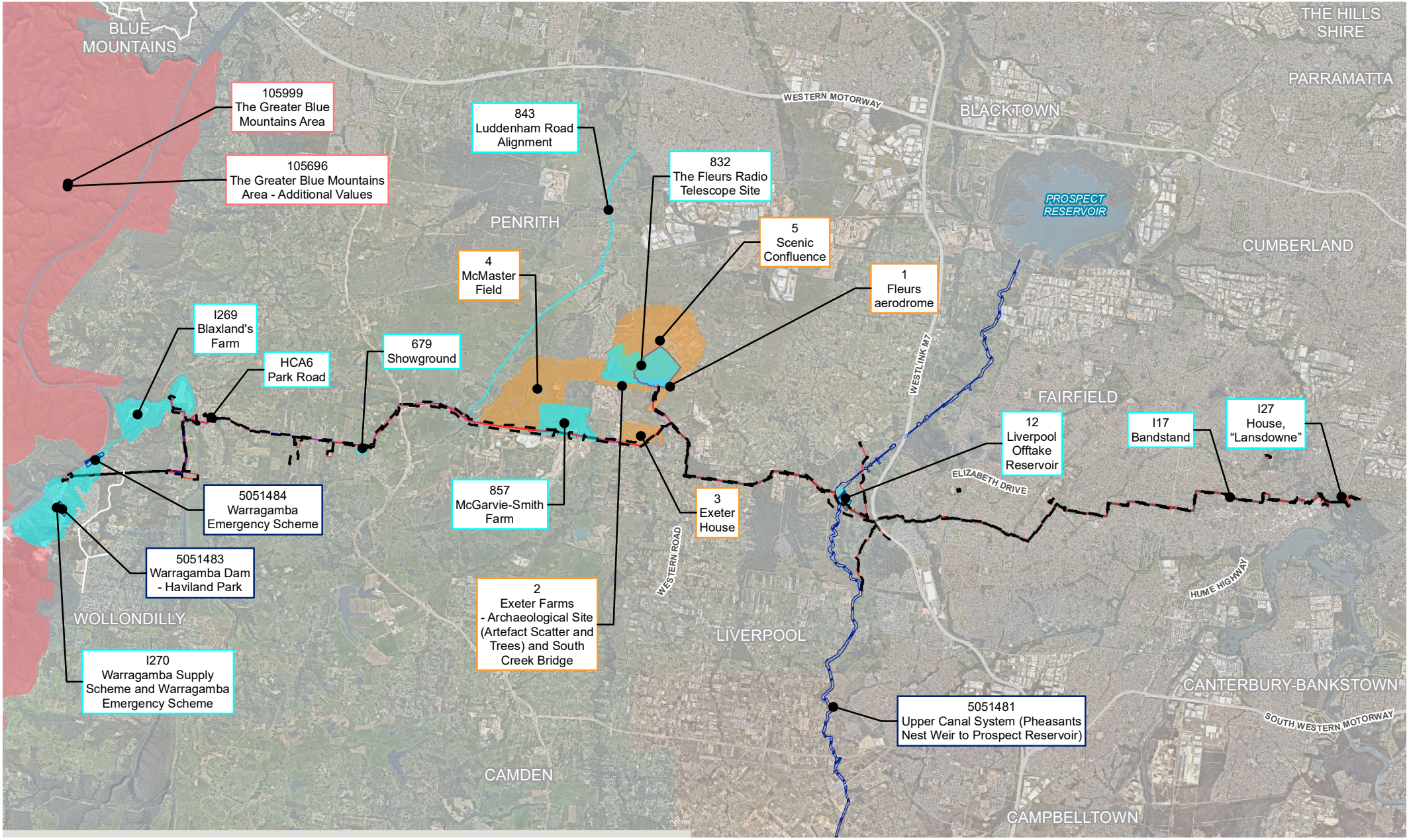
Potential Archaeological Sites in the impact assessment area

Table 10-13 lists the PAS identified wholly or partially in the impact assessment area. Appendix P includes a detailed description of each of the PAS areas.

Table 10-13 Potential areas of PAS in the impact assessment area

PAS	Archaeological potential
1 - Blaxland's Farm	The northern end of this site has moderate to moderate-high potential for historical archaeological evidence of state significance associated with John Blaxland's brewery complex on Nepean River established c.1830. The remainder of this site has low potential for historical archaeological evidence of local or state significance associated with Blaxland's gardens at Luddenham Estate.
2 - Blaxland's Gardens	This site has moderate potential for archaeological evidence of state significance associated with Blaxland's gardens at Luddenham Estate. The area along the western edge of this site, within the footprint of Bents Basin Road, has low historical archaeological potential.
3 - Blaxland's Crossing	This site has moderate potential for historical archaeological evidence of local significance in one localised area in its northwest corner in proximity to the historical bridge crossing location. The remainder of the site has low potential for archaeological evidence and is unlikely to meet the threshold for local significance.
4 - McMaster Field Station	This site has low to low-moderate potential for disturbed and limited, ephemeral evidence associated with animal grazing. This archaeological resource has low heritage significance and is unlikely to meet the threshold for local significance.
5 - McGarvie-Smith Farm	This site has low potential for disturbed and truncated historical archaeological evidence associated with agricultural activities on the periphery of both the McGarvie-Smith Farm and estate of William Johnson. The anticipated archaeological resource has low heritage significance, being unlikely to meet the threshold for local significance.
6 - Exeter House and Farm	This site has low potential for historical archaeological evidence of local significance associated with James Badgery's c.1812 Exeter Farm.
7 - Fleurs Radiophysics Field Station	This site has low potential for disturbed ephemeral archaeological evidence associated with Fleurs Estate unlikely to meet the threshold for local significance. It has high potential for evidence of Fleurs Radiophysics Field Station which is similarly unlikely to meet the threshold for local significance on the basis of extensive disturbance and removal of key elements. This site has high potential for the remains of two timber bridges on South Creek which would be of local or state significance, depending on the phase during which they were constructed.
8 - Upper Canal and Liverpool Offtake Reservoir	This site has low-moderate potential for archaeological evidence of state significance associated with the establishment and early operations of the Upper Canal. It also has low-moderate potential for archaeological evidence of local significance associated with upgrades to the Upper Canal and Liverpool Dam, with one localised area of high potential for evidence of a structure associated with operation of the Upper Canal.

PAS	Archaeological potential
9 - Lennox Reserve	Most of this site has low potential for archaeological evidence of local significance associated with agricultural use. A localised area within PAS 9 has high potential for archaeological evidence of local significance associated with a mid to late-nineteenth cottage or substantial outbuilding.
10 - Lansvale Park	This site has moderate to high potential for archaeological evidence of local significance associated with Knight's Butcher Shop and a small cottage or large outbuilding constructed in the late nineteenth century. The remaining areas have low potential for ephemeral archaeological evidence associated with agricultural activities.



Environmental Flows Pipeline
Treated Water Pipeline
Brine Pipeline
Underbore
Advanced Water Recycling Centre
Impact Area
Impact Assessment Area
National heritage items
State heritage items
Local heritage items
Potential heritage items
Waterbody

1:135,000
0 1 2km

Figure 10-5 Non-Aboriginal Heritage Items

Source: Aurecon, Sydney Water, LPI, Nearmap, ESRI
Projection: GDA2020 MGA Zone 56

10.2.4 Legislation and guidelines

Historical archaeology and built heritage in NSW are protected by Commonwealth and State legislation, and local government regulations. Table 10-14 summarises the legislation and environmental planning instruments relevant to the project.

Table 10-14 Legislation and environmental planning instruments of relevance to the project

Legislation / Instrument	Relevance to project
Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth)	The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places—defined in the EPBC Act as matters of national environmental significance. The project is in the vicinity of the Blue Mountains National Park, listed on the World Heritage List, as the *Greater Blue Mountains*, gazetted 2 December 2000. The Blue Mountains National Park is also listed on the National Heritage List. The project has been determined a controlled action and requires approval under the EPBC Act, assessed under the Bilateral Agreement.
Heritage Act 1977	The *Heritage Act 1977* (Heritage Act) provides protection for heritage places, buildings, works, relics, movable objects, precincts, land and archaeological sites that are important to the people of New South Wales. The project is State significant infrastructure which means pursuant to section 5.23 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) approvals under Part 4 or section 139 of the Heritage Act are not required for the project.
Environmental Planning and Assessment Act 1979	An Environmental Planning Instrument (EPI) is made under the EP&A Act. An EPI can be a local environmental plan (LEP), or a state environmental planning policy (SEPP). These EPIs guide land use management at a local and state level. They include provisions for heritage conservation and development assessment and approval.
Local environmental plans (LEP): Bankstown Local Environmental Plan 2015 Fairfield Local Environmental Plan 2010 Liverpool Local Environmental Plan 2008 Penrith Local Environmental Plan 2014 Wollondilly Local Environmental Plan 2011	The project is located in five local government areas to which the listed LEPs apply. Each LEP contains a schedule of local heritage items which require consideration of potential impacts as part of the project's impact assessment. Information from the LEPs has been used to inform the assessment of non-Aboriginal heritage impacts although the provisions of the LEPs do not apply to the project.

Legislation / Instrument	Relevance to project
State Environmental Planning Policy (Western Sydney Parklands) 2009	The State Environmental Planning Policy (Western Sydney Parklands) 2009 (Western Sydney Parklands SEPP) put in place planning controls that enable the Greater Sydney Parklands to develop the Western Parklands into a multi-use urban parkland for the region of western Sydney. Schedule 1 of the Western Sydney Parklands SEPP lists items of environmental heritage within the land to which the SEPP applies, including archaeological sites, buildings, and conservation areas. Information from the Western Sydney Parkland SEPP has been used to inform the assessment of non-Aboriginal heritage impacts although the provisions of the SEPP do not apply to the project.
State Environmental Planning Policy (Western Sydney Aerotropolis) 2020	The State Environmental Planning Policy (Western Sydney Aerotropolis) 2020 (Western Sydney Aerotropolis SEPP) put in place planning controls that enable development of the Western Sydney Aerotropolis. Schedule 2 of the Western Sydney Aerotropolis SEPP lists items of environmental heritage within the land to which the SEPP applies. Information from the Western Sydney Aerotropolis SEPP has been used to inform the assessment of non-Aboriginal heritage impacts although the provisions of the SEPP do not apply to the project.

The SOHI was prepared in accordance with the principles and definitions as set out in the guidelines to The Burra Charter: The Australia ICOMOS Charter for Places of Cultural Significance (Australia ICOMOS 2013) and the ICOMOS Guidance on Heritage Impact Assessments (ICOMOS, 2011).

The Heritage Council of NSW has also established guidelines for the assessment of the significance of, and impacts to, heritage items and non-Aboriginal archaeological sites. These guidelines include:

- Assessing Heritage Significance Guidelines (NSW Heritage, 2001)
- Statement of Heritage Impact Guidelines (NSW Heritage, 2002)
- Assessing Significance for Historical Archaeological Sites and Relics (NSW Heritage, 2009)
- Archaeological Assessments (NSW Heritage, 1996).

The assessment of potential impact non-Aboriginal heritage items and archaeology has been undertaken in accordance with the process and recommendations of these guidelines.

In addition to legislation and guidelines, consideration of any Conservation Management Plans (CMP) that apply within the impact assessment area, and the projects compliance with any applicable policies contained in a CMP is required.

10.2.5 Construction impact assessment

The main potential project impacts during construction include damage to items through ground disturbance during excavation, vibration from activities such as tunnelling, and the building of new infrastructure in scenic landscapes. The assessment below considers impacts to built heritage and areas of PAS in the project's impact area. It also considers any potential indirect impacts on nearby heritage items.

Impacts to listed and potential non-Aboriginal heritage items and PAS within the impact area

Table 10-15 summarises the project's potential impacts to listed non-Aboriginal heritage items, potential heritage items and PAS in the impact area. Appendix P includes a detailed assessment of these impacts. The level of impact is based on the impact definitions outlined in section 10.2.2.

Table 10-15 only addresses items identified in section 10.2.3 with potential to be impacted by the project. Any other items identified in section 10.2.3 will not be impacted by the project.

