20. Water quality

Overview

The construction and operation of the Project has the potential to adversely affect water quality in streams and marine environments. Construction of the Project will involve major earthworks, which has the potential to increase sediment run off to streams and the coast. Operation of the Project has the potential to increase contaminant levels in stream and marine environments associated with stormwater runoff from road surfaces.

Existing freshwater quality in streams is variable. Virtually all streams in the Project area have elevated nutrient levels, which is typical of the predominantly pastoral land use through most of the Project area. Levels of turbidity, metals and hydrocarbons are generally within guideline values with the exceptions being the more urbanised catchments of Kenepuru and Porirua. Water quality within Porirua Harbour varies but contaminant levels (zinc, copper and lead) are typically elevated around stormwater outfalls in the Onepoto Arm. DDT concentrations are elevated in both inlets, which is likely a result of historical pastoral land use.

Land use within catchments draining into the Harbour also influences sediment entering the Harbour. Sediment deposition rates since 1974 have averaged 5.7mm/year in the Onepoto Arm and 9.1mm/year in the Pauatahanui Inlet. Based on current average deposition rates, the Onepoto Arm will be filled-in within the next 290 - 390 years and the Pauatahanui Inlet within the next 145 – 195 years.

A high level of erosion and sediment control will be used to manage sediment from the construction of the Project entering waterbodies. High rainfall events (Q10) would cause an increase in sediment in the streams and the Harbour. Increases in suspended sediment will occur but will mimic what currently occurs during these events and will not cause any lasting adverse effects. Increases in sediment deposited in streams from these events will be minimal. For most events, the additional sediment entering the Harbour will deposit in areas where high levels of sediment deposition is already occurring and therefore is likely to have minimal impact. An exception to this is in three particular combinations of wind and rainfall events where more significant deposition is predicted in the intertidal zones near the coast. In terms of water quality, they will not, in themselves, have a significant adverse effect. In the long term (20 years) additional sediment entering the Harbour from construction of the Project will make a negligible difference to the in-filling of the two inlets.

Operation of the Project will involve treatment of all stormwater runoff from road surfaces. As a result, contaminants entering the Wainui Stream mouth and Onepoto Arm will decrease, providing a positive effect. Contaminant levels entering the Pauatahanui Inlet will mostly remain unchanged, with the exception of total petroleum hydrocarbons which are predicted to increase by 20%. This increase will not cause conspicuous oil or grease in the water or any change in odour. Similarly, it will not adversely affect recreational use (including contact recreation) of the Inlet.

20.1 Introduction

Water quality refers to the physical, chemical and biological characteristics of water.

This chapter discusses the actual and potential water quality effects arising from the construction and operation of the Project. Effects were assessed by gathering information about existing water quality in both freshwater waterbodies (i.e. streams) and in coastal waters. The potential effects on water quality arising from the Project were then modelled and assessed.

The potential effects ecological effects from changes to water quality on freshwater and marine ecology are discussed in Chapters 22 and 23, respectively.

20.2 Existing water quality

Baseline water samples were collected to allow the impacts of road construction on water quality along the length of the Project to be measured. Water quality sampling was undertaken at a number of relevant sites within the Project area. The data collected over a twelve month period shows that water quality in the streams within the affected catchments is mostly within the ANZECC Guidelines (the Guidelines)[106]. There were some exceedances of guidelines, particularly at the downstream sites of the Duck Creek, Kenepuru Stream and Porirua Stream catchments.

Information on the following parameters was collected:

- turbidity;
- metals;
- nutrients; and
- hydrocarbons.

A summary of the water quality in relation to the guideline values is shown in Table 20.1.

106. Australian and New Zealand Environment and Conservation Council (ANZECC). (2000). Australian and New Zealand Guidelines for Fresh and Marine Water Quality.

Table 20.1: Summary of water quality measurements in relation to guideline values[107]

Catchment	Sample site	Location in relation to Project	Turbidity	Metals	Nutrients	Hydrocarbons
Whareroa	Whareroa 1	Upstream	✔	✔	✕	✔
Te Puka	Te Puka 1	Upstream	✔	✔	✔	✔
	Te Puka 2	Downstream	✔	✔	✕	✔
Horokiri	Horokiri 1	Upstream	✔	✔	✔	✔
	Horokiri 2	Downstream	✔	✔	✕	✔
	Horokiri 3	Control	✔	✔	✕	✔
	Horokiri 5	Downstream	✔	✔	✕	✔
Ration	Ration 1	Upstream	✔	✔	✕	✔
	Ration 2	Downstream	✔	✕	✕	✔
Pauatahanui	Pauatahanui	Upstream	✔	✔	✕	✔
	Pauatahanui	Downstream	✕	✕	✕	✔
Duck	Duck 1	Upstream	✔	✔	✕	✔
	Duck 2	Downstream	✔	✔	✕	✔
	Duck 3	Downstream	✔	✕	✕	✔
Kenepuru	Kenepuru 1	Upstream	✔	✔	✕	✔
	Kenepuru 2	Downstream	✔	✔	✕	✔
	Kenepuru 3	Downstream	✕	✕	✕	✔
Porirua	Porirua 1	Upstream	✕	✕	✕	✔
	Porirua 2	Downstream	✕	✕	✕	✔

In summary, the baseline data collected for each catchment showed[108]:

Whareroa Stream

Water quality within the stream is generally good, although elevated levels of nutrients presumably from farming operations were recorded.

Wainui and Te Puka Streams

Water quality within these streams is generally good, although the upper reaches of the Te Puka Stream are slightly acidic, while the lower reaches have elevated nutrient levels.

107. '✔' indicates below guideline values, '✕' indicates guideline value exceeded.

108. All references to guideline values refer to the ANZECC 95% ecological guidelines.

Horokiri Stream

The water quality within the catchment is relatively good, although elevated nutrient levels were recorded at all locations except for in the uppermost reaches. The pH was typically slightly acidic.

Ration Stream

Water quality within the catchment is relatively generally good, although it deteriorates downstream, with some elevated levels of metals being detected downstream and nutrient levels consistently higher than guideline levels. Both upstream and downstream reaches are also slightly acidic.

Pauatahanui Stream

Water quality within the catchment is variable. Lower reaches of the streams recorded elevated levels of metals and turbidity, in excess of ANZECC guidelines. Water quality in Collins Stream was not specifically assessed but is likely to be similar to the lower Pauatahanui Stream as there is a high level of interaction between these streams.

Duck Creek

Water quality within the catchment is variable with nutrient levels being elevated. Lower reaches of the stream also recorded elevated levels of metals, in excess of ANZECC guidelines.

Kenepuru Stream

Water quality in this catchment is reasonably good, although it does deteriorate noticeably downstream with turbidity and levels of metals in excess of ANZECC guidelines in the lower reaches.

Porirua Stream

Water quality in this catchment is poor, with elevated nutrient levels and turbidity and metals levels in excess of ANZECC guidelines. This is considered to be reflective of the highly modified and urbanised nature of many parts of this catchment.

20.3 Water quality modelling

A number of models were developed to assist in the assessment of water quality effects associated with the Project’s construction and operation. These were:

- to assess construction effects:
  - a sediment yield model;
  - a stream sediment transport model; and
  - a harbour sediment transport model.

- to assess operational effects:
    - a contaminant load model.

20.3.1 Construction effects modelling

A sediment yield model (SYM) was developed to assess predicted sediment yield (both temporally and spatially) across the Project. Models were then developed to predict the behaviour of sediment in the two types of receiving environments (i.e. streams and coastal waters). The key elements of the construction effects modelling are shown in Figure 20.1.

