Review of Environmental Factors

Thornleigh Inlet/Outlet Main Duplication (June, 2023)

Sydney WATER

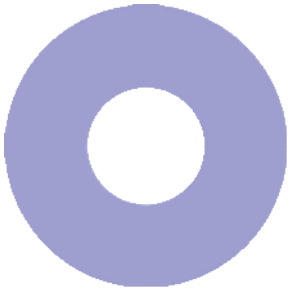
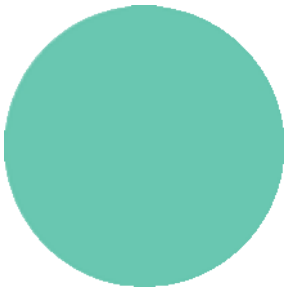

Table of contents

Figures

Tables

Determination

This Review of Environmental Factors (REF) assesses potential environmental impacts of Thornleigh Inlet/Outlet Main Duplication and was prepared under Division 5.1 of the *Environmental Planning and Assessment Act 1979* (EP&A Act), with Sydney Water both the proponent and determining authority.

The Sydney Water Project Manager is accountable to ensure the proposal is carried out as described in this REF. Additional environmental impact assessment may be required if the scope of work or work methods described in this REF change significantly following determination.

Decision Statement

During construction, the main potential environmental impacts of the proposal are typical construction impacts such as impacts on soil and water, flora and fauna, noise and vibration, and traffic and access. During operation, no impacts are expected. The proposal will not be carried out in a declared area of outstanding biodiversity value and is not likely to significantly affect threatened species, populations or ecological communities, or their habitats. Therefore, a Species Impact Statement (SIS) and/or Biodiversity Development Assessment Report (BDAR) is not required.

It is considered that, given the nature, scale and extent of impacts and implementation of the mitigation measures outlined in this REF, the proposal is unlikely to have a significant impact on the environment. Therefore, we do not require an Environmental Impact Statement (EIS) and the proposal may proceed.

Certification

I certify that I have reviewed and endorsed this REF and, to the best of my knowledge, it is in accordance with the EP&A Act and the Environmental Planning and Assessment Regulation 2021 (EP&A Regulation). The proposal has been considered against matters listed in section 171 (Appendix A) and the guidelines approved under section 170 of the EP&A Regulation. The information it contains is neither false nor misleading.

Prepared by:	Reviewed by:	Endorsed by:	Endorsed by:	Approved by:
[redacted] Grace Corrigan REF author Sydney Water Date: 14/06/2023	[redacted] Deana Filipas Environmental Representative Sydney Water Date: 19/06/2023	[redacted] Warren Paige Project Manager Sydney Water Date: 19/06/2023	Elissa Howie A/Environment and Heritage Manager Sydney Water Date: 28 June 2023	Kate Miles A/General Manager, Asset Lifecycle Sydney Water Date: 11 July 2023

1 Executive summary

Sydney Water supplies about 1.5 billion litres of drinking water every day to about 5.3 million people across Greater Sydney. This drinking water is supplied from 11 major dams and 13 water delivery systems. The drinking water network includes 22,600 km of pipes and 152 drinking water pumping stations.

Current and forecast population growth within Greater Sydney requires additional infrastructure to support increased demand for drinking water. Sydney Water is performing a range of upgrades to drinking water assets within the Prospect North and Ryde Water Delivery Systems. The proposal is part of one of six servicing packages to support growth in this precinct across north and north-west Sydney.

The proposal involves duplicating a 1.4 km long DN1800 (1,800 mm diameter) inlet/outlet main between WS0148 (Thornleigh Reservoir) and WP0159 (Thornleigh-Wahroonga Water Pumping Station). Currently, there is one main running between these two assets, and it pumps drinking water in both directions. The proposal will:

- improve water quality at Thornleigh Reservoir and maintain compliance with water quality parameters to continue to supply safe, clean drinking water
- ensure the water supply network can handle expected growth
- increase system resilience by duplicating the inlet/outlet main.

This Review of Environmental Factors (REF) assesses the potential impacts of the proposal on the surrounding environment. Our assessment concludes that the proposal is unlikely to have a significant impact on the environment and an Environmental Impact Statement (EIS) is not required. Temporary environmental impacts during construction have been identified and include:

- soil impacts related to ground disturbance
- water impacts related to groundwater extraction and works above/near waterways
- biodiversity impacts from vegetation disturbance
- noise and vibration impacts from plant, equipment, and vehicles
- traffic and access changes.

Mitigation measures will be implemented to reduce these impacts.

We are seeking feedback on our proposal presented in this REF. We will consider all submissions and prepare a Decision Report. Pending approvals, we expect that we can start construction in 2024.

2 Introduction

2.1 Context

We provide water, wastewater, recycled water and some stormwater services to over five million people. We operate under the *Sydney Water Act 1994* and have three equal objectives, to protect public health, protect the environment and be a successful business.

We are a statutory State-owned corporation and are classified as a public authority, and a determining authority for the proposal under Division 5.1 of the EP&A Act. This REF assesses the potential environmental impacts associated with Thornleigh Inlet/Outlet Main Duplication and identifies mitigation measures to avoid or minimise potential impacts.

2.2 Proposal background and need

The proposal involves duplication of a DN1800 inlet/outlet trunk main. The existing main transports drinking water in both directions between Thornleigh Reservoir (WS0148) and Thornleigh-Wahroonga Water Pumping Station (WP0159) (Sydney Water, 2023a).

The primary drivers for the proposal include:

- maintaining water quality compliance particularly in relation to:
    - water age – how long the drinking water is stored in Thornleigh Reservoir
    - hydraulic constraints – the volume of water moving in and out of Thornleigh Reservoir
- improving network redundancy from the current situation where:
    - the existing trunk main carries drinking water in both directions
    - there is minimal opportunity to take existing trunk main offline
- capacity limits at Prospect East Pumping Station, which supplies water to Thornleigh Reservoir
- operation and maintenance risks associated with the above
- servicing increased demand from future population growth in the area.

Following planning and value engineering, the preferred solution includes:

- installing part of the new water main from Thornleigh Reservoir outlet chamber to a trenchless launch shaft, using open trenching methods
- installing the remainder of the new water main from a launch shaft at Thornleigh Reservoir to a retrieval shaft at Thornleigh-Wahroonga Water Pumping Station, using trenchless methods

- connecting and configuring the new water main to the existing network.

A summary of the proposal need, proposal objectives and consideration of alternatives from this report are provided below (Sydney Water, 2023a).

2.2.1 Proposal need

The proposal is part of the Epping to St Leonards Growth Precinct Program. This program is broken up into six servicing packages. This proposal is within the Ryde and Prospect North Trunk System servicing package. This preferred servicing package covers two of the five Water Delivery Systems within the Prospect Water System – Prospect North Delivery System and Ryde Delivery System. These two Delivery Systems are interconnected and are being impacted by development.

The Prospect North and Ryde Water Delivery Systems are currently servicing a population of 1.56 million. There is significant growth happening within these systems and the population is expected to increase to 2.04 million by 2031 and 2.26 million by 2046. This proposal involves assets servicing the Prospect North Delivery System.

Thornleigh Reservoir is a critical water storage asset in the Prospect North Water Delivery System as it provides buffer storage for about 60% of this system. The specific needs that would be addressed by duplication of the main include:

- improving water quality issues at Thornleigh Reservoir (related to circulation of water and adequate water age)
- improving operational flexibility to manage the drinking water quality and maintain compliance with water quality parameters to provide safe, clean drinking water
- improving redundancy at this location (since currently there is only one main instead of a separate inlet and outlet). The existing inlet/outlet main would become an outlet main only. The new main will be bi-directional.

2.2.2 Proposal objectives

The proposal objectives are to:

- improve water quality at Thornleigh Reservoir (primary objective)
- ensure water supply network can handle expected growth (secondary objective)
- increase system resilience by duplicating the inlet/outlet main.

2.2.3 Consideration of alternatives/options

The options analysis for this proposal has been captured in two separate options assessments (Sydney Water, 2020 and Sydney Water, 2022b).

The first options assessment from 2020 identified options to service growth within the Ryde and Prospect North Trunk System. There were three short-listed options endorsed at a long list to short-list options workshop (Sydney Water, 2020). These short-list options were further developed with sub-options to service growth within Ryde and Prospect North delivery systems in the short

term (ie up to 2031). Each of the short-listed options were assessed in relation to cost and non-cost criteria, including:

- improving system capacity
- improving water quality
- improving ability to maintain the assets
- improving system contingency/reliability
- improving system resilience
- alignment with other strategies.

One of the preferred sub-options based on these criteria was the Thornleigh inlet/outlet main duplication assessed in this REF. Other preferred options have been progressed as part of separate projects.

An alignment options assessment in 2022 identified the preferred alignment for the inlet/outlet main duplication (Sydney Water, 2022b). Similar steps included developing a long list and sub-options, review against fatal flaws, and an assessment against cost and non-cost criteria. Fatal flaws which removed the sub-options from further consideration were unsatisfactory outcomes for hydraulic performance and dam safety. The preferred alignment was chosen following consideration of cost and non-cost factors including:

- hydraulic performance
- community impact
- traffic impact
- environment and heritage impacts
- operations and maintenance
- dam safety impact
- geotechnical risks
- bushfire egress impact
- constructability (eg overall tunnelling length, width of trenching corridor if excavating)
- other (eg interface with other utilities, easement requirements).

The preferred alignment is a mixture of trenching and trenchless (tunnelling), following an alignment that generally runs parallel to the existing main.

Tunnelling is the preferred methodology for the inlet/outlet main outside of the reservoir. Open trenching options were identified and discounted in the alignment options assessment, as open trenching to install the main would have major community and traffic impacts, including road closures, loss of access to residential properties, and closures of public parks. Open trenching options also had the fatal flaw of unsatisfactory hydraulic performance.

2.3 Consideration of Ecologically Sustainable Development

The proposal has been considered against the principles of ecologically sustainable development (ESD) (refer to Table 2-1 below)

Table 2-1 Consideration of principles of ecologically sustainable development (ESD)

Principle	Consideration in proposal
Precautionary principle – *if there are threats of serious or irreversible environmental damage, lack of scientific uncertainty should not be a reason for postponing measures to prevent environmental degradation. Public and private decisions should be guided by careful evaluation to avoid serious or irreversible damage to the environment where practicable, and an assessment of the risk-weighted consequences of various options.*	The proposal will not result in serious or irreversible environmental damage and there is no scientific uncertainty relating to the proposal. The options analysis has identified a preferred alignment and methodology that minimises environmental impacts. Construction environmental impacts would be minimised by implementing the mitigation measures in this REF.
Inter-generational equity – *the present generation should ensure that the health, diversity and productivity of the environment are maintained or enhanced for the benefit of future generations.*	The proposal will help to meet the needs of future generations by providing a reliable drinking water service.
Conservation of biological diversity and ecological integrity – *conservation of the biological diversity and ecological integrity should be a fundamental consideration in environmental planning and decision-making processes.*	The proposal will not significantly impact on biological diversity or impact ecological integrity. Vegetation clearing footprints have been refined during design to minimise the total amount of vegetation removed. This minimises the impact to Threatened Ecological Communities (TEC), threatened species, and habitat features. Sydney Water will provide offset planting for all vegetation removed.
Improved valuation, pricing and incentive mechanisms – *environmental factors should be included in the valuation of assets and services, such as 'polluter pays', the users of goods and services should pay prices based on the full life cycle costs (including use of natural resources and ultimate disposal of waste) and environmental goals*	The proposal will provide cost efficient use of resources and provide optimum outcomes for the community and environment. It will ensure that drinking water quality can be maintained to support future population growth in the area.

3 Proposal description

3.1 Proposal details

The proposal involves duplication of the existing DN1800 bi-directional main between Thornleigh Reservoir and Thornleigh-Wahroonga Water Pumping Station. The existing main was constructed in 1968-70, in conjunction with Thornleigh-Wahroonga Water Pumping Station and Thornleigh Reservoir. The existing main is about 17 to 46 m below ground level.

The new inlet/outlet main will be about 1.4 km long. About 200 m will be trenched (within Thornleigh Reservoir site) and 1.2 km will be tunnelled using a tunnel-boring machine (TBM). The new main will run roughly parallel to the existing main (about 30 m east of the existing main). The proposal will also involve connection of the new inlet/outlet main to the existing network.

The proposal is within Hornsby Shire Council, in the suburbs of Westleigh and Thornleigh.

The launch shaft for the tunnelling (where the TBM will start) is within Thornleigh Reservoir lot boundary. Thornleigh Reservoir is on Sydney Water owned land, at 42-82 Quarter Sessions Road, Westleigh (Lot 100, DP 1217395).

The retrieval shaft for the tunnelling (where the TBM will finish) is on public space near Thornleigh-Wahroonga Water Pumping Station, and is on Crown Land. Discrete lots within this parkland are Lots 1-4, DP 812041, and Lot 7343, DP 1167875. Thornleigh-Wahroonga Water Pumping Station is on Sydney Water owned land, at 5 Dale Close, Thornleigh (Lot 1, DP 535665).

The alignment of the new inlet/outlet main will be trenched north to south along the tree line of Thornleigh Reservoir to the launch shaft, which is south-east of Thornleigh Reservoir. The pipeline will then be tunnelled in a south-west direction to a grassy area on the south side of Zig-Zag Creek near the Thornleigh-Wahroonga Water Pumping Station site (the Crown Land used for public space described above).

The new inlet/outlet main will pass under roads and private properties, at approximate depths of between ten and 37 metres.

Figure 3-1 to Figure 3-3 show the location. Specific environmental constraints related to the proposal are identified in Section 6.

3.2 Proposed activities

3.2.1 Pre construction

Pre-construction work includes:

- preparing management plans and procedures including a Construction Environmental Management Plan (CEMP), associated sub-plans and procedures, a Community and Stakeholder Action Plan (CSAP), site inductions and safety plans

- liaising with local authorities (Hornsby Shire Council), as well as other external stakeholders, such as utility providers including Ausgrid, in accordance with Sydney Water's community relations protocols
- establishing and mobilising sites at the launch shaft and retrieval shaft, as detailed below.

Site establishment and mobilisation at the Thornleigh Reservoir site includes:

- widening the existing access road within Thornleigh Reservoir lot boundary to about six metres wide involving
    - ripping and replacing existing pavement with heavy-duty pavement
    - loading out and disposing of the pavement off-site
    - importing, placing and compacting roadbase
- trimming/removing vegetation in approved areas
- stripping topsoil and installing hardstand for storage, parking, and laydown locations in cleared, grassed areas within Thornleigh Reservoir lot boundary
- excavating for launch shaft (about 10 m by 5 m surface area and 11 m depth)
- installing temporary ground support system (eg shoring, battering) in the launch shaft and next to Thornleigh Reservoir
- levelling ground for TBM and laydown area, including installing fill material and concrete footings
- establishing drilling plant and equipment
- installing additional temporary mains power supply
- installing acoustic shed
- bringing material (eg concrete casing pipes) to site to store in laydown area.

Site establishment and mobilisation at the retrieval shaft adjacent to Thornleigh-Wahroonga Water Pumping Station includes:

- trimming/removing vegetation in approved areas including removing vegetated island within cul-de-sac of Edmundson Close
- installing temporary pavement where the island has been removed
- removing grass, topsoil, and spoil (about 500 mm depth)
- importing, placing, and compacting temporary pavement on the previously grassed area
- constructing ground support system for retrieval shaft including bored piling
- excavating retrieval shaft (minimum 11 m width and 17 m depth) and remove spoil offsite.

3.2.2 Construction

This section describes the different construction activities that will occur at Thornleigh Reservoir (including the launch shaft) and the southern construction footprint adjacent to Thornleigh-Wahroonga Water Pumping Station (including the retrieval shaft).

Activities to be performed at Thornleigh Reservoir during the day only include:

- injecting grout between the pipe sections
- transporting spoil from tunnelling into a bogey truck using a wheel loader or similar, and transporting it off site
- delivering pipes and other material to site (eg steel work, concrete encasement)
- open trenching for 200 m of pipe within Thornleigh Reservoir boundary (the access track within Thornleigh Reservoir will remain in use during this time)
- removing material from trench
- hydro-demolition of existing concrete to expose steel main/s for pipe connection/s
- constructing concrete chambers for the pipe
- dewatering groundwater, where required
- backfilling/compacting shaft with clean material (staged/ongoing activity)
- connecting new pipe into existing network.

Activities to be performed at Thornleigh Reservoir during the day and night include:

- tunnel boring (underground), tunnelling, and associated activities which will run continuously for about six months within the acoustic shed and include:
    - tunnelling up to 7.2 m per shift
    - using mud plant (shaker) to separate soil from bentonite – shaker tray and table will tip the material into a bin
    - using bentonite slurry plant to create and recycle bentonite after slurry goes through mud plant
    - using hydraulic power pack/s to drive TBM
    - maintaining bentonite production plant
    - using gantry crane or similar to lower/lift pipes into portal shaft
    - stockpiling spoil near launch shaft
    - using diesel generator to power site as contingency to mains power supply.
- welding and pushing carrier pipe through a sleeve (this is a continuous activity to be performed once tunnelling is finished and launch shaft is demobilised).

Activities to be performed at the southern construction footprint including the retrieval shaft include:

- installing a temporary steel bridge/culvert about four metres wide and 12 metres long, near the existing pedestrian footbridge. This includes excavation/piling to install bridge supports. This bridge would be used for plant, equipment, and vehicle access. Alternatively, the existing pedestrian footbridge could be widened or replaced.
- parking crane temporarily in Edmundson Close cul-de-sac
- open trenching for pipe installation
- installing concrete encasement for pipework
- backfilling/compacting shaft with clean material (staged/ongoing activity)
- using crane to lift out TBM
- hydro-demolition of existing concrete to expose steel main/s for pipe connection/s
- connecting pipes into existing network, including cutting existing pipes:
- dewatering groundwater, if required
- constructing concrete chambers for pipe
- performing welding activities.

Most works at the retrieval shaft will be during the day, with the exception of connecting pipes into the existing network. This is expected to require about 12 night shifts of work towards the end of the project.

3.2.3 Commissioning

Commissioning involves testing and running the new equipment to ensure it is working correctly and integrated with existing plant operations. The exact commissioning steps depend on the type of the equipment, but typically include:

- pressure leak testing
- checking all equipment and safety devices
- performance testing, including sampling where required.

3.2.4 Post construction

Site demobilisation would include:

- removing plant, equipment, and vehicles
- removing temporary hardstand
- removing temporary steel bridge/culvert and reinstating pedestrian footbridge
- backfilling excavations
- restoring sites (eg reinstating disturbed areas, offset planting).

The work sites will be restored as close to the pre-existing condition as reasonably practicable following construction, in consultation with landowners. The bridge supports (abutments) from the temporary steel bridge/culvert would be left in place in the event they are required for future access.

3.2.5 Operation

Access to existing assets would not be impacted during operation. New assets would be connected into the existing Sydney Water network and subject to standard operational and maintenance activities including repairs and inspections.

3.3 Materials and equipment

Plant, equipment, and vehicles include:

- light vehicles (utes and vans)
- hi-ab
- excavator (no hammer) 30 tonne
- compactors
- grader
- quick-cut saw
- semi-trailer 19 m length
- franna
- concrete pump
- smooth drum roller (non-vibratory) 14 tonne
- truck and dog (carry 30 tonne)
- 60-100 tonne crane eg gantry crane
- bored piling rig
- bentonite slurry plant
- hydraulic power packs
- grout trucks
- hydro-demolition equipment.
- hand tools and chainsaws
- elevated work platforms
- excavator (with hammer) 30 tonne
- mulchers
- water cart
- flatbed truck
- B-double trucks 26 m length
- concrete agitator trucks
- concrete vibrators and hand tools
- float trucks (semitrailer for transporting plant)
- bogie trucks (carry 10 tonne)
- 350 tonne crane
- tunnel-boring machine (TBM)
- mud plant/shaker
- road sweeper
- welding equipment.

3.4 Work sites, access, and vehicle movements

3.4.1 Construction compounds

Construction compounds and laydown areas will be required for parking, material storage, stockpiling, site offices, workshops, and amenities.

Areas within the construction footprint are proposed for the launch shaft and retrieval shaft (Figure 3-2 and Figure 3-3). However, other locations within Thornleigh Reservoir may be used where they have minimal environmental impact (such as the area marked in green in Figure 3-2). Existing amenities within Thornleigh-Wahroonga Water Pumping Station may also be used. The construction footprint (including proposed compounds and laydown areas) at Thornleigh Reservoir and Thornleigh Wahroonga Water Pumping Station is shown in Figure 3-2 and Figure 3-3 and is about 25,000 m^2.

3.4.2 Access

All sites will be accessed via the existing road network, including Quarter Sessions Road, Edmundson Close and Dale Close. Several access roads would be used including:

- an existing access road through Thornleigh Reservoir lot boundary (to be widened) for light and heavy vehicles
- a new access road around the launch shaft, including a turning bay around the launch shaft. This access road would extend off the existing access road
- a new access road for the proposed compound and laydown area on the western side of Thornleigh Reservoir
- a new temporary steel bridge/culvert over Zig Zag Creek near Edmundson Close, at the retrieval shaft, for plant, equipment, and vehicles
- access through Thornleigh-Wahroonga Water Pumping Station off Dale Close (potential) or through the footpath to the east of Thornleigh-Wahroonga Water Pumping Station, by foot.

3.4.3 Traffic generation

Traffic generated by the project is expected to include:

- at peak times, about 10-15 light vehicles per day at both the launch shaft and retrieval shaft. This will likely be during pipe removal, delivery of material, or spoil placement and removal
- at non-peak times, about 5-7 light vehicles per day at both the launch and retrieval shafts
- about 900 truck movements over about a year at the launch shaft, when spoil generating activities are conducted. Scheduling of spoil material removal is to be confirmed but could be every day or every three days
- truck movements for spoil removal at the retrieval shaft. Spoil would be generated during activities such as pipe installation, and backfill. Each activity will take 4-5 days, and about 16 truck movements a day are expected.

Traffic movement will be most frequent at start and end of shifts (for typical day shift times, this would be around 7 am and 6 pm). All deliveries and spoil removal would be during daytime work hours. Static equipment, such as the TBM, would be transported in and out at the start and end of construction.

Further information on traffic and access is provided in Section 6.1.8 of this REF.

3.5 Workforce

The construction workforce is likely to fluctuate each day, depending on the program of work. Peak number of construction workers at each of the launch shaft and retrieval shaft is around 10-15 each day, with around 5-7 workers on site during other tasks.

3.6 Working hours and proposal timeframe

Construction is proposed to start in 2024 (pending staging with other projects within the Ryde and Prospect North Trunk System servicing package) and take about two and a half years to complete.

Multiple activities may be performed concurrently. Duration of key construction activities is estimated below:

- Site mobilisation: 2-4 months.
- Day works at reservoir: 10 months.
- Night works at reservoir: 10 months.
- Works at retrieval shaft: 20 months.
- Site demobilisation: 2 months.

Most work and deliveries will be scheduled to occur during standard daytime hours:

- 7 am to 6 pm, Monday to Friday.
- 8 am to 1 pm, Saturdays.
- No work Sundays or public holidays.

Activities likely to require works outside standard daytime hours include:

- tunnel boring (underground), tunnelling, and associated activities (continuous activity)
- welding and pushing carrier pipe through a sleeve (continuous activity)
- installing carrier main after tunnelling is complete
- connecting pipes into existing network, including cutting existing pipes.

Should construction be required outside of standard hours in addition to the tasks assessed in this REF, the mitigation measures in Section 6.1.5 of this REF would be implemented.

Figure 3-1 Proposed inlet/outlet main alignment

Figure 3-2 Northern construction footprint for works around the launch shaft

Figure 3-3 Southern construction footprint for works around the retrieval shaft

3.7 Construction footprint and changes to the scope of work

The proposal details such as design/ alignment shown in this REF are indicative and based on the 80% concept design submission. The final design/alignment may change based on detailed design and/or construction planning. If the design/scope of work, construction methods or construction timing described in this document change significantly, supplementary environmental impact assessment must be prepared for the amended components in accordance with SWEMS0019. An addendum is not required provided the change:

- remains within the construction footprint of the REF and has no net additional environmental impact; or
- is outside the construction footprint of the REF but reduces the overall environmental impact of the proposal (subsection 5.4(a) of the Act).

The construction footprint for the proposal includes:

- the proposed alignment for the new inlet/outlet main (Figure 3-1). These works are all underground.
- the northern construction footprint – works associated with the launch shaft, within the Lot and DP boundary of Thornleigh Reservoir (Lot 100, DP 1217395) (areas marked in pink and green on Figure 3-2)
- the southern construction footprint – works within the Lot and DP boundaries described in Section 3.1 of this REF (area marked in pink in Figure 3-3).

Each specialist assessment (Appendix C-G, Section 6.1.3, Section 6.1.4, Section 6.1.5, Section 6.1.8) has defined their own study area and impact areas (different to the construction footprint above) based on site constraints, the surrounding environment, and predicted impacts.

Changes to the proposal outside the construction footprint can only occur:

- to reduce impacts to biodiversity, heritage or human amenity, or
- to avoid engineering (for example, geological, topographical) constraints, and
- after consultation with any potentially affected landowners and relevant agencies.

The contractor will demonstrate in writing how the changes meet these requirements, for approval by Sydney Water's Project Manager, in consultation with the environmental and community representatives.

4 Consultation

4.1 Community and stakeholder consultation

Our approach to community and stakeholder consultation is guided by the Guidelines for Community and Stakeholder Engagement (Sydney Water, 2021).

Stakeholder and community engagement is a planned process of initiating and maintaining relationships with external parties who have an interest in our activities. Community and stakeholder engagement:

- enables us to explain strategy, policy, proposals, projects or programs
- gives the community and stakeholders the opportunity to share their knowledge, issues and concerns
- enables us to understand community and stakeholder views in our decision-making processes alongside safety, environment, economic, technical and operational factors.

The nature, scale and extent of the proposal's potential impact has been evaluated in this REF. If our work impacts the community in some way, we will consult with affected groups through a variety of ways and through different stages of a project. This includes engaging the broader community and stakeholders during plan or strategy development or before making key decisions.

We will also provide local councils with reasonable notice when we would like to commence works, regardless of the need for development consent. Hornsby Shire Council will continue to be consulted about matters identified in environmental planning instruments (refer Section 4.2 below), including public safety issues, the placement of any temporary site sheds or laydown areas on council land, or full or partial road closures of council managed roadways.

A Community and Stakeholder Action Plan (CSAP) will guide community engagement activities through design and delivery of the proposal. The plan helps us provide the community and key stakeholders with clear, accurate and timely information.

The CSAP will identify stakeholders with an interest in the proposal, and ensure they are informed during proposal delivery. The CSAP will also:

- identify the directly and indirectly affected landowners and other stakeholders, including government agencies and interest groups
- identify issues likely to be of high community / stakeholder concern and determine the level of risk to the proposal's development
- identify ways to raise the level of community satisfaction and ensure that Sydney Water's reputation is protected and enhanced
- incorporate stakeholder views into the proposal planning and delivery.

4.2 Consultation on this REF

We will invite the community and stakeholders to comment on this REF. We will provide information about the proposal and the REF process, and we will invite comment through:

- Sydney Water website
- other methods identified by the CSAP.

The REF will be available to download from sydneywatertalk.com.au during the display period identified on the website. Submissions must be made in writing and received by the date identified on the website, to the email on the website.

We will collect information in written representations to help us assess the proposal. The information may be disclosed to appropriate agencies such as the EPA. If the respondent indicates at the time of submission that the information should remain confidential, Sydney Water will attempt to ensure this. However, there may be legal justification for its release, for example under the *Government Information (Public Access) Act 2009*.

At the end of the public display period, we will consider all submissions and prepare a Decision Report. This will also be available from sydneywatertalk.com.au.

4.3 Consultation before and during consultation

Consultation with key stakeholders will continue throughout detailed design, construction, and commissioning of the proposal. We will consult with community members where the proposal directly impacts them. During construction, the contractors responsible for delivering the proposal will do the consultation and, as representatives of Sydney Water, will adhere to our community relations policies and procedures. We will continually monitor the contractor's performance during proposal delivery.

We will continue to inform the community and stakeholders about the proposal start date, about where we will be working and when, as well as what to expect during each stage of the proposal's progress. During construction, we will ensure the construction contractor is mindful of the community, that they inform the community about any work that may impact nearby residents and businesses, and that they leave a positive legacy when their work is done. Engaging with the community enables Sydney Water and its contractors to listen and understand the opinions of the community. Feedback will be used to improve our performance and all complaints during the construction of the proposal and following its commissioning will be managed according to Sydney Water's Complaints Handling Process and Sydney Water's Stakeholder Engagement Policy.

4.4 Consultation required under State Environmental Planning Policies and other legislation

Sydney Water must consult with councils and other authorities for work in sensitive locations or where the work may impact other agencies' infrastructure or land (specified in Part 2.2 Division 1 of the State Environmental Planning Policy (Transport and Infrastructure) 2021 (TISEPP)).

Consultation was required under TISEPP with Hornsby Shire Council as the proposal involves:

- installing a temporary structure on, or enclosing a public place under council's management or control that is likely to disrupt pedestrian or vehicle traffic – section 2.10(1)(e)
- excavating a footpath or road for which council is the roads authority – section 2.10(1)(f).

A meeting was held between representatives from Hornsby Shire Council and Sydney Water on 21 February 2023. The meeting included discussion of the proposal scope, benefits, and objectives, as well as environmental matters related to TISEPP consultation. No specific actions were raised by council in relation to TISEPP matters. Further detail is provided in Appendix B.

Consultation will be undertaken with Crown Lands regarding easements and/or acquisition required for the proposal at the retrieval shaft.

5 Legislative requirements

5.1 Strategic context

The strategic context of the proposal is shown in Table 5-1.

Table 5-1 Consideration of strategic context relevant to the proposal

Document name	Strategic context	Relevance to proposal
Metro North West Corridor Strategic Planning 2016-2036 Final Draft Report (AAJV, 2016)	Identifies strategic planning by Sydney Water to support the Metro.	The capacity limitation of the existing Thornleigh inlet/outlet main has been flagged by Sydney Water as a risk/issue for servicing drinking water within the North West Rail Link Corridor.
North West Rail Link Corridor Strategy (NSW Transport and NSW Planning, 2013)	Defines the North West Rail Link Corridor, including the rail corridor precincts.	Identifies potential growth scenarios, and informs future planning controls and infrastructure requirements.
Draft Metropolitan Strategy for Sydney to 2031 (superseded by the Greater Sydney Region Plan—A Metropolis of Three Cities, Greater Sydney Commission, 2018)	This regional strategic plan aims to respond to the needs of Greater Sydney's people and the region's current and future structural challenges.	This proposal is consistent with this strategy as it will help meet Greater Sydney's drinking water needs.
NSW 2021: A Plan To Make NSW Number One (Department of Premier and Cabinet, 2011)	This plan is the NSW Government's ten year strategic business plan to guide policy, Government investment and budget allocation to deliver on community priorities for public services and the provision of infrastructure. There are five key strategies and 32 goals in the plan.	This proposal is consistent with the strategy of 'renovate infrastructure'.
State Infrastructure Strategy (current version: 2022-2042) (Infrastructure NSW, 2022)	This strategy sets out challenges and opportunities, strategic directions, and recommendations on the nine key objectives in the strategy.	This proposal is consistent with the strategies 'Embed reliability and resilience', 'Enhance long term water supply', and 'Design the investment program to endure'.

Document name	Strategic context	Relevance to proposal
Greater Sydney Water Strategy (DPE, 2022)	This strategy charts a direction for delivering sustainable and resilient water services to Greater Sydney for the next 20 to 40 years. This includes servicing a growing Greater Sydney. The strategy sets out priorities and actions for the delivery of water services into the future to support a sustainable, liveable and productive Greater Sydney.	This proposal is consistent with the strategy in relation to 'Invest in upgrades, new connections and leak management to address the risks posed by ageing water and wastewater systems and infrastructure'.
Hornsby Local Strategic Planning Statement (Hornsby Shire Council, 2020)	This statement includes a 20-year vision for land use, the special character and values that are to be preserved, shared community values, and how Hornsby Shire Council will manage growth and change.	This proposal is consistent with the priorities: • SP3. Protecting and improving the health of catchments and waterways and deliver well planned and designed local water infrastructure solutions. • SP9. Reducing carbon emissions and managing energy, water and waste efficiently. The proposal is not expected to impact council's ability to achieve any other priorities in the Planning Statement.

The proposal is consistent with these plans and strategies as it will support growth within Greater Sydney by providing a reliable drinking water supply to more customers.

5.2 Environmental Planning and Assessment Act

Sydney Water is the proponent and determining authority under the EP&A Act. The proposal does not require development consent and is not classified as State Significant Infrastructure. We have assessed this proposal under Division 5.1 of the EP&A Act. This REF has concluded that the proposal is unlikely to have a significant impact on the environment.

The following environmental planning instruments (Table 5-2) and legislation (Table 5-3) are relevant to the proposal. Table 5-3 also documents any licences and permits, timing and responsibility for obtaining them.

Table 5-2 Environmental planning instruments relevant to the proposal

Environmental Planning Instrument	Relevance to proposal
Hornsby Local Environmental Plan (LEP) 2013	The proposal is located on land zoned C3 Environmental Management, R3 Medium Density Residential, and R2 Low Density Residential (Figure 5-1). Bushland in urban areas (formerly Chapter 6 of the BC SEPP) is now assessed under clause 5.23 of the Hornsby LEP. Sydney Water has considered the matters listed in subclause 5.23(7) of the Hornsby LEP (refer 6.1.1 to Section 6.1.3 of the REF) to limit disturbance to public bushland.
State Environmental Planning Policy (Transport and Infrastructure) 2021 (TISEPP)	Section 2.159(1) of the TISEPP permits development by or on behalf of a public authority for water reticulation systems without consent on any land. The proposal involves work on water reticulation systems. These include buildings or places used for the transport of water, including pipes (as defined by the Standard Instruments (Local Environmental Plans) Order 2006). There are some limitations on land reserved under the National Parks and Wildlife Act, 1974 (NPW Act). As Sydney Water is a public authority and works are not on land reserved under the NPW Act, the proposal is permissible without consent.
State Environmental Planning Policy (Biodiversity and Conservation) 2021 (BC SEPP)	**Vegetation in non-rural areas (Chapter 2)** Chapter 2 of this SEPP applies as the proposal is in an area or zone listed in subsection 2.3(1). However, subsection 2.4(1) states: 'This Policy does not affect the provisions of any other SEPP….', and as the works are permissible under the TISEPP a Council permit to clear vegetation under this SEPP is not required. **Koala habitat protection (2020 and 2021) (Chapters 3 & 4)** The proposal is on land zoned koala habitat. Koala feed trees such as Blackbutt (*Eucalyptus pilularis*) are present within the study area. Koala records are located within 1.4 km of the study areas, with the most recent record occurring in 2018. Impacts to habitat are low as they are limited to trimming and minor clearing. A high level of available contiguous habitat and connectivity will be retained. Impacts to koala are considered in more detail in section 6.1.3. No additional approvals are required. **Water Catchments (Chapter 6)** Chapter 6 of this SEPP applies as the proposal is within the Hawkesbury-Nepean Catchment, a regulated catchment area. Section 6 of this REF assesses potential environmental impacts on water quality and quantity, aquatic ecology, flooding, access, cultural heritage, flora and fauna, and scenic quality. The assessment confirmed that potential impacts are minimal and meet the requirements of section 6.2 of the SEPP.

Figure 5-1 Land zoning within 200 m of proposal (Aurecon Arup, 2023b)

Table 5-3 Consideration of key environmental legislation

Legislation	Relevance to proposal	Permit or approval	Timing and responsibility
Protection of the Environment Operations (POEO) Act 1997	EPLs are required in various circumstances, defined by Schedule 1 of the POEO Act. An EPL is not required for the proposal as drilling muds and fluids have an exemption from Schedule 1 activities. Chapter 5 of the POEO Act defines different types of pollution incidents. Part 5.7 of the POEO Act specifies the duty to notify harm to the environment where there is actual or potential environmental harm. Should one of these incidents occur during construction, the response and investigation to the incident would follow SWEMS0009 Responding to incidents with an environmental impact.	NA	NA
Protection of the Environment Operations (Waste) Regulation 2014.	Treated drilling muds will be generated from tunnel boring activities. Treated drilling muds are subject to a Resource Recovery Order and Resource Recovery Exemption under Part 9, Clauses 91-93 of the *Protection of the Environment Operations (Waste) Regulation 2014*. The Order (Clause 93) imposes the requirements that must be met by suppliers of treated drilling mud to which 'the treated drilling mud exemption 2014' applies. The requirements in this order apply in relation to the supply of treated drilling mud for application to land as engineering fill or for use in earthworks. The Exemption (Clause 91-92) exempts a consumer of treated drilling mud from certain requirements under the POEO Act and the Waste Regulation in relation to the application of that waste to land, provided the consumer complies with the conditions of this exemption.	Compliance with requirements for testing, notification, record keeping, and reporting	During construction, contractor
Biodiversity Conservation (BC) Act 2016	A specialist ecology assessment (Appendix C) identified that one Threatened Ecological Community (TEC) and two threatened species listed under this act were recorded, or assessed to have a medium or greater likelihood of occurring in the study area. Tests of Significance were performed.	NA	NA

Legislation	Relevance to proposal	Permit or approval	Timing and responsibility
	No significant impacts are expected to any threatened species or communities listed under the BC Act. Preparation of a Species Impact Statement (SIS) or opting in to the NSW Biodiversity Offsets Scheme (BOS), is not required.		
National Parks and Wildlife (NPW) Act 1974	An Aboriginal and historic due diligence assessment was completed for the proposal (Appendix D). No registered Aboriginal sites are present within the study areas. No Aboriginal objects were identified during a visual inspection of the study areas. Aboriginal archaeological sensitivity of the study areas was assessed as low. The proposal is not on National Parks land.	NA	NA
Heritage Act 1977	An Aboriginal and historic due diligence assessment was completed for the proposal (Appendix D). One LEP-listed heritage item (Street Trees, ID 706) is present within the southern study area. Trimming of these trees will be required for equipment and vehicle access to/from Edmundson Avenue. A Statement of Heritage Impact (SOHI) (Appendix E) indicated that this impact would be minor.	NA	NA
Fisheries Management (FM) Act 1994	The proposal will involve impacts to Zig Zag Creek. The methodology for installing a temporary steel bridge/culvert over Zig Zag Creek may include disturbance to the creek bed and creek banks. Zig Zag Creek is not Key Fish Habitat. Therefore, a permit for dredging or reclamation is not required. However, mitigation measures will be implemented to minimise impacts to the creek including water flow. No harm to marine vegetation is required.	NA	NA
Water Act 1912/ Water Management Act 2000	Groundwater will be extracted during excavation and tunnel boring. Approximate groundwater volumes are currently being calculated, but are likely to be less than 3 ML (Sydney Water, 2023b). A Water Supply Works Approval (WSWA) application would be submitted if groundwater volumes are calculated as less than 3 ML. A Water Access Licence (WAL) application would be submitted should calculations change and estimated groundwater volumes are more than 3 ML.	WSWA (for less than 3 ML) or WAL (for more than 3 ML)	During and post REF, Sydney Water

Legislation	Relevance to proposal	Permit or approval	Timing and responsibility
	There is one waterway within the impact area for the proposal – Zig Zag Creek. It is classified as a first order stream (Strahler), under the Water Management Act 2000 (WM Act). Works are proposed for the riparian zone within 10 metres of Zig Zag Creek. As a public authority, Sydney Water does not need to obtain a controlled activity approval for any controlled activities that it carries out in, on or under waterfront land (per Clause 41 of the *Water Management (General) Regulation 2018*). Sydney Water will incorporate Department of Planning and Environment (DPE) Water guidelines for controlled activities into design.		
Roads Act 1993	Road Occupancy Licences (ROLs) will be required for works which require temporary full or partial closures of council-managed roads. No roads managed by TfNSW would experience temporary closures from the proposal. Lane closures would be required on council roads.	Road Occupancy Licence	Pre-construction, contractor
Environment Protection and Biodiversity Conservation (EPBC) Act 1999	The EPBC Act is the Australian Government's key piece of environmental legislation. The EPBC Act applies to developments and associated activities that have the potential to significantly impact on Matters of National Environmental Significance (NES) protected under the Act. One TEC and one threatened species listed under the EPBC Act were recorded or assessed to have a medium or higher potential to occur within the study area. A specialist ecologist assessment (Appendix C) included assessment against the Significant Impact Criteria for threatened entities that are deemed likely to be subject to negative impacts. The assessment identified that a significant impact from the proposal was unlikely. Impacts on Matters of National Environmental Significance are unlikely.	NA	NA

6 Environmental assessment

Section 6 of this REF describes the existing environment and assesses direct and indirect impacts of construction and operation of the proposal. It also identifies mitigation measures to minimise impacts. These will be incorporated into contract documents and a Construction Environmental Management Plan (or similar) prior to starting work.

6.1 Environmental aspects, impacts and mitigation measures

6.1.1 Topography, geology and soils

Existing environment

The existing soil landscapes are shown in Figure 6-1 and discussed in Table 6-1 below.

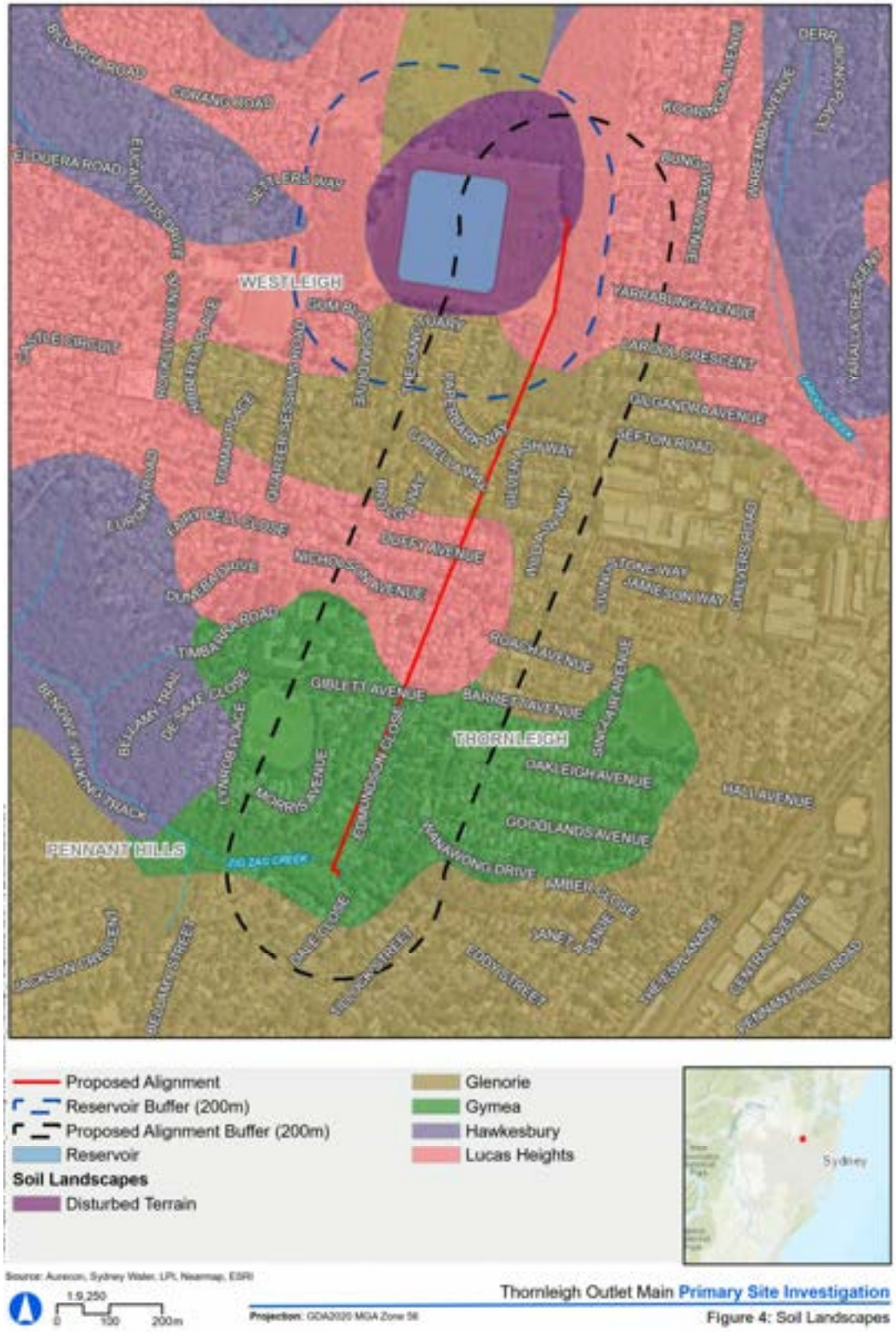

Figure 6-1 Soil landscapes within 200 m of the proposal (Aurecon Arup, 2023b)

Table 6-1 Existing environment – topography, geology, and soils

Site features	General commentary (where required)	Thornleigh Reservoir/ launch shaft	Inlet/outlet main alignment	Thornleigh-Wahroonga Water Pumping Station/ retrieval shaft
Topography (metres Australian Height Datum)	Terrain slopes in a generally downhill direction from Thornleigh Reservoir to Thornleigh-Wahroonga Water Pumping Station.	The launch shaft is at about 176.5 m AHD. The open trench section of the inlet/outlet main is between about 174 and 177 m AHD. The top of Thornleigh Reservoir is 190 m AHD and is supported by an embankment which slopes downward to the construction footprint.	Between about 177 m AHD at the launch shaft to about 130 m AHD at the retrieval shaft. The slope is about 4% gradient across the alignment.	About 135 m AHD. The low point is Zig Zag Creek at about 132 m AHD.
Geology (Sydney Water, 2022a)	NA	Ashfield Shale Fill material is expected to be encountered within Thornleigh Reservoir site.	Ashfield Shale (northern part) Hawkesbury Sandstone (southern part) Natural material with some fill material is expected near the surface between Thornleigh-Wahroonga Water Pumping Station and Thornleigh Reservoir. Natural material is expected at depth.	Hawkesbury Sandstone Alluvial material is expected along the northern boundary of Thornleigh-Wahroonga Water Pumping Station. Fill material is expected within the remainder of Thornleigh-Wahroonga Water Pumping Station site. Fill material is expected to the north of Zig Zag Creek along Edmundson Close, in the area that was previously an extended floodplain.

Site features	General commentary (where required)	Thornleigh Reservoir/ launch shaft	Inlet/outlet main alignment	Thornleigh-Wahroonga Water Pumping Station/ retrieval shaft
				The Westleigh/ Thornleigh Dyke is about one metre wide, basaltic, and expected to the north of Zig Zag Creek.
Soil (Sydney Water, 2022a)	Mapping of soil landscapes is shown in Figure 6-1.	Disturbed terrain occurs where the topography varies from flat to undulating terrain and has been disturbed by human activity to at least one metre depth. Lucas Heights landscapes feature no rock outcrops, and vegetation extensively or completely cleared. Limitations include stony soil, low fertility, and low available water capacity.	Lucas Heights – description and limitations as per previous column. Glenorie landscapes feature undulating to rolling low hills. Limitations include high soil erosion hazard, localised impermeable high plasticity, and moderately reactive soils. Gymea landscapes feature undulating terrain and infrequent rock outcrops. Limitations include localised steep slopes, and high soil erosion hazard.	Gymea – description and limitations as per previous column.
Contamination (Sydney Water Planning Partner, 2023b)	No EPA-reported contaminated sites within 1 km of the proposal. Historical aerial photographs and field	There is a low to moderate risk of PFAS contamination. There is one PFAS investigation site about 500 m north of Thornleigh	Specific contamination hazards identified along the inlet/outlet main alignment include:	HBM present at Thornleigh-Wahroonga Water Pumping Station are discussed in Section 6.1.7 of the REF.

Site features	General commentary (where required)	Thornleigh Reservoir/ launch shaft	Inlet/outlet main alignment	Thornleigh-Wahroonga Water Pumping Station/ retrieval shaft
	observations show previous disturbance from: • clearing vegetation • building water infrastructure • installing other utilities • grading for access tracks • urban development. In general, the proposal area historically consisted of undeveloped rural lots in the 1940s. Some filling, decommissioning, redevelopment and construction of new buildings and assets were observed over the years. The potential for elevated concentrations of contaminants of potential concern (CoPCs) to be present from past and present land use activities	Reservoir (Westleigh NSW Rural Fire Service). Previous investigations within Thornleigh Reservoir in 2014 indicated concentration of lead and asbestos above the human health criteria. Hazardous building materials (HBM) present at Thornleigh Reservoir are discussed in Section 6.1.7 of the REF. Additional specific contamination hazards identified at Thornleigh Reservoir include: • historic rural, agricultural lots and presumed herbicide/ pesticide use in shallow soils • earthworks and filling for reservoir construction in 1970s, including the	• filling and incidental renovations within residential housing lots since the 1970s – before this, it was vegetated lots and rural living • HBM at Thornleigh-Wahroonga Water Pumping Station. No PFAS, asbestos, or heavy metal contamination was identified during soil testing.	Additional specific contamination hazards at Thornleigh-Wahroonga Water Pumping Station includes an historical land use of rural, vegetated lots. Residential development from about the 1970s may have impacted shallow soils. No PFAS, asbestos, or heavy metal contamination was identified during soil testing.

Site features	General commentary (where required)	Thornleigh Reservoir/ launch shaft	Inlet/outlet main alignment	Thornleigh-Wahroonga Water Pumping Station/ retrieval shaft
	is considered low to moderate. Potential receptors that could be exposed to contamination include: • construction and operational workers • offsite ecological receptors • members of public. Contamination may spread through: • direct contact with contaminated soil • incidental ingestion of soil • inhaling contaminated dust/ gas/ vapour • groundwater inflows to excavations • sediment/ surface runoff.	man-made embankment • stockpiles previously observed within Thornleigh Reservoir. No PFAS, asbestos, or heavy metal contamination was identified during soil testing.		

Site features	General commentary (where required)	Thornleigh Reservoir/ launch shaft	Inlet/outlet main alignment	Thornleigh-Wahroonga Water Pumping Station/ retrieval shaft
Potentially unstable soils	Defined as slopes greater than 15% gradient	Small patch mapped within reservoir site, to the west of the dam structure.	Patches near the southern end of the alignment. The risk of soil erosion may be higher for mapped erosion prone soil landscapes Glenorie and Gymea, compared to other soil types.	Patches near the retrieval shaft, between Morris Avenue, Edmundson Close, and Nicholson Avenue. Slope instability should be considered around the creek. The risk of soil erosion may be higher for mapped erosion prone soil landscape Gymea, compared to other soil types.
Acid sulfate soils (Sydney Water Planning Partner, 2023b)	NA	None within or nearby. Site elevation of >100 m AHD also makes it highly unlikely to be present.		
Salinity (DPIE, 2023 and Sydney Water, 2022a)	NA	None within or nearby – closest soil profiles indicate no salting evident. Low to very low salinity risk within 200 m of the proposal		
Existing exploration or mining title (Sydney Water, 2022a and Regional NSW, 2023)	NA	None within or nearby		

Potential impacts

During construction, we will need to:

- remove mature vegetation and ground vegetation (up to 0.90 ha)
- excavate for launch and retrieval shafts
- excavate (open trench) for trunk main installation within reservoir
- excavate for installation of temporary steel bridge/culvert at Zig Zag Creek
- excavate the median at Edmundson Close during vegetation removal
- perform underground tunnelling using the TBM
- widen the existing access track within Thornleigh Reservoir
- establish site compound and laydown areas, including topsoil removal
- temporarily stockpile spoil material, including slurry generated from tunnel boring.

If improperly managed during construction, these activities could cause:

- potential mobilisation and erosion of soil, including potentially contaminated soil
- potential movement of sediment to surrounding land, vegetation, and waterways within and outside of the construction footprint.

The tunnelling methodology and alignment have been designed based on geotechnical investigations and specialist engineering input to minimise the risk of any soil or geology impacts.

The works are not proposing to permanently change the surface topography and drainage patterns of the area. The area will be returned to its original topography and drainage pattern following construction. All temporary hardstand would be removed and the construction footprints would be reinstated. All excavations would be backfilled and reinstated. Once the launch and retrieval shafts are backfilled, access hatches would be installed. These access hatches would be flush with, or slightly above, ground level. The increase in the area of hardstand (ie the surface area of the access hatches) is considered negligible.

Impacts to topography, geology, and soils during construction would be managed through the below mitigation measures.

Mitigation measures

With the implementation of the mitigation measures below, impacts to topography, geology, and soils can be adequately managed, and residual impacts are expected to be low. No impacts are anticipated during operation.

Table 6-2 Environmental mitigation measures — topography, geology and soils

Mitigation measures
Appropriate erosion and sediment controls should be installed at all sites to avoid sedimentation of receiving water bodies or other indirect impacts to surrounding biodiversity values. Prevent sediment moving offsite in accordance with Managing Urban Stormwater, Soils and Construction, Volume 1 and 2A (Landcom 2004 and DECC 2008), including, but not limited to: • develop a Soil and Water Management Plan (SWMP) as part of the CEMP • divert surface runoff away from disturbed soil and stockpiles • install sediment and erosion controls before construction starts • reuse topsoil where possible and stockpile separately • inspect controls at least weekly and immediately after rainfall • rectify damaged controls immediately • remove controls once surfaces have been stabilised, including removing trapped sediment in drainage lines.
Consider seeking advice from a specialist soil and water management consultant when developing the SWMP and during construction.
Minimise ground disturbance and stabilise disturbed areas progressively.
Contractor to ensure imported material is Virgin Excavated Natural Materials (VENM) or meets a relevant NSW EPA Resource Recovery Order and Resource Recovery Exemption, or is a commercially supplied material that is not waste. If using materials that are subject to a NSW EPA Resource Recovery Order/Exemption the contractor must ensure the conditions in that Order/Exemption are strictly adhered to.
Stop work in the immediate vicinity of suspected contamination. Indicators of contamination include discoloured soil, anthropogenic material within fill, asbestos, chemical or petrol odours and leachate. Contain disturbed material on an impermeable surface and cordon areas off. Notify the Sydney Water Project Manager and the Environmental Representative (who will contact Property Environmental Services) to agree on proposed management approach.
Stop work during heavy rainfall or in waterlogged conditions when there is a risk of sediment loss off site.
Sweep up any sediment/soil transferred off site at least daily, or before rainfall.
Eliminate ponding and erosion by restoring natural landforms to the pre-works condition.

6.1.2 Water and drainage

Existing environment

The existing environment is described in Table 6-3. Waterways near the proposal are shown in Figure 3-2 and Figure 3-3.

Table 6-3 Existing environment – water and drainage

Site features	General commentary (where required)	Thornleigh Reservoir/ launch shaft	Inlet/outlet main alignment	Thornleigh-Wahroonga Water Pumping Station/ retrieval shaft
Nearest stormwater drain/ waterway	NA	An unlined swale drain roughly follows the 180-181 m AHD contour within Thornleigh Reservoir lot boundary. This swale drain connects two stormwater drains within the property. There are multiple stormwater drainage pits within Thornleigh Reservoir lot boundary. An unlined drainage line runs parallel to the access road. Stormwater within the site appears to flow into the council stormwater network and then into Larool Creek. At its closest point, Larool Creek is about 320 m east of Thornleigh Reservoir lot boundary.	Council stormwater network is mapped on local streets close to the proposed alignment. It is unlikely any of these stormwater pipes would be impacted by the proposal since the inlet/outlet main would be installed at least 10 m underground.	Thornleigh-Wahroonga Water Pumping Station and proposed retrieval shaft are adjacent to a first order section of Zig Zag Creek. This is a small local creek which flows into Berowra Creek. The creek has historically undergone significant modifications. These include minor alignment modifications as well as concreting and reinforcing/ stabilisation of embankments. Thornleigh-Wahroonga Water Pumping Station and retrieval shaft are at a low point in the landscape. They are therefore likely to collect some local stormwater or rainwater from nearby higher points in the landscape.
Groundwater dependent ecosystem (GDE) (Bureau of Meteorology, 2023)	NA	Some low-potential GDE in the north and east of Thornleigh Reservoir site.	None within 200 m of the inlet/outlet main alignment.	None within 200 m of Thornleigh-Wahroonga Water Pumping Station.

Site features	General commentary (where required)	Thornleigh Reservoir/ launch shaft	Inlet/outlet main alignment	Thornleigh-Wahroonga Water Pumping Station/ retrieval shaft
Groundwater (Sydney Water Planning Partner, 2023a and 2023b)	Groundwater monitoring wells were installed during preliminary site investigations, within the proposed construction footprint. Regional groundwater flow is expected to be consistent with the topography, flowing generally north-east of Thornleigh Reservoir towards Larool Creek, and west from the southern end of the inlet/outlet main toward Zig Zag Creek. All overland flow and stormwater should percolate into groundwater where not concentrated by hardstand. Direction of groundwater is likely to be controlled by proximity to local surface water bodies and areas of higher permeability soil.	Groundwater monitoring data from November 2022 and February 2023 indicates groundwater depths within Thornleigh Reservoir site of between 1.65 m and 8.39 m below ground level. Groundwater analysis indicated exceedances of the adopted freshwater guidelines for dissolved heavy metal concentrations. These may be due to natural background levels.	Most of the tunnelling is through sandstone, and groundwater is not expected in the sandstone layer. There may be some minor groundwater seepage from other soil layers.	Groundwater monitoring data from November 2022 and February 2023 indicates groundwater depths at the retrieval shaft of between 3.74 and 3.86 m below ground level. Groundwater analysis indicated exceedances of the adopted freshwater guidelines for dissolved heavy metal concentrations. These may be due to natural background levels.

Site features	General commentary (where required)	Thornleigh Reservoir/ launch shaft	Inlet/outlet main alignment	Thornleigh-Wahroonga Water Pumping Station/ retrieval shaft
Groundwater source	Water sharing plan for the proposal is Greater Metropolitan Region Groundwater Sources 2011.	Sydney Basin Central Groundwater Source	Sydney Basin Central Groundwater Source	Sydney Basin Central Groundwater Source
Flood mapping (Hornsby Shire Council, 2023)	Mapping based on data provided by council. The 1% Annual Exceedance Probability (AEP) flood extent typically represents the area likely to be flooded during a 1-in-100-year flood event.	A small area of vegetated land within the construction footprint is within the 1% AEP flood extent. This area is west of the intersection of Koorngal Avenue and Yarrabung Avenue, and vegetation removal is required.	Some areas of land above the inlet/outlet main are within the 1% AEP flood extent, including Nicholson Avenue, Giblett Avenue, and Edmundson Close.	Most of the retrieval shaft site is mapped within the 1% AEP flood extent.

Potential impacts

The proposal will require:

- establishing additional hardstand for compounds and laydown areas
- storing fuels and chemicals on site
- cleaning the pipes and discharging the associated water to a receiving waterbody or into the Sydney Water network. The volume of water is expected to be about 1 ML
- dewatering groundwater – about 1.6 ML (Sydney Water, 2023b)
- working above or near waterways at Zig Zag Creek. Installation of the temporary steel bridge/culvert over Zig Zag Creek requires vegetation clearing, and excavation to install the concrete abutments. The steel girders and bridge deck would be installed before placing scour protection within the creek bed. Water flow through the creek would not be impacted during installation, use, and removal of this temporary structure.
- excavating and temporarily storing materials on flood-prone land. At the receival shaft, any materials brought to site, or waste generated, would be used or moved off site quickly due to the lack of storage space within the site
- removing, relocating, and reinstating existing stormwater channels which overlap with open trenching within Thornleigh Reservoir.

If improperly managed during construction, these activities may cause:

- increased surface water runoff
- scouring of unsealed ground from stormwater travelling along different alignments to existing flow patterns
- adverse impacts to water quality
- changes to water flow of Zig Zag Creek during culvert installation and use
- significant impacts to water tables and existing groundwater levels
- off-site impacts from soil, waste, and other materials displaced from flood events or heavy rain.

No impacts to existing stormwater patterns or existing flooding patterns are expected during construction. Water discharge locations would not change during operation.

Mitigation measures

With the implementation of the mitigation measures below, impacts to water and drainage can be adequately managed, and residual impacts are expected to be low. No impacts are anticipated during operation.

Table 6-4 Environmental mitigation measures — water and drainage

Mitigation measures
Use appropriate controls to avoid potential sedimentation to waterbodies (eg floatation boom).
Consider the DPI Water Guideline for watercourse crossings on waterfront land during the design and construction of works within 40 m of Zig Zag Creek (particularly the temporary steel bridge/culvert installation, use, and removal) to protect waterfront land, including restoration activities once construction is complete.
Bund potential contaminants and store on robust waterproof membrane, away from drainage lines.
Locate portable site amenities, chemical storage and stockpiles of erodible materials away from watercourses, drainage lines and flood prone areas.
For work areas within the 1% AEP flood extent, minimise the duration and quantity of material storage, particularly of erodible materials. Take all erodible waste and stockpiled materials off site as soon as possible.
Conduct refuelling, fuel decanting and vehicle maintenance in compounds where possible. If field refuelling is necessary, designate an area away from waterways and drainage lines with functioning spill kits close by.
Keep functioning spill kit on site for clean-up of accidental chemical/fuel spills. Keep the spill kits stocked and located for easy access.
During the works, stockpiles are to be kept to a minimum to ensure that off-site disposal or adequate mitigation measures to prevent sedimentation of waterways can be established in the event of a large flood warning.
If potential for intercepting groundwater is identified Sydney Water will obtain a groundwater Water Supply Works Approval and where dewatering is more than 3 ML per water year (from 1 July) a Water Access Licence from NRAR will also be obtained. The delivery contractor is responsible for: • preparing a Dewatering Management Plan at least four months prior to construction • complying with the approval conditions (such as protecting water quality; minimising aquifer extraction volumes, monitoring extraction with flow meters and recording volumes).
Consider and manage existing levels of heavy metals in the groundwater if the groundwater is dewatered to local water bodies during construction.
Discharge all water in accordance with Sydney Water's Water Quality Management During Operational Activities Policy (D0001667) including erosion controls, discharge rate, dechlorination, monitoring. Re-use potable / groundwater water where possible.
If discharge to the environment is not possible, seek approval and discharge criteria from the relevant Sydney Water Network Area Manager prior to discharge to the wastewater system. Otherwise tanker by a licensed waste contractor and dispose off-site to an appropriately licensed facility.

Mitigation measures
Conduct any equipment wash down within a designated washout area.
Ensure equipment is leak free. Repair oil/fuel leaks immediately or remove from site and replace with a leak-free item.
Prepare Drilling Fluid Management plan to avoid impacts, including: • contain and monitor drilling fluids at entry/exit points • identify and manage frac-outs • re-use and/or disposal of drilling fluids (checking waste classification).
Manage stormwater flows during construction to minimise scour.

6.1.3 Flora and fauna

Existing environment

A specialist ecological assessment was completed for the proposal (Appendix C, Biosis, 2023). The study area assessed for the proposal consisted of the construction footprint and the adjacent land likely to be directly or indirectly impacted by the proposal.

The existing environment within the study area includes native and non-native vegetation, including threatened ecological communities (TEC) as shown in Table 6-5.

Table 6-5 Plant communities in the study area

Plant Community Type (PCT) number	PCT description	Associated TEC	Vegetation condition	Approximate area within the study area (ha)
1183	Smooth-barked Apple – Sydney Peppermint – Turpentine heathy open forest on plateaux areas of the Sydney Basin Bioregion	Sydney Turpentine-Ironbark Forest in the Sydney Basin Bioregion (BC Act) Turpentine-Ironbark Forest of the Sydney Basin Bioregion (EPBC Act)	Moderate to high	3.9
1281	Turpentine – Grey Ironbark open forest on shale in the lower Blue Mountains, Sydney Basin Bioregion	Sydney Turpentine-Ironbark Forest in the Sydney Basin Bioregion (BC Act) Turpentine-Ironbark Forest of the Sydney	Low to high	2.8

Plant Community Type (PCT) number	PCT description	Associated TEC	Vegetation condition	Approximate area within the study area (ha)
		Basin Bioregion (EPBC Act)		
1787	Red Bloodwood – Scribbly Gum-Stringybark open forest on sandstone ridges along the western side of the Woronora and Hornsby plateaus	NA	High	1
NA	Urban native/ exotic	NA	NA	0.7
NA	Exotic grasslands	NA	NA	6.5

Thirty-seven threatened flora species were recorded or predicted to occur within 5 km of the study area. Six species were assessed as most likely to have habitat within the study area based on background research. Of these six species, four are either easily conspicuous all year round or the survey was performed during their flowering period when they are most visible. No threatened flora species were identified during field survey. Therefore, none of these four conspicuous species are considered likely to occur in the study area. The study area provides potential habitat for the remaining two threatened flora species:

- *Epacris purpurascens var. purpurascens* (Vulnerable, BC Act).
- Bauer's Midge Orchid *Genoplesium baueri* (Endangered, BC Act and EPBC Act).

The study area contains potential habitat for threatened fauna (Table 6-6). Sixty threatened fauna species were recorded or predicted to occur within 5 km of the study area. Sixteen species were assessed as most likely to have habitat within the study area based on background research. The impact of the proposal on this potential habitat was assessed. Potential habitat for threatened fauna has a low likelihood of being impacted during the proposal.

Table 6-6 Assessment of potential habitat for threatened fauna

Habitat feature	Presence within study area	Fauna association	Relevant threatened fauna likely to use this habitat	Likelihood of occurrence or impact
Feed trees and foraging habitat	Yes – flowering perennial species such as *Angophora* sp. and *Eucalypt* sp.	Range of arboreal and flying fauna while in flower – provide nectar. Feed tree and foraging resources.	Grey-headed Flying Fox, nectivorous bird species, insectivorous bat species, Koala, Glossy Black Cockatoo, and other Cockatoo species.	Bird species are unlikely to be impacted due to their mobility, surrounding resources and landscape connectivity. No Grey-headed flying fox camps are nearby and no breeding habitat would be impacted. Insectivorous bat species are previously recorded in the locality. They are unlikely to be impacted as their connectivity would not be impacted, their mobility, and lack of roosting features in the study area Koala feed trees are present within the study area and the closest sighting is 1.4 km from the study area. Contiguous potential habitat and vegetation connectivity would be maintained. Impacts are low as habitat removal involves trimming and minor clearing.
Hollow-bearing trees	No	Shelter and/or breeding	Multiple species	No impact expected.
Waterways (creek, river, or dam)	Yes, one waterway (Zig Zag Creek). This waterway is degraded by weeds and stormwater runoff.	Low quality habitat for amphibian species.	Red-crowned Toadlet	Multiple sightings of Red-crowned Toadlet within 1 km of the study area as recently as 2021. Likelihood of occurrence is low due to the poor water quality of the creek.

Habitat feature	Presence within study area	Fauna association	Relevant threatened fauna likely to use this habitat	Likelihood of occurrence or impact
Leaf litter and woody debris	Yes, some areas	Shelter for gastropod species.	Dural Land Snail – this species favours sheltering under rock or bark but has been observed resting in exposed areas.	Closest record of this snail is about 1.8 km from the study area. Minor impacts expected to this species due to large amount of contiguous habitat being retained and their slow dispersal rate.
Caves, karsts, cliffs, overhangs, man-made structures	None of these features were identified within the study area.	Some man-made structures provide roosting habitat.	NA	No man-made structures with potential for roosting were identified in or near the study area. Roosting habitat associated with these features would not be impacted.

Zig Zag Creek is a first order stream located south of the Edmundson Close cul-de-sac. The creek was identified as a poor condition ephemeral stream. The creek is largely modified and fed by stormwater runoff. Vegetation around the creek is highly modified – mostly planted native and exotic species with a high proportion of weed species. No key fish habitat is present within the study area.

In general, the study area has been heavily modified, and a large proportion of the vegetation has been removed for construction of Thornleigh Reservoir and Thornleigh-Wahroonga Water Pumping Station. However, native vegetation communities remain within Thornleigh Reservoir site, around Thornleigh Reservoir structure. The vegetation community along the eastern boundary of Thornleigh Reservoir site has high connectivity. This vegetation connects to adjacent vegetation outside the study area. Three priority weeds were also present in the study area. No roosting habitat (eg rock outcrops, hollow bearing trees, or other artificial structures) was identified within the study area during the field survey. Vegetation communities and ecological constraints are mapped in Figure 6-2 and Figure 6-3.

At the Thornleigh Reservoir site, no excavation can occur on the dam or embankment, to protect the structural integrity and stability of the dam and prevent dam failure. The outcome of dam failure is considered extreme. Therefore, the construction footprint including the location of the launch shaft and access track must be located outside the embankment. This means that the construction footprint must include removal of vegetation south-east of Thornleigh Reservoir. This construction footprint has been refined during concept design to reflect the most likely extent of vegetation removal. The delivery contractor will be encouraged to further refine this construction footprint and reduce the overall extent of vegetation removal during construction.

Figure 6-2 Vegetation communities and ecological constraints at the study area (Thornleigh Reservoir)

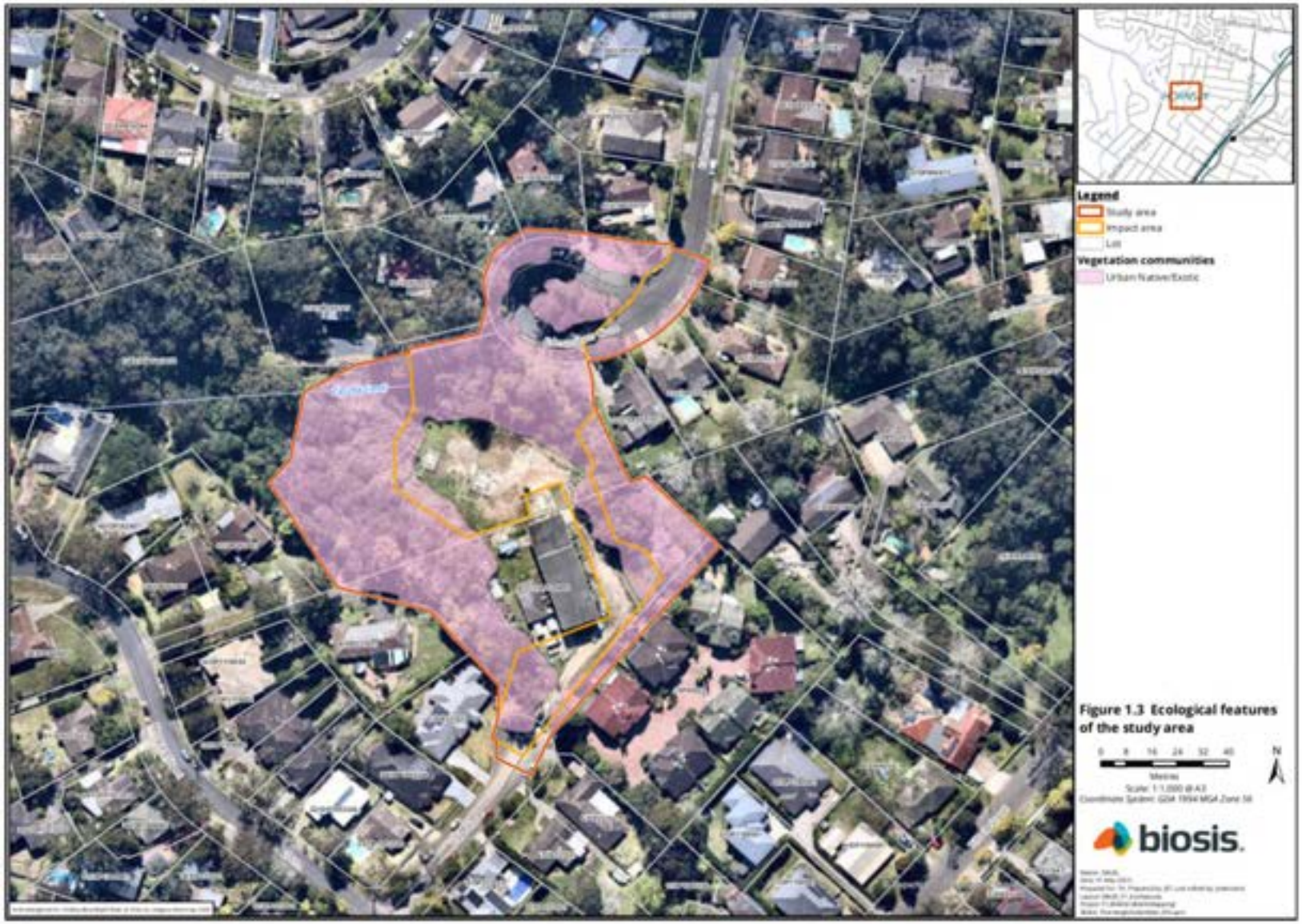

Figure 6-3 Vegetation communities and ecological constraints at the study area (retrieval shaft and surrounds)

Potential impacts

During construction, the proposal involves:

- removing non-threatened vegetation, including riparian vegetation and weeds
    - 0.02 ha of PCT 1787 (high quality) at the northern construction footprint
    - 0.35 ha of urban native/exotic at the southern construction footprint
- removing threatened native vegetation
    - 0.15 ha of PCT 1183 (moderate and high quality) at the northern construction footprint, along the widened access track
    - 0.38 ha of PCT 1281 (low, moderate, and high quality) at the northern construction footprint, along the widened access track and surrounding the launch shaft
- impact to one TEC and potential to impact one threatened flora species listed under the EPBC Act. Significant impacts are unlikely due to the low level of impact and the large number of continuous areas of habitat being retained as part of the proposal. This TEC and species are:
    - Turpentine-Ironbark Forest of the Sydney Basin Bioregion (EPBC Act)
    - Bauer's Midge Orchid *Genoplesium baueri* (Endangered, BC Act and EPBC Act)
- impact to one TEC and potential to impact two threatened flora species listed under the BC Act. Significant impacts are unlikely due to the low level of impact and the large number of continuous areas of habitat being retained as part of the proposal. This TEC and species are:
    - Sydney Turpentine-Ironbark Forest in the Sydney Basin Bioregion (BC Act)
    - *Epacris purpurascens var. purpurascens* (Vulnerable, BC Act).
    - Bauer's Midge Orchid *Genoplesium baueri* (Endangered, BC Act and EPBC Act).
- removing 0.55 ha potential habitat for the two threatened flora species listed above (combined areas of PCT 1183, PCT 1281, and PCT 1787)
- trimming street trees along the proposed construction vehicle access routes (refer section 6.1.8 of the REF) and along access tracks, especially to allow for clearance of heavy vehicles
- low likelihood of impacting habitat for threatened fauna species (refer Table 6-6)
- low likelihood of impacting any aquatic species, or habitat for threatened fauna species (refer Table 6-6). Zig Zag Creek may be temporarily impacted during construction, however no further degradation of the creek is expected as a result of vegetation removal
- indirect, localised impacts to fauna from dust, vibration, noise emissions and light spill.

