



Western Ring Route – Waterview Connection



Coastal Works Report



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Coastal Works Report

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1. Introduction

The 'Waterview Connection Project' is the final key project to complete the Western Ring Route (WRR). In 2009 the NZ Transport Agency (NZTA) confirmed that the Waterview Connection Project (Project) would be lodged with the Environmental Protection Authority as a Proposal of National Significance (RoNS). The Project will be the largest roading Project undertaken in New Zealand, and due to its size and complexity has been divided into nine Project Sectors. These Sectors broadly define the different planning and construction requirements of the Project. A diagram of these Sectors is presented in Figure 1.1.

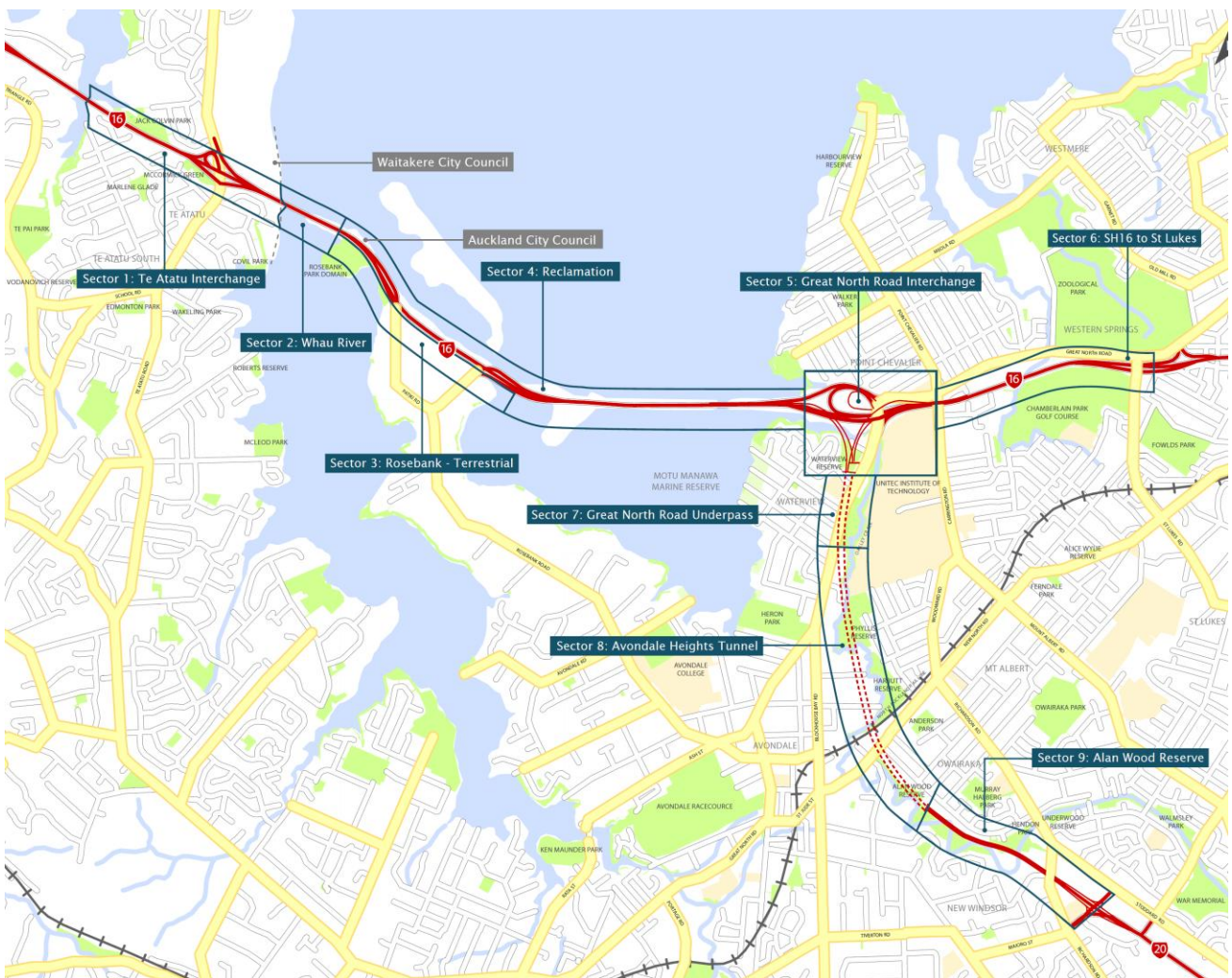


Figure 1.1 – Waterview Connection Project Sector Diagram

The improvements to SH16 provided as part of the Waterview Connection Project are approximately 8km in length, extending from the St Lukes Road Interchange to Henderson Creek, and will primarily consist of widening the existing motorway with additional lanes to accommodate the increased traffic demand from SH20.

The SH16 alignment between the Great North Road and Te Atatu Road Interchanges passes through an estuarine area, crossing parts of the central Waitemata Harbour. From the Great North Road Interchange to the Rosebank Road Interchange, and between the Patiki Road Interchange and Whau River, sections of the carriageway are formed on low man-made embankments and the improvement works will require reclamation of the Coastal Marine Area (CMA).

The section of SH16 between Great North Road and Rosebank Road is commonly referred to as the 'Causeway' (see Figure 1.2). The majority of the reclamation required for the improvements will be along the northern and southern edges of the Causeway. The ground conditions found adjacent to the Causeway are poor due to the underlying very soft Recent Alluvium (marine mud).



Figure 1.2 – Photograph of the Causeway flown in 2008

1.1 Report Purpose and Scope

The NZTA has confirmed the following Project Objectives for the Project:

1. To contribute to the region's critical transport infrastructure and its land use and transport strategies:
 - by connecting SH16 and SH20 and completing the Western Ring Route; and
 - by improving the capacity and resilience of SH16.
2. To improve accessibility for individuals and businesses and support regional economic growth and productivity:
 - by improving access to and between centres of future economic development.
3. To improve resilience and reliability of the State Highway network:
 - by providing an alternative to the existing SH1 corridor through Auckland that links the northern, western and southern parts of Auckland; and
 - by securing the SH16 Causeway against inundation.
4. To support mobility and modal choices within the wider Auckland Region:
 - by providing opportunities for improved public transport, cycling and walking; and
 - by protecting opportunities for future passenger transport development (e.g. rail).
5. To improve the connectivity and efficiency of the transport network:
 - by separating through traffic from local traffic within the wider SH20 corridor.

For the Project to comply with the Project Objectives, SH16 must be widened to improve capacity and provide opportunities for improved public transport, cycling and walking. The elevation of the motorway Causeway between Great North Road and Rosebank Road will also need to be increased to prevent inundation and therefore improve resilience.

Where reclamation is required, the philosophy has been to carefully define the extent needed to accommodate the reclamation, permanent occupation and any necessary temporary works. Therefore all design elements that might affect the overall footprint of the enlarged reclamation have to be fully assessed.

This report provides information on the proposed Project works and how these relate to reclamation and occupation of the adjacent CMA. The report describes the locations of reclamation, permanent occupation and temporary occupation in relation to the particular works. It also provides details of the likely activities, construction methodology and timing of the works in order for the environmental effects to be assessed.

1.2 Report Structure

This report summarises the Coastal Works required to complete the Project works. The following Project Sectors have works that will be undertaken within the CMA:

- **Sector 1** – Te Atatu Interchange

- **Sector 2** – Whau River
- **Sector 4** – Reclamation
- **Sector 5** – Great North Road Interchange

A description of the Project works will be defined for each Project Sector and a description of the coastal works defined for reclamation, permanent occupation and temporary occupation. Therefore each section of the report that describes a Project Sector will be structured as follows:

- **Scope of Works** – description of proposed improvements within each Project Sector;
- **Proposed Coastal Works** – description of proposed works on the foreshore and seabed;
- **Reclamation and Permanent Occupation** – description of the permanent effects on the foreshore and seabed;
- **Temporary Occupation and Construction Activities** – description of the temporary effect on the foreshore and seabed along with the anticipated activities required to construct the permanent works; and
- **Summary of Proposed Coastal Works** – summary statement of the approximate areas of reclamation, permanent occupation, temporary occupation and marine habitat remediation.

Sector 3 (Rosebank Terrestrial) works are not described in this report as the works do not require reclamation, permanent occupation or temporary occupation of the CMA. For the same reason Sectors 6 to 9 are also not described in this report.

The Coastal Works Report is supported by three supporting documents which provide further detail and engineering justification for the Project works. A summary of the three supporting documents is as follows:

- **Causeway Options Report (20.1.11-3-R-J-304)** – this report investigates and assesses the engineering solutions to provide a motorway connection between the Great North Road and Rosebank Road Interchanges and recommends a preferred solution;
- **Interpretation of Hydrodynamic Design Conditions Report (20.1.11-3-R-J-305)** – this report defines the design performance requirements the Causeway engineering must achieve taking into consideration the effects of climate change. It also establishes the elevation and coastal protection measures for the motorway embankment to secure future operation of the motorway;
- **Coastal Works Engineering Report (20.1.11-3-R-J-306)** – this report summarises the proposed engineering works in the CMA to ensure that the design meets the performance requirements concluded within the Interpretation of Hydrodynamic Design Conditions report. The report demonstrates the extent of works required in the CMA for the permanent and temporary occupation. It also details activities, methodology and timing of the construction works.

This report also cross references other assessments contained within the volume of Technical Appendices. The main assessment reports referred to are:

- Assessment of Marine Ecological Effects (20.1.11-3-R-N-1006);
- Assessment of Coastal Processes (20.1.11-3-R-N-1012);
- Assessment of Stormwater & Streamworks Effects (20.1.11-3-R-N-1013); and
- Erosion and Sediment Control Plan (20.1.11-3-R-N-1017).

1.3 Reclamation and Occupation Definition

This section discusses the definition of reclamation (in the context of the Project) and the philosophy adopted by the project team. Typically, in engineering terms, reclamation is the process of converting ground that is permanently or intermittently inundated by water into land that is permanently above sea or flood level. For the SH16 improvements this will encompass areas adjacent to the existing motorway embankment that are currently occupied by intertidal mudflats.

For this Project, the area of **Reclamation** has been given a strict definition of the creation of land from the existing to the proposed CMA boundary that is anticipated following completion of construction. The existing and proposed CMA boundary has been defined as Mean High Water Springs (MHWS), which for this Project is 1.63mRL. Refer to drawings 20.1.11-3-D-N-520-100 to 108 for the indicative locations and areas of reclamation required.

Therefore, the permanent elements of the Project works which lie below MHWS are considered as **Permanent Occupation** of the existing CMA. The permanent works cover man-made structures that support the new motorway infrastructure and include embankments below MHWS, pier locations for new bridge structures and ground improvements to the founding soils. Refer to drawings 20.1.11-3-D-N-941-100 to 109 for the indicative locations and areas of permanent occupation required.

In addition to the permanent occupation there is also the need to temporarily occupy or work within intertidal or subtidal zones. These areas will extend beyond the boundaries of the permanent footprint and are necessary in order to accommodate the requirements and activities to allow for safe construction and environmental compliance. Therefore this area is referred to in the report as **Temporary Occupation** of the CMA. The duration that the CMA will be occupied will depend on the work activity required. An approximate duration of these works is provided within this report. Refer to drawings 20.1.11-3-D-N-942-100 to 109 for the indicative locations and areas of temporary occupation required.

Finally, the area of **Marine Habitat Remediation** is defined as the area where permanent occupation required for ground improvements is greater than 0.5m below the sea bed. This area will allow marine sediments to be replaced and provide a similar marine habitat to the existing environment. Refer to the **Technical Report G.11 Assessment of Marine Ecological Effects** for further information.

An indicative representation of the areas of reclamation, permanent occupation, temporary occupation and marine habitat remediation is shown in Figure 1.3. (Note: an indicative water filled coffer dam is shown in this figure, other damming methods may be applied where geological conditions differ, and are dependant on location within the Project area).

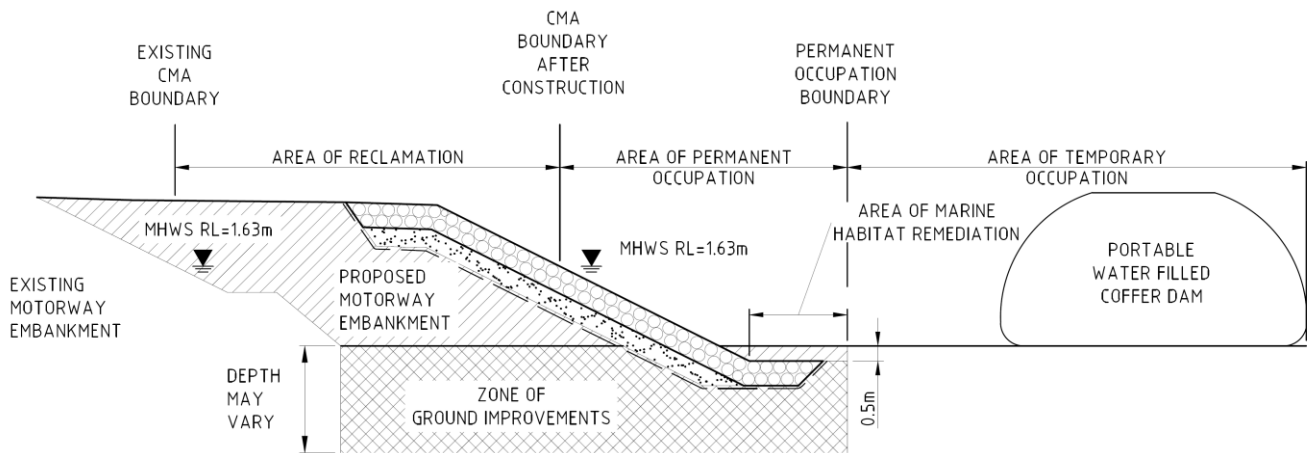


Figure 1.3 – Indicative diagram showing Reclamation, Permanent Occupation, Temporary Occupation and Marine Habitat Remediation (not to scale)

1.4 Ground Improvements

A number of possible ground improvement techniques were considered. The preferred methods considered to be most appropriate include:

- **Foundation undercut** – This technique is only proposed to be used in a limited number of locations, where the engineering design can allow approximately 2m of natural material to be removed and replaced with competent engineered fill. The depth of ground improvement will depend on findings from and interpretation of additional ground investigation, laboratory testing and further design.

This method does not require the permanent occupation of the CMA to extend beyond the proposed embankment toe.

