Wellington Water Ltd

EASTERN HILLS RESERVOIR

CONSTRUCTION NOISE AND VIBRATION IMPACT ASSESSMENT

28 FEBRUARY 2024

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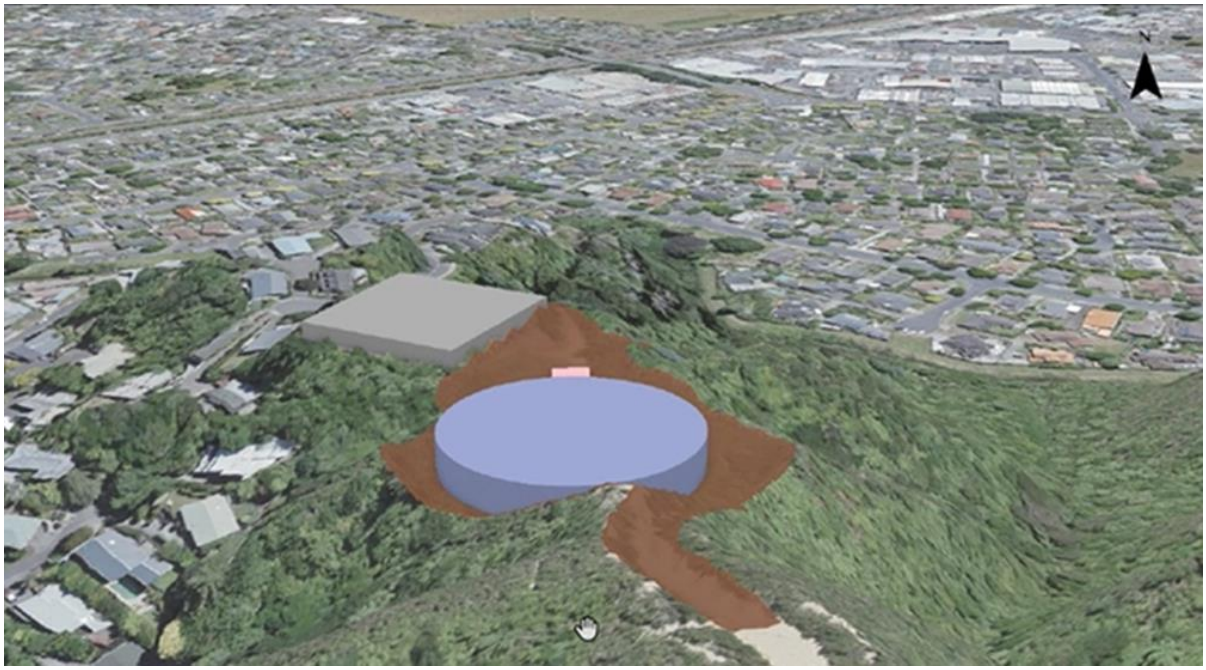

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CONSTRUCTION NOISE AND VIBRATION IMPACT ASSESSMENT

Wellington Water Ltd

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1	13/07/2023	For external legal review
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	NAME	DATE	SIGNATURE
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TABLE OF CONTENTS

EXECUTIVE SUMMARY

Wellington Water Ltd have engaged WSP to provide a Construction Noise and Vibration Impact Assessment for the proposed Eastern Hills Reservoir, located at the top of Summit Road, Fairfield, in Lower Hutt.

The project includes the construction of a 55.2m diameter above ground concrete reservoir, and new inlet, overflow and delivery pipes. This report covers the noise and vibration emissions from construction activities relating to all stages of construction.

Noise Sensitive Receptors (NSR) surrounding the proposed construction works include dwellings at Summit Road, Farrelly Grove, Tilbury Street, Balgownie Grove and Waddington Drive.

The typical construction hours are from 0700hrs to 1800hrs Monday to Saturday, with no works occurring on Sundays or Public Holidays. During the construction of the reservoir, construction works are to occur from 0300 hours for concrete activities. During the construction of the pipe over Waiwhetu Stream, dewatering and over-pumping will be required 24-hours a day.

Noise and vibration emissions have been predicted and assessed based on the draft construction methodology. For the purposes of this assessment, the project work has been broken into five stages. To assess the noise effects of the project, a total of five 'Situations' have been modelled, each associated with one or more stages of work taking place across the Site.

The following executive summary table presents the construction activities that are assessed for each situation, and the predicted acoustic impact at NSR.

Executive Summary Table: Predicted acoustic impact for modelled situations

SITUATION	DESCRIPTION OF CONSTRUCTION ACTIVITIES	PREDICTED ACOUSTIC IMPACT
A	Stage 1: Site Establishment	Acceptable
B	Stage 2: Earthworks for Reservoir	Acceptable
C	Stage 3: Pipeline Construction – with piling activities Stage 4: Reservoir / Valvehouse Construction – with piling activities	Reasonable to Obvious
D	Stage 3: Pipeline Construction – no piling activities Stage 4: Reservoir / Valvehouse Construction – no piling activities	Reasonable
D-2	Stage 3: Pipeline Construction – Night works	Acceptable to Reasonable
E	Stage 4: Reservoir Construction – night-time concrete pouring	Obvious
Site Access Road	Operation of site access roads during typical daytime and worst-case night-time periods	Daytime: Reasonable to Obvious Night-time: Obvious to Unreasonable

Noise levels will be compliant with the acoustic criteria during Situation A and B works. Non-compliances have been indicated during Situations C, D and E. An assessment has also been undertaken regarding the significance of the effects particularly from non-compliances. It is considered that the overall noise and impact ranges from a reasonable to obvious effect of noise.

Additionally, an assessment of noise from site access roads has been undertaken, although this is not expressly required by the Hutt City District Plan (HCDP). It is considered that the overall noise and impact ranges from reasonable to obvious during the daytime, and obvious to unreasonable during the night-time.

Several adoptable managerial mitigation measures are recommended to reduce the risk of adverse noise affects during Situations C, D and E. It is recommended that site hoardings are installed around the perimeter of the site, localised acoustic barriers are used around over-pumping and dewatering pumps and piling attachments.

Regarding noise impact and sleep disturbance, it is noted that some NSRs will be more sensitive than others, the local community should be well informed regarding the proposed night works and appropriate managerial mitigation measures adopted as far as practicable.

Overall, the assessment indicates that predicted noise levels fall above the acoustic criteria but due to timing, assessment location, hours of operation, and application of best practicable means of mitigation, the level of noise impact on the receiver is not unreasonable.

All NSRs are located beyond the vibration 'standoff distances' which cosmetic building damage may occur. Considering the selection, location, and duration of operation of the equipment that is set out in this assessment, it is considered that this vibration criteria will be achieved. However, it is noted that some NSRs may lie within the vibration set-back distance for human annoyance. These NSRs should be notified of vibratory construction works.

A Construction Noise and Vibration Management Plan (CNVMP) shall be adopted by the contractor to outline the mandatory mitigation measures indicated in this assessment. The CNVMP itself shall act as a mitigation measure to ensure construction noise and vibration is controlled via appropriate physical and managerial methods.

1 INTRODUCTION

1.1 GENERAL

Wellington Water Ltd (WWL) have engaged WSP to provide a Construction Noise and Vibration Impact Assessment (CNVIA) for the proposed Eastern Hills Reservoir, herein referred to as the Proposed Reservoir.

The Proposed Reservoir is located adjacent to the existing Naenae Reservoir at the top of Summit Road, Fairfield, in Lower Hutt.

The assessment is based on coordination with the design team, and the documents outlined in Table 1.1.

Table 1.1: Documents used to inform the assessment

DOCUMENT DESCRIPTION	DATE ISSUED
EHR-Consent-W011 - Site Plan, drawing no. "3-WW02102_W011"	29/05/2023
EHR-Consent-W010 - Earthworks Plan, drawing no. "3-WW02102_W010"	29/05/2023
HEB Construction Methodology Eastern Hills - Contractor methodology	15/05/2023
Eastern Hills Reservoir - Construction Methodology DRAFT	31/05/2023
Eastern Hills Reservoir Construction Programme – Programme	07/06/2023

This report is necessarily technical in nature and therefore to assist the reader, a glossary of terminology is included in Appendix A.

1.2 PURPOSE OF ASSESSMENT

This report has been prepared to support the resource consent application and the notice of requirement application for the Proposed Reservoir, providing an assessment in relation to the construction noise and vibration over the full construction programme of anticipated works.

This construction noise and vibration assessment identifies likely noise and vibration impacts generated by the project construction works, as well as recommendations for mitigation measures that can be implemented to minimise adverse effects. Additionally, an assessment of the potential noise effects of construction traffic on local roads in proximity to the site has been included, despite the Hutt City District Plan not expressly requiring noise on roads to be assessed.

2 PROJECT BACKGROUND

2.1 SITE LOCATION AND PROJECT DESCRIPTION

The Eastern Hills (previously Naenae 2) Reservoir will be a circular 15 ML above ground concrete reservoir, with a 55.2 m external diameter and a height of 8.35 m. It will be located adjacent to the existing Naenae 1 Reservoir at the top of Summit Road, Fairfield, Lower Hutt.

The Proposed Reservoir will be constructed at the same bottom water level (BWL) and top water level (TWL) elevation as the existing reservoir and will require earthwork volumes of approximately 85,000 m^3 (in-ground volume), with erosion and sediment control measures required during construction.

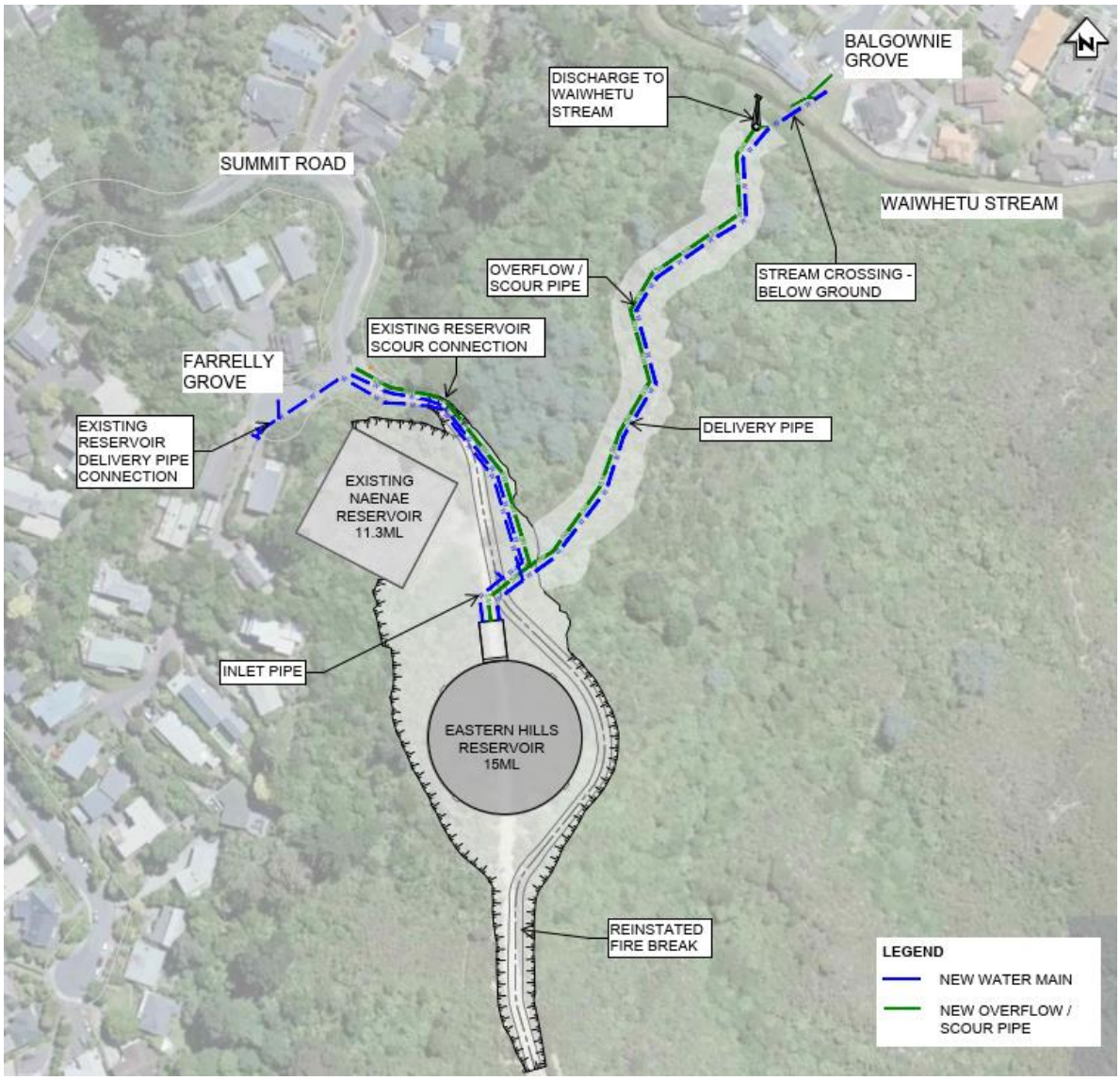


Figure 2.1: Eastern Hills Reservoir Site Plan

A new inlet pipe supplying water to the Proposed Reservoir will be constructed via a connection with the existing Naenae reservoir inlet pipe. This new connection is located at the intersection of

Summit Road and Farrelly Grove with the proposed alignment then running along the current vehicle access to the Proposed Reservoir. Both reservoirs will be supplied via the same existing bulk main from the Waterloo water treatment plant.

A new 750 mm diameter delivery pipe supplying the potable water network will run from the Proposed Reservoir down the hill to the north, across Waiwhetu Stream and into the potable water network along local roads. The new Waiwhetu Stream pipe crossing will be below ground. A new 525 mm diameter pipe will connect the existing Naenae 1 outlet to this new delivery pipe as shown in Figure 2.1.

An overflow/scour pipe from the Proposed Reservoir will be constructed adjacent to the delivery pipe down the hill, before discharging into the Waiwhetu Stream near Balgownie Grove. The purpose of the pipe is for emergency discharges or when the reservoir needs to be drained for maintenance or inspections. The pipe will discharge via scour protection, such as rip-rap or baffles, directly to Waiwhetu Stream. In addition, the existing reservoir overflow pipe will be constructed to tie-in to the Proposed Reservoir overflow pipe as shown in Figure 2.1.

2.2 CONSTRUCTION PROGRAMME

Construction works are anticipated to occur over a 30-month period commencing July 2024 and ending December 2026.

2.2.1 CONSTRUCTION STAGES

Table 2.1 indicates an overview of construction stages for the Proposed Reservoir and the expected duration of each stage, based on the latest construction programme.

Table 2.1: Construction stages overview and anticipated duration

CONSTRUCTION STAGE DESCRIPTION			EXPECTED DURATION
1	Site establishment		1-2 months
2	Earthworks for reservoir		9-10 months
3 a	Pipeline construction	Enabling works	1 month
3 b		Installation and connection	6-7 months
3 c		Stream pipe crossing and outfall	1–2 months
4 a	Reservoir and valve house construction	Piling works	Where necessary
4 b		Structural & concrete works	8-9 months
4 c		Valve house construction	2-4 months
5	Landscape and reinstatement		1-2 months

It is noted that some construction stages may overlap with others in the construction programme, therefore contributing to cumulative noise and vibration levels across different areas during the construction of the Proposed Reservoir.

