REPORT

Tonkin+Taylor

Pump Station 23 Ecological Enhancement

Coastal Processes Assessment and Consent Level Design

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Executive summary

Watercare Services Ltd (Watercare) has commissioned Tonkin and Taylor Ltd (T+T) to provide planning, coastal engineering and ecology advice in relation to ecological enhancement works in the vicinity of Pump Station 23 (PS 23), as part of the Central Interceptor (CI) project. This site is located in Auckland on the northern shores of the Manukau Harbour, approximately 2 km northwest of the Onehunga Wharf.

The ecological enhancement works include the construction of a salt marsh and bird roosting area. A rock sill has been designed to surround these areas to provide shelter for salt marsh vegetation and also minimise the loss of shelly material that surfaces the bird roosting area. Refer to Figure.1 below for the proposed layout of the ecological enhancement works. Timber bird posts are also proposed in the intertidal area to provide areas for birds to rest on, separated by water from the coastal edge at times of higher tide.

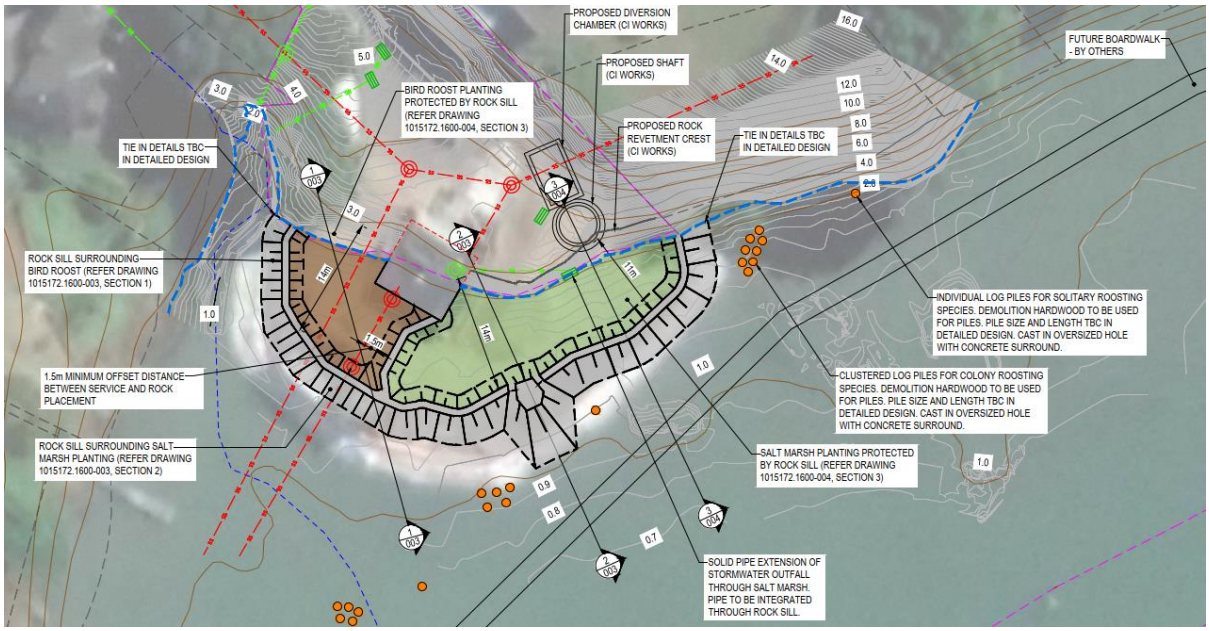


Figure.1: Proposed ecological enhancement at PS 23.

This report provides information on coastal processes, consent level engineering design, construction methodology and potential effects assessment to inform an Assessment of Environmental Effects (AEE) for resource consent. Consent level design drawings are provided in Appendix B.

This report considers a range of effects on coastal processes during construction and after the works are completed. The proposed works occupy approximately 1,000 m^2 of Coastal Marine Area (CMA), extending over an intertidal area approximately 20 m seaward of the existing high-water extent. Potential maintenance of the works could include the occasional re-placement of dislodged rocks, supplementary planting, and/or re-surfacing of shelly material bird roosting following rare large storm events.

Overall, effects on coastal processes are considered to be low. Although the proposed works occupy the CMA to have sufficient space to serve as a useful ecological enhancement function, the entire extent of the planting area, rock sill and rock platform would still operate as a natural, coastal environment. The design provides a naturalised coastal edge that responds to winds, waves and currents approaching the site. The size of the enhancement works is small in scale and its location

outside the main harbour channel prevents it from affecting coastal processes of the wider coastal environment.

1 Introduction

Watercare Services Ltd (Watercare) has commissioned Tonkin and Taylor Ltd (T+T) to provide planning, coastal engineering, and ecology advice in relation to ecological enhancement works in the vicinity of Pump Station 23 (PS 23), as part of the Central Interceptor (CI) project. This site is located in Auckland on the northern shores of the Manukau Harbour, approximately 2 km northwest of the Onehunga Wharf. It is located on the main CI project tunnel alignment and is one of the various sites consented to facilitate construction for the installation of the CI, a 14.7 km-long wastewater tunnel that will run between the Māngere Wastewater Treatment Plant and Grey Lynn.

Three ecological enhancement concepts were initially developed by Isthmus Group and T+T. Watercare has reviewed these options and received feedback from Mana Whenua, leading to the selection of 'Concept 3' as the preferred option. Concept 3 includes the construction of a salt marsh and bird roosting area. A rock sill has been designed to surround these areas providing shelter for salt marsh vegetation, and to minimise the loss of shelly material that surfaces the bird roosting area. Timber bird posts are also proposed, scattered in the intertidal area to provide areas for birds to rest on, separated by water from the coastal edge at times of higher tide.

This report provides information on coastal processes, consent level design, construction methodology and effects assessment to inform an Assessment of Environmental Effects (AEE) for resource consent. Consent level design drawings are provided in Appendix B.

This report is outlined as follows:

- Section 2 of this report describes the project site.
- Section 3 of this report discusses coastal processes pertinent to design such as water levels, currents and wave climate.
- Section 4 describes key design parameters.
- Section 5 summarises the effect of the proposed structures on coastal processes at the site.

2 Site context

2.1 Site location

The site is located in Auckland on the northern shores of the Manukau Harbour, approximately 2 km northwest of the Onehunga Wharf. Vehicle access is provided via 39 Frederick Street, Hillsborough. (Figure 2.1). The general surrounding area is residential, and there are esplanade reserves on either side of the PS 23 Site.

Figure 2.1: Site location.

2.2 Built environment

The PS 23 building is located directly on the coastal edge, built from concrete and blockwork construction. The main Central Interceptor (CI) project tunnel alignment runs adjacent to this building. This 14.7 km-long wastewater tunnel will run between the Māngere Wastewater Treatment Plant and Grey Lynn.

A piped water course runs along 35 Frederick Street into an open water course which discharges to the intertidal area immediately west of PS 23 (Figure 2.3).

Loose rocks intended as informal coastal protection extend east of PS 23 along the coastal edge. As part of the CI project, a rock revetment will be constructed in this location (drawings for this structure are included in Appendix B). A stormwater outlet is visible in the crest of the rock placement (Figure 2.2). This service has since been removed (although may be reinstated in future).

Figure 2.2: PS 23 building (labelled pump station).

Figure 2.3: View of PS 23 building (labelled pump station) and stream/open water course on site.

A temporary working platform was constructed in December 2021 with extents shown in Figure 2.4 and Figure 2.5 (images in Figure 2.2 and Figure 2.3 predate these works). An indicative outline of this temporary platform is shown Appendix A consent level design drawings. We understand this platform is constructed using GAP65 clean hardfill.

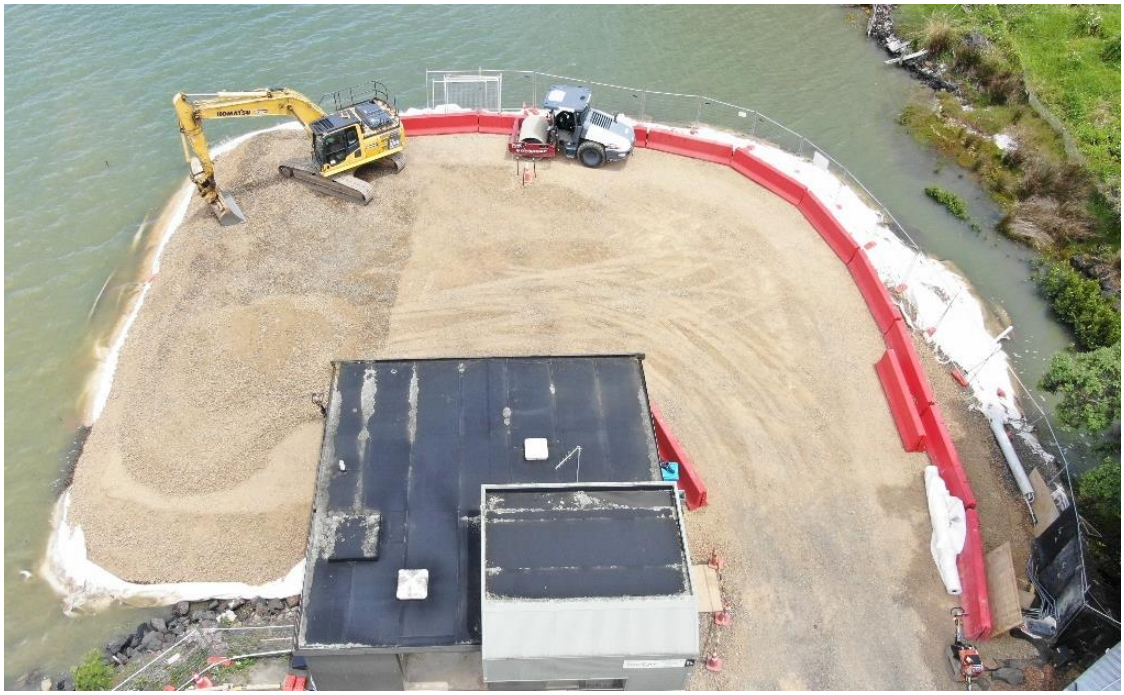


Figure 2.4: Drone photo of the temporary construction platform taken on 22 December 2021 (Watercare, 2021).

Figure 2.5: Drone photo of the temporary construction platform taken on 6 May 2022 (Watercare, 2022).

2.3 Topography and bathymetry

All horizontal datums (coordinate system) in this report are with reference to New Zealand Transverse Mercator 2000 (NZTM2000). All vertical elevations in this report are with reference to Auckland Vertical Datum 1946 (AVD46), referred to as RL (reduced level). AVD46 is 2.2 m above Chart Datum (CD), based on the mark details from Land Information New Zealand (LINZ, 2012) Chart NZ4314.

