6.5.3 Operational impacts and mitigation measures

Operation of the Proposal presents minimal potential for direct impacts on terrestrial flora and fauna. The aspects of operation with potential to impact terrestrial flora and fauna include:

- routine maintenance and repairs of pipelines, which involves access to maintenance structures
- routine maintenance and repairs to reservoirs
- wastewater overflows and leakage from maintenance structures and wastewater pipelines.

Potential impacts associated with routine maintenance are likely to be very minor and may involve some disturbance of vegetation by workers and equipment, and some excavation to gain access to underground components and pipelines. Such work will be subject to Sydney Water's existing environmental procedures for maintenance works. If required, future repairs to sites and pipelines may be subject to further environmental assessment by Sydney Water. Where permanent access tracks are required, they would preferably be constructed outside riparian areas. This may not be possible where access to wastewater infrastructure may be required. In these instances, access tracks would be designed to minimise impacts on riparian areas. Permanent access tracks are not required across waterways.

Wastewater overflows and leakages from the wastewater system have the potential to impact on native vegetation and fauna habitats. EPL compliance and meeting water quality and public health guidelines (see Section 6.4) will ensure that potential impact in this regard is minimised and not significant.

6.6 Aboriginal cultural heritage

Assessment overview

Sydney Water commissioned Biosis Pty Ltd (Biosis) to undertake an assessment of Aboriginal heritage to address the information and consultation requirements of the draft *Guidelines for Aboriginal Cultural Heritage Impact Assessment and Community Consultation* (DEC, 2005a). In 2011 Biosis prepared the *Aboriginal Heritage Assessment and Impact Management Report* (the Heritage Report) which documents the Aboriginal heritage assessment for the WDURA and AGA. This report documents:

- the desktop study which provides the regional context for Aboriginal heritage
- a sensitivity model used to predict areas of potential Aboriginal archaeological heritage
- consultation undertaken with the Aboriginal community
- field surveys which focussed on areas of high heritage sensitivity and areas potentially impacted by the Proposal eg pipeline corridors
- an assessment, in conjunction with Registered Aboriginal Parties (RAPs), of cultural and scientific heritage significance for new and existing Aboriginal heritage sites
- impact mitigation measures, identified in conjunction with the RAPs, to conserve Aboriginal cultural heritage.

The assessment was undertaken during the planning stage for the Proposal to maximise opportunities to conserve Aboriginal heritage. A number of routes have been realigned to avoid or minimise impacts to sites listed on the Aboriginal Heritage Information Management System (AHIMS) or areas of Aboriginal heritage sensitivity.

Consultation with the Aboriginal stakeholders was integral to the assessment process. It acknowledged that Aboriginal people have a unique understanding of Aboriginal heritage in the region and have a right to participate in matters that may impact their heritage. Consultation was undertaken in accordance with the following documents:

- *Guidelines for Aboriginal Cultural Heritage Impact Assessment and Community Consultation* (Draft) (DEC 2005a)
- *National Parks and Wildlife Act 1974: Part 6 Approvals – Interim Community Consultation Requirements for Applicants* (DEC 2004).

The consultation was also conducted in accordance with the *Aboriginal cultural heritage consultation requirements for proponents 2010 Part 6 National Parks and Wildlife Act 1974* (DECCW 2010b).

Sydney Water undertook consultation with the RAPs at key stages in the planning process including at the start of the assessment process and during the drafting of the final Heritage Report. A detailed description of the consultation process is provided in Section 8.2. In summary, eleven Aboriginal stakeholder groups registered an interest in the project and attended meetings.

The general assessment of Aboriginal heritage was undertaken for the entire Proposal area. A more detailed assessment was undertaken for those components for which Project Approval is being sought.

The assessment of the Proposal area provides a comprehensive overview of Aboriginal cultural heritage. The methodology investigated and described:

- the receiving environment, eg landform, geology and soils, vegetation types
- the history of local Aboriginal peoples
- previous reports and findings regarding Aboriginal cultural heritage in the Illawarra Region
- archaeological sensitivity modelling of the Proposal area
- the location, type and significance of existing Aboriginal objects, sites and places based on a desktop study of existing information
- Aboriginal cultural heritage in consultation with the RAPs.

The Proposal area methodology included modelling the likelihood of finding Aboriginal objects during construction. The modelling was necessary due to low ground visibility caused by dense vegetation. The model was based on regional Aboriginal archaeological patterns, previous field surveys and key factors such as geology, landform and waterways.

The assessment methodology for the Project Approval area focussed on field surveys of the pipeline corridors and other components. All RAPs were invited to participate in the field survey investigation program. Of the ten groups registered, only nine of the RAPs attended the field surveys. The Wodi Wodi Elders Council were a RAP but did not participate in the field surveys.

The Heritage Report describes Aboriginal heritage values in terms of:

- Aboriginal cultural heritage, an all-encompassing term that includes tangible elements, such as Aboriginal objects and sites. The term includes intangible elements, like landscape character and the history and culture of the peoples. Intangible heritage is often exhibited in Aboriginal objects and sites and other components as determined by the Aboriginal people. It can include places of contemporary significance
- Aboriginal archaeological, or scientific, heritage that relates to tangible elements like Aboriginal objects, sites and places and as determined by scientific standards, e.g. rarity and intactness.

Information regarding Aboriginal objects, sites and places is culturally sensitive and public distribution of details regarding their nature and location is prohibited. Consequently the Heritage Report, attached to the EA as Appendix F, has excluded information which may be culturally sensitive. Copies of the full Heritage Report prepared by Biosis have been provided to all RAPs and the OEH but only general information about the Aboriginal heritage assessment is described in the EA.

6.6.1 Existing environment

The Proposal area

The Illawarra Region has a rich biological environment that supported Aboriginal habitation for over 50,000 years (DEC 2005a). The land appears to have been home to the Tharawal/Dharawal language group. The named groups, or tribes, belonging to the Tharawal/Dharawal group included the Gweagal, Norongerraga, Illawarra, Threawal, Tagary, Wandeandega, Wodi Wodi and the Ory-ang-ora. The Proposal area falls within the boundaries of the Illawarra Local Aboriginal Land Council. No Native Title claims were identified either within or close to the Proposal area.

Commonwealth and State registers were examined to identify known Aboriginal heritage sites within the Proposal area. A total of 189 sites registered in AHIMS have been identified in the Proposal area. Lithic, or stone, artefact sites, are the predominant AHIMS site, accounting for 75 per cent of all sites. Eighteen potential archaeological deposits (PADs) were identified in the AHIMS register. PADs are areas where surface artefacts have been found and potentially contain sub-surface archaeological material. Sub-surface deposits are created when alluvial material covers Aboriginal objects. Three scarred trees are also listed in the AHIMS, however, one appears to have been removed as part of another development within the area.

Aboriginal objects typically accumulate in swamp and alluvial soils, particularly along the edge of waterways. The Proposal area has been significantly disturbed and eroded by agricultural activities which impact negatively on Aboriginal objects and sites.

The assessment of the Proposal area involved the development of broad scale Aboriginal archaeological predictive modelling. The model was formulated using the location of known Aboriginal sites and the results of previous archaeological studies that indicate those landforms with the potential to contain archaeological sites. Areas of high sensitivity have a high likelihood of containing Aboriginal heritage sites while areas with a low sensitivity have a low likelihood of containing sites. Descriptions of Aboriginal archaeological sensitivity are provided in Table 6-21. Figure 6-25 shows the modelled areas of archaeological sensitivity.

Table 6-21 Description of Aboriginal archaeological sensitivity

Aboriginal Archaeological Sensitivity	Description	Project components
Low *Low likelihood for intact Aboriginal heritage remains*	Areas where there has been a high degree of disturbance since the arrival of non-Aboriginal people. The landscape features indicate that the presence of Aboriginal objects is unlikely, eg areas of moderate and steep slopes or plains away from water sources. Artefacts found in this area are likely to be isolated, representative of 'background scatter', or in a highly disturbed context.	Applies to pipelines, reservoirs and other components within developed areas or the forested and/ or steep slopes of the escarpment.
Moderate *Moderate likelihood for intact Aboriginal heritage remains*	Areas where minor disturbance has occurred, or along creeks and waterways where short-term campsites may have been present. Artefact scatters are likely to vary in density, but concentrated in small areas.	Applies to pipelines within the cleared rolling foothills of the escarpment and the plains to the east of the Proposal area.
High *High likelihood for intact Aboriginal heritage remains*	The landscape features indicate that the presence of Aboriginal objects could be likely, eg areas associated with major creek lines, raised flat landforms such as ridges and hills, where disturbance has been minimal. Artefacts that remain within these areas are likely to be found in high density.	Applies to pipelines in close proximity to waterways and within undisturbed areas of vegetation in the Proposal area.

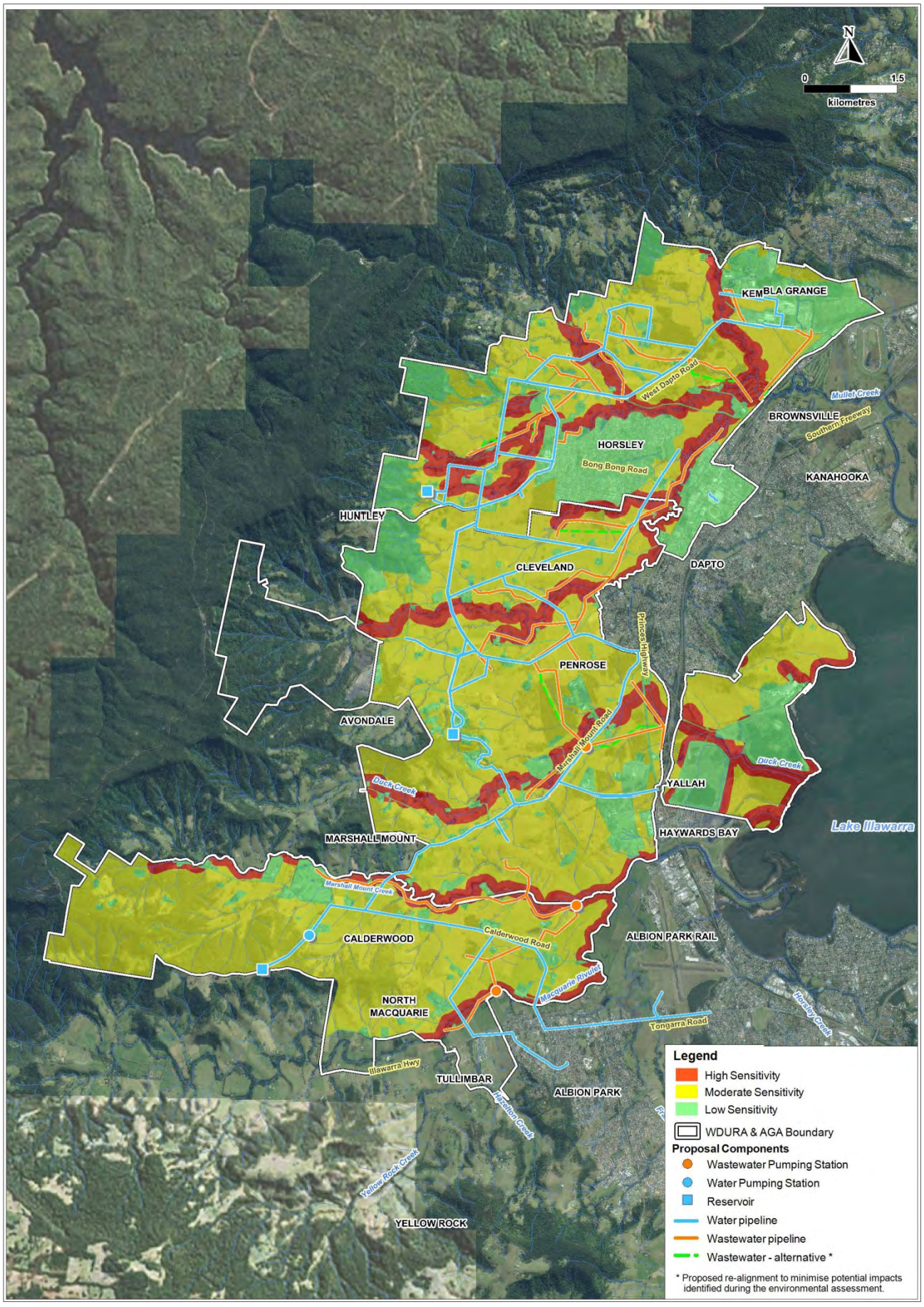


Figure 6-25 Areas of archaeological sensitivity

Project Approval area

The desktop study identified 50 AHIMS sites within the Project Approval area. Field surveys were undertaken in November 2010 and January 2011 to confirm the location of the AHIMS sites and identify any new sites. Construction activities for the new pipelines could be contained within a 10 m corridor. However, corridors, up to 65 m wide for water pipelines in the road reserves (up to 25 m either side of the road edge); 50 m wide for wastewater pipelines (25 m either side of the proposed alignment); and 100 m around the reservoir and pumping station sites, were surveyed to gain a more complete knowledge of Aboriginal cultural heritage in the vicinity of the proposed works. The expanded investigation area provides more opportunities during detailed design for relocating services without redoing the field surveys. It also reduces the likelihood of inadvertently impacting archaeological sites during construction. The areas covered by the field surveys are shown in Figure 6-26. The proposed pipeline alignments have been refined since the field surveys were undertaken and Figure 6-25 shows the refined concept alignments for water and wastewater infrastructure. The field survey identified three new sites within the Project Approval area, each comprising an isolated stone artefact. They were found close to, but not within, the pipeline corridors.

The archaeological significance of all the Aboriginal sites was assessed. Only members of the contemporary Aboriginal community are able to make an assessment of cultural heritage and its significance. Consequently, cultural significance of Aboriginal sites within WDURA and AGA was discussed and determined by the RAPs during a meeting convened in May 2011. At that meeting, the RAPs determined that all AHIMS sites, existing and new, were of high cultural significance. The RAPs also confirmed Biosis' assessment of the archaeological significance for the AHIMS sites. The majority of sites (approximately 80 per cent) were assessed as of low archaeological significance. Of these 50 AHIMS sites, seven were identified within the pipeline corridors. No AHIMS sites were identified in or around other infrastructure components and no declared places where identified. No other cultural heritage areas from other archaeological studies were identified within the Project Approval area.

Five of the seven AHIMS sites in the Project Approval area have been previously test excavated by other heritage consultants. Table 6-22 summarises the details of the seven AHIMS sites located within the pipeline corridor and the results of the test excavations including the potential for artefacts to be found in the registered sites.

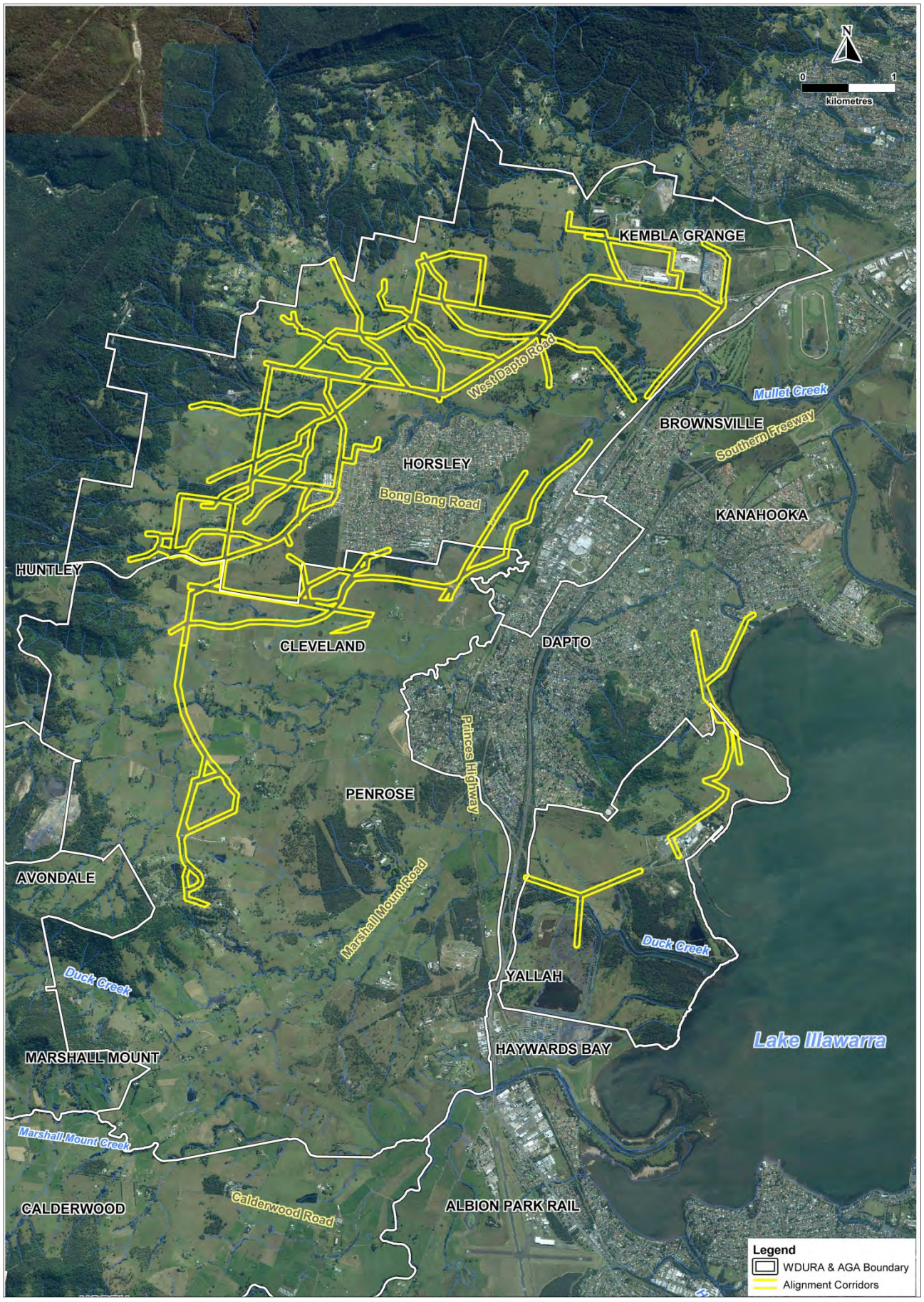


Figure 6-26 Field survey corridors

Table 6-22 AHIMS sites located within pipeline corridors in the Project Approval area

AHIMS	Site Identification	Pipeline	Site type	Landform Location	Cultural Significance	Archaeological Significance	Results of Previous Test Excavations
52-2-1033	Wongawilli Camden	Water	Artefact scatter	Alluvial terrace	High	Low	Few artefacts recovered
52-2-3271	WDRA_AX_40	Water	Isolated artefact	Spur crest	High	Low	1 artefact recovered
52-2-3274	WDRA_AX_44	Wastewater	Isolated artefact	Alluvial flat	High	Low	1 artefact recovered
52-2-3279	WDRA_AX_14	Wastewater	Artefact scatter	Lower hill slope	High	Moderate-high	146 artefacts recovered
52-2-3293	WDRA_AX_10	Water	Isolated artefact	Alluvial flat	High	Low	1 artefact recovered
52-2-3779	WDSY1	Water	Artefact scatter	Alluvial terrace	High	Low-moderate	Not excavated
52-2-3778	West Dapto	Water	PAD	Alluvial terrace	High	Low	Not excavated

The new sites were assessed, in conjunction with the RAPs, as having high Aboriginal cultural significance coupled with low archaeological significance. These sites were not excavated as part of the field surveys. Further investigation of these sites is not planned as they are unlikely to be impacted by Sydney Water's activities. These sites have been registered on the AHIMS database and their details are summarised in Table 6-23.

Table 6-23 New Aboriginal archaeological sites located within the Project Approval area

AHIMS	Site Identification	Pipeline Corridor	Site type	Landform Location	Cultural Significance	Archaeological Significance
52-2-3813	NRE-AFT1	No	Isolated artefacts	Flat	High	Low
52-2-3814	AFT-2	No	Isolated artefact	Rolling hills, ridge, upper slope	High	Low
52-2-3815	AFT-3	No	Isolated artefact	Rolling hills ridge, stream channel	High	Low

An additional site visit was undertaken in May 2011 to confirm the status of a site with shells on edge of Lake Illawarra. The visit determined the shells did not constitute a midden and no further consideration was given to this site.