The assessment considers a selection of Situations across the course of the construction programme, this includes the assessment of concurrent activities and as such considers cumulative noise levels.

2.2.2 TYPICAL CONSTRUCTION HOURS

Typical construction hours for the Proposed Reservoir are provided in Table 2.2.

Table 2.2: Typical Construction Hours

DAY OF THE WEEK	TYPICAL SITE HOURS
Monday to Friday	0700hrs to 1800hrs *
Saturday	0700hrs to 1800hrs *
Sunday and Public Holidays	No work

* Noise activities restricted before 0730hrs

2.2.3 NIGHT-TIME WORKS

Construction works are proposed on four nights during Stage 4 Reservoir Construction, during the concrete pouring and post-tensioning process; two consecutive nights are required for the reservoir slab works, and two consecutive nights for the roof topping slab.

Night works are understood to begin at approximately 0300 hours on the nights of construction.

A description of specific activities being undertaken for these works are provided in Section 5.1.1.

3 EXISTING ENVIRONMENT

3.1 NOISE SENSITIVE RECEPTORS

The Proposed Reservoir is in a distinctive topographical position, elevated above a suburban area, with residential dwellings to the west and north near the Proposed Reservoir boundary.

A shrubland area used for recreation is located to the south and east of the Proposed Reservoir.

Figure 3.1 presents the Proposed Reservoir in relation to its nearest Noise Sensitive Receptors (NSRs) and road network, located at Waddington Drive, Balgownie Grove, Summit Road, Farrelly Grove, and Tilbury Street.

Figure 3.1: NSR areas and surrounding road network to Proposed Reservoir

3.2 BASELINE NOISE CONDITIONS

A desktop assessment has been undertaken to estimate baseline noise levels in proximity to the Proposed Reservoir. Baseline noise predictions have been made based on the available road traffic data[1].

Traffic noise calculations have been undertaken using the Calculation of Road Traffic Noise (CoRTN)[2] algorithm, modified for New Zealand Conditions, and assessed in accordance with Chart 2 and 4 of CoRTN, to establish an hourly basic noise level at 10m distance from the road.

Table 3.1 indicates the parameters used for the calculation and the predicted sound pressure level in terms of $L_{Aeq,24hr}$

Table 3.1: Baseline traffic noise level prediction on surrounding roads

ROAD	AVERAGE DAILY TRAFFIC (ADT)	SPEED (KPH)	HEAVY COMMERCIAL VEHICLES	APPROXIMATE SOUND PRESSURE LEVEL @ 10M, dB $L_{AEQ,24HR}$
Summit Road	200	50	3%	50
Tilbury Street	1700	50	3%	59
Waddington Drive	2500	50	4%	61
Balgownie Grove	< 20	20	0%	< 50

Sound pressure levels from road traffic noise ranges from 50 to 61 dB $L_{Aeq,24hr}$ along the principal surrounding roads to the Proposed Reservoir, noting that the ADT flows at Summit Road and Balgownie Grove fall outside of the allowable range defined within the CoRTN methodology, hence providing a low confidence in the predicted existing levels on these roads.

Therefore, undertaking noise monitoring at the site would provide greater confidence in quantifying the existing ambient noise levels in the area.

1 Traffic data available from mobileroad.org and Construction Transport Assessment

2 Department of Transport Welsh Office, Calculation of Road Traffic Noise, 1988

4 STATUTORY PLANNING FRAMEWORK AND ASSESSMENT CRITERIA

4.1 HUTT CITY ZONING PROVISIONS

Under the Hutt City District Plan (HCDP) part of the site is zoned as 'Residential' and part of it as 'Passive Recreation'.

Figure 4.1 illustrates the HCDP zoning overlay and approximate reservoir and pipe alignment for the Proposed Reservoir.

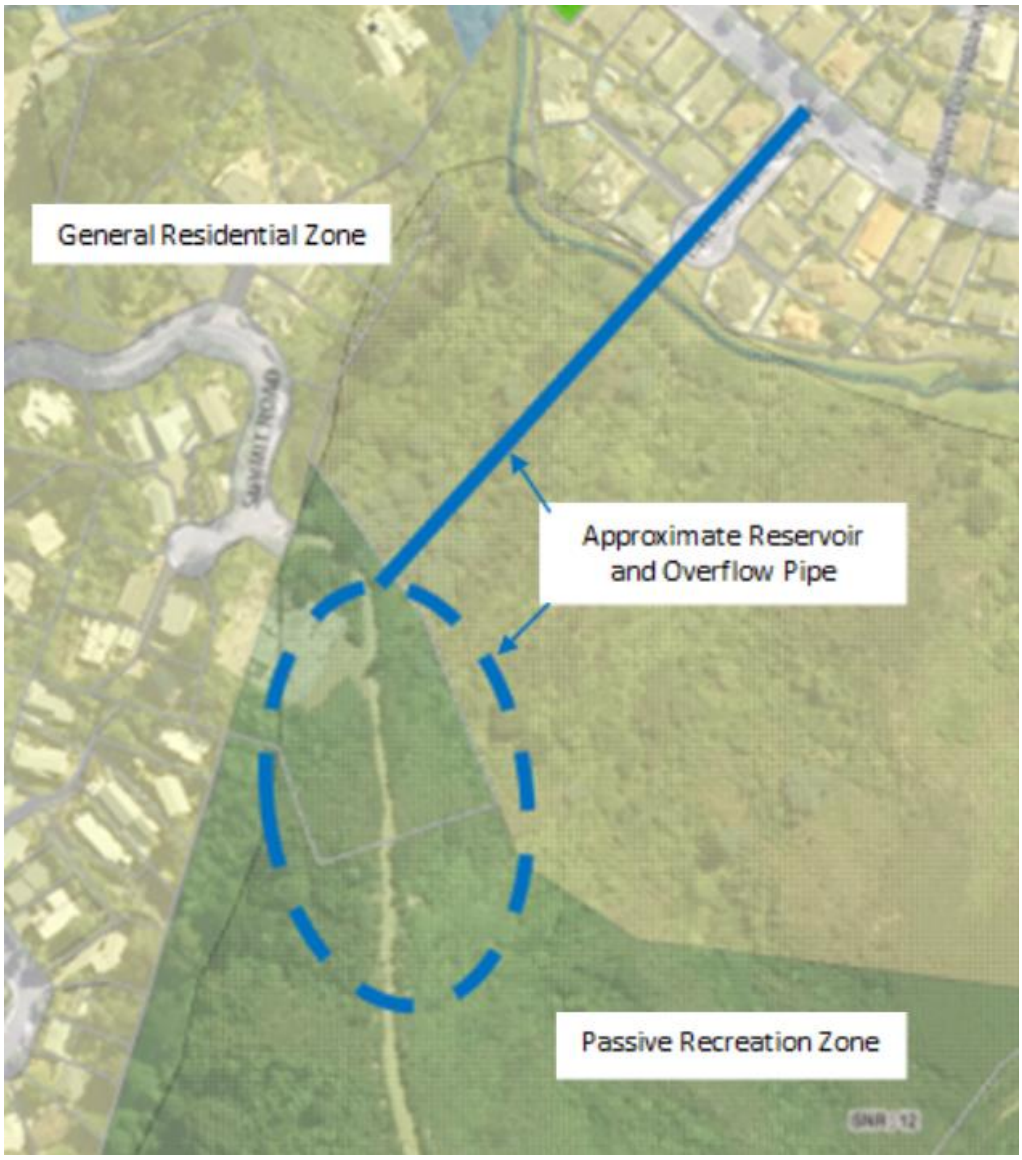


Figure 4.1: Hutt City District Plan Zoning

4.2 RELEVANT OBJECTIVES, POLICIES AND STANDARDS

4.2.1 CONSTRUCTION NOISE CRITERIA

The following construction noise criteria apply to the Proposed Reservoir.

HUTT CITY DISTRICT PLAN (HCDP)

Chapter 14C of the HCDP relates to Noise. Clause 14C 1.1 states the objective is:

> *"To maintain or enhance the amenity value of all activity areas by ensuring that the adverse effects of excessive noise on the environment are avoided or mitigated."*

The relevant HCDP policies intended to achieve this objective are reproduced below:

a) To recognise that background noise levels are markedly different throughout the City.

b) To recognise that acceptable noise levels will vary according to the nature of the principal activities occurring within activity areas.

c) To ensure that residential activity areas are protected by establishing appropriate noise levels at the interface between residential activity areas and non-residential activity areas.

d) That maximum noise levels are established within each activity area to ensure that amenity values are protected.

e) To make provision for those situations where there has already been considerable history to the establishment of specified noise conditions.

f) To recognise that noise levels may be different through a construction phase.

g) To recognise that Noise Management Plans may be appropriate to manage matters beyond those addressed in this District Plan.

To meet the policy requirements, construction noise criteria apply at the site receiving the noise from construction activities. The following noise standards in the HCDP apply:

Rule 14C 2.1 Permitted Activity – Conditions

In All Activity Areas

(f) All construction, demolition, and maintenance work shall comply with NZS 6803 "Measurement and Assessment of Noise from Construction, Maintenance and Demolition Work".

It is noted that the term excessive noise is defined under the Resource Management Act (RMA) which is reproduced below.

RESOURCE MANAGEMENT ACT 1991

The relevant section(s) of the Resource Management Act 1991 (RMA) is Section 16 "Duty to avoid unreasonable noise" and Section 326 which sets out the definition of excessive noise, are summarised below.

Section 16 of the RMA stipulates that any occupier or land or persons or carrying out activities shall adopt the best practicable option to ensure that the emission of noise from that land does not exceed a reasonable level.

Section 326 of the RMA defines the term **excessive noise**, meaning:

> *"any noise that is under human control and of such a nature as to unreasonably interfere with the peace, comfort and convenience of any person (other than a person in or at the place from which the noise is being emitted), but does not include any noise emitted by any –*
>
> *a) Aircraft being operated during, or immediately before or after, flight; or*
>
> *b) Vehicle being driven on a road (within the meaning of section 2(1) of the Land Transport Act 1998); or*
>
> *c) Train, other than when being tested (when stationary), maintained, loaded or unloaded"*

NEW ZEALAND CONSTRUCTION NOISE STANDARD NZS 6803:1999

Table 2 of NZS 6803:1999 *Acoustics – Construction Noise* (NZS 6803) outlines the recommended upper limits for construction noise received in residential zones.

The construction programme is expected to exceed 20 weeks, and as such the long-term noise standards in NZS 6803 apply.

Table 4.1 presents the stated noise limits for the specific site operational hours. These limits apply when measured 1m from the façade of the noise sensitive building.

Table 4.1: Upper limits for construction noise received in residential zones.

TIME OF WEEK	TIME PERIOD	MAXIMUM NOISE LEVEL (dBA)	
		$L_{eq,T}$	L_{max}
Weekdays	6:30am – 7:30am	55	75
	7:30am – 6:00pm	70	85
	6:00pm – 8:00pm	65	80
	8:00pm – 6:30am	45	75
Saturdays	6:30am – 7:30am	45	75
	7:30am – 6:00pm	70	85
	6:00pm – 8:00pm	45	75
	8:00pm – 6:30am	45	75

The noise limits in Table 4.1 apply at the NSRs identified in Figure 3.1. An assessment period of 1 -hour has been applied, assuming the likely operation of equipment within a reasonable worst-case 1-hour period.

4.2.2 CONSTRUCTION VIBRATION CRITERIA

The HCDP does not state or reference vibration criteria with respect to construction. However, it is possible that vibration may cause adverse effects.

Guideline values for construction vibration criteria have been proposed in accordance with DIN 4150-3:2016-12 *Vibration in buildings – Part 3: Effects on structures* (DIN 4150-3) from the German Institute for Standardisation, and BS 5228-2:2009+A1:2014 *Code of practice for noise and vibration control on construction and open sites - Part 2: Vibration* (BS 5228-2) from the British Standards Institute. These standards are widely used in New Zealand to assess vibration effects relating to cosmetic building damage and perceived vibration effects for humans.

DIN 4150-3:2016

DIN 4150-3 relates to preventing cosmetic damage to buildings (such as cracking in paint). This is stated as 'minor damage' in DIN 4150, which generally means it can easily be repaired. It is noted that cosmetic building damage thresholds are much lower than vibration levels that would result in structural damage.

Table 4.2 presents the relevant vibration limits outlined in Table 4 of DIN 4150-3. These limits are appropriate for a higher threshold value for adverse effects due to vibratory construction activities.

Table 4.2: DIN 4150-3 construction vibration limits

TYPE OF STRUCTURE	GUIDELINE VALUES FOR VIBRATION IN HORIZONTAL PLANE OF HIGHEST FLOOR, AT ALL FREQUENCIES (mm/s)
Residential buildings and buildings of similar design and/or occupancy	5

BS 5228-2:2009

BS 5228-2 provides guidance on human perception of vibration. However, we note that human perception and response to vibration varies depending upon the sensitivity of the individual, the tasks being performed, the magnitude, frequency and duration of the vibration, whether the vibration is expected, and whether there is concern that structural damage may occur.

Humans perceive vibration at much lower magnitudes than the levels of vibration that are likely to cause cosmetic building damage. Occupants of buildings are therefore likely to complain about vibration significantly below the levels likely to result in cosmetic damage to buildings.

The guidance values in BS 5228-2 are provided in Table 4.3. These levels are provided as a means of acknowledging that humans perceive vibration well before vibration generated from construction activities would impact the building structure. However, these levels can be used to provide guidance as to at what level certain management measures should be adopted.

Table 4.3: BS 5228 vibration subjective impacts

VIBRATION LEVEL (PPV)	EFFECT
0.3 mm/s	Vibration might be just perceptible in residential environments.
1.0 mm/s	It is likely that vibration of this level in residential environments will cause complaint but can be tolerated if prior warning and explanation has been given to residents.

4.3 NOISE IMPACT TERMINOLOGY

We have used the following terminology when considering the impacts on adjacent properties:

Table 4.4: Noise impact terminology

TERM	DESCRIPTION
Acceptable	The predicted noise or vibration level is at or below the acoustic criteria.
Reasonable	The predicted noise or vibration level is above the acoustic criteria, but due to timing, assessment location, hours of operation, receiver, or other factor the level of noise or vibration impact on the receiver is low.
Obvious	The predicted noise or vibration level is above the acoustic criteria and is likely to have a low or medium impact on adjacent receptors. Noise-sensitive activities are likely to be disturbing. Despite the adverse noise impact, best practicable means of mitigation have been applied to minimise adverse noise effects where possible.
Unreasonable	The noise or vibration level is likely to have a high impact on adjacent receptors. All but the least noise sensitive activities are likely to be disturbed. No mitigation has been applied and the site is not considered to follow a best practicable approach to minimise adverse noise effects where possible.

5 ASSESSMENT METHODOLOGY

This section presents the noise and vibration assessment methodology including:

- A description of specific construction activities, construction equipment and vehicle movements on haul roads per stage.
- A description of the noise and vibration modelling prediction methodology.
- Associated assumptions and limitations.