Two sources of topographic information have been reviewed in this study: Lands and Survey Limited (n.d.), and LiDAR (LINZ, 2013). Consent level design is primarily based on Lands and Survey Limited information with levels approximately 0.3 - 0.5 m lower than 2013 LiDAR levels. We consider the site-specific Lands and Survey Limited survey to be more accurate than the regional lidar information. Figure 2.6 shows ground level contours of the site from the Lands and Survey Ltd and LINZ in terms of AVD46.

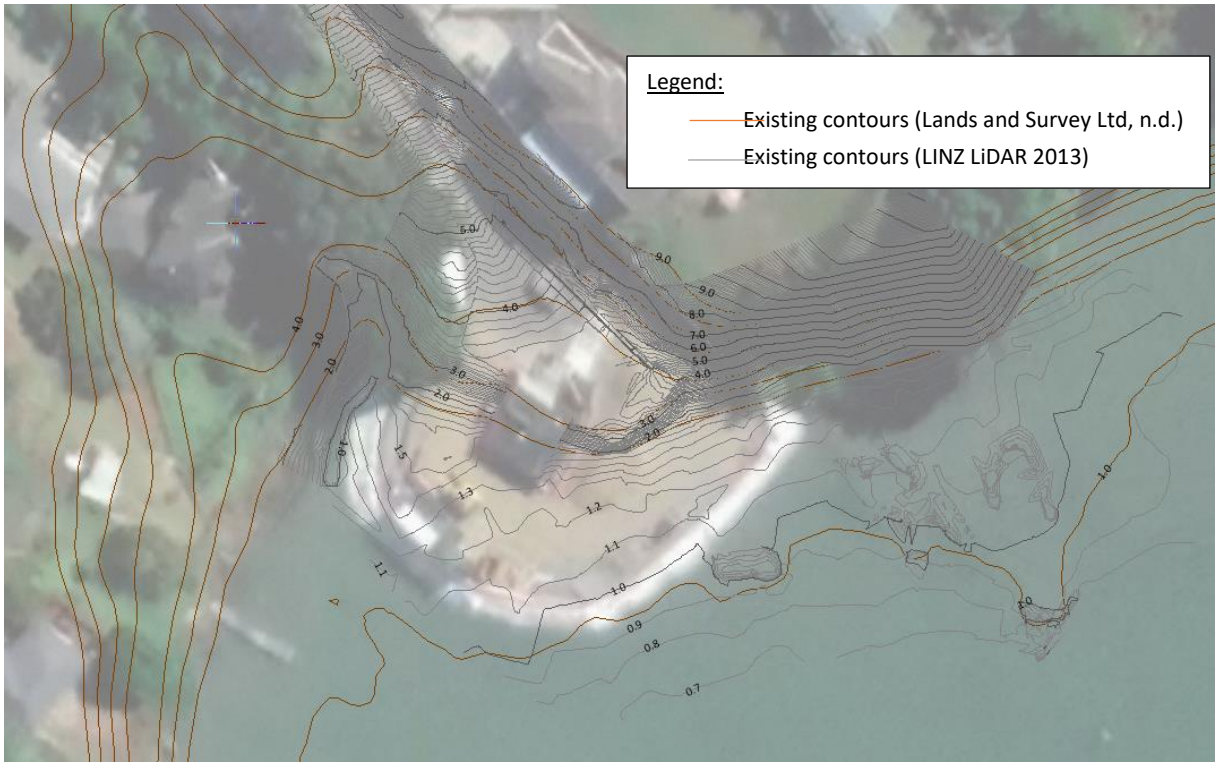


Figure 2.6: Topographical survey by Lands and Survey Ltd (xxx) and LINZ (2013).

Survey information indicates crest levels along the coastal edge of 3 m RL, sloping down steeply into the upper intertidal area of around 2 m RL.

Within the intertidal area, typical grades of 1:25 (V:H) are noted, with weathered outcrops of rocky reef exposed in a few areas, typically not more than 0.2 m higher than the surrounding area (Figure 2.7).

Figure 2.7: Intertidal area at the site.

Figure 2.8: Chart of Hillsborough Bay (LINZ, 2012). shows the Hydrographic Chart for Hillsborough Bay taken from the chart of Manukau Harbour from the LINZ database (LINZ, 2012). This chart provides seabed levels in terms of CD. It shows a wide intertidal area extending approximately 0.7 km south towards the main harbour channel. The main tidal channel is aligned east-west, less than 500 m in width, with deepest areas at around -3 m to -4 m CD.

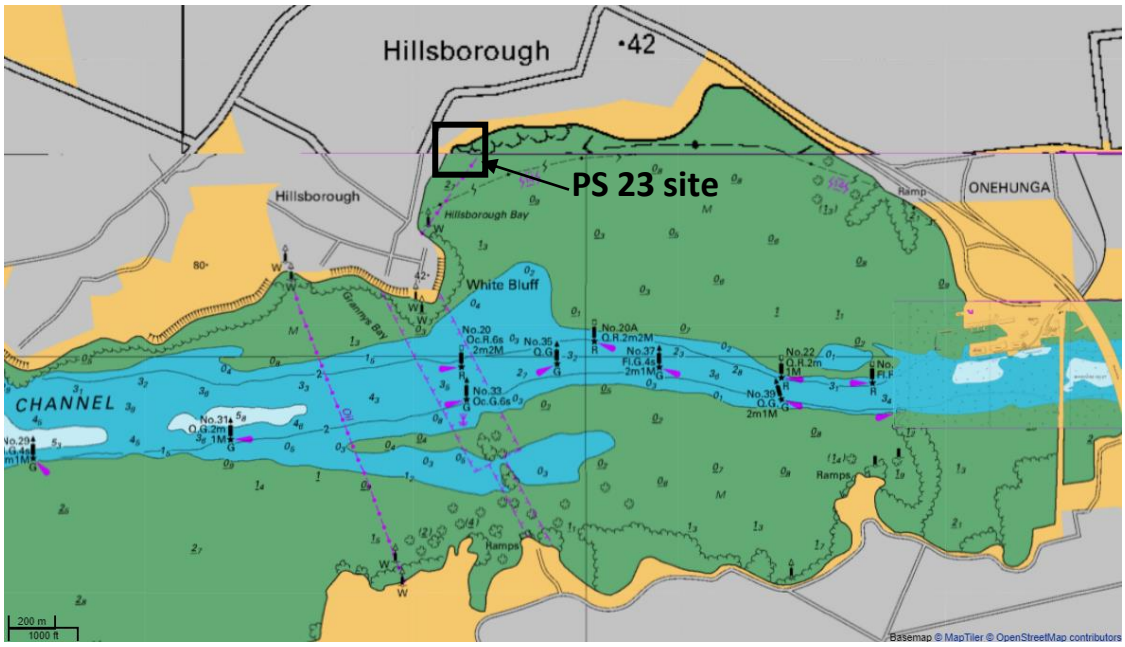


Figure 2.8: Chart of Hillsborough Bay (LINZ, 2012).

2.4 Geology and beach sediments

The GNS science 1:250k geological map of the Auckland area (GNS, 2022) indicates the site as being underlaid by East Coast Bays Formation rock, comprising alternating sandstone and mudstone with variable volcanic content and interbedded volcaniclastic grits.

A site inspection of the intertidal area was undertaken by a Senior Coastal engineer on 27 October 2021. Loose gravel and cobbles are spread over the upper intertidal area surrounding the pump station which appear to have been left over material from civil works associated with PS 23 (prior to CI works).

Small volumes of beach sand were confined to a few very sheltered areas in the supra and upper intertidal. Surface sediment within exposed areas of the intertidal area typically comprised fine silt.

This material was firm underfoot, becoming very soft in those areas closest to the open water course. Hand augers undertaken by T+T in December 2021 around the pump station building and within the intertidal area indicated 0.5 to 1.5 m of stiff to very stiff variable marine sediments overlying very stiff to hard weathered East Coast Bays Formation rock.

3 Environmental conditions

3.1 Water levels

Water level at any location varies across a range of timescales. Key components that contribute to the coastal inundation hazard assessment (Section 5) include:

- Astronomical tides;
- Barometric and wind effects, generally referred to as storm surge;
- Medium term fluctuations, including ENSO and IPO effects;
- Long-term changes in sea level; and
- Wave breaking can also contribute to water level through wave setup and run-up.

3.1.1 Astronomical tide

Published tide levels (LINZ, 2022) are available from Onehunga wharf approximately 2 km east of the PS 23 site. These levels are summarised in CD and have been converted to m RL (AVD46). This information indicates tidal ranges between 3.6 m over spring tides to 1.9 m over neap tides.

Table 3.1: Tide levels at PS 23 (taken as for Onehunga Wharf) (LINZ, 2022)

Reference levels	m CD	m RL
Mean high water springs (MHWS)	4.17	1.97
Mean high water neap (MHWN)	3.34	1.14
Mean sea level (MSL)	2.44	0.24
Mean low water neap (MLWN)	1.44	-0.76
Mean low water spring (MLWS)	0.56	-1.64
Chart datum (CD)	0.00	-2.20

3.1.2 Storm surge and storm tide

Storm surge results from the combination of barometric setup from low atmospheric pressure and wind stress from winds blowing along or onshore. This process elevates the water level above the predicted tide. The combined elevation of the predicted tide and storm surge is known as the storm tide.

Extreme storm tide levels comprising of astronomical tide and storm surge are presented in Table 3.2, adapted from Stephens *et al*. (2016). The levels for Location 15 in the Manukau Harbour (refer Figure 3-15 and Table 3-6 in Stephens *et al*. ,2016) were adopted for the project site due to its proximity to the site (approximately 0.5 km east of the project site).

Extreme sea level elevations reported in Stephens *et al*. (2016) relate to 2011 levels. We have allowed for 0.02 m of sea level rise over 11 years (2011 to present day) since this work was undertaken, based on an average sea level rise of 1.7 mm / year (Hannah and Bell, 2018). Table 3.2 shows the adjusted present-day water levels adopted at the site.

Table 3.2: Extreme sea-level at PS 23 site (present day), excluding wave setup

Annual Exceedance Probability (AEP)	39 %	18 %	10 %	5 %	2 %	1 %
Elevation (m RL)	2.52	2.59	2.65	2.73	2.85	2.94

3.1.3 Wave setup

Waves can both super-elevate the mean water level during the breaking process (termed wave setup) and cause impulsive damage due to wave run up. The low gradients across the 700 m wide intertidal area offshore from PS 23 is likely to cause wave breaking and limiting wave heights along the backshore, particularly so at lower tides. Contributions to water levels from wave setup has been allowed for in Section 3.7.2, estimated as approximately 17% of the offshore wave height (Thornton and Guza, 1983).

3.1.4 Sea level rise

Historical sea level rise (SLR) for the Auckland region has averaged 1.7 ± 0.1 mm / year (Hannah and Bell, 2018). Climate change is predicted to accelerate this rate of sea level rise into the future. The New Zealand Coastal Policy Statement (NZCPS, 2010) requires identification of coastal hazards including consideration of sea level rise over at least a 100-year planning period.