6.6.2 Construction, impacts and mitigation measures

Construction impacts

Aboriginal heritage sites may be impacted by the following construction activities:

- clearing area as part of the site preparation
- excavating or trenching for pipelines, access roads, reservoirs, etc
- remediating sites including revegetation.

All these activities could result in the removal or burial of Aboriginal objects or alterations to the landscape's cultural significance for Aboriginal people.

Sydney Water has designed and amended the Proposal to minimise impacts on Aboriginal heritage. The field surveys undertaken by Biosis (2011) covered assessment corridors that are wider than the construction zone to allow flexibility for adjustments to be made during the detailed design process (Section 3.4.1). This approach, therefore, assessed a worst case scenario and impacts are likely to be lower than assessed here. Where possible, the Proposal will be further amended during the detailed design process to avoid or minimise the remaining impacts on Aboriginal items (see Section 3.4.1). Provided the avoidance strategy (Section 3.4.1) and mitigation measures discussed in this section are implemented, impacts to Aboriginal heritage as a result of the Proposal are unlikely to be significant.

Project Approval area

Seven Aboriginal sites were found in the pipeline corridors in the Project Approval area. Five of these sites occur within proposed water pipeline alignments and coincide with either existing or proposed road reserves. AHIMS sites 52-2-3271 and 52-2-3778 were located during the field assessment on the edge of the assessment corridor along future road alignments. There is a high potential that impacts to these items would be avoided completely if the road alignment changes. Consultation would be undertaken with Council during detailed design to confirm the locations of future roads prior to construction. Three AHIMS sites (52-2-1033, 52-2-3293, and 52-2-3779) were located within existing road reserves which are generally highly disturbed.

Wastewater pipelines will generally be located within low-lying areas, close to waterways. Sydney Water may have difficulty relocating wastewater pipelines, due to design requirements of the wastewater system. Only two of the AHIMS sites within the Project Approval area are located in the wastewater corridors. Both sites were identified on the edge of the assessment corridor and would be subject to further consideration during detailed design (Section 3.4.1). Site 52-2-3274 was assessed as having a low level of archaeological significance. Site 52-2-3279 was assessed as having a moderate to high level of archaeological significance. If avoidance of the site is not possible, specific mitigation measures described in this section, would be developed in consultation with a heritage professional and relevant RAPs to minimise impacts on the item.

The three proposed reservoir sites in the Proposal area are located on elevated areas in the landscape to ensure water services could be delivered under a gravity system. Aboriginal sites are often located on spur outcrops. However, it is expected that construction of the reservoirs is unlikely to have an impact on Aboriginal heritage as no AHIMS sites are recorded in the vicinity of the reservoirs and the predictive model indicates that the sites are in either low or moderate sensitive areas.

Land for WPSs and WWPSs, access roads and lay-down areas for equipment will also be required for the Proposal. These work sites would be located to ensure AHIMS sites will not be impacted.

Impacts to AHIMS sites in the Project Approval area would be minimal. Five of the seven AHIMS sites in the Project Approval area have already been the subject of test excavations which indicate that four of the sites have low potential for sub surface artefacts and that the sites represent the general distribution of surface artefacts across the landscape. The two untested sites are considered to possess low potential (52-2-3779) and moderate to high potential (52-2-3279) for sub surface artefacts. Both of these sites are located on the edge of the pipeline corridor and may be avoided by refining the pipeline alignment during the detailed design process.

Remaining Proposal area

Registered AHIMS sites and areas identified as having moderate to high archaeological sensitivity in the remaining Proposal area (Biosis 2011) would be subject to further site specific assessment during detailed design. The avoidance and mitigation measures discussed in this section would also be implemented to ensure that impacts to Aboriginal heritage in the remaining Proposal area are minimal.

Mitigation measures

Sydney Water is committed to avoiding items of Aboriginal cultural heritage during construction. Avoidance of impact through design is the primary mitigation and management strategy, and would be considered for all registered Aboriginal archaeological sites, PADs, and areas of high archaeological and cultural sensitivity in the Proposal area. If it is not possible to avoid impacting identified Aboriginal sites, and areas of moderate to high archaeological sensitivity, alternative construction approaches such as under boring will be considered. These techniques mainly occur beneath significant soil layers and material and/or avoid material of significance, although some disturbance associated with entry and exit points will be required.

Where impacts to registered Aboriginal archaeological sites and areas of high archaeological sensitivity cannot be avoided, specific mitigation approaches would be developed in consultation with a heritage professional and relevant RAPs. This would be undertaken during detailed design (Section 3.4.1) when the extent of impact is known. The mitigation approach would correlate with the extent of the potential impact, type of site and the significance of the Aboriginal site and may include:

- spatial recording for surface sites or sites with a surface expression using a differential GPS or Total Station (with sub-metre accuracy), followed by collection of the Aboriginal object
- testing and/or salvage excavations for subsurface sites or sites with a subsurface expression using current archaeological practices. Archaeological monitoring may also be appropriate in certain circumstances
- appropriate recording of all cultural materials and impacts using photographs, sketches and written description before, during and after implementation of mitigation measures
- an appropriate level of post-excavation analysis
- temporary storage of any recovered Aboriginal objects or archaeological material in a suitable lockable container at a secure indoor venue until the completion of the relevant phase of works.
- all reasonable efforts would be made to partially, rather than completely, impact on Aboriginal heritage sites
- preparation of reports or documents concerning Aboriginal heritage according to applicable statutory requirements and professional standards
- consultation with relevant State government agencies concerning Aboriginal objects, sites and places within the Proposal area.
- consultation with relevant RAPs, as appropriate
- provision of training for relevant construction personnel in the values and conservation of Aboriginal heritage. This would include providing information regarding Aboriginal heritage issues to relevant construction personnel and contractors to ensure appropriate management of known and unknown Aboriginal objects/sites/places
- fencing and establishment of clear ‘keep clear’ or ‘no go’ zones for areas with Aboriginal heritage value.

The following measures would be implemented during construction in the event that previously undiscovered items of potential Aboriginal significance are found:

- Should previously undiscovered Aboriginal objects, sites or places (or potential Aboriginal objects, sites or places) be discovered during construction, all works in the vicinity of the find will cease and Sydney Water will determine the subsequent course of action in consultation with a heritage professional, relevant RAPs and/or the relevant State government agency as appropriate. Aboriginal objects, sites and places will be reported to the AHIMS registrar as soon as practicable.
- Should suspected Aboriginal skeletal material be identified, the materials will not be harmed, all works will cease and the area will be secured to avoid impacts. The NSW Police and OEH will be contacted as soon as practicable. No further works will occur in the area unless authorised in writing by DP&I. Should the burial prove to be archaeological, consultation will be undertaken with a heritage professional, relevant RAPs and/or the relevant State government agency.

6.6.3 Operational impacts and mitigation measures

Access to the pipelines and other components will be required during routine maintenance and repairs. As these areas would have been previously assessed and disturbed during construction, further impacts on Aboriginal heritage are considered unlikely. Procedures would be implemented to ensure the maintenance activities are unlikely to impact on Aboriginal cultural heritage.

6.7 Non-Aboriginal heritage

This section summarises the non-Aboriginal heritage assessment undertaken for the Proposal by AECOM. The report is included in Appendix G.

Non-Aboriginal heritage items within the Proposal area are significant in illustrating the areas transition from an economy based on grazing to a diverse economy, sustained largely by the dairy and mining industries. It is likely that most non-Aboriginal heritage items can be avoided during construction of the Proposal. Where an impact, or potential impact is anticipated, mitigation measures would be implemented to ensure the Proposal does not have a significant impact on non-Aboriginal heritage, including items considered to be of State heritage significance.

Assessment overview

In 2010 and 2011, AECOM Australia carried out a non-Aboriginal heritage impact assessment for the Proposal. The assessment was carried out in accordance with the *Assessing Heritage Significance guideline and the Australia International Council on Monuments and Sites* (ICOMOS) *Charter for the conservation of places of Cultural Significance* (the Burra Charter, ICOMOS 1999). The assessment included:

- a desktop assessment
- an historical overview
- analysis of aerial photos
- research into the history of ownership and development of properties and buildings in the Proposal area
- a field assessment of land potentially impacted by the Proposal.

The desktop assessment included a search of the relevant heritage registers and other documents to identify items and/or places that could be impacted by the construction and operation of the Proposal. This included the:

- National Trust (NSW)
- Register of the National Estate (RNE)
- NSW State Heritage Register (SHR)
- NSW State Heritage Inventory (SHI), including items listed by local and State government agencies under s170 of the *Heritage Act 1977* (eg Roads and Maritime Services and Railcorp)

- Illawarra Regional Environmental Plan No 1 (deemed a SEPP in 2009)
- Wollongong LEP 1990
- Wollongong LEP 2009
- City of Wollongong Heritage Study
- Shellharbour LEP 2000.

Field assessments were carried out between Monday 17 and Friday 21 January 2011. Areas targeted were identified through background research, previous knowledge of the areas and the findings of the desktop assessment. Existing and possible (unlisted and/or newly identified) non-Aboriginal heritage items were identified and recorded in the field through site notes and photographs, and mapped using a Geographic Information System (GIS).

The field study assessed heritage items within the following predicted impact zone:

- assessment area for reservoirs – 2 ha
- assessment area for pumping stations – 125 m^2
- assessment area of service alignments within a road reserve – 25m from the boundary of the road reserve, making a total width of approximately 65 m
- assessment area for service corridors – 50 m, comprising 25 m either side of the proposed alignment.

The impacts of the proposed pipelines on an item were divided into three categories as described in Table 6-24. Mitigation measures were considered to manage direct and indirect impacts of the Proposal on non-Aboriginal heritage items.

Where possible, Sydney Water will avoid impacts on non-Aboriginal heritage items by realigning the pipelines. Where this is not practicable, mitigation measures would be implemented.

Table 6-24 Description of impact categories

Category	Explanation
Direct impact	Where the current alignment will have an impact on an item or an element of its significance.
Indirect impact	Where the item was unlikely to be removed as a result of construction but could potentially be impacted by vibration during construction.
No impact	No impacts were predicted from either the alignment or location of infrastructure or from construction activities.

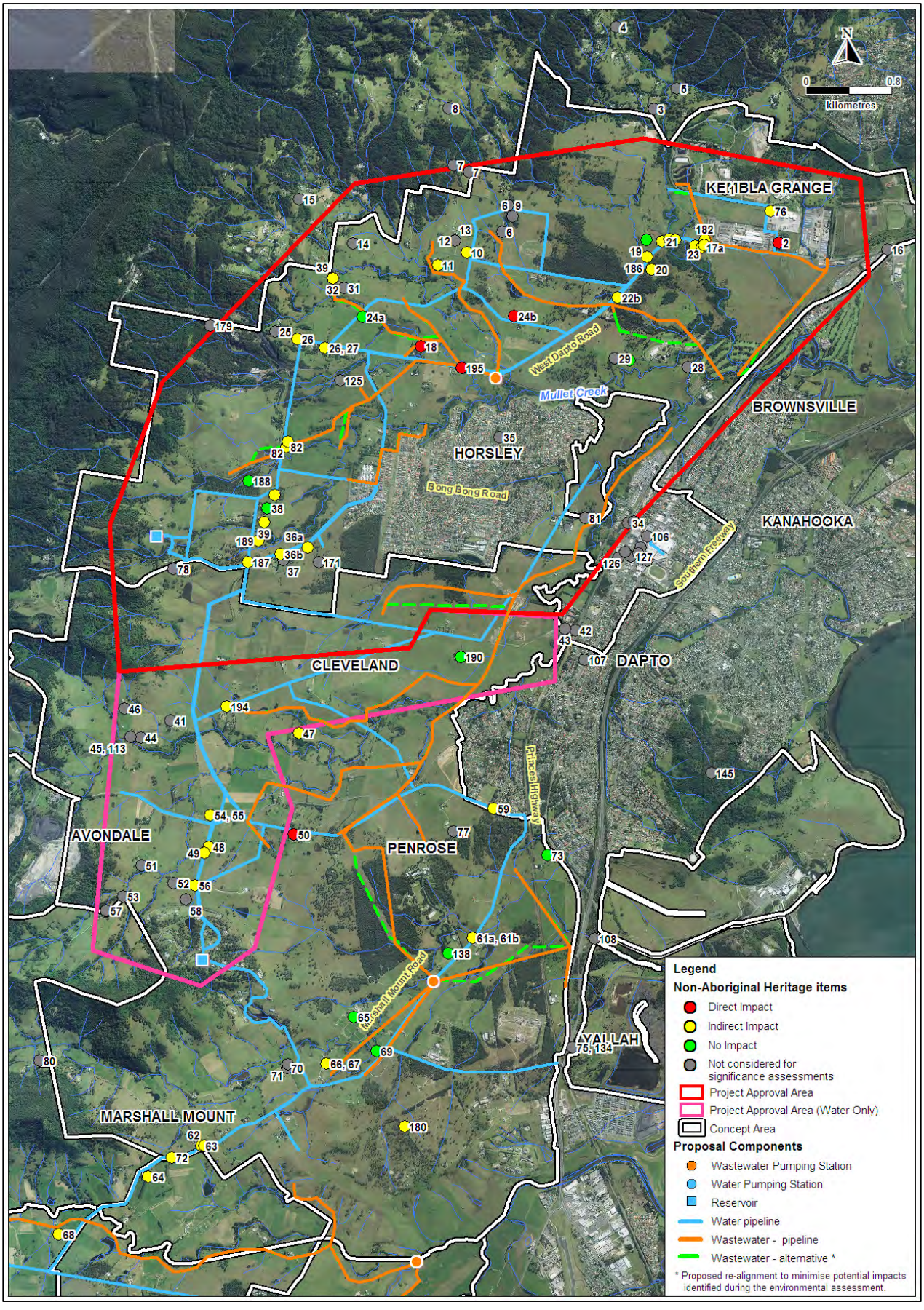
6.7.1 Existing environment

A total of 195 items were considered as part of the non-Aboriginal heritage assessment. The desktop study identified a total of 185 possible non-Aboriginal heritage items, in the vicinity of the Proposal area. Of these, a total of 135 items were identified for field study, based on their location and proximity to the proposed pipelines.

The field study identified ten new possible non-Aboriginal heritage items. These items are currently not listed on existing registers. The new possible items include:

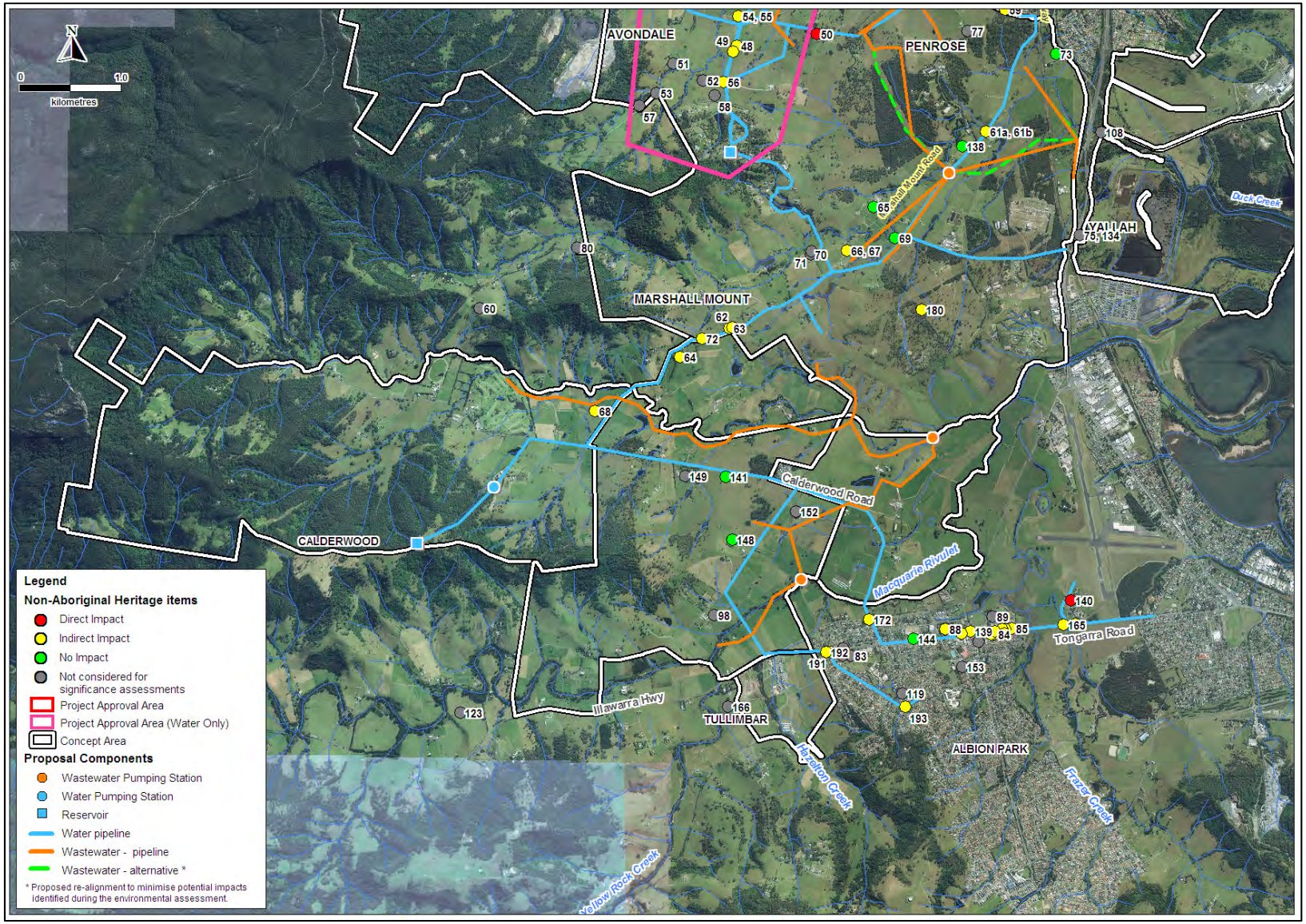
- five archaeological sites along West Dapto Road, within the Project Approval area
- one archaeological site on Hayes Lane, within the Project Approval area
- a Coral Tree Avenue, within the Project Approval area
- two houses on Tongarra Road, within the remaining Proposal area
- one house on Church Street, within the remaining Proposal area.

The locations of all possible non-Aboriginal heritage items have been mapped and are shown in Figures 6-27 and 6-28.



Note: items are identified by site numbers that were assigned during the assessment.

Figure 6-27 Possible non-Aboriginal heritage item locations in the Project Approval area



Note: items are identified by site numbers that were assigned during the assessment.

Figure 6-28 Possible non-Aboriginal heritage item locations in the remaining Proposal area

Significant heritage items and places

Within the Project Approval area there are three items listed on the RNE and two of these are listed on the SHR. Three items within the remaining Proposal area also listed on the RNE. A summary of the heritage items listed on State and national registers is provided in Table 6-25.

Table 6-25 National and State heritage listings within the Proposal area

		Non-Aboriginal items	Heritage register listings
Proposal area	Project Approval area	Cleveland homestead and outbuilding (47)	• Register of the National Estate • National Trust Register • Wollongong LEP 1990
		Dapto Railway Station (34)	• Register of the National Estate (Indicative Place) • State Heritage Register • Wollongong LEP 1990
		Dapto Railway Station - Station Master's Residence (33)	• Register of the National Estate (Indicative Place) • State Heritage Register • Wollongong LEP 1990
	Remaining Proposal area	Penrose homestead, garden and dairy (73)	• Register of the National Estate • National Trust Register • Wollongong LEP 1990
		Avondale homestead and garden (50)	• Register of the National Estate • National Trust Register • Wollongong LEP 1990
		Marshall Mount homestead, garden and outbuildings (64)	• Register of the National Estate • National Trust Register • Wollongong LEP 1990

Note: numbers in brackets represent site numbers assigned to each item during the heritage assessment.

Following the field study, AECOM undertook an assessment of 74 items in the Proposal area. These items were assessed on their ability to meet significance criteria. The significance assessments were carried out in accordance with the *Assessing Heritage Significance Guideline* (Heritage Office 2001), which forms part of the *NSW Heritage Manual*.