Thornleigh Reservoir is on private land and vegetation removal within the site will not impact public bushland. Public bushland would need to be removed at the retrieval shaft. These trees are within a grassed area on publicly accessible Crown Land, and include vegetation along Zig Zag Creek and bordering adjacent private properties. These trees are not associated with a threatened or non-threatened vegetation community. Currently, all this vegetation (the 0.35 ha of urban native/exotic vegetation listed above) has been assessed for removal.

Mitigation measures

With the implementation of the mitigation measures below, impacts to flora and fauna can be adequately managed, and residual impacts are expected to be minor.

Table 6-7 Environmental mitigation measures — flora and fauna

Mitigation measures
Vegetation clearing and disturbance
Provided it is essential for delivering the project, Sydney Water's Project Manager can approve the following vegetation removal and tree trimming, without additional environmental assessment (but only after consultation with the project's Environmental and Community Representatives and affected landowners). Sydney Water considers vegetation removal in these circumstances has minimal environmental impact. • Any minor: - vegetation trimming or - removal of exotic vegetation or - removal of planted native vegetation where the vegetation is not a threatened species (including a characteristic species of a threatened community or population), heritage listed, in declared critical habitat or in a declared area of outstanding biodiversity value. • Any removal of remnant vegetation where there is no net change to environmental impact (eg a different area of vegetation is removed but the total area is the same or less than assessed in the EIA). Written explanation of the application of this clause (including justification of the need for trimming or removal and any proposed revegetation) should be provided when seeking Project Manager approval. Any impacts to native vegetation and trees must be offset in accordance with the Biodiversity Offset Guideline (SWEMS0019.13).
Minimise vegetation clearance and disturbance, including impacts to standing dead trees and riparian zones. Where possible, limit clearing to trimming rather than the removal of whole plants.
Where the need for tree trimming is known (eg for construction vehicle access routes), complete an assessment of the impact of trimming to tree health closer to construction. Engage a suitably qualified arborist to provide an estimate of trimming extent, potential impacts and any mitigation measures.
The delivery contractor should identify initiatives to reduce the area of cleared vegetation from the maximum area assessed in this REF. Options to consider, where feasible, include but are not limited to:

Mitigation measures

- alternative construction methodologies (eg compressed construction corridors)
- arborist engagement during detailed design or pre-construction to identify Tree Protection Zones and where there may be opportunity to remove and/or trim branches and/or roots instead of removing trees (particularly where open excavation is required).

Vegetation removal must not occur until the following are complete:

- the area to be removed has been physically delineated
- the contractor's Environmental Representative has confirmed consistency with approval documentation
- pre-clearing surveys, if relevant and
- written authorisation to commence clearing from Sydney Water Project Manager.

Map and report native vegetation clearing greater than 0.01 ha in extent (and any associated rehabilitation) to the Sydney Water Environmental Representative. Track vegetation clearing as per SWEMS0015.26 Contractor Native Vegetation Clearing and Rehabilitation template.

Vegetation protection and replanting (including offset requirements)

Physically delineate vegetation to be cleared and/or protected on site and install appropriate signage prior to works commencing.

Adjust methodology (eg avoid area, hand excavate, implement exclusion fencing) to protect sensitive areas where possible (such as mature trees, known threatened species, populations or ecological communities).

Protect trees in accordance with the requirements of Australian Standard 4970-2009 for the Protection of Trees on Development Sites. Do not damage tree roots unless absolutely necessary, and engage a qualified arborist where roots >50mm are impacted within the Tree Protection Zone.

Retain dead tree trunks, bush rock or logs in-situ unless they are in the impact area and moving is unavoidable. Reposition material elsewhere on the site or approved adjacent sites. If native fauna is likely to be present, a licenced ecologist should inspect the removal and undertake fauna relocation. See Fauna Encounters on Construction Sites Factsheet if you need further guidance. CEMP to include contact details of appropriately licenced handler.

Residual impacts to native vegetation and trees will be offset in accordance with the Biodiversity Offset Guideline (SWEMS0019.13). Preliminary calculation is that there would be an offset multiplier of 2:1 applied to non-threatened vegetation and offset multiplier of 3:1 for threatened vegetation removed for this proposal.

Locations for offset vegetation must be identified based on SWEMS0019.13. These locations may include:

- on site: native revegetation or bushland restoration
- nearby site: native revegetation or bushland restoration

Mitigation measures
• Sydney Water offset site bushland restoration.
Contractor to ensure offset vegetation is maintained for at least one year after planting is completed.
Refer to SWEMS0025.11 Managing Native Re-vegetation for Construction Projects for guidance.
Flora and fauna
Inspect vegetation for potential fauna prior to clearing or trimming. If fauna is present, or ecological assessment has determined high likelihood of native fauna presence, including removal of hollow bearing trees, engage WIRES or a licenced ecologist to inspect and relocate fauna before works.
Within PCTs 1183, 1281, and 1787: Pre-clearance inspections within the impact area and immediate surrounds for *Epacris purpurascens* var. *purpurascens* (anytime) and Bauer's Midge Orchid *Genoplesium baueri* (within the flowering period February – March).
All staff on site are to be educated on the ID characteristics of the threatened species and advised to not handle fauna species under any circumstances. This information would be conveyed in Safe Work Method Statements and during toolbox talks.
If native fauna is encountered on site, stop work and allow the fauna to move away unharassed. Engage WIRES or a licenced ecologist if assistance is required to move fauna.
Avoid impeding/blocking fish passage. Retain snags and natural obstructions in waterways where possible.
If any threatened species (flora or fauna) is discovered during the works, stop work immediately and notify the Sydney Water Project Manager. Work will only recommence once the impact on the species has been assessed and appropriate control measures provided.
Other
Manage biosecurity in accordance with: • Biosecurity Act 2015 (see NSW Weedwise), including reporting new weed infestations or invasive pests • contemporary bush regeneration practices, including disposal of sealed bagged weeds to a licenced waste disposal facility. Record Pesticides and Herbicides use in accordance with SWEMS0017.
To prevent spread of weeds, clean all equipment including PPE prior to entering or leaving the work sites.
Potentially affected residents will be notified of any tree removal.
All stockpile and compound areas are to be located within existing cleared areas and existing access tracks, and will be rehabilitated at the end of construction.

6.1.4 Heritage

Existing environment and potential impacts

Aboriginal heritage

An Aboriginal and historic heritage due diligence assessment was completed for the proposal (Appendix D, AECOM, 2022). This included a desktop assessment and site visit in November 2022.

The study areas identified by the assessment are:

- Northern study area – within Thornleigh Reservoir lot boundary, including vegetation disturbance, widening of access road, launch shaft, and laydown area.
- Southern study area – near Thornleigh-Wahroonga Water Pumping Station, and including vegetation disturbance, hardstand installation, retrieval shaft, and laydown area.

The landscape context of the study areas was considered, as the nature and distribution of archaeological materials are closely connected to the environments in which they occur. Landscape features including topography, geology, soils, hydrology, and flora and fauna were considered. Existing archaeological survey data for the Cumberland Plain indicates a trend of open artefact sites being present along watercourses. At both the northern and southern study areas, there has been disturbance to these landscape features from vegetation clearance, waterway modification, construction of infrastructure including utilities, grading for access tracks, and urban development.

A search of the AHIMS database on 17 November 2022 identified that there are no previously recorded sites within the study areas. [redacted]

No evidence of past Aboriginal occupation was observed during the site visit.

The outcomes of the due diligence assessment are:

- There are no registered Aboriginal sites within the northern and southern study areas.
- No Aboriginal objects were identified during the visual inspection component of this assessment.
- Aboriginal archaeological sensitivity of the both the northern and southern study areas was assessed as low.
- No further Aboriginal heritage assessment works are considered warranted for both the northern and southern study areas.

Non-Aboriginal heritage

One non-Aboriginal heritage item was identified within the study area:

- Street Trees, Giblett Avenue, Thornleigh. Item ID 706 under the Hornsby LEP (Figure 6-5).

Figure 6-4 Location of AHIMS sites in relation to the proposal (Appendix D, AECOM, 2022)

Aboriginal heritage information must not be made publicly available or be published in any form or by any means by Sydney Water or our contractors / joint ventures, unless where approval has been sought from the AHIMS Registrar and provided in writing to Sydney Water. Sydney Water has removed this information out of respect for Aboriginal cultural heritage and the Aboriginal community.

Figure 6-5 Non-Aboriginal heritage near the southern study area of the proposal (Appendix D, AECOM, 2022)

Trimming of branches overhanging the road is required for seven of these trees (Figure 6-6). This will provide clearance (about 4.5 m height) for vehicles, plant, and equipment entering and exiting Edmundson Close. A SOHI was prepared to assess potential impacts of the proposal on the heritage value of the Street Trees (Appendix E). This included a site visit in March 2023.

The SOHI lists several outcomes regarding the Street Trees:

- The trees have local heritage significance, based on their aesthetic/technical value and representative value in the streetscape.
- All seven trees are in good health and require selective branch pruning.
- The arborist identified the trimming would have a minor impact on tree health. Since the trees are in good health, the foliage loss from the trimming is not considered significant.
- The impact of the proposal on the heritage significance of the Street Trees has been minimised.
- Trimming will not significantly impact views to or from the heritage item.
- The proposal will not impact the heritage values or overall heritage significance of the Street Trees.

Figure 6-6 Location of heritage-listed trees requiring trimming (Appendix E, AECOM, 2023)

Mitigation measures

With the implementation of the mitigation measures below, impacts to Aboriginal and non-Aboriginal heritage can be adequately managed, and residual impacts are expected to be negligible. No impacts are anticipated during operation.

Table 6-8 Environmental mitigation measures — heritage

Mitigation measures
Avoid impacts to [redacted] during construction. Contractors working on the project should be made aware of the location of this item and their obligation not to impact it.
In the event that Aboriginal objects or historic heritage items, including possible human skeletal material (remains), are identified during construction works all works in the area must cease immediately and the relevant provision of Sydney Water's Environmental Management System (SWEMS009) should be followed. The stop work procedure should be included within the Project's construction management plan
Do not make publicly available or publish, in any form, Aboriginal heritage information on sites / potential archaeological deposits, particularly regarding location.
Repeat the basic AHIMS search if it is older than 12 months. Conduct additional assessment if new sites are registered and could be impacted by the works.
Sydney Water/the contractor should engage an arborist to complete the trimming works to ensure the heritage-listed trees are not inadvertently damaged.
Sydney Water personnel and contractors should be made aware of the location of heritage item "Street Trees" (ID#706) and their obligation not to impact the trees beyond the proposed trimming works.

6.1.5 Noise and vibration

A specialist assessment was performed to assess construction noise and vibration impacts (Appendix F, Arup, 2023). No operational noise impacts are expected.

Existing environment

A nominal study area of 1 km from the construction footprint was adopted. The noise sensitive receivers within 1 km of the construction footprint have been identified as being mostly residential properties. Other land uses include recreational, educational, industrial, commercial, and places of worship.

Relevant criteria and background levels – air-borne noise

Unattended noise monitoring was undertaken to determine background noise levels for air-borne noise (Table 6-9). This monitoring established the noise management levels (NMLs) for the proposal and quantified background noise levels at the nearest sensitive receivers.

Table 6-9 Background noise levels – unattended noise monitoring results

Noise measurement ID	Location	Date	Logger and Logger serial number	Rating Background Levels (RBL), dBL_{A90}[1] (Day, Evening, Night)
L1	Thornleigh Reservoir – behind 53 The Sanctuary	5-20 December 2022	B&K EMS 63659-B3012345	35, 34, 27
L2	Thornleigh-Wahroonga Water Pumping Station – behind 20 Morgan Street	5-20 December 2022	B&K EMS 63659-B3023572	38, 35, 32

The NMLs for residential receivers were derived from the background noise levels in Table 6-9. NMLs for non-residential receivers were based on the Interim Construction Noise Guideline (ICNG) (DECC NSW, 2009). Table 6-10 shows these NMLs.

Table 6-10 NMLs for noise sensitive receivers – external noise levels

Type of receiver	Time period[1]	Highly noise affected	Standard Hours[2] $dBL_{Aeq(15\ min)}$	Outside standard hours[3] $dBL_{Aeq(15\ min)}$		
				Day	Evening	Night
Residential[6]	Day	75[4]	45	40	39	35[5]
Commercial	When in use	NA	70			
Educational	When in use	NA	55			
Place of Worship	When in use	NA	55			
Child Care	When in use	NA	55			
Industrial	When in use	NA	75			
Active recreation	When in use	NA	65			

Notes:

1_The Noise Policy for Industry (EPA, 2017) (for non-residential receivers) defines day, evening and night time periods as:

- Day: the period from 7 am to 6 pm Monday to Saturday; or 8 am to 6 pm on Sundays and Public Holidays.
- Evening: the period from 6 pm to 10 pm.
- Night: the remaining period.

2_The ICNG (DECC NSW, 2009) defines Standard hours as Monday to Friday 7 am to 6 pm and Saturday from 8 am to 1 pm.

3_Outside standard hours are defined as:

- Day: Sundays and public holidays – 8 am to 6 pm, Saturday 7 am to 8 am and 1 pm to 6 pm
- Evening: Monday to Saturday – 6 pm to 10 pm, Sunday and public holidays – 6 pm to 10 pm

- Night: Monday to Saturday – 12 am to 7 am and 10 pm to 12 am,
- Sundays and public holidays – 12 am to 8 am and 10 pm to 12 am

4_In accordance with the ICNG (DECC NSW, 2009) the highly noise affected applies to residential properties only

5_Per the Noise Policy for Industry (EPA, 2017) where the measured background noise level is below the minimum RBL (as defined below), the background is set to the minimum background:

- Day: 35 dBA
- Evening: 30 dBA
- Night: 30 dBA

6_Results of noise logger L1 (refer Table 6-9) were conservatively used to determine the NMLs to all residential receivers.

Relevant criteria and background levels – ground-borne noise

Ground-borne noise is noise generated by vibration transmitted through the ground into a structure. Ground-borne noise is usually present on tunnelling projects, when tunnelling equipment is operating underground. For this proposal, ground-borne noise may be experienced during tunnel boring. Ground-borne noise is usually not a significant disturbance to building occupants during the day. Higher ambient noise levels during the day typically mask sounds from ground-borne noise. However, during evening and night time periods, when ambient noise levels are lower, ground-borne noise is more prominent.

Objectives for internal noise levels for residential receivers in relation to ground-borne NMLs (GBNMLs) are presented below (DECC, 2009):

- Evening (6 pm to 10 pm) – 40dB(A).
- Night (10 pm to 7 am) – 35 dB(A).

Relevant criteria – vibration

The effect of vibration in buildings can be divided into three main categories:

- Human perception of vibration. This is when occupants or users of buildings are potentially disturbed by vibration.
- Effects on building contents. Some scientific equipment (such as microscopes or microelectronics) can require more stringent objectives than those applicable to human comfort. Where appropriate, these objectives should be sourced from the manufacturer or other published objectives. No receivers have been identified as containing any sensitive equipment. However, this may change following consultation.
- Effects of vibration on structures. Vibration may cause damage ranging from cosmetic to major structural damage, where the integrity of the building or structure is affected. These criteria are typically well above the level of vibration people may consider intrusive.

Potential impacts – construction air-borne noise

NMLs for air-borne and ground-borne noise represent a threshold for noise impacts to sensitive receivers. Where construction noise impacts are predicted to be above NMLs, additional reasonable and feasible mitigation measures to reduce noise impacts should be considered.

An acoustic model was prepared based on the likely construction activities, and equipment to be used during each activity. A preliminary construction staging program was provided. The model

predicted expected construction noise levels at each receiver for each activity. The program and assessed scenarios and activities are shown below (Table 6-11).

Table 6-12 summarises the noise assessment results for each construction scenario, including the predicted sound power levels during construction. Each construction scenario represents multiple activities being performed over a certain time period within the construction program. Consolidating multiple activities into different scenarios over different time periods and in specific locations means that a scenario is representative of the likely cumulative noise impact from these consolidated activities. Although the cumulative noise impacts from multiple construction scenarios in progress at the same time has not been assessed, the predicted noise levels have been based on all pieces of equipment required for each activity/scenario operating continuously at the same time. This is a worst-case assessment as it is not expected that all plant and equipment in each scenario would be used at once, and NML exceedances are likely to lower than what has been assessed.

Noise modelling results for air-borne noise, showing the sensitive receivers highly noise impacted (noise levels greater than 75 dB) during each scenario, are also presented in Figure 6-7 to Figure 6-10 and Figure 6-13, and Figure 6-15. Where no receivers are predicted to be highly noise impacted from air-borne noise during a scenario, the closest noise affected receivers are presented (Figure 6-14). Table 6-13 shows the number of receivers predicted to be impacted by noise during each construction scenario. Up to 62 residential receivers are predicted to be highly noise affected during construction of Scenario 1 at the launch and receival shaft (months 1-2), Scenario 2 at the launch shaft (months 3-4), and Scenario 5 at the launch shaft (months 11-14). The number of receivers predicted to be highly noise impacted during other scenarios range from none to 17. The noisiest construction scenarios are Scenario 1 (at the launch shaft and retrieval shaft from months 1-4) and Scenario 6b (at the launch shaft from months 23-24), which have predicted noise levels of 129 dB. During these scenarios, the likely range of equipment to be used includes multiple pieces of noisy equipment, including chainsaw, compactor, excavators (with and without hammer attachment), electric hand tools, and trucks.

An acoustic shed is proposed around the launch shaft during tunnel boring activities. When installed in accordance with manufacturer specifications, it is predicted that an acoustic shed would reduce air-borne noise levels outside the shed by about 20 dB. The modelling shows that the unmitigated noise levels of 122 dB would reduce to 102 dB with installation of this shed. This has a significant impact on the number of residential receivers predicted to be impacted by air-borne noise during tunnel boring. Unmitigated construction noise is predicted to be above NML for 4,540 residential receivers (including two highly noise affected receivers), and mitigated construction noise is predicted to be above NML for 183 residential receivers (with no highly noise affected receivers).

Sleep disturbance may be experienced by residential receivers during night works, where construction noise is predicted to be above NMLs. The mitigation measures outlined in Table 6-15 to reduce noise impacts should reduce the duration, extent, and quantity of residential receivers who may experience sleep disturbance.

Table 6-11 Construction activities and scenarios including preliminary construction staging program

ID	Activity description	Month														
		1-2	3-4	5-6	7-8	9-10	11-12	13-14	15-16	17-18	19-20	21-22	23-24	25-26	27-28	29-30
Ac01	Site mobilisation/ shaft excavation at launch site	X	X													
Ac02	Site mobilisation/ shaft excavation at retrieval site	X														
Ac03a	Work at reservoir – other day works								X	X	X	X				
Ac03b	Work at reservoir carrier main works						X	X								
Ac04a	Work in launch shaft – day			X	X	X	X	X								
Ac04b	Work in launch shaft – night			X	X	X	X	X								
Ac05a	Work at retrieval shaft – day		X	X	X	X	X	X	X	X	X	X				
Ac05b	Work at retrieval shaft – night		12 nights only of work during this period													
Ac06	Site demobilisation												X			
Ac07	Compound activities	X	X	X	X	X	X	X	X	X	X	X	X			
-	Contingency													X	X	X

Note: X represents Scenario 1, X represents Scenario 2, X represents Scenario 3, X represents Scenario 4, X represents Scenario 5, X represents Scenario 6a, X represents Scenario 6b, X represents Scenario 7.

Table 6-12 Summary of worst-case predicted noise impacts for each assessment scenario

Scenario	Description of works	Month	Hours of operation	Sound power levels (dBA)
1: Site establishment (Figure 6-7 and Figure 6-8)	Site 1 (Area 1A): Establishing access roads, vegetation removal. Compound: Supporting activities in the active sites. Site 2: Excavation of launch shaft, establishment of drilling plant and equipment installation. Site 3 (Area 3A): Establishing access roads, vegetation removal. Site 3 (Area 3C): Excavation of retrieval shaft and installation of concrete piles.	1-2	Standard hours of construction (Day)	Site 1 (Area 1A): 129 Compound: 129 Site 2: 127 Site 3 (Area 3A): 129 Site 3 (Area 3C): 116
2: Site establishment and Pipework (refer Figure 6-7 to Figure 6-10 for Scenario 1 and 3)	Site 1 (Area 1A): Establishing access roads, vegetation removal. Site 2: Excavation of launch shaft, establishment of drilling plant and equipment installation. Compound: Supporting activities in the active sites. Site 3 (Area 3B): Replace/widen existing footbridge or install new temporary bridge open trench pipe installation, connection of pipes and associated pipework activities.	3-4	Standard hours of construction (Day)	Site 1 (Area 1A): 129 Compound: 129 Site 2: 127 Site 3 (Area 3B): 125
3: Pipework (Figure 6-9 and Figure 6-10)	Site 1 (Area 1A): Deliveries Compound: Supporting activities in the active sites Site 2: Pipework and associated activities. Site 3 (Area 3B): Replace/widen existing footbridge or install new temporary bridge connection of pipes and associated pipework activities.	15-22	Standard hours of construction (Day)	Site 1 (Area 1A): 113 Compound: 113 Site 2: 121 Site 3 (Area 3B): 125

Scenario	Description of works	Month	Hours of operation	Sound power levels (dBA)
4: Tunnelling (Night) – Ground borne noise assessment (Figure 6-11 and Figure 6-12)	Site 2: Tunnelling and associated TBM activities.	5-14	Standard hours and outside standard hours of construction (24/7)	Impacts (when GBNML are exceeded) at any one receiver are anticipated to last for about 26 nights in total with a maximum of 17 nights when GBNML are exceeded by 10 dB or more.
4: Tunnelling (Night) – airborne noise (Figure 6-13)	Site 2: Tunnelling and associated TBM activities.	5-14	Standard hours and outside standard hours of construction (24/7)	Site 2: 122
4: Tunnelling (Night) – mitigated – airborne noise (Figure 6-14)	Site 2: Tunnelling and associated TBM activities.	5-14	Standard hours and outside standard hours of construction (24/7)	Site 2: 102 (assuming a 20 dB reduction provided by the installation of an acoustic shed)
5: Open Trenching and Pipework (refer Figure 6-7 to Figure 6-10 for Scenario 1 and 3)	Site 1 (Area 1A): Deliveries Site 1 (Area 1B): Open trenching and joining of pipes. Compound: Supporting activities in the active sites. Site 2: Tunnelling and associated TBM activities. Site 3 (Area 3B): Replace/widen existing footbridge or install new temporary bridge, open trench pipe installation, connection of pipes and associated pipework activities.	11-14	Standard hours of construction (Day)	Site 1 (Area 1A): 119 Site 1 (Area 1B): 128 Compound: 113 Site 2: 122 Site 3 (Area 3B): 125

Scenario	Description of works	Month	Hours of operation	Sound power levels (dBA)
6a: Tunnelling and Pipework (refer Figure 6-9 and Figure 6-10)	Site 1 (Area 1A): Deliveries Compound: Supporting activities in the active sites. Site 2: Tunnelling and associated TBM activities. Site 3 (Area 3B): Replace/widen existing footbridge or install new temporary bridge open trench pipe installation, connection of pipes and associated pipework activities.	5-10	Standard hours and outside standard hours of construction (24/7)	Site 1 (Area 1A): 113 Compound: 113 Site 2: 122 Site 3 (Area 3B): 125
6b: Tunnelling and Pipework (Night) (Figure 6-15)	Site 3 (Area 3C): Open trench pipe installation, connection of pipes and associated pipework activities.	12 nights only of work between months 3 to 22	Outside standard hours	Site 3 (Area 3C): 122
7: Site demobilisation (refer Figure 6-7 and Figure 6-8)	Site 1, Site 2 and Site 3: Removal of all plant, equipment and vehicles and backfill excavations. Compound: Supporting activities in the active sites.	23-24	Standard hours of construction (Day)	Site 1 (Area 1A): 123 Compound: 129 Site 2: 123 Site 3 (Area 3A): 123

Table 6-13 Number of receivers predicted to be impacted by construction noise during each scenario

Scenario	Day or night work	Airborne noise					Ground-borne noise		
		Below or equal to NML (compliant)	0-10 dB above NML	10-20 dB above NML	Greater than 20 dB above NML	Greater than 75 dB	Below or equal to GBNML (compliant)	0-10 dB above GBNML	Greater than 10 dB above GBNML
		Noticeable	Clearly audible	Moderately intrusive	Highly intrusive	Highly noise affected	Noticeable	Clearly audible	
1: Site establishment (Figure 6-7 and Figure 6-8)	Day	742	3046	2823	358	62	NA	NA	NA
2: Site establishment and Pipework (refer Figure 6-7 and Figure 6-10 for Scenario 1 and 3)	Day	At launch shaft: refer outcomes for Scenario 1 At retrieval shaft: refer outcomes for Scenario 3					NA	NA	NA
3: Pipework (Figure 6-9 and Figure 6-10)	Day	3935	2599	354	81	17	NA	NA	NA

Scenario	Day or night work	Airborne noise					Ground-borne noise		
		Below or equal to NML (compliant)	0-10 dB above NML	10-20 dB above NML	Greater than 20 dB above NML	Greater than 75 dB	Below or equal to GBNML (compliant)	0-10 dB above GBNML	Greater than 10 dB above GBNML
		Noticeable	Clearly audible	Moderately intrusive	Highly intrusive	Highly noise affected	Noticeable	Clearly audible	
4: Tunnelling (Night) – Ground borne noise assessment (Figure 6-11 and Figure 6-12)	NA	NA	NA	NA	NA	NA	6389	100	43
4: Tunnelling (Night) – airborne noise (Figure 6-13)	Night	2429	2910	1447	183	3	NA	NA	NA
4: Tunnelling (Night) – mitigated - airborne noise (Figure 6-14)	Night	6786	166	15	2	0	NA	NA	NA
5: Open Trenching and Pipework (refer Figure 6-7 and	Day	At launch shaft: refer outcomes for Scenario 1 At retrieval shaft: refer outcomes for Scenario 3					NA	NA	NA

Scenario	Day or night work	Airborne noise					Ground-borne noise		
		Below or equal to NML (compliant)	0-10 dB above NML	10-20 dB above NML	Greater than 20 dB above NML	Greater than 75 dB	Below or equal to GBNML (compliant)	0-10 dB above GBNML	Greater than 10 dB above GBNML
		Noticeable	Clearly audible	Moderately intrusive	Highly intrusive	Highly noise affected	Noticeable	Clearly audible	
Figure 6-10 for Scenario 1 and 3)									
6a: Tunnelling and Pipework (refer Figure 6-9 and Figure 6-10)	Both	At both launch and retrieval shaft: refer outcomes for Scenario 3					NA	NA	NA
6b: Tunnelling and Pipework (Night) (Figure 6-15)	Both	4543	1562	646	218	6	NA	NA	NA
7: Site demobilisation (refer Figure 6-7 and Figure 6-8)	Day	At both launch and retrieval shaft: refer outcomes for Scenario 1					NA	NA	NA

Figure 6-7 Predicted worst-case noise impacts at launch shaft (Scenario 1) (Appendix F, Arup, 2023)

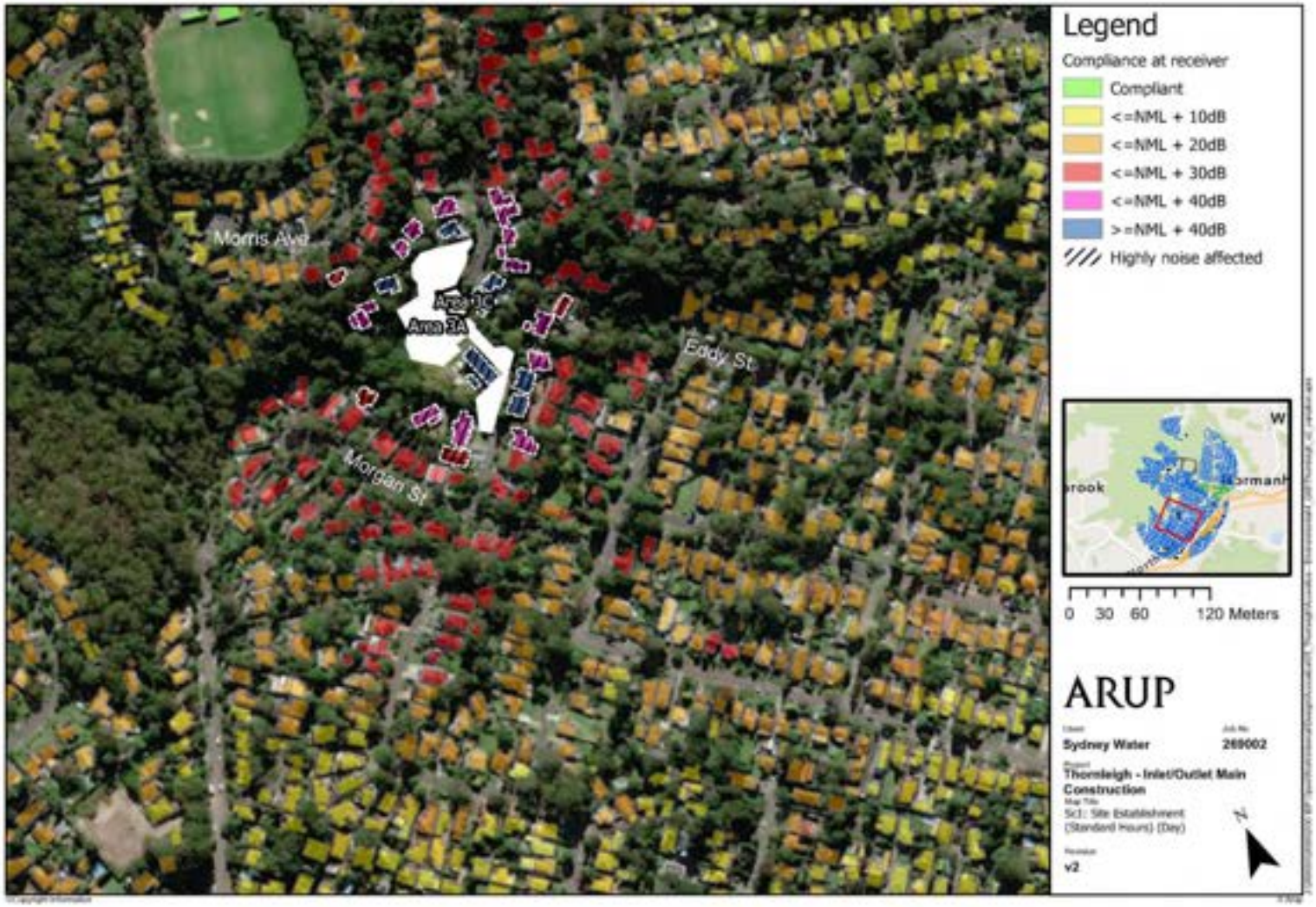

Figure 6-8 Predicted worst-case noise impacts at retrieval shaft (Scenario 1) (Appendix F, Arup, 2023)

Figure 6-9 Predicted worst-case noise impacts at launch shaft (Scenario 3) (Appendix F, Arup, 2023)

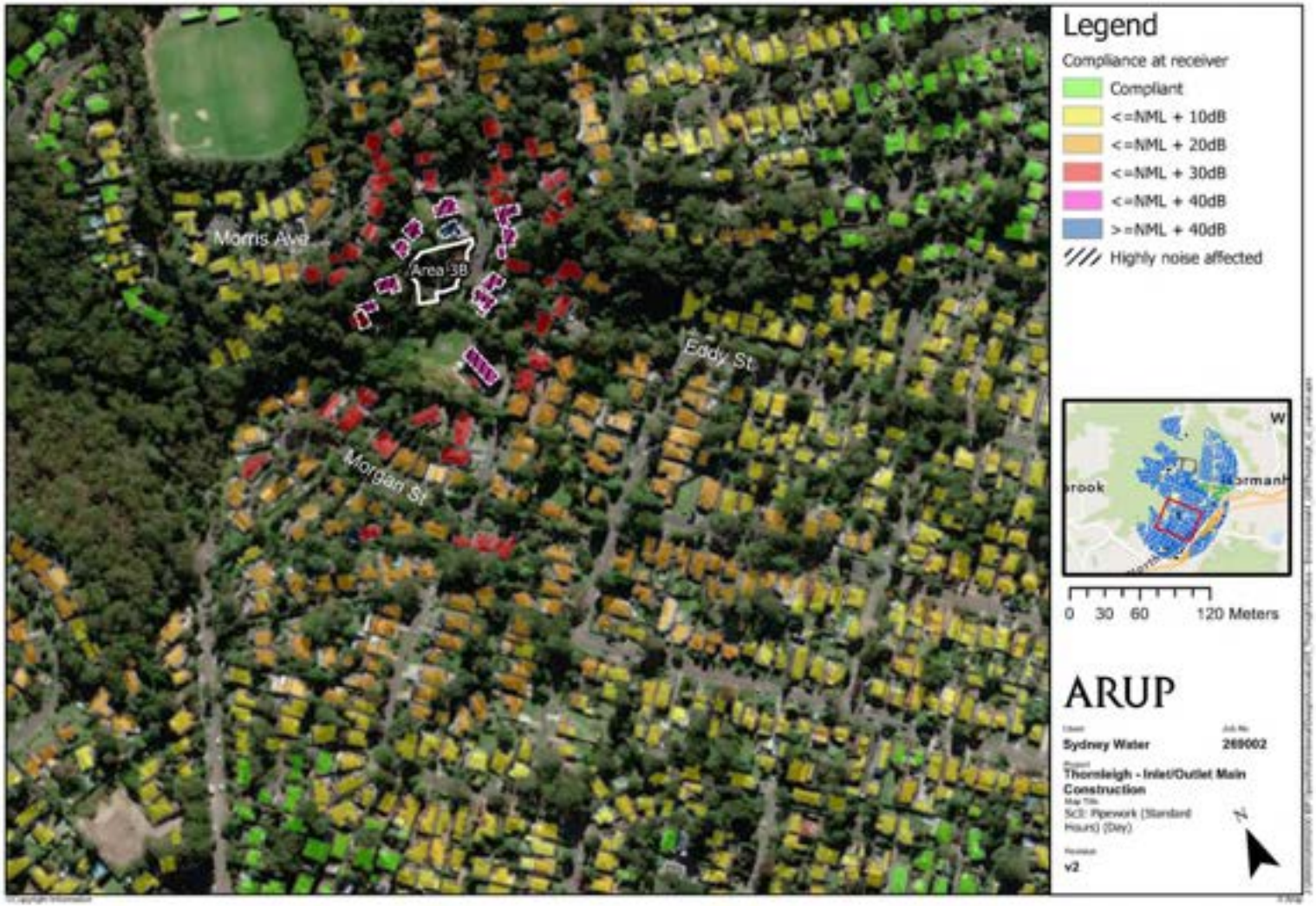

Figure 6-10 Predicted worst-case noise impacts at retrieval shaft (Scenario 3) (Appendix F, Arup, 2023)

Figure 6-11 Predicted worst-case noise impacts around launch shaft (Scenario 4 – ground-borne noise) (Appendix F, Arup, 2023)

Figure 6-12 Predicted worst-case noise impacts around retrieval shaft (Scenario 4 – ground-borne noise) (Appendix F, Arup, 2023)

Figure 6-13 Predicted worst-case noise impacts at launch shaft (Scenario 4 – air-borne noise - unmitigated) (Appendix F, Arup, 2023)

Figure 6-14 Predicted worst-case noise impacts at launch shaft (Scenario 4 – air-borne noise - mitigated) (Appendix F, Arup, 2023)

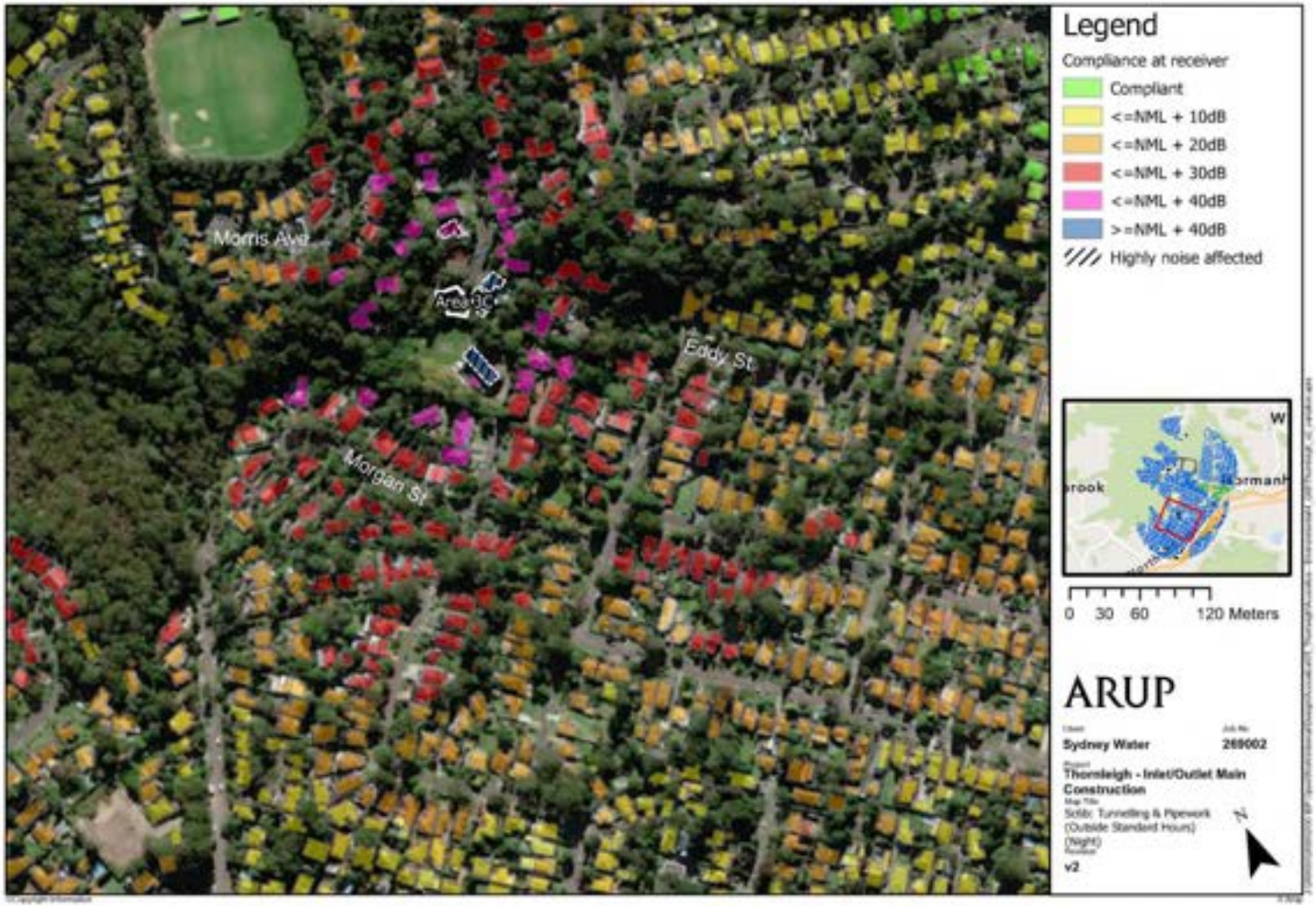

Figure 6-15 Predicted worst-case noise impacts at retrieval shaft (Scenario 6b) (Appendix F, Arup, 2023)

Plant and equipment will also move as construction progresses, changing noise impacts in relation to the nearby individual sensitive receivers. The noise levels experienced at any one location will rise and fall in accordance with factors including:

- the varying offset distance of the works
- the intensity and location of construction activities
- the intervening terrain and structure
- the type of equipment used.

In any given period, construction equipment would typically be used with maximum sound levels for only a brief amount of time. At other times, the equipment may emit lower sound levels.

Potential impacts – construction traffic noise

Movement of plant, equipment, and vehicles will generate traffic noise on the local road network while travelling to and from the proposal during construction and impact amenity of nearby receivers. As noted in section 6.1.8, no publicly available data is available on traffic volumes of the local roads. However, given the largely residential land use, traffic volumes are expected to be low and mostly limited to residents and their visitors.

Where construction traffic is on busier roads, any increase in traffic noise is likely to be negligible. On local roads, and at night time, there is greater potential for noise impacts related to traffic movements. To address this, construction traffic movements will primarily be during the day when background noise levels would be higher, as outlined in more detail in section 3.4.3.

Potential impacts – construction ground-borne noise

Ground-borne noise has been predicted using an empirical formula.

An exceedance map was produced for the assessment of ground-borne noise (Figure 6-11 and Figure 6-12). This map is used to establish indicative locations where ground borne noise criteria are most likely to be exceeded. Exceedances are presented as colour coded buildings.

The tunnel boring machine will operate continuously during tunnel boring. It would move from the launch shaft to the retrieval shaft. As the machine moves, the ground-borne noise impacts at any one receiver will rise and fall in accordance with the varying offset distance of the machine.

Over the 1.2 km of tunnelling, 143 residential receivers are predicted to be impacted by noise levels that exceed GBNMLs. Impacts for any one impacted receiver are expected to be for about 26 nights total, with a maximum of 17 nights that exceed GBNMLs for any one receiver. Ground-borne noise levels will slowly increase as the TBM moves towards the receiver, peak when the TBM is located the closest to the receiver (below the property) and slowly decrease when the TBM moves away from the receiver.

Potential impacts – construction vibration

The minimum working distances in Table 6-14 indicate the possibility of impact from vibration generating plant and equipment on nearby receivers. The minimum working distances are indicative and will vary depending on the item of plant and local geotechnical conditions. However,

if structures were to be located within the recommended minimum distance for cosmetic damage, mitigation measures should be implemented.

The closest affected residential receivers to the proposal, as well as Thornleigh Reservoir structure, could fall within the minimum working distance when the compactor or hydraulic hammer are used. Vibration impacts from tunnel boring are not expected, due to the depth of the equipment.

Use of vibratory equipment within Thornleigh Reservoir site has been minimised (eg use of static roller instead of vibratory roller) to reduce the risk of vibratory impacts to the dam structure. Excavators with milling attachments instead of jackhammer attachments may also be used to reduce vibration.

Table 6-14 Recommended minimum working distances for vibratory plant and equipment

Plant Item	Rating / Description	Minimum working distance (m)	
		Cosmetic damage	Human response – Disturbance to building occupants
		BS 7385 – Line 2[2]	
Large Hydraulic Hammer	1600 kg - 18 to 34t excavator	22 m	73 m
Piling – Bored	≤ 800 mm	2 m	10 m
Compactor[4]	Jumping Jack and plate compactor	5 m	55 m
Mechanised bored tunnelling works (Tunnel Boring Machine, Horizontal Directional Drilling, Micro-tunnelling)[5]	-	12 m	40 m

Note 2_ Minimum working distance-based screening criterion of 7.5 mm/s. Type of structure: Un-reinforced of light framed structures, residential or light commercial type buildings.

Note 4_Based on data for previous project.

Note 5_Based on TRL document (Crabb, 2000) using Godio et al formula, equation 24

Mitigation measures

With the implementation of the mitigation measures below, impacts from noise and vibration can be adequately managed, and residual impacts are expected to be minor. No impacts are anticipated during operation.

Table 6-15 Environmental mitigation measures — noise and vibration

Mitigation measures
Working hours and scheduling
Works must comply with the Interim Construction Noise Guideline (DECC, 2009). With the exception of out of hours works assessed in this REF, this includes scheduling work and deliveries during standard daytime working hours of 7 am to 6 pm Monday to Friday and 8 am to 1 pm Saturday. With the exception of out of hours works assessed in this REF, no work to be scheduled on Sunday nights or public holidays. Any proposed work outside of these hours must be justified. Justifications for additional out of hours work include (Draft Construction Noise Guideline, EPA, 2020): • the delivery of oversized equipment or structures that police or other authorities determine require special arrangements to transport along public roads • where a road occupancy licence is required for an activity likely to impact on traffic flow, such as road maintenance work or lane closures around a building site • emergency work to protect human health or avoid the loss of life or damage to property, or to prevent environmental harm • maintenance and repair of public infrastructure where disruption to essential services, required system conditions (such as low-flow conditions for pipe connections) and/or considerations of worker safety do not allow work within standard hours • public infrastructure works where work outside the recommended standard hours is supported by the affected community to shorten the length of the project. The proposal will also be carried out according to Sydney Water's Noise Management Procedure SWEMS0056. All reasonable and feasible noise mitigation measures should be justified, documented and implemented on-site to mitigate noise impacts.

Incorporate **standard daytime hours** noise management mitigation measures into the NVMP, including but not limited to:
 	
• identify and consult with the potentially affected residents prior to the commencement:
  ○ describe the nature of works; the expected noise impacts; approved hours of work; duration, complaints handling and contact details
  ○ determine need for, and appropriate timing of, respite periods (eg times identified by the community that are less sensitive to noise such as mid-morning or mid-afternoon for works near residences)
• implement a noise complaint handling procedure
• plant or machinery will not be permitted to warm-up near residential dwellings before the nominated working hours
• appropriate plant will be selected for each task, to minimise the noise impact (eg all stationary and mobile plant will be fitted with residential type silencers)

Mitigation measures

- engine brakes will not be used when entering or leaving the work site(s) or within work areas
- regularly inspect and maintain equipment in good working order
- arrange work sites where possible to minimise noise (eg generators away from sensitive receivers, site set up to minimise use of vehicle reversing alarms, site amenities and/ or entrances away from noise sensitive receivers)
- use natural landforms/ mounds or site sheds as noise barriers
- schedule noisy activities around times of surrounding high background noise (local road traffic or when other noise sources are active).

As works **beyond standard daytime hours** are needed, the contractor would:

- justify the need for out of hours work (OOHW) and why it is not possible to carry out the works during standard daytime hours
- consider potential noise impacts and: implement the relevant standard daytime hours mitigation measures; Sydney Water's Noise Management Code of Behaviour (SWEMS0056.01) and document all reasonable and feasible management measures to be implemented
- identify additional community notification requirements and outcomes of targeted community consultation
- seek approval from the Sydney Water Project Manager in consultation with the environment and communications representatives.

As **night works are needed,** the contractor would:

- justify the need for night works
- consider potential noise impacts and implement the relevant standard daytime and out of hours mitigation measures and document consideration of all reasonable and feasible management measures
- identify community notification requirements (ie for scheduled night work (not emergency works))
- notify all potentially impacted residents and sensitive noise receivers not less than one week prior to commencing night work
- seek approval from the Sydney Water Project Manager in consultation with the environment and communications representatives.

As works on **Sundays or public holidays are required**, the contractor would:

- justify why all other times are not feasible
- consider potential noise impacts and implement relevant standard daytime, out of hours and night-time mitigation measures and other reasonable and feasible management measures
- identify community notification requirements
- seek approval from the Sydney Water Project Manager in consultation with the environment and communications representatives.

Mitigation measures

Work scheduling is to consider the following:

- Works to be scheduled taking into account approved works hours, any restrictions relevant to specific equipment/activities and respite periods etc.
- Highest noise generating activities should be scheduled for the least sensitive times, where practicable.
- The acceptability for any out of hours works should be confirmed with authorities (eg delivery of oversized items, where road closures are required or for emergency works).
- For approved out of hours works, noisy activities should be scheduled early in the night to minimise the impact on adjacent residents where feasible.
- Where possible, heavy vehicle movements should be limited to daytime hours. Truck movements outside of standard construction hours require justification and Sydney Water Project Manager approval.

Community engagement

Community consultation should occur prior to, and during works as follows:

- Notify affected stakeholders (through methods such as letterbox drops, individual briefings or phone calls) of upcoming works with details of what the works will entail (such as the works purpose, duration, expected impacts and mitigation measures, complaints procedure, who is responsible for undertaking the works).
- Notification should be as specific as practicable regarding nature and timing of works and any scheduled respite periods.
- Discuss with affected receivers about any atypical sensitivities and review how scheduling of activities and other mitigation measures may aid to minimise impacts. Affected receivers are receivers mapped as experiencing non-compliant noise impacts. Atypical sensitivities include vibration sensitive equipment/processes in medical establishments, exam periods or school holidays for education establishments).
- Establish long-term personnel or processes (eg project email, phone number) to centralise project enquiries.

Project-specific mitigation measures will be determined based on a reasonable and feasible assessment performed by suitably qualified project representatives (eg community and stakeholder, project management, environment) and refined through community feedback.

Mitigation measures may include but not be limited to:

- alternative accommodation
- respite periods when scheduling work
- noisy works cut-off times
- at-source controls (eg shielding equipment).

The anticipated project-specific community mitigation measures are in Table 13 of Appendix F. They

Mitigation measures
would be reviewed and refined closer to construction and then documented in the project-specific Noise and Vibration Management Plan (and CEMP).

Plant and equipment selection
Non-tonal reversing beepers (or an equivalent mechanism) must be fitted and used on all construction vehicles and mobile plant regularly used on site and for any out of hours work. Consider the use of ambient sensitive alarms that adjust output relative to the ambient noise level.

Selection of plant and equipment is to consider the following:

- Use quieter construction methods where feasible and reasonable.
- Use only the necessary size and power of equipment.
- All plant and equipment used on site must be maintained in a proper and efficient condition, operated in a proper and efficient manner, and turned off when not in use.
- Ensure that the Responsible Person checks the conditions of the powered equipment used on site daily to ensure plant is properly maintained and that noise is kept as low as practicable.
- Where ground borne noise and vibration from TBM activities are considered excessive, the TBM machine could be operated at a slower speed. Note that a slower operation of the TBM will result in an increase of duration of works and impact program.

, Where possible reduce noise from mobile plant through additional fittings including:

- residential grade mufflers
- damped hammers such as “City” Model Rammer Hammers.

The noise levels of plant and equipment items are to be considered when equipment needs to be rented.

Site setup and behavioural practices
General recommended provisions which should be implemented initially include: • Situate noisy equipment away from noise-sensitive areas. • Use enclosures or screens to limit noise emissions of plant where possible. Type of screens could include noise curtains or hoarding (plywood board, panels of steel sheeting or compressed fibre cement board). • The type of screen is dependent on location of works and feasibility of what can be put in place, cognisant of heat and ventilation requirements. Screens are to be installed according to manufacturer specifications with no gaps. • However, note that screens will have a minimum effect to noise levels for receivers located on the upper floors of buildings or to receivers that are elevated from the construction sites. • The maps also show that screens should be considered where feasible and reasonable to reduce impacts to nearest receivers such as near the retrieval shaft during night works.

Mitigation measures

Recommended behavioural practices include:

- Appoint a named member of the site staff who will act as the Responsible Person with respect to noise and vibration.
- Site managers to periodically check the site and subjectively assess emissions to nearby receivers to proactively manage works.
- Ensure good work practices are adopted to avoid issues such as noise from dropped items, noise from communication radios is kept as low as is practicable.
- Avoid the use of radios or stereos outdoors.
- Avoid shouting and minimise talking loudly and slamming vehicle doors.

Movement of traffic within site should be managed by the following:

- Plan traffic flow, parking and loading/unloading areas to minimise reversing movements and idling traffic within the site and before entering site.
- Route heavy vehicle movements away from noise sensitive areas where possible.

Monitoring may include:

- Short-term attended measurements could be conducted in response of a complaint and to confirm alignment with predicted noise levels in the impact assessment and management measures.
- Unattended and attended measurements could be conducted within the nearest residential properties prior to TBM activities and at the beginning of the TBM activities to confirm ground borne noise level (GBNL) predictions and inform mitigation measures to receivers.

Noting the predicted exceedances of the NMLs to nearest receivers during the night-time for Scenario 4 (tunnelling during night-time), an acoustic shed should be installed around the launch shaft. Noise reduction from the acoustic shed would be anticipated to be of 20 dB or higher which would reduce considerably the number of receivers experiencing noise levels higher than NML + 30 dB. Acoustic shed is to be installed in accordance with manufacturer specifications.

Training and induction

A Construction Noise and Vibration Management Plan (NVMP) shall be prepared. This will specify the actual plant to be used and will include updated estimates of the likely levels of noise and the scheduling of activities. The NVMP should include but not be limited to:

- roles and responsibilities
- noise and vibration sensitive receiver locations and structures
- identifying works that have the potential to cause impact, accompanied by an appropriate assessment (predictive assessment or risk evaluation)
- mitigation and management strategy
- monitoring methodology (as relevant)

Mitigation measures

- community engagement strategy.

All employees, contractors, and subcontractors to receive an environmental induction which should include:

- standard noise and vibration mitigation measures
- permissible hours of work
- limitations on high noise and vibration generating activities
- location of nearest sensitive receivers.

Regularly train workers and contractors (such as at toolbox talks) to use equipment in ways to minimise noise.

Vibration

Conduct a dilapidation survey / asset condition assessment prior to works which have potential to damage existing structures.

Select equipment to minimise vibration. Where nearby buildings are located within the safe working distance, pre-construction surveys should be conducted.

The findings of the dilapidation survey / asset condition assessment may require amendment to proposed vibration criteria or management measures and therefore should be undertaken in suitable advance of the start date.

Consider less vibration intensive methodologies where practicable and use only the necessary sized and powered equipment (eg when piling is required, bored piles rather than impact driven piles will minimise vibration impacts).

Vibration monitoring:

- Attended vibration measurements would be required at the commencement of vibration generating activities that are proposed within the minimum working distances, identified in this REF.
- Where works are at risk of exceeding criteria, long-term monitoring would be required. The monitors should provide ‘real-time’ alerts when vibration criteria are exceeded.

An exceedance of the vibration criterion may necessitate a change in work method. This could include:

- re-evaluation of the vibration criterion based on results of the initial condition investigation and inspections of the structure following the commencement of works
- maintaining vibration monitoring throughout works within minimum working distances
- reducing the size of demolition and construction equipment and developing alternative methodologies to minimise vibration
- using less vibration emitting demolition methods if necessary closer to the sensitive structure
- balancing variable speed vibrating plant and operating at speeds that do not produce resonance.

6.1.6 Air and energy

Existing environment and potential impacts

The proposal is in a residential area. Potential sensitive receivers include residential properties and users of the local road network and recreational areas. No known recent or historical air quality complaints (including odour complaints) have been recorded nearby.

The proposal will potentially result in dust/ pollution from:

- dust generated during ground disturbance such as excavation
- dust generated by construction vehicles travelling on disturbed/ unsealed access routes
- emissions from machinery, equipment and vehicles used during construction
- emissions from generators used as a power source
- indirectly, from energy use related to electricity used on site to continuously power the TBM.

The slurry material generated from tunnel boring is not expected to generate significant amounts of odour. This waste material would likely be stored within the acoustic shed and would be transported off-site regularly.

During operation, there will not be changes to background odour at nearby receivers.

Mitigation measures

Impacts to air and energy during construction can be managed with the below mitigation measures.

No operational impacts related to air and energy are expected.

Table 6-16 Environmental mitigation measures — air and energy

Mitigation measures
Use alternatives to fossil fuels where practical and cost-effective. For example – source a carbon neutral electricity plan for the electricity to power the TBM.
Track energy use as per SWEMS0015.28 Contractor NGER template.
Maintain equipment in good working order, comply with the clean air regulations of the *Protection of the Environment Operations Act 1997*, have appropriate exhaust pollution controls, and meet Australian Standards for exhaust emissions.
Switch off vehicles/machinery when not in use.
Implement measures to prevent offsite dust impacts, for example: • Water exposed areas (using non-potable water source where possible such as water from excavation pits). • Cover exposed areas with tarpaulins or geotextile fabric.

Mitigation measures
• Modify or cease work in windy conditions. • Modify site layout (place stockpiles away from sensitive receivers). • Vegetate exposed areas using appropriate seeding.

Cover all transported waste.

6.1.7 Waste and hazardous materials

Existing environment

The following hazardous materials have been identified at Thornleigh Reservoir and Thornleigh-Wahroonga Water Pumping Station:

- Thornleigh Reservoir:
    - Asbestos-containing material (ACM) – inside reservoir and valve house (low-medium risk).
- Thornleigh-Wahroonga Water Pumping Station:
    - Lead paint and lead contaminated dust – external wall and inside Thornleigh-Wahroonga Water Pumping Station (low-medium risk).
    - Polychlorinated biphenyls – internal amenities building (medium risk).
    - ACM – external power pole and inside Thornleigh-Wahroonga Water Pumping Station (low-medium risk).

Potential ACM and unknown HBM may be present in inaccessible areas at Thornleigh Reservoir and Thornleigh-Wahroonga Water Pumping Station.

Preliminary soil testing indicated that soil material (not slurry) may be classified as general solid waste (Sydney Water, 2023a). More detailed classification would need to be performed closer to construction. Historic and potential soil contamination has been discussed in Section 6.1.1 of the REF (Sydney Water Planning Partner, 2023b).

Potential environmental impacts

Based on the locations of these known hazardous materials, and the proposed construction footprint, it is not expected that any known hazardous materials would be impacted.

Our corporate objectives include to be a resource recovery business with an increasing portfolio of circular economy products and services. This includes reducing waste through recycling and re-use, and encouraging our suppliers to minimise waste. The proposal will require the disturbance and/or disposal of waste streams including:

- green waste
- excavated material including treated drilling muds and sandstone excavated from the tunnel (about 15,000 cubic metres)

- sandstone blocks from excavating for the launch and retrieval shafts
- steel from the temporary steel bridge/culvert
- concrete from hydro-demolition
- general construction waste.

Treated drilling muds are subject to a Resource Recovery Order and Resource Recovery Exemption under Part 9, Clause 91-93 of the *Protection of the Environment Operations (Waste) Regulation 2014*. Opportunities to reduce, recycle and reuse on this project would be sought with the contractor and documented in the Waste and Resource Recovery Plan (WRRP) or CEMP.

The proposal is not expected to involve the transportation of asbestos waste (including soil containing asbestos)/sheeting, unless any unexpected ACM is encountered. Any ACM waste will need to be tracked using the EPA's WasteLocate online tracking System.

Mitigation measures

With the implementation of the mitigation measures below, impacts to waste and hazardous materials can be adequately managed, and residual impacts are expected to be minor. No impacts are anticipated during operation.

Table 6-17 Environmental mitigation measures — waste and hazardous materials

Mitigation measures
A Waste and Resource Recovery Plan (WRRP) must be prepared to appropriately manage and classify any materials including soils, construction/demolition wastes and associated stockpiles. The plan will be prepared by the delivery contractor (or nominated environmental consultant) and approved by the Sydney Water Project Manager in consultation with the Environmental Representative and Property Environmental Services.
Manage waste in accordance with relevant legislation and maintain records to show compliance (eg waste register, transport and disposal records). Record and submit SWEMS0015.27 Contractor Waste Report.
Minimise stockpile size and ensure delineation between different stockpiled materials.
Provide adequate bins for general waste, hazardous waste and recyclable materials.
Minimise the generation of waste and sort waste streams to maximise reuse/recycling in accordance with the Waste Avoidance and Resource Recovery Act 2001.
Prevent pollutants from escaping including by covering skip bins.
Dispose excess vegetation (non-weed) that cannot be used for site stabilisation at an appropriate green waste disposal facility.
Review existing HBM report and implement relevant mitigation measures. Conduct hazardous materials survey prior to commencement where works could impact hazardous materials not surveyed in previous HBM assessments.

Mitigation measures
Comply with the Resource Recovery Order and Resource Recovery Exemption for treated drilling mud. For the avoidance of any doubt, it is best to remove the muds from site daily.
Investigate reuse of spoil from tunnelling as a preference to off-site disposal.
Consider use of construction material (eg concrete, steel, fly ash) made from a higher-than-average proportion of recycled/reused materials.
At completion of construction, the temporary steel bridge/culvert (girders and deck) can be reused and stored offsite for subsequent use or sold on to others and subsequently re-purchased when the need arises.
The CEMP should include the following hierarchy for reuse, recycling or disposal of spoil produced during construction: • If soil produced during construction will remain within the Lot and DP from which it was produced, it can be reused if CoPC concentrations are below the applicable NEPM 2013 Tier I screening values for evaluation of potential risk to human health and the environment. • Soil produced during construction can be reused on another Sydney Water or third party site if it meets the definition of virgin excavated natural material / excavated natural material (VENM /ENM) in accordance with the applicable Resource Recovery Order / Exemption under the Protection of Environment (Waste) Operations Regulation 2014. • Soil that does not meet either of the above definitions should be transported to an appropriately licenced facility for recycling if all CoPC concentrations are below the NSW EPA (2014) Waste Classification Guidelines contaminant threshold 1 (CT1) values for General Solid Waste. The soil can be recycled at an appropriately licenced facility in accordance with any current Sydney Water contractual arrangements. Comparison of CoPCs against Brandown Resource Recovery's EPL criteria as well as Waste Classification and reuse potential (as VENM/ENM) should also be conducted as this may provide a cost saving. • If CoPC concentrations are above the CT1 values, the soil waste should be classified per the EPA Waste Classification Guidelines and disposed at an appropriately licenced facility.

6.1.8 Traffic and access

Existing environment

A Traffic and Transport Impact Assessment was prepared for the proposal (Appendix G, Aurecon Arup, 2023).

The study area for this impact assessment incorporates the general surrounding road network and proposed construction routes. It includes the existing road network, public transport, active transport, and other infrastructure.

Key features of the existing road network and active transport network are summarised in Table 6-18 below. The road network is mapped in Figure 6-16 below. All roads service surrounding

residential properties and other land uses (eg school, recreation). They are all speed-limited to 50 km/h within the study area unless school zones apply or otherwise indicated below.

Table 6-18 Features of existing road and traffic network including proposed construction access routes

Road name	Direct access to site?	Approximate width (m)	Pedestrian facilities/ active transport	Other features
Quarter Sessions Road	Yes – to Thornleigh Reservoir	10	Pedestrian crossing, footpath	School zone between Duffy Ave and Oakleigh Oval
Dale Close	Yes – to Thornleigh-Wahroonga Water Pumping Station	7.3	No formal facilities Off-road unsealed walking track between Dale Close and Edmundson Close, past Thornleigh-Wahroonga Water Pumping Station	Cul-de-sac
Edmundson Close	Yes – to retrieval shaft	6-6.5	No formal facilities Off-road unsealed walking track between Dale Close and Edmundson Close, past Thornleigh-Wahroonga Water Pumping Station	Cul-de-sac
Giblett Avenue	No	8	Footpath on northern side	Connects to Oakleigh Oval and Thornleigh West Public School at western end
Sefton Road	No	10	Footpaths on southern and western side	60 km/h east of Bryan Avenue
Duffy Avenue	No	9.5-10	Footpaths on both side, bicycle lanes on road	One of the major accesses to Pennant Hills Road in the area School zone at western end, near Quarter Sessions Road

Road name	Direct access to site?	Approximate width (m)	Pedestrian facilities/ active transport	Other features
Yarrara Road	No	7	Footpath on western side	Parallel to rail corridor Speed-limited to 40 km/h off Pennant Hills Road
Pritchard Street	No	7.5-10	Footpaths on both sides, southern side between Yarrara Road and Lovett Street only	Connects Tillock Street and Yarrara Road 3 hour parking restrictions (8.30 am to 6 pm Fridays) east of Lovett Street
Tillock Street	No	9	Footpath along eastern side	Connects Pritchard Street and Eddy Street
Morgan Street	No	7.5	No formal facilities	Connects Pritchard Street and Eddy Street
Eddy Street	No	9	Footpaths on both sides, northern side between Yarrara Road and Janet Avenue only	Connects Tillock Street and Yarrara Road
Sinclair Avenue	No	7-12.5	Footpath on western side only	Connects Duffy Avenue and Oakleigh Avenue
Barrett Avenue	No	6.5	Footpath on northern side only	Connects Nicholson Avenue and Sinclair Avenue
Nicholson Avenue	No	7	No formal facilities	Connects Quarter Sessions Road and Wanawong Drive

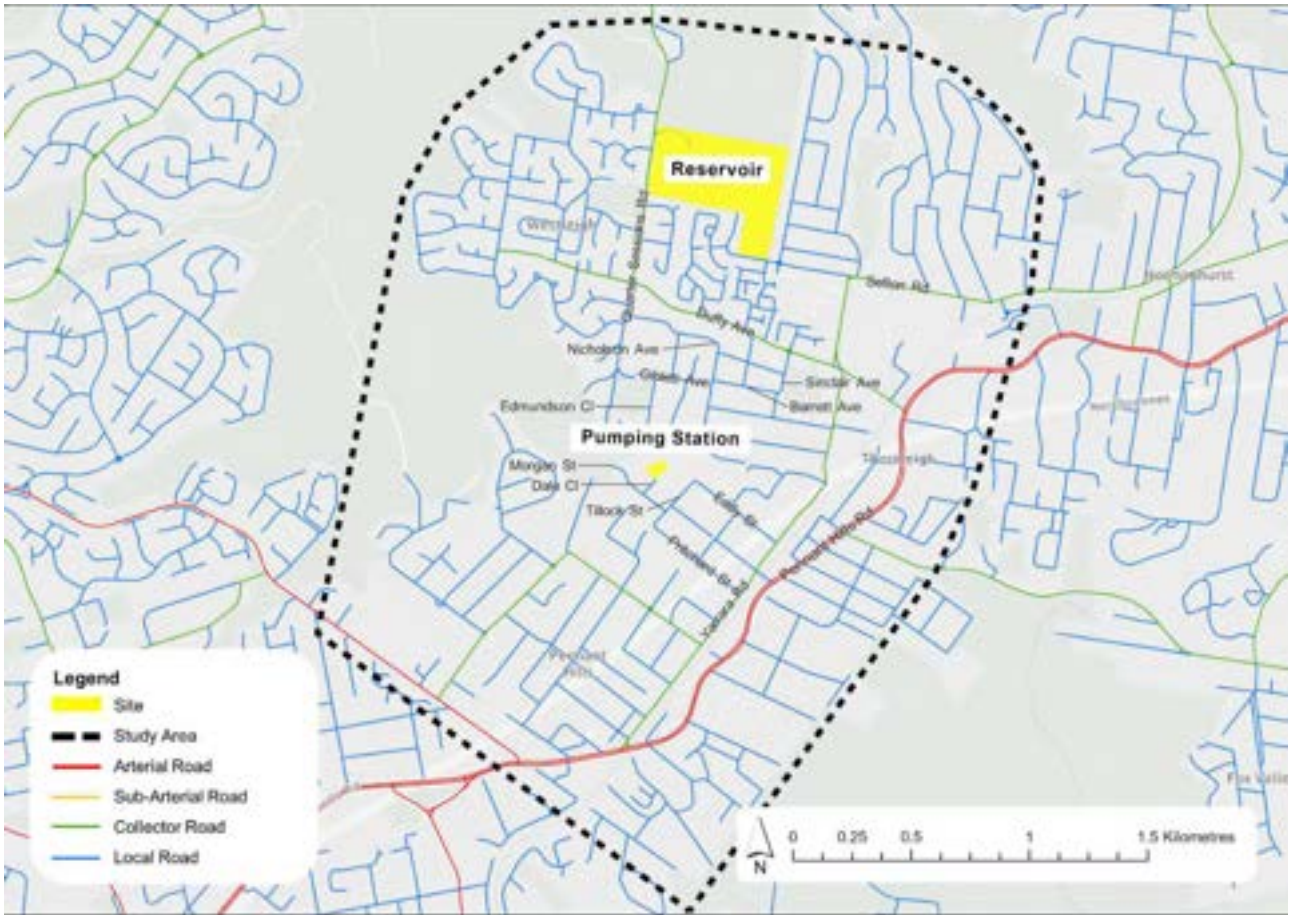

Figure 6-16 Road network surrounding the study area (Appendix G, Aurecon Arup, 2023)

Features of the public transport network within the study area include:

- Thornleigh train station is about 1.7 km south-east of Thornleigh Reservoir and 0.6 km south-east of Thornleigh-Wahroonga Water Pumping Station. This train station is served every 15 minutes during peak times (6.30 am to 10 am, 3 pm to 7 pm weekdays).
- Several bus stops are located near Thornleigh Reservoir, with the closest on Quarter Sessions Road and Corang Road (about 80-120 m north of Thornleigh Reservoir).
- The closest bus stop to Thornleigh-Wahroonga Water Pumping Station is on Goodlands Avenue, about 250 m north-east of Thornleigh-Wahroonga Water Pumping Station.
- Eight bus routes operate within the study area:
    - One Nightride bus replaces trains between midnight and 6 am.
    - Three public bus routes operate during the day, and are active between 6 am to 9 pm weekdays, 8 am to 6 pm Saturdays, and 8:30 am to 6:30 pm Sundays and public holidays.
    - Four school bus routes, between 7:47 am and 8:55 am and 2:59 pm to 3:21 pm school days.

Other nearby infrastructure projects were also considered where publicly available information was available on the transport impact and there may be cumulative impacts. The only relevant project identified was Westleigh Park Draft Master Plan. Westleigh Park is immediately to the north of Thornleigh Reservoir, on land which was previously owned by Sydney Water and now owned by Hornsby Shire Council.

Public access into Sydney Water assets within the proposal includes:

- Thornleigh-Wahroonga Water Pumping Station – the station is surrounded by security fencing. No public access is available.
- Thornleigh Reservoir – Thornleigh Reservoir is a fenced site. However, some adjoining properties have gates which allow the residents to enter Thornleigh Reservoir. Members of public have previously been observed on reservoir land. There are also fire trails along the north and east of Thornleigh Reservoir lot boundary.

Potential impacts

The proposal methodology, timeframes, and duration as detailed in section 3 of this REF will drive the level of impact. Plant, equipment, and vehicle movements will add traffic to the existing road network. The quantities of plant, equipment, and vehicle movements, including worker vehicles, described in section 3 of this REF informed the specialist assessment. Assessed construction traffic volumes are peak values and are likely to be lower for much of the construction phase.

No publicly available data is available on traffic volumes of the local roads listed in Table 6-18. However, given the largely residential land use, traffic volumes are expected to be low and mostly limited to residents and their visitors. The addition of up to 10-15 light vehicles each day, and regular truck movements at both the northern and southern construction footprint, is therefore likely to be noticeable, particularly during periods of peak local traffic (eg around school drop-off and pick-up times).

Impacts to different features of the transport network have been considered in Table 6-19.

Activities which will impact traffic and transport during construction include:

- movement of construction workers, plant, equipment, and vehicles
- truck movements for spoil removal
- installing and removing pipe jacking equipment
- construction worker parking.

The impact assessment uses the following impact classifications:

- Low – a minimal impact with low frequency.
- Medium/moderate – likely impacts to the transport network, however generally more localised.

Table 6-19 Impacts to the existing road and traffic network

Feature	Impact	Comments
Road network performance	Low	Quantity of plant, equipment and vehicle movements during peak not expected to detrimentally impact Pennant Hills Road or the greater road network, with use of preferred vehicle routes (Figure 6-17 and Figure 6-18). Open trenching is fully within Thornleigh Reservoir site and no public access roads will be impacted. Traffic control would be required to manage the conflict between light and heavy vehicles, particularly at Edmundson Close.
Parking and access	Low	No restrictions to any private or public property access would occur. Any lane closures would be managed with traffic control and driveway access would be maintained. Parking for work at reservoir can be accommodated within Thornleigh Reservoir. Construction worker parking will be required on local roads near Thornleigh-Wahroonga Water Pumping Station. The maximum estimated workforce at this location is 10-15 workers, which means that up to 15 work vehicles may park on local roads. Thornleigh train station is also about 0.6 km away and may be used.
Public transport network	Low	Quarter Sessions Road, Duffy Avenue and Yarrara Road, are used by buses and form part of the proposed construction vehicle route. Low volumes of construction traffic and no impact to bus stop operation or routes expected.
Active transport network	Medium	Potential conflicts between heavy vehicle movements and pedestrians on access roads around Thornleigh Reservoir and Thornleigh-Wahroonga Water Pumping Station. Temporary closure of walking track between Edmundson Close and Dale Close while there is active construction at the retrieval shaft. Alternative routes through local streets would extend travel times and may cause accessibility issues. Proposed construction route to/from Dale Close passes Pennant Hills Preschool. Potential interface with children and caregivers during drop-off and pick-up times. No closures of any formalised footpaths or cycleways are proposed. Implementing project-specific mitigation measures in the mitigation measure table (Table 6-20) is expected to reduce this impact from medium to low.