- **In-situ mudcrete** – This is the primary technique to be used to improve the material that will underlie much of the widened Causeway embankment. This method involves mixing the soft marine sediments with cement (between approximately 80–100kg/m³) in order to increase its strength. A diagram of this in-situ mixing technique is shown in Figure 1.4(a) and 1.4(b) and a photograph of a mixing head in Figure 1.5. The in-situ mudcrete process will treat approximately 2–12m of marine sediments with the depth of ground improvement depending on the findings from and interpretation of additional ground investigation, laboratory testing and further design.

This technique will require permanent occupation of the CMA of approximately 3–4m beyond the bottom of the proposed embankment slope.

- **Marine Deposit Displacement (MDD)** – This technique is only proposed to be used around bridge abutments and piled foundations such as the Causeway bridges and Rosebank Road on, and off-ramps. This method involves placing durable rock on top of the natural sediments and lightly compacting them to create a platform upon which a lightweight fill can be placed.

This method does not require permanent occupation of the CMA to extend beyond the proposed embankment toe.

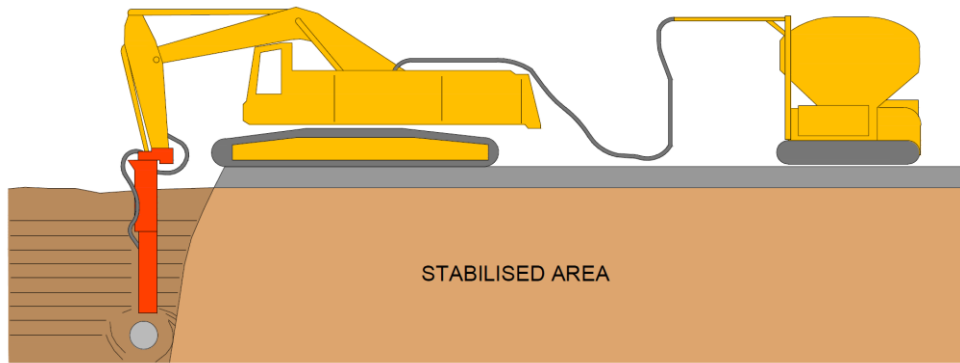


Figure 1.4(a) - In-situ Mudcrete Mixing Technique (between 2-5m)

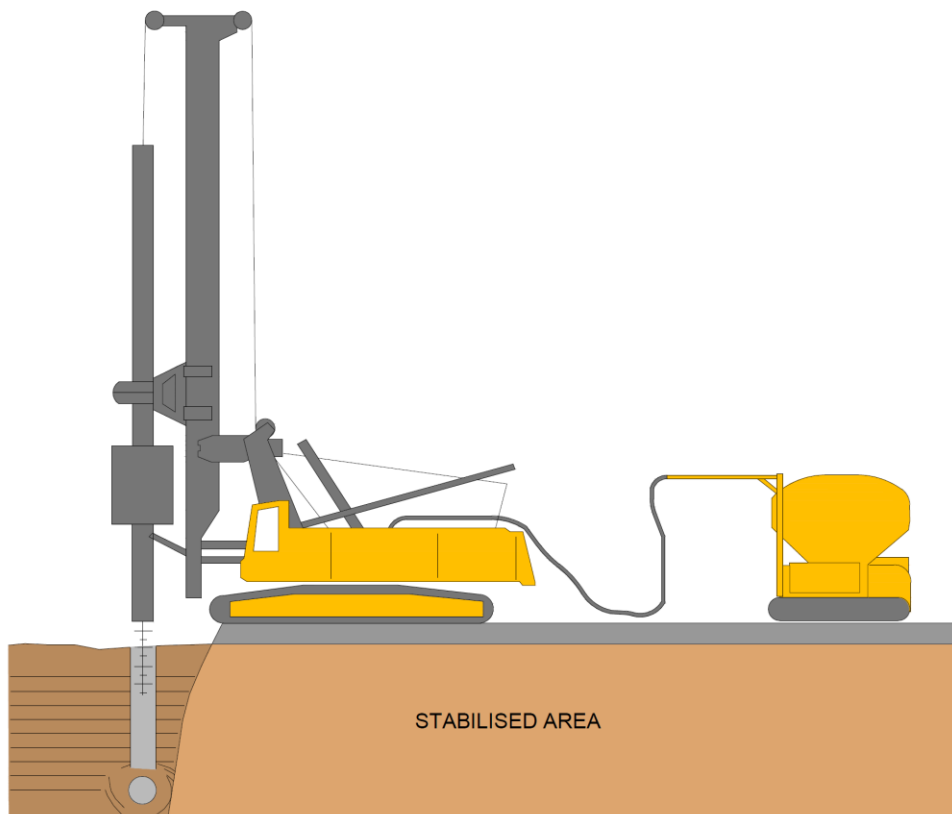


Figure 1.4(b) - Deep In-situ Mudcrete Mixing Technique (beyond 5m deep)



Figure 1.5 - In-situ Mudcrete Mixing Head

1.5 Coastal Works Drawings

All coastal works drawings referred to in this report are listed in Table 1.1 for clarity. All drawings are located in Part F [Waterview Assessment of Environmental Effects (AEE) Supporting Plans] of the Waterview AEE.

Table 1.1 - List of all Coastal Works Drawings Referred to in this Report

Plan Title	Plan Numbers	No. of Sheets
Reclamation Plans	20.1.11-3-D-N-520-100 to 108	8
CMA Permanent Occupation Plans	20.1.11-3-D-N-941-100 to 109	9
CMA Temporary Occupation Plans	20.1.11-3-D-N-942-100 to 109	9
Whau M'way and Pedestrian/Cycle way Bridges	20.1.11.3-D-S-917-220 and 221	2
Causeway M'way & Pedestrian/Cycle way Bridges	20.1.11.3-D-S-917-250 and 251	2
Great North Road Interchange	20.1.11.3-D-S-917-430 and 431	2
Great North Road Interchange Staging Platforms	20.1.11.3-D-S-610-500 and 501	2

1.6 Summary of Proposed Coastal Works

The following components of the Project require reclamation, permanent and/or temporary occupation of the CMA:

- Te Atatu stormwater wetland;
- Causeway embankments;
- Whau bridge piers and abutments;
- Causeway bridge piers and abutments;
- the realigned access road to the Rosebank Domain;
- Rosebank culvert decommissioning;
- Waterview Estuary channel realignment;
- Oakley Creek Inlet channel realignment; and
- the Great North Road Interchange motorway-to-motorway ramp piers.

1.7 Summary of Proposed Reclamation and Occupation

Table 1.2 summarises the areas of reclamation, permanent occupation and temporary occupation required to provide the improvements as part of the Waterview Connection Project.

Table 1.2 – Approximate Areas of Reclamation, Permanent Occupation, Temporary Occupation and Marine Habit Remediation (Note – Figure in brackets refers to that portion of the total occupation that is above the CMA, i.e. Aerial Occupation)

Area Type	Approximate Area (ha)
Reclamation	4.71
Permanent Occupation	4.15 (1.68)
Temporary Occupation	6.63 (0.69)
Marine Habitat Remediation	1.32

Sector 1 – Te Atatu Interchange

1.8 Scope of Works

The improvements proposed in Sector 1 of the Project include:

- widening the existing main SH16 carriageway west of the Te Atatu Interchange from two general traffic lanes in both the eastbound and westbound directions to three general traffic lanes plus bus-shoulders, in both directions;
- widening the existing mainline carriageway east of the Te Atatu Interchange from three general traffic lanes in both the eastbound and westbound directions to four general traffic lanes plus bus-shoulders, in both directions;
- realigning and increasing the capacity at the eastbound and westbound off-ramps;
- increasing the traffic movement capacity of the interchange, with Te Atatu Road northbound and southbound movements increasing by an additional lane;
- provision of a separate dedicated north-western pedestrian/cycle way facility west of the Te Atatu Interchange along the southern edge of SH16;
- increasing the width of the existing separated north-western pedestrian/cycle way facility east of the Te Atatu Interchange; and
- provision of stormwater treatment to treat run-off from the existing and proposed impervious road surfaces.

1.9 Proposed Coastal Works

Of the above improvement works in Sector 1, only the construction of a stormwater wetland will require works in the CMA. The following sections of this report outline the reclamation, permanent and temporary occupation, and construction activities required as part of the stormwater wetland.

1.10 Reclamation and Permanent Occupation

A stormwater wetland is proposed between approximately Ch6200 and Ch6350 to treat run-off from the existing and proposed impervious road surfaces. This was selected as the ideal location for a stormwater treatment device as it is adjacent to the existing low-point of the SH16 main carriageway. The stormwater wetland has been sized in proportion to the size of the catchment area that requires treatment. Three areas of outlet scour protection will also be required as these outlets are located within the CMA. For further details of

the design and location of the proposed wetland refer to the **Technical Report G.15 Assessment of Stormwater & Streamworks Effects**.

Reclamation and permanent occupation of the neighbouring CMA north of the SH16 carriageway is required for provision of the stormwater wetland. Improvements to founding soils will be required and it is proposed to use the foundation undercut method (refer to Section 1.4), with a 2m approximate depth of alluvial material being removed and replaced with competent engineered fill. This ground improvement method does not require the permanent occupation of the CMA to extend beyond the proposed embankment toe. For further details regarding the geotechnical ground improvements required refer to the **Coastal Works Engineering Report (20.1.11-3-R-J-306)**.

Drawing 20.1.11-1-D-N-520-101 shows the proposed reclamation extents. Drawing 20.1.11-1-D-N-941-101 shows the permanent occupation required for the proposed wetland.

1.11 Temporary Occupation and Construction Activities

Construction of the stormwater wetland will require temporary occupation and disturbance of the CMA beyond the area required for reclamation and permanent occupation.

It is proposed that the wetland be constructed by building up clay embankments. The preferred ground improvement measure is the foundation undercut method which will require removal of the in-situ material to an approximate depth of 2m. The excavated marine mud will be replaced with competent engineered fill to form the base of the wetland; competent engineered fill will also be used to form the embankment. For further details regarding the geotechnical ground improvements required refer to the **Coastal Works Engineering Report (20.1.11-3-R-J-306)**.

The reclamation area consists of mangrove covered tidal mudflats generally above 1.0m RL. Due to the elevation of the mudflats, this area is currently only inundated for short periods up to a depth of 0.6m (based upon MHWS). It is proposed to undertake the works between tides when the construction area is not inundated. Erosion and sediment control measures during construction will consist of a temporary rock toe with embedded geotextile to act as a temporary silt fence installed to a 5m maximum beyond the permanent embankment toe location. No construction activities will be implemented beyond the temporary rock toe silt fence. The wetland has been designed not to require any interference, diversions or works in the Henderson Creek tributary channel (Pixie Stream), either during or after construction. For further details refer to the **Erosion and Sediment Control Plan (20.1.11-3-R-N-1017)**.

The proposed construction methodology for the stormwater wetland can be summarised as follows:

- a. Install erosion and sediment control Super Silt Fence (above MHWS) to control sediment for the land based earthworks. Strip off and remove existing topsoil between motorway and Super Silt Fence;
- b. Prepare a smooth footprint area surface by clearing mangroves (including roots) within the reclamation and construction area during low tide. Hand lay 3m wide geotextile filter blanket directly on marine mud 3 to 5m clear of the proposed permanent embankment toe. Place rock in layers directly upon the geotextile using a long reach excavator and embed geotextile into the rock to create the temporary rock toe silt fence on the tidal mud flats;

- c. Form pump sumps along the inside of the temporary rock toe silt fence to remove seepage water. Contaminated water (i.e. sediment-laden) trapped between the embankment and the temporary rock toe silt fence will be pumped to temporary sediment retention ponds or tankered off site. Non-contaminated water can be pumped back into the sea, although water will not be allowed to flow directly over the mud flats. Refer to the **Erosion and Sediment Control Plan (20.1.11-3-R-N-1017)**;
- d. Using the Foundation Undercut method, excavate and remove the virgin marine mud to a depth of approximately 2m down to the East Coast Bays Formation founding level. The excavated marine mud will be removed from site. In layers, fill the excavation with competent engineered fill material and compacted to form wetland base and embankments. Refer to the **Stormwater Assessment (20.1.11-3-R-N-1013)** for the size, type and exact location of the wetland;
- e. Once backfill level is above MHWS, install a silt fence on top of the embankment fill next to the proposed permanent coastal protection. As bulk back filling progresses, the temporary rock toe silt fence can be removed, with the rocks being re-used elsewhere, if appropriate. For further details regarding the coastal protection required refer to the **Coastal Works Engineering Report (20.1.11-3-R-J-306)**.

Drawing 20.1.11-1-D-N-942-101 shows the area of temporary occupation required to construct the proposed wetland.

1.12 Summary of Proposed Coastal Works

Of the proposed works in Sector 1, only the construction of a stormwater wetland will require works in the CMA. The stormwater wetland is proposed between Ch6200 and Ch6350 and has been sized to treat run-off from the existing and proposed impervious road surfaces.

Table 2.1 summarises the areas of reclamation, permanent and temporary occupation required to provide for the stormwater wetland. Note: there is no marine habitat remediation in Sector 1.

Table 2.1 - Approximate Areas of Reclamation, Permanent Occupation and Temporary Occupation for Sector 1

Area Type	Plan Title	Plan Numbers	Approximate Area (ha)
Reclamation	Reclamation Plan	20.1.11-3-D-N-520-101	0.10
Permanent Occupation	CMA Permanent Occupation Plans	20.1.11-3-D-N-941-101	< 0.01
Temporary Occupation	CMA Temporary Occupation Plans	20.1.11-3-D-N-942-101	0.05

2. Sector 2 – Whau River

2.1 Scope of Works

Improvement works proposed for Sector 2 of the Project include:

- widening the existing motorway embankment from the Patiki Road off-ramp to Whau River, increasing the number of lanes from three to four general traffic lanes in both the eastbound and westbound directions plus bus-shoulder in each direction;
- widening the two existing bridge structures (including construction of the abutments) crossing the Whau River to accommodate an additional general traffic lane and bus-shoulder in each direction;
- increasing the width of the existing shared use pedestrian/cycle way;
- construction of a separated shared use pedestrian/cycle way bridge approximately 8m south of the proposed westbound widened Whau Bridge structure;
- realignment of the Rosebank Domain access road; and
- provision of stormwater treatment for the eastbound and westbound carriageways to treat the run-off from the existing and proposed impervious road surfaces.

