CHANNEL DEEPENING PROJECT: CONSENT APPLICATIONS

Lyttelton
Port of
Christchurch

1. INTRODUCTION

1.1 Lyttelton Port of Christchurch is the primary international gateway for the South Island with Christchurch being the major distribution centre for inbound goods. Export cargo originates from across the South Island. Export customers include a wide variety of dairy, meat, forestry, horticultural, mineral extraction and manufacturing businesses.

1.2 Lyttelton Port is the most significant port in the South Island in terms of total tonnages of cargo and containers handled, as well as in the value of imports received and in the value of certain exports.

1.3 The importance of the Lyttelton Port has been recognised in the various statutory documents prepared under the Resource Management Act, 1991 ('*RMA*') for many years. For example, Lyttelton Port is defined as a regionally significant infrastructure under the Canterbury Regional Policy Statement, and is also variously defined as a strategic, critical, and essential infrastructure in that document. At the national level, it is recognised that a sustainable transport system requires an efficient network of safe ports, servicing national and international shipping.

1.4 Lyttelton was gazetted as a port of entry in 1849 and by the 1870s dredging operations commenced. Dredging to incrementally deepen the access channel and berth areas, and to maintain the design depths, has been carried out more or less continuously since then.

1.5 In the last forty years there has been a global trend towards increased containerization, larger container vessels and fewer port calls. This trend is driven by the economies of scale associated with the higher fuel efficiency of larger ships, and the fact that larger ships can spread costs over the higher volume of containers they can carry (thereby reducing the average cost of transporting each container). Furthermore, New Zealand is also reaching a level of tonnage where transporting cargo in larger ships is expected to be more efficient.

1.6 The sequence of earthquakes to hit Canterbury significantly damaged the Port. Consequently, the Minister for Canterbury Earthquake Recovery (Honourable Gerry Brownlee) directed Environment Canterbury to develop a Lyttelton Port Recovery Plan

('Recovery Plan') to enable the complex repair, rebuild and reconfiguration of the Port and its operations to be completed in an expeditious and efficient manner.

1.7 In November last year the Minister gazetted the Recovery Plan after a lengthy process involving community input. The elements of port recovery include, amongst other matters, a new container facility and associated berths to be constructed on a reclamation in Te Awaparahi Bay, the rebuild of the existing berths at Cashin Quay (currently underway), as well as the deepening of the shipping channel so that larger vessels can access the Port. The various projects are interrelated and relevantly the design of the wharfs and associated facilities are predicated on larger vessels being able to access the Port.

1.8 In response to the global trend of larger ships, and as part of port recovery, Lyttelton Port Company Limited ('LPC') now lodges its application to deepen the shipping channel so that international vessels of up to a 14.5 metre draught can access the Port during all tides. This means that the Port could accommodate up to approx. 8,000-10,000 TEU[1] vessels.

1.9 The proposal is called the 'Lyttelton Port Channel Deepening Project' ('*Channel Deepening Project'* or *CDP*) and involves the following elements:

a. The deepening, extension,[2] and widening of the existing shipping channel;
b. The deepening and extension of the ship-turning basin in the vicinity of the Port;
c. The deepening and enlarging of the existing berth pockets serving Cashin Quay;
d. The creation of berth pockets to serve the future container facility at Te Awaparahi Bay;
e. The on-going removal of sediment that accumulates overtime in the channel, ship-turning basin and berth pockets (commonly known as '*maintenance dredging'*); and
f. The removal of seabed material from Te Awaparahi Bay required for the construction of the reclamation.

1.10 All sediment to be removed, other than sediment to be removed during maintenance dredging, is proposed to be dumped at a 1,250 hectare off-shore disposal ground using

[1] Twenty-foot equivalent container units.
[2] The deepening of the channel means the channel increases in length.

a large dredge vessel. Some 18 million cubic metres of material would need to be removed although it is proposed to be carried out in at least two stages.

1.11 Sediment removed during the maintenance dredging campaigns, using a smaller dredge vessel, is proposed to be disposed of at a new offshore maintenance disposal ground. The existing maintenance spoil ground at Godley Head is to continue to provide a backup to the proposed offshore maintenance spoil disposal ground and Gollans Bay is to continue to receive maintenance dredge spoil from the inner Harbour.

1.12 The drawings attached at **Appendix 1** illustrate the details of the project i.e.:

- The existing channel that is to be deepened and widened;
- The approximately 6.6 km channel extension;
- The ship-turning basin that is to be deepened and extended;
- The existing and future berth areas that are to be deepened and extended;
- The proposed offshore spoil disposal ground for channel deepening;
- The offshore maintenance spoil disposal ground and the Godley Head ground; and
- The location of the proposed reclamation footprint in Te Awaparahi Bay for which sediment is likely to be removed during the reclaiming of land.

1.13 Further details of the project are described in **Chapter 2**.

Project History

1.14 LPC initiated the proposal to deepen vessel access in 2007 and began consultation late in that year. Assessment work and consultation with stakeholders continued during 2008 and 2009 and an application was lodged with Environment Canterbury in December 2009. The application was initially put on hold while LPC focussed its resources on a concurrent project to expand the coal stockyard through land reclamation[3] and was left on hold, and eventually withdrawn, after the major earthquakes of 2010 and 2011.

1.15 The most significant change to the present project, compared with the proposal set out in 2009 application, involves an increase in the volume of in situ sediment that needs to be removed; from 10.7 million cubic metres to approximately 18 million cubic metres.

[3] This project has since been abandoned.

1.16 This is for three reasons:

a. First, the ship-turning basin and the berth pocket areas need to be extended to enable larger vessels to access the future container terminal at Te Awaparahi Bay, which has been provided for under the Recovery Plan;

b. Second, the navigation width of the shipping channel needs to be increased by 20m (from 180m to 200m). Further modelling of these larger vessels determined that an additional safety factor is required; and

c. Third, to remove seabed material required for the construction of the reclamation at Te Awaparahi Bay.

1.17 The other significant change is the proposal to dispose of maintenance dredge spoil at a new offshore maintenance spoil disposal ground. The orientation of the proposed offshore disposal ground for channel deepening has also been refined in response to stakeholder input.

1.18 Since 2009, there also have been advances in the modelling of the currents, waves and associated transportation of sediment. This application contains up-to-date modelling; and, together with the earlier modelling and empirical measurements, provides further confidence in the results. There has also been on-going work on how best to monitor turbidity plumes, which is explained in the assessment of environmental effects (AEE).

Purpose of this Document

1.19 Resource consents are sought for the CDP (which includes both channel deepening and subsequent maintenance dredging of the channel created after deepening) and dredging required for the construction of the reclamation at Te Awaparahi Bay. The consents sought are:

Channel Deepening

a. To dredge (disturb) seabed material for purposes of deepening, extending and widening a shipping (navigation) channel that includes a ship-turning basin and berth pockets; and to dredge (disturb) seabed material for the purposes of construction of a reclamation in Te Awaparahi Bay;

b. To discharge contaminants (dredge spoil and water) into water;

c. To discharge contaminants (seabed material and water) into water associated with dredging described in (a) above; and

d. To deposit seabed material on and disturb the seabed associated with (a) to (c) above.

Maintenance Channel Deepening

a. To dredge (disturb) seabed material for purposes of maintaining the depth of a shipping (navigation) channel that includes a ship-turning basin and berth pockets;
b. To discharge contaminants (maintenance dredge spoil and water) into water;
c. To discharge contaminants (seabed material and water) into water associated with maintenance dredging described in (a) above; and
d. To deposit seabed material on and disturb the seabed associated with (a) to (c) above.

1.20 The location of the shipping channel (including ship-turning basin and berth pockets), the reclamation that requires dredging for construction purposes, and the spoil disposal grounds are shown on the drawings contained in **Appendix 1**.

1.21 The purpose of this document is to set out those matters required for a resource consent application. Schedule 4 sets out the information required in all applications. An AEE is required and the following information relevant to this proposal is contained in the following chapters:

a. A description of the activity (**Chapter 2**);
b. The rationale for the project including the implications of not proceeding with the project (**Chapter 3**);
c. A description of any possible alternative methods and sites of discharge, including discharge into any other receiving environment **(Chapter 4)**;
d. A description of the existing environment **(Chapter 5)**;
e. An assessment of effects on the environment **(Chapter 6)**;
f. A description of the mitigation measures incorporated into the project and a description of the monitoring and associated safeguards to be undertaken (**Chapter 7)**;
g. A description of the persons affected by the activity, any consultation undertaken, and any response to the views of the person consulted **(Chapter 8)**; and
h. A description of the relevant statutory provisions and an assessment of the application in terms of those provisions **(Chapter 9)**.

1.22 The assessment reports supporting and appended to the AEE are listed in **Figure 1.1**.

Author Company	Report Topic	Report Title	Appendix Number
Brown, Copeland & Co. Ltd	Economic Assessment	Assessment of Economic Benefits of the Proposed Lyttelton Harbour Channel Deepening Project	**2**
Witaskewin	Cultural Impact Assessment	Assessment of effects on Manawhenua rights, values and interests - Lyttelton Port Company Channel Deepening Project	**3**
Boffa Miskell Ltd	Landscape and Visual Amenity Assessment	Lyttelton Port Company Channel Deepening Project Natural Character, Landscape and Visual Amenity Assessment	**4**
Rob Greenaway & Associates	Effects on Recreation and Tourism	Lyttelton Port Company Channel Deepening Project and Maintenance Dredging Assessment of effects on recreation and Tourism	**5**
Tonkin & Taylor	Effects on Aquaculture and Mahinga kai	Lyttelton Port Company Channel Deepening Project Assessment of Ecological Effects - Marine Farms	**6**
Tonkin & Taylor	Effects on Coastal Processes	LPC Channel Deepening Project Review and summary of coastal process effects	**7**
OCEL Consultants NZ Ltd	Aspects of Marine Physical Environment	Deepening and extension of the navigation channel	**8**
Met Ocean Solutions Ltd	Plumes During Dredging	Lyttelton Port Company Channel Deepening Project – Simulations of Dredge Plumes from Dredging Activities in the Channel (Report P0201-03)	**9**
Met Ocean Solutions Ltd	Plumes During Disposal (capital)	Lyttelton Port Company Channel Deepening Project – Simulations of suspended sediment plumes generated from the deposition of spoil at the offshore capital disposal site (Report P0201-02)	**10A**
Met Ocean Solutions Ltd	ROMS Validation	Lyttelton Harbour/Whakaraupō Channel Deepening Project – Pegasus Bay ROMS Hindcast Validation Report	**10B**
Met Ocean Solutions Ltd	Plumes During Disposal (maintenance)	Lyttelton Port Company Channel Deepening Project – Simulations of suspended sediment plumes generated from the deposition of spoil at proposed maintenance disposal grounds (Report P0201-06)	**11**
Met Ocean Solutions Ltd	Behaviour of Sediment after Capital Disposal	Lyttelton Port Company Channel Deepening Project – Numerical modelling of sediment dynamics for a proposed offshore capital disposal ground (Report P0201-01)	**12**

Author Company	Report Topic	Report Title	Appendix Number
Met Ocean Solutions Ltd	Behaviour of Sediment after Maintenance Disposal	Lyttelton Port Company Channel Deepening Project – Numerical modelling of sediment dynamics at proposed offshore maintenance disposal ground (report P0201-04)	**13**
Mulgor Consulting Ltd	Effects on Harbour Waves & Currents	Effects of Channel Deepening Project on Waves and Tidal Currents in Lyttelton Harbour/Whakaraupō	**14**
Cawthron Institute	Marine Ecology Assessment	Assessment of impacts to benthic ecology and marine ecological resources from the proposed Lyttelton Port Company Channel Deepening Project (Report No. 2860)	**15A**
Cawthron Institute	Reef and Shoreline Marine Ecologies	Lyttelton Harbour and Banks Peninsula Shoreline Reef Ecology: Field Survey Data Report	**15B**
Cawthron Institute	Marine Mammals Assessment	Assessment of effects on marine mammals from the Lyttelton Port Company Channel Deepening Project (Report No. 2869)	**16**
Boffa Miskell Ltd	Effects on Marine Birds	Lyttelton Port Company Channel Deepening Project Marine Avifauna Assessment	**17**
Hegley Acoustic Consultants	Noise Assessment	Port Recovery Plan - Operational Noise Assessment	**18**
Environmetrics Australia	Commentary on Statistics for Turbidity Triggers	Statistical Consideration Associated with the Establishment of Turbidity Triggers	**19**
Environmetrics Australia	Recommendations on Measuring and Determining Turbidity & Trigger-values	Recommended Data Processing and Trigger-Value Methods for the LPC CDP	**20**
Vision Environment	Water Quality Monitoring	Lyttelton Port Company Channel Deepening Project Environmental Monitoring	**21**

Figure 1.1: List of reports supporting the AEE

Note: Appendix 1 contains the project drawings
Appendix 22 contains a Draft Environmental Monitoring and Management Plan
Appendix 23 contains proposed conditions of consent for channel deepening

2. PROJECT DESCRIPTION

Introduction

2.1 Most cargo vessels travelling the world today are large in size and have deep draughts. The term ‘draught’ refers to the vertical distance from the surface of the seawater down to the lowest point of a vessel, which is the underside of the hull, as shown in **Figure 2.1**. The more cargo a vessel carries, generally the deeper its draught.

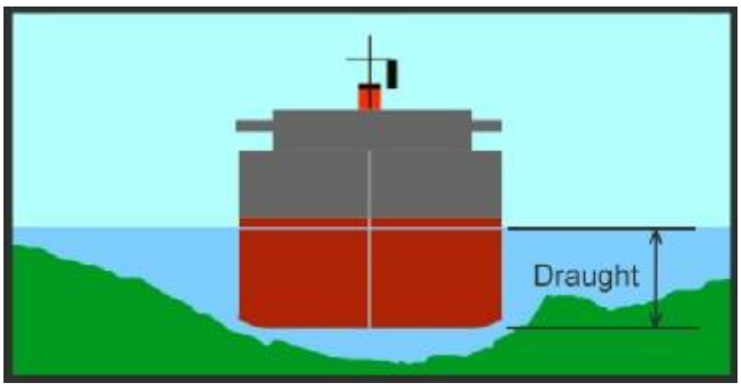

Figure 2.1: Schematic diagram illustrating the draught of a vessel.

2.2 Ports on the other hand are usually located in sheltered but often shallow harbours which are not deep enough to accommodate these large cargo vessels. Lyttelton Port is no exception.

2.3 To enable vessels to travel up a harbour and dock at the port, a shipping channel with a greater depth than the surrounding harbour is created by dredging. The areas next to the wharfs (berth pockets) and where the vessels manoeuvre (ship-turning basins) also need to be deepened by dredging.

2.4 A channel needs to have a sufficient depth of water under the bottom of the hull so the vessel can manoeuvre safely and remain afloat at all times. This is called the under-keel clearance and is illustrated in **Figure 2.2** below. As the clearance beneath the hull of a ship reduces, the handling of it becomes more difficult and unpredictable and therefore cargo carrying capacity is reduced.

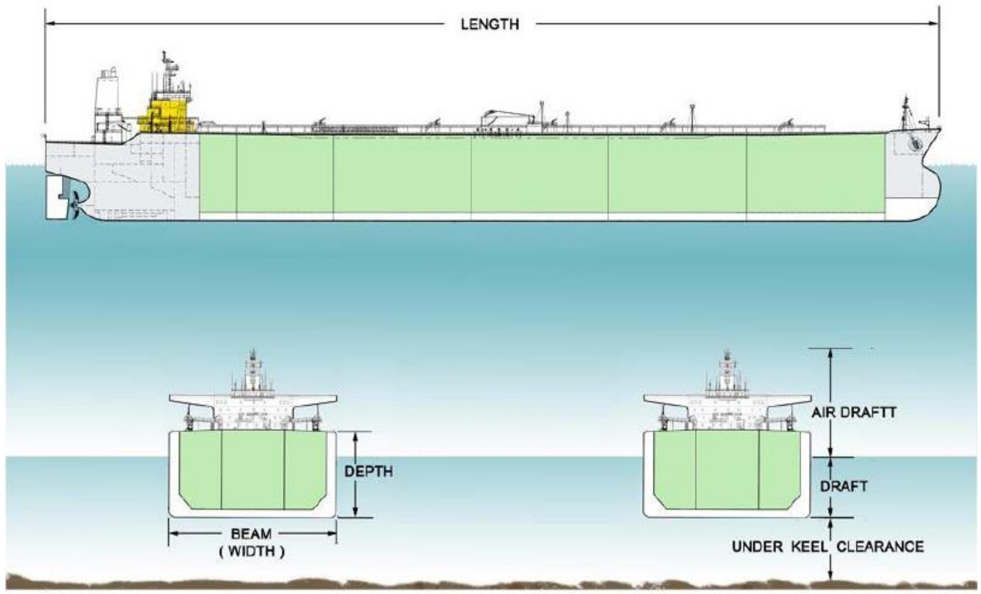

Figure 2.2: Schematic diagram illustrating a vessels dimensions, depth of draught and the under keel clearance. Typically a longer and wider vessel has a deeper draught.

2.5 The amount of under keel clearance required is largely dependent on the swell conditions and the vessel characteristics. For Lyttelton the swell is larger at or outside the heads so an increased under keel clearance is required in these areas. The reasons for the channel design are explained further in **Chapter 4**.

2.6 The depth of the shipping channel therefore determines the size of vessel that can access a port and how much cargo it can carry.

Existing Vessel Access and Dredging at Lyttelton Port

2.7 Lyttelton Port is located on the northern shores of Lyttelton Harbour/Whakaraupō, approximately halfway up the Harbour. The natural water depth at the Port is 5 m which progressively deepens to approximately 13 m at the entrance heads. Most of the Harbour between the Port and the Heads is therefore too shallow for the majority of cargo vessels and as a consequence a shipping channel, ship-turning basin and berth pockets are needed.

2.8 Dredging of the shipping channel commenced (in late 1800s) with bucket dredgers, which created a shorter channel with a depth of 7.8 m chart datum ('CD').[4]

2.9 The first suction dredge (Canterbury) arrived in 1912 and worked on the channel, which at 1943 was 10.5 m CD. This was further deepened over the period up to the mid-1970s when it reached the current depth of approximately 12.2 m CD.

2.10 As shown on **Figure 2.3** the existing shipping channel ends adjacent to Mechanics Bay. The channel enables up to 12.4 m draught vessels to enter or leave the port at high tide.

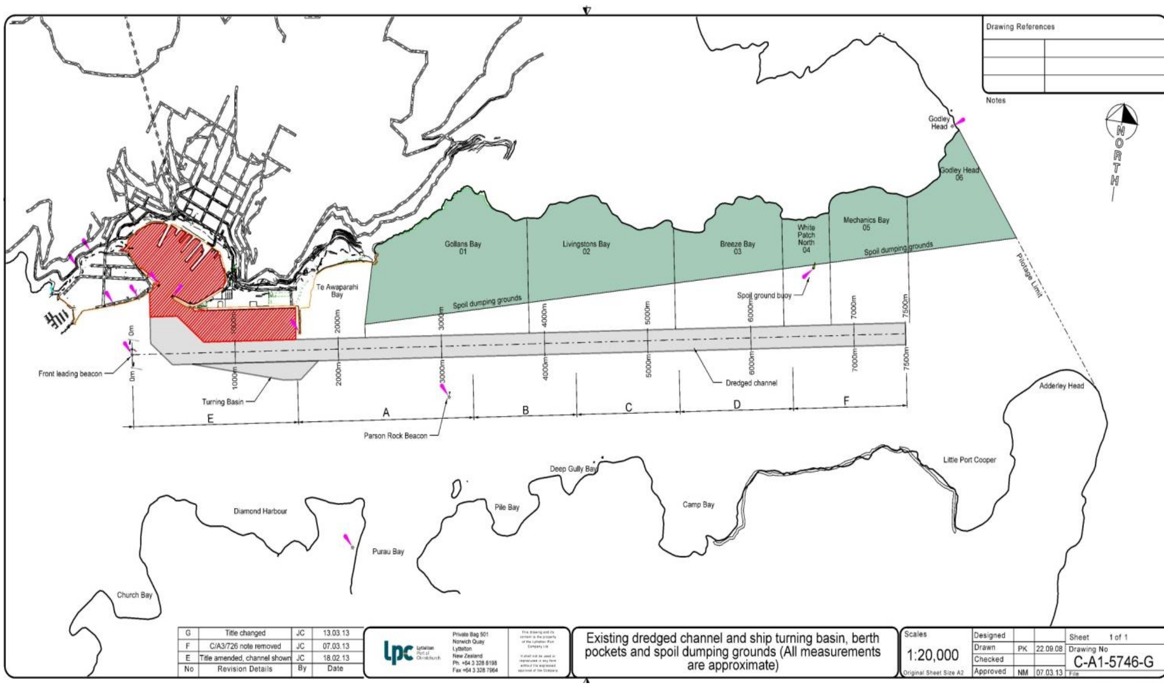

Figure 2.3: Existing shipping channel, ship turning basin and berth areas that need to be dredged. The area in green is the existing spoil dumping ground.

Proposed Deepening

2.11 As discussed further in **Chapter 4**, globally container ships are increasing in size and have deeper draughts. A deeper channel is required to ensure LPC can accommodate these larger ships. Bulk vessel (e.g. fertiliser and bulk liquid vessels) size and draught is also increasing because the same size and scale efficiencies apply.

[4] The chart datum is the level of water that charted depths displayed on nautical charts are measured from. The chart datum is generally taken from the lowest astronomical tide (mean lower low water).

2.12 The objective of the CDP[5] is to provide safe passage during all tides for a 14.5 m draught vessel. This would enable a design vessel, being an approximately 350 m long and 43 m wide container vessel, to visit the port during all tides. This vessel typically carries 8,000-10,000 twenty-foot containers or equivalent units (‘TEU’).

2.13 To achieve this, the existing shipping channel needs to be deepened, extended and widened as shown in **Figure 2.4**. Deepening and enlarging of the ship turning-basin and some berth pockets is also required, as is dredging for the construction of a reclamation in Te Awaparahi Bay. The elements of the channel deepening project are described below:

a. The depth of the shipping channel would be between approximately 16.85 - 17.85 m chart datum (the existing channel would be deepened by approximately 4.65 m to 5.65 m);
b. The base of the channel would be approximately 200 m wide (see explanation below);
c. The ship-turning basin would be deepened as above and be enlarged so vessels can manoeuvre into the future berth pockets at Te Awaparahi Bay;
d. The deepening and enlarging of the berth pockets at Cashin Quay;
e. The creation of new pockets to serve the proposed container terminal at Te Awaparahi Bay; and
f. The deepening of the seabed in Te Awaparahi Bay needed for the construction of a proposed reclamation.

2.14 The alignment of the proposed channel extension generally follows that now used by vessels to enter the existing channel which is guided by the PEL sector light on the west side of Purau Bay.[6]

2.15 The area to be dredged comprises the shipping channel and the batter slopes (together called the fairway) as shown on **Figure 2.5**. The shipping channel is the section maintained at the design depth and within which vessels will navigate. The fairway includes the side-slopes between the channel and the shallower surrounding natural sea bed level. The width of the channel needs to be wide enough for the largest vessel while

[5] Channel deepening is sometimes called ‘capital dredging’. It reflects the ‘capital expenditure’ required to carry out the work and hence means an increased asset in the form a deepened channel.
[6] The term PEL is a generalised trademark of the Physics and Engineering Laboratory which was part of the former Department of Scientific and Industrial Research (DSIR).

the fairway is dependent of the geotechnical stability of the material and how deep the channel is relative to natural sea bed.

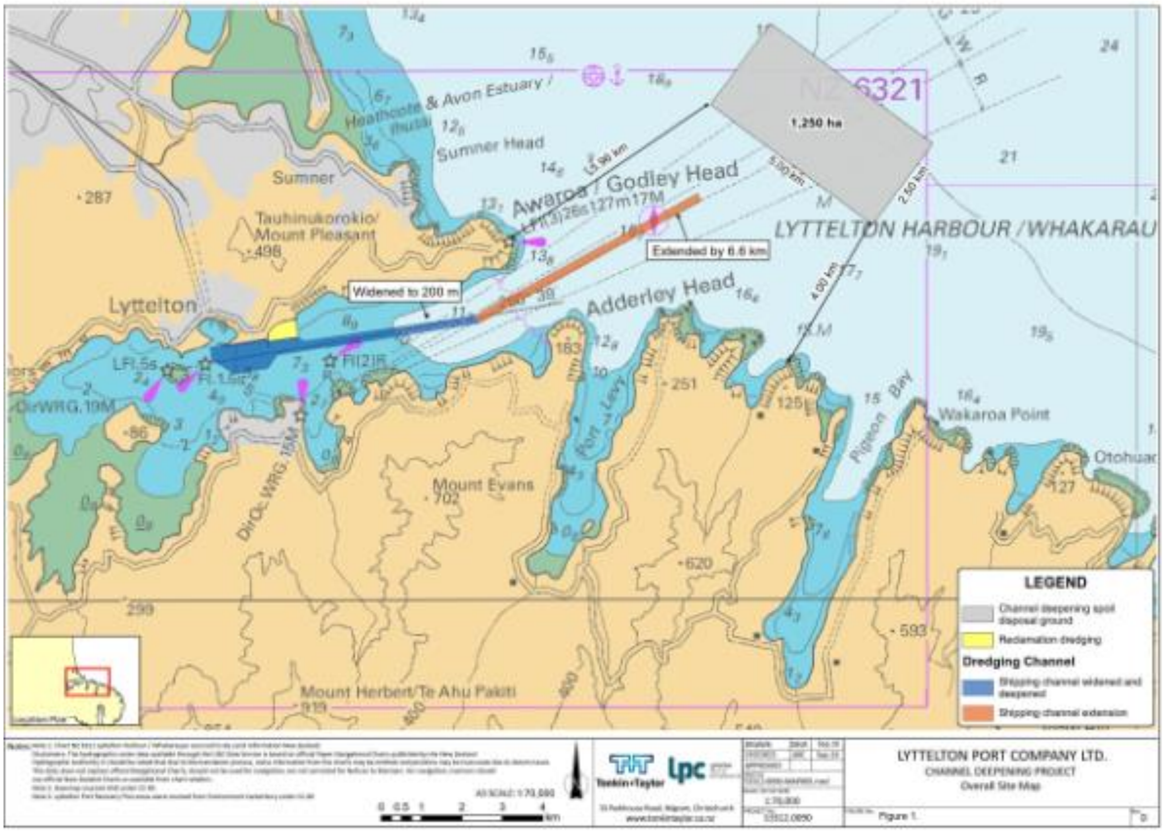

Figure 2.4: Proposed deepening and extension of the shipping channel and the proposed offshore spoil deposition ground to receive the dredge spoil. The drawing is also found as an A4 sheet in **Appendix 1**.

2.16 Experience with the existing channel means LPC has a good understanding of how to achieve stable channel side slopes for Lyttelton Harbour. These are typically a 1 in 4 slope (1 vertical to 4 horizontal) and are expected to be similar for the deeper channel. The slope angles will be further refined in the detailed design phase once further geotechnical work is completed.

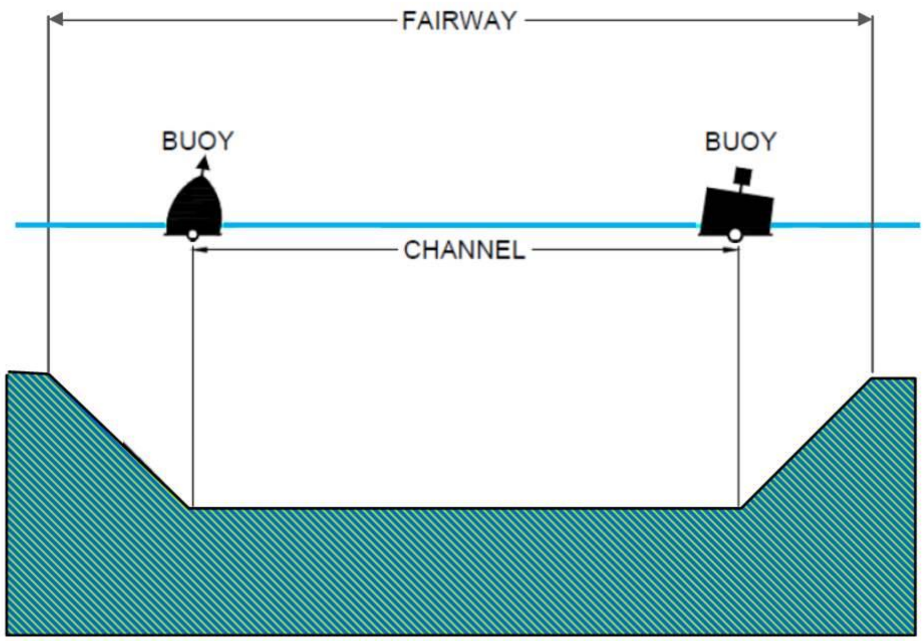

Figure 2.5: Shipping channel width definitions (derived from PIANC, Harbour approaches and channels guidelines, Report 121, 2014)

2.17 All spoil generated from the channel deepening is proposed to be deposited at a 1,250 hectare offshore spoil disposal ground which is to be located approximately 4.0 km from the shore at its nearest point, and is approximately 6.0 km from Godley Head. As shown on **Figure 2.4**, the disposal ground would be a rectangular area oriented roughly north-west to south-east and 5 km in length and 2.5 km in width. Aligned with the 20 m isobath, water depths within the ground vary between approximately 18.8 m and 21.0 m (CD) from the landward to seaward sides respectively.

