23. Marine ecology

Overview

Although the Project does not involve works or the discharge of contaminants into the coastal marine area, the marine environment is the ultimate receiving environment for sediment laden water from construction of the Project and stormwater runoff from the road surfaces from the operation of the Project. There are two marine receiving environments of relevance:

- the Kapiti Coast, comprising the mouths of the Wainui and Whareroa Streams; and
- the Porirua Harbour, comprising the Pauatahanui Inlet and the Onepoto Arm.

The mouths of the Wainui and Whareroa Streams are dynamic environments on the open coast. In contrast, the Porirua Harbour is more enclosed, accessible to the open coastal by a narrow 100m channel. Due to this and the fact that the Harbour is the receiving environment for approximately 80% of the discharges associated with the Project, ecological investigations have focused more (but not exclusively) on effects on the Harbour ecosystem.

Construction of the Project will result in increased levels of sediment entering the Harbour. Increased levels of suspended sediment as a result of high rainfall events are expected to have negligible ecological effects. There are two Q10 events (with certain wind conditions) where deposited sediment on the seabed is predicted to have moderate (Onepoto Arm) and high (Pauatahanui Inlet) adverse ecological effects. While the potential ecological effects of sediment deposition resulting from these events is moderate and high respectively, the number of factors required to occur simultaneously means that their annual occurrence probability is relatively low.

Operation of the Project will involve the discharge of treated road runoff to the Porirua Harbour which will contribute to the long term accumulation of contaminants in central subtidal basins. Operational phase discharges to the marine environment adjacent to the Wainui and Whareroa Streams will be diluted and widely dispersed given the large, high energy receiving environment.

23.1 Introduction

This chapter presents the findings of investigations undertaken to determine the likely effects of the Project on marine ecology.

Information about existing marine ecology was obtained from ecological databases and previous relevant studies. Ecological field investigations were also undertaken specifically for the Project. Once a baseline of marine ecology had been determined, the impacts of the construction and operation of the Project were assessed. This first assessment stage was undertaken without the application of any specific ecological mitigation. The Project ecologists worked closely with the design team to seek to avoid adverse ecological effects where possible. Where avoidance was not possible, ecological mitigation was then developed to mitigate those adverse effects.

The final assessment stage considered the likely environmental effects with the application of the proposed mitigation.

23.2 Ecological investigations and modelling

The identification of effects on marine ecology required the assessment of the composition and values of the existing marine ecosystems. This relied on two complementary methods:

- desktop studies of available relevant information such as ecological databases and existing datasets and previous ecological investigations; and
- field surveys.

The description of existing marine ecology given in this chapter includes a brief overview of the investigations undertaken. Further details on the methods used and findings of these investigations are contained in **Technical Report 10** on marine habitats and species.

23.3 Existing marine ecosystems

The physical and biological characteristics of the two marine environments (i.e. the Wainui Stream mouth and the Porirua Harbour) are described in this section. Key aspects described are:

- morphology;
- sediment characteristics;
- water quality; and
- habitat and species.

More information is provided about the Porirua Harbour than the Wainui Stream mouth because:

- the majority of the works (approximately 80% of the Project by length) will occur in catchments which flow into the Porirua Harbour; and
- the Whareroa and Wainui Stream mouths are much higher energy dynamic environment (being on the open coast) and hence, in general, the potential for adverse effects on this ecosystem is significantly reduced.

23.3.1 Whareroa Stream mouth

The tidal river mouth estuary of the Whareroa Stream is a modified ecosystem that discharges through a sandy beach to the high energy marine environment. The stream mouth is occasionally blocked and as such the mouth is artificially managed and there is a significant amount of drift wood present on the beach and within the lower reaches of the stream. A small saltmarsh wetland is present in the upper estuary and to the north there are relatively unmodified dunes. A retaining wall has been constructed adjacent to the south bank. Upstream of the dunes, the stream has been channelised and is considered highly modified.

23.3.1.1 Sediment characteristics

The sediment at the mouth of Whareroa Stream is dominated by sand (approximately 99%) and contains low concentrations of copper (2.7mg/kg dw), lead (5.0mg/kg dw) and zinc (22.0mg/kg dw).

