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Executive summary

The Quay Street Seawall extends from the western side of Lower Hobson Street to the western side of Marsden Wharf in Central Auckland. It has been established that the existing seawall does not meet current design standards for seismic performance, and that there are sections that are in need of general repair due to scour damage to the surface of the seawall.

Quay Street provides an important connection for Auckland. The Quay Street seawall supports the heavily trafficked Quay Street, multiple service utilities, protected heritage structures and many multi-storey commercial buildings. Quay Street is particularly important for the cities transport connectivity, including cars, trains, buses, ferries, walking and cycle ways. Quay Street and the services within it are considered essential facilities with post-disaster function and as such the seawall upgrade will be designed to IL4 and 100 year design life in accordance with the New Zealand Loadings Standard (refer to AS/NZS 1170.0).

In terms of the existing seawall condition, the majority of the structural elements of the seawall have been observed to be in an average to poor condition and the earthquake risk to the seawall has been assessed as high to extreme. Given the condition of the existing seawall, stability considerations, seismic vulnerability and results of risk assessment for the existing seawall, as well as the road and services it supports, options have been considered to improve the resilience of the Quay Street Seawall.

Consideration of options has been undertaken over a number of years in different stages. The first stage involved considering whether the status quo (“do nothing”) option was acceptable. That is, whether the risk of failure of the seawall and the consequences of that failure would be acceptable given current and anticipated future conditions. AT and AC have concluded that the risk associated with the status quo option is not acceptable and a decision was made to address the seismic vulnerability of the Quay Street Seawall to protect the road and services within it.

The second stage was to consider the different options for the seawall upgrade once it was determined that the status quo option was not acceptable. Upgrade options were thoroughly considered through MCA processes and a subsequent post-MCA option development phase. A total of 22 options were initially considered that fit into three main categories:

- Strengthening behind the existing seawall
- Strengthening or replacing the existing seawall
- Building a new wall or berm in front of the existing seawall.

The options were refined further and in order to achieve the seawall upgrade within the required timeframes, as well as provide a robust and cost effective solution which minimised environmental effects, the final design options for the three sections of the seawall were:

- Princes Wharf – Palisade wall landward of the existing seawall
- Ferry Basin – Post and panel wall seaward of the existing seawall
- Queens Wharf to Marsden Wharf – Palisade wall landward of the existing seawall.

The preferred options were selected because they are likely to have less effects on the environment in some areas compared to alternative options, and the selected options provide several benefits over other options considered.

The third stage involved refinement of the preferred options for the current upgrade project. AT progressed with preliminary design, construction planning and assessments of effects for the proposed walls concurrently and iterative adjustments were made to determine the design for which resource consent is being sought. This collaborative process resulted in adjustments to the
design, including location of the proposed walls, and construction methodologies that minimise the potential for effects, while still achieving the project’s desired technical outcomes.
1 Introduction

This report details the context for the Quay Street seawall upgrade project (Seawall Project) and the options considered for upgrading the seawall. It outlines the alternative options and locations considered to upgrade the Quay Street seawall and provides the context behind the assessment of those alternatives.

In accordance with the Resource Management Act 1991, where potential significant adverse effects may need to be addressed, a description of any possible alternative locations or methods for undertaking the activity is required. The purpose of the report is to describe the process that was undertaken to arrive at the proposed options for upgrading the Quay Street seawall and provide the context that explains the reasons for those decisions.

Firstly, a background to the project and the proposed Quay Street seawall upgrade details are provided. Then the project context describes the project history, importance of Quay Street, the geological and seismic setting, and the Quay Street seawall vulnerability in terms of the condition of the existing seawall and the seismic risks to stability of the seawall and Quay Street.

This report then describes the three stages of options assessment that has been undertaken, the first stage being a decision to proceed with an upgrade, the second stage being options identification and multi criteria assessment of those options, and the third stage being refinement of preferred options.