Table 10-15 Potential impacts to heritage items and PAS in the impact area

Item	Impact discussion	Impact level
Fleurs Aerodrome	**Built heritage** Trenching to install the treated water pipeline will result in a minor localised impact to landscaping alongside the bitumen section of the airfield. The impacts are restricted to grassed vegetation, which can be remediated post construction. The placement of the pipeline ensures there is a negligible impact to the heritage significance of the item during the construction phase of the project and enables its continued interpretation in the landscape.	Negligible
McGarvie-Smith Farm (PAS 5)	**Built heritage** The treated water pipeline will fall within the curtilage of the McGarvie-Smith Farm and be tunnelled beneath the dams on the site. The open trenching and tunnelling required for the treated water pipeline will require the removal of some established vegetation. This will have a minor and temporary impact to the rural landscape along Elizabeth Drive as the area will be revegetated where feasible, mitigating any long-term visual impacts of the construction. The project will have no impact to farm buildings. Overall, the project does not represent an adverse heritage impact to the broader heritage values of the site.	Minor
	Historical archaeological heritage PAS 5 has low potential for archaeological remains likely to meet the threshold for local significance. Construction of the treated water pipeline will result in little to no archaeological impact.	Negligible
McMaster Field Station (PAS 4)	**Built heritage** The proposed alignment for the treated water pipeline will have a minor impact to the land within the curtilage of the McMaster Field Station. The pipelines will be tunnelled beneath the dams in the curtilage of the McMaster Field Station. The open trenching and tunnelling required for the treated water pipeline will remove some established vegetation. This will have a minor and temporary impact to the rural landscape along Elizabeth Drive as the area will be revegetated where feasible, mitigating any long-term visual impacts of the construction. The project will have no impact to farm buildings.	Minor
	Historical archaeological heritage PAS 4 has low to low-moderate potential for archaeological remains which are unlikely to meet the threshold for local significance. Construction of the treated water pipeline will result in little to no archaeological impact.	Negligible

Item	Impact discussion	Impact level
Exeter Farm (PAS 6)	**Historical archaeological heritage** PAS 6 has low potential for historical archaeological remains of local significance associated with Exeter Farm. Construction of the treated water pipeline will result in little to no archaeological impact.	Negligible
Luddenham Road Alignment	**Built heritage** Construction of the treated water pipeline will involve open trenching across Luddenham Road where it intersects Elizabeth Drive. The project will not involve the physical modification of the Luddenham Road alignment, nor affect the setting of the item. The project will not change the landscape and does not represent an adverse impact to the heritage values of the Luddenham Road alignment.	Negligible
Luddenham Homestead	**Built heritage** There are no built heritage impacts associated with the use of Luddenham homestead as a construction compound. The compound will be temporary and removed upon the completion of the project.	No change
Luddenham Showground	**Built heritage** Pipeline construction is in the road verge of Park Road and will avoid impacts to landscape elements associated with the showground. There are no ongoing physical or visual impacts associated with the proposed works. The construction of the pipeline does not represent an adverse heritage impact to the showground.	Negligible
Blaxland's Farm (PAS 1)	**Built heritage** The works in the Blaxland's Farm curtilage include open trenching for the construction of the treated water pipeline with a release outlet upstream of Wallacia Weir, and air valves along Silverdale Road. The project will have no impact to built heritage on Blaxland's Farm. The project has considered the location of sensitive areas such as extant built features and avoided impact to these areas by limiting works east of the core of the Blaxland's Farm site. No long-term impacts to the heritage significance of Blaxland's Farm are expected.	Negligible

Item	Impact discussion	Impact level
	Historical archaeological heritage The original placement of the treated water pipeline and release structure to Nepean River went through the core of the Blaxland Farm site where extant archaeological remains (ruins) were visible from the surface during survey and detailed assessment of aerial photographs. This would have resulted in a major adverse impact to archaeological remains assessed as being of state significance. Sydney Water has redesigned the treated water pipeline and release structure location to move them to the east into areas of moderate to moderate-high potential for historical archaeological evidence of Blaxland's Farm. These areas are more likely to have been disturbed by twentieth-century agricultural practices and seem to be toward the margins of the site. Trenching to accommodate the treated water pipelines and associated construction activities still represents a moderate adverse impact to what is an intact early colonial archaeological site. Measures have been identified to manage impact to acceptable levels.	Moderate
Blaxland's Garden (PAS 2)	**Historical archaeological heritage** This area is depicted as 'garden' in 1859 subdivision plans. The area has the potential to yield archaeological evidence of agricultural practices at Blaxland's Luddenham Estate. There is moderate potential for unrecorded outbuildings associated with operation of the garden, including sheds, cottages, and stores to be present which could be impacted. Trenching for construction of the treated water pipelines will result in a localised impact to the site's archaeological resources.	Minor to moderate
Blaxland's Crossing (PAS 3)	**Historical archaeological heritage** Construction of the treated water pipeline is likely to result in the removal of historical archaeological evidence of local significance associated with an early colonial roadway, as well as potentially a causeway and timber bridge. This would result in a partial loss of these sites, as they are anticipated to extend further to the west to Nepean River.	Minor to moderate

Item	Impact discussion	Impact level
Warragamba Supply Scheme and Warragamba Emergency Scheme	**Built heritage** The environmental flows pipeline will extend from Bents Basin Road primarily via tunnelling where it will connect to a release location on Warragamba River upstream of Warragamba Weir. The concrete headwalls of the release structure are small structures and have a minor impact on the views and settings that contribute to the values of the area. The release structure is located outside the State Heritage Register (SHR) curtilage of the Warragamba Emergency Scheme. There are no direct or indirect impacts on significant elements associated with the construction of the environmental flow pipeline and release location.	Minor
Cabravale Memorial Park - Bandstand	**Built heritage** The works in Cabravale Memorial Park will involve site access via the gravelled access off Railway Parade. Works within Cabravale Park include the establishment of a construction area on a portion of the park away from heritage structures. The primary activity undertaken within this area will be excavation of a launch pit to allow for tunnelling of the brine pipeline under Railway Parade, the rail line and Broomfield Street. These works will only be temporary during construction with no ongoing operational impacts. The works have been planned to avoid the heritage curtilage of the war memorial and make use of open spaces and existing access roads to reduce impact to the landscaped area of the park. The use of existing access roads is unlikely to require widening, resurfacing or vegetation trimming and has no impact to built heritage or archaeological resources. Although the use of trenchless construction methods will require some landscape clearing before works, this impact will be mitigated through the revegetation of the landscape with the replanting of similar species. The works are considered to have a minor and reversible impact.	Minor
Upper Canal and Liverpool Offtake Reservoir (PAS 8)	**Built heritage** The brine pipeline will tunnel beneath Section 10 of the Upper Canal in the suburb of Cecil Hills. The transition from open trenching to tunnelling will include one launch and receival pit and a compound area for the laydown of materials. The pipeline will be tunnelled about six metres below the base of the Upper Canal and comply with WaterNSW Guidelines that specify structural engineering requirements. At the completion of these works, there will be no above-ground structures associated with this work. The methodology developed in this area has balanced the functional and technical requirements of the project with heritage values. The underbore of the canal will be at a safe structural distance and undertaken in consultation with WaterNSW. Assessment of impacts was also undertaken in accordance with the methodology for assessing impacts to items of State significance as outlined in section 10.2.2.The impact on the built heritage fabric and associated heritage values of the Upper Canal is minor.	Minor

Item	Impact discussion	Impact level
	Historical archaeological heritage While tunnelling beneath the Upper Canal is unlikely to impact on significant archaeological remains, excavation of entry and exit pits will result in removal of any significant archaeological remains within their footprints. Similarly, trenching in areas of low-moderate potential may result in removal of historical archaeological remains. Any historical archaeological remains that might be uncovered in this area are likely to be of local significance.	Minor
Lennox Reserve (PAS 9)	**Historical archaeological heritage** Trenching to install the brine pipeline will result in partial or complete removal of archaeological evidence associated with a mid to late-nineteenth century cottage or large outbuilding.	Minor to moderate
Lansvale Park (PAS 10)	**Historical archaeological heritage** Trenching to install the brine pipeline will extend through the centre of where two historical structures once stood, one associated with Knight's Butcher Shop, the other an unidentified late nineteenth-century cottage or outbuilding, and result in the removal of any associated archaeological evidence. Installation of the brine pipeline through PAS 10 will result in an adverse impact to the archaeological resources in PAS 10.	Minor to moderate

Item	Impact discussion	Impact level
Fleurs Radio Telescope Site (PAS 7)	**Built heritage** While only partially included in the curtilage of the Fleurs Radio Telescope Site, the AWRC is located on areas previously identified as containing 95% of the identified significant elements of this site. Although most of the built structures associated with this site have previously been removed or are in dilapidated condition, the construction of the AWRC will transform this landscape and remove the last remaining evidence of the sites' use. The removal of remnant fabric will have a major physical and visual impact on the cultural landscape and the remaining structures associated with this site. This will be a loss of remaining fabric that demonstrates the core heritage values of Fleurs Radio Telescope Site and may warrant a reassessment of the site's curtilage. Sydney Water has considered a range of site options for the AWRC site, as outlined in Chapter 3. Given the scale of the AWRC site and the extent of infrastructure required, there are substantial limitations on Sydney Water avoiding or minimising impacts on this item, particularly in the AWRC operational area. Sydney Water is also committed to the measures outlined in Table 10-6 for archival recording and heritage interpretation, including considering opportunities to retain significant fabric such as parabolic antennas on site. Given the strategic importance of the project to Western Sydney and these measures to record and celebrate the site's heritage, on balance the SOHI found the impacts to be acceptable.	Major
	Historical archaeological heritage Construction of the AWRC will occur within PAS 7 (Fleurs Radiophysics Field Station). Earthworks are likely to result in the removal of any historical archaeological remains. Most of PAS 7 has been assessed as having low potential for disturbed archaeological evidence of significance associated with Fleurs Radio Telescope Site. There are two localised areas on South Creek with high potential for locally significant evidence of timber bridges. The construction footprint of the AWRC is confined within areas with low archaeological potential and is unlikely to impact on areas of high archaeological potential.	Negligible
South, Kemps and Badgerys Creek Confluence Weirs Scenic Landscape	**Built heritage** Construction of the AWRC will require the removal of vegetation in parts of the South, Kemps and Badgerys Creek Confluence Weirs Scenic Landscape. The heritage significance of the cultural landscape is embodied in the remnant vegetation, presence of creeks and weirs, and early homesteads in the landscape. This is predominantly located to the north of the impact assessment area. The construction of the AWRC will have a moderate impact on the rural landscape values of the item.	Moderate

Construction impacts to non-Aboriginal heritage items in the vicinity of the project

Table 10-16 assesses the non-Aboriginal heritage items in the vicinity of the project with potential to be impacted by the project given their proximity to construction activities.

Table 10-16 Potential impacts to listed heritage items in the vicinity of the project

Item	Impact assessment	Impact level
Wallacia Hotel	The Wallacia Hotel is located in the vicinity of the compound proposed for the Luddenham Homestead Site. The compound will be located to the rear of Wallacia Hotel and does not represent an adverse impact to the Wallacia Hotel heritage values. The hotel will remain a prominent and landmark building in the streetscape.	Negligible
Wallacia Weir	The Nepean River release structure is located upstream of Wallacia Weir. The construction of the proposed outlet will have no direct or indirect impacts on the weir. The project will have a negligible impact on the actual structure and surrounding landscape.	Negligible
Lansdowne House	The historic house known as 'Lansdowne' located at 7 Henry Lawson Drive is a highly modified Federation Bungalow that neighbours Lansdowne Reserve. The brine pipeline connects to the Malabar wastewater system in Lansdowne Reserve. The connection will be made through open trenching after underboring the Prospect Creek. The proposed work will not have an adverse impact on the building, nor will it have a long-term adverse impact on the landscape setting of Lansdowne Reserve.	Negligible

The project will have no impacts on the following listed non-Aboriginal heritage items identified in the vicinity of the project due to their distance from construction activities:

- St. Andrews Anglican Church (Former).
- "Bayly Park" – house.
- Park Road Conservation Area.

Construction impacts to non-Aboriginal heritage items views and settings

Construction works will result in short-term impacts to the setting of heritage items as a result of vegetation clearing, earthworks and the presence of construction plant and machinery. Following the completion of construction most infrastructure will be below ground with disturbed areas returned to natural ground level where practical. The loss of vegetation will be mitigated through the revegetating with appropriate species.

Following the completion of construction, impacts to the views and setting associated with non-Aboriginal heritage items will be minor.

Compliance with Conservation Management Plans (CMP)

The 'Upper Canal Pheasants Nest to Prospect Reservoir Conservation Management Plan' (NSW Government Architects Office 2016) is the only CMP relevant to the project. Table 10-17 summarises the policies in the CMP relevant to the project and their applicability.