New Zealand guidance for sea level rise (MfE, 2017[1]) based on the IPCC 5th Assessment Report (IPCC, 2014) suggests various climate scenarios corresponding to different Representative Concentration Pathways (RCPs). The values in Table 10 from MfE (2017) have been adjusted to allow for the estimated SLR to the present day. The resulting SLR allowances are given in Table 3.3.

Table 3.3: Sea level rise for various projection scenarios, adapted from MfE (2017)

	Emission Scenario			
Time frame	**RCP 2.6M**	**RCP 4.5M**	**RCP 8.5M**	**RCP 8.5+**
50 years (~2080)	0.30 m	0.34 m	0.46 m	0.64 m
100 years (~2130)	0.52 m	0.66 m	1.09 m	1.41 m

3.2 Wind

Wind data was sourced from the National Institute of Water and Atmospheric Research (NIWA) weather gauging station at Auckland Airport (C74082), located approximately 10 km of this site. This data is considered representative of winds occurring in the Manukau Harbour due to its close proximity and long period of establishment. The wind data considered was collected on an hourly basis from May 1962 to May 2014 (52-year duration), measured 7 m above MSL.

Data is provided as frequencies in knots divisions from 10-degree directions. Wind speeds were converted to meters per second and using a conversion equation, were transformed to wind speeds as they would occur 10 m above MSL. The wind rose comprising wind speeds (m/s) and probability of occurrence per direction have been presented in Table 3.1.

[1] Subsequent to commencement of this work MfE (2022) guidance provides updated sea level rise projections to suit revised scenarios in IPCC AR6.

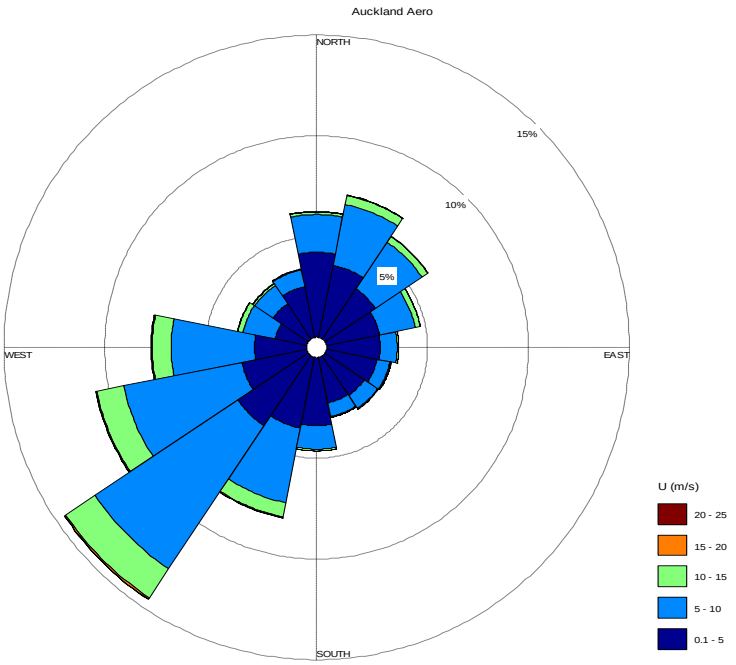


Figure 3.1: Auckand airport wind rose.

The wind rose in Figure 3.1 indicates prevailing winds from south-west, with the potential for high winds from the north-east on comparatively rarer occasions. The PS 23 site is located at the base of south facing sea cliffs with a headland at the western end of Taylor's Bay. Sheltering effects of the landform limits exposure to winds from the south, south-east and east. Collectively, wind from these directions is typically lighter (not exceeding 10 m/s) occurring less than 10% of the time.

3.3 Wave climate

The project site is located within the upper reaches of Manukau Harbour and sheltered from open coast waves outside the Manukau Harbour entrance. Inside the harbour, waves are locally generated from wind blowing across the water surface. In this setting, the largest wind waves are expected when wind speeds are also highest, occurring in a direction with the longest fetch distance, at a time when tidal water levels provide the greatest depth of water.

Wave hindcasting was undertaken to assess the wave climate from the wind speeds provided in AS/NZS1170.2 using a method provided in the Coastal Engineering Manual (CEM) (USACE, 2006) that provides the significant wave height (H_s) and peak wave period (T_p). The project site is exposed to south, south-east and east wind directions over fetch lengths of 1.6 km, 2.4 km, and 1.5 km respectively (Figure 3.2). Of these directions, highest wind wave heights shown in Table 3.4 are expected from the south-east.

Figure 3.2: Fetch distance from the project site.

Table 3.4: Wave height (H_s) and period (T_p) estimates

Direction	63% AEP (1-yr ARI) wind event		10% AEP (10-yr ARI) wind event		2% AEP (50-yr ARI) wind event		1% AEP (100-yr ARI) wind event	
	H_s (m)	*T_p (s)*	H_s (m)	*T_p (s)*	H_s (m)	*T_p (s)*	H_s (m)	*T_p (s)*
S	0.4	*1.8*	0.5	*1.8*	0.6	*1.9*	0.6	*2.0*
E	0.4	*1.7*	0.5	*1.8*	0.6	*1.9*	0.6	*1.9*
SE	0.5	*2.0*	0.6	*2.1*	0.7	*2.2*	0.8	*2.3*

By observation and as a general rule, the shallow intertidal area is expected to limit significant wave heights to 0.6d, where d is the water depth for any particular location of interest. For example, a wave height of 0.8 m in Table 3.4 under the 1% AEP southeast event requires 1.3 m of water depth before wave breaking and subsequent depth-limiting effects apply.

3.4 Tidal currents

Hydrodynamic modelling by Pritchard et al. (2016) of the Mangere inlet shows low tidal currents on intertidal flats in the vicinity of PS 23, typically not exceeding 0.2 m/s. For comparison, tidal currents of over 1 m/s occur within the main channels located approximately 1 km to the south (Figure 3.3). LINZ Paper Chart NZ 4315 tidal provides similar tidal current speeds, indicating flood tide velocities between 0.3-1.9 m and ebb tide velocities between 0.1-1.6 m/s.

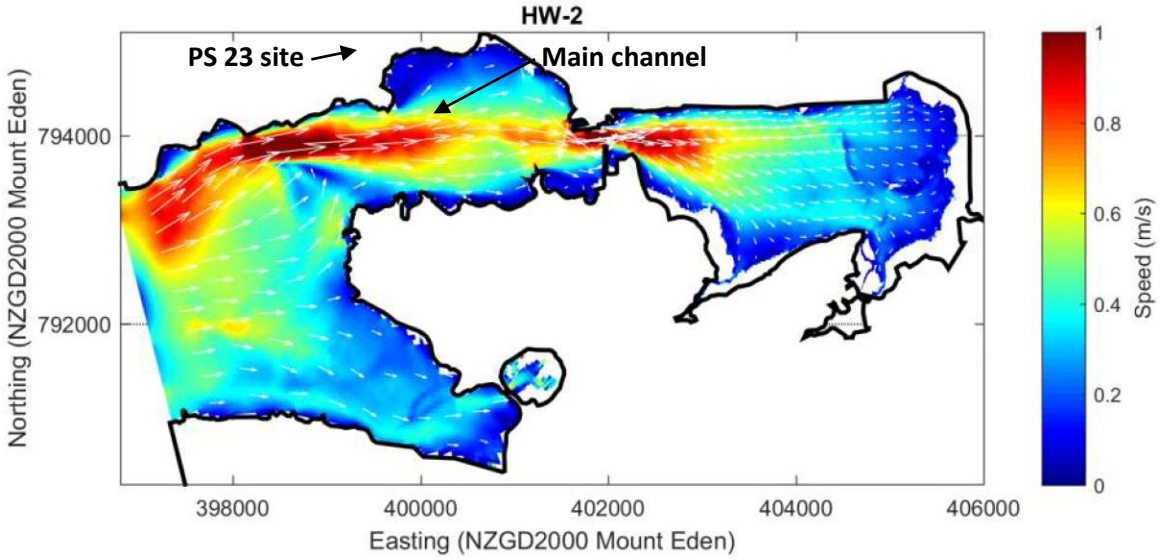


Figure 3.3: Model predicted peak flood current speed and direction on a spring tidal cycle in Mangere Inlet at 2-hours before high water (Pritchard et al., 2016)

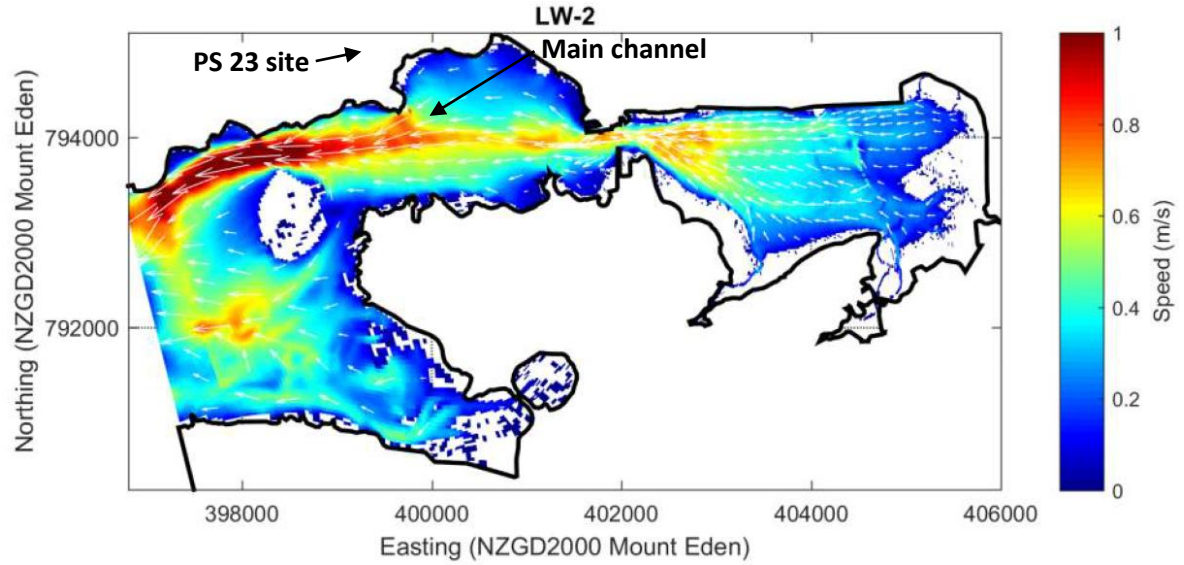


Figure 3.4: Model predicted peak ebb current speed and direction on a spring tidal cycle in Mangere Inlet at 2-hours before low water (Pritchard et al., 2016).