The assessments for Avondale (homestead and garden) and Marshall Mount (homestead, garden and outbuildings) found these to be of State significance (AECOM 2011).

6.7.2 Construction impacts and mitigation measures

The desktop study identified 185 possible non-Aboriginal heritage items in the vicinity of the Proposal area. Of these items, 50 were not included as part of the field study and significance assessment, as they were not located within the study (Proposal) area.

The remaining 135 items within the Proposal area were assessed during the field study. One of the items identified for the field study was the Tramway/Illawarra Harbour and Land Corporation Railway (171). However, the Tramway has already been addressed in the *Early Release Lead-in Works for West Horsley Environmental Assessment* (Sydney Water 2011a). The Tramway will not be directly impacted by this Proposal and consequently, has not been included in this report.

In addition, ten new possible items were identified, and included, as part of the field study. Overall, a total of 144 items within the Proposal area (discounting the Tramway (171), as described above) were assessed during the field study.

During the field study, 70 items were found not to be impacted by the Proposal due to their location and distance from the proposed pipeline alignments. Consequently, these items were not included in the significance assessment.

Significance assessments were carried out for 76 items within the Proposal area (note that due to the proximity of some items they were assessed together). Of these items, 41 are located within the Project Approval area. A summary of the number of items anticipated to be impacted by the Proposal is provided in Table 6-26. Non-Aboriginal heritage items potentially impacted by the Proposal are listed in Table 6-27.

Table 6-26 Summary of items assessed for significance and impacts (AECOM 2011)

		Number of items assessed for significance	Number of items potentially impacted		
			Direct impact	Indirect impact	No impact
Proposal area	Project Approval area	41	4	30	7
	Remaining Proposal area	35	2	26	7

Based on the significance assessments, direct impacts are likely for six items within the Proposal area. Of these, four items are located within the Project Approval area. Table 6-28 describes the items likely to be directly impacted and possible mitigation measures. Potential direct impacts include:

- construction impacts from the pipelines, requiring damage or demolition of an item
- removal of part of an item (eg fence) to accommodate work
- disturbing tree roots or requiring tree removal
- visual impacts – changing the visual curtilage.

Indirect impacts generally only involve the potential for an item to be damaged by vibration during construction. However, it can also include damage to driveways/access roads to heritage items or changes to the visual curtilage (eg a visible pipeline close to a bridge). Within the Proposal area, 56 items are likely to be indirectly impacted by the Proposal, of which 30 are located within the Project Approval area.

No impact by the Proposal is anticipated to ten items within the Proposal area, five of which are located within Project Approval area.

The Proposal would not impact on the two items listed on the State Heritage Register (Dapto Railway Station (34) and Dapto Railway Station Station Master's Residence (33)). Avondale (homestead and garden) and Marshall Mount (homestead, garden and outbuildings) were found to be of State significance (AECOM 2011) and are located within the remaining Proposal area (refer to Figure 6-27 and Figure 6-28. Figure 6-27 indicates that a water pipeline would be constructed through Avondale homestead. As stated in Table 6-28, the Proposal would not impact on the heritage significance of Avondale homestead because the water pipeline would be placed within a future road corridor.

A water pipeline would be constructed within the existing road reserve adjacent to Marshall Mount homestead. This is unlikely to impact on elements such as the gardens and outbuildings that contribute to the heritage significance of this item.

Direct impact mitigation measures

Ideally, direct impacts would be avoided by refining the pipeline alignments during detailed design. However, this is not practicable in all locations. Where rerouting the pipelines is not possible appropriate measures, such as in Table 6-28 would be implemented. Provided these measures are implemented, the Proposal is unlikely to result in significant impacts on heritage.

The following general mitigation measures also apply to the Proposal:

- where the pipeline will disturb an ecosystem or trees with heritage significance, the pipeline would be realigned, if practicable
- if a heritage item is required to be removed or damaged, archival recording would be carried out prior to any work commencing that would impact on the item
- construction personnel would be inducted on the potential to find previously unrecorded non-Aboriginal heritage items during the construction work
- if an item, or a suspected item, of non-Aboriginal heritage is discovered during work, all work in the vicinity of the find would cease and the Project Environmental Representative (PER) would be notified to determine the appropriate course of action.

Of the items likely to be directly impacted by the Proposal, Modern house and farm buildings (24b) was found not to be of heritage significance. As a result, no mitigation measures are proposed for this item (Table 6-27).

Table 6-27 Summary of items and impacts for which significance assessments were undertaken

Area	Direct impact	Indirect impact	No impact
Project Approval area	• Settler's Cemetery (Kembla Grange Cemetery) (2) • Brisbane Grove homestead, garden and dairy (18) • Modern house and farm buildings (24b) • Wongawilli Rail (195)	• Shed – Potential AMBS (194) • House and Dairy Building (82) • West Dapto Public School and Residence (10) • Glen Ayr Homestead (11) • Moreton Bay Figs - West Dapto Road (17a) • Moreton Bay Figs - West Dapto Road (17b) • West Dapto Catholic Cemetary (20) • House (21) • Concrete bridge (22a) • Concrete bridge (22b) • Fence - West Dapto Road (23) • Wongawilli Tennis Court (26) • Wongawilli Mine manager's cottage, Former Schoolhouse, Culverts, Houses, former Anglican Church, former Post Office and General Store, former Miner's Cottage, former Mine Surveyor's Cottage, former Mine Engineer's Cottage (26,27) • Stockyard – Bong Bong Road (36a) • Stockyard – Bong Bong Road (36b) • Former Poultry Farm - homestead (39) • House and dairy (40) • Cleveland homestead and outbuilding (47) • Cottage (48) • Dam and hayshed (49) • Moorland homestead and garden (55) • Fence – Corner (56) • Stockyard - Huntley Road (59) • Kembla Grange and War Cemetery (76) • New potential archaeological site 1 - store (182) • New potential archaeological site 2 - public house (183) • New potential archaeological site 3 - J Barretts Farm (184) • New potential archaeological site 4 - cottage (185) • New potential archaeological site 5 - house (186)	• Derelict house (19) • Modern house and farm buildings (24a) • Coral Vale kitchen (former) and outbuildings (32) • Former Poultry Farm – outbuildings (38) • Bridgewater (190) • Barlyn garden and dairy (30) • New site - Coral Tree Avenue (188)

Area	Direct impact	Indirect impact	No impact
		• New potential archaeological site 6 (187) • Bike ramp (189)	
Remaining Proposal area	• Mark's Villa (140) • Avondale homestead and garden (50)	• Yallah Brush (180) • One lane bridge - Marshall Mount Road (61a) • One lane bridge - Marshall Mount Road (61b) • Marshall Mount Public School and residence (62) • Marshall Mount Community Hall (63) • Marshall Mount homestead (64) • Homestead and dairy (Willow Vale) (66) • Homestead and dairy (Willow Vale) (67) • Homestead and dairy (Fairview) (68) • Culvert (72) • Albion Park Council Chambers (84) • Albion Park Courthouse (85) • Albion Park Post Office (86) • Albion Park School and former school residence (88) • Former ES & A Building (116) • Harris' Grange (124) • House, 100 Tongarra Road (131) • House, 102 Tongarra Road (132) • House, 111 Tongarra Road (133) • L.R. Mood Park (139) • Stapleton's Bridge over Frazer Creek (165) • 68 Church Street, Albion Park (193) • Ravensthorpe, including grounds and adjacent worker's cottages (154) • Tulkeroo (172) • 255 Tongarra Road(191) • Rose Cottage (192)	• Homestead and former dairy (Willow Dean) (65) • Moreton Bay Fig and Coral Tree (69) • Logbridge Farm house (138) • Marshall Mount Methodist Cemetery (141) • Moculbo (demolished) (144) • Penrose homestead, garden and dairy (73) • Oak Farm (148)

Note: numbers in brackets represent site numbers assigned to each item during the heritage assessment.

Table 6-28 Assessment of items that may be directly impacted by the pipelines

Item	Statement of Significance	Impact	Possible mitigation measures
Project Approval area			
Settler's Cemetery (Kembla Grange Cemetery) (2)	The Kembla Settlers' Cemetery is of historical significance on a local level as it provides a historical record of ordinary people who lived in the area in the early to mid-twentieth century. The site is also of social significance due to its special association with the local community of the Mount Kembla Region. This includes the presence of David Evans, who rescued many people during the Kembla Mine explosion of 1902. The cemetery is also the burial site of one 17 year old who died at Wongawilli Mine.	A water pipeline is identified as being constructed along Reddalls Road. The first two rows of graves are within 25m of the boundary of Reddalls Road. However, construction on either side of the road may impact known or unknown burial sites (lacking markers). It was common for suicides and paupers to be buried outside the fence. While construction of the water pipeline would likely avoid known existing graves, construction may impact unmarked/unknown graves.	• A remote sensing survey is recommended to be carried out along the pipeline alignment to identify the possibility of sub-surface graves being located during construction. • If burials are encountered and or need to be exhumed then all statutory requirements in addition to any heritage requirements would be met. These are partially covered in the NSW Health Policy Directive: *Burials – Exhumation of Human Remains* (DoH 2008). Any exhumation would cover the whole burial. • Burials would be treated in an ethical and respectful manner in accordance with Anglican and Presbyterian beliefs.
Brisbane Grove homestead, garden and dairy (18)	Brisbane Grove is of local historical significance as it is an example of a late nineteenth century rural homestead and associated dairy buildings. These provide a representation of a traditional dairy, including a timber milking shed, washroom, concrete drainage platform, separator and washroom, bailing area, stock and holding yards.	A water pipeline and wastewater pipeline are proposed to be constructed along West Dapto Road. The older and heritage listed buildings are over 70m from the boundary so the construction of these lines should have no impact on heritage values. A wastewater pipeline is proposed to branch from West Dapto Road and run along the western side of the buildings. Construction of this may result in the demolition of some farm buildings including the old dairy buildings. The original homestead will be within 25m of the wastewater pipeline alignment.	• If possible, the wastewater pipeline should be realigned 25 m to the north west (parallel to its current proposed alignment) to avoid impacts on the farm outbuildings. • If rerouting the pipeline is not practicable, alternatives such as under boring should be investigated to minimise impacts. • If rerouting the pipeline is not practicable and the outbuildings are to be demolished, then archival recording of the buildings should be carried out in accordance with *How To Prepare Archival Records for Heritage Items (1998)* issued by the New South Wales Heritage Office in 1998. In addition, the requirements for items of Local Significance and for items involving Industrial Archaeological Evidence should be followed. • Vibration impacts would be managed in accordance with the *German Standard DIN 4150: Part 3* – 1999.
Modern house and farm buildings (24b)	While there is likely to be a direct impact to the farm buildings, they are not of heritage significance.	A water pipeline runs through the derelict farm buildings and is likely to result in their demolition.	The House and Farm are not listed on a heritage schedule and not considered to be of heritage value. No mitigation measures are required.

Item	Statement of Significance	Impact	Possible mitigation measures
Wongawilli Rail (195)	The Wongawilli Rail Line is of local historical significance as it demonstrates an important pattern in the development of coal transportation in the Illawarra. As with other collieries in the area, Wongawilli constructed a private line to transport coal to the main government line. Additionally, it is of local significance as a rare example of a private rail line still in operation.	No impacts will occur within the section of line listed on the West Dapto (2010) LEP. A series of water and waste water pipelines will intersect or run parallel to the unlisted portion of the Line.	No management measures are required as no impacts to the heritage listed portion of the Line are anticipated.
Remaining Proposal area			
Avondale homestead and garden (50)	*Avondale is a well detailed and almost intact mid nineteenth century homestead which survives in its Victorian garden setting, and demonstrates the tastes and lifestyle of a prosperous settler of the period. The presence of Colonial Georgian stylistic features in what is essentially a vernacular homestead gives it particular interest in demonstrating creative achievement and design ideas of the time. The property has historical associations with the Osborne's, a pioneering family of the Illawarra. It is one of few properties of such age and intactness to survive in the rural Illawarra.* (Statement from RNE listing)	As stated in Section 3.1, water pipelines would be placed in existing and proposed road corridors where practicable to minimise potential environmental impacts, The impact on Avondale homestead is based on the assumption that the water pipeline is placed within a future road corridor that was provided to Sydney Water by Wollongong Council and would pass either through or just south of the main building. The pipeline would only be constructed in this location if Council obtains approval for this road alignment and this would involve assessing potential impacts on Avondale. Given the heritage significance of Avondale, it is possible that Council may revise the road alignment to avoid potential impacts, in which case Sydney Water would refine the alignment of the water pipeline such that it remains within the road corridor. Not with standing this, if the road corridor alignment is not revised, it is unlikely that Sydney Water would impact on Avondale because the pipeline is likely to be constructed at the same time as the road, in which case the impact of constructing a road through this heritage item would be attributed to the road. As such, the Proposal would be unlikely to impact on the heritage significance of Avondale.	• Avondale is listed on the Register of the National Estate, National Trust Register and Wollongong LEP 1990. Given the heritage significance, Sydney Water would liaise with Wollongong City Council to confirm whether the future final alignment of the road corridor would avoid Avondale and thereby require the water pipeline to be realigned. • Vibration impacts will be managed in accordance with the *German Standard DIN 4150: Part 3* - 1999. (DIN 1999).

Item	Statement of Significance	Impact	Possible mitigation measures
Marks Villa (140)	Mark's Villa is of local historical significance as an intact example of an early house and dairy. It provides a reminder of the strong dairying roots of Albion Park and the importance of the industry in the development and history of the area throughout the nineteenth and twentieth centuries. The item is also of local historical significance as the site has links to several known historical figures from the Albion Park area. This includes Samuel Marks, whose name endured in the name of the site to the present day. The original site of Mark's Villa was adjacent to the Illawarra Highway and is marked by a lone silo. It is of some research significance, as it may have an extant subsurface archaeological record which could possibly include the original foundations of the original homestead and other associated material culture. This could potentially contribute to our understanding of early nineteenth century life on a dairying property in the Illawarra Region.	It is proposed to construct a water pipeline running roughly north from Tongarra Road. The pipeline is planned to run through Wanalama, the dairy complex and the separate feedlot, which will destroy these items.	• if possible, the water pipeline should be relocated to avoid this item by at least 15 m. • if rerouting the pipeline is not practicable, alternatives such as under boring should be investigated to minimise impacts. • if rerouting the pipeline is not practicable and the outbuildings are to be demolished, archival recording should be made of the building using the *guideline How to prepare Archival Recording of Heritage Items* issued by the New South Wales Heritage Office (1998). The requirements for items of Local Significance and for recording items of Industrial Archaeological significance should also be followed.

Note: numbers in brackets represent site numbers assigned to each item during the heritage assessment.

Indirect (vibration) impact mitigation measures

A total of 56 items within the Proposal area have the potential to be indirectly impacted by vibration (see Table 6-27) and 30 of these are within the Project Approval area. Vibration generated by construction machinery may result in damage to these heritage items where the items are located in close proximity to work areas. Construction activities most likely to cause vibration impacts would be the compaction of surfaces following the installation of pipelines and jack hammering of rock or existing infrastructure (eg roads).

Any anticipated vibration impacts would be managed to mitigate the impacts. The *German Standard DIN 4150: Part 3 – 1999,* is the standard usually used for assessing the vibration risk to structures and assigning safe working distances. Table 6-29 indicates safe working distances from vibration-intensive machinery. These safe working distances are based on the maximum level of vibration (3mm/s) considered to be safe for heritage structures.

Table 6-29 Indicative safe working distances for vibration intensive plant

Plant item	Description	Safe working distance
Vibratory roller	< 50 kN (typically 1-2 tonnes)	10 m
	< 100 kN (typically 2-4 tonnes)	12 m
	< 200 kN (typically 4-6 tonnes)	24 m
	< 300 kN (typically 7-13 tonnes)	30 m
	> 300 kN (typically 13-18 tonnes)	40 m
	> 300 kN (typically >18 tonnes)	50 m
Vibratory pile driver	Sheet piles	4 – 40 m
Pile boring	<= 800 mm	4 m (nominal)
Jackhammer	Hand held	1 m (nominal)

Note: kN = Kilonewton

Construction activities would be managed to avoid structural damage to heritage items as a result of vibration. To avoid impacts on heritage items mitigation measures would be implemented. Appropriate mitigation measures may include:

- during construction, limits would be placed on the contractor to manage vibration levels in accordance with *German Standard DIN 4150: Part 3 – 1999*
- during detailed design, consideration would be given to the feasibility of revising the location of infrastructure to increase the distance between construction activities and heritage items
- where vibratory plant or activities are to be undertaken within 50 m of the heritage item, an assessment of potential vibration impacts would be undertaken prior to construction. The assessment may determine the vibration levels likely to be experienced at the heritage items during construction
- unless it can be demonstrated that the heritage item would not be damaged by higher vibration levels, vibration levels experienced at the heritage items are not to exceed 3 mm/s. If required, smaller sized or non-vibratory machinery would be selected so that vibration levels do not exceed 3 mm/s
- where vibration would potentially impact a heritage item, vibration monitoring may be carried out during construction to identify if safe vibration limits (3 mm/s) are being maintained
- the potential for vibration impacts and need for site specific mitigation measures would be considered after the final location of the pipelines has been confirmed during detailed design.

6.7.3 Operational impacts and mitigation measures

There is no anticipated potential to impact non-Aboriginal heritage from the normal operation of the infrastructure. However, the pipelines and ancillary infrastructure will require periodic maintenance. Sydney Water maintains procedures for maintenance activities and adherence to these procedures should ensure there is no impact to items of non-Aboriginal heritage from the operation of the infrastructure.

6.8 Soils and groundwater

Assessment overview

Sydney Water engaged Coffey Geotechnics Pty Ltd (Coffey) to assess the potential impacts on soils and groundwater from the construction, operation and maintenance of the Proposal. Coffey prepared *The West Dapto Urban Release Area and Adjacent Growth Areas - Geology, Soils and Groundwater Assessment* (Coffey, 2011), attached as Appendix H, to identify potential constraints that would need to be considered during detailed design and to address the Director-General's requirements relating to potential impacts of the Proposal on soils and groundwater.

The potential direct impacts on the geology, soils and groundwater in the Proposal area were assessed, as well as indirect impacts to nearby areas such waterways downstream of construction activities. The boundary of the study area, as assessed in the Coffey report, is shown as the 'Geology Soils and Groundwater (GSG) Study Limits' on the figures in this section. The assessment was based on:

- Coffey's knowledge of the area
- relevant legislation
- available mapping and previous studies of the area
- a field visit to ground truth the desktop conclusions.

Areas with potential soil and groundwater constraints were identified through desktop assessments and the field inspection. A risk assessment was undertaken to identify potential impacts from the Proposal. This section provides a summary of existing conditions, potential impacts associated with the construction and operation of the Proposal and mitigation measures to be considered during detailed design and construction.

As discussed in Section 6.1, the network of pipelines and associated infrastructure has been refined since the preparation of the technical report, and therefore some impacts and recommendations discussed in the technical report are no longer relevant to the Proposal.

6.8.1 Existing environment

Geology

The Proposal area is within a physiographic region east of the Illawarra Escarpment known as the Coastal Plain. The geology is dominated by near-horizontal Permo-Triassic sedimentary and volcanic rock sequences.

The Illawarra Escarpment is comprised of Hawkesbury Sandstone overlying Narrabeen Group sedimentary sequences and Illawarra Coal Measures. The Escarpment is characterised by thick talus layers (landslide deposits) interspersed with resistant rock bands in the cliffs. Minor faulting occurs near the Illawarra Escarpment.

The Coastal Plain is characterised by sediments interbedded with latites within the Shoalhaven Group. Thick channel, flood and estuarine deposits overlie these sediments. Alluvial deposits are generally found near Lake Illawarra, on slope foothills and beneath watercourses.

Landform

The Illawarra Escarpment is prone to slope instability, with rock falls and landslides. Watercourses in the upper foothills below the Escarpment are energetic, incised and capable of transporting large boulders. These watercourses are prone to rapid vertical and lateral erosion.