2.18 Approximately 18 million cubic metres of in situ material would need to be removed and deposited at the offshore ground in order to complete the channel deepening and construct the reclamation.

2.19 The deepening to serve a 14.5 m draught ship will occur in not less than two stages. The scope of each stage will depend on:

a. How trends in increasing ship-size progress;

b. How the economy grows, which in turn dictates the number and frequency of ships visiting the port and hence the need to provide a service during all tides for the design draught;

c. The economics of the channel deepening project, taking into account the above; and

d. The availability and cost of dredge vessels suitable for deployment.

2.20 One possible option is that the first stage would provide access for a 14.5 m draught vessel across the high-tide window. The first stage would require between 6-12 million cubic metres of in situ sediment being removed depending on the target depth, whether the channel is widened, the extent of material removed from the ship-turning basin and the extent of material removed during construction of the reclamation.

2.21 LPC also seeking consent to dredge the seabed in the location of the proposed reclamation in Te Awaparahi Bay. The volume of in situ seabed material to be removed during construction of the reclamation is likely to be in the order of 1.5 million cubic metres. The sediment on the seabed is known to be soft at Te Awaparahi Bay and the top layer may need to be removed:

a. To reduce the potential of instability problems arising when the reclamation is being constructed (slip-circle failures could develop when heavy rock is placed on the soft seabed material); and

b. To reduce the period of settlement, which means the reclaimed land can be used earlier with less potential for damage to infrastructure.

Maintenance dredging

2.22 The existing shipping channel, ship-turning basin and berth areas need to be regularly dredged due to sediment in-fill. This type of dredging is called ‘maintenance dredging’ as its purpose is to maintain the channel’s depth. Without regular maintenance dredging, ships would not be able to continue to access the port.

2.23 The reason for sediment in-fill is because wave-induced currents disturb sediment and mobilise it into suspension that then can migrate via currents into these deeper features. The sediment, particularly near the seafloor, behaves as a dense moving fluid and the shipping channel in particular acts as a sediment trap for this dense fluid. As a result, the shipping channel infills overtime with sediment.

2.24 On average, the shipping channel at Lyttelton shallows by approximately 0.5 m each year. The berth areas shallow much more slowly, in the order of 0.1 m each year. This

difference is due to the berth area being more sheltered from the waves and currents in the harbour.

2.25 The amount of infill, however, varies considerably in any one year, and in any one location, depending on the number and nature of swells at Lyttelton. Each year, LPC determines which sections of the channel require dredging by obtaining the bathymetry using an echo-sounder and a differential global positioning system (DGPS).

2.26 A proposed offshore maintenance spoil disposal ground is to receive spoil from maintenance dredging. The proposed ground is shown on **Figure 2.6**. The site is 1.6 km by 1.6 km or 256 ha and is located approximately 2.25 km offshore from Godley Head.

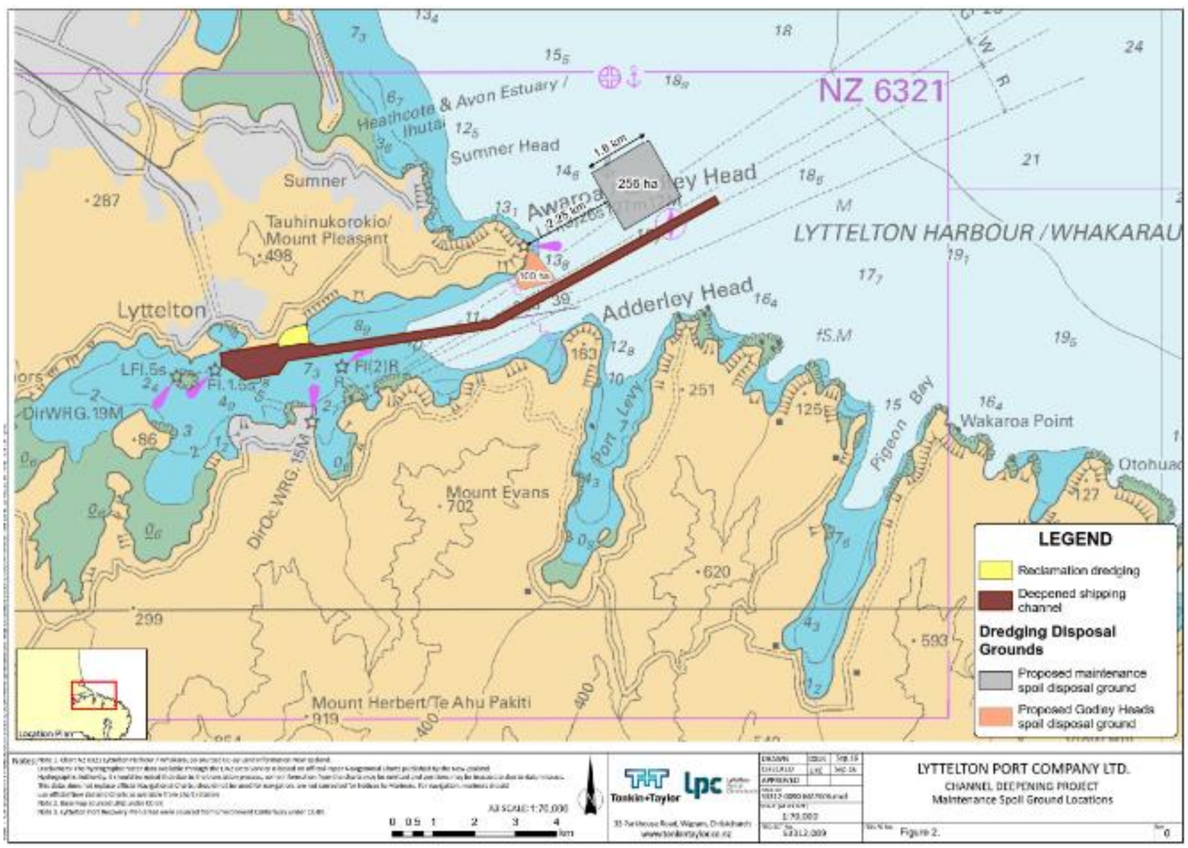

Figure 2.6: Proposed shipping channel with the proposed offshore maintenance spoil disposal ground and the proposed maintenance spoil disposal ground at Godley Head. The drawing is also found as an A4 sheet in **Appendix 1**.

2.27 The proposed offshore maintenance spoil disposal ground is expected to be the primary receptor of maintenance dredge spoil. However, it is essential that part of the existing spoil ground along the north-side of the Harbour is retained, as:

a. There may be times where the sea-state conditions at the offshore disposal ground is too rough for the smaller dredge used for maintenance dredging and so disposal needs to occur within the comparative shelter of the Harbour;

b. If there are conditions that cause an environmental effect at the offshore ground that is attributable to disposal activities, then the use of the Godley Head ground provides an alternative for temporary period; and

c. The sediment near the wharf structures may be collected by an even smaller grab or backhoe dredge that makes dumping outside the Harbour difficult due to sea-state conditions.

2.28 Godley Head is therefore proposed to be retained as a backup (again see **Figure 2.6**). Material dredged from the inner Harbour is to continue to be disposed of at Gollans Bay, which is part of the existing spoil ground (**Figure 2.1**) and authorised under LPC's Coastal Permit CRC135318.

2.29 It is difficult to accurately predict the quantity of sediment that will need to be removed from a deeper and extended channel in order to maintain channel depths. At the lower end it could be the same amount that is removed today (i.e. in the order of 300,000 – 600,000 m^3) but it could be twice that. For the purposes of this assessment the likely upper annual average is estimated to be in the order of 900,000 m^3. Initial volumes could even be above this figure in the short-term until the sediment mounds at the existing spoil deposition ground have eroded away[7] and re-circulation effectively ceases and only natural background sediment is removed.

[7] Subject to the continued use at Gollans Bay and the use at Godley Head at a backup for temporary periods.

Dredging Methodology

Introduction

2.30 The deepening project would be tendered internationally and dredging companies are expected to propose a variety of dredging methodologies.

2.31 LPC has undertaken, and is continuing to undertake, geotechnical investigation work so that the dredging companies wanting to tender have a detailed understanding of the sediment profile to be dredged. For example, it is known that in some locations a stiff to hard layer of sediment occurs below the softer layer of sediment at Lyttelton.[8] Some of this hard layer would need to be dredged, and the final determination of the extent and stiffness of this hard layer could influence the size and type of dredge a company might propose.

2.32 A Trailer Suction Hopper Dredge ('TSHD') is the most likely option for the channel deepening operation. The stiffness of the hard layer could influence the size of TSHD. However, another type of dredge cannot be discounted if further geotechnical work reveals a hard layer that is considerably more extensive or more difficult to dislodge than now thought. These other vessels are discussed later.

Dredging operation – using a Trailer Suction Hopper Dredge ('TSHD')

2.33 A TSHD is efficient at covering large areas and is recognised internationally as the most efficient dredge for the dredging of shipping channels which have a sandy to soft, silty seabed material.

2.34 A TSHD operates like a large underwater vacuum cleaner. As shown in **Figure 2.7** below, the dredge has a long, hinged, rigid suction pipe with a 'drag-head' at its end. The design of the drag head varies depending on the material to be dredged with some including teeth, cutters or water jets to dislodge and fluidise materials prior to them being sucked up by the drag-head.

The drag-head is lowered to the seabed and the silt, along with seawater, is pumped up the suction pipe, via large powerful pumps, to the vessel's hopper. The 'hopper' is a term for the ship's hold which holds the dredged sediment and water mixture until release at the spoil grounds. Sediment is released in two ways: firstly, the vessel (and hopper)

[8] Refer to Section 5.2 of the OCEL Report attached in **Appendix 8** for details.

splits apart with the sediment releasing into the water column;[9] or secondly, by trap doors that open at the base of the hopper. Either way, the point of release is some 7 – 9 m below the water surface (depending on the size of dredge used).

2.35 The dredging and subsequent deposition into the hopper takes place while the vessel is steaming slowly ahead.

2.36 Given the slurry discharged into the hopper consists of only about 25-35% sediment, it is necessary to 'overflow' during the dredging. The reason for overflowing is to reduce the amount of water within the hopper and thereby significantly increase the efficiency of the operation, i.e. each hopper load contains a greater volume or density of sediment.

2.37 The desired density of the slurry[10] is achieved by decanting the water (with some sediment) off the top of the hopper load. Because the majority of sediment in the slurry settles quite rapidly, the upper layers of water in the hopper have a relatively low proportion of sediment. The decanting process works by using an overflow valve that can be altered in height, near the surface of the load. The watery mixture flows in the inlet valve and discharges under water so as to reduce the size of any plume at the surface. The valve is activated at the appropriate time during the dredge run to release the watery mixture.

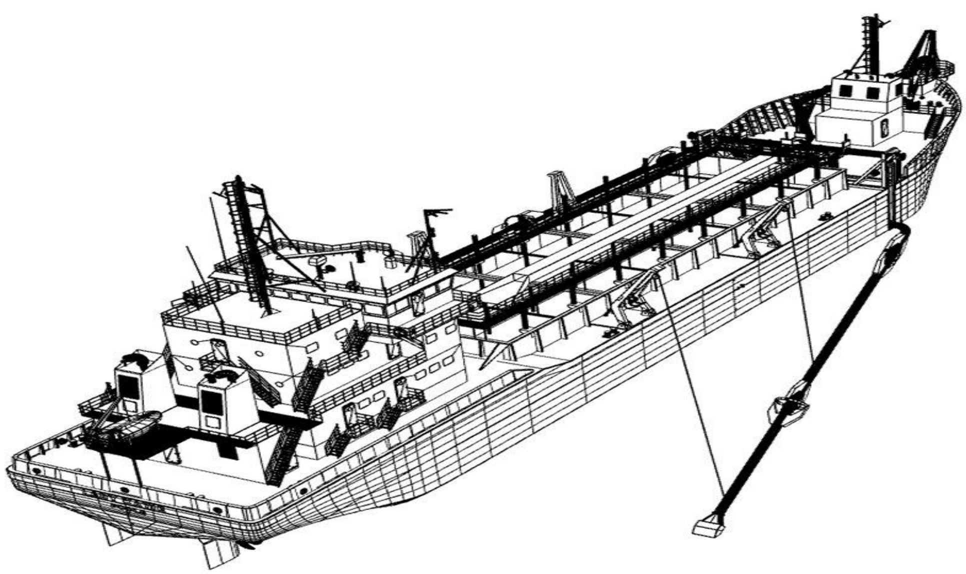

Figure 2.7: Schematic diagram of a Trailer Suction Hooper Dredge. The drag-head is lowered to the seabed and the silt on the seabed is pumped up the suction pipe to the vessel's hopper.

[9] Called split-hopper trailing suction hopper dredges.
[10] Which is likely to be in the order of 1.3 tonnes/m^3.

2.38 The valve is expected to be in operation for between 10 and 30 minutes on each dredging run.

2.39 The load will be released at a pre-determined location in the disposal ground fixed using GPS. Dredge vessels have very accurate navigation systems to ensure the vessel discharges within the consented disposal ground.

2.40 The modern TSHDs ensure that each load is released at depth, minimising the suspension of sediments in the upper layers of the water column. Upon release, the load sinks to the seabed as a dense fluid that impacts the bottom and spreads out horizontally and radially away from the impact point until the advancing front loses momentum and settlement processes become prevalent.

2.41 Some seawater enters the hopper immediately after the dredge has released its load. Some dredges will pump the seawater out of the hopper and discharge it overboard in readiness for the next run.

2.42 LPC's maintenance dredging campaigns have has used TSHD's for many decades, with the more recent vessels having a hopper capacity of approximately 1,000 m^3. A new vessel called the Mahury (or a similar vessel) is to carry out future maintenance dredging activities. A photograph of the vessel is at **Figure 2.8** below. It is a larger vessel with a hopper capacity of 1,840 m^3, and will be better able to handle the sea-states outside the Harbour heads. It will also be a more efficient dredge in terms of capacity and steaming speed. As a modern vessel, it also has the most up to date navigation and dredging technologies, including subsurface overflow discharge to reduce surface plumes.

2.43 In summary, the dredge operation comprises four phases:

a. The 'dredge run' where the dredge vessel deploys the drag head and loads the hopper with slurry;
b. Steaming to the disposal ground with a load of slurry;
c. Disposing of the slurry within the allocated disposal ground; and
d. Steaming back to the channel to commence the next dredge run.

2.44 This operation is repeated 24 hours a day until the channel is dredged to the required depth, width and length. There will be periods of time where the dredge may not operate

if weather/environmental conditions are too adverse for safe operation or scheduled maintenance work on the vessel needs to be carried out.

Figure 2.8: Photograph of the Mahury. Source: Fleetmon website

2.45 A bed-levelling operation is often performed after dredging with a TSHD. This is performed because the drag-head leaves small high spots on the floor of a seabed. These high spots are difficult and uneconomic to “chase” using a TSHD and a bed levelling device is employed instead. An eight metre long steel beam is presently used by LPC. It is approximately two-tonne in weight. After being lowered onto the seabed using a mobile crane, the beam is then pulled at right angles in the direction of travel using a bridle and chain system behind a 16 m fishing boat. This may be done following during channel deepening, and also after future maintenance dredging.

Other Dredges

2.46 It cannot be discounted that other types of dredges may need to be used during the project. For example, if the hard layer described earlier is more consolidated than now thought then a grab dredge or a back hoe dredge might be needed to remove the layer. A grab dredge is a crane with a ‘grab bucket’ (or clamshell) which is used to dredge the

material. A backhoe dredge is essentially the same except that it uses a hydraulic excavator to dredge material rather than a wire grab.

2.47 The grab and backhoe dredge can be a vessel with a hopper or alternatively the crane can work from a pontoon and load sediment onto a hopper barge that independently steams to the spoil grounds.

2.48 In the very unlikely event that the hard layer is both more consolidated and more extensive than is now thought from the data then a cutter suction dredge may need to be deployed. A cutter suction dredge is temporarily fixed to the seabed with a set of legs (termed spuds) and a section of channel is cut in an arc with a rotating cutter on the end of the suction pipe.

2.49 The cutter suction dredge can either have its own hopper or pumps the slurry into a separate barge. Sometimes the process is completed in two stages by two different items of dredging plant: firstly the channel, or parts of the channel, is cut by a specialist cutting barge, and secondly a TSHD returns to suck the material into the hopper and take to the spoil ground. Due to deployment costs a cutter dredge could well be used for duration of the stage.

2.50 A larger channel deepening dredger may not be nimble enough to dredge near Cashin Quay near wharves and associated piles or within the reclamation footprint. Therefore other dredge methods could be employed and depending on cost and equipment availability can include the following:

a. Grab dredge vessel with a hopper or a separate hopper barge;
b. Backhoe dredge vessel with a hopper or a separate hopper barge;
c. Dredging plough (blade) towed by a vessel; or
d. A land based crane which uses a grab bucket.

2.51 In these cases, it is possible that the excavated material would be placed nearby and subsequently removed by a larger TSHD and taken to the offshore spoil ground. These alternative methods also apply to the maintenance dredging operation except that the spoil would be directed to the maintenance spoil grounds.

Duration of Dredging

Channel Deepening

2.52 As previously stated, during the channel deepening project the dredging will be a 24 hour, 7 day-a-week operation. The duration of the channel deepening project will depend on two key factors:

a. First, the size of the dredge vessel and how quickly it can remove, transport and dispose of the sediment; and
b. Second, the number of project stages and the sediment to be removed during each stage.

2.53 The worldwide fleet of TSHD has a diverse range of sizes, from small vessels with a hopper capacity of <1,000 m^3 through to mega-dredges with a capacity of over 40,000m^3. Given the size of this project, it is likely that the dredge vessel will have a hopper size between approximately 5,000 m^3 and 18,000 m^3.

2.54 If the dredging was undertaken in two stages, and assuming a vessel of around 10,000 m^3 is used, each stage would take approximately 9-14 months to complete. This assumes a cycle time of two hours on average with each cycle consisting of the dredging run, the steaming out to the disposal ground, the disposing of the load, and the steaming back to the dredge location.

Maintenance Dredging

2.55 As described earlier, there is considerable variation in the volume of sediment that needs to be removed and so it is difficult to estimate the duration of maintenance dredging for each year. Furthermore a new vessel, such as the Mahury, has not yet been used in Lyttelton. However, it is expected that dredging will be carried out annually and the dredging and disposal cycle time to the proposed offshore maintenance spoil ground is likely to be in order of 1.5 hours on average, noting it will vary depending on the exact dredging location and sea-state conditions. Currently the annual dredging campaign occurs over a period of 8-12 weeks.

3. PROJECT RATIONALE

Import and Export Supply Chain

3.1 New Zealand's isolation means it has an almost total reliance on sea transport. The ports are responsible for moving more than 99% of exports and imports by volume and 85% by value.

3.2 The New Zealand economy is growing steadily and the Budget Economic and Financial Update 2016 has forecast short to medium term GDP growth of between 2.5% and 3.2% from 2017 – 2020 (The Treasury, 2016). A general rule to date is that container volumes grow at 2.5 times the GDP.

3.3 The Ministry of Business, Innovation and Employment (MBIE) Business Growth Agenda 2015 outlined six key inputs as economic growth focus points towards 2025. The first key input is building export markets. The primary industry sector contributes approximately 8% of the national GDP and over 50% of New Zealand's total exports by volume. The Ministry for Primary Industries (MPI) Our Strategy 2030 document (2015) seeks to grow the primary industry through four long-term outcomes:

a. The maximising of export opportunities;
b. Improving sector productivity;
c. Increasing sustainable resource use (and improve sector productivity) and;
d. Protecting from biological risk.

3.4 If the first two goals are achieved, primary industry exports in real terms will increase from $32 billion in June 2012 to over $64 billion by 2025 (New Zealand Government, 2015). If this comes into fruition then it is estimated that the current containerised cargo volume would increase by up to 50%.

3.5 In Canterbury the strategy is to increase the total irrigable area to 850, 000 hectares.[11] This is expected to result in increased agricultural production of $1.7 billion per annum to the Canterbury economy (Canterbury Water Management Strategy, Environment Canterbury, 2009).

[11] At present approximately 350,000 ha is irrigated.

3.6 The ability of businesses to compete internationally is a function of product quality, timeliness to market and price, all of which is either in part or largely dependent on an efficient, cost effective transportation of product. Ports are an important part of this supply chain.

3.7 With a globalised economy, New Zealand is required to be continually looking at ways to improve not only how and where it processes its goods, but also to use the most cost effective transport networks to deliver products to and from overseas markets.

3.8 As discussed later, globally there has been a trend towards larger container vessels for decades. New Zealand ports must be able to respond to this trend otherwise New Zealand will export or import goods to the global market via Australia which could increase costs. This is why a number of ports in New Zealand are becoming larger-ship capable.

Lyttelton Port of Christchurch

3.9 Lyttelton Port of Christchurch is owned by Lyttelton Port Company Limited ('LPC'). LPC is wholly owned by Christchurch City Holdings Limited, which is in turn owned by the Christchurch City Council.

3.10 LPC's landholding covers a total area of some 149 hectares, extending from Magazine Bay in the west to Gollans Bay in the east. The container terminal is operated from Cashin Quay which is situated at the eastern edge of the Lyttelton township adjacent to Te Awaparahi Bay. The port operates 24 hours a day and 7 days a week.

3.11 LPC also has owns and runs two inland ports (off-port container operations) located in Woolston and in Rolleston. These provide extensive container servicing facilities and operate five days a week.

3.12 The port services tanker vessels, container vessel, log exports, and bulk liquids imports among others. The company revenue by trade is predominantly from the container trades as shown in **Figure 3.1**. The ability to continue to provide and grow these services is paramount to the increasing productiveness of the port.

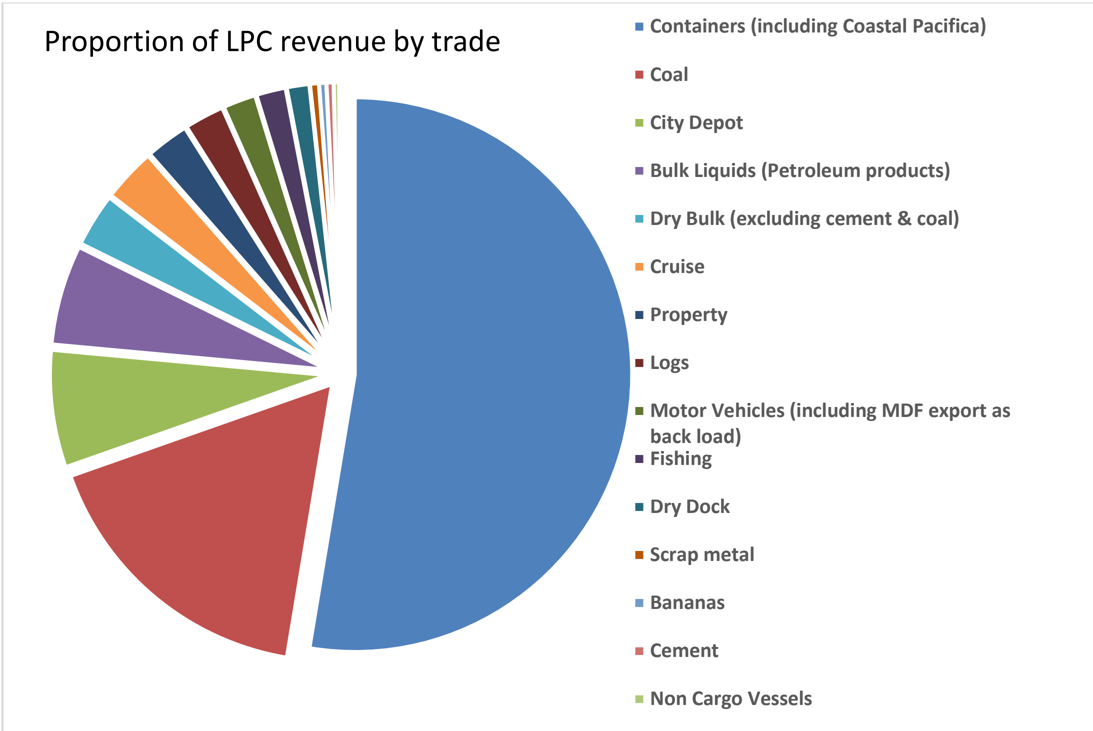

Figure 3.1: Proportion of LPC revenue by trade. Source: LPC

3.13 Section 5 of the Port Companies Act 1998 states that, “The principal objective of every port company shall be to operate as a successful business”. It therefore encourages a competitive environment between individual ports throughout the country.

3.14 LPC’s vision is:

“To be the South Island Port of choice”

3.15 Under a guiding principle of "Fast, Efficient and Safe Turnaround" LPC has the following objectives:

a. To measurably improve safety performance;
b. To be profitable over the long term;
c. To provide outstanding customer service;
d. To be an employer of choice, and
e. To be environmentally and socially responsible.

3.16 In recognition of other users of the harbour area, and to ensure the valued harbour environment is well cared for, LPC is committed to minimising any adverse effects of its

activities and facilities on the environment by adopting the following environmental principles:

a. Advocating environmentally sustainable principles in port operations;
b. Avoiding, remedying or mitigating adverse effects of its operations on the environment;
c. Where appropriate, pro-actively consult with the community on environmental issues;
d. Identifying priorities for environmental improvement;
e. Implementing and maintaining systems and procedures for continually improving environmental performance; and
f. Monitoring, documenting and reporting on environmental performance to the Board, senior management and staff.

Importance of Lyttelton Port

3.17 Lyttelton Port of Christchurch is the third largest Port in the country. Over 15% of all New Zealand's imports and exports pass through the Port.

3.18 Lyttelton Port also acts as a transhipment port for export and import cargo i.e. domestic ships arrive with export cargo that is transferred to the international ships and conversely imported cargo is collected by the domestic ships. With a decrease of manufacturing in the South Island, LPC is also a gateway for domestically produced cargo being moved from Auckland for local consumption.

3.19 LPC's container trade is roughly equal in terms of import and export cargo quantities. This is unique in terms of New Zealand's ports and is largely to do with the geographical location of the Port. Import cargo is driven by its location with respect to population centres and the productive sector, and the location of the productive sector drives the export demand.

3.20 As at 30 June 2015, LPC had $327.9 million dollars worth of property, plant and equipment. During the year ended 30 June 2015, the company collected $109.1 million in revenue, provided over 500 jobs and paid $48.5 million in salaries and wages. It spent $30.4 million on goods and services, much of this going to local Canterbury suppliers.

3.21 In terms of total tonnage, Lyttelton Port is the largest port in the South Island and the third largest in New Zealand. It is New Zealand's second largest export port behind Tauranga and accounted for 43.1% of South Island's ports overseas trade. By volume, containers make up the largest share of trade through the Port followed by coal, bulk fuels, dry bulk products, logs and cars. For the year ending 30 June 2015, 372,219 twenty-foot container equivalent units (TEUs) were moved through the port, an increase of 48.4% over the last seven years.

3.22 By way of comparison containers moving through other South Island ports in 2014/15 were:

a. Port Otago,172,000 TEU;
b. Port Nelson, 90,422 TEU; and
c. SouthPort (Bluff), 35,800 TEU.[12]

3.23 In 2014/15 Lyttelton Port handled 51% of the South Island's container movements, up from 43% in 2010/2011.

Exports

3.24 In calendar year 2015, exports through Lyttelton Port totalled $4,568 million or value, or 9% of New Zealand's total merchandise exports. This represents 39% of the South Island's value of exports, up from 29% in 2005. Note, however, that due to the exclusion of coal export values these percentages are understated.

3.25 The main export trades by value through Lyttelton Port in 2015 were dairy products ($1,771 million and 15.0% of the total for New Zealand); meat ($579 million and 11.0% of the total for New Zealand); wool ($367 million and 43.0% of the total for New Zealand); wood and wood products ($178 million and 5.1% of the total for New Zealand) and fish ($143 million and 9.8% of the total for New Zealand).

[12] PrimePort (Timaru) could not be found for 2014/2015 although it was 22,000 TEU in 2012/13.

Imports

3.26 In calendar year 2015, imports through Lyttelton Port totalled $4,001 million in value, or 7.8% of New Zealand's total merchandise imports. This represents 70% of the South Island's value of imports, up from 64% in 2005.