3.5 Sediment transport and water quality

The limited volumes of loose beach sediments observed indicate a low sand sediment budget. Fine silts deposited in the upper intertidal areas are typically mobilised by wind waves and transported by a combination of wind waves and wind driven currents. Higher suspended sediment results in increased levels of turbidity at these times. With low tidal currents and sheltered wave climate, very little sediment typically enters or leaves this coastal system.

3.6 Historical shoreline change

Historical aerial photographs from 1940 to 2022 have been reviewed to compare shoreline changes. The coastal edge in the vicinity of the PS 23 building appears to have shifted seaward between 5 and 10 m (Figure 3.5), likely due to land reclamation. Dark shadows in photographs east, and mature tree

canopy west prevent the accurate assessment of long-term change in the vegetated edge or cliff toe each side of the pump station.

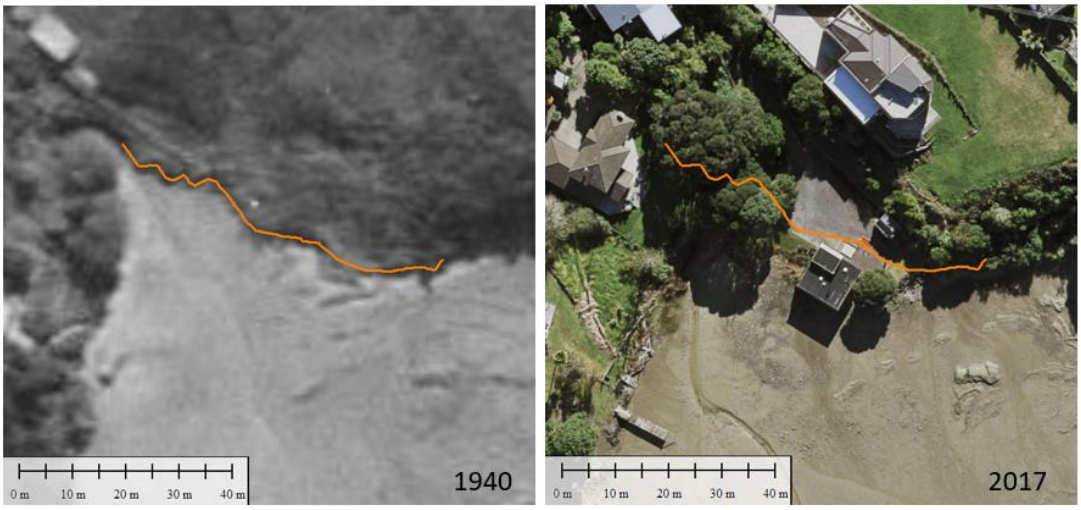


Figure 3.5: Historical shorelines over 2017 aerial imagery.

3.7 Coastal hazards

3.7.1 Erosion

The Regional assessment of areas susceptible to coastal instability and erosion (Auckland Council, 2021) indicates the 2080 erosion hazard extending between 20 m and 25 m landward of the present-day vegetated edge under the RCP 8.5 scenario. This distance increases to between approximately 25 and 35 m for 2130 under the same scenario.

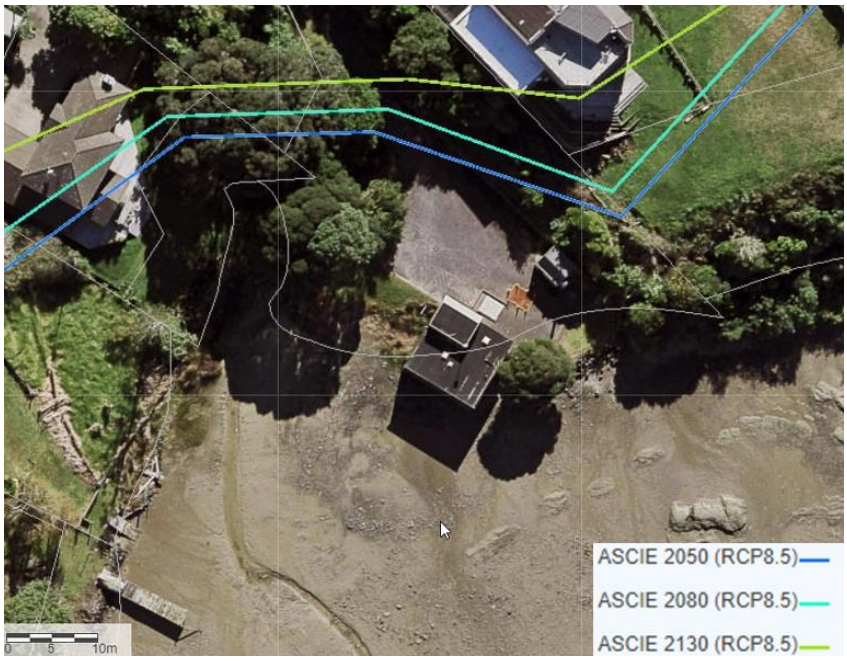


Figure 3.6: Regional erosion hazard information

Erosion of the coastal edge around the existing pump station is presently limited by the building itself situated on the coastal edge, and to a limited extent the informal rock revetment that backs the beach east. The coastal edge on which the pump station is located is likely fill material placed there as part of land reclamation works. The consented rock revetment yet to be constructed is intended to provide protection from erosion, particularly on the eastern side of the PS 23 building.

3.7.2 Inundation

Coastal inundation occurs when water levels become sufficiently high to result in surface flooding. Extreme water levels comprise astronomical tide, storm surge and future sea level rise. For design we have considered a 1% AEP storm tide level of 3.06 m RL, coinciding with a more frequent wind event such as the 50-year return period southeast wind event (2% AEP).

Extreme water levels for the present day, in 50 years and 100 years are presented in Table 3.5 . The present-day level refers to the extreme sea-level in the Manukau Harbour as given in Section 3.1.2. The future extreme water levels include sea level rise for the RCP 8.5M scenario as per Section 3.1.3.

Table 3.5: Inundation at the site

Water level component	Time horizons		
	2022	2072	2132
RCP8.5M sea level rise	0	0.46 m	1.09 m
Mean High Water Springs (MHWS)	1.97 m RL	2.43 m RL	3.06 m RL
1% AEP storm tide excluding wave setup	2.94 m RL	3.40 m RL	4.03 m RL
Wave setup from a 2% AEP SE wind	+ 0.12 m		
1% AEP storm tide including wave setup	3.06 m RL	3.52 m RL	4.15 m RL

The levels in Table 3.5 indicate minor flooding around the perimeter of the PS 23 site under the present day 1% AEP storm tide levels, with much of this area becoming inundated in 50 and 100 years under the RCP8.5M scenario in combination with similar design level events.

3.7.3 Tsunami

Tsunamis may be broadly categorised as being either local (wave arriving within 1 hr of associated event), regional (wave arriving between 1 and 3 hrs of associated event), or distant (wave arriving more than 3 hrs after associated event). Potential tsunami wave heights on the west coast are shown by Berryman (2006) to be approximately half the height of those on the east coast across a range of return periods (comparing 'Manukau west' and Manukau east'). The sheltering effects of the narrow Manukau harbour entrance are likely to further reduce tsunami derived wave heights entering the harbour body.

Auckland Civil Defence and Emergency Management have compiled comprehensive tsunami evacuation maps indicating the PS 23 site located within the "Red Zone" MCDEM (2008). The red zone is denoted as being the area evacuated in all distant and regional-source official warnings. Evacuation to higher ground outside of this hazard area is indicated a short walk (less than 50 m) up the PS 23 accessway.

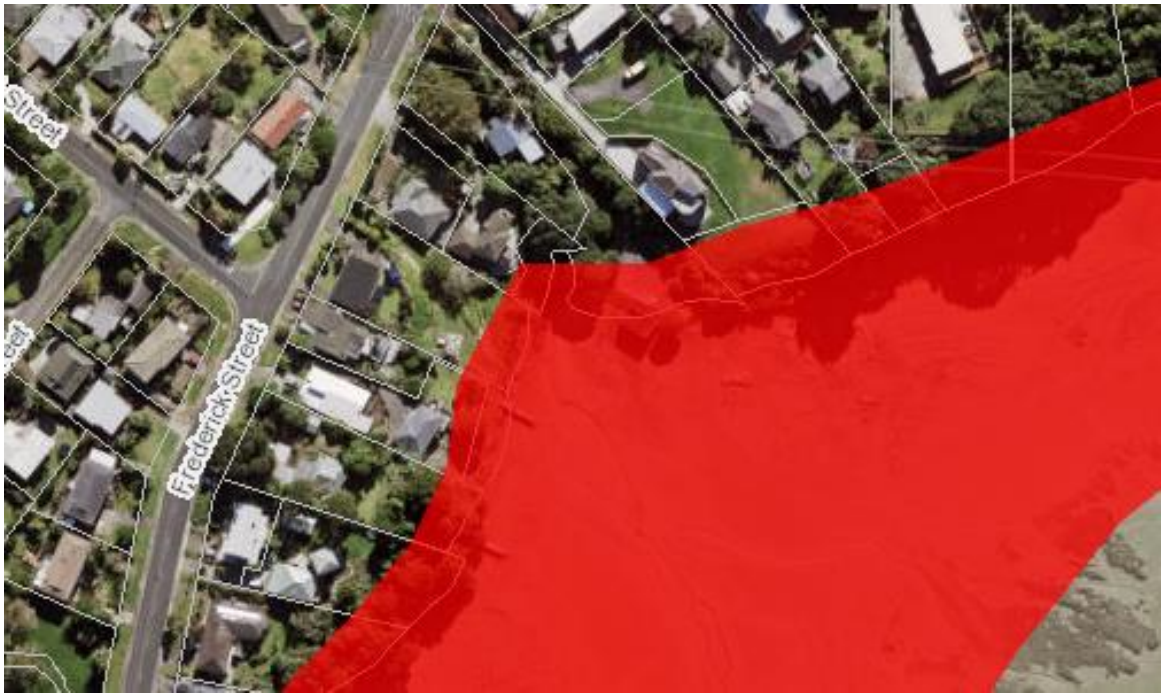


Figure 3.7: Tsunami hazard map (Auckland hazard viewer, 2022).

4 Consent level design

4.1 Overview

The ecological enhancement works include the construction of a salt marsh and bird roosting area. A rock sill has been designed to surround these areas to provide shelter for salt marsh vegetation and also minimise the loss of shelly material that surfaces the bird roosting area. Timber bird posts are also proposed in the intertidal area to provide areas for birds to rest on, separated by water from the coastal edge at times of higher tide.

The ecological enhancement works have been designed with a life of 50-years. This section considers design rationale (drawings in Appendix A), expected level of performance, and maintenance requirements.

4.2 Salt marsh

An area of salt marsh is proposed encircled by rock sill. This is intended to provide an area for vegetation to be planted and grow. Ground levels in this area require raising to MHWS which is similar to other areas in the surrounding harbour where salt marsh vegetation grows naturally. Silt material excavated from the rock sill footprint will be mixed with imported hard fill and used to infill this area to achieve required levels. Opportunities exist to reuse GAP65 used to form the existing temporary working platform. Geotextile within the surrounding rock sill has been specified to minimise fines loss through the surrounding rock. Specific plant selection will be undertaken as part of detailed design.