The Coastal Plain has been formed by the westwards retreat of the Escarpment. The Plain is generally undulating with erosion resistant latites forming steeper features such as Mount Brown. Where steeper slopes have formed they are prone to landslides. Watercourses are generally small and prone to flooding. The deposits within the watercourse channels are typically fine silts on a gravel column. Changes in sea level over the last 10,000 years have formed Lake Illawarra.

The majority of Proposal components are likely to avoid steep slopes and highly energetic watercourses as they are in the lower-lying areas east of the Escarpment. Only one aspect of the Proposal, which includes water and wastewater infrastructure, passes through the base of the Illawarra Escarpment. This has been identified as a high landslide risk area, and is situated at the northwestern extent of the Project Approval area in Wongawilli (Coffey, 2011). This area is identified as “L” on Figure 6-30.

Watercourses

The watercourses within the Proposal area have variable characteristics depending on fluvial processes and surrounding landscapes and can be subdivided into three distinct reaches: the upper reaches associated with very steep slopes of the Illawarra Escarpment; the middle reaches with an abrupt change in slope at the base of the escarpment; and the lower reaches within the low-lying coastal plains (Coffey, 2011).

Watercourses have highly variable flow regimes and large ‘flash’ floods occur relatively frequently (i.e water levels rise and fall very rapidly) and this affects watercourse morphology. The steep, high energy upper reaches of the watercourses in the Illawarra Escarpment are typically located on broad, coarse gravel to boulder deposits and are resistant to vertical erosion. Therefore, bank erosion and lateral channel migration are common generally along the outbank meander bends. At the base of the escarpment, where there is an abrupt decline in slope, flooding can cause channel changes. Watercourses running through the coastal plains, along the lower reaches, have small stable channels, low sinuosity and typically do not migrate (Coffey, 2011). As a result, they are prone to frequent overbank flooding. Flood constraints and management measures are discussed in Section 6.12.

Four high constraint watercourses were identified within the Proposal area and are identified on Figure 6-30 as “W”. Two of these watercourses were identified as having potentially eroding outer meander bends and are located in the Project Approval area in Sheaffes/Wongawilli area (northwest of West Dapto Road) (Coffey, 2011). These watercourses are within close proximity to proposed water and wastewater pipelines. The remaining two watercourses that were identified as high constraints occur in the remaining Proposal area and are crossings of Mullet Creek between Avondale and Brownsville for water and wastewater pipelines.

Crossings for water infrastructure would be co-located with future roads and/or bridges (see Section 3.2.1) and therefore have not been discussed further in this section.

Soils

Soils on the Illawarra Escarpment are generally shallow and skeletal as they overlie or are near rocky outcrops. They are also often ferrous and poorly drained.

Soils on the Coastal Plain are more variable with some skeletal soils on outcrops, uniform and gradational soils on upper slopes, and texture contrast soils on lower slopes. Acid Sulfate Soils (ASS) may be present in some areas below 10 m Australian Height Datum (AHD).

Soil landscape units based on Hazelton (1992) have been combined with geological and landform information to form Terrain Units. The Terrain Units group areas with similar soils, geology, landform and constraints (eg potential erodibility or likely presence of saline soils). A detailed description of each Terrain Unit and its constraints is provided in Table 6-30. The location of these Terrain Units is shown in Figure 6-29.

If present, saline soils are likely to be associated with low-lying former and existing estuarine, marine and coastal areas in the Fairy Meadow and Shellharbour Terrain Units. HLA (2005) mapped highly saline soils near Horsley and in the Avondale Road area. However, visual indicators of salinity such as vegetation die-off and surface salt crusting were not seen during the assessment conducted by Coffey (2011). Other available soils maps of the Illawarra Region (eg Hazelton, 1992) do not show any areas where salinity is a known problem.

ASS occur naturally and contain iron sulfides that can oxidise on exposure to air and generate sulfuric acid. The majority of the Proposal area has been mapped as 'no known occurrence of ASS'. However, some areas have been mapped as having a risk of ASS occurring in Kembla Grange, Yallah, Koonawarra and Albion Park (DLWC 2008). In addition, pyrite was observed along Mullet Creek at William Beach Park and this indicates that ASS may be present at this location. Although the majority of Proposal is likely to avoid ASS, the construction of some pipelines may encounter ASS. The areas where this may occur are shown in Figure 6-30.

Table 6-30 Terrain units in the Proposal area

Terrain Units[1]	Landform	Geology	Soils	Constraints
Coastal Plain				
Depositional Landscape[2]				
Fairy Meadow	Low-lying broad plains, valley flats and terraces below the Illawarra Escarpment	Budgong Sandstone	Alluvial loams and siliceous sands on terraces, gradational and poorly drained texture contrast soils on drainage plains	• flooding • high permeability soils • high seasonal water tables • low wet bearing strength • low fertility.
Wattamolla Road	Undulating to rolling hills with long sideslopes and broad benches	Budgong Sandstone	Texture contrast	• localised landslides • localised flooding • low wet bearing strength.
Erosional Landscape				
Bombo	Low rolling hills with benches, platforms and coastal cliffs	Latite	Shallow uniform and gradational soils on crests and upper slopes; texture contrast soils on mid - lower slopes	• shallow soils • rock falls • rock outcrops • low wet bearing strength.
Shellharbour	Low rolling hills with long sideslopes and broad drainage plains	Budgong Sandstone	Deep gradational soils on crests, upper slopes and mid-slopes, with texture contrast soils on lower slopes and drainage plains	• localised water erosion • localised shallow soils • localised landslides • highly expansive • low permeability • sodic subsoils • low wet bearing strength.
Gwynneville	Undulating to steep hills with rounded ridges, structural benches and occasional rock outcrops	Illawarra Coal Measures and Dapto Latite	Shallow, poorly drained gradational and texture contrast soils on upper slopes; shallow uniform soils on mid - lower slopes; areas of skeletal soils	• highly erodible • localised steep slopes • landslides • local flooding • expansive/impermeable subsoils • low wet bearing strength.
Albion Park	Sharply concave slopes with long gentle footslopes	Berry Siltstone	Texture contrast	• waterlogging • seasonally high watertable • high expansion.

Terrain Units[1]	Landform	Geology	Soils	Constraints
Illawarra Escarpment				
Colluvial Landscape				
Illawarra Escarpment	Steep to very steep slopes	Quaternary Talus	Deep colluvial texture contrast soils with weakly developed uniform soils where talus is recent	• widespread landslides • rock falls • steep slopes • highly erodible • reactive soils • low to moderate fertility.
Warragamba	Narrow convex crests and ridges with steep colluvial side slopes	Narrabeen Group	Weakly developed uniform soils on crests; gradational soils and ferrous texture contrast soils on upper slopes; poorly drained texture contrast soils on lower slopes	• landslide-prone • highly erodible • steep slopes • some rock outcrops.
Hawkesbury	Rolling to very steep hills, with narrow valleys and crests. Horizontal benches and broken scarps from rock outcropping. Boulders and cobbles cover up to 50% of surface	Hawkesbury Sandstone	Shallow skeletal soils on crests and ridges. Poorly drained gradational and texture contrast soils on sideslopes. Siliceous sands along valley flats. Ferrous or poorly drained gradational soils on shale outcrops	• erodible • landslides • localised steep slopes • rock outcrops • shallow, stony • highly permeable • seasonal waterlogging • low fertility.
Other				
Water[3]				• acid sulfate soils
Disturbed Terrain	Artificially disturbed to a depth of at least 1 m	Various		• uncontrolled fill • landslides • subsidence • low fertility • poor drainage • incomplete mapping due to rapid change.

1. Soil classifications are based on the findings of the relevant, publicly available studies and field observations of soil exposures, not investigative fieldwork (Coffey 2011)
2. Definitions and Landscape Type are taken from Hazelton (1992)
3. “Water” refers to major waterbodies (i.e. Lake Illawarra), rather than creeks, dams or groundwater
4. Disturbed Terrain can be found throughout the study area and the exact extents are not well known.

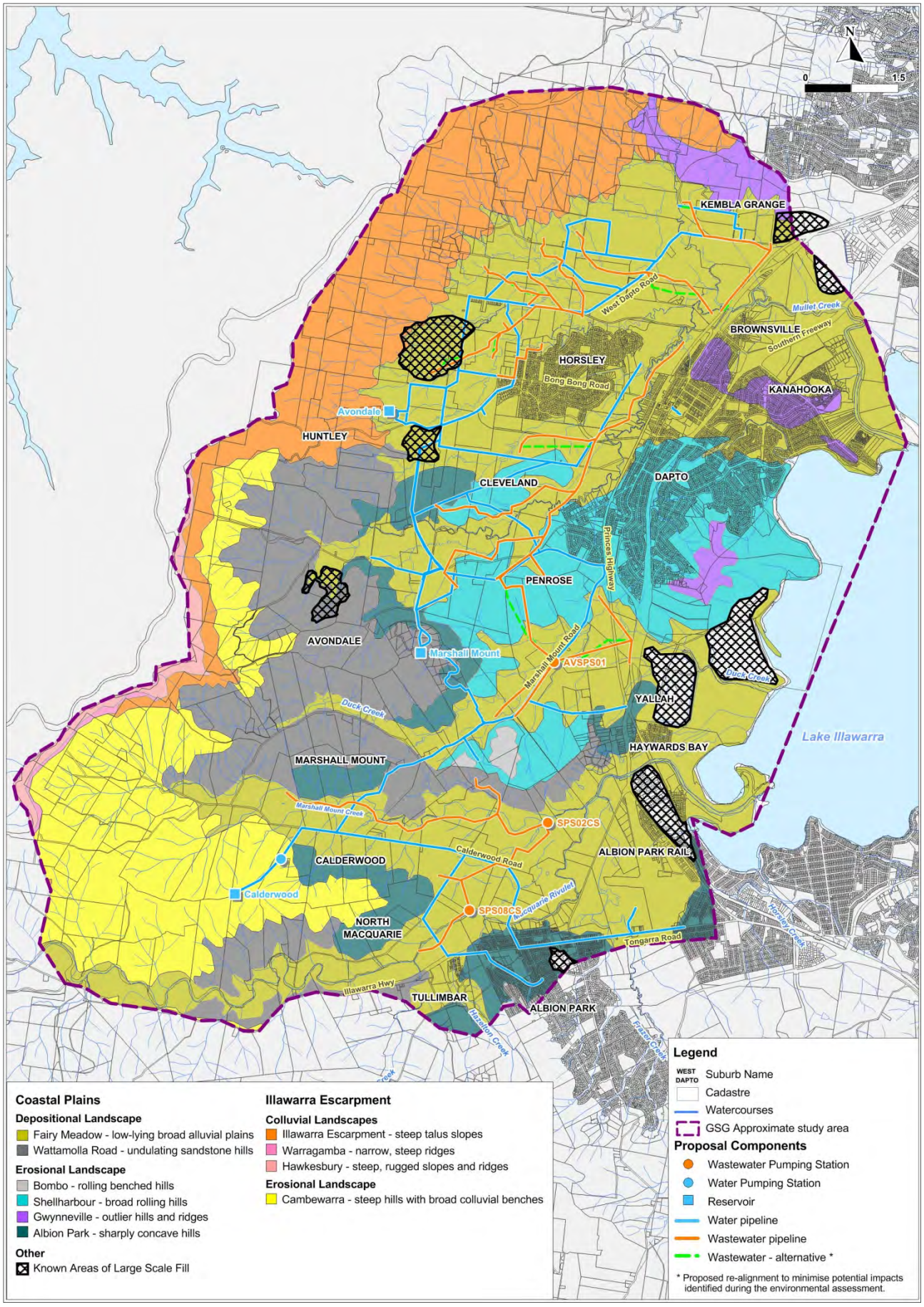


Figure 6-29 Location of Terrain Units

Disturbed lands

The Proposal area includes areas of artificially disturbed terrain. These areas are generally associated with previous construction activities, mines, or filling low elevation areas on rural properties. These areas may be prone to erosion, subsidence and drainage issues. In general, disturbed areas are not mapped. Within the Illawarra Region there are some known areas of disturbed lands including several large coalwash fill areas adjacent to the Huntley, Avondale and Wongawilli coalmines. Known areas of disturbed land are included on Figure 6-29.

Contaminated lands

In addition to disturbed lands, potentially contaminated sites exist from current or past land uses or activities, such as fuel depots, piggeries, waste disposal sites and mine operations. Although rural land uses currently dominate, there are areas where the historic activities are not known, and contamination is still possible. The location of potentially contaminated sites from both disturbed lands and other causes is shown in Figure 6-30.

In addition to disturbed lands, potentially contaminated sites exist from current or past land uses or activities, such as fuel depots, piggeries, waste disposal sites and mine operations. Although rural land uses currently dominate, there are areas where the historic activities are not known, and contamination is still possible. Potential contaminated sites were identified by reviewing historical aerial photographs, Council zoning maps, and OEH's register of declared contaminated lands. The following potential contaminated sites were identified within the Project Approval area:

- A former piggery at 340 West Dapto Road, Kembla Grange.
- An existing mining operation at Wongawilli Colliery and former mining operations at Huntley and Avondale. These were also identified as coal wash emplacement areas.
- Emplacement areas, mainly from the disposal of waste materials from coal mining and steel making at: Avon; West Dapto Road/Wylie Road, Kembla Grange; and West Dapto Road, north of Horsley.
- Whytes Gully Landfill and steel pipe manufacturing facility off Reddals Road, Kembla Grange.
- Kembla Grange Golf Course.

The following potential contaminated sites were identified within the remaining Proposal area:

- Calderwood Golf Course.
- Fuel depots in proximity to the proposed water pipeline alignment in Albion Park.

The locations of potentially contaminated sites from both disturbed lands and other causes is shown in Figure 6-30.

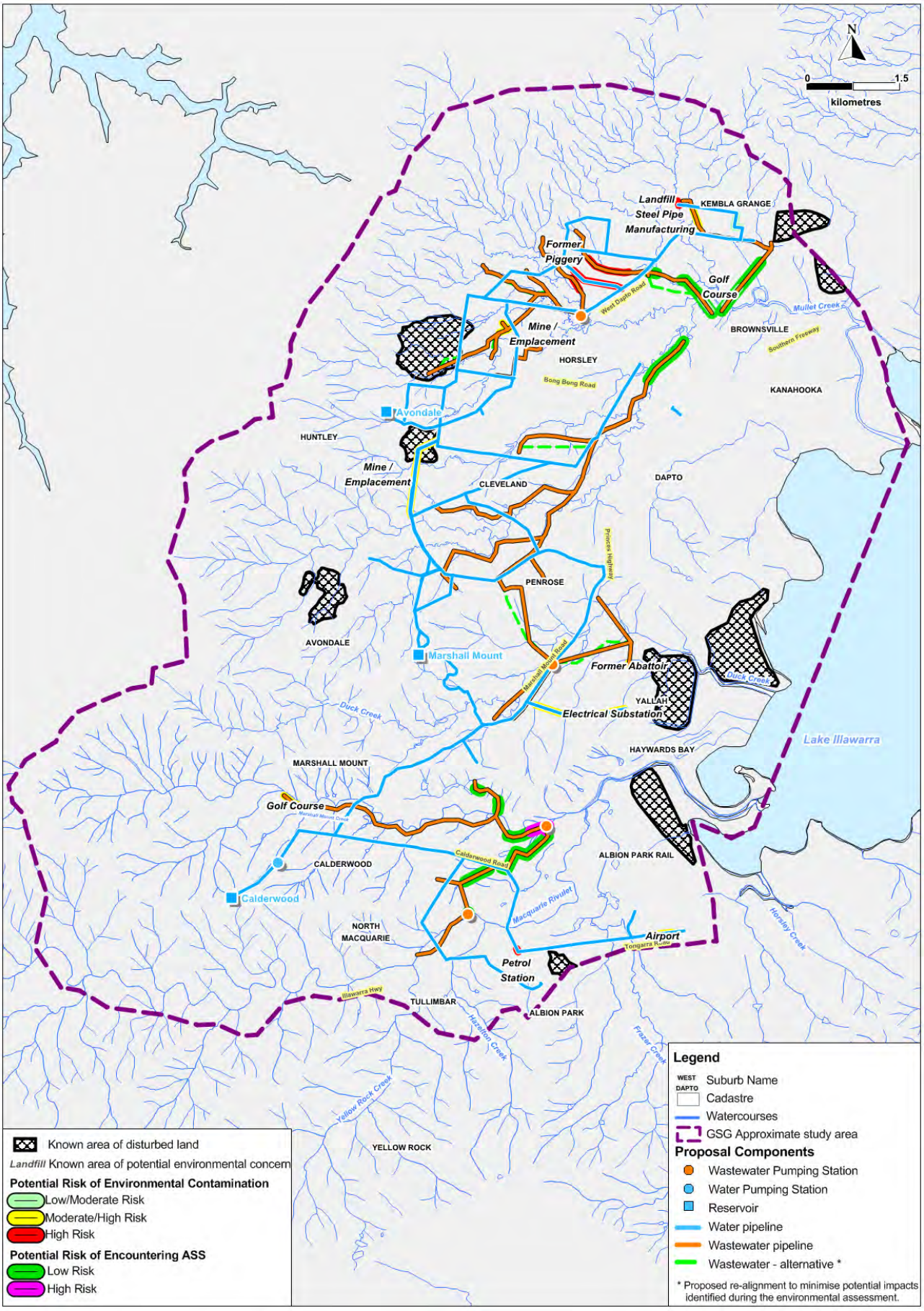


Figure 6-30 Areas of potential soil contamination and ASS risk

Groundwater

Two main aquifers exist in the Proposal area (Camp Scott Furphy 1993 and HLA 2005). One is a shallow aquifer consisting of unconsolidated gravels, clays and sands within approximately 5 m of the ground surface. Unconsolidated sediments in low-lying areas in the east of the Coastal Plain such as near Lake Illawarra are likely to have shallow groundwater between 1 m and 3 m below ground level.

The second is a deeper aquifer associated with elevated areas in the west of the Proposal area where groundwater is present in fractures and weathered seams in the underlying geology. However, shallow groundwater may also be present in elevated areas in the west, such as in gravel deposits near watercourses. In talus and landslide areas, the depth to groundwater can be variable, especially during high rainfall events.

The unconsolidated alluvial/estuarine aquifer has a higher permeability than the deeper aquifer and is likely to exhibit more groundwater flow. Groundwater recharge occurs from rainfall, runoff and recharge from bedrock. Groundwater discharge occurs as lateral flow to surface water bodies, evapotranspiration and leakage to bedrock. Seasonally high water tables are associated with the Fairy Meadow and Albion Park Terrain Units. Tidal limits also influence groundwater; for example Duck Creek has a tidal limit approximately 2 km inland from Lake Illawarra.

Groundwater flow is generally from west to east towards various watercourses and Lake Illawarra. The groundwater tends to become more saline closer to Lake Illawarra. Poor quality groundwater may be associated with contaminated sites.

There are over one hundred registered groundwater boreholes in the Proposal area. Most are drilled into the deeper of the two aquifers. Twenty-two bores are at 10 m depth or less, and are mainly registered for monitoring purposes. Borehole locations would be considered during detailed design. If any are identified along the proposed pipeline route, appropriate measures would be taken to either avoid the bore or obtain confirmation that the bore is no longer in use.

6.8.2 Construction impacts and mitigation measures

High risk areas within the Proposal area identified by Coffey (2011) are illustrated in Figures 6-30, 6-31 and 6-32. Figure 6-31 identifies locations where the design and construction would need to take into consideration specific landform risks. Areas marked ‘W’ are sensitive watercourses; areas marked ‘L’ are known landslide areas, and areas marked ‘T’ have steep slopes. As discussed in Section 3.4.1, site specific evaluation would be undertaken at locations such as these to ensure appropriate design, construction methods, and mitigation measures are developed and implemented. This would consider soil and landform risk factors along with other constraints identified in this EA. Where practicable, higher risk areas would be avoided, and if this is not possible, alternative construction and management approaches would be implemented.

Potential impacts associated with high risk areas would generally be avoided through the detailed design process outlined in Section 3.4.1. For example, creek crossings would be under bored if the localities have features such as dynamic watercourses, perennial streams, highly erodible soils and sensitive riparian corridors (as categorised in Section 6.5). This would minimise construction impacts to these areas.