23.3.1.2 Water quality

The catchment of the Whareroa Stream is primarily coastal farmland, comprising approximately 80% pasture and 20% scrub. Water quality is reported to be adversely affected by agricultural and road runoff. Stream water is humic stained with moderate concentrations of nutrients and *E. coli*.

23.3.1.3 Habitat and species

The migratory freshwater and marine fish that have been recorded in this habitat include longfin eel, giant kokopu, redfin bully, inanga, shortfin eel, banded kokopu, common bully, koaro, lamprey, yelloweyed mullet, anchovy and smelt.

Birds known to use the Whareroa Stream mouth include banded dotterel, black-backed gull, mallard, pipit, pukeko, red-billed gull, royal spoonbill, shore plover, shovelers, spur wing plover, variable oystercatcher and white-faced heron.

23.3.2 Wainui Stream mouth

The mouth of the Wainui Stream is characterised as a high energy open sandy beach. The Wainui Stream forms a small tidal stream mouth estuary, which drains to Paekakariki Beach, which is a high energy, open sandy beach. A small lagoon is present behind the beach, which passes through coastal dunes. The stream mouth is occasionally blocked and there are large amounts of driftwood in the lower reaches of the stream mouth.

23.3.2.1 Sediment characteristics

The concentration of common stormwater contaminants in surface sediment is currently low i.e. as a percentage of the ex-Auckland Regional Council (ARC) Environmental Response Criteria (ERC) amber threshold concentration copper and zinc are detected at 19% of the amber threshold, lead 14% and high molecular weight (HMW) polycyclic aromatic hydrocarbons (PAHs) 2% of the amber threshold.

Surface sediment is characterised as comprising predominantly fine sand (86%) as would be expected in a high energy open beach environment.

23.3.2.2 Water quality

Water quality is typically high, but may be compromised by runoff from the township of Paekakariki, septic tank leachate from the motor camp located upstream of the estuary and agricultural runoff in the upper reaches of the stream.

23.3.2.3 Habitat and species

Only one invertebrate (polychaete worm) was detected in the infaunal cores collected, and no epifauna were detected. This finding is typical of high energy exposed sandy / cobbly beaches. Whilst the abundance and diversity is low at this site, the ecological values are high and the risks of degradation low due to the hydrodynamic environment of the ultimate receiving environment.

Migratory freshwater fish that use the estuary include longfin and shortfin eels, torrentfish, two species of bully, banded kokopu and giant kokopu.

Shore birds that have been observed at the stream mouth include black-backed gulls, variable oyster catchers, pied stilts, banded dotterels, spur wing plovers and other common species. It is likely that shore plovers, royal spoonbills, white-faced herons, black shags, mallards, pukeko and pipits also are occasionally present

23.3.3 Porirua Harbour

Porirua Harbour (867ha) contains two shallow tidal inlets: the Onepoto Inlet (283ha) and the Pauatahanui Inlet (524ha). Both inlets have common access to the sea via a narrow 0.1km wide entrance. Maximum water depth in both inlets is approximately 3.0m. Approximately 80% of the Onepoto Arm is subtidal, whereas 60% of the Pauatahanui Inlet is subtidal[135]. The ratio of subtidal to intertidal habitat is relatively high compared to other estuaries and tidal inlets and this has important implications for sedimentation and eutrophication patterns.

The primary driver for the movement of water into and out of Porirua Harbour is tidal exchange. Approximately 60% of the incoming tide flows to the Pauatahanui Inlet, with 40% to the Onepoto Arm. Winds, waves and freshwater inflows also influence the movement of water and sediment. The larger streams that enter into Porirua Harbour have complex flood tide deltas, with dynamic and often multiple channels at the stream mouths. Circulation eddies occur in both inlets, and these are likely to contribute to accumulation of fine sediment in the central basins. Within the Pauatahanui Inlet, most deposition occurs in the western and eastern parts of the central basin, where currents and circulation eddies are weakest.

23.3.3.1 Marine habitat

The Pauatahanui Inlet is an important wildlife site providing habitat for indigenous waterfowl and migratory wading birds, and is the only large area of saltmarsh and sea grass in the Wellington region. In addition to its importance as a wildlife and plant sanctuary, the Inlet and its biota provide for a range of functions vital for the continuing health of the ecosystems and associated communities. The shellfish of the Inlet are involved in the filtering of the Inlet's water; helping to maintain its clarity and purity. The saltmarsh vegetation acts as a natural trap for the sediment arriving in the Inlet.