3.27 The main import trades by value through Lyttelton Port in 2015 were fuels ($542 million and 10.2% of the total for New Zealand); vehicles ($550 million and 7.8.0% of the total for New Zealand); plastics and plastic articles ($235 million and 11.4% of the total for New Zealand); iron and steel and iron and steel articles ($199 million and 13.9% of the total for New Zealand), fertilizers ($125 million and 17.2% of the total for New Zealand); rubber and rubber products ($98 million and 15.9% of the total for New Zealand); and electrical machinery ($140 million and 3.2% of the total for New Zealand).

3.28 For further details refer to the Brown, Copeland & Co Ltd Economic Report attached in **Appendix 2**.

Introduction of Bigger Container Ships on New Zealand's Trade Routes

3.29 In 2010 the New Zealand Shippers' Council[13] stated that approximately 28% of the current global fleet of container ships is larger than 4000 TEU in nominal capacity. Together those ships accounted for 59% of total fleet capacity, and that is forecast to increase to 80% of total fleet capacity by 2030.[14] This trend is driven by the economies of scale associated with the higher fuel efficiency of larger ships,[15] and the fact larger ships can spread costs over the higher volume of containers they can carry (thereby reducing the average cost of transporting each container).

3.30 More recent analysis by LPC suggests that the very large vessels (i.e. 15,000-22,000 TEU) will be confined to the main Asia/European/North American routes but this still creates a cascade effect on the other routes as the older and smaller vessels reach the end of their operating life are replaced with larger vessels. The build rate of new ships is

[13] The New Zealand Shippers' Council is an association of major New Zealand-based cargo owners – both importers and exporters. It includes companies and organisations with major interests in industries such as forest products, fruit, steel, dairy, meat, coal and cement. Collectively the Council accounts for more than 50% of New Zealand's total annual volume of exports.

[14] Source: The Question of Bigger Ships. Securing New Zealand's International Supply Chain. New Zealand Shippers' Council; August 2010.

[15] For example, a 6,500 TEU vessel gives a 31% reduction in CO_2 emissions (per container) compared to a 2,600 TEU vessel (New Zealand Shipper's Council, Updated 2012).

evidence of this; as of June 2015 approximately 60% of global container vessels in service had a capacity of more than 5,000 TEUs whereas 90% of all ships on order at the time were more than 5,000 TEUs capacity (see **Figure 3.2**).

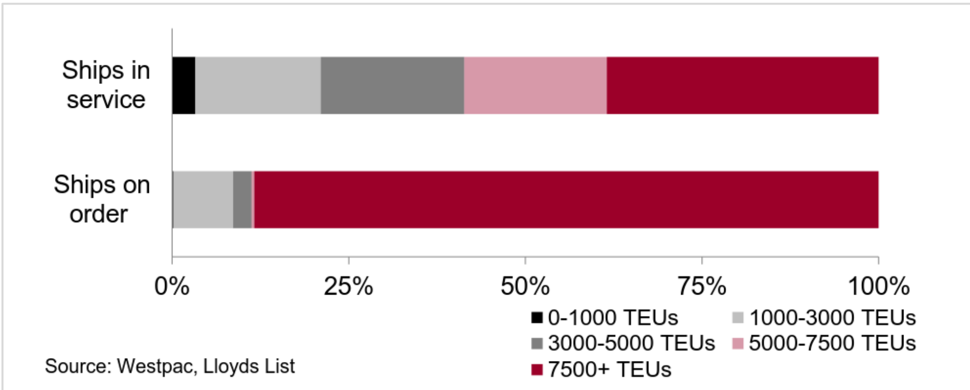

Figure 3.2: Share of global container size by capacity. Source: Norman, 2015

3.31 Based on the expected future freight growth combined with requirements for regular ship services, the maximum vessel size expected in New Zealand over the next 30 years is in the 7,000-10,000 TEU range (the new Panamax class[16]). Port of Tauranga is scheduled to receive this class of vessel for the first time in October, with a carrying capacity of 9,500 TEU (20 ft equivalent units).

3.32 The New Zealand Shippers' Council conducted a study on the economic benefits of introducing bigger container ships (5,000 – 7,000 TEU) on New Zealand trade routes and the economic costs of not introducing the same. The report concluded that there would be increased efficiencies gained with larger vessels. Conversely there would be substantial costs if shipping companies hub through Australian ports because of the increased handling costs and transit times.

3.33 The Shippers' Council considered that all four major container ports in New Zealand (Auckland, Tauranga, Lyttelton and Otago) will be required over time to increase their capability to support cargo growth, but that not all four will need to make the investment initially to become bigger ships capable:

a. A bigger ship service would be required to call at a North Island port, due to the large export and import volumes, and a South Island port, for growing export

[16] The Panama Canal has been recently enlarged to so that up to 13,000/14,000 TEUs are able to transit through the canal.

volumes, including refrigerated export cargo. Based on the Council's research and analysis Tauranga and Lyttelton are the two New Zealand ports recommended to become bigger ships capable;

b. Lyttelton Port is the logical first South Island port to become bigger ship capable because (a) it is the largest container port in the South Island in terms of both import and export volumes; and (b) development cost estimates to accommodate 7,000 TEU ships at Port Lyttelton are lower than at Port Otago; and

c. Tauranga and Lyttelton are also the largest bulk ports in New Zealand and there is an opportunity for bulk cargo owners to leverage off investment in bigger ship capable facilities at these ports.

3.34 Port of Tauranga is just completing its channel deepening project, Port of Otago is completing its deepening incrementally, while Port of Wellington is also about to seek consent for the new panama class of vessels as shown in **Figure 3.3**. Port of Auckland can receive vessels with a 13.9 m draught although this is tide dependent.

3.35 If 14.5 m draught vessels are not able to access Lyttelton in all tides then bigger ships will be subject to tidal delays for entering and leaving the Port. Tidal delays leading to cost and time losses may lead to loss in service provision. This would result in a loss of revenue for the company and some of the Port's current $327.9 million dollars' worth of property, plant and equipment will end up as stranded assets.

Port	**Design Vessel**	**Length (m)**	**Width (m)**	**Draught (m)**	**Capacity (TEU)**
Lyttelton	Axel Maersk[17]	352 m	42.8 m	14.5 m	9,000
Tauranga	Susan Maersk	347	42.8	15	8,160
Wellington	MSC Antalya	300	48	14.5	9,400
Otago	Sovereign Maersk	347	43.2	14.5 (tide restricted)	8,000

Figure 3.3: Design vessels used for various channel deepening projects.

[17] For further details about the design vessel refer to Chapter 4.

3.36 In order to continue to continue to provide cost effective export and import shipping to the Canterbury Region and support the New Zealand shipping network LPC needs to be capable of receiving these larger ships. Critical to this capability is a deeper and wider navigational channel, turning basin and berthing areas. It also requires upgrading of wharfs and cargo handling infrastructure; which, along with channel deepening, has been recognised and provided for in the Lyttelton Port Recovery Plan that was gazetted by the Minister for Canterbury Earthquake Recovery last year.

Conclusion

3.37 New Zealand needs to have an efficient freight network that is attractive to international shipping companies in order to provide competitive international shipping costs for exporters and importers. Internationally there is a trend of increasing shipping vessel size with deeper draught and larger capacity which require ports with sufficient container capacity and navigational channels deep enough to service the larger draught.

3.38 The size and type of international vessels calling at New Zealand in the future will be influenced by container volumes, port infrastructure and customer requirements for regular shipping. Not having a national network of ports able to service these international vessels would impact on the national economy and in terms of Lyttelton would impact on the regional economy and the ability for LPC to operate as a competitive business.

3.39 Lyttelton Port of Christchurch is the most significant port in the South Island in terms of total tonnages of cargo and containers handled and in the value of exports and imports and has been identified as the logical first South Island port to become bigger ship capable.

4. CONSIDERATION OF ALTERNATIVES

Section1: Channel Deepening

Channel Depth, Width and Alignment

4.1 The proposed depth, width and alignment of the shipping channel is determined by the types of larger vessels expected to visit the Port in the future. A representative vessel is used to inform the design (i.e. set the minimum dimensions of a deepened channel) and is called the 'design vessel' which in this case is 'Axel Maersk' shown in **Figure 4.1**. Other New Zealand Ports have or are preparing to dredge for similar vessels as discussed in **Chapter 3**.

Figure 4.1*:* Axel Maersk

4.2 The channel design was developed using the World Association for Waterborne Transport Infrastructure (PIANC) guidelines[18] and ship simulations. To determine the appropriate channel design the design vessel is simulated transiting the channel under various weather and sea-states as shown in **Figure 4.2**.

[18] Harbour approaches and channels guidelines. PIANC Report No. 121, 2014.

Figure 4.2: View of the container ship bridge in the ship handling simulator. The ship navigation simulation sessions were run in March 2015 at HR Wallingford's Australia Ship Simulation Centre in Fremantle, Western Australia. The simulator includes the bridge of the container ship along with two separate tug simulators. An LPC pilot ran the container ship bridge with two HR Wallingford staff running the tugs in response to commands from the LPC Pilot. Source: LPC

4.3 The specific objectives of the navigation simulation sessions were:

a. To review, validate, and, where necessary, refine the proposed shipping channel and ship-turning area;

b. To evaluate the feasibility of manoeuvring the design ship within the proposed modified port layout, in a range of wind, wave and current conditions;

c. To identify potentially unsafe conditions;

d. To identify the tug support requirements; and

e. To identify any additional aids needed for navigation.

4.4 As noted in **Chapter 2** (Figure 2.2) the channel needs to be deepened in order to obtain the appropriate under keel clearance. This has to take into account vessel response to:

a. Waves and wind causing pitching, which can cause the bow/stern to have a deeper draught;

b. Waves and wind causing heel or rolling, which can cause the sides of the vessel to have a deeper draught;

c. Squat, which is induced by forward motion resulting in the vessel 'sinking' into the water, increasing its draught; and

d. Changes in water density which alters how the vessel floats and in-turn changes the draught.

4.5 The proposed depth also needs to allow for:

a. Any inaccuracies during dredging;
b. Any inaccuracies of the depth measurements (i.e. errors in the soundings);
c. The infill rates of the channel between maintenance dredging campaigns; and
d. The nature of the seabed material.

4.6 Based on this work the shipping channel is proposed to be dredged down to the following depths:

	Inner Zone (Existing Channel)	**Transition Zone** (where the channel changes alignment – doglegs)	**Outer Zone** (seaward channel extension
Target depth[19] (approximate)	16.85 m	17.25 m	17.85 m

4.7 The increased exposure to the rougher sea state conditions is the reason for the outer seaward channel needing to be deeper. In terms of channel width, the simulator work found that the shipping channel needs to be approximately 200 metres wide at its base so as to achieve an appropriate factor of safety for large vessels. Dredging the channel width to anything less than 200 m would pose a risk to larger (and wider) vessels.

4.8 The proposed alignment of the channel extension follows the alignment that is currently used by vessels entering the existing channel. This alignment is guided by an existing PEL section light, and would therefore require no changes to the navigation procedures for entering and exiting Lyttelton Harbour. This alignment is used because it is close to the deepest part of the Harbour and is equidistant from Godley and Adderley Heads.

4.9 To conclude, the design of the channel is predicated on a design vessel which is a representative example of the larger vessels that would be able enter and exit the port in a safe manner following international guidelines. There is no other alternative in this respect.

[19] The furrows caused by dredging result in variable depths that are actually about 300mm over and under the target depth.

Method of Disposal

4.10 The disposal of dredge spoil is carried out at sea in comparable projects domestically and in Australia. Land disposal for this project is not feasible given the size of the project: some 31 million tonnes of sediment would have to be dumped over a large land area with a consequential range of environmental issues.

4.11 Further, it is highly unlikely any suitable sites would be available in Lyttelton Harbour or nearby bays or inlets and the transportation by truck to another disposal area is not feasible as it would involve, after de-watering, over 2.5 million return truck movements over at least two stages, assuming each load truck and trailer unit could hold 12 m^3 of spoil. Instead of trucks, a slurry pipeline is another alternative. However, there would be significant construction costs associated with this option and would be a potentially difficult and protracted process to secure the permissions needed for a pipeline to cross private land.

4.12 Another alternative is to use the dredge spoil as a material to reclaim land. This would require the establishment of perimeter bunds around any reclamation and the gradual infill of marine sediment. The use of dredge spoil as part of the reclamation to occur at Te Awaparahi Bay is technically possible and could yet be used. However, it is highly likely that the channel deepening project, or at least the first stage, would not overlap, or at least overlap to a useful extent, with the reclamation. Further, using the fine muds and silts from the harbour floor for reclamation is challenging geo-technically, and would require a considerable period of consolidation. The option of using a portion of the dredge spoil (particularly from later stages) in the reclamation at Te Awaparahi Bay is yet to be decided, and in any event:

a. Would need to be part of the subsequent approval process for the reclamation; and
b. The volume coming out of the channel is significantly more than is required for the reclamation.

4.13 Another option considered by other ports is to use dredge material for beach nourishment projects. This is not an option for LPC as the material being dredged is a mix of silt and clay and therefore is unsuitable for beach nourishment projects.

Location of the Disposal Ground

4.14 The use of the existing maintenance dredging spoil deposal grounds on the north-side of the Lyttelton Harbour/Whakaraupō was discounted early on because of the volumes involved.

4.15 The location of the proposed offshore spoil disposal ground was initially selected on the basis that it would be:

a. Deep enough to avoid shoaling;[20]
b. Far enough from the coast to avoid plumes of high suspended solids concentrations (i.e. turbidity) from reaching any shoreline; and
c. Close enough to the dredging work in terms managing traveling time and costs.

4.16 The proposal disposal ground has more recently been rotated anti-clockwise in response to discussion with the modellers and with Manawhenua. It means:

a. The closest point of the grounds (at the south-east boundary) is now approximately 3.6 km from the shoreline compared with 3.3 km for the earlier design; and
b. The depth to seabed, at the shallowest point, is now approximately 18.8 m CD, up from approximately 17.5 m CD for the earlier design.

4.17 This will further reduce any risk of turbidity plumes reaching the coast.

4.18 Following the site selection, the proposed disposal ground was then investigated and assessed to determine:

a. Whether plumes could reach the shoreline and inlets of Banks Peninsula;
b. Whether any benthic communities at the site were rare or had conservation interest;
c. The degree to which the existing habitat would recover following cessation of dredging, having regard to the species present and whether the material at the disposal area was similar to that being dredged;
d. Whether the location had any particular significance for Hector's dolphin and other marine mammals or marine avifauna;
e. Whether there was a significant fishery resource at this location; and

[20] Shoaling occurs when waves approaching shallower water slow are exposed to increased friction, which in turn means the wave energy below the surface of the sea is directed upward, causing an increase in wave height.

f. Whether there would be any other recreational issues.

4.19 These issues are addressed in **Chapter 6** but in essence no assessment work has revealed a fundamental issue that would necessitate an alternative location needing to be examined.

Reclamation

4.20 There are no alternatives to dredging associated with the construction of the reclamation at Te Awaparahi Bay. If dredging does not occur it would take many years for the land to stabilise sufficiently for the wharves to be constructed. This would significantly delay and undermine the recovery of Lyttelton Port, which is anticipated and given priority by the Lyttelton Port Recovery Plan and the associated objectives and policies in the Regional Coastal Environment Plan.

Section 2: Maintenance Dredging

4.21 The existing shipping channel, ship-turning basin and berth areas need to be regularly dredged due to sediment infill otherwise ships would not be able to continue to access the port. The frequency and volumes of material removed are determined by the weather conditions.

4.22 The sediment is currently being disposed at the existing spoil disposal grounds inside Lyttelton Harbour/Whakaraupō authorised under CRC135318 and shown in Chapter 2, **Figure 2.3** and also shown on the Regional Coastal Environment Plan, Planning Map 10.5

4.23 A decision to establish a new offshore maintenance spoil disposal ground was made for two reasons. First, the current disposal of spoil at the Godley Head has not translated into a reduction of dredging effort. Earlier work suggested that that the disposal of material at Godley Head should over time see at least some of the deposited spoil material escape from the Harbour system. While it cannot be discounted that this is in fact occurring, albeit very slowly and incrementally, the monitoring of the channel, illustrated by way of example in **Figure 4.1**, indicates that most of the spoil ends up back in the channel opposite and each side of Livingstone Bay.

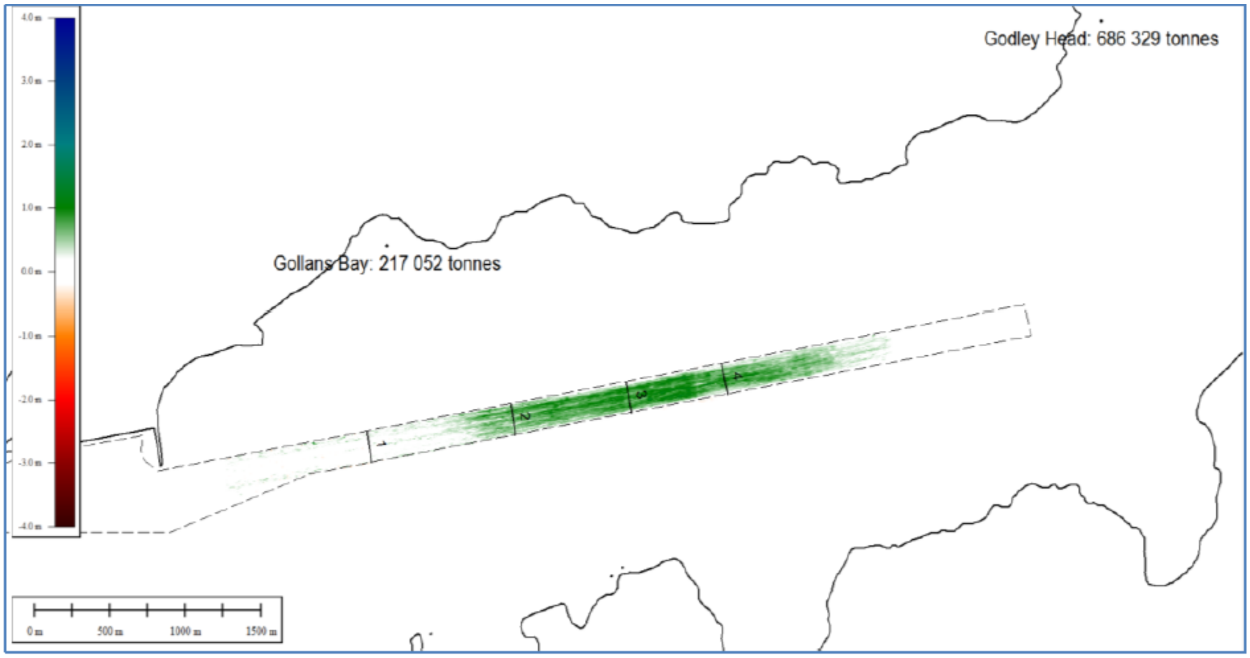

Figure 4.1: Difference in channel bathymetry between post-dredge (26/11/2014) and pre-dredge (13/08/2015) surveys, with annotation of the amount of spoil disposed in the preceding campaign. Source: LPC

4.24 It is thought that the waves associated with the large easterly storms are disturbing the relatively unconsolidated sediment at Godley Head, entraining it in the water column and transporting it back up in the Harbour with much of it ending up in the channel, which acts as a sediment trap. The disposal of maintenance dredge spoil at an offshore ground should see the amount of sediment being re-circulated into the existing channel decline overtime, and may result in a reduced dredging effort needed along the channel within the Harbour environs.

4.25 The second reason for the offshore maintenance spoil disposal ground is that Te Hapū o Ngāti Wheke would like disposal of the dredge to occur outside of the Harbour, as explained in the Cultural Impact Assessment attached in **Appendix 3**.

4.26 The proposed offshore maintenance spoil disposal ground was initially selected having regard to those matters set out in paragraph 4.15[21] and after discussions with Manawhenua. It is acknowledged that Manawhenua's strong preference is for the

[21] Taking into account that the Godley Head on the north-side of the Harbour can still be retained as a backup for a temporary periods.

offshore maintenance spoil disposal ground to be nested within the larger offshore ground to be used for channel deepening.

4.27 However, the operating costs of this alternative are substantial given the dredging cycle would be longer (30-40% longer), not only due to the increased distance to that ground, but also because a smaller maintenance dredge will be slower and less capable of dealing with exposure to rougher sea-state conditions. In other words, there do not appear to be any environmental benefits to be gained by placing maintenance spoil at the larger offshore disposal ground as opposed to the proposed offshore maintenance spoil disposal ground.

4.28 The proposed grounds has been carefully assessed against the matters described in paragraph 4.18 and no findings have revealed a fundamental issue that would necessitate the larger offshore ground needing to be used for the disposal of maintenance dredge spoil.

5. EXISTING ENVIRONMENT

Section 1: Social, Economic and Cultural Context

Tangata Whenua Settlement and Values

5.1 Both Whakaraupō[22] and Te Ara Whānui o Makawhiua (Koukourārata[23]) have a long and rich history of Ngāi Tahu land use and occupancy. The bays, coast and lands of this region are part of the history and identity of Ngāi Tahu and reflect the relationship between the tāngata whenua and the environment. The numerous pā sites, kāinga, mahinga kai areas, wāhi taonga and wāhi tapu sites hold the stories of Ngāi Tahu migration, settlement and resource use.

5.2 The Ngāi Tahu Claims Settlement Act, 1998 ('NTCSA') recognises the importance of the coastal marine area to Ngāi Tahu via the identification of the Te Tai o Mahaanui Statutory Acknowledgement ('SA') area. A statutory acknowledgement is an acknowledgement by the Crown of the particular cultural, spiritual, historical and traditional association of Ngāi Tahu with those areas.[24]

5.3 The abundance of mahinga kai resources was a primary driver for Ngāi Tahu settlement of Rāpaki and Koukourārata. They became major mahinga kai areas because of the availability of natural resources within the harbours. Koukourārata was known for kutai (mussels). Whakaraupō was specially valued for shellfish and species such as pioke (rig). The following excerpts illustrate the bounty:

> "…The whole of the coastal area offered a bounty of mahinga kai, including a range of kaimoana (sea food); sea fishing; eeling and harvest of other freshwater fish in lagoons and rivers; marine mammals providing whale meat and seal pups; waterfowl, sea bird egg gathering and forest birds; and a variety of plant resources, including harakeke (flax), fern and tī root." (NTCSA, Schedule 101)

> "During the month of February the whakarua (north-easterly) blew the pioke up the harbour and tangata whenua would gather at Govenors Bay and take the pioke from the shallows." (Te Whakatau Kaupapa, p. 5- 27)

[22] Lyttelton Harbour.
[23] Port Levy/Koukourārata.
[24] Note however that the statutory acknowledgement does not affect, and is not to be taken into account in, the exercise of any power, duty, or function by any person or entity under any statute, regulation, or bylaws except as expressly provided for in sections 208 to 211, 213 and 215 of the NTCSA.

5.4 The ancestral relationship of Ngāi Tahu to these harbours is reflected in the continued value placed on the harbours as mahinga kai. Today, the protection and restoration of mahinga kai for customary use[25] is the primary driver for Ngāi Tahu policies on harbour management, and assessments of effects related to proposed activities. The mudflats in the upper harbour and the kaimoana beds around Rāpaki are two areas of high cultural value for mahinga kai habitat.

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5.5 There are Mātaitai reserves in both harbours, provided for under the Fisheries Act 1996 (see **Figure 5.1**). The Rāpaki Mātaitai Reserve was established in 1998 as the first Mātaitai in New Zealand. The Koukourārata Mātaitai Reserve, extending across the whole of the harbour, was established in December 2000. The purpose of these reserves is to conserve, protect and restore the customary fisheries resource. They provide for the protection of the marine environment through tikanga-based management of fisheries,[26] and are further evidence of the strong relationship between Ngai Tahu and their ancestral lands and waters.

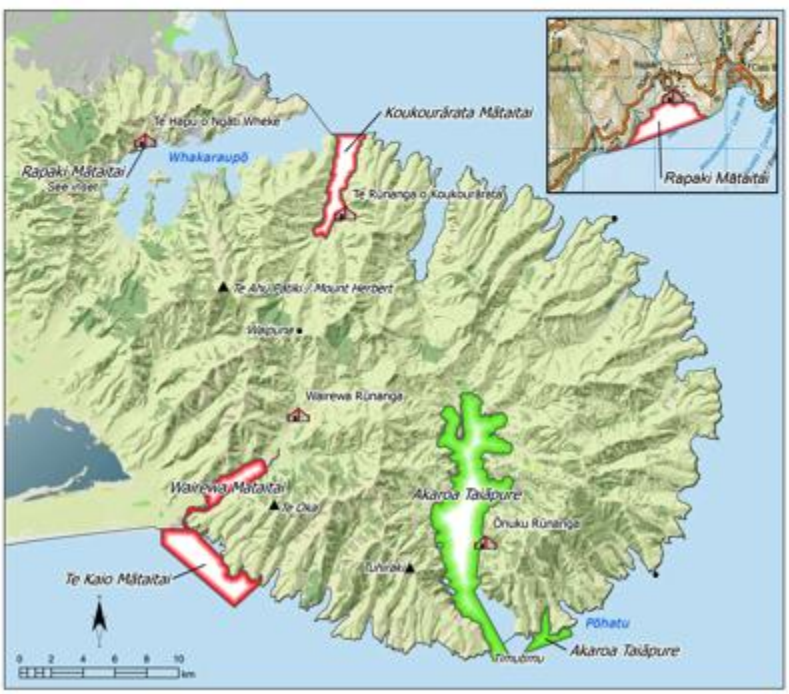

Figure 5.1: Mātaitai and Taiāpure reserves on Banks Peninsula. Source: Te Rūnanga o Ngāi Tahu

[25] Customary use can include customary commercial fisheries, such as the pāua and lobster fisheries along the northern bays of Banks Peninsula.
[26] Mahaanui Iwi Management Plan “Issue TAN4 Explanation”

5.6 An application by Te Hapū o Ngāti Wheke for a Whakaraupō Mātaitai which would cover the inner two thirds of the Harbour is currently lodged with the Ministry for Primary Industries (see **Figure 5.2**). This is consistent with aspirations to maintain and improve the kaimoana and fishery resources in the Harbour.

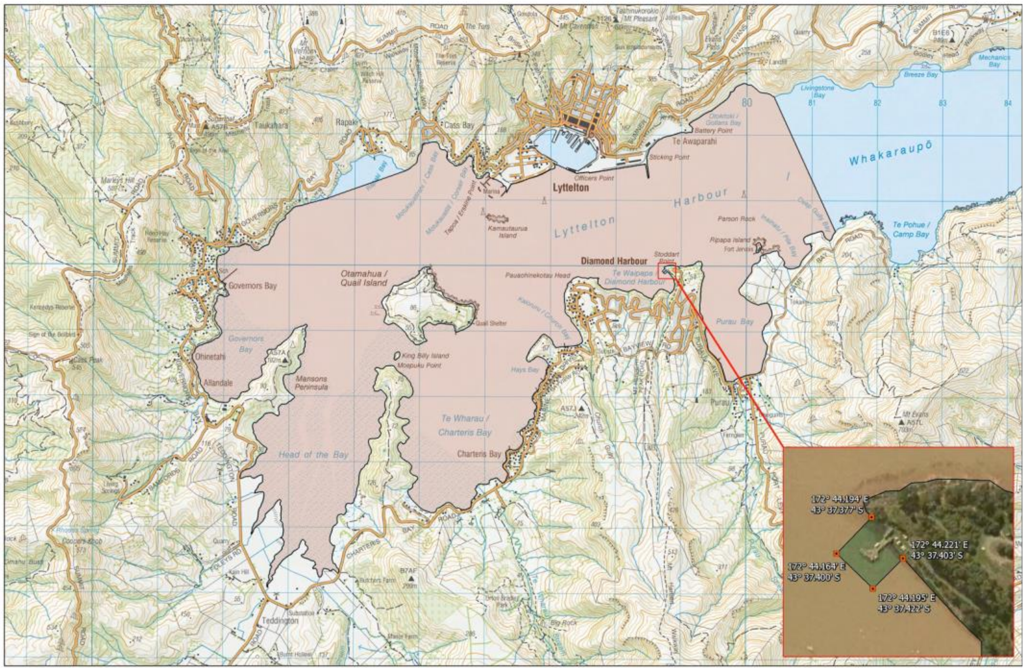

Figure 5.2: Map 1 of the Proposed Whakaraupō Mātaitai Reserve. Source: Te Rūnanga o Ngāi Tahu

5.7 Management of shellfish stock for mahinga kai and for commercial purposes, in the form of marine farms, is carried out by local tangata whenua today. Rimurapa was traditionally used to transport live shellfish from one location to another, to seed new beds with new varieties or to assist in the buildup of depleted stocks. Shellfish seeding is a traditional form of aquaculture still practiced today, including in Whakaraupō, where Ngāti Wheke has re-seeded cockles to Whakaraupō, brought in from Ōtakou.