Preferred routes for movement of construction plant, equipment, and vehicles are shown below (Figure 6-17 and Figure 6-18). These preferred routes have been identified to minimise impacts to the road network. Factors considered include:

- having traffic mostly enter and exit local roads via Pennant Hills Road, the nearest arterial road. All heavy vehicles would enter and exit via Pennant Hills Road, which carries about 33,139 vehicles per day (2021 data)
- suitability of surrounding roads (eg turning circle, number of turns, truck weight limits)
- minimising driving past sensitive areas such as schools where possible.

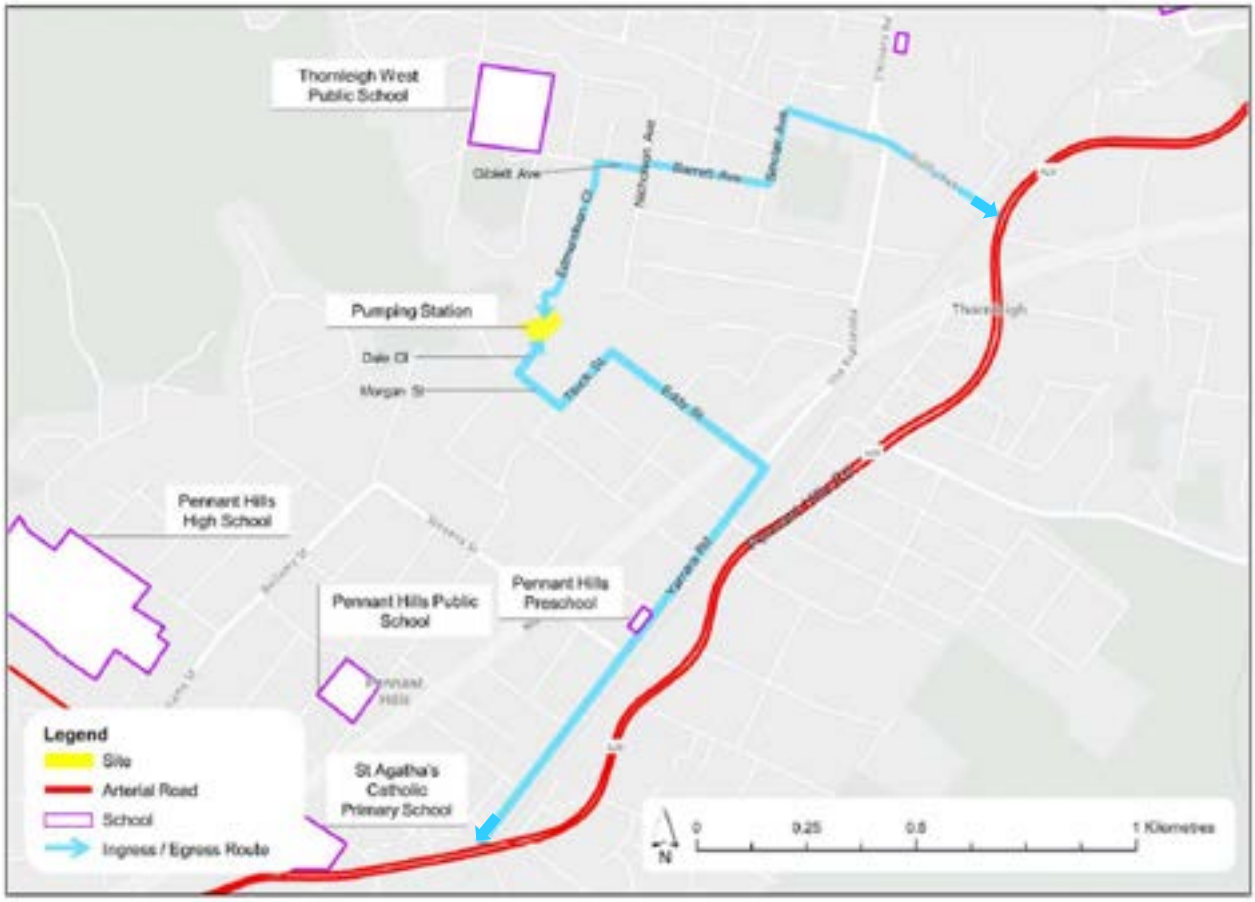

Figure 6-17 Proposed construction vehicle route to/from Thornleigh-Wahroonga Water Pumping Station (Appendix G, Aurecon Arup, 2023)

Figure 6-18 Proposed construction vehicle route to/from Thornleigh Reservoir (Appendix G, Aurecon Arup, 2023)

Mitigation measures

With the implementation of the mitigation measures below, impacts to traffic, transport, and access can be adequately managed, and residual impacts are expected to be low.

No impacts to traffic, transport, and access are anticipated during operation. No additional traffic movements during operation are expected. The pipes and connections would continue to be maintained at regular frequencies in accordance with appropriate specifications.

Table 6-20 Environmental mitigation measures — traffic and access

Mitigation measures
General
Obtain relevant council approval in relation to restriction of 3 tonne and over trucks on Yarrara Road. Review the vehicle weight restrictions on the proposed construction vehicle access routes closer to construction to determine if any additional council approvals are required.

Mitigation measures
Only follow the proposed construction vehicle access routes. Should any potential alternative access routes be identified prior to or during construction, the impacts to traffic, transport, and access from these routes would need to be assessed separately.
Road network performance
Prepare and implement Traffic and Pedestrian Management Plan before construction starts.
Schedule construction traffic movements outside of peak road network periods (6:30 am-10 am and 3 pm-7 pm) where possible (excluding TBM operation).
Minimise light vehicle traffic movements during crane activities.
Prepare Traffic Management Plan, Traffic Control Plans and ROLs (which require council approval). Use traffic controllers.
Parking and access
Encourage use of public transport or car-pooling.
When parking within the Thornleigh Reservoir site, park in approved, disturbed areas only. When parking near the retrieval shaft, make sure not to block any driveways or public footpaths.
Public transport network
Bus network operators to be notified of construction vehicle traffic and when heavy vehicles may be present.
Active transport network
Use signage to alert pedestrians of heavy vehicle access. Traffic controllers may be required in key conflict areas at pre-school pick-up and drop-off times (8 am-9.30 am and 2.30 pm-4 pm).
Provide B-class hoarding to maintain safe pedestrian access.
Avoid construction traffic movements during pre-school pick-up and drop off times.
Public access to be restricted to Thornleigh Reservoir during construction (eg additional fencing, engagement with adjacent properties).

6.1.9 Social and visual

Existing environment

The existing environment surrounding the construction footprint includes the largely low-density residential suburbs of Thornleigh and Westleigh. This area has the potential to experience direct or indirect social and visual amenity impacts during construction. The wider area of Hornsby Shire is

characterised by natural landscapes (including bushland and waterways), urban residential, rural, and open spaces. This area is valued as a location where 'the city meets the bush' for its variety of landscapes, quality of lifestyle, and green space. For example, canopy cover in urban areas within Hornsby Shire is almost 40% (Hornsby Shire Council, 2020).

Potential impacts

Temporary social and visual amenity impacts likely to be experienced during construction include:

- night works which may require use of artificial lighting
- long-term noise impacts, particularly around the launch shaft and retrieval shaft
- potential for dust generation impacting nearby receivers
- disruption to local traffic including reduced access to public space (Crown Land described in section 3.1) at retrieval shaft
- long-term above-ground construction setup including site compounds and laydown areas at launch shaft and retrieval shaft
- installation and use of acoustic shed at launch shaft during tunnelling. These sheds are typically custom-built and need to be at least the size of the launch shaft and at least the height of the TBM. It would be installed before tunnelling starts and would be removed once tunnelling is complete (likely about a year). It would likely be visible to nearby residential properties, eg along The Sanctuary or Sefton Road. This shed acts as a visual shield (as well as a noise barrier) to the plant, equipment, and amenities required for continuous tunnelling activities during use of the TBM.
- some vegetation removal may border private properties. Vegetation removal may increase the visibility of the construction sites to nearby receivers. The suburbs of Thornleigh and Westleigh have large areas of canopy cover, so vegetation removal may have a minor negative impact on visual amenity of the area at a suburban scale.

These temporary visual impacts would be managed through the mitigation measures listed below, including ongoing engagement with stakeholders, such as council and residents.

No operational impacts to social and visual amenity are expected. Offset planting and rehabilitation of disturbed areas once construction is complete will improve social and visual amenity. No new above-ground structures will be visible during operation. The access hatches at the launch and retrieval shafts would be a similar size to existing access hatches near Thornleigh-Wahroonga Water Pumping Station. These access hatches would also be fenced off, and would sit at slightly above ground level, to be above the 1% AEP flood level. The visual character of the environment would not change once construction and restoration is complete.

Mitigation measures

With the implementation of the mitigation measures below, impacts to social and visual amenity can be adequately managed, and residual impacts are expected to be low. Other amenity impacts such as noise, traffic, and air quality would be managed by implementing the mitigation measures listed elsewhere in this REF. No impacts are anticipated during operation.

Table 6-21 Environmental mitigation measures — social and visual

Mitigation measures
Undertake works in accordance with Sydney Water Communications policies and requirements including: • notify impacted residents and businesses • erect signs to inform the public on nature of work • personnel treat community enquiries appropriately.
Restore work sites to pre-existing condition or better.
Minimise visual impacts (eg retain existing vegetation where possible).
Direct artificial light away from sensitive receivers where possible (ie residents, fauna or roadways).
Maintain work areas in a clean and tidy condition.
Handle complaints in accordance with Sydney Water's Complaints Handling Process and Sydney Water's Stakeholder Engagement Policy.

6.1.10 Cumulative and future trends

Potential environmental impacts

Other projects which are occurring in the area include:

- Westleigh Park Draft Master Plan – adjacent to Thornleigh Reservoir – proposed by Hornsby Shire Council – construction date unknown
- Thornleigh-Wahroonga Water Pumping Station – electrical and control infrastructure upgrade, currently in construction, expected to be complete in 2023
- Ruddock Park Upgrade – opposite Thornleigh Reservoir entry on Quarter Sessions Road – delivered by Hornsby Shire Council – construction should be complete by mid-2023.

During various stages of construction, Thornleigh Reservoir and Thornleigh-Wahroonga Water Pumping Station would need to be temporarily isolated and would be unable to be used during these times. During these times, water supply to customer will not be adversely impacted.

No State Significant Projects were identified within 1 km of the proposal (as of June 2023). There may be other local development occurring in the area, but it is not anticipated that a cumulative impact would result. Outstanding development applications for the suburbs of Thornleigh and Westleigh are related to development of existing buildings (as of June 2023). No new large subdivisions or residential construction was identified. The contractor will work with local developments and Hornsby Shire Council to reduce impacts as required.

Hornsby Shire Council identified future trends related to climate change within the local government area (Hornsby Shire Council, 2021). Sydney Water considered which of these future trends could impact the proposal. Generally, an increase in extreme weather events may limit

access to assets, or damage assets. Those factors relevant to the proposal are summarised below:

- Bushfire – an increase in average and severe fire weather in the near future (by 2030) and far future (by 2070) is predicted across Greater Sydney. The proposal is within a designated bushfire prone area (NSW Rural Fire Service, 2023). An increase in bushfires may increase demand on water supply.
- Flooding and extreme rain/storms – an increase in rainfall extremes in the near future (by 2030) and far future (by 2070) is predicted across Greater Sydney. The retrieval shaft is within flood prone land. Extreme rain events may impact water quality within the catchment and increase the quantity of water within the catchment requiring treatment.
- Extreme heat – an increase in days above 35 degrees Celsius is predicted in 2030 (four more days) and 2070 (11 more days). This may increase demand on water supply and increase electricity demand.

The proposal has considered future trends and is unlikely to further exacerbate future trends as it is an underground asset installed to support ongoing supply of drinking water in an area of forecast population growth. The proposal will help provide a more reliable water supply that will help support any change in water demand as a result of these trends.

The proposal may be impacted by future trends. The retrieval shaft will be installed within the 1% AEP flood level and the access hatch would likely be raised to be outside of this level.

Mitigation measures

With the implementation of the mitigation measures below, cumulative impacts can be adequately managed, and residual impacts are expected to be low. No impacts are anticipated during operation.

Table 6-22 Environmental mitigation measures — cumulative and future trends

Mitigation measures
Ongoing engagement required with Sydney Water operational staff to manage temporary isolations at Thornleigh Reservoir and Thornleigh-Wahroonga Water Pumping Station.
Ongoing engagement with Hornsby Council and developers of projects in construction in the same locality at the same time as this proposal.

6.1.11 General Environmental Management

Table 6-23 Environmental mitigation measures — general environmental management

Mitigation measures

Should the proposal change from this REF, no further environmental assessment is required provided the change:
• remains within the study area for the REF and has no net additional environmental impact; or
• is outside the assessment/study area for the REF but:
  ○ reduces impacts to biodiversity, heritage or human amenity, or
  ○ avoids engineering (for example, geological, topographical) constraints, and
  ○ after consultation with any potentially affected landowners and relevant agencies.
The contractor must demonstrate in writing how the changes meet these requirements, for approval by Sydney Water's Project Manager in consultation with the environmental and community representatives.

Sydney Water's Project Manager (after consultation with the project's environment and community representatives, and affected landowners) can approve temporary ancillary construction facilities (such as compounds and access tracks), without additional environmental assessment or approval if the facilities meet the following principles: • limit proximity to sensitive receivers • no disruption to property access • no impact to known items of non-Aboriginal and Aboriginal heritage • outside high-risk areas for Aboriginal heritage • use existing cleared areas and existing access tracks • no impacts to remnant native vegetation or key habitat features • no disturbance to waterways • potential environmental impacts can be managed using the mitigation measures in this REF • no disturbance of contaminated land or acid sulfate soils • will be rehabilitated at the end of construction. The contractor must demonstrate in writing how the proposed ancillary facilities meet these principles. Any facilities that do not meet these principles will require additional environmental impact assessment. The agreed location of these facilities must be shown on the CEMP site plan and appropriate environmental controls installed.
Prepare a Construction Environmental Management Plan (CEMP) (including sub-plans and work method statements required by other mitigation measures) addressing the requirements of this environmental assessment. The CEMP should identify licence, approval and notification requirements. Prior to the start of work, all project staff and contractors will be inducted in the CEMP. The CEMP must be readily available on site and include a site plan which shows: • go/ no go areas and boundaries of the work area

Mitigation measures
• location of environmental controls (including erosion and sediment controls, any fences or other measures to protect vegetation or fauna, spill kits, stockpile areas) • location and full extent of any vegetation disturbance.

Prepare an Incident Management Plan (IMP) outlining actions and responsibilities during:

- predicted/ onset of heavy rain during works
- spills
- unexpected finds (eg. heritage and contamination)
- other potential incidents relevant to the scope of works.

To ensure compliance with legislative requirements for incident notification (eg. *Protection of the Environment Operations Act 1997*), Sydney Water's employees and contractors will follow SWEMS0009 Responding to incidents with an environmental impact procedure.

All site personnel should be inducted into the IMP.

Assign single person with accountability for coordinating communication and information flow across contractors and consultants and provide the contact details of this person in the CEMP.

7 Conclusion

Sydney Water has prepared this REF to assess the potential environmental impacts of Thornleigh inlet/outlet main duplication. The proposal is required to:

- improve water quality at Thornleigh Reservoir (primary objective)
- ensure water supply network can handle expected growth (secondary objective)
- increase network resilience by duplicating the inlet/outlet main.

During construction, the main potential environmental impacts of the proposal are typical construction impacts such as impacts on soil and water, flora and fauna, noise and vibration, and traffic and access. During operation, no impacts are expected. Given the nature, scale and extent of impacts and implementation of the mitigation measures outlined in this REF, the proposal is unlikely to have a significant impact on the environment. Therefore, an environmental impact statement is not required under Division 5.1 of the EP&A Act.

The REF considers how the proposal aligns with the principles of ESD. The proposal will result in positive long-term environmental improvements. The proposal will not result in the degradation of the quality of the environment and will not pose a risk to the safety of the environment.

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9 Appendices

Appendix A – Section 171 checklist

Section 171 checklist	REF finding
Any environmental impact on a community	There may be impacts during construction on soil and water, flora and fauna, noise and vibration, and traffic and access. There will be environmental improvements by providing a reliable drinking water service to the local community that supports forecast population growth and maintains compliance with water quality parameters for safe, clean drinking water.
Any transformation of a locality	The proposal will not result in the transformation of a locality. Land use would not change once construction is complete.
Any environmental impact on the ecosystems of the locality	The proposal would result in environmental impacts to ecosystems of the locality. Temporary impacts to air, soil, water and biodiversity will be managed during construction. Vegetation communities, including TECs, would be disturbed with up to 0.9 ha requiring removal. However, this vegetation would not be fragmented and there would be no loss of connectivity. There will be environmental improvements by ensuring a reliable drinking water service that continues to comply with water quality parameters for safe, clean drinking water, thus minimising any impacts on the ecosystem.
Any reduction of the aesthetic, recreational, scientific or other environmental quality or value of the locality	The proposal will have a reduction in the environmental quality or value of the locality during construction. This is from temporary closures of public areas and vegetation removal around the retrieval shaft. These areas would be restored and reopened, and no operational impacts are expected.
Any effect upon a locality, place or building having aesthetic, anthropological, archaeological, architectural, cultural, historical, scientific or social significance or any other special value for present or future generations	The proposal will not have any effect upon a locality, place or building having aesthetic, anthropological, archaeological, architectural, cultural, historical, scientific or social significance, or any other special value for present or future generations. Impacts to the known heritage item within the construction footprint (street trees) are not expected to be significant.
Any impact on the habitat of any protected animals (within the meaning of the *Biodiversity Conservation Act 2016*)	The proposal would have a minor impact on the habitat requirements of protected animals. There is a low likelihood of impacting any threatened fauna habitat.
Any endangering of any species of animal or plant or	The proposal will not be endangering any species of animal, plant or other form of life, whether living on land, in water or in the air. Some TECs require

Section 171 checklist	REF finding
other form of life, whether living on land, in water or in the air	removal and two threatened flora species may be present within the construction footprint. These species and communities are unlikely to become endangered because of this proposal, since the vegetation removal is localised and would not isolate or fragment any potential habitat.
Any long-term effects on the environment	The proposal will not have any long-term impacts on the environment but will have a long-term benefit by providing a reliable and modern drinking water service to support predicted population growth.
Any degradation of the quality of the environment	The proposal will not cause the degradation of the quality of the environment. Vegetation removal during construction would be offset once construction is complete.
Any risk to the safety of the environment	The proposal will not increase risk to the safety of the environment.
Any reduction in the range of beneficial uses of the environment	The proposal will have a temporary reduction in the range of beneficial uses of the environment during construction with temporary closures of public areas around the retrieval shaft. No reductions in beneficial use are expected during operation.
Any pollution of the environment	Environmental mitigation measures will mitigate the potential for the proposal to pollute the environment. No pollution of the environment is expected.
Any environmental problems associated with the disposal of waste	The disposal of wastes will be conducted in accordance with the environmental mitigation measures, and no environmental problems associated with the disposal of waste are expected. The delivery contractor will comply with EPA requirements for treated drilling mud.
Any increased demands on resources (natural or otherwise) that are, or are likely to become, in short supply	The proposal will not increase demand on resources, that are, or are likely to become, in short supply. The delivery contractor will be encouraged to use reused or recycled materials where possible.
Any cumulative environmental effect with other existing or likely future activities	The proposal may have minor cumulative environmental impacts with other existing or likely future activities. This would be managed through consultation with these other projects.
Any impact on coastal processes and coastal hazards, including those under projected climate change conditions	The proposal will not have any impact on coastal processes or hazards, and coastal processes and coastal hazards will not have any impact on the proposed activity.

Section 171 checklist	REF finding
Any applicable local strategic planning statements, regional strategic plans or district strategic plans made under the EP&A Act, Division 3.1	The proposal to service growth and the applicable strategic planning statements or plans have been considered in the system planning and options selection process (refer Section 5.1 of the REF).
Any other relevant environmental factors.	The proposal has been assessed against the factors listed above, and there are no other relevant environmental factors to consider.

Appendix B – Consideration of TISEPP consultation

TISEPP section	Yes	No
Section 2.10, council related infrastructure or services – consultation with council		
Will the work:		
Potentially have a substantial impact on stormwater management services provided by council?		X
Be likely to generate traffic that will strain the capacity of the road system in the LGA?		X
Connect to, and have a substantial impact on, the capacity of a council owned sewerage system?		X
Connect to, and use a substantial volume of water from a council owned water supply system?		X
Require temporary structures on, or enclose, a public space under council's control that will disrupt pedestrian or vehicular traffic that is not minor or inconsequential?	X	
Excavate a road, or a footpath adjacent to a road, for which the council is the roads authority, that is not minor or inconsequential?	X	
Section 2.11, local heritage – consultation with council		
Is the work likely to affect the heritage significance of a local heritage item, or of a heritage conservation area (not also a State heritage item) more than a minor or inconsequential amount?		X
Section 2.12, flood liable land – consultation with council		
Will the work be on flood liable land (land that is susceptible to flooding by the probable maximum flood event) and will works alter flood patterns other than to a minor extent?		X
Section 2.13, flood liable land – consultation with State Emergency Services		
Will the work be on flood liable land (land that is susceptible to flooding by the probable maximum flood event) and undertaken under a relevant provision*, but not the carrying out of minor alterations or additions to, or the demolition of, a building, emergency works or routine maintenance? * (e) Div.14 (Public admin buildings), (g) Div.16 (Research/ monitoring stations), (i) Div.20 (Stormwater systems)?		X
Section 2.14, development with impacts on certain land within the coastal zone– council consultation		
Is the work on land mapped as coastal vulnerability area and inconsistent with a certified coastal management program?		X
Section 2.15, consultation with public authorities other than councils		
Will the proposal be on land adjacent to land reserved under the *National Parks and Wildlife Act 1974* or land acquired under Part 11 of that Act*? If so, consult with DPE (NPWS).*		X
Will the proposal be on land in Zone C1 National Parks and Nature Reserves or on a land use zone that is equivalent to that zone? *If so, consult with DPE (NPWS).*		X
Will the proposal include a fixed or floating structure in or over navigable waters? *If so, consult TfNSW.*		X
Will the proposal be on land in a mine subsidence district within the meaning of the *Coal Mine Subsidence Compensation Act 2017*? *If so, consult with Subsidence Advisory NSW.*		X
Will the proposal be on land in a Western City operational area specified in *the Western Parkland City Authority Act 2018,* Schedule 2 and have a capital investment value of $30 million or more? *If so, consult the Western Parkland City Authority*.		X
Will the proposal clear native vegetation on land that is not subject land (ie non-certified land)? *If so, notify DPE at least 21 days prior to work commencing. (Requirement under s3.24 Chapter 3 Sydney Region Growth Centres - of the SEPP (Precincts – Central River City) 2021).*		X

Appendix C – Specialist study (ecology)

Thornleigh Outlet Main
Flora and fauna assessment

FINAL REPORT

Prepared for Sydney Water

9 June 2023

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- NSW Environment, Energy and Science Group for access to the BioNet Atlas of NSW Wildlife.
- NSW Department of Primary Industries Fisheries for access to the predicted distribution maps for threatened species and fish communities.

Biosis staff involved in this project were:

- Astrid Mackegard (mapping)
- Jen Townsend (mapping)

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Contents

Tables

Figures

Summary

Biosis Pty Ltd (Biosis) was commissioned by Sydney Water to undertake a flora and fauna assessment of multiple areas of land proposed for an inlet / outlet main from Thornleigh Reservoir to Thornleigh-Wahroonga water pumping station (subject sites). The subject sites are across two locations within the Hornsby Local Government Area (LGA) at Lots 100 DP1217395 and 7343 DP116787 approximately 30 kilometres North-west of the Sydney Central Business District (CBD).

The subject site, defined by the extent of proposed works, is surrounded by the study area which includes adjacent areas likely to be directly or indirectly affected by the proposal or extended to include the lots containing the subject site (the study area). The subject site includes two sites, the Thornleigh Reservoir (WS0148) and the Thornleigh-Wahroonga water pumping station (WP0159). This assessment approach has been undertaken to allow for assessment of both the subject site as well as any additional areas in the broader study area which are likely to be affected by the proposal, either directly or indirectly. Identified constraints will be used to guide detailed design, with an emphasis on avoiding impacts where feasible.

Ecology values and impacts

Key ecological features found within the study area include:

- 7.7 ha of native vegetation including one Threatened Ecological Community (TEC) listed under the New South Wales (NSW) *Biodiversity Conservation Act 2016* (BC Act), *Sydney Turpentine-Ironbark Forest in the Sydney Basin Bioregion* and one TEC listed under the Environmental Protection and Biodiversity Conservation Act *Turpentine-Ironbark Forest of the Sydney Basin Bioregion*.
- Habitat for threatened species including
  - *Epacris purpurascens var. purpurascens* (Vulnerable, BC Act).
  - Bauer's Midge Orchid *Genoplesium baueri* (Endangered, EPBC Act and BC Act).
- Zig Zag Creek, a first order stream

Two Matters of National Environmental Significance or their habitat, listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) were located within the study area. Impacts to the threatened species and communities present or likely to occur, listed under the EPBC Act have been considered through undertaking a Significant Impact Criteria (SIC) assessments (refer to Appendix 1).

The study area also contains one TEC and habitat for two threatened flora species, listed under the BC Act. Impacts to the threatened species and communities present or likely to occur, listed under the BC Act have been considered through undertaking a Test of Significance (ToS) (refer to Appendix 2)

No waterway occurs within the Thornleigh reservoir site (WS0148) and one waterway occurs at site (WP0159). The waterway is classified as a first order stream (Strahler), under the *Water Management Act 2000* (WM Act). Works are proposed for the riparian zone within 10 metres of Zig Zag creek however, as a public authority, Sydney Water does not need to obtain a controlled activity approval from the Natural Resources Access Regulator for any controlled activities that it carries out in, on or under waterfront land.

As the proposal is not considered likely to have a significant impact to any entity listed under the BC Act, Sydney Water are not required to prepare a Species Impact Statement (SIS) or opt into the NSW Biodiversity Offsets Scheme (BOS).

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1 Introduction

1.1 Project background

Sydney Water proposes to build a new DN1800 inlet/outlet main, about 1.4 kilometre long, running between the Thornleigh Reservoir (WS0148) and the Thornleigh-Wahroonga Water Pump Station (WP0159). The new inlet/outlet main will run parallel to an existing inlet/outlet main and will include a pipe about 1.8 metres in diameter that will be installed via an underground tunnel boring machine (about 1.2 kilometres) and trenched installation (about 0.2 kilometres). Due to the large diameter of the pipeline, significant sized valves will need to be installed in chambers at each end of the pipeline. In addition, excavation of large sized launch and retrieval pits will be required at each end of the pipeline to facilitate the use of a tunnel boring machine. The proposed development is part of the works required due to the significant growth of the Prospect Water System.

Biosis was commissioned by Sydney Water to undertake a flora and fauna assessment of the subject site and broader study area (Figure 1).

1.2 Scope of assessment

The objectives of this investigation are to:

- Describe the flora (ferns, conifers, and flowering plants), vertebrate fauna (birds, mammals, reptiles, frogs)
- Map native vegetation and other habitat features.
- Review the implications of relevant biodiversity legislation and policy.
- Identify potential implications of the proposed development and provide recommendations to assist with development design.
- Recommendation of further ecological assessments that may be required.

1.3 Location of the study area

The subject site is located within the Hornsby LGA at Lots 100 DP1217395 (WS0148) and 7343 DP1167875 (WP0159) approximately 30 kilometres North-west of the Sydney (CBD) (Figure 1). Site (WS0148) and (WP0159) encompass approximately 20 hectares of private and public land and the adjacent road reserves. Lot 100 DP1217395 is currently zoned C3 - Environmental management and 7343 DP116787 is zoned R2 - Low Density Residential and RE1 - Public Recreation.

The study area is within the:

- Sydney Basin Bioregion.
- Greater Sydney Local Land Services (LLS) Management Area.
- Municipality of Hornsby LGA.

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Legend

- Study area
- Impact area

Threatened ecological community

- Turpentine-Ironbark Forest of the Sydney Basin Bioregion (BC Act, EPBC Act)

Vegetation communities

- Urban Native/Exotic
- 1183 - Smooth-barked Apple - Sydney Peppermint - Turpentine heathy open forest on plateaux areas of the Sydney Basin Bioregion - Moderate
- 1183 - Smooth-barked Apple - Sydney Peppermint - Turpentine heathy open forest on plateaux areas of the Sydney Basin Bioregion - High
- 1281 - Turpentine - Grey Ironbark open forest on shale in the lower Blue Mountains, Sydney Basin Bioregion - Low
- 1281 - Turpentine - Grey Ironbark open forest on shale in the lower Blue Mountains, Sydney Basin Bioregion - Moderate
- 1281 - Turpentine - Grey Ironbark open forest on shale in the lower Blue Mountains, Sydney Basin Bioregion - High
- 1787 - Red Bloodwood - Scribbly Gum - Stringybark open forest on sandstone ridges along the western side of the Woronora and Hornsby plateaus,High
- Exotic grasslands

Figure 1.1 Ecological features of the study area

0 60 120 180 240 300

Metres

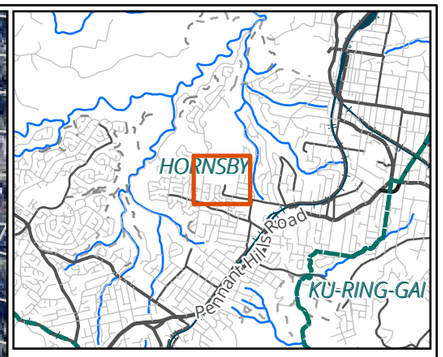
Scale: 1:8,000 @ A3

Coordinate System: GDA 1994 MGA Zone 56

N

biosis

Matter: 38426,
Date: 31 May 2023 ,
Prepared for: TH, Prepared by: JET, Last edited by: jtownsend
Layout: 38426_F1_Ecofeatures
Project: P:\38400s\38426\Mapping\
38426_ThornleighOutletMain_FFA.aprx



Legend

- Study area
- Impact area
- Lot

Threatened ecological community

- Turpentine-Ironbark Forest of the Sydney Basin Bioregion (BC Act, EPBC Act)

Vegetation communities

- 1183 - Smooth-barked Apple - Sydney Peppermint - Turpentine heathy open forest on plateaux areas of the Sydney Basin Bioregion - Moderate
- 1183 - Smooth-barked Apple - Sydney Peppermint - Turpentine heathy open forest on plateaux areas of the Sydney Basin Bioregion - High
- 1281 - Turpentine - Grey Ironbark open forest on shale in the lower Blue Mountains, Sydney Basin Bioregion - Low
- 1281 - Turpentine - Grey Ironbark open forest on shale in the lower Blue Mountains, Sydney Basin Bioregion - Moderate
- 1281 - Turpentine - Grey Ironbark open forest on shale in the lower Blue Mountains, Sydney Basin Bioregion - High
- 1787 - Red Bloodwood - Scribbly Gum - Stringybark open forest on sandstone ridges along the western side of the Woronora and Hornsby plateaus,High
- Exotic grasslands

Figure 1.2 Ecological features of the study area

0 20 40 60 80 100

Metres

Scale: 1:3,000 @ A3

Coordinate System: GDA 1994 MGA Zone 56

N

biosis

Matter: 38426,
Date: 31 May 2023 ,
Prepared for: TH, Prepared by: JET, Last edited by: jtownsend
Layout: 38426_F1_Ecofeatures
Project: P:\38400s\38426\Mapping\
38426_ThornleighOutletMain_FFA.aprx

Legend

- Study area
- Impact area
- Lot

Vegetation communities

- Urban Native/Exotic

Figure 1.3 Ecological features of the study area

0 8 16 24 32 40

Metres

Scale: 1:1,000 @ A3

Coordinate System: GDA 1994 MGA Zone 56

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Matter: 38426,
Date: 31 May 2023 ,
Prepared for: TH, Prepared by: JET, Last edited by: jtownsend
Layout: 38426_F1_Ecofeatures
Project: P:\38400s\38426\Mapping\
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2 Methods

2.1 Database and literature review

Prior to completing the field investigation, information provided by Sydney Water as well as other key information was reviewed, including:

- Australian Government Department of Climate Change, Energy, the Environment and Water (DCCEEW) Protected Matters Search Tool for matters protected by the EPBC Act.
- NSW Environment, Energy and Science (EES) BioNet Atlas of NSW Wildlife, for items listed under the BC Act.
- The NSW Department of Primary Industries (DPI) Spatial Data Portal for FM Act listed threatened species, populations and communities
- NSW DPI *Biosecurity Act 2015* for Priority listed weeds for the Greater Sydney Local Land Services (LLS) area.
- EES Vegetation Information System (VIS) mapping, including.
    - Southeast NSW native vegetation classification and mapping (DPE 2010)

The implications for the project were assessed in relation to key biodiversity legislation and policy including:

- *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).
- *Environmental Planning and Assessment Act 1979* (EP&A Act).
- *Biodiversity Conservation Act 2016* (BC Act).
- *Local Land Services Act 2013* (LLS Act).
- *Water Management Act 2000* (WM Act).
- *Biosecurity Act 2015.* (Biosecurity Act).
- State Environmental Planning Policy (Biodiversity and Conservation) 2021.
- *Hornsby Local Environmental Plan 2013*
- *Hornsby Development Control Plan 2013*

2.2 Field investigation

A field investigation of the study area was undertaken on November 11, 2022, by Todd Horton (Botanist). Vegetation within the study area was surveyed using the random meander technique (Cropper 1993) over 6 person hours.

General classification of native vegetation in NSW used in this report is based on the classification system in Keith (2004) which uses three groupings of vegetation: vegetation formation, vegetation class and vegetation type, with vegetation type the finest grouping. The grouping referred to in this report is Plant Community Type (PCT) as defined by the Biodiversity Assessment Method (BAM) (DPIE 2020), and has been the standard used across NSW since 2016.

The vegetation types, within the study area, were stratified into PCTs broadly based on previous vegetation mapping, and the vegetation boundaries marked with a hand-held GPS in the field. Appropriate PCTs were selected on the basis of species composition and structure, known geographical distribution, landscape position, underlying geology, soil type, and any other diagnostic features.

A habitat-based assessment was completed to determine the presence of suitable habitat for threatened species previously recorded (EES 2022) or predicted to occur (Commonwealth of Australia 2022) within 5 kilometres. This list was filtered according to species descriptions, life history, habitat preference and soil preference to determine those species most likely to be present within the study area.

2.2.1 Permits and licences

The flora and fauna assessment was conducted under the terms of Biosis' Scientific Licence issued by the Environment, Energy and Science Group under the *National Parks and Wildlife Act 1974* (SL100758, expiry date 31 May 2023). Fauna survey was conducted under approval CSB 17/892 from the NSW Animal Care and Ethics Committee (expiry date 31 January 2024).

3 Results

The study area has been heavily modified, and a large proportion of the vegetation has been removed for construction of the reservoir and pump station and associated works however, retained vegetation remains around the exterior of the reservoir site in particular. Vegetation consisted of both remnant native vegetation and urban native/exotic vegetation (Table 1). Connectivity is present along the eastern boundary northward and connecting to adjacent vegetation outside the study area. Three priority weeds were also present within the study area (Section 3.3.1).

Regional soil landscape mapping indicates that the study area occurs on the Disturbed, Gymea, Glenorie and Lucas heights soil landscapes on the St Albans 1:1,000,000 map sheet (Chapman et al. 1989).

Disturbed

This soil landscape consists of geology heavily disturbed by human activity. Disturbed areas are often landscaped, artificially drained or filled, inundated with waste and levelled to slopes of <3%. Landform elements include berms, cut faces, embankments, mounds, pits and trenches.

Gymea

This soil landscape consists of Hawkesbury sandstone geology with minor shale and laminite lenses. It occurs on undulating to rolling low hills with local relief 20-80 metres and slopes of 10-25 %. Sideslopes with narrow to wide outcropping sandstone rock benches (10-100 metres), often forming broken scarps of <5 metres.

Lucas Heights

Mittagong Formation geology interbedded shale, laminite and fine to medium grained quartz sandstone. The Mittagong Formation is located stratigraphically between the Ashfield Shale and Hawkesbury Sandstone. It is often relatively shallow. Minor areas of Hawkesbury Sandstone and minor areas of Ashfield Shale may occur. Gently undulating plateau, 200-1000 metres in width, with level to gently inclined slope gradients of <10 %. Local relief is <30 metres. Rock outcrop is absent.

Glenorie

This soil landscape is underlain by Wianamatta Group Ashfield Shale and Bringelly Shale formations. The Ashfield Shale is comprised of laminite and dark grey shale. Bringelly Shale consists of shale, calcareous claystone, laminite, fine to medium grained lithic-quartz sandstone (Herbert, 1983). Low rolling and steep hills. Local relief 50-120 metres, slopes 5-20 %. Convex narrow (20-300 metres) ridges and hillcrests grade into moderately inclined sideslopes with narrow concave drainage lines. Moderately inclined slopes of 10-15 % are the dominant landform elements.

3.1 Vegetation communities

Prior to the field investigation, Biosis confirmed that various native vegetation communities including one TEC has been mapped in the broader landscape (EES 2022, DPE 2010), these include:

- *PCT 1081 - Red Bloodwood - Grey Gum woodland on the edges of the Cumberland Plain, Sydney Basin Bioregion*
- *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 1281 - Turpentine - Grey Ironbark open forest on shale in the lower Blue Mountains, Sydney Basin Bioregion.* This PCT is consistent with the TEC *Sydney Turpentine-Ironbark Forest in the Sydney Basin Bioregion* (Critically Endangered, EPBC Act and BC Act).
- *Urban Native/Exotic.*

The vegetation of the study area was found to comprises five communities:

- *PCT 1183 - Smooth-barked Apple - Sydney Peppermint - Turpentine heathy open forest on plateaux areas of the Sydney Basin Bioregion*
- *PCT 1281 - Turpentine - Grey Ironbark open forest on shale in the lower Blue Mountains, Sydney Basin Bioregion*
- *PCT 1787 – Red Bloodwood - Scribbly Gum - Stringybark open forest on sandstone ridges along the western side of the Woronora and Hornsby plateaus*
- *Exotic grassland*
- *Urban Native/Exotic*

The structure, floristic composition and condition of these communities are described in Table 1. A key focus of the field investigation was to assess the vegetation of the study area against the final determinations for BC Act listed TECs and key diagnostics features and condition thresholds for EPBC Act listed TECs to determine presence or absence. The results of this assessment are included in Table 1.

Table 1 Vegetation communities of the study area

1183 – *Smooth-barked Apple - Sydney Peppermint - Turpentine heathy open forest on plateaux areas of the Sydney Basin Bioregion*	
PCT	1183
Description and condition	Approximately 3.9 ha of *Smooth-barked Apple - Sydney Peppermint - Turpentine heathy open forest on plateaux areas of the Sydney Basin Bioregion* was recorded within the study area. The community was present in a high condition and consisted of a canopy of Smooth-barked Apple *Angophora costata*, Blackbutt *Eucalyptus pilularis* and Turpentine *Syncarpia glomulifera.* The shrub layer of Sweet Pittosporum *Pittosporum undulatum* and Parramatta Wattle *Acacia parramattensis.* Ground layer of Blady Grass *Imperata cylindrica*, Blue Flax-lily *Dianella caerulea*, Common Maidenhair *Adiantum aethiopicum*, Creeping Beard Grass *Oplismenus imbecillis,* Kangaroo grass *Themeda triandra*, Spiny-headed Mat-rush *Lomandra longifolia*, Variable Sword-sedge *Lepidosperma laterale* and Wiry Panic *Entolasia stricta*.
Threatened ecological community	**Commonwealth EPBC Act:** Turpentine-Ironbark Forest of the Sydney Basin Bioregion (Critically Endangered) **NSW BC Act:** Sydney Turpentine-Ironbark Forest in the Sydney Basin Bioregion (Critically Endangered) Justification: The community within the study area, occurs within the correct region and contains characteristic diagnostic species of the listed TECs.
Picture: PCT 1183	

1281 - *Turpentine - Grey Ironbark open forest on shale in the lower Blue Mountains, Sydney Basin Bioregion*	
PCT	1281
Description and condition	Approximately 2.8 ha of *Turpentine - Grey Ironbark open forest on shale in the lower Blue Mountains, Sydney Basin Bioregion* was recorded within the study area. The community was present in low, moderate and high condition. Low and moderate condition found in the study area was due to reduced floristic diversity and weed inclusion due to edge effects. Vegetation consisted of a canopy of Smooth-barked Apple, Turpentine, Blackbutt, Grey Ironbark *Eucalyptus paniculata.* The shrub layer consisted of a shrub layer of Coffee Bush *Breynia oblongifolia*, Prickly Beard Heath *Leucopogon juniperinus,* Elderberry Panax *Polyscias sambucifolia*, Sweet Pittosporum, Large Mock-olive *Notelaea longifolia.* The ground layer consisted of variety of herbs and grasses including Blady Grass, Blue Flax-lily *Dianella Caerulea*, Creeping Beard grass *Oplismenus imbecillis*, Wiry Panic *Entolasia stricta,* Whiteroot *Pratia purpurascens*, Spiny-headed Mat-rush *Lomandra longifolia*, Variable Sword-sedge *Lepidosperma laterale*, Weeping grass *Microlaena stipoides.* Exotic species present included Farmer's friend *Bidens pilosa*, Large-leaf privet *Ligustrum lucidum*, Japanese honeysuckle *Lonicera japonica*, Mickey mouse plant *Ochna serrulata*, Ground Asparagus *Asparagus aethiopicus* and Lantana *Lantana camara.*
Threatened ecological community	**Commonwealth EPBC Act:** Turpentine-Ironbark Forest of the Sydney Basin Bioregion (Critically Endangered) **NSW BC Act:** Sydney Turpentine-Ironbark Forest in the Sydney Basin Bioregion (Critically Endangered) Justification: The community within the study area, occurs within the correct region and contains characteristic diagnostic species of the listed TECs.
Picture: PCT 1281	

1787 - *Red Bloodwood - Scribbly Gum - Stringybark open forest on sandstone ridges along the western side of the Woronora and Hornsby plateaus*	
PCT	1787
Description and condition	Approximately 1 ha of Red Bloodwood - Scribbly Gum - Stringybark open forest on sandstone ridges along the western side of the Woronora and Hornsby plateaus was recorded within the study area. The community was present in a high condition. Vegetation consisted of a canopy of Smooth-barked Apple *Angophora costata*, Hard-leaved Scribbly gum *Eucalyptus sclerophylla*, Red Bloodwood *Corymbia gummifera.* The shrub layer of Finger Hakea *Hakea dactyloides,* Slender Tea-tree *Leptospermum trinervium*, Spiny Bossiaea *Bossiaea obcordata,* Conesticks *Petrophile pulchella,* Sweet pittosporum *Pittosporum undulatum* and Broad-leaved Geebung *Persoonia levis.* The ground layer consisted of Wiry panic *Entolasia stricta*, Fish Bone *Lomandra obliqua*, Many-flowered Mat-rush *Lomandra multiflora,* Blueberry lily *Dianella revoluta,* Pomax *Pomax umbellata* and *Dampiera stricta.* Exotic species present included Farmer's friend *Bidens pilosa*, Large-leaf privet *Ligustrum lucidum*, Japanese honeysuckle *Lonicera japonica*, whiskey grass *Andropogon virginicus* and Lantana *Lantana camara.*
Threatened ecological community	**Commonwealth EPBC Act:** Not listed **NSW BC Act:** Not listed.
Picture: PCT 1787	

Exotic grassland	
Description and condition	Approximately 6.5 ha of exotic grassland was recorded within the study area. The community existed primarily of exotic grasses such as Kikuyu *Cenchrus clandestinus*, Rhodes grass *Chloris gayana*, Fireweed *Senecio madagascariensis,* Purple top *Verbena bonariensis,* Lamb's Tongue *Plantago lanceolata.*
Picture: Exotic grassland	

Urban Native Exotic	
Description and condition	Approximately 0.7 ha of urban native exotic was recorded within the study area. The community consisted of almost entirely planted native and exotic vegetation. Native species included Silky Oak *Grevillea robusta*, Sweet Pittosporum *Pittosporum undulatum*, Swamp She-oak Casuarina glauca, Spiny-headed Mat-rush Lomandra longifolia and Kangaroo apple *Solanum aviculare* Exotic species included Camphor laurel *Cinnamomum camphora*, Japanese Honey suckle *Lonicera japonica,* Lantana *Lantana camara,* Broad-leaved Privet *Ligustrum lucidum*, Dandelion *Taraxacum officinale*, Lamb's Tongue *Plantago lanceolata,* Chinese Wisteria *Wisteria sinensis*, Coral tree *Erythrina* spp., Giant reed *Arundo donax,* Wandering Trad *Tradescantia fluminensis* and Tobacco Bush *Solanum mauritianum*
Picture: Urban Native Exotic	

3.2 Aquatic habitats

No key fish habitat is mapped within the study area. Aquatic habitat within the study area was limited to Zig Zag creek a poor condition ephemeral first order stream (Strahler). The waterway is largely modified and fed by stormwater runoff. Vegetation around the waterway is highly modified consisting of primarily planted native and exotic species with a high occurrence of weed species. While the works may lead to some temporary impacts to waterways within the study area, the overall impacts of the project will not likely lead to further degradation to the waterway. As such, no further assessment of these waterways has been undertaken.

3.3 Threatened species

Background searches identified 37 threatened flora species and 60 threatened fauna species recorded (EES 2022) or predicted to occur (Commonwealth of Australia 2022) within 5 kilometres of the study area.

Those species considered most likely to have habitat within the study area based on the background research are as follows:

Flora

- *Darwinia biflora* (Vulnerable, EPBC Act and BC Act).
- *Epacris purpurascens* var. *purpurascens* (Vulnerable, BC Act).
- Bauer's Midge Orchid *Genoplesium baueri* (Endangered, EPBC Act and BC Act).
- Tangled Bedstraw *Galium australe* (Endangered, BC Act).
- *Tetratheca glandulosa* (Vulnerable, BC Act).
- Deane's Paperbark *Melaleuca deanei* (Vulnerable, EPBC Act and BC Act).

Fauna

- Gang-gang Cockatoo *Callocephalon fimbriatum* (Endangered, EPBC Act and Vulnerable, BC Act).
- Glossy Black-Cockatoo *Calyptorhynchus lathami* (Vulnerable, BC Act).
- Little Lorikeet *Glossopsitta pusilla* (Vulnerable, BC Act).
- White-throated Needletail *Hirundapus caudacutus* (Vulnerable, EPBC Act).
- Koala *Phascolarctos cinereus* (Endangered, EPBC Act and BC Act).
- Grey-headed Flying-fox *Pteropus poliocephalus* (Vulnerable, EPBC Act and Vulnerable, BC Act).
- Red-crowned Toadlet *Pseudophryne australis* (Vulnerable, BC Act).
- Dural Land Snail *Pommerhelix duralensis* (Endangered, EPBC Act and Endangered, BC Act).
- Little Bent-winged Bat *Miniopterus australis* (Vulnerable, BC Act).
- Large Bent-winged Bat *Miniopterus orianae oceanensis* (Vulnerable, BC Act).
- Greater Broad-nosed Bat *Scoteanax ruepellii* (Vulnerable, BC Act).
- Yellow-bellied Sheathtail-bat *Saccolaimus flaviventris* (Vulnerable, BC Act).
- Eastern Coastal Free-tailed Bat *Micronomus norfolkensis* (Vulnerable, BC Act).
- Eastern False Pipistrelle *Falsistrellus tasmaniensis* (Vulnerable, BC Act).
- Barking Owl *Ninox connivens* (Vulnerable, BC Act).
- Powerful Owl *Ninox strenua* (Vulnerable, BC Act).

An assessment of the habitat values of the study area is provided in Table 2 for threatened flora species and Table 3 for threatened fauna species, and discusses areas of value and potential impacts for all species with a medium or greater likelihood of occurrence, and determines the need for a Tests of Significance (ToS) for species listed under the BC Act, or Significant Impact Criteria (SIC) Assessment for species listed under the EPBC Act.

Table 2 Assessment of habitat for threatened flora species

Species	Local distribution and habitat requirements	Likelihood of occurrence or impact
Darwinia biflora	Approximately 276 individuals have been recorded within 5 km of the study area, with the closest being within 470 m. *Darwinia biflora* is usually found along the edges of weathered shale-capped ridges near an intergrade with Hawkesbury sandstone.	Approximately 0.55 ha of potential habitat is expected to be removed. This species favours sites containing sandstone-based vegetation on upper and mid-slopes. This is a conspicuous species and can be identified all-year round. No individuals were recorded during targeted meanders in suitable habitat. Therefore, no further assessment has been undertaken.
Epacris purpurascens* var. *purpurascens	Approximately 73 individuals have been recorded within 5 km of the study area, with some of these records existing within the study area itself. *Epacris purpurascens* var. *purpurascens* is a conspicuous species found in sclerophyll forest, heath scrubland and swamps, all of which have a strong shale influence.	Approximately 0.55 ha of vegetation associated with the species is expected to be removed within the study area. Areas of native vegetation, especially where there is shale influence are expected to provide potential habitat for this species. Whist flowers are required to distinguish from related species, the vegetative form is detectable all-year round. Though this species was not detected within the impact area, given the proximity of known records, the proposed works could have a tangible impact on this species via disturbance to potential habitat. Therefore, a ToS assessment has been undertaken.
Bauer's Midge Orchid	Has been recorded within 300 m of the study area. It is a terrestrial orchid which grows in dry sclerophyll forests amidst moss gardens on sandstone substrates. Bauer's Midge Orchid can be cryptic and is hard to see when not in flower which occurs from December to March.	Habitat is located across the study area where there is dry sclerophyll forest, particularly with an open shrub layer. This species is only detectable during flowering (February to March) which the survey fell outside. Given the possibility of impacting this species, a ToS and SIC assessment has been undertaken.

Species	Local distribution and habitat requirements	Likelihood of occurrence or impact
Tetratheca glandulosa	Approximately 185 records exist within 5 km of the study area, with the closet being within 500 m. Numerous small populations also occur in vegetation contiguous to that of the study area. It is a small spreading shrub which grows in shale-sandstone transition areas and is associated with the Lucas Heights, Gymea, Lambert and Faulconbridge soil landscapes.	Approximately 0.55 ha of habitat is expected to be removed. Habitat is located across sites with sandstone-based vegetation on upper and mid-slopes. Detection is reliant on flowering which can occur from July to November. Given the survey was conducted in November, during the peak flowering period, if the species was present, it is likely to have been detected. Therefore, further assessment has not been undertaken.
Tangled Bedstraw	Approximately seven records of this species occur within 5 km of the study area, with the closest being within 500 m. This species is a twining herb with an extant population in Nadgee Nature Reserve and historically recorded at Nowra and Narooma. Grows in a variety of communities including North Coast Wet Sclerophyll Forests, South Coast Sands Dry Sclerophyll Forests, Eastern Riverine Forests, Coastal Valley Grassy Woodlands and Coastal Headland Heaths.	Whilst records occur within the surrounding landscape, populations of this species generally occur further south (I.e., Southern NSW, Victoria, Tasmania). No individuals were detected during field investigations. This species is considered to have a low likelihood of occurring within the study area as survey as undertaken during flowering and fruiting season (October to February) and the species was not detected. Further assessment has not been undertaken.
Deane's Paperbark	Approximately 47 records of this species occur within 5 km of the study area, with the closest being within 1.2 km. This species is a medium sized shrub found growing in two distinct populations in the Ku-ring-gai/Berowra and Holsworthy/Wedderburn areas along with a few outliers at Springwood and in the Wollemi National Park, Yalwal and the Central Coast regions. Grows in ridgetop woodland on sandstone substrates in alluvial soils.	The study area contains habitat and historical records suggest this species occur within the surrounding landscape. No individuals were recorded during targeted meanders in suitable habitat, and given the species is conspicuous, it is unlikely to remain undetected if present within the study area. This species is considered to have a low likelihood of occurring within the study area. Further assessment has not been undertaken.

Based on the size of the study area, the survey effort is considered comprehensive to assess the presence of the flora species outlined in Table 2. ToS and SIC assessments have been undertaken for species deemed to have medium or greater likelihood of occurring. No further assessment is required for species with a low likelihood of occurrence.

Table 3 Assessment of habitat for threatened fauna species

Habitat feature	Threatened fauna association	Likelihood of occurrence or impact
Feed trees and foraging habitat	*Angophoras,* Eucalypts and other flowering perennial species recorded in the study area may provide nectar resources suitable for a range of arboreal and flying fauna (such as Grey-headed Flying-fox and nectivorous bird species) whilst in flower. The *Allocasuarinas*, *Angophoras*, and *Eucalypts* recorded in the study areas may provide feed tree resources for Koalas. The *Allocasuarina* trees within the study area provide foraging resources for the Glossy Black Cockatoo and other Cockatoo species including the Yellow-tailed Black-Cockatoo *Calyptorhynchus funereus*.	Based on the transient nature of the listed bird species and surrounding resources and connectivity within the landscape there is not likely to be a substantial impact to the following species: • Gang-gang Cockatoo • Little Lorikeet • White-throated Needletail The *Allocasuarina* trees within the study areas provide potential foraging resources for the Glossy Black-Cockatoo. However, due to the surrounding resources, small area of proposed impact and lack of hollow-bearing trees, it is unlikely that the proposed works will significantly impact the Glossy Black Cockatoo. Koala feed trees such as Blackbutt *Eucalyptus pilularis* are present within the study area. Koala records are located within 1.4 kilometres of the study areas, with the most recent record occurring in 2018. Impacts to habitat are low as they are limited to trimming and minor clearing. A high level of available contiguous habitat and connectivity will be retained No Grey-headed Flying-fox camps occur within either study areas. The closest camp is located 9 km southeast from the study area. The proposed works will not impact breeding habitat for the Grey-headed Flying-fox and assessment of impacts is not required. Native vegetation may provide suitable foraging habitat for threatened insectivorous bat species previously recorded within the locality: • Eastern False Pipistrelle • Eastern Coastal Free-tailed Bat • Little Bent-winged Bat • Large Bent-winged Bat • Yellow-bellied Sheathtail-Bat • Greater Broad-nosed Bat These species are highly mobile, forging across a variety of habitats within the locality. Within urban environments these species may utilise natural rock outcrops, hollows or man-made structures for roosting. No roost structures were identified within the immediate vicinity of the impact area and removal of vegetation will result in a

Habitat feature	Threatened fauna association	Likelihood of occurrence or impact
		small reduction to the overall available foraging area. The proposed works will not impact connectivity for these mobile species. Microbat species are unlikely to be impacted by the small-scale vegetation clearing proposed, in the context of the urban environment. Barking and Powerful owls may also use native vegetation for roosting and foraging habitat. However, no nesting habitat is present in the form of large hollows. Therefore, these species are unlikely to be impacted by the small-scale vegetation clearing proposed.
Hollow-bearing trees	No hollow-bearing trees were identified in either study areas. The majority of threatened fauna species records within 5 km of the study area use hollow-bearing trees for shelter and/or breeding.	No hollow-bearing trees were identified within the impact area or will be impacted by the proposed works. Therefore, the species associated with the hollow-bearing trees will not have sheltering or breeding habitat impacted.
Waterways (creek, river or dam)	One first order watercourse, Zig Zag Creek, was present within the study area. The waterway is degraded by weeds and stormwater runoff. The watercourse provides low quality habitat for amphibian species such as the Red-crowned Toadlet.	The Red-crowned Toadlet has a high number of records within the locality with the closest record within one kilometre of study area and has been observed as recent as 2021. However, despite the presence of this species in the locality, the likelihood of occurrence for the Red-crowned Toadlet is low due to the poor water quality of Zig-Zag Creek. Therefore, an assessment of impact is not required for this species.
Leaf litter and Woody debris	The study areas contain areas of leaf litter and woody debris that provide shelter for Gastropod species. The Dural Land Snail favors sheltering under rocks or bark and has been observed resting in exposed areas such as exposed rock or leaf litter.	The study areas contain leaf litter and woody debris habitat that is used for shelter by the Dural Land Snail. The closest record was approximately 1. 8km away. Due to the large amount of contiguous habitat being retained and the slow dispersal rate of this species, impacts are considered to be minor. Therefore, no further assessment is required.
Caves, karsts, cliffs, overhangs, man-made structures	No caves, karsts, cliffs, overhangs or man-made structures were identified in either study areas.	No man-made structures with potential for roosting by threatened species were identified within or adjacent to the impact area. Therefore, species roosting habitat associated with these features will not be impacted and no further assessment is required.

Based on the size of the study area, the survey effort is considered comprehensive to assess habitat presence for the species outlined in Table 3. The proposed works are considered to have a low likelihood of impacting these species. Therefore, no further assessment is required.

3.3.1 Priority weeds

Three priority weeds for Greater Sydney LLS Region, which includes the Hornsby LGA, have been recorded in the study area, and are listed in Table 4, along with their associated Biosecurity Duty in accordance with the Biosecurity Act.

The Biosecurity Act provides for the identification, classification and control of priority weeds with the purpose of determining if a biosecurity risk is likely to occur. A priority weed is any weed identified in a local strategic plan, for a region that includes that land or area, as a weed that is or should be prevented, managed, controlled or eradicated in the region.

The General Biosecurity Duty as outlined in the Biosecurity Act states:

> *All plants are regulated with a general biosecurity duty to prevent, eliminate or minimise any biosecurity risk they may pose. Any person who deals with any plant, who knows (or ought to know) of any biosecurity risk, has a duty to ensure the risk is prevented, eliminated or minimised, so far as is reasonably practicable.*

Table 4 Priority weeds within the study area

Scientific name	Common name	Relevant biosecurity duty
Arundo donax	Giant Reed	General Biosecurity Duty
Asparagus aethiopicus	Ground Asparagus	General Biosecurity Duty
Lantana camara	Lantana	General Biosecurity Duty

To prevent biosecurity impacts from occurring as a result of the presence of the above listed priority weeds within the study area, all practical steps should be taken to control and eradicated the weeds from the study area as per the relevant biosecurity duties outlined above, or prior to or during any future vegetation removal.

4 Ecological impacts and recommendations

The proposed outlet works involve the following impacts to ecological features:

- Removal of non-threatened native vegetation
  - 0.02 ha of PCT 1787
  - 0.35 ha of Urban native exotic
- Removal of threatened native vegetation
  - 0.15 ha of PCT 1183 (Sydney Turpentine Ironbark Forest TEC)
  - 0.38 ha of PCT 1281 (Sydney Turpentine Ironbark Forest TEC)

4.1 Environment Protection and Biodiversity Conservation Act 1999

The EPBC Act is the Australian Government's key piece of environmental legislation. The EPBC Act applies to developments and associated activities that have the potential to significantly impact on Matters of National Environmental Significance (NES) protected under the Act. Under the EPBC Act, activities that have potential to result in significant impacts on Matters of NES must be referred to the commonwealth minister for the DCCEEW water for assessment.

One TEC and one threatened species listed under the EPBC Act were recorded or assessed to have a medium or greater potential to occur within the study area. Assessments against the Significant Impact Criteria (CoA 2013) have been prepared for threatened entities that are deemed likely to be subject to negative impacts (Appendix 1) and concluded that a significant impact was not likely to result from the project. A significant impact was deemed unlikely due to the low level of impact, and the large number of continuous areas of habitat being retained as part of the works.

On the basis of criteria outlined in Commonwealth of Australia (2013) it is considered unlikely that a significant impact on a Matter of NES would result from the project. Therefore, Sydney Water are not required to refer the proposed action to the Australian Government Minister for the Environment and Energy to determine whether the action requires approval under the EPBC Act.

4.2 Biodiversity Conservation Act 2016

One TEC and two threatened species listed under the BC Act has a medium or greater likelihood of occurring within the study area. Tests of Significance have been prepared for threatened entities that are deemed likely to be subject to negative impacts (Appendix 2) and concluded that a significant impact was not likely to result from the project. A significant impact was deemed unlikely due to the low level of impact, and the significant contiguous areas of habitat being retained as part of the works.

Tests of Significance indicate that a significant effect is not likely to result from the proposal. As the proposal is not considered likely to have a significant impact to any entity listed under the BC Act, Sydney Water are not required to prepare a Species Impact Statement (SIS) or opt into the NSW Biodiversity Offsets Scheme (BOS).

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4.3 Water Management Act 2000

The WM Act provides for the sustainable and integrated management of the state's water for the benefit of both present and future generations based on the concept of ecologically sustainable development. Under the WM Act an approval is required to undertake controlled activities on waterfront land, unless that activity is otherwise exempt under Section 91E. Waterfront land is defined within the Act as the bed of any river, lake or estuary and any land within 40 metres of the riverbanks, lake shore or estuary mean high water mark.

However, as a public authority, Sydney Water does not need to obtain a controlled activity approval from the Natural Resources Access Regulator for any controlled activities that it carries out in, on or under waterfront land.

While Sydney Water is exempt from the controlled activity approval process, the design considerations and management measures detailed in the relevant WM Act guidelines (NSW Office of Water 2012) should be considered.

4.4 State Environmental Planning Policies

4.4.1 SEPP (Biodiversity and Conservation) 2021

Chapter 4 Koala Habitat Protection

Chapter 4 of the SEPP (Koala Habitat Protection 2021) must be addressed if a development is within a Local Government Area listed in Schedule 2 of the SEPP. The study area occurs within the Hornsby LGA, which is listed on Schedule 2.

However, as the project is being assessed under Part 5 of the EP&A Act, consideration of Chapter 4 of this SEPP is not required.

SEPP (Transport and Infrastructure) 2021

The SEPP (Transport and Infrastructure) 2021 consolidates and repeals the provisions of the following four SEPPs with the following relevant to this biodiversity assessment:

- Chapter 2 – Infrastructure (prior SEPP (Infrastructure) 2007), contains planning rules and controls from the Infrastructure SEPP for infrastructure in NSW, such as for hospitals, roads, railways, emergency services, water supply and electricity delivery.

Chapter 2, Infrastructure is relevant to this assessment as water supply infrastructure is considered as 'development permitted without consent'.

4.5 Development Control Plans/Local Environmental Plans

LEPs and DCPs are created by Councils in consultation with their community and guide planning decisions for LGAs. They apply either to the whole or part of a LGA and make provision for the protection or utilisation of the environment through zoning of land and development controls.

Elements of the LEP/DCP objectives are not relevant to this assessment as the works relate to chapter 2 of the SEPP (Transport and Infrastructure) 2021 and are considered as 'development permitted without consent' and 'exempt development', respectively. Elements of the LEP/DCP objectives are not discussed further.

4.6 Indirect Impacts

Temporary disturbance to wildlife from noise emissions and light spill during construction works are likely to be localised to within 50-100 metres of the construction footprint. Noise, light, dust, and vibration during the construction phase may disturb any fauna, including threatened microbats and other hollow-dependent species that may be inhabiting nearby hollow-bearing trees BTs or man-made structures, however this is not considered likely to have a significant long-term impact on wildlife that may occur within the study area or surrounding environment.

As operational noise is expected to be minimal after the construction period, occurring primarily within daylight hours, and if the Sydney Water safeguards in Table 5 of this report are followed, the works are not expected to have a significant impact on wildlife within the area.

4.7 Sydney Water Impact Assessment

Under Part 5 of the EP&A Act Sydney Water must assess the environmental impact of all its activities. Sydney Water must seek to avoid, minimise and mitigate these impacts, even if the works do not have a significant impact. Where there is likely to be a significant impact, or set thresholds are triggered, then statutory offsets apply.

As the proposal is unlikely to result in a significant effect on threatened species, populations or communities listed under the BC Act or the FM Act, consideration of the BOS is not warranted.

However, *Sydney Water Biodiversity Offset Guidelines* (Sydney Water 2019) will apply, details of the projects impact are provided in Table 5 below.

Table 5 Sydney Water Biodiversity Offset Guidelines Assessment

Ecological value	Impacts	Recommendations
Threatened ecological communities	Impacts to threatened ecological communities include: • 0.15 ha of Sydney Turpentine Ironbark Forest (PCT 1183) • 0.38 ha of Sydney Turpentine Ironbark Forest (PCT 1281)	• Protect retained vegetation in accordance with the requirements of *Australian Standard 4970-2009 for the Protection of Trees on Development Sites* (Standards Australia 2009). • Where possible, minimise all trimming activities. • Identify locations of retained TECs as No Go zones during the site induction. This should include discussion of the implications of the BC Act (potential fines and offsets) should there be an incident that impacts on the TECs. • Install appropriate exclusion fencing to the boundary of the TECs and any construction areas where there is some potential for accidental encroachment. Include appropriate signage. • Offsetting to follow *Sydney Water Biodiversity Offset Guidelines* (Sydney Water 2019)

Ecological value	Impacts	Recommendations
Threatened flora/fauna habitat	Impacts to threatened flora and fauna habitat includes: • Removal and trimming of 0.55 ha potential habitat for the following threatened flora species: – Bauer's Midge Orchid – *Epacris purpurascens var. purpurascens*	• Offsetting to follow *Sydney Water Biodiversity Offset Guidelines* (Sydney Water 2019) • Conduct a pre-clearance assessment for each of the listed species prior to the commencement of any removal of vegetation. This approach, however, will need to be adjusted for Bauer's Midge Orchid which can only be surveyed for during flowering (typically February-March).
Non-threatened native vegetation	Impacts non-threatened native vegetation include: • 0.02 ha of Sydney hinterland exposed sandstone woodland (PCT 1787)	• No-go fencing installed for retained vegetation. • Vegetation to be retained will be protected in accordance with the requirements of *Australian Standard 4970-2009 for the Protection of Trees on Development Sites* (Standards Australia 2009) • Offsetting to follow *Sydney Water Biodiversity Offset Guidelines* (Sydney Water 2019)
Number of locally indigenous native trees and tree hollows to be removed that are not part of a vegetation community	• 15 locally indigenous native trees to be removed not part of a community • No tree hollows to be removed • Minimal trimming required to street trees below 5 m clearance	• No-go fencing installed for retained vegetation. • Vegetation to be retained will be protected in accordance with the requirements of *Australian Standard 4970-2009 for the Protection of Trees on Development Sites* (Standards Australia 2009) • Offsetting to follow *Sydney Water Biodiversity Offset Guidelines* (Sydney Water 2019)
Number of non-locally indigenous native or exotic trees or tree hollows to be removed	• Ten exotic trees to be removed not part of a community • No tree hollows to be removed • Minimal trimming required to street trees below 5 m clearance	• No-go fencing installed for retained vegetation. • Vegetation to be retained will be protected in accordance with the requirements of *Australian Standard 4970-2009 for the Protection of Trees on Development Sites* (Standards Australia 2009) • Offsetting to follow *Sydney Water Biodiversity Offset Guidelines* (Sydney Water 2019)

5 Conclusion and recommendations

Given there are requirements for removal of native vegetation including canopy trees for the project, the focus of the recommendations is to minimise disturbance to any surrounding native vegetation and fauna habitat. The recommendations have been separated into Sydney Water standard safeguards Table 6 and Table 7 project specific recommendations.

Table 6 Sydney Water standard safeguards

Safeguard category	Safeguard information	Location
Topography, geology and soils		
2.1	Appropriate erosion and sediment control measures should be installed at all sites to avoid sedimentation of receiving water bodies or other indirect impacts to surrounding biodiversity values including: • Divert surface runoff away from disturbed soil and stockpiles. • Install sediment and erosion controls before construction starts. • Reuse topsoil where possible and stockpile separately. • Inspect controls at least weekly and immediately after rainfall. • Rectify damaged controls immediately. • Remove controls once surfaces have been stabilised, including removing trapped sediment in drainage lines.	All locations
2.2	Minimise ground disturbance and stabilise disturbed areas progressively.	All locations
2.6	Stop work during heavy rainfall or in waterlogged conditions when there is a risk of sediment loss off site.	All locations
2.7	Sweep up any sediment/soil transferred off site at least daily, or before rainfall.	All locations
2.7	Eliminate ponding and erosion by restoring natural landforms to the pre-works condition.	All locations
Water and drainage		
3.1	Use appropriate controls to avoid potential sedimentation to waterbodies (e.g. floatation boom).	All locations
3.3	Minimise the impacts to creeks where creek crossings are required. Prior to construction the methodology will be assessed based on: • Geotechnical and constructability issues (e.g. depth of cover, potential for future scouring). • Construction footprint and duration. • Ease of reinstatement. • Environmental issues (flora and fauna, geomorphology, contamination, heritage, water quality and hydrology). • Any issues raised during consultation with Department of Primary Industries.	All locations
3.6	Bund potential contaminants and store on robust waterproof membrane, away from drainage lines.	All locations

Safeguard category	Safeguard information	Location
3.8	Locate portable site amenities away from watercourses or drainage lines.	All locations
3.16	Conduct refuelling, fuel decanting and vehicle maintenance in compounds where possible. If field refuelling is necessary, designate an area away from waterways and drainage lines with functioning spill kits close by.	All locations
Flora and fauna		
4.2	Residual impacts to native vegetation and trees will be offset in accordance with the Sydney Water Biodiversity Offset Guideline.	All locations
4.5	Minimise vegetation clearance and disturbance, including impacts to standing dead trees and riparian zones. Where possible, limit clearing to trimming rather than the removal of whole plants.	All locations
4.6	Physically delineate vegetation to be cleared and/or protected on site and install appropriate signage prior to works commencing.	All locations
4.7	Adjust methodology (e.g. avoid area, hand excavate, implement exclusion fencing) to protect sensitive areas where possible (such as mature trees, known threatened species, populations or ecological communities).	All locations
4.8	Protect trees in accordance with the requirements of Australian Standard 4970-2009 for the Protection of Trees on Development Sites. Do not damage tree roots unless absolutely necessary, and engage a qualified arborist where roots >50mm are impacted within the Tree Protection Zone	All locations
4.11	Retain dead tree trunks, bush rock or logs in-situ unless they are in the impact area and moving is unavoidable. Reposition material elsewhere on the site or approved adjacent sites. If native fauna is likely to be present, a licenced ecologist should inspect the removal and undertake fauna relocation.	All locations
4.12	Inspect vegetation for potential fauna prior to clearing or trimming. If fauna is present, or ecological assessment has determined high likelihood of native fauna presence, including removal of hollow-bearing trees, engage a licenced ecologist to inspect and relocate fauna before works.	All locations
4.13	If native fauna is encountered on site, stop work and allow the fauna to move away un-harassed. Engage a licenced ecologist if assistance is required to move fauna	All locations
4.14	Avoid impeding/blocking fish passage. Retain snags and natural obstructions in waterways where possible.	All locations
4.17	Stop work immediately and notify the Sydney Water Project Manager if any threatened species (flora or fauna) is discovered during the works. Work will only recommence once the impact on the species has been assessed and appropriate control measures provided.	All locations
4.19	Manage biosecurity in accordance with: • *Biosecurity Act 2015* (see NSW Weedwise), including reporting new weed infestations or invasive pests • Contemporary bush regeneration practices, including disposal of sealed bagged weeds to a licenced waste disposal facility.	All locations

Safeguard category	Safeguard information	Location
4.21	To prevent spread of weeds: • Clean all equipment including PPE prior to entering or leaving the work sites. • Wrap straw bales in geo-fabric to prevent seed spread.	All locations
4.27	Minimise impacts on native vegetation in non-certified areas, native vegetation retention areas and areas outside the growth centre. Options to consider where feasible include: • Alternative construction methodologies (under bore vegetation and waterways, compressed construction corridors). • avoiding impact to hollow bearing and habitat trees.	All locations
4.28	Vegetation removal must not occur until the following are complete: • The area to be removed has been physically delineated. • The Contractor's Environmental Representative has confirmed consistency with approval documentation. • Pre-clearing surveys, if relevant. • Written authorisation to commence clearing from Sydney Water Project Manager.	All locations

Table 7 Project specific safeguards

Safeguard information	Location
All stockpile and compound areas are to be located within existing cleared areas and existing access tracks and will be rehabilitated at the end of construction.	All locations
Pre-clearance inspections within the impact area and immediate surrounds for *Epacris purpurascens* var. *purpurascens* (anytime) and Bauer's Midge Orchid *Genoplesium baueri* within the flowering period February – March.	Within PCT 1183, PCT 1281, PCT 1787
All staff on site are to be educated on the ID characteristics of the threatened species and advised to not handle fauna species under any circumstances during toolbox talks.	All locations
No-go fencing installed for retained vegetation to ensure surrounding area remains undisturbed.	All locations

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Appendices

Appendix 1 Significant Impact Criteria assessments

The following section provides for Significant Impact Criteria assessments as outlined in the *Matters of National Environmental Significance: Significant impact guidelines 1.1* (Commonwealth of Australia 2013) for all biota listed under the EPBC Act that have likelihood of impact or occurrence rated as medium or greater.