2 Background

The Quay Street seawall extends from the western side of Lower Hobson Street to the western side of Marsden Wharf in Central Auckland. The seawall forms the harbour edge of an historic reclamation, which supports Quay Street, as well as the services contained within the road corridor.

It has been established that the existing seawall does not meet current design standards for seismic performance and that there are sections that are in need of general repair due to scour damage to the surface of the seawall. There is also the opportunity to create resilience to future climate and changing use patterns, particularly the impacts of ship wash as ferry and cruise ship operations intensify their activity.

Completing the upgrade is now an important enabler of the wider Downtown Infrastructure Development Programme (Downtown Programme) to ready the precinct for the America’s Cup (AC36) and Asia-Pacific Economic Cooperation (APEC) events in 2021.

The Downtown Programme is a result of a collaboration between Auckland Transport (AT), Auckland Council (AC), Panuku Development Auckland, Auckland Tourism Events and Economic Development (ATEED) and Regional Facilities Auckland (RFA). The Programme includes a number of projects as part of overall improvements to the city centre. This includes, but is not limited to, the proposed relocation of Piers 3 and 4, a new Downtown Public Space, a new mooring dolphin at the end of Queens Wharf and the proposed seawall upgrade, being the subject of this consent.

3 Proposed Quay Street Seawall Upgrade

The proposed seawall upgrade has been divided into four sections for the purpose of resource consent applications and construction, as follows (from west to east):

- Princes Wharf section
- Ferry Basin section
- Ferry Building section
The proposed typical solutions for the sections considered in this report are:

- Princes Wharf – Palisade wall landward of the existing seawall within Quay Street road reserve
- Ferry Basin – Post and panel wall seaward of the existing seawall within coastal marine area (CMA)
- Queens Wharf to Marsden Wharf – Palisade wall landward of the existing seawall within Quay Street road reserve.

A separate resource consent application is prepared for each of the sections, and each section will be constructed as a standalone project once consented. The sections may therefore be constructed sequentially, or there may be some overlap in the construction programme.

Resource consent applications for the Princes Wharf, Ferry Basin, and Queens Wharf to Marsden Wharf sections will be lodged concurrently. Design options are still being considered for the Ferry Building section and the resource consent application for this section will be lodged at a later date. Therefore, this report does not focus on the project context for the Ferry Building section and no discussion is provided of an options assessment for the Ferry Building section as this is ongoing.

4 Project context

Upgrade of the Quay Street seawall has been considered over a number of years as part of proposals to upgrade Quay Street. It has been understood that the wall, in some sections, is over 100 years old and has degraded over time to a point where repairs have been required for some sections. Furthermore, the existing seawall was not designed for seismic loading, including potential liquefaction and lateral spreading. A risk assessment has determined that the seismic susceptibility of the seawall and the potential impact of failure of the seawall on Quay Street, the services within Quay Street, and nearby buildings warrants remedial options be considered.

4.1 Project history

Work commenced in 2012 to assess the condition of the Quay Street seawall between Lower Hobson Street and Gore Street in downtown Auckland. AT had proposals for both short and long term upgrades to Quay Street at that time and was interested in the condition of the seawall in relation to static and seismic stability as well as the ability of the seawalls to retain the reclamation fills without significant settlement causing risks to services in the road or the function of the road itself. As a result, AT undertook an assessment of the potential risk of liquefaction and associated lateral spreading to Quay Street and the seawall.

As part of that work, a number of reports were produced including:

- “Quay Street Seawall Geotechnical Desk Study” (T+T reference 28557 dated August 2012)
- “Quay Street Seawall Geotechnical and Ground Contamination Assessment” (T+T reference 28557.002 Ver 1.0 dated September 2012)
- “Quay Street Seawall Assessment of Maintenance Requirements” (T+T reference 28557.004 dated June 2013)
- “Communications and Consultation Plan Quay Street Seawall Project” (T+T reference 28557.005 dated December 2013)
4.2 Quay Street importance

Quay Street provides an important connection for Auckland. The Quay Street Seawall retains reclamation fills that support the heavily trafficked Quay Street, multiple service utilities, protected heritage structures, and many multi-storey commercial buildings.