2.2 Proposed Coastal Works

Of the above improvement works in Sector 2, the Whau Bridge piers and abutments, Causeway embankments and the Rosebank Domain access road realignment will require works in the CMA. The following sections of this report outline the reclamation, permanent and temporary occupation, and construction activities required for the improvement works in the CMA.

2.3 Reclamation and Permanent Occupation

2.3.1 Whau Bridges - Permanent Piers

Widening of the existing Whau Bridges is required to accommodate the proposed motorway (8 general traffic lanes and 2 bus shoulders). The widening of the existing bridges will require additional piers to support the extra traffic lanes. A new bridge separated from the existing bridges is proposed to support the shared pedestrian/cycle way. Therefore permanent occupation of the CMA is required for the new reinforced concrete piles permanently located in the Whau River. For details of these proposed piles refer to drawing 201113-D-N-941-103.

To accommodate the additional traffic lanes and upgraded motorway cross section, the eastbound existing bridge will be widened by approximately 7.25m. The westbound bridge will be widened by approximately 8.0m. Both widened bridges will accommodate 4 x 3.5m wide traffic lanes and a 3.5m wide bus shoulder. A separate bridge will be provided for a 3m wide pedestrian/cycle way. Refer to the **Coastal Works Engineering Report (20.1.11-3-R-J-306)** for further details.

Cast in-situ bridge piles (for the widened bridges) will be concreted inside a sacrificial metal casing. The metal casing will be installed by top driving to a pre-determined depth. The marine mud will then be removed from within the metal casing by an auger piling rig and taken off site. The metal casing is required as the pile excavations in marine mud at this location will not be self supporting. All of the proposed piles are aligned with the existing bridge piles for structural reasons and can provide continual watercraft navigation along the Whau River.

There are 21 proposed permanent piles (within the CMA) 1.5m in diameter, for the eastbound Whau Bridge widening. There are also 21 proposed permanent piles (within the CMA) 1.5m in diameter for the westbound Whau Bridge widening. The proposed piles will be similar in shape and diameter to the existing bridge piles. The 7 proposed permanent piles (within the CMA) for the separate pedestrian/cycle way bridge are also 1.5m in diameter.

Drawing 20.1.11-1-D-N-941-103 shows the permanent occupation locations for the widening of the Whau Bridges and separate pedestrian/cycle way bridge.

2.3.2 Whau Bridge - Abutments

Whau Bridge will be widened on both sides and a new pedestrian/cycle way bridge constructed as part of the improvements, therefore the existing abutments will also need to be widened. The marine deposits are relatively thick at the eastern Whau Bridge abutment (Ch4650 to Ch4700) therefore it is likely that the widening of the abutments may induce settlement. Bridge structures have little tolerance to settlement so ground improvements will be required. The preferred technique to be adopted in this area is Marine Deposit Displacement (MDD). This technique is described in Section 1.4.

The lightweight used in this location may extend at least 50m longitudinally from the bridge abutment and will provide a transition zone between the larger settlements expected at the Causeway embankment to a minimal amount for the bridge structure.

The area of the CMA occupied by the permanent works will be the boundary defined by the outer edge of the ground improvement which will not extend beyond the proposed embankment toe. For further details regarding the geotechnical ground improvements required refer to the **Coastal Works Engineering Report (20.1.11-3-R-J-306)**.

Drawing 20.1.11-1-D-N-520-103 shows the proposed reclamation extents, with drawing 20.1.11-1-D-N-941-103 showing the permanent occupation required for the Whau Bridge abutments.

2.3.3 Causeway Embankment

SH16 crosses around 250m of intertidal area just to the east of Whau River (Ch4400 to Ch4650) and is constructed on a man-made embankment. The motorway improvement works require the embankment to be widened into the intertidal area. In addition to the proposed motorway cross section (8 general traffic lanes, 2 bus shoulders and the separate shared pedestrian/cycle way), the widened embankment will also accommodate stormwater treatment in the form of hybrid bio-filters located flush with the proposed bus shoulders. Refer to the **Technical Report *G15 Assessment of Stormwater & Streamworks Effects*** for details.

The marine sediments in this area are weak and ground improvements will be required. The area of the CMA occupied by the permanent works will be the boundary defined by the outer edge of the ground improvement (approximately 4m beyond the toe of the new embankment). It is considered that in-situ mudcrete (as described in Section 1.4) is the most appropriate ground improvement technique to be adopted in this section.

For further details regarding the geotechnical ground improvements required refer to the **Coastal Works Engineering Report (20.1.11-3-R-J-306)**.

Drawing 20.1.11-1-D-N-520-103 shows the proposed reclamation extents, with drawing 20.1.11-1-D-N-941-103 showing the permanent occupation extents required for the proposed motorway embankment widening and ground improvements between the Patiki Road off-ramp and the Whau River.

2.3.4 Access to Rosebank Domain

The motorway between the Patiki Road on-ramp and the Rosebank Domain Raceway will be widened. A separate shared use pedestrian/cycle way will be constructed adjacent to the westbound carriageway (to the south) to provide continuity to the north-western pedestrian/cycle way. Subsequently the existing access road to the Rosebank Domain Raceway will need to be realigned. The proposed realignment is 6m wide, conforming to relevant standards for a two way two lane local access road. A 1.0m shoulder is also proposed on either side of the realigned access road.

Permanent occupation of the neighbouring CMA south of SH16 is required to provide the access road (approximately Ch3970 to Ch4100) to Rosebank Domain. Improvements to founding soils will be required and it is proposed to use the foundation undercut method, where the alluvial material is removed and replaced with competent engineered fill. This ground improvement method does not require permanent occupation of the CMA to extend beyond the proposed embankment toe. For further details regarding the geotechnical ground improvements required refer to the **Coastal Works Engineering Report (20.1.11-3-R-J-306)**.

There is a small drainage channel that drains the intertidal area to the west of Rosebank Peninsula, conveying intertidal waters to the Whau River near Rosebank Domain Raceway. The channel is typically 3-5 m in width. This channel will require relocation to facilitate the realignment of the Rosebank Domain Raceway access road. Refer to the **Technical Report *G.4 Assessment of Coastal Processes*** a description of the rationale for channel migration (see also Section 3.4.4 for additional information).

Drawing 20.1.11-1-D-N-520-104 shows the proposed reclamation, with drawing 20.1.11-1-D-N-941-104 showing the permanent occupation required for the realigned access road to the Rosebank Domain Raceway.

2.4 Temporary Occupation and Construction Activities

2.4.1 Whau Bridges - Temporary Piers

Construction of the Whau Bridges will require temporary occupation and disturbance of the CMA beyond the area required for permanent occupation.

Key constructability issues that have been considered are:

- Construction phasing including maintaining traffic flow through the construction period; and
- Temporary staging platforms for the Whau Bridge widening work.

2.4.1.1 Construction Phasing

The proposed Whau Bridge widening construction sequence is as follows:

- Phase One – widen the eastbound carriageway bridge and construct the separate pedestrian/cycle way bridge on the westbound side of the motorway from the two temporary staging platforms (details of the proposed staging platforms are discussed in the following section);
- Phase Two – connect the new and existing eastbound road bridges. Construct the stitch joint between the existing eastbound bridge and the widened section of the eastbound bridge. It is expected that Phase One and Two combined (including the pedestrian/cycle way bridge) will take approximately 18 months (i.e. months 1 to 18 of the construction programme);
- Phase Three – construct the westbound motorway bridge widening from one of the temporary staging platform. It is expected that Phase Three will take approximately 21 months (i.e. months 19 to 39 of the construction programme);
- Phase Four – complete strengthening of the existing structures and improvements to the median barriers on each of the existing bridges. No coastal works are involved in this phase; and
- Phase Five – complete the final surfacing and lane marking to the bridges and approaches. No coastal works are involved in this phase.

For further details of the works required within each phase, refer to the **Coastal Works Engineering Report (20.1.11-3-R-J-306)**.

2.4.1.2 Temporary Staging Platforms

The construction of the Whau Bridges will be completed from temporary platforms constructed adjacent to the widening. These platforms will allow the bridges to be constructed without the need for construction plant to be placed on the existing bridge decks, which will ensure the existing structures are not overloaded and the existing motorway traffic lanes can be maintained during construction.

Refer to drawing 201113-D-N-942-103 for the proposed location of the temporary staging platforms. Allowance for 7m (wide) temporary platforms has been provided, with 0.5m clearance to the permanent bridges for formwork to be located. The temporary platforms will be supported by temporary steel piles, driven into the underlying mud until a sufficient bearing capacity is achieved. The temporary piles are arranged

in pairs at approximately 9m centres longitudinally and 5–6m centres laterally. It is expected that the temporary steel piles will be 600mm in diameter. The temporary piles will support a steel superstructure with a timber decking to form the surface of the temporary platforms. The permanent piles for both the existing bridges and the proposed bridges and the temporary piles for the temporary platforms are indicatively shown on drawings 201113-D-N-942-103. A total of 88 temporary 600mm diameter steel piles are shown (44 for each temporary platform).

The temporary platforms will be set at a level high enough so as not to reduce the vertical clearance to the sea level, therefore the existing bridge freeboard will be maintained during construction. The westbound staging platform will be located between the motorway extension and the proposed pedestrian/cycle way bridge to enable construction of both bridges from the same platform.

Following construction, the temporary platforms will be removed by using cranes located on the temporary platforms. The piles will be removed through the use of vibration equipment attached to the cranes.

The temporary platforms will be designed to provide construction access from the east and west river banks. A span will be left clear for continued river navigation. Therefore navigation of Whau River will remain open during construction but there may be a requirement for brief (several hours at a time during the night or for a couple of hours either side of high tide) navigation closures for certain construction operations.

It is expected that the eastbound temporary platform will be in place for the first 18 months of construction. The westbound platform is required to be in place for approximately the first 39 months of construction.

2.4.2 Whau Bridge - Abutments

Construction of the Whau Bridge abutments (Ch4650 to Ch4700) will require temporary occupation and disturbance of the CMA beyond the area required for permanent occupation.

The placement of rock as part of the MDD ground improvement can be undertaken at any state of the tide. However, the light tamping will only be undertaken when the site is free of standing water. The lightweight fill will be low density polystyrene clad in concrete (or equivalent clad material) and will be designed so that it will not be adversely affected by the marine environment (i.e. breakdown or degrade) – refer to the **Coastal Works Engineering Report (20.1.11-3-R-J-306)** for further details.

Super Silt Fences will be used to control sediment for the land based earthworks only. Refer to the **Erosion and Sediment Control Plan (20.1.11-3-R-N-1017)**.

The proposed construction methodology for the Whau Bridge abutments can be summarised as follows:

- a. Install erosion and sediment control Super Silt Fence to control sediment for the land-based earthworks. Strip off and remove existing top soil between motorway and Super Silt Fence;
- b. Clear mangroves (including roots) within the occupation and construction area during low tide;
- c. Implement the MDD by placing durable rock onto the marine mud (with a geotextile separator) and lightly tamping using an excavator until approximately a 1m deep foundation has been created. On

top of the rock crust, place the lightweight fill material up to design level to form the abutments – refer to the Coastal Works Engineering Report for further details;

- d. Install a silt fence on top of the embankment fill next to the coastal protection once backfill level is above MHWS.

Drawing 20.1.11-1-D-N-942-103 shows the area of temporary occupation required to construct the Whau Bridge abutments.

2.4.3 Causeway Embankment

Construction of the Causeway embankments (Ch4400 to Ch4650) will require temporary occupation and disturbance of the CMA beyond the area required for permanent occupation.

In-situ mudcrete is considered to be the most appropriate form of ground improvement technique to be used in this area. This method entails mixing cement (between approximately 80–100kg/m³) with the marine sediments. This technique requires the working area to be kept free of standing water, therefore a cofferdam structure will be required. It is considered that a sheet pile dam is the most appropriate form of cofferdam to be used within this area (refer to Figure 3.1). For further details regarding the geotechnical ground improvements required refer to the **Coastal Works Engineering Report (20.1.11-3-R-J-306)**.

The in-situ mudcrete process will treat marine sediments, with the area of ground improvements extending from the toe of the existing embankment to the proposed boundary of permanent occupation;

The new embankment will then be constructed on top of this improved ground. Fill material to be placed below MHWS level will be granular durable rock with a low fines content. The cofferdam will remain in place until the embankment is above MHWS level.

Erosion and sediment control measures during construction will consist of a sheet pile dam with an integrated silt fence. This will be located approximately 2m beyond the edge of the ground improvement works.

