Appendix I

Noise and vibration assessment

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WATER AND WASTEWATER SERVICES OF WEST DAPTO URBAN RELEASE AREA AND ADJACENT GROWTH AREAS NOISE AND VIBRATION ASSESSMENT

TE977-01F03 (REV 4) NOISE AND VIBRATION ASSESSMENT (FINAL).DOC

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GLOSSARY OF ACOUSTIC TERMS

The following is a brief description of the technical terms used to describe noise to assist in understanding the technical issues presented.

Adverse Weather — Weather effects that enhance noise (that is, wind and temperature inversions) that occur at a site for a significant period of time (that is, wind occurring more than 30% of the time in any assessment period in any season and/or temperature inversions occurring more than 30% of the nights in winter).

Ambient Noise — The all-encompassing noise associated within a given environment at a given time, usually composed of sound from all sources near and far.

Assessment Period — The period in a day over which assessments are made.

Assessment Point — A point at which noise measurements are taken or estimated. A point at which noise measurements are taken or estimated.

Background Noise — Background noise is the term used to describe the underlying level of noise present in the ambient noise, measured in the absence of the noise under investigation, when extraneous noise is removed. It is described as the average of the minimum noise levels measured on a sound level meter and is measured statistically as the A-weighted noise level exceeded for ninety percent of a sample period. This is represented as the $\mathbf{L_{90}}$ noise level (see below).

Decibel [dB] — The units that sound is measured in. The following are examples of the decibel readings of every day sounds:

0dB The faintest sound we can hear

30dB A quiet library or in a quiet location in the country

45dB Typical office space. Ambience in the city at night

60dB Martin Place at lunch time

70dB The sound of a car passing on the street

80dB Loud music played at home

	90dB The sound of a truck passing on the street
	100dB The sound of a rock band
	115dB Limit of sound permitted in industry
	120dB Deafening
dB(A):	A-weighted decibelsThe ear is not as effective in hearing low frequency sounds as it is hearing high frequency sounds. That is, low frequency sounds of the same dB level are not heard as loud as high frequency sounds. The sound level meter replicates the human response of the ear by using an electronic filter which is called the "A" filter. A sound level measured with this filter switched on is denoted as dB(A). Practically all noise is measured using the A filter.
Frequency	Frequency is synonymous to pitch. Sounds have a pitch which is peculiar to the nature of the sound generator. For example, the sound of a tiny bell has a high pitch and the sound of a bass drum has a low pitch. Frequency or pitch can be measured on a scale in units of Hertz or Hz.
Impulsive noise	Having a high peak of short duration or a sequence of such peaks. A sequence of impulses in rapid succession is termed repetitive impulsive noise.
Intermittent noise	The level suddenly drops to that of the background noise several times during the period of observation. The time during which the noise remains at levels different from that of the ambient is one second or more.
L_{max}	The maximum sound pressure level measured over a given period.
L_{min}	The minimum sound pressure level measured over a given period.
L_1	The sound pressure level that is exceeded for 1% of the time for which the given sound is measured.
L_{10}	The sound pressure level that is exceeded for 10% of the time for which the given sound is measured.
L_{90}	The level of noise exceeded for 90% of the time. The bottom 10%

	of the sample is the L_{90} noise level expressed in units of dB(A).
L_{eq}	The "equivalent noise level" is the summation of noise events and integrated over a selected period of time.
Reflection	Sound wave changed in direction of propagation due to a solid object obscuring its path.
SEL	Sound Exposure Level (SEL) is the constant sound level which, if maintained for a period of 1 second would have the same acoustic energy as the measured noise event. SEL noise measurements are useful as they can be converted to obtain Leq sound levels over any period of time and can be used for predicting noise at various locations.
Sound	A fluctuation of air pressure which is propagated as a wave through air.
Sound Absorption	The ability of a material to absorb sound energy through its conversion into thermal energy.
Sound Level Meter	An instrument consisting of a microphone, amplifier and indicating device, having a declared performance and designed to measure sound pressure levels.
Sound Pressure Level	The level of noise, usually expressed in decibels, as measured by a standard sound level meter with a microphone.
Sound Power Level	Ten times the logarithm to the base 10 of the ratio of the sound power of the source to the reference sound power.
Tonal noise	Containing a prominent frequency and characterised by a definite pitch.

EXECUTIVE SUMMARY

Background

The West Dapto Urban Release Area (WDURA) and the Adjacent Growth Areas (AGA) are major green-field sites identified in the Department of Planning's (DoP) Illawarra Regional Strategy (IRS) to meet the future housing needs over the next 40 years. Sydney Water is responsible for the planning of water and wastewater for the new development areas. In line with the IRS, Sydney Water has developed an integrated servicing strategy (the Proposal) to provide water and wastewater services for the equivalent of approximately 35,000 dwellings by 2050. The area covered by the proposed strategy is generally bounded by Farmborough Heights in the north, Albion Park in the south, Lake Illawarra to the east and the Illawarra Escarpment to the west.

Sydney Water is preparing an Environmental Assessment to consider and assess the environmental impact of the Proposal, and to meet the requirements of Part 3A of the Environmental Planning & Assessment Act, and specifically the Director General's Requirements (DGR's). Sydney Water's Preliminary Environmental Assessment (PEA) and the DGR's have identified that the Proposal could potentially generate noise levels above existing background. Therefore a detailed assessment of the potential for noise and groundborne vibration impacts is required.

Scope of Assessment

The scope of this assessment includes the environmental noise and vibration impact of the proposed construction activities, construction traffic and operational activities associated with the Proposal.

This assessment includes a level of detail suitable for Concept Plan Approval for the entire Proposal and Project Approval for those components required for early development. There is no real distinction between Project and Concept locations in terms of methodology. However, more detailed mitigation advice is provided for the Project Approval areas where appropriate.

Predicted Impacts and Recommendations for Operation

Noise emissions from operation of water and wastewater pumping stations were assessed against the relevant noise criteria set out in the NSW 'Industrial Noise Policy' (INP). Noise emissions are predicted to comply where distances to the nearest residential boundary are greater than approximately 40m for wastewater pumping stations, and approximately 25m for water pumping stations.

Where these setback distances can not be achieved, inclusion of mitigation measures such as acoustic screens or fences, enclosures, or acoustic louvers will provide the required noise reductions and compliance will be achieved.

Vibration from pumping station sites is minimal and compliance is expected at all surrounding receivers.

Operational noise and vibration from reservoir sites is also not expected to cause any impacts.

Predicted Impacts and Recommendations for Construction

Construction noise from pumping station and reservoir sites may exceed the construction noise management level, dependent on the location of the works and the plant and equipment used. Construction noise levels at receivers that are greater than 500m from pumping station and reservoir sites will typically comply.

Residences within 25 metres of pipeline construction activity have the potential to be 'highly noise affected' and noise levels will potentially exceed the day time construction noise criteria at all receiver locations within approximately 100m of the pipeline corridor.

Reasonable and feasible noise control recommendations are presented in Sections 6.6.1 and 6.6.2 of this report for consideration and implementation during construction phase planning and delivery. Some residual construction noise impacts may remain where it is not reasonable or feasible to implement the degree of mitigation required. However, these impacts will be temporary, for the duration of the construction phase only.

Construction traffic impacts can not be accurately predicted at this stage. However, adverse impacts can be minimised by nominating traffic routes along main roads and through industrial or commercial areas rather than local residential streets wherever possible. Management od construction traffic is discussed in Section 6.6.7.

Occupants of buildings within 30 metres of the proposed construction activity may notice vibrations as a result of rock breakers, compactors and/or vibratory rollers. The vibration levels may be non-compliant at times. However, due to the temporary nature of the work and the variety of equipment used, any non-compliances will likely only be experienced for short durations on a few days. People in residential premises greater than 30 metres from construction works are unlikely to notice vibrations.

Structural damage as a result of these works is unlikely and compliance with structural vibration standards is expected at all times. Vibration management measures are provided in Section 6.6.6 to minimise vibration impact from construction activities.

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1 INTRODUCTION

1.1 Background

The West Dapto Urban Release Area (WDURA) and the Adjacent Growth Areas (AGA) are major green-field sites identified in the Department of Planning's (DoP) Illawarra Regional Strategy (IRS) to meet the future housing needs over the next 40 years. Sydney Water is responsible for the planning of drinking water and wastewater for the new development areas. In line with IRS, Sydney Water has developed an integrated servicing strategy (the Proposal) to provide water and wastewater services for the equivalent of approximately 35,000 dwellings by 2050. The area covered by the proposed strategy is generally bounded by Farmborough Heights in the north, Albion Park in the south, Lake Illawarra to the east and the Illawarra Escarpment to the west.

The Proposal is predicated upon the extension of both the Illawarra water system and Wollongong and Shellharbour wastewater treatment systems. The Proposal is limited to the provision of trunk pipelines and bulk storage of drinking water and wastewater services. Stormwater systems and household reticulation systems are not included.

In October 2009, the Minister for Planning made a declaration under Section 75B (1) of the *Environment Planning & Assessment Act* (EP&A Act), that the Proposal is to be assessed under Part 3A of the EP&A Act. A Major Project Application and Preliminary Environmental Assessment (PEA) have been completed and Director-General's Requirement's (DGR's) have been issued. Sydney Water is seeking Concept Plan Approval for the entire Proposal and concurrently seeking Project Approval for those components required for early development in response to development timeframes. Project Approval for the remaining components will be sought at a later date to align with the NSW Government's release of the precincts.

Consequently, Sydney Water is preparing an Environmental Assessment to meet the requirements 3A of the EP&A Act, and specifically the DGR's. The PEA and DGR's have identified that the Proposal could potentially generate noise levels above existing background. Therefore a detailed assessment of the potential for noise and groundborne vibration impacts is required.

1.2 Objectives

The purpose of the environmental assessment is to meet the requirements for obtaining an approval for the Proposal under Part 3A of the EP&A Act. In this regard, this noise and vibration assessment must address the Director-General's Requirements issued for this Proposal by the Director-General for the Department of Planning as stated below:

> ***Noise and Vibration*** *- the Environmental Assessment shall include an assessment of noise and vibration impacts during construction and operation and in a cumulative context with existing development. Construction traffic noise must also be addressed. The assessment must take into account the following guidelines, as relevant: Interim*

Construction Noise Guidelines (DECC 2009), Environmental Criteria for Road Traffic Noise (EPA, 1999), Industrial Noise Policy (EPA, 2000) and Assessing Vibration: A Technical Guideline (DECC, 2006).

IN accordance with the Director-General's Requirements, noise impact from the operation of the proposed facilities is assessed in accordance with the NSW 'Industrial Noise Policy' 2000 (the "INP", Environment Protection Authority). Traffic noise on public roads from site generated traffic is assessed against the NSW 'Environmental Criteria for Road Traffic Noise' 1999 (the "ECRTN", Environment Protection Authority).

Construction noise impact is assessed in accordance with the NSW 'Interim Construction Noise Guideline' 2009 (the "ICNG", Department of Environment, Climate Change and Water), while vibration impact as a result of construction is assessed for human annoyance using the NSW 'Assessing Vibration: a technical guideline' 2006 (Department of Environment and Climate Change). The potential for structural damage is assessed against acceptable industry standards.

Based on the guidelines and requirements, the acoustic assessment presented herein provides details of the types of receivers surrounding the facilities, applicable criteria leading to project-specific noise levels, predicted noise levels at the nominated receivers, and where necessary, in-principle noise and vibration mitigation advice to meet the project specific noise and vibration objectives.

The work documented in this report was carried out in accordance with the Renzo Tonin & Associates Quality Assurance System, which is based on Australian Standard / NZS ISO 9001.

1.3 Scope of the Assessment

A desktop assessment has previously been undertaken for potential noise and vibration impacts associated with The Proposal (Reference TE977-01F01 (Rev 1) Desktop Review dated 10 December 2010).

The desktop assessment included the review of existing reports and other information in relation to the assessment area, identifying potential noise sensitive receivers, discussion of the existing and future noise environments, establishing the project noise and vibration goals and the potential noise and vibration impacts as a result of the proposed water related services.

The desktop assessment highlighted that existing land use in the assessment area is predominantly rural or semi-rural residential, with some commercial and industrial areas. Therefore existing background noise levels are low in most areas, reflecting their rural nature and present use. Background noise levels are likely to change over time as the release area develops. It is expected that background noise levels will increase as a result of the

development of the area, as the background noise environment is contributed to by traffic and general suburban 'hum'.

The desktop assessment proposed that guidance would be taken from Australian Standard 1055:2-1997 'Acoustics: Description and Measurement of Environmental Noise', to estimate future background noise levels, which remains the approach in this assessment. However background noise monitoring has also been conducted at the most sensitive sites to quantify existing noise levels.

The desktop assessment concluded that:

- due to the progressive nature of pipeline construction, adjacent receivers will likely only be affected for short durations and any noise and vibration impacts from the pipeline construction could be suitably managed using common techniques and measures.
- Construction activities at the reservoirs and pumping stations will be of longer duration in the one location and impacts will depend on the proximity of sensitive receivers. However, noise and vibration impacts could also be suitably managed.
- Noise and vibration generated from pumping facilities during operation could be suitably attenuated by appropriate noise control and design measures, which are readily available and could be incorporated into the design of the facilities. It is unlikely that the pumping facilities will have a significant impact on the noise environment at nearby affected receivers.

The "assessment area" for this study includes the land that may be directly impacted by the construction and operation of the Proposal. The assessment area includes areas both within and outside the WDURA and AGA's.

The specific assessment areas for operational noise from pumping stations and reservoirs are areas adjacent to each site, for a surrounding radius of approximately 50m. The specific assessment areas for construction noise and vibration are within a radius of approximately 500m from the infrastructure site, or in the case of pipelines, approximately 500m either side of the pipeline trench.

This assessment includes a level of detail suitable for Concept Plan Approval for the entire Proposal and Project Approval for those components required for early development. There is no real distinction between Project and Concept locations in terms of methodology. Project Approval specific elements of the assessment include operational sites within the Project Approval Areas and specific upgrade locations outside, and construction noise and vibration impacts at the same locations.

1.4 Outline of Sydney Water's Responsibilities

Sydney Water's responsibilities are to construct and operate the water and wastewater services in accordance with the Director General's Requirements, and the following environmental guidelines:

- Interim Noise Construction Guidelines (DECC 2009),
- Environmental Criteria for Road Traffic Noise (EPA, 1999),
- Industrial Noise Policy (EPA, 2000), and
- Assessing Vibration: A Technical Guideline (DECC, 2006).

The specific components of these guidelines are outlined in Section 5.1 and Section 6.1.

2 PROJECT DESCRIPTION

2.1 The Proposal

The Proposal involves design, construction and operation (including commissioning and maintenance) of drinking water and wastewater services. Infrastructure components to be constructed as part of the Proposal include:

- drinking water trunk pipelines
- waste water pipelines
- new water pumping stations and upgrades to existing water pumping stations
- new waste water pumping stations and upgrades to existing waste water pumping stations
- transfer of waste water flows from the new growth areas to Wollongong or Shellharbour Waste Water Treatment Plants for treatment and either reuse or ocean discharge
- potential amplification and/or upgrades to Wollongong and Shellharbour Waste Water Treatment Plants
- at least one and potentially three new water reservoirs.

The drinking water and waste water pipelines are proposed to be located in road reserves, public reserves and on private land. For hydraulic efficiency, drinking water is transported to reservoirs at high points through pipelines by pumping and/or gravity. The drinking water is then transported to receivers through pipelines by pumping and/or gravity.

The boundaries of the Project Approval areas and the locations of both existing and proposed infrastructure items such as pumping stations, reservoirs and pipelines are shown in Figure 1.