Crest levels of the rock sill are set approximately 0.3 m (1 x D_{n50}) above salt marsh levels to provide protection from wave attack. The rock grading within the sill and the salt marsh substrate are intended to allow tidal water to enter and leave the salt marsh with each tide. The substrate of the salt marsh and bird roost has a fall of approx. 40H:1V to avoid stormwater ponding.

Uniform growth and longevity of planting is not expected. Plants close the rock sill perimeter are more exposed to overtopping and may remain sparse over time. It is expected that any replacement planting reconsider adjustments from the initial planting plan to reduce ongoing maintenance. Sea level rise will affect the viability of planting within the salt marsh area with time. Raising the height of the rock sill over time and increasing planting levels within the salt marsh area is one option that could mitigate these effects.

4.3 Bird roost

An area for bird roosting is proposed to be encircled by rock sill. This is intended to provide an area for sea and shore birds to rest. The surface substrate is to be coarse broken shell, imported to site. This material is similar to material located atop bird roosting sites elsewhere in the Manukau Harbour. The angular and coarse nature of this material allows for interlocking and reduces the potential for windblown loss over time.

Crest levels of the rock sill in these areas are set at 2.6 m RL, 0.6 m (2 x D_{n50}) above salt marsh levels. This provides additional protection from wave overtopping and minimising cross contamination from comparatively silty substrate within the salt marsh area.

Shelly beach sediment is not abundant in this area and the loss of material due to wave action or wind transport will require subsequent replacement/ renourishment.

4.4 Bird posts

Timber piles are to be installed in indicative locations shown in the consent level design drawings in Appendix A. The tops of these posts are to be modified to allow for birds to rest on. Some variation

to the tops of the poles in each cluster is recommended to encourage different species, e.g., a hollow top would be suitable for nesting by white-fronted terns, and an open platform might encourage some birds to roost together.

Piles/posts are likely to be demolition hardwood or marine grade, cast in oversized holes with 25 MPa concrete surround of 100 mm. Founding depth of piles, timber grade, size and length, and height above ground to be confirmed in detailed design.

4.5 Rock structure

The rock sill that encloses the bird roost and salt marsh is designed to dissipate wave energy from wind waves. This will assist with retaining the unconsolidated substrate landward, being the planting medium (salt marsh) and shelly material (bird roost).

4.5.1 Rock size

Rock sizing has been calculated with the method of Van der Meer in the Rock Manual (CIRIA, 2007). Wave heights associated with a range of recurrence intervals have been considered in Section 3.3. The proposed location of the rock sill toe is located at around 1.0 m RL. Allowing for 0.46 m of sea level rise over 50-years under the RCP8.5M scenario, this indicates water depths at the toe of this structure at MHWS of around 1.4 m. Wave heights from rare 1% AEP wind speeds are unlikely to be depth limited at this time, and not reliant on the coincidence of extreme water levels associated with storm surge.

Design of rock armour has been based on the 2% AEP (50-year ARI) southeast wind speed resulting in a wave height of 0.7 m.

The following design parameters have been adopted:

- Rock sill maximum front slope of 1 to 2 (V:H).
- Quarry rock density of 2650 kg/m^3 for armour.
- Relative density of 1.57.
- Damage level parameter: 2 (5% damage).
- Notional permeability parameter for rock sill of 0.5.
- Crest should be at least 0.9 m wide, i.e., 3 x D_{n50} (armour rock), based on CIRIA (2007) guidelines, to provide adequate interlocking of the rock at the crest.

Gradients less than the critical design slope above have been selected in places for ecological enhancement.

Design nominal rock sizing throughout is:

- Armour rock for sill and platform: Dn50 = 0.3 m (M50 = 72 kg).
- Underlayer/core for rock sill around bird roost: Dn50 = 0.1 m (M50 = 4.8 kg).

4.5.2 Crest levels

The design sill crest level is an important parameter as this determines the transmitted wave height during large storm events, reducing the risk of damage and erosion to the planting area and bird roost during these events. The method of Goda and Ahrens (2008) has been used to estimate wave transmission over the rock sill.

Considering the present day MHWS water level coinciding with a 1% AEP wave height of 0.8 m, crest levels of 2.3 m RL around the salt marsh will result in a 60% reduction in wave height over the sill crest (i.e., 0.8 m incident wave height, the transmitted wave over the sill becomes 0.3 m). This crest

height is considered adequate to reduce wave energy while still allowing some exchange of water. The crest should be at least 0.9 m wide to provide adequate interlocking of the rock at the crest.

4.5.3 Toe scour

A scour assessment based on Van Rijn (2012) estimates scour depth in silty material as between 0.2-0.4 m. A minimum embedment depth of 0.4 m has been allowed for beneath the rock sill.

4.5.4 Settlement

Geotechnical investigations indicate potentially compressible stiff marine sediments of variable thickness, increasing in depth at the western end of the building footprint towards the water course. Preliminary calculations indicate less than 30 mm differential settlement between the seaward extent of this structure and the backshore separated by a distance of approximately 10 m. The resulting differential settlement gradient of 1:300 (V:H) for the rock sill which is considered within tolerable ranges for this type of structure.

4.5.5 Rock maintenance

A damage level parameter of 2 (5% damage) means that design level events that are comparatively rare may result in occasional rock dislodgement.

5 Coastal effects assessment

This section considers potential coastal process effects. The level of effect has been derived in a similar manner to those outlined in NZTA (2017). The risk level for an identified coastal environmental effect is determined by combining the likelihood and consequence rating using the risk matrix, reproduced from NZTA (2017) in Table 6.1.

Table 6.1: Risk level matrix (reproduced from NZTA, 2017)

		CONSEQUENCE		
		Low	Medium	High
LIKELIHOOD	Unlikely	Low	Moderate	High
	Likely	Low	Moderate	High
	Very likely	Moderate	High	High

5.1 Occupation and disturbance of the CMA

Prior to construction of the temporary working platform (at time of survey in June 2020), the MHWS line was located within the proposed footprint of these works. The proposed works will occupy approximately 900 m^2 of the existing CMA. Construction may result in the light disturbance of ground 5 m seaward of the occupied ground from foot traffic and vehicle movements, resulting in a total disturbed inter-tidal area of ~ 1100 m^2.

5.2 Shoreline location

The construction of the proposed rock sill, salt marsh planting and bird roosting site are located within the existing intertidal area. These works will move the location of the shoreline (defined by MHWS) seaward to the intersection of the MHWS level and the face of the constructed works. However, the salt marsh will continue to function as a coastal environment, with water extending into the protected planting area at high tides.

The extent of the notional shift in MHWS varies subject to location along the project site up to approximately 20 m.

It is noted that intertidal survey of ground levels around the temporary working platform will be resurveyed at the detailed design phase and these area measurements may be subject to some minor change. It is considered any change will be within +/- 5% of the values stated above.

5.3 Effects on coastal processes

Table 6.2 provides a summary of the potential effects of the design on coastal processes and the relative significance/importance of these effects in a similar manner to those outlined in NZTA (2017) as discussed above.

Table 6.2: Assessment of level of effect of the design

Coastal environmental effect	Effect	Likelihood	Consequence	Effect level
Water levels	There will be no measurable effects on extreme water levels caused by the proposed works within the local or wider harbour environment. Similarly, the tidal regime will not be affected by the proposed works.	Unlikely	Low	Low
Waves	This sill dissipates wave energy through wave breaking on the armoured slopes and over the crest.	Unlikely	Low	Low
Currents	Due to comparatively shallow water depths and distance from the main tidal channels, low tidal currents occur in the area of the proposed works, and these will be unaffected.	Unlikely	Low	Low
Sediment processes	Rates of sediment transport and sediment budget are small. Sediment transport is expected to remain minimal. These processes will be largely unchanged due to proposed works. The salt marsh will be filled to the upper extent of its capacity to confine loose material and will therefore not remove additional sediment from the surrounding coastal system after completion. Increased shelter from wind waves west of this structure may allow for intermittent accumulation of beach sediment in this area, which is expected to be removed through stream flow erosion from the water course during periods of higher flows.	Unlikely	Low	Low
Coastal hazards (erosion and inundation)	Coastal hazard comprises erosion and inundation. The increased level of protection to the existing coastal edge from this structure will reduce the potential for coastal erosion behind it. No change to inundation hazard over the existing PS 23 platform is expected.	Unlikely	Low	Low
Adjacent shoreline	Properties west of this structure will be afforded increased protection from wind waves (particularly largest potential wind waves from SE) and less susceptible to potential erosion in these conditions. East of the proposed structure, potential for erosional 'end effects' are considered unlikely on account of the low existing sediment budget, the sheltered nature of this site, the elliptical planform shape and the porosity of the structure that is similarly dissipative to that of the existing coastal edge.	Unlikely	Low	Low
Crest	Crest and bed levels may be raised if increased levels of inundation and exposure results in increased levels of maintenance.	Unlikely	Low	Low
Water quality	There will be no notable long-term adverse effects on water quality. There may be some minor short term turbidity effects during earthworks and fill placement during construction lasting several tide cycles. No long-term effects are anticipated by these works. Specific mitigation measures and environmental monitoring is required to avoid or mitigate potential adverse effects on the environment during construction.	Likely	Low	Low
Discharge via open water course	Water course located to one side of proposed works and unlikely to be affected by occupation.	Unlikely	Low	Low

6 Conclusions

The ecological enhancement works include the construction of a salt marsh and bird roosting area. A rock sill has been designed to surround these areas providing shelter for salt marsh vegetation, and to minimise the loss of shelly material that surfaces the bird roosting area. Timber bird posts are also proposed, scattered in the intertidal area to provide areas for birds to rest on, separated by water from the coastal edge at times of higher tide.

The proposed works will occupy approximately 900 m^2, and potentially disturb 1,100 m^2 of Coastal Marine Area (CMA) extending over an intertidal area approximately 20 m seaward of the existing high-water extent. Effects on coastal processes are considered to be low. Effects associated with increased turbidity associated with earthworks could occur during construction and measures to mitigate this risk will be necessary as part of a construction management plan (noting an indicative Construction Methodology is contained in Appendix C).

In the longer term, potential maintenance of these works could include the rectification of minor rock dislodgement, supplementary planting or re-surfacing of shelly material bird roosting following rare large storm events. The raising of rock sill crest levels and the ground levels could be considered if sea level rise results in the gradual loss of salt marsh or repeat loss of shelly substrate within the bird roosting area.

Overall, the design does not adversely affect coastal processes at the site or the surrounding environment. The size of the enhancement works is small in scale and its location outside the main harbour channel prevents it from affecting coastal processes of the wider coastal environment. Although the proposed works occupy the CMA to have sufficient space to serve as a useful ecological enhancement function, the entire extent of the planting area, rock sill and rock platform would still operate as a natural, coastal environment.