Threatened ecological communities

Turpentine-Ironbark Forest of the Sydney Basin Bioregion (Turpentine-Ironbark Forest)

Turpentine-Ironbark Forest is listed as a Critically Endangered Ecological Community (CEEC) under the EPBC Act. Turpentine-Ironbark Forest is an open forest, with dominant canopy trees including Turpentine, Grey Gum *Eucalyptus punctata*, Grey Ironbark *Eucalyptus paniculata* and Thin-leaved Stringybark *Eucalyptus eugenoides*. In areas of high rainfall (over 1050 mm per annum) Sydney Blue Gum is more dominant. The shrub stratum is usually sparse and may contain mesic species such as Sweet Pittosporum *Pittosporum undulatum* and Elderberry Panax *Polyscias sambucifolia*. The ecological community occurs in Sydney and is heavily fragmented, with only 0.5 % of its original extent remaining intact. Remnants mostly occur in the Baulkham Hills, Hornsby, Ku-ring-gai, Parramatta, Ryde, Sutherland and Hurstville local government areas. Good examples can be seen in small reserves such as Wallumatta Nature Reserve and Newington Nature Reserve.

Turpentine-Ironbark Forest within the study area

Turpentine-Ironbark Forest aligns with PCT 1183 and 1281 within the study area. A total of 2.8 ha hectares of Turpentine-Ironbark Forest occurs within study area with 0.4 ha occurring in the impact area which is subject to self-assessment under the EPBC Act. An assessment of the impacts of this vegetation in accordance with the *Matters of National Environmental Significance Significant impact guidelines* is provided below.

Table A.1 SIC assessment for Turpentine-Ironbark Forest of the Sydney Basin Bioregion

SIC assessment for critically endangered and endangered ecological community
Reduce the extent of an ecological community.
When assessed at both the local and national scale the proposed impacts of the project will not result in a substantial reduction to the extent of Turpentine-Ironbark Forest. A total of approximately 2.8 ha of the TEC is present within the study area, and of that, approximately 0.4 ha is proposed to be impacted by the proposed works. However, impacts are limited to trimming for entry to complete works as well as clearing of small area with a much larger contiguous area of Turpentine Ironbark Forest to be retained. Trimming works will also be temporary in nature and will be allowed to regrow once works are completed. Any vegetation to be retained will be protected in accordance with the requirements of *Australian Standard 4970-2009 for the Protection of Trees on Development Sites* (Standards Australia 2009). Given this, it is unlikely that a relatively localised impact will result in a significant reduction of the extent of Sydney Turpentine-Ironbark Forest.
Fragment or increase fragmentation of an ecological community.
The Listing Advice for the TEC states that it occurs in a highly fragmented state and generally as small remnants. Whilst patches of this TEC within the study area form part of a larger contiguous patch of intact vegetation, the vegetation to be impacted mostly occurs along existing edge and as such is already subject to disturbance and potential for invasion by exotic species. The proposed works will result in impacts towards 0.4 ha of the community; however this is limited to the minor trimming and clearing of small area of vegetation along an existing edge, and as such will not fragment or increase

SIC assessment for critically endangered and endangered ecological community
fragmentation of the ecological community.
Adversely affect habitat critical to the survival of an ecological community.
The Matters of National Environmental Significance Significant impact guidelines (Commonwealth of Australia 2013) state the 'Habitat critical to the survival of a species or ecological community' refers to areas that are necessary: • For the long-term maintenance of the species or ecological community (including the maintenance of species essential to the survival of the species or ecological community, such as pollinators), • To maintain genetic diversity and long-term evolutionary development, or • For the reintroduction of populations or recovery of the species or ecological community. No such habitat has been identified in a recovery plan for Turpentine-Ironbark Forest, nor is it listed on the Register of Critical Habitat maintained by the minister under the EPBC Act. Nonetheless, the proposed works will impact upon 0.4 ha of this community. These impacts are however limited minor trimming and clearing of a small area of edge effected vegetation. Given that the proposed impacts are of a small and localised scale, and contiguous patches will remain in the broader landscape, it is unlikely that the proposal will have an adverse effect on any habitat that is critical to the community's survival.
Modify or destroy abiotic factors necessary for an ecological community's survival, including reduction of groundwater levels, or substantial alteration of surface water drainage patterns.
The proposed works will result in localised disturbance to soil, hydrology and topography. However, the proposal is not expected to result in substantial alteration to surface water patterns as the impact area will be rehabilitated following completion of construction works. The final form where works are to take place will ensure ground levels are re-profiled to a stable landform consistent with original contours. Alterations to hydrological patterns may also occur, but the area of the TEC impacted in this is not expected to be substantial as the works are not expected to significantly increase runoff or prevent sol drainage. Sydney Water safeguards (outlined in Section 5 of this report) would ensure that downstream indirect impacts (such as sediment and nutrient transportation) would be controlled and would not impact remaining areas of the TEC. As such, the proposal is not expected to result in impacts that modify or destroy abiotic factors necessary for the survival of the community.
Cause a substantial change in the species composition of an occurrence of an ecological community, including a decline or loss of functionally important species, for example through regular burning or flora and fauna harvesting.
The occurrence of Turpentine-Ironbark Forest is defined as the patch of the community that occurs within the study area and extends into an adjacent area in a contiguous manner without major breaks in connectivity. Impacts required for the proposed works are limited to minor trimming and the clearing of a small section of vegetation along an existing edge. As such, it is unlikely to further reduce species diversity, simplify community structure or reduce connectivity. The adjacent areas of the community within the broader area will remain intact and are unlikely to suffer substantial changes in species composition.
Cause a substantial reduction in the quality or integrity of an occurrence of an ecological community, including but not limited to: - ***Assisting invasive species establishment*** ***- Causing regular mobilisation of fertilisers, herbicides or other chemicals or pollutants into the ecological community which kill or inhibit the growth of species in the ecological community.***

SIC assessment for critically endangered and endangered ecological community
All Turpentine-Ironbark Forest within the study area is subject to existing weed invasion, pest animals, erosion and chemical inputs as a result of surrounding land uses. Nonetheless, the proposed works are not expected to increase weed or pest invasion, or cause mobilisation of fertilisers, herbicides or other chemicals within the CEEC. Construction activities will be managed through the Sydney Water safeguards listed in Section 5 of this report, which includes management activities to reduce the spread of weeds, as well as practices to avoid further sedimentation and pollution. Therefore, the proposed works are unlikely to cause a substantial reduction in the quality or integrity of an occurrence of the CEEC.
Interfere with the recovery of an ecological community.
A National Recovery Plan for Turpentine-Ironbark Forest has not been produced, however the Approved Conservation Advice (DoE 2014) sufficiently outlines the priority actions needed for this ecological community. Some of the high priority conservation actions significant to the proposed works are: • Protect and conserve remaining areas of the ecological community, including protecting potential areas of natural or managed retreat (e.g., upslope and upstream of current occurrences). • Avoid further clearance and destruction of the ecological community. • Retain other native vegetation remnants, near patches of the ecological community, where they are important for connectivity, diversity of habitat and act as buffer zones between the ecological community and threats or development zones. The proposed works will result in vegetation clearance and alterations to hydrology. However, interference with the recovery of the community can be minimised by implementing management strategies, such as those mentioned in the Sydney Water safeguards in Section 5 of this report, and ensuring any potential impacts are avoided if possible.
Conclusion.
Based on the assessment provided above, it is concluded that the Turpentine-Ironbark Forest is unlikely to be significantly impacted by the proposed works. This conclusion was made on the basis that the proposed works are: • Unlikely to contribute to substantial fragmentation of the community. • Unlikely to contribute to local scale reduction in the extent and functionality of the community. • Unlikely to adversely affect habitat critical to the community's survival. • Unlikely to interfere with the recovery of the ecological community. Therefore, no further assessment is required.

Threatened flora species

Bauer's Midge Orchid Genoplesium baueri– Endangered species EPBC Act

Bauer's Midge Orchid is listed as Endangered under the Commonwealth EPBC Act. This species is a terrestrial orchid and is endemic to NSW. Due to the cryptic nature of this species, records are limited. However, the distribution of the species is generally considered to be from Ulladulla to Port Stephens. This orchid usually grows in heathland to shrubby woodland on sands or sandy loams or open forest, shrubby forest and heathy forest on well-drained sandy and gravelly soils.

Bauer's Midge Orchid within the study area

Habitat is located across sites with sandstone-based vegetation. No records occur within the study area; however, records are present to the north-east of the study area. This species was not detectable during the time of survey, therefore, it's presence of absence within the study area is unknown. A self-assessment of whether the proposal is likely to lead to a significant impact on Bauer's Midge Orchid is provided below.

Table A.2 SIC assessment for Bauer's Midge Orchid

SIC assessment for Bauer's Midge Orchid
Lead to a long-term decrease in the size of a population.
Bauer's Midge Orchid generally flowers in February-March and remains dormant beneath the soil and is likely to go undetected outside of flowering time. Considering this, and that nearby previous records and the presence of associated vegetation communities occur within the study area, potential habitat for the species is likely present. Approximately 0.55 ha of vegetation associated with this species, within the study area will be impacted by the proposed works. Impacts to this potential habitat are limited to small area of vegetation that has been subject to previous disturbance and is subject to edge effects. Pre-clearance surveys are recommended to be completed during the optimal survey period (February - March) prior to works commencing to determine if the species is present and prevent it from being directly impacted. With this in consideration, the potential impacts to a population of the species can be considered small and localised in nature and as such, it is considered unlikely that there will be a long-term decrease in the size of a population of a species.
Reduce the area of occupancy of the species.
Approximately 0.55 ha of vegetation associated with this species within the study area will be impacted by the proposed works. However, this removal is predominantly in the form clearing/trimming along the edges of existing vegetation. Further to this, over 2.8 ha of potential habitat has been mapped within the study area which will remain connected to Berowra Valley national park. Therefore, whilst it is possible the proposed works will impact upon on a very small proportion of potential habitat within the locality, it is not considered a significant reduction. Hence, the removal of habitat as a result of the current proposal are not considered substantial enough to result in a reduction to the area of occupancy of the species.
Fragment an existing population into two or more populations.
The proposed works will remove approximately 0.55 ha of vegetation associated with this species within the study area will be impacted by the proposed works. However, this removal is predominantly in the form clearing/trimming along the edges of existing vegetation. Although the impact area dissects potential habitat, associated impacts are not considered substantial and will not result in substantial decreases in connectivity of habitat. No fragmentation is expected to result from the proposed works as no large strands of habitat will be removed.
Adversely affect habitat critical to the survival of a species.

SIC assessment for Bauer's Midge Orchid
Critical habitat has not been declared for Bauer's Midge Orchid.
Disrupt the breeding cycle of a population.
There is a lack of literature surrounding the reproduction of Bauer's Midge Orchid. Studies do suggest that the species reacts positively to fire, with the majority of individuals seen flowering increasing after a fire-event (Riley and Banks 2002). Unlike other species, Bauer's Midge Orchid does not produce new tubers each season, rather it produces a tuber-like perennial root. Further to this, whilst the flowering season is generally considered to be between February - March, individuals do not always produce flowers each year, with some remaining dormant for large periods of time (Jones 2006). Recommendations have been made in this report (Section 5) to minimise soil disturbances, and pre-clearance surveys to be conducted during the optimal survey period (February - March) prior to the commencement of works. Detection of the species within any impact area would allow the works to be programmed to avoid disruption to the breeding cycle of a population.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.
The species was not recorded in the study area and pre-clearance surveys during the optimal survey period (February - March) are recommended to be completed prior to works commencing. Nonetheless, as the species can remain dormant in the soil, it is possible that any disturbances to the soil may result in a decrease to the amount of habitat in the immediate vicinity of the proposed works. However, impacts are small, localised and limited to clearing along the existing vegetation edge. This local scale loss of habitat is not considered likely to cause the species to decline considering there are higher quality patches of habitat available across the study area and within neighbouring reserved lands.
Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat.
Invasive species will be managed by Sydney Water utilising the control methods outlined in the Sydney Water Safeguards in Section 5 of this report. This includes: • Contemporary bush regeneration practices, including disposal of sealed bagged weeds to a licenced waste disposal facility • Wrapping straw bales in geo-tech fabric to prevent the spreading of exotic seeds Therefore, the project is unlikely to exacerbate the current level of invasive species threat operating within the study area to the point that they become harmful to Bauer's Midge Orchid. The proposed works will not 'open up' habitat that was previously inaccessible to invasive species and as such is unlikely to exacerbate the current level of invasive species threat operating within the study area to the point that they become harmful to Bauer's Midge Orchid.
Introduce disease that may cause the species to decline.
As per the Sydney Water Safeguards mentioned in Section 5 of this report, all equipment used throughout the duration of the proposed works, including PPE, will be cleaned prior to entering or leaving the work sites. This will prevent the spread of any known diseases and therefore the proposed work is unlikely to introduce a disease that causes any Bauer's Midge Orchid population to decline.
Interfere with the recovery of the species.
A Recovery Plan has not been prepared for Bauer's Midge Orchid. However, the approved Conservation Advice identifies several conservation actions for the recovery of the species: • Ensure sites where species occurs are protected from disturbance by trail bike riding, rubbish dumping and track and road maintenance by barriers and/or fencing. • Maintain natural habitat of the species.

SIC assessment for Bauer's Midge Orchid
• As the species exists in well-drained habitat types, any alteration to hydrology at all sites should be avoided The proposed works may slightly interfere with one of the above conservation actions due to the works requiring the clearing of a limited area of potential habitat. However, these impacts are considered minor and localised as much of the contiguus habitat will remain and therefore unlikely to significantly impact the recovery of the species.
Conclusion.
Based on the assessment provided above, it is concluded the project is unlikely to lead to a significant impact towards Bauer's Midge Orchid. This conclusion can be made on the basis that: • Impacts towards potential habitat for the species are minimal and are limited to clearing to a small section of potential habitat • Pre-clearance surveys are recommended to be completed prior to works commencing to prevent any previously undetected individuals from being impacted. • The proposed works will not; fragment any remaining populations, interrupt with the species breeding cycle or interfere with the recovery of the species. • Sydney Water Safeguards, as mentioned in Section 5 of this report, will be implemented to prevent the spread of invasive weeds and diseases.

Appendix 2 Tests of Significance

The following section provides for Tests of Significance as outlined in Section 7.3 of the BC Act for all species listed as a medium likelihood of occurring within the study area.

Threatened ecological communities

Sydney Turpentine-Ironbark Forest in the Sydney Basin Bioregion– Critically Endangered Ecological Community BC Act

Sydney Turpentine-Ironbark Forest is listed as a CEEC under the BC Act. Sydney Turpentine-Ironbark Forest is an open forest, with dominant canopy trees including Turpentine, Grey Gum *Eucalyptus punctata*, Grey Ironbark *Eucalyptus paniculata* and Thin-leaved Stringybark *Eucalyptus eugenoides*. In areas of high rainfall (over 1050 mm per annum) Sydney Blue Gum is more dominant. The shrub stratum is usually sparse and may contain mesic species such as Sweet Pittosporum and Elderberry Panax *Polyscias sambucifolia*. The ecological community occurs in Sydney and is heavily fragmented, with only 0.5 percent its original extent remaining intact. Remnants mostly occur in the Baulkham Hills, Hornsby, Ku-ring-gai, Parramatta, Ryde, Sutherland and Hurstville local government areas. Good examples can be seen in small reserves such as Wallumatta Nature Reserve and Newington Nature Reserve (NSW Threatened Species Scientific Committee 2019).

Sydney Turpentine-Ironbark Forest within the study area

Sydney Turpentine-Ironbark Forest aligns with PCT's 1183 and 1281, and generally occurs in low condition within the study area. A total of 6.7 hectares of Sydney Turpentine-Ironbark Forest occurs within the study area with 0.4 hectares occurring in the impact area which is subject to assessment under the BC Act. An assessment of the impacts of this vegetation in accordance with the *Threatened species test of significance* is provided below.

Table A.3 Test of Significance for Sydney Turpentine-Ironbark Forest in the Sydney Basin Bioregion

Test of Significance for Sydney Turpentine-Ironbark Forest
In the case of a threatened species, whether the proposed development or activity is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.
Not applicable, not a threatened species.
In the case of an endangered ecological community or critically endangered ecological community, whether the proposed development or activity: ***(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or*** ***(ii) Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.***
The proposed works will impact approximately 0.55 ha of a much larger, 2.8 ha contiguous patch of Turpentine-Ironbark Forest. This community is present in a low, moderate and high condition states. Clearing for the proposal is unlikely to further reduce species diversity or simplify community structure more broadly. Impacts are limited to clearing/trimming of a small section of a larger contiguus patch of Turpentine Ironbark Forest. Any adjacent vegetation to be retained will be

Test of Significance for Sydney Turpentine-Ironbark Forest
protected in accordance with the requirements of *Australian Standard 4970-2009 for the Protection of Trees on Development Sites* (Standards Australia 2009). The vegetation to be impacted does not comprise any ecological components critical to the survival of the CEEC in the locality as most of the area to be cleared is in degraded condition and subject to edge effects. The adjacent areas of the community within the broader area will remain intact and are unlikely to suffer changes in species composition.
In relation to the habitat of a threatened species or ecological community: ***(i) the extent to which habitat is likely to be removed or modified as a result of the proposed development or activity, and*** ***(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed development or activity, and*** ***(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species or ecological community in the locality.***
The habitat supporting the local occurrence of the CEEC comprises a large intact area of the community that has been able to persist despite clearing within the surrounding landscape. These areas of habitat occur with a patchy distribution across the study area. The proposal will impact 0.4 ha of habitat for the CEEC, which is limited to clearing/trimming of a small patch within a much larger patch of contiguous Turpentine Ironbark Forest that will be retained. A portion of the section being removed is already subject to edge effects resulting from previous clearing occurring within the area. The area of habitat to be directly and indirectly impacted by the proposal is not considered important to the long-term survival of the community in the locality.
Whether the proposed development or activity is likely to have an adverse effect on any declared area of outstanding biodiversity value (either directly or indirectly).
To date no AOBVs have been declared within the proposal's study area.
Whether the proposed development or activity is or is part of a key threatening process or is likely to increase the impact of a key threatening process.
The proposed works have the potential to result in the following key threatening process which is listed under the Schedule 4 of the BC Act, and to which are considered relevant to Sydney Turpentine-Ironbark Forest: • Clearing of native vegetation. The proposed works requires clearing of land where this community occurs, resulting in the removal of 0.55 ha of the CEEC. Given impacts are limited to the removal of small section with much of the larger contiguous patch being retained, the project is unlikely to increase the impact of any key threatening processes.
Conclusion.
The proposed works are unlikely to significantly affect Sydney Turpentine-Ironbark Forest for the following reasons: • The proposed works are limited to the clearing of a small section of a larger contiguous area of the CEEC. • The proposed works are localised, and the study area has already been exposed to a number of disturbances which are unlikely to be further exacerbated by the proposed works. • The proposed works is unlikely to significantly alter floristic or structural diversity of the CEEC within the study area, particularly given that impacts are limited to ground disturbances only. • The localised nature of the proposed works will not significantly trigger or exacerbate any key threatening processes. Application of the BOS or preparation of a SIS is therefore not required.

Threatened flora species

Bauer's Midge Orchid Genoplesium baueri– Endangered species BC Act

Bauer's Midge Orchid is listed as Endangered under the BC Act This species is a terrestrial orchid and is endemic to NSW. This species is cryptic in nature, with individuals regularly retaining dormancy beneath the soil. Nonetheless, the flowering period for the species is considered to be between February - March, which produces fleshy, brittle flowers which are yellow/green in colour. The species has been recorded from locations between Ulladulla and Port Stephens, with approximately half of these records being made before 1960. Currently the species is known from just over 200 plants across 13 sites.

Bauer's Midge Orchid within the study area

Previous records of Bauer's Midge Orchid exist in the surrounding locality. Approximately 11 records within 5 kilometres of the study area, with the most recent collected in 1995.

This species was not detectable during the time of survey, therefore, it's presence or absence within the study area is unknown

Impacts to the species potential habitat are likely to occur within sections of clearing within PCT 1281. No individual plants were recorded in any areas to be impacted. The local population of Bauer's Midge Orchid referred to herein includes all extant individuals and soil stored propagules that may be present within the study area and extends into the habitats provided in contiguous bushland remnants. An assessment of whether the proposal is likely to lead to a significant impact to Bauer's Midge Orchid is provided below.

Table A.4 Test of Significance for Bauer's Midge Orchid

Test of Significance for Bauer's Midge Orchid
In the case of a threatened species, whether the proposed development or activity is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.
Approximately 0.55 ha of vegetation associated with this species within the study area will be impacted by the proposed works. Potential impacts to Bauer's Midge Orchid and/or its habitat resulting from the proposed works are in the form of clearing/trimming within a small section within a much larger section of potential habitat. This activity has the potential to impact upon unrecorded individuals or any individuals present beneath the soils surface, both of which would affect the lifecycle of the affected individuals, or clusters of plants, within the population. To alleviate the possibility of disrupting the breeding cycle of the species, pre-clearance surveys are recommended to be completed during the optimal survey period for the species (February – March) prior to works commencing. If the species is found at any impact area, said area would be avoided until the completion of flowering and fruiting. It is therefore unlikely that the proposed works will have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.
In the case of an endangered ecological community or critically endangered ecological community, whether the proposed development or activity: ***(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or*** ***(ii) Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.***
Not applicable, not an ecological community.

Test of Significance for Bauer's Midge Orchid

In relation to the habitat of a threatened species or ecological community:

(i) the extent to which habitat is likely to be removed or modified as a result of the proposed development or activity, and

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed development or activity, and

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species or ecological community in the locality.

Approximately 0.55 ha of vegetation associated with this species within the study area will be impacted by the proposed works. As impacts to this potential habitat are limited to minor amounts of groundcover removal in areas already subject to previous disturbance, as well as the clearing/trimming along the edges of tracks to allow machinery and equipment to access the works areas, an area of habitat would not become fragmented or isolated from another area of habitat. The majority of areas to be impacted occur within areas that have already undergone previous disturbance for previous pipeline works and are considered to contain marginal habitat for the species. The extent of this habitat removal is not considered to be substantial when assessed in the context of the local population of the species which occurs throughout the adjacent bushland areas.
In light of the above, the proposed works are not considered likely to impact upon the species habitat at a level likely to lead to the extinction of the species in the locality.

Whether the proposed development or activity is likely to have an adverse effect on any declared area of outstanding biodiversity value (either directly or indirectly).

To date no AOBVs have been declared within the proposal's study area.

Whether the proposed development or activity is or is part of a key threatening process or is likely to increase the impact of a key threatening process.

The proposed works have the potential to result in the following key threatening process which is listed under the Schedule 4 of the BC Act, and to which are considered relevant to Bauer's Midge Orchid:

- Clearing of native vegetation.

Approximately 0.84 ha of vegetation within the study area will be impacted by the proposed works, with approximately 0.4 ha being vegetation associated with the species. However, impacts to this potential habitat are limited to minor amounts of groundcover removal in areas already subject to previous disturbance, as well as the clearing/trimming along the edges of tracks to allow machinery and equipment to access the works areas. Given some areas of potential habitat to be impacted by the proposal will be in the form of partial clearing, pre-clearance surveys will be completed during the optimal survey period for the species (February – March) prior to works commencing and that large areas of contiguous vegetation similar to that in the study area will be retained, the proposed works are unlikely to increase the impact of any key threatening processes.

Conclusion.

In consideration of the above, the proposed activity is not likely to significantly affect Bauer's Midge Orchid within the study area or wider locality, as:

- The proposed works are localised, and the study area has already been exposed to a number of disturbances which are unlikely to be further exacerbated by the proposed works.

Test of Significance for Bauer's Midge Orchid
• The proposed works is unlikely to significantly alter the extent of a populations to the point where they become locally extinct. • Pre-clearance surveys will be completed prior to works commencing to prevent any previously undetected individuals from being impacted. • The removal of potential habitat will not result in the isolation or fragmentation of locally occurring habitat within the study area and as such is unlikely to affect its long-term survival in the locality. • The localised nature of the proposed works will not significantly trigger or exacerbate any key threatening processes. Application of the BOS or preparation of a SIS is therefore not required.

Epacris purpurascens var. purpurascens – Vulnerable species BC Act

Epacris purpurascens var. *purpurascens* is a shrub endemic to the Sydney Basin Bioregion in NSW and currently listed as Vulnerable under the BC Act. *E. purpurascens* var. *purpurascens* has been recorded from Gosford in the north, to Narrabeen in the east, Silverdale in the west and Avon Dam vicinity in the south. It is described as an erect shrub, 50 – 180 centimetres tall, with leaves spreading and recurved above, ovate to heart-shaped, 7 – 21 millimetres long, 4.4 – 9 millimetres wide, with sharply pointed tips. Flowers are showy, 7 – 10 millimetres in diameter and appear between July – September, crowded along the branchlets, often white or pink (NSW Scientific Committee 1999). In some past surveys *Epacris purpurascens* var. *purpurascens* has been confused with *Woollsia pungens* and Pink Swamp Heath *Sprengelia incarnata* when not in flower. In *Woolsia pungens,* the corolla lobes are contorted in bud, whereas in *Epacris purpurascens* var. *purpurascens,* the corolla lobes are imbricate in bud (National Parks and Wildlife Services NSW 2002). Pink Swamp Heath has large sheathing leaves relative to the small non-sheathing leaves of *Epacris* spp. (National Parks and Wildlife Services NSW 2002). *Epacris purpurascens* var. *purpurascens* occurs in sclerophyll forest, scrubs and swamps, favouring open woodlands with a strong shale soil influence (NSW Scientific Committee 1999). Additionally, this species has been observed to exhibit a preference for disturbed habitat which can include drainage lines or depressions, areas of skeletal soils and areas of indurated laterite gravels or rock fragments (NSW Scientific Committee 1999).

Epacris purpurascens var. purpurascens within the study area

Previous records from 2012 of *Epacris purpurascens* var. *purpurascens* exist towards the southern section of Thornleigh reservoir within the study area, approximately 100 metres from the impact area.

The proposed works will result in the removal and trimming of up to 0.55 hectares of potential habitat for the species. An assessment of whether the proposal is likely to lead to a significant impact to *Epacris purpurascens* var. *purpurascens* is provided below.

Table A.5 Test of Significance for *Epacris purpurascens* var. *purpurascens*

Test of Significance for *Epacris purpurascens var. purpurascens*
In the case of a threatened species, whether the proposed development or activity is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.
Approximately 0.84 ha of vegetation within the study area will be impacted by the proposed works, of which approximately 0.55 ha is considered potential habitat for *Epacris purpurascens* var. *purpurascens*. Potential impacts to *Epacris purpurascens var. purpurascens* habitat resulting from the proposed works are in the form of trimming and clearing of a small amount of potential habitat for this species. No individuals were detected during the field investigation, however, as there are historical recorded within the study area in proximity to the impact area, pre-clearance surveys are recommended to be completed during the optimal survey period for the species prior to works commencing. It is therefore unlikely that the proposed works will have an adverse effect on the life cycle of the species such that a viable

Test of Significance for *Epacris purpurascens var. purpurascens*
local population of the species is likely to be placed at risk of extinction.
In the case of an endangered ecological community or critically endangered ecological community, whether the proposed development or activity: ***(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or*** ***(ii) Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.***
Not applicable, not an ecological community.
In relation to the habitat of a threatened species or ecological community: ***(i) the extent to which habitat is likely to be removed or modified as a result of the proposed development or activity, and*** ***(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed development or activity, and*** ***(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species or ecological community in the locality.***
The proposed works requires the removal of 0.55 ha of potential habitat for *Epacris purpurascens* var. *purpurascens*. Removal of vegetation is limited to a small overall area and will occur along existing edges. Large areas of potential habitat present within contiguous vegetation, will remain intact. Vegetation to be retained will maintain a high level of habitat connectivity. Given the extent of contiguous habitat available, and the existing population of *Epacris purpurascens* var. *purpurascens* present in the surrounding environment, it is unlikely that the impact is of high importance for the long-term survival of the species. Therefore, the impact is unlikely to put the population at risk of decline or extinction.
Whether the proposed development or activity is likely to have an adverse effect on any declared area of outstanding biodiversity value (either directly or indirectly).
To date no AOBVs have been declared within the proposal's impact area.
Whether the proposed development or activity is or is part of a key threatening process or is likely to increase the impact of a key threatening process.
The proposed works have the potential to result in the following key threatening process which is listed under the Schedule 4 of the BC Act, and to which are considered relevant to *Epacris purpurascens* var. *purpurascens*: • Clearing of native vegetation. The proposed works requires clearing of vegetation, resulting in the removal of 0.55 ha of potential habitat for *Epacris purpurascens* var. *purpurascens*. Given some areas of potential habitat to be impacted by the proposal will be in the form of trimming and partial clearing, and that large areas of contiguous vegetation similar to that in the study area will be retained, the proposal is unlikely to increase the impact of any key threatening processes.

Test of Significance for *Epacris purpurascens var. purpurascens*

Conclusion.

In consideration of the above, the proposed activity is not likely to significantly affect *Epacris purpurascens* var. *purpurascens* within the study area or wider locality, as:

- The proposed works are localised, the study area has already been exposed to a number of disturbances and ample contiguous habitat will remain intact.
- The proposed works is unlikely to significantly alter the extent of a populations to the point where they become locally extinct.
- Pre-clearance surveys are recommended to be completed prior to works commencing to prevent any previously undetected individuals from being impacted.
- The removal of potential habitat will not result in the isolation or fragmentation of locally occurring habitat within the study area and as such is unlikely to affect its long-term survival in the locality.
- The localised nature of the proposed works will not significantly trigger or exacerbate any key threatening processes.

Entry to the BOS or preparation of a SIS is therefore not required.

Appendix D – Specialist study (archaeological and Aboriginal heritage)

Aboriginal heritage information must not be made publicly available or be published in any form or by any means by Sydney Water or our contractors / joint ventures, unless where approval has been sought from DPC's AHIMS Registrar and provided in writing to Sydney Water.

For those REFs which are being publicly displayed, all Aboriginal heritage information which identifies individual sites must be removed.

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14 December 2022

Grace Corrigan
Environmental Scientist
Sydney Water
Level 11, 1 Smith Street, Parramatta NSW 2150

Dear Grace,

Re: Aboriginal and historic due diligence assessment for proposed water infrastructure located in Thornleigh, NSW

1.0 Introduction

AECOM Australia Pty Ltd (AECOM) was commissioned by Sydney Water Corporation (Sydney Water) to undertake an Aboriginal and historic heritage due diligence assessment for the installation of a new outlet main between the Thornleigh Reservoir (WS0148) and the Thornleigh-Wahroonga Water Pump Station (WP0159) located in Thornleigh, NSW (the "study area", Figure 1 and Figure 2).

The purpose of this assessment is to identify potential impacts to Aboriginal and historic heritage values as a result of the proposed works and to provide Sydney Water with appropriate management advice. The contents of this letter report have been compiled with reference to Heritage NSW's *Due Diligence Code of Practice for the Protection of Aboriginal Objects in NSW 2010 (DECCW, 2010c)*.

2.0 Proposed Activity

Sydney Water proposes to build a new DN1800 inlet/outlet main, approximately 1.4 km in length, running between the Thornleigh Reservoir (WS0148) and the Thornleigh-Wahroonga Water Pump Station (WP0159). The new outlet main will run parallel to an existing inlet/outlet main and will include a pipe approximately 1.8 m in diameter that will be installed via an underground tunnel boring machine and trenched installation. Due to the large diameter of the pipeline, significant sized valves will need to be installed in chambers at each end of the pipeline. In addition, excavation of large sized launch and retrieval pits will be required at each end of the pipeline to facilitate the use of a tunnel boring machine.

Proposed ground surface disturbances resulting from the works will include:

- Targeted vegetation removal, including tree removal around the launch and retrieval pits, as well as access tracks;
- Trimming of selected vegetation to allow vehicle access to site;
- Widening of selected access tracks both at and reservoir and pump station locations; and
- Excavation of launch and retrieval pits, with an associated construction/laydown area.

3.0 Study Area

The study area comprises multiple spatially discrete areas encompassing the proposed areas of direct disturbance at each end of the proposed pipeline. For this assessment, the study area has been separated into the northern study area (works near the Thornleigh Reservoir) (Figure 1) and the southern study area (works near Water Pump Station WP0159) (Figure 2).

The northern study area is located within the Thornleigh Reservoir site (Lot 100 DP1217395) and includes areas where road widening of the existing access track within the reservoir site, tree trimming and removal, and a launch pit/laydown area is required. The southern study area is located approximately 1.1 km southwest of the reservoir site, adjacent to the Edmundson Close cul-de-sac around the grounds of the existing Water Pump Station site. In this area road widening, tree trimming and removal, hardstand and a retrieval pit/laydown area is required.

4.0 Relevant Legislation & Policy

4.1 National Parks and Wildlife Act 1974

The *National Parks and Wildlife Act 1974* (NPW Act), administered by Heritage NSW, is the primary legislation for the protection of Aboriginal cultural heritage in NSW. The NPW Act gives the Secretary

of the Department of Premier and Cabinet (DPC) responsibility for the proper care, preservation and protection of 'Aboriginal objects' and 'Aboriginal places', defined under the Act as follows:

- an *Aboriginal object* is any deposit, object or material evidence (that is not a handicraft made for sale) relating to Aboriginal habitation of NSW, before or during the occupation of that area by persons of non-Aboriginal extraction (and includes Aboriginal remains).
- an *Aboriginal place* is a place declared so by the Minister administering the NPW Act because the place is or was of special significance to Aboriginal culture. It may or may not contain Aboriginal objects.

Part 6 of the NPW Act provides specific protection for Aboriginal objects and places by making it an offence to harm them and includes a 'strict liability offence' for such harm. A 'strict liability offence' does not require someone to know that it is an Aboriginal object or place they are causing harm to in order to be prosecuted. Defences against the 'strict liability offence' in the NPW Act include the carrying out of certain 'Low Impact Activities', prescribed in Clause 58 of the *National Parks and Wildlife Amendment Regulation 2019* (NPW Regulation), and the demonstration of due diligence.

An Aboriginal Heritage Impact Permit (AHIP) issued under Section 90 of the NPW Act is required if impacts to Aboriginal objects and/or places cannot be avoided. An AHIP is a defence to a prosecution for harming Aboriginal objects and places if the harm was authorised by the AHIP and the conditions of that AHIP were not contravened. Applications for an AHIP must be accompanied by assessment reports compiled in accordance with the *Guide to Investigating, Assessing and Reporting on Aboriginal Cultural Heritage in NSW* (OEH, 2011) and the *Code of Practice for Archaeological Investigation of Aboriginal Objects in NSW* (DECCW, 2010b). Applications must also provide evidence of consultation with Aboriginal communities. Consultation is required under Part 8A of the NPW Regulation and is to be conducted in accordance with the *Aboriginal Cultural Heritage Consultation Requirements for Proponents* (DECCW, 2010a). AHIPs may be issued in relation to a specified Aboriginal object, Aboriginal place, land, activity or person or specified types or classes of Aboriginal objects, Aboriginal places, land, activities or persons. Section 89A of the NPW Act requires notification of the location of Aboriginal sites within a reasonable time, with penalties for non-notification. Section 89A is binding in all instances.

4.2 The Heritage Act 1977

The *Heritage Act 1977* was enacted to conserve the environmental heritage of NSW. Parts 3 and 6 of the Heritage Act 1977 provide specific protection for heritage items of local or State significance by means of Interim Heritage Orders (IHO) (Part 3), listing on the State Heritage Register (SHR) (Part 3A) and the requirement for excavation permits (Part 6). Items that are assessed as having State heritage significance can be listed on the SHR by the Minister on the recommendation of the Heritage Council.

Archaeological relics (any relics that are buried) are protected by the provisions of Division 9 of the *Heritage Act 1977*. Under Section 139, a person must not disturb or excavate any land knowing or having reasonable cause to suspect that the disturbance or excavation will or is likely to result in a relic being discovered, exposed, moved, damaged or destroyed unless the disturbance or excavation is carried out in accordance with a Section 140 Excavation Permit.

Proposals to alter, damage, move or destroy heritage items protected by an IHO or listed on the SHR require an approval under Section 60 of the *Heritage Act 1977*. Demolition of whole buildings will not normally be approved except under certain conditions (Section 63).

Under Section 170 of the *Heritage Act*, NSW government agencies are required to maintain a register of heritage items and to review and, if necessary, amend this register not less than once each year. Each agency is responsible for ensuring that listed items are maintained with due diligence in accordance with State Owned Heritage Management Principles (NSW Heritage Office, 2005).

5.0 Data Sources

Information regarding the known and potential Aboriginal heritage values of the study area was obtained from:

- A review of the landscape context of the study area and surrounds;

- A review of existing Aboriginal Heritage Information Management System (AHIMS) data for land within and surrounding the study area, obtained from Heritage NSW on 17 November 2022;
- A review of historic heritage registers/lists to identify previously recorded historic heritage items within and surrounding the study area;
- A review of the findings of past Aboriginal and historic heritage investigations within the local area; and
- A visual inspection of the study area on 8 November 2022 by AECOM Principal Heritage Specialist Geordie Oakes.

Figure 1 The northern study area

Figure 2 The southern study area

6.0 Landscape Context

Consideration of the landscape context of the study area is based on the proposition that the nature and distribution of Aboriginal archaeological materials are closely connected to the environments in which they occur. Environmental variables such as topography, geology, hydrology and the composition of local floral and faunal communities will have played an important role in influencing how Aboriginal people moved within and utilised their respective Country. Amongst other things, these variables will have affected the availability of suitable campsites, drinking water, economic[1] plant and animal resources, and raw materials for the production of stone and organic implements. At the same time, an assessment of historical and contemporary land use activities, as well as geomorphic processes such as soil erosion and aggradation, is critical to understanding the formation and integrity of archaeological deposits, as well as any assessments of subsurface archaeological potential.

Key observations from a review of the landscape context of the study area are presented in Table 1.

Table 1 Review of landscape context of the Study area

Environmental Variable	Key Observations
Topography	The topography of the northern study area has been significantly altered during construction of the existing reservoir. While difficult to establish with any degree of certainty due to historical disturbances, the topography of the northern study area prior to land disturbance would have been consistent with that of the broader region i.e., undulating rolling rises and low hills. Elevation across the northern study area currently ranges from 172 m AHD to 178 AHD, providing a total local relief of 6 m. The southern study area is likewise significantly disturbed. However, prior to impacts would have consisted of creek flats associated with Zig Zag Creek. Elevation across the southern study area currently ranges from 132 m AHD to 136 AHD, providing a total local relief of 4 m..
Hydrology	The northern study area around the Thornleigh Reservoir site does not contain any mapped watercourses. The closest watercourse is Larool Creek located over 400 m to the east. The southern study area lies directly adjacent to a 1st order section of Zig Zag Creek, a small local watercourse. Zig Zag Creek generally flows westward before joining Tedbury Creek 1 km west of the study area. The creek has undergone significant modifications historically including minor alignment modifications as well as concreting and reenforcing/stabilisation of embankments Existing archaeological survey data for the Cumberland Plain indicate a strong trend for the presence of open artefact sites along watercourses, specifically, on creek banks and 'flats' (i.e., flood/drainage plains), terraces and bordering lower slopes (Kohen 1986). Although this distribution pattern can be attributed in part to geomorphic dynamics and archaeological sampling bias, with extensive fluvial erosion activity along watercourses resulting in higher levels of surface visibility and, by extension, concentrated survey effort, an occupational emphasis on watercourses is supported by the results of numerous subsurface investigations (e.g., AECOM 2013b, 2015; AMBS 2000; Craib et al. 1999; GML 2012; Jo McDonald CHM 2001, 2003, 2005a, 2006a, 2006b, 2007, 2009a, 2009b). Collectively, these investigations have demonstrated that assemblage size and complexity tend to vary significantly in relation to stream order and landform, with larger, more complex assemblages concentrated on elevated, low gradient landform elements adjacent to higher order watercourses (≥3rd order). Outside of these contexts, surface and subsurface artefact distributions have typically been found to be sparse and discontinuous and are often referred to as 'background scatter'.

[1] I.e., edible and/or otherwise useful (e.g., medicine, clothing)

Environmental Variable	Key Observations
Geology	Reference to the 1:100,000 Geological Map Sheet for Sydney (9130) indicates that the surface geology of the northern study area has been mapped as Ashfield Shale (Rwa) and the southern study area as Hawkesbury Sandstone (Rh). Ashfield Shale (Rwa), the lowermost formation of the Middle Triassic Wianamatta Group, consists of a "sequence of dark-grey to black, sideritic claystone - siltstone which grades upwards into a fine sandstone - siltstone laminate" (Bembrick et al., 1991: 17). The formation has a minimum thickness of 44.6 m and maximum thickness of 61.6 m (Bembrick et al., 1991: 17). Hawkesbury Sandstone comprises a medium to coarse-grained quartz sandstone with minor shale and laminate lenses that weathers cavernously to form overhangs (i.e., rockshelters) and also occurs as flatted-topped outcrops (platforms) and isolated boulders (McDonald, 2008).
Soils	Soils within the northern study area have been mapped as belonging to the Glenorie and Lucas Heights Soil Landscapes. Soils of the Glenorie soil landscape are characterised as red podzolic soils on crests, red and brown podzolic soils on upper slopes, and grading down to yellow and gleyed podzolic soils along drainage lines. Dominant A-Horizon soils comprise dark brown friable, silt or silt clay loam. Soils of the Lucas Heights Soil Landscape comprises moderately deep, hardsetting yellow podzolic soils and yellow soloths with loosy sands loam A horizons. Soil within the southern study area has been mapped as belonging to the Gymea (ERgy) Soil Landscape. The Gymea soil landscape is characterised by yellow earths and earthy sands on crests, siliceous sands on leading edges of benches, gleyed podzolic soils and yellow podzolic soils on shale lenses and siliceous sands and leached sands along drainage lines. Dominant A-Horizon soils comprise loose coarse sandy loams.
Flora & Fauna	Native vegetation within the northern study has been extensively modified as a result of historical land use and today mostly consist of native/exotic weeds, as well as a section of Turpentine Ironbark Forest. Likewise, in the southern study area vegetation has been significantly modified and comprises native/exotic weeds, as well as patches of Peppermint-Angophora Forest.
Land Disturbance	Historical aerial photographs and field observations indicate that both the northern and southern study areas have been variously disturbed by vegetation clearance, the construction of water infrastructure, installation of utilities, grading for access tracks and generally from urban development.

7.0 Aboriginal Heritage

7.1 AHIMS Database

The AHIMS database, administered by Heritage NSW, contains records of all Aboriginal objects reported to the Director General of the Department of Premier and Cabinet in accordance with Section 89A of the *National Parks and Wildlife Act 1974*. It also contains information about Aboriginal places, which have been declared by the Minister to have special significance with respect to Aboriginal culture. Previously recorded Aboriginal objects and declared Aboriginal places are known as 'Aboriginal sites'.

A search of the AHIMS database was undertaken on 17 November 2022 for a 5 x 5 km search area centred on the study area. A total of 30 Aboriginal archaeological sites were identified within the search area comprising of 20 rock shelters with various other archaeological features (i.e., deposit, art etc.,), three grinding groove sites, two modified trees, one art site, one open artefact site, one habitation structure, one hearth and one area of PAD. Consideration of the locations of previously recorded sites indicates that none are located directly within the study areas [redacted]

[redacted]

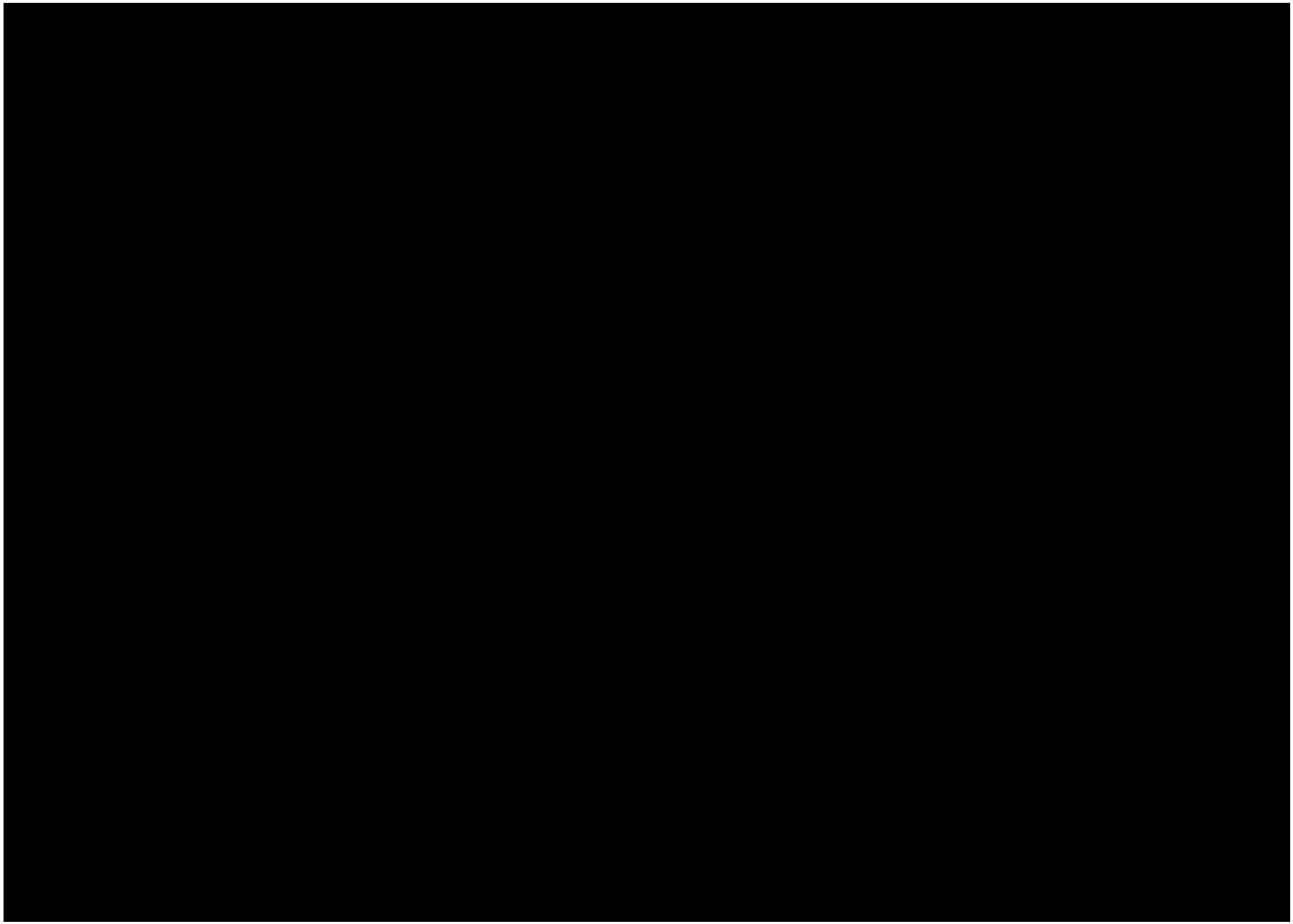
7.2 Previous Aboriginal Heritage Investigations

Existing AHIMS data indicate that several Aboriginal archaeological investigations have been undertaken in the Thornleigh area. A review of their findings is provided below:

- In 1996, Koettig completed an Aboriginal heritage study for Hornsby Shire Council across the Hornsby Shire Council area. [redacted]
- In 2009, Australian Museum Business Services (AMBS) undertook a Heritage Impact Assessment for the proposed Wahroonga Estate redevelopment at the intersection of Fox Valley Road and Comenarra Parkway. [redacted]
- In 2011, Jackson completed an Aboriginal Site Survey for the proposed site of a mountain bike track in the either Berowra Valley Regional Park or Bantry Bay in Garigal National Park. [redacted]

Aboriginal heritage information must not be made publicly available or be published in any form or by any means by Sydney Water or our contractors / joint ventures, unless where approval has been sought from the AHIMS Registrar and provided in writing to Sydney Water. Sydney Water has removed this information out of respect for Aboriginal cultural heritage and the Aboriginal community.

Figure 3 AHIMS sites



8.0 Historic Heritage

8.1 Database/List Searches

A search of historic heritage registers/lists (statutory and non-statutory) was undertaken on 17 November 2022 to identify previously recorded historic heritage items located within the works area. The search results are provided in Table 2 and indicate there is one locally listed heritage item within the study area – “Street Trees” located on Giblett Avenue, Thornleigh (Figure 3). Trimming of these trees is proposed as part of the works in the southern study area.

Table 2 Historic heritage register/list searches

Heritage Register	Results	Location
NSW State Heritage Register (SHR)[1]	None	N/A
Hornsby LEP 2013[1]	“Street Trees” (ID#706)	Southern study area
World Heritage List[1]	None	N/A
National Heritage List[1]	None	N/A
Commonwealth Heritage List[1]	None	N/A
Register of National Estate[2]	None	N/A
EPBC Protected Matters Search Tool	None	N/A
TfNSW Heritage and Conservation Register[1]	None	N/A
Sydney Water Heritage Register[1]	None	N/A

*1 – Statutory Heritage Registers
2 – Non-Statutory Heritage Registers

Figure 4 Historic heritage sites

9.0 Visual Inspection

A visual inspection of the works area was undertaken on 8 November 2022 by AECOM Principal Heritage Specialist Geordie Oakes. The purpose of this inspection was to help establish whether the proposed works will, or are likely to, harm any Aboriginal objects or historic heritage items. During the visual inspection notes were taken regarding Ground Surface Visibility (GSV), Ground Integrity (GI, i.e. land condition), archaeological sensitivity and impact risk. Impact risk was determined on the basis of archaeological sensitivity, as well as the nature of proposed Project-related impacts. Results of the inspection included the following:

- No evidence of past Aboriginal occupation was observed during the visual inspection.
- GSV across both the northern and southern study areas was varied, with areas of poor visibility associated with highly vegetated area and area of improved visibility on access tracks and areas of disturbance/erosion.
- Consistent with examined aerials, the visual inspection indicated that land associated with both the northern and southern study areas has been severely disturbed by vegetation clearance, the construction of water infrastructure, installation of utilities, grading for access tracks and generally from urban development (Plates 1-2 – Appendix A).
- [redacted]
- An inspection of the location of the LEP listed street trees was completed with the trees confirmed as being located along Giblett Avenue (Plate 5-6 – Appendix A).
- Considering the nature and extent of past ground disturbance activities within both the northern and southern study areas, as well as the findings of past Aboriginal heritage investigations completed within the region, the Aboriginal archaeological sensitivity of the study areas were assessed as low.

10.0 Key Findings

The key findings of this due diligence assessment are as follows:

- There are no registered Aboriginal sites within the northern and southern study areas.
- No Aboriginal objects were identified during the visual inspection component of this assessment.
- Aboriginal archaeological sensitivity of the both the northern and southern study areas was assessed as low.
- The LEP listed “street trees” were confirmed to be located along Giblett Avenue within the southern study area.

Table 3 provides a summary of the key questions asked as part of the *Due Diligence Code of Practice for the Protection of Aboriginal Objects in New South Wales* (DECCW, 2010:10). Should the answer to Question 4 be ‘yes’, further investigation and impact assessment is required.

Table 3 Due diligence questionnaire

No.	Due Diligence Question	Response
1	*Will the activity disturb the ground surface (or culturally modified trees)?*	Yes
2a	*Are there any relevant confirmed site records or other associated landscape feature information on AHIMS?*	No
2b	*Are there any other sources of information of which a person is already aware?*	No
2c	*Are there any landscape features that are likely to indicate presence of Aboriginal objects?*	No

3	*Can harm to Aboriginal objects listed on AHIMS or identified by other sources of information and/or can the carrying out of the activity at the relevant landscape features be avoided?*	N/A
4	***Does a desktop assessment and visual inspection confirm that there are Aboriginal objects or that they are likely?***	***No***

11.0 Recommendations

On the basis of the above findings, the following recommendations are made:

1. No further Aboriginal heritage assessment works are considered warranted for both the northern and southern study areas.
2. [redacted]
3. In order to permit impacts (i.e., trimming) to the Hornsby LEP 2013 listed heritage item "Street Trees", Sydney Water should engage an Arborist to undertake an assessment of the proposed impacts to the trees from the trimming. In addition, a Statement of Heritage Impact (SoHI) should be prepared to determine whether the works would impact the heritage significance of the trees. If impacts to the trees are considered greater than minor or negligible, the SoHI must then be submitted to Council providing 28 days for Council to respond.
4. In the event that Aboriginal objects or historic heritage items, including possible human skeletal material (remains), are identified during construction works all works in the area must cease immediately and the relevant provision of Sydney Water's Environmental Management System (SWEMS009) should be followed. The stop work procedure should be included within the Project's construction management plan

Yours faithfully

[redacted]

Geordie Oakes
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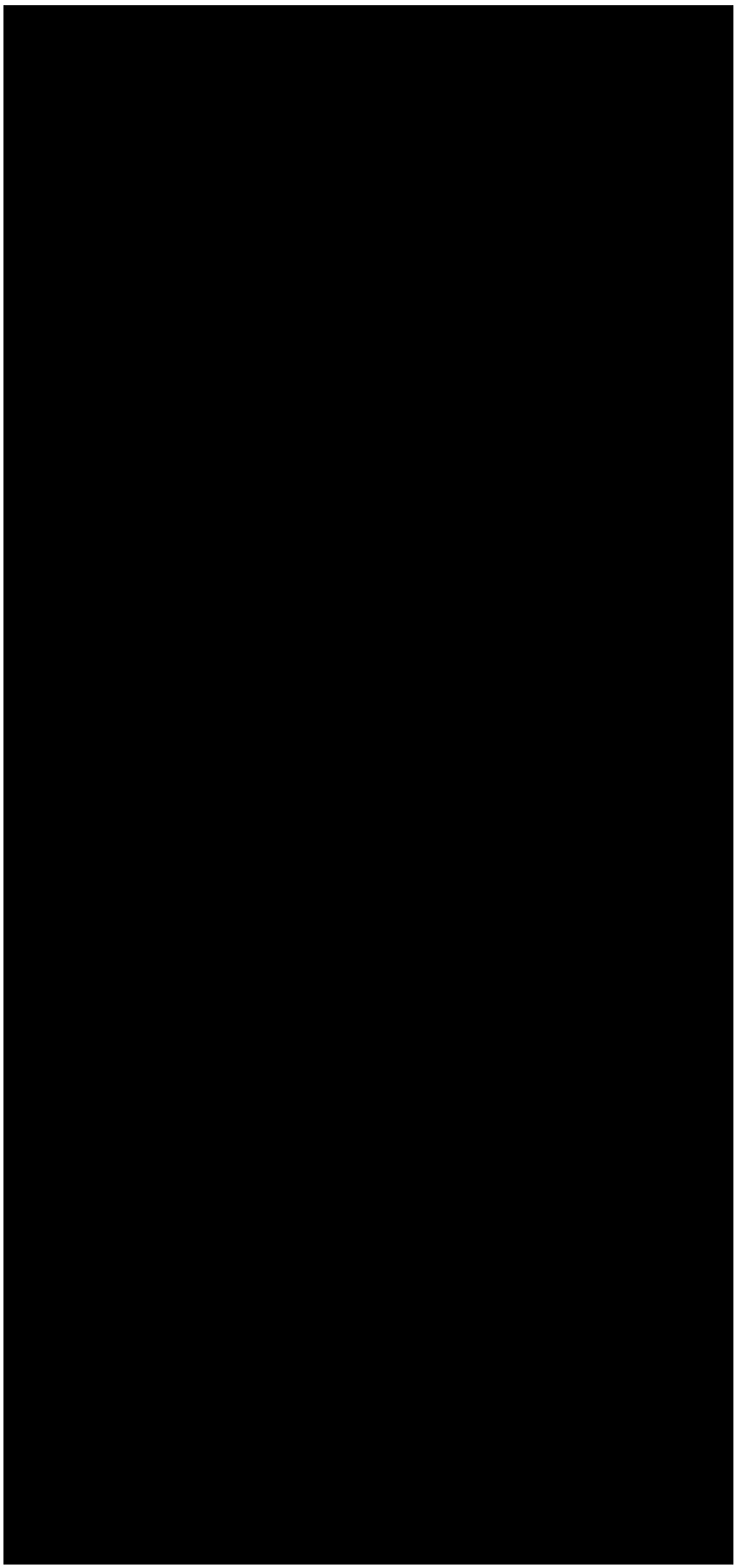
Appendix A – Site Photos

Plate 1: View south showing the northern study area (source: AECOM 2022)

Plate 2: View northwest showing the southern study area (source: AECOM 2022)



Aboriginal heritage information must not be made publicly available or be published in any form or by any means by Sydney Water or our contractors / joint ventures, unless where approval has been sought from the AHIMS Registrar and provided in writing to Sydney Water. Sydney Water has removed this information out of respect for Aboriginal cultural heritage and the Aboriginal community.

Plate 5: View west showing historic heritage site "Street Trees" (source: AECOM 2022)

Plate 6: View east showing historic heritage site "Street Trees" (source: AECOM 2022)

Appendix E – Specialist study (non-Aboriginal heritage)

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24 April 2023

Grace Corrigan
Environmental Scientist
Sydney Water
Level 11, 1 Smith Street
Parramatta NSW 2150

Dear Grace,

Re: Statement of Heritage Impact for the trimming of seven trees listed under Local Environmental Plan (LEP) heritage item "Street Trees" (ID#706) as part of the Thornleigh Inlet/Outlet Main Project, Sydney, NSW

1.0 Introduction

AECOM Australia Pty Ltd (AECOM) was commissioned by Sydney Water Corporation (Sydney Water) to prepare a Statement of Heritage Impact (SoHI) to assess potential impacts to Hornsby Local Environmental Plan (LEP) 2013 listed heritage item “Street Trees” (ID#706) as part the Thornleigh Inlet/Outlet Main Project, Sydney, New South Wales (NSW). Accordingly, this SoHI has been prepared to assess potential impacts to the item from the proposed works.

2.0 Proposed Activity

Sydney Water proposes to build a new DN1800 inlet/outlet main, approximately 1.4 kilometres (km) in length, running between the Thornleigh Reservoir (WS0148) and the Thornleigh-Wahroonga Water Pump Station (WP0159). The new outlet main will run parallel to an existing inlet/outlet main and will include a pipe approximately 1.8 metres (m) in diameter that will be installed via an underground tunnel boring machine and trenched installation. Due to the large diameter of the pipeline, significant sized valves will need to be installed in chambers at each end of the pipeline. In addition, excavation of large sized launch and retrieval pits will be required at each end of the pipeline to facilitate the use of a tunnel boring machine.

As part of the installation of the chamber and valve at the Thornleigh-Wahroonga Water Pump Station (WP0159) site a large crane and associated machinery will need to access the area along Giblett Avenue in Thornleigh where heritage item “Street Trees” (ID#706) is located, with the trees lining the northern side of the road (see Figure 1). Sydney Water has advised that the trees may require trimming along a section of Giblett Avenue between Nicholson Avenue and Dobson Street where some tree branches overhang the road.

3.0 Legislation

3.1 Environmental Planning and Assessment Act 1979

The *Environmental Planning and Assessment Act 1979* (EP&A Act) allows for the preparation of planning instruments to direct development within NSW. This includes LEPs, which are administered by local government and contain provisions to guide land use and the process for development applications. LEPs usually include clauses requiring that heritage be considered during development applications and that a schedule of identified heritage items be provided. The EP&A Act also allows for the gazettal of State Environmental Planning Policies (SEPPs).

3.2 Heritage Act 1977

The NSW *Heritage Act 1977* (as amended) was enacted to conserve the environmental heritage of NSW. Under Section 32, places, buildings, works, relics, movable objects or precincts of heritage significance are protected by means of either Interim Heritage Orders (IHO) or by listing on the NSW State Heritage Register (SHR). Items that are assessed as having State heritage significance can be listed on the SHR by the Minister on the recommendation of the NSW Heritage Council.

Under Section 170 of the *Heritage Act 1977*, NSW Government agencies are required to maintain a register of heritage assets. The register places obligations on the agencies, but not on non-

government proponents, beyond their responsibility to assess the impact on surrounding heritage items.

Archaeological features and deposits are afforded statutory protection by the 'relics provision'. Section 4(1) of the *Heritage Act 1977* (as amended 2009) defines 'relic' as follows:

> *any deposit, artefact, object or material evidence that:*
>
> *(a) relates to the settlement of the area that comprises New South Wales, not being Aboriginal settlement, and*
>
> *(b) is of State or local heritage significance.*

The 'relics provision' requires that no archaeological relics be disturbed or destroyed without prior consent from the Heritage Council of NSW. Therefore, no ground disturbance works may proceed in areas identified as having archaeological potential without first obtaining an Excavation Permit pursuant to Section 140 of the *Heritage Act 1977*, or an Archaeological Exception under Section 139 of the *Heritage Act 1977*.

The Heritage Council must be notified of the discovery of a relic under Section 146 of the *Heritage Act 1977.*

3.3 Local Environment Plan

Heritage item "Street Trees" (ID#706) is located wholly within the boundary of the Hornsby Local Government Area (LGA). Part 5, Section 5.10 of the Hornsby LEP 2013 addresses heritage conservation within the LGA. Section 5.10 of the Hornsby LEP 2013 states:

> *(1) The objectives of this clause are as follows:*
>
> *a) to conserve the environmental heritage of Hornsby,*
>
> *b) to conserve the heritage significance of heritage items and heritage conservation areas, including associated fabric, settings and views,*
>
> *c) to conserve archaeological sites,*
>
> *d) to conserve Aboriginal objects and Aboriginal places of heritage significance.*
>
> *(2) Development consent is required for any of the following:*
>
> *e) demolishing or moving any of the following or altering the exterior of any of the following (including, in the case of a building, making changes to its detail, fabric, finish or appearance):*
>
> *f) a heritage item,*
>
> *g) an Aboriginal object,*
>
> *h) a building, work, relic or tree within a heritage conservation area,*
>
> *i) altering a heritage item that is a building by making structural changes to its interior or by making changes to anything inside the item that is specified in Schedule 5 in relation to the item,*
>
> *j) disturbing or excavating an archaeological site while knowing, or having reasonable cause to suspect, that the disturbance or excavation will or is likely to result in a relic being discovered, exposed, moved, damaged or destroyed,*
>
> *k) disturbing or excavating an Aboriginal place of heritage significance,*
>
> *l) erecting a building on land:*
>
> (i) on which a heritage item is located or that is within a heritage conservation area, or
>
> (ii) on which an Aboriginal object is located or that is within an Aboriginal place of heritage significance,

m) subdividing land:

(i) on which a heritage item is located or that is within a heritage conservation area, or

(ii) on which an Aboriginal object is located or that is within an Aboriginal place of heritage significance.

(3) Development consent under this clause is not required if

a) the applicant has notified the consent authority of the proposed development and the consent authority has advised the applicant in writing before any work is carried out that it is satisfied that the proposed development –

b) is of a minor nature or is for the maintenance of the heritage item, Aboriginal object, Aboriginal place of heritage significance or archaeological site or a building, work, relic, tree or place within the heritage conservation area, and

c) would not adversely affect the heritage significance of the heritage item, Aboriginal object, Aboriginal place, archaeological site or heritage conservation area.

4.0 Data Sources

Information regarding the values and potential impacts to heritage item “Street Trees” (ID#706) was obtained from the following sources:

- A review of background reports relevant to the listing;
- A review of historic heritage registers/lists relevant to the listing;
- A visual inspection of the trees associated with the listing on 8 November 2022 by AECOM Principal Heritage Specialist Geordie Oakes; and
- An arborist inspection of the listed trees that require trimming by Kane Hollstein from Canopy Consulting on 22 March 2023.

Figure 1 Heritage listings

5.0 Heritage Item Description

Heritage item “Street Trees” (ID#706) is listed on Schedule 5 (Environmental Heritage) of the Hornsby LEP 2013 as a local heritage item under “Item – Landscape”. The trees are mapped as running along the northern side of Giblett Avenue between Nicholson Avenue and Quarter Sessions Road within the road reserve. While very little information is available about the item on the LEP listing, reference to the Hornsby Shire Heritage Study (Permual Murphy Wu, 1993) inventory sheets suggests that the trees were identified as part of this study primarily under “Roadside Trees” (L309), but also referred to in listings for “Thornleigh West Public School” (L310) and “Oakleigh Park” (L311). A brief description of each listing is provided in Table 1 below.

Table 1 Description of "Street Trees" (ID#706) and associated listings (Hornsby Shire Heritage Study, 1993)

Name	Reference no.	Description	Significance
Roadside Trees	L309	Street verge conserving Stringybark and Smooth Bark Angophora stand outside school.	Street conserving mature indigenous trees giving local Australian identity and notable in streetscape. Of local significance.
Thornleigh West Public School	L310	School grounds conserving mature and semi-mature indigenous trees including Turpentines, Smooth Bark Angophora and Stringybark up to c20 m high. Also, sympathetic planting of mixed Eucalypt and native shrubs from the 1970s.	School grounds conserving indigenous planting of native species from c1970s notable streetscape. Of local significance.
Oakleigh Park	L311	Fine stand of mature and semi-mature indigenous trees in forest formation particularly on north-eastern corner on edge of playing field. Trees, mainly Turpentine.	Stand of indigenous turpentine conserved around playing field and notable in local area and streetscape. Of local significance.

6.0 Significance Assessment

To understand how a development would impact on a heritage item, it is essential to understand why an item is significant. An assessment of significance is undertaken to explain why a particular item is important and to enable the appropriate site management and curtilage to be determined. Cultural significance is defined in *The Australia ICOMOS Charter for Places of Cultural Significance 2013* (Australia ICOMOS, 2013) as meaning "aesthetic, historic, scientific, social or spiritual value for past, present or future generations" (Article 1.2). Cultural significance may be derived from a place’s fabric, association with a person or event, or for its research potential. The significance of a place is not fixed for all time, and what is of significance to us now may change as similar items are located, more historical research is undertaken, and community tastes change.

The process of linking this assessment with an item's historical context has been developed through the NSW Heritage Management System and is outlined in the guideline *Assessing Heritage Significance* (NSW Heritage Office, 2001), part of the NSW Heritage Manual (Heritage Branch, Department of Planning). The *Assessing Heritage Significance* guidelines establish seven evaluation criteria (which reflect four categories of significance and whether a place is rare or representative) under which a place can be evaluated in the context of State or local historical themes. Similarly, a heritage item can be significant at a local level (i.e., to the people living in the vicinity of the site), at a State level (i.e., to all people living within NSW) or be significant to the country as a whole and be of National or Commonwealth significance.

In accordance with the guideline *Assessing Heritage Significance*, an item would be of State significance if it meets two or more criteria at a State level, or of local heritage significance if it meets one or more of the criteria outlined in Table 2. The Heritage Council requires the summation of the significance assessment into a succinct paragraph, known as a Statement of Significance. The Statement of Significance is the foundation for future management and impact assessment.

Table 2 Significance assessment criteria

Criterion	Inclusions/exclusions
Criterion (a) *– an item is important in the course, or pattern, of NSW's cultural or natural history (or the cultural or natural history of the local area).*	The site must show evidence of significant human activity or maintains or shows the continuity of historical process or activity. An item is excluded if it has been so altered that it can no longer provide evidence of association.
Criterion (b) – an item has strong or special association with the life or works of a person, or group of persons, of importance in NSW's cultural or natural history (or the cultural or natural history of the local to area).	The site must show evidence of significant human occupation. An item is excluded if it has been so altered that it can no longer provide evidence of association.
Criterion (c) *– an item is important in demonstrating aesthetic characteristics and/or a high degree of creative or technical achievement in NSW (or the local area).*	An item can be excluded on the grounds that it has lost its design or technical integrity or its landmark qualities have been more than temporarily degraded.
Criterion (d) *– an item has strong or special association with a particular community or cultural group in NSW (or the local area) for social, cultural or spiritual reasons.*	This criterion does not cover importance for reasons of amenity or retention in preference to a proposed alternative
Criterion (e) *– an item has potential to yield information that will contribute to an understanding of NSW's cultural or natural history (or the cultural or natural history of the local area). Significance under this criterion must have the potential to yield new or further substantial information.*	Under the guideline, an item can be excluded if the information would be irrelevant or only contains information available in other sources.
Criterion (f) – an item possesses uncommon, rare or endangered aspects of NSW's cultural or natural history (or the cultural or natural history of the local area).	An item is excluded if it is not rare or if it is numerous, but under threat. The item must demonstrate a process, custom or other human activity that is in danger of being lost, is the only example of its type or demonstrates designs or techniques of interest.
Criterion (g) *– an item is important in demonstrating the principal characteristics of a class of NSW's (or local area's):* *cultural or natural places cultural or natural environments.*	An item is excluded under this criterion if it is a poor example or has lost the range of characteristics of a type.

6.1 Significance Assessment of "Street Trees" (ID#706)

An assessment of significance of "Street Trees" (ID#706) based on the Hornsby Shire Heritage Study (Permual Murphy Wu, 1993) inventory sheets is provided in Table 3. The trees are treated as a single group in the assessment.

Table 3 Significance assessment

Criterion	Assessment
Historical significance	The trees do not fulfil this criterion.
(b) Association values	The trees do not fulfil this criterion.
(c) Aesthetic/technical values	Aesthetically trees add to the visual quality of the landscape providing visual aesthetics and landmark qualities. The trees fulfil this criterion at a local level.
(d) Social values	The trees do not fulfil this criterion.
(e) Research potential	The trees do not fulfil this criterion.
(f) Rarity	The trees do not fulfil this criterion.

Criterion	Assessment
(g) Representative values	The listing contains indigenous trees provide a local Australian identity to the streetscape and are notable features in the streetscape. The trees fulfil this criterion at a local level.
Intactness and integrity	All the trees are healthy and in good condition.

6.2 Statement of Significance

Trees associated with the listing “Street Trees” (ID#706) were likely planted in the 1970s. Aesthetically, the trees add to the visual quality of the landscape providing visual aesthetic and landmark qualities. They are native, providing a local Australian identity to the streetscape. On the basis of the above, the trees are considered to be of local heritage significance.

7.0 Visual Inspection

A visual inspection of the general works area was undertaken on 8 November 2022 by AECOM Principal Heritage Specialist Geordie Oakes. The purpose of this inspection was to help establish whether the proposed works will, or are likely to, harm any historic heritage items. During the visual inspection Sydney Water noted that some of the trees listed under LEP heritage item “Street Trees” (ID#706) would require trimming. Accordingly, AECOM recommended that an arborist inspection be undertaken and an associated assessment be prepared to assess the proposed impacts to the trees from the trimming.

The arborist inspection was subsequently completed by arborist Kane Hollstein from Canopy Consulting, accompanied by Sydney Water engineers, on 22 March 2023. The arborist inspection and assessment (Appendix A) identified seven trees that may potentially require minor trimming (Figure 2). The results of the assessment are provided in Table 4 below.

Table 4 Arborist assessment

Tree #	Species	Age	Health	Required trimming
1	Turpentine	Mature	Good	Selective and reduction pruning of a 70-millimetre (mm) diameter and 40 mm diameter branch. The pruning is considered minor with the tree being in good health and therefore capable of sustaining some minor foliage loss.
2	Turpentine	Mature	Good	Selective and reduction pruning of two 100 mm diameter and one 120 mm. The pruning is considered minor with the tree being in good health and therefore capable of sustaining some minor foliage loss.
3	Turpentine	Mature	Good	Selective and reduction pruning of four 30 mm diameter and one 40 mm diameter. The pruning is considered minor with the tree being in good health and therefore capable of sustaining some minor foliage loss.
4	Turpentine	Semi-mature	Good	Selective and reduction pruning of four 30 mm diameter branches. The pruning is considered minor with the tree being in good health and therefore capable of sustaining some minor foliage loss.
5	Sweet Gum	Mature	Good	Selective and reduction pruning of a 50 mm diameter and 60 mm diameter branch. The pruning is considered minor with the tree being in good health and therefore capable of sustaining some minor foliage loss.
6	Sweet Gum	Mature	Good	Selective and reduction pruning of a 100 mm diameter and 110 mm diameter branch. The

Tree #	Species	Age	Health	Required trimming
				pruning is considered minor with the tree being in good health and therefore capable of sustaining some minor foliage loss.
7	Turpentine	Mature	Good	Selective one 30 mm diameter branch. The pruning is considered minor with the tree being in good health and therefore capable of sustaining some minor foliage loss.

Figure 2 Impact assessment

8.0 Statement of Heritage Impact

The objective of a SoHI is to evaluate and explain how the proposed development, rehabilitation or land use change will affect the value of the heritage item and/or place. A SoHI should also address how the heritage value of the item/place can be conserved or maintained, or preferably enhanced by the proposed works.

This report has been prepared in accordance with the NSW Heritage Office & NSW Department of Urban Affairs and Planning (1996) *NSW Heritage Manual* and NSW Heritage Office (2002) *Statements of Heritage Impact*. The guidelines pose a series of questions as prompts to aid in the consideration of impacts due to the proposed works. In keeping with the guideline format, the following section poses and addressees these specific questions. The series of questions of greatest relevance to the proposed works are "New Landscape Works and Features" and include the following:

- How has the impact of the new work on the heritage significance of the existing landscape been minimised?
- Has evidence (archival and physical) of previous landscape work been investigated? Are previous works being reinstated?
- Has the advice of a consultant skilled in the conservation of heritage landscapes been sought? If so, have their recommendations been implemented?
- Are any known or potential archaeological deposits affected by the landscape works? If so, what alternatives have been considered?
- How does the work impact on views to, and from, adjacent heritage items?