135. 'Subtidal' refers to the area below water at low tide. 'Intertidal' (or littoral or foreshore) refers to the area between high and low tide.

The Onepoto Arm has less ecological value than Pauatahanui Inlet, but still contains large areas of mud flats, shell beds, populations of coastal fish and small areas of salt marsh of ecological value. Part of the Onepoto Arm was reclaimed for a causeway for the railway. The construction of this causeway created three shallow lagoons from the Harbour. When SH1 was re-aligned in the 1970s alongside the railway, these lagoons were partially filled in and Aotea Lagoon was developed into a recreational area.

23.3.3.2 Marine species

Around 43 species of fish are thought to live in the Porirua Harbour. Of these, long finned eel, lamprey and inanga (Galaxias species) are recognised as declining and pipefish are sparse, but secure populations do occur overseas. There are highly diverse shallow subtidal macro-invertebrate communities within both the Pauatahanui Inlet and the Onepoto Arm. The Pauatahanui Inlet has a high diversity and abundance of benthic[136] invertebrates. The Onepoto Arm is slightly less diverse and has a higher proportion of sediment and organic enrichment tolerant species.

In the intertidal zone infaunal invertebrate taxa were detected with a dominance of polychaete worms, bivalves, gastropods. Cockles were detected at all sites sampled in the most recent field survey at a variety of densities. However, cockle density is likely to be higher at sites lower on the intertidal sand and mudflats and also in shallow subtidal areas. Sediment grain size and sediment quality are likely to be factors that influence the density and distribution of cockles in the Harbour. A high diversity of molluscs (bivalves and gastropods) was detected, with the area around the Pauatahanui Stream mouth having the highest diversity. Typically this group of organisms is less diverse or absent when habitat quality is low.

Five main subtidal biological types were detected:

- cockle (*Austrovenus stutchburyi*) dominated;
- nut shall (*Nucula hartvigiana*) dominated;
- annelid worm (*polychaete*) dominated;
- eelgrass (*Zostera sp.*) habitat; and
- annelid worm (*Serpulidae*) habitat.

No subtidal rocky reef habitat was encountered at any of the survey sites, but does occur at the Harbour mouth and outer Harbour. Cockles in the Pauatahanui Inlet are an important biological component as they are a food source for a variety of organisms, affect the distribution of predator species, affect nitrogen and oxygen fluxes between water and sediment and are an important substrate for the attachment of algae and other molluscs. Eelgrass is present in the shallow subtidal areas. Eelgrass habitat is considered as being ecologically significant due to its contribution to primary productivity and detrital food webs and through its structural complexity, providing habitat for a range of species.

136. 'Benthic' refers to flora and fauna (benthos) living on the bottom of a body of water (stream or sea).

Seagrass meadows (which as noted above are present) have also been shown to enhance bottom stability, reduce sediment accumulation, and enhance nutrient cycling. Seagrass was found to be extensive in both Inlets, saltmarsh covers approximately 51ha in the Pauatahanui Inlet, but is largely absent in the Onepoto Arm. Some nuisance macroalgae has been found in both the Pauatahanui Inlet (around the Pauatahanui Stream) and the Onepoto Arm (around the Porirua Stream).

23.3.3.3 Sediment

The Harbour throat experiences a net average deposition rate of 27.1mm/year of fine sand[137]. Since 1980, much of this fine sand has been trapped against the breakwaters and Mana Marina entrance. The predominant source of sediment entering the Porirua Harbour is from both bed load and suspended load from the Porirua, Kakaho, Ration, Pauatahanui, Duck, and Brown streams. The land uses in these catchments are predominantly pastoral, urban or commercial forestry.

The mean sedimentation rate in Porirua Harbour is estimated to be 0.75-7mm in a 13 month period. The sediment rates are very low in the Pauatahanui Inlet and very low to moderate in the Onepoto Arm.

In terms of sediment contaminants, a survey of heavy metal concentrations in Porirua Harbour[138], determined that (in terms of ecological response criteria (ERC)[139]):

- the average concentration of copper and zinc in sediment samples exceeded the amber (and in some cases the red) threshold; and
- the average concentration of lead did not exceed any thresholds.