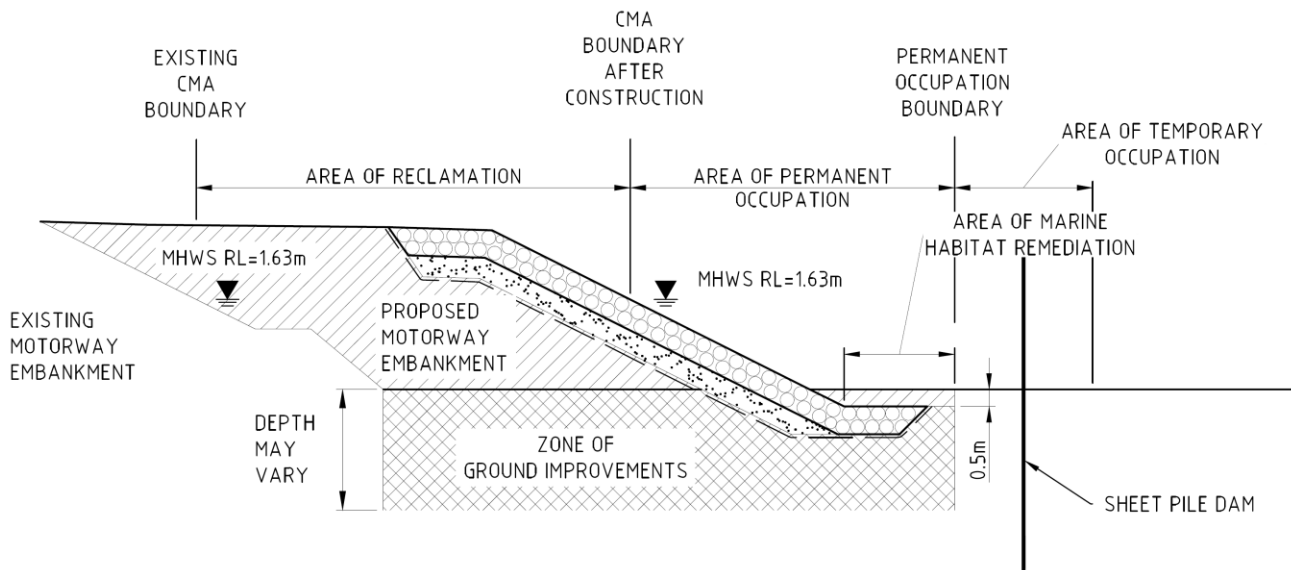


Figure 3.1 – Indicative section showing location of sheet pile dam (not to scale)

The proposed construction methodology for the Causeway embankment can be summarised as follows:

- a. Install the cofferdam using plant located on the existing Causeway;
- b. Strip off and remove existing top soil between motorway and the sheet pile dam;
- c. Create an entrance platform to allow the ground improvement plant equipment to access the work area;
- d. Clear coastal vegetation within the work area, including roots;
- e. Create a working entrance platform (approximately 5m wide by 15m long) by placing a layer of geotextile and geogrid onto the marine sediments. The geotextile will act as a separator between the marine mud and working platform, while the geogrid will act as a reinforcing layer. Next a layer of coarse gravel will be placed and compacted into the marine sediments until a platform with an adequate strength is created (due to the very soft properties of the marine sediments it is possible that this layer will be up to approximately 1m thick in places). Only one working entrance platform is required per work face;
- f. Several sumps are to be formed inside the work area so that any water seepage past the cofferdam or through the existing Causeway embankment can be collected. Contaminated water (i.e. sediment-laden) trapped between the embankment and cofferdam will be pumped to temporary sediment retention ponds or tankered off site. Non-contaminated water can be pumped back into the sea, although water will not be allowed to flow directly over the mud flats;
- g. Following completion of the working entrance platform a 0.6m layer of medium coarse gravel (GAP 65 or similar) will be placed incorporating two layers of geogrid reinforcement. Finally to complete the platform and provide protection to the geogrid reinforcement a 150mm layer of medium coarse gravel (GAP 65 or similar) will be placed. This platform will be permanent and will protect the ground improved area, together with allowing the plant equipment to operate;

- h. Excavate and store (in an area of proposed reclamation, permanent and/or temporary occupation) a sufficient volume (approximately 2m³ per metre chainage of motorway) of marine mud to be used as the back fill for the area of marine habitat remediation; The in-situ mudcrete process will treat marine sediments. The area of ground improvements will extend from the toe of the existing embankment to the proposed boundary of permanent occupation;
- i. Following completion of the ground improvement works the new Causeway embankments will be constructed. A geotextile will be placed along the benched slope of the existing Causeway embankment, extending down and along the surface of the improved ground to a point where the intertidal shoulder fill meets the granular filter layer. Then the selected intertidal shoulder fill is to be placed to a level above MHWS. The seaward facing slope will have a gradient of 1V:2H;
- j. A key will be excavated into the improved ground to act as toe support. A geotextile layer will be placed on the front slope of the intertidal shoulder fill and also placed into the excavated key. The chosen granular filter layer will then be placed, followed by placement of the rock armour protection. Finally, the stored marine mud will be placed back over the proposed rock armour toe to form the area of marine habitat remediation;
- k. Contaminated water (i.e. sediment-laden) trapped between the new embankment and dam will be pumped to temporary sediment retention ponds or tankered off site. Non-contaminated water can be pumped back into the sea, although water will not be allowed to flow directly over the mud flats. The area of marine habitat remediation can then be backfilled with the stored marine mud. Once this has been completed the cofferdam can be removed;
- l. Once the sheet pile dam is removed the remaining shoulder (above sea level) will be constructed using the selected fill material. Several layers of geogrid reinforcement will be installed within this material to provide adequate stability.

Drawing 20.1.11-1-D-N-942-103 shows the area of temporary occupation required to construct the causeway embankment between Ch4400 and Ch4650.

For further details regarding the coastal protection required refer to the **Coastal Works Engineering Report (20.1.11-3-R-J-306)**.

2.4.4 Access to Rosebank Domain

Construction of the Rosebank Domain access road will require temporary occupation and disturbance of the CMA beyond the area required for permanent occupation.

The access road will be constructed by building up an engineered embankment. The ground improvement measures using the foundation undercut method will require removal of the in-situ material to an approximate depth of 2m. The excavated marine mud will be replaced with competent engineered fill to form the embankment and base of the access road.

The reclamation and occupation area consists of mangrove-covered tidal mudflats generally above 1.0m RL. Due to the elevation of the mudflats, this area is currently only inundated for short periods up to a depth of 0.6m (based upon MHWS). It is proposed to undertake the works when the construction area is not inundated

between tides. Erosion and sediment control measures during construction will consist of a temporary rock toe with embedded geotextile to act as a temporary silt fence installed to a 5m maximum beyond the permanent embankment toe location. No construction activities will be implemented beyond the temporary rock toe silt fence. For further details refer to the **Erosion and Sediment Control Plan (20.1.11-3-R-N-1017)**.

The small channel that drains the intertidal area to the west of Rosebank Peninsula will require relocation to facilitate the realignment of the Rosebank Domain Raceway. This channel will be allowed to naturally migrate laterally and reform on the outside of the ground-treatment works protected by super silt fences. To facilitate the natural migration of the drainage channel, the widening of the reclamation and associated ground treatment works needs to proceed slowly in stages out into the existing drainage channel. This is to provide sufficient time for the channel to migrate laterally to avoid upstream ponding as the tide level drops. To allow this channel to migrate laterally, mangroves and their rooting systems will need to be removed (excavated) on the southern side of the drainage channel to allow erosion processes to operate more freely on the southern flank of the channel. Refer to the **Technical Report G.4 Assessment of Coastal Processes** for the rational for the use of this technique.

The proposed construction methodology for the access to Rosebank Domain can be summarised as follows:

- a. Install erosion and sediment control Super Silt Fence (above MHWS) to control sediment for the land based earthworks. Strip off and remove existing topsoil between motorway and Super Silt Fence.
- b. Prepare a smooth footprint area surface by clearing mangroves (including roots) within the reclamation and construction area during low tide. Hand lay 3m wide geotextile filter blanket directly on marine mud 3 to 5m clear of the proposed permanent embankment toe. Place rock in layers directly upon the geotextile using a long reach excavator and embed geotextile into the rock to create the temporary rock toe silt fence on the tidal mud flats (refer to Figure 3.2)
- c. Form pump sumps along the inside of the temporary rock toe silt fence to remove seepage water. Contaminated water (i.e. sediment-laden runoff) should be pumped to the temporary sediment retention ponds or into tankers and removed from site. Non-contaminated water can be pumped back into the sea, although water will not be allowed to flow directly over the mud flats.
- d. Excavate and remove the virgin marine mud approximately 2m deep down to founding level. The excavated marine mud will be removed from site. Fill excavation with competent engineered fill material in layers and compact to form access road sub-grade and embankments.
- e. The area of marine habitat remediation can then be backfilled with the stored marine mud. Once backfill level is above MHWS, install a silt fence on top of the embankment fill next to the proposed permanent coastal protection. As bulk back filling progresses, the temporary rock toe silt fence can be removed, with the rocks being re-used elsewhere, if appropriate. For further details regarding the coastal protection required refer to the **Coastal Works Engineering Report (20.1.11-3-R-J-306)**.

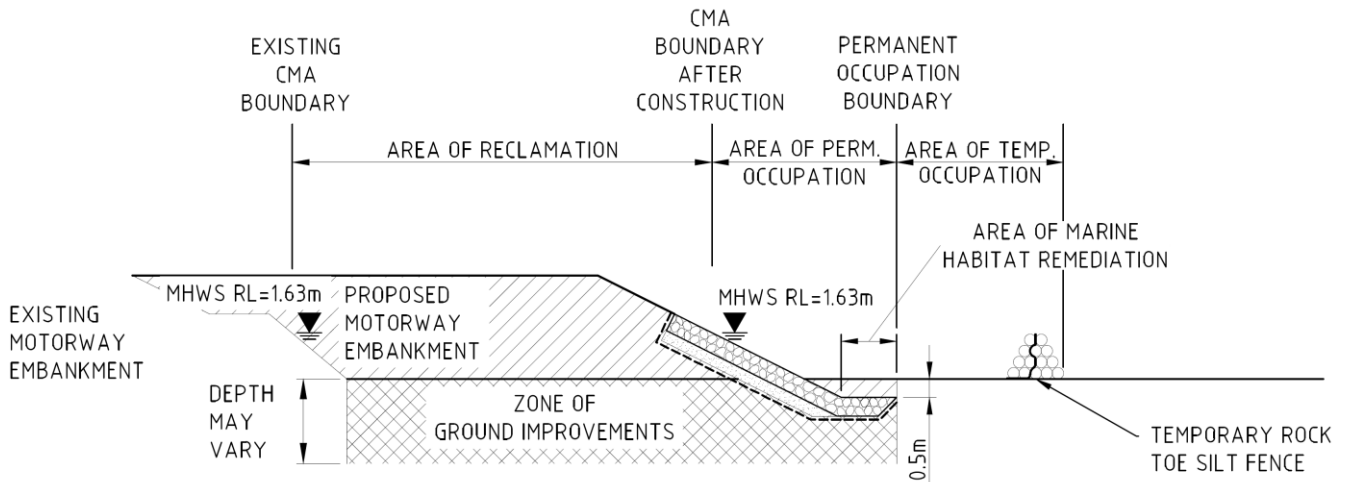


Figure 3.2 – Indicative section showing location of temporary rock toe silt fence (not to scale)

Drawing 20.1.11-1-D-N-942-104 shows the area of temporary occupation required to construct the Rosebank Domain access road.

2.5 Summary of Proposed Coastal Works

Of the proposed works in Sector 2, the Whau Bridge piers and abutments, Causeway embankments and the realigned access road to the Rosebank Domain will require works in the CMA.

Table 3.1 summarises the areas of reclamation, permanent occupation, temporary occupation and marine habitat remediation required to provide for the improvements to SH16 as part of the Project.

Table 3.1 – Approximate Areas of Reclamation, Permanent Occupation, Temporary Occupation and Marine Habitat Remediation for Sector 2 (Note – Figure in brackets refers to that portion of the total occupation that is above the CMA, i.e. Aerial Occupation)

Area Type	Plan Title	Plan Numbers	Approximate Area (ha)
Reclamation	Reclamation Plan	20.1.11-3-D-N-520-103 & 104	0.41
Permanent Occupation	CMA Permanent Occupation Plans	20.1.11-3-D-N-941-103 & 104	1.11 (0.93)
Temporary Occupation	CMA Temporary Occupation Plans	20.1.11-3-D-N-942-101 & 104	0.6 (0.27)
Marine Habitat Remediation	Area calculated	Area calculated	0.16

3. Sector 4 – Causeway Reclamation

3.1 Scope of Works

Sector 4 of the Project will include the more significant work within the CMA to provide for the SH16 improvements. These coastal works arise from the need to:

- realign the Patiki Road off-ramp to accommodate the additional general traffic lane in the eastbound direction;
- widen the eastbound carriageway to accommodate an additional general traffic lane and provide a location for stormwater treatment between Ch3800 and Ch4025;
- block the existing culvert that crosses the motorway at approximately Ch2900;
- increase the number of general traffic lanes travelling in the eastbound and westbound directions between the Rosebank Road and Great North Road Interchanges (2 additional lanes westbound and 1 additional lane eastbound);
- realign the Rosebank Road and Great North Road Interchange ramps to allow for the motorway widening;
- allow for the northbound and southbound SH20 ramp connections;
- upgrade the existing bus-shoulders (increasing width) in the eastbound and westbound directions between the Rosebank Road and Great North Road Interchanges;
- enhance the existing shared pedestrian/cycle way (increasing width) between the Rosebank Road and Great North Road Interchanges;
- raise the mainline carriageway to future proof the motorway against inundation and wave overtopping, to a suitable design year and return period, taking into consideration the effects of climate change;
- accommodate settlement effects to meet the design conditions required to future proof the motorway against inundation and overtopping;
- provide coastal protection to safeguard the new embankment against erosion and scour taking into consideration the effects of climate change;
- provide ground improvements to stabilise the marine mud to the north and south of the existing embankment to allow for the widened motorway;
- provide stormwater treatment to the north and south of the proposed carriageways to treat the run-off from the existing and proposed impervious road surfaces (refer to the **Technical Report G.15 Assessment of Stormwater & Streamworks Effects**);

- widen the two existing Causeway bridge structures (including the construction of the abutments) crossing the Waterview Estuary Inlet to accommodate the additional general traffic lanes and upgraded bus shoulders;
- construct a shared use pedestrian/cycle way bridge separated by approximately 8m south of the proposed westbound widened Causeway bridge structure; and
- realign the Waterview Estuary and Oakley Creek channels.

3.2 Proposed Coastal Works

Of the improvement works in Sector 4, the Causeway bridge piers and abutments, the Rosebank culvert decommissioning, realignment of the Waterview Estuary and Oakley Creek channels, and the widening and raising of Causeway embankments will require works in the CMA. The following sections of this report outline the reclamation, permanent and temporary occupation and construction activities required for the proposed works in the CMA.

3.3 Causeway Options

The Causeway embankment between the Great North Road Interchange and Rosebank Road requires widening to accommodate the additional general traffic lanes, bus shoulders, pedestrian/cycle way and stormwater treatment. Five general traffic lanes and a bus shoulder are proposed in the westbound direction, while four general traffic lanes and a bus shoulder are proposed for the eastbound carriageway.

A number of potential engineering solutions have been considered to provide the motorway link across the Waitemata Harbour between the Great North Road and Rosebank Road Interchanges. The options considered and the options selection assessment is recorded in the **Causeway Options Report (20.1.11-3-R-J-304)**. A summary of the Causeway Options Report has been included for clarity, and can be seen below.

To establish the optimum Causeway improvement solution, a series of potential 'high level' options were tabled, and these options were then assessed in order to produce a shortlist.

Consequently, the high level options were refined into a shortlist of six, Causeway and/or viaduct options that were assessed further:

- A. Widening of the existing Causeway with wall structures to form a 'trough';
- B. Widening of the existing Causeway with revetments to form a 'trough';
- C. Widening and raising of the existing Causeway with wall structures;
- D. Widening and raising of the existing Causeway with revetments;
- E. Placing a viaduct structure over the existing Causeway;
- F. Raising of the existing Causeway, and widening with viaduct structures.