Construction of the Proposal has the potential to result in: erosion and sedimentation, potential impacts to natural watercourse features, exposure of acid sulfate soils and contaminated soils, contamination of soils, and groundwater impacts. These impacts are unlikely to be significant as the mitigation measures listed below and the avoidance measures described in Section 3.4.1 would be implemented.

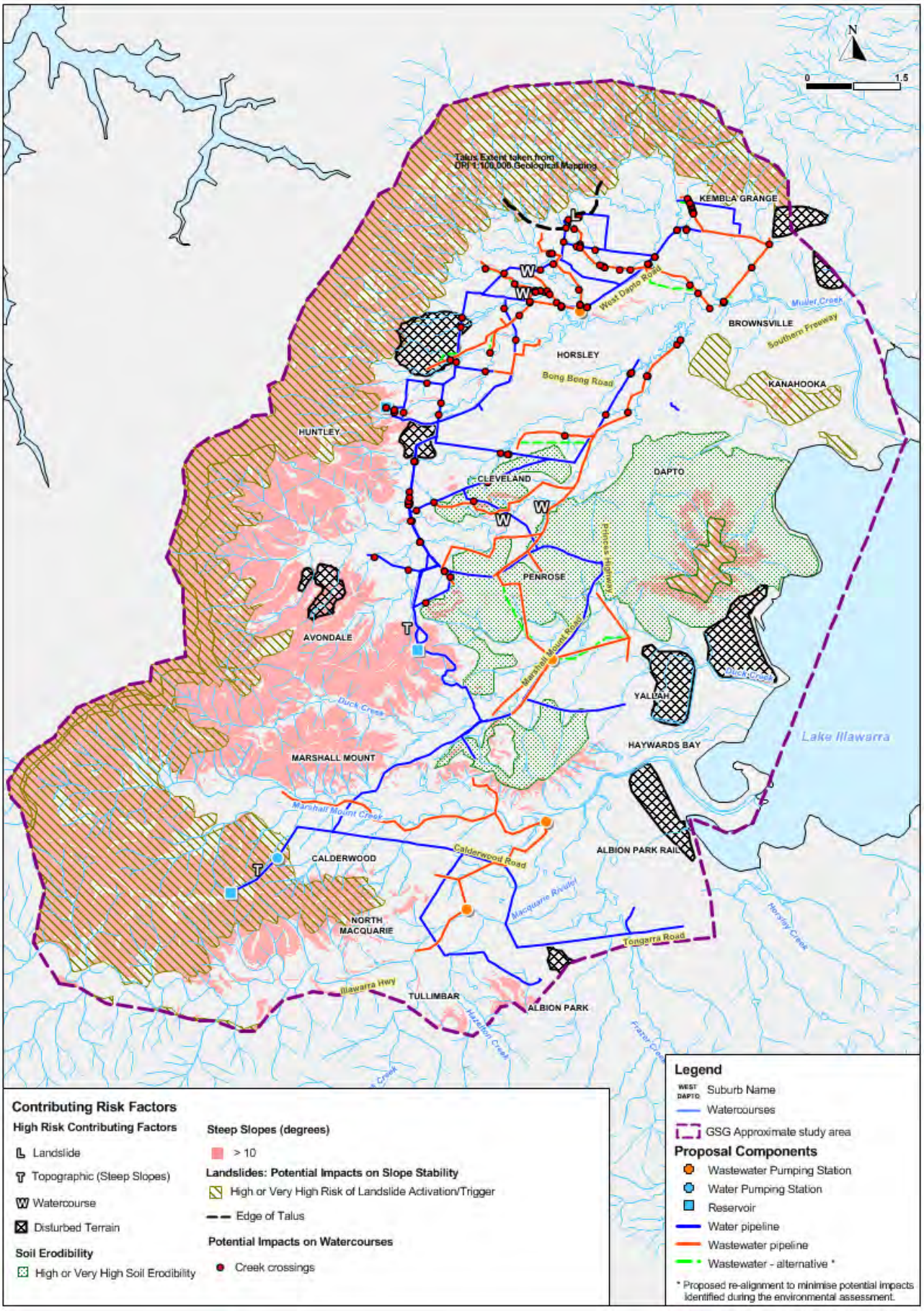


Figure 6-31 Potential risk factors

Landslides

The soils and groundwater assessment found that there is an area of landslide risk in the Wongawilli area (marked 'L' on Figure 6-31). This area is at the base of the Illawarra Escarpment and coincides with the extent of the mapped talus. Construction of both water and wastewater pipelines is proposed in this area. If trenches are not suitably constructed, the talus could be impacted, triggering a landslide which would result in damage to the infrastructure. This impact is considered to be minor as further geotechnical investigations would be undertaken during detailed design to confirm the actual extent of the talus in this area, and the location of the proposed pipelines will be reviewed accordingly. If practicable, the pipelines would be located to avoid impacting the talus. Where there is a potential risk of impacting the talus, consideration would be given to design and construction techniques to maintain the stability of the slopes in the area. This process may refer to relevant guidelines, such as the *National Landslide Risk Framework for Australia* (AGS, 2007).

Mapping of faults in the Proposal area undertaken by Coffey (2011) indicated that no infrastructure would be located over faults.

Watercourses

Due to the dynamic nature of some watercourses in the study area, the Proposal has the potential to impact the fluvial geomorphology of watercourses (the natural processes and pressures operating on a river system), by changing the natural pathway or channel geometry. During detailed design, consideration would be given to design measures and construction methods to minimise the potential for impacts on fluvial geomorphology. This would address the intent of relevant guidelines, including DIPNR (2004), Southern Rivers Catchment Management Authority (CMA 2006), Landcom (2004), NOW (2008) and WCC (2009c).

Most of the Proposal is located within the Coastal Plain, and pipelines would cross watercourses within the lower reaches that are generally stable with low potential for channel migration. Two watercourses were identified within the Sheaffes/Wongawilli area as being high risk due to geomorphological issues (Figure 6-31). These locations, which are also mapped as Category 1 watercourses (Section 6.5), have potentially eroding outer meander bends which is indicative of dynamic watercourses. Water and wastewater pipelines are proposed within close proximity to these two high risk locations. There is the potential for the meander bends to erode and impact on these pipelines. This potential impact is considered to be minor because consideration would be given to design and construction techniques (as discussed in Section 3.4.1) to ensure that potential impacts associated with these geomorphological processes are mitigated. If watercourse crossings are required at these locations, consideration would be given to pipe burial depths, taking into account the potential for the bed and banks to scour. The potential for channel migration would also be considered when confirming the launch and receival points for under boring.

Two other high risk watercourse crossings identified by Coffey (2011) occur in the remaining Proposal area, and are crossings of Mullet Creek between Avondale and Brownsville for water and wastewater pipelines. Mullet Creek is mapped as a Category 1 watercourse (refer to Figures 6-23 and 6-24 in Section 6.5) and would most likely be under bored.

Construction of the wastewater pipelines will require works in riparian areas including a number of creek crossings. Riparian areas are generally considered to be highly susceptible to erosion due to the high energy landform characteristics in these areas. Construction would use a combination of trenching and under boring, and the construction method at each creek crossing would be selected following consideration of environmental, engineering and operational constraints (refer to Section 3.4.1). Site-specific evaluations would focus on sensitive locations such as dynamic watercourses, highly erodible soils and sensitive riparian corridor characteristics. If additional watercourses are considered to present risks similar to the four high constraint sites described above they would be managed similarly.

The riparian assessments undertaken for the Proposal (ELA, 2011) categorised watercourses in the Proposal area into three categories based on several contributing factors including the extent of bank erosion (ELA, 2011). These categorisations are discussed in Section 6.5 and would be considered during detailed design when selecting each proposed creek crossing method. Where practicable, the principle mitigation measure would be to avoid the higher risk areas (see Section 3.4.1). Under boring would generally be used for Category 1 streams and high risk areas that cannot be avoided and this would reduce the risk of erosion and sedimentation and associated impacts on water quality and hydrology. Where possible, the exit and entry points for under boring would be located outside the riparian corridor (refer to the 'top of bank' mapping in Section 6.5). Under boring would also avoid the need to divert creeks and in turn avoid potential impacts associated with instream works, such as blocking fish passage and changing the bed slope of creeks.

Where practicable, watercourses would only be trenched if they are minor, shallow, ephemeral, highly disturbed and weed infested. Potential impacts would include introduction of preferential pathways for water runoff, erosion of creek beds and banks and sedimentation. Mitigation measures would be developed and implemented to minimise impacts during construction and would include:

- trenching when the creek bed is dry to avoid the need for temporary water diversions
- avoiding works during or immediately following heavy rain events
- implementing erosion and sedimentation controls in accordance with *Managing Urban Stormwater: Soils and Construction* (Volume 1, Landcom 2004 and Volume 2A, DECC 2008).

Following construction works, restoration would be undertaken as soon as practicable to ensure stream banks are appropriately re-instated to their pre-works condition and disturbed riparian zones are revegetated. Restoration and stabilisation of disturbed riparian areas would involve the use of temporary erosion and sediment controls such as coir logs and erosion matting (such as jute mesh) until vegetation is re-instated.

Soil erosion and sedimentation

Disturbance, excavation and stockpiling of soils will be required to construct the Proposal. If not properly managed, disturbed soils can be eroded by runoff from the construction sites into the surrounding terrestrial and aquatic environments and this can cause impacts such as sedimentation and eutrophication. The risks associated with these impacts are largely dependent on the:

- extent of soil disturbance
- location of the construction site relative to environmental and catchment features (eg. creeks, vegetation)
- characteristics of the terrain unit.

Table 6-31 summarises the above three factors that influence the risk of erosion and sedimentation impacts from the construction of Proposal components. Figure 6-31 indicates areas considered to have a high risk of erosion due to soil erodability, steep slopes, landslides, watercourses or geomorphological features. These risk factors would be considered further as the project is refined during the detailed design process (see Section 3.4.1). The Proposal components that have the highest erosion and sedimentation risk during construction are the wastewater pipelines and pumping stations, and the Avondale Reservoir. The risk of erosion is likely to be comparatively high for these components because the pipelines are generally located close to creeks that are prone to flooding, and a large proportion of the pipelines would be within the Fairy Meadow Terrain Unit which is known to have high seasonal water tables. Flooding is discussed in Section 6.12. There is considered to be a high risk of erosion and sedimentation when constructing the Avondale Reservoir as this will require extensive excavation and is located close to steep slopes.

Erosion and sedimentation risks would be reduced to acceptable levels by developing and implementing appropriate and standard erosion and sedimentation mitigation measures. Mitigation measures detailed in *Managing Urban Stormwater: Soils and Construction* (Volume 1, Landcom 2004 and Volume 2A, DECC 2008) would be implemented throughout construction to ensure that

erosion and sedimentation is appropriately managed. These measures would aim to retard flow velocities and retain mobilised sediment within the construction sites. Vehicle and machinery movement would be restricted to existing access tracks and construction corridors and entry and egress points would be stabilised to minimise movement of soil offsite. Post-construction stabilisation to reinstate and protect soil profiles and to revegetate the riparian zones would be undertaken as soon as practicable after construction is completed.

The Proposal is unlikely to have a significant impact on soil erosion and sedimentation because the detailed design process in Section 3.4.1 would identify refinements to avoid impacts where practicable and mitigation measures would be implemented in accordance with the *Managing Urban Stormwater: Soils and Construction* (Volume 1, Landcom 2004 and Volume 2A, DECC 2008) to ensure that residual impacts are appropriately managed.

Table 6-31 Summary of factors influencing erosion and sedimentation risks for construction of Proposal components (without mitigation measures)

Component	Extent of soil disturbance during construction + depth	Proximity to environmental and catchment features	Characteristics of terrain unit
Wastewater pipelines	Minor – Typical (staged) disturbed construction area = 30 m long x 10 m wide, and about three to five metres deep (Once pipelines are installed disturbed areas are progressively rehabilitated)	Generally located in the lowest part of the catchment immediately adjacent to creeks and drainage lines. These areas may contain some remnant native vegetation	Generally constructed in the Fairy Meadow terrain unit. Some sections also constructed in Shellharbour and Wattamolla Terrain Units. Some construction in soils assessed as having high or very high soil erodibility (see Figure 6-31).
Wastewater pumping stations	Minor - Typical disturbed construction area = 20 m long x 25 m wide at an approximate maximum depth of 5 metres. (Notes: the site will also contain an access road and wastewater pipelines, therefore the whole site is assumed to be potentially impacted (<0.4 ha area)).	Generally located in the lowest part of the catchment immediately adjacent to creeks and drainage lines. These areas may contain some remnant native vegetation.	All three new WWPSs will be constructed within the Fairy Meadow Terrain Unit. Constraints include potential flooding and high seasonal water tables.
Drinking water pipelines	Minor - Typical (staged) disturbed construction area = 30 m long x 10 m wide, and up to 1.8 m deep (Note: once pipelines are installed disturbed areas are progressively rehabilitated).	Generally located in cleared road reserves or in the higher parts of the landscape. Little or no remaining remnant native vegetation.	Generally constructed in the Fairy Meadow terrain unit. Some sections also constructed in Shellharbour, Albion Park, Wattamolla and Cambewarra Terrain Units. Some construction would occur in soils assessed as having high or very high soil erodibility (see Figure 6-31).
Calderwood Pumping Station (WPS)	Minor - Typical disturbed construction area = 20 m long x 25 m wide at an approximate maximum depth of 1.5 metres. (The site would also contain an access road and drinking water pipelines, therefore the whole site is assumed to be potentially impacted (<0.4 ha area)).	Located in cleared rural land on high parts of the landscape.	Cambewarra Terrain Unit – Sensitive to water erosion.

Component	Extent of soil disturbance during construction + depth	Proximity to environmental and catchment features	Characteristics of terrain unit
Calderwood Reservoir	*Moderate – The reservoir site (less than 2 ha area) is assumed to be impacted at a depth of up to three metres.	Mostly likely to be constructed on cleared rural land on a high point of the landscape surrounded by native vegetation.	Cambewarra Terrain Unit – Sensitive to water erosion.
Marshall Mount Reservoir	*Moderate – The reservoir site (less than 2 ha area) is assumed to be impacted at a depth of up to three metres.	Site is located on cleared rural land in an elevated part of the landscape.	Wattamolla Terrain Unit.
Avondale Reservoir	*Moderate – The reservoir site (less than 2 ha area) is assumed to be impacted at a depth of approximately 12 metres.	Site is located on cleared rural land on high parts of the landscape.	Fairy Meadow Terrain Unit.

*The risk assessment was carried out assuming a worst case scenario. Actual impacts are likely to be less than predicted.

Salinity

Coffey's assessment indicated that salinity is unlikely to be an issue for the Proposal. However, if during construction any areas are identified as being affected by soil salinity, the potential impacts would be considered and appropriate mitigation measures implemented. Appropriate measures may include:

- the use of salt resistant construction methods and materials
- no reuse of excavated saline soils for backfilling.

Acid Sulfate Soils

Figure 6-30 indicates areas where there is a risk of construction activities encountering ASS. These areas are generally associated with wastewater pipelines and pumping stations in lower lying areas where soils that have been mapped as having a risk of being ASS.

The location of the WWPSs would be optimised during the detailed design process outlined in Section 3.4.1. If practicable, the WWPSs may be relocated to avoid ASS. Given the widespread nature of the ASS in the mapped areas around Mullet Creek and Albion Park it is unlikely to be practicable to relocate all infrastructure that may impact on ASS. Where it is necessary to construct infrastructure in ASS, mitigation measures would be implemented to minimise the impacts. Such mitigation measures are well established for construction activities in ASS and are based on standard industry guidelines. Consequently, it is unlikely that there would be any significant impacts caused by constructing infrastructure in ASS.

Standard mitigation measures are designed to:

- avoid spreading ASS to other soils or groundwater
- return the ASS to below the waterline as soon as possible after excavation
- neutralise ASS
- either reuse or dispose of the ASS.

Impacts from ASS would be appropriately managed in accordance with relevant guidelines such as the *Acid Sulfate Soils Management Advisory Committee: Acid Sulfate Soils Assessment Guidelines* (ASSMAC 1998).

Soil contamination

The Proposal has the potential to disturb known areas of contamination. As detailed above, areas of potential contamination identified on Figure 6-30 would be considered during detailed design. These areas would typically be avoided, where practicable.

Prior to construction, appropriate studies and assessments would be carried out to identify and manage any localised contaminated soils. Soils would be analysed for a broad range of potential contaminants to provide an indication of potential waste classification against the *Waste Classification Guidelines-Part 1* (DECCW 2009a) for off-site disposal purposes and also to determine any other mitigation measures that may be required. It is not currently anticipated that remediation is likely to be required as part of the Proposal. Sydney Water will consider the provisions of SEPP No. 55 – Remediation of Land if any unexpected remediation work is required as part of the Proposal. Relevant guidelines made or approved under the *Contaminated Land Management Act 1997* will also be considered if contaminated soil is encountered during construction.

If not managed appropriately, there is also a low risk of soil, groundwater and surface water contamination during the construction phase from accidental spillage of chemicals such as fuels, oils and chemicals required for construction. During construction, fuel (diesel and petrol) and oils will be used in vehicles and equipment. At each construction area, small volumes of fuels (generally about 200 Litres (L)) may be stored and used to refuel some construction equipment such as generators, saw cutters etc. There may also be small quantities of chemicals used during construction (generally in containers of less than 20 L). Any fuels or chemicals will be stored, handled and disposed of to meet relevant standards. Bunded or contained areas and a spill kit will be provided as appropriate.

The storage of large quantities of fuels on or around the site would generally be avoided as vehicles and equipment would be refuelled offsite. Where on-site refuelling is unavoidable, mini-tankers would be used. Mini-tankers would be required to follow standard procedures and have a spill kit to minimise the risk and impact of spills.

Groundwater

Impacts to groundwater may generally be caused by construction activities that encounter shallow groundwater from the shallow aquifer, near watercourses, registered bores or other landforms. Potential impacts would include groundwater entering excavations, or the excavations creating preferential flow paths for groundwater. Permeable layers may be encountered including deeper sediments associated with watercourses such as Mullet Creek and in palaeochannels which are frequent throughout the Proposal area. This could result in high groundwater inflows during trenching or excavation. Figure 6-32 identifies locations where there is a risk of groundwater being intercepted during construction.

Impacts to groundwater during construction would be temporary and are not considered to be significant. Pipeline trenches, for instance, would not exceed 50 m (length) by 2 m (in width), and would be backfilled within two weeks, limiting the potential for groundwater to pool in the excavation. Where required, mitigation measures would be implemented during construction to minimise groundwater inflow into excavations. This would include engineering controls such as shoring and sheet piling. If groundwater is encountered during construction, it would be pumped out into a contained area, tested and if necessary appropriately treated prior to re-use, discharge or disposal. Provided appropriate mitigation measures are implemented, construction impacts on shallow groundwater are not expected.

Construction through contaminated areas, if not managed appropriately, may have potential impacts on groundwater quality. If excavation cannot be avoided in contaminated areas, site specific management measures would be implemented to ensure that preferential pathways for movement of contaminated groundwater would not be created.

Long-term groundwater impacts from the Proposal are considered unlikely as construction is short term and most components will only require shallow excavations. It is unlikely that construction will have any impacts on the deep aquifer. Construction activities may intercept the shallow aquifer, however, changes to recharge and evapotranspiration rates are expected to be low because the construction footprint of the Proposal (including reservoirs and pumping stations), is small.

During detailed design, registered groundwater bores within proximity to proposed alignments would be identified and avoided where practicable. If bores are located along alignments, confirmation would be obtained from bore owners to ensure that the bore is no longer in use prior to proceeding with construction.