Quay Street is particularly important for transport connectivity, including cars, trains, buses, ferries, walking and cycle ways. March 2017 surveys show approximately 7,300 pedestrians enter and exit the main ferry terminal on Quay Street per day and approximately 44,700 passengers use the Britomart rail station per day. The five day average daily traffic count on Quay Street is about 24,000. The seawall provides essential support to Quay Street and any failure of the seawall would compromise the transport function of Quay Street.

The Quay Street seawall also supports services located beneath Quay Street, including high voltage power supply, Chorus communication and water mains supply. Disruption of these services could severely impact businesses and public infrastructure on Quay Street as well as potentially the wider downtown Auckland area.

Quay Street and the services within it are considered essential facilities with post-disaster function, in accordance with the design brief agreed by the Auckland Council City Centre and Waterfront Executive Steering Group (ESG)\(^1\). On the strength of this, the seawall upgrade will be designed to Importance Level 4 (IL4) in accordance with the New Zealand Loadings Standard (refer to AS/NZS 1170.0). The design brief also stipulates the Quay Street Seawall upgrade will have a robust design life of 100 years.

4.3 Geological setting

The Quay Street Seawall Geotechnical and Ground Contamination Assessment report (T+T reference 28557.002 Ver 1.0 dated September 2012) provides details of the geological setting for the Quay street.

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\(^1\) As provided by Xigo on behalf of Auckland Transport and Auckland Council on 5 December 2017, following a meeting with the Auckland Council City Centre and Waterfront ESG.
Street seawall. More recent investigations have been undertaken to update understanding of the
ground conditions in the vicinity of the seawall.2

4.3.1 Published geology

Reclamation fill has formed the current downtown waterfront ground surface in Auckland. The fill is
underlain by Holocene age marine/alluvial sediments and Pleistocene age sediments of the Tauranga
Group3. The Holocene age marine/alluvial sediments are referred to herein as the Upper Tauranga
Group and the Pleistocene sediments are referred to herein as the Lower Tauranga Group.

Beneath the sediments, Waitematā Group rock (East Coast Bays Formation (ECBF)) are present and
consist predominantly of an alternating sequence of siltstone and sandstone. A relatively thin layer
(generally less than 2 m thick) of extremely weathered material mantles the rock. The Waitematā
Group underlies much of the Auckland urban area and the total thickness is inferred to be 1000 m to
2000 m.

4.3.2 Geological model

Historic and project specific geotechnical investigations have been utilised to develop a geological
model appropriate for the Quay Street Seawall upgrade. In summary, the subsurface geological units are:

- Reclamation fill (varied types)
- Upper Tauranga Group (Holocene age sediments)
- Lower Tauranga Group (Pleistocene age sediments)
- Waitematā Group (ECBF residual soils)
- Waitematā Group (ECBF sandstone and siltstone rock).

Example geological cross sections through the Princes Wharf (cross section A1), Ferry Basin (cross
section B2), and Queens Wharf to Marsden Wharf (cross section D2) sections of the seawall are
presented in Figure 4.1, Figure 4.2, and Figure 4.3 respectively.

![Geological Cross Section A1](image)

Figure 4.1 Example geological cross section through the Princes Wharf section of the Quay Street Seawall.

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2 The ground model and recommendations/opinions related to the ground model in this report are based on data from
discrete boreholes at point locations. The nature and continuity of the subsoil away from the test locations is inferred so it
must be appreciated that actual conditions may vary from the assumed model.

In the New Zealand context, Auckland is in an area of relatively low seismicity. Inferred seismicity of the region is dictated by the distance to known faults and understanding of the maximum magnitude and return period of earthquakes on those faults. This information is available in the New Zealand National Seismic Hazard Model.4

The nearest known fault to Auckland is the Wairoa North fault, which is approximately 25 km south west of downtown Auckland and capable of a Magnitude 6.7 event with a return period of approximately 13,000 years. There is potential for an active fault in the Hauraki Gulf 40 km from downtown Auckland as an extension of the Kerepehi fault, which is capable of a Magnitude 7.2 event with a return period of approximately 20,000 years. The central portion of the Kerepehi fault, about 95 km from downtown Auckland, has an estimated Magnitude of 6.9 with a return period of 5,400 years.