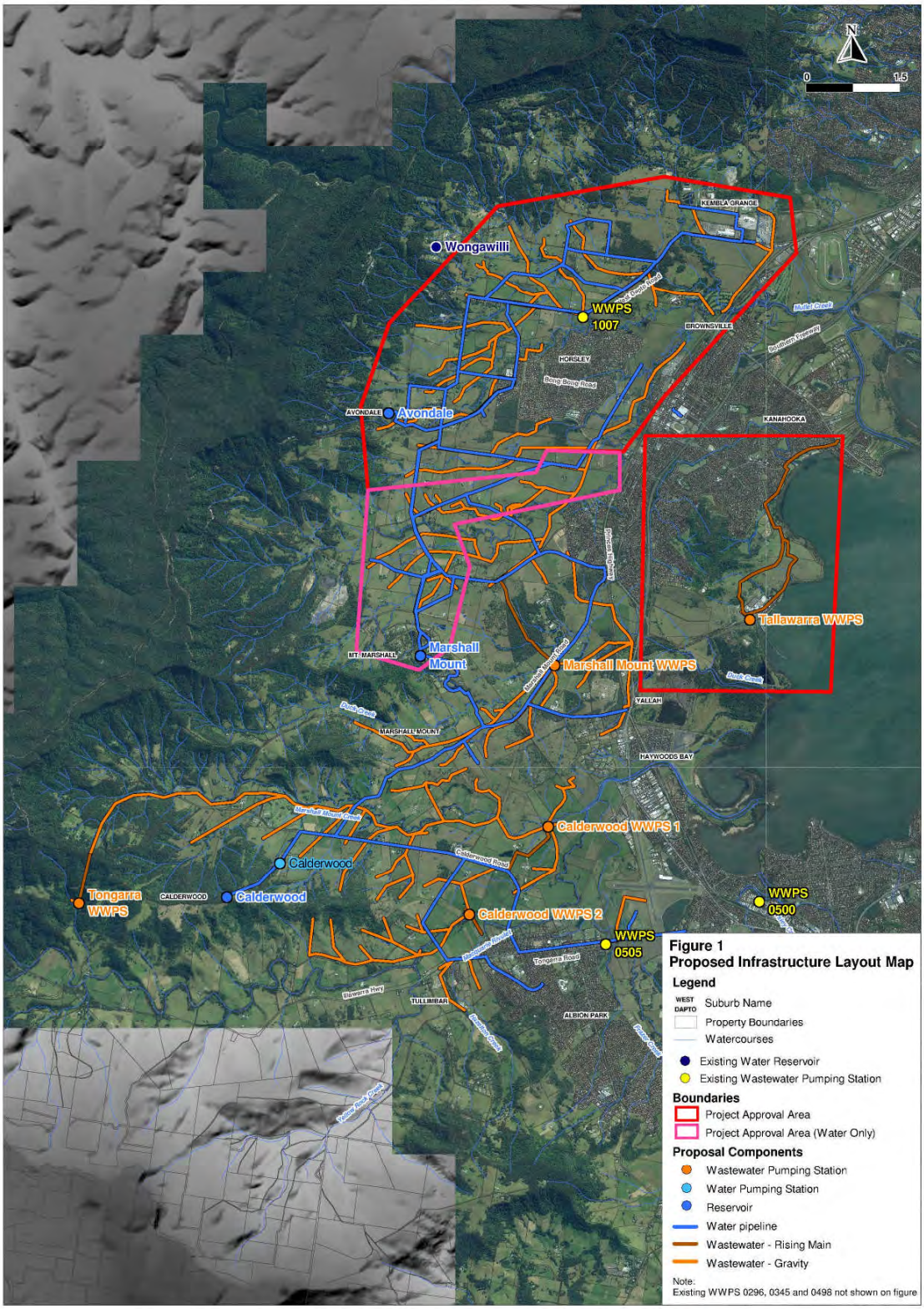

Figure 1 – Proposed Infrastructure Layout Map

2.1.1 Pumping Stations

New water and wastewater pumping stations have been proposed at a number of locations throughout the WDURA and AGAs. The proposed locations are listed in Table 1 and aerial photographs showing these locations are presented in Appendix A.

Table 1 – Proposed New Pumping Station Locations

Pumping Station	Location	Figure in Appendix A	Approval Stage
Tallawarra WWPS	Yallah Bay Road	Figure 2	Project*
Marshall Mount WWPS	231 Marshall Mount Road, Marshall Mount	Figure 3	Concept
Calderwood WWPS 1	off Calderwood Road, Calderwood	Figure 4	Concept
Calderwood WPS	479 Calderwood Road, Calderwood	Figure 5	Concept
Tongarra WWPS	approximately 1km north of the Illawarra Highway, Tongarra	Figure 6	Concept
Calderwood WWPS 2	off North Macquarie Road, Calderwood	Figure 7	Concept

**Approval stage status to be confirmed in Sydney Water's EA.*

As a result of additional demand, some existing pumping station sites may be augmented with the possibility of creating additional noise and vibration from the existing sites. These sites are listed in Table 2 and aerial photographs showing these locations are presented in Appendix B.

Table 2 – Proposed Sites for Augmentation

Pumping Station	Location	Figure in Appendix B	Approval Stage
WWPS 1007	397 West Dapto Rd, Horsley	Figure 8	Project
WWPS 0500	River Oak Place, Oak Flats	Figure 9	Project*
WWPS 0296	Lot 1867 Northcliffe Drive at the intersection of Northcliffe Drive and George Street, Berkeley	Figure 10	Concept
WWPS 0505	Lot 1 on the corner of Stapleton Avenue and Tongarra Road, Albion Park	Figure 11	Concept
WWPS 0345	37 Jason Avenue, Shellharbour	Figure 12	Concept
WWPS 0498	Lot 1 of Ocean Beach Drive, Shellharbour	Figure 13	Concept

**Approval stage status to be confirmed in Sydney Water's EA.*

2.1.2 Reservoirs

Additional reservoirs have been proposed at a number of locations for the WDURA and AGA's. These sites are listed in Table 3 and aerial photographs showing these locations are presented in Appendix C.

Table 3 – Proposed New Reservoirs

Pumping Station	Location	Figure in Appendix C	Approval Stage
Avondale Reservoir	Lot 21 of Bong Bong Rd, Huntley	Figure 14	Project
Marshall Mount Reservoir	Lot 1 on the Corner of Parkland Avenue and Mountain View Terrace, Avondale	Figure 15	Concept
Calderwood Reservoir	Approximately 1km south of Calderwood Road, Calderwood	Figure 16	Concept

There is also an existing reservoir at Wongawilli. This reservoir site is within the project approval area and will require minor augmentation.

Table 4 – Existing Reservoirs

Pumping Station	Location	Figure in Appendix C	Approval Stage
Wongawilli Reservoir	Smiths Lane, Wongawili	Figure 17	Project

2.1.3 Drinking and Wastewater Pipelines

The drinking water and wastewater pipes required for this project will run throughout the WDURA and AGA's. The pipes will generally be installed below ground but will include some surface facilities such as valves, scour chambers, ventilation shafts and access chambers. Drinking water pipelines will generally be located in the road reserve, although some sections will be constructed in public reserves and on private land. Wastewater pipelines will be constructed in low-lying areas and in the vicinity of waterways in line with gravity wastewater system design.

With the exception of repairs and maintenance along the pipelines, it is not anticipated that there will be noise generated from the pipelines once construction has been completed. The location of the drinking and wastewater pipelines are shown in the infrastructure layout plan in Figure 1.

2.1.4 Wollongong WRP and Shellharbour WWTP

The Preliminary Environmental Assessment indicates that the existing Wollongong Water Recycling Plant (WRP) and Shellharbour Wastewater Treatment Plant (WWTP) currently servicing the area have sufficient uncommitted spare capacity to cater for some growth in the WDURA and AGA's.

Sydney Water's detailed planning has identified upgrade of the plants in 2034 for Wollongong WRP and 2050 for Shellharbour WWTP. These works are part of the WDURA and AGA's Concept approval. Specific noise and vibration assessments of these works may be part of a latter project approval application.

2.2 Noise Sensitive Receivers

There are a range of noise sensitive receivers that may potentially be affected by noise, including residential areas, commercial and industrial premises, recreational areas, educational centres, places of worship, hospitals and nursing homes.

In terms of existing receivers, from review of existing aerial photographs and site visits, the nearest receivers are those listed in Table 5. These receivers are shown on the figures in Appendix A, B and C. In terms of proposed future residential development, sensitive receivers may be located adjacent to the boundary of the proposed infrastructure locations

Table 5 – Infrastructure and Nearest Receivers

Infrastructure Item	Nearest Receiver	Receiver Type
Pumping Stations		
WWPS 1007	441 West Dapto Rd	Residential
Tallawarra WWPS	54 Carlyle Cl	Residential
Marshall Mount WWPS	164 Marshall Mount Rd	Residential
Calderwood WWPS1	144 Calderwood Rd	Residential
Calderwood WPS	479 Calderwood Rd	Residential
Tongarra WWPS	3018 Illawarra Hwy	Residential
Calderwood WWPS2	340 North Macquarie Rd	Residential
WWPS 0500	Industrial Rd / Casuarina St 116A Koona St	Industrial Residential
WWPS 0296	12 George St	Residential
WWPS 0505	2 Stapleton Ave	Residential
WWPS 0345	39 Jason Ave	Residential
WWPS 0498	1 Ocean Beach Drive	Residential
Reservoirs		
Wongawilli Reservoir	140 Smiths Ln	Residential
Avondale Reservoir	464 Bong Bong Rd	Residential
Marshall Mount Reservoir	2 Parkland Ave	Residential
Calderwood Reservoir	479 Calderwood Rd	Residential

2.3 Operation Stage

During operation, noise and vibration will be generated from pumping equipment at the pumping station sites. Pumping equipment will 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 will cycle on and off according to demand.

Based on our site visits to existing Sydney Water infrastructure, reservoirs and pipelines will not generate any significant noise during operation.

The Wollongong and Shellharbour Wastewater Treatment Plants are already significant sites. Upgrade of these sites is not expected to increase noise levels significantly.

2.4 Construction Stage

Construction will contribute to the local noise environment mainly through vehicles transporting personnel and materials to and around the construction sites and operation of construction equipment such as excavators, cranes, boring rigs, compressors and generators. Vibration from construction activities has the potential to impact residents and buildings in close proximity to construction work involving rock breakers, compactors and other similar high vibrating equipment.

2.4.1 Pipelines

The main construction technique for delivery of pipeline infrastructure will be trenching. Boring may also be used where appropriate to minimise disturbance in locations where there are particular environmental, safety, access or surface feature issues (for example, creek crossings).

Trenches for drinking water pipelines will generally be up to about 1.7 metres wide and 1.5 metres deep, with a construction footprint width of about six to ten metres. Trenches for wastewater pipelines will have similar width and construction footprint but may be around 3 metres deep or deeper, depending on topography.

Water pipes are generally between 300 millimetres and 1200 millimetres in diameter. Wastewater pipes are generally between 300 millimetres and 1800 millimetres in diameter.

Due to the transient and progressive nature of pipeline construction, adjacent sensitive receivers will only be affected for short durations.

2.4.2 Pumping Stations and Reservoirs

Construction activities at the reservoirs and pumping stations will be of longer duration in the one location and impacts will depend on the proximity of sensitive receivers.

Construction of pumping stations and reservoirs will involve the following key activities:

- site preparation and excavation
- construction of buildings and tanks etc
- ancillary construction works such as roads, fencing, etc
- commissioning in accordance with standard commissioning procedures
- landscaping and restoration

Typical construction equipment will include, for example, excavators, compactors, rock breakers, saw cutters, welding equipment, delivery and concrete trucks, powered hand tools, generators, micro-tunnelling or directional drilling rigs and/or cranes.

2.4.3 Wastewater Treatment Plants

Construction activities and equipment at the Wollongong and Shellharbour Wastewater Treatment Plants will be similar to those at pumping stations and impacts will depend on the proximity of sensitive receivers.

3 METHODOLOGY

3.1 Field Survey Methodology

A Field Survey Methodology report (Reference TE977-01F01 (rev 2) dated 22 December 2010) was prepared outlining the methodology to be implemented during field visits to gather information and measure existing noise and vibration levels. This report was provided to DECCW for comment and no response was received. The methodology for all noise and vibration monitoring in the field was as follows:

- Review relevant infrastructure and site plans to identify potential noise and vibration sources and sensitive receivers potentially affected by the construction and operation of the Proposal,
- Prepare a list of likely noise and vibration monitoring locations,
- Attend the proposed WDURA and AGA sites and conduct site inspections to become familiar with the sites, local transport routes and the local environments,
- During the site inspection, visit the proposed noise and vibration monitoring sites to confirm appropriate locations for set up of the monitors,
- Determine if additional unattended background noise monitoring sites will be required,
- During the site visit determine appropriate locations for short term attended noise and vibration measurements,
- Update proposed monitoring locations list as required and submit to SW and agencies for review,
- Attend final selected sites and conduct noise and vibration monitoring as outlined below.

The final field survey strategy differed slightly from the above to increase efficiencies, by combining the site inspection and monitor setups. The preferred sites were attended with the intention of monitoring, however where any site was not appropriate or where the owners did not agree to the monitoring, the next nearest property was approached, until a suitable site was found.

Both long term and short term noise monitoring and vibration measurements were conducted. Long term monitoring was used at locations where receivers may be affected by permanent noise sources such as pumping stations. Short term monitoring was used to supplement the long term monitoring generally for the following situations:

- Where the nearest existing residences are far from the infrastructure site and future operational noise levels are expected to be inaudible,

- Where the infrastructure work is not yet confirmed and may not go ahead,
- Where the owners of nearby properties have requested no access,
- along pipeline routes and sites where impacts are expected to be from temporary construction activities only.

Short-term attended noise and vibration monitoring was also conducted at existing pumping station sites in and around the study area. This monitoring was for the purpose of collecting noise and vibration source data from indicative equipment that could then be used as source data for predictive modelling. These existing sites were monitored during the morning period with the aim of capturing worst case operational conditions.

3.2 Long Term Noise Monitoring

For long term unattended noise monitoring, RTA Technology noise monitors were used to monitor ambient noise levels at the nominated monitoring locations. The noise monitoring equipment to be used complies with Australian Standard 1259.2-1990 "Acoustics - Sound Level Meters" and is designated as Type 2 instruments suitable for field use.

A noise monitor consists of a sound level meter and a computer housed in a weather resistant enclosure. Ambient noise levels are recorded at a rate of 10 samples per second. Every 15 minutes, the data is processed statistically and stored in memory.

The equipment was calibrated prior and subsequent to the measurement period using a Brüel & Kjær Type 4230 calibrator.

Any measurements affected by extraneous noise, wind (greater than 5m/s) or rain was excluded from the recorded data in accordance with Australian Standard *AS2702-1984 Acoustics – 'Methods for the Measurement of Road Traffic Noise'* and the NSW DECCW's noise monitoring policy.

Weather data was obtained from the Bureau of Meteorology (BOM) from the nearest automatic weather station (AWS) to the noise monitoring sites for the duration of the noise monitoring period. The data was then modified to allow for the height difference between the AWS, where wind speed and direction is recorded at a height of 10m above ground level, and the microphone location, which is at 1.5m above ground level. The correction factor applied to the data is taken from *Australian Standard AS1170.2 1989 Section 4.2.5.1*.

3.3 Short Term Noise Measurements

For short term attended noise measurements, a Brüel & Kjær Type 2250 precision sound level analyser, a Brüel & Kjær Type 2260 'Investigator' precision sound level analyser using "Enhanced Sound Analysis Software Type BZ7206" or a Panasonic CF-19 Soundbook precision sound analyser was used. Statistical noise levels were acquired in both overall and third-octave band frequencies. These instruments comply with AS IEC 61672.1 2004 "Electroacoustics - Sound Level Meters" and are designated as Type 1 instruments having accuracies suitable for field and laboratory use.

The sound level analysers were calibrated prior and subsequent to the measurements using a Brüel & Kjær Type 4231 calibrator.

3.4 Short Term Vibration Measurements

For short term vibration measurements a Panasonic CF-19 Soundbook consisting of four input channels and the Samurai software package was be used. Vibration levels were measured in third-octave band frequencies in three orthogonal axes using three Endevco Type 61C13 Accelerometers through three of the four channels.

This instrument complies with AS IEC 61672.1 2004 “Electroacoustics - Sound Level Meters” and is designated as a Type 1 instrument having an accuracy suitable for field and laboratory use.

Vibration monitoring was undertaken in accordance with the relevant standards, namely:

- DECCW’s ‘Accessing Vibration; a technical guideline’ 2006;
- British Standard BS 6472-1992 ‘Evaluation of human exposure to vibration in buildings (1-80Hz)’; and
- German Standard DIN 4150 – Part 3 – ‘Structural vibration in buildings – Effects on structures’.

Based on the above standards, weighted acceleration rms (m/s^2 rms) levels were measured for the purpose of determining existing vibration levels for assessing human comfort and peak velocity (m/s) vibration levels were measured for the purpose of determining existing vibration levels for assessing structural damage.