5.8 The storage of kaimoana in taiki, or coastal storage pits, was also traditionally undertaken. Pits were usually hollows in the rocks that would be covered by water at high tide, and were used to store shellfish such as Pāua and mussels. Historically, tāngata whenua living at Koukourārata would travel to a neighbouring bay in the autumn, make up small beds of kaimoana and store them under piles of rocks for the winter.[27]

[27] Tau, TM et al. 1990, in Mahaanui Iwi Management Plan 2013 "Issue KP9 Explanation".

5.9 Marine farms are a contemporary expression of mahinga kai. Te Rūnanga o Koukourārata has a joint venture partnership with the two mussel farms in the outer stretches of the bay. Further details of Manawhenua rights, values and interests are contained in a cultural impact assessment prepared by Witaskewin attached in **Appendix 3**.

European Settlement and the Port

5.10 So far as is known, the first European to actually visit the district was Captain Chase in the *Pegasus* in 1809. In 1830 Captain Morrell anchored in Whakaraupō in the *Antarctic*, the first whaling ship to have entered the inlet. Lyttelton Harbour/Whakaraupō then became known as Port Cooper. Whaling visits continued, but on a much reduced basis, up until about 1840, and from the early 1840s a period of 'squatting' began, which prefigured formal settlement.

5.11 On 10 August 1849 Walter Mantell, Commissioner of Native Lands, obtained Ngāi Tahu signatures to a deed of purchase by the Crown of the Port Cooper and the Port Levy/Koukourātata 'blocks.' Within a year Port Cooper had been selected as a colony by the Anglican Canterbury Association chaired by Lord Lyttelton.

5.12 The idea of Lyttelton Township and the port were conceived in 1847 by Edward Gibbon Wakefield and John Robert Godley, who formed the Canterbury Association as part of their planned programme of systematic colonisation.

5.13 The survey of the new town of Lyttelton was completed by the end of September 1849 by Captain Joseph Thomas and Charles Torlesse, and on 30 August 1849 Lyttelton was gazetted as a port of entry. Cavendish Bay beach was modified with a seawall, culverts and a 45 metre long by 4.5 metre wide jetty and from this time on Lyttelton Port has became an integral part of the Harbour environment.

5.14 The township soon had over 200 inhabitants and grew from there. The port and township were given a major boost when a decision was made to construct a rail tunnel between Lyttelton and Christchurch. It was the first in the world to be driven through the rim of an extinct volcano and the Lyttelton rail tunnel was opened in 1867.

5.15 In 1876 the Lyttelton Timeball Station was erected and started signalling Greenwich Mean Time to ships in the harbour that year.

5.16 The Lyttelton Harbour Board was established in 1877 and was responsible for the management of both the commercial and recreational facilities of the harbour. The Board consisted of 13 members elected at the Local Body Elections every three years and representing areas which extended from the Rangitata River in the south to the Conway River in the north.

5.17 As Christchurch and its hinterland developed, so did the port. This included the building of the moles to protect shipping from harbour winds, the reclaiming of land to provide flat cargo handling areas, and, with the advent of containerisation, the establishment of Lyttelton as a container port in the mid-1970s.

5.18 One of the first projects by the Harbour Board was to commence dredging using a dredge and two steam hopper barges. This operation continued to 1890 after which a dredge was periodically chartered from the Otago Harbour Board. Dredging ceased at the Port from 1895 until 1900 when the *Manchester* arrived from Liverpool. The Manchester dredged until 1911 and over this period removed 7,369,671 tons of mud from the outer channel and the Inner Harbour.[28]

5.19 In addition, a pontoon “Priestman” dredge was deployed from 1904 to 1909 to dredge the berth areas. This was in turn replaced by a grab hopper dredge called the *Tewhaka*.

5.20 The first trailer suction dredge *Canterbury* was purchased and commenced work in 1912. It was said at the time that the new dredge was far more efficient because it could dredge while steaming ahead: it was doing more than twice the amount of work of the *Manchester* as well as cutting the channel more evenly.

5.21 Harbour Boards continued to administer the port, including the dredging operations, until the introduction of the Port Companies Act in 1988, which separated the commercial role and the non-trading (recreational and safety) roles of the Harbour Board by forming LPC. The commercial assets, the land and facilities, required to operate as commercial port were transferred from the Harbour Board to the company. Since that time LPC has been charged with managing the port in the same manner as any other commercial business.

[28] Source: Press 1912.

5.22 LPC made a commercial decision to contract out the maintenance dredging work. It sold its last dredge *Peraki*, and the vessels *Pelican* and the *New Era* have been used since around the late 1980s.

5.23 Dredging has therefore been performed more or less a continuously since the 1870s.

Lyttelton Harbour/Whakaraupō and Port Levy/Koukourārata Today

5.24 As roads were established around the harbour so were small settlements, which today consist of both holiday and permanent residential homes. Pastoral farming is the main rural land use, although a number of areas in both private and public ownership have been left to regenerate back into native bush.[29] The outer harbour has a more remote feel because of a lack of roads and houses. For example the 2013 census showed 75 people lived in Port Levy/Koukourārata although this number presumably grows during holiday periods.

5.25 The Port is a major feature of Lyttelton Harbour/Whakaraupō with berths and cargo storage areas associated with Cashin Quay and the inner Harbour, as well as petroleum storage, a dry dock, and engineering facilities to the west and the coal stockyard to the east.

5.26 Banks Peninsula as a whole is considered to be a regionally outstanding landscape[30] although a detailed landscape study identifies the crater rim areas and some key headlands as chiefly being the areas that have outstanding values.[31] Many parts of the coast are also considered to exhibit high natural character and this includes the headland and bays each side of Port Levy/Koukourārata. Further details of the landscape and seascape and their values are discussed in the report prepared by Boffa Miskell and attached in **Appendix 4**. Given these valued landscapes, the recreational opportunities and its proximity to Christchurch, there is likely to be a continued demand for permanent or holiday homes in Banks Peninsula generally.

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[29] Banks Peninsula was close to 100% forested when Europeans arrived but by the turn of the 20th century had little more than 1% cover. Today it is estimated that about 15% is in bush or scrubland. Source: Banks Peninsula Landscape Study, 2007 (Boffa Miskell Ltd).
[30] 2013 Canterbury Regional Policy Statement, see Appendix 4.
[31] Banks Peninsula Landscape Study, 2007 (Boffa Miskell Ltd).

5.27 Lyttelton Harbour/Whakaraupō is an important destination for recreationalists both on and off the water.[32] There are two yacht clubs located in the harbour: the Naval Point club at Lyttelton and the Charteris Bay yacht club and each hold regular club days. In addition, private yachts, wind surfers, and sea kayakers frequent the harbour, as do motorised craft. There are a number designated swing mooring areas and boatshed areas as well as jetties in various bays throughout the harbour.[33] People also swim at various bays in the harbour, and at Port Levy/Koukourārata.

5.28 A number of Lyttelton-based commercial recreation companies can be found on-line:

a. Jack Tar Sailing Company – chartered sightseeing and sail training in a classic yacht, with the possibility of dolphin viewing (http://jacktarsailing.co.nz/);

b. Learn 2 Sail – sailing tuition on Lyttelton Harbour/Whakaraupō (http://www.learn2sail.co.nz/);

c. Lyttelton Tug – public Sunday afternoon cruises from December to April or May and charters from September to June (approximately) by the Tug Lyttelton Preservation Society (http://www.nzmaritime.co.nz/tug.htm);

d. Black Cat Cruises – operates the Diamond Harbour Ferry as well offering trips to Quail Island and private charters and dinner cruises (http://www.blackcat.co.nz/);

e. Fox II – evening sailing charters on a classic sailing trawler in Lyttelton Harbour/ Whakaraupō, October to December (http://www.charterguide.co.nz/hts/604.htm); and

f. Volo Jetski Adventures – jet ski harbour tours and fly boarding (water 'jet pack'), including dolphin-spotting (http://www.volojetskis.co.nz/).

5.29 In terms of recreational fishing, a wide variety of fish species has been anecdotally reported in Lyttelton Harbour/Whakaraupō with most fishing taking place from boats in the outer Harbour. However, the lack of water clarity often affects the fishing and diving experience.[34] The best recreational fishing is reported to be a long way further off the coast or alternatively further up the coast off Motanau Island or at Kaikoura. Kingfish are reported to be caught off Taylors Mistake after Christmas.

[32] Rob Greenaway & Associates, attached at **Appendix 5.**
[33] These are shown on the Regional Coastal Environment Plan Maps, November 2005.
[34] Comment from Canterbury Sports Fishing Club members during consultation.

5.30 Surfing is popular at Taylors Mistake and Sumner although there are no surf breaks of national significance along this part of the coast.[35]

5.31 As described earlier, Te Hapū o Ngāti Wheke (Rāpaki) have traditionally fished for a range of species including pātiki (flounder), hoka, (red cod), aua (herring), hokarari (ling) koiro (conga eel) and the delicacy pīoke (sand shark). However fishing stocks today are insufficient to provide a regular food source for those living at Rāpaki.[36]

5.32 Tuatua (shellfish) such as pipi, tuaki (cockle), kutai (green lipped mussle), pāua, tio (oyster), kina (sea urchin) and pūpū (cat's eye) are found around Banks Peninsula but their populations, and the size of individuals, are variable. A key issue for Te Hapū o Ngāti Wheke and Koukourārata is to enable shellfish populations to recover so that there is a plentiful source of kaimoana.

5.33 Commercially, mussel farms that have established along the bays and headlands of northern Bank Peninsula, from Port Levy/Koukourārata to Squally Bay as shown on **Figure 5.3**. There are 24 active consents, held by 6 different consent holders. These consents authorise the growing of a number of species, including green shell mussels (*Perna canaliculus*), blue shell mussels (*Mytilus galloprovincialis*), algae (*Macrocystis pyrifera*, Ecklonia *radiata*, *Gracilaria spp.*, *Pterocladia lucida*, and *Undaria pinnatifida*), and for the collection of mussel spat. To date only green shell mussels are farmed along with the collection of green shell mussel spat.

5.34 The long-line method of mussel cultivation is used. That involves suspending the mussels in the water column, and leaving them to rely on the natural supply of food. The long-line ropes are attached to a series of about 50 plastic buoys, and screw-anchored to the seabed at both ends. The mussels are attached to a continuous rope that is lashed to the long-line at the surface, and loops down to around 10 m water depth. A typical farm consists of 8-10 long-lines, of about 100 m length, in an area of 2-3 hectares. Larger farms, such as at Squally Bay, are broken up into multiple smaller blocks. The report prepared by Tonkin Taylor attached in **Appendix 6** provides further background on the marine farms and key wild mahinga kai species.

[35] Rob Greenaway & Associates, attached at **Appendix 5.**
[36] Mahaanui Iwi Management Plan, page 256.

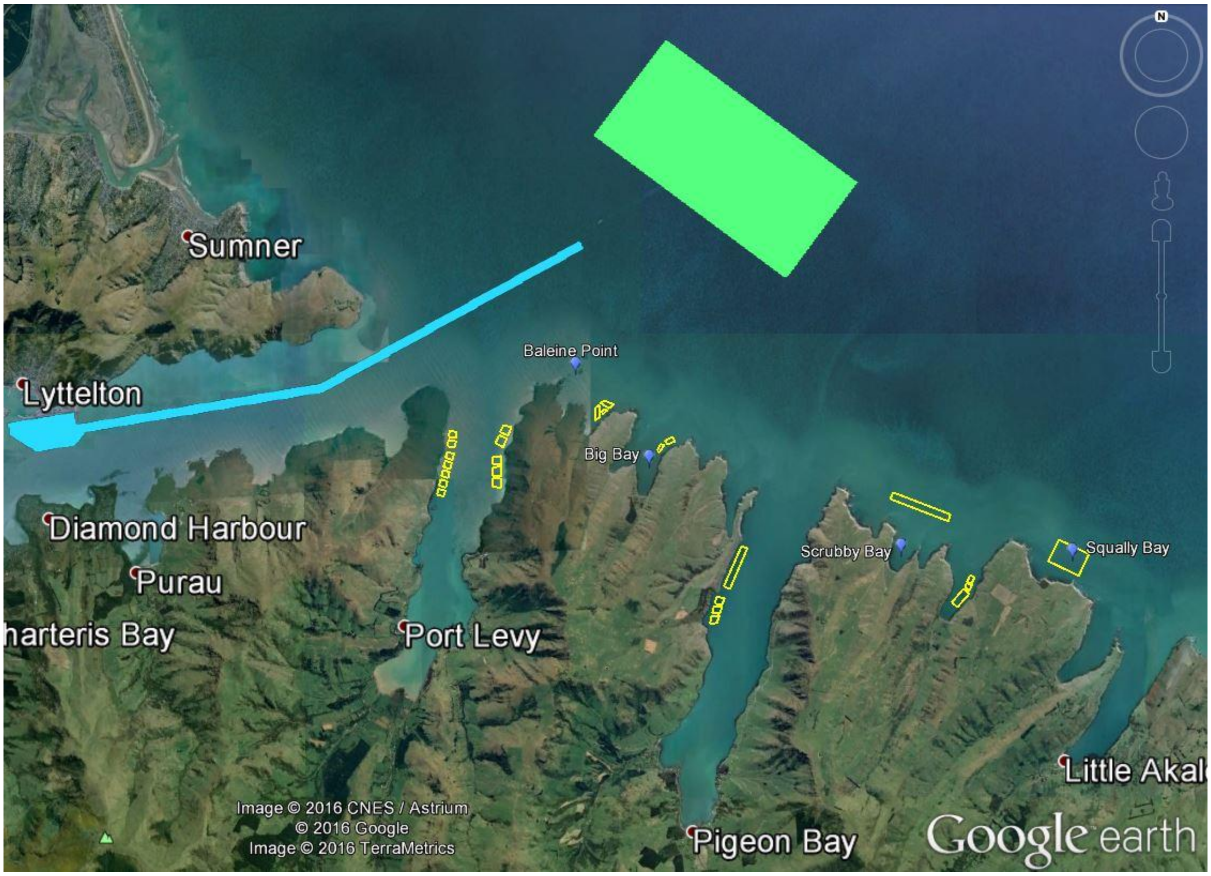

Figure 5.3: Existing marine farm sites (yellow open polygons) along the northern side of Banks Peninsula. Source: Tonkin & Taylor Ltd, 2016.

5.35 On land, there are a number of Crown and Local Government Reserves with associated walkways and mountain bike tracks that are managed by the City Council and the Department of Conservation.[37] Godley Head is an important visitor destination not only for its views but also because of its military heritage associated World Wars I and II, and the military buildings and gun emplacements constructed to protect the harbour and Christchurch.

5.36 Quail Island is also a visitor destination. It was used as a quarantine station and a small leprosy colony by the early European settlers. The island was then leased out for farming, but since the 1970s has become a recreational reserve and today the focus is on restoring native vegetation. Predator control has enabled the reestablishment of a

[37] There are also walkways on private farmland. This includes the well known Orton Bradley Park which is run by a body corporate and registered as a charitable trust, and further afield, the Banks Peninsula Walkway.

population of the rare white-flippered penguin. LPC has been a sponsor of this conservation work.

5.37 In summary, the harbours, bays and the coastline and the volcanic derived landscapes are fundamental to the character of Banks Peninsula. These attributes make the Peninsula a popular place for living, holidays and recreation. At the same time, Lyttelton Port, the marine farms and other commercial fishing operations are dependent on the Banks Peninsula coastal environment.

Canterbury and West Coast Economies

5.38 Statistics New Zealand estimated total employment in the Canterbury region in February 2015 at 284,110, representing 13.9% of the total persons employed in New Zealand. A breakdown of the employment numbers by sector and other matters discussed in this section are contained in the economic report attached in **Appendix 1**.

5.39 Apart from the tourism related aspects of sectors such as retail trade, education and training and accommodation and food services, the key drivers of the Canterbury economy remain largely agriculture and manufacturing. Employment in other sectors is to a large extent driven by the demand for goods and services by these industries and their employees with the so called “multiplier” effects creating additional jobs for the region’s economy.

5.40 Multipliers for a region such as Canterbury are typically in excess of two. In other words for each job created in an industry such as tourism, agriculture or manufacturing there is at least one additional job created in other industries providing goods and services required by that industry or the personal requirements of that industry’s employees and dependants. Conservatively assuming a Canterbury regional multiplier of only 2.0, the agriculture, forestry and fishing and manufacturing industry groups alone generate 99,840 jobs or 35% percent of the total employment in the Canterbury region. These two industry groups are highly dependent upon Lyttelton Port for exporting their finished products and importing goods required as inputs to their production activities.

5.41 Future employment growth and associated economic wellbeing for the Canterbury region is also likely to be largely associated with the three key economic drivers of agriculture, manufacturing and tourism, although disruptions due to the 2010 and particularly 2011

earthquakes have impeded tourism activity and is likely to do so for a number of years to come.

5.42 Until recently, Canterbury was a fast growing dairying region in New Zealand. Part of Fonterra's rationale behind the selection of Darfield for its new milk powder plant and more recent Studholme applications were the sites' proximity to Lyttelton Port (in terms of both distance and the availability of nearby direct rail access) for finished product exports and inputs to the production process.

5.43 Tourism (the third key driver of the Canterbury regional economy) is also dependent to a lesser extent upon Lyttelton Port, whilst the cruise ship trade is a small but growing segment of the tourism industry in Canterbury.

5.44 The West Coast regional economy relies on agricultural, mining and tourism sectors. Future economic growth for the West Coast economy is likely to depend on these three key economic sectors. The existing coal mining operations on the West Coast are heavily reliant on the Midland railway line and the coal export facility at Lyttelton. The West Coast is also reliant on Lyttelton Port and the complementary rail and road networks for imports including machinery, equipment, fuel and fertilizers.

Section 2: Natural and Physical Environment

Geological and Physical Oceanographic Setting

5.45 Lyttelton Harbour/Whakaraupō is a 15 km long, rock-walled inlet with an average width of approximately 2 km. As shown below in **Figure 5.4**, the upper harbour widens to form the three bays, Governor's Bay, Head of the Bay and Charteris Bay, separated by peninsulas and Quail Island. The harbour has a low-tide area of approximately 43 km^2 and a central, long axis oriented in an ENE-WSW direction.

Figure 5.4: Whakaraupō/Lyttelton Harbour. Source: satellite mosaic from Google Earth, 15 Feb 2011

5.46 The wider area of Banks Peninsula comprises two large Miocene (11 to 8 million years old) volcanoes, the central areas of which have collapsed and been eroded. Subsequent drowning by the sea has formed the Lyttelton and Akaroa inlets. The underlying volcanic rocks of the peninsula are commonly mantled by deposits of loess, up to 20 m thick and blown from the Canterbury Plains during the glacial period from approximately 2.6 million until 11.7 thousand years ago, and also loess colluvium (volcanic detritus). This fine sediment is readily eroded from the hill slopes and transported to the sea.

5.47 Prior to the glacial period Banks Peninsula was an island but was connected to land as the Canterbury Plains prograded from the continuing deposition of glacial outwash gravels and fines sourced from the Alps. These same gravels and fines continue to wash out into the sea and deposit on the continental shelf.

5.48 It has been estimated that up to 47m of sediment has in-filled the Harbour over many thousands of years.[38] As a result of this accretion and the high rates of resuspension, the seabed of the Harbour is flat in profile. Rocks are exposed at only two locations: Parsons Rock, north of Ripapa Island, and Shag Reef, north-east of Quail Island.

5.49 The infilling of the harbour basin has caused the formation of extensive tidal flats in Governor's Bay, Head of the Bay and Charteris Bay, which cover a combined area of about 11km^2 at mean low water springs. The historical clearance of forest and tussock grassland has led to an increase in soil erosion and stream sediment yields. Today, much of the cleared land around the Lyttelton Harbour/Whakaraupō and Port Levy/Koukourārata catchment is in grassland.

5.50 Ocean swells and winds from Pegasus Bay penetrate the Harbour up to the Port. These swells and waves have the ability to suspend the fine benthic sediments particularly in the shallower bays of the outer Harbour. There is only limited penetration of swell waves past the Port and into the upper Harbour where the wave climate is instead dominated by wind waves generated locally across moderate water fetches. However, the extensive shallows of the upper Harbour flats mean that these short period waves also maintain high levels of sediment suspension. The upshot is Lyttelton Harbour/Whakaraupō is often a turbid environment.

5.51 Although there is some variation, the overriding feature in the Harbour is a benthic community that is inherently tolerant of these turbid conditions: it has adapted to periods of very high suspended sediments resulting from persistent wave re-suspension of fine sediments.

[38] Although recent drilling by LPC suggests the sediment profile is deeper.

5.52 Banks Peninsula forms the dividing line between the Canterbury Bight to the south and Pegasus Bay to the north. Both the Canterbury Bight and Pegasus Bay are relatively shallow parts of the continental shelf. Much of the shelf was exposed as land during the last glaciation because sea levels were lower due to water being trapped in the large ice sheets. It was not until some 5,000-7,000 years ago that the present sea levels were attained resulting in the drowning of the shelf and the various inlets that form Banks Peninsula as mentioned earlier.

5.53 Pegasus Bay is a wide bay with most of the coastline comprising low-lying and generally stable sand and gravel beaches backed by extensive sand dune systems. The continental shelf at this point is wide, extending well offshore. Inshore regions are relatively shallow, deepening only gradually seawards with the 20 m and 30 m contours at 10 km and 35 km from the coastline, respectively, at Godley Head.

5.54 As shown in **Figures 5.5 and 5.6**, the main rivers continue to introduce large quantities of sediment to both Pegasus Bay and the Canterbury Bight. It is estimated that some 11 million tonnes of sediment is discharged into the Canterbury coastal marine area per annum. This large supply of predominantly fine sediment, augmented by loess which is eroded off Banks Peninsula, blankets the continental shelf. During large wave events, the sediment is re-suspended and is available for movement by currents. Further discussion of the coastal processes operating in the project areas is found in the report on coastal processes prepared by Tonkin Taylor and attached in **Appendix 7**.

5.55 As a result even calm waters are slightly turbid, which accounts for the characteristic aquamarine colour. Water clarity is often poor.

5.56 The satellite image in **Figure 5.7** shows the coastal plume of sediment drifting north around Banks Peninsula. The plumes are carried north by the Southland current which sweeps up the east coast of the South Island.

5.57 In the northern lee of Banks Peninsula a banner bank has formed as sediment from the Southland current drops out of suspension in the relatively protected waters. **Figure 5.8** illustrates the size and location of the banner bank and how the jutting out of Banks Peninsula causes a fluctuating anticlockwise eddy of the Southland current in Pegasus Bay.

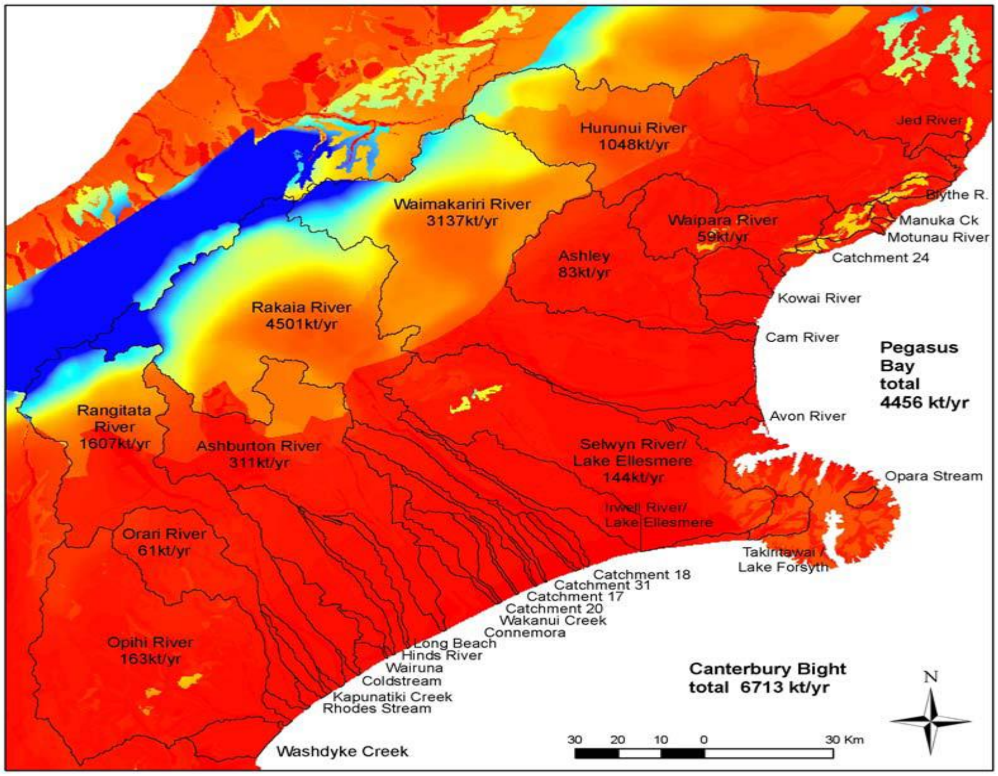

Figure 5.5: Estimated annual sediment yields for the major rivers draining to the Canterbury Bight and Pegasus Bay. Data from NIWA sediment yield model Source: Hicks *et al,* 2003.

Figure 5.6: Aerial photograph of a sediment plume from the Waimakariri River during flood conditions: Source Met Ocean Solutions Ltd, 2016

Figure 5.7: NASA satellite image of Banks Peninsula and Pegasus Bay showing the turbid coastal zone with a plume drifting northward past Banks Peninsula. Source: Fenwick *et al*., 2003.

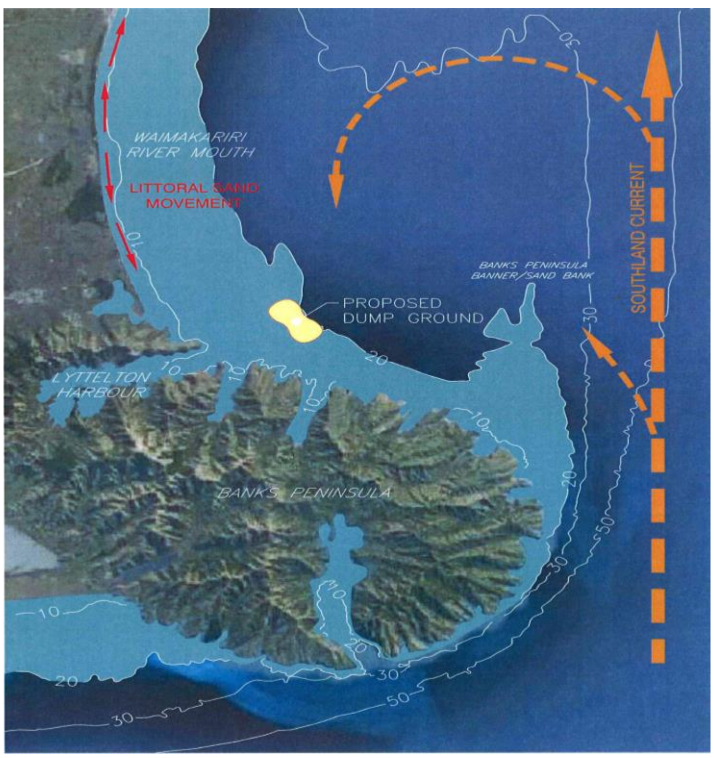

Figure 5.8: Extension of the 20 m contour depth at the north-eastern end of Banks Peninsula illustrating the banner bank as well as the antic-clockwise eddy of the Southland Current. Proposed offshore deposition ground shown in yellow. Source: OCEL Consultants NZ Ltd.

5.58 OCEL Ltd has measured turbidity optically (i.e. the degree of cloudiness) and the results at many locations show an exponential rise in turbidity near the seabed, reflecting the soft-sediment layer that is partially fluidised near the bottom (see **Figure 5.9**). Poor visibility is a feature of diving near the seabed, and features such as trenches associated with the CCC sewage outfall or the shipping channel fill up with sediment. As discussed below, sediment is disturbed and entrained into the water column during swell conditions. For further details refer to the report prepared by OCEL Ltd attached in **Appendix 8**.