An intertidal sediment quality survey in Porirua Harbour[140] indicated elevated contaminant concentrations in surface sediment samples from Onepoto and Browns streams and Duck Creek. At all three stream mouths, total DDT levels exceeded effects thresholds[141]. At Browns Stream mouth, levels of lead, zinc and various polycyclic aromatic hydrocarbons (PAHs) were also exceeded. This is likely to be reflective of the urban development in the Browns Stream catchment. Onepoto Stream mouth has levels of lead in excess of thresholds.

137. Measured between 1974 and 2009

138. Glasby et al. (1990)

139. ERC were developed by the Auckland Regional Council to report on sediment and water quality. It uses a traffic light system where: green sites are low impact sites; amber sites are showing signs of degradation; red sites are higher impact sites where significant degradation has already occurred. Auckland Regional Council (ARC) (2004). Blueprint for monitoring urban receiving environments. Auckland Regional Council Technical Publication No. 168.

140. Sorenson & Milne (2009)

141. DDT is assumed to be from historical land use in these catchments.

23.3.3.4 Ecological value

Both inlets contain relatively diverse invertebrate assemblages and species that are known to be sensitive to organic enrichment and to silt and clay. Sediment grain varied amongst sites in each of the Inlets, with some sites in each Inlet having a high proportion of silt and clay and some having a high proportion of sand and gravel. These differences are largely due to different historic and current land use practices, in addition to having somewhat different hydrodynamic environments. Sediment contaminants were significantly higher in the Onepoto Arm as compared to the Pauatahanui Inlet and habitat modification is more extensive in the Onepoto Arm.

The Pauatahanui Inlet has the following ecological values:

- High ecological values in terms of:
    - Benthic invertebrate community typically highly diverse with high species richness.
    - Benthic invertebrate community contains many taxa that are sensitive to organic enrichment and mud.
    - Intertidal surficial sediments typically comprise approximately 50-70% very fine sand and silt / clay.
    - Depth of oxygenated surface sediment typically >1.0cm.
    - Contaminant concentrations in surface sediment rarely exceed low effects threshold concentrations.
- Moderate ecological values in terms of:
    - Subtidal surficial sediments typically comprise approximately 50-70% very fine sand and silt / clay (although central basin sites approaching 100%).
    - Habitat modification limited.

The Onepoto Arm has the following ecological values:

- High ecological values in terms of:
    - Marine sediments typically comprise <50% very fine sand and silt / clay.
- Moderate ecological values in terms of:
    - Benthic invertebrate community typically has moderate species richness and diversity.
    - Benthic invertebrate community contains many taxa that are sensitive to organic enrichment and mud.
    - Depth of oxygenated surface sediment typically >0.5cm.
- Low ecological values in terms of:
    - Elevated contaminant concentrations in surface sediment, above ISQG-High or ARC-red affects threshold concentrations.
    - Habitat highly modified.

Overall, it is considered that the Pauatahanui Inlet has high ecological values and the Onepoto Arm has moderate ecological values.

23.4 Construction effects on marine ecology

The potential effects on marine ecology from construction of the Project are from increased sediment entering the coast. The risk of other contaminants such as oil and fuel entering streams is considered very low and hence this has not been assessed as a potential effect on marine ecology. Protocols for managing contaminants and emergency procedures for accidental spills are contained in the draft CEMP.

Effects on marine ecology can occur from both suspended sediment and from sediment deposited on the seabed (benthos). Broadly, the magnitude of the effect on marine ecosystems is a function of:

- the sensitivity of the marine organism;
- the level of sedimentation (depth of sediment);
- the concentration of total suspended sediment; and
- the duration of exposure (length of time sediment remains on the seabed or in suspension).

It is considered, in terms of the effects of increased sediment on marine ecology, two particular types of effects require consideration:

- the effect during construction period during and immediately after an extreme weather event (up to a Q10 event);
- the long term residual (up to 20 years from the commencement of works) effect of increased sediment from construction of the Project.

Prior to a discussion on these two particular potential effects, the hydrodynamic sediment modelling undertaken to assess the sediment effects is briefly described.