The assessment concluded that the preferred option [of the Options A to F] was to widen and raise the existing motorway embankment with revetments [Option D].

The design then focused on the Causeway alignment, assessing symmetrical or asymmetrical (to the north or south) widening. The assessment concluded that the preferred alignment was to widen both sides symmetrically about the existing Causeway centreline.

The assessment then considered stormwater treatment for the proposed Causeway and what influence this would have on the proposed Causeway width. Two options were considered, a 'narrow' Causeway [Option D(N)] utilising pre-cast channels and proprietary cartridge filter units, or a 'wider' Causeway [Option D(W)] incorporating Bio-filters. Refer to the **Technical Report G.15 Assessment of Stormwater & Streamworks Effects Report** for details related to Bio-filters. The assessment concluded that the wider footprint Causeway option was preferred.

The benefits of the wider footprint include:

- design tolerances for the Bio-filters provide greater flexibility in allowing for the effects and uncertainty of differential settlement across and along the Causeway;
- it provides the 9m minimum safety clear zone (from the edge of the general traffic lane to the proposed rock armour (northern side) or from the edge of the general traffic lane to the proposed pedestrian/cycle way (southern side)), thus removing the need for shoulder barriers and therefore improving safety. Removing the need for shoulder barriers provides an added benefit of providing uninterrupted views to the Waitemata Harbour and marine reserve, thereby enhancing the vehicle occupants' experience;
- it reduces the use of pipe networks which are affected by differential settlement;
- Bio-filters require less stringent and intensive maintenance regimes than filter cartridges and open grated channels;
- a greater width provides increased flexibility for maintaining traffic flows during the construction staging process and allows existing bus shoulder operation through all but one phase of construction;
- providing a wider causeway cross-section will allow it to be raised more easily in the future if sea level rise is greater than currently predicted.

Figure 4.1 charts the assessment development during the design period.

As the Causeway embankment for the preferred option was wider than originally envisaged it was considered prudent to reassess this option against the viaduct structure option with both options being developed to a similar level of detail.

To take into consideration option development over a number of years, and to provide a clear holistic assessment summary between the initial options [Options A to F] and the sub-options [Options D(1), D(2), D(N) and D(W)] all the potential Causeway options considered were assessed, with the conclusions included in the **Causeway Options Report (20.1.11-3-R-J-304)**. The option assessment concluded that Option D(W) 'symmetrically widening and raising of the existing Causeway with revetments, incorporating grassed Bio-filters' as the preferred option. Refer to Fig 4.2 for a typical cross section of the preferred option.

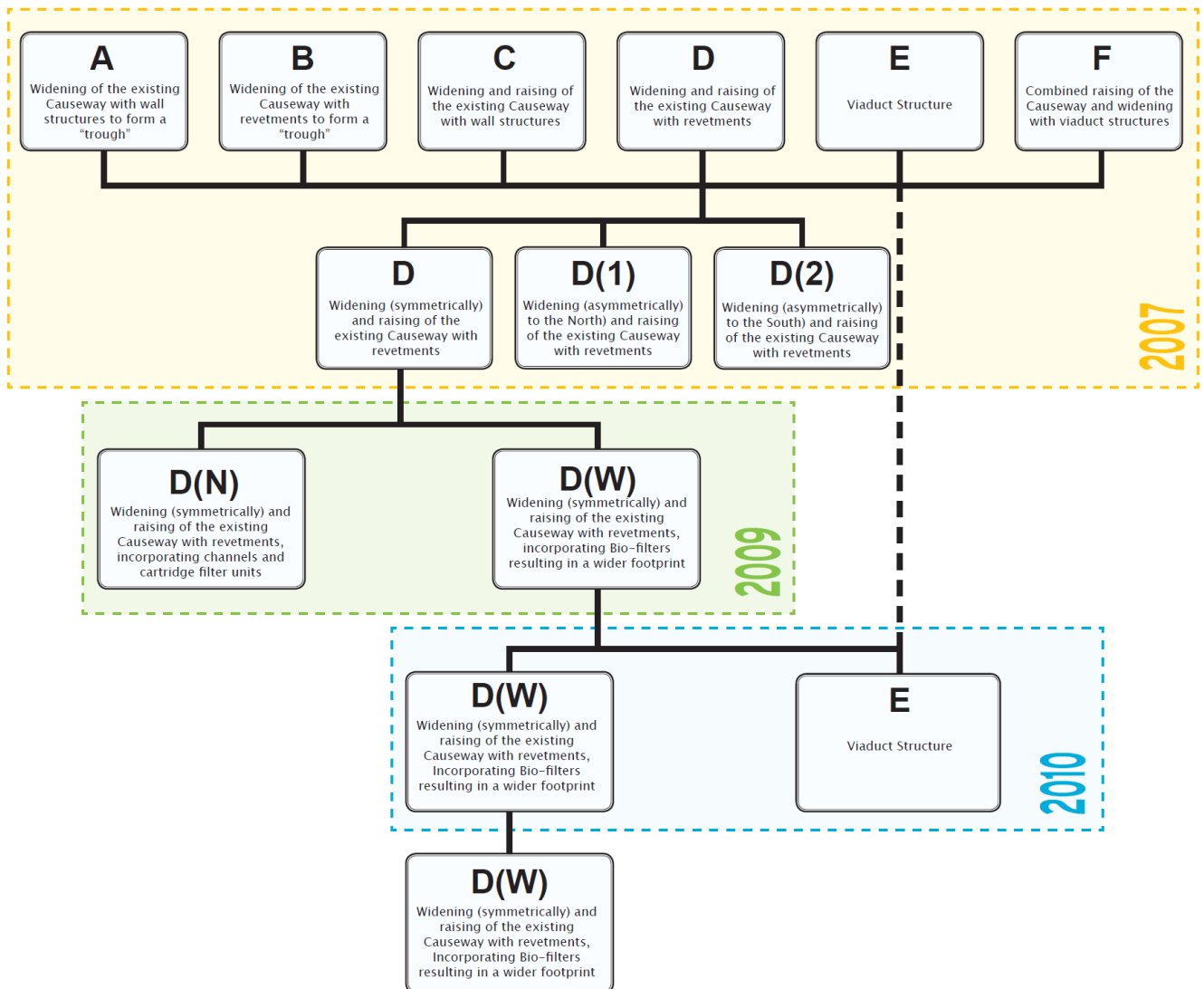


Figure 4.1 Causeway Option Flowchart

The embankment improvement works must also protect the road surface from sea water inundation and wave overtopping to meet performance requirements. This includes allowances for sea level rise and storm intensity due to climate change. In order to improve security and resilience of the carriageway, the level and width of the Causeway needs to be increased. Details of these performance requirements are contained within the **Interpretation of Hydrodynamic Design Conditions Report (20.1.11-3-R-J-305)**. The proposed northern crest (refer to Figure 4.2) must be constructed to an elevation of 3.65m RL. This includes allowance for settlement of the Causeway, so that in the 2090-2099 decade the northern crest will be above 3.0mRL. For details of this settlement allowance refer to the **Coastal Works Engineering Report (20.1.11-3-R-J-306)**.

3.4 Reclamation and Permanent Occupation

3.4.1 Causeway Embankment

The existing Causeway has experienced prolonged settlement since its construction in the 1950's and this was a key consideration when developing the proposed design. This settlement will be remobilised by the placement of additional fill to raise the Causeway. Settlement and stability analysis has been undertaken to determine the effects of the improvement works and this concluded that embankment instability and settlement would occur if ground improvement measures are not undertaken prior to construction of the new Causeway.

Without ground improvements, the widened and raised Causeway can be expected to suffer slope failures similar to that shown in Figure 4.3.

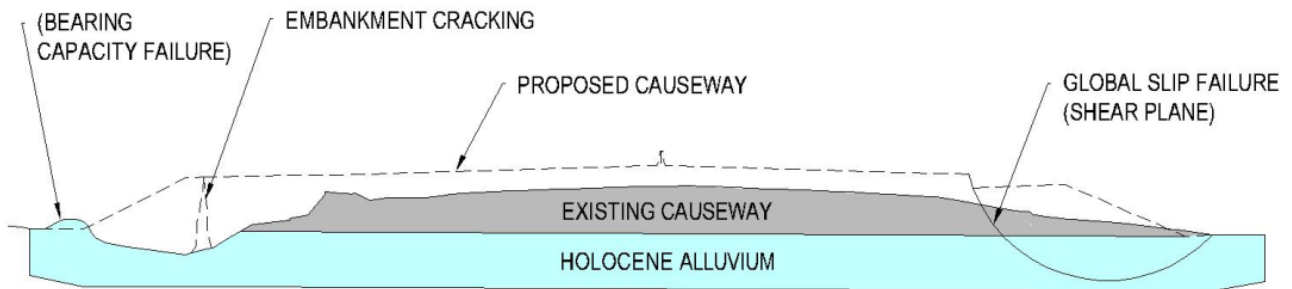


Figure 4.3 – Typical slope failure modes of a new Causeway without ground improvement works (not to scale)

Figure 4.4 is an indicative cross section through the Causeway showing the primary ground improvement measure (in-situ mudcrete) that is proposed in Sector 4.

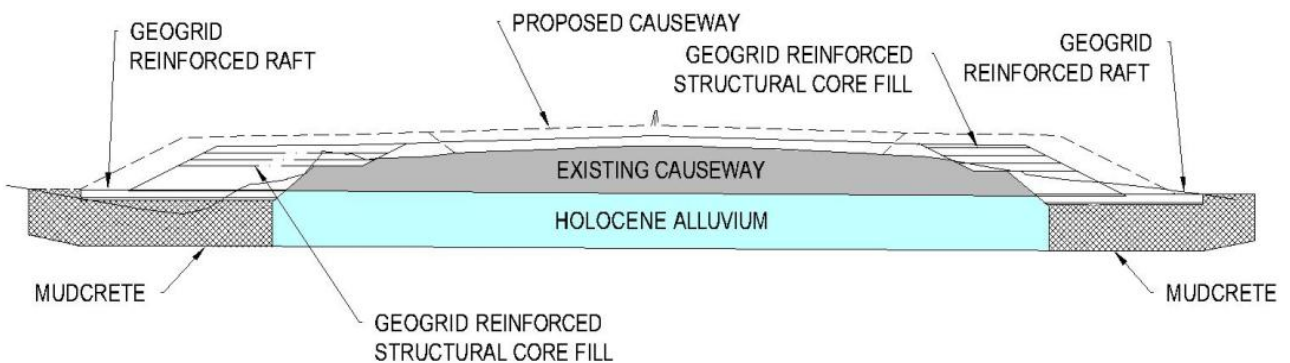


Figure 4.4 – Indicative sketch showing details of ground improvements (not to scale)

For further details regarding the ground improvements required within Sector 4 refer to the **Coastal Works Engineering Report (20.1.11-3-R-J-306)**.

Drawings 20.1.11-1-D-N-520-104 to 108 show the proposed extent of the reclamation, with drawings 20.1.11-1-D-N-941-104 to 108 showing the permanent occupation extents.

3.4.2 Causeway Bridges – Permanent Piers

The proposed permanent CMA occupation in Sector 4 consists of permanent reinforced concrete piles required for the bridge widening and construction of a new separate pedestrian/cycle way bridge. Widening of the existing Causeway bridges is required to accommodate the proposed motorway (9 general traffic lanes, 2 bus shoulders and the separate shared pedestrian/cycle way). For details showing the locations of the proposed piles refer to drawings 201113-D-N-941-108.

To accommodate the additional traffic lanes and upgraded motorway cross section, the eastbound bridge is required to be widened by approximately 5.6m. The westbound bridge is required to be widened by approximately 9.0m. The new eastbound bridge will accommodate 4 x 3.5m wide traffic lanes and a bus shoulder and the westbound bridge will accommodate 5 x 3.5m wide traffic lanes and a bus shoulder. A separate bridge will be provided for a 3m wide pedestrian/cycle way.

Reinforced concrete pre-cast bridge piles will be top driven to a pre-determined founding soil stratum to support the widening of the existing motorway bridges. All of the new permanent piles are aligned with the existing bridge piles.

Cast in-situ bridge piles for the separate pedestrian/cycle way bridge are proposed. These will be concreted inside a sacrificial metal casing. The metal casing will be installed by top driving to a pre-determined depth. The marine mud will then be removed from within the metal casing by an auger piling rig and taken off site. The metal casing is required as the pile excavations in marine mud at this location will not be self-supporting

There are 12 proposed permanent piles (within the CMA), approximately 0.5m in diameter, for the eastbound Causeway Bridge widening. There are 24 proposed permanent piles (within the CMA), 0.5m in diameter, for the westbound Causeway Bridge widening. The proposed 0.5m diameter bridge piles are similar in diameter to the existing bridge piles.

There are 4 proposed permanent piles (within the CMA) for the separate pedestrian/cycle way bridge. These are approximately 1.0m in diameter.

Drawing 20.1.11-1-D-N-520-108 shows the proposed bridge pile locations, with drawing 20.1.11-1-D-N-941-108 showing the permanent occupation extents.

3.4.3 Causeway Bridges - Abutments

As part of the improvements, the Causeway bridge will be widened on both sides, therefore the existing abutments will need to be widened. MDD ground improvement will be adopted in this area. A new pedestrian/cycle way bridge will also be constructed. The area of the CMA occupied by the permanent works will be defined by the edge of the ground improvement. This ground improvement method does not require the permanent occupation of the CMA to extend beyond the proposed embankment toe. For further details

regarding the geotechnical ground improvements required refer to the **Coastal Works Engineering Report (20.1.11-3-R-J-306)**.

Drawing 20.1.11-1-D-N-520-108 shows the proposed bridge pile locations, with drawing 20.1.11-1-D-N-941-108 showing the permanent occupation extents.

3.4.4 Channel Realignments

As discussed in the previous sections, the Causeway will be widened into existing intertidal areas. Generally this only encroaches onto the mudflat areas, however there are three locations where the widening works will extend into tidal drainage channels. It has been determined that these channels require relocation to allow the Causeway improvement works to be completed. These locations are:

- Waterview Channel – Site 1 – Chainage 1550 to 1710 (south);
- Oakley Creek Channel – Site 2(lower) – Chainage 810 to 870 (south); and
- Oakley Creek Channel – Site 3(upper) – Chainage 660 to 700 (south).

The Assessment of Coastal Processes discusses the options considered for channel realignment (refer to the **Technical Report *G.4 Assessment of Coastal Processes*** for further information.