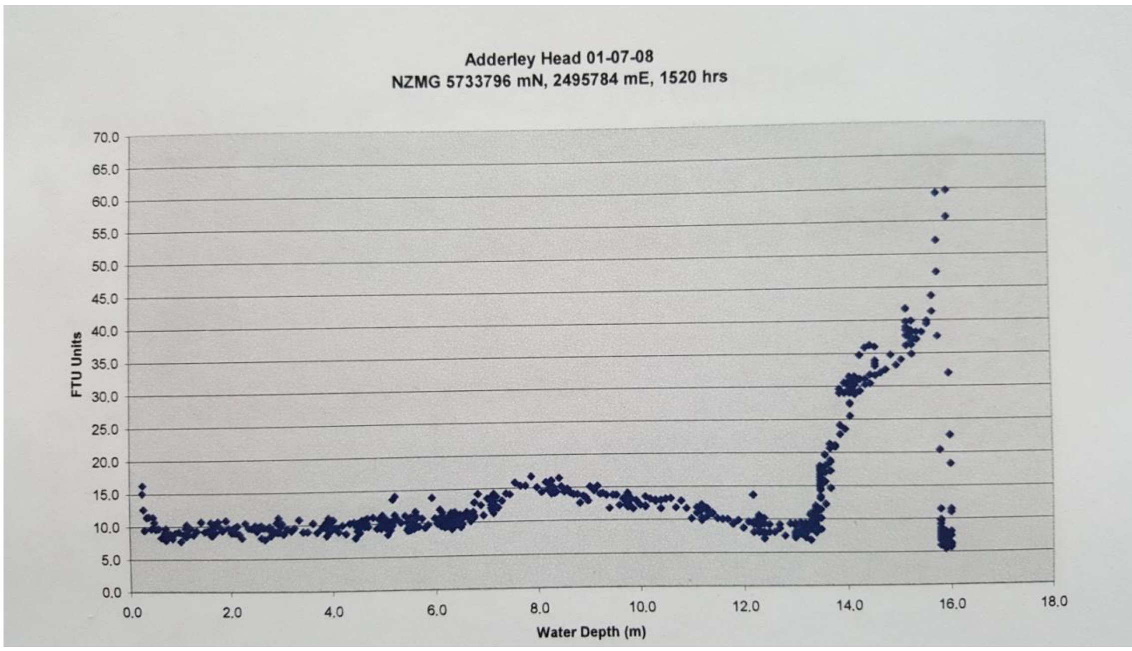

Figure 5.9: Marked increase of background turbidity near the seabed at Adderley Head. Source: OCEL Consultants NZ Limited, 2016.

Introduction to Waves and Currents

5.59 LPC has commissioned a range of studies since 2007 to better understand the coastal processes in the project area. How the waves and currents behave is of particular interest given the transportation of sediment generated from the dredging and deposition of spoil is a key issue associated with the project.

5.60 Waves have three parameters that describe them: their height (the distance between trough and crest), their period (time between crests), and direction. In a long, narrow

harbour like Lyttelton Harbour/Whakaraupō, wave direction is essentially constant, directed along the longitudinal axis of the harbour.

5.61 Sea waves are created by the action of the wind blowing over the sea or ocean. The friction from the wind causes the surface water to move in ripples which eventually form full waves.[39] The stretch of ocean water over which the wind blows is called the fetch; and, generally, the longer the fetch and/or the faster the wind speed the larger the wave. This is why the largest waves or swells usually occur during and just after storms.

5.62 Sea waves are also generated by local winds, such as the daily sea breeze that rises almost every morning in summer as the land heats up and draws cool ocean air shorewards. The period (time) between crests for sea waves is up to 7-8 seconds.

5.63 Swell waves, on the other hand, are generated by storms far away that have propagated over hundreds or even thousands of kilometres of ocean and have a period greater than 7-8 seconds.

5.64 Waves have the potential to disturb the seabed and entrain sediment in the water column. In principle, the longer the period between the wave crest, the deeper the wave orbital velocities can penetrate the water column, and if strong enough can reach the seafloor and generate bed shear stress needed to move the sediment particles and entrain them into the water column.[40]

5.65 It follows that in deeper areas, longer-period (swell) waves are need to disturb the sediment whereas shallower areas shorter wave-periods will also be able to disturb sediment. These principles are shown diagrammatically in **Figure 5.10**.

5.66 This is why the upper Harbour for example is generally more turbid than the outer Harbour or in Pegasus Bay because relatively small sea waves can more regularly entrain sediment.

[39] As waves near the coast the frictional force from the seabed acts on the base of the wave so it slows down relative to the top of the wave. Eventually a critical point is reached where the top of the wave (the crest) curves over and creates a breaking wave.
[40] The sediment grain size is also an important in determining the shear strength of the sediment and hence the degree of shear stress needed to move the sediment.

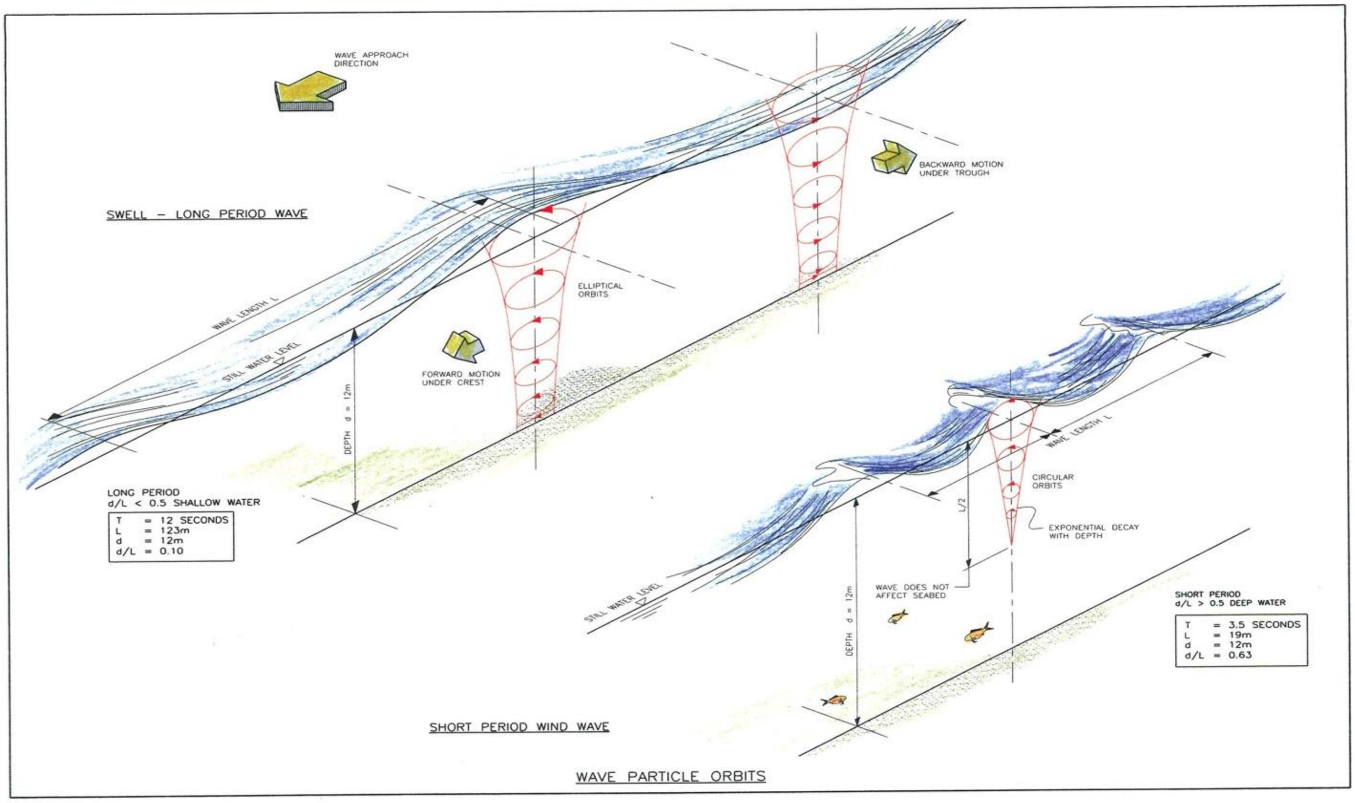

Figure 5.10: The long period wave in this diagram is shown to disturb the seabed. It is notable that material will be transported shoreward under the crest of the wave but then is counteracted by a backward motion under the trough. Conversely, the short period wind wave does not disturb the bottom at this depth. Diagram prepared by OCEL Consultants NZ Ltd.

5.67 The waves are the predominant mechanism for entraining sediment into the water column. The sediment is then carried principally by the sea currents, which are discussed next.

5.68 There are five sorts of currents. For simplicity these can be considered as tidal currents and non-tidal currents. Tidal currents occur when the ocean rises and falls in response to gravity pull principally from the moon and sun.

5.69 Non-tidal currents can be generated by a range of processes, e.g.:

a. Large-scale oceanic currents (geostrophic currents).[41] The Southland current flowing northwards past Bank Peninsula, causing a fluctuating back-eddy in Pegasus Bay is a relevant example (see **Figure 5.8**);

[41] Geostrophic currents are formed due to pressure gradients being caused by large-scale planetary processes where the water moves from where the pressure is higher toward where the pressure is lower.

b. Seiche induced currents. Seiche is a Swiss word to describe the tide-like oscillations of Lake Geneva. The term is commonly used to describe the oscillation of a body of water;

c. Wave-induced currents that form when storms occur or when swells are produced from storms further away (even thousands of kilometres away). Wave height gradients over an area can generate wave-induced currents;

d. Wind-induced currents that form from the wind, which are usually stronger in the upper part of the water column.

5.70 Near the coast and in inlets such as Lyttelton Harbour/Whakaraupō, the tidal currents are the dominant forcing whereas further offshore the non-tidal currents become more important. The term "*residual current*" is used to describe the observed net current speed and direction after subtracting the astronomical tidal current.[42] Calculating the residual current is important because sediment is preferentially transported in the direction of the residual current.

5.71 An asymmetry in the ebbing and flooding tidal currents can result in short period residual currents. Net residual currents can also result from eddy structures near headlands such as the entrance to Lyttelton Harbour/Whakaraupō that preferentially form during a specific tidal phase.

5.72 In summary, it is the waves that in most circumstances entrain the sediment in the water column. Once entrained the tidal currents, by and large, move this sediment back and forth before settling out but sediment can be transported in a preferential direction due to the "residual" current.

5.73 Hydrodynamic models are developed to resolve the different types of currents operating and then integrate the currents to predict the net movement of the current in an area. These models are discussed next.

[42] Residual currents are difficult to quantify because they are to some extent stochastic (the result of random processes), which means that we can only be sure what they were at a particular location over the period of measurement. In contrast, tides are deterministic, meaning mathematical models based on Newton's laws can be used to determine how they vary in time and space.

Modelling and Measurement of Currents and Waves in the Project Area

5.74 Hydrodynamic models have been used to characterise currents and waves in the project area. This has been augmented by measurement work. A hydrodynamic model is a tool that describes the motion of water[43] and is generated by inputting 10 years of tidal-and large-scale ocean current information, meteorological conditions, as well as the local bathymetry[44] into a computer. The model then generates a model of tides at any one location.

5.75 'ROMS' has been used to model the currents at the proposed offshore disposal grounds. ROMS is an acronym for 'Regional Ocean Modelling System', and it examines both tidal and residual (non-tidal) currents over large areas. In essence the ROMS model uses the previous 10-years data[45] to assume what will occur in the future.[46]

5.76 'SELFE' has been used inside Lyttelton Harbour/Whakaraupō. SELFE is an acronym for 'Semi-implicit, Eulerian-Lagrangian Finite Element.' SELFE provides more accurate predictions than ROMS for shallow-waters near and abutting the coastline but can only be used in smaller areas because it is computationally demanding and impractical to do at this time.

5.77 Detail of how the models work and the assumptions behind them are contained in the specialist reports prepared by Met Ocean Solutions Ltd and Mulgor Consulting Ltd. These models are also used to underpin the sediment transport models used by Met Oceans Ltd and discussed in **Chapter 6**. It is only in recent years that computers have become powerful enough to model sediment transport and so this work is a significant advance in the evolution of this project since 2008.

5.78 The reports prepared by Met Ocean Solutions Ltd address:

a. Plumes generated by dredging activities (**Appendix 9**);

b. Plumes generated by disposal activities at the proposed offshore capital spoil disposal ground (**Appendix 10**);

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[43] The basis of computational hydrodynamic models is a set of equations that describe the motion of fluids: the Navier-Stokes equations. These equations are derived from Newton's laws of motion and describe the action of force applied to the fluid and the resulting changes in flow.

[44] Bathymetry is data defining the depth of the seafloor.

[45] Called hindcast modelling.

[46] An older model, developed by the National Institute of Water and Atmosphere ('NIWA'), is presented in the AEE simply to illustrate how the tidal currents broadly behave in Pegasus Bay and around Northern Banks Peninsula.

c. Plumes generated by disposal activities at the proposed offshore maintenance spoil disposal ground (**Appendix 11**);

d. Behaviour of sediment after deposition at the proposed offshore capital spoil disposal ground (**Appendix 12**); and

e. Behaviour of sediment after deposition at the proposed offshore maintenance and at Godley Head spoil disposal ground (**Appendix 13**).

5.79 The report prepared by Mulgor Consulting Ltd addresses the effects of a deepened channel on waves and tidal currents and non-tidal seiche currents within Lyttelton Harbour/Whakaraupō and is attached in **Appendix 14**.

5.80 Measurement of currents has also been completed using an Acoustic Doppler Current Profiler (ADCP). ADCPs are sonar devices, detecting the Doppler shift of back-scattered sound signals and can analyse current speed and direction through the whole water column.

5.81 An ADCP can be used in two ways:

a. It can be suspended from the side of a boat and the boat will go back and forth collecting data to obtain a 3-dimensional record of current over the subject area during a tidal cycle.

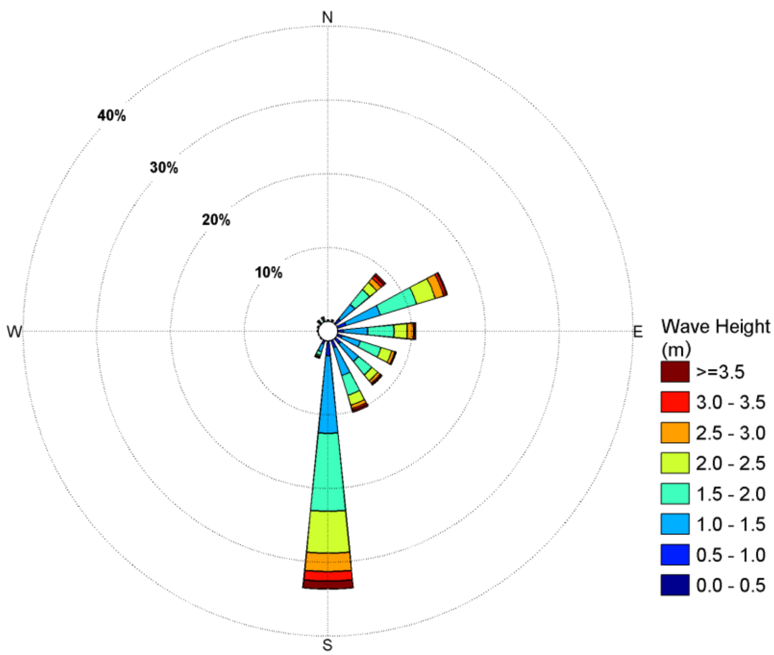
b. Alternatively, the ADCP can be placed on the seabed (bottom-mounted) and measure the currents at a particular location over many tidal cycles and in different weather states. The bottom-mounted ADCP also has the ability to measure any tidal imbalances occurring at a location over a period of time.

5.82 Drogues are an older method that is still used when weather conditions are too rough to deploy a boat-mounted ADCP. Drogues are buoys with concrete weights which are released from a boat and tracked using a GPS. The weight sits in the water below the buoy.

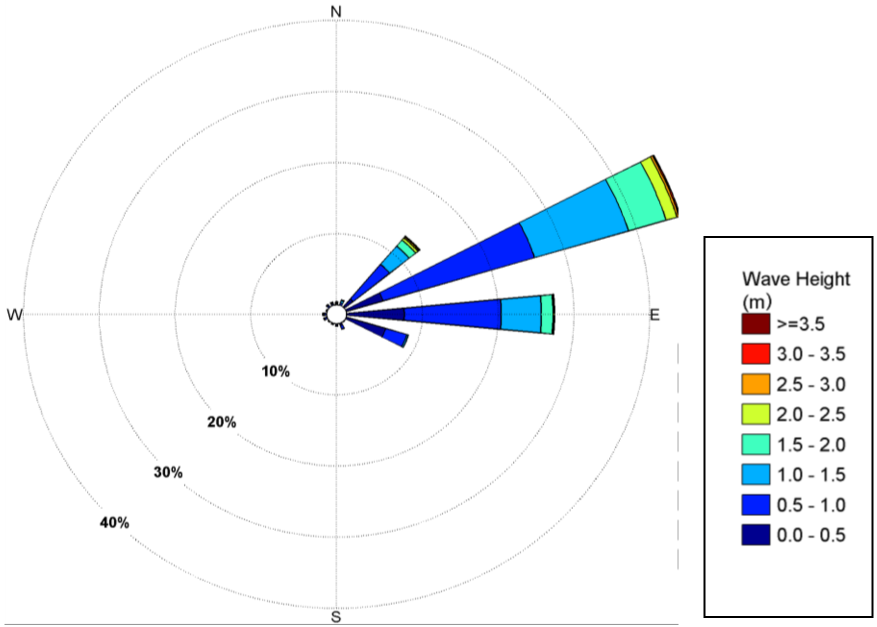
5.83 LPC has employed all three measuring techniques, and further measurement work is currently taking place to provide a robust baseline before dredging commences and to provide further information to enable the modelling work to be updated.

General Description of the Waves and Currents in Pegasus Bay

5.84 The offshore wave climate in Pegasus Bay is dominated by southerly swell conditions, mixed with less frequent wave events from the southeast and northeast quarters (see **Figure 5.11a**). Most northerly events are locally generated with lower wave periods, but can still be relatively energetic in terms of wave heights (i.e. up to 3.5 m and more). In contrast, at the proposed offshore disposal grounds the wave conditions are from the east-northeast quadrant (see **Figure 5.11b**). The change in direction is due to the waves refracting around Banks Peninsula as illustrated in **Figure 5.8** earlier.[47]



[47] Refer to the Met Oceans Solutions Ltd report attached in Appendix 10 for further detail.



Figures 5.11a and 5.11b: Wave roses from the 10-year wave climate approximately 6km east of the nearest point of Banks Peninsula (above) and offshore disposal ground (below). Source: Met Ocean Solutions, 2016.

5.85 Turning to the tidal currents, **Figure 5.12** illustrates how the tidal currents operate along Pegasus Bay and around the northern-side of Bank Peninsula. Each ellipse on Figure 5.9 illustrates the general direction and strength of the M_2 tide[48] at any one point. In deep ocean water, off the continental shelf, the tidal ellipse is usually circular whereas near the coast the ellipse is thin with a considerably shorter minor axis, reflecting a comparatively stronger, unidirectional tidal current.

5.86 The long, thin ellipsoid at the north-eastern corner of Banks Peninsula shows a stronger, unidirectional tidal current running around Banks Peninsula, while the more circular ellipse outside Lyttelton Harbour reflects a greater onshore-offshore tidal component in the area. This is due to water entering and exiting Lyttelton Harbour.

[48] The tide is the largest or strongest tidal component over one high and low tide cycle: roughly a 12½ hour cycle.

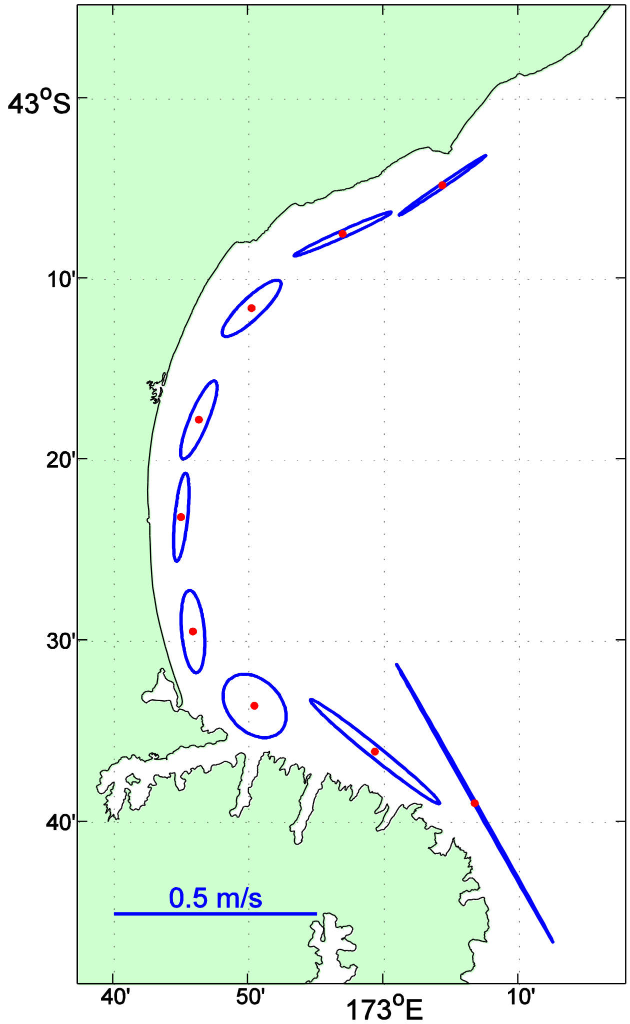


Figure 5.12: Tidal ellipses for the M_2 tide around the coastline of Pegasus Bay. Source: Mulgor Consulting Ltd, 2009.

5.87 The stronger, unidirectional tidal currents switch from ebb to flood (and vice versa) in a few seconds or minutes, whereas when the minor axis is appreciable (fat ellipse), the current has a cross channel component as the tide switches from ebb to flood (and vice versa).

5.88 As illustrated in **Figure 5.8** previously the jutting out of Banks Peninsula causes a fluctuating anticlockwise eddy of the Southland current in Pegasus Bay. As shown in **Figure 5.13**, the residual currents derived from the ROMS model for the month of February 2006 demonstrates the eddy operating. As discussed later this appears to be the driver of the residual current at the proposed disposal ground.

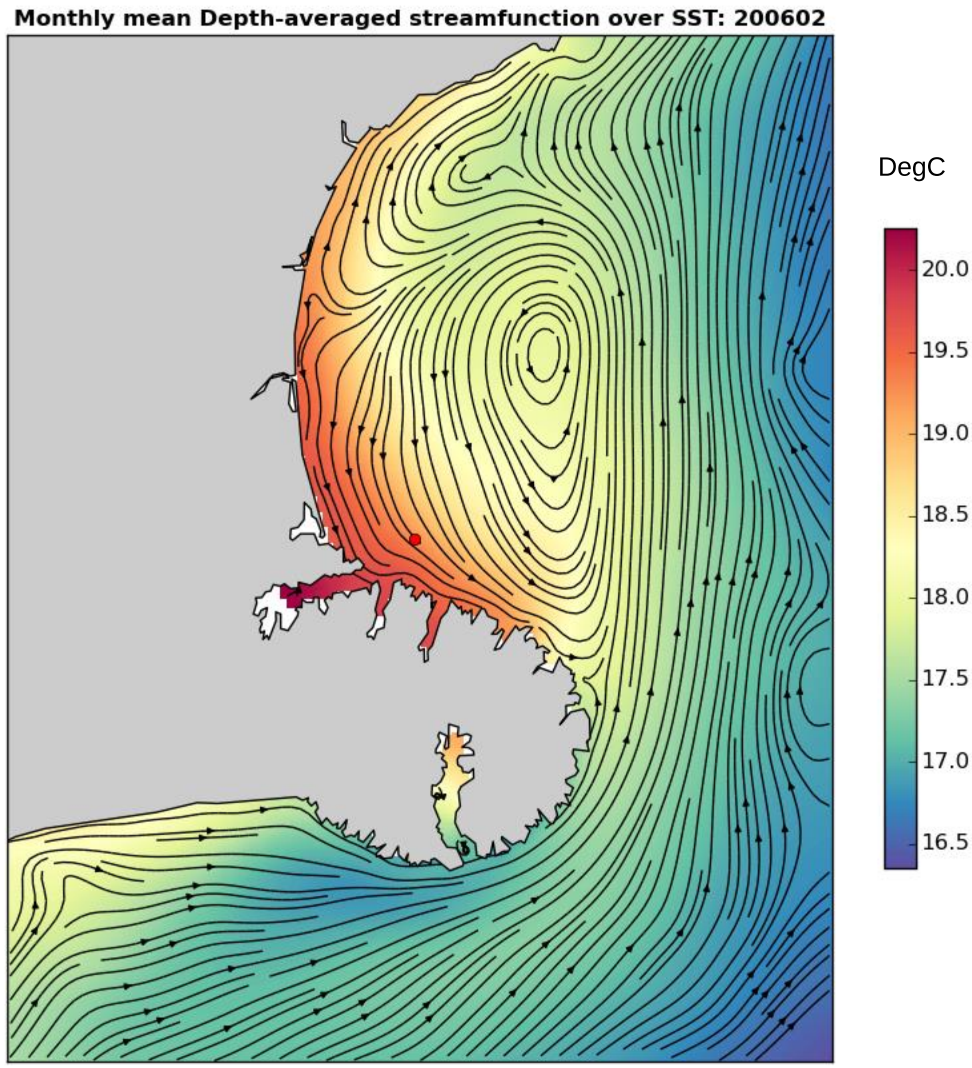


Figure 5.13: Monthly averaged residual flow for February 2006 for the ROMS Pegasus Bay, showing good agreement with literature-based flow features. The red dot at the proposed disposal ground is where current observations were used to validate the model results. Temperatures show the gradation from the cooler offshore waters within the Southland Current to the warmer near-shore waters, which form part of the eddy in the lee of Banks Peninsula. Source: Met Ocean Solutions Ltd, 2016.

Description of the Waves in Lyttelton Harbour/Whakaraupō

5.89 The present wave climate in Lyttelton Harbour/Whakaraupō and Port Levy/Koukourātata is presented in **Figure 5.14** which shows a contour map of the mean significant wave height.[49] At the Harbour entrances, the wave heights are at their largest and the heights attenuate further up the Harbour.

[49] 'Significant Wave Height' is the height that would be estimated by a ship's master from the bridge of a large vessel and is used to characterise the sea state at any given time (i.e. calm or rough). Technically, the significant wave height (SWH), or H_s or H_{sig}, is the average wave height (trough to crest) of the one-third largest waves.

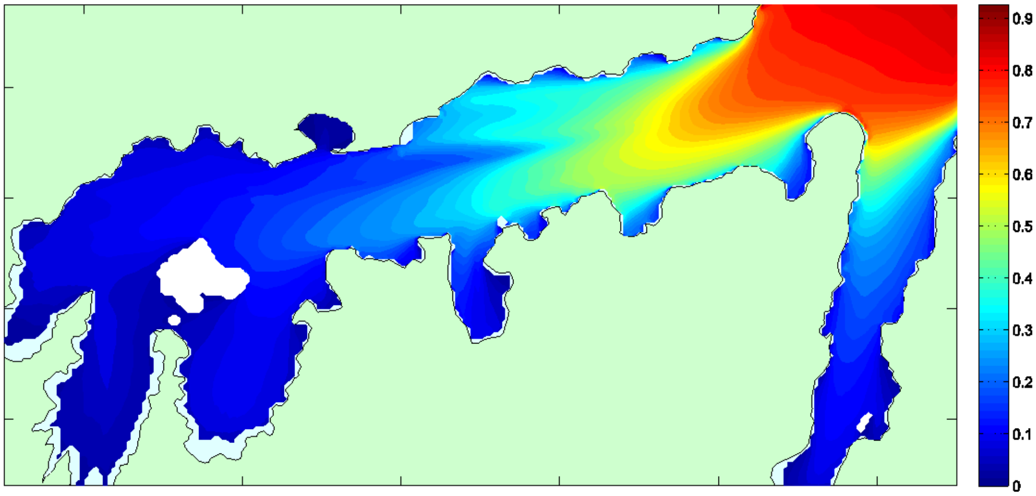


Figure 5.14: Distribution of mean significant wave height in Lyttelton Harbour/Whakaraupō and Port Levy/Koukourārata. Source: Mulgor Consulting Ltd, 2016.

5.90 The attenuation with distance in Lyttelton Harbour/Whakaraupō is shown clearly in **Figure 5.15** which shows the variation in various wave height statistics along the thalweg,[50] which is shown in **Figure 5.16**. The 95% and 99% statistics represent the wave heights that are only exceeded for 5% and 1% of the time respectively.

5.91 **Figure 5.17** shows that for all wave height statistics, there is rapid attenuation in wave height between 1 and 6 km from the Harbour entrance, but thereafter the attenuation is much slower. The attenuation is caused by the effects of shoaling[51] and friction and by refraction from the centre of the harbour to the northern and southern beaches where the waves break. These processes result in a reduction in the wave energy that has entered the Harbours.

5.92 The attenuation of swell waves is much larger than that of sea waves. For example, at 6 km from the harbour entrance, the swell waves have reduced to one tenth of their height at the entrance (see **Figure 5.18**).

[50] The thalweg is the line of maximum depth.
[51] Shoaling is the deformation of the waves, which starts when the water depth becomes less than about half the wavelength. The shoaling causes a reduction in the wave propagation velocity as well as shortening and steeping of the waves.