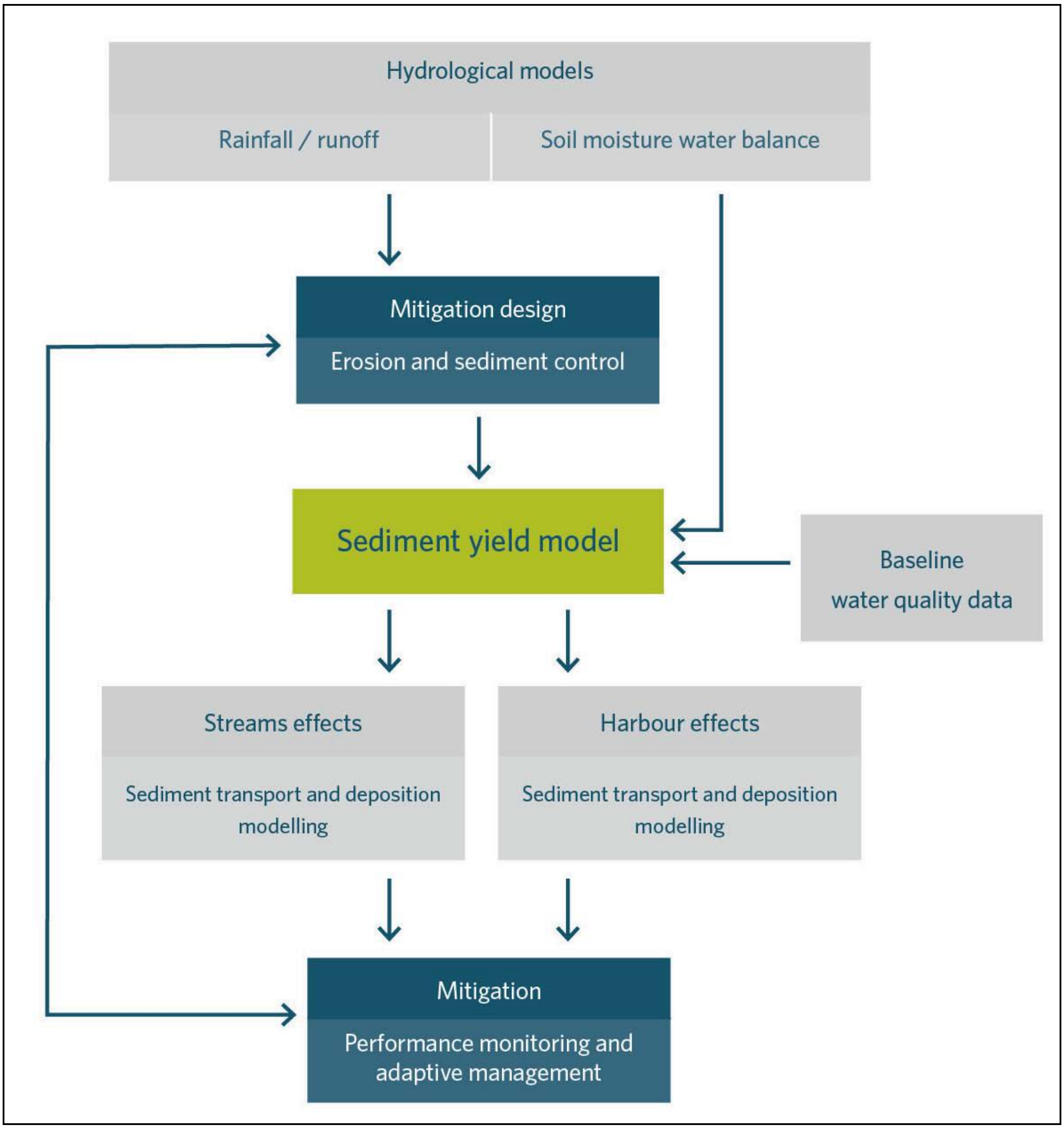

Figure 20.1: Modelling undertaken to assess water quality effects from construction

The SYM is described in **Technical Report 15** but a key aspect is that it relies on the achievement of particular erosion and sediment control (ESC) performance levels. Key performance assumptions are:

- sediment removal efficiency (SRE) of 75%; and
- sediment pond efficiency of 70% for the design storm event.

A stream sediment transport model was developed to assess the level and nature of sediment transport in key streams during the construction of the Project. This model was based on information from the hydraulic model (regarding stream flow etc.) and from the sediment yield information.

A harbour sediment transport model was developed to assess the level and nature of sediment transport in the Porirua Harbour during the construction of the Project. This model required information about the hydrodynamics (the movement of water by wave action and tides etc.) of the Harbour.

The stream and harbour sediment transport models allowed the effects of sediment transport and deposition in these two receiving environments to be assessed.

20.3.2 Operational effects modelling

Two methods were used to assess predicted contaminant levels for stormwater runoff from a specific area. A contaminant load model (CLM) was developed to assess predicted contaminant levels for stormwater runoff for stream catchments. Motorway and catchment data was used to predict contaminant levels for stormwater runoff at specific locations along the road alignment, as well as for whole stream catchment. Key stormwater contaminants considered were:

- total suspended sediment (TSS);
- zinc;
- copper; and
- total petroleum hydrocarbons[109] (TPH).

The key aspects of the modelling of operational water quality effects are shown in Figure 20.2.

109. Contaminant load model only.

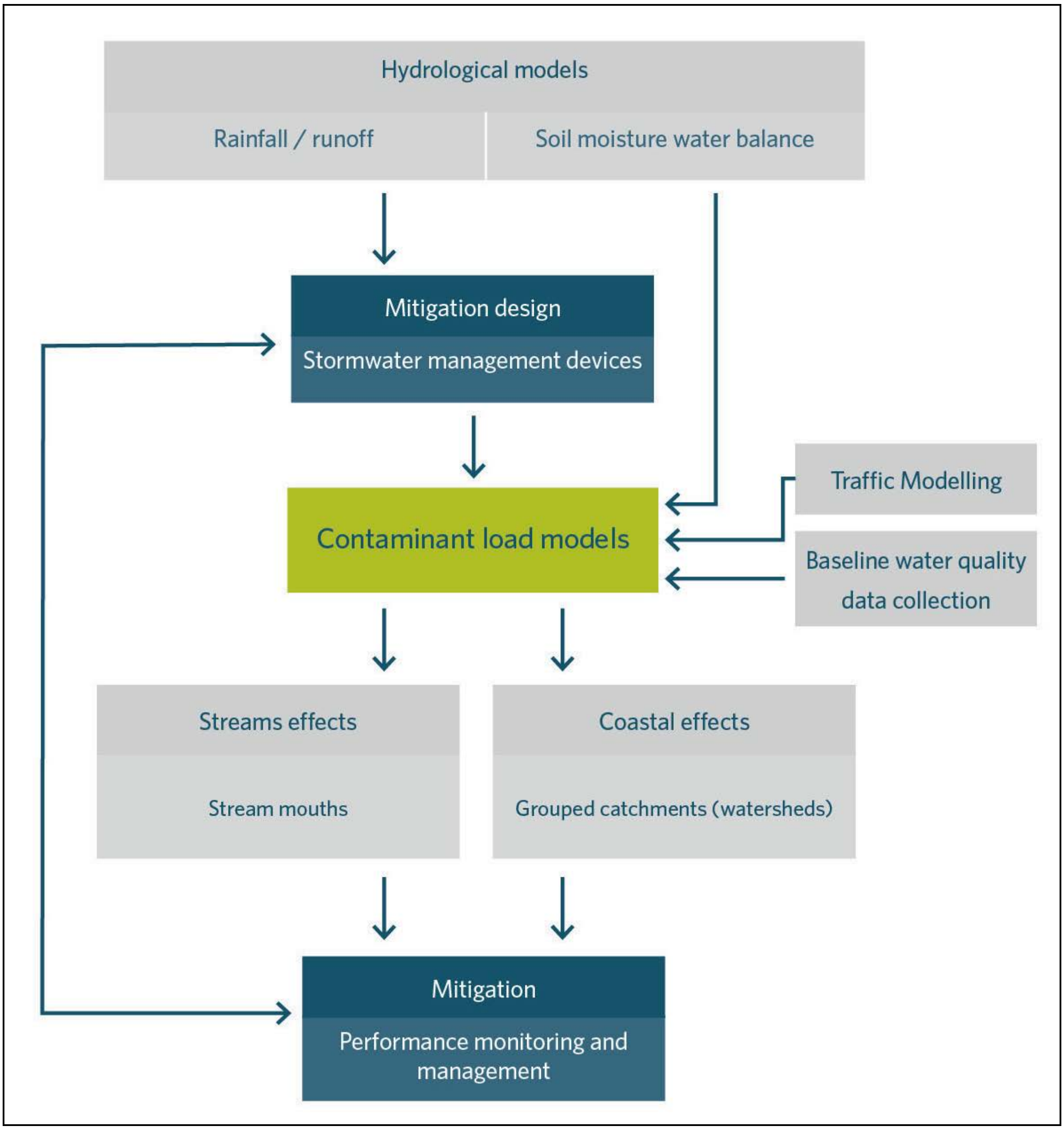

Figure 20.2: Modelling undertaken to assess water quality effects during operation

The CLM takes into account factors such as the predicted change in land use (including change not solely as a result of the Project) in the runoff area and the predicted traffic volumes on key roads. It was used to estimate the stormwater contaminant load for the following 2031 scenarios:

- without the Project;
- with the Project with no stormwater treatment; and
- with the Project and with stormwater treatment.