For a description of the channel relocation methodology refer to Section 4.5.5 and the **Technical Report *G.4 Assessment of Coastal Processes***.

3.4.5 Rosebank Culvert

The western end of Waterview Estuary is semi-connected to the main drainage channel serving the Pollen Island wetland under the existing motorway via twin 600mm diameter culvert pipes at approximately CH2900 near the Rosebank Road Interchange. Based on historical aerial photographs flown in 1959 (refer to the **Technical Report *G.4 Assessment of Coastal Processes***) it is evident that the culvert pipes were incorporated into the original Causeway construction Project in 1952. A survey in mid-2010 shows that the culvert pipes have an invert level of approximately 0.25m RL, at either end. At this elevation the culvert pipes would have only provided conveyance of water for around 40% of a tidal period, centred on high tide. As-built drawings from the time of construction are unavailable and therefore historical reasons for designing/constructing the culvert pipes at this elevated level are unclear. The original construction in this area included reclamation across a channel draining Waterview Estuary. These culverts were probably provided to form connection to the Waitemata Harbour.

Site visits during 2009 and 2010 indicate that the culvert pipes are blocked, with the channel at either end of the culvert pipes silted up and not functioning hydraulically. Established mangroves are present near the ends of the culvert pipes indicating that there has not been any substantial flow through the culvert pipes for several years. The high invert elevation and extensive sedimentation in this part of Waterview Estuary has led to the blocking of the culvert pipes over time.

In widening the Causeway for the proposed improvements, these culvert pipes could be:

- 1) blocked off and decommissioned;

- 2) extended to the new width of the motorway;
- 3) completely replaced with a new culvert over the new width of the motorway, at a lower invert level and with channel clearance also undertaken.

In consultation with coastal specialists, the preferred option is to permanently seal off the two culvert pipes and decommission them. Refer to the **Technical Report G.4 Assessment of Coastal Processes** for further information.

3.5 Temporary Occupation and Construction Activities

During the construction work, it will be necessary to permit the free flow of motorway traffic at all times and it will therefore be necessary to undertake the embankment raising and elevating in a number of phases. A simplified typical construction phasing methodology is presented in Figure 4.5. For further details refer to the **Coastal Works Engineering Report (20.1.11-3-R-J-306)**.

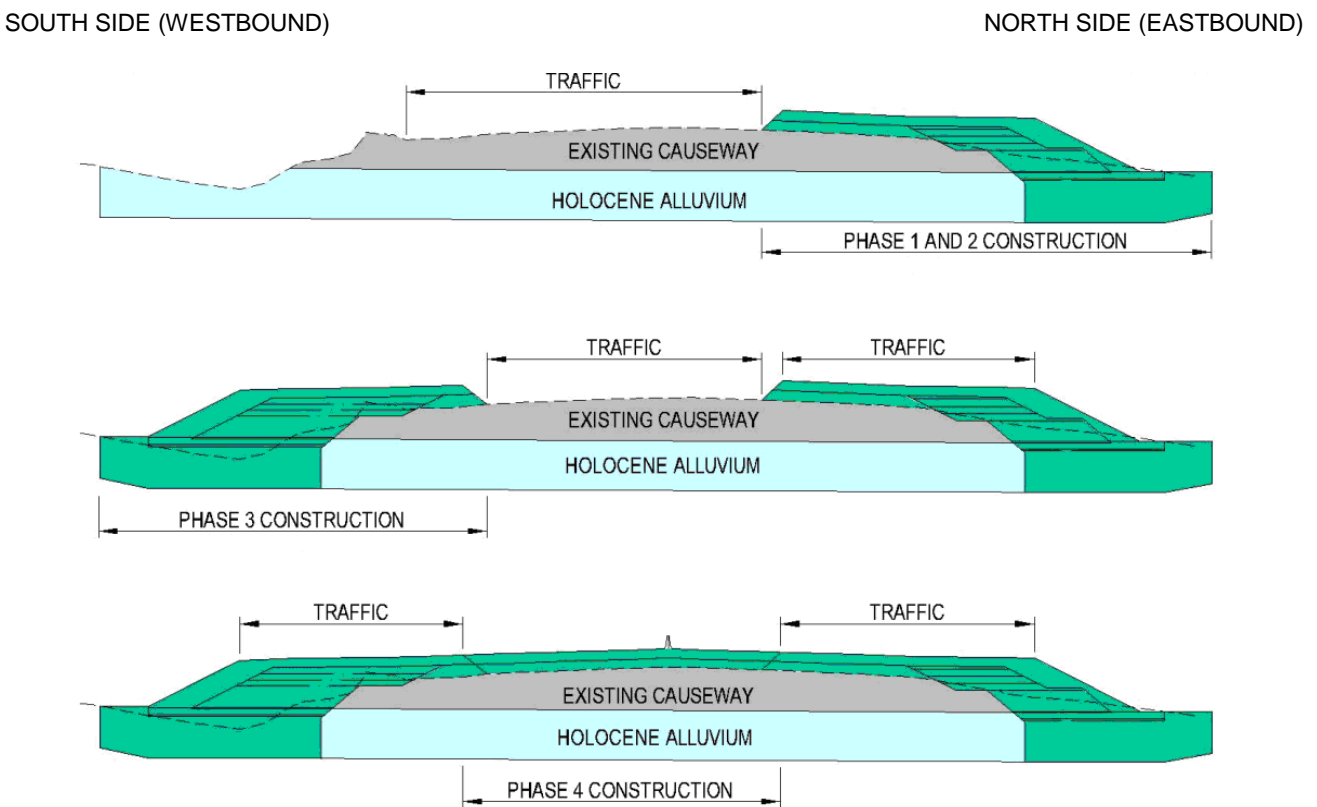


Figure 4.5 – Simplified Indicative Construction Phasing Methodology (not to scale)

The works will begin on the eastbound carriageway with three separate work faces being in operation at the same time. Once the eastbound carriageway is nearing completion the works will be switched to the westbound carriageway. The general phases of works (to be undertaken on each side) are as follows:

- Phase 1 – establishing the new revetment and toe extent (eastbound), and undertaking ground improvements;
- Phase 2 – placing of shoulder fill to achieve the new (eastbound) carriageway design level (no works required in the CMA);
- Phase 3 – establishing the new revetment and toe extent (westbound), undertaking ground improvements, and placement of shoulder fill to achieve the new (westbound) carriageway design level;
- Phase 4 – placing of bulk fill to achieve the carriageway design level for new central part of the Causeway (no works required in the CMA).

3.5.1 Construction Programme

Sufficient time has been allowed within the construction programme to provide the necessary works. The coastal works to be undertaken and the typical construction periods in Sector 4 include:

- Reclamation (including ground improvements) and coastal occupation – eastbound – 18 months;
- Embankment and pavement construction – eastbound – 7 months (no works required in the CMA);
- Reclamation (including ground improvements) and coastal occupation – westbound – 17 months;
- Embankment and pavement construction – westbound – 5 months (no works required in the CMA);
- Placement of fill and pavement construction – central section – 12 months (no works required in the CMA).

3.5.2 Causeway Embankment

A key element driving the successful construction of the Causeway embankment will be the completion of the initial ground improvement works. As discussed in the previous sections, the main type of ground improvement works to be undertaken in Sector 4 is in-situ mudcrete. However, this can only be undertaken while the work area is free of standing water; therefore a cofferdam will need to be installed around each work area to keep out the seawater. Further details of the type of cofferdam utilised are discussed below. The area of ground improvements will extend from the toe of the existing embankment to the proposed boundary of permanent occupation;

3.5.2.1 Cofferdams

As discussed above, a cofferdam will be required where in-situ mudcrete ground improvement will be undertaken. This is in order to detain the seawater and allow 'dry working' to be undertaken. The cofferdam will also provide protection to the existing Causeway embankment from erosion, as the existing coastal protection (rock armour) will need to be removed prior to commencement of work. This will be initially in local areas to permit access and tie in the cofferdams, but ultimately removal of all the existing rip rap will be required. The coffer dams will also control sediment loss into the surrounding harbour.

A portable water filled cofferdam is the preferred option to be used for much of the site. The depth of very soft sediments makes the use of conventional methods such as sheet piling very challenging. However, a sheet piled cofferdam is considered a suitable option for areas to the east of the Causeway Bridges as the bedrock is

relatively shallow making this a feasible option. Furthermore, this area is also densely vegetated and sheet piling will require a smaller footprint than a portable water filled cofferdam, so the amount of vegetation that will need to be cleared is reduced. For the locations of these cofferdams refer to the **Erosion and Sediment Control Plan (20.1.11-3-R-N-1017)**.

Portable water filled dam

A temporary water filled dam will be used to create a dry working area for all of the mudcrete works to be undertaken to the west of Causeway bridges. The size of cofferdam is dependent on the elevation of the mudflats. However, a 5m high dam will typically be used within the harbour area, while a 2.5m high dam will be used along Traherne Island (northern side only). The installation process of the portable water filled cofferdam is summarised below:

- a. Coastal vegetation (including mangroves and their roots) is to be removed from the area where the portable cofferdam is to be placed at low tide;
- b. A rolled-up cofferdam is to be placed onto the cleared area of the mudflats at low tide (5m beyond the outer extent of ground improvements), refer to Figure 4.6. A pump will be connected to the cofferdam and seawater will be pumped from a local tidal drainage channel into the cofferdam. The cofferdam will be rolled out along the mudflats as it fills until the installation is complete. Extra sections of cofferdam will be attached and the above steps repeated;
- c. T-sections will be attached to the inflated cofferdams and extended into the existing Causeway embankment. Coastal protection will require removal at these areas to allow a relatively impermeable seal between the cofferdam and embankment to be created;
- d. Sumps will be excavated at certain locations along the cofferdam and pumps used to remove excess water;
- e. Excavate and store (in an area of proposed reclamation, permanent and/or temporary occupation) a sufficient volume (approximately 2m³ per metre chainage of motorway) of marine mud to be used as the back fill for the area of Marine Habitat Remediation;
- f. Once in place, the ground improvement works can commence;
- g. On completion of the ground improvement works, any loose or remaining sediment will be removed from site before the cofferdams are decommissioned by either pumping the water into a nearby cofferdam or by pumping the water back into the sea (water will not be allowed to drain over the tidal mudflats).

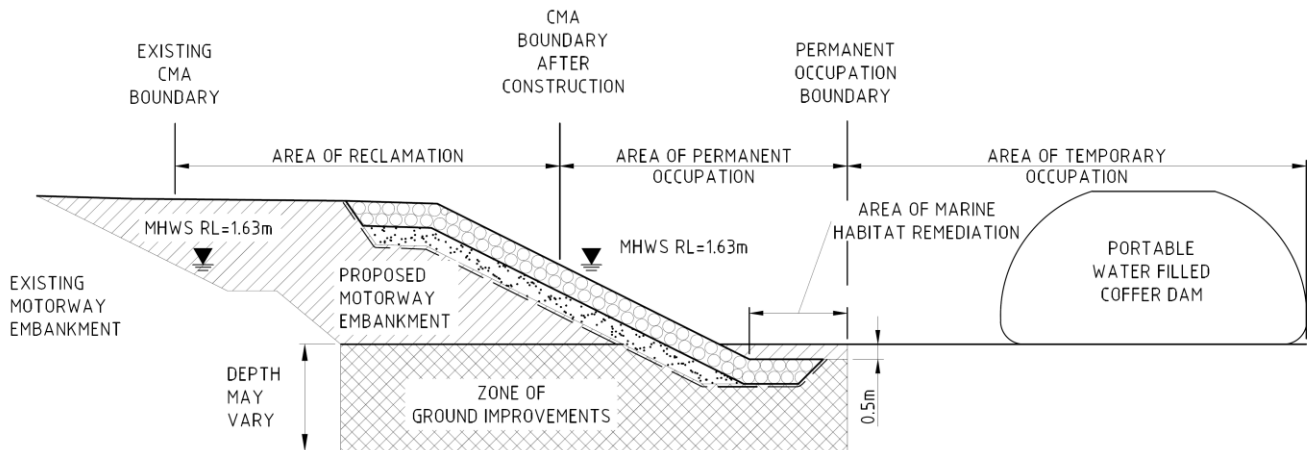


Figure 4.6 – Indicative section showing location of portable water filled dam (not to scale)

Sheet pile dam

A sheet piled coffer dam is the preferred approach to create dry working areas for works to be undertaken to the east of the Causeway bridges. The typical length of these piles will be around 10m and the installation process is summarised as follows:

- a. Sheet piles will be vibro-driven through the marine sediments from a long reach tracked crane located on the existing Causeway embankment to a depth of around 10m below ground level. The piles will be located approximately 2m beyond the toe of the proposed embankment slope, refer to Figure 4.7;
- b. Once installed, a silt fence and wave buffer will be installed to the face of the sheet piles;
- c. Sumps will be excavated at certain locations along the cofferdam and pumps used to remove excess water;
- d. Excavate and store (in an area of proposed reclamation, permanent and/or temporary occupation) a sufficient volume (approximately 2m³ per metre chainage of motorway) of marine mud to be used as the back fill for the area of Marine Habitat Remediation;
- e. Ground improvement works can then commence;
- f. On completion of the ground improvement works the piles will be removed using a similar crane located on the new embankment.