Given known faults are a reasonable distance from Auckland and the large magnitude events on those faults have a reasonably large return period, the seismic design loadings are relatively low. The design life and importance level influences the seismic design requirements.

Figure 4.2 Example geological cross section through the Ferry Basin section of the Quay Street Seawall.

Figure 4.3 Example geological cross section through the Queens Wharf to Marsden Wharf section of the Quay Street Seawall.

As mentioned in Section 4.2, the upgrade of the Quay Street seawall will be designed to a high importance level (IL4) with the objective of maintaining post-earthquake function of Quay Street, the services within it, and the connection to public transport services. It is also to be designed for a design life of 100 years as it protects critical infrastructure. Therefore, the design levels of earthquake shaking for the Seawall Project are reasonably high, being an event with a return period of at least 1 in 2,500 years (equivalent to a 0.04% chance of that event occurring each year).

4.5 Quay Street seawall vulnerability

The September 2012 report on the geotechnical and ground contamination assessment for the Quay Street seawall (T+T reference 28557.002) included condition assessments of the existing seawalls, geotechnical assessment, and a risk analysis. Recent investigations and analysis has supported the findings from the 2012 report. The 2016 Quay St Seawall Condition Assessment Report (Beca reference 3910830) also commented on the condition of the existing seawall.

4.5.1 Existing seawall condition assessment

The September 2012 report included a description of the history of different sections of the seawall as well as condition assessment of those sections. The seawall was divided into three wall types:

- Wall Type 1: Princes Wharf to Lower Albert Street (Princes Wharf and Ferry Basin)
- Wall Type 2: Lower Albert Street to Queens Wharf (Ferry Building)
- Wall Type 3: Queens Wharf to Marsden Wharf.

Wall Type 1, which is about 100 years old, was found to have a number of voids, vertical and diagonal cracks, and significant deterioration of the face. Wall Type 2 is not relevant to this report as it relates to the Ferry Building section. Wall Type 3, which is about 135 years old, showed minor deterioration of basalt blocks and complete deterioration of mortar between the basalt blocks. The conclusion of that condition assessment was there were sections of the seawall that may need repair to avoid collapse of the wall.

A more recent seawall condition assessment was carried out in 2016. This assessment found that the majority of the structural elements of the seawall in the areas of Wall Type 1 and 3 were in an average to poor condition. Some significant defects were identified such as scour beneath portions of the wall and major transverse and diagonal cracking at a number of locations. It was recommended to repair scour holes, investigate portions with significant damage more extensively, and undertake yearly inspections of the wall.

4.5.2 Existing seawall seismic vulnerability

Geotechnical assessment of the stability of the different sections of the seawall considered in this report has showed that it was unlikely to fail under static conditions, provided the wall remained intact, although the stability of the seawall is less than what would be required for a new structure. The walls were found to have earthquake resistance of 25% to 50% of the design standards at the time of the September 2012 report and it was concluded that sections of the seawall may not survive a moderate sized earthquake for Auckland with a return period of about 1 in 250 years (based on the New Zealand Loadings Standard). For comparison, IL4 structures (those required for post disaster function) with a design working life of at least 50 years should be designed for a return period of at least 1 in 2,500 years.

Liquefaction is the process by which earthquake shaking increases the water pressure in the ground in sandy and silty soil layers resulting in temporary loss of soil strength. Liquefaction can give rise to significant land and building damage, for example through the ejection of sediment to the ground.
surface, differential settlement of the ground due to volume loss in liquefied soil, horizontal movement of the ground (lateral spreading), and increased loading on retaining walls.