The information from the CLM allowed the efficiency of proposed treatment measures to be assessed and the stormwater contaminant effects of the Project to be identified.

The motorway and catchment data method does not account for changes in the catchment, other than as a result of the Project. This method was used to estimate the stormwater contaminant load for the following scenarios:

- without the Project;
- with the Project, without stormwater treatment; and
- with the Project, with stormwater treatment.

20.4 Water quality effects during construction

Construction of the Project will involve a number of activities that have the potential to generate sediment, principally:

- earthworks; and
- works in and around streams (e.g. construction of fords, bridges, retaining walls and culverts etc.).

Sediment can be generated in two main ways:

- when rain falls on exposed earth (i.e. un-vegetated cut faces or fill slopes); or
- when works in stream beds disturb and entrain sediment.

Increased sediment levels could have a number of adverse effects, including:

- damaging aquatic (freshwater and marine) habitat;
- altering the morphology of streams and / or harbours (i.e. aggradation / degradation of beds);
- reducing the aesthetic properties of water (e.g. visual clarity and odour).

Sediment has been assessed as the only contaminant with the potential to have adverse environmental effects during construction. It is recognised that there is always risk on a major construction project that accidental spills will result in other contaminants (e.g. fuel) entering waterways. While this risk can never be completely eliminated, it can be effectively managed through good on-site environmental management. The draft CEMP contains protocols for working with contaminants on-site as well as containing emergency spill procedures in the unlikely event that a contaminant is spilt near a waterway. The few areas of contaminated land identified within the Project area are also a potential source of contaminants to waterways but none are particularly close to waterways and the draft CSMP contains procedures for managing contaminated material safely and this includes managing the risk to waterways.

Accordingly, contaminants other than sediment have not been considered further in the assessment of potential water quality effects during construction.

20.4.1 Erosion and sediment control

Preliminary erosion and sediment control (ESC) measures have been developed for the Project, consistent with GWRC[110] and the NZTA (draft)[111] erosion and sediment control guidelines. These principles include:

- minimising disturbance;
- staging construction;
- protecting steep slopes;
- protecting water bodies;
- stabilising exposed areas rapidly;
- installing perimeter controls;
- controlling surface water; and
- using sediment retention devices.

Table 20.2 outlines ESC measures and their proposed application to the Project.

Table 20.2: Proposed erosion and sediment control measures for the Project

ESC measure	Proposed application to the Project
Sediment retention ponds	Sediment retention ponds will be used for the retention and treatment of the majority of sediment laden runoff along the road alignment. Ponds will be fitted within the proposed designation. Alternative methods of pond construction, e.g. the use of tanks or shipping containers, will be used where topography constraints are an issue.
Chemical treatment[112]	All sediment retention ponds and earth decanting bunds will be chemically treated to increase their efficiency.
Sediment fences	Sediment fences provide perimeter controls both around and within earthworks site. Sediment fences may be required in areas where the topography does not allow for construction of sediment retention devices and the catchment area is greater than 0.3ha.
Silt socks	Silt socks can be used in areas requiring continual access and can be pinned to steep slope areas. Another advantage of the silt socks is that they can be chemically dosed which improves their effectiveness.
Decanting earth bunds	Treatment of sediment laden runoff via decanting earth bunds when space requirements restrict the use of sediment retention ponds. They will typically be used on the large cut slope faces.
Stormwater inlet protection	Protection of existing stormwater networks, such as Waitangirua and Linden.

110. GWRC, Erosion and sediment control guidelines for the Wellington region, 2002 (reprinted 2006).

111. NZTA, Draft erosion and sediment control standard for state highway infrastructure, 2011.

112. Chemical treatment is a commonly used ESC method involving the addition of chemicals to sediment retention ponds to improve their effectiveness. It is recommended in GWRC's ESC guidelines where 'the performance of sediment retention ponds needs to be increased to reduce the immediate effect of sediment on the receiving environment and/or reduce the cumulative effect of sediment yield within the catchment'.

Sediment retention ponds (or decanting earth bunds, where space is limited) will be the main sediment control devices used to remove sediment prior to discharge to streams. Sediment fences and silt socks will be used to limit sediment laden runoff entering these devices.

Sediment retention ponds operate by allowing the sediment to settle out from suspension of the main runoff, and be retained in the pond. The rate at which sediment falls is called the particle settling velocity (or particle fall velocity). The settling velocity is governed by the flow regime in the pond, particle size and the density of the particle (relative to water). In general, as particles increase in size they have an increased settling velocity. The effectiveness all ponds will be improved by adding a chemical reagent which binds multiple particles together forming a larger particle with accelerated settling properties.

20.4.2 Effects of sediment on streams

The stream sediment transport model was used to predict the accumulated sediment mass and depth along the length of nine[113] key streams, namely:

- Whareroa Stream;
- Wainui / Te Puka Stream;
- Horokiri Stream;
- Ration Stream;
- Collins Stream;
- Pauatahanui Stream;
- Duck Creek;
- Kenepuru Stream; and
- Porirua Stream.

Sediment quality was assumed to be similar to existing sediment runoff, which would be likely to contain some nutrients (nitrogen and phosphorus) and potentially minor amounts of metals and / or pesticides. As such, only sediment quantity (rather than quality) was assessed by the stream sediment model.

Two particular aspects of sediment quantity are of relevance:

- **suspended sediment** - entrained sediment suspended in the water column, measured as TSS or turbidity; and
- **deposited sediment** - sediment that has fallen out of suspension and deposited on the stream bed, measured as millimetres (mm) of deposition on the bed or by total amount (in tonnes).

113. Collins Stream was modelled separately and the Wainui and Te Puka Streams were modelled together (as they are both part of the same catchment).

20.4.2.1 Suspended sediment

As rain mobilises sediment (through rain drops striking bare ground and also through overland flow) suspended sediment is only an issue during and immediately after a rainfall event. In all streams, TSS currently becomes elevated immediately after a rainfall event. Construction of the Project will result in increased TSS in stream during rainfall events. A 1/3 Q2 event effectively represents a 90th percentile rainfall event which could reasonably be expected to occur on a regular basis throughout the construction period.

Predicted increases in TSS from the Project during a 1/3 Q2 event vary between catchments with the highest increase being in Collins Stream (79%) and the lowest being in Porirua Stream (2%). The Project may result in some noticeable decrease in visual clarity and colour during and immediately after an event but this will have no lasting effect on water quality in streams. Due to the high hydraulic activity of many of the streams, spikes in TSS typically only persist for a matter of hours after an event. As such, increase suspended sediment will have a minor adverse effect on stream water quality.

The potential ecological effects of these brief increases in suspended sediment are discussed in Chapter 22.

20.4.2.2 Deposited sediment

For each stream the modelling involved assessment of deposited sediment for the following events:

- 1/3 Q2;
- Q2;
- Q10; and
- Q50.

For all events, two scenarios where modelled:

- baseline **(without Project)**;
- peak construction of the Project with ESC measures in place **(with Project)**.

Deposited sediment can be described either in terms of the total amount (in tonnes) or in terms of the depth of the deposition on the stream bed (in mm).

Table 20.3 details the percentage increase in sediment amounts deposited in streams from the four modelled events.

Table 20.3: Percentage change in sediment deposition caused by the Project (2021)

Catchment	Change in modelled sediment deposition (%)			
	1/3 Q2	Q2	Q10	Q50
Whareroa	5	6	6	12
Te Puka / Wainui	29	31	19	44
Horokiri	16	14	13	20
Ration	43	17	119	91
Pauatahanui	1	1	1	1
Duck	30	28	6	43
Kenepuru	14	18	19	38
Porirua	2	1	1	1

In percentage terms, the predicted increases in some catchments are significant, particular the Te Puka / Wainui, Ration and Duck. However, the total amount of sediment deposited in streams does not provide any real indication of actual deposition depths on stream beds, which is primarily a function of stream morphology.

Table 20.4 shows the predicted baseline sediment deposition rates and the predicted rates with the Project for the four events and across the streams.