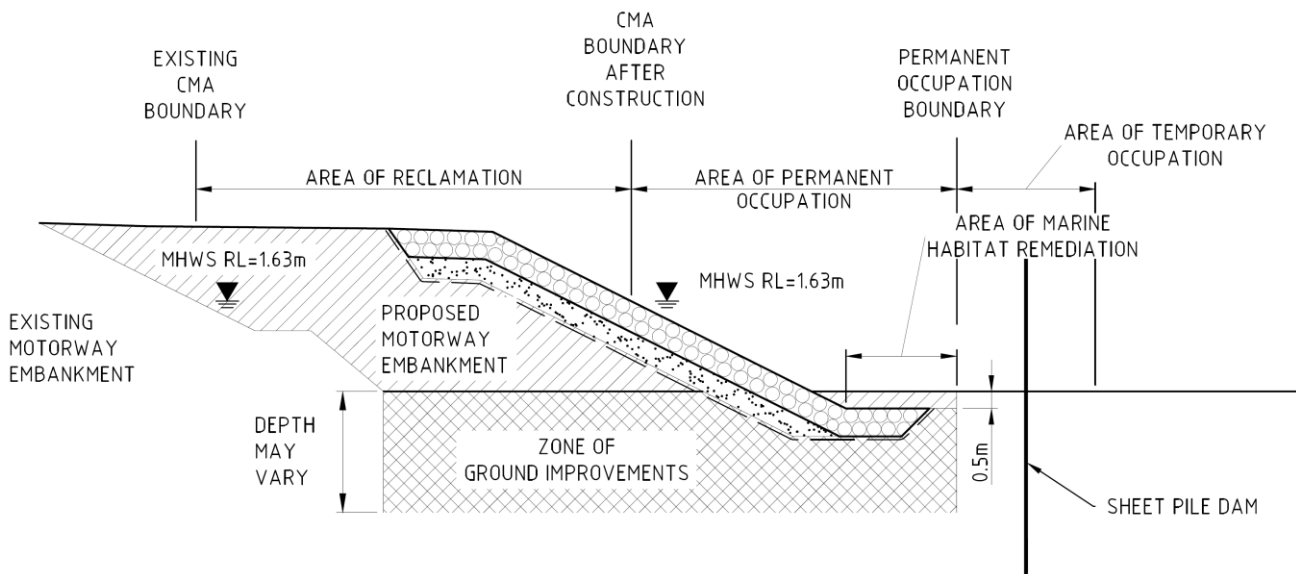


Figure 4.7 - Indicative section showing location of sheet pile dam (not to scale)

3.5.2.2 Ground Improvements and Embankment Construction

As discussed in the previous sections, a number of different ground improvements will be undertaken within Sector 4. The ground improvement works will generally be undertaken on the tidal mudflats and will not commence until the cofferdam or sediment control measures are installed. A summary of the typical ground improvement and embankment construction stages to be undertaken is discussed below:

- a. Install the cofferdam or sediment control;
- b. Clear coastal vegetation within the work area (including roots);
- c. Create a working entrance platform (approximately 5m wide by 15m long) by placing a layer of geotextile and geogrid onto the marine sediments. The platform will allow the ground improvement plant equipment to access the work area. The geotextile will act as a separator between the marine mud and working entrance platform, while the geogrid will act as a reinforcing layer. Next, a layer of coarse gravel will be placed and compacted into the marine sediments until a platform with an adequate strength is created (due to the very soft properties of the marine sediments it is possible that this layer will be approximately 1m thick in places). Only one working entrance platform will be required per work face;
- d. Several sumps are to be formed inside the work area so that any water seepage past the cofferdam or through the existing Causeway embankment can be collected. Contaminated water (i.e. sediment-laden) trapped between the new embankment and cofferdam should be pumped to temporary sediment retention ponds or tankered off site. Non-contaminated water can be pumped back into the sea, although water will not be allowed to flow directly over the mud flats;
- e. Following completion of the working entrance platform, approximately a 0.6m layer of medium coarse gravel (GAP 65 or similar) will be placed incorporating two layers of geogrid reinforcement. Finally, to

complete the platform and provide protection to the geogrid reinforcement, a 150mm layer of medium coarse gravel (GAP 65 or similar) will be placed. This platform will allow the plant equipment to operate;

- f. Excavate and store (in an area of proposed reclamation, permanent and/or temporary occupation) a sufficient volume (approximately 2m³ per metre chainage of motorway) of marine mud to be used as the back fill for the area of marine habitat remediation;
- g. The in-situ mudcrete process will treat marine sediments. The area of ground improvements will extend from the toe of the existing embankment to the proposed boundary of permanent occupation;
- h. Following completion of the ground improvement works the new Causeway embankments will be constructed. A geotextile will be placed along the benched slope of the existing Causeway embankment, extending down and along the surface of the improved ground to a point where the intertidal shoulder fill meets the granular filter layer. Then the selected intertidal shoulder fill is to be placed to a level above MHWS. The seaward facing slope will have a gradient of 1V:2H;
- i. A key will be excavated into the improved ground to act as toe support. A geotextile layer will be placed on the front slope of the intertidal shoulder fill and also placed into the excavated key. The chosen granular filter layer will then be placed, followed by placement of the rock armour protection. Finally, the stored marine mud will be placed back over the proposed rock armour toe to form the area of marine habitat remediation;
- j. Contaminated water (i.e. sediment-laden) trapped between the new embankment and cofferdam will be pumped to temporary sediment retention ponds or tankered off site. Non-contaminated water can be pumped back into the sea, although water will not be allowed to flow directly over the mud flats. The stored marine mud can then be replaced to form the area of marine habitat remediation. Once this has been completed the cofferdam can be removed;
- k. Once the cofferdam (either water filled or sheet pile) is removed the remaining embankment works (above sea level) will be completed. Several layers of geogrid reinforcement will be installed within this material to provide adequate stability.

3.5.2.3 Embankment Slip

As stated previously, widening and raising the existing Causeway will involve construction activities taking place within a zone of soft marine mud. Left untreated, this soft marine mud will offer limited strength to support the widened Causeway embankment when stressed, creating the potential for slip failure to occur. The probability of a failure occurring is reduced through several design approaches, in particular the adoption of ground improvement techniques, but the probability of a localised slip failure cannot be completely eliminated. The design therefore accommodates a small probability of localised embankment slip, which is shown to be wholly contained within the zone of temporary occupation.

For further details regarding the global stability of the proposed embankment during construction refer to the **Coastal Works Engineering Report (20.1.11-3-R-J-306)**.

3.5.2.4 Chenier (shell) Beach Deposits

Disturbance of chenier (shell) beach deposits will be required in Sector 4. Where potential burial of the shell deposits could occur under the widened embankments or where construction works will potentially disturb or damage the shell material, the shell deposits will be removed and securely stockpiled during construction. After completion of the improvement works, the shell material will be replaced in front of the new revetments at the same geographical locations and allowed to reform a natural profile. Refer to the **Technical Report G.4 Coastal Processes Assessment** for further information.

3.5.3 Causeway Bridges – Temporary Piers

Construction of the Causeway bridges will require temporary occupation and disturbance of the CMA beyond the area required for permanent occupation.

Key constructability issues that have been considered are:

- Construction Phasing including traffic management; and
- Temporary Staging platforms.

3.5.3.1 Construction Phasing

Construction of the widening to the Causeway Bridges and construction of Sector 4 earthworks must be phased to coincide with each other and the Great North Road Interchange ramp construction. The motorway Project has been designed to allow a construction method which minimises the disruption to the traffic during the construction period.

The Causeway Bridge construction sequence will follow a similar methodology to the construction sequence for the Whau Bridge as discussed in Section 3.3.1.

The existing number of traffic lanes will be maintained throughout construction although under speed restriction. Night time work will be required at certain times, but will be minimised where possible. The existing eastbound bus shoulder will not be operational across the bridge during Phases One and Two. Pedestrian/cycle way provision, similar to existing, will be maintained during construction. The following works will be undertaken:

- Phase One – widen the eastbound motorway bridge and construct the separate pedestrian/cycle way bridge on the westbound side of the carriageway from the two temporary staging platforms. Details of the proposed staging platforms are discussed below;
- Phase Two – complete the stitch joint between the existing eastbound bridge and the widened section of the eastbound bridge. It is expected that Phase One and Two combined will take approximately 12 months (i.e. months 1 to 12);
- Phase Three – construct the westbound motorway bridge widening from the other temporary staging platform. It is expected that Phase Three will take approximately 12 months (i.e. months 34 to 46);
- Phase Four – complete strengthening of the existing structures and improvements to the median barriers on each of the existing bridges – no coastal works involved;

- Phase Five – complete the final surfacing and lane marking to the bridges and approaches – no coastal works involved.

For further details of the works required within each phase, refer to the **Coastal Works Engineering Report (20.1.11-3-R-J-306)**.

3.5.3.2 Temporary Staging Platforms

Widening of the Causeway Bridges and construction of the separate Causeway pedestrian/cycle way bridge is assumed to be completed from temporary platforms constructed adjacent to the widening in a similar manner to the proposed temporary staging platforms for the Whau River bridges. The westbound staging platform will be located between the motorway extension and the proposed pedestrian/cycle way bridge to enable construction of both bridges from the same platform.

The temporary platforms will be set at a high enough level so as not to reduce the vertical clearance to the sea level, therefore the existing bridge freeboard will be maintained during construction. The inlet channel is not navigable and therefore no provision for navigation during construction will be provided. Public access under the Causeway Bridges during construction will also be prohibited (i.e. no access for kayakers, canoeists or any other activities).

Refer to drawing 20113-D-N-942-108 for the proposed location of the temporary staging platforms. A total of 52 temporary 600mm diameter steel piles are shown (22 for the eastbound and 30 for the westbound temporary platform).

It is expected that the eastbound temporary platform will be in place for the first 12 months of construction. The westbound platform is required to be in place from about month 13 through to month 46 of construction.

3.5.4 Causeway Bridges – Abutments

Construction of the Causeway Bridge Abutments will require temporary occupation and disturbance of the CMA beyond the area required for permanent occupation.

The ground improvement technique that will be adopted in this area is Marine Deposit Displacement (MDD), refer to Section 1.4. Lightweight fill material will be placed on top of the rock foundation to achieve the design level.

The placement of the rock can be undertaken at any state of the tide, however, the light tamping will only be undertaken when the site is free of standing water. The lightweight fill will be low density polystyrene and will be designed so that it will not be adversely affected by the marine environment (i.e. break down or degrade). For further details regarding the geotechnical ground improvements required refer to the **Coastal Works Engineering Report (20.1.11-3-R-J-306)**. For erosion and sediment control measures during construction refer to the Land Disturbance Assessment Report.

The proposed construction methodology can be summarised as follows:

- a. Install erosion and sediment control Super Silt Fence to control sediment for the land based earthworks. Strip off and remove existing top soil (if present) between motorway and super silt fence;
- b. Clear mangroves (including roots) within the areas of reclamation, permanent and temporary occupation during low tide;
- c. Implement the MDD by placing durable rock onto the marine mud (with a geotextile separator) and lightly tamping using an excavator until a 1m deep foundation has been created. On top of this rock crust place the lightweight fill material up to design level to form the abutments.

Drawing 20.1.11-1-D-N-942-108 shows the area of temporary occupation required to construct the Causeway bridge abutments.

3.5.5 Channel Realignment – Waterview Estuary

To provide a new tidal drainage channel where the existing Waterview Estuary is affected by the improvement works the following channel relocation methodology is proposed. These works will be completed before Causeway widening works commence.

- **Phase 1 and 2 – Preparation Works**

- a. Two barges will be temporarily moored against the existing coastal protection on the southern side of the existing Causeway. A long reach excavator will then be tracked onto one of the barges;

It is estimated that this preparation work would take approximately 1 week to complete.

- **Phase 3 and 4 – Excavation of new Channel**

- a. At high tide both of the barges will be floated onto the area between the proposed and existing channels;
- b. Excavation of the proposed channel will be undertaken at low tides. During high tides the barges will move progressively along the proposed channel, with excavation taking place at low tides. Excavation will proceed from the middle progressing towards the ends of the channel. To prevent significant sediment release during excavation a bund of marine mud will be left in place at either end of the proposed channel;
- c. Excavated marine material is to be transferred to either a suitable temporary storage lagoon constructed in an area of proposed reclamation, permanent and/or temporary occupation or stockpiled at a site compound;
- d. Scour protection is to be placed progressively onto the northern slope of the newly excavated channel at low tide and at the end of every work shift. The proposed channel will not remain unprotected for more than 1 tidal cycle;
- e. The final part of the excavation works will require excavation of the two bunds at either end of the proposed channel to connect into the existing channel. This will be done over two progressive low tide cycles. These connection works are to be undertaken at favourable tidal conditions (i.e. the connection excavation at the downstream end will be undertaken as the tide is falling before low tide so the new channel breakthrough can be achieved in a more controllable manner).

It is estimated that the excavation works will take approximately 2 to 4 weeks to complete.

- **Phase 5 and 6 – Infilling of Existing Channel**

- a. Prior to infilling the existing channel the existing channel will need to be blocked off. Bunds of durable rock material (AP 150–300 Basalt, Greywacke or similar) will be placed at both ends to prevent significant flow of seawater through the existing channel. Scour protection can then be placed onto the southern slope of the rock bunds.
- b. Once the new channel is functional, infilling of the existing channel behind the rock bunds can commence. During low tides, utilising the barges and long reach excavator, the existing channel will be infilled with the stored material. After infilling is complete the top layer of the material will be levelled to provide a suitable area for placement of the temporary water filled cofferdam.
- c. Following installation of the temporary water filled cofferdam the in-situ mudcreting (as part of the Causeway widening works) can then continue as normal through the existing channel location.

It is estimated that the infilling works will take approximately 2 to 4 weeks to complete. For further details and drawings refer to the **Coastal Works Engineering Report (20.1.11-3-R-J-306)**.

3.5.6 Channel Realignment – Oakley Creek Inlet

A similar methodology used for the Waterview Inlet Channel will be adopted for the excavation of the two channels at the Oakley Creek Inlet. The excavation works of these areas are smaller in size to the Waterview Inlet work and it is estimated that the works at each channel will take approximately 2 to 4 weeks to complete. For further detail refer to the **Coastal Works Engineering Report (20.1.11-3-R-J-306)**.

3.6 Summary of Proposed Coastal Works

Of the proposed works in Sector 4 of the Project, the proposed Causeway Bridge piers and abutments, the Rosebank culvert decommissioning and the proposed Causeway embankments will require works in the CMA.

Table 4.1 summarises the areas of reclamation, permanent occupation, temporary occupation and marine habitat remediation required to provide for the improvements to SH16 as part of the Project.

Table 4.1 – Approximate Areas of Reclamation, Permanent Occupation, Temporary Occupation and Marine Habitat Remediation for Sector 4 (Note – Figure in brackets refers to that portion of the total occupation that is above the CMA, i.e. Aerial Occupation)

Area Type	Plan Title	Plan Numbers	Approximate Area (ha)
Reclamation	Reclamation Plan	20.1.11-3-D-N-520-104 to 108	4.20
Permanent Occupation	CMA Permanent Occupation Plans	20.1.11-3-D-N-941-104 to 108	2.68 (0.41)
Temporary Occupation	CMA Temporary Occupation Plans	20.1.11-3-D-N-942-104 to 108	5.66 (0.11)
Marine Habitat Remediation	Area calculated	Area calculated	1.16

4. Sector 5 – Great North Road Interchange

4.1 Scope of Works

Improvement works proposed for Sector 5 of the Project include:

- providing for the new southbound motorway-to-motorway link from westbound SH16 to southbound SH20 (Ramp 3);
- providing for the new northbound motorway-to-motorway link from SH20 to westbound SH16 (Ramp 2);
- providing for the new Southbound motorway-to-motorway link from eastbound SH16 to southbound SH20 (Ramp 1);
- providing for the new northbound motorway-to-motorway link from SH20 to eastbound SH16 (Ramp 4);
- realigning of the Great North Road on and off-ramps to accommodate the SH20 to SH16 motorway links;
- altering the existing SH16 carriageway geometry to tie-in with the Sector 4 SH16 carriageway geometry; and
- upgrading and altering the alignment of the existing north-western shared use pedestrian/cycle way between Great North Road and the Causeway (Sector 4).