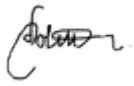
7 Applicability

This report has been prepared for the exclusive use of our client Watercare Services Limited, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

We understand and agree that our client will submit this report as part of an application for resource consent and that Auckland Council as the consenting authority will use this report for the purpose of assessing that application.

Tonkin & Taylor Ltd
Environmental and Engineering Consultants

Report prepared by:



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Colette van der Merwe
Civil Engineer

Authorised for Tonkin & Taylor Ltd by:

P.P 

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Karen Baverstock
Project Director

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Peter Quilter
Senior Coastal Engineer

Reviewed by Coastal Technical Director Dr Tom Shand

COVA
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Watercare Services Limited (Watercare) (2021). Drone photo of the temporary construction platform taken on 22 December 2021.

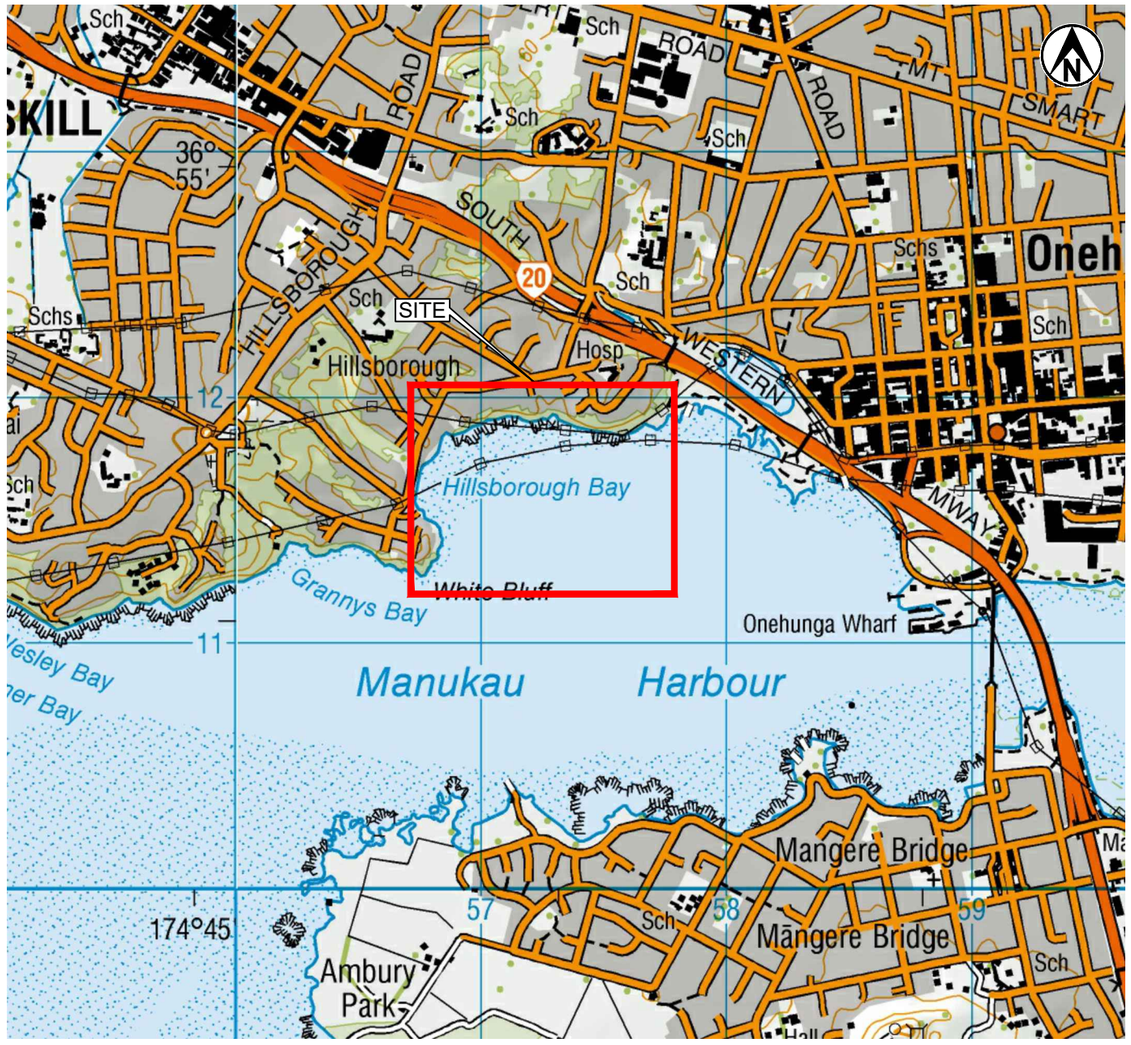
Watercare Services Limited (Watercare) (2022). Drone photo of the temporary construction platform taken on 6 May 2022.

Appendix A Consent level design drawing

\\ttgroup.local\files\AKLProjects\1015172\1015172.1600 - PS 23 Bird roost\WorkingMaterial\Stage 2 - resource consenting (concept 3)\Task 1 - CAD\new\1015172.1600-000.dwg 2022-Oct-07 10:53:50 am Plotted By: CHARLIE LI

WATERCARE SERVICES LIMITED
PUMP STATION 23 ECOLOGICAL ENHANCEMENT
Draft Consent Level Design Issue

DRAWING	Rev	Title
• 1015172.1600-000	1	DRAWING LIST AND LOCALITY PLAN
• 1015172.1600-001	1	EXISTING LAYOUT
• 1015172.1600-002	1	PROPOSED LAYOUT
• 1015172.1600-003	1	PROPOSED SECTIONS - SHEET 1 OF 2
• 1015172.1600-004	1	PROPOSED SECTIONS - SHEET 2 OF 2



TOPOMAP SOURCED FROM LINZ DATA SERVICE <https://data.linz.govt.nz/layer/50767-nz-topo50-maps/> , LICENSED BY LINZ FOR RE-USE UNDER THE CREATIVE COMMONS ATTRIBUTION 4.0 NEW ZEALAND LICENCE (CC BY 4.0). ACCESSED 09/08/2022.

LOCALITY PLAN
SCALE 1:25,000

• Denotes drawing this issue: 07/10/2022

A3 SCALE 1:25000
0 0.5 1.0 1.5 (km)
ORIGINAL IN COLOUR

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REV	DESCRIPTION	CAD	CHK	DATE
1	DRAFT CONSENT LEVEL DESIGN ISSUE	CHLI	PWQ	07.10.22

DESIGNED	COVA	Aug.22
DRAWN	CHLI	Aug.22
DESIGN CHECKED	PWQ	Oct.22
DRAWING CHECKED	JC	Oct.22

DRAWING STATUS: DRAFT CONSENT LEVEL DESIGN

NOT FOR CONSTRUCTION

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APPROVED DATE

CLIENT WATERCARE SERVICES LIMITED
PROJECT PUMP STATION 23 ECOLOGICAL ENHANCEMENT
TITLE ECOLOGICAL ENHANCEMENT WORKS
DRAWING LIST AND LOCATION PLAN
SCALE (A3) 1:25000 DWG No. 1015172.1600-000 REV 1

\\ttgroup.local\files\AKLProjects\1015172\1015172.1600 - PS 23 Bird roost\WorkingMaterial\Stage 2 - resource consenting (concept 3)\Task 1 - CAD\new\1015172.1600-001.dwg 2022-Oct-07 10:54:31 am Plotted By: CHARLIE LI

NOTES:
1. COORDINATE SYSTEM IS IN NEW ZEALAND TRANSVERSE MERCATOR (NZTM2000).
2. LEVELS ARE IN METRES RELATIVE TO AUCKLAND VERTICAL DATUM 1946 (AVD46).
3. CONTOURS EXISTING SERVICES SOURCED FROM LAND AND SURVEY LTD (N.D.).
4. AERIAL SOURCED FROM GOOGLE EARTH (2022).

LEGEND

- EXISTING MAJOR CONTOURS FROM LANDS AND SURVEY LTD (1m INTERVALS)
- EXISTING CONTOURS FROM LANDS AND SURVEY LTD (0.1m INTERVALS)
- EXISTING CONTOURS (LINZ LiDAR (2013)
- WATERCARE DESIGNATIONS
- TOP OF BATTER OF TEMPORARY CONSTRUCTION PLATFORM
- BOTTOM OF BATTER OF TEMPORARY CONSTRUCTION PLATFORM
- PROPERTY BOUNDARIES
- STORMWATER WATER COURSE
- MHWS LINE (1.9 m AVD46)
- EDGE OF ROCK
- BUILDING EXTENT
- EXISTING STORMWATER MANHOLE
- EXISTING WASTEWATER MANHOLE
- EXISTING CESSPIT
- EXISTING STAKES
- EXISTING DRAINAGE CULVERT
- SS SS EXISTING SANITARY SEWER LINES
- SW SW EXISTING STORMWATER LINES

PUMP STATION 23

WASTEWATER CHAMBER TRANSMISSION

EDGE OF ROCK

WATER COURSE - INDICATIVE ALIGNMENT

A3 SCALE 1:500
0 5 10 15 20 25 (m)

ORIGINAL IN COLOUR

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REV	DESCRIPTION	CAD	CHK	DATE
1	DRAFT CONSENT LEVEL DESIGN ISSUE	CHLI	PWQ	07.10.22

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DRAWING CHECKED	JC	Oct.22

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CLIENT WATERCARE SERVICES LIMITED

PROJECT PUMP STATION 23 ECOLOGICAL ENHANCEMENT

TITLE ECOLOGICAL ENHANCEMENT WORKS EXISTING LAYOUT

SCALE (A3) 1:500 DWG No. 1015172.1600-001 REV 1

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NOTES:
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2. LEVELS ARE IN METRES RELATIVE TO AUCKLAND VERTICAL DATUM 1946 (AVD46).
3. CONTOURS SOURCED FROM LAND AND SURVEY LTD (N.D.).
4. AERIAL SOURCED FROM GOOGLE EARTH (2022).