Table 10-17 Upper Canal CMP policy review

CMP Policy	Discussion
Policy 9: Ensure the significance of the Upper Canal and the key heritage management requirements relating to it are included in all SCA policy and procedure documents governing operation of the Canal and major works planning.	The project will have no impacts on the significance of the Upper Canal. The project is consistent with this policy.
Policy 10: Conserve surviving historic landscape features associated with the Canal, particularly the avenues of pines, cultural plantings at cottage and depot sites and historic plantings associated with the intersection of the Canal with old travel routes.	The project will have no physical impact on the Upper Canal, or any permanent impacts to any significant landscape features. The project is consistent with this policy.
Policy 36: Make decisions requiring change to the Upper Canal with a clear understanding of the implications for the identified heritage values of the Canal and seek to minimise negative heritage impacts.	The project does not require change to the Upper Canal and incorporates measures to mitigate and avoid impacts to the Upper Canal. The project is consistent with this policy.
Policy 66: When installing below ground services, avoid areas of identified historical or Aboriginal archaeological potential and avoid impacts to elements of Exceptional heritage significance.	The preliminary heritage assessment identified areas of archaeological potential and heritage significance that the project has been designed to avoid including those associated with the Upper Canal. Where tunnelling under the Upper Canal, the design incorporates measures to mitigate and avoid any impacts to the canal. No areas of archaeological potential or Exceptional Heritage significance associated with the Upper Canal will be impacted by the project. The proposed works are consistent with this policy.
Policy 71: Where excavation is unavoidable, seek advice from a suitably qualified and experienced historical or Aboriginal archaeologist early in the planning stages for any work and undertake historical archaeological and Aboriginal cultural heritage assessment as appropriate.	The EIS includes assessment of historical archaeology (this section) and Aboriginal cultural heritage (section 10.1) completed by specialist consultants. The assessment has considered the archaeological impacts to the Upper Canal. The works are considered appropriate and to have a minor and reversible impact on the heritage significance of the Upper Canal. The project is consistent with this policy.

10.2.6 Operational impact assessment

All the disturbance to non-Aboriginal heritage for the project will occur during construction and no additional impacts are expected during operation.

The treated water pipeline, brine pipeline and environmental flows pipeline, will all be below ground level and the release locations positioned so they have negligible impact on non-Aboriginal heritage items or archaeology during operation. The operational pipelines will have no ongoing impact to the structures, landscape or settings of the identified heritage items.

The operation of the release structures will require ongoing access for regular inspection and maintenance. Access to these locations will make use of existing access roads or access tracks established during construction within the assessed disturbance footprint. There are no additional impacts associated with access for the operational use of the release structures.

Prior to the AWRC becoming operational, archival recording of Fleurs Radio Telescope will have taken place. Combined with the incorporation of heritage interpretation into the AWRC design, operational impacts on non-Aboriginal heritage will be minor.

A Landscape Character and Visual Impact Assessment (LCVIA) (Aurecon Arup, 2021g) has been prepared for the project and is summarised in section 11.3 and included in full in Appendix T. The LCVIA contains a series of photomontages to visually communicate the likely long-term impacts of the project on the landscape character and setting of heritage items in the project's impact area. Photomontages have been prepared for the three sites which have substantial above-ground infrastructure:

- Nepean River release structure
- Warragamba River release structure
- AWRC.

Operational impacts of release structures at Nepean River and Warragamba River were found to be low due to their scale, placement in the landscape and lack of visibility from publicly accessible areas.

The LCVIA found that the overall visual impact of the AWRC once it is built will be moderate. In relation to non-Aboriginal heritage items this indicates potential for moderate visual impacts to items in the immediate vicinity such as:

- Fleurs Radio Telescope on the AWRC site
- treated water release structure at Wallacia on Blaxlands Farm
- environmental flows release structure at Warragamba in proximity to the Warragamba Supply and Emergency Scheme.

No other non-Aboriginal heritage items are expected to be visually impacted by the project. The LCVIA has been undertaken based on landscaping having matured one year. As landscaping develops over time residual impacts will reduce further.

10.2.7 Impact of future stages

The assessment of non-Aboriginal heritage impacts has assessed the full disturbance footprint for Stage 1 and future stages of the project. No additional non-Aboriginal heritage impacts are anticipated to occur in future stages.

10.2.8 Cumulative impacts

An assessment of potential cumulative impact to non-Aboriginal heritage was undertaken in relation to the following projects:

- Western Sydney Aerotropolis Growth Area (WSAGA)
- Western Sydney International Airport
- Sydney Metro-Western Sydney Airport line
- Northern Road upgrade
- Warragamba Dam wall raising
- M12 Motorway.

With the exception of WSAGA and M12 Motorway the potential for cumulative impacts to occur was found to be negligible to minimal as they are spatially separated, would not impact on the same heritage items and have also incorporated measures to avoid or minimise non-Aboriginal heritage item impacts where possible.

WSAGA

The project is essential to facilitate the urban development of the WSAGA. Although development of the WSAGA would likely have a larger impact to non-Aboriginal heritage due to its large spatial extent, the project represents a minor incremental increase to heritage impacts when considered cumulatively with development across the WSAGA. The management measures in section 10.2.9 are suitable to manage this cumulative impact, and no additional management measures are required.

M12 Motorway

Transport for NSW (TfNSW) is preparing to construct and operate the M12 Motorway project to provide direct access between the Western Sydney Airport at Badgerys Creek and Sydney's motorway network. The M12 Motorway will run between the M7 Motorway at Cecil Hills and The Northern Road at Luddenham for a distance of about 16 kilometres. The M12 Motorway alignment traverses large land parcels that were historically used for a range of activities, including agricultural and astronomical research.

The Non-Aboriginal Heritage Assessment Report (Jacobs-Arcadis, 2019) prepared for the M12 Motorway project identified eight heritage items and potential heritage items that overlap with Sydney Water's project area. Table 10-18 lists these items and the potential cumulative impacts associated with the project.

Table 10-18 Cumulative non-Aboriginal impacts with the M12 Motorway

Item	Description of impacts	Level of cumulative impact
McGarvie-Smith Farm	Work associated with M12 Motorway will result in removal of key heritage elements from this item. In comparison to the M12 Motorway, the open trenching and tunnelling required for the treated water pipeline will have a minor and temporary impact to the rural landscape along Elizabeth Drive. This will not see the loss of significant built features.	Minor
Fleurs Radio Telescope	Fleurs Radio Telescope will experience direct and indirect cumulative impacts in association with the construction of M12 Motorway. The construction footprint of the M12 Motorway is limited to the southern boundary of the site, on an east-west axis and will require the partial demolition of the Shain Cross array. TfNSW assessed this work as having a minor impact on the heritage significance of the item. As outlined in Table 10-15, construction of the AWRC is considered to have a major impact on this item. Collectively, construction of both projects involves the loss of historic landscape elements and the original layout of the cross arrays. This reinforces the value of archival recording and interpretation.	Major
Luddenham Road Alignment	As detailed in section 10.2.5 the project will have a negligible impact to the Luddenham Road Alignment. Therefore, potential for cumulative impacts with the M12 Motorway is negligible.	Negligible
Upper Canal System (Pheasants Nest Weir to Prospect Reservoir)	While the brine pipeline will be built in the curtilage of the heritage item, the works will not impact the significant fabric or landscaping associated with the Upper Canal and Liverpool Offtake Reservoir. The works will be located below ground and have no impact to views of the heritage item. The M12 Motorway would have a negligible impact on the Upper Canal System therefore the potential for there to be cumulative impact with the project is negligible.	Negligible
McMaster Field Station	The M12 Motorway will result in removal of key heritage elements. The cumulative impacts associated with the project that will arise from the construction and installation of the treated water pipelines is considered minor. In comparison to the M12 Motorway project, the open trenching and under boring required for the treated water pipeline will have a minor and temporary impact to the rural landscape along Elizabeth Drive. This will not see the loss of significant built features.	Minor
Fleurs Aerodrome	There will be a negligible cumulative impact on the heritage significance of this item as the impacts from the project will occur in an area already impacted by the construction footprint of the M12 Motorway.	Negligible

Item	Description of impacts	Level of cumulative impact
Exeter Farm Archaeological Site	As detailed in section 10.2.5 the project will have a negligible impact to the Exeter Farm Archaeological site. Therefore, potential for cumulative impacts with the M12 Motorway are negligible.	Negligible
South, Kemps and Badgerys Creek Confluence Weirs Scenic Landscape	The AWRC is located in the southern portion of the South, Kemps and Badgerys Creek Confluence Weirs Scenic Landscape. The projects collectively will have a minor cumulative impact on the heritage values of the landscape. The M12 Motorway would have hydrological impacts to the South, Kemps and Badgerys Creek catchments and also have indirect visual impacts to the landscape.	Minor

10.2.9 Management measures

Table 10-19 outlines the management measures Sydney Water proposes to manage non-Aboriginal heritage impacts.

Table 10-19 Non-Aboriginal heritage management measures

ID	Impact	Mitigation measure	Timing
NAH01	Impacts to built heritage – Cabravale Memorial Park	Establish a 'heritage protection zone' around key features of the Cabravale Memorial Park. This will include: • no-go zones and fencing around the Bandstand, 170mm Minenwerfer and Vietnam War Comradeship memorial • where possible, using existing roads and access tracks. Where this is not possible and driving directly over grassed areas is required, applying surface material to the ground cover to spread loads and prevent destruction of these areas • remediating any damage to the landscape upon completion of the work.	Prior to construction

ID	Impact	Mitigation measure	Timing
NAH02	Impacts to built heritage - Upper Canal and Liverpool Offtake Reservoir	Construction activities in proximity to the Upper Canal and Warragamba Pipelines will be undertaken in accordance with WaterNSW 'Guideline for Development Adjacent to the Upper Canal and Warragamba Pipelines'. This will include: • dilapidation survey prior to any construction work commencing • monitoring of vibration and ground movement during tunnelling construction.	Detailed design Prior to construction
NAH03	Impacts to built heritage – Fleurs Radio Telescope Site	Prior to the removal of identified historic elements related to the Fleurs Radio Telescope site, photographic archival recording will be undertaken by an experienced heritage consultant and in accordance with the Photographic Recording of Heritage Items using Film or Digital Capture, NSW Heritage Office, 2006.	Prior to construction
NAH04	Impacts to built heritage at AWRC site	Prepare a Heritage Interpretation Framework for the project, incorporating the retention of Aboriginal and non-Aboriginal heritage features at the AWRC site where practical. The framework will include consideration of: • incorporating historic features into the AWRC design • interpretive public art and soundscapes • retention and interpretive use of the two parabolic antennas • creation of a heritage display of historic material in the AWRC • preparation of digital interpretive resources related to the history of the site • preparation of an oral history of the Fleurs Field Station.	Detailed design During operation

ID	Impact	Mitigation measure	Timing
NAH05	Impacts to Potential Archaeological Sites (PAS) of moderate to high significance	Manage ground disturbance (excavation) in the following PAS areas of moderate to high significance by: • avoiding disturbance where practical • where disturbance cannot be avoided, complete archaeological testing in accordance with the Archaeological Research Design and Excavation Methodology (ARDEM) in Appendix P • complete archaeological salvage and archival recording where this is recommended in archaeological testing. The sites of moderate to high significance are: • Blaxland's Farm • Blaxland's Gardens • Blaxland's Crossing • McMaster Field Station • Upper Canal • Lennox Reserve • Lansvale Park Coordinate this program with Aboriginal heritage salvage excavation, in locations where salvage is required for both.	Detailed design Prior to construction During construction
NAH06	Impacts to PAS of low significance	Manage disturbance in the following PAS areas of low significance through an unexpected finds procedure: • McGarvie-Smith Farm • Exeter House and Farm • Fleurs Radiophysics Field Station.	Detailed design Prior to construction During construction
NAH07	Accidental impact to non-Aboriginal heritage item.	Any accidental damage to heritage items is to be treated as an incident, with appropriate recording and notification.	During construction
	Impact to non-Aboriginal heritage – unexpected finds	This impact is appropriately managed by measures in section 10.1 (Aboriginal heritage).	Prior to construction

ID	Impact	Mitigation measure	Timing
	Contractors do not understand heritage obligations	This impact is appropriately managed by measures in section 10.1 (Aboriginal heritage).	During construction
	Impact to heritage character or landscape from above-ground structures on AWRC site	This impact is appropriately managed by the 'Urban design' measures in Chapter 15 (Project synthesis)	Detailed design

10.3 World and National heritage

This section describes the Greater Blue Mountains World Heritage Area (GBMWHA), which is listed on the World Heritage List and National Heritage List. It also assesses the project's impacts on this area during construction and operation and summarises the specialist report (EMM Consulting, 2021) in Appendix Q.

World and National heritage impact summary

The project is not located within the boundary of any World or National heritage-listed items so will not have any direct impacts on any listed items. The treated water release locations at Nepean River and Warragamba River are located adjacent and upstream of the Greater Blue Mountains World Heritage Area (GBMWHA). Construction of this infrastructure is not expected to have any indirect impacts on the GBMWHA so this section only addresses potential operational impacts.