3.5 Assessment Methodology

Following the field surveys and noise measurements, the assessment methodology was as follows:

- Review and analyse the noise and vibration data measured at existing sites and determine appropriate sound power levels for pumping stations,
- Review plans and maps and determine distances to nearby receivers,
- Setup a computer noise model incorporating the measured sound power levels as input data and predict noise levels over various distances and determine noise and vibration impacts. Modelling was employed to determine predicted noise levels at distances for both pumping station sites and pipeline routes. (Impacts were determined under calm meteorological conditions as wind and temperature inversions will have no significant impacts due to the relatively small distances to the nearest receivers),
- Recommend noise mitigation measures to ameliorate predicted impacts,
- Review our company database and determine appropriate sound power levels and vibration levels for construction plant,
- Predict construction noise and vibration levels over various distances and determine noise and vibration impacts,
- Recommend noise and vibration mitigation measures to ameliorate predicted impacts.

4 EXISTING ACOUSTIC ENVIRONMENT

4.1 Qualitative Existing Acoustic Environment

Existing land use in the assessment area is predominantly rural or semi-rural residential, with some commercial and industrial areas. There are also significant developed residential areas in the assessment area in Horsely, South Dapto and Albion Park. Once the release area is developed, most areas will be dominated by large-scale residential areas. Commercial and industrial areas will also expand. Some areas will be retained for conservation and open space uses.

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. Background noise levels are likely to change over time as the release areas are developed. It is expected that background noise levels will increase as a result of the development of the area, as the background noise environment is contributed to by traffic and general suburban 'hum'.

It is difficult to predict precisely by how much existing background noise levels will increase. Guidance can be taken from the estimated average background noise levels provided in Appendix A of 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 below.

Table 6 - Estimated Average L_{A90} Background Noise Based on AS 1055:2-1997, dB(A)

Noise Area Category	Description of Neighbourhood	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

Note: The LA90 background noise level is the level of noise exceeded for 90% of the time.

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 increased development that is proposed to occur within the WDURA & AGA's.

4.2 Quantitative Existing Acoustic Environment

In order to quantify the existing noise and vibration environment, long term unattended noise monitoring and short term attended noise and vibration measurements were undertaken at various locations, determined to be representative of the nearest existing receivers. The results of the noise monitoring can be used to establish construction and operational noise criteria to be used during the early planning stages of the project.

Background noise varies over the course of any 24 hour period, typically from a minimum at 3am in the morning to a maximum during morning and afternoon traffic peak hours. Therefore, the NSW *Industrial Noise Policy* (INP, Environment Protection Authority 2000) requires that the level of background and ambient noise be assessed separately for the daytime, evening and night-time periods. The INP defines these periods as follows:

- **Day** is defined as 7:00am to 6:00pm, Monday to Saturday and 8:00am to 6:00pm Sundays & Public Holidays.
- **Evening** is defined as 6:00pm to 10:00pm, Monday to Sunday & Public Holidays.
- **Night** is defined as 10:00pm to 7:00am, Monday to Saturday and 10:00pm to 8:00am Sundays & Public Holidays.

4.3 Noise & Vibration Monitoring Locations

Based on the requirements of the INP, background and ambient noise levels have been monitored and separated into the day, evening and night periods for the long term unattended monitoring locations.

To obtain representative levels for all existing locations, long-term noise monitoring was carried out throughout February and March 2011. The initial round of measurements was conducted from Wednesday 2nd February to Thursday 10th February. The second round was conducted from 24th February to 4th March 2011.

Noise measurements were carried out generally in accordance with Australian Standard AS1055-1997 “Acoustics – Description and Measurement of Environmental Noise” and the INP.

Long term and short term noise monitoring and vibration measurements were undertaken at numerous locations considered to be representative of the nearest and the most affected by noise impacts from the construction and operation of the proposed infrastructure. The locations selected for long term unattended noise monitoring were generally chosen to represent residences potentially affected by the operation of permanent pumping station sites, including those being potentially augmented.

Appendix D details the noise monitoring methodology and the graphical recorded output from the long term noise monitoring is included in Appendix E**.**

The graphs in Appendix E were analysed to determine an assessment background level (ABL) for each day, evening and night period in each 24 hour period of noise monitoring, and based on the median of individual ABLs an overall single Rating Background Level (RBL) for the day, evening and night period is determined over the entire monitoring period in accordance with the NSW 'Industrial Noise Policy' (INP).

Short term attended noise measurements were conducted where receivers were likely to be affected by daytime construction works only, where no suitable location for long term noise monitoring measurements could be found, or where long term monitoring was deemed unnecessary. Long term and short term noise monitoring locations are listed in Table 7 and Table 8 respectively, and shown on the figures in Appendix A, B and C.

Table 7- Long Term Background Noise Monitoring Locations

Monitoring Location	Period	Nearest Infrastructure Item
468 West Dapto Rd	24/02/2011 - 04/03/2011	WWPS 1007
14 Woodside Circuit	02/02/2011 - 10/02/2011	Pipelines
145 Marshall Mount Rd	02/02/2011 - 10/02/2011	Marshall Mount WWPS
112 Koona St	02/02/2011 - 10/02/2011	WWPS 0500
2 Stapleton Ave	02/02/2011 - 10/02/2011	WWPS 0505
39 Jason Ave	24/02/2011 - 04/03/2011	WWPS 0345
1 Ocean Beach Drive	24/02/2011 - 04/03/2011	WWPS 0498
140 Smiths Ln	02/02/2011 - 10/02/2011	Wongawilli Reservoir
2 Parkland Ave	24/02/2011 - 04/03/2011	Marshall Mount Reservoir

Table 8- Short Term Background Monitoring Locations

Monitoring Location	Date	Nearest Infrastructure Item
Intersection of Wongawilli Rd & Jersey Farm Rd	16/03/2011	Pipelines
Intersection of Northcliffe Drive & George St	04/03/2011	WWPS 0296
464 Bong Bong Rd	04/03/2011	Avondale Reservoir
Intersection of Avondale Rd & Turnbull Cres	16/03/2011	Pipelines
54 Carlyle Cl	04/03/2011	Tallawarra WWPS
Intersection of Nth Marshall Mt Rd & Marshall Mt Rd	16/03/2011	Pipelines
479 Calderwood Rd	04/03/2011	Calderwood WPS / Calderwood Reservoir
144 Calderwood Rd	04/03/2011	Calderwood WWPS 1
340 North Macquarie St	04/03/2011	Calderwood WWPS 2
3018 Illawarra Hwy	02/02/2011	Tongarra WWPS

Noise and vibration measurements were also conducted at existing pumping stations to obtain existing operational noise and vibration levels.

Table 9- Short Term Operational Noise and Vibration Monitoring Locations

Monitoring Location	Date
WWPS 0505	16/03/2011
WWPS 0498	16/03/2011
WWPS 1145	16/03/2011
Apollo/Clipper Ave WWPS	16/03/2011

4.4 Existing Background & Ambient Noise Levels

Existing measured ambient and background noise levels from long term and short term noise monitoring are presented in Table 10. The results of the long term noise monitoring are applicable for the assessment of construction and operational noise. The results of the short term attended noise measurements are applicable for the assessment of daytime construction noise.

Table 10 – Measured Existing Background (L_{90}) & Ambient (L_{eq}) Noise Levels, dB(A)

Monitoring Location	L_{90} Background Noise Levels			L_{eq} Ambient Noise Levels			Nearest Infrastructure Item
	Day	Eve	Night	Day	Eve	Night	
468 West Dapto Rd	37	39	38	54	53	50	WWPS 1007
14 Woodside Circuit	36	33	34	53	52	47	Pipelines
145 Marshall Mount Rd	34	33	30	51	48	46	Marshall Mount WWPS
112 Koona St	36	34	30	51	58	41	WWPS 0500
2 Stapleton Ave	48	42	36	66	64	59	WWPS 0505
39 Jason Ave	40	41	36	56	49	45	WWPS 0345
1 Ocean Beach Drive	42	41	36	55	53	48	WWPS 0498
140 Smiths Ln	34	38	37	54	48	46	Wongawilli Reservoir
2 Parkland Ave	31	35	32	42	43	41	Marshall Mount Reservoir
Intersection of Wongawilli Rd & Jersey Farm Rd	40	-	-	60	-	-	Pipelines
Intersection of Northcliffe Drive & George St	54	-	-	61	-	-	WWPS 0296
464 Bong Bong Rd	29	-	-	38	-	-	Avondale Reservoir
Intersection of Avondale Rd & Turnbull Cres	44	-	-	56	-	-	Pipelines
54 Carlyle Cl	48	-	-	45	-	-	Tallawarra WWPS
Intersection of Nth Marshall Mt Rd & Marshall Mt Rd	35	-	-	57	-	-	Pipelines
479 Calderwood Rd	42	-	-	58	-	-	Calderwood WPS / Calderwood Reservoir

Monitoring Location	L_{90} Background Noise Levels			L_{eq} Ambient Noise Levels			Nearest Infrastructure Item
	Day	Eve	Night	Day	Eve	Night	
144 Calderwood Rd	34	-	-	58	-	-	Calderwood WWPS 1
340 North Macquarie St	38	-	-	58	-	-	Calderwood WWPS 2
3018 Illawarra Hwy	51	-	-	73	-	-	Tongarra WWPS

Note: The LA90 background noise level is the level of noise exceeded for 90% of the time.

The LAeq noise level is the level of noise equivalent to the energy average of noise levels occurring over the measurement period.

4.5 Adjusted Background Noise Levels

As discussed in Section 4.1 above, the future acoustic environment within the WDURA and AGA's is likely to change as a result of future development within the assessment area. Taking into consideration AS1055, it is reasonable to expect that background noise levels could increase by up to 5dB(A) as a result of general increased development that is proposed to occur within the WDURA and AGA's. However, it is also anticipated that the forecast future background noise level will not increase above the base background noise level assigned in AS1055 for Category R2, that is $L_{A90(7am\ to\ 6pm)}$ 45 dB(A); $L_{A90(6pm\ to\ 10pm)}$ 40 dB(A); and $L_{A90(10pm\ to\ 7am)}$ 35 dB(A).

The adjusted future background noise levels are therefore presented in Table 11. The future background noise levels have been determined by the following process:

- 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 allow assessment of night time operational noise.

Table 11 – Estimated Future Background Noise Levels

Monitoring Location	L_{90} Background Noise Levels		
	Day	Evening	Night
468 West Dapto Rd	42	40	38
14 Woodside Circuit	41	38	35
145 Marshall Mount Rd	39	38	35
112 Koona St	41	39	35
2 Stapleton Ave	48	42	36
39 Jason Ave	45	41	36
1 Ocean Beach Drive	45	41	36
140 Smiths Ln	39	40	37
2 Parkland Ave	36	40	35
Intersection of Wongawilli Rd & Jersey Farm Rd	45	-	35
Intersection of Northcliffe Drive & George St	54	-	35
464 Bong Bong Rd	34	-	35
Intersection of Avondale Rd & Turnbull Cres	45	-	35
54 Carlyle Cl	48	-	35
Intersection of Nth Marshall Mt Rd & Marshall Mt Rd	40	-	35
479 Calderwood Rd	45	-	35
144 Calderwood Rd	39	-	35
340 North Macquarie St	43	-	35
3018 Illawarra Hwy	51	-	35

4.6 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 presented in Table 12 below, while existing noise levels are presented Table 13. Measurements were typically taken approximately 1m from noise and vibration source.

Table 12 – 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

Location		RMS Acceleration (m/s^2)			Peak Velocity (mm/s)		
		X-Axis	Y-axis	Z-axis	X-Axis	Y-axis	Z-axis
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

Table 13 – Measured Existing Leq Operational Noise Levels

Infrastructure	Location	Leq Noise level (dB)																											
		Frequency (Hz)																											
		25	31.5	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1k	1.25k	1.6k	2k	2.5k	3.15k	4k	5k	6.3k	8k	10k	Total dB(A)
WPS 313	Front of building at vent & pipe	60	61	59	63	55	56	54	57	58	48	46	48	40	38	38	37	37	38	39	36	35	46	47	46	36	28	24	54
	Rear of building at vent & pipe	50	51	53	66	54	61	54	54	66	52	54	54	49	46	50	51	46	46	44	40	42	51	39	38	35	27	23	59
WWPS 1145	Front of building at vent	45	45	43	41	44	53	45	46	46	43	41	47	46	39	37	44	43	41	41	39	36	34	31	26	26	22	20	51
Clipper/Apollo	At pump (rear of building)	53	54	60	57	56	52	49	49	47	45	48	44	51	42	38	42	40	41	40	38	37	35	32	30	28	27	24	52
WWPS 0498	Main water pipe	53	53	58	58	57	54	68	62	53	51	52	52	52	50	49	49	48	48	44	41	38	37	37	33	32	28	26	58
	Centre of site (over steel plate)	59	56	57	57	60	61	62	53	53	60	54	55	49	50	51	49	48	47	45	43	40	38	37	31	28	24	20	58
	Centre Room at vent	57	60	63	60	63	64	63	61	62	57	56	58	53	54	53	49	50	49	47	43	41	38	35	31	27	23	19	60
WWPS 0345	front of building at door vent	53	54	59	60	59	55	67	61	53	52	52	55	55	63	52	52	58	53	52	50	47	43	38	34	30	28	24	64
	Rear of building east at door	58	59	61	63	60	58	65	54	50	49	49	48	46	44	47	51	49	47	45	41	39	35	34	32	30	27	24	57
	Rear of building west rear	65	68	73	79	77	73	84	71	62	60	52	49	46	46	46	49	47	45	45	41	39	36	34	32	31	29	26	66
WWPS 0505	Front of building	56	58	61	63	58	59	61	59	56	53	53	51	50	50	52	55	56	54	52	51	51	48	46	42	40	37	33	63
	Rear of building at door vent	52	56	62	57	61	58	57	55	57	53	50	51	53	50	49	52	53	50	47	46	44	41	38	34	31	28	24	60
	Rear of site over metal plate	54	57	57	57	61	64	64	59	57	56	55	59	54	53	55	54	54	49	47	45	44	43	41	36	32	29	26	61
	On driveway next to metal plate	52	52	55	59	59	67	59	53	55	52	53	55	52	50	50	52	50	46	44	45	45	40	34	33	30	28	29	59

5 OPERATIONAL NOISE & VIBRATION ASSESSMENT

5.1 Operational Noise Goals

5.1.1 General Operation

Noise impacts from the operation of the proposed reservoir and Pumping Station sites are assessed in accordance with the NSW 'Industrial Noise Policy' (INP), as outlined in the Director General's Requirements. The INP provides noise criteria for the assessment against intrusiveness and amenity. It is noted that 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 amenity assessment is applicable for residential type 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.

According to the INP, the intrusiveness of a noise source may generally be considered acceptable if the equivalent continuous (energy-average) A-weighted level of noise from the source (represented by the L_{Aeq} descriptor) does not exceed the background noise level measured in the absence of the source by more than 5dB(A).

The intrusiveness criterion is summarised as follows:

$L_{Aeq} \leq L_{A90}$ background noise level plus 5dB(A)

To limit continuing increases in noise levels, the maximum ambient noise level within an area from industrial noise sources should not normally exceed the acceptable noise levels specified in Table 2.1 of the INP, the applicable parts of which are reproduced in Table 14 below.

Table 14 – Amenity Criteria – Recommended L_{Aeq} Noise Levels from Industrial Sources

Type of Receiver	Indicative Noise Amenity Area	Time of Day	Recommended L_{Aeq} Noise Level, dB(A)[1]	
			Acceptable	Recommended Maximum
Residence	Suburban	Day[2]	55	60
		Evening[3]	45	50
		Night[4]	40	45

Notes:
1. *Noise levels apply at the property boundary that is most exposed to industrial noise, and at a height of 1.5m above ground level. If the property boundary is more than 30m from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30m of the residence.*
2. ***Day** refers to the period from 7am to 6pm (Monday to Saturday) and 8am to 6pm (Sundays & Public Holidays)*
3. ***Evening** refers to the period from 6pm to 10pm*
4. ***Night** refers to the period from 10pm to 7am(Monday to Saturday) and 10pm to 8am (Sundays & Public Holidays)*

Therefore, in accordance with the INP, noise impact should be assessed in terms of both intrusiveness and amenity. Based on the long term unattended noise monitoring and the estimated future background noise levels presented in Table 11, the applicable industrial noise criteria are as follows.