LEGEND

- EXISTING STORMWATER MANHOLE
- EXISTING WASTEWATER MANHOLE
- EXISTING CESSPIT
- LOG PILES (INDICATIVE)
- PROPOSED SALT MARSH VEGETATION
- PROPOSED ROCK SILL
- PROPOSED BIRD ROOST

LEGEND

- EXISTING MAJOR CONTOURS FROM LANDS AND SURVEY LTD (1m INTERVALS)
- EXISTING CONTOURS FROM LANDS AND SURVEY LTD (0.1m INTERVALS)
- EXISTING CONTOURS (LINZ LiDAR (2013)
- WATERCARE DESIGNATIONS
- TOP OF BATTER OF TEMPORARY CONSTRUCTION PLATFORM
- BOTTOM OF BATTER OF TEMPORARY CONSTRUCTION PLATFORM
- PROPERTY BOUNDARIES
- STORMWATER WATER COURSE
- MHWS LINE (1.9 m AVD46)
- EDGE OF ROCK
- BUILDING EXTENT
- PROPOSED ROCK CREST EXTENT
- PROPOSED ROCK TOE EXTENT
- PROPOSED ROCK REVETMENT (CI WORKS)
- EXISTING SANITARY SEWER LINES
- EXISTING STORMWATER LINES

PROPOSED DIVERSION CHAMBER (CI WORKS)

PROPOSED SHAFT (CI WORKS)

PROPOSED ROCK REVETMENT CREST (CI WORKS)

BIRD ROOST PLANTING PROTECTED BY ROCK SILL (REFER DRAWING 1015172.1600-004, SECTION 3)

TIE IN DETAILS TBC IN DETAILED DESIGN

TIE IN DETAILS TBC IN DETAILED DESIGN

FUTURE BOARDWALK - BY OTHERS

ROCK SILL SURROUNDING BIRD ROOST (REFER DRAWING 1015172.1600-003, SECTION 1)

1.5m MINIMUM OFFSET DISTANCE BETWEEN SERVICE AND ROCK PLACEMENT

ROCK SILL SURROUNDING SALT MARSH PLANTING (REFER DRAWING 1015172.1600-003, SECTION 2)

INDIVIDUAL LOG PILES FOR SOLITARY ROOSTING SPECIES. DEMOLITION HARDWOOD TO BE USED FOR PILES. PILE SIZE AND LENGTH TBC IN DETAILED DESIGN. CAST IN OVERSIZED HOLE WITH CONCRETE SURROUND.

CLUSTERED LOG PILES FOR COLONY ROOSTING SPECIES. DEMOLITION HARDWOOD TO BE USED FOR PILES. PILE SIZE AND LENGTH TBC IN DETAILED DESIGN. CAST IN OVERSIZED HOLE WITH CONCRETE SURROUND.

SALT MARSH PLANTING PROTECTED BY ROCK SILL (REFER DRAWING 1015172.1600-004, SECTION 3)

SOLID PIPE EXTENSION OF STORMWATER OUTFALL THROUGH SALT MARSH. PIPE TO BE INTEGRATED THROUGH ROCK SILL.

WATER COURSE - INDICATIVE ALIGNMENT

A3 SCALE 1:500
0 5 10 15 20 25 (m)
ORIGINAL IN COLOUR

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DESIGNED	COVA	Aug.22	DRAWING STATUS: DRAFT CONSENT LEVEL DESIGN
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DESIGN CHECKED	PWQ	Oct.22	
DRAWING CHECKED	JC	Oct.22	

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CLIENT: WATERCARE SERVICES LIMITED
PROJECT: PUMP STATION 23 ECOLOGICAL ENHANCEMENT
TITLE: ECOLOGICAL ENHANCEMENT WORKS PROPOSED LAYOUT
SCALE (A3): 1:500 DWG No. 1015172.1600-002 REV 1

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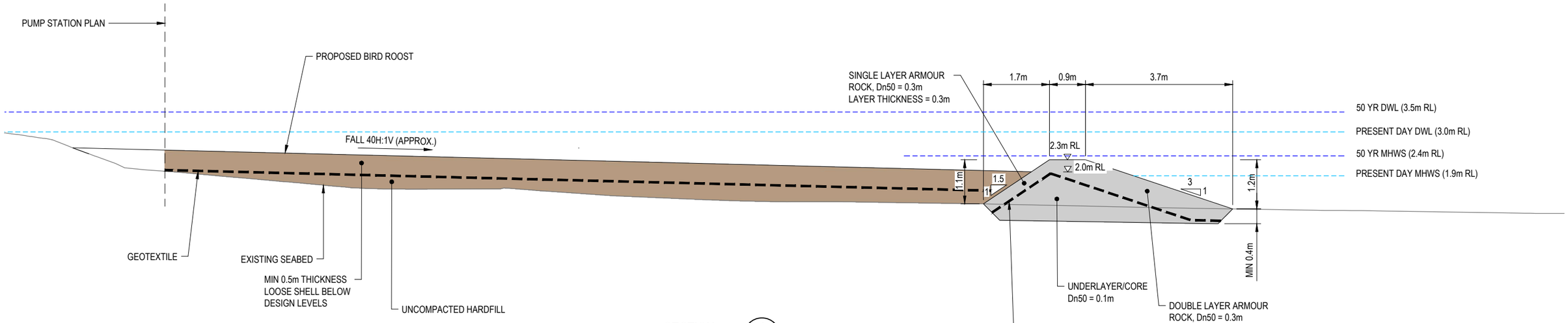
2. LEVELS ARE IN METRES RELATIVE TO AUCKLAND VERTICAL DATUM 1946 (AVD46).
3. ECOLOGICAL ENHANCEMENT EXTENTS AND LOCATION CONCEPT ONLY, SUBJECT TO CHANGE DURING DETAILED DESIGN.



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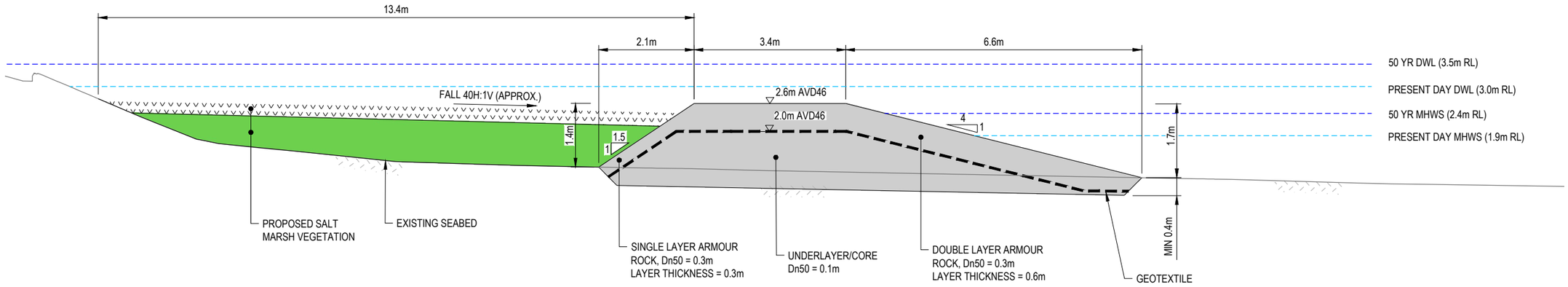

SECTION 2/002
SCALE 1:100

A3 SCALE 1:100
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DRAWING CHECKED	JC	Oct.22

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CLIENT **WATERCARE SERVICES LIMITED**
PROJECT **PUMP STATION 23 ECOLOGICAL ENHANCEMENT**
TITLE ECOLOGICAL ENHANCEMENT WORKS PROPOSED SECTIONS - SHEET 1 OF 2
SCALE (A3) 1:100 DWG No. 1015172.1600-003 REV 1

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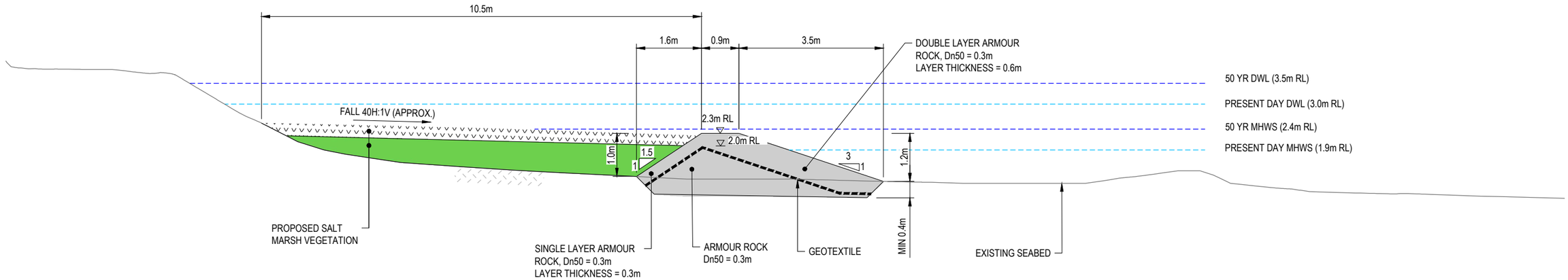

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A3 SCALE 1:100
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ORIGINAL IN COLOUR

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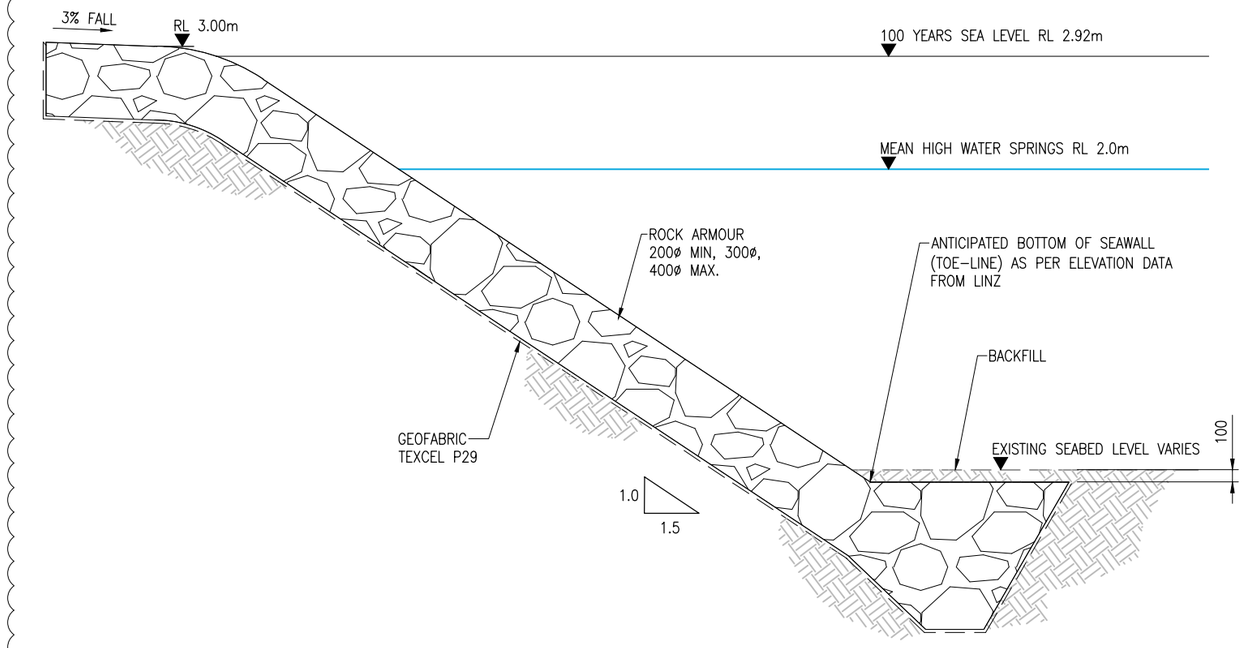
CLIENT **WATERCARE SERVICES LIMITED**
PROJECT **PUMP STATION 23 ECOLOGICAL ENHANCEMENT**
TITLE ECOLOGICAL ENHANCEMENT WORKS
PROPOSED SECTIONS - SHEET 2 OF 2
SCALE (A3) 1:100 DWG No. 1015172.1600-004 REV 1