Release of treated water into Nepean River and Warragamba River during operation has the potential to indirectly impact values of the GBMWHA. Sydney Water has assessed impacts on attributes of the GBMWHA associated with geomorphology, water quality, biodiversity, Aboriginal heritage, visual and non-Aboriginal heritage.

Treated water releases from the project will result in an increase of water depth in Nepean River of about 5 cm for Stage 1 of the project (50 ML/day) and about 10 cm for the ultimate releases of up to 100 ML/day and changes to wetted perimeter are expected to remain within the river channel. These changes are not expected to have a significant impact on any World or National heritage values of the GBMWHA. For biodiversity, the impact is slight due to small additional wetted areas on lower riverbanks and slight increase in saturation frequency in flood events. The impacts on Platypus and Echidna are considered negligible. For most other values (including geomorphology, visual and heritage) the changes associated with the project are also negligible resulting in an overall neutral impact from the project.

The management measures proposed in other sections of the EIS in relation to biodiversity, waterways, heritage and visual are appropriate to also manage and monitor potential impacts on the GBMWHA and no additional management measures are considered necessary.

10.3.1 Relevant Secretary's Environmental Assessment Requirements

Table 10-20 shows the Secretary's Environmental Assessment Requirements (SEARs) relevant to World and National heritage and where in this section they are addressed.

Table 10-20 Project SEARs relating to World and National Heritage impacts

SEARs	EIS section where requirement addressed
Attachment 1 *Impacts* 9. The EIS must include an assessment of the relevant impacts of the action on the matters protected by the controlling provisions, including:	

SEARs	EIS section where requirement addressed
i. a description and detailed assessment of the nature and extent of the likely direct, indirect and consequential impacts, including short term and long term relevant impacts;	Section 10.3.5
ii. a statement whether any relevant impacts are likely to be unknown, unpredictable or irreversible;	Section 10.3.5
iii. analysis of the significance of the relevant impacts; and	Section 10.3.5
iv. any technical data and other information used or needed to make a detailed assessment of the relevant impacts.	Section 10.3.5
Avoidance, mitigation and offsetting 10. For each of the relevant matters protected that are likely to be significantly impacted by the action, the EIS must provide information on proposed avoidance and mitigation measures to manage the relevant impacts of the action including: i. a description, and an assessment of the expected or predicted effectiveness of the mitigation measures, ii. any statutory policy basis for the mitigation measures; iii. the cost of the mitigation measures; iv. an outline of an environmental management plan that sets out the framework for continuing management, mitigation and monitoring programs for the relevant impacts of the action, including any provisions for independent environmental auditing; v. the name of the agency responsible for endorsing or approving each mitigation measure or monitoring program.	No matters in relation to World or National heritage have been identified as likely to be significantly impacted by the project. No additional management measures are proposed to manage impacts on World or National heritage, as outlined in section 10.3.8. Chapter 14 describes the overall environmental management approach for the project.
11. Where a significant residual adverse impact to a relevant protected matter is considered likely, the EIS must provide information on the proposed offset strategy, including discussion of the conservation benefit associated with the proposed offset strategy.	No significant residual adverse impact is considered likely Table 10-30.
12. For each of the relevant matters likely to be impacted by the action the EIS must provide reference to, and consideration of, relevant Commonwealth guidelines and policy statements including any: v. management plan for a World Heritage property or National Heritage place'	Section 10.3.4 and section 10.3.5

SEARs	EIS section where requirement addressed
Heritage (World and National Heritage)	
17. The EIS must identify and describe the characteristics and values, including Outstanding Universal values, of the Greater Blue Mountains Area – World Heritage property and National Heritage place that is likely to be impacted by all stages of the proposed action with appropriate reference to relevant management plans. The assessment of impacts should include information on: i. the modification, destruction, fragmentation, isolation, disturbance of an important or substantial area of habitat;	Section 10.3.5
ii. impacts on other users of the area;	Section 10.3.5
iii. the potential impacts on important amenities, navigation, culturally or historically significant sites, threatened or migratory species or sensitive habitat;	Section 10.3.5
iv. the potential visual impacts;	Section 10.3.5
v. a description of any specific mitigation and management measures proposed to protect or enhance the affected values of the World Heritage property or National Heritage place.	Section 10.3.8
18. Where a significant residual adverse impact to a World Heritage property and/or a National Heritage place is considered likely the EIS must provide information on the proposed offset strategy. The offset strategy must: i. include a discussion and supporting evidence of the conservation benefit associated with the proposed offset strategy. The conservation benefit must demonstrate, at a minimum, how the proposed offset will improve the integrity and resilience of the heritage values of the impacted heritage place or property; and ii. be consistent with the *Environment Protection and Biodiversity Conservation Act 1999 Environmental Offset Policy (2012)*: www.environment.gov.au/epbc/publications/epbc-act-environmental-offsets-policy or an endorsed state policy.	No significant residual impacts are expected, and no offsets are needed under the EPBC Act.

10.3.2 Methodology and assumptions

The methodology undertaken to identify potential impacts from the project on the GBMWHA included:

- desktop review of key information including:
  - World and National Heritage Listing information for the GBMWHA, to inform developing attributes that define the heritage values
  - reviewing relevant specialist studies undertaken for the Environmental Impact Statement (EIS) and additional information provided by those specialists to understand potential impacts on the GBMWHA
- impact assessment based on the desktop review
- Identification of any required management measures.

Desktop review

World and National heritage information review and attribute definition

Identifying the attributes that define the values for the GBMWHA was a key first step to inform assessment of project impacts. Attributes provide the physical, or tangible, characteristics and elements against which it is possible to measure an impact. The SEARs refer to these as the 'characteristics' but in a listing they are traditionally referred to as attributes. Alterations to attributes arising from a project are defined as an impact.

Listings under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) commonly have identified attributes. Although this is not the case for the GBMWHA, several World Heritage and EPBC Act criteria are relevant as outlined in Table 10-23 and Table 10-24. In addition, since its original listing, further values have been identified for the GBMWHA in:

- Blue Mountains National Park Plan of Management (NSW Parks and Wildlife Service 2001)
- Values for a new generation: Greater Blue Mountains World Heritage Area (Benson (ed.), 2015)
- The Greater Blue Mountains Area – Additional Values, nomination held in the Australian Heritage Database (Nominators, no date).

The assessment reviewed the values in each of these three documents to identify the attributes of the GBMWHA against which project impacts were assessed. These are outlined further in Table 10-23 and Table 10-24. The values identified for the World and National heritage listing are the same.

Desktop studies

Several EIS studies provided information to support assessment of the project against the identified attributes. These studies were:

- Ecohydrology and Geomorphology Impact Assessment (Streamology, 2021)
- Hydrodynamic and Water Quality Impact Assessment (Aurecon Arup, 2021)

- Aquatic Ecology Impact Assessment (CT Environmental, 2021)
- Biodiversity Development Assessment Report (Biosis, 2021)
- Aboriginal Cultural Heritage Assessment Report (Kelleher Nightingale Consulting, 2021)
- Statement of Heritage Impact (Extent, 2021).

Additional desktop information was reviewed including heritage registers for heritage listings in the study area and research information on animal species including the Platypus and Echidna.

Study area

The assessment has considered a study area of about 13 km along Nepean River, where it passes through the GBMWHA, and using a 300 m buffer from the central line of Nepean River. This takes a conservative approach to where potential impacts can occur.

Impact assessment

The impacts of the project on the GBMWHA were assessed in accordance with the following guidelines:

- Department of the Environment Matters of National Environmental Significance: Significant Impact Guidelines 1.1 (DoE, 2013).
- International Council on Monuments and Sites (ICOMOS) Guidance on Heritage Impact Assessment for Cultural World Heritage Places (ICOMOS, 2001).

DoE (2011) sets out criteria to determine whether there is a real chance or possibility that an activity will have a significant impact on a Matter of National Environmental Significance (MNES). The assessment criteria include:

- values associated with geology or landscape
- biological and ecological values
- wilderness, natural beauty or rare or unique environment values
- non-Aboriginal heritage values
- other cultural heritage values including Indigenous heritage values.

Significant impact may occur where an action will damage, modify, alter, obscure, inhibit landscape processes or otherwise negatively impact on a geological formation, landscape, ecological community, aesthetic values, Indigenous or historical sites.

The following categories were used to determine the significance of the effect of the change:

- major beneficial
- moderate beneficial
- minor beneficial
- negligible beneficial
- neutral (no change)

- negligible adverse
- minor adverse
- moderate adverse
- major adverse.

This scale recognises that a project may benefit the heritage values of a site, and not necessarily have a negative impact.

ICOMOS (2001) was used to assess the value or contribution of the identified attributes to the outstanding universal values (OUV). This used a grading scale of:

- very high
- high
- medium
- low
- negligible
- unknown.

Table 10-21 shows how these have been combined to assess the scale and severity of impact. Impacts can be either adverse or beneficial.

Table 10-21 Scale and severity of potential impacts

Value of heritage asset	No change	Negligible change	Minor change	Moderate change	Major change
Very High	Neutral	Slight	Moderate/ Large	Large/ Very Large	Very Large
High	Neutral	Slight	Moderate/ Slight	Moderate/ Large	Large/ Very Large
Medium	Neutral	Neutral/ Slight	Slight	Moderate	Moderate/ Large
Low	Neutral	Neutral/ Slight	Neutral/ Slight	Slight	Slight/ Moderate
Negligible	Neutral	Neutral	Neutral/ Slight	Neutral/ Slight	Slight

10.3.3 Existing environment

The following sections provide a summary of the existing environment in the study area. Appendix Q provides further detail, including the historical context and natural features of the wider GBMWHA.

World and National heritage listings

Table 10-22 outlines the closest World and National heritage-listed items to the project. The project does not have any infrastructure located within, or with direct impacts to, any World and National heritage-listed items.

Table 10-22 World and National Heritage items near the project

List	Item	Proximity to the project
World Heritage List National Heritage List	The Greater Blue Mountains Area	About 1.5 km downstream of the treated water release structure to Nepean River and about 3 km downstream of the environmental flows release structure to Warragamba River.
World Heritage List	Australian Convict Sites (Old North Road)	About 55 km downstream of the treated water release structure.
Commonwealth Heritage List	None	

Only the GBMWHA is considered further in this assessment. The curtilage of the World Heritage - listed portion of the Old North Road does not intersect with Nepean or Hawkesbury Rivers. The project will therefore have no direct or indirect impacts on the Old North Road.

Figure 10-6 shows the area of the GBMWHA in relation to the project. The GBMWHA comprises 10,000 square kilometres (km^2) of bushland, covering seven National Parks (Wollemi, Yengo, Gardens of Stone, Blue Mountains, Kanangra-Boyd, Nattai and Thirlmere Lakes) and the Jenolan Karst Conservation Reserve. The project's potential indirect impacts are limited to the Blue Mountains National Park.

Although the project has no direct impacts on GBMWHA, it is considered further in this assessment given the potential for indirect impacts from the release of treated water at Nepean River and Warragamba River. As shown in Figure 10-7, this is because the GBMWHA is located downstream of operational releases into Nepean River.