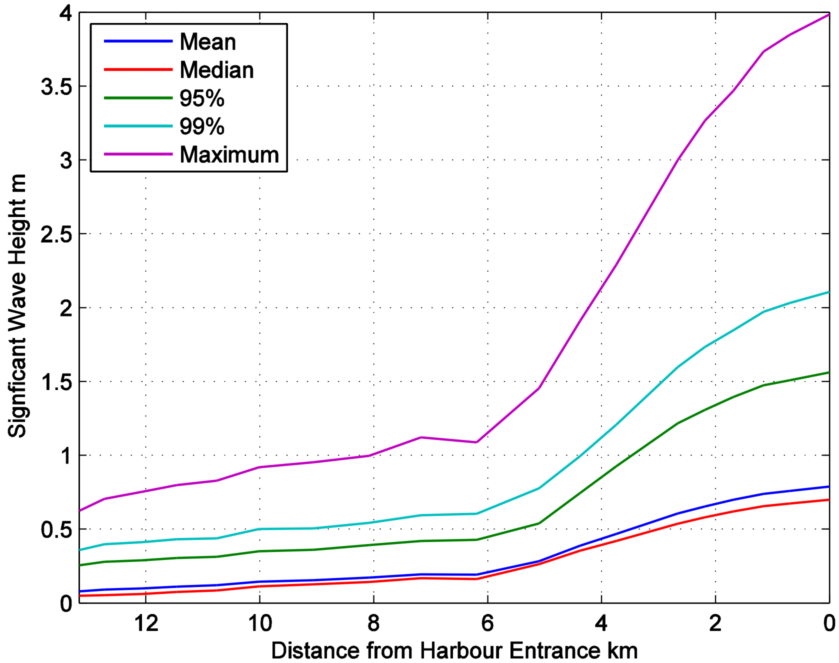


Figure 5.15: Dissipation in wave heights up the Harbour. Source: Mulgor Consulting Ltd, 2016.

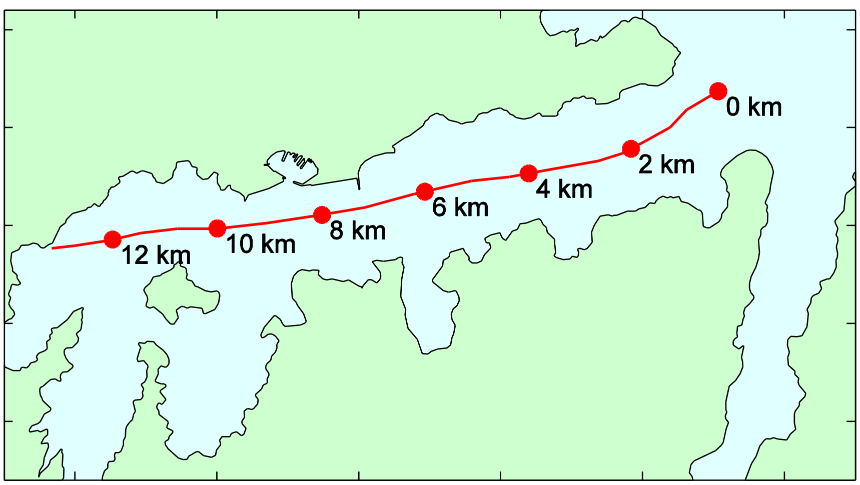


Figure 5.16: The thalweg in Lyttelton Harbour/Whakaraupō and distances from the entrance. Source: Mulgor Consulting Ltd, 2016.

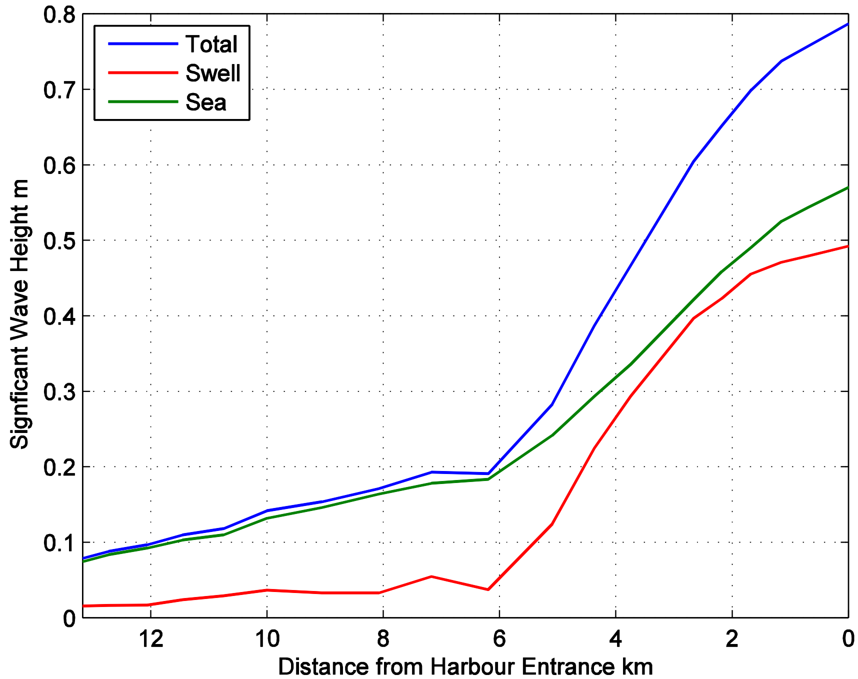


Figure 5.17: Dissipation in sea and swell wave heights up the Lyttelton Harbour/Whakaraupō. Source: Mulgor Consulting Ltd, 2016.

5.93 It is notable that, in general terms, swells in the mid to outer Harbour represent a significant proportion of the wave energy whereas that proportion decreases with distance into the harbour, becoming essentially negligible at Rāpaki.

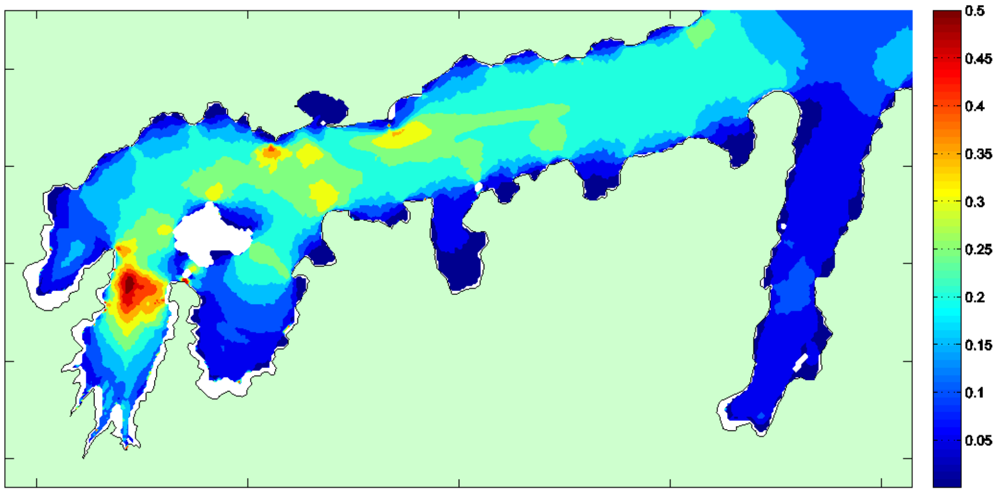
5.94 The time between the between crests of the waves (period) also reduces further up the Harbour. The waves at a particular location and at a particular time will have a whole range of periods from a second or two (chop or sea waves) to thirteen seconds (swell). The distribution of energy with period is called the wave spectrum. The period of the dominant waves is called the "peak period" because that is the period of maximum energy.

5.95 At the Harbour entrance, wave periods are about 9 seconds and reduce further up the Harbour, dropping to about 7 seconds at Governors Bay. This reduction in period again corresponds to long-period waves dissipating due to shoaling and friction as they propagate into the shallow water of the Harbour, while the short-period, locally-generated waves are affected less.

Description of Currents in Lyttelton Harbour/Whakaraupō

5.96 In the Harbour the tidal currents predominate with incoming tides and outgoing tides flowing up and down the axis of the Harbour. **Figure 5.18** shows the current speeds at mid-ebb (flow out of the harbour) and mid-flood (flow into the harbour) during perigean spring tides.[52]

5.97 The largest currents speeds occur around the ends of the Cashin Quay and Naval Point breakwaters and in the Head of the Bay where the water is quite shallow (~ 1.5 m). Relatively large currents also occur at various places around Quail Island. This occurs because the island displaces the tidal flow, causing the flow to speed up as it passes around the obstruction. The effect is most pronounced around points or features that protrude into main tidal flow.



[52] The perigean spring tide is a tide that occurs three or four times a year when the Moon's perigee (its closest point to Earth during its 28-day elliptical orbit) coincides with a spring tide (when the Earth, Sun and Moon are nearly aligned every two weeks).

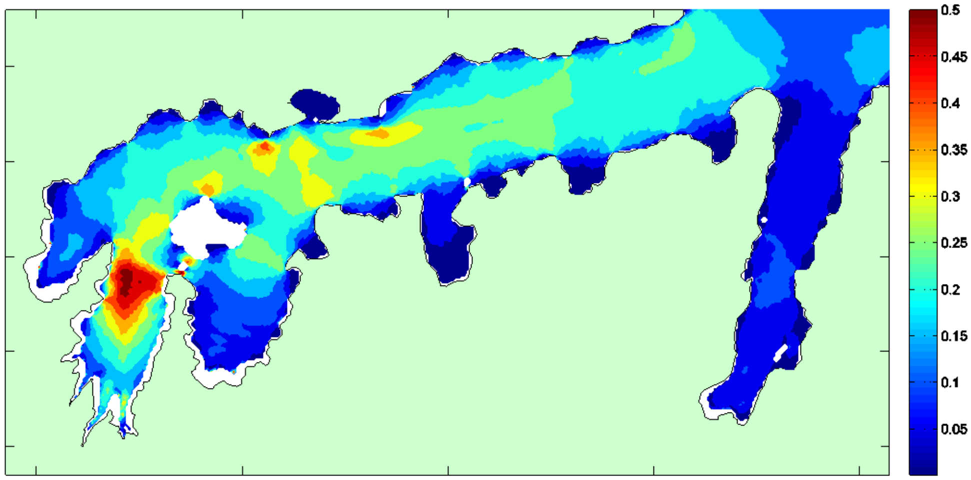


Figure 5.18: Speed (m/s) of tidal current at mid-ebb tide (top) and mid-flood tide (bottom) for a perigean spring tide. Source: Mulgor Consulting Ltd, 2016.

5.98 A number of drogue releases have been carried out by OCEL Consultants NZ Ltd over the years to examine the excursion distances of the tidal currents. An excursion distance is how far an object will be moved by either the flood or ebb tide over a specified number of tidal cycles. **Figure 5.19** for example shows the excursion distances for various drogues.

5.99 The drogue released in the upper Harbour was tracked for two days but did not leave the upper harbour. The results indicate tidal excursion distances are in the order of 3.5 km. While the asymmetry of the tide allows the interchange of water between those (conceptual) partitions shown on **Figure 5.19** it does illustrate that it will take several tidal cycles for the bulk of the water from the upper reaches to leave the harbour system altogether.

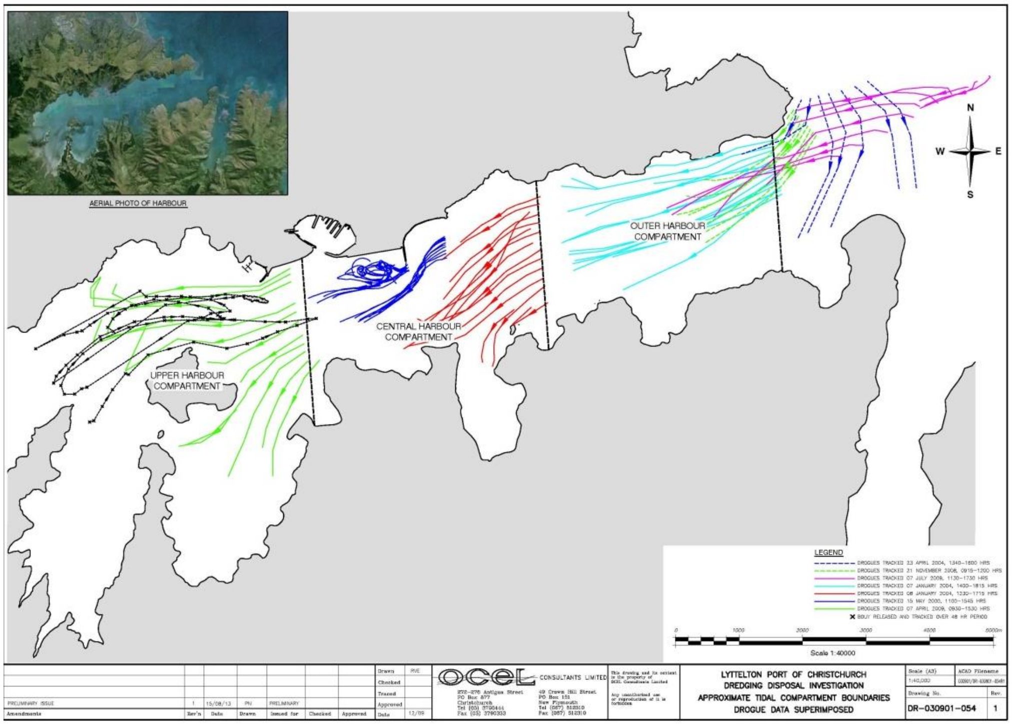


Figure 5.19: Approximation of the three compartments in Lyttelton Harbour derived from drogue results. Drawing provided by OCEL Consultants NZ Ltd.

5.100 As part of examining the potential effects of dredging on the upper Harbour (see **Chapter 6**), neutrally buoyant particles were dropped into the velocity field in the hydrodynamic model for the primary *M2* tidal current, as illustrated in **Figures 5.20 and 5.21**. This work also provides an estimate of the tidal excursion distances.

5.101 **Figure 5.20** shows the trajectories that neutrally-buoyant particles take when released from various locations in the Upper Harbour at mid-ebb in a perigean spring tide. The trajectories are for two tidal cycles. Except for the particle released in Charteris Bay, there is remarkably little variation in the trajectories between one tidal cycle and another. Further analysis of the Charteris Bay trajectory has shown that it is not sensitive to the exact position where the particle is released; the trajectories always drift towards Quail Island. The extent of the trajectories is quite variable, with the longest being 4 km for the particle released to the north of Quail Island to 2 km for the particle released in Governors Bay.

The trajectories of particles released at mid-ebb and mid-flood tides at Diamond Harbour are shown in **Figure 5.21**. A particle released at ebb tide will travel towards the open

sea, but return to close to the same spot and oscillate back and forth. On the other hand, a particle released at flood tide will travel around into Charteris Bay and with each tidal cycle will drift slowly towards Quail Island.

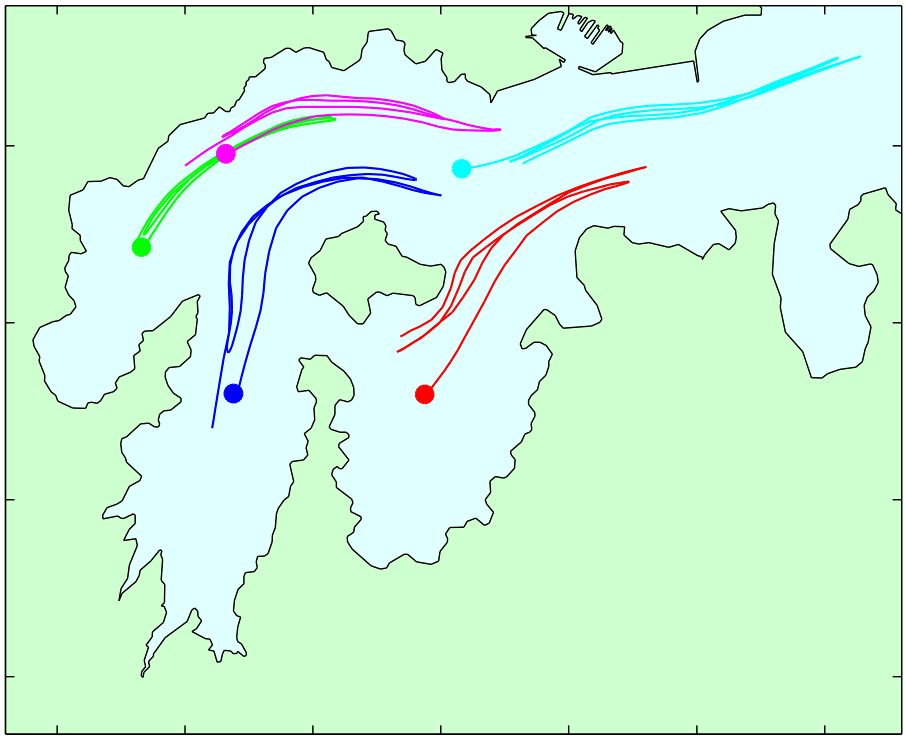


Figure 5.20: Trajectories of neutrally-buoyant particles released in the upper Harbour for the present scenario. The blobs are at the point of release. Source: Mulgor Consulting Ltd, 2016.

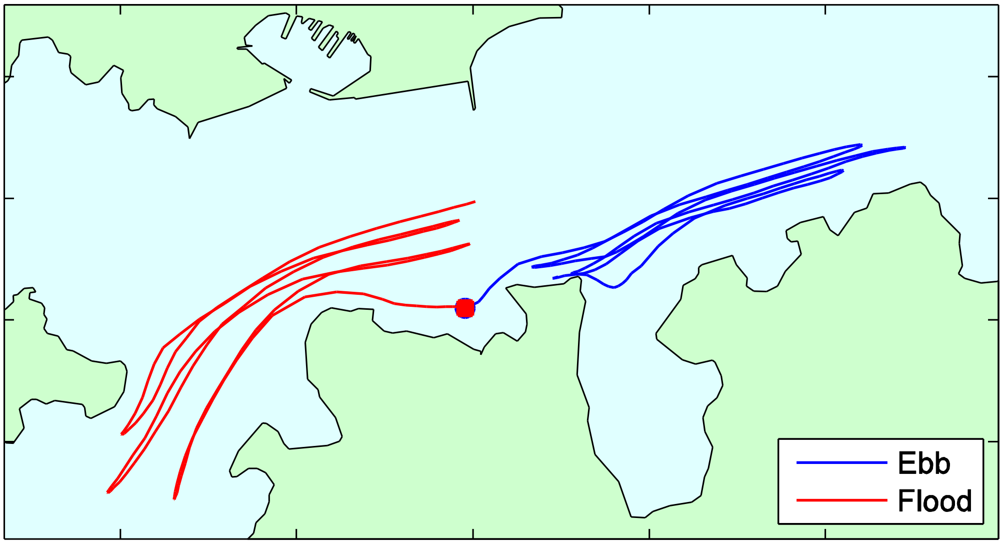


Figure 5.21: Trajectories of neutrally buoyant particles released at mid-ebb and mid-flood tide at Diamond Harbour. Source: Mulgor Consulting Ltd, 2016.

5.102 A typical excursion of a particle over the full tidal cycle is 2 to 4 km and the patterns are consistent with the drogue studies that show the Harbour consists conceptually of three tidal compartments: outer, middle and upper; and there is indirect communication between them. This work shows that sediment cannot be readily transported between the dredging and disposal areas and the upper Harbour. If there had been evidence of any significant quantities of sediment accumulating in the upper Harbour escaping into the central Harbour area for example, then it would have found its way into shipping channel and necessitating a more frequent dredging effort.

Residual Currents due to Tidal Imbalances in Lyttelton Harbour/Whakaraupō

5.103 The tidal currents do not move the water as a uniform block up and down the Harbour; rather, there are various tidal imbalances. The ADCP measurement work confirmed a tidal imbalance at the Harbour entrance, expressed in a clockwise eddy shown in **Figure 5.22**. It appears the bulk of water entering the middle to the southern parts of the harbour entrance during the flood tide creates the clockwise eddy. As discussed in **Chapter 4**, because of this work disposal of maintenance dredge spoil has been focussed at Godley Head because it was assumed at least a portion of sediment would escape the Harbour system due to the residual current associated with the eddy.

5.104 Sticking Point Breakwater also causes a clockwise eddy (or gyre) seen immediately to the east of it.

Description of Currents at the entrance of Port Levy/Koukourārata

5.105 A survey using a boat-mounted ADCP shows the ebb current shearing off Adderley Head to the east, past the mouth of Port Levy/Koukourārata before swinging around to the north-west further out. A weak clockwise eddy develops in the mouth of Port Levy/Koukourārata at the end of the ebb current and continues for a couple of hours into the flood tide. A very weak anti-clock wise eddy develops just after high tide. The two eddies appear to develop as the tidal current shears past what is essentially the still water of the Port Levy/Koukourārata Inlet.

5.106 The mean tidal current has a major axis speed of 0.08 m/s[53] directed in the ENE-WSW direction at the harbour entrance. The minor axis speed is negligible. The work is further described in the OCEL Ltd report attached in **Appendix 8**. This is consistent with the tidal ellipses generated and shown in **Figure 5.13**.

5.107 A residual current is directed SSE into Port Levy/Koukourārata and is about half the speed of the tidal current (approximately 0.04 m/s). It is not known whether this weak residual current relates to the weak clockwise eddy forming but it is assumed that it must be counteracted with an equivalent small residential current in the opposite direction at the edges of the inlet mouth.

5.108 Drogues were also released on the ebb tide north north-east of Adderley Head. This was to further test whether the outgoing tidal current from Lyttelton Harbour could enter Port Levy/Koukourārata. It was carried out during a light north-easterly wind tending north-west. The results are shown on **Figure 5.23**. The outer buoys again show the current passing the Port Levy/Koukourārata mouth. Interestingly, the inner buoys appeared to be caught in the clock-wise eddy which was detected by the ADCP on the ebb tide described above. No drogues entered Port Levy/Koukourārata.

[53] 1 metre/sec = 1.94 knots.
1 knot = 1 nautical mile/hour = 1.85 kilometres/hour = 0.51 metres/sec.

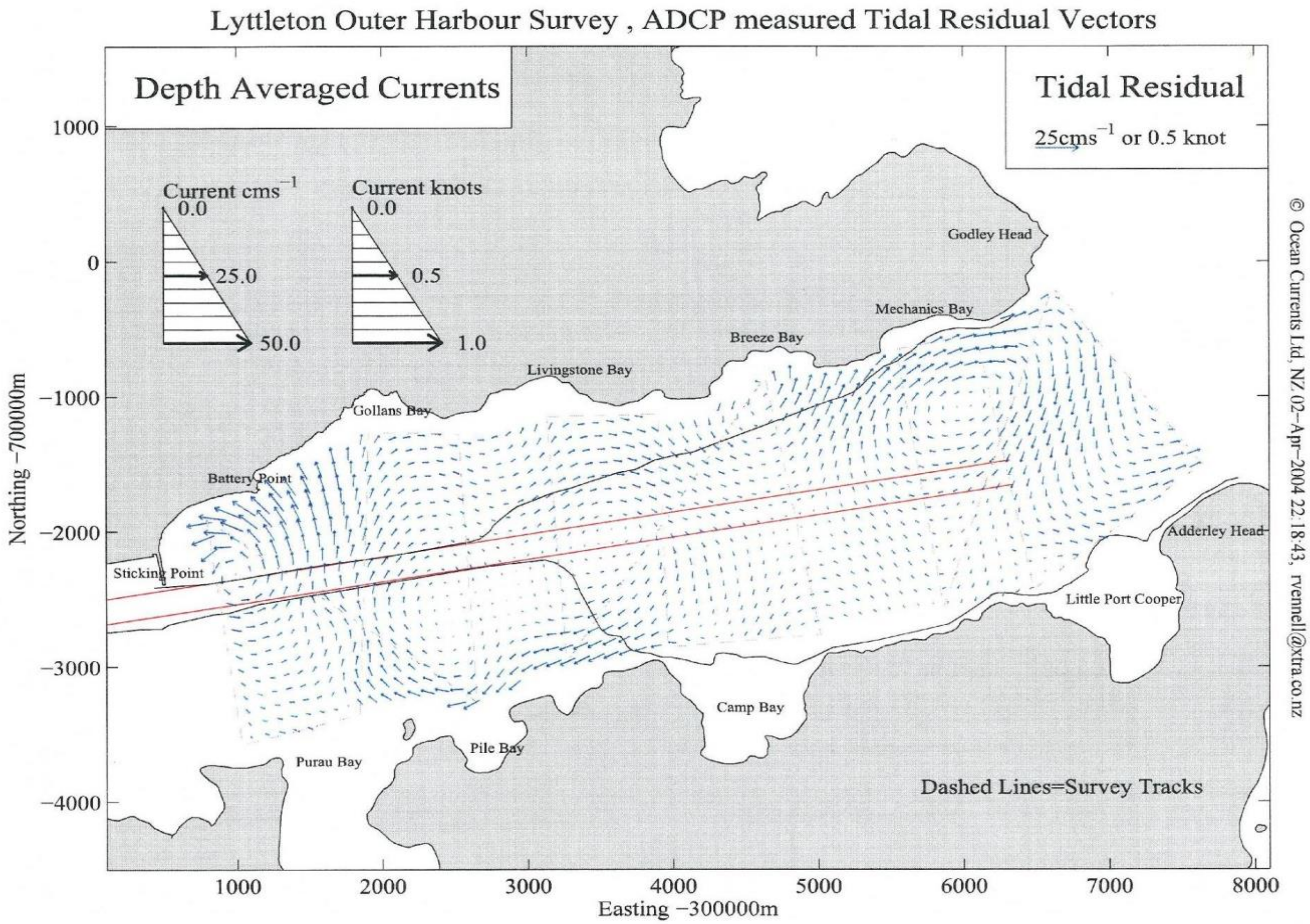


Figure 5.22: Tidal Residual, mean currents on 100 m grid. The strength of the current is shown by the vectors. The anticlockwise gyre off by Mechanics Bay. This tidal imbalance enables sediment to be removed out of the harbour system. Another clockwise gyre can be seen to the east of Sticking Point Breakwater. Source: OCEL Consultants NZ Ltd, 2013.

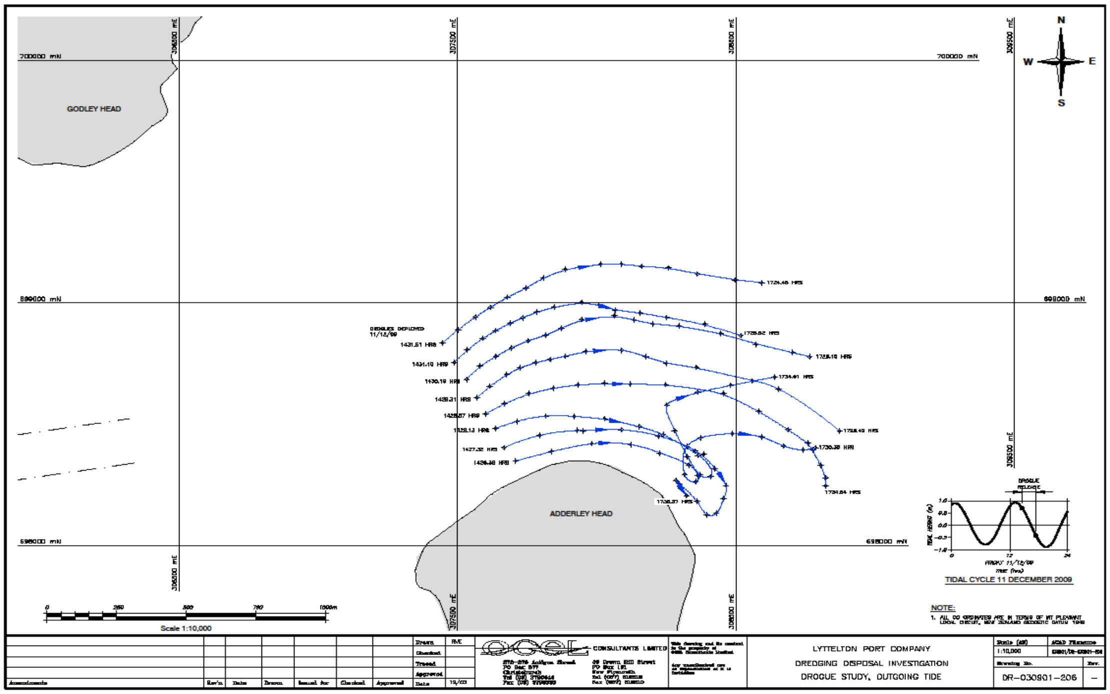


Figure 5.23: Drogue releases north north-west of Adderley Head on the ebb (outgoing) tide. Source: OCEL Consultants NZ Ltd, 2013.

Description of the Waves and Currents at the Proposed Offshore/CDP Disposal Grounds

5.109 The M_2 tidal ellipse has been generated from the ROMS model and, as expected, the tidal ellipse is more circular and has a weaker tidal current compared to the main axis of Lyttelton Harbour i.e. less than 0.1 m/s in the long axis - see **Figure 5.24**.