23.4.1 Hydrodynamic sediment modelling

Construction of the Project will require large areas of open earthworks which have the potential to add to sediment loads entering the Porirua Harbour[142]. The potential changes in the sediment patterns in the Harbour associated with the Project construction are dependent on a variety of environmental conditions (primarily related to wind and rainfall). Event based and long term simulation modelling was undertaken to determine the effects on marine ecological values.

Event based modelling focuses on determining patterns of sediment deposition and total suspended sediment in 2 year and 10 year return period rainfall events, under calm, northerly and southerly wind environments, during the period of maximum earthworks. The event based modelling was further

142. The fate of sediment entering the open coast (i.e. the Whareroa and Wainui Stream mouths) was not modelled as this is a high energy environment and is rapidly transported offshore.

explored for higher risk events to determine the effect of the Project on various sediment deposition thresholds of ecological relevance. The modelling isolates areas of the Harbour which receive 5-10mm of sediment due to the Project (or pushed into this threshold due to the Project) from the area that does not currently receive this amount of sediment (i.e. without the Project). The scientific literature indicates that the most sensitive marine invertebrate species may be affected at this depth of sediment, if sustained for longer than three days. The modelling further isolates areas of the Harbour that receive >10mm of sediment due to the Project (or pushed into this threshold due to the Project) that, without the Project construction, do not received >10mm sediment. Invertebrate community composition is likely to be adversely affected at this depth of deposition, if sustained for longer than three days.

In addition, a long term simulation was undertaken (20 year period) to determine the cumulative effects of sediment deposition on the Harbour due to the Project.

23.4.1.1 Factors affecting sediment deposition

The deposition of sediment in the Harbour varies both spatially and temporally and is mainly a function of the location and volume of sediment discharged from stream mouths and the concurrent hydrodynamic conditions (which is itself influenced by a number of factors including wind speed and direction and tides).

23.4.1.2 Summary of modelling results

The modelling indicated that much of the terrestrial sediment entering the Harbour is deposited in the shallow intertidal zone near stream mouths. In these areas total suspended sediment (TSS) is also highest, exacerbated by wave induced suspension of bed material in shallow water. Fine sediment is transported further away from stream mouths.

Modelling of rainfall events indicates that maximum deposition bed depths and TSS concentrations are experienced during or shortly after the peak of the storm event. Over a 24 hour period following the peak of the storm, sediments are distributed throughout the Harbour by currents and tidal exchange. Minimal redistribution of sediment occurs three (3) and seven (7) days after storm events[143]. The primary areas where sediment deposits and TSS is elevated following storm events are around the mouth of Kakaho Stream, the shallow intertidal eastern end of the Pauatahanui Inlet and the sheltered shallow western side of the Onepoto Arm.

23.4.2 Sensitivity of marine species

With respect to the duration of deposited sediment remaining in place, most marine invertebrates can tolerate a deposition of sediment for up to three days by isolating themselves from environmental stressors (e.g. bivalves close their valves, other invertebrates cease feeding). If the sediment deposition persists for longer than three days, sublethal and lethal effects begin to occur in the most sensitive taxa. Less sensitive organisms may tolerate sediment deposition for a longer period before

143. Sediment redistribution refers to deposited sediment becoming entrained again and being transported and re-deposited in a new location.

adverse effects begin to occur. The assessment considered the depth of sediment deposition at three days following the peak of the rainfall events modelled, in order to capture effects on the most sensitive species from a sedimentation event.

Marine invertebrates are considered to be more susceptible to the discharge of sediment, as most taxa have limited mobility or are permanently attached, whereas fish can move to areas that are less affected. The marine invertebrates present in the Harbour include both sensitive and tolerant taxa. The intertidal and near shore shallow subtidal invertebrate community composition includes species that are sensitive to mud e.g. gastropods, bivalves and certain species of polychaete. Species that are tolerant of mud are also present e.g. mud crabs and oligochaete worms.

In the Porirua Harbour, sediments tend to be coarser within the intertidal areas, whereas fine sediment accumulates subtidally. Therefore, it is anticipated that adverse effects may be experienced by marine organisms inhabiting intertidal areas at shallow depths of sediment deposition compared to organisms inhabiting the subtidal fine sediment habitats. In the assessment those areas of Harbour that receive sediment during various rainfall events that pushes the total deposition in an event to 5-10mm and to >10mm were considered. Individual sensitive species may be adversely affected at 5-10mm deposition (both intertidally and subtidally), and a large number of species (and potentially communities) may be adversely affected at >10mm deposition. Organisms inhabiting the very fine sediment within subtidal basins may be able to tolerate greater depths of deposition. However, in order to be conservative, the same effects thresholds have been used across the entire Harbour.