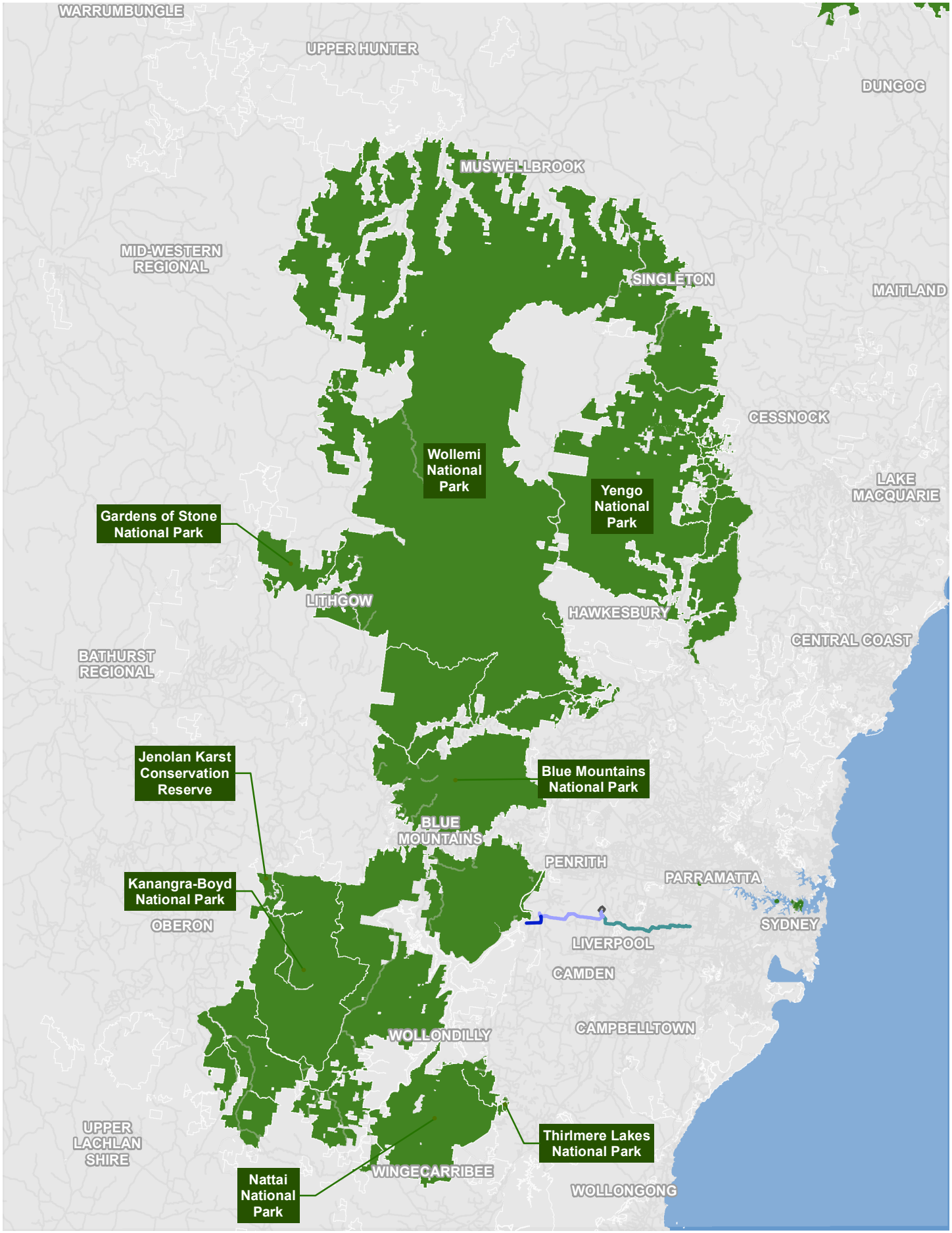
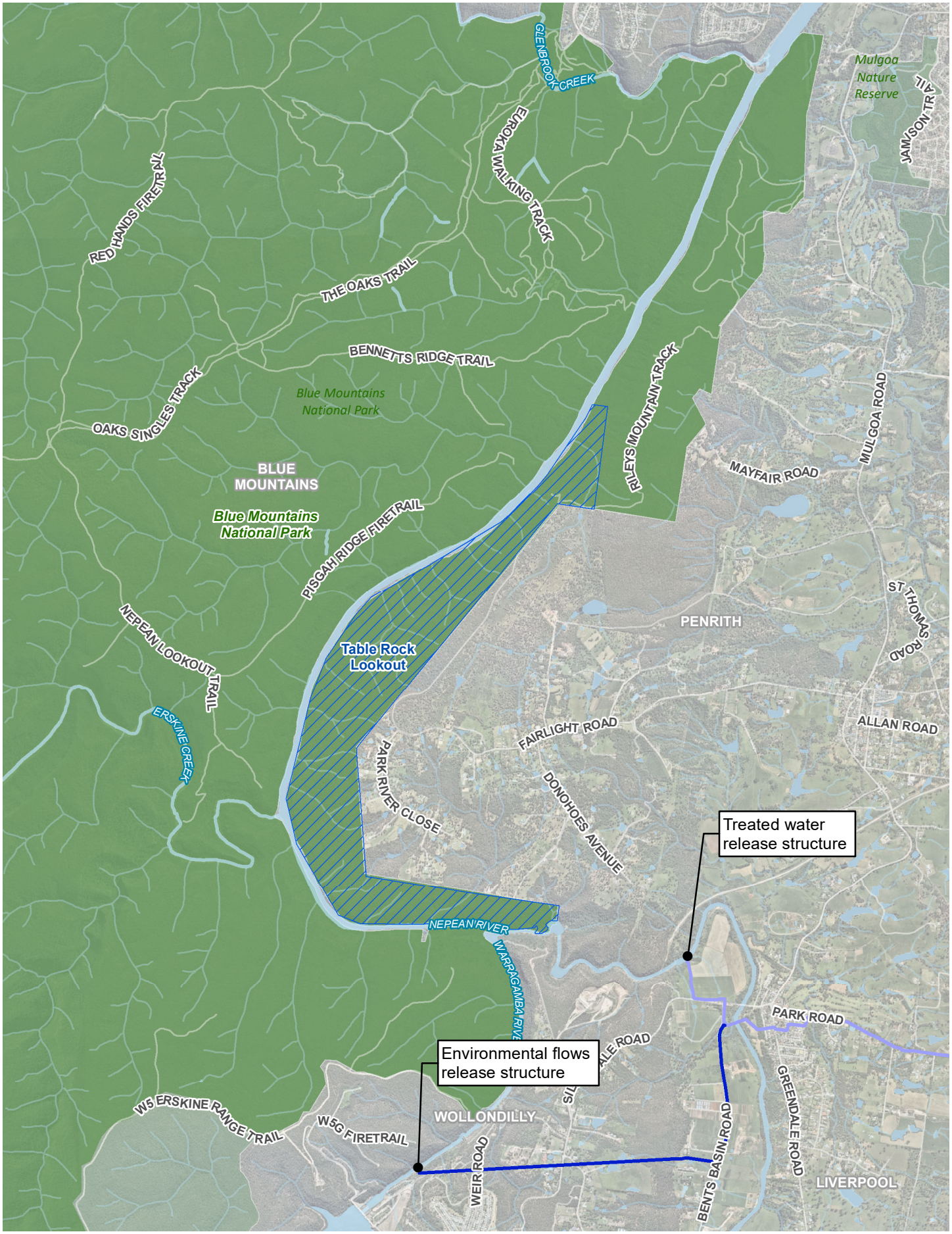


Figure 10-6 Greater Blue Mountains World Heritage Area curtilage

Source: Aurecon, Sydney Water, LPI, Nearmap, ESRI
Projection: GDA2020 MGA Zone 56



Advanced Water Recycling Centre

Advanced Water Recycling Centre

Treated water pipeline

Brine pipeline

Environmental flows pipeline

Local Heritage Item

Greater Blue Mountains World and National Heritage Area

1:50,000
0 250 500m

Figure 10-77 Project interaction with the Greater Blue Mountains World Heritage Area

Source: Aurecon, Sydney Water, LPI, Nearmap, ESRI
Projection: GDA2020 MGA Zone 56

Heritage values and attributes

Table 10-23 and Table 10-24 summarise the potential interactions between the World and National heritage value criteria, attributes and the project. These interactions are the basis of the impact assessment in section 10.3.5.

Table 10-23 Potential interactions between the project and the World Heritage value criteria of the GBMWHA

Value criteria	Attribute	Potential interaction with project (Yes/ No)
(xi) to be outstanding examples representing significant on-going ecological and biological processes in the evolution and development of terrestrial, fresh water, coastal and marine ecosystems and communities of plants and animals	Eucalyptus and eucalypt-dominant vegetation, including diverse range of species.	Yes
	Wet and dry sclerophyll forest, mallee heathlands.	Yes
	Localised swamp, wetland and grassland.	No
	Primitive relictual species: Wollemi pine (*Wollemia nobilis*) and Blue Mountains pine (*Pherosphaera fitzgeraldii*).	No
(xii) to contain the most important and significant natural habitats for in-situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation	Diversity: Myrtaceae (150 species), Fabaceae (149 species), and Proteaeceae (77 species).	Yes
	Diversity: vertebrate taxa, including platypus and echidna; butterfly and moth species; cave invertebrates.	Yes

Table 10-24 Potential interactions between the project and the National Heritage value criteria of the GBMWHA

Value criteria	Attribute	Potential interaction with project?
Criterion A – Historical Process: the place has significant heritage value because of the place's importance in the course, or pattern, of Australia's natural or cultural history	Eucalyptus species	Yes
	Evidence of post-1788 human uses	Yes
	Dissecting rivers as sculpting forces	Yes
	Geological features that demonstrate long/complex geological history	Yes
	Erosional landforms	Yes
	Indigenous sites that demonstrate an ancient and continuing connection	Yes
	Conservation movement and appreciation of the GBMWHA through bushwalking, tourism etc	Yes
Criterion B -the place has significant heritage value because of the place's possession of uncommon, rare or endangered aspects of Australia's natural or cultural history	Primitive species: Wollemi pine (*Wollemia nobilis*) and Blue Mountains pine (*Pherosphaera fitzgeraldii*).	No
	Water quality and flow regimes, as they relate to the Hawkesbury-Nepean and Goulburn-Hunter Rivers particularly.	Yes
	Painted and engraved Indigenous rock art.	Yes
Criterion C - the place has significant heritage value because of the place's potential to yield information that will contribute to an understanding of Australia's natural or cultural history	Indigenous archaeological sites.	Yes
	Research into biodiversity or geodiversity.	Yes
	Indigenous connections to land.	Yes
Criterion D - the place has significant heritage value because of the place's importance in demonstrating the principal characteristics of:	Eucalyptus and eucalypt-dominant vegetation, including diverse range of species.	Yes
	Wet and dry sclerophyll forest, mallee heathlands.	Yes

Value criteria	Attribute	Potential interaction with project?
(i) a class of Australia's natural or cultural places; or (ii) a class of Australia's natural or cultural environments.	Localised swamp, wetland and grassland.	No
	Diversity: Myrtaceae (150 species), Fabaceae (149 species), and Proteaeceae (77 species).	Yes
	Diversity: vertebrae taxa, including platypus and echidna; butterfly and moth species; cave invertebrates.	Yes
	Jenolan and Wombeyan Caves.	No
	Newnes Plateau	No
	Smooth pagodas	No
	Geological features that demonstrate long/complex geological history.	Yes
	Erosional landforms (smooth pagodas, Three Sisters and similar formations)	No
Criterion E - the place has significant heritage value because of the place's importance in exhibiting particular aesthetic characteristics valued by a community or cultural group.	Views and vistas, particularly uninterrupted views	Yes
	Jenolan Caves	No
	Rock formations, particularly in Wollemi and Garden of Stone National Parks.	No
Criterion F - the place has significant heritage value because of the place's importance in demonstrating a high degree of creative or technical achievement at a particular period	Indigenous rock art.	Yes
Criterion G - the place has significant heritage value because of the place's strong or special association with a particular	Connections for Indigenous peoples, as demonstrated through: • Indigenous archaeological sites • Indigenous rock art sites • Indigenous sacred sites.	Yes

Value criteria	Attribute	Potential interaction with project?
community or cultural group for social, cultural or spiritual reasons	Connections for bushwalkers, conservationists. Connections for bushwalkers and conservationists are intangible, but would be impacted by changes to significant elements of the GBMWHA.	Yes
Criterion H - the place has significant heritage value because of the place's special association with the life or works of a person, or group of persons, of importance in Australia's natural or cultural history	None identified – this would be an intangible value	No
Criterion I - the place has significant heritage value because of the place's importance as part of Indigenous tradition	Significant elements of indigenous tradition, including: • Indigenous archaeological sites. • Indigenous rock art sites. • Indigenous sacred sites.	Yes

Landscape setting

The study area consists of a steep gorge with dense native vegetation covering both sides of Nepean River. The eastern bank includes the local heritage-listed Table Rock Lookout, with views along Nepean River and west into the GBMWHA. The western bank includes the GBMWHA with steep rocky formations. The GBMWHA possesses scenic, aesthetic and geological significance. As outlined in the Blue Mountains National Park Plan of Management (DPIE, 2001) important scenic features and significant geological, geomorphic and/or pedological features identified within the Blue Mountains National Park include:

- the Jamison Valley cliffs, including the Three Sisters
- Grose Valley cliffs, particularly Mount Banks
- Canyons and pagodas of the Grose, Wollangambe and Bungleboori catchments
- igneous features of the Yerranderie area
- colluvial deposits associated with the Kurrajong fault including Portal Waterhole, Blue Gum Swamp and Burralow Creek
- karst areas, diatremes and basalt caps

- Wianamatta Shale areas
- hanging swamps and valley swamps
- talus lakes of the Grose Valley and elsewhere
- palaeontological sites, including at Mount Hay, Narrow Neck and Broken Rock Range.