5.110 The tidal currents have also been measured using bottom-mounted ADCPs at the proposed offshore spoil dumping ground, and 1 km shoreward of the grounds. The tidal currents represented 60-70% of the total current energy for a 67-day measurement period. The mean tidal current has a major axis speed of 0.100 m/s[54] directed in the ESE-WNW direction (parallel to the coastline) and a minor axis speed of 0.048 m/s in the NNE-SSW direction (normal to the coastline). These results are consistent with the model and also boat-mounted ADCP results.

54 1 metre/sec = 1.94 knots.
1 knot = 1 nautical mile/hour = 1.85 kilometres/hour = 0.51 metres/sec.

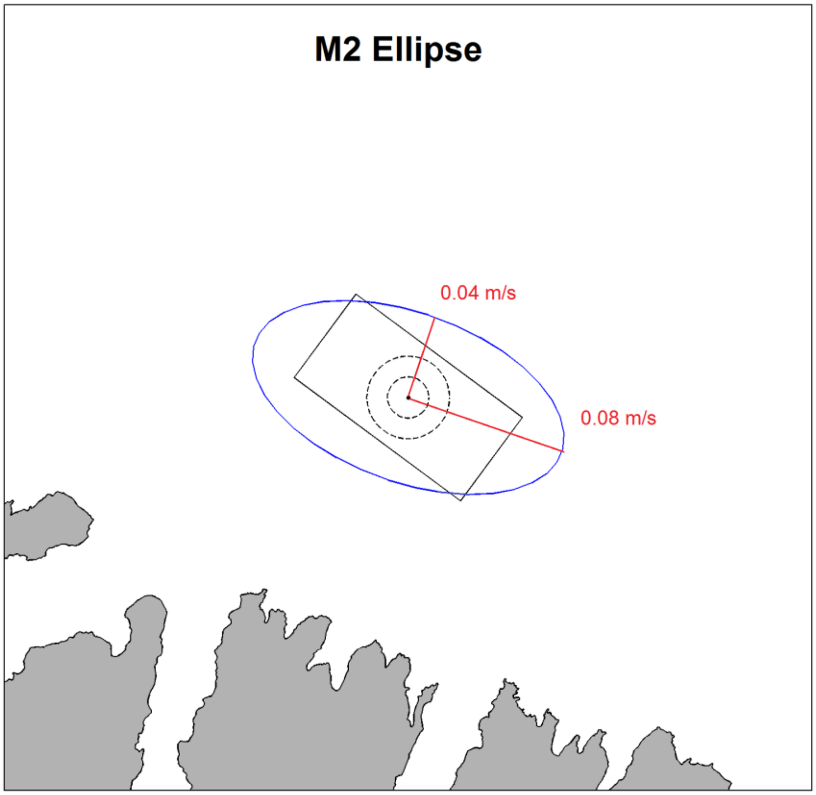


Figure 5.24: Tidal ellipse for the M_2 tidal at the proposed off-shore dumping ground. Source: Met Ocean Solutions Ltd, 2016.

5.111 The ROMS model has been used to calculate the residual currents at the proposed offshore grounds. As shown in **Figure 5.25** the residual currents at the proposed offshore dump ground is dominated by long-shore northwest or southeast-directed currents with magnitudes of up to approximately 0.3 m/s during peak events. However, when considered over the 10-year period the residual currents in each direction cancel themselves out and there is only a very small net residual in the order of 0.001 m/s towards the south-east.

5.112 The measurement work carried out by ADCPs over a 40-day period also records residual currents in the southeast and north-west direction at the proposed offshore grounds. The residual currents were recorded as being constant towards the southeast, with magnitudes that are one-third to half the tidal currents, but punctuated with stronger residual currents to the south-east or occasionally to the north-west. The irregular residual current event was observed to occur over 1-2 days with a return period of 1-

2 weeks. It was assumed these effects were caused fluctuations associated with the gyre of the Southland current. The model could not resolve these individual events.

5.113 Met Ocean Solutions Ltd also examined how residual currents behave in different wave events (caused by different weather events) and notes that in most events the residual currents are of a small magnitude, directed to the southeast or northwest. However, the two most energetic southerly wave events tend to be associated with northwest-directed residuals while others show predominantly southeast-directed residuals.

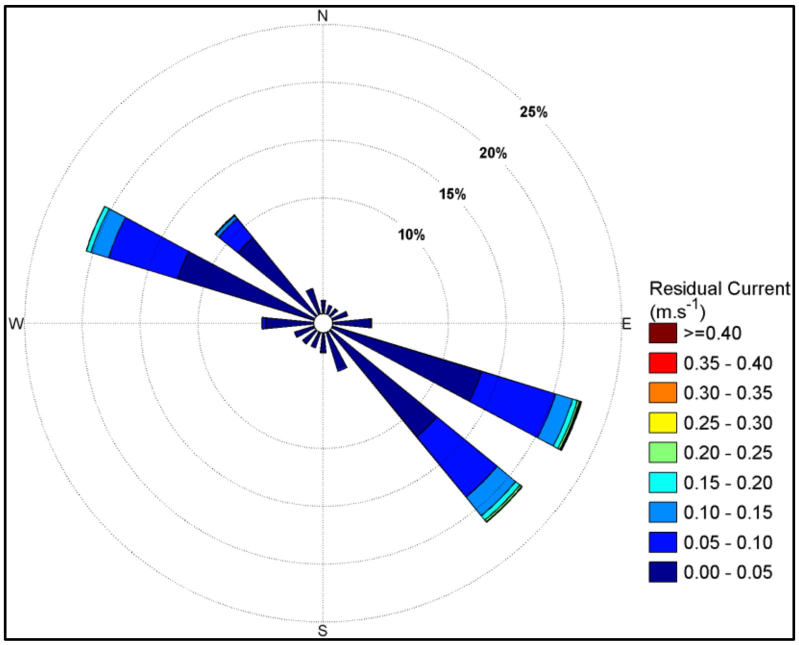


Figure 5.25 Residual current rose from the 10-year hindcast residual (non-tidal currents modelled at the centre of the proposed offshore dump ground. Source: Met Oceans Solutions Ltd.

Description of the Waves at the Offshore Grounds

5.114 The wave rose at the proposed offshore disposal ground is shown in **Figure 5.10b**. The mean significant wave height (Hs) is estimated at the centre of the spoil ground to be 0.987 m and at eastern boundary 1.12 m. This is slightly greater than the HS wave height at the entrance to the Harbour which is approximately 0.8 m.

5.115 Similarly, the wave periods are about 9.7 seconds which is slightly larger than those at the entrance of the Harbour (~9.0 seconds) and unsurprisingly the swell waves dominant over sea waves, occurring 75% of the time.

Biological Setting

5.116 The biological setting discussed below has been summarised from reports prepared by the Cawthron Institute and Boffa Miskell.

5.117 The reports prepared by Cawthron address effects on benthic and marine ecological resources (**Appendix 15A**) and effects on marine mammals (**Appendix 16**). The report prepared by Boffa Miskell addresses effects on marine avifauna (**Appendix 17**).

5.118 **The benthic habitats** of Pegasus Bay are typically composed of relatively uniform semi-consolidated mud which lack any hard substrate features. As a consequence the benthic communities as a rule are comparatively sparse with quite low species richness, often having a numerical prevalence of polychaete taxa[55] as well as taxa such as ostrocods, crabs and cumaceans.

5.119 The shallow **sub-tidal reefs** along the exposed coastline are dominated by giant kelp (*Macrocystis pyrifera*) and the common kelp *Ecklonia radiata* and in places the bull kelp (*Durvillea antarctica*). A variety of other taxa occur, including the tunicate *Pyura pachydermatina*, and a rich understorey of bryozoans, mussels (*Perna canaliculus*), ascidians and sponges. Mobile gastropod species are also abundant, predominant species being the Pāua *Haliotis iris,* the topshell *Trochus viridis* and the turbinid *Cookia sulcata*. The sea urchin *Evechinus chloroticus* has been recorded at depths of 3–5m. Finfish in this zone include banded wrasse, spotties and leather jackets.

5.120 The **intertidal zone** is characterised by abundant tubeworms and barnacles as well as periwinkles, limpets, chitons and cat’s eye snails in the upper shoreline zone. In the mid-shore zone, mussels, oysters and algae become more prevalent. The low-shore areas are characterised by the taxa in the mid-shore zone although sponges and tunicates begin to occur and the diversity of algae continues to increase.

[55] Taxa (plural) means a group of organisms, in this case from different orders.

5.121 The most notable **marine mammal** in the area is the Hector's dolphin / Upokohue (*Cephalorhynchus hectori*). Banks Peninsula has a relatively large population with approximately 1500 of these individuals. The greatest densities of dolphins along the northern bays occur between Baleine Point (the eastern-most headland of Port Levy/Koukourātata and Stony Beach (just west of Okains Bay) although the highest densities in Banks Peninsula are found in the eastern bays.

5.122 A Banks Peninsula Marine Mammal Sanctuary was created under section 22 of the Marine Mammals Protection Act 1978 around Banks Peninsula in 1988 to protect Hector's Dolphin from being caught in set nets. The sanctuary was extended in 2008 and now extends from the Waipara River to the Rakaia River, and out to a distance of twelve nautical miles. Seismic surveying work is also controlled within this area.

5.123 In addition there is a total ban on all set netting in specified areas of Banks Peninsula during the summer period and only trawl nets with defined low headline heights may be used within two nautical miles of the shore.

5.124 Other infrequent transient dolphin species along the coast include the cosmopolitan common dolphins, bottlenose dolphins, dusky dolphins, and orca.

5.125 Southern right and hump back whales are notable seasonal transients. Since the cessation of whaling, the southern right whale populations have been gradually increasing and internationally they listed as "least concern" due to on-going population recovery. It is unclear whether the southern right whales belong to a distinct, small population or whether they are part of a larger sub-antarctic population. The southern right whales nevertheless are listed as a "Nationally Vulnerable" species by New Zealand's National Threat Classification.

5.126 Due to the recent revelation of illegal commercial whaling in the 1960s and 1970s and the slow population recovery, the Oceania stock of humpback whales is considered endangered internationally but is simply considered a *migrant* under the New Zealand Threat Classification System.

5.127 Small populations of New Zealand fur seal (*Arctocephalus forsteri*) can be found around many of the headlands of Banks Peninsula and the occasional sighting of the leopard

seal (*Hydrurga leptonyx*) has been reported.[56] The New Zealand fur seal in general has shown recovery around New Zealand and Australia, and Banks Peninsula is one of many high density areas, mainly associated with breeding rookeries. The closest breeding colonies are in the eastern and southern bays of the Peninsula, over 20 km away from the proposal sites.. It is noted, however, that New Zealand fur seals cover large distances, rarely remaining at any one location year-round and non-breeding haul-outs can occur along the coast around Lyttelton Harbour.

5.128 Lyttelton Harbour and the surrounding coastline also provide a diversity of habitat types for **marine avifauna** for nesting, roosting and foraging activities.

5.129 A subset of 17 marine avifauna species have been identified as having an association with the waters of the Lyttelton Harbour or the offshore disposal area, and a local breeding or wintering population within Lyttelton Harbour or the wider Bank Peninsula.

5.130 These 17 species comprise penguins, fairy prion and sooty shearwater, tern, shag, gull and waders, and inhabit two major ecosystems; the coastal (including the outer Lyttelton Harbour and the offshore area where dredged material will be disposed) and intertidal areas within the Lyttelton Harbour.

5.131 The foraging behaviour and diets of these species are described in the marine avifauna report (**Appendix 17**). A number of these species have very high or high ecological value because they have been respectively classified as ‘Threatened – Nationally Vulnerable’ and ‘At Risk’.

5.132 The relatively shallow and semi-sheltered waters of the area support a large range of demersal and pelagic fish species, all of which are widespread in occurrence and distributed widely along the east coast of the South Island.

5.133 Recreational fishing in Lyttelton Harbour/Whakaroupo is not highly rated, but does occur.

5.134 With respect to **finfish** blue cod, red cod, red gurnard, butterfish, sea perch, rock lobster, Pāua, kina, mussels and blue moki are targeted by recreational fishers in the near-shore coastal environment of Banks Peninsula. Many of these species are strongly or exclusively associated with near-shore reef habitats.

[56] http://www.birdingnz.net/forum/viewtopic.php?f=12&t=2883&start=10.

5.135 The upper Harbour mudflats are an important nursery for fish species such as sole (*Peltorhamphus novaezeelandiae*), red cod (*Pseudophycis bachus*), spotted stargazer (*Genyagnus monopterygius*) and flounder (*Rhombosolea* sp.). The upper Harbour is targeted for flatfish.

5.136 Department of Conservation has reported that commercial fishers catch flatfish, red gurnard, rough skate, and elephant fish in waters less than 50 m deep and lemon sole, red cod, red gurnard, tarakihi, warehou, spiny dogfish, and barracouta are caught in waters between 50m and 100m. In the middle depth fishery between 100m and 200m the main trawl species are red cod, barracouta, warehou, ghost shark, jack mackerel, and spiny dogfish.

5.137 The Ministry of Primary Industries data extract for Pegasus Bay species records that flatfish are targeted inshore, with elephant fish (*C. milii*) and red gurnard (*Chelidonichthys kumu*) representing high value by-catch. Approximately 63 tonnes of flatfish species was caught over a three-year period in a 'cell' centred at the Harbour entrance. The two cells within which the proposed offshore disposal ground sits shows a much smaller catch weight. The data appears consistent with comments during a meeting between LPC and commercial fishers in July 2007 where it was stated that fishing boats catch the more valuable yellow-bellied flounder (*Rhombosolea leporina*) outside a line between Godley Head and Baleine Point over 6-8 months in each year. Sand flounder (*R. plebeia*) is targeted further offshore where it is sandier. These two species, together with some sole, form the principal component of Pegasus Bay flatfish catches.

5.138 Other species are concentrated well offshore from Lyttelton Harbour/Whakaraupō and the proposed offshore disposal ground locations. The catch weight recorded against the area offshore from the easternmost longitude of Banks Peninsula (effectively from outside Pegasus Bay) represented 83% of the total. The proposed offshore disposal ground partially occupies two grid cells that represent a combined catch weight of 0.8% of that for the total area considered.

Survey Results of the Seabed and Seafloor Communities

5.139 The benthic environment has been characterised by using a combination of discrete benthic sampling and broad survey methods, outlined as follows:

a. Collection of benthic sediment samples for physical, chemical and ecological analyses (macrofauna);

b. Sampling of benthic epifauna (surface-dwelling fauna) using a research dredge;

c. Broad-scale sonar imaging of the seabed over the wider area;

d. Quantitative surveys of shallow subtidal reef substrates; and

e. Semi-quantitative intertidal surveys.

Channel Extension and Offshore Disposal Grounds

5.140 As shown on the map in **Figures 5.26a** and **5.26b** a large number of benthic stations have been sampled over the years for the Channel Deepening Project and during the monitoring of maintenance dredging.

Physical Characteristics of the Sediment

5.141 Sediment within the top 15cm of the seabed was sampled in order to help explain the benthic communities present. Grab contents (taken from each survey station shown below) indicated a relatively uniform benthic substrate of fine cohesive mud with little in the way of larger shell or mineral particulates. The grain size analyses performed in the laboratory confirmed these observations, with all samples being dominated by the fine mud and silt fraction (particle sizes of less than 63 μm).[57] This was expected given the high riverine inputs of fine sediment into Canterbury Bight and into Pegasus Bay and the locally eroded loess from Bank Peninsula.

5.142 The organic content of the surface sediment was relatively low which indicates sufficient oxygenation of the sediment due to diffusion, re-suspension of sediment, and due to mixing by soft sediment benthic communities. No strongly anoxic conditions were observed in any of the sediments.

[57] The south side of the Harbour however had a greater percentage of sand.

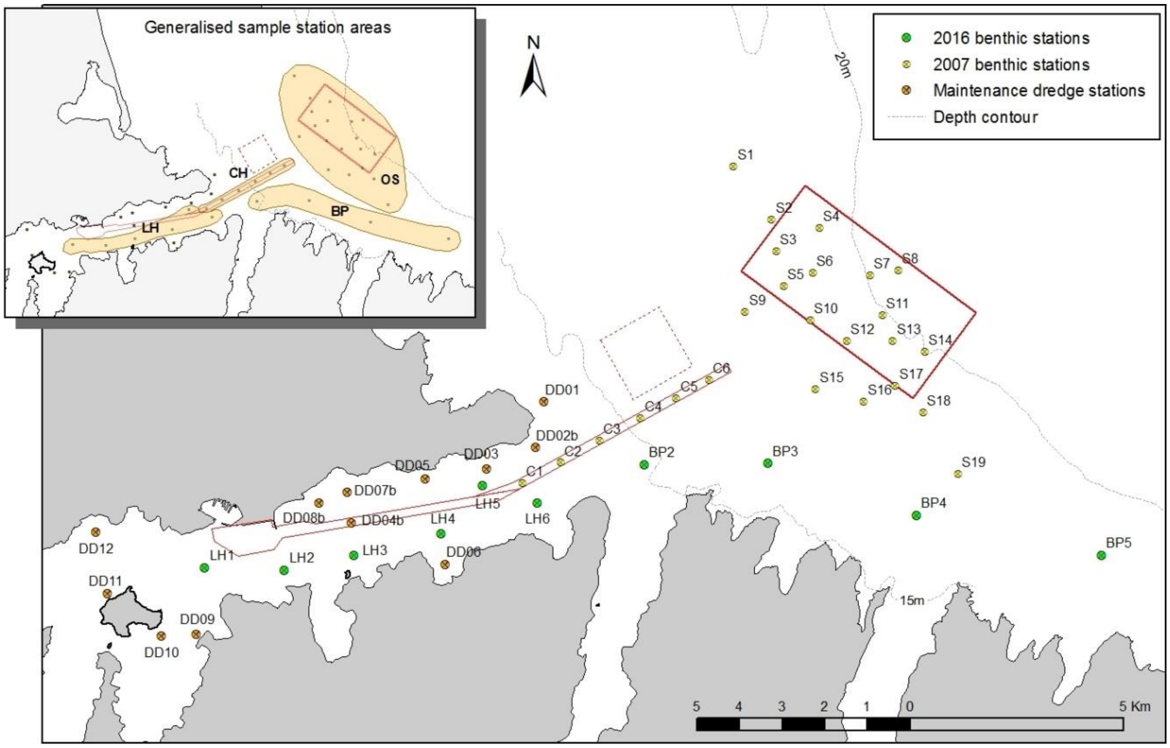


Figure 5.26a: Spatial layout of benthic grab sampling stations. Field surveys conducted October 2007 to January 2008 and in February 2016. Benthic sampling stations (1992 – 2015) associated with LPC's maintenance dredging consent are also shown. Source: Cawthron Institute Report 2860, 2016.

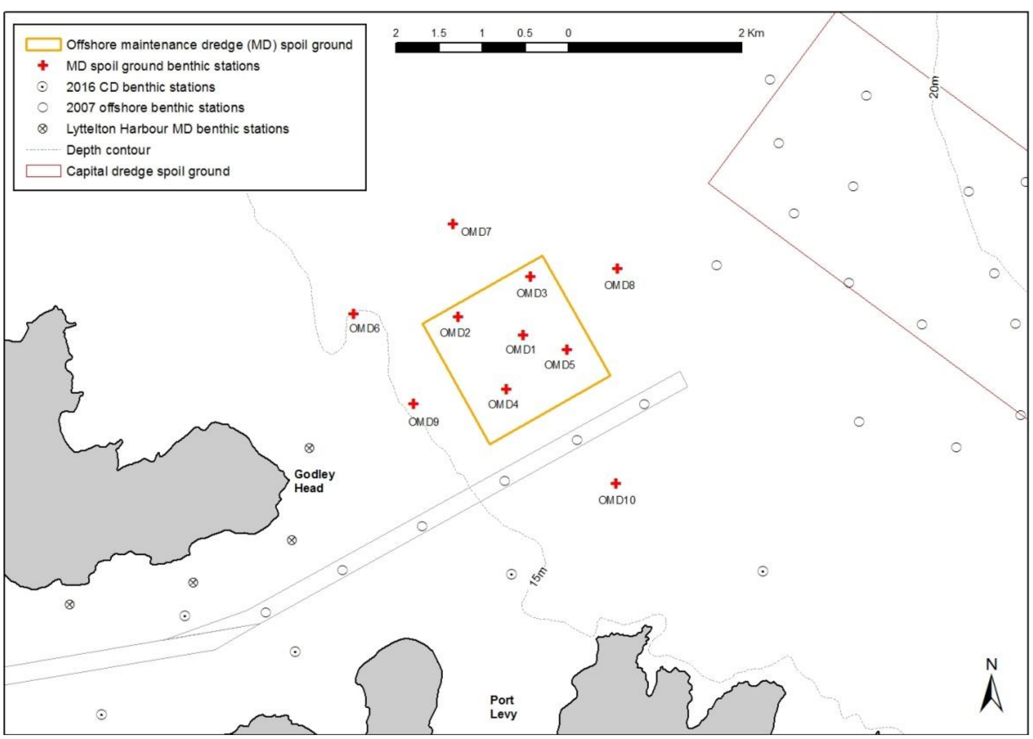


Figure 5.26b: Spatial layout of benthic grab sampling stations at proposed offshore maintenance spoil ground. Field surveys conducted August 2016 Source: Cawthron Report 2860, 2016.

5.143 Samples from the benthic stations were also assessed for the trace metals of copper, lead, nickel, zinc, and chromium. The levels of these metals at the offshore stations were essentially low and uniform and likely to be representative of natural background concentrations. All were well below the trigger levels listed in the Australian and New Zealand Environment and Conservation Council (ANZECC) sediment quality guidelines (2000)[58].

5.144 The sampling stations along the proposed channel extension (C1-C6) generally exhibited similarly low trace metal levels. Mercury was detected at Stations C1, C2 and C3 although the levels were well below the ISQG low threshold value contained in the ANZECC guidelines.

5.145 The inner-most sampling station C1 exhibited elevated copper and chromium levels with chromium exceeding the ISQG-low threshold value in 2007. However, the site was re-sampled in triplicate in 2012 and the results were well below the ISQG-low threshold. This appears to confirm the original hypothesis that the first sample was a discrete particulate contamination such as a flake of paint from hull anti-fouling coatings.

Underlying Sediment

5.146 Geotechnical investigations have been carried out to determine the strength of underlying sediment which is to be dredged. This was required in order to provide an indication of dredging effort needed: the harder the material the longer it takes to rip or cut it and suck it up the dredge hopper. A hard layer was suspected to exist and has been confirmed by the present investigations. The layer varies in thickness, and more than one layer has been identified in some locations of the Harbour. Penetration tests suggest a large trailer suction hopper dredge should be able to rip the layer prior to suction but a backhoe dredge or a cutter suction dredge remains a contingency in case detailed results prove otherwise.

Communities on the Seafloor

5.147 The following sampling of the seafloor communities was performed at the sampling stations shown on the map in **Figure 5.26**:

[58] The Interim Sediment Quality Guidelines (ISQG) has a low and a high threshold level for which biological effects are predicted. The lower threshold (ISQG-Low) indicates a *possible* biological effect while the upper threshold (ISQG-High) indicates a *probable* biological effect.

a. Benthic macro-invertebrates (small animals >0.5mm) sampled from the upper 10 cm of sediment using a 13 cm diameter core; and

b. Benthic epifauna[59] (animals >10 mm) sampled from the surface of the seabed using a small research dredge with steel wire mesh.

5.148 As describer earlier, broad scale sonar imaging of the seafloor was also carried out over a wider area to check for any low relief changes in substrate or biogenic structures or substances.[60]

5.149 The surveys found that the sediment-dwelling macro-invertebrate communities were relatively sparse with quite low species richness although there appears to be an increase of taxa richness with increased water depth. Number of species per core sample ranged from 9 to 34 outside the Harbour heads with 4 to 28 taxa from six stations within the central to outer harbour. Overall, polychaete taxa represented eight out of the twelve most abundant taxa over the areas sampled and around 70% of all individuals counted. Other common taxa include ostrocods, mud crabs and cumaceans.

5.150 The area of the proposed channel extension, which has a slightly greater proportion of silt- and clay-sized particulates, was found to have a more impoverished range and abundance of fauna relative to the proposed offshore disposal grounds.

5.151 A total of 31 separate benthic trawls have been conducted between inshore Pegasus Bay, between Godley Head and Otohuao Head with 25 in the vicinity of the proposed offshore spoil disposal grounds, 4 between the spoil ground and the adjacent coast to the south and 2 in the channel extension area as shown in **Figure 5.27**. The 22 trawls were carried out in 2007-8 spread over three surveys during the spring and summer.

5.152 The benthic epifauna outside the Harbour heads, as sampled using a research dredge with 10 mm mesh, was found to be very sparse with universally low abundances and only 23 species identified overall, some of which were inferred by the existence of shell remnants only. The results of two trawls in the proposed channel extension area

[59] Animals that reside on the surface of the seafloor. This compares with benthic "infauna" which resides within the sediment.

[60] A biogenic substance is a substance produced by life processes. It may be either constituents, or secretions, of plants or animals.

suggested a particularly impoverished epifaunal community, with only four species identified.

5.153 Taxa recorded included *Mollusca* (e.g. knobbed whelk, wedge shell, sea slug), *Crustacea* (e.g. mantis shrimp, policemean crab, mud crab), *Echinodermata* (e.g. heat urchin, cushion star, brittle star) and polychaete worms (e.g. sea mouse, parchment worm). As for the sediment-dwelling macro-invertebrates, the species found are typical of a dynamic soft-bottom seabed environment.

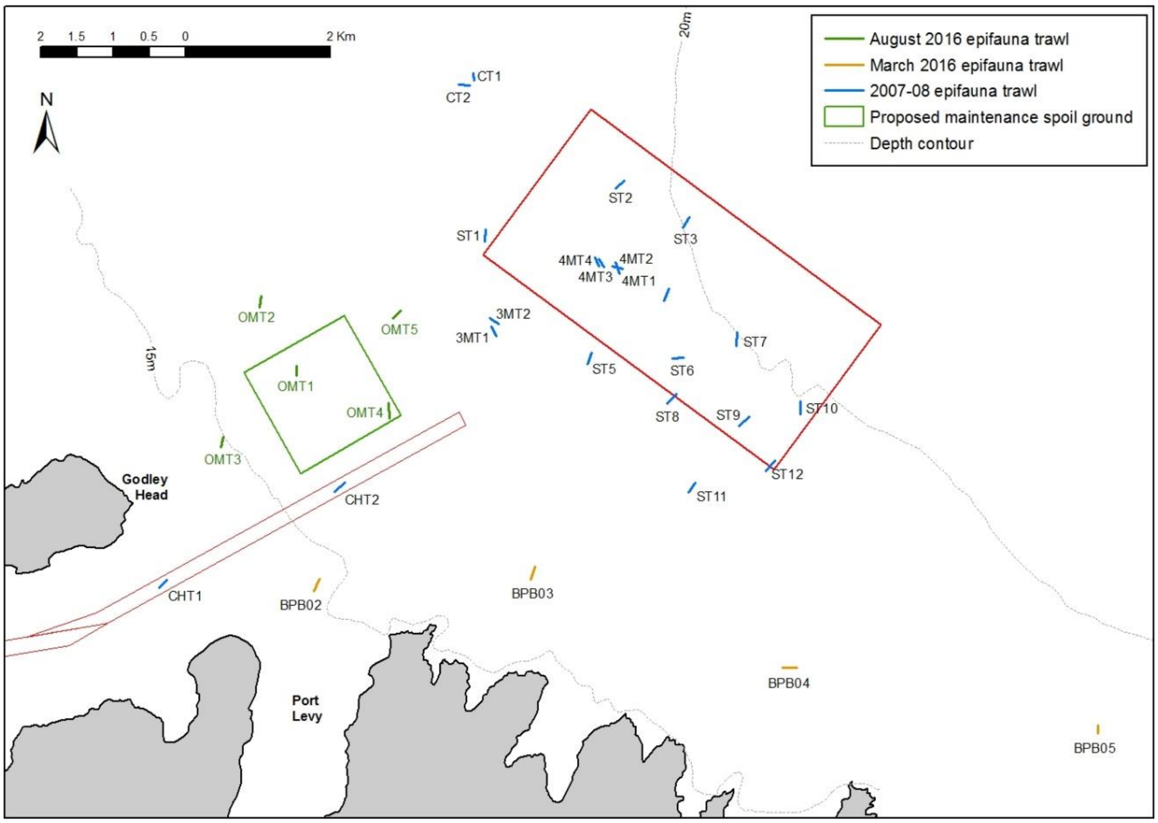


Figure 5.27: Spatial layout of epifaunal dredge trawls conducted October 2007 to January 2008 and in February 2016 (for the BP stations) and August 2016 (for the OM stations) Source: Cawthron Institute, 2016.