8.1 Assessment of impacts to significance

"Street Trees" (ID#706) has been assessed as of local heritage significance. The arborist assessment has determined that the proposed trimming works will not significantly impact the health of the trees and will be minor. Following the *Statements of Heritage Impact* (2002) document, Table 5 below provides an assessment of whether the proposed works will have a negative impact on the heritage significance of "Street Trees" (ID#706).

Table 5 Minor Additions Questions

Minor Additions Questions	Answers
How has the impact of the new work on the heritage significance of the existing landscape been minimised?	Yes, the trees will only be subject to minor trimming.
Has evidence (archival and physical) of previous landscape work been investigated? Are previous works being reinstated?	Not applicable.
Has the advice of a consultant skilled in the conservation of heritage landscapes been sought? If so, have their recommendations been implemented?	An arborist's advice has been sought and has advised that the proposed trimming works are considered minor.
Are any known or potential archaeological deposits affected by the landscape works? If so, what alternatives have been considered?	Not applicable.
How does the work impact on views to, and from, adjacent heritage items?	The trimming will not significantly affect views to or from the heritage item.

8.2 Statement of Heritage Impact

The impacts to heritage significance are summarised in Table 6.

Table 6 Summary of the Nature of the Impacts

Impact Type	Impact
Major negative impacts (substantially affects fabric or values of state significance)	None

Impact Type	Impact
Moderate negative impacts (irreversible loss of fabric or values of local significance; minor impacts on State significance)	None
Minor negative impacts (reversible loss of local significance fabric or where mitigation retrieves some value of significance; loss of fabric not of significance but which supports or buffers local significance values)	None
Negligible or no impacts (does not affect heritage values either negatively or positively)	The works will not affect the heritage values of “Street Trees” (ID#706)
Minor positive impacts (enhances access to, understanding or conservation of fabric or values of local significance)	None
Major positive impacts (enhances access to, understanding or conservation of fabric or values of state significance)	None

9.0 Recommendations

This SoHI has assessed potential impacts from trimming of seven trees associated with LEP listed “Street Trees” (ID#706).

The key findings of this SoHI are as follows:

- The SoHI has determined that the proposed trimming works will not significantly impact the health of the trees and will be minor. These works will not affect the overall heritage significance of “Street Trees” (ID#706).
- Views to and from “Street Trees” (ID#706) will not be affected by the proposed works.

On the basis of the above the following recommendations are made:

1. As per Clause 3 (b) of Section 5.10 of the Hornsby LEP 2013, Development Consent is not required if works to a LEP listed heritage item are assessed as minor. Accordingly, consent from Council is not required for the tree trimming works.
2. Sydney Water should engage an arborist to complete the trimming works to ensure the trees are not inadvertently damaged.
3. Sydney Water personnel and contractors should be made aware of the location of heritage item “Street Trees” (ID#706) and their obligation not to impact the trees beyond the proposed trimming works.

Yours faithfully

Geordie Oakes
Principal Heritage Specialist
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Direct Dial: +64 2 89340610
Direct Fax: +64 2 89340001

10.0 References Cited

Australia ICOMOS. (2013). *The Burra Charter: The Australia ICOMOS Charter for Places of Cultural Significance*. Australia ICOMOS. http://australia.icomos.org/wp-content/uploads/The-Burra-Charter-2013-Adopted-31.10.2013.pdf

NSW Heritage Office. (2001). *Assessing Heritage Significance*. http://www.heritage.nsw.gov.au/docs/assessingheritagesignificance.pdf

NSW Heritage Office & Department of Urban Affairs & Planning. (2002). *Statements of Heritage Impact* (Issue 2). Heritage Office & Department of Urban Affairs & Planning. https://www.environment.nsw.gov.au/Heritage/publications/index.htm#S-U

NSW Heritage Office, & NSW Department of Urban Affairs and Planning. (1996). *NSW Heritage Manual*. Heritage Office & Department of Urban Affairs & Planning. http://www.heritage.nsw.gov.au/03_index.htm#M-O

Permual Murphy Wu. (1993). *Hornsby Shire Heritage Study*. Unpublished report prepared for Hornsby Shire Council.

Appendix A – Arborist Assessment

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Basic Tree Report

05 Apr 2023

Site/Client Details

Client:	AECOM
Contact Name:	Geordie Oakes
Address	Giblett Avenue, Thornleigh, New South Wales, Hornsby Shire, 2120, Australia
Date:	22 Mar 2023
Time:	12:09 pm
Local Government Area (LGA):	Hornsby Shire

Consulting Arborist

Name	Qualification
Kane Hollstein	Dip. Arb., AQF Level 5

Client concerns	Impact of potential tree trimming along heritage tree avenue.

Method

To record the above-ground health and condition of the trees, a Visual Tree Assessment (VTA), adapted from (Lonsdale, 2009), was undertaken from ground level on 22 Mar 2023 by Consulting Arborist Kane Hollstein.

This involved an inspection of the trees:

- Physical and biological traits
- Inherent genetic and/or structural defects
- Growth characteristics
- Local environmental and climatic conditions
- Immediate growing environment and surrounding built infrastructure

No foliage or soil samples were taken. No detailed below-ground investigation was performed.

Trees were assessed from within the site only unless otherwise stated.

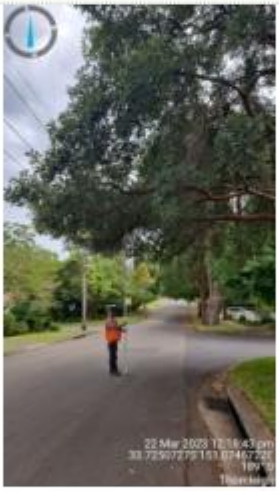
Tree dimensions, including height, canopy spread and Diameter at Breast Height (DBH) were estimated.

AECOM

Tree Details

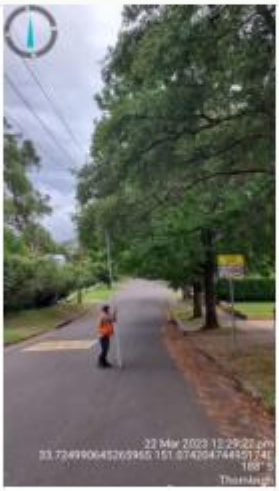
Tree Number	1
Latin Name	Syncarpia glomulifera
Common Name	Turpentine Tree
Estimated Height (m):	15
Estimated Spread (m):	8
Tree Health/Vigour:	Good
Tree Structural Condition:	Good
Age Class:	Mature
Estimated Remaining Useful Life Expectancy (ULE):	>40 years
Is the tree exempt under local plannning laws?	No
Diameter at Breast Height (@ 1.4m above ground level) (cm):	50
Recommendations	Selective branch prune
	Reduction prune
Comments	Selective and reduction pruning of a 70mm diameter and 40mm diameter branch as shown in the figures below won't have a significant impact to the tree. The pruning is considered minor with the tree being in good health and therefore capable of sustaining some minor foliage loss. Measuring staff in image is set to 4.5m. Following pruning, passage of 4m high crane will be possible.
Photos	

Tree Number	2
Latin Name	Syncarpia glomulifera
Common Name	Turpentine Tree
Estimated Height (m):	15
Estimated Spread (m):	13
Tree Health/Vigour:	Good
Tree Structural Condition:	Good
Age Class:	Mature
Estimated Remaining Useful Life Expectancy (ULE):	>40 years
Is the tree exempt under local plannning laws?	No
Diameter at Breast Height (@ 1.4m above ground level) (cm):	70
Observations	Co-dominant stems
Recommendations	Selective branch prune
Comments	Selective and reduction pruning of two 100mm diameter and one 120mm diameter branch as shown in the figures below won't have a significant impact to the tree. The pruning is considered minor with the tree being in good health and therefore capable of sustaining some minor foliage loss. Measuring staff in image is set to 4.5m. Following pruning, passage of 4m high crane will be possible.
Photos	



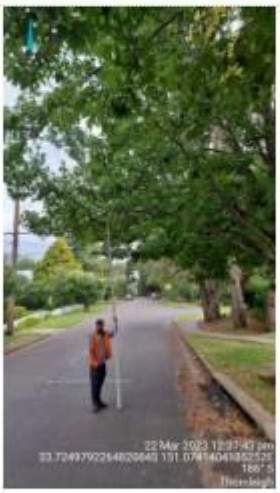
Tree Number	3
Latin Name	Syncarpia glomulifera
Common Name	Turpentine Tree
Estimated Height (m):	18
Estimated Spread (m):	12
Tree Health/Vigour:	Good
Tree Structural Condition:	Good
Age Class:	Mature
Estimated Remaining Useful Life Expectancy (ULE):	>40 years
Is the tree exempt under local plannning laws?	No
Diameter at Breast Height (@ 1.4m above ground level) (cm):	50
Observations	Wound(s)
Recommendations	Selective branch prune
	Reduce end weight
Comments	Selective and reduction pruning of four 30mm diameter and one 40mm diameter branch as shown in the figures below won't have a significant impact to the tree. The pruning is considered minor with the tree being in good health and therefore capable of sustaining some minor foliage loss. Measuring staff in image is set to 4.5m. Following pruning, passage of 4m high crane will be possible.
Photos	

Tree Number	4
Latin Name	Syncarpia glomulifera
Common Name	Turpentine Tree
Estimated Height (m):	17
Estimated Spread (m):	8
Tree Health/Vigour:	Good
Tree Structural Condition:	Good
Age Class:	Semi-mature
Estimated Remaining Useful Life Expectancy (ULE):	>40 years
Is the tree exempt under local planning laws?	No
Diameter at Breast Height (@ 1.4m above ground level) (cm):	45
Recommendations	Reduce end weight
	Selective branch prune
Comments	Selective and reduction pruning of four 30mm diameter branches as shown in the figures below won't have a significant impact to the tree. The pruning is considered minor with the tree being in good health and therefore capable of sustaining some minor foliage loss. Measuring staff in image is set to 4.5m. Following pruning, passage of 4m high crane will be possible.
Photos	



Tree Number	5
Latin Name	Liquidambar styraciflua
Common Name	Sweet Gum
Estimated Height (m):	21
Estimated Spread (m):	13
Tree Health/Vigour:	Good
Tree Structural Condition:	Good
Age Class:	Mature
Estimated Remaining Useful Life Expectancy (ULE):	15-40 years
Is the tree exempt under local plannning laws?	No
Diameter at Breast Height (@ 1.4m above ground level) (cm):	55
Recommendations	Selective branch prune
	Reduce end weight
Comments	Selective and reduction pruning of a 50mm diameter and 60mm diameter branch as shown in the figures below won't have a significant impact to the tree. The pruning is considered minor with the tree being in good health and therefore capable of sustaining some minor foliage loss. Measuring staff in image is set to 4.5m. Following pruning, passage of 4m high crane will be possible.
Photos	

Tree Number	6
Latin Name	Liquidambar styraciflua
Common Name	Sweet Gum
Estimated Height (m):	23
Estimated Spread (m):	12
Tree Health/Vigour:	Good
Tree Structural Condition:	Good
Age Class:	Mature
Estimated Remaining Useful Life Expectancy (ULE):	15-40 years
Is the tree exempt under local plannning laws?	No
Diameter at Breast Height (@ 1.4m above ground level) (cm):	55
Recommendations	Selective branch prune
Comments	Selective and reduction pruning of a 100mm diameter and 110mm diameter branch as shown in the figures below won't have a significant impact to the tree. The pruning is considered minor with the tree being in good health and therefore capable of sustaining some minor foliage loss. Measuring staff in image is set to 4.5m. Following pruning, passage of 4m high crane will be possible.
Photos	



Tree Number	7
Latin Name	Syncarpia glomulifera
Common Name	Turpentine Tree
Estimated Height (m):	23
Estimated Spread (m):	13
Tree Health/Vigour:	Good
Tree Structural Condition:	Good
Age Class:	Mature
Estimated Remaining Useful Life Expectancy (ULE):	>40 years
Is the tree exempt under local plannning laws?	No
Diameter at Breast Height (@ 1.4m above ground level) (cm):	90
Observations	Co-dominant stems
	Deadwood minor (<3cm diameter)
	Dieback
Recommendations	Selective branch prune
Comments	Selective one 30mm diameter branch as shown in the figures below won't have a significant impact to the tree. The pruning is considered minor with the tree being in good health and therefore capable of sustaining some minor foliage loss. Measuring staff in image is set to 4.5m. Following pruning, passage of 4m high crane will be possible.
Photos	

Notes

This summary document is provided only as advice following a site consultation inspection and does not constitute full arborist report.

The inspection is undertaken from ground level only and from within the site unless otherwise stated.

As a result of our recommendations, council consent may be required to undertake works to trees.

This document in no way provides consent to undertake pruning or other works to trees.

It is **strongly recommended** that you contact the consent authority prior to undertaking any pruning to trees, whether above ground or below.

Any pruning recommended as an outcome of our assessment is to be in accordance with AS 4373 - 2007 - Pruning of amenity trees and the Safe Work Australia Code of Practice 'Guide to Managing Risks of Tree Trimming and Removal Work' 2016.

Assumptions and Limitations

1. Any description or information provided to the consultant by the client or third party is assumed to be correct.
2. All information has been sourced with care and verified to the best of the consultant's knowledge. Any opinions not duly researched is based upon the consultant's experience and observations.
3. The consultant shall not be required to give testimony or attend court by reason of this summary document unless under a contractual agreement, including payment of additional fees and charges for such services.
4. Modification or extraction of key contextual components invalidates the entire summary document.
5. There is no warranty, explicit or implicit that the problems and deficiencies associated with the site or vegetation may not arise in future.
6. Unless stated otherwise, the information contained within the summary document will address the items outlined in the project brief or that were examined during any site assessment and reflect the condition of those items at the time of inspection.
7. Unless otherwise specified, the inspection is limited to ground-based inspection of accessible areas without dissection, excavation or probing.
8. This report and its recommendations reflect an impartial assessment of the tree and its condition based on the available evidence and projected outcomes.

Appendix F – Specialist study (noise and vibration)

ARUP

Sydney Water

Thornleigh - Inlet/Outlet Main Construction

Construction Noise and Vibration Impact Assessment

Reference: ACD01

v 4 | 28 June 2023

This report takes into account the particular instructions and requirements of our client. It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

Job number 269002

Arup Australia Pty Ltd | ABN 76 625 912 665

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ARUP

Document Verification

Project title	Thornleigh - Inlet/Outlet Main Construction
Document title	Construction Noise and Vibration Impact Assessment
Job number	269002
Document ref	ACD01
File reference	269002-ACD01_v3_Thornleigh_CNVIA.pdf

Revision	**Date**	**Filename**	269002-ACD01_v1_Thornleigh_CNVIA.pdf		
1	31 Jan 2023	**Description**	Construction Noise and Vibration Impact Assessment - DRAFT		
			Prepared by	**Checked by**	**Approved by**
		Name	Cynthia Nguyen	Clemence Terraz	Mitchell Allen
		Signature			
2	2 March 2023	**Filename**	Construction Noise and Vibration Impact Assessment – DRAFT 2		
		Description	Updated to address Sydney Water Comments Includes details regarding scenarios conducted concurrently		
			Prepared by	**Checked by**	**Approved by**
		Name	Clemence Terraz	Mitchell Allen	Mitchell Allen
		Signature			
3	15 June 2023	**Filename**	Construction Noise and Vibration Impact Assessment – FINAL		
		Description	Updated to assess latest construction areas and scenarios.		
			Prepared by	**Checked by**	**Approved by**
		Name	Cynthia Nguyen	Clemence Terraz	Mitchell Allen
		Signature	[redacted]		

4	28 June 2023	**Filename**	Construction Noise and Vibration Impact Assessment – FINAL		
		Description	Minor updates to wording		
			Prepared by	**Checked by**	**Approved by**
		Name	Cynthia Nguyen	Clemence Terraz	Mitchell Allen
		Signature	[redacted]		

Issue Document Verification with Document ✓

Contents

Tables

Figures

Appendices

1. Introduction

Sydney Water is seeking approval for construction of a new water pipeline (DN1800) to be built between Thornleigh Reservoir (WS0148) and Thornleigh-Wahroonga water pumping station (WP0159) (The Project). The project is part of Package 2 of the wider Epping to St Leonards program of works which aims to provide more system resilience, operation flexibility and improve water quality in the Greater Sydney Metropolitan Area.

The pipeline is anticipated to be built using tunnel boring techniques. Tunnelling works are likely to be conducted 24 hours a day over a period of approximately 9 months. Overall duration of construction works for the Project is approximately 30 months.

This Construction Noise and Vibration Impact Assessment (CNVIA) is to support a Review of Environmental Factors (REF) submission.

This CNVIA has been conducted with reference to:

- EPA (previously known as DECC) Interim Construction Noise Guideline (ICNG) [1]
- Assessing Vibration: A Technical Guideline [2]
- NSW Noise Policy for Industry [3]
- German Standard DIN 4150-3: Structural Vibration [4]
- Transport Roads & Maritime Services Construction Noise and Vibration Strategy [5]

This CNVIA:

- Identifies location of the Project and nearest sensitive receivers
- Identifies proposed hours of construction
- Establishes construction noise management levels and vibration criteria in accordance with NSW Policies and Guidelines, relevant Australian and International Standards and noise measurements taken on site.
- Assesses predicted noise and vibration impacts against established criteria
- Identifies noise and vibration mitigation and management measures to minimise construction noise and vibration impacts onto nearest sensitive receivers.

A glossary of the acoustic terminology used in this document is presented in Appendix A.

2. Project Description

The proposed construction methodology is to use a Tunnel Boring Machine (TBM) from Thornleigh Reservoir (WS0148) to Thornleigh-Wahroonga water pumping station (WP0159). The TBM launch shaft is shown in Figure 1 as Site 2, while the TBM retrieval shaft is shown as Site 3 Area 3C. Open trenching is also proposed near the TBM launch shaft (refer to Site 1 Area 1B in Figure 1) located within the Thornleigh Reservoir. It is understood that the TBM will be conducted 24 hours a day 7 days a week over a period of approximately 9 months. Overall duration of construction works for the Project is approximately 30 months. Open trenching is proposed to be conducted during standard hours of construction.

Figure 1 shows the locations of the proposed construction works.

Construction activities and construction program were provided by Sydney Water and are reproduced in Table 1 and Table 2 respectively. Those were used to develop the scenarios assessed in this report.

Figure 1: Proposed construction works, Thornleigh

Table 1: Proposed Activities

Activity no.	Typical activity	Sites	Key tasks / methodology steps
Ac01	Site mobilisation (launch site - including access road upgrade, veg removal, excavation of launch pit, establishment of drilling plant & equipment, installation of acoustic shed)	Site 1 – Area 1A Site 2	At reservoir/launch site Veg trimming/removal in approved areas Upgrade of the existing access track – Rip and replace existing pavement with wider, more robust pavement able to withstand the heavy construction plant loads. Excavate existing pavement, load out and dispose off-site. Import, place and compact road base to new road footprint dimensions. Place and compact asphalt layers Excavate launch pit and install ground support system. Includes removal of spoil offsite Level area for TBM and laydown, strip topsoil, install fill as needed, construct concrete footings of shed, install all weather pavement. Mobilise all drilling equipment including TBM, site shed, plant, etc that will be contained with the acoustic shed. Install acoustic shed Bring material to site to store in laydown area, eg Concrete casing pipes
Ac02	Site mobilisation (retrieval site - includes ground prep, veg mgt, installation of ground support system (concrete piles), Excavation of receival pit)	Site 3 – Area 3A Site 3 – Area 3C	Site mobilisation and set up. Veg trimming/removal in approved areas including removal of vegetation and kerbing within the island at the cul-de-sac at Edmundson Close. Asphalt footprint of removed cul-de-sac Remove grass, topsoil, and spoil (approx. 500mm depth) on council land and replace with all-weather temporary pavement. Includes importing, placing and compacting of road base. Receival pit construction Construct ground support system. Involves piling rig and concreting activities. Excavate receival pit and remove spoil offsite.
Ac03a	Day time activities at reservoir	Site 1 – Area 1A Site 2	Use wheel loader to transport spoil into bogey truck Bogey truck to take the spoil off site (day only) Pipe delivery only during daytime hours Use truck and dog to remove around 12 loads of material for launch pit Deliveries and spoil removal during the daytime hours only

Activity no.	Typical activity	Sites	Key tasks / methodology steps
Ac03b	Daytime activities at reservoir (Installing carrier main, open trench pipe installation, concrete chamber construction, connections)	Site 1 – Area 1B Site 1 - Area 1A Site 2	Once the tunnelling is finished, another contractor will undertake welding and pushing of carrier pipe through RCP sleeve (hole left by the TBM). Grout injection after it's all joined together Open trench for the first ~200m of pipe within the reservoir Around 132 loads of material to remove using truck and dog for open trench Delivery of pipes to site Delivery of all other materials to site Concrete encasement and steelwork for the pipe Construction of concrete chambers Contingency for dewatering groundwater Ongoing backfill/compaction of shaft (with clean material) Connection of pipes into existing network
Ac04a	Day activities at reservoir (tunnelling activities, installing carrier main)	Site 1 – Area 1A Site 2 TBM Pipeline	Tunnelling and associated activities at TBM. TBM to be running 24/7 for the ~9 months of tunnelling along the alignment Mud plant (shaker) to separate soil from bentonite– shaker tray and table – will tip the material into a bin Bentonite slurry plant to create and recycle bentonite after slurry goes through mud plant Hydraulic power pack/s that drive TBM Bentonite production plant Gantry crane over portal shaft – crane will lower/lift pipes into shaft Spoil stockpiling near launch pit Diesel generator to power site if permanent upgrade not practical or as a back up in permanent power supply goes down. Install carrier main after tunnelling is complete Delivery of all other materials to site

Activity no.	Typical activity	Sites	Key tasks / methodology steps
Ac04b	Night activities at reservoir (tunnelling activities, installing carrier main)	Site 2 TBM pipeline	Tunnelling and associated activities at TBM. TBM to be running 24/7 for the ~9 months of tunnelling along the alignment Mud plant (shaker) to separate soil from bentonite (use at night) – shaker tray and table – will tip the material into a bin Bentonite slurry plant to create and recycle bentonite after slurry goes through mud plant (use at night) Hydraulic power pack/s that drive TBM (use at night) Bentonite production plant (night-time maintenance required) Gantry crane over portal shaft – crane will lower/lift pipes into shaft Spoil stockpiling near launch pit Diesel generator to power site if permanent upgrade not practical or as a back up in permanent power supply goes down. Install carrier main after tunnelling is complete
Ac05a	Work at retrieval shaft / site (Daytime activities)	Site 3 – Area 3B	Widen/replace existing footbridge or install new temporary footbridge with 6m bridge suitable for light vehicles Remove the existing footbridge. Install new culvert over bridge. Set up base rock layer, form and pour slab over top, set culvert on top Bring crane to site Park crane in Edmundson Cl cul-de-sac Open trench pipe installation Concrete encasement of pipework Ongoing backfill/compaction of shaft (with clean material) Use crane to lift out TBM Contingency for dewatering groundwater Construction of concrete chambers Welding activities
Ac5b	Work at retrieval shaft / site (Night-time activities)	Site 3 – Area 3C	Connection of pipes into existing network (night) includes cutting existing pipes
Ac06	Site demobilisation (both sites)	Site 1 – Area 1a Site 2 Site 3 – Area 3A	Removal of all plant, equipment, and vehicles Remove temporary hardstand Backfill excavations Restore sites eg reinstate disturbed areas, perform offset planting

Activity no.	Typical activity	Sites	Key tasks / methodology steps
Ac07	Compound activities	Compound	Supporting relevant activities.

Table 2: Proposed Program and assessed scenarios

ID	Activity description	Month														
		1-2	3-4	5-6	7-8	9-10	11-12	13-14	15-16	17-18	19-20	21-22	23-24	25-26	27-28	29-30
Ac01	Site mobilisation/pit excavation at launch site	X	X													
Ac02	Site mobilisation/pit excavation at retrieval site	X														
Ac03a	Work at reservoir – other day works								X	X	X	X				
Ac03b	Work at reservoir carrier main works						X	X								
Ac04a	Work in launch pit – day			X	X	X	X	X								
Ac04b	Work in launch pit – night			X	X	X	X	X								
Ac05a	Work at retrieval pit – day		X	X	X	X	X	X	X	X	X	X				
Ac05b	Work at retrieval pit – night		12 nights only of work during this period													
Ac06	Site demobilisation												X			
Ac07	Compound activities	X	X	X	X	X	X	X	X	X	X	X	X			
-	Contingency													X	X	X

Note: X represents Scenario 1, X represents Scenario 2, X represents Scenario 3, X represents Scenario 4, X represents Scenario 5, X represents Scenario 6a, X represents Scenario 6b, X represents Scenario 7.

Table 2 shows that some activities (described in Table 1) will be conducted concurrently. Accordingly, the following scenarios (also identified in Table 2) have been derived for the purpose of this assessment. Those scenarios are representative of concurrent activities and take into account hours of construction.

- Scenario 1 (month 1-2): Site establishment (Site 1 (Area 1A), Compound, Site 2, Site 3 (Area 3A, Area 3C))
- Scenario 2 (month 3-4): Site establishment & pipework (Site 1 (Area 1A), Compound, Site 2 & Site 3 (Area 3B))
- Scenario 3 (month 15-22): Pipework (Site 1 (Area 1A), Compound, Site 2 & Site 3 (Area 3B))
- Scenario 4 (month 5-14): Tunnelling (Night works) (Site 2)
- Scenario 5 (month 11-14): Open trenching & pipework (Site 1 (Area 1A, Area 1B), Compound, Site 2 & Site 3 (Area 3B))
- Scenario 6a (month 5-10): Tunnelling & Pipework (Day works) (Site 1 (Area 1A), Compound, Site 2, Site 3 (Area 3B))
- Scenario 6b (month 3-22): Pipework (Night works) (Site 3 (Area 3C))
- Scenario 7 (month 23-24): Site demobilisation (Site 1 (Area 1A), Compound, Site 2 & Site 3 (Area 3A))

3. Existing acoustic environment

3.1 Surrounding land uses

Receivers potentially impacted by the construction of the Project are defined based on the type of occupancy and their sensitivity to cosmetic or structural damage.

The noise sensitive receivers near the construction site have been identified as being mostly residential properties. A nominal study area of 1 km from the construction works has been adopted for this assessment as a screening analysis for any noise sensitive receivers with the potential to experience construction noise impacts.

Noise sensitive receivers within 250 m from the construction sites have been presented in Appendix E.

3.2 Noise monitoring

Noise monitoring was undertaken in the area for the purpose of deriving construction noise criteria and quantifying the noise environment at nearby residential receivers.

Long-term unattended and short-term attended monitoring was conducted at the locations presented in Table 3 and shown in Appendix E and Figure 1.

Table 3: Noise monitoring locations

ID	Measurement Type	Purpose	Location
L1	Both long-term unattended and short-term attended	Establish noise criteria, quantify and qualify noise levels at logger location.	Thornleigh reservoir (behind 53 The Sanctuary Westleigh NSW)
L2		Establish noise criteria, quantify and qualify noise levels at logger location.1	Thornleigh pump station (behind 20 Morgan St Thornleigh NSW)

3.2.1 Unattended long-term monitoring

Unattended background noise monitoring was conducted in December 2022 at L1 and L2. The monitoring results are reproduced below in Table 4. During the monitoring period, construction activities were undertaken in the area unrelated to this project. The periods during which those construction activities were undertaken have been excluded from the monitoring results.

Table 4: Unattended noise measurement results

Noise measurement ID	Location	Date	Logger and Logger serial number	Rating Background Levels (RBL), dBL_{A90}[1]			L_{Aeq} Ambient Levels dBL_{Aeq}[1]		
				Day	Evening	Night	Day	Evening	Night
L1	Thornleigh Reservoir (WS0148)	5/12/22-20/12/22	B&K EMS 63659-B3012345	35	34	27	52	48	42
L2	Thornleigh water pumping station (WP0159)	5/12/22-20/12/22	B&K EMS 63659-B3023572	38	35	32	50	50	43

Note:

1_ The NPfI [3] defines day, evening and night time periods as:

- Day: the period from 7 am to 6 pm Monday to Saturday; or 8 am to 6 pm on Sundays and Public Holidays.
- Evening: the period from 6 pm to 10 pm.
- Night: the remaining period.

3.2.2 Attended short-term monitoring

Short-term 15 minute attended noise measurements were undertaken on Monday 5 December 2022. The measured noise levels and site observations are summarised in Table 5. Further detailed information regarding the noise monitoring is presented in Appendix B.

Table 5: Short-term noise monitoring results, dB(A)

Location ID	Date and start time	Measured levels		Noise sources contributions
		$dBL_{A90(15min)}$	$dBL_{Aeq(15min)}$	
L1	5 Dec 22 10:54	33	40	Ambient levels dominated by local fauna, no audible traffic noise was present.
L2	20 Dec 22 08:04	38	49	Ambient levels dominated by local fauna and distant construction work.

4. Construction noise criteria

4.1 Airborne construction noise management levels (NMLs)

Construction noise targets are derived in accordance with the ICNG [1]. Targets are summarised in Table 6. Refer to Appendix C for further details on the derivation of these noise targets.

Table 6: Noise management levels for noise sensitive receivers -external noise levels

Type of receiver	Time period[1]	Highly noise affected	Standard Hours[2] $dBL_{Aeq(15\ min)}$	Outside standard hours[3] $dBL_{Aeq(15\ min)}$		
				Day	Evening	Night
Residential[6]	Day	75[4]	45	40	39	35[5]
Commercial	When in use	N/A	70			
Educational	When in use	N/A	55			
Place of Worship	When in use	N/A	55			
Child Care	When in use	N/A	55			
Industrial	When in use	N/A	75			
Active recreation	When in use	N/A	65			

Notes:

1_The NPfI [3] defines day, evening and night time periods as:

- Day: the period from 7 am to 6 pm Monday to Saturday; or 8 am to 6 pm on Sundays and Public Holidays.
- Evening: the period from 6 pm to 10 pm.
- Night: the remaining period.

2_The ICNG [1] defines Standard hours as Monday to Friday 7 am to 6 pm and Saturday from 8 am to 1 pm.

3_Outside standard hours are defined as:

- Day: Sundays and public holidays – 8 am to 6 pm, Saturday 7 am to 8 am and 1 pm to 6 pm
- Evening: Monday to Saturday – 6 pm to 10 pm, Sunday and public holidays – 6 pm to 10 pm
- Night: Monday to Saturday – 12 am to 7 am and 10 pm to 12 am,
- Sundays and public holidays – 12 am to 8 am and 10 pm to 12 am

4_In accordance with the ICNG [1], the highly noise affected applies to residential properties only

5_Per the NPfI, where the measured background noise level is below the minimum RBL (as defined below), the background is set to the minimum background;

- Day: 35 dBA
- Evening: 30 dBA
- Night: 30 dBA

6_Results of noise logger L1 were conservatively used to determine the NMLs to all residential receivers

4.2 Ground-borne noise management levels (GBNMLs)

Ground-borne noise is noise generated by vibration transmitted through the ground into a structure. Ground-borne construction noise is usually present on tunnelling projects when equipment such as tunnel boring machines, road headers, rock hammers and drilling rigs are operated underground. The ground-borne noise inside buildings initially propagates as ground-borne vibration, before entering the building, which causes floors, walls and ceilings to gently vibrate and hence radiate noise.

Ground-borne noise is usually not a significant disturbance to building occupants during daytime periods due to higher ambient levels which mask the audibility of ground-borne noise emissions. During night-time periods however, when ambient noise levels are often much lower, ground-borne noise is more prominent and may result in adverse comment from building occupants.

Ground borne noise is dependent on the soil properties, the distance between the source of the vibration and the receiver and the energy transmitted into the ground from the source.

The following ground-borne noise levels from the ICNG [6] for residences indicate when management actions should be implemented. These levels recognise the temporary nature of construction and are only applicable when ground-borne noise levels are higher than airborne noise levels. The ground-borne noise levels are for evening and night-time periods only, as the objectives are to protect the amenity and sleep of people when they are at home.

Table 7: Ground-Borne Noise Management Levels – internal noise levels – for residential properties

Land use	Period	Ground-Borne Noise objectives $L_{Aeq(15min)}$
Residential	Evening (6pm to 10pm)	40 dBA
	Night (10pm to 7am)	35 dBA

4.3 Construction traffic noise criteria

When trucks and other vehicles are operating within the boundaries of the various construction sites, vehicle noise contributions are included in the overall predicted $L_{Aeq(15minute)}$ construction site noise emissions. When construction related traffic moves onto the public road network, traffic generated noise is assessed in accordance with the NSW *Road Noise Policy* (RNP) [7].

When assessing traffic noise generated on an existing road network, an initial screening test is adopted that evaluates whether existing road traffic noise levels are expected to increase by more than 2 dBA due to the additional traffic generated by the Project.

Where noise levels are predicted to increase by more than 2 dBA (i.e. 2.1 dBA or greater) more detailed assessment is required in accordance with the RNP and against the criteria outlined in Table 8 (Table 3 of the RNP).

Table 8: Road traffic criteria for traffic generating development – residential receivers.

Road category	Type of project / land use	Assessment criteria – dBL_{Aeq}	
		Day (7:00am-10:00pm)	**Night (10:00pm-7:00am)**
Freeway/ arterial/sub-arterial roads	Existing residences affected by additional traffic on existing freeways / arterial / sub-arterial roads generated by land use developments	$L_{Aeq,(15\ hour)}$ 60 (external)	$L_{Aeq,(9\ hour)}$ 55 (external)
Local Roads	Existing residences affected by additional traffic on existing local roads generated by land use developments	$L_{Aeq(1hour)}$ 55 (external)	$L_{Aeq(1hour)}$ 50 (external)

Note: These criteria are for assessment against façade corrected noise levels 1 metre in front of a building façade.

4.4 Sleep disturbance

The ICNG [6] recommends that where construction works occurs during the night-time period, potential of sleep disturbance should be considered. The ICNG makes reference to the ECRTN [8] which is a superseded guidance document and has been replaced by the RNP [7] which states:

- maximum internal noise levels below 50 – 55 dBA are unlikely to result in sleep disturbances
- one or two internal noise level events above 65 – 70 dBA are unlikely to significantly affect health and wellbeing.

Assuming a 10 dB reduction from outdoor to indoor with windows open, those levels would then be:

- maximum external noise levels below 60 – 65 dBA are unlikely to result in sleep disturbances
- one or two external noise level events above 75 – 80 dB(A) are unlikely to significantly affect health and wellbeing.

More current and up to date criteria to assess sleep disturbance can be found in the NPfI [3] and are reproduced below:

- $L_{Aeq,15min}$ 40 dBA or the prevailing RBL plus 5 dB, whichever is the greater, and/or
- L_{AFmax} 52 dBA or the prevailing RBL plus 15 dB, whichever is the greater.

Where these targets are exceeded, the ICNG recommends that a detailed maximum noise level (L_{Amax}) event assessment be undertaken. Factors to take into consideration should include maximum levels and extent and frequency of maximum noise levels events exceeding the RBL.

The ICNG night-time NMLs (equal to 35 dBA L_{Aeq} (30 dBA RBL + 5 dBA), Refer to Section 3.2 and Section 4.1) are more stringent than the NPfI sleep disturbance criteria in the first dot point (40 dBA L_{Aeq}).

In addition, it is noted that the difference between the ICNG L_{Aeq} criterion of 35dBA (i.e. RBL + 5 dB) is in the order of 17 dB when compared to the L_{Amax} criterion in the second dot point (52 dBL_{Amax}).

An analysis was undertaken of the relative L_{Aeq} and L_{Amax} construction noise impacts for various sites. The difference between the predicted L_{Aeq} and L_{Amax} noise levels was found to be in the order of 8-15 dB. This difference is less than the difference noted between L_{Aeq} and L_{Amax} criteria which means that compliance with the ICNG L_{Aeq} NMLs would imply that compliance with the L_{Amax} criteria is met.

Hence, assessment of night-time noise emissions against the ICNG L_{Aeq} NMLs are considered sufficient to assess sleep disturbance.

5. Construction noise assessment

5.1 Assessment methodology

5.1.1 Assessment methodology – airborne noise

The following methodology has been used to assess airborne construction noise:

- Construction scenarios, duration of scenarios and equipment to be used were provided by and discussed with Sydney Water. (Refer to Section 5.2).
- An acoustic model was developed using the environmental noise modelling software package SoundPLAN v8.1 to predict noise impacts at the nearest receivers. The model was used to predict noise levels at the nearest receivers as contour noise maps. The model includes:
  - Existing topography
  - Existing building structures
  - Noise sources
  - Noise sensitive receivers
  - Ground and air absorption
  - Contours are modelled 2m above ground
- ISO 9613-2:1996 [9] was used to predict construction noise levels at the receivers for typical scenarios of construction activity. This includes corrections for screening, topographical effects, atmospheric absorption, and reflective surfaces.
- The contour noise maps were used to establish if/where noise management levels as defined in Section 4 are expected to be exceeded. The contour noise maps were used to create exceedance maps.
- No noise mitigation measures were included in the assessment (except for Scenario 4 which includes estimated noise reductions from the construction of an acoustic shed at the launch pit)
- All plant and equipment (listed in Table 9 for each site) was assumed to be operating concurrently across a construction site and at 100% throughout the 15-minute assessment period.
- Exceedances of the criteria are presented in Appendix F as colour coded buildings.

The results shown in Appendix F are indicative only.

During construction, plant and equipment will move through the Project area as the Project progresses, changing noise impacts in relation to the nearby individual sensitive receivers. Furthermore, the noise levels experienced at a particular location will rise and fall in accordance with the varying offset distance of the works, the intensity and location of construction activities, the intervening terrain and structure and the type of equipment used. It is unlikely that all construction equipment will be operating at their maximum sound levels simultaneously. In any given period, typically construction equipment would be used with maximum sound levels for only a brief amount of time and at other times the equipment may emit lower sound levels carrying out activities.

The method of assessment above is considered to be conservative.

5.1.2 Assessment methodology – ground-borne noise

The prediction of the vibrations at the ground surface due to a TBM is complex as the vibrations are a function of the vibrational excitation provided by the TBM, the ground properties and the distance between the vibration source and the points of interest.

As so many variables are involved in the determination of the vibration levels in the ground due to tunnelling, no explicit relationships exist which allow accurate predictions of the vibration magnitudes to be made for any given source and ground conditions.

Approximate empirical relations have been developed based on experience and a limited number of case studies, relating the resultant peak particle velocity at the ground surface to the distance from the TBM for different ground conditions.

In the absence of project specific measurements, ground-borne noise has been predicted using an empirical formula.

The following methodology has been used to assess ground-borne construction noise:

- Ground borne noise levels have been predicted using Godio et al equation 25 (reproduced below) of the TRL document [10]:

  $$L_p = 127 - 54\, log_{10}\, r$$

  Where:

  – L_p is the predicted ground-borne noise level in dBA

  – r is the distance from the source to the receiver

  Note that while the above equation considers the distance from source to receiver only, it provides a useful first estimate for prediction of the vibration levels likely to be generated by future mechanised tunnelling works.

- An exceedance map was produced for the assessment of ground-borne noise (refer to Appendix F.3). This map is used to establish if/where ground borne noise criteria as defined in Section 4.2 are exceeded. Exceedances of the criteria are presented as colour coded buildings.

It is noted that, during TBM tunnelling activities, the boring machine will move from the entry point to the exit point changing ground borne noise impacts in relation to the nearby individual sensitive receivers. The ground borne noise levels experienced at a particular location will rise and fall in accordance with the varying offset distance of the machine.

The results shown in Appendix F3 are indicative only but serve as a useful screening analysis to identify potential impacts associated with the works.

5.2 Construction Activities and Assessment Scenarios

Based on the construction work methodology and equipment provided for this project as well as our understanding of the Project, the construction works have been broken down into main scenarios (described in Section 2, Table 9 and Table 10). Those scenarios include activities conducted concurrently at various sites (described in Figure 1). Equipment and associated sound power levels for those activities are described in Table 9. Table 10 indicates the type of assessment provided for each scenario. Note that the construction scenarios and equipment will be reviewed at a later stage when actual plant to be used is known.

Equipment sound power levels (L_w) have been sourced from AS2436 [11], CNVS [5], DEFRA [12] and Arup database. It should be noted that during different construction stages, it is unlikely that all machinery would be operating at the same time at 100% of the 15-minute assessment period (like the modelling assumes) but taking a ‘worse-case’ scenario approach helps to identify where noise impacts could be a concern and assists in the specification of mitigation and management measures.

Table 9: Construction equipment and sound power levels

Plant item	Source	Sound power level	Number of items																														
			Sc1: Site establishment					Sc2: Site establishment & pipework				Sc3: Pipework				Sc4: Tunnelling (Outside standard hours)	Sc5: Open trenching & pipework					Sc6a: Tunnelling & Pipework (Standard hours)				Sc6b: Tunnelling & Pipework (Outside standard hours)	Sc7: Site demobilisation			
			Site 1	Compound	Site 2	Site 3		Site 1	Compound	Site 2	Site 3	Site 3	Site 2	Site 1	Compound	Site 2	Site 3	Site 2	Site 1		Compound	Site 3	Site 1	Site 2	Compound	Site 3	Site 1	Compound	Site 2	Site 3
			Area 1A			Area 3A	Area 3C	Area 1A			Area 3B	Area 3B		Area 1A			Area 3B		Area 1A	Area 1B		Area 3B	Area 1A			Area 3C	Area 1A			Area 3A
Angle Grinder	DEFRA	108																		1						1				
Chainsaw - petrol	CNVG	114	1	1		1		1	1																			1		
Circular Saw (Hand-held)	DEFRA	115									1	1					1					1				2				
Compactor	AS2436	120[2]	1	1		1		1	1		1	1					1					1					1	1	1	1
Concrete Agitator Truck	AS2436	111	1	1			1	1	1		1	1					1					1						1		
Concrete Pencil Vibrator	AS2436	105	1	1				1	1		2	2					2					2						1		
Concrete Pump	CNVG	109	1	1			1	1	1		1	1					1					1						1		
Concrete Pump Truck	AS2436	113									1	1					1			1		1								
Crane (Franna)	CNVG	98	1	1				1	1				1		1					1	1				1			1		
Crane (Mobile)	AS2436	113									2	2				1	2	1		1		2		1		2				
Crane (Truck Mounted)	CNVG	108	1	1		1		1	1																		1	1	1	1
Elevated Work Platform (Cherry Picker)	AS2436	105	1	1		1		1	1																			1		
Excavator (30t)	CNVG	110	1	1	1	1		1	1	1	2	2	1				2		1			2				2	1	1	1	1
Excavator (30t) + hydraulic hammer	CNVG	127[2]	1	1	1	1		1	1	1										1								1		
Gantry Crane	AS2436	105			1		1			1						1		1	1					1						
Generator (Diesel)	AS2436	113											1			1		1						1		1				
Grader	AS2436	115	1	1				1	1																			1		
Grout truck	AS2436	113																		1										
Hand Tools (Electric)	AS2436	110	1	1		1		1	1		1	1	1			1	1	1		2		1		1		1	1	1	1	1
Hydro demolition	CNVG[1]	109															1			1										
Hydraulic Power Pack	DEFRA	106									1	1	1			1	1	1				1		1		1				
Light Vehicle - 4WD	CNVG	103	2	2		2		2	2		3	3	2		1	3	3	3		3	1	3		3	1	1	3	2	3	3
Mud pump	Springs Rd, Noise assessment [13]	107											1			1		1		1				1						
Mulcher (Chipper)	CNVG	116	1	1		1		1	1																			1		
Piling (Bored)	AS2436	111					1																							
Road Lorry (Empty)	DEFRA	111	1	1				1	1		2	2			1		2			1	1	2			1			1		
Road Sweeper (Lorry Mounted)	BS5228	101											1														1		1	1
Roller (Smooth-drum)	CNVG	107	1	1				1	1																			1		

Plant item	Source	Sound power level	Number of items																												
			Sc1: Site establishment					Sc2: Site establishment & pipework				Sc3: Pipework				Sc4: Tunnelling (Outside standard hours)	Sc5: Open trenching & pipework					Sc6a: Tunnelling & Pipework (Standard hours)				Sc6b: Tunnelling & Pipework (Outside standard hours)	Sc7: Site demobilisation				
			Site 1	Compound	Site 2	Site 3		Site 1	Compound	Site 2	Site 3	Site 3	Site 2	Site 1	Compound	Site 2	Site 3	Site 2	Site 1		Compound	Site 3	Site 1	Site 2	Compound	Site 3	Site 1	Compound	Site 2	Site 3	
			Area 1A			Area 3A	Area 3C	Area 1A			Area 3B	Area 3B		Area 1A			Area 3B		Area 1A	Area 1B		Area 3B	Area 1A			Area 3C	Area 1A			Area 3A	
Shale Shaker	Springs Rd, Noise assessment [13]	104											1			1		1						1							
Slurry Pump	Arrow LNG Plant NVIA [14]	96											1			1		1						1							
Truck (Dump)	AS2436	117				1					1	1	1			1	1	1	1			1		1			1		1	1	
Truck (Road Truck/Truck & Dog)	CNVG	108	1	1	1		1	1	1	1				3	1	2		2	3		1		3	2	1		1	1	1	1	
Truck (Water Cart)	AS2436	108	1	1				1	1				1														1	1	1	1	
Water Pump	DEFRA	96																								1					
Welder	AS2436	110														1		1		2				1		1					
Total sound power level (Lw) - dBA			129	129	127	129	116	129	129	127	125	125	121	113	113	122	125	122	119	128	113	125	113	122	113	122	123	129	123	123	

Notes:

1_Noise emissions from the hydro demolition equipment have been assumed to be similar to noise emissions from a vacuum truck.

2_A penalty of 5dB has been added to equipment that has special characteristics (i.e. tonality, low frequency noise, impulsive or intermittent) per the CNVS [5].

5.3 Assessment results

5.3.1 Assessment results - Airborne and ground borne noise

This section outlines the noise modelling results and provides assessment compared to project-specific NMLs and GBNMLs in Section 4. The scenarios in Table 10 have been assessed.

Table 10: Scenarios assessed.

<table>
<tr><th rowspan="3">Scenario</th><th rowspan="3">Description of works</th><th rowspan="3">Month</th><th rowspan="3">Hours of operation</th><th rowspan="3">Sound power levels (dBA)</th><th colspan="7">Location</th><th rowspan="3">Assessment results</th><th rowspan="3">Number of receivers (within study area) where noise levels are predicted to exceed the NMLs (during assessment period)</th></tr>
<tr><th colspan="2">Site 1</th><th rowspan="2">Site 2</th><th rowspan="2">Compound</th><th colspan="3">Site 3</th></tr>
<tr><th>Area 1A</th><th>Area 1B</th><th>Area 3A</th><th>Area 3B</th><th>Area 3C</th></tr>
<tr><td>1: Site establishment</td><td>Site 1 (Area 1A): Establishing access roads, vegetation removal.

Compound: Supporting activities in the active sites.

Site 2: Excavation of launch pit, establishment of drilling plant and equipment installation.

Site 3 (Area 3A): Establishing access roads, vegetation removal.

Site 3 (Area 3C): Excavation of receival pit and installation of concrete piles.</td><td>1-2</td><td>Standard hours of construction (Day)</td><td>Site 1 (Area 1A): 129

Compound: 129

Site 2: 127

Site 3 (Area 3A): 129

Site 3 (Area 3C): 116</td><td>x</td><td></td><td>x</td><td>x</td><td>x</td><td></td><td>x</td><td>Refer to Appendix F.1: Airborne noise assessment for site establishment conducted during standard hours of construction (day)</td><td>Standard Hours
<table><tr><td>Compliant</td><td>742</td></tr><tr><td><=NML+10dB</td><td>3046</td></tr><tr><td><=NML+20dB</td><td>2823</td></tr><tr><td><=NML+30dB</td><td>311</td></tr><tr><td><=NML+40dB</td><td>35</td></tr><tr><td>> NML+40dB</td><td>12</td></tr><tr><td>HNA[1]</td><td>62</td></tr></table></td></tr>
</table>

Scenario	Description of works	Month	Hours of operation	Sound power levels (dBA)	Location							Assessment results	Number of receivers (within study area) where noise levels are predicted to exceed the NMLs (during assessment period)
					Site 1		Site 2	Compound	Site 3				
					Area 1A	Area 1B			Area 3A	Area 3B	Area 3C		
2: Site establishment & Pipework	Site 1 (Area 1A): Establishing access roads, vegetation removal. Site 2: Excavation of launch pit, establishment of drilling plant and equipment installation. Compound: Supporting activities in the active sites. Site 3 (Area 3B): Widen/replace existing footbridge or install new temporary footbridge, open trench pipe installation, connection of pipes and associated pipework activities.	3-4	Standard hours of construction (Day)	Site 1 (Area 1A): 129 Compound: 129 Site 2: 127 Site 3 (Area 3B): 125	x		x	x		x		Impacts to nearest receivers located near the launch shaft (Site 1 & Site 2) are predicted to be comparable to those predicted to receivers near the launch shaft for Scenario 1: Site establishment. Impacts to nearest receivers located near the retrieval shaft (Site 3) are predicted to be comparable to those predicted to receivers near the retrieval shaft for Scenario 3: Pipework.	

<table>
<tr><th rowspan="3">Scenario</th><th rowspan="3">Description of works</th><th rowspan="3">Month</th><th rowspan="3">Hours of operation</th><th rowspan="3">Sound power levels (dBA)</th><th colspan="7">Location</th><th rowspan="3">Assessment results</th><th rowspan="3">Number of receivers (within study area) where noise levels are predicted to exceed the NMLs (during assessment period)</th></tr>
<tr><th colspan="2">Site 1</th><th rowspan="2">Site 2</th><th rowspan="2">Compound</th><th colspan="3">Site 3</th></tr>
<tr><th>Area 1A</th><th>Area 1B</th><th>Area 3A</th><th>Area 3B</th><th>Area 3C</th></tr>
<tr><td>3: Pipework</td><td>Site 1 (Area 1A): Deliveries

Compound: Supporting activities in the active sites

Site 2: Pipework and associated activities

Site 3 (Area 3B): Widen/replace existing footbridge or install new temporary footbridge, connection of pipes and associated pipework activities.</td><td>15-22</td><td>Standard hours of construction (Day)</td><td>Site 1 (Area 1A): 113

Compound: 113

Site 2: 121

Site 3 (Area 3B): 125</td><td>x</td><td></td><td>x</td><td>x</td><td></td><td>x</td><td></td><td>Refer to Appendix F.2: Airborne noise assessment for pipework conducted during standard hours of construction (day)</td><td>Standard Hours<table><tr><td>Compliant</td><td>3935</td></tr><tr><td><=NML+10dB</td><td>2599</td></tr><tr><td><=NML+20dB</td><td>354</td></tr><tr><td><=NML+30dB</td><td>66</td></tr><tr><td><=NML+40dB</td><td>14</td></tr><tr><td>> NML+40dB</td><td>1</td></tr><tr><td>HNA[1]</td><td>17</td></tr></table></td></tr>
</table>

Scenario	Description of works	Month	Hours of operation	Sound power levels (dBA)	Location							Assessment results	Number of receivers (within study area) where noise levels are predicted to exceed the NMLs (during assessment period)
					Site 1		Site 2	Compound	Site 3				
					Area 1A	Area 1B			Area 3A	Area 3B	Area 3C		
4: Tunnelling (Night) – Ground borne noise assessment	Site 2: Tunnelling and associated TBM activities.	5-14	Standard hours & outside standard hours of construction (24/7)									Refer to Appendix F.3: Ground-borne noise assessment for tunnelling during outside standard hours of construction (night). It is noted that as the TBM moves slowly from the launch shaft to the retrieval shaft over a 9 months period, impacts (when GBNML are exceeded) at any one receiver are anticipated to last for approximately 26 nights in total with a maximum of 17 nights when GBNML are exceeded by 10 dB or more. GBN levels will slowly rise when the TBM moves towards the receiver, peak when the TBM is located the closest to the receiver and slowly decrease when the TBM moves away from the receiver.	Outside Standard Hours (Night) <u>Ground-borne noise (Residences only)</u> Compliant: 6389 <=GBNML+10dB: 100 > GBNML+10dB: 43

<table>
<tr><th rowspan="3">Scenario</th><th rowspan="3">Description of works</th><th rowspan="3">Month</th><th rowspan="3">Hours of operation</th><th rowspan="3">Sound power levels (dBA)</th><th colspan="7">Location</th><th rowspan="3">Assessment results</th><th rowspan="3">Number of receivers (within study area) where noise levels are predicted to exceed the NMLs (during assessment period)</th></tr>
<tr><th colspan="2">Site 1</th><th rowspan="2">Site 2</th><th rowspan="2">Compound</th><th colspan="3">Site 3</th></tr>
<tr><th>Area 1A</th><th>Area 1B</th><th>Area 3A</th><th>Area 3B</th><th>Area 3C</th></tr>
<tr><td>4: Tunnelling (Night) – airborne noise</td><td>Site 2: Tunnelling and associated TBM activities.</td><td>5-14</td><td>Standard hours & outside standard hours of construction (24/7)</td><td>Site 2: 122</td><td></td><td></td><td>x</td><td></td><td></td><td></td><td></td><td>Refer to Appendix F.4: Airborne noise assessment for tunnelling conducted outside standard hours of construction (night)</td><td>Airborne noise<table><tr><td>Compliant</td><td>2429</td></tr><tr><td><=NML+10dB</td><td>2910</td></tr><tr><td><=NML+20dB</td><td>1447</td></tr><tr><td><=NML+30dB</td><td>166</td></tr><tr><td><=NML+40dB</td><td>15</td></tr><tr><td>> NML+40dB</td><td>2</td></tr><tr><td>HNA[1]</td><td>3</td></tr></table></td></tr>
<tr><td>4: Tunnelling (Night) – mitigated - airborne noise</td><td>Site 2: Tunnelling and associated TBM activities.</td><td>5-14</td><td>Standard hours & outside standard hours of construction (24/7)</td><td>Site 2: 102 (assuming a 20 dB reduction provided by the installation of an acoustic shed)</td><td></td><td></td><td>x</td><td></td><td></td><td></td><td></td><td>Refer to Appendix F.5: Airborne noise assessment for tunnelling conducted outside standard hours of construction (night) – assuming 20 dB reduction to installation of an acoustic shed.</td><td>Airborne noise<table><tr><td>Compliant</td><td>6786</td></tr><tr><td><=NML+10dB</td><td>166</td></tr><tr><td><=NML+20dB</td><td>15</td></tr><tr><td><=NML+30dB</td><td>2</td></tr><tr><td><=NML+40dB</td><td>0</td></tr><tr><td>> NML+40dB</td><td>0</td></tr><tr><td>HNA[1]</td><td>0</td></tr></table></td></tr>
</table>

Scenario	Description of works	Month	Hours of operation	Sound power levels (dBA)	Location							Assessment results	Number of receivers (within study area) where noise levels are predicted to exceed the NMLs (during assessment period)
					Site 1				Site 3				
					Area 1A	Area 1B	Site 2	Compound	Area 3A	Area 3B	Area 3C		
5: Open Trenching & Pipework	Site 1 (Area 1A): Deliveries Site 1 (Area 1B): Open trenching and joining of pipes. Compound: Supporting activities in the active sites Site 2: Tunnelling and associated TBM activities. Site 3 (Area 3B): Widen/replace existing footbridge or install new temporary footbridge, open trench pipe installation, connection of pipes and associated pipework activities.	11-14	Standard hours of construction (Day)	Site 1 (Area 1A): 119 Site 1 (Area 1B): 128 Compound: 113 Site 2: 122 Site 3 (Area 3B): 125	x	x	x	x		x		Impacts to nearest receivers located near the retrieval shaft (Site 3) are predicted to be comparable to those predicted to receivers near the retrieval shaft for Scenario 3: Pipework. Impacts to nearest receivers located near the launch shaft (Site 1) are predicted to be comparable to those near the launch shaft for Scenario 1: Site establishment with potentially slightly higher levels experienced at the receivers in Kooringal Avenue adjacent to the open trenching location (Site 1 (Area 1B)).	

<table>
<tr><th rowspan="3">Scenario</th><th rowspan="3">Description of works</th><th rowspan="3">Month</th><th rowspan="3">Hours of operation</th><th rowspan="3">Sound power levels (dBA)</th><th colspan="7">Location</th><th rowspan="3">Assessment results</th><th rowspan="3">Number of receivers (within study area) where noise levels are predicted to exceed the NMLs (during assessment period)</th></tr>
<tr><th colspan="2">Site 1</th><th rowspan="2">Site 2</th><th rowspan="2">Compound</th><th colspan="3">Site 3</th></tr>
<tr><th>Area 1A</th><th>Area 1B</th><th>Area 3A</th><th>Area 3B</th><th>Area 3C</th></tr>
<tr><td>6a: Tunnelling & Pipework</td><td>Site 1 (Area 1A): Deliveries

Compound: Supporting activities in the active sites

Site 2: Tunnelling and associated TBM activities.

Site 3 (Area 3B): Widen/replace existing footbridge or install new temporary footbridge, open trench pipe installation, connection of pipes and associated pipework activities.</td><td>5-10</td><td rowspan="2">Standard hours & outside standard hours of construction (24/7)</td><td>Site 1 (Area 1A): 113

Compound: 113

Site 2: 122

Site 3 (Area 3B): 125</td><td>x</td><td></td><td>x</td><td>x</td><td></td><td>x</td><td></td><td colspan="2">Impacts to nearest receivers located near the retrieval shaft (site 3) and launch site (site 1 & site 2) are expected to be comparable to those predicted to receivers for Scenario 3: Pipework.</td></tr>
<tr><td>6b: Tunnelling & Pipework (Night)</td><td>Site 3 (Area 3C): Open trench pipe installation, connection of pipes and associated pipework activities.</td><td>12 nights only of work between month 3 to 22</td><td>Site 3 (Area 3C): 122</td><td></td><td></td><td></td><td></td><td></td><td></td><td>x</td><td>Refer to Appendix F.5: Airborne noise assessment for pipework conducted during outside standard hours of construction (night).</td><td>Outside Standard Hours (Night)
<table><tr><td>Compliant</td><td>4543</td></tr><tr><td><=NML+10dB</td><td>1562</td></tr><tr><td><=NML+20dB</td><td>646</td></tr><tr><td><=NML+30dB</td><td>182</td></tr><tr><td><=NML+40dB</td><td>31</td></tr><tr><td>> NML+40dB</td><td>5</td></tr><tr><td>HNA[1]</td><td>6</td></tr></table></td></tr>
</table>

Scenario	Description of works	Month	Hours of operation	Sound power levels (dBA)	Location							Assessment results	Number of receivers (within study area) where noise levels are predicted to exceed the NMLs (during assessment period)
					Site 1		Site 2	Compound	Site 3				
					Area 1A	Area 1B			Area 3A	Area 3B	Area 3C		
7: Site demobilisation	Site 1, Site 2 & Site 3: Removal of all plant, equipment and vehicles and backfill excavations. Compound: Supporting activities in the active sites	23-24	Standard hours of construction (Day)	Site 1 (Area 1A): 123 Compound: 129 Site 2: 123 Site 3 (Area 3A): 123	x		x	x	x			Impacts to receivers close to the compound are predicted to be comparable to those predicted in Scenario 1. Impacts to receivers located near the other construction sites (site 1(Area 1A, site 2 and site 3 (Area 3A)) are expected to be lower than those predicted for Scenario 1.	

Note:

1_HNA is highly noise affected.

The noise exceedance maps in Appendix F identify buildings that exceed the NMLs and GBNMLs. These maps show exceedances of NMLs and GBNMLs (established in Section 4) at individual existing buildings.

5.3.2 Assessment results – Construction traffic

The construction of the Project will generate an increase in vehicle movements on the surrounding road network. Additional vehicle movements will be generated by:

- The arrival and departure of construction plant, equipment and vehicles.
- The haulage and delivery of road work materials, and removal of waste to and from the construction zones
- The arrival and departure of construction workers at the start and end of each workday and night shift, which will result in an increased traffic demand and turning manoeuvres to and from the construction site access.
- Potential traffic diversion due to lane closures because of construction works

There is insufficient data to conduct a detailed assessment to establish if the noise levels will meet the 2 dB increase screening criteria and the RNP criteria as exiting traffic data is not available for the roads that will be used during construction.

However, depending on the type of roads used to access work areas, additional traffic generated by the construction of the Project may impact on the amenity of the nearby receivers. Where construction traffic is directed to busy roads, any increase in traffic noise is likely to be negligible. On local roads, there is greater potential for impact, especially during the night-period. Accordingly, construction traffic should be planned to minimise impact on sensitive receivers on lower order roads wherever practicable (Refer to Section 7).

5.4 Cumulative impacts

There could be a risk of cumulative acoustic impacts where other construction works non-related to this Project are being undertaken in the area concurrently.

Two projects have been identified as being potentially conducted concurrently with this Project following consultation of the Hornsby Council website: The Westleigh Park creation and the Ruddock Park Upgrade.

To address potential cumulative acoustic impacts due to concurrent construction works taking place in the vicinity of sensitive receivers, the contractor should liaise with other projects to address cumulative construction noise impacts.

It should also be noted predicted noise levels represent a conservative worst-case scenario where all indicated equipment is operating simultaneously and continuously over fifteen minutes. Noise levels experienced by surrounding receivers are likely to be lower than those predicted, and therefore exceedances of NMLs are likely to be lower than those shown in Appendix F. However, taking a ‘worse-case’ scenario approach helps to identify where noise impacts could be a concern and assists in the design of mitigation measures.

6. Vibration

6.1 Criteria

The effect of vibration in buildings can be divided into three main categories:

1. **Human perception of vibration**: when the occupants or users of the building are potentially disturbed by vibration**.** Relevant guidance is provided in NSW *Assessing Vibration: a technical guideline* [15]. This document is based on BS 6472:1992 [16].
2. **Effects on building contents**: People can perceive floor vibration at levels well below those likely to cause damage to typical building contents. However, some scientific equipment (e.g. electron microscopes and microelectronics manufacturing equipment) can require more stringent objectives than those applicable to human comfort. Where appropriate, objectives for the satisfactory operation of

critical instruments or manufacturing processes should be sourced from manufacturer's data and/or other published objectives [17, 18, 19, 20].

No receivers have been identified as containing any sensitive equipment. This may require updating following the consultation process.

3. **Effects of vibration on structures:** A level of vibration where the integrity of the building or the structure itself may be affected, ranging from cosmetic to major structural damage. The relevant criteria are typically well above the level of vibration which people may consider intrusive. Guidance may be found in AS 2187:Part 2 [21], BS 7385 Part 2 [22] and DIN 415 [23] which also has criteria of particular reference for heritage structures and buried pipework. DIN 415 [23] is generally recognised to be conservative and is often referred to for the purpose of assessing structurally sensitive buildings.

   Heritage buildings and structures should not be assumed to be more sensitive to vibration unless they are found to be structurally unsound and should otherwise be assessed in accordance with BS7385-2.

   Heritage areas and structures have been identified in the study area and are shown in Appendix E.

Vibration criteria are described further in Appendix D.

6.2 Vibration assessment

The minimum working distances in Table 14 provide an indication of the possibility of impact due to vibration generating plant and equipment onto nearby receivers. The minimum working distances are indicative only and will vary depending on the item of plant and local geotechnical conditions. Notwithstanding, if receivers where to be located within the recommended minimum distance for cosmetic damage mitigation measures should be implemented.

Review of the sites, receiver locations and proposed equipment to be operating within the sites indicates that the closest affected residential receivers to the sites, as well as the Reservoir, could fall within the minimum working distance when the compactor or hydraulic hammer are used.

7. Mitigation and management measures

It should be emphasised that Construction Contractor will have a key role in managing potential noise and vibration impacts during the works and should review and implement the following noise mitigation and management measures in Table 11 and Table 12 below where feasible and reasonable.

Table 11 presents Sydney Water safeguards related to noise and vibration based upon document SWEMS0019.07. Table 12 presents additional mitigation measures which should be considered.

Table 11: Sydney Water noise safeguard

Noise and vibration	
8.1	Works must comply with the ICNG [6], including scheduling work and deliveries during standard daytime working hours of 7am to 6pm Monday to Friday and 8am to 1pm Saturday. No work to be scheduled on Sunday nights or public holidays. Any proposed work outside of these hours must be justified. The Proposal will also be carried out in accordance with: • Sydney Water's Noise Management Procedure SWEMS0056 which outlines the behaviours required to minimise noise impacts on the community when working outside standard hours and on public holidays. All reasonable and feasible noise mitigation measures should be justified, documented and implemented on-site to mitigate noise impacts. Work may sometimes need to be scheduled outside of standard hours in certain situations, including: • delivery of oversized equipment/ structures • where an ROL is required for an activity impacting on traffic flow • emergency work to protect human health or avoid loss of life or damage to property • maintenance and repair of public infrastructure where disruption to essential services (such as water/ sewer) require work out of hours • any other work which can be justified (**work schedule, convenience or cost are not considered sufficient justification**). If justified, the following hierarchy should be implemented for out of (standard) hours works (OOHW) (from most to least preferable, in accordance with the ICNG [6] and TfNSW CNVS [24]): • Saturday afternoons (1pm to 5pm) • Sunday daytime (8am to 6pm) • weekday evening periods (6pm to 10pm) • weekday nights (10pm to 7am) all other times (eg Sunday night).
8.2	Incorporate **standard daytime hours noise management safeguards** into the CEMP, including but not limited to: • identify and consult with the potentially affected residents prior to the commencement: o describe the nature of works; the expected noise impacts; approved hours of work; duration, complaints handling and contact details. o determine need for, and appropriate timing of respite periods (eg times identified by the community that are less sensitive to noise such as mid-morning or mid-afternoon for works near residences) • implement a noise complaints handling procedure (Guidance regarding noise and vibration complaints management process is included in Section 7.1**)** • • plant or machinery will not be permitted to warm-up near residential dwellings before the nominated working hours. • appropriate plant will be selected for each task, to minimise the noise impact (eg all stationary and mobile plant will be fitted with residential type silencers)

Noise and vibration	
	• engine brakes will not be used when entering or leaving the work site(s) or within work areas. • regularly inspect and maintain equipment in good working order • arrange work sites where possible to minimise noise (eg generators away from sensitive receivers, site set up to minimise use of vehicle reversing alarms, site amenities and/ or entrances away from noise sensitive receivers). • use natural landforms/ mounds or site sheds as noise barriers • schedule noisy activities around times of surrounding high background noise (local road traffic or when other noise sources are active).
8.3	As/if works **beyond standard daytime hours are needed**, the Contractor would: • justify the need for out of hours work (OOHW) and why it is not possible to carry out the works during standard daytime hours • consider potential noise impacts and: implement the relevant standard daytime hours safeguards; Sydney Water's Noise Management Code of Behaviour (SWEMS0056.01) and document all reasonable and feasible management measures to be implemented • identify additional community notification requirements and outcomes of targeted community consultation • seek approval from the Sydney Water Project Manager in consultation with the environment and communications representatives. SWEMS0056.01 suggests some additional safeguards such as: • truck radios (commercial) switched off upon arrival at site • truck CB radios used with the truck cabin doors closed • extra care taken while loading or unloading trucks • no unnecessary loud voices (eg using CB radios, mobile phones or conversing). Note – generally if OOHWs are around 2-3 nights (or less than 1 week), a REFA (Review of Environment Factors Addendum) and further assessment is unlikely to be required (depends on level of sensitivity of receivers and level of noise risk on a case by case basis). The potential for OOHWs should be documented and assessed within the REFA, wherever possible. This safeguard and the OOHW form should be approved for unforeseen OOHWs.
8.4	As/if **night works are needed,** the Contractor would: • justify the need for night works • consider potential noise impacts and implement the relevant standard daytime and out of hours safeguards and document consideration of all reasonable and feasible management measures • identify community notification requirements (ie for scheduled night work (not emergency works)), • notify all potentially impacted residents and sensitive noise receivers not less than one week prior to commencing night work. • seek approval from the Sydney Water Project Manager in consultation with the environment and communications representatives. Some additional safeguards include: • additional monitoring or acoustic barriers • complete works before 10pm if possible • schedule noisiest works before midnight if possible • briefing workers on the need to minimise noise.
8.5	As/if works on **Sundays or public holidays are required**, the Contractor would: • justify why all other times are not feasible • consider potential noise impacts and, implement relevant standard daytime, out of hours and night-time safeguards and other reasonable and feasible management measures • identify community notification requirements

Noise and vibration	
	• seek approval from the Sydney Water Project Manager in consultation with the environment and communications representatives. Noise and vibration management safeguards for those works should be documented into the CEMP.
8.6	Conduct a dilapidation survey / asset condition assessment prior to works which have potential to damage existing structures.
8.7	Monitor compliance with the recommended vibration levels in DIN 4150-3 1999: Structural Vibration – Part 3; Effects of vibration on structures. Effects of vibration on structures for heritage buildings and other potentially at-risk structures following confirmation by the contractor(s) prior to start of any works of the sensitivity of those buildings/structures.
8.8	Consider less vibration intensive methodologies where practicable and use only the necessary sized and powered equipment.

Table 12: Construction noise mitigation and management measures

Item	Detail
Noise and vibration management plan	A Construction Noise and Vibration Management Plan shall be prepared. This will specify the actual plant to be used and will include updated estimates of the likely levels of noise and the scheduling of activities. The CNVMP should include but not be limited to the following: • Roles and responsibilities • Noise and vibration sensitive receiver locations and structures • Identify works that have the potential to cause impact, accompanied by an appropriate assessment (predictive assessment or risk evaluation) • Mitigation and management strategy • Monitoring methodology (as relevant) • Community engagement strategy.
Works scheduling	• Works to be scheduled taking into account approved works hours, any restrictions relevant to specific equipment/activities and respite periods etc. • Highest noise generating activities should be scheduled for the least sensitive times, where practicable. • The acceptability for any out-of-hours works should be confirmed with authorities (e.g. delivery of oversized items, where road closures are required or for emergency works). • For approved out of hours works, noisy activities should be scheduled early in the night to minimise the impact on adjacent residents where feasible. • Where possible, heavy vehicle movements should be limited to daytime hours.
Community consultation - process	Community consultation should occur prior to, and during works as follows: • Notify affected stakeholders (through methods such as letterbox drops, individual briefings or phone calls) of upcoming works with details of what the works will entail (such as the works purpose, duration, expected impacts and mitigation measures, complaints procedure, who is responsible for undertaking the works) • Notification should be as specific as practicable regarding nature and timing of works and any scheduled respite periods • Discuss with affected receivers about any atypical sensitivities and review how scheduling of activities and other mitigation measures may aid to minimise impacts o (affected receivers = receivers mapped as experiencing non-compliant noise impacts) o (atypical sensitivities = such as vibration sensitive equipment/processes in medical establishments, exam periods or school holidays for education establishments) • Establish long-term personnel or processes (e.g. project email, phone number) to centralise project enquiries • Follow the complaints management process in section 7.1 of this report for any complaints, including complaints registers and standard response times.

Item	Detail
Community consultation - assessment	• Project-specific mitigation measures will be determined based on a reasonable and feasible assessment performed by suitably qualified project representatives (eg community and stakeholder, project management, environment) and refined through community feedback. • Mitigation measures may include but not be limited to: o Alternative accommodation Offer of alternative accommodation should be offered to residences where NML are predicted to be exceeded by 30 dB or more for more than two consecutive nights where feasible and reasonable. Offer of alternative accommodation should be offered to residences where GBNMLs are predicted to be exceeded by 10 dB or more for more than two consecutive nights where feasible and reasonable. (Refer to Table 10) Note that monitoring could be conducted to confirm predictions (See section below regarding noise monitoring) o Respite periods when scheduling work Example includes: ▪ scheduling highest noise generating activities during the least sensitive times, where practicable, ▪ conducting activities in blocks of 3 hours block) o Noisy works cut-off times o At-source controls eg shielding equipment • The anticipated project-specific community mitigation measures are in Table 13 of this report. These measures have been informed by Table 9 and Table 10 of the CNVS [5]. They should be reviewed and refined closer to construction and then documented in the project-specific Noise and Vibration Management Plan (CNVMP).
Non-tonal and ambient sensitive reversing alarms	Non-tonal reversing beepers (or an equivalent mechanism) must be fitted and used on all construction vehicles and mobile plant regularly used on site and for any out of hours work. Consider the use of ambient sensitive alarms that adjust output relative to the ambient noise level.
Equipment Location/site planning/Temporary screen and shed	General recommended provisions which should be implemented initially include: • Situate noisy equipment away from noise-sensitive areas. • Use enclosures or screens to limit noise emissions of plant where possible. Type of screens could include noise curtains or hoarding (plywood board, panels of steel sheeting or compressed fibre cement board). • The type of screen is dependent on location of works and feasibility of what can be put in place, cognisant of heat and ventilation requirements. Screens are to be installed according to manufacturer specifications with no gaps. However, note that screens will have a minimum effect to noise levels for receivers located on the upper floors of buildings or to receivers that are elevated from the construction sites. Noting the predicted exceedances of the NMLs to nearest receivers during the night-time for Scenario 4 (tunnelling during night-time), the feasibility of installing an acoustic shed should be considered on Site 2. Noise reduction from the acoustic shed would be anticipated to be of 20 dB or higher (as shown in Appendix F.5) which would reduce considerably the number of receivers experiencing noise levels higher than NML + 30 dB. The maps also show that screens should be considered where feasible and reasonable to reduce impacts to nearest receivers such as near the Site 3 Area 3C during Scenario 6b when works are conducted during the night-time.