23.4.3 Event based sediment effects

Both Q2 and Q10 events were modelled to consider what the ecological effects of the sediment associated with these events would be. Two aspects have the potential to adversely affect marine ecology:

- total suspended sediment (TSS); and
- deposited sediment.

23.4.3.1 Total suspended sediment

In order to assess the effects of suspended sediment on marine organisms an understanding of both concentration and duration of exposure is required. Marine taxa have differing sensitivities to suspended sediment concentration and duration. Organisms can be affected by suspended sediment primarily through clogging of gills and other filter structures, inability to visually detect prey, and reduced light.

The most sensitive species researched (pipi or *Paphies australis*) shows sublethal adverse effects at 75g/m^3 when continuously exposed for periods in excess of 13 days. Under a variety of rainfall events and wind conditions, the results indicate that in the combined Q10 rainfall event situation, suspended sediment, at one day post the peak of the rainfall event, reaches concentrations that may cause adverse effects on marine organisms if exposure was sustained. However, by three days post the peak of the rainfall event, the concentration of suspended sediment derived from runoff throughout Porirua Harbour is below effects threshold concentrations.

As such, in all scenarios modelled within both arms of the Harbour the effect of suspended sediments is always negligible.

23.4.3.2 Deposited sediment

The approach to the assessment of effects of sedimentation has been to gain an understanding from the modelling outputs of the location and area affected by sediment deposition at biological effects threshold depths and duration and then determine from the deposition maps (refer to **Technical Report 15**) whether the areas receiving sediment were sensitive to deposition. Our assessment of ecological values indicated that within Porirua Harbour the central subtidal basins are not particularly sensitive to sediment deposition due to being characterised by a depauperate invertebrate community and deep fine anoxic sediment. In contrast, the shallow subtidal and intertidal areas have diverse invertebrate communities, comprising both sensitive and tolerant organisms, and a more coarse sediment grain size distribution.

For most of the Q10 events under the various wind conditions, the resultant increased area of Harbour that is predicted to receive sediment (three days following the rainfall event) at the thresholds considered (i.e. 5-10mm and >10mm) is considered to have minimal effects. This is due to the deposition occurring primarily within the subtidal basin areas that currently accumulate fine sediment during rainfall events and are characterised by a severely diminished invertebrate community with lower ecological values.

However, there are two rainfall and wind scenarios that have been assessed as potentially resulting in significant adverse effects on marine ecological values (Table 23.1).

Table 23.1: Potentially ecologically significant sediment generating events

Event	Sediment deposition predicted	Probability of occurrence over two year period[144]	Ecological significance of adverse effect
Q10 event in Kenepuru Catchment, with S-SE wind	2.7ha (Onepoto Arm) of primarily intertidal and shallow subtidal habitat receiving >10mm	7% (3 - 14%)	Moderate
Q10 event in Duck Catchment, with N-NW wind	3.0ha receiving 5-10mm deposition, and 3.2ha receiving >10mm deposition (both primarily in intertidal and shallow subtidal habitats within the Pauatahanui Inlet)	12% (4 - 23%)	High

While the likelihood of these events occurring is low, the consequences of the events on small areas of the Porirua Harbour are considered ecologically significant, particularly in the near shore habitats.

144. Probabilities provided relate to a 5m/s or stronger wind occurring at the same time as a Q10 rainfall event. The Harbour model run and ecological assessment is based on a 10m/s or stronger wind occurring at the same time as a Q10 rainfall event and consequently the probabilities are over estimates, i.e. conservative.

If the Project was being constructed and one of these two events was to occur the sediment that is deposited in the Harbour would increase by 5-6% compared to what would occur without the Project being under construction. However, the additional effects of the Project on sediment deposition in the Harbour, whilst comprising a small proportion of the total sediment deposition occurring, remain of medium-high significance.