4.2 Proposed Coastal Works

Of the improvement works in Sector 5, only the proposed motorway-to-motorway ramp piers will require works in the CMA.

4.3 Reclamation and Permanent Occupation

4.3.1 Great North Road Interchange Ramp Construction

For details of the proposed viaducts for the Great North Road Interchange refer to drawings 201113-D-S-917-430 and 431. The new permanent occupation in Sector 5 consists of proposed viaduct piles/piers for the new northbound motorway-to-motorway link from SH20 to westbound SH16 (Ramp 2), and the new southbound motorway-to-motorway link from SH16 to SH20 (Ramp 3). The shape of the piers are circular to reduce scouring action. Viaduct piles will be concreted inside a sacrificial metal casing that is top driven down to the required founding level. The casing extends up to the top of the normal tidal range. Above this point, the circular pier is constructed with temporary formwork that is removed after concreting, exposing the finished concrete surface.

4.3.1.1 Ramp 1

No permanent occupation of the CMA is required for Ramp 1.

4.3.1.2 Ramp 2

The Ramp 2 permanent occupation consists of 2.1m diameter concrete bored piles in permanent steel casings that transition into 1.8m diameter concrete piers at the top of the normal tidal range **(Pier numbers 2, 4, 5 and 6)**.

4.3.1.3 Ramp 3

The Ramp 3 permanent occupation consists of 2.1m diameter concrete bored pile in a permanent steel casing that transitions into a 1.8m diameter concrete pier at the top of the normal tidal range **(Pier number 13)**.

4.3.1.4 Ramp 4

No permanent occupation of the CMA is required for Ramp 4.

4.4 Temporary Occupation and Construction Activities

4.4.1 Great North Road Interchange Ramp Construction

Construction of the ramp viaduct structures will require temporary occupation and disturbance of the CMA beyond the area required for permanent occupation.

Key constructability issues to be considered are:

- Construction phasing, including traffic management; and
- Temporary Staging platforms.

4.4.1.1 Construction Phasing

The viaduct construction sequence is assumed to be as follows:

- a. Construct temporary staging platforms;
- b. Construct piles to top of normal tidal range;
- c. Construct piers to underside of pier crosshead beam;
- d. Construct pier crosshead beams;
- e. Install precast concrete Super-T deck units between crossheads;
- f. Pour in-situ concrete topping slab;
- g. Remove temporary staging;
- h. Install road surfacing, line markings and secondary elements.

The first stage of the works involves the installation of the temporary piling in the CMA. It is envisaged that the Contractor will progressively install all the required temporary piles in one continuous sequence to avoid additional mobilisation and demobilisation costs. This would include the piles for the temporary platforms required for crane access during the installation of the Super-T deck units.

The temporary access platforms supported by the piles will then be installed in locations to suit the Contractor's construction sequence. With a project of this size, the Contractor is likely to have more than one piling rig and construction team, so piling and pier construction works will most probably be undertaken at multiple locations at any one time.

Platforms around the piers are required for the construction of the piers and the pier crosshead beams, and are also required for access during the placement of the Super-T deck units. Once this work is complete the temporary platforms and their support piles can be removed.

The estimated construction period for the Great North Road Interchange is approximately 2 years, so the temporary platforms could be in place for up to 18 months in some locations, depending on the Contractor's construction sequence.

4.4.1.2 Temporary Staging Platforms

It is assumed construction of the viaducts in the CMA will be completed from temporary platforms built adjacent to the viaduct alignment. It is envisaged that temporary platforms will be built from both the northern and southern sides of the CMA, allowing the central creek channel to remain undisturbed. Refer to drawing 20.1.11.3-D-N-942-109 for proposed locations of the temporary platforms.

The temporary platforms provide the required access to pile boring equipment, allow for 360 degree construction access around the pile and also provide a working platform to protect from spoil dropping from the auger into the CMA. Temporary platforms are also required at specific locations to provide a working platform for the crane required to lift into place the precast Super-T deck beams.

All temporary platforms will be supported by temporary driven piles that are driven into the underlying material until a sufficient bearing capacity is achieved. The temporary piles will support a steel superstructure with a thick timber decking to form the surface of the temporary platform. The temporary piles for the temporary platforms are shown on drawing 20.1.11.3-D-N-610-942-109.

Following completion of the construction works the temporary platforms will be dismantled in the reverse order to how they were constructed with the temporary piles removed completely from the CMA, using cranes and vibration equipment.

4.4.1.3 Ramp 1

Work for Ramp 1 involves creating the following temporary platforms within the CMA:

- 10m x 12m adjacent to Pile 8 as a crane access platform to facilitate the installation of the Super-T deck units between piers 7 and 8.

4.4.1.4 Ramp 2

Work for Ramp 2 involves creating the following temporary platforms within the CMA:

- 10m x 5m at Pile 7 as a working and protection platform;
- 10m x 7m at Pile 6 as a working and protection platform;
- 10m x 18m at Pile 5 as a working and protection platform and also to allow for piling rig access;
- 17m x 12m adjacent to pile 4 as a crane access platform to facilitate the installation of the Super-T deck units between piers 4 and 5;
- 18m x 12m at Pile 4 as a working and protection platform;
- 10m x 5m at Pile 3 as a working and protection platform;
- 10m x 13m at Pile 2 as a working and protection platform; and
- 26m x 15m triangular platform adjacent to pile 2 to assist in site access and to provide a platform for the crane during installation of the Super-T deck units between piers 2 and 3.

4.4.1.5 Ramp 3

Work for Ramp 3 involves creating the following temporary platforms within the CMA:

- 10m x 7m at Pile 13 as a working and protection platform; and
- 16m x 17m adjacent to pile 14 to provide a platform for the crane during installation of the super-t deck units between piers 13 and 14.

4.4.1.6 Ramp 4

Work for Ramp 4 involves creating the following temporary platforms within the CMA:

- 10m x 6m adjacent to pile 7 as a working and protection platform; and
- 12m x 10m adjacent to pile 6 to provide a platform for the crane during the installation of the Super-T deck units between piers 6 and 7.

4.5 Summary of Proposed Coastal Works

Of the improvement works in Sector 5, only the proposed motorway-to-motorway ramp piles will require works in the CMA.

Table 5.1 summarises the areas of permanent occupation and temporary occupation to provide for the improvements to SH16 as part of the Project.

Table 5.1 – Approximate Areas of Permanent Occupation and Temporary Occupation (Note – Figure in brackets refers to that portion of the total occupation that is above the CMA, i.e. Aerial Occupation)

Area Type	Plan Title	Plan Numbers	Approximate Area (ha)
Reclamation	N/A	N/A	N/A
Permanent Occupation	CMA Permanent Occupation Plans	20.1.11-3-D-N-941-109	0.35 (0.34)
Temporary Occupation	CMA Temporary Occupation Plans	20.1.11-3-D-N-942-109	0.32 (0.31)

5. Conclusion

For the Project to comply with the Project Objectives, SH16 must be widened to improve capacity and provide opportunities for improved public transport, cycling and walking. The elevation of the motorway Causeway between Great North Road and Rosebank Road and the embankment between Patiki Road and Whau River will also need to be increased to prevent inundation and wave overtopping during storms therefore improving resilience.

Where reclamation and occupation of the CMA is required, the philosophy has been to carefully define the extent required to accommodate the reclamation, permanent occupation and any necessary temporary works. Therefore all design elements that might affect the overall footprint have been fully assessed.

This report provides information on the proposed Project works and how these relate to reclamation and occupation of the adjacent CMA. The report describes the locations of reclamation, permanent occupation and temporary occupation in relation to the particular works. It also provides details of the likely activities, construction methodology and timing of the works in order for the environmental effects to be assessed.

An indicative diagrammatic representation of the areas of reclamation, permanent occupation, temporary occupation and marine habitat remediation is shown in Figure 6.1.

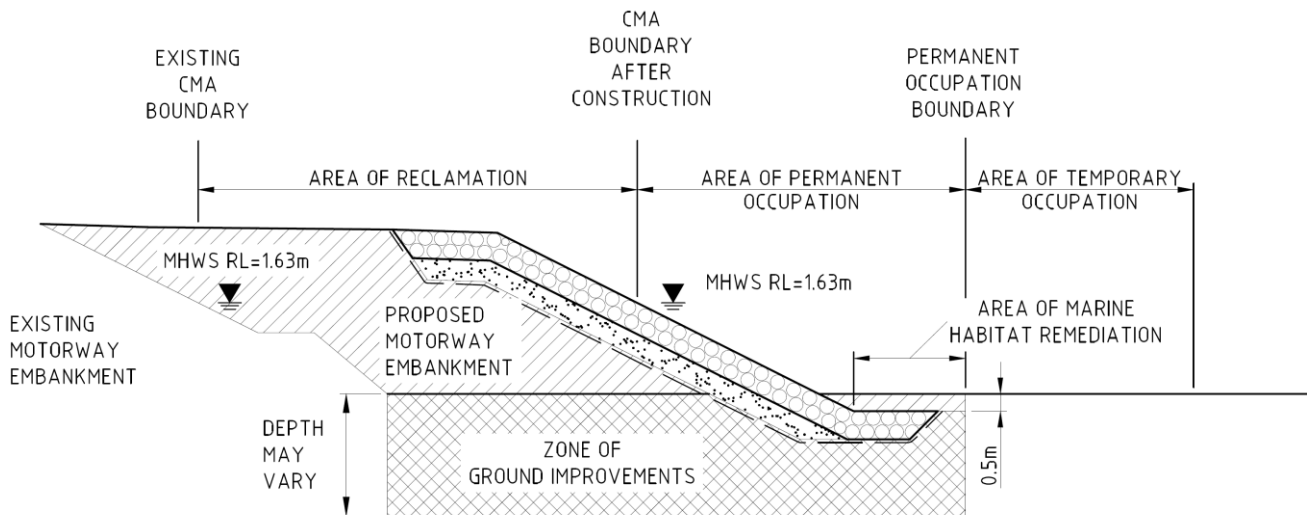


Figure 6.1 – Indicative diagram showing Reclamation, Permanent Occupation, Temporary Occupation and Marine Habitat Remediation (not to scale)

The following components of the Project require reclamation, permanent occupation and/or temporary occupation of the CMA:

- Te Atatu stormwater wetland;
- Causeway embankments;
- Whau bridge piers and abutments;
- Causeway bridge piers and abutments;
- the realigned access road to the Rosebank Domain;
- Rosebank culvert decommissioning;
- Waterview Estuary channel realignment;
- Oakley Creek Inlet channel realignment; and
- the Great North Road Interchange motorway-to-motorway ramp piers.

Table 6.1 summarises the areas of reclamation, permanent occupation, temporary occupation and marine habitat remediation required to provide for the coastal works to SH16 as part of the Project.

Table 6.1 – Approximate Areas of Reclamation, Permanent Occupation, Temporary Occupation and Marine Habitat Remediation (Note – Figure in brackets refers to that portion of the total occupation that is above the CMA, i.e. Aerial Occupation)

Area Type	Sector 1 (ha)	Sector 2 (ha)	Sector 4 (ha)	Sector 5 (ha)	Total (ha)
Reclamation	0.10	0.41	4.20	0	4.71
Permanent Occupation	0.01	1.11 (0.93)	2.68 (0.41)	0.35 (0.34)	4.15 (1.68)
Temporary Occupation	0.05	0.6 (0.27)	5.66 (0.11)	0.32 (0.31)	6.63 (0.69)
Marine Habitat Remediation	0	0.16	1.16	0	1.32

The following technical reports assess the environmental impacts of the temporary and permanent works within the CMA, as detailed within this report:

- Technical Report G.11 Assessment of Marine Ecological Effects;
- Technical Report G.4 Assessment of Coastal Processes;
- Technical Report G.15 Assessment of Stormwater & Streamworks Effects; and
- Technical Report G.22 Erosion and Sediment Control Plan.

6. References

Aurecon (2010) "Western Ring Route – Waterview Connection - **Causeway Options Report 20.1.11-3-R-J-304**", August 2010

Aurecon (2010) "Western Ring Route – Waterview Connection - **Interpretation of Hydrodynamic Design Conditions Report 20.1.11-3-R-J-305**", August 2010

Aurecon (2010) "Western Ring Route – Waterview Connection - **Coastal Works Engineering Report 20.1.11-3-R-J-306**", August 2010

Aurecon and Tonkin & Taylor (2010): Western Ring Route – Waterview Connection – Erosion and Sediment Control Plan, *prepared for NZTA*.

Aurecon and Tonkin & Taylor (2010): Western Ring Route – Waterview Connection – Assessment of Stormwater & Streamworks Effects, *prepared for NZTA*.

Bofa Miskell (2010): Western Ring Route – Waterview Connection – Assessment of Marine Ecological Effects, *prepared for NZTA*.

Niwa and Tonkin & Taylor (2010): Western Ring Route – Waterview Connection – Assessment of Coastal Processes, *prepared for NZTA*.

All coastal works drawings referred to in this report are listed in the table below. All the drawings are located in Part F (Waterview AEE Supporting Plans) of the Waterview AEE.

Drawing Set	Drawing Title	Drawing Numbers	No. of Sheets
F.18	Reclamation Extent	20.1.11-3-D-N-520-100 to 108	8
F.12	CMA Permanent Occupation Plans	20.1.11-3-D-N-941-100 to 109	9
F.13	CMA Temporary Occupation Plans	20.1.11-3-D-N-942-100 to 109	9
F.08	Whau River Motorway and Pedestrian Bridges	20.1.11.3-D-S-917-220 and 221	2
F.08	Causeway Motorway and Pedestrian Bridges	20.1.11.3-D-S-917-250 and 251	2
F.08	Great North Road Interchange	20.1.11.3-D-S-917-430 and 431	2
F.13	CMA Temporary Occupation Plans	20.1.11.3-D-N-942-109	1