Water quality and hydrology

The study area is situated within the Lower Nepean River Management Zone of the Hawkesbury-Nepean Catchment. Nepean River has been assigned a Strahler stream order of 9 and is not a Wild River under the *National Parks and Wildlife Act 1974*. The depth of Nepean River varies between 2 m and 11 m within the study area. Flows are controlled by Warragamba Dam and a series of weirs including Wallacia Weir, Warragamba Weir and Penrith Weir. This control results in in the river being slow flowing with low velocities through most of the study area. The river base is bedrock, with some coarse-grained sediment (Streamology, 2021). Slightly higher velocities are noted immediately downstream of Warragamba River confluence. This area has been historically modified by sand mining, which has altered the morphology and sediment loads in this area (Streamology, 2021).

Baseline water flow monitoring has been collected at Warragamba Weir, Warragamba Dam and Wallacia Weir. No flow data was collected from within the GBMWHA. Data collected from these points indicates that median flow within Nepean River in the study area is 229 ML/day, with low flows during summer and higher flows during autumn and winter. WaterNSW releases flows from Warragamba Dam via the water supply pipe at Megarritys Creek.

Baseline water quality assessments undertaken in the Hydrodynamic and Water Quality Impact Assessment (Aurecon Arup, 2021) indicate the following existing conditions in relation to the Australian and New Zealand Guidelines (ANZG) for Fresh and Marine Water Quality (2018):

- Nitrogen levels in the river between Penrith Weir and Bents Basin are generally elevated and above waterway objective of 0.35 mg/L for both the wet and dry years.
- Total phosphorus concentrations appear consistently below the objective of 0.025 mg/L.
- Ammonia concentrations are generally shown to be compliant.
- Nitrate levels are generally recorded above the waterway objective.
- Phosphate levels are compliant with the waterway objective.
- Between Penrith Weir and Bents Basin (which includes the study area), chlorophyll a concentrations are relatively low but still generally above the waterway objective.
- Salinity levels are compliant with the waterway ANZG objective.
- Within the limited data available, suspended sediment levels are compliant with waterway objectives and within the study area they are relatively low with maximum concentrations recorded up to ~20 mg/L.

Geomorphology

The landscape of the study area consists of rugged rolling to very steep hills of Hawkesbury Sandstone. The sandstone is overlayed with shallow lithosols/siliceous sands, earthy sands and yellow earths. Localised areas of deeper sand can be found associated with benches, joints and fractures. Nepean River sits within a confined gorge, which has been assessed as being in good geomorphic condition. Significant outcrops of bedrock and riparian vegetation contribute to a stable channel.

Biodiversity

The terrestrial biodiversity impact assessment for the project has identified the following vegetation communities within the impact area in the GBMWHA:

- PCT (Plant Community Type) 835 Forest Red Gum – Rough-based Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion. This PCT meets the key diagnostic criteria for the listing of River-flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (Critically Endangered, EPBC Act, Endangered, NSW Biodiversity Conservation Act 2016).
- PCT 1078 Prickly Tea-tree - sedge wet heath on sandstone plateaux, central and southern Sydney Basin Bioregion (Tree-tree - sedge wet heath) (comprising Coastal Upland Swamp EEC).
- PCT 1181 Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion.
- PCT 1284 Turpentine - Smooth-barked Apple moist shrubby forest of the lower Blue Mountains, Sydney Basin Bioregion (comprising Sydney Turpentine-Ironbark Forest CEEC).
- PCT 1292 Water Gum - Coachwood riparian scrub along sandstone streams, Sydney Basin Bioregion.

The area does not have habitat suitable for Wollemi Pine (*Wollemia nobilis*) or the Blue Mountains Pine (*Pherosphaera fitzgeraldii*) and there are no recorded individuals in the study area.

P & J Ecological Consultants (2017a, 2017b, 2017c and 2017d) contains tables identifying the fauna sighted within the Blue Mountains National Park. Of note amongst the identified fauna are the Blue Mountains Water Skink (*Eulamprus leuraensis*), the Platypus (*Ornithorhynchus anatinus*) and the Echidna (*Tachyglossus aculeatus*): the first as a species known only within a restricted habitat within the Blue Mountains National Park and the second and third as species specifically identified within the heritage listings.

Background research returned no previous records for the Blue Mountains Water Skink within 10 km of the impact assessment area. The Blue Mountains Water Skink is restricted to swamp and sedge habitats in the middle and upper Blue Mountains between the Newnes Plateau and Hazelbrook (NSW National Parks and Wildlife Service, 2001). The study area is therefore outside its known range.

Platypus prefer shallow rivers and streams with steep banks into which they can dig their burrows. Burrows are usually located 0.5 m above the water level. Their home ranges can vary between 2.9 and 7 km for males and 1.5 km for females. Platypus feed on benthic aquatic macro-invertebrates, including species from the Trichoptera (caddisfly), Diptera (fly), Coleoptera (beetle), Ephemeroptera (mayfly), and Odonata (dragonfly and damselfly) orders. Platypus generally feed within the top two metres of the water column, focusing on the stream margins. Biosis undertook a search of Bionet records for Platypus within the study area, incorporating a four kilometre buffer, being the average home range. No sightings have been recorded within the study area, although 13 have been reported within the buffer including:

- two records within the GBMWHA with:
  - one on Erskine Creek, about 2.5 km upstream from Nepean River
  - one at Duck Hole, on Glenbrook Creek, about 6 km upstream from Nepean River
- eleven records downstream of the GBMWHA with:
  - two records associated with tributaries of Nepean River (Mulgoa Creek and School House Creek)
  - six records of individuals foraging within Nepean River near the Western Motorway overpass
  - two deceased or injured individuals
  - one record 720 m upstream of Wallacia Weir.

The number of records associated with the Western Motorway is likely to be a factor of ease of public access via Tench Reserve.

Given the spread of the recorded sightings, it is considered likely that Platypus exist within the study area, particularly as Nepean River through this stretch is likely to contain their primary food source of benthic invertebrates.

Similarly, BioNet records sightings of Echidnas in the areas surrounding the study area, with only one sighting within the study area, near the Table Rock Lookout. As primarily land-based animals, that consume ants and termites, echidnas use water for hydration and they are also known to bath and swim. As such they and their food sources are not affected by minor changes in nearby water bodies.

Aquatic ecology

Nepean River is identified habitat for the Macquarie Perch (*Macquaria australasica*), which is listed as Endangered under the EPBC Act. The Aquatic Ecology Assessment (CT Environmental, 2021) of the macroinvertebrate community structure indicates the presence of species that range from pollution tolerant to pollutant sensitive, with overall family richness being low. Both aquatic and terrestrial Groundwater Dependent Ecosystems (GDEs) are considered to exist along the banks of Nepean River. Nine species of macrophyte (aquatic plants) have been recorded within Nepean River, consisting of six native and three exotic species.

Aboriginal cultural values

Sydney Water has consulted with Registered Aboriginal Parties (RAPs) as part of the project's Aboriginal Cultural Heritage Assessment. Responses regarding Nepean River identified it as the life blood of the people, especially the Darug nation. Nepean River provided food and water, a place to grind axes, but also identity. It also formed a trading route, song line and the associated landforms are used as clan boundary markers.

Nepean River is located next to the Indigenous Land Use Agreement (ILUA) between the Gundungurra People and the NSW Government. The ILUA specifies that the Gundungurra be afforded the opportunity to be consulted with respect to the management of land and waterways within National Park Lands, WaterNSW land, Forestry Corporation of NSW lands and Blue Mountains City Council Lands. Nepean River falls outside of the ILUA and is therefore not strictly relevant to the project.

Sydney Water is undertaking an Aboriginal Cultural Values Study with the local Aboriginal communities to increase insight into the intangible cultural heritage values of the western Sydney area. The study is focused on South Creek and Nepean River.

Aboriginal heritage

The study area sits at the intersection of two major environmental areas, including the rugged upland Hawkesbury sandstone environment of the Greater Blue Mountains area to the west, and to the east the undulating crest and valley landform that is typical of the Cumberland Plain. The unique topography, geology and landform characteristics influences the types of Aboriginal sites that may be preserved within the study area.

The archaeological resources likely to be encountered in the study area are sandstone overhangs that retain evidence of Aboriginal pigmented art on walls, as well as overhangs with occupation deposits containing stone, shell, bone or charcoal. Grinding grooves may also be present in areas of relatively flat outcropping sandstone adjacent to (or within the path of) running or pooled water, including areas where water runoff from wet weather occurs. Several short perpendicular drainage lines enable water runoff to drain into Nepean River. These locations are where access down to the water may have been possible for past Aboriginal populations, and therefore evidence of occupation in the form of artefact sites may be preserved – provided that such sites have not been subjected to past flooding and scouring of deposits. Otherwise, it will have been difficult to access Nepean River and its resources, and there may have been a greater preference for using the resources of the surrounding creeklines and waterways instead. Over time, the effect of frequent flooding along Nepean River has resulted in the weathering of the bedrock to form steep gorges, with very little deposition of artefact containing material evident in the study area.

A search of the AHIMS database was completed that covered an area of about 108 km^2, about 9 km by 12 km between Glenbrook and Wallacia, and also extended beyond the study area into the GBMWHA and as far east as Mulgoa Creek.

The AHIMS search identified 118 registered Aboriginal sites in the search area. Five of these sites are mapped within the study area. Most of the 118 sites are open artefact sites located in relatively open country to the east of Nepean River. Closed rock shelter sites with art and occupation deposit, and grinding grooves predominate in the densely vegetated and steeply sloping areas to the west of Nepean River. The open artefact sites are typically within 500 m of creeklines where limited development has occurred, especially along Littlefields Creek, Mulgoa Creek, Jerry's Creek and their associated tributaries. Table 10-25 outlines the variation in the type of Aboriginal heritage sites identified in the AHIMS search.

Table 10-25 Aboriginal sites registered on the AHIMS database within the 108 km^2 search area.

Site feature	Number	Percentage
Artefact sites	85	72.03
Open camp site	64	54.23
Isolated find	18	15.25
Potential Archaeological Deposit (PAD)	3	2.54
Shelters	18	15.25
Shelter with art	8	6.78
Shelter with deposit	6	5.08
Shelter with art and deposit	1	0.85
Shelter with art and stone arrangement	1	0.85
Shelter with art and deposit and grinding groove	2	1.69
Culturally modified trees	6	5.08

Site feature	Number	Percentage
Axe grinding grooves	4	3.39
Stone arrangements	3	2.54
Art sites (Pigmented or engraved)	2	1.69
TOTAL	**118**	**100**

Non-aboriginal heritage

The GBMWHA consists of a range of themes and sites that contribute to its overall historic heritage significance. However, none of the identified sites within the GBMWHA are located within the study area that can potentially be impacted by the project. Most of the study area is inaccessible to the public due to the topography, which limits activities such as bush walking.

The Table Rock Lookout (I141) heritage item is locally listed on the Penrith Local Environment Plan. It is located downstream of the release locations at Nepean River and Warragamba River, on the eastern side of Nepean River. The Table Rock Lookout site consists of dense eucalypt forests, with formal walking trails, car parks and other small-scale infrastructure supporting nature-based activities. The primary walking trail leads to Table Rock Lookout, a large flat rock that provides views in both directions along Nepean River and west into the GBMWHA. No access to the riverbank is available from the Lookout. The item has been associated with bushwalking and local tourism since the early 1900s. Evidence of the former flying fox across Nepean may be seen through holes or bolts within the rocks at the departure and landing points. Figure 10-7 shows the location of this item in relation to the project.

Value of heritage assets

Table 10-26 outlines the nature of each heritage value of the GBMWHA within the study area. These have been derived from ICOMOS Guidance on Heritage Impact Assessment for Cultural World Heritage Places (ICOMOS, 2001).

Table 10-26 Heritage values of the GBMWHA within assessment area

Heritage value	Integrity and authenticity	Value	Justification
Geodiversity and Geomorphology	High	Low	The study area does not contain the features identified as being of World or National Heritage value.
Water - flows	Low	Low	Warragamba River and Nepean River are controlled waterways with weirs. They do not operate as natural rivers and therefore have low integrity and authenticity and make a low contribution to the GBMWHA.

Heritage value	Integrity and authenticity	Value	Justification
Biodiversity	High	High	The vegetation communities within the study area display a high degree of authenticity and integrity.
Aquatic ecology	Low	Low	Water quality has affected the family richness and the introduction of exotic species impacts the integrity and authenticity.
Aboriginal heritage connections	High	High	Connections are likely to be highly valued by the Aboriginal community.
Aboriginal heritage sites	Unknown	Low	The study area does not contain any known art or other Aboriginal heritage sites,
Aesthetics (visual)	High	Low	While containing views of the GBMWHA, the area is not identified as one of the key lookouts in the Blue Mountains.
Non-Aboriginal heritage sites	Low/Moderate	Low	Although associated with tourism in the Blue Mountains, the Table Rock Lookout (I141) heritage item it is not a key site.