23.4.4 Long term residual effects of sediment deposition

Sediment from construction of the Project that is deposited in the near shore (intertidal and shallow subtidal) areas of the Harbour will, over time, move to and accumulate in the subtidal basins. In the long term, the additional sediment discharged to the Harbour as a result of construction of the Project, adds to the cumulative effects of sedimentation of the central subtidal marine environment in both inlets of the Harbour. The modelling of sediment deposition patterns in the Harbour twenty years after the commencement of construction indicates a difference in bed deposition depth in the subtidal basin areas of up to 5cm that is attributable to the Project.

In the Pauatahanui Inlet, sediment is accumulated in the central subtidal basins, whereas in the Onepoto Arm accumulation is in the southern subtidal area. The maximum depth of deposition of sediment of 5cm amounts to a maximum deposition of 2.5mm per year on average.

The long term simulation without the Project constructed indicates that approximately 61ha of the marine habitat in the Onepoto Arm and 204ha in the Pauatahanui Inlet will accumulate >100mm of sediment in 20 years' time (Table 23.2).

Table 23.2: Harbour area affected by long term (20 year) sediment accumulation

	Area affected without the Project (ha)		Area affected with the Project (ha) and % increase	
Depth of sediment	Onepoto Arm	Pauatahanui Inlet	Onepoto Arm	Pauatahanui Inlet
>100mm	57.68	114.18	57.77 (0.15%)	115.27 (0.95%)
>200mm	3.76	57.80	4.15 (10.37%)	58.91 (1.92%)
>300mm	0	32.12	0	33.21 (3.39%)
TOTAL	**61.44**	**204.1**	**61.92 (0.79%)**	**207.39 (1.61%)**

With the Project, the area that will accumulate >100mm of sediment in 20 years' time increases to 62ha in the Onepoto Arm and 207ha in the Pauatahanui Inlet. These results clearly show that the majority of the sediment that is predicted to accumulate in the Porirua Harbour in the next 20 years is not from the Project. The long term simulation results without the road are likely to be an underestimate of sediment runoff and accumulation, as further urban development and felling of forestry blocks, which are associated with high sediment runoff, have not been included in the model assumptions, but are highly likely to be undertaken in the next twenty years.

The increase in total Harbour area that accumulates >100mm of sediment in 20 years is 0.79% in the Onepoto Arm and 1.6% in the Pauatahanui Inlet. While this additional sediment from the Project predicted to accumulate in the subtidal basin areas is a small proportion of the total sediment predicted to accumulate in these areas, it has some minor additive adverse effects on the ecological values and functioning of the estuary in the long term through habitat modification. A summary of the long term ecological effect of sediment redistribution in the Porirua Harbour is described in Table 23.3.

Table 23.3: Significance of long- term sediment re- deposition with the Porirua Harbour

Description (listed north to south)	Ecological value	Assessment of impact magnitude	Assessment of impact significance
Pauatahanui Inlet			
Intertidal and shallow subtidal	High	Negligible	Low
Shallow subtidal margins	Moderate	Negligible	Very low
Central subtidal basins	Low	Moderate	Very low
Onepoto ArmOnepoto Arm			
Intertidal zone	Moderate	Negligible	Very low
Central subtidal basins	Low	Moderate	Very low

This summary shows that in all marine environments the ecological significance of sediment redistribution as a result of the Project is low or very low in the long term.

23.5 Operational effects on marine ecology

Currently, common stormwater contaminants are detected at below biological effects thresholds in surface sediment from the Pauatahanui Inlet, whereas the Onepoto Arm surface sediment is commonly above biological effects thresholds. Higher concentrations of contaminants are present in the central subtidal basins within the Pauatahanui Inlet. It is in this part of the inlet, where ecological values are lower, that contaminant concentrations could further increase in the long term, regardless of whether the Project is constructed or not.

During the operational phase of the Project, treated runoff from the road will discharge to the Porirua Harbour via streams and to the open coast via Wainui and Whareroa Streams. As with any stormwater discharge into such an environment, there will be cumulative effects in the long term arising from the accumulation of contaminants contained in discharges.

The receiving environment of the Wainui and Whareroa Streams are high energy and afford large dilution. The discharge of treated stormwater will contribute in the long term to the accumulation of contaminants in marine sediments in sheltered low energy environments such as the Porirua Harbour. This is considered to have negligible, if any, effect on marine ecology in the Harbour.

In summary, the operational stormwater discharges to all marine receiving environments will have negligible effects.