Table 15 – 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 Rd	47	45	43	55	45	40
14 Woodside Circuit	46	43	40	55	45	40
145 Marshall Mount Rd	44	43	40	55	45	40
112 Koona St	46	44	40	55	45	40
2 Stapleton Ave	53	47	41	55	45	40
39 Jason Ave	50	46	41	55	45	40
1 Ocean Beach Drive	50	46	41	55	45	40
140 Smiths Ln	44	45	42	55	45	40
2 Parkland Ave	41	45	40	55	45	40

Notes: 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.*

2. ***Bold** indicates strictest noise criteria*

Given that the proposed pumping station sites will operate continuously 24 hours per day, seven days per week, the strictest noise criteria for the night time period are to be used for assessment purposes.

Furthermore, it is noted that during operation there is unlikely to be significant traffic generated by the Proposal. Vehicular movements will be in response to maintenance and security and are unlikely to exceed 2-3 vehicles per month. Therefore, operational traffic on public roads will not cause any significant noise impacts.

5.1.2 Sleep Disturbance

Sleep disturbance from night operations is assessed in accordance with the Application Notes of the INP and the ECRTN and are based on short-duration high-level noise events represented by the L_{max} noise descriptor.

A sleep disturbance criterion of $L_{A1(1min)} \leq L_{A90(15min)}$ + 15dB(A) (externally), will be used as a first step guide. Where this is not met, a more detailed analysis including reference to the research material contained in the ECRTN will be completed.

The ECRTN guideline recommends the following night time noise goals to minimise potential impacts and preserve acoustic amenity within receivers:

- Maximum internal noise levels below 50-55 dB(A) are unlikely to cause awakening reactions.
- One or two events per night with maximum internal noise levels of 65-70 dB(A) are not likely to affect health and wellbeing.

The assessment considers maximum noise levels and the extent and frequency of maximum noise level events exceeding the applicable sleep disturbance criteria.

Table 16 below summarises the sleep disturbance criteria that are applied for this study to nearby residences affected by the operation of the proposed reservoirs and pumping station sites. These levels are assessable outdoors at the facades of residential premises.

Table 16 – Applicable Sleep Disturbance Criteria, dB(A)

Infrastructure Site	Monitoring Location	Night Time L_{A90} Noise Level[1]	Sleep Disturbance Criteria
WWPS 1007	468 West Dapto Rd	38	LA1 ⩽ 38 + 15 = 53
Marshall Mount WWPS	145 Marshall Mount Rd	35	LA1 ⩽ 35 + 15 = 50
WWPS 500	112 Koona St	35	LA1 ⩽ 35 + 15 = 50
WWPS 505	2 Stapleton Ave	36	LA1 ⩽ 36 + 15 = 51
WWPS 0345	39 Jason Ave	36	LA1 ⩽ 36 + 15 = 51
WWPS 0498	1 Ocean Beach Drive	36	LA1 ⩽ 36 + 15 = 51
Calderwood WWPS1	144 Calderwood Rd	35	LA1 ⩽ 35 + 15 = 50
Calderwood WWPS2	340 North Macquarie Rd	35	LA1 ⩽ 35 + 15 = 50
Calderwood Reservoir	479 Calderwood Rd	35	LA1 ⩽ 35 + 15 = 50
Tongarra WWPS	3018 Illawarra Hwy	35	LA1 ⩽ 35 + 15 = 50
Tallawarra WWPS	54 Carlyle Cl	35	LA1 ⩽ 35 + 15 = 50
WWPS 296	12 George St	35	LA1 ⩽ 35 + 15 = 50

Notes:

1. *Based on estimated future background noise level.*
2. *Noise as a result of reservoir operation expected to be minimal and well below the criteria.*

5.2 Operational Noise Sources

The results of short term noise monitoring at existing wastewater pumping stations as presented in Table 13 have been analysed. From all the measured data, and assuming future pumping stations are similar in design and operation to the existing sites, it has been determined that the maximum L_{Aeq} sound power levels that can be expected from operation of the new infrastructure is as follows:

- Wastewater Pumping Stations – 75dBL_{Aeq} (PWL)
- Water Pumping Stations – 70dBL_{Aeq} (PWL)

5.3 Predicted Operational Noise Impacts

5.3.1 Pumping Station Sites

While residential housing may not currently be in close proximity to the pumping stations, it is expected that future residential development will encroach on the various Sydney Water infrastructure sites, although the distance to the nearest residence is not yet known. Therefore distance calculations for operational noise have been conducted based on the sound power levels presented in Section 5.2, and taking distance losses only into account. The modelling determines the amount of noise attenuation over the set distance.

Table 17 below summarises the predicted noise levels at nominated distances as a result of the operational noise from the proposed or augmented infrastructure sites. Operational noise from reservoirs is determined to be insignificant and therefore no reservoir predictions are shown.

Table 17 – Predicted Operational Noise Levels for Pumping Stations

Infrastructure Site	Predicted $L_{Aeq(15min)}$ Noise Levels					Applicable Noise Criteria	
	Distance (m)					$L_{Aeq(15min)}$	L_{A1}
	10	20	30	40	50		
WWPS 1007*	**52**	**46**	**42**	40	38	40	53
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
Tongarra WWPS	**52**	**46**	**42**	40	38	40	50
Tallawarra WWPS*	**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

Notes: Bold font represents exceedance of the applicable noise criteria
** indicates site is within project approval area*

Predicted operational noise levels at potential residences impacted upon by the pumping stations sites are presented in the table above and were found to typically comply with the most stringent night time noise criteria where distances were greater than approximately 40m for wastewater pumping stations, and approximately 25m for water pumping stations.

These predicted levels assume no solid boundary fences at either the residences or the infrastructure sites. Where solid fences did exist, for example a residential colourbond fence, this will provide an additional approximately 5dBA reduction.

Furthermore, given that the noise characteristics from pumps are typically continuous with no short-duration type noise, it is expected that noise levels from the pumps at the infrastructure sites will comply with the sleep arousal criteria where distances are greater than about 15m.

5.3.2 Reservoir Sites

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

5.3.3 Pipelines

Any pipeline noise is generally contained within the pipe and therefore there is no noise source to quantify.

5.3.4 Wastewater Treatment Plants

An REF was conducted in 2003 for The Shellharbour Optimisation & Amplification of Wastewater Treatment Plant project which involved optimisation and amplification of the existing Treatment Plant which is located on Junction Road, Shellharbour. The purpose of the project was to increase the capacity of the STP, and the works were generally contained within the boundaries, or nearby to the existing site.

The Noise and Vibration Assessment for the project conducted by Vipac concluded that no cumulative noise impacts were expected due to any new or existing noise sources that are part of the WDURA & AGA's project.

Similarly for any augmentation of either site in the future, noise impacts are probably not likely if the additional works are contained within the existing site boundaries and the new noise sources are similar to the existing sources on site.

5.4 Recommended Operational Noise Mitigation Measures

Sydney Water's standard design practice in terms of operational noise control for Sydney Water assets is as follows:

Reservoir sites

- Any asset that could potentially generate non-compliant noise levels (Automatic Inlet Control Valve, Pressure Reducing Valve, etc) are enclosed within chambers or brick structures

- Assets within chambers may or may not be fully enclosed depending on the expected noise levels from operation of particular asset types. Full chamber covers are installed where assets could potentially generate non-compliant noise levels. Anderson Grid covers are installed for low or no noise assets as they provide for better air circulation & less condensation build up.

Water and wastewater pumping stations

- For larger Pumping stations, brick buildings with acoustic louvres and soundproof doors are employed.

- For smaller stations (package plants), full acoustic enclosures are employed.

In summary, the brick buildings and enclosures that are typical of Sydney Water pumping station sites, together with the use of acoustic louvres in ventilation openings where required, will provide the required noise reductions.

Wastewater Treatment Plant Upgrades

No noise mitigation is recommended at this Concept Approval Stage.

5.5 Operational Vibration Impacts

Based on the vibration measurements conducted at the existing Sydney Water sites and the likely distances to future residential premises, vibration from the operation of new pumping stations will be negligible and will not impact on the nearest residences.

5.6 Operational Impacts and Mitigation Measures Summary

Table 18 summarises the operational impacts and recommended mitigation at the five nominated Project Approval Sites.

Table 18 – Operational Impacts and Mitigation Summary

Infrastructure Site	Proposed Works	Predicted Impacts	Recommended Mitigation Measures	Anticipated Level of Compliance with Mitigation
Tallawarra WWPS (Figure 2)	Construct new pumping station	No existing residences within 40m so no impacts to existing residences. Site is within industrial area so no new residences to be constructed nearby	None required	Compliance at all receivers
WWPS 1007 (Figure 8)	Augment existing pumping station	No existing residences within 40m so no impacts to existing residences. Potential impacts to new residences within 40m of the pumping station	If new residences are to be constructed within 40m then implement Sydney Water's standard noise treatments	Compliance at all existing and new residences
WWPS 0500 (Figure 9)	Augment existing pumping station	No existing residences within 40m so no impacts to existing residences. Site is within industrial area so no new residences to be constructed nearby	None required	Compliance at all receivers
Avondale Reservoir (Figure 14)	Construct new reservoir	No operational impacts expected	None required	Compliance at all existing and new residences
Wongawilli Reservoir (Figure 17)	Minor works	No operational impacts expected	None required	Compliance at all existing and new residences

6 CONSTRUCTION NOISE ASSESSMENT

6.1 Construction Noise & Vibration Goals

6.1.1 Construction Noise

Construction noise is assessed using the NSW Department of Environment, Climate Change and Water's (DECCW) 'Interim Construction Noise Guideline' (ICNG) 2009, which is in accordance with the Director General's Requirements.

The ICNG provides two methods for assessment of construction noise, being either a quantitative or a qualitative assessment.

A quantitative assessment is recommended for major construction projects of significant duration, and involves the measurement and prediction of noise levels, and assessment against set criteria.

A qualitative assessment is recommended for small projects with a short-term duration where works are not likely to affect an individual or sensitive land use for more than three weeks in total. It focuses on minimising noise disturbance through the implementation of feasible and reasonable work practices, and community notification.

Construction activities associated with the water related services for the WDURA and AGA's will involve the installation of pipelines and the construction of the reservoir and pumping station.

Given the significant scale of the construction works proposed for this Project, a quantitative assessment will be undertaken, consistent with the ICNG's requirements.

Management Levels

Table 19 below (reproduced from Table 2 of the ICNG) sets out the noise management levels and how they are to be applied. The guideline intends to provide respite for residents exposed to excessive construction noise outside the recommended standard hours whilst allowing construction during the recommended standard hours without undue constraints.

In Table 19 below, the rating background level (RBL) is used when determining the management level. The RBL is the overall single-figure background noise level measured in each relevant assessment period (during or outside the recommended standard hours).

Table 19 – Noise at Residences Using Quantitative Assessment

Time of Day	Management Level $L_{Aeq\ (15\ min)}$*	How to Apply
Recommended standard hours: Monday to Friday 7 am to 6 pm Saturday 8 am to 1 pm No work on Sundays or public holidays	Noise affected RBL + 10dB(A)	The noise affected level represents the point above which there may be some community reaction to noise. • Where the predicted or measured $L_{Aeq\ (15\ min)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. • The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected 75dB(A)	The highly noise affected level represents the point above which there may be strong community reaction to noise. • Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: 1. times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences) 2. if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected RBL + 5dB(A)	• A strong justification would typically be required for works outside the recommended standard hours. • The proponent should apply all feasible and reasonable work practices to meet the noise affected level. • Where all feasible and reasonable practices have been applied and noise is more than 5dB(A) above the noise affected level, the proponent should negotiate with the community. • For guidance on negotiating agreements see section 7.2.2 of the *NSW Interim Construction Noise Guideline*.

** Noise levels apply at the property boundary that is most exposed to construction noise, and at a height of 1.5 m above ground level. If the property boundary is more than 30 m from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30 m of the residence. Noise levels may be higher at upper floors of the noise affected residence.*

The daytime background noise levels measured at the long term and short term monitoring locations (refer to Table 10) are considered to be representative of the RBL for residences near the proposed construction works, since the background noise environment at the time of construction will likely be similar to the existing noise environment before any development has taken place. Therefore, the measured background noise levels (from Table 10), rather than estimated future background noise levels (from Table 11) have been used for setting construction noise management levels.

The management level depends on the time of day the works are carried out. During standard hours, the management level is “RBL + 10dBA”. Receivers exposed to construction noise greater than this, up to 75dBA, are considered to be “noise affected”. Receivers are considered to be “highly noise affected” when they are exposed to construction noise of more than 75dBA.

The management levels that apply to residential receivers during the recommended standard hours are summarised in Table 20.

Table 20 – Summary of Construction Noise Management Levels, dB(A)

Infrastructure	Receiver Type	Measured L_{A90} Background Noise Level[1]	Management Level[2] $L_{Aeq(15min)}$
WWPS 1007*	Residence	37	47
Tallawarra WWPS*	Residence	48	58
Marshall Mount WWPS	Residence	34	44
Calderwood WWPS1	Residence	34	44
Calderwood WPS	Residence	42	52
Tongarra WWPS	Residence	51	61
Calderwood WWPS2	Residence	38	48
WWPS 500*	Residence	36	46
WWPS 0296	Residence	54	64
WWPS 505	Residence	46	56
WWPS 0345	Residence	40	50
WWPS 0498	Residence	41	51
Wongawilli Reservoir*	Residence	33	43
Avondale Reservoir*	Residence	29	39
Marshall Mount Reservoir	Residence	31	41
Calderwood Reservoir	Residence	42	52

Note: 1. Based on measured background noise levels as presented in Table 10.
2. RBL + 10dBA. Applicable during the recommended standard hours.
** Indicates Pproject Approval locations.*

In addition to the management levels applicable to residential type receivers, Table 21 below (reproduced from Table 3 of the ICNG) sets out the noise management levels for various sensitive land use developments.

Table 21 – Noise at Other Sensitive Land Uses Using Quantitative Assessment

Land use	Management level, $L_{Aeq\ (15\ min)}$ (applies when property is being used)
Classrooms at schools and other educational institutions	Internal noise level 45 dB(A)
Hospital wards and operating theatres	Internal noise level 45 dB(A)
Places of worship	Internal noise level 45 dB(A)
Active recreation areas	External noise level 65 dB(A)
Passive recreation areas	External noise level 60 dB(A)

Land use	Management level, $L_{Aeq\ (15\ min)}$ (applies when property is being used)
Community centres	Depends on the intended use of the centre. Refer to the 'maximum' internal levels in AS2107 for specific uses.

Management Levels for Pipeline Works

The management levels for pipelines will vary greatly as the pipeline works will be carried out in areas with both high and low background noise levels. During standard hours, an estimate of the management level for any particular section of pipeline would be to refer to the management level in Table 20 for the infrastructure item closest to the section of pipeline in question.

For out of hours work, the RBL will likely be around 30dBA due to the time of day, and therefore an appropriate management level is 35dBA.

6.1.2 Road Traffic Noise Generated by Construction Activity

During construction works there is potential for noise impacts from construction traffic movements. However, the actual routes proposed for the construction traffic are currently unknown.

Road traffic noise impact is assessed in accordance with the NSW DECCW's 'Environmental Criteria for Road Traffic Noise' (ECRTN) 1999, in accordance with the Director General's Requirements.

Table 22 below (reproduced from Table 1 of the ECRTN) provides the relevant road traffic noise criteria based on the type of development and the road classification. The relevant development categories for the proposed construction works are Categories 8 and 13.

Table 22 – 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	$L_{Aeq(1hr)}$ 60	$L_{Aeq(1hr)}$ 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	$L_{Aeq(1hr)}$ 55	$L_{Aeq(1hr)}$ 50	

*Notes: * Noise levels apply at 1m from the facade that is most exposed to road traffic noise, and at a height of 1.5m above ground level.*

By reference to the policy set out above, the suitable traffic noise limit adopted for the assessment of this proposal is $L_{Aeq(1hr)}$ = 55dB(A) during the day (7:00am to 10:00pm) for local roads and $L_{Aeq(1hr)}$ = 60dB(A) during the day for collector roads. Where existing noise levels already exceed these limits, then a **2dB(A) noise increase on existing noise levels as a result of the construction traffic is permissible**, provided it can be shown that traffic noise mitigation here is not feasible and practicable.