5.1 CONSTRUCTION STAGE ACTIVITIES AND EQUIPMENT

Table 5.1 outlines the construction activities and equipment for each stage, alongside the peak daily number of heavy commercial vehicles (HCV) associated with that stage of work attending the Proposed Reservoir (noting that there may be some overlap between stages). These activities and vehicle movements are based on construction methodologies provided by prospective contractors.

Table 5.1: Construction activities and equipment per stage

STAGE	ACTIVITIES	EQUIPMENT	HCVS – PEAK DAILY
1	Site establishment • Site clearance • Vegetation removal • Formation of temporary access road • Site setup	• Site office generator • Chainsaws, tree felling and mulching • Excavators moving earth • Truck movements to deliver site facilities and equipment	20
2	Earthworks for reservoir • Excavation and loading out of material	• Excavators moving earth and cutting site to reference level • Truck movements loading and unloading	50
3 a	Pipeline enabling works • Lizard relocation • Vegetation removal	• Chainsaws, tree felling and mulching • Excavators moving earth • Truck movements loading and unloading	5
3 b	Pipeline installation and connection • Lizard rehousing • Trench excavation • Install delivery pipe and overflow pipe • Install cross-connections between Naenae and proposed reservoir	• Hydraulic excavators cutting material • Truck movements, loading and unloading • Compaction rollers • Limited vibratory driving of sheet piles (adjacent to stream) • Concrete trucks and pumps • In-situ concrete placement	50

STAGE	ACTIVITIES	EQUIPMENT	HCVS – PEAK DAILY
		• Pipe laying and backfill compaction	
3 c	Stream pipe crossing and outfall • Install bubble-up chamber, swale with rip rap to stream • Install pipe crossing below Waiwhetu Stream	• Hydraulic excavators cutting material • Truck movements, loading and unloading • Concrete trucks and pumps • Pipe laying and backfill compaction • Trench dewatering pumps	5
4 a	Reservoir piles • Installing soldier piles around the perimeter of the Proposed Reservoir. • In-situ concrete capping beam	• Bored piles • Concrete formwork and in-situ pour.	5
4 b	Reservoir structural & concrete works • Substructure and base slab, walls and columns, beams and roof, waterproofing	• Concrete delivery, pumping and vibrating in pours spread over the period • Pre-cast deliveries • Erection of formwork with hammering • Short term concrete breaking/ roughening tools • Large cranes lifting panels into place	60
4 c	Valve house construction • Stage 1: Construction of base slab, pipes, and anchor blocks • Stage 2: Roof, walls and mechanical fit out	• Concrete delivery, pumping and vibrating in pours spread over the period • Short term concrete breaking/ roughening tools • Compaction Rollers • Pipe laying and backfill compaction. • Truck movements, loading and unloading • Erection of formwork with hammering • Large cranes lifting panels into place	15
5	Landscape and reinstatement • Reconnect access track • Planting and landscaping	• Trucks delivering topsoil and mulch • Excavators spreading topsoil and mulch • Chipseal surfacing of access road. • Planting of trees and shrubs	20

Appendix B provides:

- A list of equipment assumed to be used during construction, the associated sound power of that equipment, and the percentage of time in use over a worst-case 1-hour period.
- The vibration levels for specific high vibration equipment.

The equipment selection and its associated sound power and vibration levels are based on BS 5228-1:2009+A1:2014 *Code of practice for noise and vibration control on construction and open sites* (BS 5228-1), NZS 6803, NZTA *State highway construction and maintenance noise and vibration guide*, or previous measurements of similar equipment.

The evaluation and assessment have been conducted under the assumption that the equipment or plant will not exceed the levels outlined in Appendix B.

Light construction works (such as light handheld tools, manual digging, etc.) are also expected to occur on site. These activities are not expected to produce noise or vibration levels that will modify the resultant average ($L_{Aeq,T}$) or maximum (L_{max}) than those predicted and have therefore not been included, unless otherwise specified.

5.1.1 DESCRIPTION OF CONSTRUCTION ACTIVITIES PER STAGE

A description of the activities undertaken at each stage, in accordance with Table 5.1, is provided below. Specific consideration to the acoustic nature of activities and equipment has been made.

STAGE 1 – SITE ESTABLISHMENT

- Vegetation will be removed within the extent of the reservoir and pipeline excavation areas and may be trimmed for vehicle access along Summit Road. A woodchipper will be used on site to break-down vegetation prior to loading on trucks for disposal off site.
- Site office portacabins and welfare facilities will be installed on top of and adjacent to the existing reservoir.
- Site security fences will be established around the perimeter of the planned excavation area and the site perimeter.
- The existing access road will be improved to allow construction vehicle access to the main site activity area.

STAGE 2 – EARTHWORKS FOR RESERVOIR

- Bulk earthworks are the first significant construction activity and will require a large volume of excess spoil to be excavated and removed from the Site. This will result in up to 50 truck movements per day along Summit Road and connecting roads.
- For the excavation, 2 to 3 excavators will be mobilised. One of the excavators will primarily be used for ripping the material and transferring to stockpiles, while the others will be responsible for loading the material onto trucks.
- For loading out of material, rigid 6- and 8-wheel trucks will be used to remove spoil concurrently with the operation of the excavators. Truck and trailer units will be used when enough space allows on site.

STAGE 3 – PIPELINE CONSTRUCTION

- Vegetation will be removed within the pipeline trench corridor (approximately 14m width) to accommodate the positioning of the excavator, material stockpiling and access for transporting dumpers.

- An excavator will be utilised to excavate the trench and will move the trench shield into position. The bedding and new pipe will be laid whilst the excavator moves forward and continue to excavate for the next section of pipe. The trench will be backfilled and compacted using a plate compactor or sit on roller.
- Dewatering pumps and sheet piling will be used during the construction of the below-ground pipe stream crossing. The stream will also be over-pumped during these works. Dewatering and over-pumping will be undertaken 24-hours a day whilst pipe installation across Waiwhetu Stream is undertaken.

STAGE 4 – RESERVOIR AND VALVE HOUSE CONSTRUCTION

- Slope stabilisation soldier piles will be installed around parts of the Proposed Reservoir circumference. These 1200 mm diameter bored reinforced concrete piles will be spaced approximately 3.6 m apart and embedded into competent rock. An in-ground reinforced concrete capping beam will be installed after the piles.
- During the first concrete placement, a single night-time pour (from approximately 0300 – 0800 hours) for the base slab will be executed using two concrete pumps positioned at the north end of the reservoir. During this concrete pour, approximately 50 concrete trucks will be required for delivery of concrete to site. Following the concrete pour, a second night of works is required to remove formwork and to post-tension the slab. This will require cranes and excavators that will access the site during the day only.
- Pre-cast reservoir wall panels, columns, beams, and slabs will be delivered to site by two transporters per day for the walls and roof structure. Materials will be offloaded to the laydown area using a crawler crane. Transporter deliveries may arrive prior to 0700 hours since precast elements may be considered notifiable loads, and delivery times may be subject to restrictions.
- The panels will be installed vertically using a crane, temporary propping, and hand tools, starting from the south side to the north side of the reservoir.
- After installing the pre-cast roof slabs, a second single night-time pour for the topping slab will be executed using two concrete pumps. Approximately 40 concrete trucks will be required to pour the roof slab of the reservoir.
- The reservoir pipes and valve house will be installed in two phases. Phase 1 will be concurrent with the first concrete pour, and phase 2 will occur as the reservoir construction nears completion. Principally hand tools and concrete pumps will be used during this activity.

STAGE 5 – LANDSCAPE AND REINSTATEMENT

- After completion of the main reservoir structure, Summit Road access will be re-instated.
- Planting and landscaping activities will be carried out during the final stages of site completion and commissioning.
- Activities during this stage are not expected to cause high levels of noise except for some road grading activities to make good the Summit Road access and potential for a few small excavators working sporadically.

5.2 PREDICTION METHODOLOGY

5.2.1 3D ACOUSTIC NOISE MODELLING

A 3D noise prediction model has been prepared using SoundPLAN Version 8.2 noise modelling software to inform the assessment.

Modelling inputs include the outlined construction activities and equipment during various stages of work, as presented in Section 5.1 and Appendix B.

The noise calculations for construction noise sources has been undertaken in accordance with NZS 6803 prediction methodology, with noise propagation in line with ISO 9613 *Acoustics — Attenuation of sound during propagation outdoors* (ISO 9613). This considers source type, movement of equipment during the assessment period, on-time, attenuation due to distance, terrain, absorption by the atmosphere and ground, and reflections from building facades.

The assessment assumes theoretical downwind conditions in all directions from all sources, which provides a conservative approach for assessment.

Table 5.2 presents the noise modelling parameters adopted for this assessment.

Table 5.2: Noise modelling parameters

PARAMETER	VALUE	SOURCE
Calculation method	NZS 6803 and ISO 9613	-
Terrain contours	1 m vertical heights	Project information and LINZ
Buildings	Building footprints Assume each storey of any buildings are 3.5m high	Project information and LINZ
Ground Absorption Coefficient	0.5 to 1.0 (depending on area)	-
Number of Reflections	3	-
Noise Contour and Receptor Height	1.5 m above ground level at single storey dwellings. 5 meters above ground level for two-storey dwellings.	-

Noise sources for each construction activity have been implemented in the model as a selection of point, line and area sources that are placed to provide a reasonable worst-case / conservative prediction at nearby NSRs.

The maximum noise level (L_{AFmax}) setback distances have been calculated by determining noise levels generated by the loudest piece of equipment per stage, predicting the likely screening effects caused by noise barrier mitigation, and calculating the distance for which the noise limit thresholds may be exceeded for each item of equipment.

5.2.1.1 MODELLED SITUATIONS FOR NOISE ASSESSMENT

A total of six 'Situations' have been modelled for the noise assessment. Each Situation coincides with the construction stages and incorporates concurrent activities taking place across the Proposed Reservoir.

The modelled Situations have been chosen as representative snapshots through the construction programme and are considered to follow reasonable worst-case assumptions, for a conservative assessment.

Table 5.3 provides a description of concurrent activities captured by the modelled Situations and their approximate start and end dates based on the latest construction programme.

Table 5.3: Modelled Situations

SITUATION	DESCRIPTION OF CONCURRENT ACTIVITIES	START DATE	END DATE
A	Stage 1: Site Establishment	July 2024	September 2024
B	Stage 2: Earthworks for Reservoir	September 2024	June 2025
C	Stage 3: Pipeline Construction – with piling activities Stage 4: Reservoir / Valvehouse Construction – with piling activities	June 2025	March 2026
D	Stage 3: Pipeline Construction – no piling activities Stage 4: Reservoir / Valvehouse Construction – no piling activities	June 2025	August 2026
D-2	Stage 3: Pipeline Construction – Night works dewatering and over-pumping only.	June 2025	August 2026
E	Stage 4: Reservoir Construction – night-time concrete pouring	July 2025	April 2026

It is noted that the above Situations are based on likely construction activities occurring concurrently at various times throughout construction. This may or may not occur in reality.

Therefore, over the course of construction there may be some variation in noise levels, the adopted acoustic assessment methodology is considered to be a reasonably conservative approach.

Stage 5 landscape and reinstatement activities have not been modelled using 3D prediction methods since those activities are not expected to produce high levels of noise, except for road grading which is captured within the maximum noise level assessment.

5.2.1.2 MITIGATION MODELLING

Mitigation measures have been iteratively developed and modelled in SoundPLAN software. Temporary localised barriers are the most effective form of mitigation for construction activities, as described in Section 8.

5.2.2 SITE HAULAGE ROADS

Haulage road noise levels from the entrance of the site have been predicted in accordance with the methodology in Annex D from NZS 6803, based on the below information.

A conservative assumption of HCV movements for the construction programme comprises:

- Movement of 12 HCV movements per hour during peak day, along Tilbury St and Summit Rd.
- Movement of 6 HCV movements per hour during peak day, along Waddington Dr and Balgownie Gr.

- Movement of 20 HCV movements per hour at night during peak concrete works, along Tilbury St and Summit Rd.
- Average speed of 15 km/h.
- 113 dB L_{Amax} sound power level for truck movements.
- Acoustic correction applied for twin engine vehicles going uphill/downhill.

5.2.3 VIBRATION CALCULATIONS

Items of plant causing high levels of vibration have been predicted based on the methodology outlined in the Waka Kotahi NZ Transport Agency's *State Highway Construction and Maintenance Noise Vibration Guide* (version 1.1, dated August 2019).

This method assumes hard soil conditions (compacted clay, exposed rock), and slab-on-grade foundation type for all adjacent properties.

5.2.4 ASSUMPTIONS AND LIMITATIONS

The following list of assumptions and limitations apply to the noise and vibration prediction methodology, particularly regarding source implementation in the model.

- Construction activity locations are based on the latest design and contractor documentation, including proposed methodology, construction plant and master schedule.
- Noise sources are implemented as a selection of point, area and line sources where appropriate within the model. Area sources are typically implemented in main work areas and calibrated using point sources and receivers to an equivalent sound power level, to ensure noise propagates from all areas of the active Site.
- An assessment period of 1-hour has been applied, assuming the likely operation of equipment within a reasonable worst-case 1-hour period.
- Mitigation in the form of noise barriers around specific items of equipment has been assumed at a 5 m distance from the item of equipment. Where practicable, noise barriers should be placed as close as possible to the noise source.
- There is always a level of uncertainty in predicting noise from construction activities. Numerous variables including variations in the specific models of equipment, the exact location of each item on site, and how the operator uses the equipment, will affect the accuracy of the noise predicted.

6 PREDICTED NOISE AND VIBRATION LEVELS

6.1 CONSTRUCTION NOISE LEVELS

This section outlines the predicted noise levels at NSRs. A description of the associated noise effects is provided in Section 7.

6.1.1 AVERAGE CONSTRUCTION NOISE LEVELS ($L_{Aeq,1hr}$)

The predicted average noise levels ($L_{Aeq,1hr}$) for each Situation are presented in Table 6.1 to Table 6.3.

The result tables indicate NSR addresses that exceed the noise limit threshold with no mitigation measures, and subsequently indicate compliance after specific mitigation measures are applied.

Generally, where NSR addresses are not included below, they achieve acoustic criteria with no mitigation.

Specific physical mitigation measures are presented in Section 8.2.1. Where the noise levels are exceeded without noise mitigation, the measures outlined in Section 8.2.1 have been included in the calculations.

Appendix C presents noise contours for each modelled Situation.

SITUATION A - SITE ESTABLISHMENT

Table 6.1 presents the predicted construction noise levels at affected NSRs for Situation A.

Table 6.1: Predicted average noise levels for Situation A

NSR ADDRESS	AVERAGE NOISE LEVEL AT RECEPTOR ($L_{Aeq,1hr}$)		ACHIEVES CRITERIA (70 DB L_{Aeq}) WITH MITIGATION?
	UN-MITIGATED	MITIGATED	
49C Tilbury Street, Fairfield, Lower Hutt	71	60	Yes

It is predicted that 1 NSR exceeds the noise limit thresholds in the unmitigated scenario.