Table 20.4: Stream sediment deposition

Stream	Storm event	Predicted sediment deposition (mm)		
		Without Project	With Project	Change
Whareroa	Q50	11	19	8
	Q10	7	7	0
	Q2	7	7	0
	1/3 Q2	7	7	0
Te Puka / Wainui	Q50	6	9	3
	Q10	4	4	0
	Q2	3	3	0
	1/3 Q2	3	3	0
Horokiri	Q50	5	5	0
	Q10	5	5	0
	Q2	4	4	0
	1/3 Q2	2	2	0
Ration	Q50	7	10	3
	Q10	4	8	4
	Q2	3	3	0
	1/3 Q2	3	3	0
Pauatahanui	Q50	1	1	0
	Q10	2	2	0
	Q2	1	1	0
	1/3 Q2	0	0	0

Stream	Storm event	Predicted sediment deposition (mm)		
		Without Project	With Project	Change
Duck	Q50	1	1	0
	Q10	2	2	0
	Q2	1	1	0
	1/3 Q2	0	0	0
Kenepuru	Q50	5	5	0
	Q10	4	4	0
	Q2	3	3	0
	1/3 Q2	1	1	0
Porirua	Q50	3	3	0
	Q10	3	3	0
	Q2	3	3	0
	1/3 Q2	3	3	0

The figures in Table 20.4 show that the actual deposition depths in most streams in most events are predicted to be negligible. For 1/3 Q2 and Q2 events, a number of which can reasonably be expected to occur throughout the construction period, very minimal, if any, increased deposition depth is predicted.

In summary, addition sediment deposition on stream beds is predicted to occur in relatively few instances (typically a Q50 event, with the exception of a Q10 event in Ration Stream). Even in these few instances, the predicted rates (of between 3 and 8mm) are not predicted to fundamentally alter the morphology or hydraulic characteristics of affected streams and, as such, are not significant in hydraulic terms. Deposition on stream beds does have the potential to have adverse ecological effects and this is discussed in Chapter 22.

20.4.3 Effects on harbour sedimentation

Sediment generated during construction of the Project will be transported via streams to either the Kapiti Coast or the Porirua Harbour. The Wainui Stream mouth is a high energy environment whereas the Porirua Harbour is a low energy environment. This difference has significant implications for sediment entering these two environments. In the high energy Wainui Stream mouth, the predicted low percentage of additional sediment is rapidly transported off shore and hence has negligible, if any, environmental effect. Sediment entering a low energy environment, however, may not be transported to the open sea and has the potential to cause adverse effects, particularly in terms of:

- deposition on harbour beds contributing to in-fill of the Harbour; and
- a reduction of the ecological, cultural and recreational values of the Harbour.

Due to the potential environmental effects of increased sediment entering the Porirua Harbour during construction of the Project, the fate of this sediment has also been modelled.

The Project will not involve the discharge of sediment directly to coastal water. Any sediment entering coastal water will be transported by streams. As discussed in relation to the consideration of sedimentation effects on streams, the high level of ESC measures proposed means that sediment is only likely to cause potentially adverse effects after significant rainfall events. Like the modelling undertaken to assess potential effects on streams, the Harbour modelling was 'event-based' scenario modelling. The two key event magnitudes modelled were:

- Q2 events; and
- Q10 events.

Examination of meteorological data demonstrates that rainfall events are often localised and so while a Q10 event might occur in the Horokiri catchment, Q2 or lower events might be occurring at the same time in other catchments.

In consultation with the Project ecologists, Q50 events for the Harbour were not modelled because of the unlikelihood of this magnitude of event occurring during the peak construction period and the limited additional impact of the Project likely in this magnitude of event.

As well as event-based modelling of sediment entering the Harbour, potential long term (i.e. after 20 years from the start of construction) increases in sediment deposition were also modelled. It is recognised that, as the receiving environment for much of the sediment runoff from the construction of the Project, there could be potential adverse cumulative effects on the Harbour from increased sediment loads over the entire construction period.

20.4.3.1 Event based modelling results

One of the most important determinants of the fate of sediment in the Harbour is the wind strength and direction, as this influences wave motion and hydrodynamics. In general terms, strong winds create stronger currents and wave motion which keeps sediment in suspension or re-suspends deposited sediment. For this reason, the 'with Project' and 'without Project' scenarios for each event were modelled for a range of different wind scenarios. As discussed is Chapter 6 in relation to meteorological conditions across the Project area, the intensity of rainfall events can vary between catchments and is certainly not uniform.

Based on the wind records from the gauging stations in the region of the Harbour it is clear that there are three dominant wind directions that act on the Harbour; these are the northerly, southerly and calm wind conditions. The analysis of the available data indicates similar probabilities of heavy rainfall occurring during all three wind directions with possibly a slightly higher coincidence of heavy rain occurring during a northerly wind direction.

Based on this analysis a number of coincident rainfall and wind scenarios were modelled, as listed in Table 20.5. The flow records in the streams were compared to develop a realistic rainfall distribution during a Q10 over part of the catchments feeding into the Harbour.

Table 20.5: Scenarios for event- based modelling of sediment in the Harbour

Wind direction	Freshwater and sediment inflows
Calm	Q2 for all catchments
Northerly	Q2 for all catchments
Southerly	Q2 for all catchments
Calm	Q10 in Kenepuru and Porirua catchments, Q2 elsewhere
Calm	Q10 in Pauatahanui and Duck catchments, Q2 elsewhere
Calm	Q10 in Horokiri catchment, Q2 elsewhere
Northerly	Q10 in Kenepuru and Porirua catchments, Q2 elsewhere
Northerly	Q10 in Pauatahanui and Duck catchments, Q2 elsewhere
Northerly	Q10 in Horokiri catchment, Q2 elsewhere
Southerly	Q10 in Kenepuru and Porirua catchments, Q2 elsewhere
Southerly	Q10 in Pauatahanui and Duck catchments, Q2 elsewhere
Southerly	Q10 in Horokiri catchment, Q2 elsewhere

The modelled scenarios are considered to cover a sufficient range of events that could realistically occur during the construction period.

Overall, the sediment yield model predicts increases of terrestrial sediment entering the Harbour in a Q2 and Q10 events of up to 4.7% and 4.9% respectively. In terms of suspended sediment, the model predicts that three days following a Q2 or Q10 event, TSS concentrations will be no greater than 0.25kg/m^3 (250g/m^3).

The ecological significance of this is discussed in Chapter 23.

In terms of sediment deposition, the model results show that much of the terrestrial sediment entering the Harbour deposits near the stream mouths. This is also the areas of highest TSS concentrations which are made worse by the wave induced suspension of bed material in the shallows. The finer sediment material which has lower settling velocities is transported via fluvial, tidal and / or wave induced currents around the arms of the Harbour. There are noticeably lower TSS concentrations in the main channels at the entrances to each of the Harbour arms as the catchment runoff mixes with the sea water.

The Harbour sediment modelling provided the following predictions in relation to the influence of a 90th percentile wind over three days on deposition (modelled to ascertain the worst case scenario):

- Both northerly and southerly wind conditions help keep sediment in suspension as well as re-suspending some deposited sediment. This results in the TSS concentrations being higher and more persistent than in the calm situations.
- The sediment distribution under calm conditions is less widespread and, therefore, contains deeper deposits in some areas, particularly near the stream mouths.

- Under northerly wind conditions, the TSS concentrations and bed deposition tends towards the eastern side of the Onepoto Arm and towards the southern side of the Pauatahanui Inlet. In contrast, under southerly wind conditions the TSS concentrations and bed deposition tends towards the western side of the Onepoto Arm and the northern side of the Pauatahanui Inlet.

The Harbour modelling team worked closely with the Project ecologists to determine what information about sediment deposition in the Harbour was required to assess the potential effects on marine ecology. The ecologists indicated that effects on marine species were predominantly a function of:

- sensitivity of species (not related to modelling);
- level of exposure to sediment (the depth of sediment on the bed); and
- the duration of exposure to sediment (the length of time sediment remains on the bed).

The deposition modelling focused on providing information on the last two aspects. The ecologists determined key threshold criteria for both deposition depth (less than 5mm; 5 – 10mm; more than 10mm) and duration (less than 3 days; 3 – 7 days; more than 7 days). The ecological significance of these thresholds is discussed in Chapter 23 on marine ecology but they are used in this chapter as a basis for the discussion of event based sediment deposition in the Harbour.

Modelling results are reported in terms of changed in areas (measured in m^2) above or below sediment deposition thresholds (5mm or 10mm).

Technical Report 15 provides details, including maps, of the deposition levels and locations predicted under different rainfall and wind scenarios modelled. A summary of the key results for Q2 and Q10 events (which have been modelled as worst case scenarios) is as follows.

20.4.3.2 Q2 events

A Q2 rainfall event during construction could contribute up to an additional 200 tonnes of sediment to the Harbour. This equates to an approximately 5% increase from what would be expected from the same rainfall event if the Project was not being constructed. The model predicts that there will be little impact on sediment deposition patterns. Additional deposition caused by the Project is likely to be in isolated pockets, typically less than 5mm deep, and in locations already heavily impacted and largely in the sub-tidal areas of the Harbour.