Liquefaction analysis carried out to date indicates lenses of material that could potentially liquefy at 1 in 250 year to 1 in 500 year return period levels of earthquake shaking. These lenses could be continuous beneath the existing seawall and extend landward. These lenses are generally at depth below the ground surface, with a thick layer unlikely to liquefy above them so that surface manifestation of liquefied material is not expected. However, as there is the potential that the lenses are continuous and there is a risk of lateral spreading of land on these potentially liquefied layers, this could result in movement of Quay Street towards the sea.

For the Quay Street seawall, lateral spreading could result in evacuation of land, ground cracking, and settlement. It is unlikely the land will be completely lost but the movement is likely to cause damage to Quay Street, services, and buildings within and adjacent to the evacuated land. The movement can also extend back past Quay Street towards Customs Street.

If the existing seawall fails due to seismic shaking alone then there will be no, or limited, horizontal restraint to prevent lateral spreading towards the sea from occurring. If liquefaction and lateral spreading occurs then the extent of evacuation could extend behind the wall beyond Quay Street and towards Customs Street, causing damage to private property beyond Quay Street and potentially facilities such as the Britomart Transport Centre. However, it is expected that the presence of building basements on the southern side of Quay Street could limit the extent of lateral spreading and associated evacuation.

4.5.3 Risk assessment

A risk assessment undertaken as part of the September 2012 report (T+T reference 28557.002) categorised the earthquake risk to the seawall as high to extreme, in accordance with the Auckland Council Corporate Risk Criteria at the time. The risk assessment involved the identification of hazards (including a risk workshop with attendees from AT, AC, and other stakeholders), identification of events (e.g. earthquake and scour events), risk analysis, and assessment of treatment options. The conclusions of that risk assessment included:

- Auckland is susceptible to earthquake shaking, which should be recognised, and none of the existing seawalls have been designed to withstand even a moderate earthquake, and are significantly below current seismic design standards
- Portions of the seawall cannot be relied upon to remain intact to resist static or seismic loadings and should be repaired immediately
- Liquefaction and lateral spreading could result in significant damage to land and property supported by the seawall as far back as Customs Street, even if the walls did not completely collapse due to seismic shaking.

In terms of seawall remedial options, several were considered for the full length of the seawall between Princes Wharf and Marsden Wharf and the most likely economic and feasible solution was considered to be a post and panel wall constructed in front (seaward) of the existing seawall.

5 Seawall upgrade options

Given the condition of the existing seawall, stability considerations, seismic vulnerability and results of risk assessment for the existing seawall, as well as the road and services it supports, options have been considered to improve the resilience of the Quay Street seawall. Consideration of options has been undertaken over a number of years in different stages. The first stage involved considering whether to upgrade the seawall or not. The second stage was to consider the different types of seawall upgrade once it was determined that the status quo (“do nothing”) option was not
acceptable. Lastly, the third stage involved refinement of the preferred options for the current upgrade project.

5.1 Stage 1: Acceptability of status quo

In considering options for upgrading the Quay Street seawall, the first stage involved deciding whether the status quo was acceptable. That is, whether the risk of failure of the seawall and the consequences of that failure would be acceptable given current and anticipated future conditions.

AT and AC have concluded that the risk associated with the status quo option is not acceptable given the consequences outlined in Section 5. The existing seawall is over 100 years old, is overall in average to poor condition, in need of repair, and has substantial ongoing maintenance requirements. It has not been designed for a seismic event, is likely to fail even in a moderate earthquake, and seismic failure could result in loss of essential facilities with post-disaster function.

A decision was made to address the seismic vulnerability of the Quay Street seawall to protect the road and services within it.

5.2 Stage 2: Options assessment

Once a decision was made to address the seismic vulnerability of the Quay Street seawall, upgrade options were thoroughly considered through multi-criteria assessments (MCA) and a subsequent post-MCA option development phase. Each of the options assessment processes is described below, and then detail is provided for each of the three sections of the seawall.