Item	Detail
Plant and equipment	• Use quieter construction methods where feasible and reasonable. • Use only the necessary size and power of equipment • All plant and equipment used on site must be: – maintained in a proper and efficient condition; and – operated in a proper and efficient manner. • Turn off all plant and equipment when not in use • Ensuring that the Responsible Person checks the conditions of the powered equipment used on site daily to ensure plant is properly maintained and that noise is kept as low as practicable. • Where ground borne noise and vibration from TBM activities are considered excessive, the TBM machine could be operated at a slower speed. Note that a slower operation of the TBM will result in an increase of duration of works and impact program.
Staffing	• Appoint a named member of the site staff who will act as the Responsible Person with respect to noise and vibration; • Site managers to periodically check the site and subjectively assess emissions to nearby receivers to proactively manage works. • All employees, contractors, and subcontractors to receive an environmental induction which should include: – Standard noise and vibration mitigation measures – Permissible hours of work – Limitations on high noise and vibration generating activities – Location of nearest sensitive receivers • Regularly train workers and contractors (such as at toolbox talks) to use equipment in ways to minimise noise; • Ensure good work practices are adopted to avoid issues such as noise from dropped items, noise from communication radios is kept as low as is practicable; • Avoid the use of radios or stereos outdoors; and • Avoid shouting and minimise talking loudly and slamming vehicle doors.
Traffic and loading areas	• Plan traffic flow, parking and loading/unloading areas to minimise reversing movements and idling traffic within the site and before entering site. • Route heavy vehicle movements away from noise sensitive areas where possible.
Silencers on Mobile Plant	Where possible reduce noise from mobile plant through additional fittings including: • Residential grade mufflers • Damped hammers such as “City” Model Rammer Hammers
Rental plant and equipment	The noise levels of plant and equipment items are to be considered in rental decisions
Structural surveys	• Select equipment to minimise vibration. Where nearby buildings are located within the safe working distance, pre-construction surveys should be conducted as per Section 7.2. • The findings of the survey may require amendment to proposed vibration criteria or management measures and therefore should be undertaken in suitable advance of the start date.
Noise Monitoring	• Short-term attended measurements could be conducted in response of a complaint and to confirm alignment with predicted noise levels in the impact assessment and management measures. • Unattended and attended measurements could be conducted within the nearest residential properties prior to TBM activities and at the beginning of the TBM activities to confirm ground borne noise level (GBNL) predictions and inform mitigation measures to receivers.

Item	Detail
Vibration Monitoring	• Attended vibration measurements would be required at the commencement of vibration generating activities that are proposed within the Cosmetic Damage minimum working distances, identified in Section 7.3. • Where works are at risk of exceeding criteria, long-term monitoring would be required. The monitors should provide 'real-time' alerts when vibration criteria are exceeded. • An exceedance of the vibration criterion may necessitate a change in work method. This could include: – Re-evaluation of the vibration criterion based on results of the initial condition investigation and inspections of the structure following the commencement of works. – Maintain vibration monitoring throughout works within 'minimum working distances'. – Reduce the size of demolition and construction equipment and develop alternative methodologies to minimise vibration. – Use less vibration emitting demolition methods if necessary closer to the sensitive building or structure • Balance variable speed vibrating plant and operate at speeds that do not produce resonance.

Table 13 below provides a summary of the anticipated project specific community consultation measures to be put in place depending on the extend of the exceedances of the NMLs. This table has been informed by the CNVS [5]and should be reviewed and refined for the development of the CNVMP.

Table 13: Indicative community consultation measures

Construction hours	Receiver perception	Above NML	Management Measures[1.2.3,4]
Airborne noise			
Standard hours (day)	Noticeable	<= NML (Compliant)	-
	Clearly audible	<= NML + 10	-
	Moderately intrusive	<= NML + 20	N
	Highly intrusive	> NML + 20	N
	Highly noise affected (75 dBA or greater)	>= 75 dBA	N, SN
Outside standard hours (night)	Noticeable	<= NML (Compliant)	-
	Clearly audible	<= NML + 10	N
	Moderately intrusive	<= NML + 20	N, SN
	Highly intrusive	> NML + 20	N, SN, AA, RP
	Highly noise affected (75 dBA or greater)	>= 75 dBA	N, SN, AA, RP
Ground borne noise			
Outside standard hours (night)	Noticeable	<= GBNML (Compliant)	-
	Clearly audible	<= GBNML + 10	N, SN
	Moderately intrusive	<= GBNML + 20	N, SN, AA
	Highly intrusive	> GBNML + 30	N, SN, AA

Notes:
1_N: Notifications (such as letter box drops)
2_SN: Specific notifications such as individual briefings or phone call
3_AA: Alternative accommodation
4_RP: Respite Period

7.1 Complaints handling

Complaints handling will be performed in accordance with Sydney Water's Complaints Handling Process and Sydney Water's Stakeholder Engagement Policy.

Appropriate records are to be maintained of complaints to include timing, reported issues, actions taken and measures to be included for on-going works. The complaints log will need to be filed with a nominated person from the appointed contractor's project team. A nominated staff member, such as the construction manager or Community Engagement Team, will be responsible for receiving and responding to enquiries, feedback and complaints.

Given the potential for exceedances at night and the duration of the works, it is recommended that should a noise or vibration complaint be received, the following information be recorded in complaints register:

- the name and address of the complainant (if provided);
- the time and date the complaint was received;
- the nature of the complaint and the time and date the noise was heard;
- the name of the employee who received the complaint;
- actions taken to investigate the complaint, and a summary of the results of the investigation;
- required remedial action, if required;
- validation of the remedial action; and
- summary of feedback to the complainant.

A permanent register of complaints must be held.

All complaints received must be fully investigated and reported to management. The complainant must also be notified of the results and actions arising from the investigation.

The investigation of a complaint will involve where applicable:

- noise or vibration measurements at the affected receiver;
- an investigation of the activities occurring at the time of the incident;
- inspection of the activity to determine whether any undue noise or vibration is being emitted by equipment; and
- whether work practices were being carried out either within established guidelines or outside these guidelines.

Where an item of plant is found to be emitting excessive noise or vibration, the cause is to be rectified as soon as possible. Where work practices within established guidelines are found to result in excessive noise or vibration being generated then the guidelines must be modified so as to reduce noise emissions to acceptable levels. Where guidelines are not being followed, the additional training and counselling of employees must be carried out.

Site investigation, site inspection and /or measurements be used to validate the results of any corrective actions arising from a complaint where applicable.

7.2 Building and buried services condition surveys

Structures should be considered in the Construction Noise and Vibration Management Plan. Property surveys (or dilapidation surveys) should be conducted before start of construction works where it has been established that the property, structure or utility is at risk of damage (such as a property which is located within the minimum working distance for example (Refer to Section 7.3)) during the construction work. The survey findings could require amendment to proposed vibration criteria or management measures and therefore should be undertaken in suitable advance of when the works start.

7.3 Vibration – minimum working distances

As a guide, the recommended minimum working distances for vibration intensive plant in Table 14 (derived from Table 20 of the CNVS [5]) provide an indication of the possibility of impact due to vibration generating plant and equipment onto nearby receivers. While the minimum working distances are indicative only and will vary depending on the item of plant and local geotechnical conditions, if a receiver is located within the minimum working distance, vibration monitoring might be required, and equipment selection and/or method of construction might have to be reviewed.

Table 14: Recommended minimum working distances for vibration intensive plant

Plant Item	Rating / Description	Minimum working distance (m)			
		Cosmetic damage			Human response – Disturbance to building occupants [15]
		BS 7385 – Line 1[1]	BS 7385 – Line 2[2]	DIN 4150[3]	
Small Hydraulic Hammer	(300 kg – 5 to 12t excavator)	1 m	2 m	5 m	7 m
Medium Hydraulic Hammer	(900 kg – 12 to 18t excavator)	3 m	7 m	15 m	23 m
Large Hydraulic Hammer	1600 kg- 18 to 34t excavator)	9 m	22 m	44 m	73 m
Piling – Vibratory	Sheet piles	9 m	22 m	44 m	73 m
Piling – Bored	≤ 800 mm	1 m (nominal)	2 m	5 m	10 m
Vibratory roller	< 50 kN (~ 1 to 2t)	2 m	5 m	11 m	15 m to 20 m
	< 100 kN (~ 2 to 4t)	2 m	6 m	13 m	20 m
	< 200 kN (~ 4 to 6t)	5 m	12 m	26 m	40 m
	< 300 kN (~ 7 to 13t)	6 m	15 m	31 m	100 m
	> 300 kN (~ 13 to 18t)	8 m	20 m	40 m	100 m
	> 300 kN (> 18t)	10 m	25 m	50 m	100 m
Compactor[4]	Jumping Jack and plate compactor	3 m	5 m	9 m	55 m
Jackhammer	Hand-held	1 m (nominal)	1 m (nominal)	3 m	5 m
Mechanised bored tunnelling works (Tunnel Boring Machine, Horizontal Directional Drilling, Micro-tunnelling)[5]	-	5 m	12 m	21 m	40 m

Note 1_Refer to Table 24 Line 1. Minimum working distance based screening criterion of 25 mm/s as per Section **D**.3. Type of structure: Reinforced or framed structures, Industrial and heavy commercial buildings.

Note 2_Refer to Table 24 Line 2. Minimum working distance based screening criterion of 7.5 mm/s as per Section **D**.3. Type of structure: Un-reinforced of light framed structures, residential or light commercial type buildings.

Note 3_Refer to Table 25 Line 3. Minimum working distance based on screening criterion of 3 mm/s as per Section **D**.3. Type of structure: Structures that because of their particular sensitivity to vibration, cannot be classified under:

- buildings used for commercial purposes, industrial buildings and buildings of similar design or
- residential buildings and buildings of similar design and/or occupancy

and are of great intrinsic value (e.g. listed buildings under a preservation order)

Note 4_Based on data for previous project.

Note 5_Based on TRL document [10] using Godio et al formula, equation 24

8. Conclusion

This report presents an assessment of predicted airborne noise, ground-borne noise and vibration impacts associated with the new water pipeline to be installed between Thornleigh Reservoir (WS0148) and Thornleigh-Wahroonga water pumping station (WP0159).

The assessment identified noise and vibration receivers impacted by the construction works. The impacts are shown as exceedances maps showing the extent of the impacts. Mitigation measures to be implemented to reduce the impacts have also been identified.

The mitigation measures include:

- developing a Construction Noise and Vibration Management Plan, which would review the modelled construction details, noise and vibration impacts and mitigation measures (including community consultation and complaint handling procedure)
- minimising noise by placing temporary noise screens between receivers and noisy plant where practicable, especially when work is to be conducted during the night-time. The assessment recommends investigating the installation of an acoustic shed for works conducted during the night-time for extended period of time which is likely to reduce predicted noise impact by 20 dB or more (refer to Scenario 4)
- engaging with community by providing notification of works, alternative accommodation and respite period depending on predicted levels above NML and GBNML and duration of works.
- reviewing methods of construction and conducting vibration monitoring where works are located within the minimum working distances

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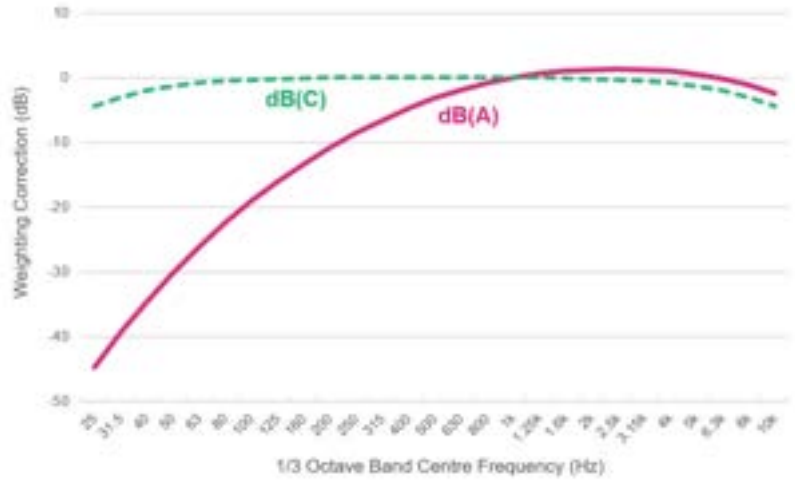
Appendix A

Acoustic Glossary

A.1 Acoustic Glossary

Term	Definition
Background noise level	The background noise level is the noise level that is generally present at a location at all or most times. Although the background noise may change over the course of a day, over shorter time periods (e.g. 15 minutes) the background noise is almost-constant. Examples of background noise sources include steady traffic (e.g. motorways or arterial roads), constant mechanical or electrical plant and some natural noise sources such as wind, foliage, water and insects. **Rating Background Level (RBL / min$L_{A90,1hour}$)** A single-number figure used to characterise the background noise levels from a complete noise survey. The RBL for a day, evening or night time period for the overall survey is calculated from the individual Assessment Background Levels (ABL) for each day of the measurement period, and is numerically equal to the median (middle value) of the ABL values for the days in the noise survey.
Decibel (dB)	The logarithmic scale used to measure sound and vibration levels. Human hearing is not linear and involves hearing over a large range of sound pressures, which would be unwieldy if presented on a linear scale. Use of a logarithmic scale allows all sound levels to be expressed based on how loud they are relative to a reference sound (typically 20 µPa, which is the approximate human threshold of hearing). For sound in other media (e.g. underwater noise) a different reference level (1 µPa) is used instead. An increase of approximately 10 dB corresponds to a subjective doubling of the loudness of a noise. The minimum increase or decrease in noise level that can be noticed is typically 2 to 3 dB.
dB weighting curves	The frequency of a sound affects its perceived loudness and human hearing is less sensitive at low and very high frequencies. When seeking to represent the summation of sound pressure levels across the frequency range of human hearing into a single number, weighting is typically applied. Most commonly, A-weighting, denoted as dB(A), is used for environmental noise assessment. This is often supplemented by the linear or C-weighting curves, where there is the potential for excess low-frequency sound at higher sound pressure levels. 
dB(A)	dB(A) denotes a single-number sound pressure level that includes a frequency weighting ('A-weighting') to reflect the subjective loudness of the sound level. The frequency of a sound affects its perceived loudness. Human hearing is less sensitive at low and very high frequencies, and so the A-weighting is used to account for this effect. An A-weighted decibel level is written as dB(A). Some typical dB(A) levels are shown below.

Sound Pressure Level dB(A)	Example
130	Human threshold of pain
120	Jet aircraft take-off at 100 m
110	Chain saw at 1 m
100	Inside nightclub
90	Heavy trucks at 5 m

80	Kerbside of busy street
70	Loud stereo in living room
60	Office or restaurant with people present
50	Domestic fan heater at 1m
40	Living room (without TV, stereo, etc)
30	Background noise in a theatre
20	Remote rural area on still night
10	Acoustic laboratory test chamber
0	Threshold of hearing

$L_{90(period)}$

The sound level exceeded for 90% of the measurement period.

The L_{90} is often defined as the 'average minimum' or 'background' noise level for a period of measurement. For example, 45 $dBL_{A90,15min}$ indicates that the sound level is higher than 45 dB(A) for 90% of the 15-minute measurement period.

$L_{eq(period)}$

The equivalent ('eq') continuous sound level, used to describe the level of a time-varying sound or vibration measurement.

The L_{eq} is often defined as the 'average' level, and mathematically, is the energy-average level over a measurement period – i.e. the level of a constant sound that contains the same sound energy as the measured sound.

Sound Power and Sound Pressure

The sound power level (L_w) of a source is a measure of the total acoustic power radiated by a source. The sound pressure level (L_p) varies as a function of the environment and distance from a source.

The sound power level is an intrinsic characteristic of a source (analogous to its mass), which is not affected by the environment within which the source is located.

Structureborne noise

The transmission of noise energy as vibration of building elements. The energy may then be re-radiated as airborne noise. Structureborne noise is controlled by structural discontinuities, i.e. expansion joints and floating floors.

Vibration

Waves in a solid material are called 'vibration', as opposed to similar waves in air, which are called 'sound' or 'noise'. If vibration levels are high enough, they can be felt; usually vibration levels must be much higher to cause structural damage.

A vibrating structure (e.g. a wall) can cause airborne noise to be radiated, even if the vibration itself is too low to be felt. Structureborne vibration limits are sometimes set to control the noise level in a space.

Vibration levels can be described using measurements of displacement, velocity and acceleration. Velocity and acceleration are commonly used for structureborne noise and human comfort. Vibration is described using either metric units (such as mm, mm/s and mm/s^2) or else using a decibel scale.

Appendix B

Noise monitoring methodology

B.1 Noise monitoring

B.1.1 Equipment

Unattended and attended monitoring was carried out using the following equipment:

Table 15: Monitoring equipment details

Measurement location	Type	Equipment/model	Serial No.	SLM Type
L1	Long term measurement.	B&K EMS 63659-B	3012345	Class 1
	Short term measurements	B&K 2250	3029878	Class 1
L2	Long term measurement	B&K EMS 63659-B	3023572	Class 1
	Short term measurements	B&K 2250	3029878	Class 1

Notes: All meters comply with AS IEC 61672.1 2004 “Electroacoustics - Sound Level Meters” and are designated either Class 1 or Class 2 as per Table 15 and are suitable for field use.

The equipment was calibrated prior and subsequent to the measurement period using a Bruel & Kjaer Class 4231 calibrator. No significant drift in calibration was observed.

B.1.2 Exclusions

B.1.2.1 Meteorological conditions

Weather conditions have the potential to affect the results of the noise monitoring. In accordance with the NPfI [3], any noise monitoring conducted during periods of extraneous weather conditions was excluded from the data set. Weather data from the Bureau of Meteorology’s (BOM) Sydney Olympic Park weather station, located within 30 km of the construction sites was used to process data in accordance with the NPfI [3].

B.1.2.2 Other exclusions

During the long-term monitoring period, construction activities were undertaken in the area unrelated to this project. The periods during which those construction activities were undertaken have been excluded from the monitoring results.

Periods of exclusions can be seen in the Table 16 below, in accordance with the email provided by Sydney Water.

Table 16: Monitoring exclusions

Monitoring Location	Date	Time
L1	7/12/22	09:00am – 5:30pm
	8/12/22	07:00am – 5:30pm
	9/12/22	07:00am – 4:30pm
	12/12/22	07:30am – 11:30am
L2	5/12/22	08:00am – 04:30pm
	6/12/22	07:00am – 06:00pm
	7/12/22	07:00am – 08:30am

B.1.3 Long-term unattended noise measurements

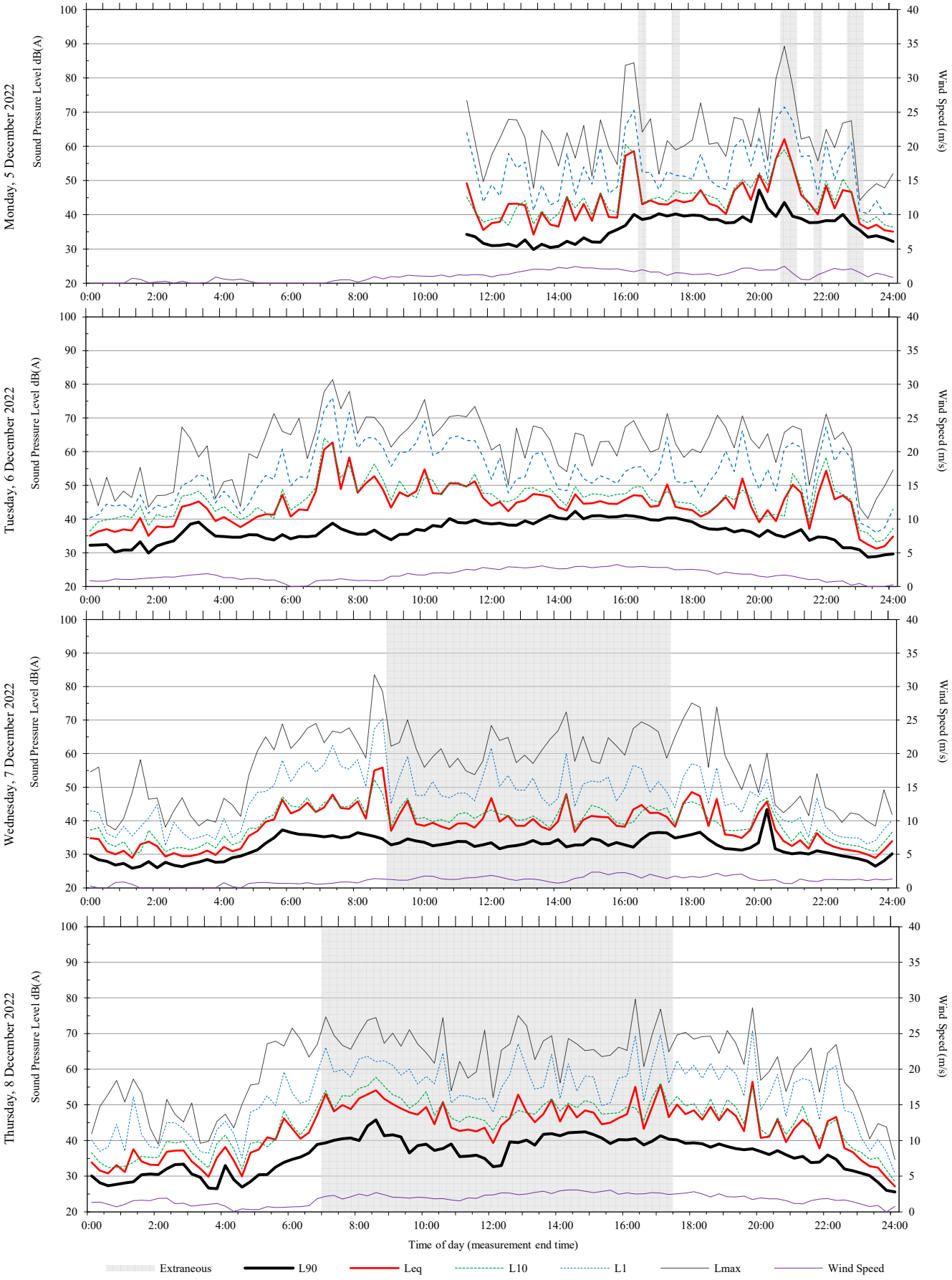
Long-term noise monitoring was carried out by Arup from Monday 5 December to Wednesday 22 December 2022. Monitoring was conducted in accordance with Appendix B1 of the NPfI . The NPfI separates the 24-hour day into three different time periods – day, evening and night, as detailed below in Table 17.

Table 17: Standard NPfI time periods

Period	Day of Week	Time period
Day	Monday-Saturday Sunday, Public Holidays	7:00 am-6:00 pm 8:00 am-6:00 pm
Evening	Monday-Sunday	6:00 pm -10:00 pm
Night	Monday-Saturday Sunday, Public Holidays	10:00 pm -7:00 am 10:00 pm -8:00 am

Unattended monitoring: L1 - Thornleigh Reservoir (Free Field)

ARUP



Unattended monitoring: L1 - Thornleigh Reservoir (Free Field)

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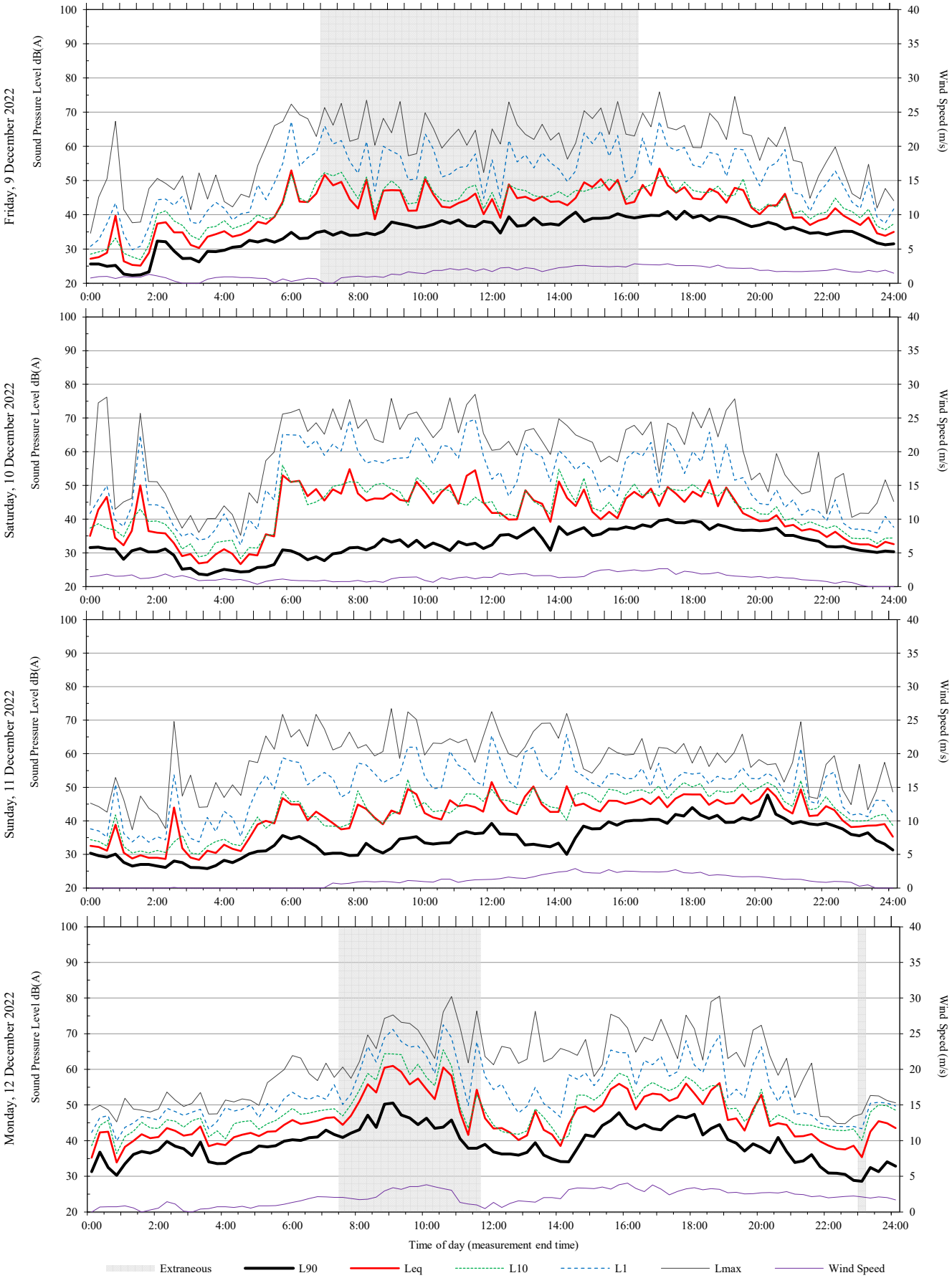

Unattended monitoring: L1 - Thornleigh Reservoir (Free Field)

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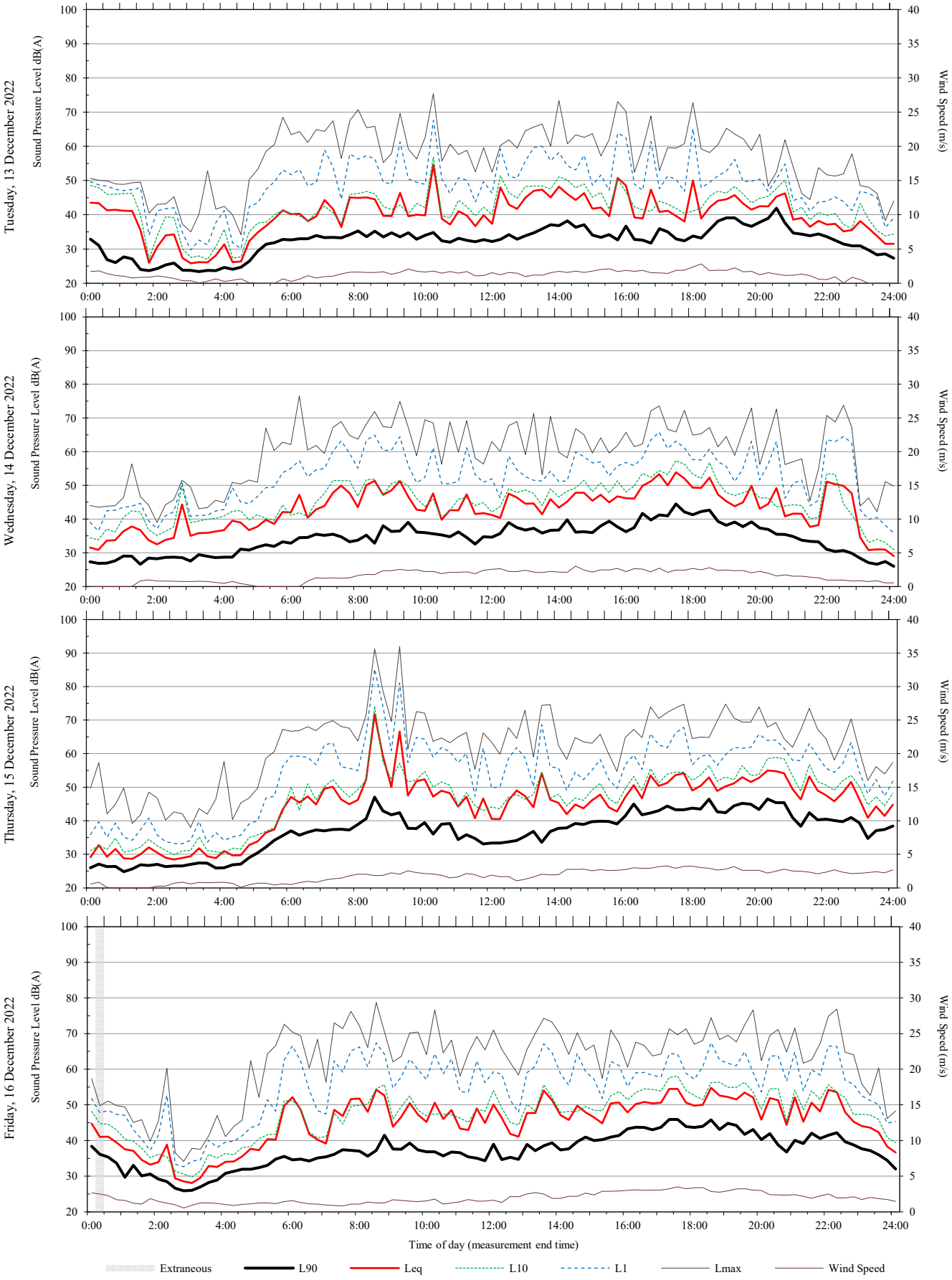

Unattended monitoring: L1 - Thornleigh Reservoir (Free Field)

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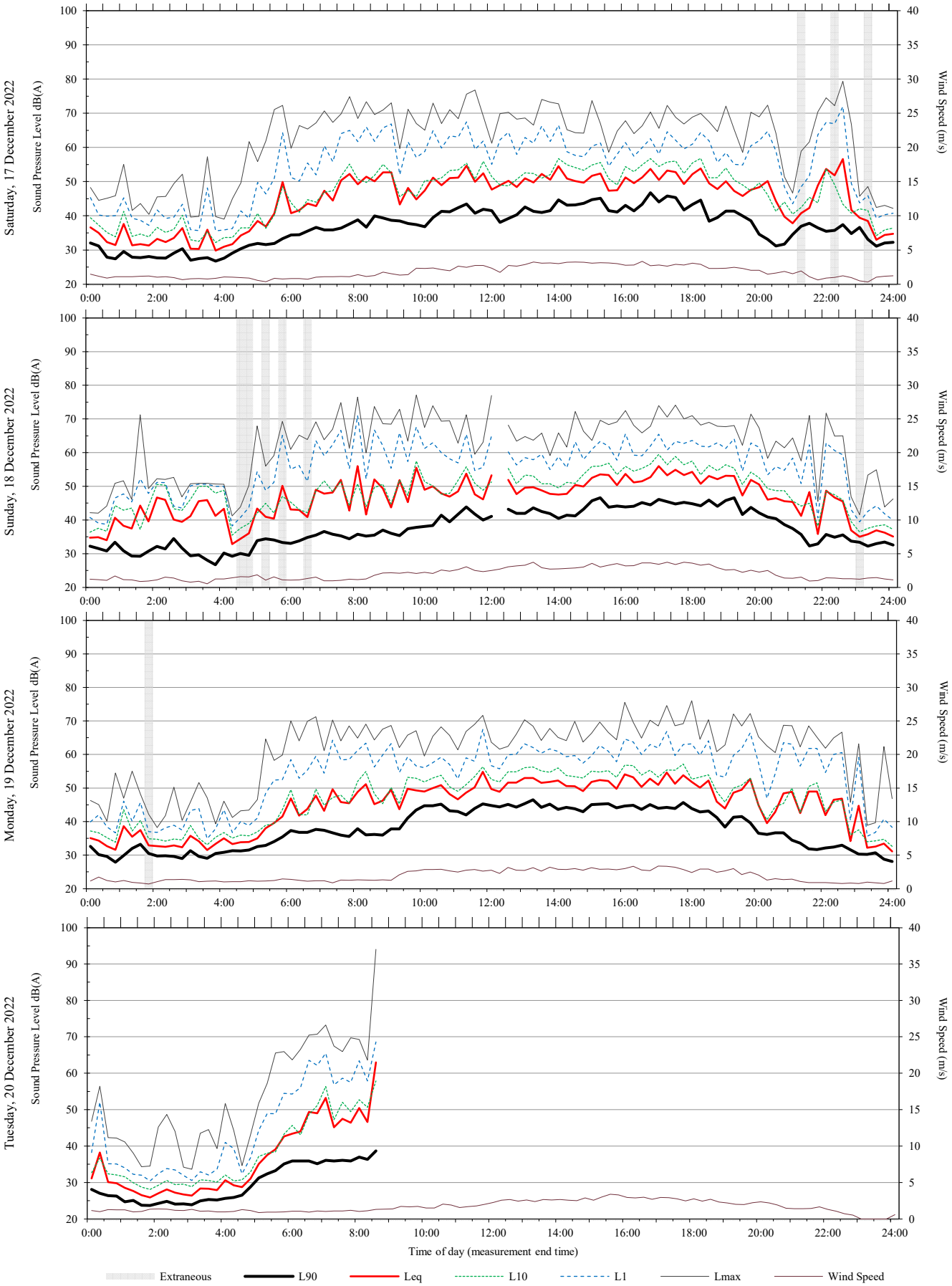

Unattended monitoring: L2 - Thornleigh Pumping Station (Free Field)

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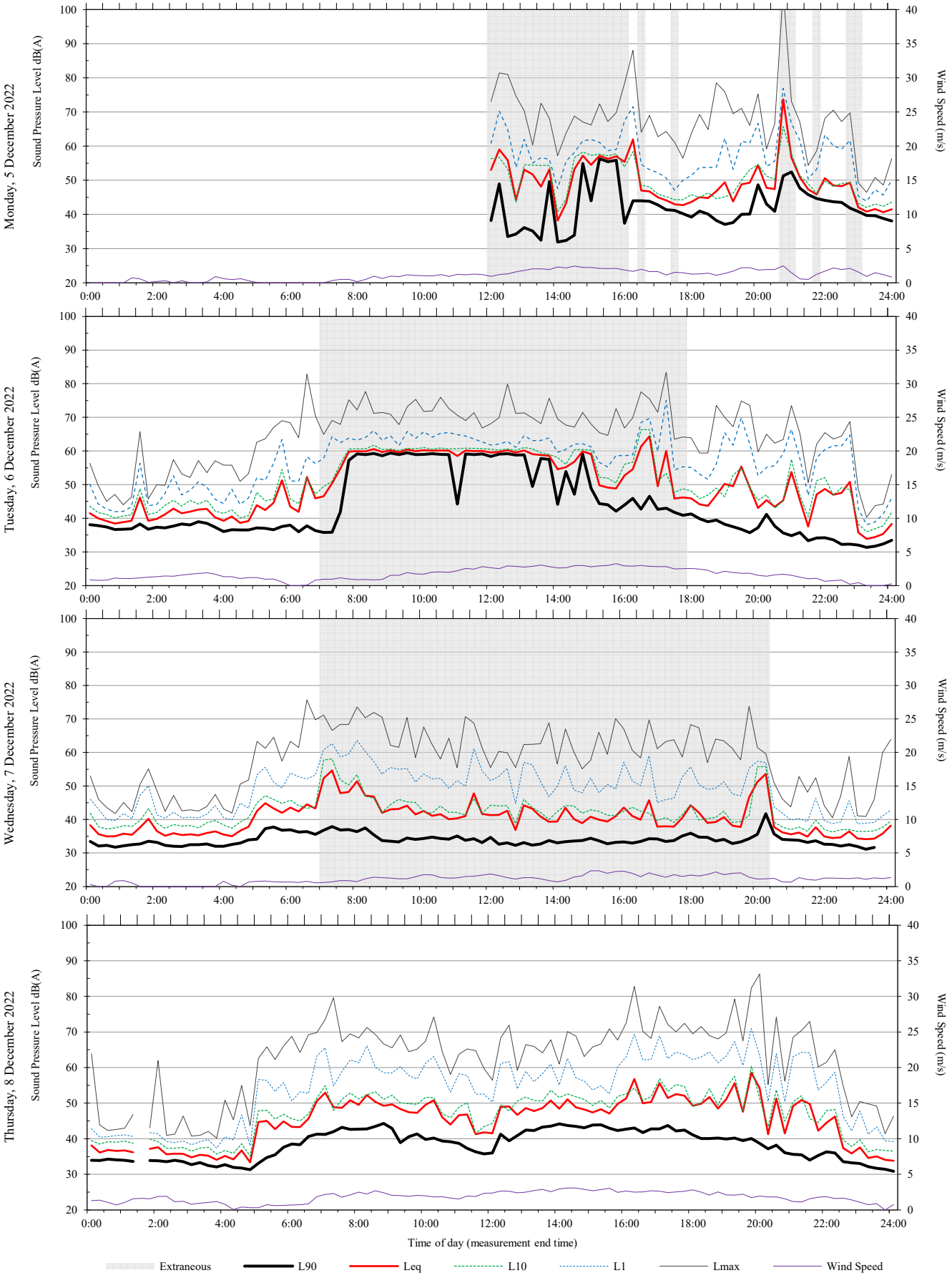

Unattended monitoring: L2 - Thornleigh Pumping Station (Free Field)

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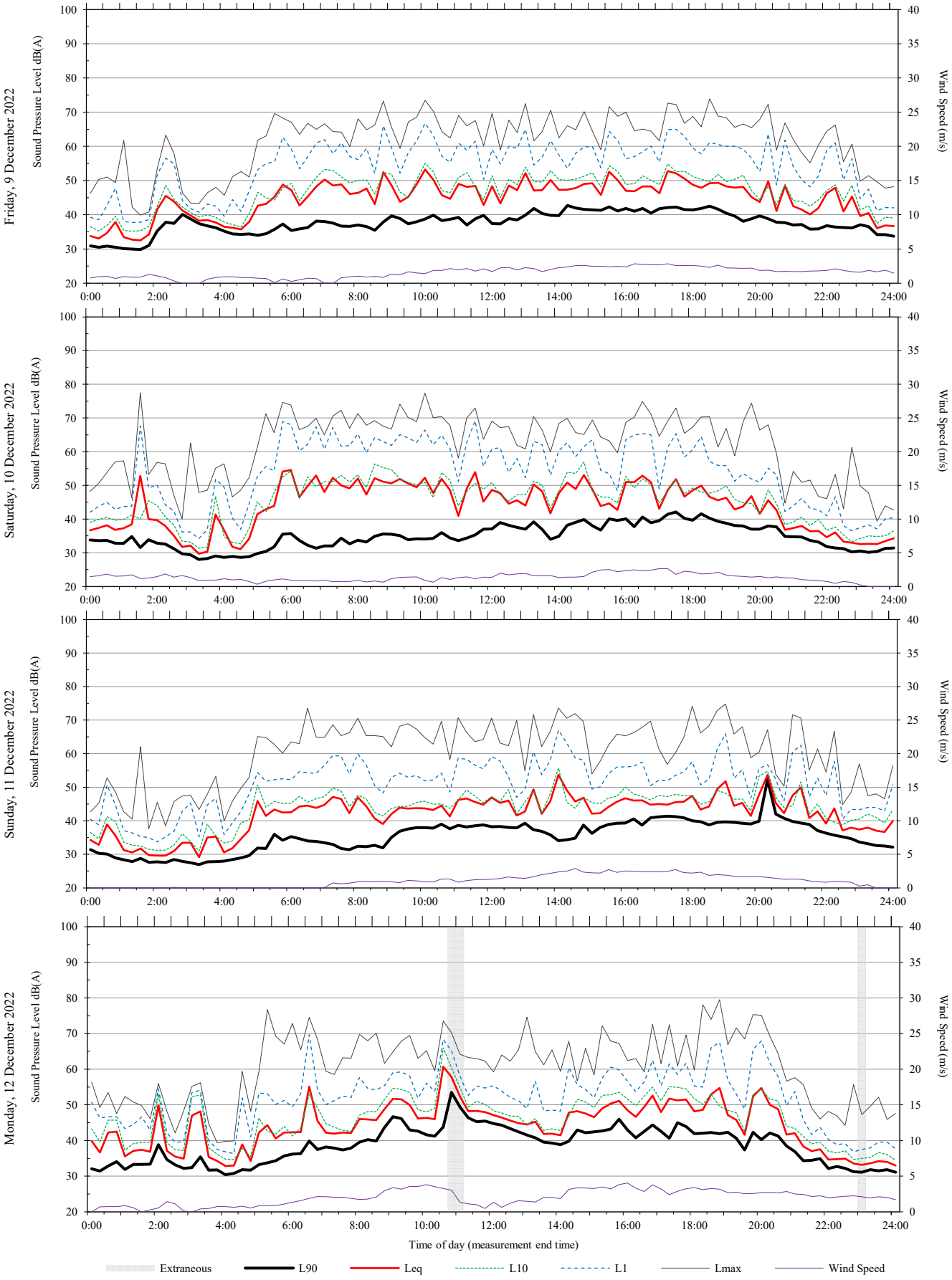

Unattended monitoring: L2 - Thornleigh Pumping Station (Free Field)

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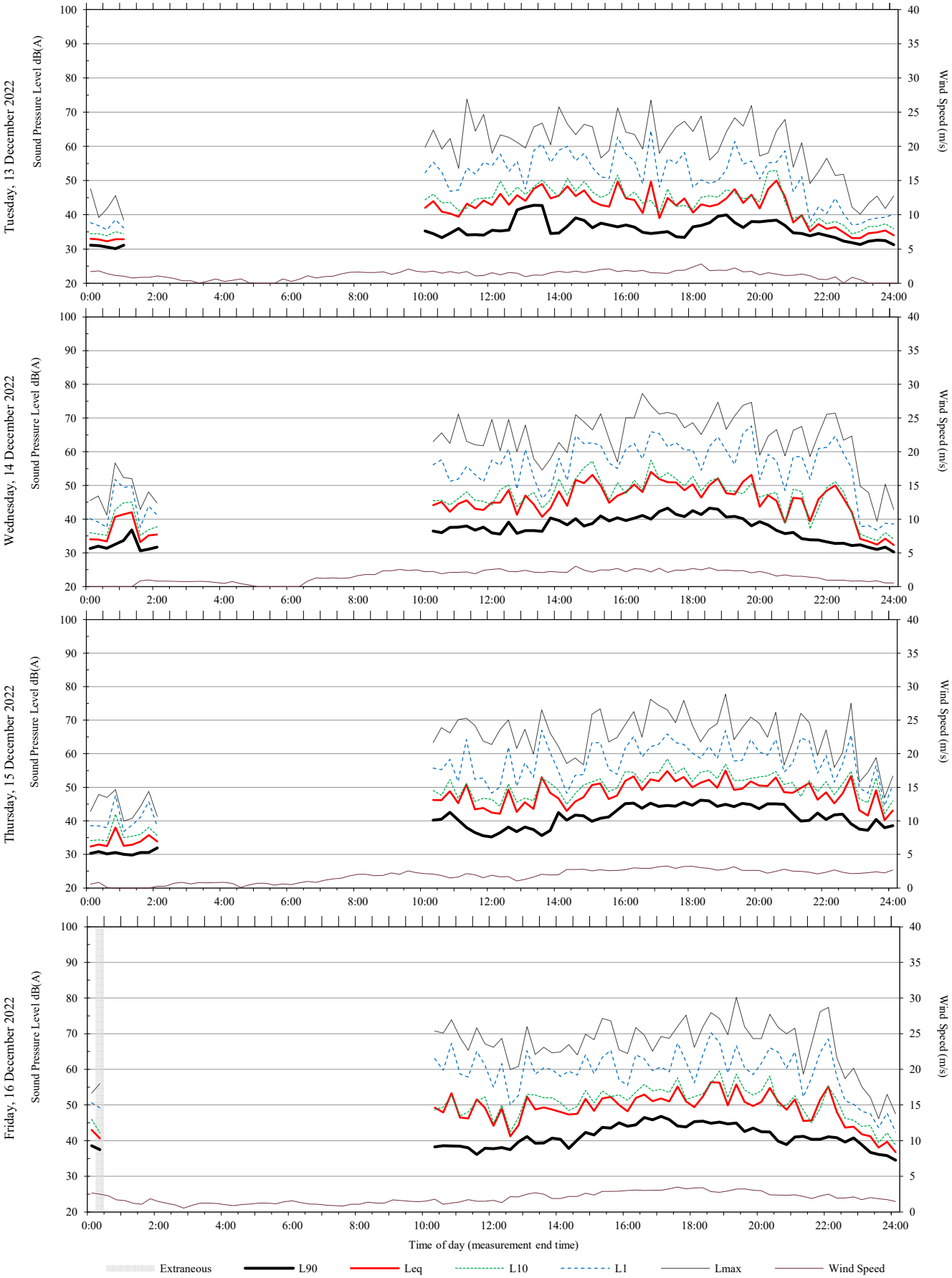

Unattended monitoring: L2 - Thornleigh Pumping Station (Free Field)

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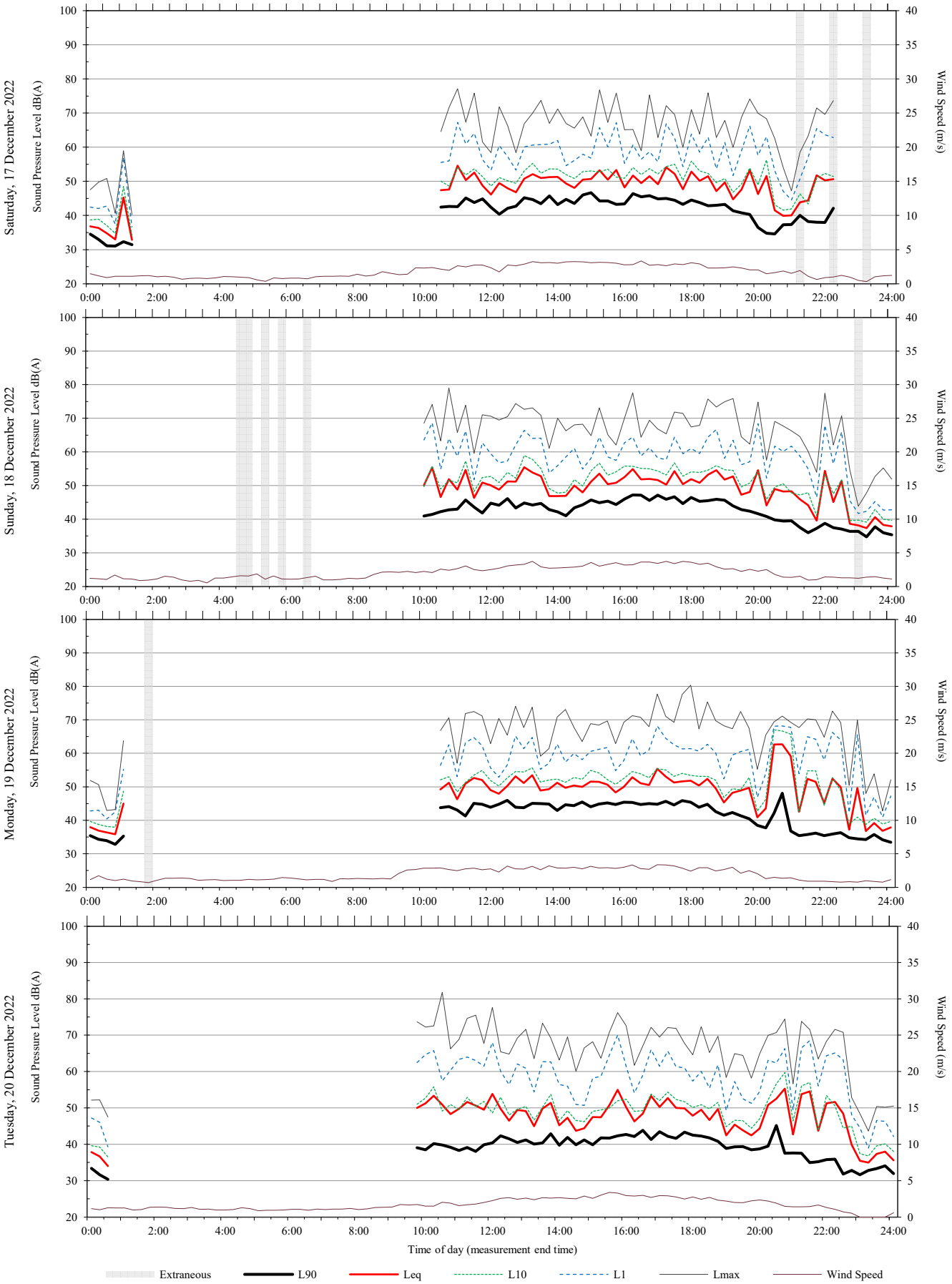


Appendix C

Construction Noise Criteria

To establish residential criteria, the background noise is typically to be measured, while for all other receiver types the criteria is fixed.

The ICNG [1]provides recommended noise levels for airborne construction noise at sensitive land uses. The guideline provides construction management noise levels above which all 'feasible and reasonable' work practices should be applied to minimise the construction noise impact. The ICNG works on the principle of a 'screening' criterion – if predicted or measured construction noise exceeds the ICNG levels then the construction activity must implement all 'feasible and reasonable' work practices to reduce noise levels.

The ICNG sets out management levels for noise at sensitive receivers and how they are to be applied. For residential receivers, the RBL is used when determining the management level. The management level for residential is reproduced in Table 18. For other sensitive land uses, the management levels are based on a fixed criteria independent of ambient noise levels. Those management levels are reproduced in Table 19.

Table 18: Construction noise management levels at residential and hotel receivers

Time of day	Management level [1] $dBL_{Aeq\ (15\ min)}$	How to apply
Recommended standard hours: Monday to Friday 7am to 6pm Saturday 8am to 1pm No work on Sundays or public holidays	Noise affected RBL + 10dB	The noise affected level represents the point above which there may be some community reaction to noise. Where the predicted or measured LAeq (15 min) is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected 75	The highly noise affected level represents the point above which there may be strong community reaction to noise. Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: - times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences - if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected RBL + 5dB	A strong justification would typically be required for works outside the recommended standard hours. The proponent should apply all feasible and reasonable work practices to meet the noise affected level. Where all feasible and reasonable practices have been applied and noise is more than 5dB above the noise affected level, the proponent should negotiate with the community. For guidance on negotiating agreements see section 7.2.2 of the ICNG.

1 – Noise levels apply at the property boundary that is most exposed to construction noise, and at a height of 1.5 m above ground level. If the property boundary is more than 30 m from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30 m of the residence. Noise levels may be higher at upper floors of the noise affected residence.

Table 19: Construction noise management levels at other noise sensitive land uses

Land use	Where objective applies	Management level, $dBL_{Aeq\ (15\ min)}$[1]
Commercial premises	External noise level	70
Educational premises	Internal noise level	45
	External noise level	55[2]
Places of worship	Internal noise level	45
	External noise level	55[2]
Childcare[3]	Internal noise level	45
	External noise level	55[2]
Community Centre[4]	Internal noise level	45
	External noise level	55[2]
Industrial	External noise level	75
Active recreation	External noise level	65
Passive recreation	External noise level	60

Notes

1– Noise management levels apply when properties are in use.

2- Assuming a 10dB addition to internal criteria for windows open

3- Internal noise level based on AS2107 [25] max design level for Teaching Spaces/Single Classroom – Primary Schools

4- Internal noise level based on AS2107 [25] max design level for Municipal building – function area

Appendix D

Vibration Criteria

D.1 Disturbance to building occupants

Potential vibration disturbance to human occupants of buildings is made in accordance with the NSW DEC *'Assessing Vibration; a technical guideline'* [15]. The criteria outlined in the guideline is based on the British Standard BS 6472-1992 [16]. Sources of vibration are defined as either 'Continuous', 'Impulsive' or 'Intermittent', as described in Table 20.

Table 20: Types of vibration – Definition

Type of vibration	Definition	Examples
Continuous vibration	Continues uninterrupted for a defined period (usually throughout the day-time and/or night-time)	Machinery, steady road traffic, continuous construction activity (such as tunnel boring machinery).
Impulsive vibration	A rapid build-up to a peak followed by a damped decay that may or may not involve several cycles of vibration (depending on frequency and damping). It can also consist of a sudden application of several cycles at approximately the same amplitude, providing that the duration is short, typically less than 2 seconds	Infrequent: Activities that create up to 3 distinct vibration events in an assessment period, e.g. occasional dropping of heavy equipment, occasional loading and unloading.
Intermittent vibration	Can be defined as interrupted periods of continuous or repeated periods of impulsive vibration that varies significantly in magnitude	Trains, nearby intermittent construction activity, passing heavy vehicles, forging machines, impact pile driving, jack hammers. Where the number of vibration events in an assessment period is three or fewer, this would be assessed against impulsive vibration criteria.

Table 21 reproduces the 'Preferred' and 'Maximum' values for continuous and impulsive vibration and

Table 22 reproduces the 'Preferred' and 'Maximum' values for intermittent vibration (Table 2.2 and 2.4 of the Guideline respectively [15]).

Table 21: Preferred and maximum vibration acceleration levels for human comfort, m/s^2

Location	Assessment period[1]	Preferred values		Maximum values	
		z-axis	x- and y-axes	z-axis	x- and y-axes
Continuous vibration (weighted root-mean-square (RMS) acceleration, m/s^2, 1-80Hz)					
Residences	Daytime	0.010	0.0071	0.020	0.014
	Night-time	0.007	0.005	0.014	0.010
Offices, schools, educational institutions and places of worship	Day- or night-time	0.020	0.014	0.040	0.028
Workshop	Day- or night-time	0.040	0.029	0.080	0.058
Impulsive vibration (weighted[2] RMS acceleration, m/s^2, 1-80Hz)					
Residences	Daytime	0.30	0.21	0.60	0.42
	Night-time	0.10	0.071	0.20	0.14
Offices, schools, educational institutions and places of worship	Day- or night-time	0.64	0.46	1.28	0.92
Workshop	Day- or night-time	0.64	0.46	1.28	0.92

Table 22: Acceptable vibration dose values (VDV) for intermittent vibration ($m/s^{1.75}$)

Location	Daytime[1]		Night-time	
	Preferred value	Maximum value	Preferred value	Maximum value
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80	0.40	0.80
Workshops	0.80	1.60	0.80	1.60

Notes:

1. Daytime is 7 am to 10 pm and night-time is 10 pm to 7 am
2. Note that the VDV is dependent upon the level and duration of the vibration event and the number of vibration events occurring during the assessment period; a higher vibration level is permitted if the total duration of the vibration event(s) is small.

D.2 Impact on building contents – Sensitive equipment

Some scientific equipment (e.g. electron microscopes and microelectronics manufacturing equipment) can require more stringent objectives than those applicable to human comfort.

Where vibration sensitive scientific and/or medical instruments are in use within an identified vibration sensitive receiver, objectives for the satisfactory operation of the instrument should be sourced from manufacturer's data. Where manufacturer's data is not available, generic vibration criterion (VC) curves as published by the Society of Photo-Optical Instrumentation Engineers [18] or the ASHRAE Chapter 49 [19] may be adopted, as presented in Table 23. Baseline vibration levels could also be measured to inform the establishment of appropriate criteria.

Table 23: Application and interpretation of the generic Vibration Criterion (VC) curves (as defined in the CNVS)

Criterion Curve	Max Level (µm/sec, rms)[1]	Detail size (micron)[2]	Description of use
VC-A	50	8	Adequate in most instances for optical microscopes to 400X, microbalances, optical balances, proximity and projection aligners, etc.
VC-B	25	3	An appropriate standard for optical microscopes to 1000X, inspection and lithography equipment (including steppers) to 3 micron line widths.
VC-C	12.5	1	A good standard for most lithography and inspection equipment to 1 micron detail size.
VC-D	6	0.3	Suitable in most instances for the most demanding equipment including electron microscopes (TEMs and SEMs) and E-Beam systems, operating to the limits of their capability.
VC-E	3	0.1	A difficult criterion to achieve in most instances. Assumed to be adequate for the most demanding of sensitive systems including long path, laser-based, small target systems and other systems requiring extraordinary dynamic stability.

Note 1: As measured in one-third octave bands of frequency over the frequency range 8 to 100 Hz

Note 2: The detail size refers to the line widths for microelectronics fabrication, the particle (cell) size for medical and pharmaceutical research, etc. The values given consider the observation that the vibration requirements of many items depend upon the detail size of the process.

D.3 Impact on structures and services

Potential structural or cosmetic damage to buildings as a result of vibration is typically assessed in accordance with British Standard 7385 Part 2 [26] and/or German Standard DIN4150-3 [23]. Additional information is also provided in the CNVS.

D.3.1 Standard structures

British Standard 7385 Part 1:1990 [27], defines different levels of structural damage as:

- Cosmetic – The formation of hairline cracks on drywall surfaces, or the growth of existing cracks in plaster or drywall surfaces; in addition, the formation of hairline cracks in mortar joints of brick/concrete block construction.
- Minor – The formation of large cracks or loosening of plaster or drywall surfaces, or cracks through bricks/concrete blocks.
- Major – Damage to structural elements of the building, cracks in supporting columns, loosening of joints, splaying of masonry cracks, etc.

BS7385-2 (Table 1 and Section 7.4.2) sets limits for the protection against the different levels of structural damage and those levels are reproduced in Table 24. The criteria relate predominantly to transient vibration that does not give rise to resonant responses in structures, and to low rise buildings.

Table 24: BS 7385-2 Structural damage criteria

Line	Type of structure	Damage level	Peak component particle velocity (PCPV), mm/s[1]		
			4 Hz to 15 Hz	15 Hz to 40 Hz	40 Hz and above
1	Reinforced or framed structures Industrial and heavy commercial buildings	Cosmetic	50		
		Minor[2]	100		
		Major[2]	200		
2	Un-reinforced or light framed structures Residential or light commercial type buildings	Cosmetic	15 to 20	20 to 50	50
		Minor[2]	30 to 40	40 to 100	100
		Major[2]	60 to 80	80 to 200	200

Notes:

1. Peak Component Particle Velocity is the maximum Peak particle velocity in any one direction (x, y, z) as measured by a tri-axial vibration transducer.
2. Minor and major damage criteria established based on British Standard 7385 Part 2 (1993) Section 7.4.2
3. All levels relate to transient vibrations in low-rise buildings. Continuous vibration can give rise to dynamic magnifications that may require levels to be reduced by up to 50%.

Where the dynamic loading caused by continuous vibration is such as to give rise to dynamic magnification due to resonance, especially at the lower frequencies where lower guide values apply, the values in Table 24 may need to be reduced by up to 50%. Activities considered to have the potential to cause dynamic loading in some structures (e.g. residences) include rock breaking/hammering and sheet piling activities. On the basis that the predominant vibration energy occurs at frequencies greater than 4 Hz (and usually in the 10 Hz to 100 Hz range) a conservative vibration damage screening level per receiver type is given below:

- Reinforced or framed structures: 25.0 mm/s PCPV
- Unreinforced or light framed structures: 7.5 mm/s PCPV

At locations where the predicted and/or measured vibration levels are greater than above, a more detailed analysis of the building structure, vibration source, dominant frequencies and dynamic characteristics of the structure would be required to determine the applicable safe vibration level.

D.3.2 Sensitive structures

German Standard *DIN 4150 – Part 3 'Structural vibration in buildings – Effects on Structure'* [23] is generally recognised to be conservative and is often referred to for the purpose of assessing structurally sensitive buildings.

Heritage buildings and structures should not be assumed to be more sensitive to vibration unless they are found to be structurally unsound and should otherwise be assessed in accordance with BS7385-2. If a heritage building or structure is found to be structurally unsound (following inspection) DIN 4150-3, line 3 as outlined in Table 25, provides a conservative cosmetic damage objective that should be adopted unless alternative limits are justified by a dilapidation or structural survey. The sensitivity of heritage buildings and other potentially at-risk structures are subject to confirmation by the contractor prior to start of any works.

Table 25: DIN 415-3 structural damage guideline values

Line	Type of structure	Peak component particle velocity (PCPV), mm/s				
		Vibration at the foundation at a frequency of			At horizontal plane of highest floor	In the vertical direction, at floor slabs
		1 Hz to 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz[1]	All frequencies	All frequencies
3	Structures that because of their particular sensitivity to vibration, cannot be classified under lines 1 and 2 and are of great intrinsic value (e.g. listed buildings under a preservation order)[3]	3	3 to 8	8 to 10	8	20[2]

Notes

1. At frequencies above 100 Hz, the values given in this column may be used as minimum values.
2. Guideline value might have to be lowered to prevent minor damage
3. Line 1 refer to buildings used for commercial purposes, industrial buildings and buildings of similar design, while Line 2 refers to residential buildings and buildings of similar design and/or occupancy

D.3.3 Buried services

DIN 4150-2:2016 sets out guideline values for vibration effects on buried pipework (see Table 26).

Table 26: Guideline values for short-term vibration impacts on buried pipework

Line	Pipe material	Peak component particle velocity (PCPV) measured on pipe, mm/s
1	Steel, welded	100
2	Vitrified clay, concrete, reinforced concrete, pre-stressed concrete, metal (with or without flange)	80
3	Masonry, plastic	50
-	High pressure gas pipelines*	75 Monitoring required if predicted above 50. No piling within 15 m of pipeline without detailed assessment.

Note:

For gas and water supply pipes within 2 m of buildings, the levels given in DIN4150-3 [23] should be applied. Consideration must also be given to pipe junctions with the building structure as potential significant changes in mechanical loads on the pipe must be considered.

For Rock breaking/hammering and sheet piling activities are considered to have the potential to cause dynamic loading in some structures and it may therefore be appropriate to reduce the transient values by 50%.

* Based on UK National Grid's specification [28]

Other services that maybe encountered include electrical cables and telecommunication services such as fibre optic cables. While these may sustain vibration velocity levels from between 50 mm/s and 100 mm/s, the connected services such as transformers and switchgear, may not. Where encountered, site specific vibration assessment in consultation with the utility provider should be carried out.

Sydney Water specialist engineering assessment procedure [29] also references vibrational limits for buried services, Table 6 of the procedure is replicated below.

Asset Type	Threshold values for velocity (PPV) measured on the asset in mm/s
Brittle Pipe Assets- RC, VC/EW, CICL	Maximum PPV intermittent vibrations 10mm/s Maximum PPV for continuous vibrations 5mm/s
Ductile Pipe Assets- SCL, DI, PVC, PE, PP, GRP	Maximum PPV intermittent vibrations 20mm/s Maximum PPV for continuous vibrations 10mm/s
Masonry	3mm/s
Unreinforced concrete	3mm/s

Note:

Table 6 [29] is applicable for buried assets, in sound condition, and laid in a typical soil trench in stable ground. Alternative criteria shall be developed for other asst types, above ground assts, concrete encased pipes, pipes on piled/special supports and pipes in tunnels or of other unusual construction or ground conditions.