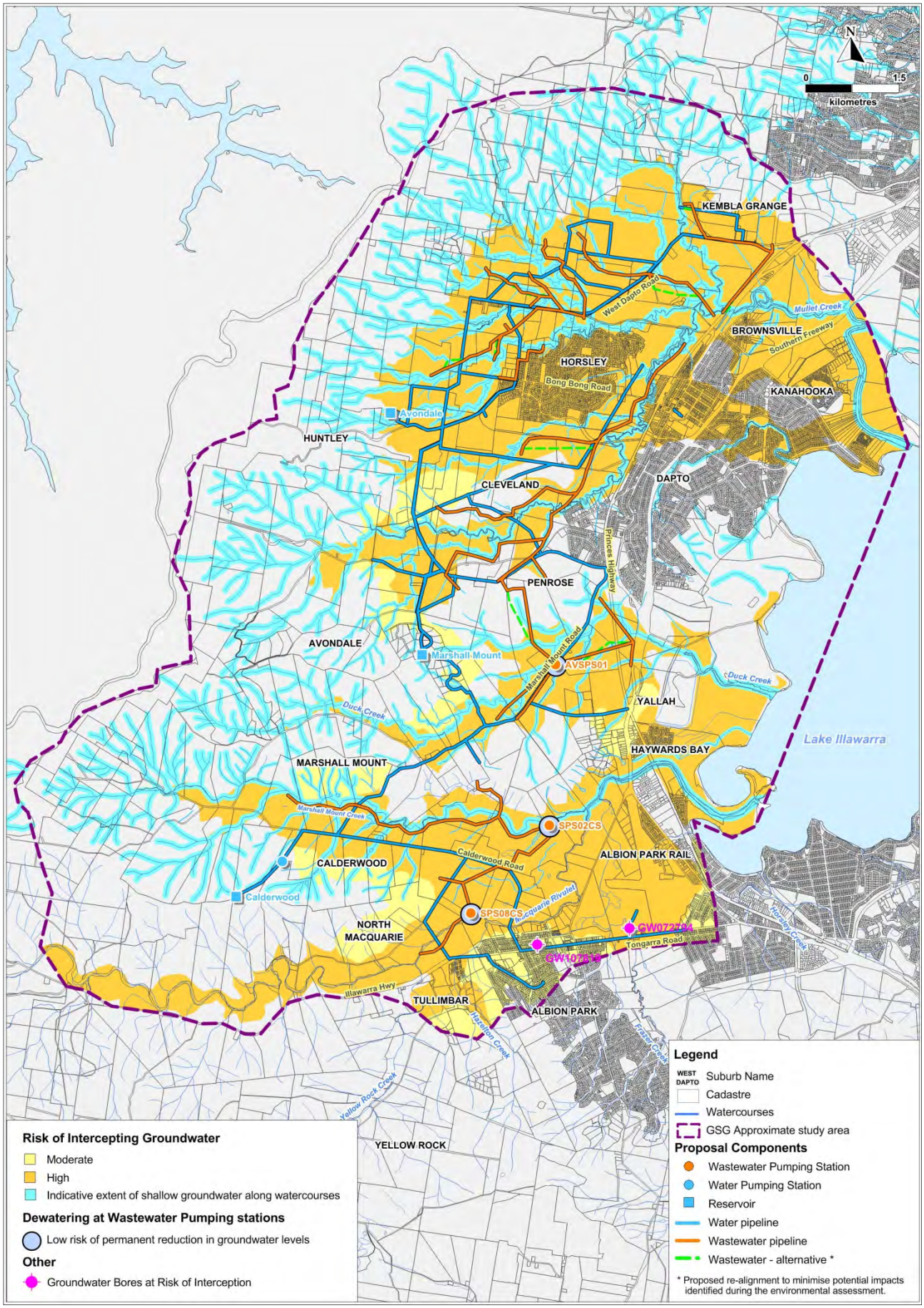


Figure 6-32 Potential risks of groundwater being intercepted

6.8.3 Operational impacts and mitigation measures

The Proposal will require maintenance during operation and this may involve localised excavation if assets need to be exposed. Appropriate and standard erosion and sedimentation mitigation measures would be implemented to ensure any future maintenance activities have minimal impact. These measures would be generally in accordance with Sydney Water's standard procedures for managing potential soil and groundwater impacts, and *Managing Urban Stormwater: Soils and Construction* (Volume 1, Landcom 2004 and Volume 2A, DECC 2008).

Where permanent access tracks are required, they would preferably be constructed outside riparian areas. This may not be possible where access to wastewater infrastructure may be required. In these instances, access tracks would be suitably designed to minimise impacts on riparian areas. Permanent access tracks are not required across waterways.

The location of ancillary infrastructure (including scour valves, pump scours etc.) would be determined during detailed design. Appropriate mitigation measures would be established to mitigate potential impacts during operation such as erosion from scour points.

6.9 Noise and vibration

6.9.1 Assessment overview

A noise and vibration assessment was undertaken by Renzo Tonin Pty Ltd to assess the potential impacts associated with the construction and operation of the Proposal. Renzo Tonin's report is in Appendix I. The noise assessment was carried out in accordance with the following guidelines:

- *Interim Construction Noise Guideline (ICNG)* (DECC 2009) – for noise impacts associated with general construction activities
- *Environmental Criteria for Road Traffic Noise (ECRTN)* (EPA 1999) – for noise impacts associated with construction traffic
- *Industrial Noise Policy (INP)* (EPA 2000b) – for noise impacts associated with the operation of the Proposal.

The vibration impacts were assessed in accordance with *Assessing Vibration: A Technical Guideline* (DEC 2006d) as well as the following industry standards:

- British Standard *BS 6472-1992 Evaluation of human exposure to vibration in buildings (1-80Hz)* (BSI 1992)
- British Standard *BS 7385-1993: Part 2 Evaluation and measurement of vibration in buildings* (BSI 1993)
- German Standard *DIN 4150 – Part 3 Structural vibration in buildings – Effects on structures* (DIN 1999).

The assessment involved:

- desktop assessment
- characterising the existing and predicted future noise environment
- identifying sensitive receivers
- long-term and short-term noise monitoring
- establishing the assessment criteria
- modelling construction noise and vibration; and operational noise emissions
- assessing noise and vibration emissions against the criteria.

As discussed in Section 6.1, the network of pipelines and associated infrastructure has been refined since the preparation of the technical report, and therefore some impacts and recommendations discussed in the Renzo Tonin report are no longer relevant to the Proposal.

Renzo Tonin applied the same methodology to assess infrastructure for which Concept Approval and Project Approval is sought, however more detailed mitigation advice is provided for the Project Approval area where appropriate.

6.9.2 Existing and future environment

Overview of the existing and future environment

Existing land use in the assessment area is predominantly rural or semi-rural residential, with some commercial and industrial areas. Developed residential areas in the assessment area are located at Horsley, South Dapto and Albion Park. The existing noise environment is dominated by natural sounds from surrounding rural open spaces and bushland, and intermittent traffic noise from arterial and local roads.

Once the Proposal area is developed, most areas will be characterised by large-scale residential precincts. Commercial and industrial areas will also be established and some areas will be retained for conservation and open space uses. It is expected that background noise levels will increase as a result of development in the area, as the background noise environment is contributed to by traffic and general suburban "hum".

It is difficult to predict precisely how much existing background noise levels would increase by. Guidance can be taken from the estimated background noise levels provided in Australian *Standard 1055:2-1997 'Acoustics: Description and Measurement of Environmental Noise'*, which provides indicative background noise levels for different residential areas in Australia. Noise area categories relevant to this assessment are summarised in Table 6-32 below.

Table 6-32 Estimated average L_{A90} background noise based on AS 1055:2-1997

Noise area category	Description of neighbourhood	L_{A90} background noise dB(A)					
		Monday to Saturday			Sundays and public holidays		
		0700 - 1800	1800 – 2200	2200 - 0700	0900 – 1800	1800 - 2200	2200 – 0900
R1	Areas with negligible transportation	40	35	30	40	35	30
R2	Areas with low density transportation	45	40	35	45	40	35

The Category R1 description is considered to be consistent with the existing acoustic environment in the rural parts of the assessment area, while Category R2 is consistent with the likely future suburban residential development in the assessment area and the existing developed areas. The standard shows that the increase in the background noise level between these two categories is 5dB(A). It is therefore reasonable to expect that background noise levels could increase by approximately 5dB(A) as a result of general development.

Background noise environment

In order to quantify the existing noise and vibration environment, both long-term unattended noise monitoring and short term attended noise and vibration measurements were undertaken. Monitoring was undertaken at locations considered to be representative of existing and future receivers.

Long-term noise monitoring was undertaken to quantify the existing background levels for receivers affected during construction and operation. The monitoring points were generally chosen to represent residences potentially affected by the operation of pumping stations. Long-term noise monitoring was carried out in February and March 2011. The initial measurements were conducted from Wednesday 2 February to Thursday 10 February. A second round of monitoring was conducted from 24 February to 4 March 2011.

Short term attended noise measurements were obtained at locations where receivers are likely to be affected by daytime construction works. The short term monitoring was undertaken when no suitable location for long term noise monitoring could be found or long term monitoring was deemed unnecessary.

Measured ambient and background noise levels from long term and short term noise monitoring are presented in Table 6-33.

Once the existing noise levels were quantified, the future background noise levels were predicted using AS 1055. As discussed above, the Proposal area is currently considered an R1 area (negligible transportation) and is likely to ultimately change to an R2 area (low transportation) once urban development occurs. This equates to a 5 A-weighted decibels (dB(A)) increase in existing background noise (refer to Table 6-32). The future background noise levels in Table 6-33 were estimated by adding 5 dB(A) to the measured levels, except in the following circumstances:

- where existing background noise levels for a particular assessment period (ie. day, evening or night) were more than 5dB(A) below the base background noise level assigned in AS1055, then 5dB(A) has been added to the measured level
- where existing background noise levels for a particular assessment period were within 5dB(A) of the base background noise level assigned in AS1055, then the base background noise level is assigned as the estimated future background noise level
- where an existing background noise level was above the base background noise level for the corresponding assessment period, then the existing background noise level is assigned as the estimated future background noise level
- where short term noise measurements were conducted and no night time levels were measured, the base night time background noise level from AS1055 has been assigned to assess night time operational noise.

Table 6-33 Measured and future background noise levels (L_{90})

Monitoring location	Nearest infrastructure item	Measured background noise levels (L_{90}), dB(A)			Estimated future background noise levels (L_{90}), dB(A)		
		Day	Evening	Night	Day	Evening	Night
Long term monitoring							
468 West Dapto Road	WWPS 1007	37	39	38	42	40	38
14 Woodside Circuit	Pipelines	36	33	34	41	38	35
145 Marshall Mount Road	Marshall Mount WWPS	34	33	30	39	38	35
112 Koona Street	WWPS 0500	36	34	30	41	39	35
2 Stapleton Avenue	WWPS 0505	48	42	36	48	42	36
39 Jason Avenue	WWPS 0345	40	41	36	45	41	36
1 Ocean Beach Drive	WWPS 0498	42	41	36	45	41	36
2 Parkland Avenue	Marshall Mount Reservoir	31	35	32	36	40	35
Short term monitoring							
Intersection of Wongawilli Road & Jersey Farm Road	Pipelines	40	-	-	45	-	35
Intersection of Northcliffe Drive & George Street	WWPS 0296	54	-	-	54	-	35
464 Bong Bong Road	Avondale Reservoir	29	-	-	34	-	35

Monitoring location	Nearest infrastructure item	Measured background noise levels (L_{90}), dB(A)			Estimated future background noise levels (L_{90}), dB(A)		
		Day	Evening	Night	Day	Evening	Night
Intersection of Avondale Road & Turnbull Crescent	Pipelines	44	-	-	45	-	35
Intersection of North Marshall Mount Road & Marshall Mount Road	Pipelines	35	-	-	40	-	35
479 Calderwood Road	Calderwood WPS / Calderwood Reservoir	42	-	-	45	-	35
144 Calderwood Road	Calderwood WWPS 1	34	-	-	39	-	35
340 North Macquarie Street	Calderwood WWPS 2	38	-	-	43	-	35

Note: The L_{A90} background noise level is the level of noise exceeded for 90% of the time.

Existing vibration levels

Attended vibration measurements were undertaken concurrently with the short term attended noise measurements at existing pumping stations on 16th March 2011. Existing vibration levels are summarised in Table 6-34.

Table 6-34 Measured existing operational vibration levels

Location		RMS acceleration (m/s^2)			Peak velocity (mm/s)		
		X-axis	Y-axis	Z-axis	X-axis	Y-axis	Z-axis
WPS 313	Front of building at vent & pipe	0.233	0.199	0.042	1.51	1.15	0.30
	Rear of building at vent & pipe	0.027	0.188	0.069	0.24	1.51	1.69
WWPS 1145	Front of building at vent	0.009	0.009	0.015	0.40	0.75	1.53
Clipper/ Apollo WWPS	At pump (rear of building)	0.024	0.156	0.063	0.43	3.49	2.14
WWPS 0498	Main water pipe	0.029	0.019	0.007	0.30	0.36	0.84
	Centre of site (over steel plate)	0.024	0.030	0.076	0.14	0.55	0.79
	Centre Room at vent	0.020	0.022	0.040	0.54	0.60	1.71
WWPS 0345	front of building at door vent	0.005	0.004	0.010	0.09	0.12	0.37
	Rear of building east at door	0.008	0.104	0.121	0.11	3.06	1.10
	Rear of building west rear	0.015	0.010	0.202	0.65	0.86	0.96
WWPS 0505	Front of building	0.024	0.024	0.014	0.19	0.69	0.84
	Rear of building at door vent	0.049	0.044	0.161	0.10	0.97	1.31
	Rear of site over metal plate	0.178	0.377	0.301	0.37	1.20	2.14
	On driveway next to metal plate	0.033	0.040	0.062	0.21	0.60	1.69

6.9.3 Construction impacts and mitigation measures

Construction of the Proposal would generate noise and vibration due to the need to operate plant and machinery. The noise and vibration levels are expected to be consistent with those experienced during construction of similar infrastructure within Sydney Water's area of operations.

Typical construction activities

Construction would involve works within road reserves, public reserves and on private land. Most construction work is likely to occur during standard hours stipulated in the ICNG (ie. 7am to 6pm, Monday to Friday; and 8am to 1pm on Saturdays). Work outside the recommended hours is likely to be required during pipeline construction for the following activities:

- micro tunnelling and/or directional drilling (may require 24 hour operation for a week or more)
- removing trees, undertaking road crossings, road restorations, etc
- delivering oversized items
- emergency works.

Table 6-35 lists construction activities and the associated plant and equipment likely to be used to construct the Proposal.

Table 6-35 Proposed typical construction activities

Activity	Description of activity	Indicative plant / equipment	Hours of use
Reservoir and pumping station site construction	General land clearing, tree and stump removal. Excavation of soil and rock, loading, haulage. Delivering raw materials. Constructing infrastructure.	Rock breaker, bulldozer, front end loader, tracked excavator, crane, trucks, vibrating compactor, grader, pneumatic hand tools, silenced air compressor, chain saw, concrete saw, concrete truck/pumps.	Daytime works (night works not expected).
Pipelines	Excavating trenches and pits, delivery and placement of precast pipes and pits, filling and compacting.	Rock breaker, front-end loader, crane, roller, grader, drilling rig, chainsaw, concrete saw, compactor, tracked excavator, concrete truck/pumps, trucks, silenced air compressor, pneumatic hand tools.	Daytime works (occasional night works possible).

Construction noise

The impact of construction noise was assessed using DECCW's *Interim Construction Noise Guideline* (ICNG, DECC 2009). The guideline intends to provide respite for residents outside of the recommended standard hours of construction whilst allowing construction during the recommended standard hours to be carried out without undue constraints. The recommended construction hours are Monday – Friday 7am – 6pm, Saturday 8am – 1pm and no work on Sundays or public holidays.

The ICNG recommends a quantitative assessment be carried out for major construction projects. The approach recommends the measurement and prediction of noise levels and their assessment against set noise management levels. Construction noise emissions were determined by modelling the noise sources, receiver locations, topographical features of the area and possible noise controls using Cadna-A computer noise modelling program. The program calculates the contribution of each noise source at each specified receptor point and allows for the prediction of the total noise from a site.

The ICNG specifies construction noise management levels be set by increasing the background noise level by 10 dB(A) for works during the recommended construction hours, and increasing the background level of 5 dB(A) for works outside the recommended construction hours. According to the ICNG, sensitive receivers exposed to construction noise greater than 75 dB(A) are considered to be 'highly noise affected'.

The management levels that apply to the nearest residential receivers during the construction of the pumping stations and reservoirs are summarised in Table 6-36. Figure 6-33 to Figure 6-35 show the pumping station (WWPS 1007 and Calderwood WPS) and reservoir (Avondale) sites and include distance markers to assist in understanding the extent of potential impacts. Figures for the remaining pumping stations and reservoirs are provided in Appendix I.

Noise management levels for the construction of the pipelines are summarised Table 6-37. As construction is likely to precede development of the WDURA and AGAs, these noise management levels are based on the existing measured background noise levels (refer to Table 6-33) rather than the estimated future background noise levels. The following sections summarise construction noise impacts and mitigation measures and indicate that noise management levels are likely to be exceeded. The extent of the exceedance is influenced by the construction activity being undertaken and the distance to the nearest sensitive receiver.

Table 6-36 Predicted construction noise levels for pumping stations and reservoirs

Infrastructure Site	Predicted $L_{Aeq\ (15min)}$ Noise Levels						Nearest affected receiver address	Distance (m)	Noise Management Level[1] $L_{Aeq\ (15\ minutes)}$	Exceedance (dB)
	Distance (m)									
	20	50	100	200	500	1000				
Project Approval area										
WWPS 1007	80-84	72-76	66-70	59-63	51-55	45-49	441 West Dapto Road	250	47	12-16
Avondale Reservoir	81-85	73-77	67-71	60-64	52-56	46-50	464 Bong Bong Road	50	39	34-38
Marshall Mount Reservoir	81-85	73-77	67-71	60-64	52-56	46-50	2 Parkland Avenue	70	41	32-36
Remaining Proposal area										
Yallah WWPS	80-84	72-76	66-70	59-63	51-55	45-49	164 Marshall Mount Road	60	44	28-32
Calderwood WWPS1	80-84	72-76	66-70	59-63	51-55	45-49	144 Calderwood Road	475	44	7-11
Calderwood WWPS2	80-84	72-76	66-70	59-63	51-55	45-49	340 North Macquarie Road	385	48	3-7
WWPS 500	80-84	72-76	66-70	59-63	51-55	45-49	116A Koona Street	105	46	20-24
WWPS 505	80-84	72-76	66-70	59-63	51-55	45-49	2 Stapleton Avenue	7	56	24-28
WWPS 0345	80-84	72-76	66-70	59-63	51-55	45-49	39 Jason Avenue	10	50	30-34
WWPS 0498	80-84	72-76	66-70	59-63	51-55	45-49	1 Ocean Beach Drive	15	51	29-33
WWPS 296	80-84	72-76	66-70	59-63	51-55	45-49	12 George Street	85	64	2-6
Calderwood WPS	80-84	72-76	66-70	59-63	51-55	45-49	479 Calderwood Road	20	52	25-19
Calderwood Reservoir	81-85	73-77	67-71	60-64	52-56	46-50	479 Calderwood Road	750	52	0

[1] Measured L_{A90} background noise level plus 10 dB(A) applicable during standard construction hours.