Specific mitigation measures are shown to reduce noise levels and achieve the criteria, as presented in Section 8.2.1. As such, the predicted noise impact is predicted to be **acceptable**.

SITUATION B - EARTHWORKS FOR RESERVOIR

It is predicted that no NSRs will exceed the noise limit thresholds for Situation B in the un-mitigated scenario. General mitigation measures are presented in Section 7.2.1. As such, the predicted noise impact is predicted to be **acceptable**.

SITUATION C - PIPELINE & RESERVOIR / VALVEHOUSE CONSTRUCTION – WITH PILING

Table 6.2 presents the predicted construction noise levels at affected NSRs for Situation C. This scenario includes the construction of the pipeline with piling occurring near Waiwhetu Stream, and piling associated with the Proposed Reservoir. This excludes any over-pumping or dewatering.

Table 6.2: Predicted average noise levels for Situation C

NSR ADDRESS	AVERAGE NOISE LEVEL AT RECEPTOR ($L_{Aeq,1hr}$)		ACHIEVES CRITERIA (70 DB L_{Aeq}) WITH MITIGATION?
	UN-MITIGATED	MITIGATED	
10 Balgownie Grove, Naenae, Lower Hutt	79	76	No
11 Balgownie Grove, Naenae, Lower Hutt	82	78	No
2 Balgownie Grove, Naenae, Lower Hutt	85	80	No
3 Balgownie Grove, Naenae, Lower Hutt	76	74	No
4 Balgownie Grove, Naenae, Lower Hutt	78	75	No
5 Balgownie Grove, Naenae, Lower Hutt	91	82	No
6 Balgownie Grove, Naenae, Lower Hutt	89	83	No
7 Balgownie Grove, Naenae, Lower Hutt	82	79	No
9 Balgownie Grove, Naenae, Lower Hutt	72	72	No
10 Farrelly Grove, Fairfield, Lower Hutt	73	72	No
2 Farrelly Grove, Fairfield, Lower Hutt	71	66	Yes
9 Farrelly Grove, Fairfield, Lower Hutt	73	73	No
33 Summit Road, Fairfield, Lower Hutt	75	75	No
31 Summit Road, Fairfield, Lower Hutt	76	76	No
35 Summit Road, Fairfield, Lower Hutt	74	74	No
46 Waddington Drive, Naenae, Lower Hutt	72	72	No
26 Waddington Drive, Naenae, Lower Hutt	73	71	No
28 Waddington Drive, Naenae, Lower Hutt	79	76	No
32 Waddington Drive, Naenae, Lower Hutt	79	76	No
34 Waddington Drive, Naenae, Lower Hutt	74	72	No
36 Waddington Drive, Naenae, Lower Hutt	72	72	No
40 Waddington Drive, Naenae, Lower Hutt	72	71	No
25 McEnroe Grove, Naenae, Lower Hutt	72	71	No
27 McEnroe Grove, Naenae, Lower Hutt	74	73	No
35 Waddington Drive, Naenae, Lower Hutt	74	72	No
37 Waddington Drive, Naenae, Lower Hutt	75	73	No
39 Waddington Drive, Naenae, Lower Hutt	72	70	Yes
41 Waddington Drive, Naenae, Lower Hutt	71	70	Yes
43 Waddington Drive, Naenae, Lower Hutt	71	70	Yes

It is predicted that 25 NSRs are to exceed the noise limit thresholds even with mitigation applied. This is due to the height of the piling head being above acoustic site hoardings, and therefore providing minimal noise reduction.

Specific mitigation measures are shown to reduce noise levels and achieve the criteria at 4 NSRs.

The specific noise limit exceedances at each NSR are indicated in Appendix C.

Section 6.1.3 provides further commentary regarding potential noise effects at NSR's that are predicted to remain above the noise limit, considering contextual elements of the works. As such the predicted noise impact at those affected NSRs is predicted to be reasonable to obvious.

SITUATION D - PIPELINE & RESERVOIR / VALVE HOUSE CONSTRUCTION – NO PILING

Table 6.3 presents the predicted construction noise levels at affected NSRs for Situation D. This includes the construction of the pipework down the hill and over Waiwhetu Stream, and

construction of the Proposed Reservoir once all piling has finished. This includes over- pumping and dewatering of Waiwhetu Stream.

Table 6.3: Predicted average noise levels for Situation D

NSR ADDRESS	AVERAGE NOISE LEVEL AT RECEPTOR ($L_{Aeq,1hr}$)		ACHIEVES CRITERIA (70 DB L_{Aeq}) WITH MITIGATION?
	UN-MITIGATED	MITIGATED	
2 Balgownie Grove, Naenae, Lower Hutt	73	69	Yes
5 Balgownie Grove, Naenae, Lower Hutt	78	70	Yes
6 Balgownie Grove, Naenae, Lower Hutt	77	71	No
7 Balgownie Grove, Naenae, Lower Hutt	73	70	Yes
31 Summit Road, Fairfield, Lower Hutt	71	70	Yes

It is predicted that 5 NSRs will exceed the noise limit thresholds in the unmitigated scenario. With the inclusion of noise mitigation, one property remains over the noise limit threshold by 1 dB.

The specific noise limit exceedances at each NSR are indicated in Appendix C.

Section 6.1.3 provides further commentary regarding potential noise effects at NSRs that are predicted to remain above the noise limit, considering contextual elements of the works. As such, the predicted noise impact at those affected NSRs is predicted to be reasonable.

SITUATION D-2 – OVER-PUMPING AND DEWATERING NIGHT WORKS

Table 6.4 presents the predicted construction noise levels at the closest NSRs for over-pumping and dewatering works during the night-time (when two pumps and a generator operate only).

Table 6.4: Predicted average noise levels for Situation D-2

NSR ADDRESS	AVERAGE NOISE LEVEL AT RECEPTOR ($L_{Aeq,1hr}$)		ACHIEVES CRITERIA (45 DB L_{Aeq}) WITH MITIGATION?
	UN-MITIGATED	MITIGATED	
10 Balgownie Grove, Naenae, Lower Hutt	50	35	Yes
11 Balgownie Grove, Naenae, Lower Hutt	47	35	Yes
2 Balgownie Grove, Naenae, Lower Hutt	56	34	Yes
3 Balgownie Grove, Naenae, Lower Hutt	48	31	Yes
4 Balgownie Grove, Naenae, Lower Hutt	52	33	Yes
5 Balgownie Grove, Naenae, Lower Hutt	63	38	Yes
6 Balgownie Grove, Naenae, Lower Hutt	73	45	Yes
7 Balgownie Grove, Naenae, Lower Hutt	68	43	Yes
9 Balgownie Grove, Naenae, Lower Hutt	47	33	Yes
10 Farrelly Grove, Fairfield, Lower Hutt	53	41	Yes
9 Farrelly Grove, Fairfield, Lower Hutt	53	42	Yes
33 Summit Road, Fairfield, Lower Hutt	55	44	Yes
29 Summit Road, Fairfield, Lower Hutt	48	37	Yes
31 Summit Road, Fairfield, Lower Hutt	58	45	Yes
35 Summit Road, Fairfield, Lower Hutt	52	41	Yes
36 Waddington Drive, Naenae, Lower Hutt	50	32	Yes

All properties are predicted to achieve the night-time noise limits with mitigation. However, it is noted that the noise generated by pumps and generators vary depending on the manufacturer

and loading of the equipment. When over-pumping and dewatering first occurs, noise measurements of the equipment shall be undertaken, and specific noise mitigation measures implemented to control noise to achieve the noise limit based on the measurements.

Based on specific mitigation being incorporated, the noise impacts are predicted to be **acceptable.**

SITUATION E - RESERVOIR CONSTRUCTION – NIGHT-TIME CONCRETE POURING

Noise limit exceedances are indicated at NSRs in proximity to the Proposed Reservoir and wider area due to night-time concrete pouring works with mitigation.

Specific mitigation measures, as presented in Section 8.2.1, are shown to reduce noise levels at the surrounding NSRs by 1 to 3 dB. Despite the proposed mitigation measures the night-time limit criteria are still likely to be exceeded. Section 6.1.3 provides further commentary regarding potential noise effects at NSRs that are predicted to remain above the noise limit.

It is noted that night-time activities are proposed to be undertaken on four nights over the whole construction programme. Managerial mitigation measures will be used in addition to physical mitigation measures, to minimise adverse noise effects at NSRs. As such, the predicted noise impact at those affected NSRs is predicted to be **reasonable to obvious**.

Figure 6.1 presents a 3D aerial view of Situation E in relation to the surrounding environment in addition to the 2D contours presented in Appendix C.

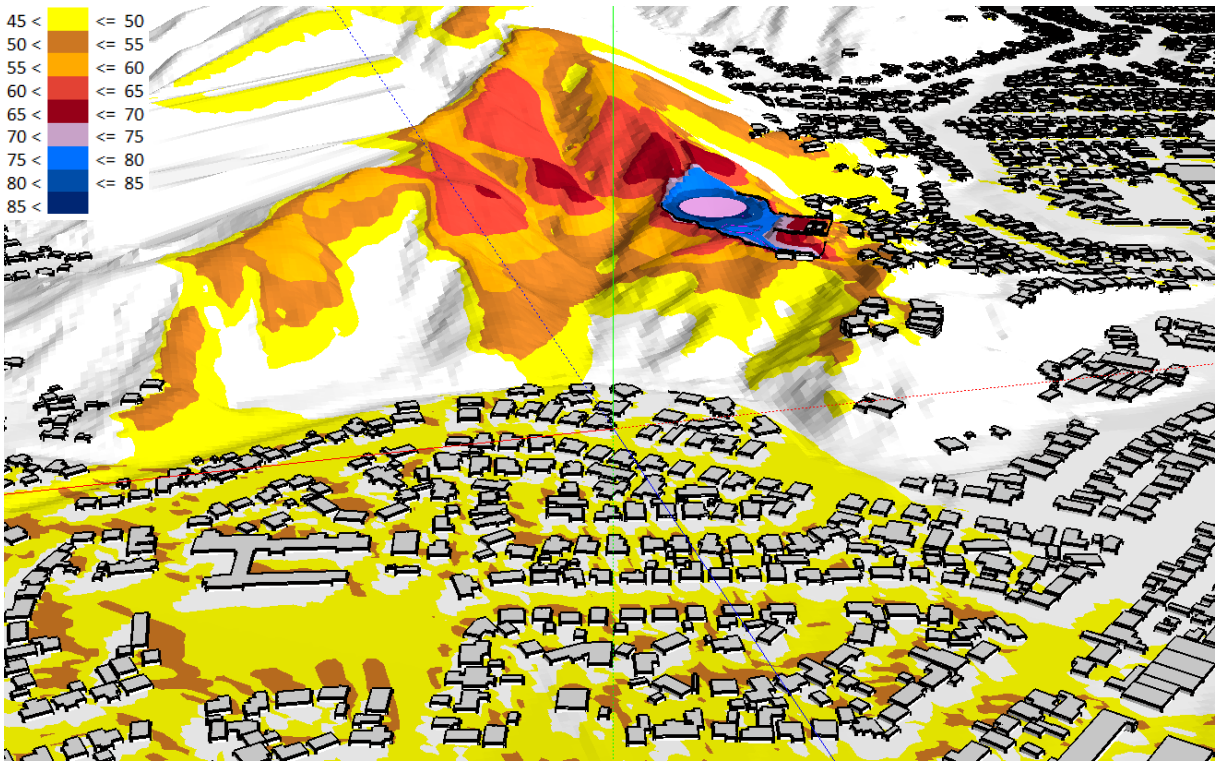


Figure 6.1: 3D aerial view of noise model results during Situation E looking South

6.1.2 MAXIMUM CONSTRUCTION SITE NOISE LEVELS (L_{AFMAX})

A maximum noise level assessment has been undertaken for the loudest construction activities occurring on-site. The predicted maximum noise levels and standoff distances to achieve the noise limits for each piece of high noise producing equipment, is presented in Table 6.5.

The standoff distance is the distance from any noise generating equipment at which the noise limits are achieved. Any NSR within the standoff distance may exceed the noise criteria for instantaneous maximum noise events.

Table 6.5: Maximum noise level standoff distances (un-mitigated)

	EQUIPMENT	MAXIMUM NOISE LEVEL OF EQUIPMENT (dB $L_{A,MAX}$ @10M)	STANDOFF DISTANCE TO ACHIEVE NOISE CRITERIA (Metres)		APPROX NO. OF NSRS INSIDE STANDOFF DISTANCE *	
			85 dB $L_{A,MAX}$	75 dB $L_{A,MAX}$	85 dB $L_{A,MAX}$	75 dB $L_{A,MAX}$
1	Excavator	77	< 5	-	0	-
2	Piling	105 *	100	-	26	-
3	Vibratory Roller	84	9	-	0	-
4	Chainsaw	85	10	-	0	-
5	Truck Pass	85	10	30	First row of dwellings to road	
6	Grader	86	11	35	0	0

* The approximate number and location of NSRs inside standoff distance is based on indicative working locations as presented in Appendix C

** Maximum noise events of piling equipment range between 95 – 105 dB depending on specific operation of the equipment, maximum noise events within the lower part of this range will produce lower standoff distances.

The operation of equipment on site shall consider the set-back distance required to achieve compliance (i.e. operate equipment further than the set-back distance away from NSRs where practicable).

Where it is not practicable to operate equipment further than the setback distances in Table 6.5, physical mitigation is required to reduce the noise levels, such as installation of temporary noise barriers around the noise generating element of equipment.

The highest risk for maximum noise level exceedances at this site is from the operation of piling equipment. Maximum noise events will be present for all methods of piling; however, the overall rate and magnitude of exceedances will depend heavily on the chosen method. For example, CFA or rotary bored piling is likely to cause less exceedances of the noise limit threshold compared to percussive / hammer / vibratory piling methods.

The first step of mitigation is to choose quieter methods of piling and equipment as far as practicable.

The second step of mitigation is to install temporary noise barriers. The effectiveness of noise barriers can vary, but typically up to 5 dB reduction in noise levels can be achieved with partial screening between source and receptor, and up to 10 dB reduction in noise levels can be achieved with full screening.

Table 6.6 presents the set-back distance for piling activities with partial and full screening.

Table 6.6: Maximum noise level standoff distances (mitigated)

EQUIPMENT		STANDOFF DISTANCE TO ACHIEVE NOISE CRITERIA WITH PARTIAL SCREENING (Metres)	STANDOFF DISTANCE TO ACHIEVE NOISE CRITERIA WITH FULL SCREENING (Metres)
		85 dB L_{Amax}	**85 dB L_{Amax}**
2	Piling	55	30

It is shown that the standoff distance for maximum noise level exceedances reduces when installing temporary noise barriers that provide screening between the noise source and receptor. When full screening is achieved the standoff distance is optimised.

Approximately 9 NSRs are predicted to exceed the noise criteria with partial screening, and approximately 2 NSRs are predicted to exceed the noise criteria with full screening, as indicated by the maximum noise level buffers in Appendix C.

Additionally, the maximum noise level data for piling has been assumed as a worst-case in this assessment; the specified level (105 dB at 10m distance) applies particularly to male casing installation.