20.4.3.3 Q10 events

A Q10 rainfall event during construction could contribute up to an additional 270 - 650 tonnes of sediment. This equates to an approximately 4 - 9% increase from what would be expected from the same rainfall event if the Project was not being constructed. Under most wind and Q10 rainfall conditions, the model predicts that the additional sediment deposits in less ecologically sensitive areas, with sediment predominantly being deposited in sub-tidal zones in locations already receiving significant deposition. However, the modelling did indicate that in three particular Q10 events, there was a higher probability of greater quantities of the additional sediment being deposited at depths that exceed the 5mm threshold in potentially sensitive locations (predominantly the inter-tidal zones).

These three events of interest would only occur during a worst case scenario (being up to 35ha of open earthworks and a 90th percentile wind (10m/s or greater) blowing at a given direction for three consecutive days at the same time as the particular rainfall event) are:

- northerly wind direction with a Q10 event in the Pauatahanui and Duck catchments, Q2 events elsewhere;
- northerly wind direction with a Q10 event in Horokiri catchment and Q2 events elsewhere; and
- southerly wind direction with a Q10 event in the Kenepuru and Porirua catchments and Q2 events elsewhere.

These three events have been identified as those with the potential to cause deposition at levels and in locations which could have an adverse ecological effect. From a water quality perspective they are not particularly significant as they do not fundamentally alter the morphology of the Harbour, nor will they lead to any lasting reductions in visual clarity of the water.

The potential ecological effects of two[114] of these events are discussed in Chapter 23.

20.4.3.4 Long term modelling results

In the long term simulation an additional 3000 tonnes of sediment is estimated to enter the Harbour as a result of all the construction activities[115]. This represents an increase of around 2% of the total terrestrial sediment load entering the Harbour over a 20 year period. The long term model results indicated that there was little loss of terrestrial sediment from the Harbour and that much of the sediment would be deposited over time in the deeper central basins. Table 20.6 shows how the total area of each inlet predicted to receive >100mm, >200mm or >300mm, both with and without the Project.

Table 20.6: Areas of Porirua Harbour predicted to receive greater than 100mm, 200mm and 300mm of sediment deposition 20 years after commencement of construction of the Project

	Onepoto Arm		Pauatahanui Inlet	
	Without Project	With Project	Without Project	With Project
Total area (m^2)	2,400,000		4,600,000	
Total area > 100mm (m^2)	576,822	577,708	1,141,842	1,152,769
Total area > 200mm (m^2)	37,556	41,478	577,968	589,065
Total area > 300mm (m^2)	0	28	321,156	332,077

114. The northerly wind direction with a Q10 event in Horokiri catchment and Q2 events elsewhere was initially considered but further analysis showed that this event would not result in deposition in the Pauatahanui Inlet and hence was not considered further in relation to potential effects on marine ecology.

115. Based on average weather conditions occurring over the period of construction comprising Q2 and Q10 events.

It can be seen that in the long term, the vast majority of sediment predicted to enter the Harbour will not be from construction of the Project. 20 years from the start of construction of the Project there would be almost no detectable increase in sedimentation rates in the Onepoto Arm of the Harbour and only an average increase of between 0.1 and 0.2mm/yr in the Pauatahanui Inlet. This minimal change is considered to be acceptable.

A final point of note regarding the long term effects on the Harbour is that the collection of field data, sediment yield modelling and the hydrodynamic and sediment transport modelling undertaken to assess the potential sedimentation effects of the Project on the Harbour has already greatly increased the level of knowledge around sediment behaviour in the Harbour. It is already well recognised that existing sediment runoff is a threat to the Harbour.

The Harbour modelling will be of considerable benefit in the long term collaborative management of the Harbour between a number of different stakeholders. Although not a direct form of mitigation, it is considered that the benefits of this detailed modelling of the Harbour will assist with the long term management of sediment entering the Harbour.

20.4.4 Discharge of stormwater from concrete batching plant

The discharge of stormwater from the concrete batching plant triggers Rule 2 of the Regional Discharges to Land Plan (discharges into or onto land not otherwise provided for by a rule in the Plan). Regard is had to the matters set out in Rule 2 for consideration of resource consents, in particular Clause 5.3 of the Plan. It is also noted that a concrete batching plant, specifically the potential for discharge of cement from the site, would meet the definition in Appendix 1 of the Plan for Hazardous Substances as “Ecotoxic: Substances or wastes, which if released, present or may present immediate or delayed adverse impacts on the environment by means of bioaccumulation and / or toxic effects upon biotic systems”.

The main potential effect of discharge to land from the concrete batching plant relates to the ecotoxicity of cement and the potential effects on the natural environment in the streams and watercourses downstream of the site. The key aim is therefore to avoid cement discharge beyond the site.

As discussed in Chapter 8 of this report, the concrete batching plant includes the following key components:

- a temporary concrete batching plant unit comprising hoppers, aggregate storage bins, a cement silo, conveyors and a concrete mixing drum;
- aggregate storage bunkers; and
- a water tank or tanks.

In addition there will be a precast concrete construction yard, where concrete components are cast, stressed, cured and stored before loading and transporting onto the construction site proper.

The site will have a single designated ‘dirty’ area, comprising the concrete batching plant and the concrete truck access, delivery and loading area. The second area is the surrounding pre-cast construction yard which has its own stormwater controls. The concrete batching plants and the concrete truck access, delivery and loading areas will be located on concrete pads which will drain to the holding tanks described below. The perimeter of the concrete pad will be bunded with a mountable kerb to contain dirty water. The site may also operate a concrete truck wash-out area which will also drain to the tanks.

All runoff from the 'dirty' areas of the concrete batching plant will drain to holding tanks. The runoff and washdown water is expected to have high pH and high sediment loads. The tanks will have multiple stages to allow any sediment to settle out. The use of a multi-stage tank system allows for the large sediment to settle out for removal in the first stage

The remainder of the concrete batching plant activities comprise cast concrete and aggregate storage areas which will be located within the yard area. The water from the yard areas drain to stormwater treatment devices which will be designed to provide treatment before discharging to the receiving environment. The 'dirty' yard areas will have sediment control measures in place around the full extent of the works as shown in Figure 8.1.

A Concrete Batching Plant Management Plan (CBMP) will be developed prior to the commencement of construction of the Plant to manage the actual and potential effects of the Plant on the environment. The CBMP will include methods to manage discharges to air and methods to manage stormwater quality effects. The suite of management plans applicable to the Project also includes a number of other plans that are relevant to the operation of the concrete batching plant. For example, noise and vibration from the Plant will be managed through the CNVMP, and traffic will be managed through the CTMP. The CAQMP also sets out principles for the management of air quality effects including dust management.

The CBMP will set out a process for the provision of further information to GWRC prior to the commencement of construction including identification of the specific contaminants associated with the concrete batching plant including quantities of cement, and any other hazardous substances (as defined in Appendix 1 of the Discharges to Land Plan). The CBMP will have regard to the following principles:

Deliveries and storage

- Storage containers will be covered to prevent rainwater entry, and any storage of raw materials except for aggregate shall be stored in an appropriate enclosure. Environmentally hazardous substances (including cement) will be stored in a manner that prevents the entry of rainwater into the container and in a secondary containment device (such as a bund).
- An Emergency Spill Response Plan will be developed and will set out methods to manage all hazardous substances stored on site.
- The aggregate used for the concrete batching plants will include sand and quarried or recycled aggregate or other material such as glass. The aggregate will be delivered to the site by truck and will be stored in designated bunkers for each aggregate type (e.g. sand, pap7 type aggregate). Finer aggregates will be covered to prevent discharges to air.
- Cement will be delivered via tanker and transferred to the on-site cement silo pneumatically to ensure the transfer of cement is fully enclosed.

Rubbish

- Rubbish on-site is likely to include cement bags, and additive packaging. All storage bins will have, as a minimum, sealed bottoms and lids.
- Waste compactors and bins will be located and operated in such a manner as to prevent leachate / wastes leaking from the bins and entering the stormwater system.