6.1.3 Construction Vibration

Disturbance to Buildings Occupants

For disturbance to human occupants of buildings, we refer to DECCW's 'Assessing Vibration; a technical guideline', published in February 2006. This document provides criteria which are based on the British Standard BS 6472-1992, '*Evaluation of human exposure to vibration in buildings (1-80Hz)'*.

Vibration sources are defined as C*ontinuous, Impulsive or Intermittent.* Section 2 of the technical guideline defines each type of vibration as follows:

> '***Continuous*** *vibration continues uninterrupted for a defined period (usually throughout the day-time and/or night-time).*
>
> ***Impulsive*** *vibration is a rapid build up to a peak followed by a damped decay that may or may not involve several cycles of vibration (depending on frequency and damping). It can also consist of a sudden application of several cycles at approximately the same amplitude, providing that the duration is short, typically less than 2 seconds.*
>
> ***Intermittent*** *vibration can be defined as interrupted periods of continuous or repeated periods of impulsive vibration that varies significantly in magnitude'.*

The criteria are to be applied to a single weighted root mean square (rms) acceleration source level in each orthogonal axis. Section 2.3 of the guideline states:

> *'Evidence from research suggests that there are summation effects for vibrations at different frequencies. Therefore, for evaluation of vibration in relation to annoyance and comfort, overall weighted rms acceleration values of the vibration in each orthogonal axis are preferred (BS 6472).'*

Preferred and maximum values for continuous and impulsive vibration are defined in Table 2.2 of the guideline and are reproduced below.

Table 23 – Preferred and maximum weighted rms values for continuous and impulsive vibration acceleration (m/s^2) 1-80Hz

Location	Assessment period[1]	Preferred values		Maximum values	
		z-axis	x- and y-axis	z-axis	x- and y-axis
Continuous vibration					
Critical areas[2]	Day- or night-time	0.005	0.0036	0.010	0.0072
Residences	Daytime	0.010	0.0071	0.020	0.014
	Night-time	0.007	0.005	0.014	0.010
Offices, schools, educational institutions and places of worship	Day- or night-time	0.020	0.014	0.040	0.028
Workshops	Day- or night-time	0.04	0.029	0.080	0.058
Impulsive vibration					
Critical areas[2]	Day- or night-time	0.005	0.0036	0.010	0.0072
Residences	Daytime	0.30	0.21	0.60	0.42
	Night-time	0.10	0.071	0.20	0.14
Offices, schools, educational institutions and places of worship	Day- or night-time	0.64	0.46	1.28	0.92
Workshops	Day- or night-time	0.64	0.46	1.28	0.92

Notes: 1. *Daytime is 7.00 am to 10.00 pm and night-time is 10.00pm to 7.00 am*

2. *Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. There may be cases where sensitive equipment or delicate tasks require more stringent criteria than the human comfort criteria specify above. Stipulation of such criteria is outside the scope of their policy and other guidance documents (e.g. relevant standards) should be referred to. Source: BS 6472-1992*

Intermittent vibration is to be assessed using vibration dose values (VDVs). The VDV method is a fourth power approach which is more sensitive to peaks in the acceleration waveform and makes corrections to the criteria based on the duration of the source's operation. The VDV can be calculated using the overall weighted rms acceleration of the vibrating source in each orthogonal axis and the total period during which the vibration may occur. Weighting curves are provided in each orthogonal axis in the guideline. Preferred and maximum VDV values are defined in Table 2.4 of the guideline and are reproduced below.

Table 24 – Acceptable vibration dose values for intermittent vibration (m/s$^{1.75}$)

Location	Daytime [1]		Night-time [1]	
	Preferred values	Maximum values	Preferred values	Maximum values
Critical areas[2]	0.10	0.20	0.10	0.20
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80	0.40	0.80
Workshops	0.80	1.60	0.80	1.60

Location	Daytime [1]		Night-time [1]	
	Preferred values	Maximum values	Preferred values	Maximum values

Notes: 1. *Daytime is 7.00 am to 10.00 pm and night-time is 10.00pm to 7.00 am*

2. *Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. These criteria are only indicative, and there may be a need to assess intermittent values against the continuous or impulsive criteria for critical areas. Source: BS 6472-1992*

Structural Damage to Buildings

Currently there exists no Australian Standard for assessment of structural building damage caused by vibrational energy. Therefore, reference is made to both the British and German standards below which are relevant to the assessment of structural damage.

British Standard

British Standard 7385: Part 2 "Evaluation and measurement of vibration in buildings", can be used as a guide to assess the likelihood of building damage from ground vibration. BS7385 suggests levels at which 'cosmetic', 'minor' and 'major' categories of damage might occur.

BS7385 recommends that the peak particle velocity is used to quantify vibration and specifies damage criteria for frequencies within the range 4Hz to 250Hz, which is the range usually encountered in buildings. At frequencies below 4Hz, a maximum displacement value is recommended. The levels from the standard are given below in Table 25.

Table 25 – BS 7385 Structural Damage Criteria

Group	Type of Structure	Peak component particle velocity, mm/s		
		4Hz to 15Hz	15Hz to 40Hz	40Hz and above
1	Reinforced or framed structures Industrial and heavy commercial buildings		50	
2	Un-reinforced or light framed structures Residential or light commercial type buildings	15 to 20	20 to 50	50

The peak vibration limits set for minimal risk of 'cosmetic' damage are: 15mm/s for un-reinforced or light framed structures, for example residential or light commercial buildings (Group 2; increasing as the frequency content of the vibration increases) and 50mm/s for reinforced or framed structures, for example industrial and heavy commercial buildings (Group 1; constant across all frequencies). 'Minor' damage is considered possible at vibration magnitudes which are twice those given and 'major' damage to a building structure may occur at levels greater than four times those values.

These values relate to transient vibrations and to low rise buildings. Continuous vibration can give rise to dynamic magnifications due to resonances and may need to be reduced by up to 50%.

The levels set by this standard are considered 'safe limits' up to which no damage due to vibration effects has been observed for certain particular types of buildings. Damage comprises minor non-structural effects such as hairline cracks on drywall surfaces, hairline cracks in mortar joints and cement render, enlargement of existing cracks and separation of partitions or intermediate walls from load bearing walls.

This standard states that it considers sources of vibration including blasting, demolition, piling, ground treatments, compaction, construction equipment, tunnelling, road and rail traffic and industrial machinery.

As stated in the standard, it sets guide values for building vibration based on the lowest levels above which damage has been credibly demonstrated. That is, it gives guidance on the levels of vibration above which building structures could be damaged.

German Standard

The German standard DIN 4150 - Part 3 - "Structural vibration in buildings - Effects on Structures", also provides recommended maximum levels of vibration that reduce the likelihood of building damage caused by vibration. This standard too, presents recommended maximum limits over a range of frequencies measured in any direction at the foundation or in the plane of the uppermost floor.

The minimum 'safe limit' of vibration at low frequencies for commercial and industrial buildings is 20mm/s. For dwellings it is 5mm/s and for particularly sensitive structures (eg historical with preservation orders etc), it is 3mm/s. These limits increase as the frequency content of the vibration increases. These values are presented in Table 26 below and are generally recognised to be conservative.

Table 26 – DIN 4150-3 Structural Damage Criteria

Group	Type of Structure	Vibration Velocity, mm/s			
		At Foundation at Frequency of			Plane of Floor Uppermost Storey
		Less than 10Hz	10Hz to 50Hz	50Hz to 100Hz	All Frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
2	Dwellings and buildings of similar design and/or use	5	5 to 15	15 to 20	15

Group	Type of Structure	Vibration Velocity, mm/s			
		At Foundation at Frequency of			Plane of Floor Uppermost Storey
		Less than 10Hz	10Hz to 50Hz	50Hz to 100Hz	All Frequencies
3	Structures that because of their particular sensitivity to vibration, do not correspond to those listed in Group 1 or 2 and have intrinsic value (eg buildings under a preservation order)	3	3 to 8	8 to 10	8

6.2 Proposed Construction Activities

Construction activities associated with the water related services for the WDURA and AGA's will involve:

- Construction of reservoirs,
- Construction of drinking water and waste water pumping stations,
- Upgrade/augmentation of pumping stations and treatment plants, and
- Excavation and installation of drinking water and wastewater pipelines.

Construction works will take place within road reserves, public reserves and on private land.

Most construction works will occur during the day during the standard hours stipulated in the ICNG (ie. 7am to 6pm, Monday to Friday; and 8am to 1pm on Saturdays). However night work will likely be required during pipeline construction for the following activities:

- Micro tunnelling and/or directional drilling (may require 24hour operation for a week or more to ensure the efficacy of the method)
- Removing trees, undertaking road crossings, road restorations, etc
- Delivery of oversized items
- Emergency works

According to the ICNG, no noise assessment would be required for emergency works, however the other listed activities should aim to meet the 'out of hours' management level (refer Table 19).

The following table lists construction activities and the associated plant and equipment likely to be used to carry out the necessary construction work for the project.

Table 27 – Proposed Typical Construction Activities

Activity	Description of Activity	Plant/ Equipment	No. Units	Hours of use
Reservoir & Pumping Station Site Construction	General land clearing, tree and stump removal. Excavation of soil and rock, loading, haulage. Delivery	Rock breaker	1	Daytime works (night works not expected).
		Bulldozer	1	
		Front end loader	1	

Activity	Description of Activity	Plant/ Equipment	No. Units	Hours of use
	of raw materials. Construction of infrastructure.	Tracked excavator	1	
		Crane	1	
		Trucks	2	
		Vibrating compactor	1	
		Grader	1	
		Pneumatic hand tools	4	
		Silenced Air Compressor	1	
		Chain saw	1	
		Concrete saw	1	
		Concrete truck/pumps	1	
Pipelines	Excavation of trenches and pits, delivery and placement of precast pipes and pits, filling and compacting.	Rock Breaker	1	Daytime works (occasional night works possible).
		Front-end loader	1	
		Crane	1	
		Roller	1	
		Grader	1	
		Drilling rig	1	
		Chainsaw	1	
		Concrete Saw	1	
		Compactor	1	
		Tracked Excavator	1	
		Concrete truck/pumps	1	
		Trucks	2	
		Silenced air compressor	1	
		Pneumatic hand tools	3	

6.3 Construction Noise & Vibration Sources

6.3.1 Construction Noise Sources

The following table lists construction plant and equipment likely to be used during the construction phase for this project and their corresponding typical sound power levels.

Table 28 – Typical Construction Equipment & Sound Power Levels, dB(A)

Plant Item	Plant Description	L_{Aeq} Sound Power Levels, dB(A) re 1pW
1	Rock Breaker	117
2	Concrete Saw	115
3	Chainsaw	114
4	Drilling rig	111
5	Bulldozer	110
6	Crane	110

Plant Item	Plant Description	L_{Aeq} Sound Power Levels, dB(A) re 1pW
7	Front End Loader	110
8	Pneumatic Hand Tools (general)	110
9	Compactor	110
10	Graders	110
11	Tracked Excavator	107
12	Vibratory Roller	106
13	Concrete Truck	106
14	Water Cart	104
15	Truck (>20tonne)	103
16	Concrete Pump	102
17	Light commercial vehicles (eg 4WD)	100
18	Silenced Air Compressor	95

Notes: 1. The sound power data within the column marked 'Typical' has been used in this study to calculate typical noise levels at the nominated assessment locations.

The sound power levels for the majority of activities presented in the above table are based on maximum levels given in Table D2 of Australian Standard 2436 - 1981 "Guide to Noise Control on Construction, Maintenance and Demolition Sites", DECCW's ICNG, information from past projects and information held in our library files.

6.3.2 Construction Vibration Sources

Typical vibration levels from construction equipment most likely to cause significant vibration are summarised below. The information was sourced from a variety of reference materials available in the Renzo Tonin & Associates library.

Table 29 – Typical Ground Vibration Generated by Construction Plant

<table>
<tr><th>Activity</th><th>Typical Ground Vibration</th></tr>
<tr><td>Hydraulic rock-breakers and road-headers</td><td>Typical ground vibration levels at various distances from rock-breakers and road-headers operating in hard sandstone are summarised below. Use of smaller machines can reduce levels of vibration significantly. Vibration associated with even large road-headers is significantly lower than from rock-breakers, due to the nature of the operation (grinding versus impulsive breaking of the rock).
<table>
<tr><th rowspan="2">Plant</th><th colspan="6">Vibration (mm/s) at given distance</th></tr>
<tr><th>5m</th><th>10m</th><th>20m</th><th>30m</th><th>40m</th><th>50m</th></tr>
<tr><td>Heavy rock-hammer</td><td>4.5</td><td>1.3</td><td>0.4</td><td>0.2</td><td>0.15</td><td>0.1</td></tr>
<tr><td>Light rock-hammer</td><td>1</td><td>0.3</td><td>0.1</td><td>0.05</td><td>0.01</td><td>-</td></tr>
<tr><td>Large road-header</td><td>0.5</td><td>0.13</td><td>0.04</td><td>0.02</td><td>-</td><td>-</td></tr>
</table>
Source: Richard Heggies Associates.</td></tr>
<tr><td>Compactor</td><td>Compactors typically generate 20mm/s at distances of approximately 5m, 2mm/s at distances of 15m. At distances greater than 30m, vibration are usually below 0.3mm/s.</td></tr>
</table>

Activity	Typical Ground Vibration
Bulldozers / Excavators	Typical ground vibration levels from bulldozers / excavators range from 1 mm/s to 2 mm/s at distances of approximately 5 m. At distances greater than 20 m, vibration levels are usually below 0.2 mm/s.
Vibratory rollers	Ground vibration caused by vibratory rollers can range up to 1.5mm/s at distances of 25m. The highest levels of vibration usually occur as the roller is brought to rest and the frequency of the centrifugal forces passes through resonance with the natural frequency of the roller/ground/structure. Machinery should therefore not be brought to rest when in the vicinity of susceptible buildings, especially dwellings. Higher levels could occur at closer distances, however, no damage would be expected for any building at distances greater than approximately 12m (for a medium to heavy roller).
Truck traffic	Typical vibration from heavy trucks passing over normal (smooth) road surfaces generate relatively low vibration levels in the range of 0.01 - 0.2mm/s at the footings of buildings located 10 - 20m from a roadway. Very large surface irregularities can cause levels up to five to ten times higher. In general, ground vibration from trucks is usually imperceptible in nearby buildings. The rattling of windows and other loose fittings that is sometimes reported is more likely to be caused by airborne acoustic excitation from very low frequency (infrasonic) noise radiated by truck exhausts and truck bodies. While this may cause concern to the occupants, the phenomenon is no different from the rattling caused by wind or people walking or jumping on the floor and fears of structural damage or even accelerated ageing are usually unfounded.
Micro tunnelling	We understand micro tunnelling is a drilling process with little vibration emission. Specific vibration data is not available at this stage for micro tunnelling activities however due to the nature of the process and its likely distance from existing receivers, this activity are not expected to cause any adverse vibration impacts.

Source: Renzo Tonin & Associates Database and Library Files

6.4 Potential Construction Noise Impacts

6.4.1 Reservoirs and Pumping Stations

Table 30 below summarises the predicted noise levels during the construction phase for the proposed and augmented reservoirs and pumping stations for the WDURA and AGAs.