10.3.4 Legislation, policy and guidelines

Table 10-27 outlines the legislation, policies and guidelines that relate to the World and National Heritage impact assessment.

Table 10-27 World and National heritage legislation and policies

Legislation/ policy	Purpose	Application to the project
Environment Protection and Biodiversity Conservation Act (EPBC Act), 1999	The EPBC Act provides a legal framework to protect and manage nationally and internationally important heritage places, as well as flora, fauna, ecological communities and water resources. The EPBC Act establishes the National Heritage List (NHL), Commonwealth Heritage List (CHL) and the non-statutory Register of the National Estate (RNE).	The project requires approval under the EPBC Act. The project may have indirect impacts on the World Heritage and Nationally Listed GBMWHA and has been referred and been deemed a controlled action (EPBC 2020/8816). The project is being assessed under the Commonwealth Government's bilateral agreement with the NSW Government. By complying and addressing the EPBC Act, the project will also meet the requirements of the World Heritage Convention to which Australia is a signatory.
Greater Blue Mountains World Heritage Area Strategic Plan and Addendum (DPIE, 2009)	The Greater Blue Mountains World Heritage Area (GBMWHA) Strategic Plan provides an overarching framework in which the individual national parks that comprise the area can be managed. The Strategic Plan lays out the strategic objects of the plan as being: • identify, protect, conserve, present, transmit to future generations and, where necessary, rehabilitate the World Heritage values of the GBMWHA • integrate the protection of the GBMWHA into a comprehensive planning program	The impact assessment demonstrates how the project aligns with or impacts on the ten management issues identified in the Strategic Plan. This primarily includes integrity, major impacts, biodiversity, water catchment protection, cultural heritage, landscape, natural beauty and aesthetic values. The objectives, and management responses for each of the identified issues are provided Appendix Q.

Legislation/ policy	Purpose	Application to the project
	• give the GBMWHA a function in the life of the Australian community • strengthen appreciation and respect for the GBMWHA's World Heritage values, particularly through educational and information programs, and keeping the community broadly informed about the condition of the World Heritage values of the GBMWHA • take the appropriate scientific, technical, legal, administrative and financial measures necessary for implementing these principles • provide for continuing community and technical input in managing the GBMWHA • manage the broad range of values, both World Heritage and non-World Heritage, ensuring that achieving the long-term conservation of the reserves' World Heritage values is the over-riding principle The Strategic Plan recognises ten management issues including: • integrity • major impacts • biodiversity • geodiversity • water catchment protection • cultural heritage (i.e. historic and indigenous) • landscape, natural beauty and aesthetic values • recreation and visitor use	

Legislation/ policy	Purpose	Application to the project
	• social and economic issues related to commercial tourism • education, community participation and consultation.	
Blue Mountains National Park Plan of Management (DPIE, 2001)	The Plan of Management outlines the significance of the Blue Mountains National Park, key risks and policies and actions to protect the values. The Plan of Management identifies that the Blue Mountain National Park holds natural, Aboriginal and historic heritage values.	The impact assessment addresses how the project aligns with relevant policies in the Plan of Management.
Department of the Environment (DoE) Matters of National Environmental Significance: Significant Impact Guidelines 1.1 (DoE, 2013)	This guideline provides guidance around the assessment of impact severity for Matters of National Environmental Significance (MNES). The guideline sets out criteria to determine whether there is a real chance or possibility that an action will have a significant impact.	This guideline has informed the impact assessment on the aspects to be considered regarding how the project will affect the GBMWHA.
International Council on Monuments and Sites (ICOMOS) Guidance on Heritage Impact Assessment for Cultural World Heritage Places (ICOMOS, 2001)	This guideline provides a nine-point scale to determine the significance of the effect of change. These are: • major beneficial • moderate beneficial • minor beneficial • negligible beneficial • neutral • negligible adverse • minor adverse • moderate adverse • major adverse.	The impact assessment has used this guideline as a basis to determine the affect the project will have on the values of the GBMWHA.

10.3.5 Impact assessment

The interaction between the project and the GBMWHA is limited to indirect impacts associated with the operational release of treated water to Warragamba River and Nepean River. No impacts during construction are expected, and no further assessment to construction activities are considered in this section.

Operational releases of treated water will pass through a small section of the GBMWHA where it borders Nepean River. The environmental flows release structure is located outside of the GBMWHA, downstream (north-east) of the Warragamba Dam wall, and upstream of Warragamba Weir. Warragamba River stretches about 3 km before reaching the boundary of the GBMWHA at the confluence of Warragamba River and Nepean River. The treated water release structure is outside of the GBMWHA boundary and on Nepean River, upstream of the Wallacia Weir.

Treated water released from the two release structures will flow along Nepean River which is bordered by the GBMWHA for about 13 km. As outlined in section 10.3.2, the study area is conservative with project impacts unlikely to be across this whole area. Impacts are likely to be limited to the area of inundation as a result of the estimated 5 cm to <10 cm increase in water level. Due to the minimal increase in water level of Nepean River, impacts are limited to indirect impacts, with no impacts to amenities, users or navigation within the GBMWHA expected.

As the World and National values for the GBMWHA are the same, one assessment of impacts to heritage values has been completed in accordance with the MNES guidelines. This section provides a summary of impacts. Appendix Q includes more detailed consideration of impacts and alignment with the key documents and detailed attributes.

Water quality and hydrology

The Hydrodynamic and Water Quality Impact Assessment (Aurecon Arup, 2021) modelled the effect of 50 ML/day and 100 ML/day treated water releases under a number of environmental conditions. These flows represent the Stage 1 and ultimate capacity flows of the project respectively.

The project has the potential to have positive and neutral water quality changes downstream of the release locations at Nepean River and Warragamba River, including:

- lower nutrient concentrations within 20 km of the release locations, which will include a portion of the study area
- reduction in oxygen sag, meaning the oxygen level in the water is closer to saturation
- no material changes in algal bloom peaks
- improved turbidity
- no changes in E.coli and enterococci loads.

Modelling indicated that the variations between 50 ML/day and 100 ML/day are minimal, and that increased water releases will have a diluting effect on nutrient levels, but will not off-set the spikes related to wet weather run-off.

Impacts to water quality are rated as a negligible change resulting in a negligible impact for an overall impact of negligible beneficial.

Geomorphology

Low flow conditions upstream of the release location are controlled by Wallacia Weir, which minimises the impact on flow velocities and depths within the study area. Nepean River, within the GBMWHA stretch, is confined with bedrock substrate.

Water velocity and shear stress, being the point at which sediment is mobilised, will see a negligible change of <0.01 m/s from the project (Streamology, 2021). Even in conjunction with a rise in water level of about 5 cm, the modelling indicates that there is no increase in flows above bed mobilisation thresholds, meaning no additional erosion is anticipated. As the river will remain within the stable channel and the change in velocity is negligible, no additional erosional effects are anticipated and therefore no alterations to the geodiversity or geomorphology of the study area are anticipated.

Using the flow data collected from gauge 212202 at Wallacia Weir between 2010 and 2018, 'baseline' median flow has been identified at 229 ML/day in Nepean River. With the addition of 50 ML/day, the future mean flow is anticipated to be 279 ML/day at Stage 1 capacity and 329 ML/day at the ultimate capacity of the AWRC of 100 ML/day. The modelling results shown in Table 10-28 indicate that the up to 5 cm increase in river level at 50 ML/day could be anticipated within Nepean River where it passes through GBMWHA, and a <10 cm increase at 100 ML/day.

Table 10-28 Modelled changes in Nepean River

Metric	Current	50 ML/day	100 ML/day
Median water flow	229 ML/day	279 ML/day	329 ML/day
Water level	Baseline	Up to 5 cm	<10 cm
Wetted perimeter	Baseline	<2 m	<2 m

Impacts to geomorphology are rated as a negligible change resulting in a negligible impact for an overall impact of neutral.

Biodiversity

Biodiversity impacts are limited to the areas that will be inundated as result of water level rise from operational releases of treated water. This includes inundation of biodiversity values within the additional wetted area on the lower riverbanks and increased saturation frequencies during flood events higher up the river banks.

Impacts to terrestrial fauna from the project relate to the loss of habitat equal to the increase in the wetted perimeter. Table 10-29 outlines the extent of impact from inundation under different flow scenarios. There is 0.62 ha of vegetation within the 229 ML/day (the median flow rate) inundation extent. At 50 ML day, 0.74 ha will fall into this range, an increase of 0.12 ha. At 100 ML/day, 0.81 ha will fall into this range, an increase of 0.19 ha above the current situation. Expected changes to biodiversity values as a result of inundation frequency include:

- Biodiversity values located between the existing low flow extent (25 ML/day) and median flow extent (229 ML/day), are currently subject to inundation >50% of the time.
  - With an increase of 50 ML/day the frequency with which these biodiversity values will be inundated will increase from >50% of the time to >63% of the time.
  - With an increase of 100 ML/day the frequency with which these biodiversity values will be inundated will increase from >50% of the time to >74% of the time.
- Biodiversity values located between the existing median flow extent (229 ML/day) and the potential future median flow extent for 50 ML/day releases (279 ML/day), are currently subject to inundation between 40 and 50% of the time, which will increase to >50 % of the time.
- Biodiversity values located between the existing median flow extent (229 ML/day) and the future median flow extent for 100 ML/day releases (329 ML/day), are currently subject to inundation between 27-50% of the time, which will increase to >50% of the time.

It is not anticipated this will result in a loss of food sources, burrows, hollows or habitat fragmentation. It is not anticipated that the indirect impacts associated with the project will lead to the death of individuals in the short or long term. The forecast increases in water quality may be beneficial to the health of animals who access Nepean River as a source of water. Appendix J provides a full description of each Plant Communtiy Types (PCT) and the locations in which they have been mapped.

The project will not result in modification, destruction, fragmentation, isolation, disturbance of an important area or substantial area of habitat within the GBMWHA. Impacts to biodiversity are rated as a negligible change resulting in a slight impact for an overall impact of slight.

Table 10-29 Biodiversity impacts from inundation

Flow scenario	PCT 835	PCT 1078	PCT 1181	PCT 1284	PCT 1292	Total
Existing conditions						
Biodiversity values within 229 ML/day inundation extant (ha)	0.46	0.04	0.06	0.03	0.03	0.62
50 ML/day release scenario						
+50 ML/day releases: 279 ML/day (ha)	0.55	0.06	0.07	0.03	0.03	0.74

Flow scenario	PCT 835	PCT 1078	PCT 1181	PCT 1284	PCT 1292	Total
% change in inundation	20	50	17	0	0	
Hectares change (ha)	0.09	0.02	0.01	0.00	0.00	0.12
100 ML/day release scenario						
+100 ML/day releases: 329 ML/day (ha)	0.59	0.07	0.07	0.04	0.04	0.81
% change in inundation	28	75	17	33	33	
Hectares change (ha)	0.13	0.03	0.01	0.01	0.01	0.19

The project is not expected to have a direct or indirect impact on the Platypus (*Ornithorhynchus anatinus*). Changes to the water quality and flow regimes of Nepean River from the project will be negligible and are unlikely to cause stress to individuals living in or passing through Nepean River within the GBMWHA. Increases in water quality may result in improved benthic aquatic macro-invertebrate communities, increasing the available food resources.

Impacts to Platypus (*Ornithorhynchus anatinus*) are likely to be negligible as:

- burrows are typically situated at least 50 cm above the water level and a rise of 10 cm could be accommodated by individuals by restructuring the entrance of their burrow if required
- no alteration to home ranges will occur as a result of the project
- while the depth of the water will be subject to a minor increase, individuals will continue to be able to feed within the top two metres of the water column and along the river banks
- benthic aquatic macro-invertebrates will not be impacted by changes in water quality and flow regimes and will therefore remain available as a food source. It is possible that the increase in water quality will improve the benthic communities within the GBMWHA stretch of Nepean River, thereby increasing the available food sources.

No impacts to Echidnas (*Tachyglossus spp.*) have been identified as arising from the project.

Aquatic ecology

Operational releases of treated water will result in an increase to the water level and velocity of Nepean River. The increase in inundation of between 5 cm and <10 cm, which is <1 percent change in of the existing level, will have a negligible impact on riparian flora and macrophytes. It also has the potential to benefit aquatic fauna due to the small increase in aquatic habitat availability. This change is not deemed to have a significant impact on the outstanding values of the GBMWHA.