Stormwater and wastewater

- Methods will be specified to ensure any contaminants including cement avoid contacting stormwater runoff from "clean" areas of the site. Clean stormwater shall be collected and directed around the perimeter of the site away from "dirty" areas.
- Where practicable, water for the concrete will be sourced from re-use of surface water collected from the site and washdown water. Additional water may be required which will be sourced from reticulated mains water supply.
- Process water shall be captured and reused on site.
- "Dirty" areas shall be clearly defined and contained as a separate system to "clean" stormwater areas. Water collected from the "dirty" areas including the concrete batching plant, cement unloading and driveway areas shall be collected and stored on site for reuse.
- The stormwater treatment devices required on this site shall be designed to in accordance with the standards set out in the Assessment of Water Quality Effects report (**Technical Report 15**).
- A continuous turbidity and pH meter will be located at the discharge point from the Concrete Batching Plant treatment system. Discharges from the concrete batching plant will be required to meet a turbidity and pH discharge standard. This level will initially be set at 50 NTU and pH between 6 and 9. Where the turbidity level is exceeded, or pH is greater than 9, further treatment will be required via chemical treatment and / or pH management prior to discharge. Alternatively this stormwater will be discharged to the reticulated sewer.

Conditions of consent are proposed requiring the preparation of the CBMP.

In summary, it is concluded that the actual and potential effects of discharges to land from the concrete batching plant will be minimal subject to careful on-site management methods.

20.5 Water quality effects during operation

Operation of the Project has the potential to adversely affect water quality in streams and coasts through stormwater runoff from road surfaces.

Contaminants in stormwater can have a number of adverse effects, including:

- damaging aquatic (freshwater and marine) habitat;

- making water unsuitable for contact recreation (e.g. swimming) and / or human fish consumption[116];
- contaminating drinking water supplies;
- reducing the aesthetic properties of water (e.g. visual clarity and odour).

The cultural effects of predicted changes to water quality are discussed in Chapter 24.

20.5.1 Stormwater design philosophy

The key tenet of the stormwater philosophy for the Project is that all stormwater that comes into contact with the road surface will pass through a treatment device. Treatment will either be by wetlands where possible, or by propriety treatment devices in all other areas.

20.5.1.1 Wetlands

Constructed wetlands are highly effective treatment systems designed to utilise the contaminant removal benefits of natural wetlands. They are capable of 77% removal of influent TSS as well as significant removal of dissolved heavy metals such as copper, zinc and phosphorous. Wetlands are also capable of providing flow attenuation, public amenity, and support for aquatic life and wildlife. For these reasons, wetlands are considered to be the best-practice treatment option wherever site criteria can be met. The most significant criterion is space, which has limited the use of wetlands in areas of steep topography.

Five specific areas of the Main Alignment met the site criteria and have been considered for constructed wetland treatment, as detailed in Table 20.7.

Table 20.7: Proposed wetland locations

Wetland	Location	Area treated	Description
W1	MacKays Crossing - Te Puka (SH1)	0m to 2,100m	Located between MacKays Crossing and Te Puka terrace at approximately 940m.
W2	Horokiri Valley	5,550 to 7,550m	Located in Horokiri Valley at approximately 7,550m. There is suitable flat and low-lying land available on the other side of the Horokiri Stream to the road alignment for a wetland. It is proposed that runoff is transported from the road across the stream into the wetland via an open-flow rectangular channel. There is potential for flooding at this site. The hydrology assessment shows that there is a risk of approximately 10-12mm of flooding in a Q10 event, which is considered acceptable for wetland use.

116. The ANZECC guideline for human fish consumption is referred to as: “Water quality guidelines for the protection of human consumers of aquatic foods”. For specific metals (e.g. zinc and copper) the guidelines detailed are for “chemical compounds in water found to cause tainting of fish flesh and other aquatic organisms”.

Wetland	Location	Area treated	Description
W3	Horokiri Valley (BHFFP)	8,600 to 10,200m	Located immediately after deep cut sections of the road in Horokiri Valley at approximately 10,200m where the road is at grade and the surrounding land is relatively flat. There is sufficient space between the road alignment and Horokiri Stream for a suitably sized wetland.
W4	Horokiri Valley south	10,200 to 11,800m	Located in the lowest-lying section of the Horokiri valley. There are steep hills to the west of the road alignment but a large, flat space suitable for wetland use lies to the east of the alignment. There is also proposed vegetation planting in the surrounding area so the use of a wetland would be complementary to this.
W5	SH58 / Pauatahanui	15,600 to 17,700m	Located at the intersection of the Main Alignment with SH58 at 17,500m. There is land within the proposed designation to the south-east of this intersection that is suitable and large enough for wetland use. There is also some spare capacity within the intersection itself that could be used creatively for wetland use. Although there is insufficient space for an entire wetland system within this area, a forebay area and sediment pond could be created in this space and connected to a larger banded bathymetric pond to the south-east of the intersection. Considering a design like this could create additional public amenity for the intersection and help visually tie the intersection to its rural surroundings. A constructed wetland at this location may also provide additional habitat and spawning areas for native fish These matters will be considered during detailed design.

20.5.1.2 Proprietary treatment devices

Where stormwater cannot be treated by a wetland, proprietary treatment devices will be used. They have few site constraints and will be effective for use as treatment on almost any section of the road alignment. They are highly effective in treating runoff with high sediment loads, however, they do not offer some of the potential benefits of well-maintained wetlands. The steep nature of the road precludes the use of wetlands in many locations and accordingly, proprietary devices are proposed for a significant proportion of the road alignment.

Proprietary treatment devices are capable of treating a wide range of catchment areas, depending on the size of the devices. Appropriate catchment areas for these devices have been based on economic and environmental factors. Beyond this catchment size, the additional cost of treating larger areas becomes relatively linear. Therefore treatable catchment areas should be a minimum of 15,000m^2 (1.5Ha) where possible to take advantage of cost savings.

In determining appropriate treatable catchment areas, the cost of forebay areas and piping was considered. Forebay areas to the side of the road are required for every proprietary treatment device to avoid lane closures during maintenance of the devices. Increasing the catchment area per device reduces the amount of devices and forebay areas required which is potentially more economic. However, the economic trade-off of having a larger catchment area is the increased piping diameter to convey runoff. Keeping catchment areas relatively small also reduces the risk of attenuation and better matches natural predevelopment stormwater flows. For these reasons, it was estimated that the maximum treatable area per device should be kept to 25,000m^2.

20.5.1.3 Treatment approach summary

Table 20.8 provides a summary of the stormwater treatment proposed for each of the catchments in the Project area.

Table 20.8: Proposed stormwater treatment by catchment

Catchment	Area treated (ha)	
	Wetland (% of total catchment)	Proprietary (% of total catchment)
Whareroa Stream	528,420 (**100%**)	-
Te Puka / Wainui Stream	320,587 (**20%**)	1,262,158 (**80%**)
Horokiri Stream	2,045,111 **(69%)**	903,292 **(31%)**
Ration Stream	64,115 (**5%**)	1,229,816 (**95%**)
Collins Stream	158,808 (**100%**)	-
Pauatahanui Stream	536,864 (**44%**)	689,994 (**56%**)
Duck Creek	-	1,599,919 (**100%**)
Kenepuru Stream	-	959,988 (**100%**)
Porirua Stream	-	906,871 (**100%**)

20.5.2 Stormwater effects on stream water quality

In almost all catchments the Project will make a very minimal (1% or less) change to the level of impervious cover in the catchment. In the Te Puka catchment impervious cover will increase by approximately 2% which is reflective of the fact that there is virtually no development in this catchment currently.

As discussed earlier, a contaminant load model (CLM) and motorway and catchment data was used to predict contaminants in stormwater runoff. The CLM modelled the concentration of TSS, zinc, copper and total petroleum hydrocarbons (TPH) for three scenarios:

- without the Project;
- with the Project, without stormwater treatment; and
- with the Project, with stormwater treatment.

The following figures show the predicted concentrations for TSS, zinc and copper using the motorway and catchment data method and for TPH from the CLM.