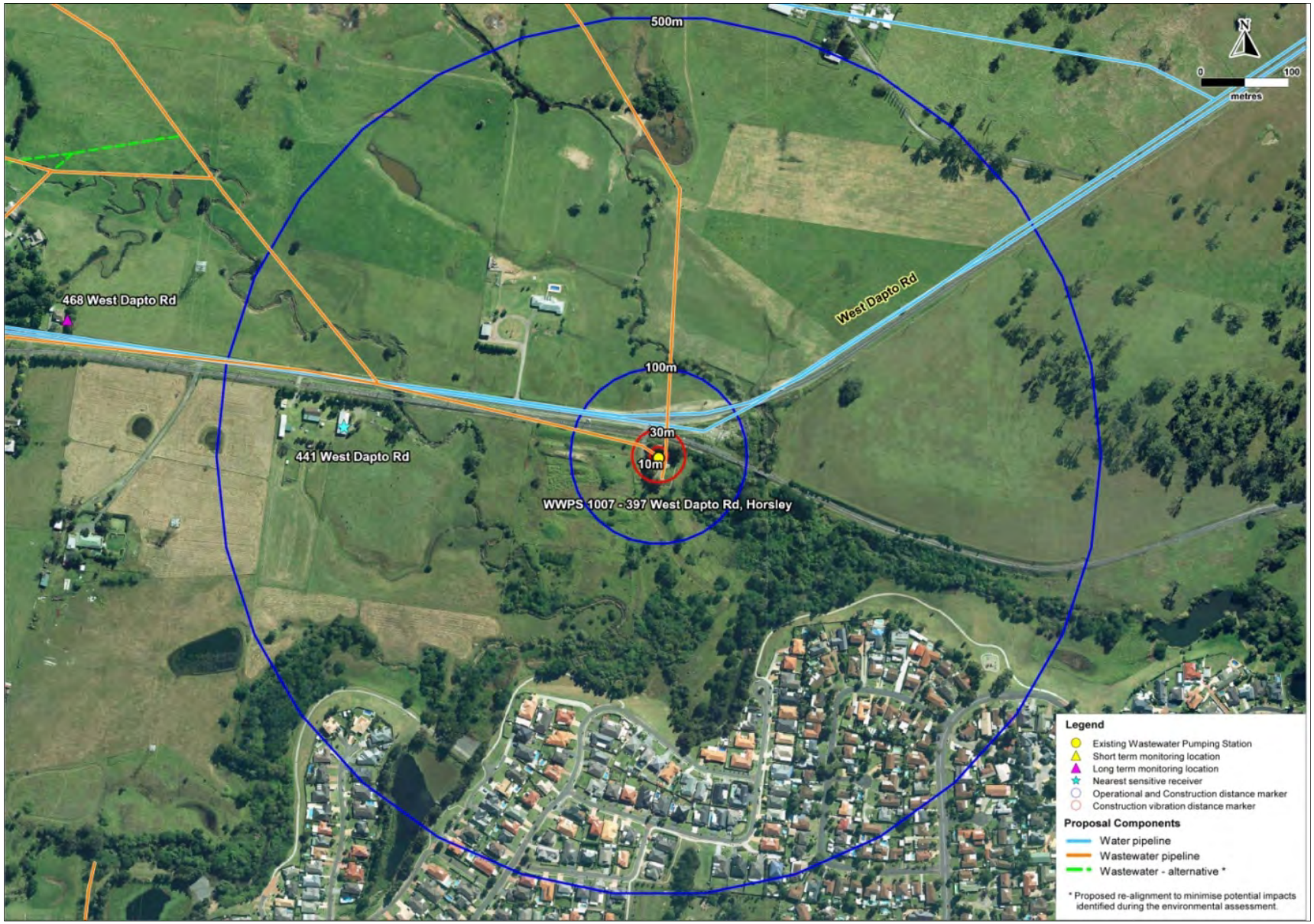


Figure 6-33 Sensitive receivers nearest to WWPS 1007

Figure 6-34 Sensitive receivers nearest to WWPS 0500

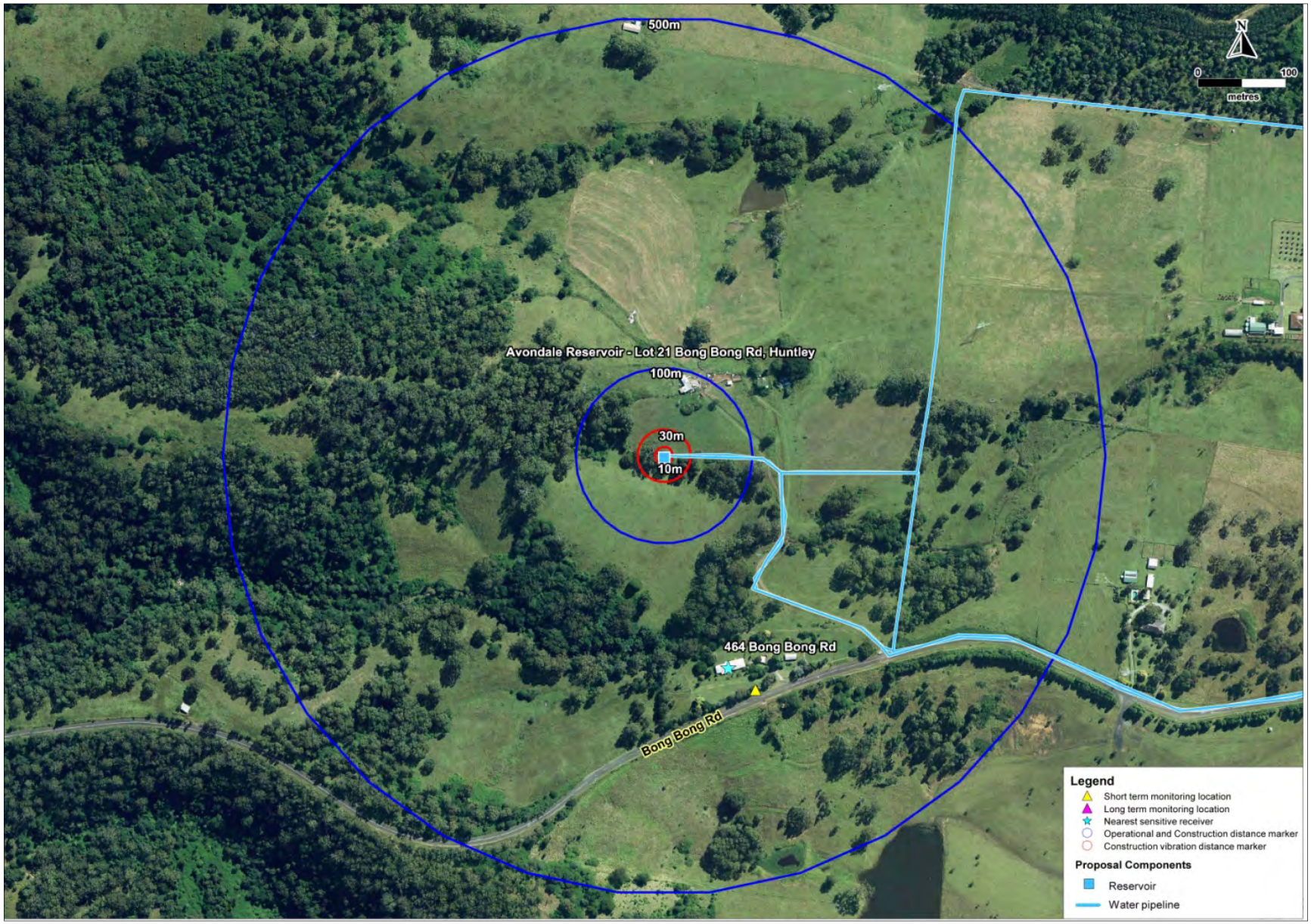


Figure 6-35 Sensitive receivers nearest to Avondale Reservoir

Reservoirs and pumping stations

The expected noise levels that would be generated during construction of the reservoirs and pumping stations were predicted and are summarised in Table 6-36. Construction of pumping stations would generally take between six and nine months, and construction of reservoirs would take approximately 12 months. At the majority of construction sites, nearby residences would experience noise that exceed the noise management levels shown Table 6-36. Sensitive receivers within 50 m of construction works are predicted to experience noise levels exceeding 75 dB(A) and would be classed as highly noise affected under the ICNG. Noise levels at receivers greater than 500 m from the construction works would typically comply with the noise management levels without any mitigation measures being implemented. It is likely that a 10 dB noise reduction at the nearest receivers could be achieved by ensuring that equipment is in good order, diesel machines have good quality mufflers, and sheds and stockpiles on site have been strategically arranged so that they provide some shielding to the nearby residents. A full list of standard mitigation measures that could be implemented to minimise noise emissions where reasonable and feasible is provided in Table 6-40.

Drinking and wastewater pipelines

As construction of the drinking and wastewater pipelines would be transient and move progressively along the corridors, the noise management levels for pipeline construction would vary greatly along the pipeline corridors. Construction would generally be undertaken within approximately 5 m either side of the pipeline. It is not practical to calculate background noise levels and associated noise management levels at all points along these corridors. As the distance between residential receivers and the construction activities would vary along the pipeline corridors, noise levels have been predicted for varying distances from the pipeline corridor (refer to Table 6-37).

The modelling results show that noise levels would potentially exceed the day time construction noise criteria at all receiver locations within approximately 100 m of the pipeline corridors. This estimate is conservative and does not take into consideration shielding that may be provided by buildings or topography.

The louder equipment, including the rock breaker, concrete saw and chainsaw, would result in a 'highly noise affected' level of over 75 dB(A) within approximately 25 m of construction activity. As there are residential premises within 25 m of the pipeline corridors in some locations, these residences may be exposed to high noise levels during these activities. The remainder of the construction equipment generate lower noise levels and would generally comply with the 'highly noise affected' level of 75 dB(A) within approximately 10 m to15 m from the plant location.

Physical and standard management measures would be used to reduce impact on sensitive receivers from construction noise. Typical noise management measures are detailed in Table 6-40.

Table 6-37 Predicted construction noise levels along the pipeline corridors

Plant description	Predicted noise levels at varying distances from source, dB(A)								
	10 m	15 m	20 m	25 m	30 m	40 m	50 m	100 m	150 m
Rock breaker	85	81	78	76	74	71	69	61	57
Concrete saw	83	79	76	74	72	69	67	59	55
Chainsaw	82	78	75	73	71	68	66	58	54
Drilling rig	79	75	72	70	68	65	63	55	51
Front end loader	78	74	71	69	67	64	62	54	50
Crane	78	74	71	69	67	64	62	54	50
Grader	78	74	71	69	67	64	62	54	50
Pneumatic hand tools	78	74	71	69	67	64	62	54	50

Plant description	Predicted noise levels at varying distances from source, dB(A)								
	10 m	15 m	20 m	25 m	30 m	40 m	50 m	100 m	150 m
Compactor	78	74	71	69	67	64	62	54	50
Tracked excavator	75	71	68	66	64	61	59	51	47
Roller	74	70	67	65	63	60	58	50	46
Concrete truck	74	70	67	65	63	60	58	50	46
Truck	71	67	64	62	60	57	55	47	43
Concrete pump	70	66	63	61	59	56	54	46	42
Silenced air compressor	63	59	56	54	52	49	47	39	35
Typical cumulative [1]	89	85	83	81	79	76	73	66	62

1.Typical cumulative noise level does not include chainsaw (since they tend to be used separately for clearing prior to the start of the main works) or drilling rig (as the rig will be used separately and only in specific locations where trenching is not feasible.

Out of hours works

Construction work would generally be limited to recommended working hours in the ICNG (DECC 2009), however, out of hours work may be required during pipeline construction. Night work would likely include equipment such as:

- micro tunnelling and/or directional drilling rig
- trucks to deliver oversized items.

The ICNG sets the noise management level for out of hours work at 5 dB(A) above noise background level at night time. The night time background levels in the Proposal area have been measured around 30 dBA. Based on these levels any receivers within about 500 m of the works could experience noise levels that exceed the management level (ie 35 dB(A)).

For out of hours work, the ICNG indicates that:

- 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 goals.

All feasible and reasonable practices would be implemented to minimise noise impacts.

Traffic noise generated by construction activity

During construction, there is potential for noise impacts from construction traffic movements. The impact from road traffic noise was assessed in accordance with the EPA's *Environmental Criteria for Road Traffic Noise* (ECRTN, EPA 1999). Table 6-38 (Table 1 of the ECRTN) provides the relevant road traffic noise criteria based on the adjacent land use and road classification.

Table 6-38 NSW Environmental criteria for road traffic noise

Type of development	Criteria		
	Day, dB(A)	Night, dB(A)	Where criteria are already exceeded
8. Land use developments with potential to create additional traffic on collector roads	$L_{Aeq(1\ hr)}$ 60	$L_{Aeq(1\ hr)}$ 55	Where feasible and reasonable, existing noise levels should be mitigated to meet the noise criteria. Examples of applicable strategies include appropriate location of private access roads; regulating time of use; using clustering; using 'quiet' vehicles; and using barriers and acoustic treatments. In all cases, traffic arising from the development should not lead to an increase in existing noise levels of more than 2 dB.
13. Land use developments with potential to create additional traffic on local roads	$L_{Aeq(1\ hr)}$ 55	$L_{Aeq(1\ hr)}$ 50	

Section 7.2 provides an estimate of the traffic movements that are likely to be required during construction of the Proposal and indicates that there would be negligible increase in overall traffic movements. As such, the impact of increased noise associated with construction traffic is considered insignificant. Adverse impacts would be minimised by nominating traffic routes along main roads and through industrial or commercial areas rather than local residential streets wherever possible.

Construction vibration impacts

Vibration impacts of constructing the Proposal were assessed in terms of disturbance to human occupants of buildings and of structural damage to buildings.

The assessment of impacts on human occupants of buildings was carried out in accordance with *Assessing Vibration: a technical guideline* (DEC 2006d), which provides criteria for assessing vibration impacts based on the British Standard *BS 6472-1992 Evaluation of human exposure to vibration in buildings (1-80Hz)* (BSI 1992). Vibration sources are described as continuous, impulsive or intermittent. The standard sets preferred and maximum values for continuous and impulsive vibration, and vibration dose values for intermittent vibration.

The assessment of structural impacts on buildings was carried out in accordance with the British Standard *BS 7385-1993: Part 2 Evaluation and measurement of vibration in buildings* (BSI 1993) and the German Standard *DIN 4150 – Part 3 Structural vibration in buildings – Effects on structures* (DIN 1999). Both standards set 'safe limits' of vibration at different frequencies for different types of buildings. Safe limits are vibration levels up to which no damage due to vibration effects have been observed for particular types of buildings.

Table 6-39 summarises vibration expected to be generated by construction plant. Occupants of buildings within 30 m of the construction activities may notice vibration. Due to the temporary nature of the work and the variety of equipment used, any non-compliances would likely only be experienced for short durations on a few days. People in residential premises greater than 30 m from construction sites are unlikely to notice vibration. Structural damage is unlikely and compliance with structural vibration standards is expected at all times.

Table 6-39 Potential vibration impact

Approximate distance	Comment on potential vibration impact
Up to 10 m	Adverse impacts as a result of use of rock-breaker, compactor and vibratory roller is probable. Adverse impacts from bulldozers and excavators is possible.
10 – 20 m	Low probability of adverse impacts for most activities. Adverse impact as a result of rock breaker, compactor, and vibratory roller is possible. Structural damage is unlikely.
20 – 30 m	Adverse impacts as a result of heavy rock-breaker, heavy vibratory roller and compactor are possible. Structural damage is unlikely.
Greater than 30 m	Low probability of adverse impacts for all activities

Site specific buffer distances would be established for plant and equipment most likely to result in vibration. This would set out the recommended separation distance between the plant and equipment and the nearest sensitive receiver. Where construction activity occurs in close proximity to sensitive receivers, minimum buffer distances to affected receivers would be determined by site measurements and maintained to comply with relevant vibration limits.

Section 6.7.2 discusses the potential for vibration during construction to impact on heritage items and outlines management measures to be implemented to mitigate these impacts.

Construction noise and vibration impacts and mitigation measures

Many of the impacts have been assessed without appropriate mitigation measures. For example, at any site it is expected that 10 dB(A) noise reduction could realistically be achieved by ensuring that equipment is in good order, diesel machines have good quality mufflers, and any sheds and stockpiles are strategically arranged to provide some shielding. This section provides various mitigation measures that would be considered during the detailed design and construction phases to minimise noise and vibration impacts during construction. It is expected that impacts from noise and vibration would not be significant if appropriate mitigation measures were implemented.

Table 6-40 lists general construction noise management measures that would be implemented where practicable to minimise impacts to sensitive receivers.

Table 6-40 General construction noise management measures

Construction noise management measures	
Source controls	
Time constraints	Where practicable, limit work to daylight hours. Consider implementing respite periods with low noise-producing construction activities.
Scheduling	Perform noisy work during less sensitive time periods.
Equipment restrictions	Select low-noise plant and equipment. Ensure equipment has mufflers installed.
Emission restrictions	Establish stringent noise emission limits for specified plant and equipment. Implement noise monitoring audit program to ensure equipment remains within specified limits.
Substitute methods	Use quieter construction methods where possible. For example, when piling is required, bored piles rather than impact-driven piles would minimise noise impacts. Similarly, diaphragm wall construction techniques, in lieu of sheet piling, would have significant noise reduction benefits.
Limit equipment on site	Only have necessary equipment on site.
Limit activity duration	Where possible, concentrate noisy activities at one location and move to another as quickly as possible. Any equipment not in use for extended periods during construction would be switched off.
Equipment Location	Where practicable, noisy plant and equipment would be located as far as possible from noise sensitive areas, optimising attenuation effects from topography, natural and purpose built barriers and materials stockpiles.
Site access	Vehicle movements outside construction hours, including loading and unloading operations, would be minimised and avoided where possible.
Equipment maintenance	Ensure equipment is well maintained and fitted with adequately maintained silencers which meet the design specifications.
Reduced equipment power	Use plant and equipment with appropriate size and power levels for the task.
Quieter work practices	Implement worksite induction training to educate staff on noise sensitive issues and the need to make as little noise as possible.

Construction noise management measures	
Reversing alarms	Consider alternatives, such as manually adjustable or ambient noise sensitive types ("smart" reversing alarms). Alternative site management strategies can be developed, in accordance with the Occupational Health and Safety Plan, with the concurrence of the Occupational Health and Safety Officer.
Path controls	
Noise barriers	Where practicable, locate equipment to take advantage of the noise barriers provided by existing site features and structures, such as embankments and storage sheds.
Increased distance	Where practicable, locate noisy plant as far away from noise-sensitive receptors as possible.
Site access	Where practicable, select and locate site access roads as far away as possible from noise-sensitive areas.
Receptor controls	
Temporary relocation	In extreme cases where construction would be prolonged at an individual location and substantial exceedances of the noise and vibration criteria are predicted, consideration may be given to temporary relocation.
Community information and notification	Community information, notification and complaint responses are essential aspects of all construction noise management programs. They typically involve: • a community information program before construction and/or activities are commenced that have a high risk of exceeding noise and vibration criteria. This usually involves a leaflet distribution and direct discussions and negotiations with affected residents, explaining the type, time and duration of expected noise emissions, and the reasonable and feasible mitigation measures proposed • the involvement of affected residents in the development of acceptable noise management strategies • a nominated community liaison officer with a contact telephone number. • a complaints hotline • timely responses to complaints, providing information on planned actions and progress towards the resolution of concerns.
Noise monitoring	Conduct noise compliance monitoring in critical areas and/or in response to community complaints.

Table 6-41 summarises mitigation measures that would be implemented to minimise noise from construction traffic.

Table 6-41 Construction traffic management measures

Potential impact	Mitigation measures
Noise impacts from construction traffic	• where practicable, use main roads and avoid local streets • where practicable, provide space on site for vehicle parking • where practicable, control site access times so that vehicles are not active prior to 7am • maintain road pavements • install signs to encourage quiet driving • minimise construction traffic during out of hours work.

Table 6-42 summarises mitigation measures that would be implemented to minimise vibration. Section 6.7.2 outlines measures that would be implemented to minimise potential vibration impacts on heritage items.

Table 6-42 Construction vibration management measures

Potential impact	Mitigation measures
Vibration impacts from construction	A management procedure would be implemented to deal with vibration complaints. Each complaint would be investigated and where vibration levels are found to be exceeding the set limits, appropriate amelioration measures would be put in place to mitigate impacts. Where vibration is found to be excessive, management measures would be implemented to aim to comply with the vibration limits. Management measures may include modifying construction methods by using smaller equipment, establishing more stringent safe buffer zones, and if necessary, time restrictions for the most excessive vibration activities. If required, time restrictions would be negotiated with affected receivers.

Table 6-43 summarises preliminary safe working distances for high vibration generating plant. If necessary, these buffer distances could be confirmed on site by vibration measurements.

Table 6-43 Preliminary safe working distances for vibration intensive plant

Plant item	Rating / description	Safe working distance	
		Cosmetic damage	Human response
Vibratory roller	Light (less than 100 kN)	5 m	15 m – 20 m
	Medium (more than100 kN, less than 300kN)	12 m	40 m
	Heavy (more than 300 kN)	20 m	100 m
Rock breaker	300 kg	2 m	7 m
	900 kg	7 m	23 m
	1600 kg	22 m	73 m
Compactor	-	5 m – 15 m	30 m
Pneumatic hand tools	Hand held	1 m (nominal)	5 m
Dozers	-	-	5 m
Loaders	-	-	5 m
Truck movements	-	-	10 m

6.9.4 Operational impacts and mitigation measures

Noise generated by the operation of the Proposal would generally result from operating the reservoirs, pumping stations and the wastewater treatment plants. Any pipeline noise is generally contained within the pipe and therefore there is no noise source to quantify. This assessment of operational noise impacts focuses on the impacts from the pumping stations and reservoirs.