Alterations in modelled water velocity for the study area, as shown in Table 10-9, range between no change and 0.01 m/s. Flows at the confluence of Glenbrook Creek, which marks the boundary of the GBMWHA, and Nepean River indicate that flows may increase by up to >0.3 m/s. Impacts have the potential to alter macroinvertebrate community assemblages due to the range of flow changes being within the range considered to impact individual taxonomic groups. However, impacts to aquatic macroinvertebrates, macrophytes and aquatic fauna are considered to be negligible.

Negative impacts to the Macquarie Perch are not anticipated and minor positive increases in water quality may improve food sources and thereby population health. The project does not contravene the strategies contained within the National Recovery Plan and may contribute to the protection and restoration of Macquarie Perch habitat (Strategy 2) through the modelled minor improvements in water quality. Aquatic ecology impacts are rated as a negligible beneficial change resulting in a negligible beneficial impact for an overall impact of neutral.

Aboriginal cultural values

The project will not alter the ability of Aboriginal people to visit and connect to Nepean River within the study area. No significant impacts are identified to Aboriginal heritage sites or the environment more broadly and it is therefore considered that the project does not inhibit the ability of Aboriginal people to care for country. Impacts to Aboriginal cultural values are rated as a negligible change resulting in a negligible impact for an overall impact of neutral.

Aboriginal heritage

Of the five sites mapped within the study area, three were incorrectly mapped and are outside the study area. The two remaining sites are located beyond the existing and anticipated water levels: 'Euroka Clearing (Glenbrook)' (AHIMS ID #45-5-0116) which is 43 m Above Sea Level (ASL) and 'Euroka Clearing; Glenbrook; Nepean River;' (#45-5-0119) which is 13 m ASL.

No previously identified sites have been recorded within the estimated inundation area from the increase water level. The inaccessible nature of the banks of Nepean River, while not precluding the existence of sites, does make them unlikely, particularly within the predicted 10 cm in the water level. Predictive modelling indicates Indigenous people preferenced elevated areas away from inundation zones. Sites that will exist on the water's edge are grinding grooves that, if present, will not be impacted by the increase to the wetted perimeter

Impacts to Aboriginal heritage sites are rated as a negligible change resulting in a negligible impact for an overall impact of neutral.

Visual

The environmental flows release structure is partially located above ground and close to the GBMWHA. The release structure will be shielded by the surrounding topography and vegetation which will minimise its visual impact in the environment. Figure 10-7 shows the location of W5 Erskine Range Trail and W5G fire trail on the western side of Warragamba River within GBMWHA. These are not accessible to the public and offer no substantial viewpoints in which the

environmental flows release structure is visible. As such, the release structure is unlikely to be visible from the GBMWHA.

The increase water level of Nepean River as a result of operational releases of treated water is not expected to result in a visual impact to the GBMWHA. This is due to the estimated height increase of between 5 cm and <10 cm unlikely to be noticeable from any lookout locations along the 13 km stretch of Nepean River along the GBMWHA. The project will not impact on any users or amenities of the area. Visual impacts are rated as a negligible change resulting in a negligible impact for an overall impact of neutral.

Non-Aboriginal heritage

Table Rock Lookout is located at the top of the gorge on the eastern side of Nepean River as shown in Figure 10-7. It has local heritage significance. As the estimated increase in water level of Nepean River from the project is between 5 cm and <10 cm, it is unlikely the project will impact upon the heritage significance of the item. Impacts to historical heritage are rated as a negligible change resulting in a negligible impact for an overall impact of neutral.

Overall heritage impact statement

Table 10-30 summarises the potential impacts from the project on the different assessment criteria of the GBMWHA. These criteria are identified in *Matters of National Environmental Significance: Significant Impact Guidelines 1.1* (DoE, 2013). The project is unlikely to have a significant impact on the heritage values of the GBMWHA. None of the potential impacts are considered to be unknown, unpredictable or irreversible.

Table 10-30 Significant impact assessment criteria

Criterion	Significant impact (Yes/ No)
Geology or landscape values	
damage, modify, alter or obscure important geological formations in a World/National Heritage property;	No. Raising the water level of Nepean River between 5 cm and 10 cm will not damage, modify, alter or obscure important geological formations.
damage, modify, alter or obscure landforms or landscape features, for example, by excavation or infilling of the land surface in a World/National Heritage property;	No. The project will not damage, modify, alter or obscure landforms or landscape features. The project will not require any excavation or infill within the GBMWHA.
modify, alter or inhibit landscape processes, for example, by accelerating or increasing susceptibility to erosion, or stabilising mobile landforms, such as sand dunes, in a World/National Heritage property;	No. Due to the channelised nature of Nepean River, no acceleration or increased susceptibility to erosion is anticipated. The increased water flows will not modify, alter or inhibit landscape processes.

Criterion	Significant impact (Yes/ No)
divert, impound or channelise a river, wetland or other water body in a World/National Heritage property; and	No. The project will not divert, impound or channelise Nepean River or Warragamba River.
substantially increase concentrations of suspended sediment, nutrients, heavy metals, hydrocarbons, or other pollutants or substances in a river, wetland or water body in a World/National Heritage property.	No. The project will not substantially increase concentrations of suspended sediment, nutrients, heavy metals, hydrocarbons, or other pollutants or substances in Nepean River.
Biological and ecological values	
reduce the diversity or modify the composition of plant and animal species in all or part of a World/National Heritage property;	No. The project may result in the loss of individual trees due to increases in inundation periods over a very small area of increased inundation (0.19 ha). However, the overall diversity and composition will not be altered to any measurable extent. Negative impacts to aquatic ecology, including Macquarie Perch, are not anticipated.
fragment, isolate or substantially damage habitat important for the conservation of biological diversity in a World/National Heritage property;	No. While impacts have been identified, these will not fragment or isolate and are unlikely to result in substantial damage habitat important for conservation.
cause a long-term reduction in rare, endemic or unique plant or animal populations or species in a World/National Heritage property; and	No. The project will not result in a long-term reduction to rare, endemic or unique plant of animal populations or species. Reduction in the number of individual trees will be permanent, but is not considered a significant impact (Biosis, 2021).
fragment, isolate or substantially damage habitat for rare, endemic or unique animal populations or species in a World/National Heritage property.	No. While impacts have been identified, these will not fragment or isolate and are unlikely to result in substantial damage to habitat important for conservation.

Criterion	Significant impact (Yes/ No)
Wilderness, natural beauty or rare or unique environment values	
involve construction of buildings, roads, or other structures, vegetation clearance, or other actions with substantial, long-term or permanent impacts on relevant values	No. The project will not require any construction of buildings, roads, or other structures, vegetation clearance, or other actions with substantial, long-term or permanent impacts on relevant values of the GBMWHA.
introduce noise, odours, pollutants or other intrusive elements with substantial, long-term or permanent impacts on relevant values	No. Water quality modelling indicates a slight overall improvement in water quality. Modelling indicates the project will not result in the introduction of noise, odours, pollutants or other elements with impacts on the values.
Non-Aboriginal heritage values	
permanently remove, destroy, damage or substantially alter the fabric of a National Heritage place in a manner which is inconsistent with relevant values; extend, renovate, refurbish or substantially alter a National Heritage place in a manner which is inconsistent with relevant values;	No. The project will not permanently remove, destroy, damage, extend, renovate, refurbish or substantially alter the fabric of a National Heritage place.
permanently remove, destroy, damage or substantially disturb archaeological deposits or artefacts in a National Heritage place;	No archaeological deposits have been identified within the inundation area.
involve activities in a National Heritage place with substantial and/or long-term impacts on its values;	No. Impacts to the National historical heritage values from the project will be negligible.
involve the construction of buildings or other structures within, adjacent to, or within important sight lines of, a National Heritage place which are inconsistent with relevant values; and	No. The project does not include construction within the GBMWHA.

Criterion	Significant impact (Yes/ No)
make notable changes to the layout, spaces, form or species composition of a garden, landscape or setting of a National Heritage place in a manner which is inconsistent with relevant values.	No. The increase in water level of Nepean River by between 5 cm and <10 cm will not notably change the layout, spaces, form or species composition of a garden, landscape or setting of the GBMWHA.
Other cultural heritage values	
restrict or inhibit the continuing use of a National Heritage place as a cultural or ceremonial site causing its values to notably diminish over time;	No. The project will not restrict or inhibit the continuing use of the GBMWHA as a cultural or ceremonial site causing its values to notably diminish over time.
permanently diminish the cultural value of a National Heritage place for a community or group to which its National Heritage values relate;	No. The project will not result on impacts to archaeological or rock art sites or restrict access. The cultural value will not be diminished.
destroy or damage cultural or ceremonial, artefacts, features, or objects in a National Heritage place; and	No. The project will not result on impacts to archaeological or rock art sites as none have been identified within the inundation area.
notably diminish the value of a National Heritage place in demonstrating creative or technical achievement.	No. The project will not notably diminish the value of the GBMWHA in demonstrating creative or technical achievement.
Aboriginal heritage values	
restrict or inhibit the continuing use of a National Heritage place as a cultural or ceremonial site causing its values to notably diminish over time;	No. The project will not restrict or inhibit the continuing use of the GBMWHA as a cultural or ceremonial site causing its values to notably diminish over time. The area of inundation has not been identified as containing cultural or ceremonial sites.
permanently diminish the cultural value of a National Heritage place for an Indigenous group to which its National Heritage values relate;	No. The increase in water level of Nepean River by between 5 cm and 10 cm will not permanently diminish the cultural value as there will be no noticeable change to the landscape.

Criterion	Significant impact (Yes/ No)
alter the setting of a National Heritage place in a manner which is inconsistent with relevant values;	No. The increase in water level of Nepean River by between 5 cm and 10 cm will not notably change the setting.
remove, destroy, damage or substantially disturb archaeological deposits or cultural artefacts in a National Heritage place;	No. The project will not remove, destroy, damage or substantially disturb archaeological deposits or cultural artefacts. No archaeological deposits have been identified within the inundation area.
destroy, damage or permanently obscure rock art or other cultural or ceremonial, artefacts, features, or objects in a National Heritage place;	No. The project will not destroy, damage or permanently obscure rock art or other cultural or ceremonial, artefacts, features, or objects. No archaeological or rock art sites have been identified within the inundation area.
notably diminish the value of a National Heritage place in demonstrating creative or technical achievement;	No. The study area does not contain sites that demonstrate creative or technical achievement.
permanently remove, destroy, damage or substantially alter Indigenous built structures in a National Heritage place; and	No. The study area does not contain Indigenous built structures.
involve activities in a National Heritage place with substantial and/or long-term impacts on the values of the place.	No. The increase in water level of Nepean River by between 5 cm and 10 cm will not notably impact on the values.

10.3.6 Impacts of future stages

The assessment has considered the impact from both Stage 1 and the ultimate capacity of the project. The project will result in a water level increase in Nepean River of between 5 cm for Stage 1 (50 ML/day release), and 10 cm (100 ML/day ultimate capacity). Construction of future stages will be restricted to the Advanced Water Recycling Centre (AWRC) site at Kemps Creek which will not impact the GBMWHA. Project pipelines, including the release structures will be built to their ultimate capacity at Stage 1. No additional impacts to the GBMWHA are expected from future stages of the project that have not been already been considered in this assessment.

10.3.7 Cumulative impacts

Cumulative impacts on the GBMWHA are unlikely to occur from the project. The EIS has considered cumulative impacts from several major infrastructure projects in the area, including the WaterNSW Warragamba Dam wall raising project. Information about the Warragamba Dam wall raising project on GBMWHA was not available at the time of writing the EIS. However, impacts for the Warragamba Dam wall raising project are likely to primarily be upstream of the Warragamba Dam, compared to project impacts which are further downstream in Nepean River. Given the project's minor indirect impacts on a very small section of the GBMWHA, Sydney Water considers that the project's contribution to overall cumulative impacts to the GBMWHA is low.

Cumulative impacts on the GBMWHA from other major projects considered in the EIS, such as the M12 Motorway, Western Sydney International Airport, Sydney Metro Western Sydney Airport and The Northern Road upgrade are unlikely due to their location away from the GBMWHA boundary.

10.3.8 Management measures

SEAR 10, Attachment 1, requires that information on the proposed avoidance and mitigation measures be provided where significant impact has been identified, including the predicted effectiveness, statutory basis, cost and management plans. That level of detail is not required as no significant impact has been identified. The assessment indicates the impact will range from slight (biodiversity), through none (geomorphology, Aboriginal or non-Aboriginal heritage sites) to slightly beneficial (water quality and aquatic ecology).

This impact assessment has summarised the impacts from several different specialist studies that have informed the project EIS. These studies propose a range of management and monitoring measures that are considered suitable for addressing impacts on the GBMWHA. As such, no additional management measures are required to those covered in the biodiversity, waterways, heritage and visual sections of the EIS.