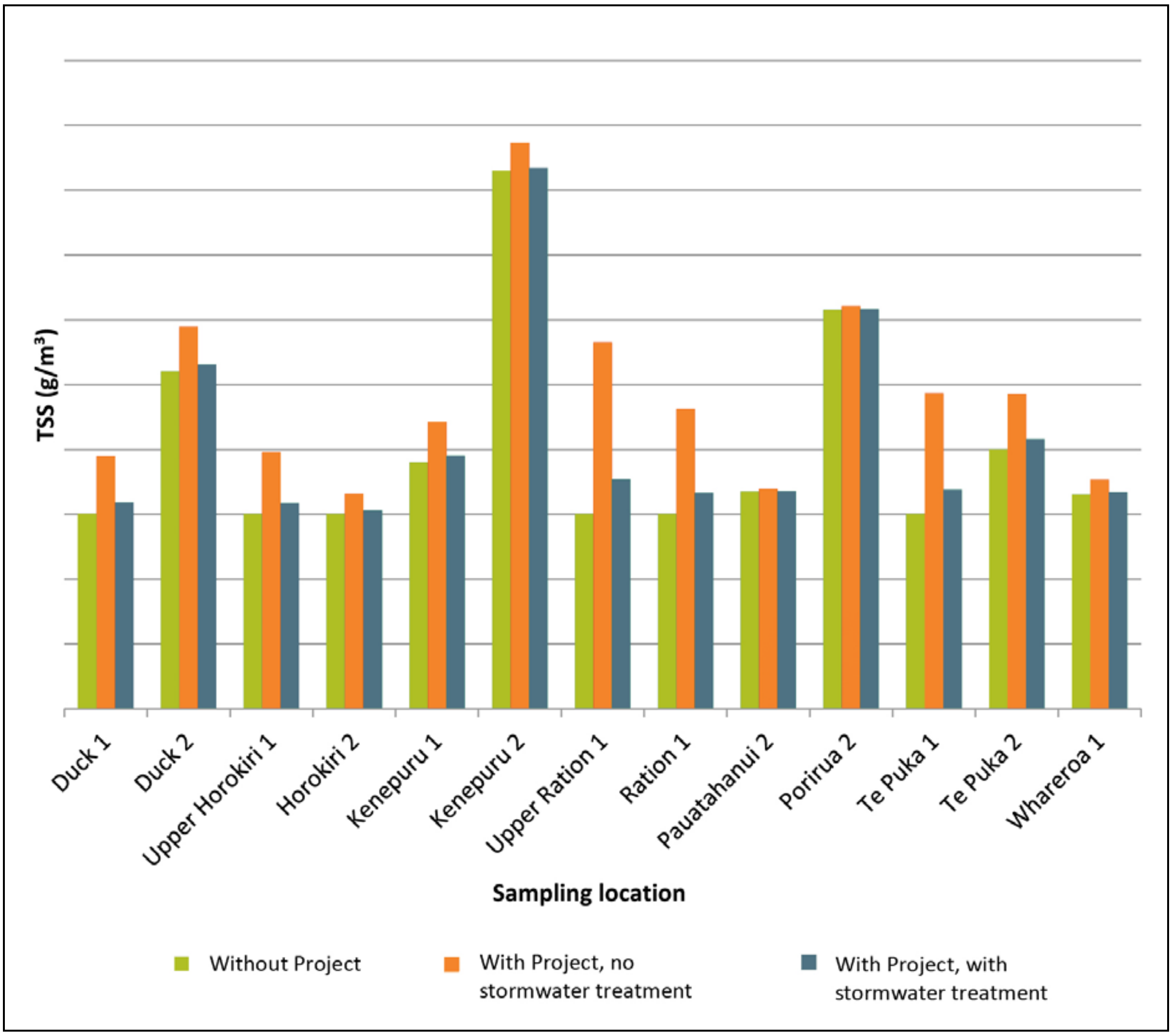

Figure 20.3: TSS concentration across representative sample locations

Predicted TSS concentrations reduce slightly (or are unchanged in the Whareroa catchment) for the 'with Project' scenario in all catchments. This is due to change in land use to paved road surface, which will generate less sediment than the existing pastoral land use.

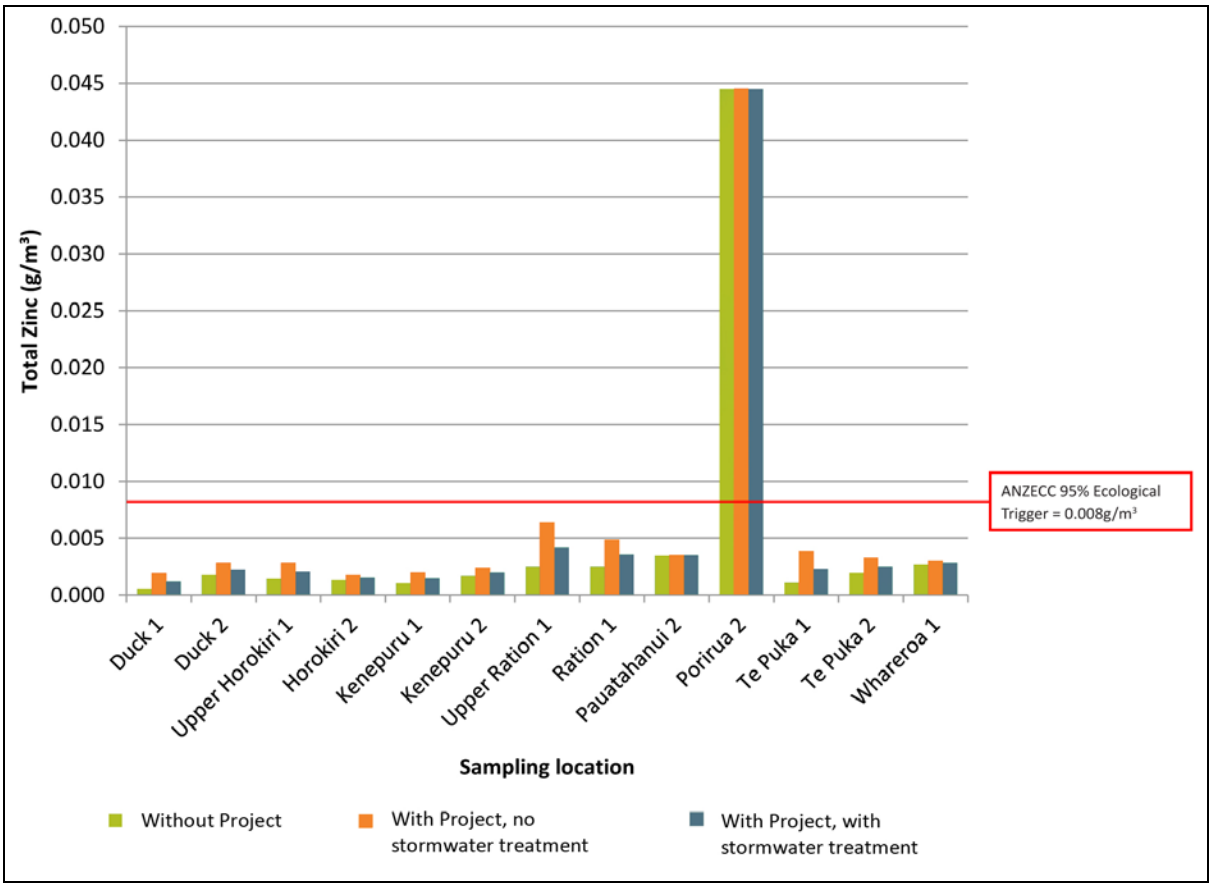

Figure 20.4: Zinc concentration across representative sample locations

The Project will cause relatively minimal changes to zinc concentrations in all the catchments, with some catchment showing slight increases and some catchment, slight decreases. The Project will not cause the ANZECC ecological threshold to be exceeded in any catchment where it currently is not. In all catchments, including those where ecological triggers are currently exceeded, the predicted zinc concentrations will be well within guidelines for stock drinking water, contact recreation and human consumption of fish species.