Table 30 – Predicted Construction Noise Levels for Pumping Stations and Reservoirs

Infrastructure Site	Predicted L_{Aeq}(15min) Noise Levels						Nearest Affected Receiver Address	Distance (m)	Applicable Noise Criteria L_{90} +10	Exceedance (dB)
	Distance (m)									
	20	50	100	200	500	1000				
WWPS 1007	80-84	72-76	66-70	59-63	51-55	45-49	441 West Dapto Rd	250	47	12-16
Marshall Mount WWPS	80-84	72-76	66-70	59-63	51-55	45-49	164 Marshall Mount Rd	60	44	28-32
Calderwood WWPS1	80-84	72-76	66-70	59-63	51-55	45-49	144 Calderwood Rd	475	44	7-11
Calderwood WWPS2	80-84	72-76	66-70	59-63	51-55	45-49	340 North Macquarie Rd	385	48	3-7
Tongarra WWPS	80-84	72-76	66-70	59-63	51-55	45-49	3018 Illawarra Hwy	1335	61	0
Tallawarra WWPS	80-84	72-76	66-70	59-63	51-55	45-49	54 Carlyle Cl	1085	58	0
WWPS 500	80-84	72-76	66-70	59-63	51-55	45-49	116A Koona St	105	46	20-24

Infrastructure Site	Predicted L_{Aeq}(15min) Noise Levels						Nearest Affected Receiver Address	Distance (m)	Applicable Noise Criteria L_{90} +10	Exceedance (dB)
	Distance (m)									
	20	50	100	200	500	1000				
WWPS 505	80-84	72-76	66-70	59-63	51-55	45-49	2 Stapleton Ave	7	56	24-28
WWPS 0345	80-84	72-76	66-70	59-63	51-55	45-49	39 Jason Ave	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 St	85	64	2-6
Calderwood WPS	80-84	72-76	66-70	59-63	51-55	45-49	479 Calderwood Rd	20	52	25-19
Avondale Reservoir	81-85	73-77	67-71	60-64	52-56	46-50	464 Bong Bong Rd	50	39	34-38
Wongawilli Reservoir	81-85	73-77	67-71	60-64	52-56	46-50	140 Smiths Ln	20	43	38-42
Marshall Mount Reservoir	81-85	73-77	67-71	60-64	52-56	46-50	2 Parkland Ave	70	41	32-36
Calderwood Reservoir	81-85	73-77	67-71	60-64	52-56	46-50	479 Calderwood Rd	750	52	0

The results show that at the majority of proposed construction and augmentation sites, nearby residences will experience exceedances of the applicable criteria.

Receivers that are greater than 500m from the construction works will typically comply without any mitigation.

6.4.2 Drinking and Waste Water Pipelines

Construction and installation of the drinking and waste water pipelines will be progressive. Construction activity will generally be undertaken within approximately 5 metres either side of the pipeline. Residences are typically set back around 20 metres from the road, although some residences are as close as 10 metres to the road while others are more than 50 metres from the road alignment. As the distance between each residential receiver to the proposed works will vary along the length of the pipeline, noise levels have been predicted for varying distances from the pipeline corridor. The predicted noise levels are summarised in Table 31.

Table 31 – Predicted Construction Noise Levels Along Pipeline Corridor

Plant Item	Plant Description	Predicted Noise Levels at Varying Distance from Source, dB(A)								
		10m	15m	20m	25m	30m	40m	50m	100m	150m
1	Rock Breaker	85	81	78	76	74	71	69	61	57
2	Concrete Saw	83	79	76	74	72	69	67	59	55
3	Chainsaw	82	78	75	73	71	68	66	58	54
4	Drilling Rig	79	75	72	70	68	65	63	55	51
5	Front End Loader	78	74	71	69	67	64	62	54	50
6	Crane	78	74	71	69	67	64	62	54	50
7	Grader	78	74	71	69	67	64	62	54	50
8	Pneumatic Hand Tools	78	74	71	69	67	64	62	54	50

Plant Item	Plant Description	Predicted Noise Levels at Varying Distance from Source, dB(A)								
		10m	15m	20m	25m	30m	40m	50m	100m	150m
9	Compactor	78	74	71	69	67	64	62	54	50
10	Tracked Excavator	75	71	68	66	64	61	59	51	47
11	Roller	74	70	67	65	63	60	58	50	46
12	Concrete Truck	74	70	67	65	63	60	58	50	46
13	Truck	71	67	64	62	60	57	55	47	43
14	Concrete Pump	70	66	63	61	59	56	54	46	42
15	Silenced Air Compressor	63	59	56	54	52	49	47	39	35
Typical Cumulative[1]		**89**	**85**	**83**	**81**	**79**	**76**	**73**	**66**	**62**

Notes: 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.

The modelling results show that the louder equipment, including the rock breaker, concrete saw and chainsaw will result in a 'highly noise affected' level of 75dB(A) within approximately 25 metres of construction activity. As there are residential premises within 25 metres of the proposed pipeline corridor, these residences will be exposed to high noise levels during these activities. The remainder of the construction equipment will generally comply with the 'highly noise affected' level of 75 dB(A) within approximately 10-15 metres from the plant location.

Noise levels will potentially exceed the day time construction noise criteria at all receiver locations within approximately 100m of the pipeline corridor. Note that this estimate does not take into consideration shielding that may be provided by buildings or topography. Reasonable and feasible noise control recommendations are presented in Sections 6.6.1 and 6.6.2 of this report.

Out of Hours Works

Out of hours work will likely be required during pipeline construction. The likely equipment to be used may include:

- Micro tunnelling and/or directional drilling rig,
- Trucks for delivery of oversized items,
- Utility vehicles associated with Traffic Committee

Since the noise goal for out of hours work is 'RBL + 5dBA', and since night time RBL's in the project area are around 30dBA, (giving a noise goal of 35dBA), any receivers within about 500m of the works could be adversely impacted.

For out of hours work, the ICNG indicates that:

- A strong justification would typically be required for works outside the recommended standard hours.
- The proponent should apply all feasible and reasonable work practices to meet the noise goals.
- Where all feasible and reasonable practices have been applied and noise is more than 5dB(A) above the noise goals, the proponent should negotiate with the community.

Since noise levels are likely to be more than 5dBA above the noise goals, community information, notification and/or negotiation will be an important noise management strategy.

6.5 Construction Vibration Impacts

The relationship between vibration and the probability of causing human annoyance or damage to structures is complex. This complexity is mostly due to the magnitude of the vibration source, the particular ground conditions between the source and receiver, the foundation-to-footing interaction and the large range of structures that exist in terms of design (eg dimensions, materials, type and quality of construction and footing conditions). The intensity, duration, frequency content and number of occurrences of vibration, are all important aspects in both the annoyances caused and the strains induced in structures. The pattern of vibration radiation is very different to the pattern of airborne noise radiation, and is very site specific.

Vibration generated by construction plant was estimated at various distances and expected vibration impacts are shown in Table 32. It is noted that vibration impacts are based on human annoyance.

Table 32 – Potential Vibration Impact

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

Residential buildings (both existing and proposed) may potentially fall within 10 to 30 metres of the proposed construction activity. Occupants in these buildings are likely to notice vibrations as a result of rock breakers, compactors and vibratory rollers. Recommendations to reduce the potential impact of vibration generating construction works are presented in Section 6.6.6 of this report and summarised in Table 37.

People in residential premises greater than 30 metres from construction works are unlikely to notice vibrations. Structural damage as a result of construction works at any site is unlikely.

6.6 Recommended Construction Phase Mitigation Measures

6.6.1 Physical Noise Mitigation Measures

Implementation of noise control measures, such as those suggested in Australian Standard 2436-2010 "Guide to Noise and Vibration Control on Construction, Demolition and Maintenance Sites", are expected to reduce predicted construction noise levels. Reference to Australian Standard 2436, Appendix C, Table C1 suggests possible remedies and alternatives to reduce noise emission levels from typical construction equipment. Table C2 in Appendix C of AS2436 presents typical examples of noise reductions achievable after treatment of various noise sources. Table C3 in Appendix C of AS2436 presents the relative effectiveness of various forms of noise control treatment.

Table 33 presents noise control methods, practical examples and expected noise reductions according to AS2436 and according to Renzo Tonin & Associates' opinion based on experience with past projects.

Table 33 – Relative Effectiveness of Various Forms of Noise Control, dB(A)

Noise Control Method	Practical Examples	Typical noise reduction possible in practice		Maximum noise reduction possible in practice	
		AS 2436	Renzo Tonin & Assoc.	AS 2436	Renzo Tonin & Assoc.
Distance	Doubling of distance between source and receiver	6	6	6	6
Noise Control Kits	Residential class mufflers & engine silencing	5 to 10	5 to 10	20	20
Screening	Acoustic barriers such as earth mounds, temporary or permanent noise barriers	5 to 10	5 to 10	15	15
Acoustic Enclosures	Engine casing lagged with acoustic insulation and plywood	15 to 25	10 to 20	50	30
Substitution by alternative process	Use electric motors in preference to diesel or petrol	-	15 to 25	-	40

The Renzo Tonin & Associates' listed noise reductions are conservatively low and should be referred to in preference to those of AS2436, for this project.

More details are presented below for the types of measures considered feasible and reasonable for this project.

It is noted that additional to physical measures, noise management measures will be implemented which will further reduce noise impacts. These are described in Section 6.6.2.

Noise Control Kits for Mobile Plant

The mobile plant listed above, can be fitted with 'noise control kits' to reduce their noise emissions.

Such 'noise control kits' comprise:

- high performance 'residential-grade' exhaust mufflers,
- additional engine cowling / enclosure lined inside with sound absorbent industrial-grade foam, and
- air intake and discharge silencers / louvres.

Noise Screens

Noise screens (or noise barriers) achieve attenuation of a source by increasing the distance the sound must travel from the source to the receiver. For example, in the absence of a barrier sound can travel directly from the source to the receiver, whereas with a barrier blocking the line-of-sight, the sound must travel from the location of the noise source to the top of the barrier and then towards the receiver. The difference in these two lengths is often termed the *path difference.* Acoustic attenuation afforded by a barrier is proportional to the path difference, which is generally proportional to the barrier height.

As a general rule, a barrier that just breaks the line-of-sight to the noise source will achieve 5dB attenuation. As the barrier height increases relative to the receiver (or by moving closer to the barrier and further within the barrier's acoustic shadow) a greater attenuation is experienced. It is therefore recommended that any proposed noise screens shall be constructed so as to break line-of-sight between the subject plant and the nearest receiver/s, and where possible extend approximately 0.5m higher than the line-of-sight.

The ability of sound to diffract, or bend around (or over) objects means that even though a high sound insulation barrier may be located in between a noise source and receiver, the noise source can to some degree still be heard. To reduce the effects of diffraction, the barrier height would have to be significantly increased which would thereby result in the noise level in the barrier's acoustic shadow being more dependent on the sound insulation performance of the barrier as opposed to its height. However, this is uncommon and provided the barrier is not constructed of very light-weight materials, height is the more important factor.

The construction of noise barriers can be from any durable material with sufficient mass (min. 10kg/m2 - dependent on the level of overall performance required) to prevent direct noise transmission such as sheet steel, fibrous-cement, timber etc, or any combination of such

materials, provided they withstand the elements. Profiled sheet steel or plywood sheeting is adequate for use as a noise screen.

In addition to the above, all inner surfaces (plant side) of noise screens can be lined with acoustically absorptive material. This may consist of open-cell foam or polyester fibre insulation of at least 50mm thickness and density approximately 30kg/m^3.

Fixed temporary noise barriers will not be a reasonable and practical option for this project, however, mobile acoustic screens can be used close to the noise source, which could provide up to 10dB(A) noise reduction benefits if the correct height, length and materials are used.

Acoustic Enclosures for Stationary Plant

For stationary plant, partial acoustic enclosures can be installed that are made from similar materials as described above for noise screens. These can easily provide a noise reduction of 15dB(A).

6.6.2 Noise Management Measures

In addition to physical noise mitigation measures presented in Section 6.6.1 above, the following general noise management measures will further provide noise reduction benefits for the control of construction noise impacts to the nearest affected receiver locations.

Table 34 – General Construction Noise Management Measures

Construction Noise Management Measures	
Source controls	
Time constraints	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 quality 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 will minimise noise impacts. Similarly, diaphragm wall construction techniques, in lieu of sheet piling, will 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 work shall be switched off.
Equipment Location	Noisy plant and equipment shall 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, shall 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 only necessary size and power.
Quieter work practices	For example, implement worksite induction training, educating staff on noise sensitive issues and the need to make as little noise as possible.
Reversing alarms	Consider alternatives, such as manually adjustable or ambient noise sensitive types ("smart" reversing alarms) and closed circuit TV systems. 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	Locate equipment to take advantage of the noise barriers provided by existing site features and structures, such as embankments and storage sheds.
Project Planning	Construction shall be programmed so that noise barriers or mounding required to control noise are built as soon as possible.
Increased distance	Locate noisy plant as far away from noise-sensitive receptors as possible.
Site access	Select and locate site access roads as far away as possible from noise-sensitive areas.
Receptor controls	
Architectural treatment	Install permanent at-dwelling treatments early to gain noise benefits during the construction phase as well as for operational noise.
Temporary relocation	In extreme cases.
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 high risk activities are commenced. 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.

6.6.3 Standard Mitigation Measures

Of all the listed noise mitigation and management measures presented above, it is expected that at any site, 10dBA noise reduction could realistically 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 neighbours. These are referred to as "standard mitigation measures" from here on in this report.

6.6.4 Out of Hours Work

The noise management levels for out of hours work will typically be the lowest of any for the project and therefore noise impacts are potentially the greatest. All reasonable a feasible noise mitigation measures as outlined in Section 6.6.1 and 6.6.2 should be implemented, with a focus on minimising the number of plant items operating and the duration of those operations. Community information and notification will be an important noise management strategy for residences within 500m.

Where receivers are well setback from the work site, some activities that do not require power tools or machines may be compliant.

6.6.5 Vibration Buffer Distances

Based on our database containing vibration measurements from past projects and library information, Table 35 below presents the recommended safe working distances for high vibration generating plant.

Table 35 – Recommended Safe Working Distances for Vibration Intensive Plant

Plant Item	Rating / Description	Safe Working Distance	
		Cosmetic Damage	Human Response
Vibratory Roller[1]	Light (<100kN)	5m	15m – 20m
	Medium (>100kN, <300kN)	12m	40m
	Heavy (>300kN)	20m	100m
Rock Breaker[1]	300kg	2m	7m
	900kg	7m	23m
	1600kg	22m	73m
Compactor[2]	-	5m - 15m	30m
Pneumatic Hand Tools[1]	Hand held	1m (nominal)	5m
Dozers[2]	-	-	5m
Loaders[2]	-	-	5m
Truck Movements[2]	-	-	10m

Notes: 1. TIDC Construction Noise Strategy (Rail Projects) November 2007
2. Renzo Tonin & Associates project files, databases & library

It is recommended that site specific buffer distances be determined once vibration emission levels are measured from each plant item prior to the commencement of their regular use on

site. Where construction activity occurs in close proximity to sensitive receivers, minimum buffer distances to affected receivers shall be determined by site measurements and maintained in order to comply with relevant vibration limits.

6.6.6 Vibration Management Measures

In addition to the vibration buffer distances presented, the following vibration management measures are provided to minimise vibration impact from construction activities to the nearest affected receivers and to meet the relevant human comfort vibration and structural damage limits:

1. A management procedure shall be implemented to deal with vibration complaints. Each complaint shall be investigated and where vibration levels are established as exceeding the set limits, appropriate amelioration measures shall be put in place to mitigate future occurrences.

2. Where vibration is found to be excessive, management measures shall be implemented to ensure vibration compliance is achieved. Management measures may include modification of construction methods such as using smaller equipment, establishment of safe buffer zones as mentioned above, and if necessary, time restrictions for the most excessive vibration activities. Time restrictions are to be negotiated with affected receivers.

3. Where construction activity occurs in close proximity to sensitive receivers, vibration testing of actual equipment on site will be carried out prior to their commencement of site operation to determine acceptable buffer distances to the nearest affected receiver locations.

Furthermore, the following general construction vibration management measures are provided.

Table 36 – General Construction Vibration Management Measures

Source controls	
Time constraints	Limit work to daylight hours. Consider implementing respite periods with low vibration-producing construction activities.
Scheduling	Perform work with high vibrations during less sensitive time periods.
Equipment restrictions	Select low-vibration plant and equipment.
Substitute methods	Use less vibration emitting construction methods where possible. For example, when piling is required, bored piles rather than impact-driven piles will minimise vibration impacts. Similarly, diaphragm wall construction techniques, in lieu of sheet piling, will have significant vibration reduction benefits.
Limit equipment on site	Only have necessary equipment on site.
Site access	Vehicle movements outside construction hours, including loading and unloading operations, shall be minimised and avoided where possible.
Reduced equipment power	Use only necessary size and power.

Path controls	
Safe buffer distance	Determine safe buffer distances through vibration measurements prior to the commencement of use of equipment expected to produce high vibration levels.
Receptor controls	
Structural surveys and vibration monitoring	Pre-construction surveys of the structural integrity of vibration sensitive buildings may be warranted. At locations where there are high-risk receptors, vibration monitoring shall be conducted during the activities causing vibration.
Temporary relocation	In extreme cases.
Consultation	Community consultation, information, participation and complaint responses are essential aspects of all construction vibration management programs. They typically involve: - A community information program before construction and/or high risk activities are commenced. This usually involves a leaflet distribution and direct discussions and negotiations with affected residents, explaining the type, time and duration of expected vibration emissions. - The involvement of affected residents in the development of acceptable vibration 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.
Vibration Monitoring	Vibration compliance monitoring for all major equipment and activities within close proximity to sensitive receivers shall be undertaken.