Wastewater treatment plants

Renzo Tonin's assessment did not include changes at the Wollongong WRP or Shellharbour WWTP. A full quantitative assessment was not considered necessary because if it becomes necessary to upgrade the plants the changes would most likely be minor and only involve similar types of noise generating equipment that would not generate significant amounts of noise. The intrusive noise generated from the treatment plants is generally broad-band and without offensive characteristics. It is therefore expected that operational noise levels from any amplifications or upgrades would not be noticeable and further assessment is not warranted at this stage. A full quantitative assessment to ensure impacts are minimal would be undertaken if it becomes necessary to upgrade these plants.

Pumping stations

During operation, noise and vibration will be generated by pumps and associated equipment at the pumping station sites. Pumping equipment is likely to be housed within brick buildings or enclosures and therefore noise will generally be well contained. Pumping stations can potentially operate 24 hours per day, 7 days per week, however, they would cycle on and off according to demand.

Noise management levels

Noise impacts during operation of the reservoirs and pumping stations have been assessed in accordance with the NSW INP (EPA 2000b). The INP provides noise criteria for the assessment against intrusiveness and amenity. The intrusiveness assessment is only applicable for residential type receivers and is based on the measured or assumed future background noise levels at each site. The intrusiveness of a noise source is considered acceptable if Leq of the noise from the source does not exceed the background noise level by more than 5 dB(A).

The amenity assessment is applicable to residential receivers as well as other noise sensitive receivers such as schools, hospitals, churches, recreational areas, commercial premises and industrial premises, and is based on absolute noise levels. The INP specifies recommended minimum noise levels that industrial noise sources should not normally exceed and these have been used as amenity criteria.

Based on the long term unattended noise monitoring and the estimated future background noise levels (Table 6-33), the applicable industrial noise criteria have been calculated and are presented in Table 6-44. As the Proposal would operate continuously 24 hours per day, seven days per week, the night time amenity criteria (which is the most stringent of all the operational criteria) has been used for the operational assessment.

Table 6-44 Applicable industrial noise criteria

Monitoring Location	Intrusiveness Criteria $L_{Aeq,15min}$			Amenity Criteria[1] $L_{Aeq,period}$		
	Day	Evening	Night	Day	Evening	Night
468 West Dapto Road	47	45	43	55	45	40
14 Woodside Circuit	46	43	40	55	45	40
145 Marshall Mount Road	44	43	40	55	45	40
112 Koona Street	46	44	40	55	45	40
2 Stapleton Avenue	53	47	41	55	45	40
39 Jason Avenue	50	46	41	55	45	40
1 Ocean Beach Drive	50	46	41	55	45	40
140 Smiths Lane	44	45	42	55	45	40
2 Parkland Avenue	41	45	40	55	45	40

1. Residential location has been categorised as 'Suburban'. Given that the existing noise environment is not influenced by existing industry, the Amenity Criteria have not been modified in accordance with Table 2.2, NSW INP.

Sleep disturbance from night operations was assessed in accordance with the Application Notes of the INP and the ECRTN, based on short-duration high-level noise events represented by Lmax. A criterion of $L_{A1(1min)} \leq L_{A90(15min)} + 15$ dB(A) was used. Table 6-45 provides the sleep disturbance criteria for nearby residences affected by the operation of the proposed pumping station sites. Sleep disturbance criteria are not provided for reservoirs or pipelines as these are likely to generate very low levels of operational noise.

Table 6-45 Sleep disturbance criteria

Monitoring location	Nearest infrastructure item	Night time L_{A90} noise level dB(A) (estimated based on future background)	Sleep disturbance criteria dB(A)
468 West Dapto Road	WWPS 1007	38	53
145 Marshall Mount Road	Marshall Mount WWPS	35	50
112 Koona Street	WWPS 0500	35	50
2 Stapleton Avenue	WWPS 0505	36	51
39 Jason Avenue	WWPS 0345	36	51
1 Ocean Beach Drive	WWPS 0498	36	51
Intersection of Northcliffe Drive & George Street	WWPS 0296	35	50
479 Calderwood Road	Calderwood WPS / Calderwood Reservoir	35	50
144 Calderwood Road	Calderwood WWPS 1	35	50
340 North Macquarie Street	Calderwood WWPS 2	35	50

Note: The L_{A90} background noise level is the level of noise exceeded for 90% of the time.

Pumping station sites

While residences may not currently be in close proximity to the pumping station sites, this is unlikely to be the case following future residential development. The distance between the pumping stations and the nearest residence would be confirmed once the subdivision plans are finalised. However, it is expected that the distances between future residences and pumping stations would be similar to those in existing developed areas.

Operational noise levels have been calculated based on the indicative sound power levels for plant and equipment likely to be used at the pumping stations and these noise levels reduce as distance to the nearest receiver increases.

Table 6-46 summarises the predicted noise levels at nominated distances when the pumping stations are operating. Predicted operational noise levels at potential residences impacted upon by the pumping stations typically comply with the most stringent night time noise criteria where distances were greater than approximately 40 m for WWPSs, and approximately 25 m for WPSs. These predicted noise levels are conservative and assume no solid boundary fences at either the residences or the pumping station sites. Where solid fences exist, for example a residential colourbond fence, this would reduce noise levels by approximately 5 dBA.

Given that the noise characteristics from pumps are typically continuous with no short-duration noise, it is expected that noise levels from the pumps would comply with the sleep disturbance criteria where distances are greater than about 15 m. Where residences are located less than 15 m from a pumping station appropriate mitigation measures will be implemented.

Table 6-46 Predicted operational noise levels for pumping stations

Infrastructure site	Predicted $L_{Aeq(15min)}$ noise levels					Applicable noise criteria	
	Distance (m)					L_{Aeq} (15 min)	L_{A1}
	10	20	30	40	50		
Project Approval area							
WWPS 1007	**52**	**46**	**42**	40	38	40	53
Remaining Proposal area							
Marshall Mount WWPS	**52**	**46**	**42**	40	38	40	50
Calderwood WWPS1	**52**	**46**	**42**	40	38	40	50
Calderwood WWPS2	**52**	**46**	**42**	40	38	40	50
WWPS 500	**52**	**46**	**42**	40	38	40	50
WWPS 505	**52**	**46**	**42**	40	38	40	51
WWPS 0345	**52**	**46**	**42**	40	38	40	51
WWPS 0498	**52**	**46**	**42**	40	38	40	51
WWPS 296	**52**	**46**	**42**	40	38	40	50
Calderwood WPS	**47**	**41**	37	35	33	40	50

Note: Bold font represents exceedance of the applicable noise criteria.

Reservoir sites

Reservoirs generally operate with very low noise emissions and there are no significant noise sources to quantify.

Sydney Water's standard treatments for operational noise control for Sydney Water assets are summarised in Table 6-47.

Table 6-47 Sydney Water's standard operational noise treatments

Infrastructure site	Potential impact	Mitigation measures
Reservoir	Noise from operation of Automatic Inlet Control Valve or Pressure Reducing Valve.	Enclose items within chambers or brick structures.
WPSs and WWPSs	Noise from operation of pumps.	Brick buildings with acoustic louvres and soundproof doors for large stations. Full acoustic enclosures for small stations.

6.10 Air quality

6.10.1 Existing environment

Wollongong City Council's *State of the Environment Report 2009/2010* (WCC 2010b) indicates that air quality across Wollongong is highly variable, but in recent years standards have rarely been exceeded at its regional monitoring stations. The variability in air quality is primarily related to domestic and industrial emissions in conjunction with prevailing weather conditions.

The main sources of air pollution in the Wollongong and Shellharbour Regions are industrial activities, particularly from the Port Kembla area, high levels of motor vehicle usage, hazard reduction burning, general domestic pollution, and 'natural' particulates such as pollen and dust. Odours in the Proposal area can be considered typical of those encountered in a rural/residential environment located on the edge of an industrial area. The *West Dapto Release Area Draft Local Environmental Study* (MG Planning 2006) notes that the pollutants affecting the WDURA are predominately produced outside the area and transported in via prevailing winds.

Odour

Odours can reduce the amenity of an area and cause public annoyance. Sydney Water currently has limited odour producing infrastructure in the Proposal area. The main source of odour from Sydney Water's operations is from wastewater infrastructure, eg odour control units, vent shafts and wastewater pumping stations, wastewater pipelines, and at the Wollongong WRP and Shellharbour WWTP.

Odour impacts associated with both WWTPs have been addressed through recent upgrade work at Shellharbour WWTP and Wollongong WRP (Sydney Water 1999; Sydney Water 2003a). These assessments concluded that there would be no significant impacts from the upgrades of the WWTP and WRP. As indicated in Figure 3-5 and 3-7, the Wollongong WRP and Shellharbour WWTP have existing odour controls and to date, under normal operating conditions, the upgraded WWTP and WRP do not have a history of odour complaints.

6.10.2 Construction impacts and mitigation measures

Particulates

The construction activities most likely to impact air quality are those that generate dust. These activities include construction of trenches, excavation, spoil stockpiles, vehicle movements, demolition activities, and wind erosion of cleared areas and stockpiles particularly during dry windy conditions. Vehicle and machinery exhaust emissions could also impact air quality during construction.

Rehabilitation will occur progressively during construction of the pipelines to ensure surface disturbance is minimised. In addition, some clearing and disturbance will occur for the construction of the reservoirs and pumping stations. These disturbed areas will be relatively small in size.

The potential impacts from construction activities on dust generation are considered to be minor and will be managed through typical dust suppression measures that could include stockpiling spoil, minimising ground disturbance and covering loads (refer to Section 6.8.2).

Vehicle emissions are also a source of airborne particulates. All site vehicles will be maintained to ensure that particulate emission are minimised.

Additional odour and other gaseous emissions from the WWTPs or existing infrastructure during construction are considered unlikely as Sydney Water services will continue as normal throughout the construction period.

Given that standard management measures can be implemented to minimise air quality impacts during construction, Sydney Water considers it unlikely that the Proposal would have a significant impact on air quality.

Odour

No odour impacts are anticipated during construction of the Proposal.

6.10.3 Operational impacts and mitigation measures

Particulates

The operation of the Proposal is not anticipated to generate dust or other airborne particulates.

Odour

Wastewater flows from the Proposal will be accommodated within the existing approved capacity of the Shellharbour WWTP and Wollongong WRP until approximately 2031. Upgrades to the plants after 2031 may be required to increase dry weather treatment capacity at Wollongong WRP by 5% and Shellharbour WWTP by 10% to cater for development of WDURA and AGAs. These upgrades would be minor and additional odour impacts directly attributable to the additional flows at these plants beyond those previously assessed would be minor and unlikely to have a significant impact. The potential for increased odour impacts on land uses adjacent to the treatment plants would be considered during the detailed design process and odour assessments would be undertaken if required. However, based on available information on the wastewater treatment plants, odour is not expected to be a nuisance following the upgrades.

If an odour assessment is required for the treatment plant upgrades, the assessment will be prepared in accordance with the *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (DECC 2005b), *Assessment and Management of Odour from Stationary Sources in NSW* (DEC 2001a) and *Technical Notes: Draft policy: Assessment and Management of Odour from Stationary Sources in NSW* (DEC 2001b).

Operation of the wastewater pipelines has the potential to generate local odour impacts, if they are not properly designed and operated. Offensive odours generally occur when the wastewater becomes anaerobic (that is, lacking oxygen) due to poor ventilation or stagnant conditions in the pipelines (ie low or no flows). Designing the pipelines with adequate slope and ventilation would significantly reduce the risk of odour emissions.

Given the extent of future development in the WDURA and AGAs, it is important to assess the operational odour impact as a result of the Proposal on surrounding residents and businesses. Precinct planning is also critical to ensure land uses adjacent to the WWPSs are compatible in order to minimise potential odour impacts. In the future it is likely that residences may be built in close proximity to ventilation shafts. However the increased population will result in increased flows in the wastewater pipelines, therefore resulting in a decreased release of any potentially annoying odours. Residents may experience some odour from ventilation shafts but appropriate design and location would reduce the likelihood of odour.

Odour management of both new and existing wastewater infrastructure will be carried out in accordance with the requirements of the POEO Act and Sydney Water's existing procedures. Odour complaints will be registered and investigated. Engineering, operational or other odour reduction measures will be implemented where verified odour complaints are received about odour releases from the wastewater system.

As a result of these measures, significant odour impacts from wastewater infrastructure are considered unlikely.

6.11 Hazards and risk

Overview

This section assesses the potential hazards and risks associated with storing and using hazardous materials during the construction or operation of the Proposal. In undertaking this assessment the Department of Urban Affairs and Planning guideline *Applying SEPP 33* (DUAP 1994) was considered.

SEPP 33 – Hazardous and Offensive Development, provides a systematic approach for assessing development proposals for potentially hazardous and offensive industry or storage. The SEPP defines potentially hazardous and offensive developments, specifies the requirements for the assessment of potential hazards, and specifies matters to be considered when granting development approvals.

The general risk associated with storing and using hazardous material related to leaks and spills of chemicals. A risk assessment undertaken for the Proposal (refer to Section 6.11) considered the overall risk associated with chemical leaks and spills to be low to medium.

6.11.1 Existing environment

Sydney Water currently stores hazardous materials at numerous locations for use in drinking water and wastewater treatment processes. A summary of locations where chemicals would be used and stored for the Proposal is provided in Table 6-48.

The hazardous materials used and stored in Sydney Water's water and wastewater systems are predominantly Class 5.1 (oxidising agents) and Class 8 (corrosive) materials. Both Class 5.1 and Class 8 materials pose little risk to surrounding land uses due to their negligible or low levels of toxicity, flammability or explosiveness (NTC 2007). However, spills and leaks of these materials have the potential to cause damage to the environment and infrastructure. Small quantities of fuels and other dangerous goods are also stored and used in Sydney Water's water and wastewater systems.

Storing hazardous materials in prescribed quantities is a scheduled activity under the POEO Act and requires a licence issued under the POEO Act. Sydney Water's water and wastewater system EPLs provide the regulatory basis for the use and storage of hazardous materials in the drinking water and wastewater treatment systems.

The use and storage of hazardous materials must conform to relevant standards and codes, primarily *Australian Standard (AS) 1940-2004 - The Storage and Handling of Flammable and Combustible Liquids* (Standards Australia 2004) and the *Australian Dangerous Goods Code* (NTC 2007). The transportation and unloading of chemicals must conform to the Road and Rail Transport (Dangerous Goods) (Road) Regulation 1998. Sydney Water complies with these codes and monitors compliance with annual audits under its Water and Wastewater Integrated Management System.

Table 6-48 Current use and storage of hazardous materials

Material name	Illawarra WFP	Water pipeline network	Wollongong WRP	Shellharbour WWTP	Wastewater pipeline network
Carbon dioxide	✓				
Ferric chloride	✓		✓	✓	
Chlorine	✓				
Sodium hydroxide	✓		✓	✓	
Fluoro silicic acid	✓				

Material name	Illawarra WFP	Water pipeline network	Wollongong WRP	Shellharbour WWTP	Wastewater pipeline network
Sodium hypochlorite		✓	✓	✓	
Calcium hypochlorite		✓			
Ammonia			✓		
Sulphuric acid			✓		
Phosphoric acid			✓		
Sodium Bisulphite			✓	✓	
Aluminium Sulfate			✓		
Ferrous chloride					✓

Sydney Water holds WorkCover Dangerous Goods Licenses that permit the storage of approved quantities of dangerous materials for some facilities. The WorkCover licenses regulate the occupational health and safety aspects of the storages.

6.11.2 Construction impacts and mitigation measures

Construction vehicles and equipment will use fuel (petrol and diesel) and oil during construction. At each construction area, small volumes of fuel (generally about 200 L) will be stored and used to refuel generators, saw cutters and other similar types of construction equipment. There may be small quantities of chemicals used during construction (generally in containers of less than 20 L).

The quantity of fuel and chemicals stored on construction sites will be only that contained within vehicles, construction equipment and small containers and therefore does not represent a significant hazard. The storage of fuels on or around the site can generally be avoided and vehicles and equipment may generally be refuelled off site. Where on-site refuelling is unavoidable, mini-tankers would be used. Mini-tankers would be required to follow standard procedures to minimise the risk of explosion or fire. All other chemicals would be stored in secondary containment units in accordance with the materials safety data sheets.

Implementing appropriate mitigation measures should ensure the risk of leaks and/or spills of hazardous materials are minimised. Appropriate mitigation measures may include:

- maintain compliance with relevant standards and codes, primarily *Australian Standard 1940-2004: The Storage and Handling of Flammable and Combustible Liquids and the Dangerous Goods Code*
- inspect machinery, plant and equipment for signs of fuel or oil leakage
- keep a construction industry standard, hazardous materials spill kit on site at all times.

6.11.3 Operational impacts and mitigation measures

Using and storing hazardous material while operating the Proposal may impact the environment if they escape containment. Sydney Water currently uses and stores hazardous materials for the existing wastewater and drinking water treatment systems in the Illawarra Region. The use and storage of these hazardous materials conforms to all relevant standards and codes which ensures minimal risk to the environment. The primary codes are *AS 1940-2004 The Storage and Handling of Flammable and Combustible Liquids* (Standards Australia 2004) and the *Dangerous Goods Storage Code* (NTC 2007) and any new facilities would need to comply with the same requirements.

The Illawarra WFP has sufficient capacity to meet the drinking water demands of the Proposal (Sydney Water 2011c). The WFP currently operates in accordance with the relevant standards and codes for storing and using hazardous materials. Since there are no anticipated changes to the use and storage of hazardous materials at the WFP further assessment and a PHA are not necessary.

A maximum of 10 tonnes (10,000 kL) of ferrous chloride may be stored at the proposed WWPSs at Kembla Grange, Yallah/Marshall Mount and Calderwood. Ferrous chloride is classed as Class 8 and grouped as Packing Group III under the Australian Dangerous Goods Code. A PHA is not required for any of these sites because the amount stored is less than the SEPP 33 screening threshold of 50 tonnes. No chemicals will be stored at the water reservoirs.

A current PHA exists for both the Wollongong WRP and the Shellharbour WWTP. The PHA for the Wollongong WRP was prepared as part of the *Review of Environmental Factors for Wollongong Recycled Water Scheme, Stage 2* (Sydney Water 2006a). The Wollongong WRP PHA considered and assessed the use and storage of chemicals associated with the plant treating a projected 52 ML/d for average dry weather flow (Sydney Water 2006a). This projected average dry weather flow rate includes the proposed flow transfers from the Project Approval areas. As such, the Project Approval does not require an update of the Wollongong WRP PHA. The Wollongong WRP PHA concluded that:

- the risk of injury to the surrounding community from the site is extremely low
- the risk to the natural environment and to operators and other people present on site is very low.

The PHA for Shellharbour WWTP was prepared as part of the *Review of Environmental Factors for the Optimisation and Amplification of Shellharbour Sewage Treatment Plant* (Sydney Water 2003a). The Shellharbour WWTP PHA considered and assessed the use and storage of chemicals associated with the plant treating a projected 16 ML/d for average dry weather flow (Sydney Water 2003a). This projected flow rate includes the proposed flow transfers from development in the Project Approval areas. As such, the Project Approval does not require an update of the Shellharbour WWTP PHA. The Shellharbour WWTP PHA concluded that the proposed upgrade of the plant (and hence the plant itself) is not potentially hazardous and is unlikely to pose a significant risk to the community.

The need for upgrades/amplifications at either Wollongong WRP or Shellharbour WWTP and the timing of any works is dependent upon the scale and rate of residential development in the WDURA and AGAs. Risks associated with using and storing chemicals at the plants will be re-assessed at the time licenses and/or approvals are sought for increasing their use and storage. This re-assessment process may involve updating the established PHAs for the plants.

Sydney Water maintains compliance with all standards and codes for hazardous material and monitors compliance via annual audits under its Water and Wastewater Integrated Management System. It is anticipated that complying with existing and future license requirements will not alter the current risks to the environment from hazardous materials.