5.2.1 2014 Multi-Criteria Assessment (MCA)

In 2013/2014 a review of a number of seawall strengthening and replacement options was carried out in order to short list preferred options and compare quantitative and qualitative aspects of those options. This work concluded with an options assessment and summary report in May 2014 (T+T reference 28557.008), which presented a summary of the options evaluated together with conclusions of a MCA.

A total of 22 options were initially considered that fit into three main categories:

- Strengthening behind the existing seawall
- Strengthening or replacing the existing seawall
- Building a new wall or berm in front of the existing seawall.

The 22 options were rationalised to 11 option types and then preferred and contingency options were provided for each section of the seawall, along with important issues that would need to be resolved or investigated in further detail. These options and issues came out of the detailed MCA that utilised engineering and non-engineering assessment criteria.

Engineering and non-engineering criteria used in the MCA covered technical feasibility, cost, environmental, urban design, heritage, and archaeology. Inputs were also gained through consultation with various stakeholders, such as Mana Whenua, heritage, archaeology, and conservation. Each option was scored and ranked based on how well they scored in each of the engineering and non-engineering criteria to arrive at the preferred and contingency options.

5.2.2 2017 Multi-Criteria Assessment

Options for upgrade of the seawall were considered again in September 2017 (T+T reference 1002795.v2) as an important enabler of the wider Downtown Programme to ready the precinct for AC36 and APEC events in 2021. The work built on the options assessment carried out in 2014 but
was undertaken in accordance with the current baseline condition of the seawall and the desired 2021 outcomes.

An updated MCA was undertaken to present preferred options for the upgrade of the seawall. Following consultation with AT and key stakeholders, the options were refined to achieve a robust, cost effective upgrade of the seawall within the timeframes available. The assessment considered whole of life costs (CAPEX and OPEX) as well as non-financial costs and benefits of construction and over the design life such as improved resilience for Quay Street. The assessment also considered opportunities to create resilience to future climate and changing use patterns, particularly with the increasing intensity of ferry and cruise ship operations impacting scour.

Preferred options for each section were presented in a Planning and Implementation Strategy report in September 2017.

5.2.3 Post Multi-Criteria Assessment option development

Following the preparation of the Planning and Implementation Strategy, ongoing development of the options was undertaken taking into consideration AT and AC requirements as well as interaction with key stakeholders. This was primarily for the Queens Wharf to Marsden Wharf section where the wall upgrade being located seaward or landward of the existing seawall was being considered. The design brief agreed by the ESG summarises the development of the options that occurred following the MCA processes.

5.2.4 Princes Wharf preferred option

The preferred option for the Princes Wharf section of the seawall comprises an in-ground palisade pile wall, in accordance with the Planning and Implementation Strategy report. This option was the highest scoring in the MCA among other options including bracing the existing wall to the wharf structure, inclined ground anchors, and a palisade wall with tie back anchors to the existing wall.

The in-ground palisade wall landward of the existing seawall protects Quay Street and the services within it. The existing seawall is a Ports of Auckland Limited (POAL) asset in this section and POAL is not planning any upgrade works for the foreseeable future.

The palisade wall option is preferred because it is likely to have less overall adverse effects on the environment, and it also provides benefits over other options considered.

In particular, the proposed palisade wall option will not impact on the existing seawall and will have negligible effect on water quality, subject to implementation of appropriate management procedures as detailed in the Adaptive Environmental Monitoring and Maintenance Response Plan for Erosion and Sediment Control reports. Alternate options considered would result in potentially greater adverse effects on mana whenua values particularly related to water quality, heritage values of the existing seawall, and on owners, occupiers and users of Princes Wharf.

In addition, as the exact position of the piles is not critical and they can be aligned to avoid disruption of services within the road reserve. The capping beam on top of the piles can be buried well below the finished level to mitigate obstruction to future developments and planting of trees.

The reinforced concrete pile in-ground wall, would also have minimal ongoing maintenance requirements and associated costs after completion, compared to the other potential options for this area.