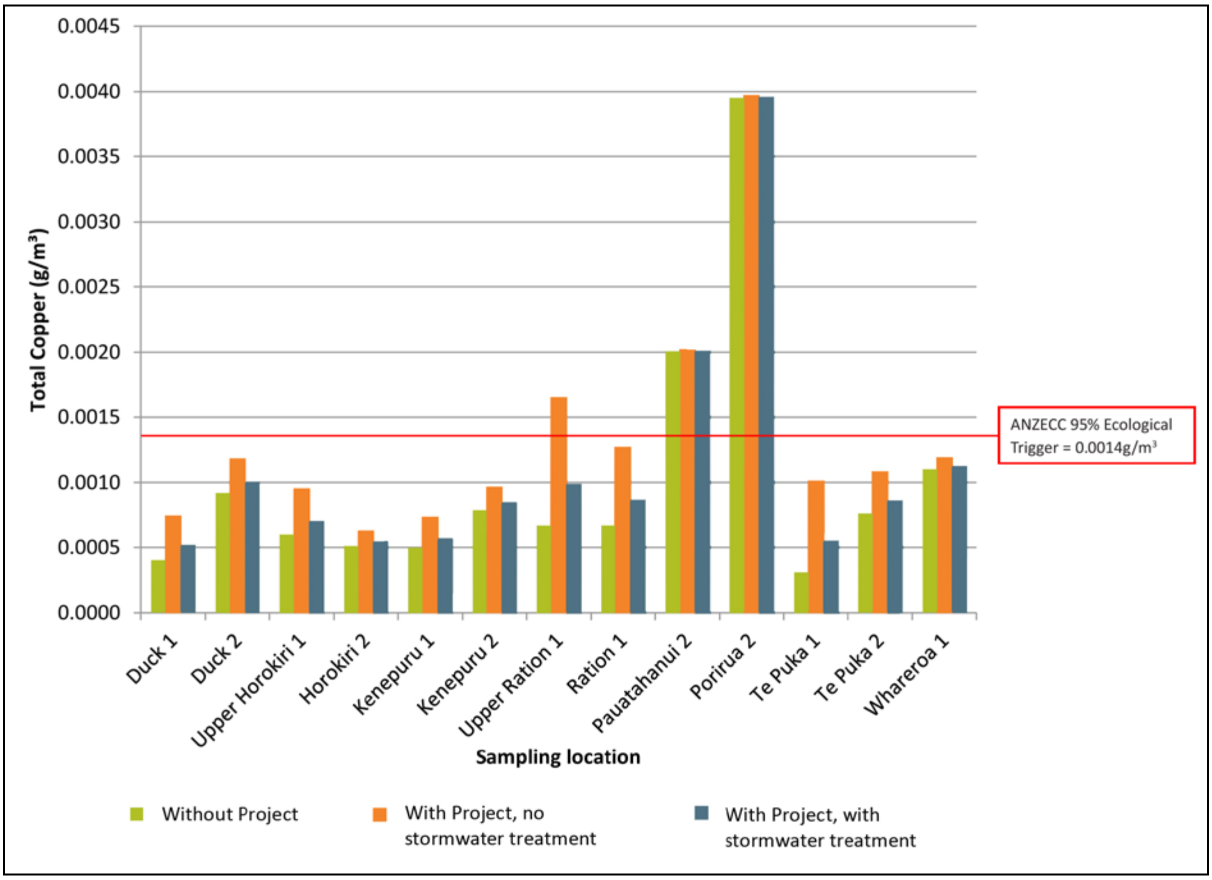

Figure 20.5: Copper concentration across representative sample locations

The Project will result in some changes to copper concentrations in all the catchments, with some catchments showing slight increases and some catchments slight decreases. In only one catchment (Ration) will the Project cause the ANZECC ecological threshold to be exceeded where it currently is not. The Project will not cause the copper guideline values for stock drinking water, contact recreation and human fish consumption to be exceeded in any of the affected catchments (including Ration).

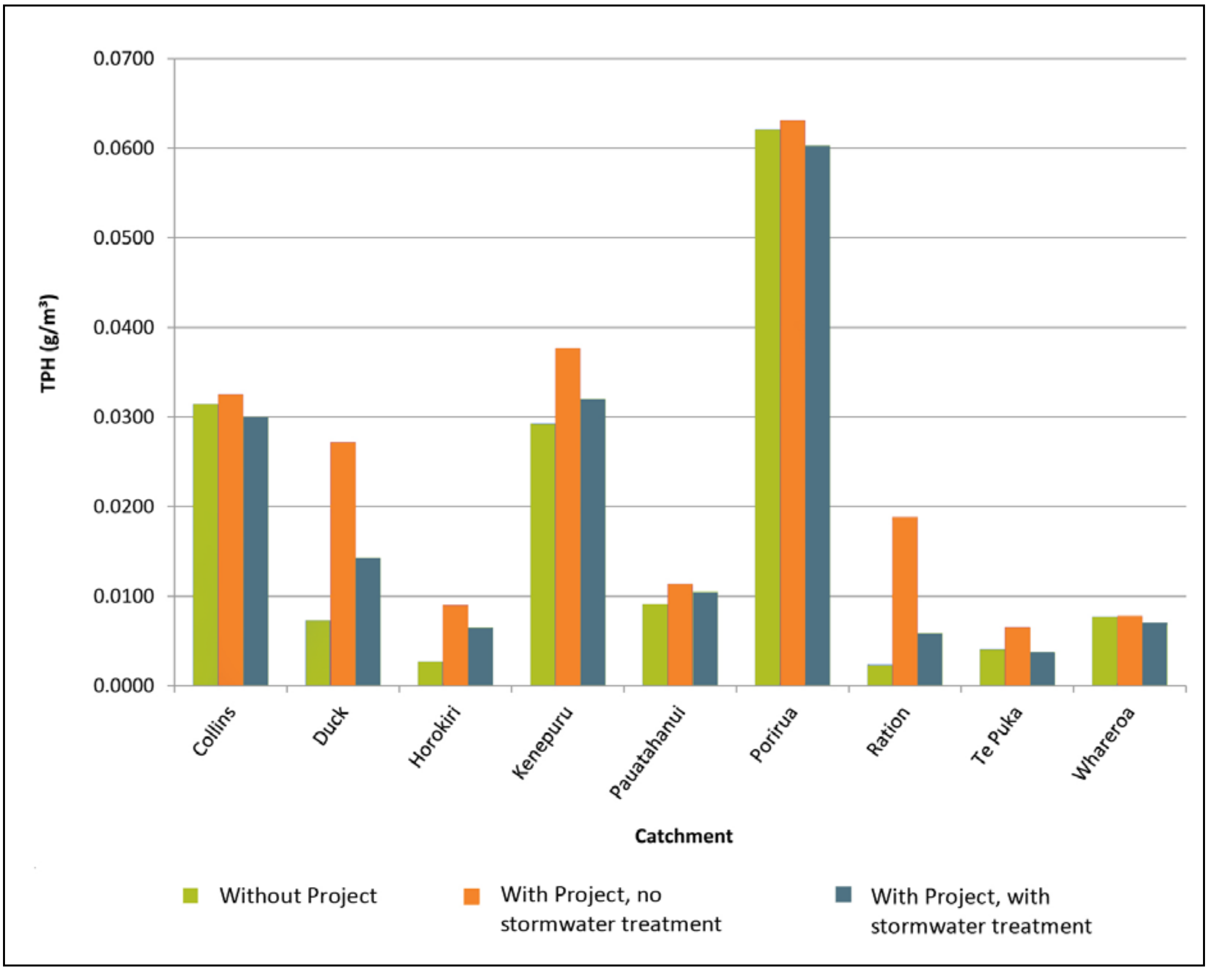

Figure 20.6: TPH concentration across representative sample locations (CLM)

The model predicted minimal increases of TPH in the Duck, Horokiri, Kenepuru, Pauatahanui and Ration streams. These catchments are currently mainly rural and the introduction of the predicted traffic volumes into these catchments would be expected to have this type of result.

While some streams are predicted to receive increased concentrations of TPH it is not expected that this would be at levels that would lead to any conspicuous oil or grease. Similarly, no objectionable odour associated with hydrocarbons was noted in any streams and this is not predicted to change as a result of the Project. Any change in visual clarity or odour associated with increased levels of hydrocarbons will be minimal and acceptable.

The potential effects on freshwater ecology from predicted changes to water quality in the streams are discussed in Chapter 22.

20.5.3 Effects on marine water quality

The CLM was also used to estimate contaminant loads in the marine receiving environments:

- the Kapiti Coast, being;
    - the Wainui Stream mouth; and
    - the Whareroa Stream mouth.
- the Pauatahanui Inlet; and
- the Onepoto Arm.

The contaminant loads entering the three marine receiving environments was predicted by adding the predicted contaminant loads for each of the streams draining into them. Table 20.9 shows the difference (in percentage terms) for the four contaminants entering the three marine receiving environments.

Table 20.9: Percentage change in contaminant loads (2031)

Receiving environment	TSS	Zn	Cu	TPH
Kapiti Coast	-1%	-4%	-9%	-14%
Pauatahanui Inlet	0%	2%	1%	20%
Onepoto Arm	-1%	-6%	-16%	-44%

The summary results show that for the Kapiti Coast and the Onepoto Arm, the Project will result in reductions in contaminant levels of all four modelled contaminants.

For the Pauatahanui Inlet, for all contaminants except TPH, the Project is to result in minimal (2% or less) changes in contaminant levels. THP entering the Pauatahanui Inlet is expected to increase by 20%. This increase is due to the introduction of significant traffic volumes into catchments (Horokiri, Ration, Pauatahanui, Collins and Duck) that drain into the Pauatahanui Inlet.

The predicted increase in TPH into the Pauatahanui is not significant from a water quality perspective in that it will not cause conspicuous oil or grease in the water or any change in odour. Similarly, it will not adversely affect recreational use (including contact recreation) of the Inlet.

The potential effects on marine ecology from predicted changes to water quality in the marine receiving environments are discussed in Chapter 23.