Maximum noise events associated with other piling procedures such as female casing installation, removal and boring / spinning off may result in maximum noise levels 5 - 10 dB lower.

Furthermore, when sheet piling occurs the screening offered by barriers will increase and thus reduce the standoff distance as the sheet is piled deeper into the ground. This assessment assumes least beneficial piling conditions. Therefore, for the most-part it is likely that fewer NSRs will be affected by maximum noise level events due to the conservative assumptions taken within the assessment.

6.1.3 SITE ACCESS ROAD NOISE LEVELS

The HCDP does not expressly require noise from vehicles on roads to be assessed. However, due to the sensitive nature of residential dwellings located along Tilbury Street, Summit Road, Waddington Drive and Balgownie Grove, a desktop assessment of the likely noise levels from HCV movements on these roads has been undertaken and potential noise effects assessed.

During the daytime, based on 12 HCV movements per hour travelling along Tilbury Street / Summit Road, the predicted average noise level at the closest NSRs ranges from 74 to 79 dB $L_{Aeq,1h}$.

Additionally, up to 6 HCV movements per hour along Waddington Drive / Balgownie Grove is assumed on a worst-case day, noting that this road will be used far less often for site access. The predicted average noise level at the closest NSRs along Waddington Drive / Balgownie Grove ranges from 69 to 76 dB $L_{Aeq,1h}$.

HCVs are required during two early morning periods for the in-situ pour of the concrete foundation and lid of the reservoir. Approximately 50 HCVs would be required (100 movements) in the early morning period (between 0300 – 0800 hours). We have calculated the noise based on 20 HCV movements in a worst-case 1-hour period travelling along Tilbury Street/Summit Road. The predicted noise levels at the first row of properties along Tilbury Street/Summit Road are presented in Table 6.7.

Table 6.7: Noise from 20 HCV movements during a concrete pour on Tilbury Street/Summit Road

NSR ADDRESS	AVERAGE NOISE LEVEL AT RECEPTOR ($L_{Aeq,1hr}$)		ACHIEVES CRITERIA?
	PREDICTED NOISE LEVEL	TARGET	
1 Farrelly Grove, Fairfield, Lower Hutt	62	45	No
2 Farrelly Grove, Fairfield, Lower Hutt	54	45	No
3 Farrelly Grove, Fairfield, Lower Hutt	61	45	No
4 Farrelly Grove, Fairfield, Lower Hutt	58	45	No
5 Farrelly Grove, Fairfield, Lower Hutt	60	45	No
6 Farrelly Grove, Fairfield, Lower Hutt	71	45	No
7 Farrelly Grove, Fairfield, Lower Hutt	71	45	No
8 Farrelly Grove, Fairfield, Lower Hutt	70	45	No
9 Farrelly Grove, Fairfield, Lower Hutt	66	45	No
10 Farrelly Grove, Fairfield, Lower Hutt	76	45	No
493 Riverside Drive, Fairfield, Lower Hutt	69	45	No
495 Riverside Drive, Fairfield, Lower Hutt	70	45	No
1 Summit Road, Fairfield, Lower Hutt	79	45	No
2 Summit Road, Fairfield, Lower Hutt	76	45	No
3 Summit Road, Fairfield, Lower Hutt	79	45	No
5 Summit Road, Fairfield, Lower Hutt	78	45	No
6 Summit Road, Fairfield, Lower Hutt	76	45	No
7 Summit Road, Fairfield, Lower Hutt	77	45	No
8 Summit Road, Fairfield, Lower Hutt	77	45	No
9 Summit Road, Fairfield, Lower Hutt	76	45	No
10 Summit Road, Fairfield, Lower Hutt	75	45	No
11 Summit Road, Fairfield, Lower Hutt	76	45	No
12 Summit Road, Fairfield, Lower Hutt	77	45	No
13 Summit Road, Fairfield, Lower Hutt	76	45	No
14 Summit Road, Fairfield, Lower Hutt	77	45	No
15 Summit Road, Fairfield, Lower Hutt	77	45	No
17 Summit Road, Fairfield, Lower Hutt	76	45	No
18 Summit Road, Fairfield, Lower Hutt	58	45	No
19 Summit Road, Fairfield, Lower Hutt	75	45	No
20 Summit Road, Fairfield, Lower Hutt	74	45	No
21 Summit Road, Fairfield, Lower Hutt	74	45	No
22 Summit Road, Fairfield, Lower Hutt	58	45	No
23 Summit Road, Fairfield, Lower Hutt	75	45	No
24 Summit Road, Fairfield, Lower Hutt	63	45	No
25 Summit Road, Fairfield, Lower Hutt	67	45	No
26 Summit Road, Fairfield, Lower Hutt	77	45	No
27 Summit Road, Fairfield, Lower Hutt	62	45	No
29 Summit Road, Fairfield, Lower Hutt	58	45	No
31 Summit Road, Fairfield, Lower Hutt	59	45	No
33 Summit Road, Fairfield, Lower Hutt	65	45	No
35 Summit Road, Fairfield, Lower Hutt	74	45	No

NSR ADDRESS	AVERAGE NOISE LEVEL AT RECEPTOR ($L_{Aeq,1hr}$)		ACHIEVES CRITERIA?
	PREDICTED NOISE LEVEL	TARGET	
23 Tilbury Street, Fairfield, Lower Hutt	65	45	No
47A Tilbury Street, Fairfield, Lower Hutt	58	45	No
47B Tilbury Street, Fairfield, Lower Hutt	59	45	No
49 Tilbury Street, Fairfield, Lower Hutt	54	45	No
49A Tilbury Street, Fairfield, Lower Hutt	54	45	No
49B Tilbury Street, Fairfield, Lower Hutt	52	45	No
49C Tilbury Street, Fairfield, Lower Hutt	55	45	No
61 Tilbury Street, Fairfield, Lower Hutt	55	45	No
63 Tilbury Street, Fairfield, Lower Hutt	53	45	No
2 Tilbury Street, Fairfield, Lower Hutt	76	45	No
f3 Tilbury Street, Fairfield, Lower Hutt	76	45	No
4 Tilbury Street, Fairfield, Lower Hutt	76	45	No
6 Tilbury Street, Fairfield, Lower Hutt	76	45	No
7 Tilbury Street, Fairfield, Lower Hutt	77	45	No
2/7 Tilbury Street, Fairfield, Lower Hutt	69	45	No
8 Tilbury Street, Fairfield, Lower Hutt	76	45	No
9 Tilbury Street, Fairfield, Lower Hutt	76	45	No
10 Tilbury Street, Fairfield, Lower Hutt	77	45	No
12 Tilbury Street, Fairfield, Lower Hutt	75	45	No
13 Tilbury Street, Fairfield, Lower Hutt	78	45	No
14 Tilbury Street, Fairfield, Lower Hutt	69	45	No
15 Tilbury Street, Fairfield, Lower Hutt	71	45	No
17 Tilbury Street, Fairfield, Lower Hutt	68	45	No
19 Tilbury Street, Fairfield, Lower Hutt	65	45	No
1 Tilbury Street, Fairfield, Lower Hutt	75	45	No
21 Tilbury Street, Fairfield, Lower Hutt	62	45	No
348A Waiwhetu Road, Fairfield, Lower Hutt	65	45	No
350 Waiwhetu Road, Fairfield, Lower Hutt	71	45	No
7 Laura Fergusson Grove, Fairfield, Lower Hutt	68	45	No
9 Laura Fergusson Grove, Fairfield, Lower Hutt	65	45	No
1 Glen Evans Crescent, Fairfield, Lower Hutt	70	45	No
3 Glen Evans Crescent, Fairfield, Lower Hutt	70	45	No
5 Glen Evans Crescent, Fairfield, Lower Hutt	68	45	No
7 Glen Evans Crescent, Fairfield, Lower Hutt	69	45	No
11 Glen Evans Crescent, Fairfield, Lower Hutt	67	45	No

Additionally, the maximum noise level of an individual truck pass is assumed to be 85 dB L_{Amax} at 10m distance. NSRs within a buffer distance of 30m from truck passes will be subject to maximum noise levels of 75 dB L_{AFmax} or greater, this encompasses the first row of dwellings adjacent to the road, as indicated in the construction noise buffers in Appendix C.

Based on the predicted site access noise levels it is indicated that a temporary increase in noise levels will be experienced compared to the predicted existing baseline levels, as indicated in Section 3.2.

Based on the predicted noise levels and possible opportunities for mitigation, the following conclusions are made:

- Daytime noise levels due to construction traffic are **reasonable to obvious** at the nearest NSRs.
- Night-time noise levels due to construction traffic are **obvious to unreasonable** at the nearest NSRs.

As such, it is recommended that noise from trucks using site access roads should be addressed within the Construction Noise and Vibration Management Plan (CNVMP), which should set out managerial mitigation measures to effectively mitigate against potential adverse effects as far as practicable. The CNVMP should be always followed by the contractor. Proposed management measures include noise and vibration monitoring of trucks using the site access road at occasions across the construction programme.

6.2 CONSTRUCTION VIBRATION LEVELS

This section outlines the predicted vibration levels and associated vibration effects.

6.2.1 PEAK PARTICLE VELOCITY (PPV) VIBRATION LEVELS.

The approximate number of NSRs inside the standoff distance is also provided in Table 6.8.

The standoff distance is the distance from any vibration generating equipment at which the vibration limits are achieved. Any NSR within the standoff distance is predicted to exceed the vibration criteria. The approximate number of NSRs inside the standoff distance is also provided in Table 6.8.

Table 6.8: Vibration standoff distances

	EQUIPMENT	VIBRATION LEVEL OF EQUIPMENT (mm/s PPV @10M)	STANDOFF DISTANCE TO ACHIEVE VIBRATION CRITERIA (Metres)		APPROX NO. OF NSRS INSIDE STAND-OFF DISTANCE *	
			5 mm/s	1 mm/s	5 mm/s	1 mm/s
1	Piling - Rotary (CFA)	0.48	1	5	0	0
2	Piling – Sheet Piles	2.50	5	25 *	0	2
3	Excavator	1.90	4	19 *	0	2
4	Vibratory Roller	3.60	8	36 *	0	5
5	HCV Pass	0.03	< 1	< 1	0	0

* The approximate number and location of NSRs inside standoff distance is based on indicative working locations as presented in Appendix C

The operation of equipment on site should consider the set-back distance required to achieve compliance (i.e. operate equipment further than the set-back distance away from NSRs where practicable).

6.2.2 SITE ACCESS ROAD VIBRATION LEVELS

The HCDP does not require vibration to be assessed from vehicles on the road. However, due to the sensitive nature of residential roads at Tilbury Street, Summit Road, Waddington Drive and Balgownie Grove, a desktop assessment of likely vibration levels from HCV movements on these roads has been undertaken and potential vibration effects have been assessed.

Based on the vibration standoff distances indicated in Table 6.8, a typical HCV pass will cause 1 mm/s PPV at less than 1 m distance, as such perceived human response to vibration and cosmetic building damage is unlikely.

However, it is noted that vibration calculations are based on the best available data at the time of this assessment, this includes provision for a truck travelling at a constant speed on a highway at grade but does not include provision for site specific details such as surface irregularities, engine braking, the specific model of a truck under fully laden conditions used for construction works.

As such, it is recommended that vibration from trucks using the site access road is measured and monitored as a mitigation and management measure outlined in the CNVMP.

7 ASSESSMENT OF EFFECTS

7.1 ASSESSMENT OF NOISE EFFECTS

Table 7.1 summarises the noise effects for each modelled situation and construction stage.

Table 7.1: Summary of noise effects for modelled situations

SITUATION	SUMMARY OF NOISE EFFECTS FOR MODELLED SITUATIONS	PREDICTED OVERALL IMPACT
A	During Site Establishment activities, 1 NSR is predicted to exceed the noise criteria without mitigation measures. The exceedance of this receptor is 1 dB which is negligible and not considered to be a noticeable exceedance in terms of noise perceptibility. However, installation of site hoarding barriers (refer to Figure 8.1) at the start of construction will screen noise and provide the community with reassurance that construction is being carried out with consideration to potential noise disturbances. The perceived noise caused by construction activities on the site will be reduced due to of installing site hoarding and it will influence a reduction in noise levels by screening the line of sight to NSRs. Once this mitigation measure is applied the identified NSR is predicted to achieve the noise criteria and the overall noise impact is predicted to be **acceptable**.	Acceptable
B	During Earthworks for Reservoir activities, all NSRs are predicted achieve the noise criteria without mitigation measures and the overall noise impact is predicted to be **acceptable**. However, site hoarding barriers installed during site establishment should remain in place for the whole duration of construction as a best practicable means of mitigation to ensure noise remains reasonable. Additionally, excavator equipment used during this stage is positioned at the top of the hill and will likely overlook the site boundary barriers. As construction progresses the earthworks will perform as a self-screening mechanism, and noise levels will be naturally mitigated to the nearest NSRs. At the end of earthworks, the construction works area may have shifted, at this time the site hoarding barriers should be re-established to break any potential new line of sight across to receptors, in preparation for the future construction stages.	Acceptable
C	During Pipeline and Reservoir Construction with piling activities, 25 NSRs are predicted to exceed the noise criteria, even with the specific mitigation measures outlined in Section 8.2.1. Noise exceedances at 12 of the NSR's are 1 – 3 dB exceedances. This is likely to be imperceptible to barely perceptible above the noise criteria. Therefore, the overall noise impact is predicted to be **reasonable**. Noise exceedances at 8 further NSRs are 4 – 6 dB higher than the 70 dB $L_{Aeq,T}$ noise limit. These exceedances are a perceptible of obvious increase in level of noise over the 70 dB $L_{Aeq,T}$ noise criteria. At times these exceedances may cause some temporary adverse effects and noise complaints if noise levels are experienced over a long duration or during sensitive time periods. Therefore, when considering the overall noise impact is predicted to be **reasonable**.	Reasonable to Obvious