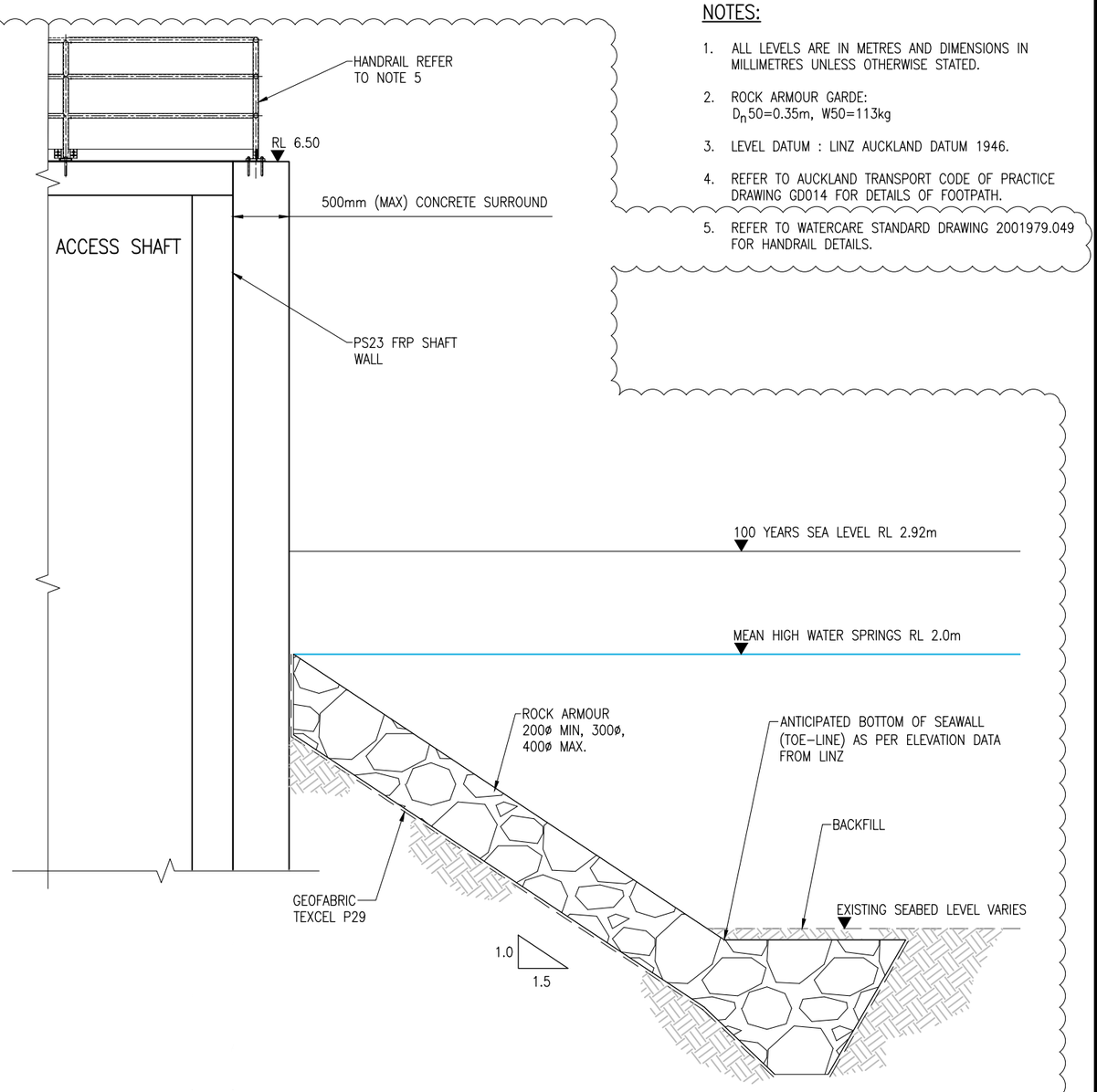
Appendix B Proposed rock revetment (Central Interceptor works)

NOTES:

1. ALL LEVELS ARE IN METRES AND DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE STATED.
2. ROCK ARMOUR GARDE: D_n50=0.35m, W50=113kg
3. LEVEL DATUM : LINZ AUCKLAND DATUM 1946.
4. REFER TO AUCKLAND TRANSPORT CODE OF PRACTICE DRAWING GD014 FOR DETAILS OF FOOTPATH.
5. REFER TO WATERCARE STANDARD DRAWING 2001979.049 FOR HANDRAIL DETAILS.



TYPICAL SEAWALL DETAIL
SCALE. 1:25



TYPICAL SEAWALL DETAIL AT SHAFT
SCALE. 1:25

D

CONSENT ISSUE

SCALE 1:25 (A1) 0 500 1000 1500 2000 2500mm

JACOBS AECOM McMILLEN JACOBS ASSOCIATES

ISSUE	DATE	AMENDMENT	BY	APPD.
D	27.05.21	CONSENT ISSUE – SECTION 2 REMOVED, REVISED AS SHOWN	ID	CDEB
C	12.04.21	IFC – BOTTOM OF SEAWALL & HOLD 1 ADDED – REVISED AS SHOWN	ID	BMM
B	29.01.21	IFC – DRAWING TITLE UPDATED ONLY	SS	DJK
A	30.01.20	CONSTRUCTION ISSUE	PMF	EB
–	30.08.17	TENDER ISSUE	PJG	NK
1	14.03.17	ISSUED FOR CLIENT REVIEW	PJG	DJK

DESIGNED	CW	02.17
DES. CHECKED	DJK	02.17
DRAWN	JRJ	02.17
DWG. CHECKED	CW	02.17
PROJECT LEADER	NK	08.17
INFRAST'R APP'D	SG	08.17
BY		DATE

OPERATIONS

INFRASTRUCTURE

Watercare

PS23 – CENTRAL INTERCEPTOR (DSCIN)
00 SITE GENERAL
PROPOSED SEAWALL DETAILS

CAD FILE 2011804.025	DATE 27.05.21
ORIGINAL SCALE A1 1:25	CONTRACT No. 6661
REF. No. CI–CIVIL	ISSUE
DWG. No. 2011804 .025	D

Plot Date: May 27, 2021 - 11:38am C:\pw_work\copy of ian.dunthorne@aecom.com\dms524131\ 2011804.025.dwg

Appendix C Construction methodology

Consent level design drawings are included in Appendix A. This section outlines the anticipated construction methodology associated with the following specific project components:

- Site establishment, laydown areas and preparation work.
- Rock sill and rock platform.
- Salt marsh and bird roost.

The project will be constructed either as the existing temporary working platform is removed, or after its removal. Overall, these works are expected to be completed within a duration of 6 months.

We envisage this work to be undertaken in the following stages:

1 Establish on site:

   a. Establish site office, facilities, and laydown areas (materials storage, machinery storage etc.).
   b. These areas will be fenced off as necessary to avoid public access risk.
   c. Traffic control will be necessary i.e., access and truck movements. The construction areas will be clearly marked with specific access corridors to minimise the areas of disturbance.
   d. Construction access would be gained from the PS 23 site (via Frederick St) or from Taylors Bay.

2 Site preparation:

   a. The project will be constructed either as the existing temporary working platform is removed, or after its removal.
   b. Removal of any debris (e.g., leftover material from temporary platform, biodegradable materials that are not suitable beneath salt marsh / bird roost fill) from the project footprint and dispose at suitable landfill.

3 Rock structures:

   a. Toe excavation along the rock sill and rock platform roughly aligns with the excavated material stockpiled landward for mixing with imported planting medium.
   b. The rock sill and rock platform will be constructed from the foreshore working within the tide windows to avoid working in the wet.
   c. The rock armour will be constructed with layers of imported angular quarry rock over a geotextile filter fabric. The slope formation will be undertaken with an excavator, the fabric placed by hand and the armour rock placed with an excavator and shaped to form the design profile.

4 Bird roost areas:

   a. Imported hardfill medium will be end-tipped from the foreshore edge. GAP65 material that forms the temporary working platform may be considered as a substitute for imported fill in detailed design.
   b. Placement of shell material over granular fill base to form bird roosting substrate.

5 Salt marsh planting areas:

a. Imported hardfill medium will be end-tipped from the foreshore edge. GAP65 material that forms the temporary working platform may be considered as a substitute for imported fill in detailed design.
b. Planting medium for salt marsh mixed with in-situ sediments recovered from sill toe excavation will be placed over hardfill, shaped to design profile with an excavator.
c. Planting will be undertaken during late autumn and winter to provide greatest likelihood of success.
d. The planting will be installed as soon as practicable following placement of planting medium, improving stability as the plants establish.

6 Bird posts:

a. The installation of bird posts will require the excavation of weathered rock to form a hole that is large enough to accommodate the timber post/pole and allow for concrete to flow around this post without leaving air voids. The hole shall be deep enough to ensure fixity of the pole. Dimensions are to be confirmed in detailed design.
b. To minimise the area disturbed around each post we recommend an augured hole.
c. Concrete is not to surround upper portions of pile embedment surrounded by material subject to scour or sediment transport (i.e., loose material that can be excavated by hand with a shovel). We recommend that geotechnical hand augers be undertaken in the proposed location of bird posts as part of detailed design.
d. The colour of the concrete may be tinted to suit the colour of rock exposures nearby.
e. Curing accelerants are required to ensure that this concrete hardens before flood tide.

The following project wide control measures will be implemented to mitigate potential adverse construction effects that should be addressed as part of a Construction Management Plan:

- Machinery will not be maintained, refuelled on the beach, or stored on the beach overnight;
- Machinery will be checked daily for any leaks and regularly serviced;
- Erosion and sediment controls within the CMP would likely require the following:
  - Minimise areas of disturbance to that necessary to undertake construction;
  - Ensuring work in the intertidal zone will be undertaken “in the dry” around the lower stages of the tide window to avoid working within water;
  - Weather (tide, wind, wave) forecasts will be monitored to ensure work areas are stabilised prior to any significantly inclement weather that may result in loss of sediment into the CMA;
  - All supratidal (above MHWS) demolition and excavation will be contained within silt controls or behind rock sills;
- A spill kit will be maintained on site at all times to contain any accidental spills; and
- Noise and vibration management will be undertaken in accordance with NZS6803 and comply with permitted activity standards or CI resource consent conditions.

Watercare buried services (sewer lines) are located beneath the footprint of the proposed ecological enhancement works, and we understand Watercare may need to access these services by trenching in the future.

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