Appendix E

Receiver map

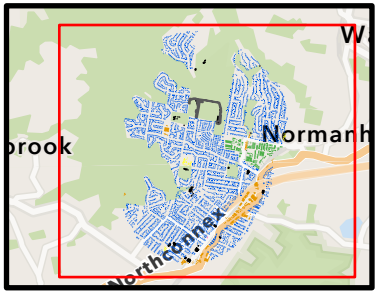
Legend

Construction site

- Construction site
- TBM pipeline
- Unattended Noise Monitoring

Receiver

- Residential
- Industrial
- Place of Worship
- Commercial
- Educational
- Recreational
- Child Care
- Ancillary



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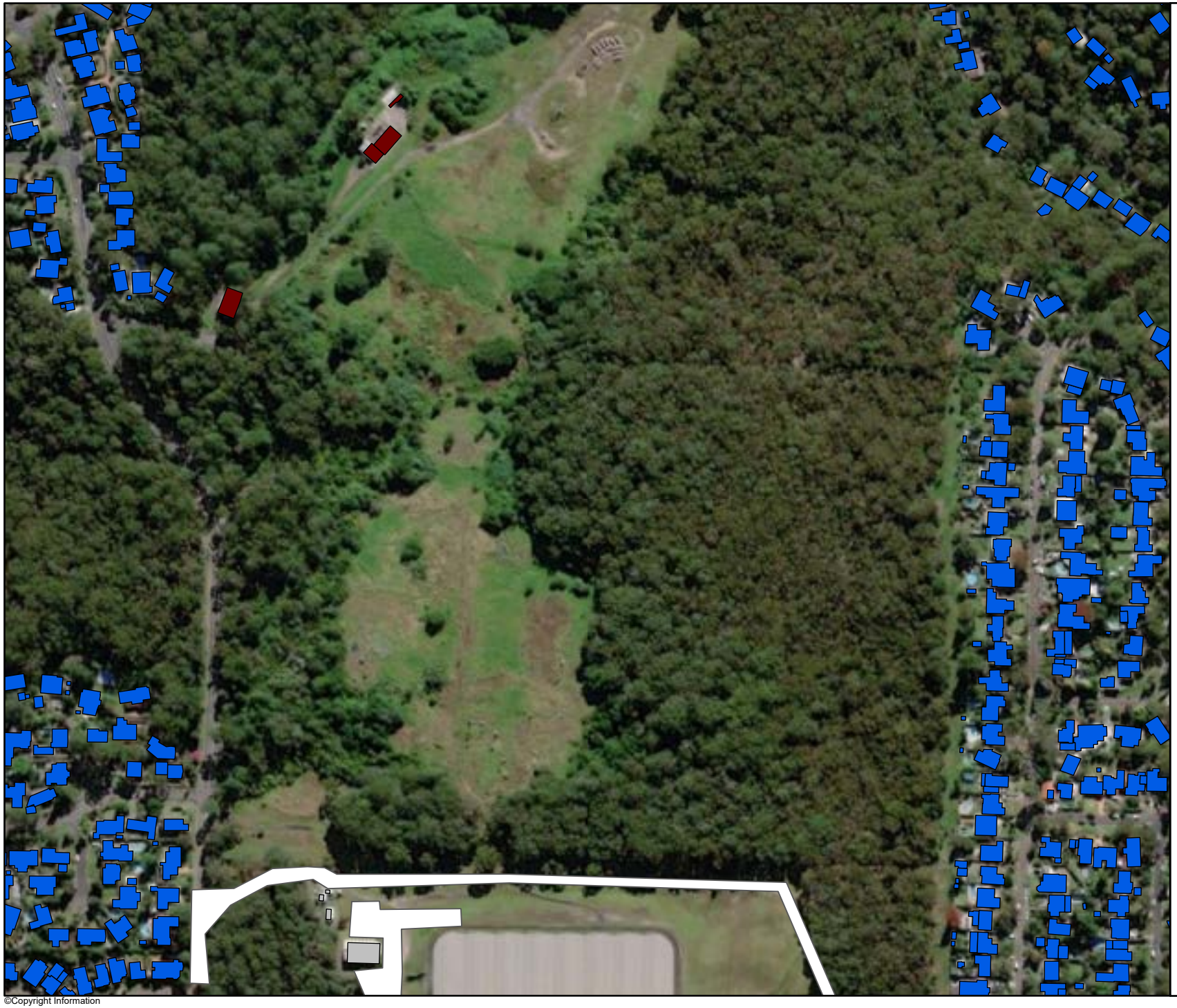

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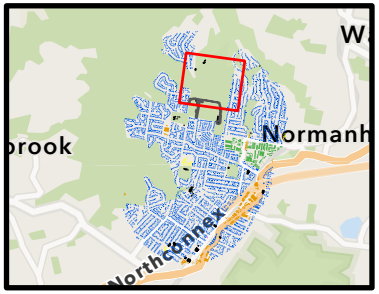

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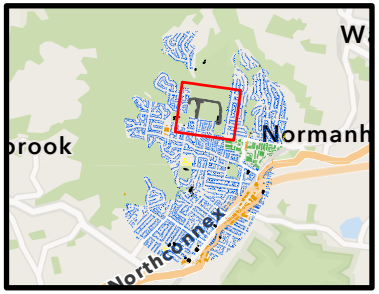

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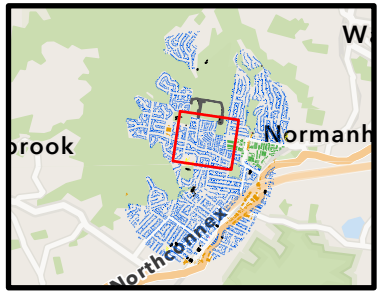

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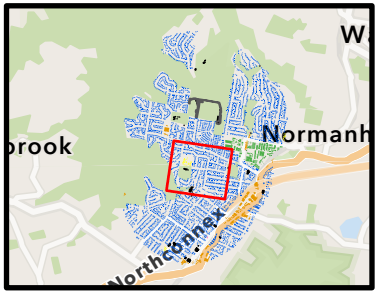

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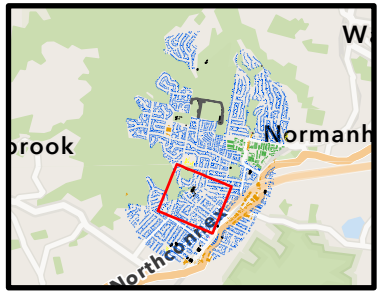

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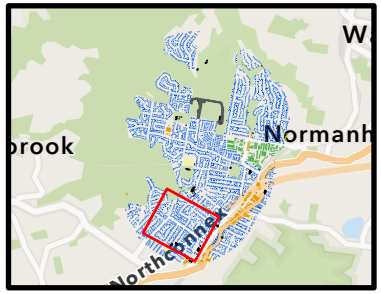

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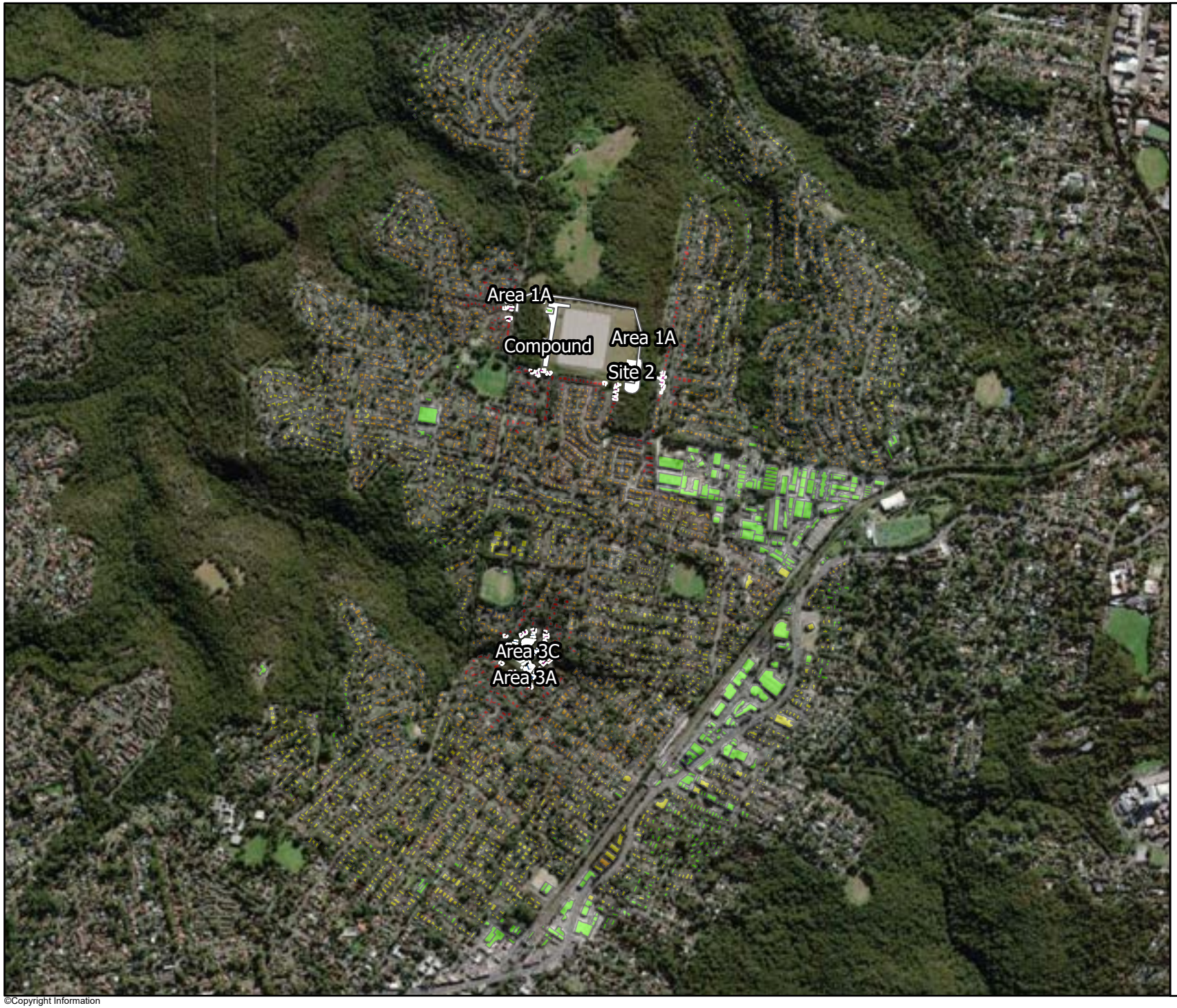
Appendix F

Noise exceedance maps

F.1 Scenario 1: Site Establishment (Airborne noise) (Standard Hours)

Timeframe: Month 1-2 (refer to Table 2)



Legend

Compliance at receiver

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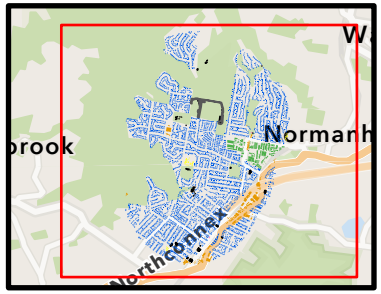
- <=NML + 20dB
- <=NML + 30dB
- <=NML + 40dB
- >=NML + 40dB
- Highly noise affected



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Project
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Map Title
Sc1: Site Establishment (Standard Hours) (Day)

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Legend

Compliance at receiver

- Compliant
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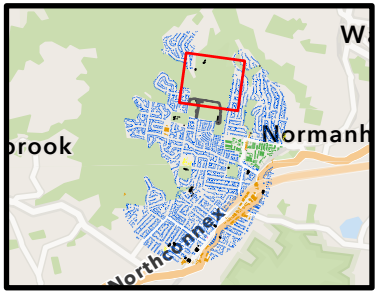
- <=NML + 20dB
- <=NML + 30dB
- <=NML + 40dB
- >=NML + 40dB
- Highly noise affected



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Project
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Legend

Compliance at receiver

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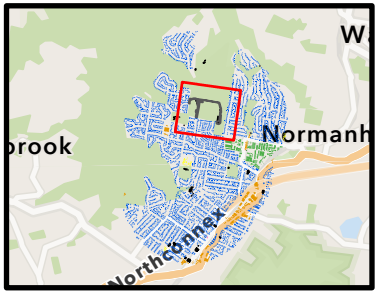

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Compliance at receiver

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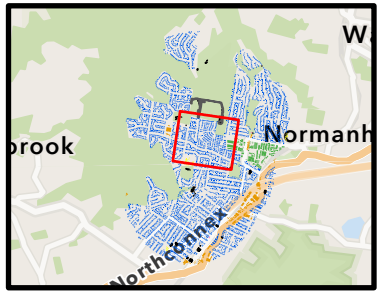

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Compliance at receiver

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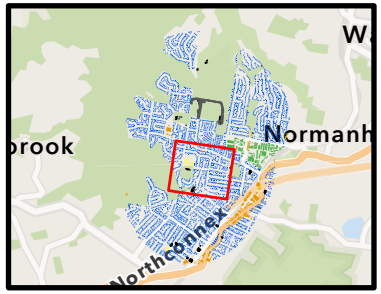

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Project
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Map Title
Sc1: Site Establishment (Standard Hours) (Day)

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Legend

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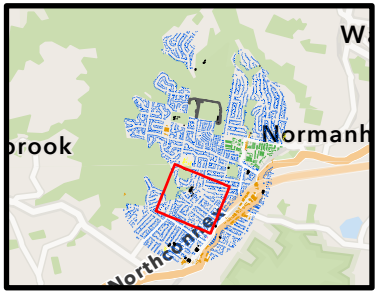

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Job No
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Project
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Map Title
Sc1: Site Establishment (Standard Hours) (Day)

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Legend

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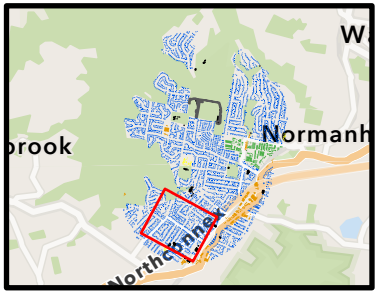

0 30 60 120 Meters

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Job No
269002

Project
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Map Title
Sc1: Site Establishment (Standard Hours) (Day)

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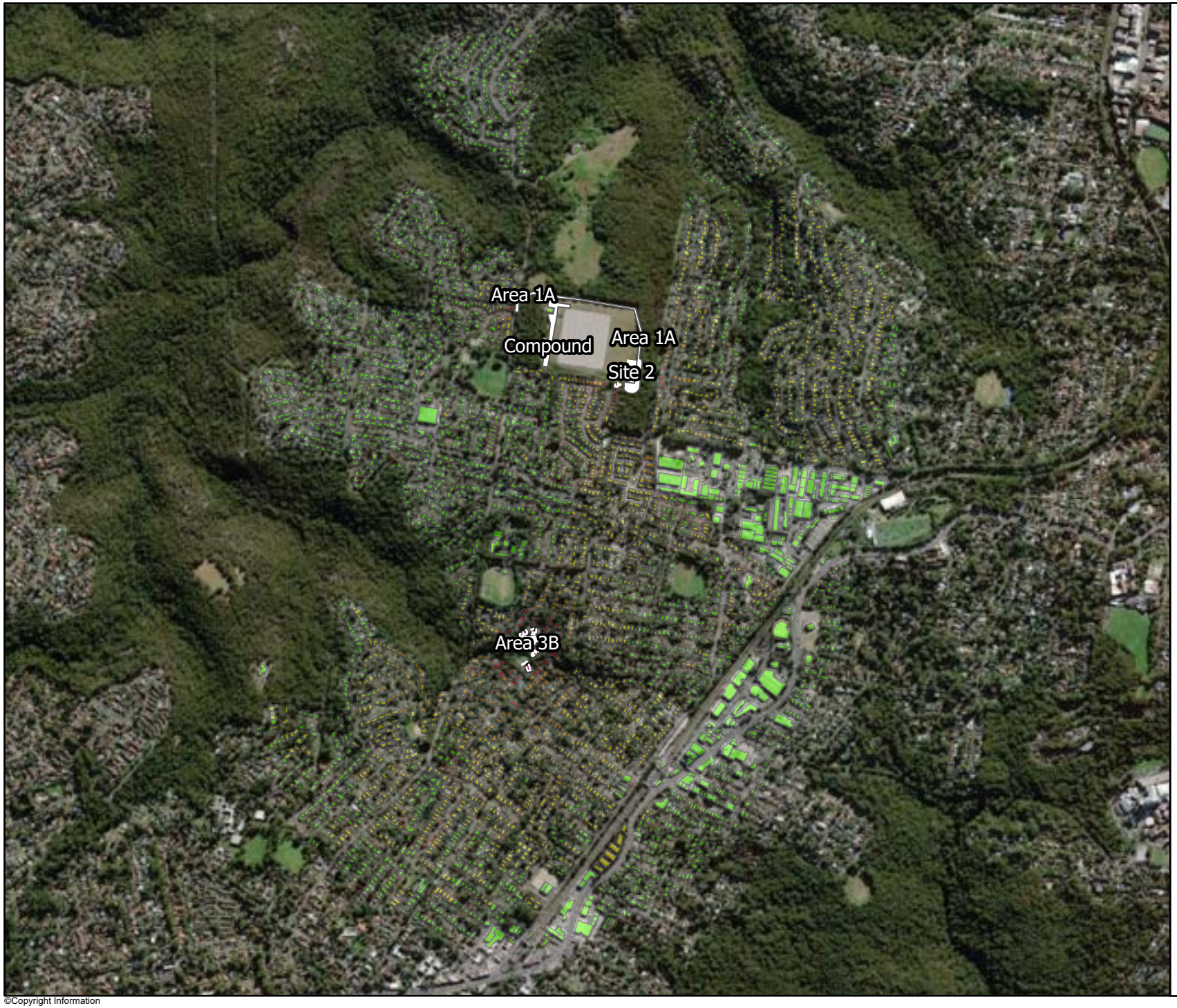
F.2 Scenario 3: Pipework (Airborne noise) (Standard Hours)

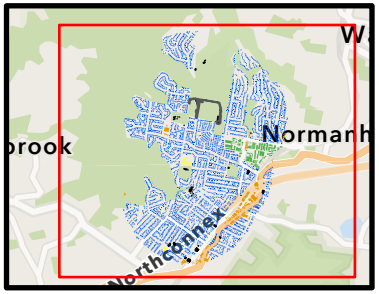
Timeframe: Month 15-22 (refer to Table 2)



Legend

Compliance at receiver

- Compliant
- <=NML + 10dB
- <=NML + 20dB
- <=NML + 30dB
- <=NML + 40dB
- >=NML + 40dB
- Highly noise affected



0 155 310 620 Meters

ARUP

Client
Sydney Water

Job No
269002

Project
Thornleigh - Inlet/Outlet Main Construction

Map Title
Sc3: Pipework (Standard Hours) (Day)

Revision
v2

N

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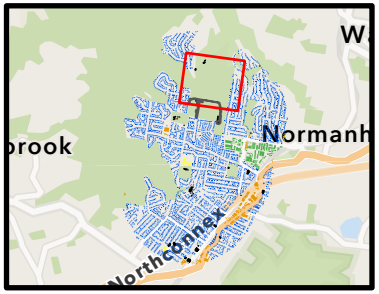
Legend

Compliance at receiver

- Compliant
- <=NML + 10dB
- <=NML + 20dB
- <=NML + 30dB
- <=NML + 40dB
- >=NML + 40dB
- Highly noise affected



0 30 60 120 Meters

ARUP

Client
Sydney Water

Job No
269002

Project
Thornleigh - Inlet/Outlet Main Construction

Map Title
Sc3: Pipework (Standard Hours) (Day)

Revision
v2

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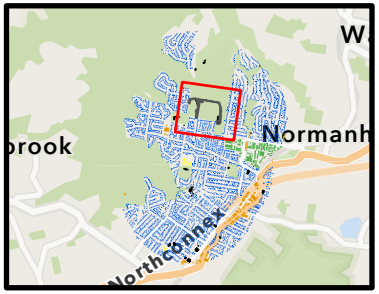
Legend

Compliance at receiver

- Compliant
- <=NML + 10dB
- <=NML + 20dB
- <=NML + 30dB
- <=NML + 40dB
- >=NML + 40dB
- Highly noise affected



0 30 60 120 Meters

ARUP

Client
Sydney Water

Job No
269002

Project
Thornleigh - Inlet/Outlet Main Construction

Map Title
Sc3: Pipework (Standard Hours) (Day)

Revision
v2

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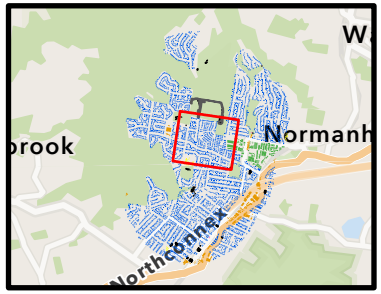
Legend

Compliance at receiver

- Compliant
- <=NML + 10dB
- <=NML + 20dB
- <=NML + 30dB
- <=NML + 40dB
- >=NML + 40dB
- Highly noise affected



0 30 60 120 Meters

ARUP

Client
Sydney Water

Job No
269002

Project
Thornleigh - Inlet/Outlet Main Construction

Map Title
Sc3: Pipework (Standard Hours) (Day)

Revision
v2

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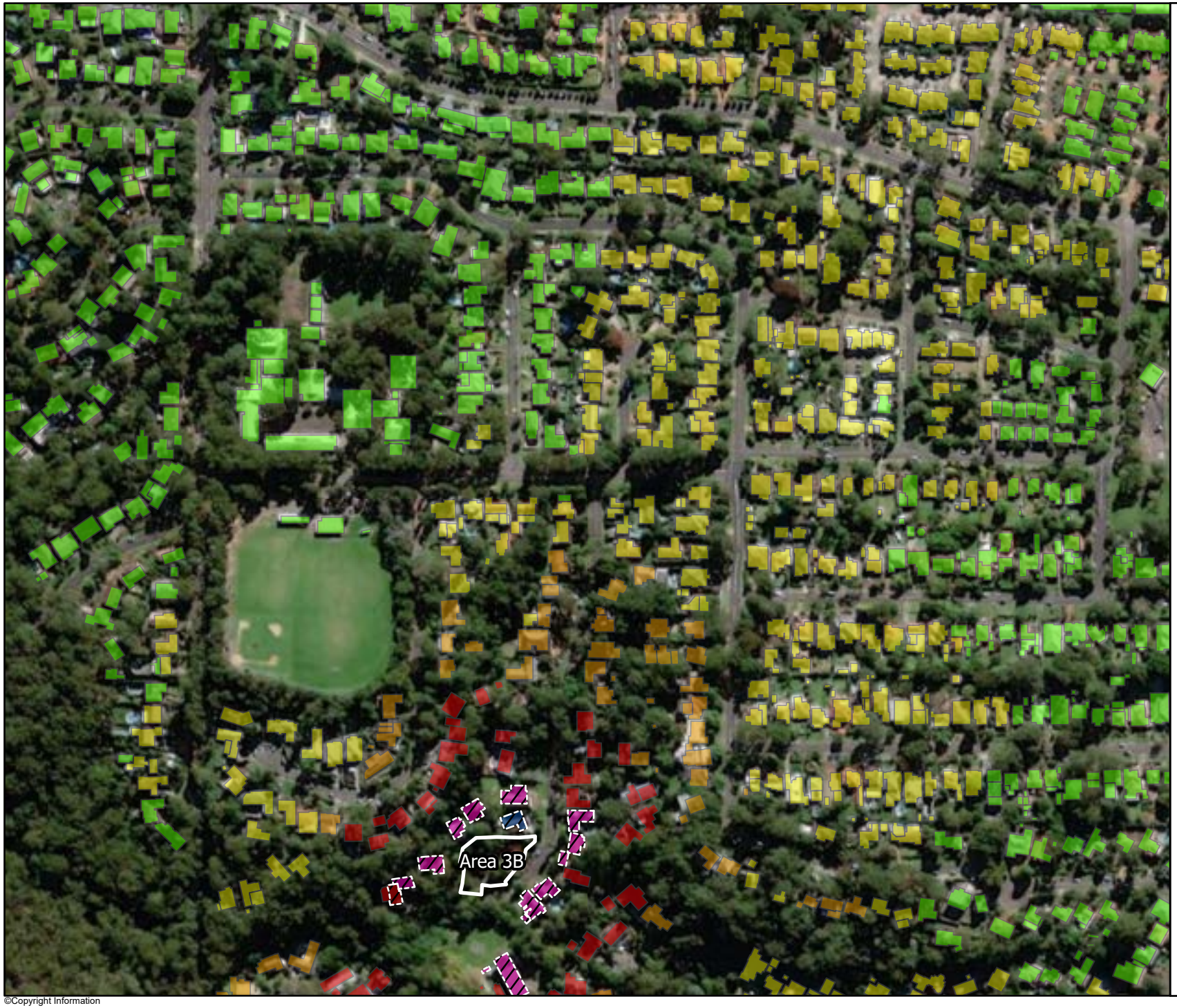
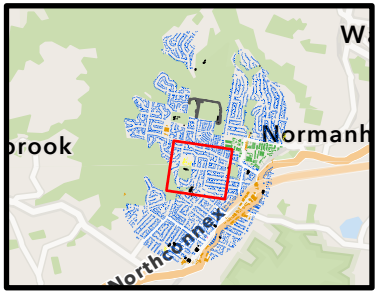


Legend

Compliance at receiver

- Compliant
- <=NML + 10dB
- <=NML + 20dB
- <=NML + 30dB
- <=NML + 40dB
- >=NML + 40dB
- Highly noise affected



0 30 60 120 Meters

ARUP

Client
Sydney Water

Job No
269002

Project
Thornleigh - Inlet/Outlet Main Construction

Map Title
Sc3: Pipework (Standard Hours) (Day)

Revision
v2

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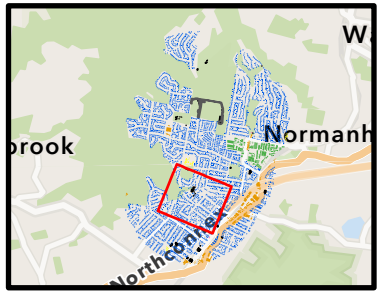
Legend

Compliance at receiver

- Compliant
- <=NML + 10dB
- <=NML + 20dB
- <=NML + 30dB
- <=NML + 40dB
- >=NML + 40dB
- Highly noise affected



0 30 60 120 Meters

ARUP

Client
Sydney Water

Job No
269002

Project
Thornleigh - Inlet/Outlet Main Construction

Map Title
Sc3: Pipework (Standard Hours) (Day)

Revision
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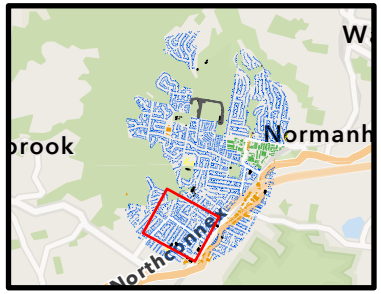
Legend

Compliance at receiver

- Compliant
- <=NML + 10dB
- <=NML + 20dB
- <=NML + 30dB
- <=NML + 40dB
- >=NML + 40dB
- Highly noise affected



0 30 60 120 Meters

ARUP

Client
Sydney Water

Job No
269002

Project
Thornleigh - Inlet/Outlet Main Construction

Map Title
Sc3: Pipework (Standard Hours) (Day)

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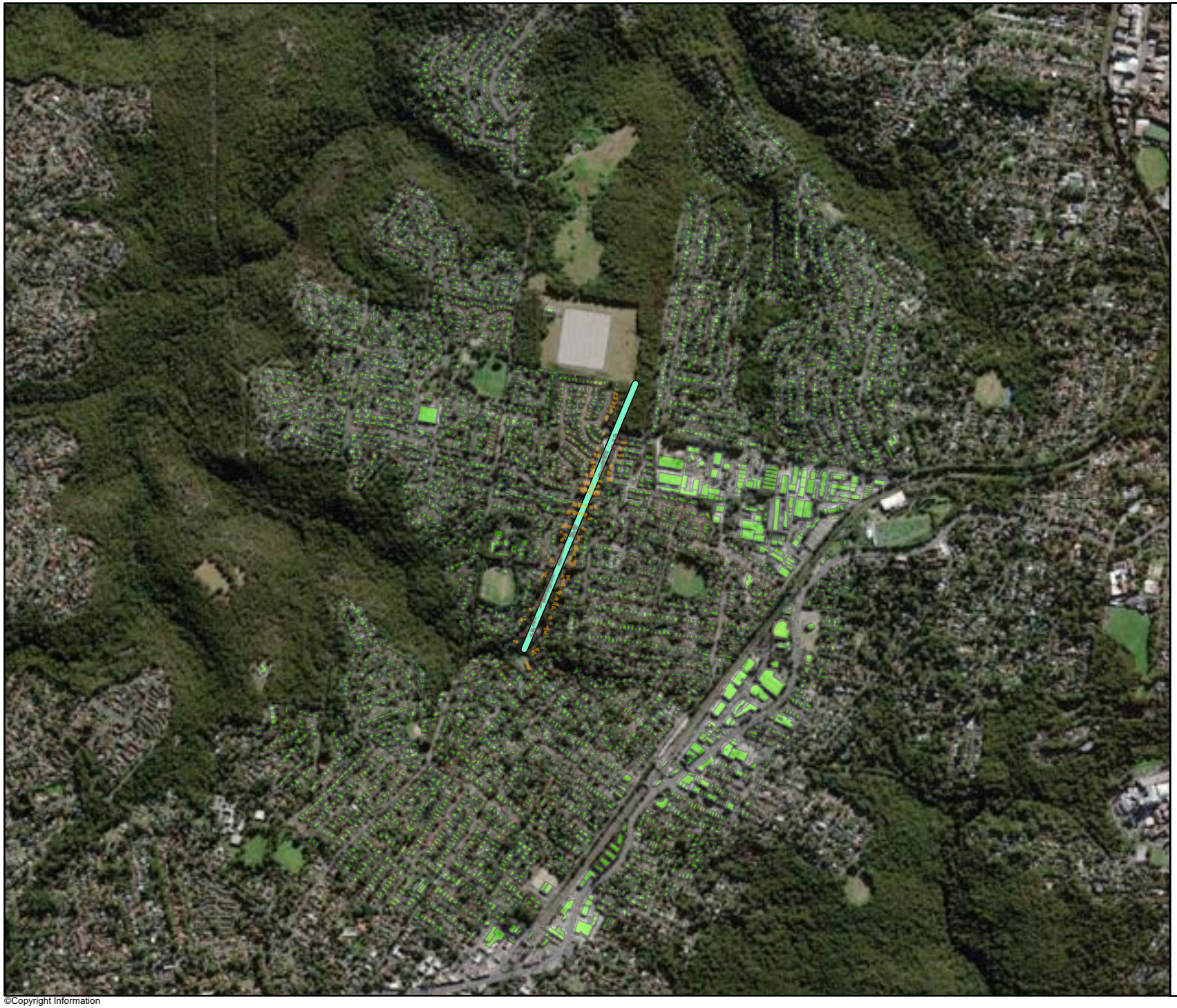
F.3 Scenario 4: Tunnelling (Ground-borne noise) (Outside Standard Hours (Night))

Timeframe: Month 5-14 (refer to Table 2)

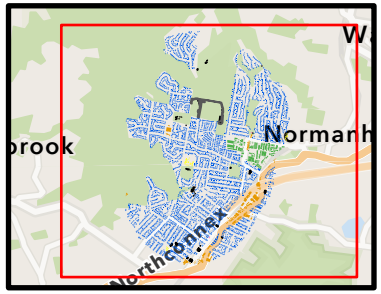


Legend

- TBM pipeline

Ground borne noise compliance

- <=GBNML (Compliant)
- <=GBNML +10dB
- > GBNML +10dB



0 155 310 620 Meters

ARUP

Client
Sydney Water

Job No
269002

Project
Thornleigh - Inlet/Outlet Main Construction

Map Title
Sc4: Tunnelling - Ground borne noise (Outside Standard Hours) (Night)

Revision
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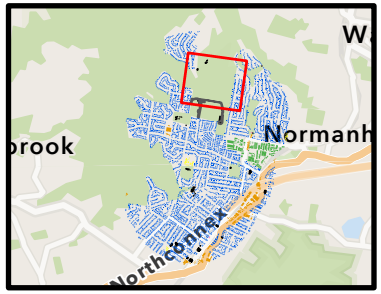
Legend

- TBM pipeline

Ground borne noise compliance

- <=GBNML (Compliant)
- <=GBNML +10dB
- > GBNML +10dB



0 30 60 120 Meters

ARUP

Client
Sydney Water

Job No
269002

Project
Thornleigh - Inlet/Outlet Main Construction

Map Title
Sc4: Tunnelling - Ground borne noise (Outside Standard Hours) (Night)

Revision
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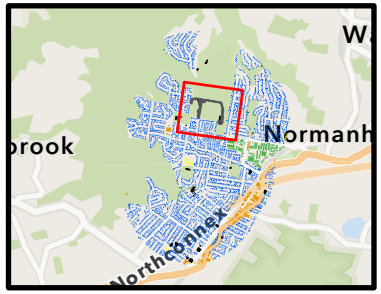
Legend

- TBM pipeline

Ground borne noise compliance

- <=GBNML (Compliant)
- <=GBNML +10dB
- > GBNML +10dB



0 30 60 120 Meters

ARUP

Client
Sydney Water

Job No
269002

Project
Thornleigh - Inlet/Outlet Main Construction

Map Title
Sc4: Tunnelling - Ground borne noise (Outside Standard Hours) (Night)

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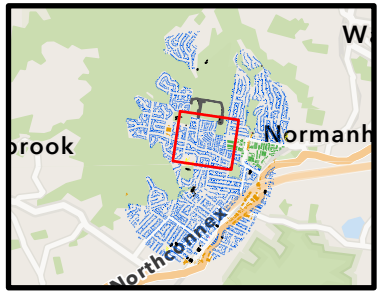
Legend

- TBM pipeline

Ground borne noise compliance

- <=GBNML (Compliant)
- <=GBNML +10dB
- > GBNML +10dB



0 30 60 120 Meters

ARUP

Client
Sydney Water

Job No
269002

Project
Thornleigh - Inlet/Outlet Main Construction

Map Title
Sc4: Tunnelling - Ground borne noise (Outside Standard Hours) (Night)

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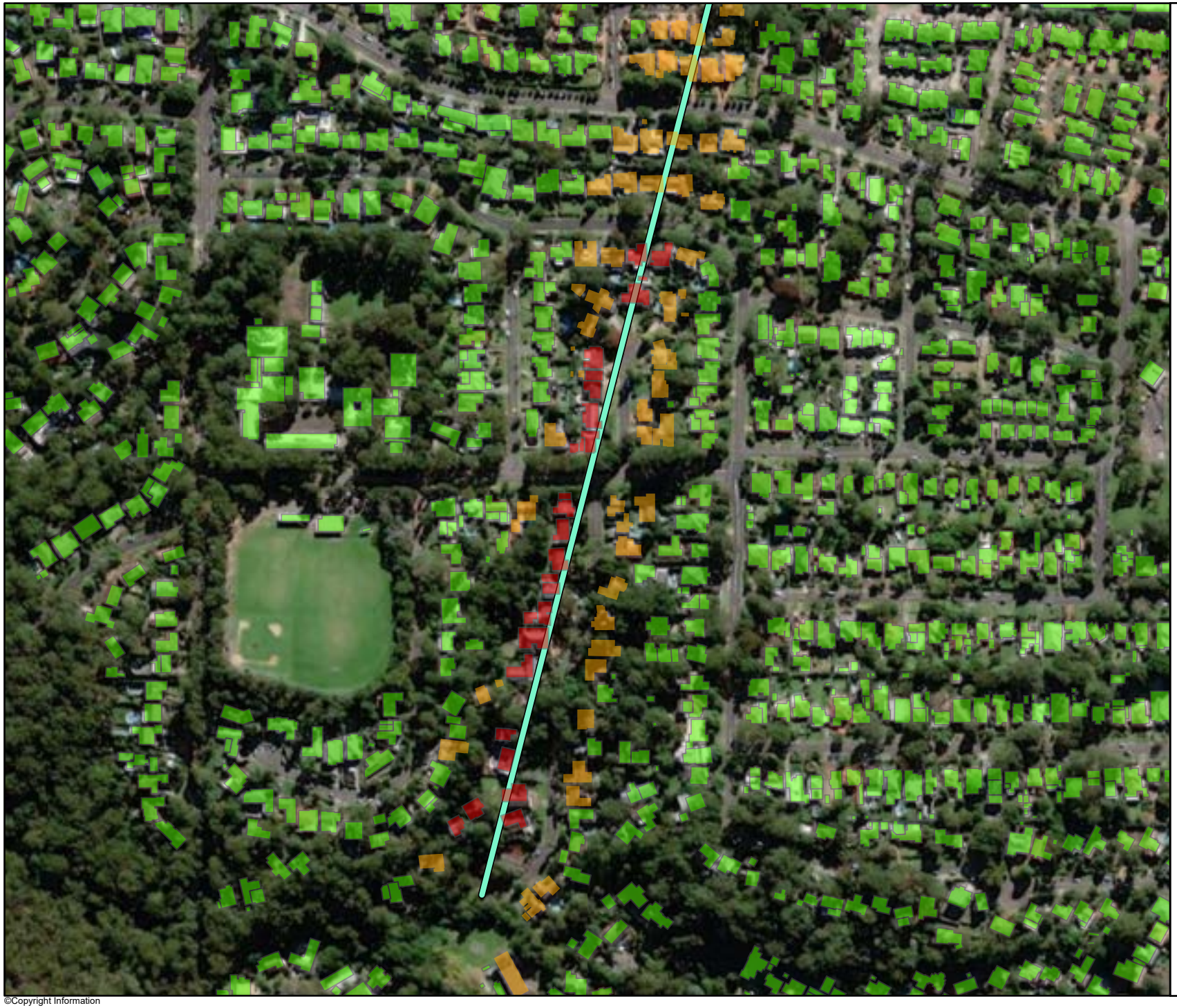
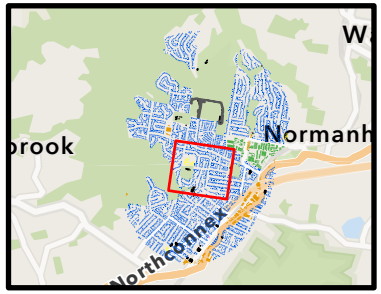


Legend

- TBM pipeline

Ground borne noise compliance

- <=GBNML (Compliant)
- <=GBNML +10dB
- > GBNML +10dB



0 30 60 120 Meters

ARUP

Client
Sydney Water

Job No
269002

Project
Thornleigh - Inlet/Outlet Main Construction

Map Title
Sc4: Tunnelling - Ground borne noise (Outside Standard Hours) (Night)

Revision
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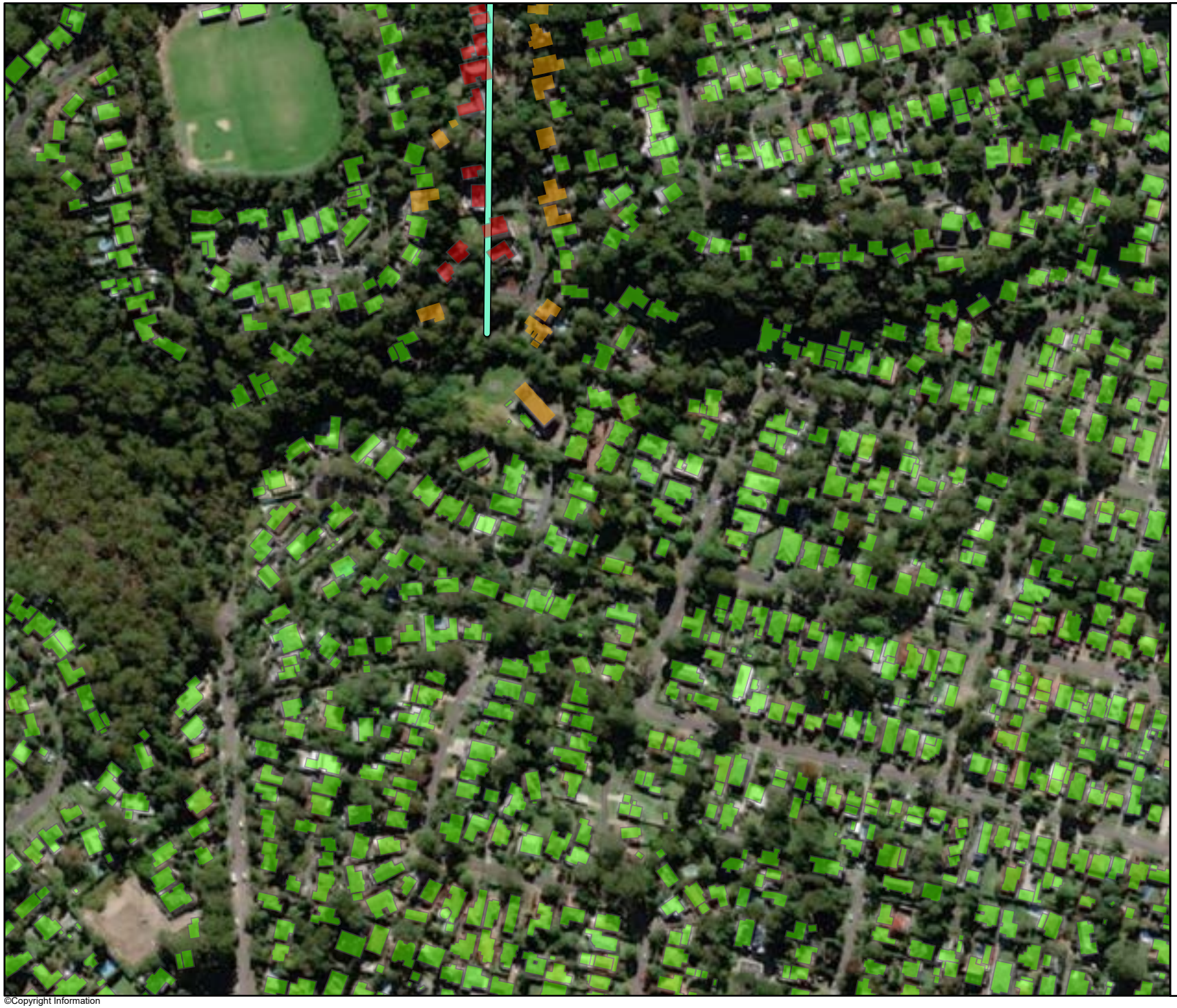
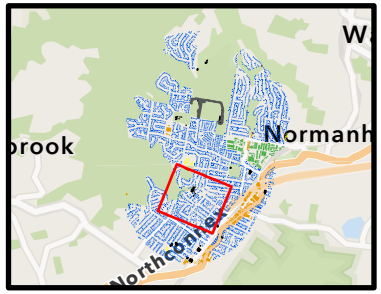


Legend

- TBM pipeline

Ground borne noise compliance

- <=GBNML (Compliant)
- <=GBNML +10dB
- > GBNML +10dB



0 30 60 120 Meters

ARUP

Client
Sydney Water

Job No
269002

Project
Thornleigh - Inlet/Outlet Main Construction

Map Title
Sc4: Tunnelling - Ground borne noise (Outside Standard Hours) (Night)

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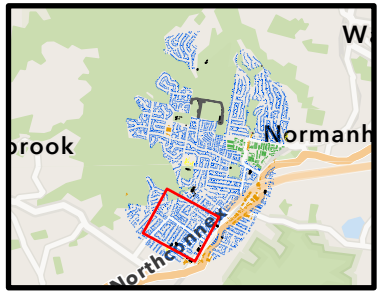
Legend

- TBM pipeline

Ground borne noise compliance

- <=GBNML (Compliant)
- <=GBNML +10dB
- > GBNML +10dB



0 30 60 120 Meters

ARUP

Client
Sydney Water

Job No
269002

Project
Thornleigh - Inlet/Outlet Main Construction

Map Title
Sc4: Tunnelling - Ground borne noise (Outside Standard Hours) (Night)

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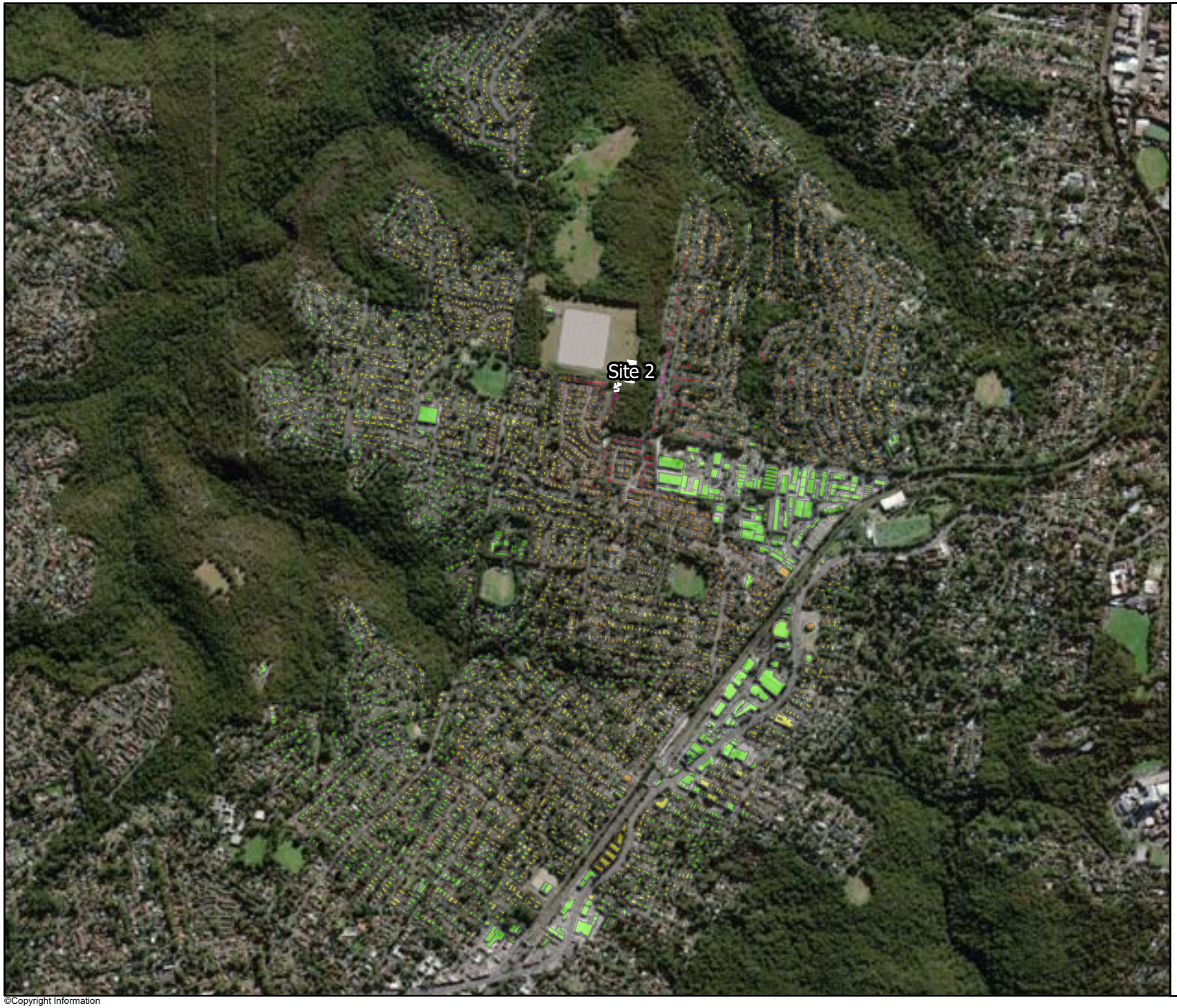
F.4 Scenario 4: Tunnelling (Airborne noise) (Outside Standard Hours (Night))

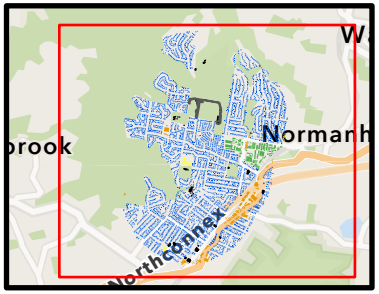
Timeframe: Month 5-14 (refer to Table 2)



Legend

Compliance at receiver

- Compliant
- <=NML + 10dB
- <=NML + 20dB
- <=NML + 30dB
- <=NML + 40dB
- >=NML + 40dB
- Highly noise affected



0 155 310 620 Meters

ARUP

Client
Sydney Water

Job No
269002

Project
Thornleigh - Inlet/Outlet Main Construction

Map Title
Sc4: Tunnelling (Outside Standard Hours) (Night)

Revision
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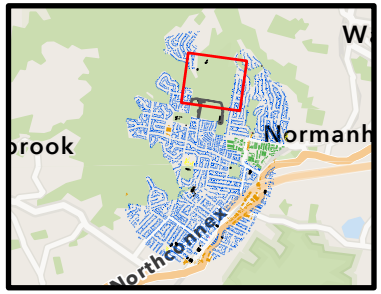
Legend

Compliance at receiver

- Compliant
- <=NML + 10dB
- <=NML + 20dB
- <=NML + 30dB
- <=NML + 40dB
- >=NML + 40dB
- Highly noise affected



0 30 60 120 Meters

ARUP

Client
Sydney Water

Job No
269002

Project
Thornleigh - Inlet/Outlet Main Construction

Map Title
Sc4: Tunnelling (Outside Standard Hours) (Night)

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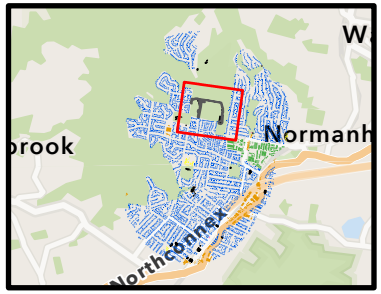
Legend

Compliance at receiver

- Compliant
- <=NML + 10dB
- <=NML + 20dB
- <=NML + 30dB
- <=NML + 40dB
- >=NML + 40dB
- Highly noise affected



0 30 60 120 Meters

ARUP

Client
Sydney Water

Job No
269002

Project
Thornleigh - Inlet/Outlet Main Construction

Map Title
Sc4: Tunnelling (Outside Standard Hours) (Night)

Revision
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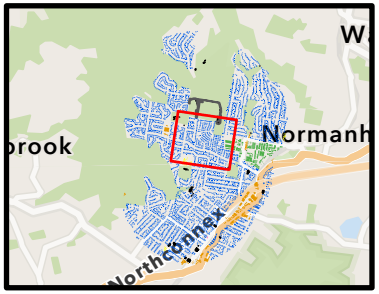
Legend

Compliance at receiver

- Compliant
- <=NML + 10dB
- <=NML + 20dB
- <=NML + 30dB
- <=NML + 40dB
- >=NML + 40dB
- Highly noise affected



0 30 60 120 Meters

ARUP

Client
Sydney Water

Job No
269002

Project
Thornleigh - Inlet/Outlet Main Construction

Map Title
Sc4: Tunnelling (Outside Standard Hours) (Night)

Revision
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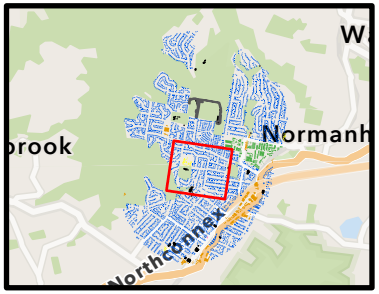
Legend

Compliance at receiver

- Compliant
- <=NML + 10dB
- <=NML + 20dB
- <=NML + 30dB
- <=NML + 40dB
- >=NML + 40dB
- Highly noise affected



0 30 60 120 Meters

ARUP

Client
Sydney Water

Job No
269002

Project
Thornleigh - Inlet/Outlet Main Construction

Map Title
Sc4: Tunnelling (Outside Standard Hours) (Night)

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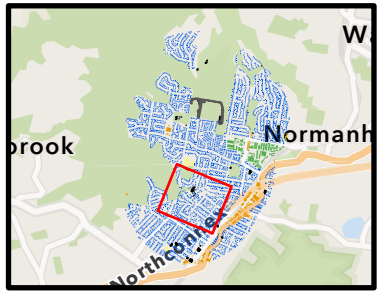
Legend

Compliance at receiver

- Compliant
- <=NML + 10dB
- <=NML + 20dB
- <=NML + 30dB
- <=NML + 40dB
- >=NML + 40dB
- Highly noise affected



0 30 60 120 Meters

ARUP

Client
Sydney Water

Job No
269002

Project
Thornleigh - Inlet/Outlet Main Construction

Map Title
Sc4: Tunnelling (Outside Standard Hours) (Night)

Revision
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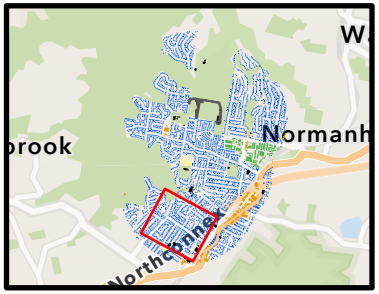
Legend

Compliance at receiver

- Compliant
- <=NML + 10dB
- <=NML + 20dB
- <=NML + 30dB
- <=NML + 40dB
- >=NML + 40dB
- Highly noise affected



0 30 60 120 Meters

ARUP

Client
Sydney Water

Job No
269002

Project
Thornleigh - Inlet/Outlet Main Construction

Map Title
Sc4: Tunnelling (Outside Standard Hours) (Night)

Revision
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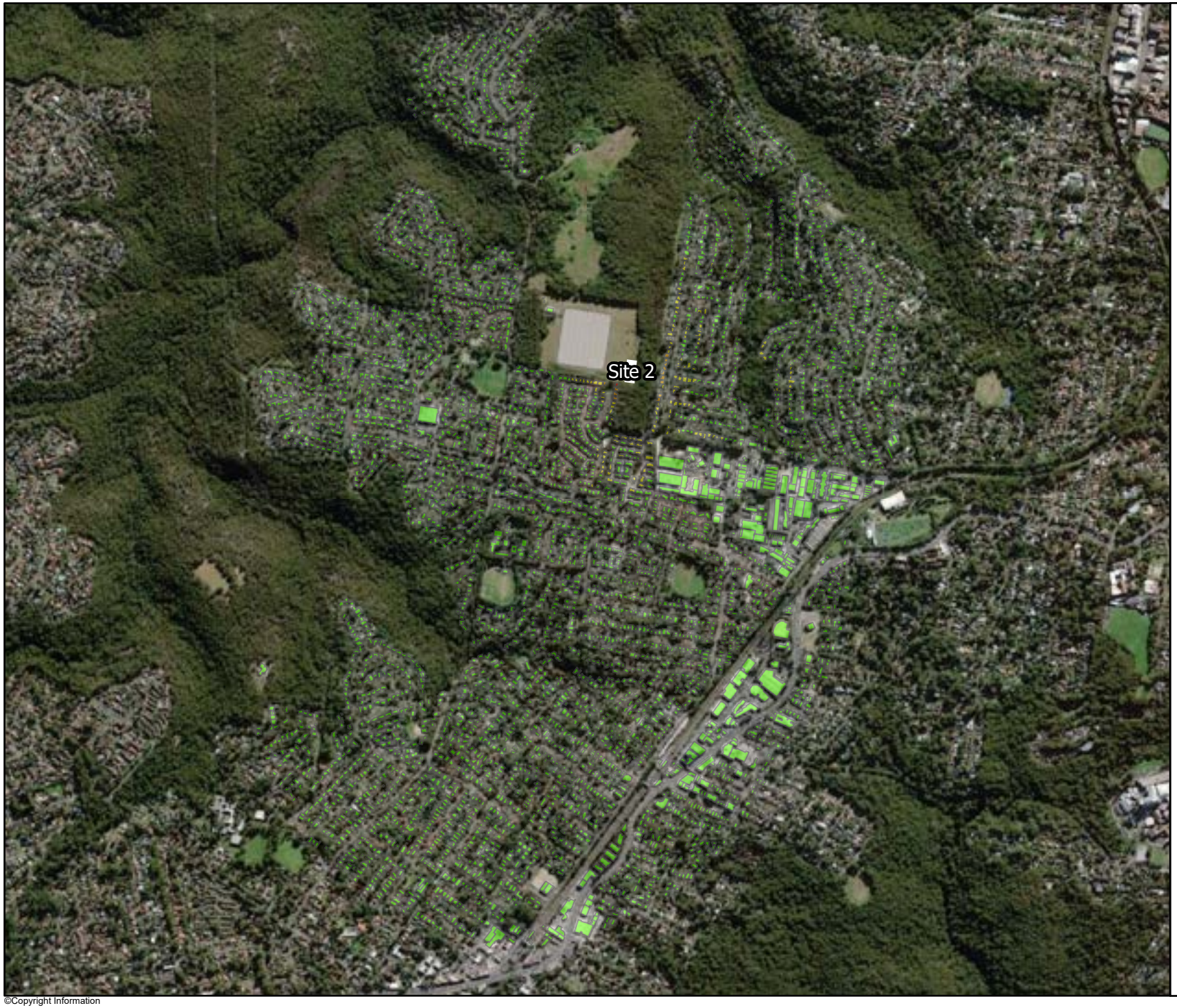
F.5 Scenario 4: Tunnelling (Airborne noise) (Outside Standard Hours (Night)) – MITIGATED

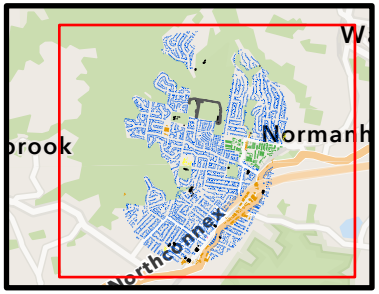
Timeframe: Month 5-14 (refer to Table 2)



Legend

Compliance at receiver

- Compliant
- <=NML + 10dB
- <=NML + 20dB
- <=NML + 30dB
- <=NML + 40dB
- >=NML + 40dB
- Highly noise affected



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ARUP

Client
Sydney Water

Job No
269002

Project
Thornleigh - Inlet/Outlet Main Construction

Map Title
Sc4: Tunnelling (Outside Standard Hours) (Night) Mitigated

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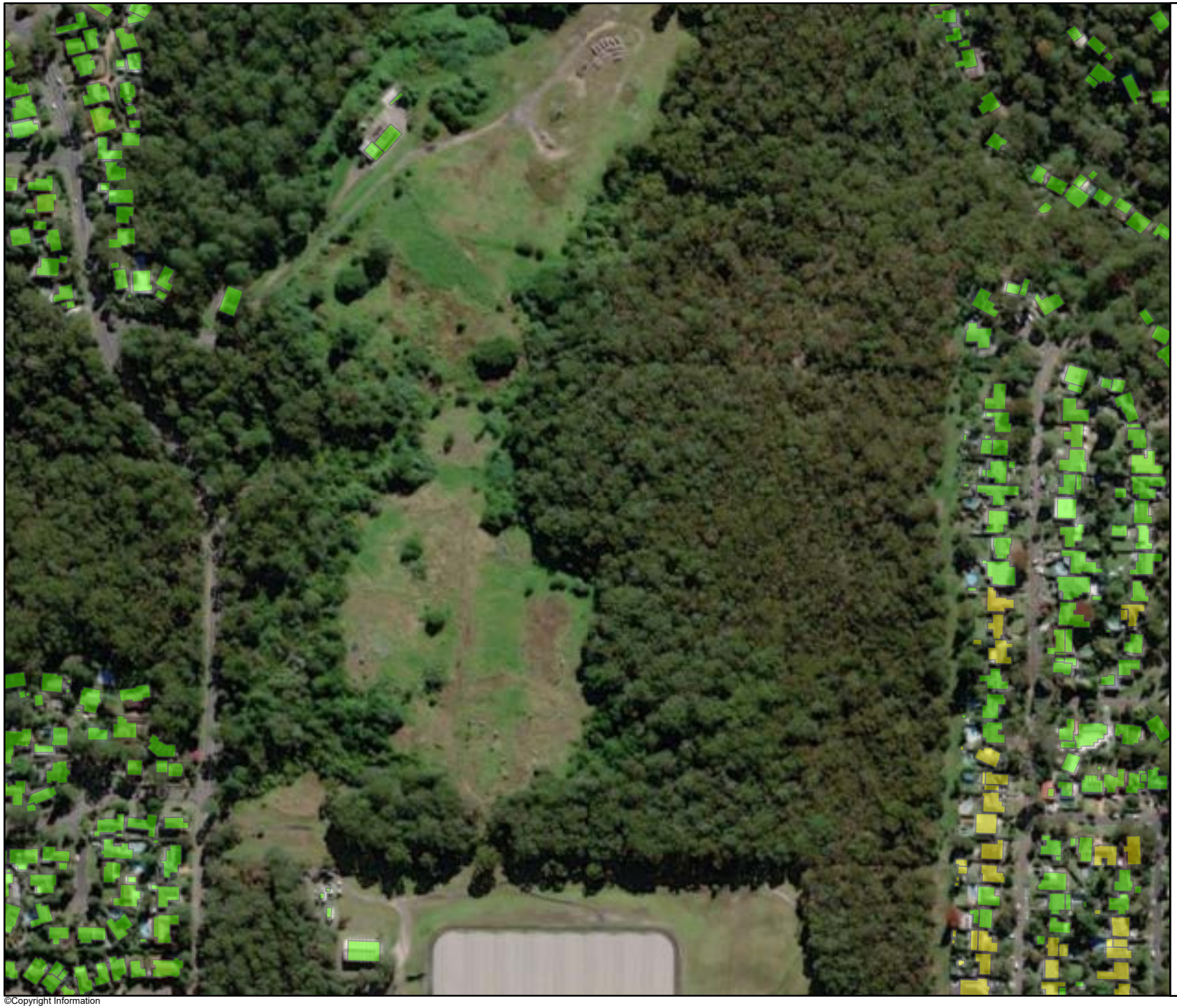

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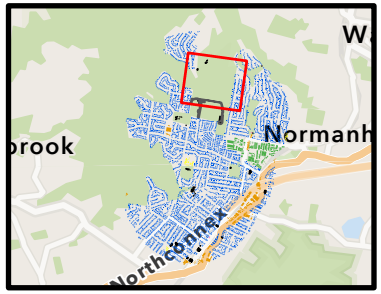

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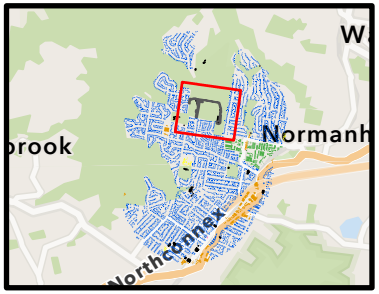

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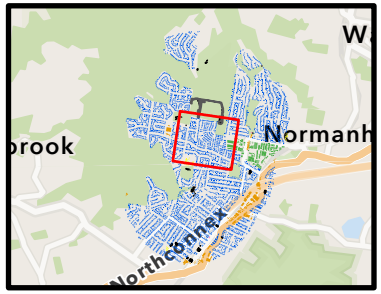

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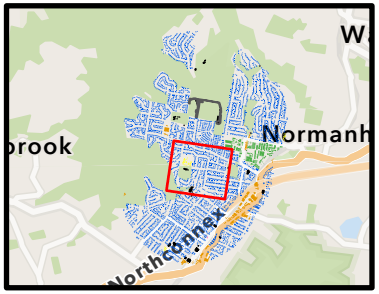

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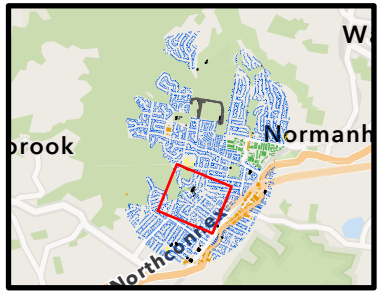

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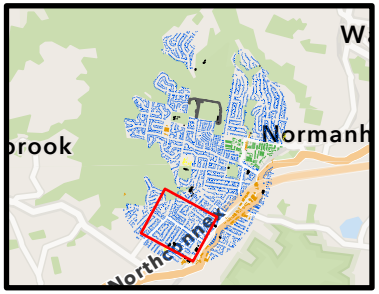

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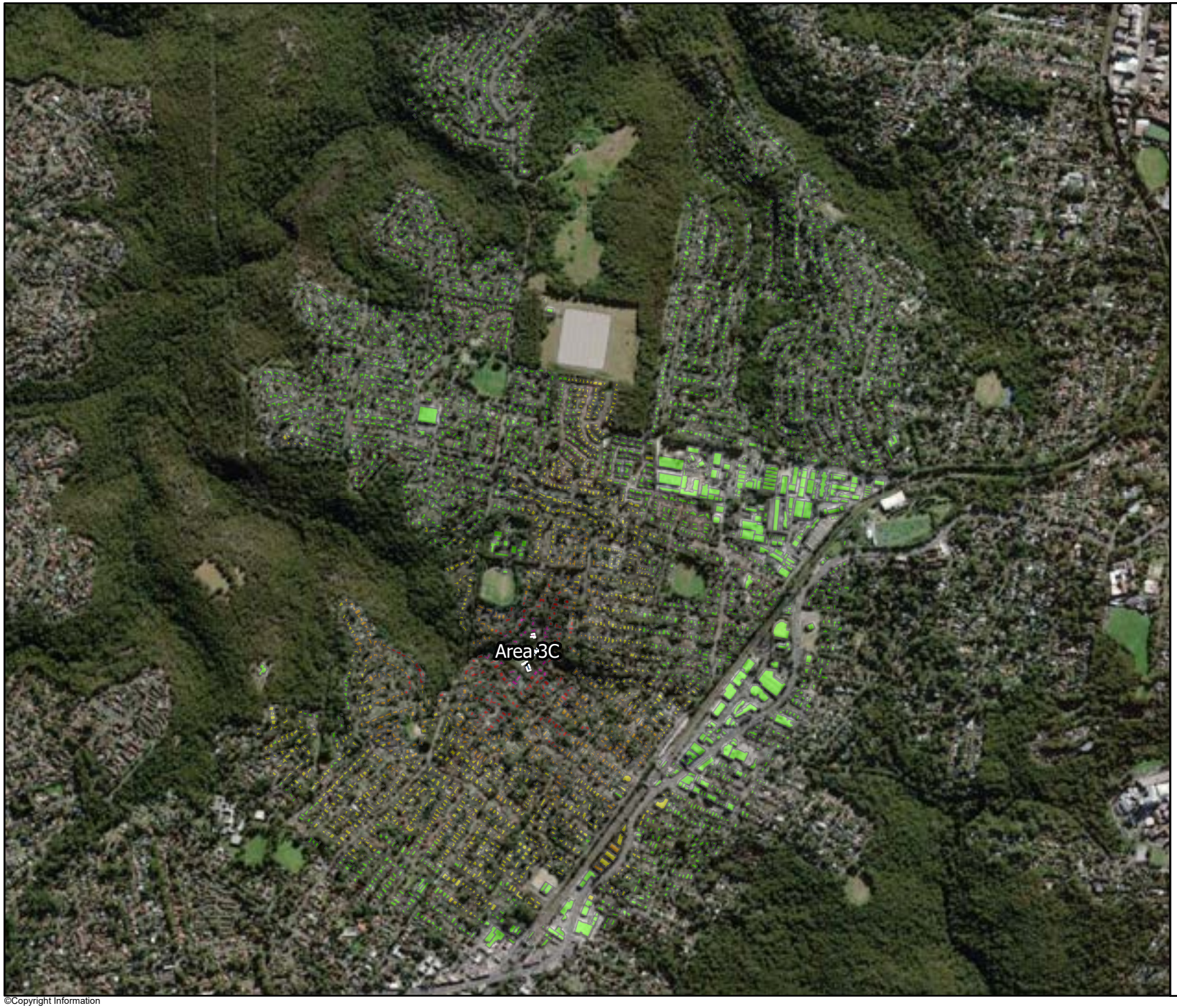
F.6 Scenario 6b: Pipework (Airborne noise) (Outside Standard Hours (Night))

Timeframe: 12 nights only of work during Month 3-22 (refer to Table 2)



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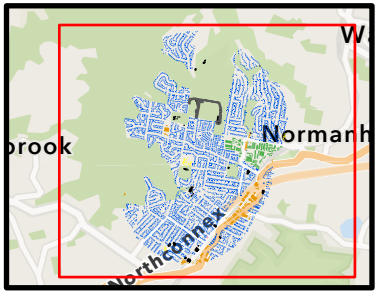

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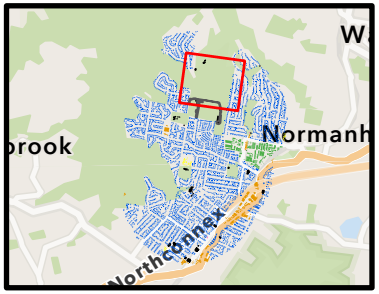

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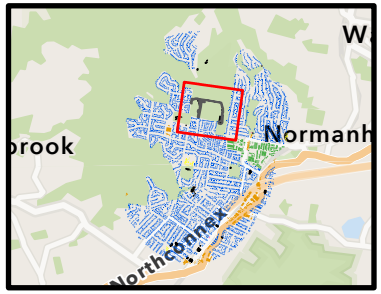

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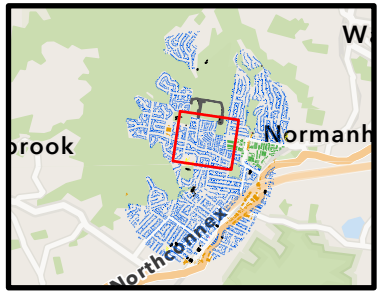

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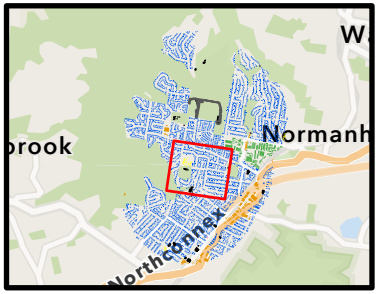

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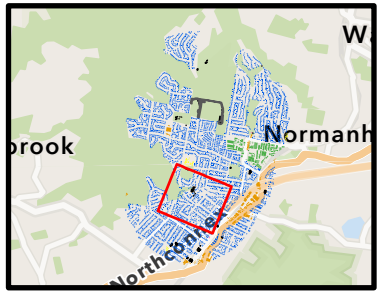

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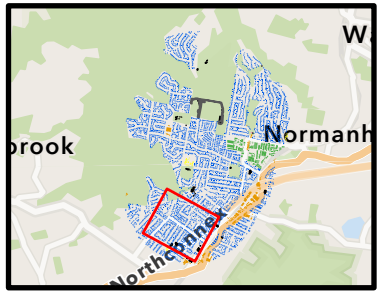

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Appendix G – Specialist study (traffic and transport)

27 June 2023

Thornleigh Inlet / Outlet Main: Construction Impact

Traffic and Transport Impact Assessment

aurecon ARUP

Document Verification

Revision	Date	Document			
Draft 1	7 Dec 2022	Filename	2022 12 07 Thornleigh Inlet REF Draft V1		
		Description	First draft		
			Prepared by	Checked by	Approved by
		Name	Matthew Hanania	Bryony Vaughan	Sam Oswald
Draft 2	1 Feb 2023	Filename	2023 02 01 Thornleigh Inlet REF Final		
		Description	Second draft		
			Prepared by	Checked by	Approved by
		Name	Matthew Hanania	Bryony Vaughan	Bryony Vaughan
Draft 3	13 Feb 2023	Filename	2023 02 13 Thornleigh Inlet REF Final		
		Description	Third draft		
			Prepared by	Checked by	Approved by
		Name	Matthew Hanania	Bryony Vaughan	Bryony Vaughan
Final	27 June 2023	Filename	2023 06 27 Thornleigh Inlet REF Final		
		Description	Final		
			Prepared by	Checked by	Approved by
		Name	Matthew Hanania	Bryony Vaughan	Bryony Vaughan

Table of Contents

Report Structure & Glossary

The chapter structure and associated content is outlined in Table 1.

Table 1: Content and chapter structure

Chapter	Content
Introduction	Outlines the project description, purpose of this document and relevant legislation and policy.
Methodology	Sets out the methodology used to assess the transport impacts of the project on the surrounding environment during construction.
Existing environment	Details the existing environment surrounding the project. Several modes of transport are addressed in this section, including private vehicles, public transport, cycling and walking. This chapter also highlights any future infrastructure schemes that need to be considered as part of this study.
Transport impact assessment	The impact assessment uses the methodology outlined in chapter two to assess any impacts of the project during construction. This chapter assesses the impacts upon several modes, including private vehicles, public transport, cycling and walking. Key impacts are defined at the end of this chapter.
Proposed mitigation measures	Following the identification of any key issues, mitigation measures during construction are presented. These mitigation measures are proposed to reduce the impacts of the construction phase on the surrounding transport network.

Glossary of Terms and Abbreviations	
Term	**Meaning**
AADT	Annual Average Daily Traffic
CBD	Central Business District
HV	Heavy vehicle
km	Kilometre
km/h	Kilometres per hour
LV	Light vehicle
NSW	New South Wales
REF	Review of Environmental Factors
ROL	Road Occupancy Licence
TBM	Tunnel boring machine
TfNSW	Transport for NSW
The project	Thornleigh Inlet / Outlet Main
TTIA	Traffic and Transport Impact Assessment

1 Introduction

Arup was appointed by Sydney Water under the Arup Aurecon Integrated Planning Partnership to provide traffic and transport services to support the development of the Alignment Optioneering Memorandum and Review of Environmental Factors (REF) for the construction of a new inlet / outlet main from Thornleigh Reservoir (WS0148) to Thornleigh-Wahroonga water pumping station (WP0159).

1.1 Background & Context

The Epping to St Leonards project addresses infrastructure requirements (new and upgrades) to service significant growth in the Prospect Water System. The Prospect Water System is the largest and most central Water Supply System in the Greater Sydney Metropolitan area. It comprises of five interconnected Water Delivery Systems: Prospect North, Prospect East, Prospect South, Ryde and Potts Hill.

This project is Package 2 of the wider Epping to St Leonards program of works. Package 2 seeks to provide more system resilience and operation flexibility through a new DN1800 inlet / outlet main from Thornleigh Reservoir (WS0148) to Thornleigh-Wahroonga water pumping station (WP0159). Furthermore, the package also seeks to improve water quality in WS0148 by improving water circulation and giving operators more flexibility in filling / emptying cycles of the reservoir.

A previous assessment was undertaken to assess the preferred aligned options being considered for the project.

Option A1 was chosen as the preferred pipe alignment based on consideration of constructability, hydraulics, and community impacts. It was also found option A1 would have a low impact on the surrounding vegetation and on the surrounding network from a traffic and transport perspective.

1.2 Document Purpose

This Traffic and Transport Impact Assessment (TTIA) has been developed to assess the preferred alignment option (A1) and identify mitigation measures to be implemented during construction to address the impacts identified.

1.3 Legislative and Policy Context

The legislation and policy included in Table 2 has been considered as part of this TTIA.

Table 2: Legislation and policy

Legislation and policy relevant to the TTIA option assessment report		
Legislation/Policy	**Description**	**Relevance**
Guide to Traffic Generating Developments (RTA, 2002)	The Guide examines how to assess traffic generating developments and identify impacts upon the wider transport network. The level of assessment can vary depending on the type of development.	This project will generate traffic relating to construction works. Therefore, this Guide has been used as it provides the appropriate methodology for assessing all types of traffic generating development.

Legislation and policy relevant to the TTIA option assessment report		
Guide to Traffic Management Part 12: Integrated Transport Assessments for Developments (Austroads, 2020)	The document guides planners and engineers who design, develop and manage a variety of land use developments in identifying and managing the impacts on the transport network arising from these developments.	This project is a traffic generating development. Therefore, this Guide has been used as it provides the appropriate methodology for assessing all types of traffic generating developments.

2 Methodology

2.1 Methodology structure

To assess the impact of the project on the transport and traffic network, the following methodology has been used:

- Review available data and documentation to understand the transport requirements of the project in construction.
- Review other infrastructure schemes that overlap with the programme for the project and their likely cumulative impact on the surrounding road network.
- Liaise with the Sydney Water project team to derive robust assumptions for the traffic generation of the project in construction.
- Identify key routes to be used by construction vehicles and assess the potential traffic impacts.
- Identify any impacts to public transport, walking and cycling.
- Classify the significance of all identified impacts.
- Develop mitigation measures to manage the identified impacts.

2.2 Project location

Thornleigh Reservoir (DP1217395 Lot 100) and Thornleigh-Wahroonga water pumping station (Lot 1/DP535665) is located in Westleigh and Thornleigh, respectively. These suburbs are located approximately 21 km northwest of the Sydney CBD. A locality plan showing the aerial view of the project location and site surrounds are provided in Figure 1.

Figure 1 Project location (Aerial Sourced from Nearmap 2022)

3 Existing Environment

3.1 Existing Road Network

Thornleigh Reservoir is linked to the wider road network via a sealed access road from Quarter Sessions Road (shown in Figure 2). Access is to be maintained at all times along Quarter Sessions Road as it is the only evacuation route out of Westleigh in the event of a bushfire. The access road is to be widened to approximately 6 m throughout.

Figure 2 Thornleigh Reservoir (WS0148) primary access road intersection with Quarter Sessions Road (Sourced from Google Maps Street View 2022)

Quarter Sessions Road is a two-way two-lane collector road that links residential developments to the north and De Saxe Close to the south. Key features of this section of road are described below:

- Parking lanes in both directions between Gum Blossom Drive and De Saxe Close and only in the northbound direction north of Gum Blossom Drive.
- Approximately 10 m wide (kerb to kerb).
- Provides direct residential access to properties.
- Pedestrian crossing (zebra) south of intersection with Duneba Drive, providing access to Thornleigh West Public School.
- 40 km/h school zone (8:00 am to 9:30 am and 2:30 pm to 4:00 pm) between north of Duffy Avenue intersection and the Oakleigh Oval Access Road, otherwise 50 km/h.
- Footpath provided along the northbound kerb north of Duffy Avenue and along both sides south of Duffy Avenue.

The Thornleigh-Wahroonga water pumping station is bounded to the east and west by low density residential housing with vehicle access provided off Dale Close to the south (Figure 3). Dale Close is a cul-de-sac local residential access road with unrestricted kerbside parking on both sides of the road. Dale Close is approximately 7.3 m wide and connects to Morgan Street at the southern end. There are no formal pedestrian or cyclist facilities provided on either side of Dale Close.

Figure 3 Thornleigh-Wahroonga water pumping station (WP0159) vehicle access road intersection with Dale Close (Sourced from Google Maps Street View 2022)

Pedestrian access is provided on the northern end of the Thornleigh-Wahroonga water pumping station via Edmundson Close (Figure 4), which connects further south to Dale Close. Edmundson Close is a cul-de-sac that connects to Giblett Avenue at the northern end. The road is narrow (approximately 6.0 m to 6.5 m wide) and allows for on-street parking for residents. No formal pedestrian or cyclist facilities are provided along the road.

Figure 4 Thornleigh-Wahroonga water pumping station (WP0159) pedestrian access intersection with Edmundson Close (Sourced from Google Maps Street View 2022)

The following roads have been analysed within this report due to the vehicular impact associated with the construction of the Thornleigh-Wahroonga water pumping station.

3.1.1 Giblett Avenue

Giblett Avenue is a local street running east-west between Nicholson Avenue at the eastern extent and ends at the western extent at Thornleigh West Public School. Key features of the road include:

- Connects to Thornleigh West Public School car park and access at the western extent of the road.
- Pedestrian link to Oakleigh Oval, no vehicular access.
- 40 km/h school zone (8:00 am to 9:30 am and 2:30 pm to 4:00 pm) west of Edmundson Close.
- Two-way two-lane sealed road approximately 8 m wide.
- On-street parking for residential properties allowed.
- Footpath available along the northern side of the road.

3.1.2 Sefton Road

The collector road portion of Sefton Road between Bryan Avenue and Knox Place has a posted speed limit of 60 km/h. The local road portion of Sefton Road between the south-eastern extent of the Thornleigh Reservoir site and Bryan Avenue has a posted speed limit of 50 km/h. Sefton Road provides access to other minor streets and direct access to residential properties. The road is approximately 10 m wide and allows for on-street parking for residents. Footpaths are provided along the southern and western sides of the road.

3.1.3 Duffy Avenue

Duffy Avenue is a collector road and the extents potentially impacted by the project include the section between Quarter Sessions Road and Pennant Hills Road. The road runs east-west and is one of the major accesses to Pennant Hills Road. It is a two-way two-lane road with approximately 2.5 m wide shoulders used for on-street parking but also line marked as bicycle lanes. Footpaths are also available along both sides of the road. The road is posted as 50 km/h, with the exception of the western extent approaching Quarter Sessions Road marked as a school zone i.e., 40 km/h. The road cross-section is approximately 9.5 m to 10 m wide and allows for on-street parking within the formalised shoulders.

3.1.4 Yarrara Road

Yarrara Road is a collector road running parallel to the Sydney Train rail corridor that provides a connection between Pennant Hills Road and The Esplanade to the northeast end of the road. Just off of Pennant Hills Road, Yarrara Road has a posted speed limit of 40 km/h due to high pedestrian activity associated with the commercial, retail and public transportation uses. Further north, the speed limit is 50km/h. The road cross-section is approximately 7 m wide and allows for on-street parking within the formalised shoulders.

3.1.5 Pritchard Street

Pritchard Street is a local road connecting Tillock Street at its western end and Yarrara Road at its eastern end. Pritchard Street has a posted speed limit of 50km/h and 3P (Monday to Friday, 8:30 am–6pm) parking restrictions on both sides of the road east of Lovett Street with unrestricted kerbside parking elsewhere on the street.

3.1.6 Tillock Street

Tillock Street is a local road bounded by Pritchard Street and Eddy Street with unrestricted kerbside parking on both sides of the road and a posted speed limit of 50km/h.

3.1.7 Morgan Street

Morgan Street is a local road bounded by Pritchard Street and Eddy Street with unrestricted kerbside parking on both sides of the road and a posted speed limit of 50km/h.

3.1.8 Eddy Street

Eddy Street is a local road bounded by Tillock Street and Yarrara Road with a No Parking restriction (Monday to Friday, 8am – 10:30am) on the southern side of the road just east of Janet Avenue. Eddy Street has a posted speed limit of 50km/h.

3.1.9 Sinclair Avenue

Sinclair Avenue is a local road bounded by Duffy Avenue and Oakleigh Avenue with unrestricted kerbside parking on both sides of the road and a posted speed limit of 50km/h.