SITUATION	SUMMARY OF NOISE EFFECTS FOR MODELLED SITUATIONS	PREDICTED OVERALL IMPACT
	The five remaining properties receive noise levels 8 – 13 dB over the 70 dB $L_{Aeq,T}$ construction noise criteria. This level of noise is likely to cause adverse effects and noise complaints if noise levels are experienced over a long duration or during sensitive time periods, the overall noise impact is predicted to be **obvious**. These noise producing activities (specifically piling) in context are expected to occur on for a 2 – 3 week period during the daytime only. Once piling finishes, construction will move back to non-piling activities which are predicted to cause lower levels of noise, as indicated in Situation D. Managerial mitigation measures are key to minimise adverse noise effects at the nearest NSRs as described in Section 8.3. As such, considering the context of noise for this situation, the overall noise impact is predicted to be **not unreasonable**. Additionally, maximum noise events from equipment are likely to cause potential exceedances at Balgownie Grove. In an unmitigated scenario 25 NSRs are likely to exceed the noise criteria. However, the use of site hoarding barriers will screen the piling head as it drives the pile into the ground. The screen will provide a level of noise reduction whilst the piling head is below the screen, and line of sight to the receptor is reduced / eliminated. So, whilst the predicted noise level may exceed the limit, the screen will provide benefit for the duration that each pile driver is below the barrier, mitigating properties from experiencing high levels of noise. It is noted that maximum noise levels represent one-off events and are very much dependent on the exact activity being undertaken. For such exceedances, managerial mitigation measures are key to minimise adverse noise effects. It would be prudent to undertake regular attended noise measurements during sensitive piling activities, or to implement continuous noise logging in proximity to the NSRs at Balgownie Grove.	
D	During Pipeline & Reservoir Construction with no piling activities, NSRs at 2, 5, 6 and 7 Balgownie Grove along with 31 Summit Road are predicted to exceed the noise criteria without mitigation measures. Specific mitigation measures must be applied as indicated in Section 8.2.1. After best practicable specific mitigation measures are applied, only 6 Balgownie Grove is predicted to remain above the noise criteria. Noise exceedances at this property is 1 dB above the limit once mitigation is applied A 1 dB increase from the criteria is likely to be imperceptible. As such, considering the context of noise for this situation, the overall noise impact is predicted to be **reasonable**.	Reasonable
D-2	Two pumps and a generator are to be used to dewater and over-pump Waiwhetu Stream during the night-time once piling has finished. This will continue through Stage D until the pipe is installed across Waiwhetu Stream. The two pumps and generator are to be installed within an acoustic enclosures as detailed in Annex B of NZS 6803 and behind the 3 metre site hoardings. This mitigation is outlined in Section 8.2.1. With this mitigation, all properties are predicted to achieve the 45 dB $L_{Aeq,T}$ noise limit at night, and therefore effects from night over-pumping and dewatering are **acceptable**.	Acceptable

SITUATION	SUMMARY OF NOISE EFFECTS FOR MODELLED SITUATIONS	PREDICTED OVERALL IMPACT
E	Principally, noise effects for this construction scenario will be from HCV's accessing the site. Since the HCDP does not expressly require noise from vehicles on roads to be assessed, the summary of noise effects due to HCV movements on site access roads is separated from the on-site construction activities and is presented in the 'Site Access Roads' situation summary below. For the on-site night-time concrete pouring activities, with best practicable specific mitigation measures applied, NSRs are predicted to exceed the noise criteria as presented in Appendix C. Exceedances from construction activities occurring within the site boundary are principally indicated at the bottom of the valley to the north-east of the site, and in Tilbury Street, Summit Road and Farrelly Grove to the west. But the presence of exceedances does not necessarily mean that those adverse noise effects are significant, (such as some exceedances at the bottom of the valley to the north-east of the site). It is noted that a typical façade in New Zealand housing stock would conservatively achieve 20 dB of sound reduction with closed windows. The WHO guidelines for community noise (1999) and NZS 2107:2016 *Acoustics – Recommended design internal sound levels and reverberation times* (NZS 2107) recommends a 30 dB(A) internal noise level in bedrooms during the night for good quality sleep. Considering the 30 dB $L_{Aeq,T}$ internal noise level guidance and an estimate for façade reduction of a typical dwelling (20 dB reduction with windows closed), it is considered that the noise limit criteria for an adverse effect could be increased to 50 dB $L_{Aeq,T}$ when assessed at the façade of the building. By applying this external noise limit, the potential adverse effects are localised to the first two rows of dwellings to the west, and the south facing façade of dwellings to the north-east of the site. Noise exceedances at night are likely to cause adverse noise effects due to sleep disturbance, based on the WHO and NZS 2107 internal noise criteria. It is noted that these predicted noise levels will be experienced on two of the four nights which night-works occur over the whole construction programme. These two nights are during the night-time concrete pours, where one night is when concrete pouring occurs (the night when the exceedances will occur) and one1 night of post-tensioning the slab (no high-noise equipment is required) over two sets of night works (one for the base slab one for the roof slab). Managerial mitigation measures are key to minimise adverse noise effects, as described in Section 8.3. It is noted that the proposed construction methodology of pouring concrete in one pour is already an optimised construction method, since it is understood that two separate pours would result double the amount of night work to complete the task. Residents should be informed of the construction process in the months and weeks leading up the concrete pours by way of educating about the importance of pouring in one go to achieve the required safe construction quality. This may involve site open days to allow the community to visit the site and speak to community liaison representatives about the project. A last resort for mitigation is to provide temporary accommodation for residents who are significantly affected by sleep disturbance, when night works are taking place. For the first set of night-time works it is likely that managerial mitigation measures are the best course of action. When the second set of night-time works takes place the extent of disruption and sleep disturbance will be known and there is a potential opportunity to take further mitigation steps and to provide temporary accommodation to those most affected. A key managerial measure will include following a defined complaints handling protocol so that those most affected parties can be identified before the second set of night-time works and reasonable action can be taken in advance of those adverse noise effects.	Reasonable to Obvious

SITUATION	SUMMARY OF NOISE EFFECTS FOR MODELLED SITUATIONS	PREDICTED OVERALL IMPACT
	As such, considering the context of noise, the duration of the exceedances, the heightened management procedures, noise monitoring, and communication, the overall noise impact is predicted to be **not unreasonable**.	
Site Access Road	During the daytime it is predicted that average noise levels from HCVs along site access roads will cause a temporary increase in noise levels compared to the predicted existing baseline levels. It is recommended that noise from trucks using site access roads should be addressed within the CNVMP, which should set out managerial mitigation measures to effectively mitigate against potential adverse effects as far as practicable. As such, the overall noise impact is predicted to be **reasonable to obvious**. During the night-time, noise effects will principally be from HCV's accessing the site. This is because trucks will traverse local roads which have low levels of traffic, and as such are likely to experience a large change in the noise levels received from the existing environmental noise to the noise generated by HCVs accessing the site. It is unlikely that practicable physical mitigation measures can be included along Tilbury Street and Summit Road due to non-acoustic reasons (such as removal of access to properties, and length and height of screening required). Many NSRs along this route are predicted to exceed the night-time noise criteria by over 30 dB at the worst-case receptors. The maximum noise level of an individual truck pass is predicted to exceed the 75 dB L_{AFmax} criteria at the first row of dwellings to the road, which may result in sleep disturbance effects.. It is noted that these predicted noise levels will be experienced on two of the four nights which night-works occur over the whole construction programme. These two nights are during the night-time concrete pours, where one night is when concrete pouring occurs (the night when the exceedances will occur) and one1 night of post-tensioning the slab (no high-noise equipment is required) over two sets of night works (one for the base slab one for the roof slab). A last resort for mitigation is to provide temporary accommodation for residents who are significantly affected by sleep disturbance, when night works are taking place. For the first set of night-time works it is likely that managerial mitigation measures are the best course of action. When the second set of night-time works takes place the extent of disruption and sleep disturbance will be known and there is a potential opportunity to take further mitigation steps and to provide temporary accommodation to those most affected. A key managerial measure will include following a defined complaints handling protocol so that those most affected parties can be identified before the second set of night-time works and reasonable action can be taken in advance of those adverse noise effects. The CNVMP should specially refer to mitigation control measures for HCVs during the night-time. Proposed management measures include noise and vibration monitoring of trucks using the site access road at occasions across the construction programme. The overall night-time noise impact is predicted to be **obvious to unreasonable**.	Daytime: Reasonable to Obvious Night-time: Obvious to Unreasonable

7.2 ASSESSMENT OF VIBRATION EFFECTS

The construction activities listed in Table 6.8 are indicated to produce ground borne vibration in the surrounding environment, the magnitude of vibration depends on the construction activity.

Vibratory rolling, sheet piling, and excavation are shown to produce the highest levels of vibration, and hence the largest stand-off distance applies, whereas rotary piling methods produce lower levels of vibration. The required piling method is dependent on ground conditions which may be determined during the construction staging. No NSRs lie within 8 m distance of potential vibratory rolling positions, therefore cosmetic building damage to dwellings is not expected to occur.

Where amenity areas of NSRs lie within the 1 mm/s set-back distance, residents should be notified of the vibratory construction works; exceedance of this threshold may result in complaints by residents of perceptible vibration caused by the construction works.

At the time of construction works, if any piling location does not follow the methodology indicated at the time of this assessment, then the above set-back distances must be considered, and appropriate action taken by the contractor to ensure the 5 mm/s vibration limit is not exceeded.

8 MITIGATION

8.1 GENERAL

The construction noise and vibration assessment presented in Section 6 indicates that specific mitigation measures are required to meet compliance with noise limit thresholds.

Specific mitigation measures, that must be applied to construction activities in alignment with the construction noise assessment, are identified in Section 8.2.1.

A CNVMP is recommended to be adopted as a condition of consent. This document shall be followed and updated by the contractor for the duration of the project.

The CNVMP shall include an appropriate level of detail for the contractor to follow and shall be adopted as far as reasonably practicable in accordance with the Resource Management Act (RMA).

8.2 PHYSICAL MITIGATION MEASURES

Physical mitigation shall be used to reduce noise emissions from the construction works. For the Proposed Reservoir the key to reducing the actual level of noise and vibration are:

- Equipment selection, operation, and siting of equipment.
- Adoption of physical barriers to block the line of sight between source and receiver.

Specific analysis on these physical mitigation measures is discussed below.

8.2.1 SPECIFIC MEASURES

Specific mitigation measures are required to comply with the noise criteria, as detailed in Table 8.1.

Table 8.1: Specific mitigation measures

SITUATION		SPECIFIC MITIGATION MEASURES
A	Site Establishment	At the start of site establishment, it is recommended that 3m tall site hoarding barriers are installed around the boundary of the site. The wood-chipper / mulcher equipment when operating should be placed in a screened area on the Site and surrounded by noise barriers to eliminate the line of sight to all nearby sensitive receptors when in operation. A chainsaw and wood-chipper should not be used during the early morning time 0700 to 0900 hours. Chainsaws and wood-chippers should operate no more than 15 minutes of every 1-hour period in the same location on site. Site clearance equipment should be evenly distributed around the Site and not in one location, so that noise levels to minimise cumulative noise for any one NSR.
B	Earthworks for Reservoir	The 3m tall site hoarding barriers installed during Site Establishment should remain in place. Follow managerial mitigation measures outlined in Section 8.3 as far as practicable.

SITUATION		SPECIFIC MITIGATION MEASURES
C	Pipeline & reservoir construction – with piling activities	Site barriers (minimum 3m height) shall be implemented as far as practicable to the Balgownie Grove properties. This is shown in Section 8.2.1.1. Barriers are required to meet the minimum specifications outlined in Section 8.2.1.1 in the location shown in Figure 8.1. Piling activities should generally aim to use quieter methods such as rotary bored piles, or using piling head covers/attachments to reduce the noise emissions of the equipment. Where other methods of piling are required, such as sheet piling for pipeline construction, it is mandatory to provide screening to nearby receptors.
D	Pipeline & reservoir construction – no piling activities	Barriers installed during Situation C shall be kept during this Situation. Barriers are required to meet the minimum specifications outlined in Section 8.2.1.1 in the location shown in Figure 8.1.
D-2	Pipeline & reservoir construction – night dewatering and over-pumping	Barriers installed during Situation C shall be kept during this Situation. acoustic enclosures are to be installed around the pumps and generators as outlined in Section 8.2.1.2.
E	Pipeline & reservoir construction – night-time works	Site boundary barriers (3m height) shall remain set up during this construction stage. The key for this stage is to employ managerial mitigation measures, since with noise barrier mitigation in place it is considered that there will be widespread potential adverse effects.
Site Access Road	HCVs using the site access road during all stages	Managerial mitigation shall be employed in the form of a CNVMP as outlined in Section 8.3. Physical barriers are not considered to be possible or appropriate to mitigate noise from construction vehicles using the site access road. A last resort for mitigation is to provide temporary accommodation for residents who are significantly affected by sleep disturbance, when night works are taking place. For the first set of night-time works it is likely that managerial mitigation measures are the best course of action. When the second set of night-time works takes place the extent of disruption and sleep disturbance will be known and there is a potential opportunity to take further mitigation steps and to provide temporary accommodation to those most affected. A key managerial measure will include following a defined complaints handling protocol so that those most affected parties can be identified before the second set of night-time works and reasonable action can be taken in advance of those adverse noise effects.

8.2.1.1 BARRIER DESIGN

Barriers can lower the received noise level at NSRs when the line of sight is eliminated. It is noted that barriers are less effective at mitigating noise for storeys above ground level since the line of sight is less easy to remove between the noise producing and noise sensitive element.

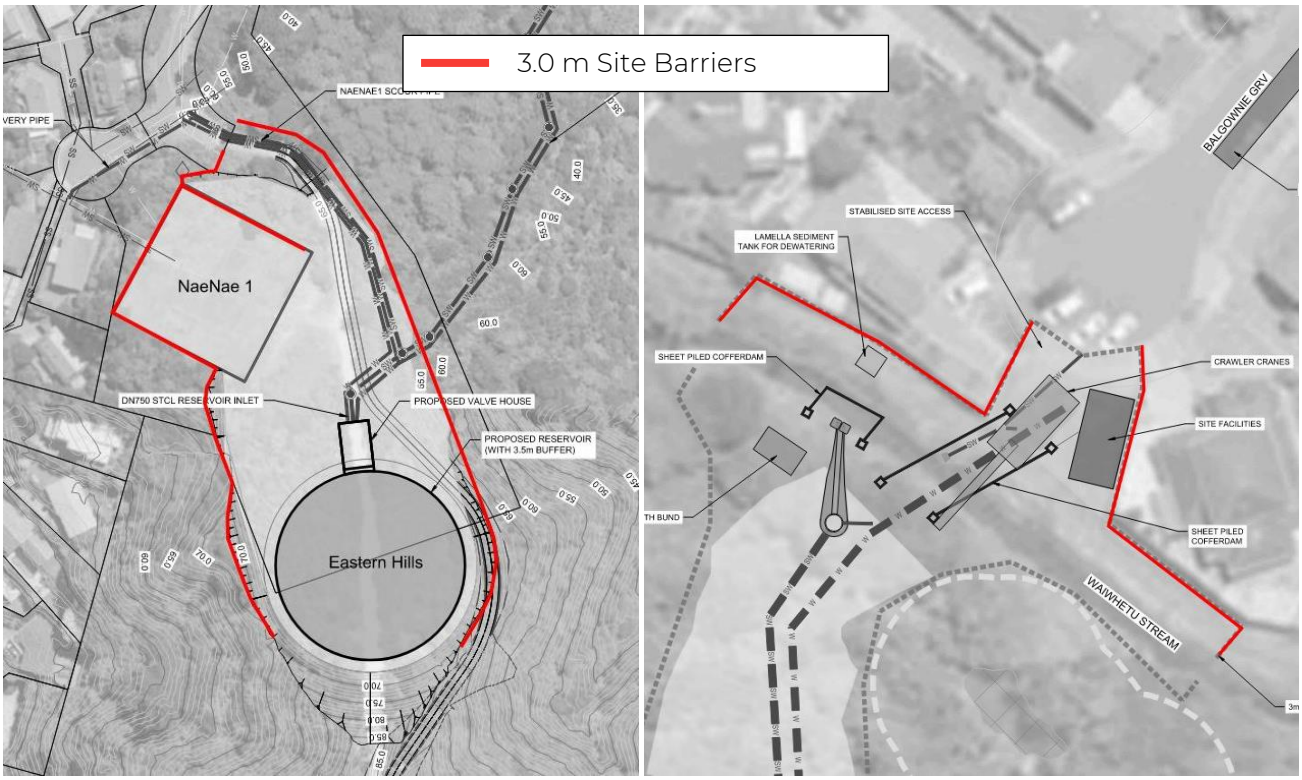
Barriers shall be set up around the site perimeter at the site establishment stage and shall be reestablished after the earthworks are completed.