5.2.5 Ferry Basin preferred option

The preferred option for the Ferry Basin section of the seawall comprises a post and panel wall immediately seaward of the existing seawall. This option was the highest scoring in the MCA among
other options including bracing the existing wall to the wharf structure, inclined ground anchors, and ground stabilisation (jet grouting).

The proposed post and panel wall seaward of the existing seawall protects Quay Street and the services within it, as well as providing improved resilience in relation to scour effects arising from vessels manoeuvring within the Ferry Basin.

The post and panel wall option is preferred because it is likely to have less overall adverse effects on the environment, and it also provides benefits over other options considered.

In particular, the proposed post and panel wall is an effective solution in addressing maintenance issues and scour present for the existing seawall and provides ongoing durability with minimal ongoing maintenance costs. As this option is constructed entirely seaward of the wall, there is minimal impact on services. Alternate options considered would result in potentially greater adverse effects as they rely on the capacity of the existing seawall and they do not address existing scour issues in the Ferry Basin, so would require regular ongoing maintenance and remediation. The jet grouting alternative would result in potentially greater adverse effects on mana whenua values particularly related to water quality.

In addition, the facing of the wall could be textured to encourage more rapid algae and other marine biology to grow providing an enhancement of environmental value from the seawall.

5.2.6 Queens Wharf to Marsden Wharf preferred option

After consideration of a number of options in the MCA, such as bracing to the existing wharf structure, inclined ground anchors, and ground stabilisation (jet grouting), two options were shortlisted for the seawall upgrade of the Queens Wharf to Marsden Wharf section:

- In-ground pile wall seaward of the existing wall (low height)
- In-ground palisade wall landward of the existing wall.

The in-ground pile wall seaward of the existing wall was the preferred option in the MCA. It addresses existing maintenance issues and scour, provides ongoing durability with minimal ongoing maintenance costs, and provided seismic upgrade of the wall while minimising potential adverse effects on heritage values in this section through leaving the top part of the existing seawall exposed.

However, complexities identified with construction seaward of the existing wall by contracting advisors, the complex scenario identified beneath the breastworks in this section during recent inspection. Addressing existing maintenance issues and scour was also found to be less critical for this section of the seawall. These factors and the resulting cost implications on construction seaward of the existing wall in this section led to the in-ground palisade wall landward of the existing wall being the preferred option.

The palisade wall option is likely to have less overall adverse effects on the environment, and it also provides benefits over other options considered.

In particular, the proposed palisade wall option will not impact on the existing seawall and will have negligible effect on water quality, subject to implementation of appropriate management procedures as detailed in the Adaptive Environmental Monitoring and Maintenance Response Plan for Erosion and Sediment Control reports. Alternate options considered would result in potentially greater adverse effects on mana whenua values particularly related to water quality and heritage values of the existing seawall.

In addition, there would be minimal ongoing maintenance requirements and associated costs after completion, in contrast to other potential options for this area.
5.3 Stage 3: Refinement of preferred options

Following selection of the preferred option, AT progressed with preliminary design, construction planning and assessments of effects for the proposed walls. These activities were undertaken in parallel, with iterative adjustments made to determine the design for which resource consent is being sought.

This collaborative process has resulted in adjustments to the design, including location of the proposed walls, and construction methodologies that minimise the potential for effects, while still achieving the project’s desired technical outcomes. Design refinements that have been implemented, including reasons for the proposed choice, are discussed in Sections 5.3.1 to 5.3.3 below.

5.3.1 Princes Wharf

Design refinements for the Princes Wharf section included:

- Changing the proposed palisade wall alignment to avoid one of the trees (labelled Tree 18 on the resource consent drawings) that the arborist considered unlikely to survive temporary relocation, in accordance with the first preference for tree management described in the Arborlab Arboricultural report, which is to retain and protect trees on site
- Lowering of the capping beam to accommodate tree roots when trees are re-instated
- Changing the wall alignment to minimise impacts on nearby services
- Reduction in the extent of the proposed construction area to accommodate pedestrian and cycle access adjacent to 139 Quay Street and maintain general traffic and bus lanes on Quay Street
- Selection of a base-case piling methodology that minimises noise and vibration and subsequent setting of project vibration limits on this basis.