6.6.7 Construction Traffic Management

Although construction traffic noise levels can not be predicted since we do not know the routes to be travelled, the number of vehicles or times, the following management measures should be implemented where reasonable and feasible:

- Traffic routes for construction vehicles should avoid local residential streets wherever possible and instead utilise main roads or routes through industrial or commercial areas.
- Provide ample space on site for vehicles so that they do not queue outside residences.
- Control the traffic coming on to the site to ensure that where possible, construction traffic is not active prior to 7am and is distributed evenly throughout the day.
- Maintaining road pavements to ensure that large surface irregularities do not develop over time and accentuate heavy vehicle noise emissions.
- Install clearly marked sign-posts encouraging drivers to drive more responsibly (eg. ‘Please Drive Quietly’, ‘No Engine / Exhaust Brake Zone’ etc).

- Minimise construction traffic at night where out of hours works are to occur.

6.7 Construction Impacts and Mitigation Measures Summary

Table 37 summarises the construction noise and vibration impacts at the five sites within the project approval areas. The final level of compliance assumes a 10dB noise reduction is 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 neighbours. These are described as "standard mitigation measures" in the table.

The final level of compliance also assumes that the construction phase will be completed prior to any proposed adjoining residential land uses being developed and/or completed.

Table 37 – Construction Impacts and Mitigation Summary

Infrastructure Site	Proposed Works	Predicted Impacts	Recommended Mitigation Measures	Anticipated Level of Compliance with Mitigation
Tallawarra WWPS (Figure 2)	Construct new pumping station	No noise or vibration impacts at residences or industrial receivers.	None required	Compliance at all receivers for noise and vibration
WWPS 1007 (Figure 8)	Augment existing pumping station	12–16dBA excedance of noise goals at nearest residences. Two rural residences and many residences within developed Horsely residential area potentially affected. No vibration impacts expected.	Standard noise mitigation measures	Noise compliance during most activities. 2 – 6dB exceedance possible in worst case. Vibration compliance at all receivers.
WWPS 0500 (Figure 9)	Augment existing pumping station	Existing residential boundaries within 50m. 23-27dBA exceedance possible and many residences in Koona St potentially affected. No vibration impacts expected.	Standard mitigation measures plus all other reasonable and feasible measures	Some residual noise impacts possible due to close proximity of residences. Vibration compliance at all receivers.
Avondale Reservoir (Figure 14)	Construct new reservoir	Existing residential boundaries within 50m. and low background noise in rural area. 34-38dBA exceedance possible. Five residences potentially affected. No vibration impacts expected.	Standard mitigation measures plus all other reasonable and feasible measures. Inform/notify residents prior to commencement of works	Some residual noise impacts possible due to close proximity of residences and low background noise. Vibration compliance at all receivers.

Infrastructure Site	Proposed Works	Predicted Impacts	Recommended Mitigation Measures	Anticipated Level of Compliance with Mitigation
Wongawilli Reservoir (Figure 17)	Minor works	Existing residential boundaries within 20m. and low background noise in rural area. 38-42dBA exceedance possible. Sixteen residences potentially affected. No vibration impacts expected as footings of residences not within 30m	Standard mitigation measures plus all other reasonable and feasible measures. Inform/notify residents prior to commencement of works	Some residual noise impacts possible due to close proximity of residences and low background noise. Vibration compliance at all receivers.
Project Approval Pipelines	Construct pipelines	Residences within approx. 25m of the pipeline may be 'highly noise affected and residences within 100m may be 'noise affected' Residences within 500m of the pipeline may be affected by out of hours works. Vibration impacts possible for residences within 30m of pipeline	Employ all reasonable and feasible mitigation measures. Conduct Community information/notification for out of hours works.	Some residual impacts possible due to close proximity of residences and low background noise. Vibration compliance with appropriate buffer distances.
All Project Approval sites	Construction traffic	Noise impacts not quantifiable at this stage but possible. No vibration impacts expected.	Use main roads and avoid local streets. Do not queue outside residences prior to 7am	Noise compliance achievable with mitigation. Vibration compliance at all receivers.

7 CONCLUSION

Renzo Tonin & Associates have completed an investigation of environmental noise and vibration impacts from infrastructure associated with the water related services proposed by Sydney Water for the West Dapto Urban Release Area and Associated Growth Areas. Noise and vibration impacts from the infrastructure sites to the nearest affected receivers during both the construction and the operational phases have been quantified and compared to the appropriate noise and vibration guidelines.

The Project Approval sites have been assessed individually with specific noise and vibration mitigation and management measures provided for each site. The mitigation and management measures provided in this report also apply generally to the Concept Approval sites.

The findings of this study are:

Operational Noise

- Noise emissions from new pumping stations may potentially exceed the most stringent night time noise criteria where residences are within approximately 25m of an unmitigated mechanical noise source and if there is no shielding from boundary fences or other site buildings.
- As long as pumps and mechanical equipment are housed in masonry buildings that are typical of Sydney Water sites, along with any required screens, enclosures and acoustic louvers in ventilation openings, no adverse noise impacts are expected.
- No significant operational noise will be generated by new reservoirs.
- No significant operational noise will be generated by new pipelines.
- The potential operational impacts and required mitigation measures for those sites that are within the project approval areas have been summarised in Table 18.

Operational Vibration

- While some vibration emissions were measurable up close to equipment at existing Sydney Water sites, no adverse vibration impacts are expected even at the closest future residential premises (existing or proposed).

Construction Noise

- Construction noise impacts at receivers surrounding the new or augmented pumping stations are likely, particularly those receivers within 500m of the sites and with clear

line of site to the construction activities. Reasonable and feasible noise mitigation and management measures have been recommended to minimise these impacts.

- During pipeline construction, the loudest equipment such as the rock breaker, concrete saw and chainsaw may exceed the 'highly noise affected' level of 75dB(A) within approximately 25m of construction activity. The remainder of the construction equipment may cause some noise impacts however will generally not cause residents to be 'highly noise affected'. Any residence within approximately 100m of the pipeline construction activity and with clear line of site may experience some adverse noise impacts, although these impacts will be short term due to the transitory nature of the works. Reasonable and feasible noise mitigation and management measures have been recommended to minimise these impacts.
- The potential construction impacts and required mitigation measures for those sites that are within the project approval areas have been summarised in Table 37.

Construction Vibration

- For residences within 10 to 30 metres of the proposed construction activity, human annoyance as a result of vibration from the use of rock breakers, compactors and vibratory rollers is possible, although structural damage is unlikely.
- People in residential premises within 30 metres of construction works are unlikely to notice vibrations.
- Reasonable and feasible construction vibration mitigation and management measures, including indicative safe working distances, have been provided to minimise the impact of construction vibration.