Specific barriers shall be installed around pumps and generators that are used for overnight dewatering and over-pumping.

Careful positioning of noise barriers can bring about 5 – 10 dBA reduction in noise levels when constructed in accordance with the following guidance:

- The minimum height of barriers shall be specified such that no part of the noise source will be visible from the NSR where practicable.
- The length of the barrier should typically be at least five times greater than its height.
- Barriers should have no gaps or openings at joints in the barrier material.
- A barrier material with minimum surface mass of 10 kg/m2 shall be used.
- Ordinary building materials and fixed site cabins can be positioned in such a way that they provide additional noise screening.

Figure 8.1 indicates the acoustic site barrier set up to be established for construction works.



Acoustic site hoarding location at Reservoir

Acoustic site hoarding location on Balgownie Cres

Figure 8.1: Acoustic site barriers for construction noise mitigation

Figure 8.2 and Figure 8.3 presents indicative 3D aerial views of the noise model including the proposed noise barrier set up at the Reservoir that should be established for construction works.

It is noted that the location of site facilities is indicative at this stage.

If site facilities move, they should be replaced by noise barriers to an equivalent height and sufficient mass, to maintain the acoustic screening effect.

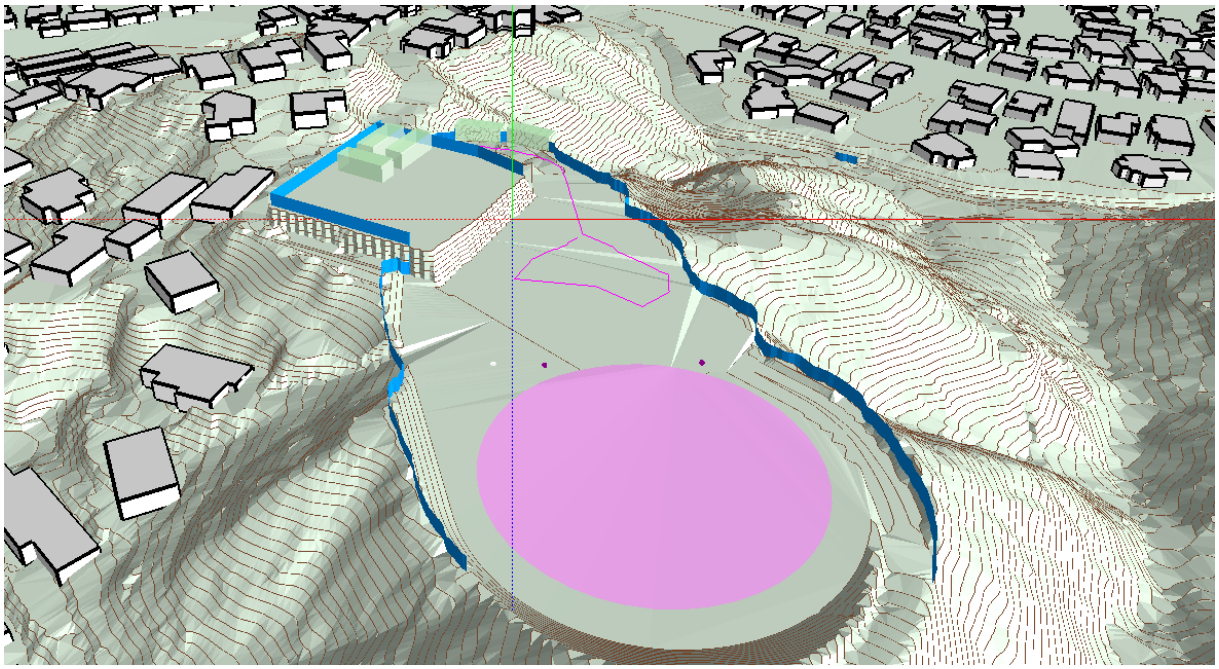


Figure 8.2: 3D aerial view of noise model looking North

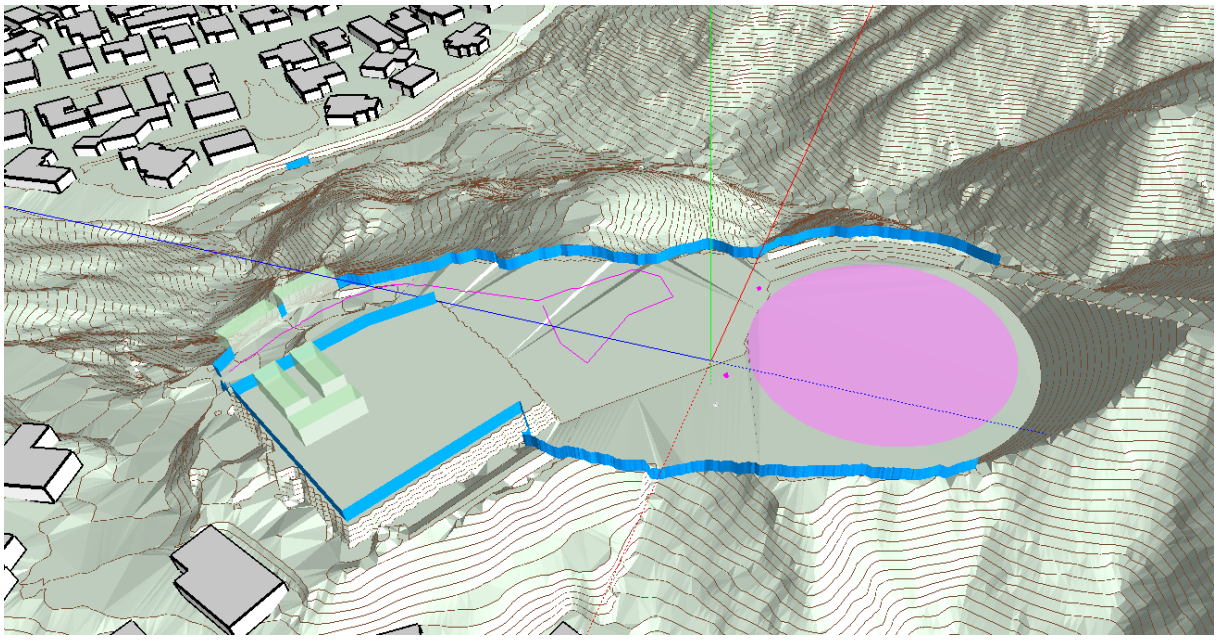


Figure 8.3: 3D aerial view of noise model looking East

8.2.2 ACOUSTIC ENCLOSURES

Due to the proximity of the pumps to adjacent residential receptors, it is recommended that all pumps and generators associated with night-time over-pumping and dewatering are installed within an acoustic enclosure. Examples of acoustic enclosures to control noise from this equipment is detailed in Annex B of NZS 6803, with relevant diagrams provided in Figure 8.1.

Figure 8.4 outlines the acoustic enclosure design to be used around pumps and generators which are to be used for night-time dewatering and over-pumping.

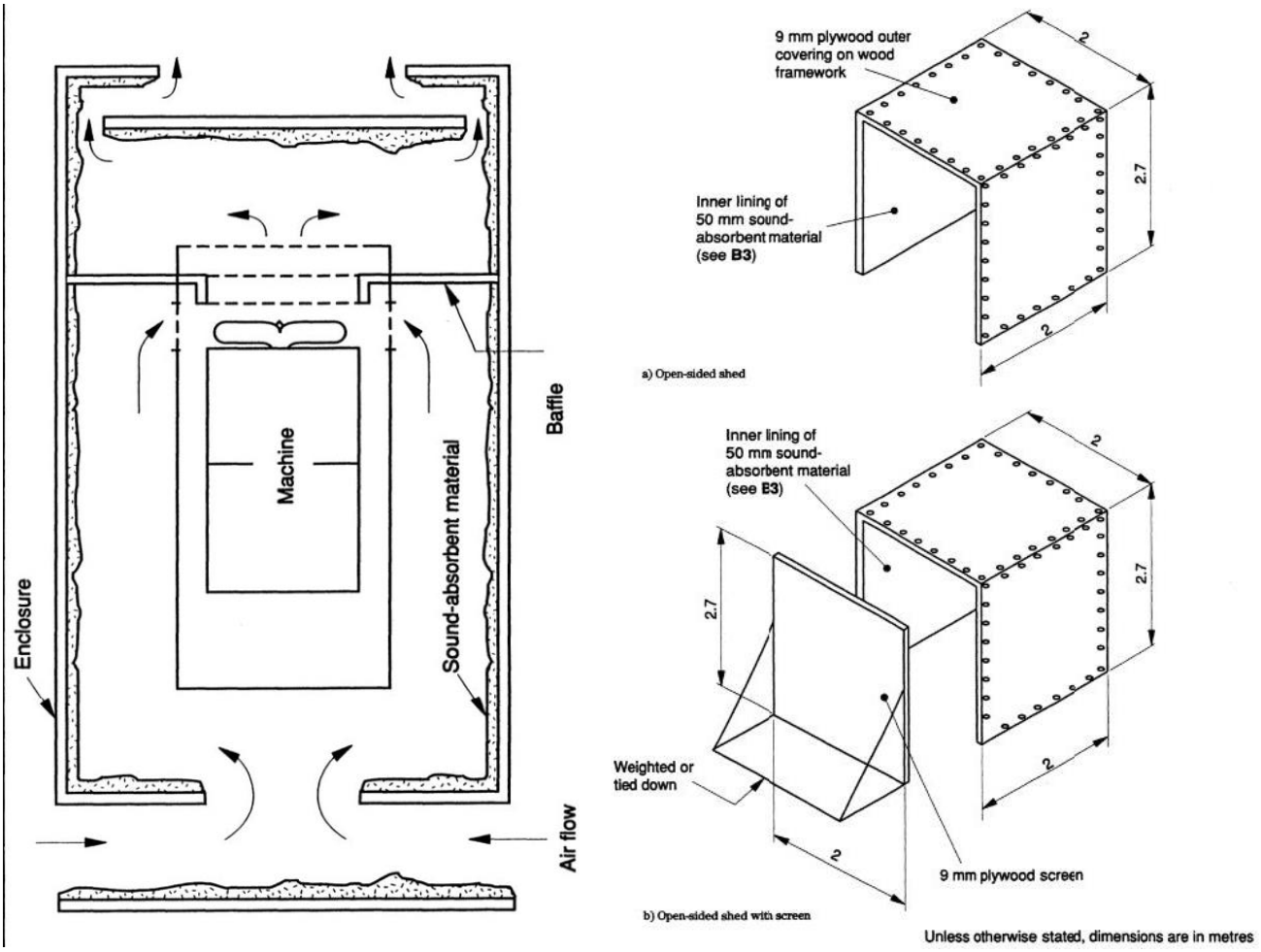


Figure 8.4: Acoustic Enclosure Details from Annex B of NZS 6803

The open side with the screen is to face the hill/stream and orientated away from the properties on Summit Road.

8.3 MANAGERIAL MITIGATION MEASURES

Managerial mitigation will be implemented to reduce the effects of noise and vibration. For this site, the key managerial mitigation measures for noise and vibration are:

- Consideration to the scheduling of works and duration of loud equipment operation.
- Opting for quieter and newer equipment models during all construction stages.
- HCV engines should be turned off when not in use, vehicles should not be left to idle when parked or waiting (this applies to on-site and off-site locations).
- Vehicle stereos and radios should be turned off when approaching site on residential roads.
- HCVs should follow a one-way turning system on the site to avoid unnecessary reverse sirens.
- Staff should be trained to follow a good level of conduct on site.

- Validation measurements and noise monitoring during the construction programme to ensure compliance with noise limits and to keep a log of construction noise and activities levels for when complaints are received.
- Engagement with the local community on the likely effects of noise and vibration and working to address concerns at an early stage.
- An established site contact and effectively managed complaints handling procedure which is followed at all times.
- Piling machines should be measured on site at the beginning of construction to ensure acoustic predictions are accurate and in line with site noise levels.

A comprehensive overview of managerial mitigation measures will be developed within a Construction Noise and Vibration Management Plan (CNVMP). In practice, the Contractor will be responsible for implementing the mitigation measures where practicable and safe to do so.

9 CONCLUSION AND RECOMMENDATIONS

9.1 GENERAL

WSP has been engaged by Wellington Water Ltd to assess the construction noise and vibration impacts for the proposed Eastern Hills Reservoir, at the top of Summit Road, Fairfield, Lower Hutt.

Construction activities that have been assessed on the site include:

- Site Establishment.
- Earthworks for Reservoir.
- Pipeline Construction.
- Reservoir and Valve House Construction.
- Landscape and Reinstatement.

The assessed situations have been developed in accordance with the proposed construction methodology that has been developed by the contractor.

Table 9.1 presents the construction activities that are assessed for each situation, and the predicted acoustic impact at NSR.

Table 9.1: Predicted acoustic impact for modelled situations

SITUATION	DESCRIPTION OF CONSTRUCTION ACTIVITIES	PREDICTED ACOUSTIC IMPACT
A	Stage 1: Site Establishment	Acceptable
B	Stage 2: Earthworks for Reservoir	Acceptable
C	Stage 3: Pipeline Construction – with piling activities Stage 4: Reservoir / Valvehouse Construction – with piling activities	Reasonable to Obvious
D	Stage 3: Pipeline Construction – no piling activities Stage 4: Reservoir / Valvehouse Construction – no piling activities	Reasonable
D2	Stage 3: Night-time dewatering and over-pumping	Acceptable
E	Stage 4: Reservoir Construction – night-time concrete pouring	Obvious
Site Access Road	Operation of site access roads during typical daytime and worst-case night-time periods	Daytime: Reasonable to Obvious Night-time: Obvious to Unreasonable

Based on the selected construction equipment, and the indicated mitigation methods within this assessment, it is predicted that the construction noise and vibration levels will be compliant with the acoustic criteria during Situation A and B works, the overall noise impacts during these stages are acceptable.

Non-compliances have been predicted during Situations C, D and E. Where non-compliances are predicted an assessment has been undertaken regarding the significance of these effects, as presented within Section 7. It is considered that the overall noise impact ranges from a reasonable to obvious perception of noise.

Additionally, an assessment of noise from site access roads has been undertaken, although this is not expressly required by the Hutt City District Plan (HCDP). It is considered that the overall noise and impact ranges from reasonable to obvious during the daytime, and obvious to unreasonable during the night-time.

Several adoptable managerial mitigation measures are recommended to reduce the risk of adverse noise affects during Situations C, D and E. Regarding noise impact and sleep disturbance, it is noted that some receptors will be more sensitive than others, the local community should be well informed regarding the proposed night works and appropriate managerial mitigation measures adopted as far as practicable.