It is considered that further adjustment of the wall alignment to sit outside of the tree rootzones;

- If located to the north of the rootzone, may result in prohibitive construction issues associated with relocation of services and the proximity to the ANZ Building located at 139 Quay
- If located to the south of the rootzone, may compromise the effectiveness of the seismic upgrade, and result in prohibitive traffic management issues.

5.3.2 Ferry Basin

Design refinements for the Ferry Basin section included:

- Reduction in the extent of the proposed post and panel wall to avoid impacts on the heritage steps at the eastern end of the Ferry Basin, in response to concerns raised by the project heritage consultant and representatives from Heritage New Zealand and Auckland Council’s heritage team
- Reduction in the proposed construction area to maintain the desired level of services for buses exiting Albert Street
- Design of a construction methodology that keeps the proposed post and panel wall as close as possible to the existing seawall to minimise the amount of minor reclamation required
- Selection of a base-case piling methodology that minimises noise and vibration and subsequent setting of project vibration limits on this basis
- Exclusion of the jet grouting piling technique due to constructability issues below sea level and potential contamination of the harbour
- Providing temporary staging seaward of the proposed seawall at the western end of the section to allow construction while maintaining one of the trees (labelled Tree 18 on the resource consent drawings) that the arborist considered unlikely to survive temporary relocation, in accordance with the first preference for tree management described in the Arborlab Arboricultural report, which is to retain and protect trees on site.

5.3.3 Queens Wharf to Marsden Wharf

Design refinements for the Queens Wharf to Marsden Wharf section included:

- Reduction in the length of the proposed palisade wall to avoid one of the trees (labelled Tree 14 on the resource consent drawings) that the arborist considered unlikely to survive temporary relocation, in accordance with the first preference for tree management described in the Arborlab Arboricultural report, which is to retain and protect trees on site
- Lowering of the capping beam to accommodate tree roots when trees are re-instated
- Changing the wall alignment to minimise impacts on nearby services
- Selection of a base-case piling methodology that minimises noise and vibration and the subsequent setting of project vibration limits on this basis
- Reduction in the proposed construction area to maintain a dedicated bus lane on Quay Street where requested by AT Metro.

It is considered that further adjustment of the wall alignment to sit outside of the tree rootzones;

- If located to the north of the rootzones, may result in the tree’s being compromised through the general work requirements
- If located to the south of the rootzone, may result in prohibitive traffic management issues, and compromise the effectiveness of the seismic upgrade.

6 Conclusions

Given the condition of the existing seawall, stability considerations, seismic vulnerability and results of risk assessment for the existing seawall, as well as the road and services it supports, AT and AC have concluded that the risk associated with the status quo option (“do nothing”) is not acceptable. A decision was made to address the seismic vulnerability of the Quay Street Seawall to protect the road and services within it.

Quay Street and the services within it are considered essential facilities with post-disaster function and as such the seawall upgrade will be designed to IL4 and 100 year design life, in accordance with the New Zealand Loadings Standard (refer to AS/NZS 1170.0).

Upgrade options were thoroughly considered through MCA processes and a subsequent post-MCA option development phase.

The design options selected for the the three sections of the seawall considered in this report were:

- Princes Wharf – Palisade wall landward of the existing seawall
- Ferry Basin – Post and panel wall seaward of the existing seawall
- Queens Wharf to Marsden Wharf – Palisade wall landward of the existing seawall.

The preferred options were selected because they are likely to have less effects on the environment in some areas compared to alternative options, and the selected options provide several benefits over other options considered.

These options have been further refined in consultation with technical specialists and key stakeholders to determine the design for which resource consent is sought.
7 Applicability

This report has been prepared for the exclusive use of our client Auckland Transport, 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.

Tonkin & Taylor Ltd

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