APPENDIX A PROPOSED LOCATIONS OF NEW PUMPING STATIONS

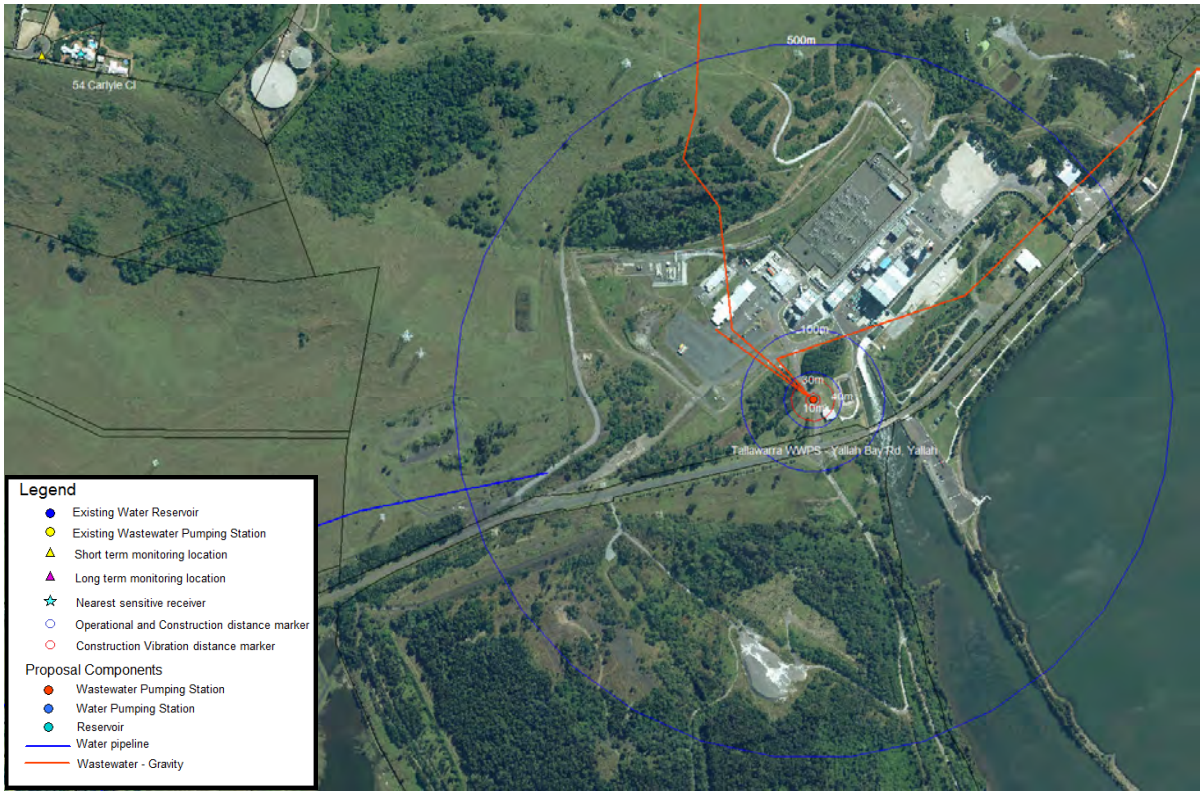

Figure 2 - Tallawarra WWPS

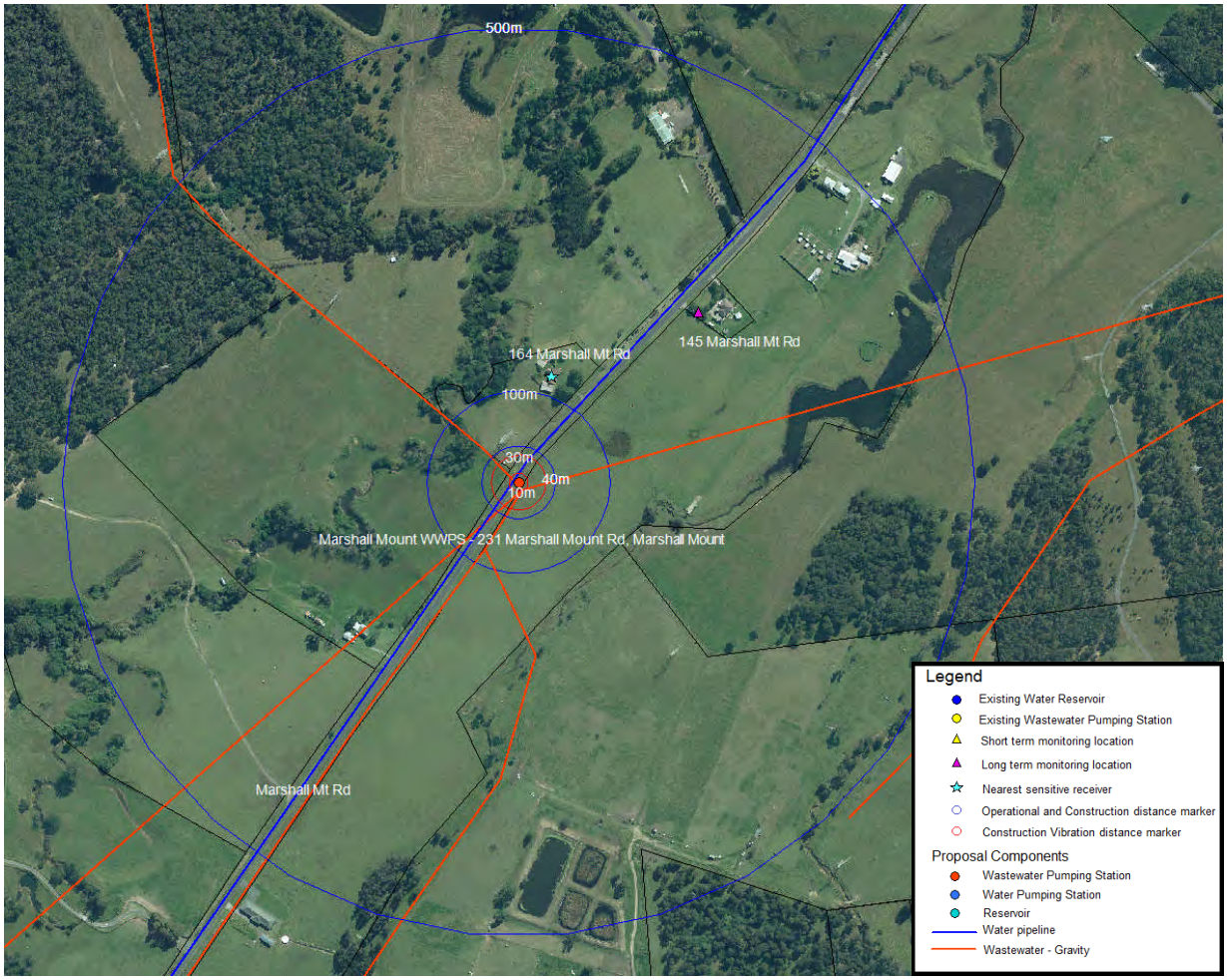

Figure 3 - Marshall Mount WWPS

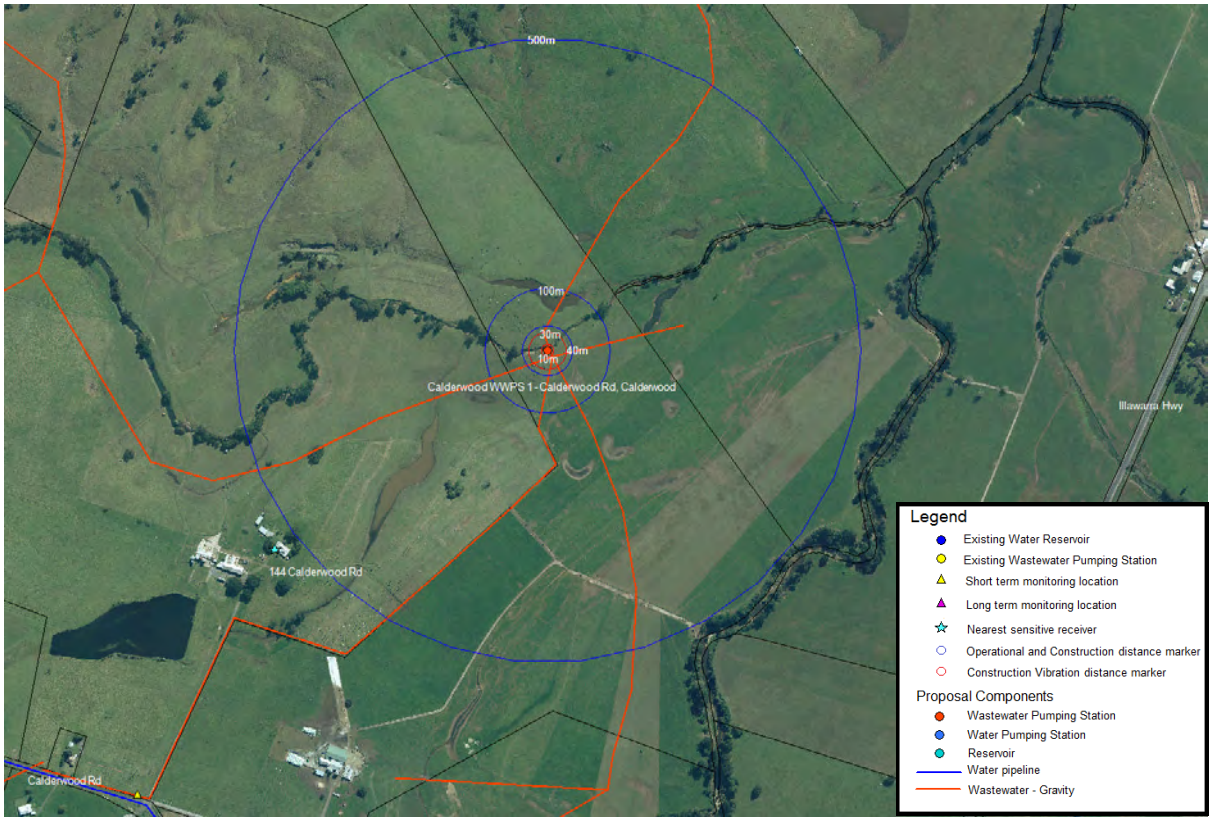

Figure 4 - Calderwood WWPS1

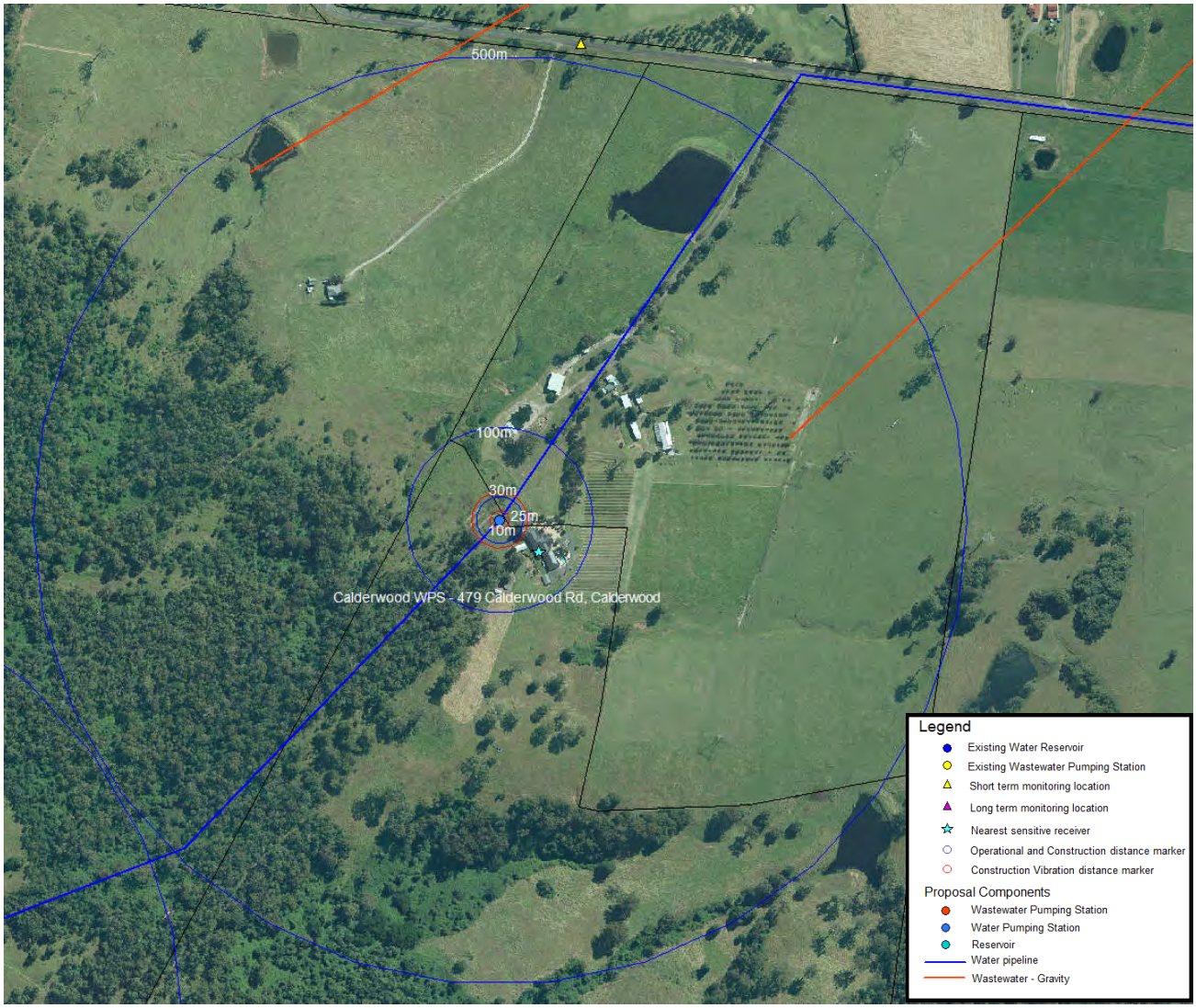

Figure 5 – Calderwood WPS

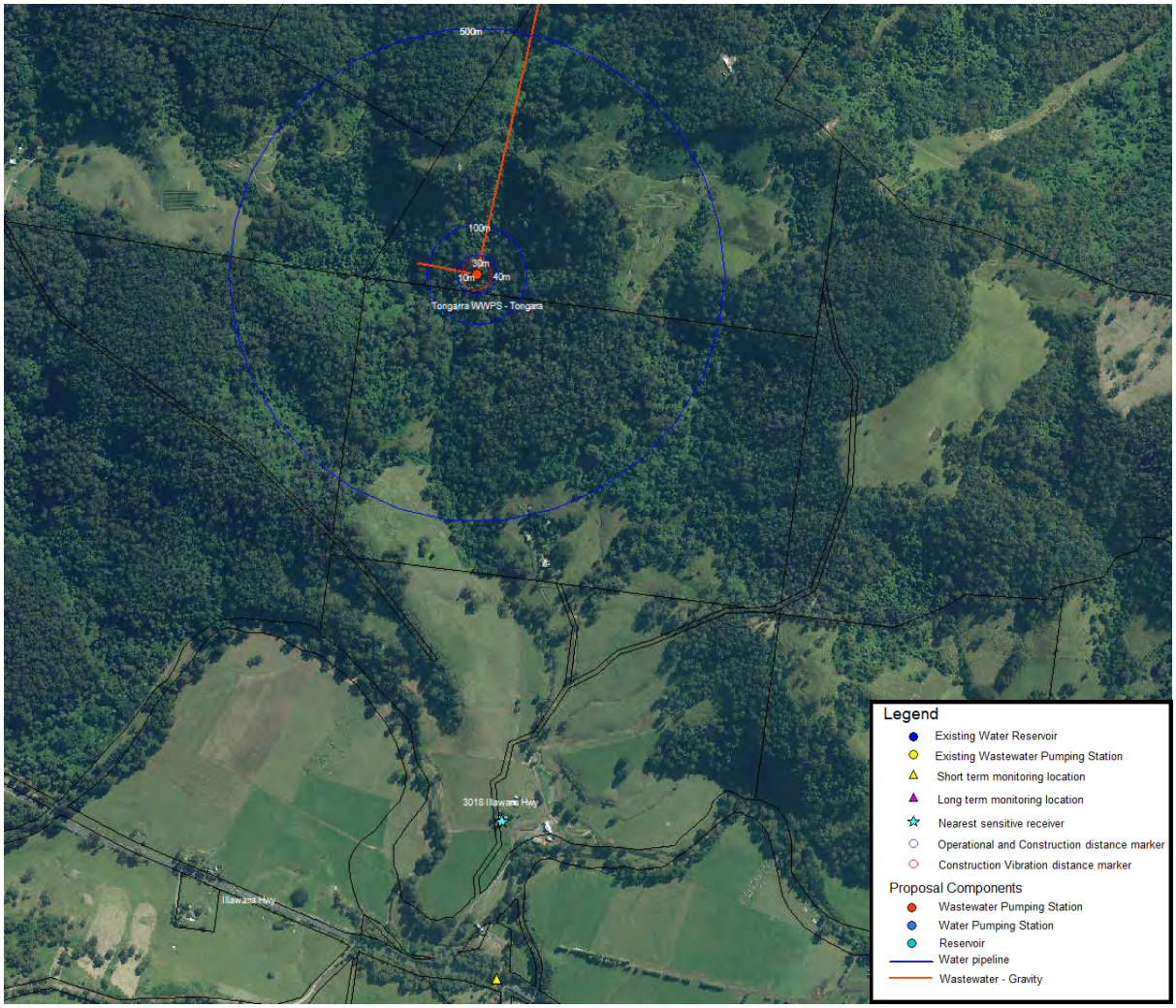

Figure 6 - Tongarra WWPS

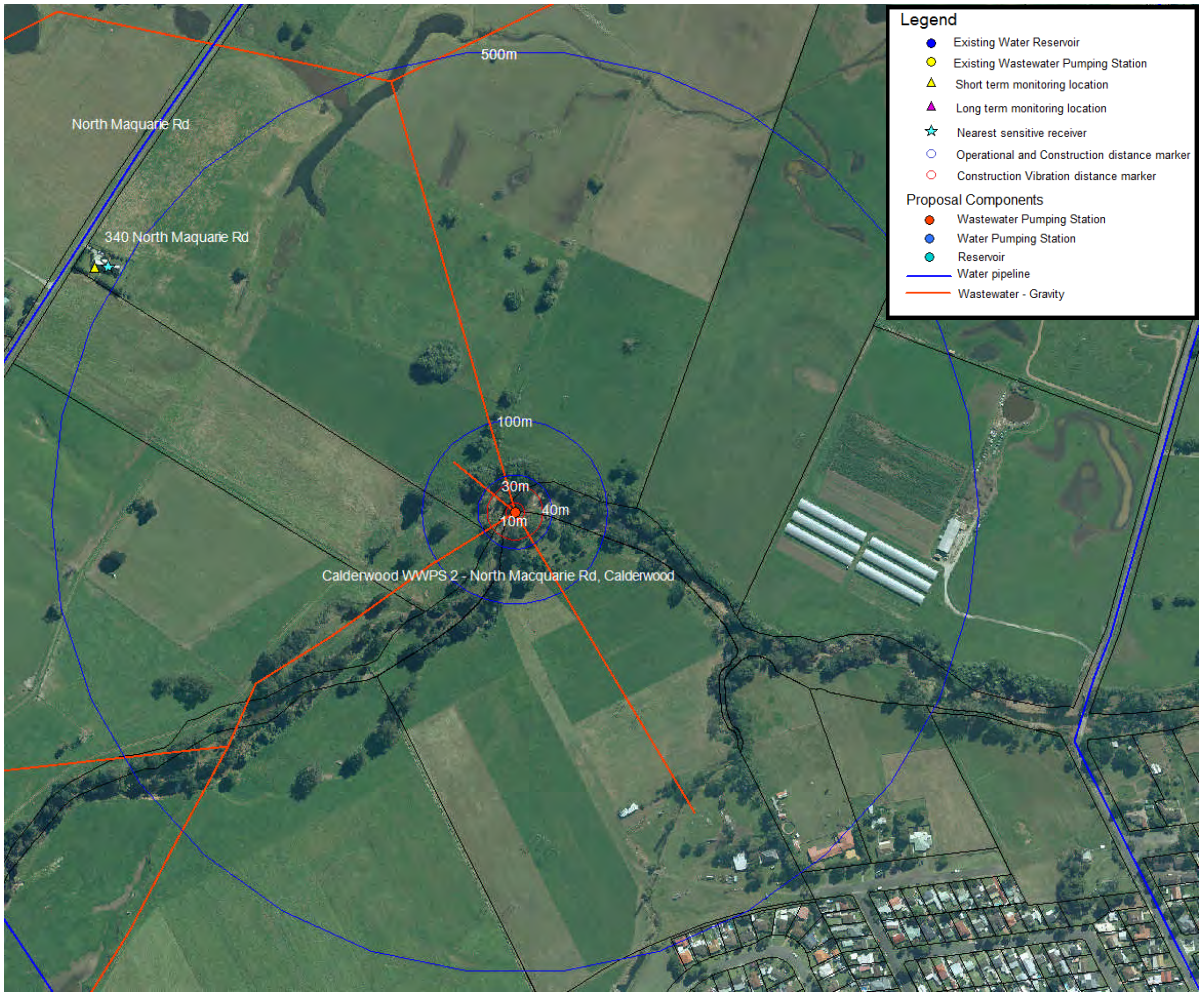

Figure 7 - Calderwood WWPS2

APPENDIX B LOCATIONS OF POTENTIALLY AUGMENTED PUMPING STATIONS

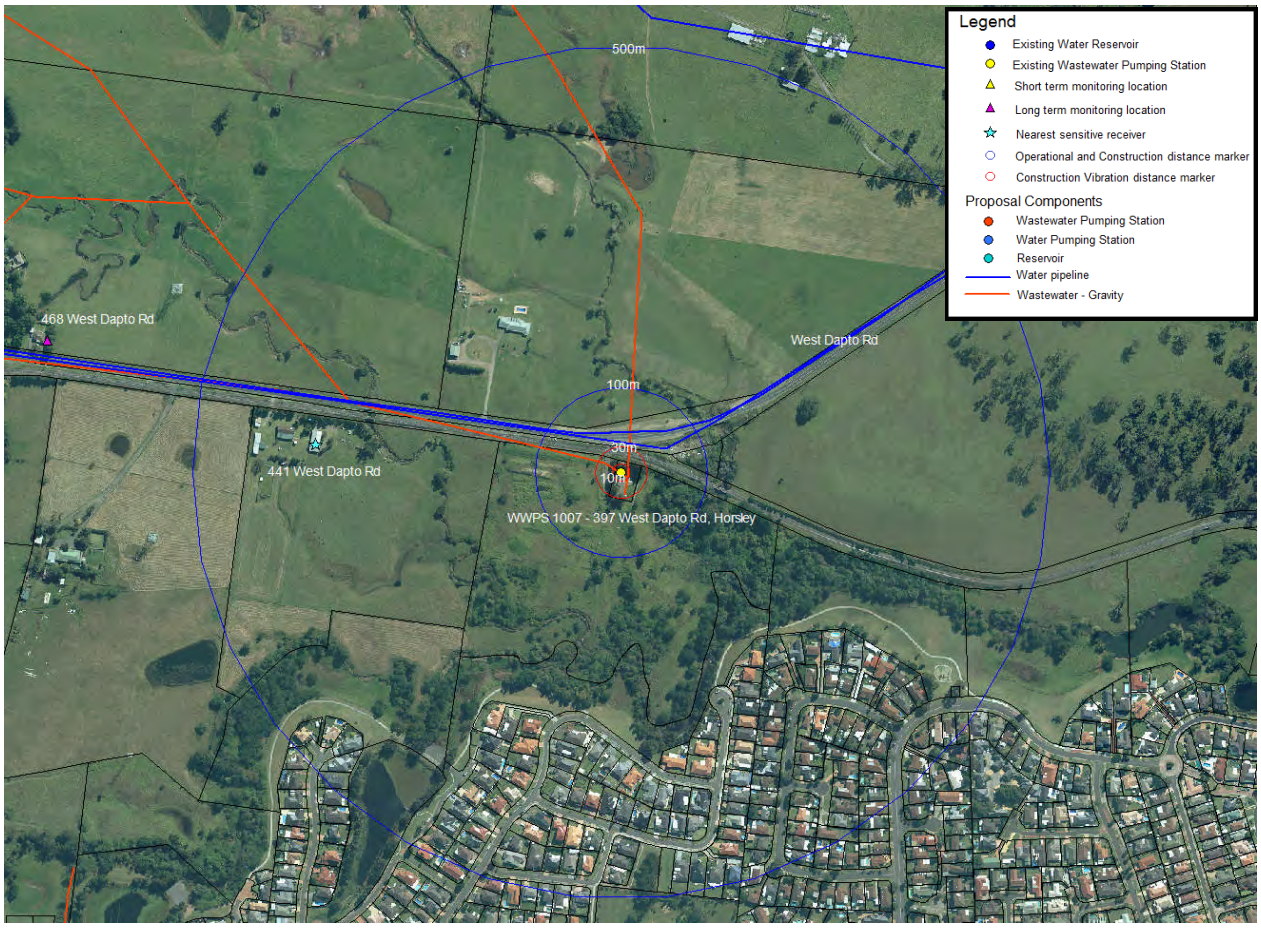

Figure 8 – WWPS 1007

Figure 9 – WWPS 0500

Figure 10 – WWPS 0296

Figure 11 – WWPS 0505

Figure 12 – WWPS 0345