Overall, the assessment indicates that predicted noise levels fall above the acoustic criteria but due to timing, assessment location, hours of operation, and application of best practicable means of mitigation, the level of noise impact on the receiver is not unreasonable.

All receivers are located beyond the 'standoff distances' within which vibration levels exceeding the proposed DIN 4150 vibration criteria for cosmetic building damage are predicted. Considering the selection, location, and duration of operation of the equipment that is set out in this assessment it is considered that this vibration criteria will be achieved. However, it is noted that some amenity areas of NSRs may lie within the vibration set-back distance for human annoyance, and so residents should be notified of vibratory construction works.

To mitigate and minimise the impact of noise and vibration on adjacent NSRs, we recommend designation conditions and conditions of consent are adopted, as outlined below.

9.2 RECOMMENDED CONDITIONS OF CONSENT

We recommend the following conditions be included in the final resource consent, notice of requirement and altered designation:

A CNVMP shall be implemented, in accordance with Annex E2 of NZS 6803:1999 and Policy 14C 1.1 (g) of the HCDP.

10 LIMITATIONS

This report ('Report') has been prepared by WSP New Zealand Limited ('WSP') exclusively for Wellington Water ('Client') in relation to the Construction Noise and Vibration Impact Assessment for Eastern Hills Reservoir ('Purpose') and in accordance with the Wellington Water Consultant Project Engagement form dated 10th March 2023 ('Agreement'). The findings in this Report are based on and are subject to the assumptions specified in the Report Offer of Services dated 10th March 2023. WSP accepts no liability whatsoever for any use or reliance on this Report, in whole or in part, for any purpose other than the Purpose or for any use or reliance on this Report by any third party.

APPENDIX A

GLOSSARY OF TECHNICAL TERMS

TERM	DESCRIPTION
A-weighting, dBA	The unit of sound level, weighted according to the A-scale, which takes into account the increased sensitivity of the human ear at some frequencies at low levels.
Ambient noise	The all-encompassing sound, at a given place at a certain time, being usually a composite of sounds from many sources near and far.
Decibel (dB)	A scale for comparing the ratios of two quantities, including sound pressure and sound power. The difference in level between two sounds s_1 and s_2 is given by 20 log10 (s_1 / s_2). The decibel can also be used to measure absolute quantities by specifying a reference value that fixes one point on the scale. For sound pressure, the reference value is 20µPa.
Façade Level	A noise level measured/assessed at a distance of 1 metre in front of a sound reflecting object such as a building façade and including the contribution of the sound reflection.
Free-Field Level	Far from the presence of sound reflecting objects (except the ground), usually taken to mean at least 3.5 metres.
$L_{eq,T}$	A noise level index called the equivalent continuous noise level over the time period T. This is the level of a notional steady sound that would contain the same amount of sound energy as the actual, possibly fluctuating, sound that was recorded.
$L_{10,T}$	A statistical analysis noise descriptor being a sound pressure level exceeded for 10% of the measurement period.
$L_{Max,T}$	A noise level index defined as the maximum noise level during the period T. L_{Max} is sometimes used for the assessment of occasional loud noises, which may have little effect on the overall L_{eq} noise level but will still affect the noise environment. Unless described otherwise, it is measured using the 'fast' sound level meter response.
L_{peak}	The instantons peak pressure level recorded during the measurement period.
NSR	Noise Sensitive Receptor: For this assessment, this term refers to any residential property.
Octave Band	A range of frequencies whose upper limit is twice the frequency of the lower limit.
PPV	Peak Particle Velocity: Measure of the greatest instantaneous velocity change in a specific spot during a measurement period.
Sound Power Level (SWL)	The logarithmic measure in decibels of the sound power (P) generated by a source.
Sound Pressure	Sound, or sound pressure, is a fluctuation in air pressure over the static ambient pressure.
Sound Pressure Level (SPL)	The sound level is the sound pressure relative to a standard reference pressure of 20µPa ($20x10^{-6}$ Pascals) on a decibel scale.

APPENDIX B

EQUIPMENT NOISE AND VIBRATION DATA

CONSTRUCTION EQUIPMENT					
SITUATON	**ACTIVITY**	**EQUIPMENT**	**SWL L_{wAeq} (dB)**	**SWL $L_{wA,MAX}$ (dB)**	**% ON TIME**
A	Site Establishment	Tracked Mobile Crane	103	-	100%
		Chainsaw	113	113	25%
		Woodchipper	113	113	25%
		Clearing site: Wheeled backhoe loader	96	-	100%
		20T Excavator	99	105	100%
		13T Excavator	107	-	100%
		Handheld and general site powertools	100	-	100%
		Truck Idling	91		100%
		Diesel Generator	107	-	100%
		6–8-wheel Rigid Truck	-	113	-
B	Earthworks for Reservoir	Tracked Mobile Crane	103	-	100%
		Truck Idling	91		100%
		Diesel Generator	107	-	100%
		30T Excavator	104	105	100%
		20T Excavator	99	105	100%
		13T Excavator - Loading Lorries	107	-	100%
		6–8-wheel rigid Truck	-	113	-
C	Pipeline & reservoir construction – with piling activities	Tracked Mobile Crane	103	-	100%
		Excavator (trenching)	99	105	100%
		Excavator (backfilling)	102	105	100%
		Vibratory compaction roller	105	112	100%
		Vibratory sheet piling	116	133	100%
		Concrete truck, pump and boom	108	-	100%
		Tracked Mobile Crane	103	-	100%
		Poker Vibrator	106	-	100%
		Concrete Breaker	120	120	100%
		Diesel Generator	107	-	100%
		Handheld and general site powertools	100	-	100%
		6–8-wheel rigid Truck	-	113	-
D	Pipeline & reservoir construction – no piling activities	Tracked Mobile Crane	103	-	100%
		Excavator (trenching)	99	105	100%
		Excavator (backfilling)	102	105	100%
		Vibratory compaction roller	105	112	100%
		Concrete truck, pump and boom	108	-	100%
		Tracked Mobile Crane	103	-	100%
		Poker Vibrator	106	-	100%
		Concrete Breaker	120	120	100%
		Diesel Generator	107	-	100%

CONSTRUCTION EQUIPMENT					
SITUATON	**ACTIVITY**	**EQUIPMENT**	**SWL L_{wAeq} (dB)**	**SWL $L_{wA,MAX}$ (dB)**	**% ON TIME**
		Handheld and general site powertools	100	-	100%
		6–8-wheel rigid Truck	-	113	-
D-2	Night works dewatering and over-pumping only.	Overpumping pump	90	-	100%
		Dewatering pump	82	-	100%
		Generator	94	-	100%
E	Pipeline & reservoir construction – night-time works	Tracked Mobile Crane	103	-	100%
		Concrete truck, pump and boom	108	-	100%
		Poker Vibrator	106	-	100%
		Handheld and general site powertools	100	-	100%
		6–8-wheel rigid Truck	-	113	-

VIBRATORY EQUIPMENT		
ACTIVITY		**VIBRATION LEVEL (mm/s PPV @10m)**
1	Piling - Rotary (e.g., CFA)	0.48
2	Piling – Sheet Piles	2.50
3	Excavator	1.90
4	Vibratory Roller	3.60
5	HCV Pass	0.03

APPENDIX C

NOISE ASSESSMENT CONTOURS

The following noise contours are presented for situations with mitigation measures applied:

- Situation A – Site Establishment
- Situation B – Earthworks for Reservoir
- Situation C – Pipeline & Reservoir Construction – with piling activities
- Situation D – Pipeline & Reservoir Construction – no piling activities
- Situation E – Pipeline & Reservoir Construction – night-time works
- Site Access Road – Daytime
- Site Access Road – Night-time
- Maximum Noise Level Buffers for Piling near Balgownie Grove
- Maximum Noise Level Buffers for Piling at Proposed Reservoir
- Maximum Noise Level Buffers for Grading at Site Entrance
- Maximum Noise Level Buffers for Site Access Roads

N

KEY

Proposed Development

Buildings

Noise Level (LAeq,1h)

70 dB

75 dB

80 dB

85 dB

WSP
100 Beaumont Street,
PO Box 5848
Auckland
+64 9 355 9500

PROJECT
Wellington Water
Eastern Hills Reservoir

DRAWN	APPROVED	REV	REV DATE	TITLE
LT	SM	00	10/07/2023	Construction Noise Contours
PROJECT NO	SCALE	PLAN NO	SHEET NO	DESCRIPTION
3-WW021.02	Not to scale	n/a	1 of 11	Situation A - with mitigation

N

KEY

Proposed Development

Buildings

Noise Level (LAeq,1h)

70 dB

75 dB

80 dB

85 dB

WSP
100 Beaumont Street,
PO Box 5848
Auckland
+64 9 355 9500

PROJECT
Wellington Water
Eastern Hills Reservoir

DRAWN	APPROVED	REV	REV DATE	TITLE
LT	SM	00	10/07/2023	Construction Noise Contours
PROJECT NO	SCALE	PLAN NO	SHEET NO	DESCRIPTION
3-WW021.02	Not to scale	n/a	2 of 11	Situation B - with mitigation

N

KEY

Proposed Development

Buildings

Noise Level (LAeq,1h)

70 dB

75 dB

80 dB

85 dB

WSP
100 Beaumont Street,
PO Box 5848
Auckland
+64 9 355 9500

PROJECT
Wellington Water
Eastern Hills Reservoir

DRAWN	APPROVED	REV	REV DATE	TITLE
RP	SM	01	18/09/2023	Construction Noise Contours
PROJECT NO	SCALE	PLAN NO	SHEET NO	DESCRIPTION
3-WW021.02	Not to scale	n/a	3 of 11	Situation C - with mitigation

N

KEY

Proposed Development

Buildings

Noise Level (LAeq,1h)

70 dB

75 dB

80 dB

85 dB

WSP
100 Beaumont Street,
PO Box 5848
Auckland
+64 9 355 9500

PROJECT
Wellington Water
Eastern Hills Reservoir

DRAWN	APPROVED	REV	REV DATE	TITLE
RP	SM	01	18/09/2023	Construction Noise Contours
PROJECT NO	**SCALE**	**PLAN NO**	**SHEET NO**	**DESCRIPTION**
3-WW021.02	Not to scale	n/a	4 of 11	Situation D - with mitigation

N

KEY

- Proposed_Development
- Buildings
- 300m Site Buffer

Noise Level (LAeq,1h)

- 45 dB
- 50 dB
- 55 dB
- 60 dB
- 65 dB
- 70 dB
- 75 dB
- 80 dB
- 85 dB

WSP
100 Beaumont Street,
PO Box 5848
Auckland
+64 9 355 9500

PROJECT
Wellington Water
Eastern Hills Reservoir

DRAWN	APPROVED	REV	REV DATE	TITLE
LT	SM	00	10/07/2023	Construction Noise Contours
PROJECT NO	SCALE	PLAN NO	SHEET NO	DESCRIPTION
3-WW021.02	Not to scale	n/a	5 of 11	Situation E - with mitigation

N

N.B. Daytime operation of site access road is likely to cause noise levels in the range of 69 to 74 dB $L_{Aeq,1h}$ on the worst-case day. This is likely to occur on a few occasions during the whole construction works.

N.B. Daytime operation of site access road is likely to cause noise levels in the range of 74 to 79 dB $L_{Aeq,1h}$

KEY

- Proposed Development
- Buildings
- Buildings near access road

Noise Level (LAeq,1h)

- 70 dB
- 75 dB
- 80 dB
- 85 dB

WSP
100 Beaumont Street,
PO Box 5848
Auckland
+64 9 355 9500

PROJECT
Wellington Water
Eastern Hills Reservoir

DRAWN	APPROVED	REV	REV DATE	TITLE
LT	SM	00	14/08/2023	Construction Noise Contours
PROJECT NO	**SCALE**	**PLAN NO**	**SHEET NO**	**DESCRIPTION**
3-WW021.02	Not to scale	n/a	6 of 11	Site Access Road - Daytime

N

KEY

Proposed Development

Buildings

Noise Level (LAeq,1h)

45 dB	70 dB
50 dB	75 dB
55 dB	80 dB
60 dB	85 dB
65 dB	

WSP
100 Beaumont Street,
PO Box 5848
Auckland
+64 9 355 9500

PROJECT
Wellington Water
Eastern Hills Reservoir

DRAWN	APPROVED	REV	REV DATE	TITLE
RP	SM	01	15/09/2023	Construction Noise Contours
PROJECT NO	**SCALE**	**PLAN NO**	**SHEET NO**	**DESCRIPTION**
3-WW021.02	Not to scale	n/a	7 of 11	Site Access Road - Night-time

N

KEY

- Proposed Development
- Buildings
- Indicative work location
- Piling - Full Screening (85 dB LAmax)
- Piling - Partial Screening (85 dB LAmax)
- Piling - No Screening (85 dB LAmax)

WSP
100 Beaumont Street,
PO Box 5848
Auckland
+64 9 355 9500

PROJECT
Wellington Water
Eastern Hills Reservoir

DRAWN	APPROVED	REV	REV DATE	TITLE
LT	SM	00	16/08/2023	Construction Noise Buffers (L_{Amax})
PROJECT NO	SCALE	PLAN NO	SHEET NO	DESCRIPTION
3-WW021.02	Not to scale	n/a	8 of 11	Indicative work location near Balgownie Grove

N

KEY

- Proposed Development
- Buildings
- Indicative work location
- Piling - Full Screening (85 dB LAmax)
- Piling - Partial Screening (85 dB LAmax)
- Piling - No Screening (85 dB LAmax)

WSP
100 Beaumont Street,
PO Box 5848
Auckland
+64 9 355 9500

PROJECT
Wellington Water
Eastern Hills Reservoir

DRAWN	APPROVED	REV	REV DATE	TITLE
LT	SM	00	16/08/2023	Construction Noise Buffers (L_{Amax})
PROJECT NO	SCALE	PLAN NO	SHEET NO	DESCRIPTION
3-WW021.02	Not to scale	n/a	9 of 11	Indicative work location at Proposed Reservoir

N

KEY

- Proposed Development
- Buildings
- Indicative work location
- Grader (75 dB LAmax)

WSP
100 Beaumont Street,
PO Box 5848
Auckland
+64 9 355 9500

PROJECT
Wellington Water
Eastern Hills Reservoir

DRAWN	APPROVED	REV	REV DATE	TITLE
LT	SM	00	16/08/2023	Construction Noise Buffers (L_{Amax})
PROJECT NO	SCALE	PLAN NO	SHEET NO	DESCRIPTION
3-WW021.02	Not to scale	n/a	10 of 11	Indicative work location at Site Entrance

N

KEY

- Proposed Development
- Buildings
- Indicative truck location
- Truck Pass (85 dB LAmax)
- Truck Pass (75 dB LAmax)

WSP
100 Beaumont Street,
PO Box 5848
Auckland
+64 9 355 9500

PROJECT
Wellington Water
Eastern Hills Reservoir

DRAWN	APPROVED	REV	REV DATE	TITLE
LT	SM	00	16/08/2023	Construction Noise Buffers (L_{Amax})
PROJECT NO	**SCALE**	**PLAN NO**	**SHEET NO**	**DESCRIPTION**
3-WW021.02	Not to scale	n/a	11 of 11	Site Access Roads