3.1.10 Barrett Avenue

Sinclair Avenue is a local road bounded by Nicholson Avenue and Sinclair Avenue with unrestricted kerbside parking on both sides of the road and a posted speed limit of 50km/h.

3.1.11 Nicholson Avenue

Nicholson Avenue is a local road bounded by Quarter Sessions Road and Wanawong Drive with unrestricted kerbside parking on both sides of the road and a posted speed limit of 50km/h.

The wider road network within and surrounding the study area as defined by the general road network and proposed construction routes is shown in Figure 5.

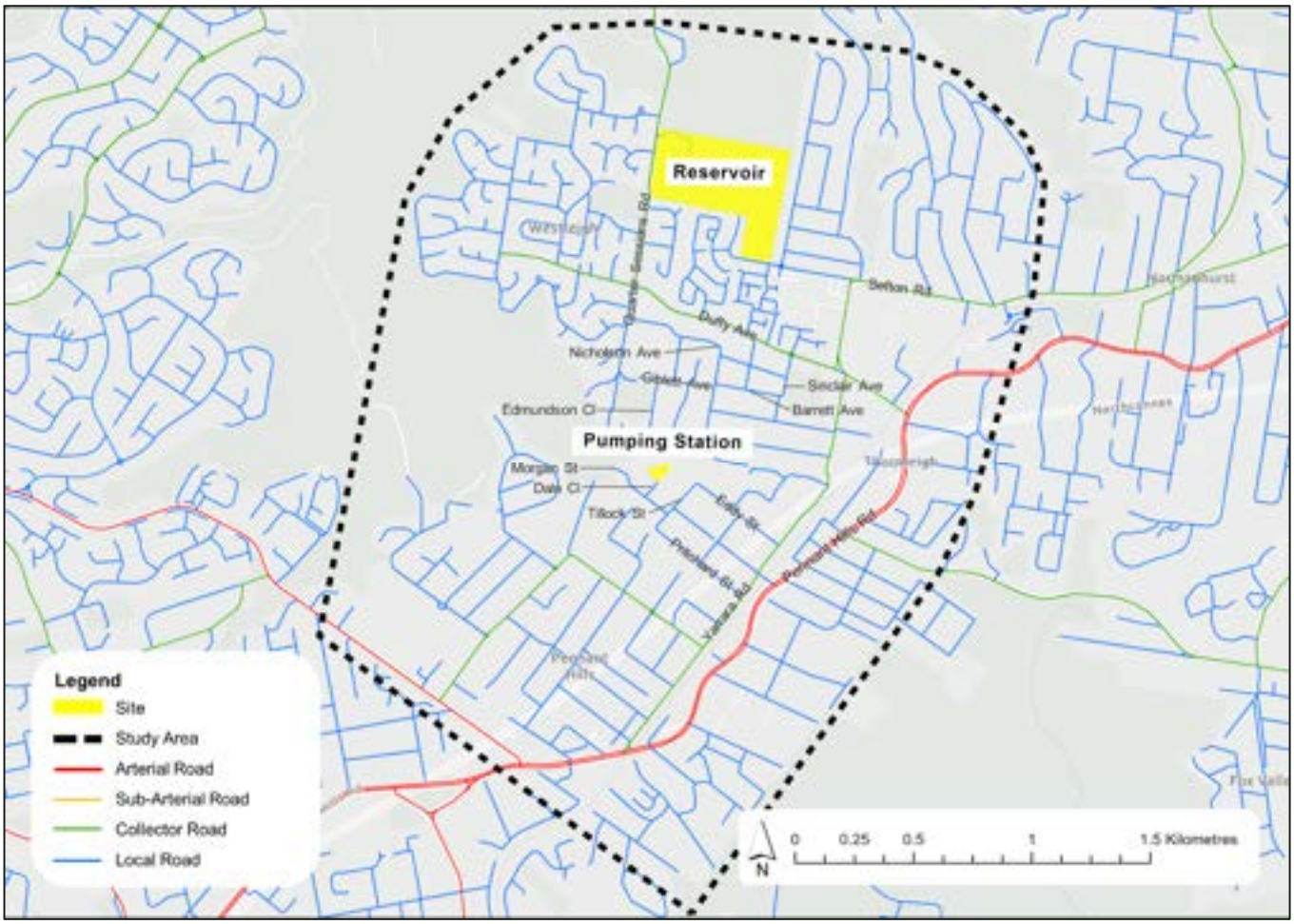


Figure 5 Road network surrounding the study area

3.2 Public Transport

Thornleigh Station is the closest train station to the study area and is located approximately 1.7 kilometres and 600 metres to the southeast from the Thornleigh Reservoir and Thornleigh-Wahroonga water pumping station, respectively. Hornsby Station is located approximately 2.6 km and 3.6 km to the northeast from the Thornleigh Reservoir and Thornleigh-Wahroonga water pumping station, respectively.

Thornleigh Station is served by the T9 – Northern Line providing direct connections to Epping, Strathfield, Central and Chatswood. Hornsby Station is serviced by the T1 – North Shore Line and provides a connection to Chatswood, Central, Strathfield and Parramatta. Both stations are serviced at 15-minute intervals during peak times (Monday to Friday, 6:30 – 10 am and 3 – 7pm).

Several bus stops are located near Thornleigh Reservoir on Quarter Sessions Road and Corang Road (approximately 80-120 m north of the access). Thornleigh-Wahroonga water pumping station is served by a single bus stop located on Goodlands Avenue approximately 250 m northeast of the pumping station.

A summary of bus routes is shown in Table 3. A summary of the public transport network is shown in Figure 6.

Several dedicated school bus routes serve the surrounding schools including Pennant Hills High School, Thornleigh West Public School and Normanhurst West Public School. A summary of the school bus network is shown in Figure 7.

Table 3: Bus routes within the study area of the project

Bus Route Details			
Route No.	**Description**	**Frequency**	**Relevant Stops**
586	Westleigh to Pennant Hills	15 buses (bidirectional), 6 am – 7 pm, Monday to Friday	Quarter Sessions Road Corang Road Duffy Avenue Goodlands Avenue
587	Hornsby to Westleigh (Loop Service)	26 buses, 6 am – 9 pm, Monday to Friday 10 buses, 8 am – 6 pm, Saturday 6 buses, 8:30 am – 6:30 pm, Sunday and Public Holidays	Quarter Sessions Road Duffy Avenue Sefton Road
588	Hornsby to Normanhurst West (Loop Service)	22 buses, 6 am – 7:30 pm, Monday to Friday 10 buses, 8 am – 5:30 pm, Saturday 5 buses, 10 am – 6 pm, Sunday and Public Holidays	Sefton Road Kooringal Avenue

N80	City Town Hall to Hornsby via Strathfield	10 buses (bidirectional), 12:00 am – 6 am, Monday to Sunday and Public Holidays	Duffy Avenue Chilvers Road Sefton Road
8029	Duffy Av before Sinclair Av, Thornleigh to Waitara PS via Westleigh	1 bus, 7:55 am – 9:13 am, Monday to Friday	Giblett Avenue Quarter Sessions Road
8004	Wahroonga Station to Pennant Hills HS via Thornleigh	1 bus, 8:03 am – 8:46 am, Monday to Friday	Duffy Avenue
8024	Barker College Junior School to Thornleigh West PS via Pennant Hills	1 bus, 7:47 am – 8:55 am, Monday to Friday	Giblett Avenue
9040	Normanhurst West PS to Thornleigh Station via Westleigh	1 bus, 2:59 pm – 3:21 pm, Monday to Friday	Giblett Avenue

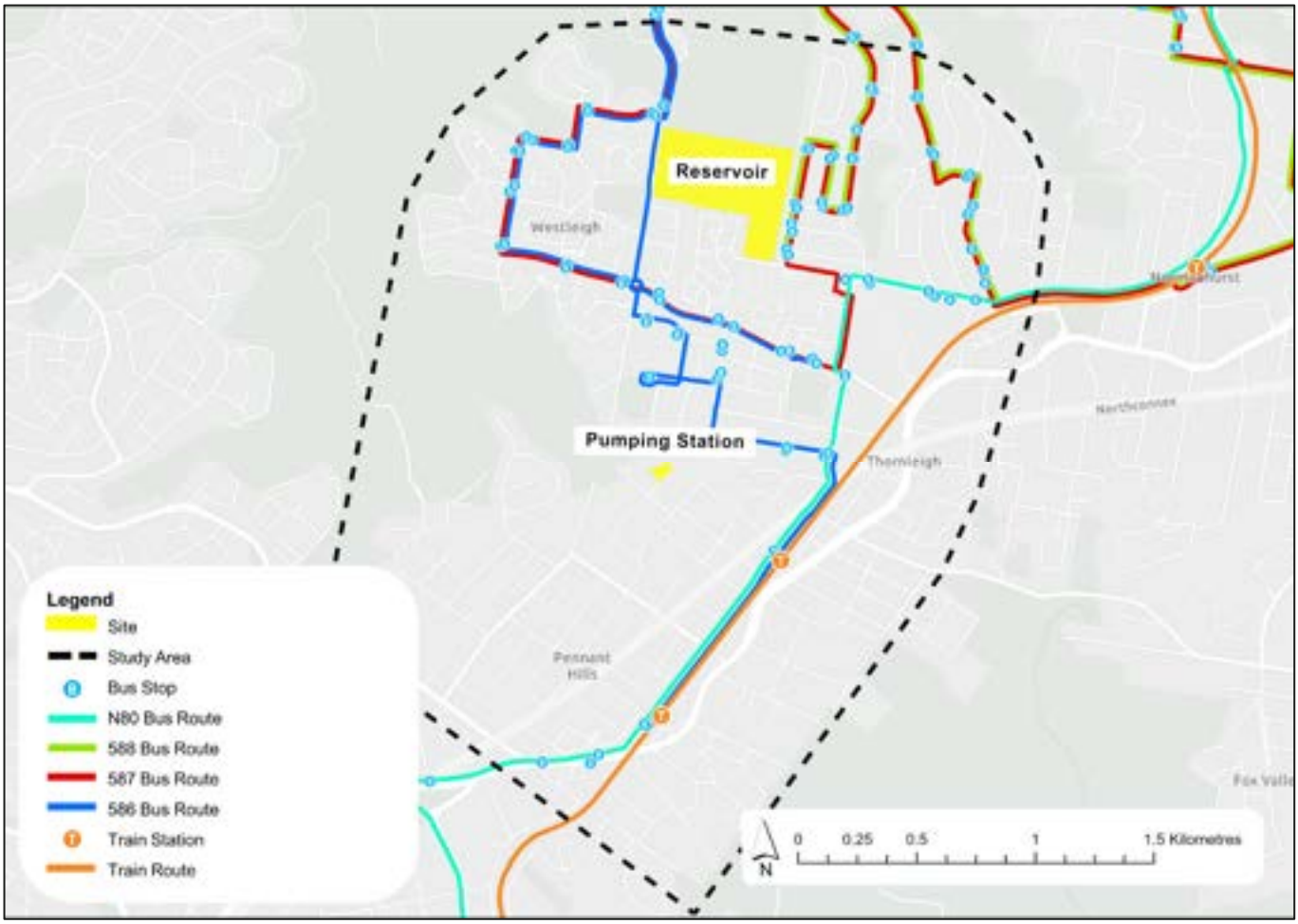


Figure 6 Public transport network

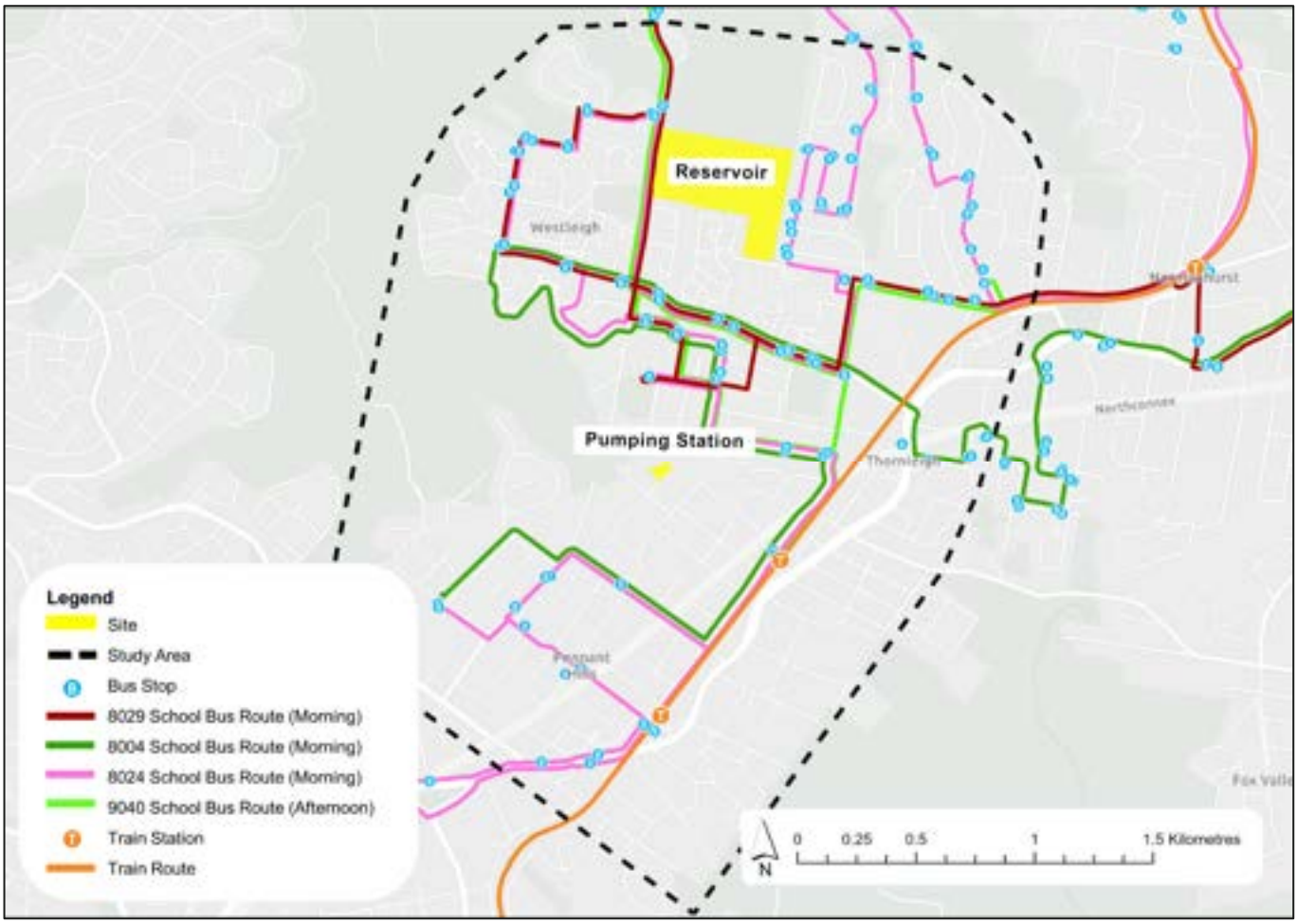


Figure 7 School bus network

3.3 Active Transport

Given the residential nature of the land uses surrounding the site, pedestrian and vehicle volumes are low on the surrounding streets. Footpaths are provided on western side of Quarter Sessions Road and northern side of Giblett Avenue. Footpaths are not provided on the eastern side of Quarter Sessions Road, Dale Close and Edmundson Close. In these cases, pedestrians are required to walk on the carriageway or road shoulders.

An off-road unsealed walking track is provided through the Thornleigh-Wahroonga water pumping station from Edmundson Close to Dale Close over Zig Zag Creek.

The cycling network surrounding the site is shown in Figure **8**.

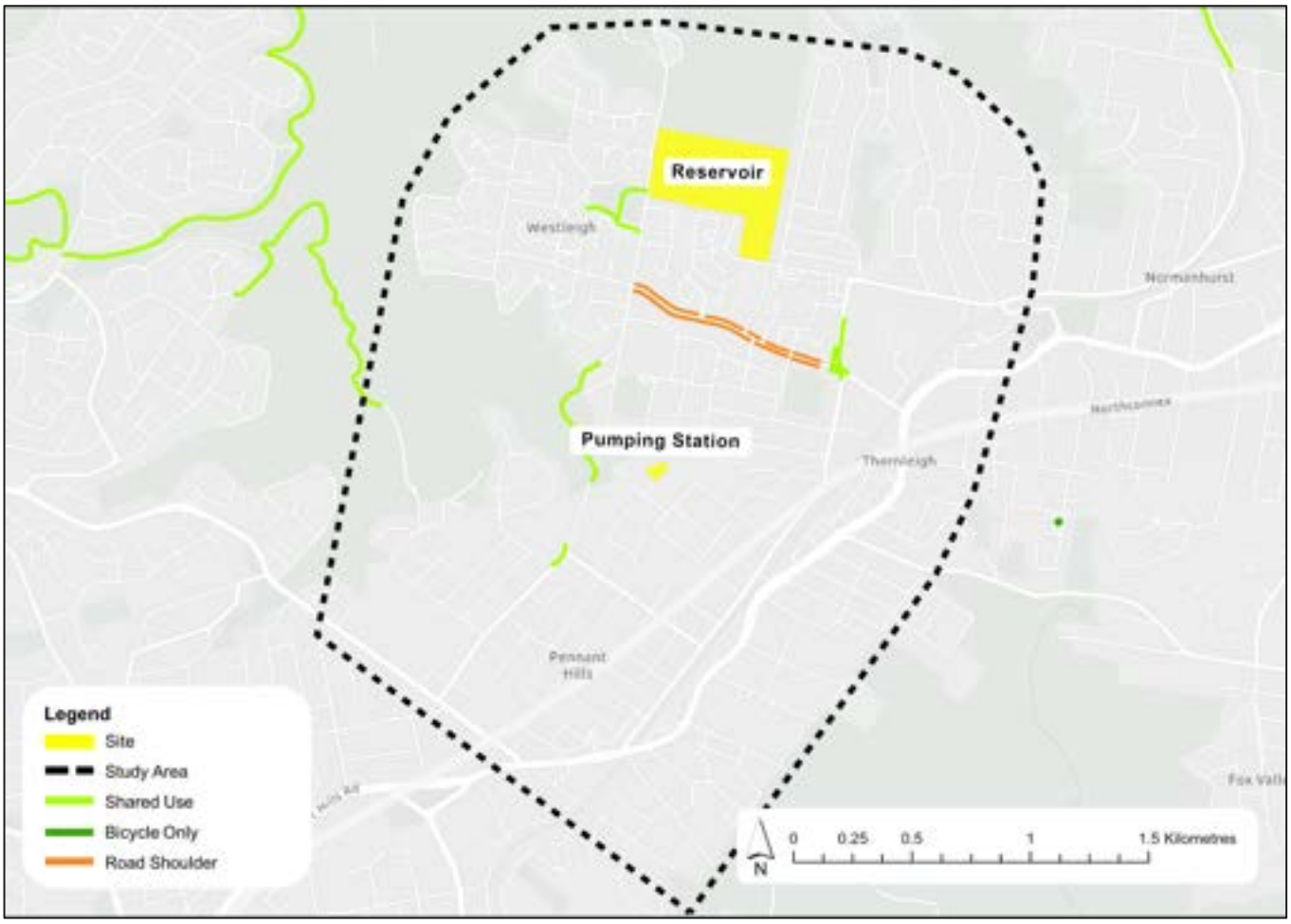


Figure 8 Cycling network around the study area (Source: Cycleway Finder, Transport for NSW, 2022)

3.4 Other infrastructure schemes

Several infrastructure schemes are planned or ongoing in the study area. Where publicly available information was available on the expected transport impact of these schemes they have been considered within this assessment. Those schemes which will be fully constructed by the time Thornleigh Inlet is constructed have been excluded.

3.4.1 Thornleigh Station Upgrade

The NSW government is currently undertaking upgrades of Thornleigh Station as part of the Transport Access Program and is expected to be completed in 2023 (TfNSW, 2022). Benefits of this upgrade include:

- Three new lifts to provide access to the station platforms
- Weather protection screens and canopies at the lift entries
- Improved access to the waiting rooms
- A new family accessible toilet and unisex ambulant toilet
- Upgrades to the bus stop and seating on The Esplanade
- New accessible pedestrian pathways throughout the station and entrances

- Upgrades to the existing accessible parking spaces in the commuter car park
- A new accessible parking space and kiss and ride area on Railway Parade
- New bicycle hoops
- New canopy coverage over the Boarding Assistance Zone on Platform 3
- Improvements to CCTV, lighting and wayfinder signage
- Electrical upgrades to accommodate new infrastructure
- Modifications to existing stairs
- New stairs on Railway Parade walkway connecting to the existing station footbridge.

It is understood that impacts are limited to the immediate vicinity of Thornleigh Station including, temporary removal of parking spaces on Railway Parade and The Esplanade, footpath changes, relocation of a bus stop on The Esplanade. Construction is expected to be completed in mid-2023 and is not expected to significantly impact the construction of the Project.

3.4.2 Westleigh Park

Westleigh Park is located to the immediate north of the Thornleigh Reservoir as depicted in Figure 9. The site was formerly owned by Sydney Water.

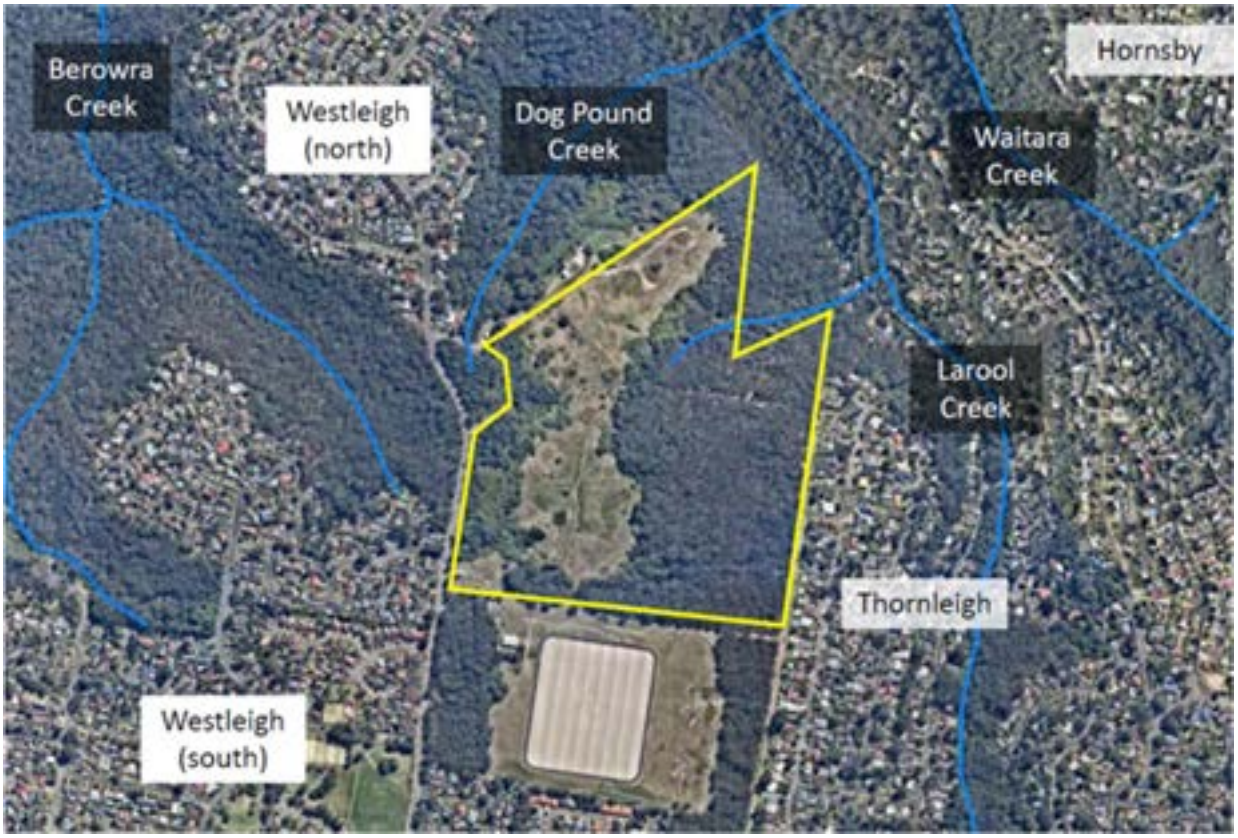


Figure 9 Westleigh Park Locality Plan (Source: Draft Westleigh Park Master Plan Document, Hornsby Shire Council)

3.4.3 Westleigh Park Draft Master Plan

Hornsby Shire Council has sought to develop a sustainable plan for community use of the site known as Westleigh Park and has developed a draft Master Plan. The potential facilities include multi-use sporting fields for various organised sports and provision of playground(s) and passive recreation.

The key aspects of the master plan from an access, circulation and parking perspective area as follows:

- A new roundabout at the northern intersection of Warrigal Drive with Quarter Sessions Road
- Conversion of the southern section of Warrigal Drive to a one-way egress road to Warrigal Drive
- A new access point from Quarter Sessions Road located along the southern boundary of the site
- Possibility of future road access to Sefton Road through the Sydney Water site
- 350 car parking spaces located across the subject site
- Improved pedestrian and cycle access via shared pedestrian/cycle paths along the new access roads.

From discussions with the Thornleigh Inlet / Outlet Main project team, we understand that Quarter Sessions Road will provide primary access to Thornleigh Park and that the Sefton Road extension is still subject to discussions with Sydney Water.

3.4.4 Westleigh Park Traffic Study

A Traffic and Access Assessment Report for the Westleigh Park development was prepared for Hornsby Shire Council by Positive Traffic Pty Ltd in December 2019. The report was reviewed and extracts of key findings of the report relevant to this study are listed below:

- The intersection of Duffy Avenue / Chilvers Road / The Esplanade currently operates near capacity on weekdays during the PM peak period.
- The intersection of Sefton Road / Larool Crescent currently operates at a poor level of service during both the AM and PM weekday peak periods due to high delays for right turn exiting traffic.

4 Transport Impact Assessment

Construction impacts on road network performance, parking and access, public transport and active transport are detailed below. The chosen pipe alignment A1 covers a tunnelled distance of 1.18 km and trenched distance of 0.17 km, totalling 1.35 km.

All impacts have been classified as outlined in Table 4.

Table 4 Impact classifications

Impact classification	Description
Low	Minimal impact with low frequency
Medium/moderate	Likely impacts to the transport network; however, generally more localised. Recommended that these impacts be monitored prior to the implementation of mitigation measures
High	Frequent impacts which may cover larger areas of the transport network. Will require further mitigation measures

4.1 Construction Methodology

Construction is expected to take approximately two years with drilling occurring for approximately six months. A launch shaft for the TBM is expected to be located in the southeast corner of the reservoir site with a generally straight alignment tunnel connecting to a receival shaft in the pumping station site. A spoil stockpile is expected to be located within the reservoir site in addition to a stockpile of jacking and carrier pipe taking an area of approximately 4,800m^2. A site compound including an acoustic shed (as determined by specialist noise and vibration assessment) with associated access roads and manoeuvring areas is required.

Current understanding of the construction methodology and techniques is subject to change as determined by the contractor / tunnelling specialist.

4.2 Construction hours

Proposed construction is expected to start early 2024, and typical construction activities such as deliveries, spoil removal, trenching and placement would be undertaken during standard daytime hours as much as possible:

- Monday to Friday: 7:00 am to 6:00 pm
- Saturday: 8:00 am to 1:00 pm
- Sundays or public holidays: No work permitted

TBM operation will occur 24/7 to prevent the TBM being exposed to large frictional forces. Any works outside of agreed construction hours will occur during the night, deliveries, spoil removal and placement paused and will occur towards the end of the construction program.

An Out of Hours Permit is required to carry out work on building sites outside normal permitted times.

4.3 Indicative construction vehicle access routes

For both sites potential routes have been developed for construction traffic from the nearest arterial route, being Pennant Hills Road. Arterial routes are typically roads of significant traffic volume connecting regional roads (collectors) to local roads. This exercise considered the vehicle types, suitability of surrounding roads and access points to each site. Where possible, construction vehicle routes have been designed to minimise passing sensitive areas such as schools.

It should be noted, trucks and buses (over 12.5 metres long or 2.8 metres clearance height) travelling between the M1 and M2 are banned from using Pennant Hills Road and must use NorthConnex. However, an exemption is granted to trucks and buses if they have a genuine delivery or pick up destination only accessible via Pennant Hills Road.

From the arterial road network (Pennant Hills Road), vehicles accessing the Thornleigh-Wahroonga water pumping station (WP0159) would travel along Yarrara Road and turn left onto Eddy Street, Tillock Street and right onto Morgan Street and Dale Close. Access to the Thornleigh-Wahroonga water pumping station via Edmundson Close would be provided through Pennant Hills Road, Duffy Avenue, Sinclair Avenue, Barrett Avenue, Nicholson Avenue and Giblett Avenue. Edmundson Close access is preferred due to the size of the cul-de-sac accommodating tighter turning circles. Alternative routes from Pennant Hills Road via Wells Street were not chosen due to an increase in the number of turns required as well as tighter turning requirements onto Wells Street.

From the arterial road network (Pennant Hills Road), vehicles accessing the Thornleigh Reservoir (WS0148) would turn left onto Duffy Road then right onto Quarters Sessions Road.

It should be noted that the section of Yarrara Road just north of Fulbourne Avenue has a 3 tonne and over truck limit, however, it is not possible to enter the site without encroaching on Yarrara Road. As a result, Council approval must be sought.

The proposed construction vehicle routes to and from Thornleigh-Wahroonga water pumping station and Thornleigh Reservoir are shown in Figure 10 and Figure 11, respectively.

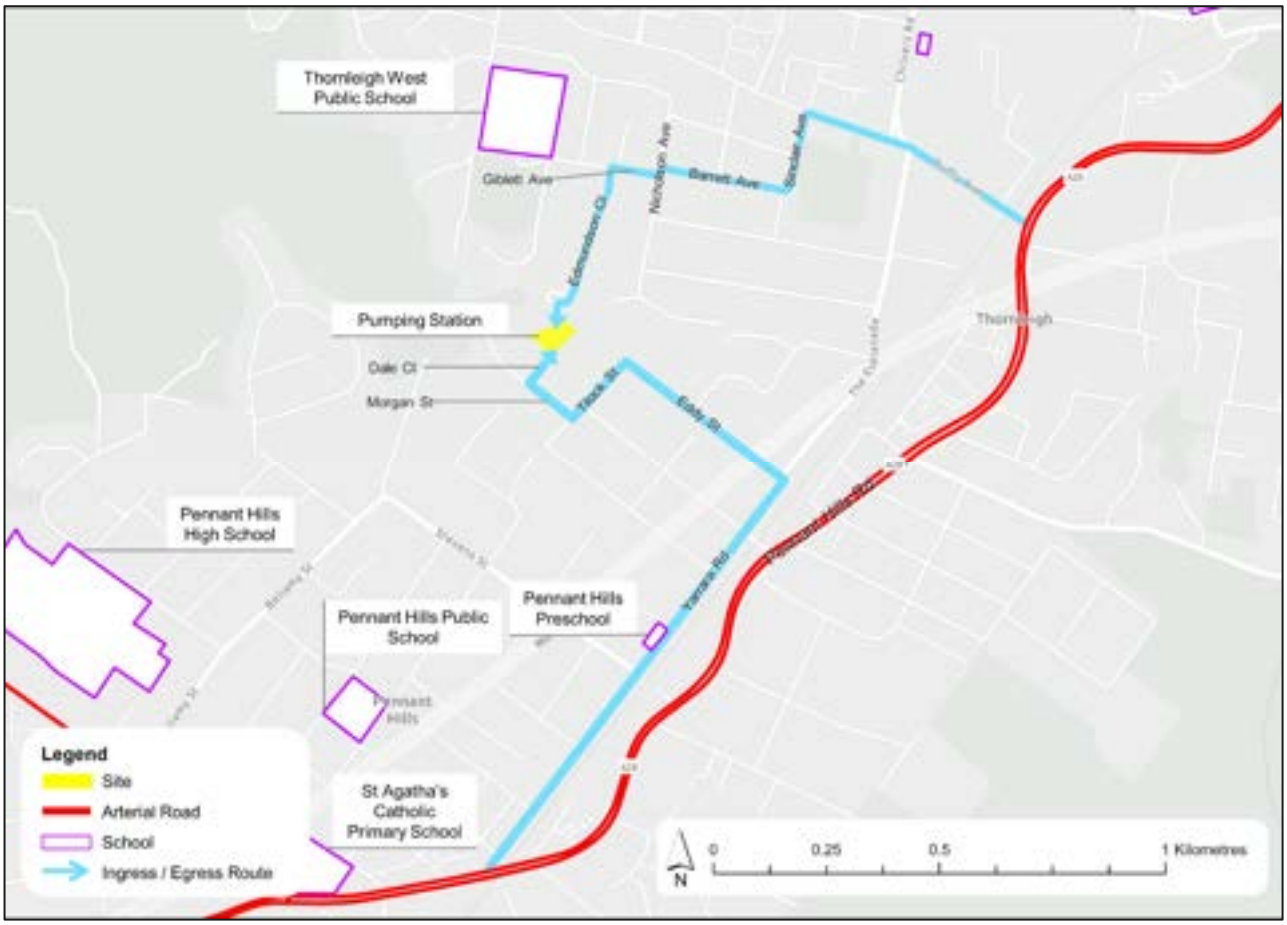


Figure 10 Construction vehicle route to and from Thornleigh-Wahroonga water pumping station (WP0159)

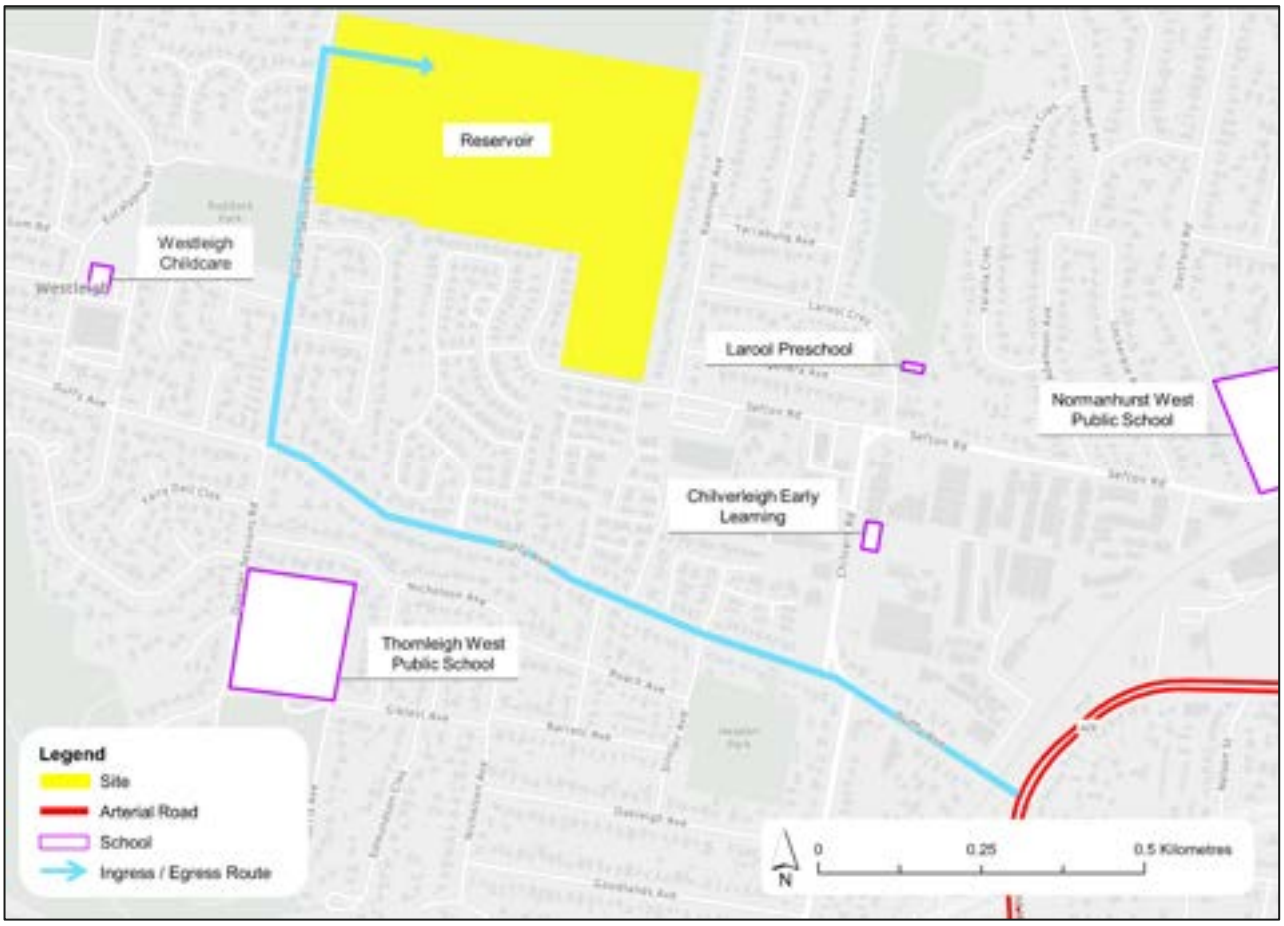


Figure 11 Construction vehicle route to and from Thornleigh Reservoir (WS0148)

4.4 Construction workers and vehicles

A range of construction vehicle types are expected to be used throughout the construction phase and the vehicles to be used by the Contractor are not limited to those listed in this section.

- Standard Dual Cab Utes
- Utility Vans
- Bogies / tippers
- Truck and Dog Trailer
- 19 m Semi Trailer Trucks
- 26 m B-Double Trucks
- 60 T – 100 T Crane
- 60 – 500 T Crawler

The Edmundson Close cul-de-sac is expected to be utilised for operation of crane activities including installation and removal of pipe jacking equipment for multiple days. Light vehicle traffic on Edmundson Close would be discouraged during this time. Traffic management planning including preparation of a Traffic Management Plan, Traffic Control Plans and ROL would be required.

4.5 Traffic Generation

4.5.1 Vehicle Movements

The construction team at the Thornleigh Reservoir will use either:

- 15 Truck and Dog Trailers on a three-cycle-turn-around every third day i.e., 15 loads every third day for spoil removal.
- 5 Truck and Dog Trailer movements a day.

A maximum of 5 trucks movements in the peak hour (total inbound and outbound) has been assumed for a more conservative impact assessment of the reservoir. This is to allow for the movement of grout.

There is no space on the Thornleigh-Wahroonga water pumping station site for spoil storage. As such, spoil removal is required for the following stages of construction of which each will take approximately 4-5 days:

- Receival pit excavation
- Spoil from piling activity
- Pipe work installation
- Backfill

A maximum of four 6-wheelers per day are expected to make 3-4 trips per day each for spoil removal for the Thornleigh-Wahroonga water pumping station, equating to a maximum of 16 trips per day.

The impact on the local road network from vehicles arriving and departing would be low and insignificant to trigger the application for a ROL, however a ROL will be required for the removal of cul-de-sac and taking over cul-de-sac for crane activities. No trenching is required on roads.

Light vehicle (LV) movements would usually occur over a 1-hour period and 2-hour period in the beginning and end of the construction period each day, respectively. Heavy vehicle (HV) movements would occur periodically between 7:00 am and 5:00 pm. Typical construction would involve up to 5-7 workers. This may increase to up to 10-15 workers during peak construction periods.

The forecast number of peak construction movements at each site during construction is summarised in

Table 5. The peak period of construction traffic will occur during delivery of material or spoil placement or removal.

It should be noted these are peak values and vehicle movements are expected to be lower than these values for large periods of the construction phase. Light vehicle movements are predominately driven by the number of workers on site.

Table 5: Summary of peak construction traffic generation

Vehicle type		Time period	Peak hour movements (inbound and outbound)[1]	
Light vehicle	AM peak	6:45 am to 7:45 am (one hour)	15 movements per hour (inbound only)	
	PM peak	4:30 pm to 6:30 pm (two hours)	8 movements per hour (outbound only)	
Heavy vehicle	AM peak	7 am to 12 pm	Reservoir	5 movements per hour (total inbound and outbound)
			Pumping Station	16 movements per day (total inbound and outbound)

[1]Inbound movements correspond to vehicles entering the site. Outbound movements correspond to vehicles leaving the site.

4.6 Construction Worker Parking

Some construction worker parking is to be expected on the local roads surrounding the Thornleigh-Wahroonga water pumping station including Dale Close and Edmundson Close with some parking available within the pit retrieval site. Workers may make use of existing public transport options, including Thornleigh Station which is a 12-minute walk away. Workers will also be encouraged to car pool.

All construction worker parking and stockpile removal vehicle parking would be accommodated on-site for the Thornleigh Reservoir.

4.7 Construction Impact Assessment

4.7.1 Impacts on road network performance

As discussed, the peak period of construction traffic will occur during delivery of material or spoil placement or removal. Peak construction periods are expected to generate 15 light vehicles and 5 heavy vehicle movements for the reservoir and 16 for the pumping station. Traffic generated by nearby infrastructure schemes is expected to be relatively minor.

Pennant Hills Road is an arterial road that carries high volumes of traffic totalling 33,139 Annual Average Daily Traffic (AADT) volume in 2021[1]. Thus, the minimal (5 movements) traffic volumes associated with the peak construction periods is not expected to detrimentally impact Pennant Hills Road or the greater road network discussed in Section 3.1.

0.17 km of trenching is expected to be undertaken entirely within Thornleigh Reservoir with no roads trenched across.

Therefore, impacts on the surrounding road network relating to construction traffic are expected to be low.

[1] TfNSW Traffic Volume Viewer 2021, 30m East of Beecroft Road, Pennant Hills 2120

4.7.2 Impacts on parking and access

All construction worker parking and stockpile removal vehicle parking at the Thornleigh Reservoir would be accommodated on-site. Therefore, no impacts to parking on surrounding roads are expected.

Some construction worker parking on the local roads surrounding the Thornleigh-Wahroonga water pumping station is expected, however, due to its vicinity to Thornleigh Station, impacts are expected to be limited and low.

4.7.3 Impacts on the public transport network

Quarter Sessions Road, Duffy Avenue and Yarrara Road are used by buses and also form part of the proposed construction vehicle route. Low impacts on bus services are expected given the low volumes of traffic being generated. Bus operators are to be notified of expected construction vehicle traffic. No impacts are anticipated on the operation of bus stops.

4.7.4 Impacts on the active transport network

Potential conflicts may arise between heavy vehicle movements and pedestrians on access roads at the Thornleigh Reservoir and Thornleigh-Wahroonga water pumping station sites. These conflicts are identified as medium impact.

The walking track between Edmundson Close and Dale Close through the Thornleigh-Wahroonga water pumping station is expected to close during periods of proposed construction work.

Alternative routes through the local street network pose extended travel times and accessibility issues. It is suggested B-Class hoarding be erected within the Thornleigh-Wahroonga water pumping station and launch pit site to maintain safe pedestrian access throughout proposed construction. It is noted that there is already fencing provided around the pumping station.

The proposed construction routes for the Dale Close pumping station access passes Pennant Hills Preschool. As such, heavy vehicle movements for the pumping station would be discouraged during the morning (8 am – 9:30 am) and afternoon (2:30 pm – 4 pm) school pick-up and drop-off periods where possible. Impacts associated with this access are considered medium. Access to the pumping station via Edmundson Close does not pass any schools and is therefore not expected to have an impact.

No other impacts to pedestrians or cyclists are expected given that no footpath or cycleway closures elsewhere are proposed during construction or stockpile removal.

5 Proposed Mitigation Measures

This section outlines potential mitigation measures required to minimise the impacts of the project throughout the construction phase. All proposed mitigation measures should be developed further by the appointed contractor as part of their detailed Construction Management Plan.

The impacts and proposed mitigation measures relating to the project are summarised in Table 6.

Table 6 Mitigation and effectiveness

Project specific mitigation measures – construction			
Potential Impact	**Impact significance**	**Mitigation measure**	**Impact significance following mitigation**
Impacts of construction vehicles on surrounding road network performance, particularly Pennant Hills Road.	Low	Prepare and implement Traffic and Pedestrian Management Plan prior to construction. Construction traffic movements scheduled outside of peak road network periods (6:30 – 10 am and 3 – 7pm) where possible (excluding tunnel boring machine (TBM) operation). Only follow construction vehicle access routes as detailed in this report. Encourage the use of public transport and carpooling. Notification to bus network of when heavy vehicle might be present.	Low
Potential conflict between heavy vehicles and pedestrians on access road to Thornleigh Reservoir and Thornleigh-Wahroonga water pumping station.	Medium	Use signage to alert pedestrians of heavy vehicle access. Traffic Controllers may be required in key conflict areas at school, pick up / drop off times (8 am – 9:30 am and 2:30 pm – 4 pm).	Low
Restriction on 3 tonne and over trucks on Yarrara Road.	Medium	Obtain relevant council approval.	Low
Extended travel times and accessibility issues with closure of the walking track between Edmundson Close and Dale Close.	Medium	Provide B-Class hoarding to maintain safe pedestrian access.	Low
Potential conflict between heavy vehicles and children on Yarrara Road.	Medium	Discourage construction traffic movements through preschool zones during pick-up and drop-off times (8 am – 9:30 am and 2:30 pm – 4 pm). Only follow construction vehicle access routes as detailed in this report.	Low

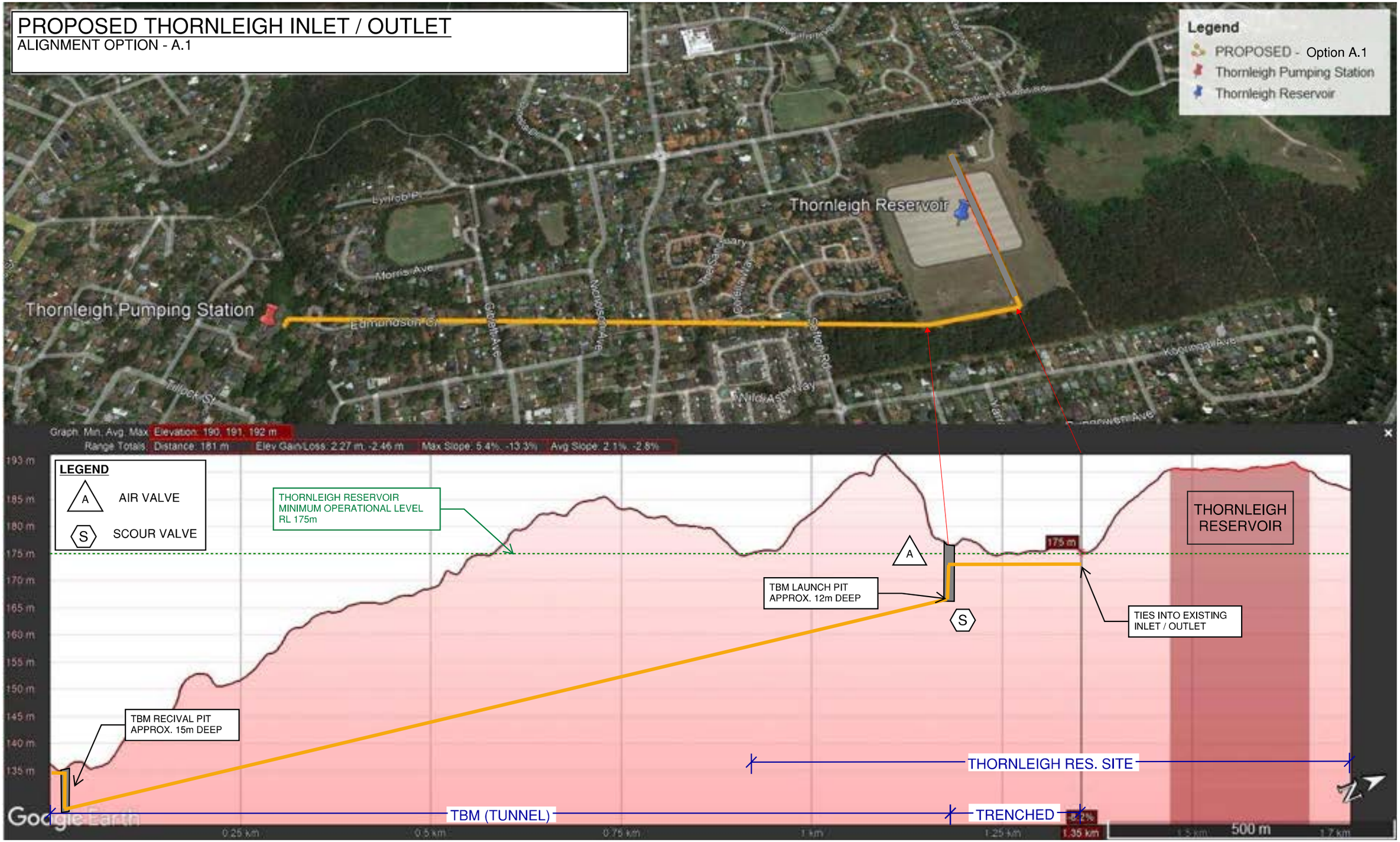
Potential conflict between light vehicle traffic and crane activities on Edmundson Close.	Medium	Minimise light vehicle traffic movements during crane activities. Preparation of Traffic Management Plan, Traffic Control Plans and ROL (which require Council approval). Placement of traffic controllers.	Low

6 Appendix A

6.1 Proposed Thornleigh Inlet / Outlet Main – Alignment Option A1

PROPOSED THORNLEIGH INLET / OUTLET

ALIGNMENT OPTION - A.1



7 Appendix B

7.1.1 Construction Memo

For Information Only

Sydney Water Ref: 20038363
Rev.01 – DRAFT: For Information Only

Memorandum – Thornleigh Inlet / Outlet Main

Initial Construction Methodology / Understanding Memo

This memo summarises the construction techniques that may be employed in the delivery of Thornleigh inlet / Outlet main in response to a direct request from the consultants developing a traffic impact assessment

Context

The Epping to St Leonards projects addresses infrastructure requirements (new and upgrades) to service significant growth in the Prospect Water System. The Prospect Water System is the largest and most central Water Supply System in the Greater Sydney Metropolitan area. It comprises of five interconnected Water Delivery Systems: Prospect North, Prospect East, Prospect South, Ryde and Potts Hill.

This project is Package 2 of the wider Epping to St Leonards program of works. Package 2 seeks to provide more system resilience and operation flexibility through a new DN1800 inlet / outlet main from Thornleigh Reservoir (WS0148) to Thornleigh-Wahroonga water pumping station (WP0159), see **Figure 1** below for locality. Furthermore, the package also seeks to improve water quality in WS0148 by improving water circulation and giving operators more flexibility in filling / emptying cycles of the reservoir.

Figure 1: Locality Plan (aerial sourced from Nearmaps 2022)

This memorandum summarises of the current understanding of construction expected to occur between WS0148 and WP0159. This memorandum will aim to address the following key topics relevant to the traffic study being conducted by Arup (2022):

- Material storage site
- Site compound location and size
- TBM launch pit / receival pit footprints
- Traffic generation
    - Type of vehicles
    - Quantity
- Program
    - Construction hours
    - After hours work

Current Construction Understanding

The content below summarises the design teams understanding of construction techniques and how they may be employed during delivery. The construction methodology will be determined by the contractor / tunnelling specialist. Prior to commencement of construction and during the detailed design the contractor / tunnelling specialist is to be consulted to comment on the relevance of the understanding captured within this memo.

These construction techniques were developed assuming DN2200 pipejack with DN1800 carrier pipe solution.

Material Storage Site

Spoil Stockpile

The site will require a significant area to stockpile fill removed from the tunnel. Various areas around the reservoir site may be deemed suitable by the contractor to stockpile spoil.

It was noted by the design team that production rates would be 2 advances of the jacking pipes per nightshift, being 4 to 4.8m (7.2m of tunnel per night at best). This spoil would likely need to be settled on site before disposing of or placing elsewhere.

Piping Segmental Unit Stockpile

Depending on the contractors material procurement strategy, a significant area may be required to store sections of jacking and carrier pipe. The area identified for potential levelling, compaction and future storage is shown in **Figure 2** below and is equal to 4,800m^2.

Figure 2: Potential area for construction compound, laydown, spoil and material storage

Site Compound

The concept design team with support from senior project engineers have identified the following likely requirements of a site compound:

Acoustic Shed

An acoustic shed will be required in order to maintain 24/7 operation of the tunnel boring machine (TBM). A potential layout of inside and surrounding the acoustic shed can be found in **Figure 5** in **Appendix A** below.

This acoustic shed is to house the following:

- Jacking Shaft of min 9.5m x 5.0m clear opening (typically allow up to 800-1000mm each side of these for spaceproofing/collar, safety barriers around etc), assuming we have high level rock at the jacking shaft worksite area to enable rectangular shaft construction
- The bentonite production plant (night-time maintenance required and is noisy)
- A gantry crane over the portal shaft
- Sufficient space to store over-night consumption of segmental tunnel elements without the need to open acoustic doors – approx. 20m^2 for segments stockpiling
- The bentonite slurry plant that creates and recycles bentonite after slurry has been through the mud plant. The bentonite slurry plant is approx. 3.5m wide x 20m long combined with mud plant and slurry production/recycling tank
- The mud plant (shaker) that separates the spoil from the bentonite (see **Figure 6** in **Appendix B** below)
- The hydraulic power pack(s) that drive the TBM (approx. 3m wide by 4m long)
- Space for loading separate spoil onto trucks
- Sufficient area to store overnight spoil production without moving the spoil outside at night
- Sufficient room under or adjacent to the mud plant to allow spoil to drop from the mud plant either into an overnight stockpile or into multiple semi-trailer bogie.
- Sufficient room to move the bogie in any out of the shed and under the mud plant, or alternatively, sufficient room for something like a CAT930 FEL (wheel loader) to move spoil out of the mud plant an into bogey during daylight hours.
- Sufficient room for two (2) shipping containers with spare equipment, tools, PPE, cutter repair etc. to serve as workshops for overnight maintenance and breakdown (approx. 6m x 8m, allows 3m x 6m space between the containers for a work area)
- Mechanical workshops (probably two (2) 6m containers) with sufficient equipment and spares to manage over-night break downs
- Sufficient room for an overnight office (approx. 6m wide by 6m long)
- Sufficient room for toilets (approx. 3m wide by 6m long). Locate below the office.
- Sufficient room for a lunchroom (crib room) (approx. 6m wide x 6m long)

The acoustic shed will require a footprint of approx. 700m^2. The entire area around the acoustic shed, including the below access road and lay down areas equates to approximately 2,000m^2. This can be seen in **Figure 5** in **Appendix A**.

This area will need to be levelled and constructed to all weather pavement. Vegetation and topsoil to be stripped. Build up with engineered fill/road base (compaction only by nonvibratory equipment).

The contractor will require endorsement of the proposed compound area and position by the Dam Safety Committee. Likely to be dependent on proximity to the reservoir embankment.

Access Road

Upgrades to the existing access track will be required to accommodate heavy construction vehicles. Width will likely be maintained at 3 to 3.5m in width (one way).

Road width around the acoustic shed will likely be increased to 6m. to allow for large vehicle turning movements.

There are multiple options for turning bays within the site, depending on final configuration of the construction compound, a turning bay could be positioned in south east corner of the embankment or around the acoustic shed and laydown area, as shown in **Figure 5** in **Appendix A**.

Machinery Lay-down Manoeuvring Area

Storage outside of the acoustic shed will be required. Area also to be allowed to allow truck to make deliveries into shed.

NOTE: Typically, the slurry separation plant shakers are off to the side of the separation plant, so the construction site and shed layout may require rearranging the to allow for this, as well as truck access beside them.

TBM Launch and Receival Pits

Launch Shaft

The potential location of the launch shaft can be seen in **Figure 8** in **Appendix C.**

Based on the existing geotechnical information available, the launch shaft will likely be constructed using bored piles to a depth approximately 5m - 8m. The lower section of the shaft will likely be excavated and supported with rock bolts and shotcrete. The launch shaft will be approximately 11m deep in total. See indicative measurements in **Figure 3** below.

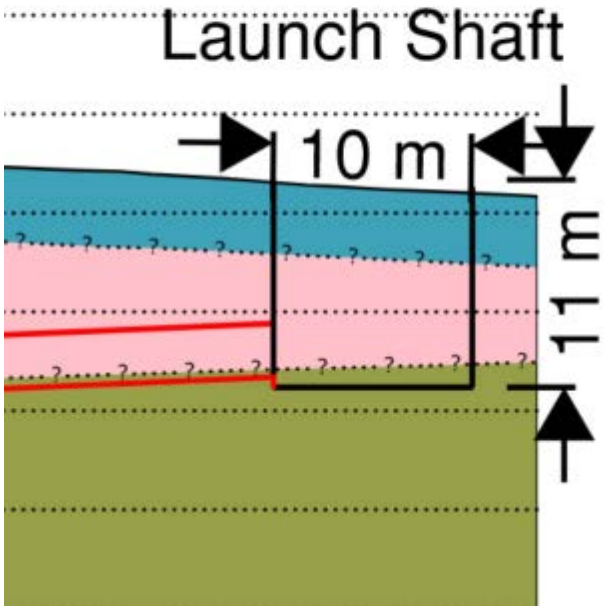


Figure 3: Launch shaft, geology and indicative measurements

Launch Shaft of min 10m x 5.0m clear opening (typically allow up to 800-1000mm each side for spaceproofing/collar, safety barriers around etc). This is assuming high level rock at the jacking shaft worksite area to enable rectangular shaft construction.

Receival Shaft

The potential location of the receival shaft can be seen in **Figure 9** in **Appendix C.**

The tunnel will then follow a straight alignment in close proximity to the existing tunnel and will cross under Zig Zag Creek at a similar level to the existing tunnel (approximately 14m). Once the TBM has excavated under the creek the tunnel will run horizonal and join into the receival shaft just north of the pump station at 5 Dale Close. The receival shaft is proposed to be approximately 17m deep to cross safely under the creek. This depth is deeper than the connection to the existing DN1200 pipe at approximately 6m. It is proposed to install a vertical drop for the connection with existing DN1200 pipe, see **Figure 4** below.

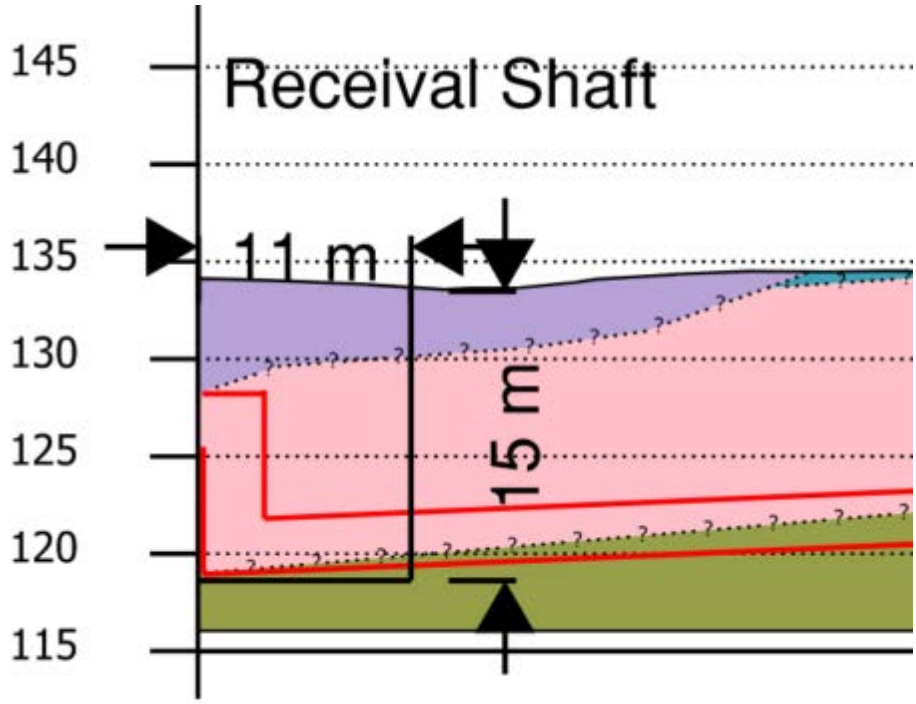


Figure 4: Receival shaft, geology and indicative measurements

Receival shaft of min 11m clear opening (typically allowing up to 700-800mm each side of this for spaceproofing/collar, safety barriers etc). Note this is only for the removal of the pipejacking TBM and does not allow for any additional excavation/connection into the existing mains at the pump station end.

Traffic Generation

Type of Vehicles

Vehicles attending the site will vary, however it can be assumed that the following vehicle types will be attending site:

- Standard Dual Cab Utes
- Utility Vans
- Boggies/tippers (carry 10T = approx 6m^3)
- Truck and Dog Trailer (carry 30T = approx 17m^3)
- 19m Semi Trailer Trucks
- 26m B-Double Trucks

- 60t-100T Crane
- Crawler-LR1100

Dimensions and turning paths of various construction vehicles have been included in **Appendix D.**

Quantity

The quantity of vehicles entering the site per day is difficult to estimate and will vary with different stages of the project.

Peak vehicle movements will likely be during delivery of material or spoil placement / removal is occurring.

Assuming spoil placement will result in peak vehicle movements, an approximate loose volume of material to be removed at the reservoir site was calculated. This equated to 15,000m^3, this calculation can be found in **Appendix E.**

Considering a Truck and Dog Trailer (earth moving) can carry approx. 30T - 17 m^3, 900 truck movements would be required over a year period to dispose of / place the spoil produced by the TBM and other construction activities at the reservoir site.

Program

The duration of the construction is to be confirmed by the contractor, however it is anticipated that construction will take approximately two years, with drilling occurring for approximately six months.

Production rates are expected to be 7.2m of tunnel at best. It is expected that construction crews will likely get two advances per nightshift, maybe three at best (this equates to 7.2m of tunnel per night).

Construction Hours

Construction will occur 24/7 in order to stop the TBM being exposed to large frictional forces, however construction activities will be moved inside the acoustic shed during this time. Modelling will be conducted during the detailed design once requirements for acoustic dampening are known

After Hours Work

Construction will occur during the night. During these times the acoustic shed doors will be closed, deliveries will pause, spoil removal and placement will halt. All works will be undertaken within the acoustic shed.

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Appendix A – Potential Layout of Acoustic Shed

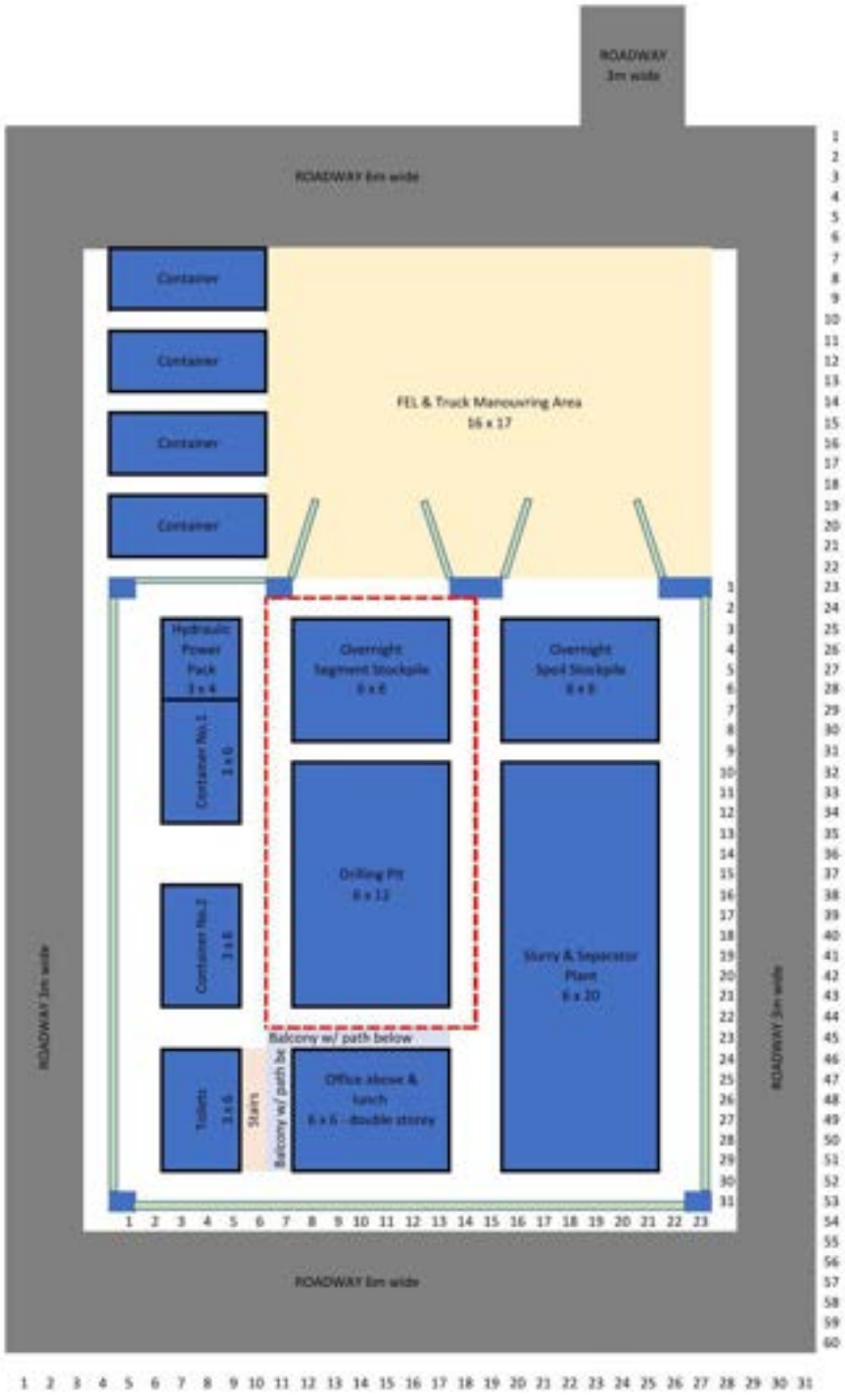

Figure 5: Potential Layout of Acoustic Shed

Appendix B – Typical Separation Plant

Figure 6: Typical Slurry Separation Plant

Figure 7: Typical Separate and Bentonite Plan (footprint 3.5m wide x 20m long)

Appendix C – Launch and Receival Pit Locations

Figure 8: Potential Location of TBM Launch Shaft on Reservoir Site

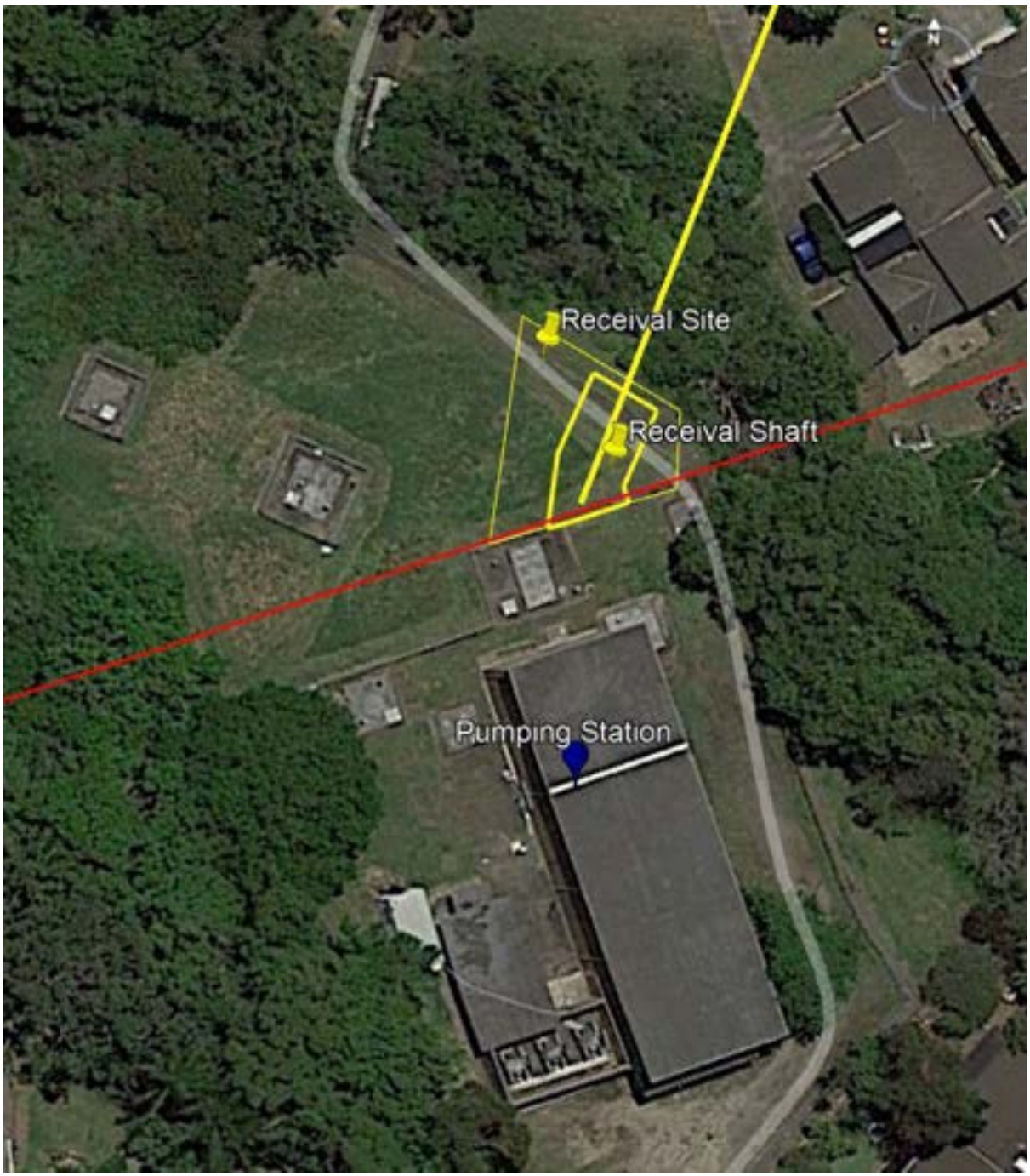

Figure 9: Potential Location of TBM Receival Shaft on at Pumping Station Site

Appendix D – Australian Construction Vehicle Turning Radius

Passenger vehicle (5.2 m)

- 6.3 m radius

Service vehicle (8.8 m)

- 9 m radius, 5 km/h
- 12.5 m radius, 5 km/h
- 15 m radius, 5 to 15 km/h
- 20 m radius, 15 to 20 km/h
- 30 m radius, 20 to 30 km/h

Single unit truck/bus (12.5 m)

- 12.5 m radius, 5 km/h
- 15 m radius, 5 to 15 km/h
- 20 m radius, 15 to 20 km/h
- 30 m radius, 20 to 30 km/h

Long rigid bus (14.5 m)

- 12.5 m radius, 5 km/h
- 15 m radius, 5 to 15 km/h
- 20 m radius, 15 to 20 km/h
- 30 m radius, 20 to 30 km/h

Articulated bus (19 m)

- 12.5 m radius, 5 km/h
- 15 m radius, 5 to 15 km/h
- 20 m radius, 15 to 20 km/h
- 30 m radius, 20 to 30 km/h

Prime mover and semi-trailer (19 m)

- 12.5 m radius, 5 km/h
- 15 m radius, 5 to 15 km/h
- 20 m radius, 15 to 20 km/h
- 30 m radius, 20 to 30 km/h

Figure 10: Extract from the Austroads Swept Paths Standard Vehicle Turning Radius - AP-G34-13 - Turning Paths.pdf

Appendix E – Volume of Spoil Removed from TBM

Fill Calculations

Tunneling

Bank volume (2.5m drill head) = 1.25 x 1.25 x 1,155 x pi = 5,670m^3

Swell factor of 80% for sandstone rock

Loose vol = 1.8 x 5,670 = 10,206m^3

Launch pit

Bank volume (pit size 10m(diameter)x 11m(d)) = pi x 5 x 5 x 10 = 785m^3

Swell factor of 80% for sandstone rock

Loose vol = 1.8 x 785 = 1,413m^3

Open trench

Bank vol (approx. 100m length) = 195(l) x 3.5(w) x 2.5(d) = 1,710m^3

Swell factor of 80% for sandstone rock

Loose vol = 1.8 x 1,710 = 3,071m^3

Thus, total spoil volumes we want to dispose of at the reservoir site is as follow:

Bank vol = 5,670 + 785 + 1,710 = 8,165m^3

Loose vol = 10,206 + 1,413 + 3,071 = 14,690m^3

Truck Movement Calculations

Assumed density of Sandstone = 2.3T/m^3

Truck and Dog Trailer capacity = 30T

Tunnelling

Weight = 5,670 x 2.3 = 13,041T

Using truck & dog = 435 loads

Launch pit

Weight = 785 x 2.3 = 341T

Using truck & dog = 12 loads

Open trench

Weight = 1,710 x 2.3 = 3,933T

Using truck & dog = 132 Loads

The construction team could use five (5) Truck and Dog Trailers on a three (3) cycle turn-around every third day. Ie, 5 x 3 = 15 loads (450T) every third day. During the tunneling, 435 loads / 15 loads = 29 days of spoil removal. If spoil is taken off site every third day then 29 x 3 = 87 days of tunnelling (4.5 months which is close to what has been assumed)

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