5.154 Side-scan sonar coverage of the channel extension area and the wider vicinity of the proposed spoil ground confirmed that the substrate and habitat described from the grab samples existed uniformly over the study area. No features of special scientific or conservation interest were identified by the offshore benthic surveys. The sonar tracks of the side scan are shown in **Figure 5.28**.

5.155 In summary, both substrate and biological characteristics of the offshore soft sediment benthic environment were consistent with a number of previous surveys of Pegasus Bay, indicating that the seabed area off Godley Head is typical of the benthic ecology of the wider benthic area in similar water depths.

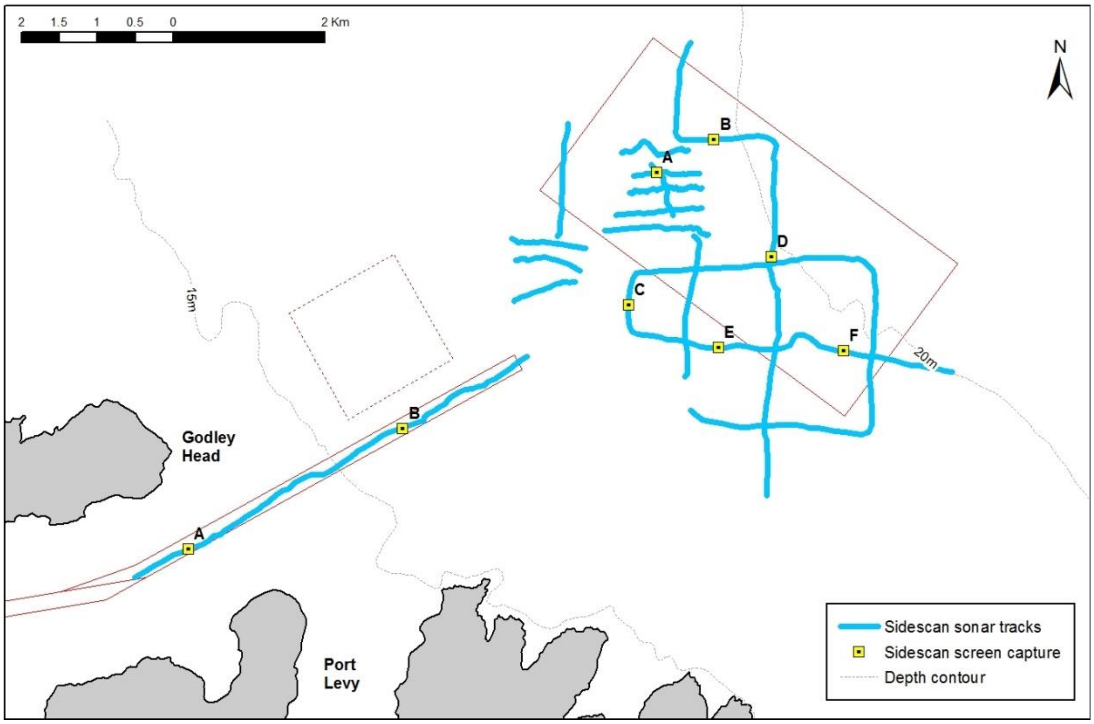


Figure 5.28: Side-scan sonar coverage of the proposed channel extension and spoil ground areas (60 m swathe width).Source: Cawthron, 2016.

<u>Shoreline Reefs</u>

5.156 The subtidal habitats and community assemblages of the shoreline reefs in Lyttelton Harbour, Port Levy, Pigeon Bay and the northern coast of Banks Peninsula were surveyed in February 2016 as shown in **Figure 5.29**. Each reef investigated was surveyed both parallel and perpendicular to the shoreline as illustrated generally in **Figure 5.30**.

5.157 Even though surveys were carried out after a period of settled conditions, it was notable that water clarity was poor along this coastline, with turbidity increasing into the inlets and Harbour in response to increased shoreline surge. Sediment tolerant taxa formed a

component of the species inventory but settled sediment was generally limited to thin veneers in these surge-affected areas.

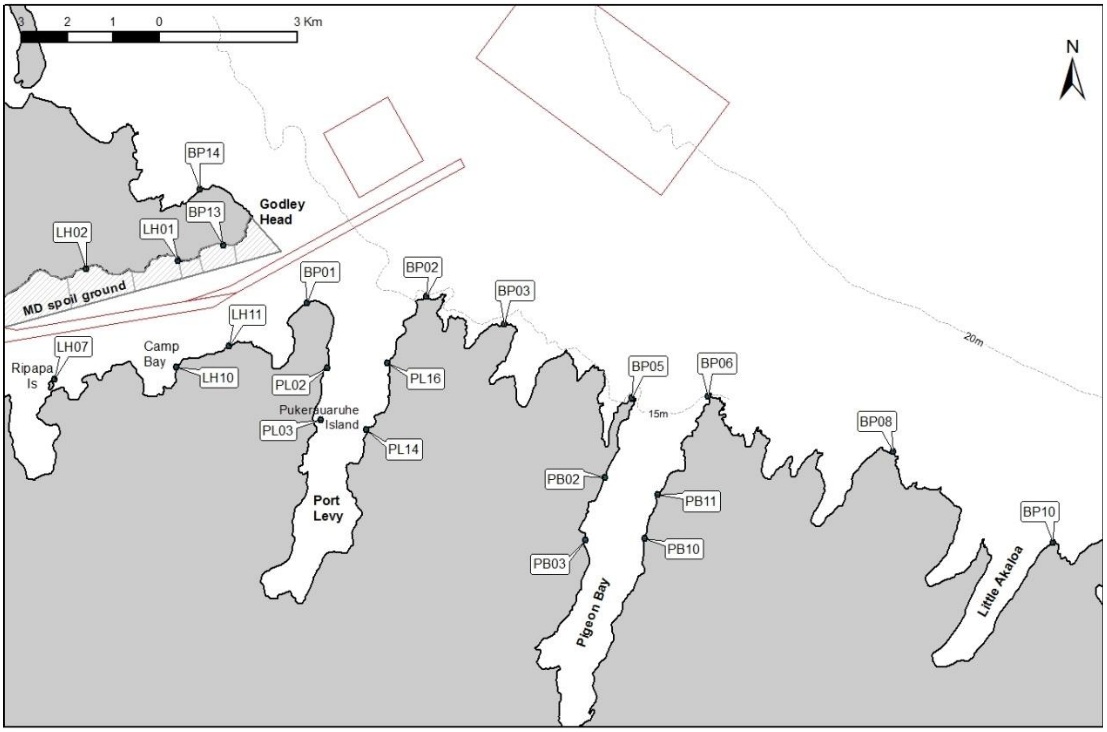


Figure 5.29: Locations of subtidal sites for surveys conducted in February 2016. Source: Cawthron 2016.

Figure 5.30: Generalised example layout of subtidal shoreline transects used to characterise subtidal reef habitats. Source: Cawthron, 2016.

5.158 Substrates recorded were dominated by bedrock and boulder reefs with only minor variation across the areas surveyed. Reef communities were characterised by a relatively high and uniform taxa richness across sites with 71 taxa recorded overall. These communities are considered representative of the wider area, being comparable to those previously found in published studies of the Banks Peninsula region and summarised earlier.

5.159 Kelp forest of varying density was a consistent feature of transects in 4m water depth, with the prevalent species being *Ecklonia radiata* and *Macrocystis pyrifera*. However, large canopy-forming macroalgae such as these were sparse at 7m depths.

5.160 Coverage of reef substrate was generally dominated by encrusting coralline algae at the 4m depth level; whereas, beds of solitary ascidians were frequently the dominant cover at 7m depth. Large green-lipped mussels were also common and formed dense beds at sites on the northern shoreline of Lyttelton Harbour.

5.161 Pāua were found across all areas and were counted and measured along 50 m littoral fringe transects at 0.5 m (CD) water depth. Pāua size ranged between 60.5 mm and 132.5 mm, with only 2.1% greater than the 125 mm legal size. Pāua densities ranged between 12 and 185 individuals per 50 m^2 across sites.

5.162 Despite often limited visibility, a range of fish species were also observed within the kelp forest habitats of BP sites, including triplefins, spotties, blue cod, leather jackets, blue moki and banded wrasse. Fish were more frequently observed at outer sites and at Taylor's Mistake.

Intertidal reef habitats of Lyttelton Harbour and Port Levy

5.163 A total of ten intertidal sites have been surveyed semi-quantitatively i.e. in terms of presence / absence / relative abundance. Eight of the sites are located Lyttelton Harbour/Whakaraupō and two in Port Levy/Koukourārata as shown in **Figure 5.31**. The locations of sites in Lyttelton Harbour represent a gradient in environmental conditions and exposure from the entrance to the upper Harbour. Two sites surveyed in the outer section of Port Levy were located one on either shoreline of the inlet: one on the west and one on the east.

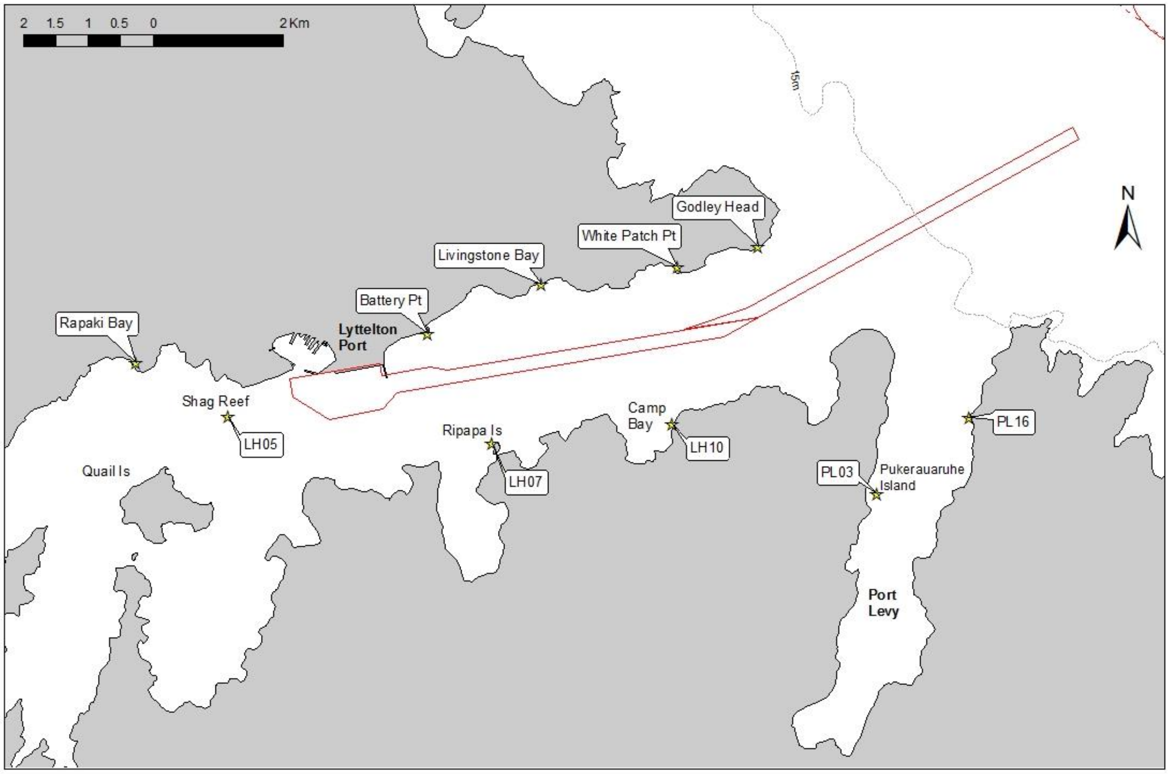


Figure 5.31: Locations of semi-quantitative intertidal surveys conducted 2012 – 2016. Source: Cawthron, 2016.

5.164 The intertidal assemblage of animals and plants recorded from these sites are considered to be generally characteristic of the region and show variability principally according to the degree of exposure to wave energy.

5.165 The upper-intertidal zone at most sites was patchily dominated by barnacles (*Chamaesipho columna* and *Epopella plicata*), periwinkles (*Nodilittorina cincta* and *Nodilittorina unifasciata*), spotted topshell (*Diloma aethiops*) and limpets (*Cellana ornata and C.radiata*). The little black mussel *Xenostrobus pulex* was also abundant and characteristic of the high to mid-shore.

5.166 The mid-shore features a band of the polychaete tubeworm *Spirobranchus cariniferus* which can attain dense colonies in shaded locations with reduced water movement. The blue mussel (*Mytilus galloprovincialis*) and barnacles are also dominant sessile invertebrates of the mid-shore. A variety of grazing and predatory gastropods were also present, including limpets, whelks (*Haustrum haustorium, H. scobina, Cominella* sp.), cat's eye snails (*Turbo smaragdus*), *D. aethiops* and several species of chitons.

Macroalgae were generally scarce to occasional in the mid-shore, but included patches of *Gelidium caulacantheum*, coralline turf, *Porphyra columbina*, encrusting coralline and some brown algal species in tide pools, most notably *Hormosira banksii* where wave energy is not too vigorous.

5.167 As expected, the low-shore supported the highest diversity of invertebrates and macroalgae. There were abundant patches of blue and green-lipped mussel, with a wide diversity of brown and red macroalgae growing amongst them. Additionally, there was a variety of invertebrates in low shore tidal pools; including porcelain crabs (*Petrolisthes elongatus*), slipper limpets (*Sigapatella novaezelandiae*), cushion seastars (*Patiriella regularis*), anemones (*e.g. Oulactis mucosa, Anthothoe albocincta*) and chitons (*e.g. Chiton pelliserpentis, C. glaucus*). Representative images of intertidal habitats within Lyttelton Harbour are shown in **Figure 5.33**.

5.168 Overall the surveys revealed no intertidal organisms or communities of special scientific or conservation interest. The non-indigenous seaweed *Undaria pinnatifida* was recorded in the low shore to immediate subtidal on both shores of the Harbour. Pāua (*Haliotis iris*) were notably common within pools on the low shore at the Livingstone Bay site in December 2013. Although deposited sediment appears to be a natural feature of the upper Harbour, Rāpaki Bay and Shag Reef sites, there have been no observations of fine sediment accretion at any of the central and outer Harbour sites.

Brachiopod *Pumilus antiquatus* in Lyttelton Harbour/Whakaraupō

5.169 Brachiopods are hard-shelled, filter feeding organisms also known as roman lamp shells although they are not molluscs. They are known in fossil records from early Cambrian times, some 540 million years ago. There are 32 brachiopod species known from New Zealand waters and nine occur at depths of less than 30 m, giving New Zealand a greater diversity and abundance of shallow-water brachiopods than any other comparable region in the world.

5.170 Of note *Pumilus antiquatus* is small brachiopod which appears to be rare or very limited in distribution. It is classified as Nationally Critical. Its presence was recorded within Lyttelton Harbour/Whakaraupō in the 1950s, and it was noted to be in a unique association with two other species of brachiopod species at Ripapa Island. Consequently, the Island is listed as a sensitive site.

5.171 It unclear how well studied this community is (especially in terms of distribution beyond the Ripapa Island setting) or even whether the site has been re-visited since before now. The area where the species was located in 1950s was re-examined in August 2014 and February 2016 but was not found.

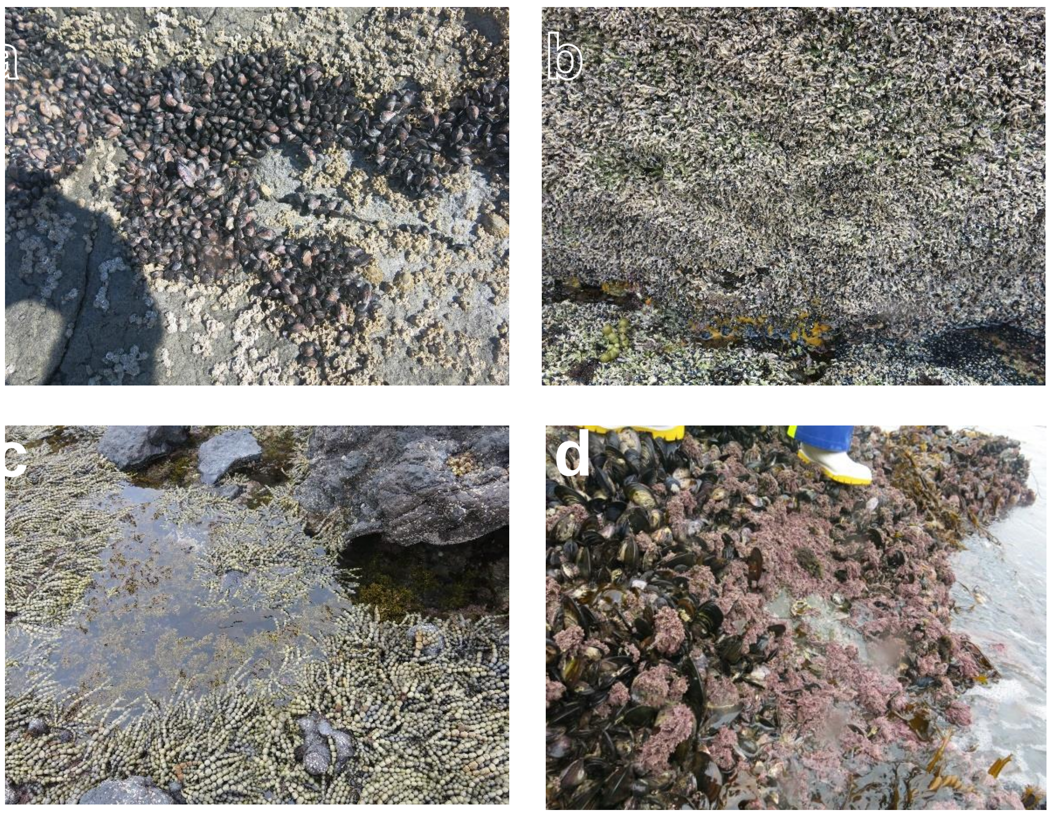


Figure 5.31: Representative images of intertidal habitats within Lyttelton Harbour: a) the high shore was generally dominated by barnacles and blue mussels, b) the mid-shore often had a conspicuous band of blue tube worm, c) rock pools were common in the mid- to low shore where a wide diversity of macroalgae was recorded, d) green-lipped mussels formed dense beds mixed with coralline turfing algae in the low-shore to shallow subtidal. Source: Cawthron, 2016.

Conclusion

5.172 The modelling, measurement and assessment work in summary concludes:

- Pegasus Bay receives considerable supplies of sediment from the Alps;

- More locally the inlets of Bank Peninsula receive loess from the hillsides;
- Sediment grain size in the project area is dominated by silts and clays;
- The marine environment is therefore naturally turbid, and a fluid-mud layer above the seabed means there is poor visibility near the seabed for much of the time;
- Any undulations in the seabed are quickly filled in by the fluid mud, resulting in the seabed being an essentially flat feature in Pegasus Bay and the inlets;
- The local benthic communities are inherently tolerant of turbid conditions;
- The shoreline reef communities are more diverse and some species will be more sensitive to turbidity than others although there is no evidence of sediment settling at all in the outer bays due to high surge conditions;
- Despite the turbid conditions, there are a range of finfish species, including flatfish (flounder and sole) that are targeted by commercial and recreational fishers;
- There is a relatively large population of Hector's dolphin in the area, and a marine sanctuary protects the dolphins from set-netting;
- The waves well offshore from Banks Peninsula are mainly from the south;
- Closer to shore the waves refract around Banks Peninsula and are predominantly from the north-east;
- Both longer-period swell waves and shorter-period sea waves dissipate as they travel up Lyttelton Harbour/Whakaraupō; but more so the swell waves;
- The principal non-tidal current is the Southland current;
- The Southland current is directed to the east south-east as a result of back eddy (that has formed due to the jutting out of Banks Peninsula);
- The residual current from this back eddy is generally weak, but nevertheless it results in a net transport of sediment to the east south-east;
- Because Lyttelton Harbour is long and narrow the tidal currents dominate;
- Some localised imbalances of the tidal current occur and an eddies form.The most prominent eddies are at the Harbour entrance and near the Sticking Point breakwater;
- Because Lyttelton Harbour/Whakaraupō is long it takes a number of tidal cycles for sediment to escape from or to reach the upper Harbour. Sediment cannot be

readily transported between the dredging and disposal areas and the upper Harbour or vice versa;

- The tidal currents from Lyttelton Harbour/Whakaraupō shear past Port Levy/Koukourārata, which appears to create a weak eddy and a weak residual current being directed into the inlet.

5.173 The studies considered in this report have resulted in a better understanding of how sediment is likely to be transported in the project area and the likely ecological responses to plumes associated with dredging and disposal activities, which is a key issue associated with the project.

5.174 The landscapes and coastal natural character of Banks Peninsula and the inlets make the place very desirable to live or holiday. Marine-based recreation is popular due partly to its proximity to a large population centre. Mussel farms in the area are important to the local economy with Te Rūnanga o Koukourārata having interests in mussel farms along the northern coastline.

5.175 Culturally the area has a long and rich history of Ngāi Tahu land use and occupancy with the abundance of mahinga kai resources being the primary reason for Ngāi Tahu settlement of Rāpaki and Koukourārata.

5.176 The ancestral relationship of Ngāi Tahu to these harbours is reflected in the continued value placed on the harbours as mahinga kai. Today, the protection and restoration of mahinga kai for customary use is the primary driver for Ngāi Tahu policies on harbour management with Mātaitai reserves in both Harbours, and a second much larger one being proposed for Whakaraupō.

5.177 Lyttelton Port was established as part of early European settlement and has grown to serve the economic and social needs of Canterbury, as the primary national and international gateway for goods. To enable shipping access to the Port dredging has been carried out since more or less continuously since the mid-1880s.

6. ASSESSMENT OF ENVIRONMENTAL EFFECTS

6.1 Chapter 6 is set out in four parts. **Part A** describes the benefits of the project to the Canterbury community. **Part B** assesses the actual or potential effects from the proposed deepening and extension of the channel while **Part C** assesses the actual or potential effects from the subsequent maintenance dredging. **Part D** addresses the actual and potential effects on Manawhenua rights, values and interests. The cultural impact assessment (CIA) considers both channel deepening and maintenance dredging together and so both activities are addressed in Part D.

PART A: BENEFITS OF CHANNEL DEEPENING

6.2 As discussed in **Chapter 3** (Project Rationale), Central Government's business growth agenda is to increase primary industry from $32 billion in June 2012 to over $64 billion by 2025 (New Zealand Government, 2015). If this comes into fruition then it is estimated that New Zealand's current containerised cargo volume would increase by up to 50%. In Canterbury specifically, the strategy is to increase the total irrigable area to 850,000 hectares which will contribute to a significant increase in agricultural production.

6.3 This increase is occurring within the broader context of needing to protect New Zealand against the risk of shipping companies hubbing through Australian ports and resulting in increased costs to exporters and importers.

6.4 Also discussed in **Chapter 3,** the New Zealand Shippers' Council has stated that Lyttelton Port should be the logical first South Island port to become bigger ship capable because it is the largest container port in the South Island in terms of both import and export volumes.

6.5 Larger ships are now beginning to arrive in New Zealand and so this project post-earthquake has become a priority. The design and upgrade work being completed post-earthquake and as part of Port Recovery is predicated on serving larger vessels. If Lyttelton Port cannot deepen its channel it will not be able to use its assets to their full extent.

6.6 If Lyttelton Port becomes big ship capable it is estimated that freight costs will decrease by greater than 10% for Canterbury and West Coast shippers of overseas containerised cargo. If Lyttelton Port does not become big ship capable, freight costs are estimated to

increase by between 11 and 50% for Canterbury shippers of overseas cargo and between 50 and 100% for West Coast shippers of overseas cargo. These cost penalties will negatively impact on business profitability and competitiveness and increase costs for consumers.

6.7 The benefit of this project is to provide cost effective shipping to the Canterbury Region and support the wider shipping network in New Zealand, and it would play its part in the recovery of Canterbury after the devastating earthquakes.

PART B: EFFECTS OF CHANNEL DEEPENING

Section 1: Effects of an Increased Channel Footprint

6.8 The channel extension represents an area which would be lost as natural seabed habitat. The extension area would be approximately 125 ha and cover around 5% of the Harbour entrance and its approaches but represents a much smaller proportion of the total area of similar soft-sediment habitat within inshore Pegasus Bay.

6.9 The benthic biota subject to dredging will be lost although is expected to quickly re-establish. A structural change to the benthic communities is, however, anticipated for two reasons:

a. First, the channel would be deeper and the sediment is likely to be slightly different texturally thus promoting some species over others; and
b. Second, annual maintenance dredging would shift the community structure to one that is more dominated by rapidly colonising species, representing an intermediate successional community.

6.10 Despite the above, previous survey work of the existing shipping channel suggests any structural change to the benthic community within the channel is likely to constitute no more than a minor change in terms of the functioning of benthic ecosystems over the wider area. Furthermore, since the extended channel will be effectively aligned with the Lyttelton Harbour shoreline morphology and tidal flow regime, it is expected that the channel would only have a localised effect on hydrodynamic processes important to the ecological resources of the area.

6.11 In terms of fishery, the extension of the shipping channel beyond Godley Head and Baleine Point would encroach into part of an area where yellow-bellied flounder is targeted by commercial inshore fishers. The change in habitat is expected to have a no more than a minor effect in terms of productive seabed directly affected although a deepened channel would presumably disrupt the fishing effort with any trawling having to avoid the channel with its comparatively steep batter slopes.

Section 2: Changes to Waves & Currents from Channel Deepening

Introduction

6.12 As described in **Chapter 1** (Introduction) of the AEE, the Lyttelton Port Recovery Plan has been gazetted. The elements of Port Recovery referred to in the gazetted Plan include a new container facility and associated berths in Te Awaparahi Bay as well as the deepening of the shipping channel so that larger vessels can access the Port. The new container terminal is to be constructed on approximately 24 ha of land to be reclaimed from Te Awaparahi Bay. This would be in addition to the near 10 ha that has already been reclaimed.

6.13 Both the channel deepening and the reclamation will change the wave and current regimes in Lyttelton Harbour/Whakaraupō and so it is appropriate to assess the changes to wave and current regimes together with the reclamation, rather than in isolation.

6.14 Mulgor Consulting Ltd (see **Appendix 14**) has therefore examined the wave and current regimes after the completion of the first stage of the channel deepening and the first stage of reclamation, and then after the completion of both projects.

6.15 For the purposes of modelling, Stage 1 assumes a channel deepening cut of approximately 2.0 m and a completed 34 ha reclamation (including the existing 10 ha reclamation) while Stage 2 assumes the completed projects i.e. channel deepening with a cut of approximately 4 - 5 m and the completed reclamation.

6.16 For completeness, the channel deepening has also been evaluated without any reclamation. This is fanciful, however, given the channel deepening and reclamation at Te Awaparahi Bay are both integral parts of Port Recovery.

Waves

6.17 As shown in **Figure 6.1 (a) and (b)**, the results of modelling predicts that the wave heights along the deepened shipping channel would reduce because of the extra depth and conversely wave heights along the northern and southern bays would increase due to refraction effects of a deeper channel.

6.18 In the vicinity of the reclamation and the deepened ship-turning basin, wave heights are predicted to generally reduce, while in the upper Harbours of both Lyttelton Harbour/Whakaraupō and at Port Levy/Koukourārata the change in wave heights is predicted to be small. There is little difference between wave heights between the assumed staging of both the channel deepening and reclamation projects described earlier.

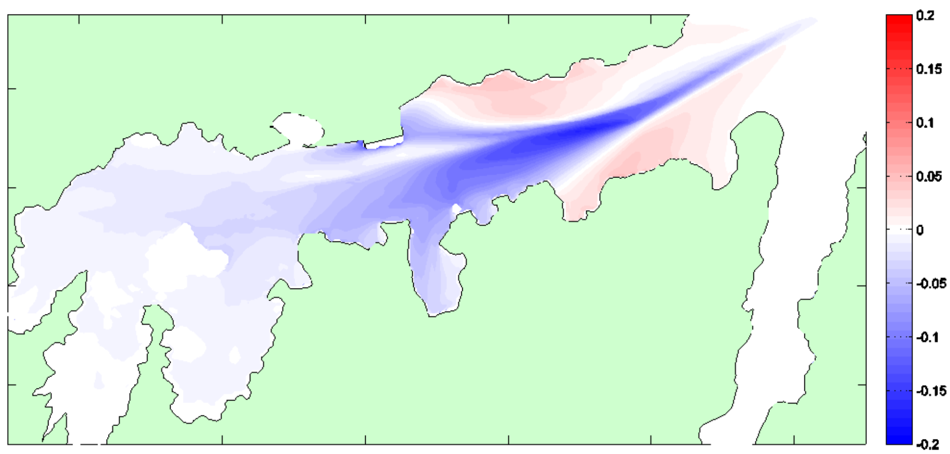


Figure 6.1 (a) Difference in mean wave height (m) for Stage 1: Source: Mulgor Consulting Ltd, 2016.

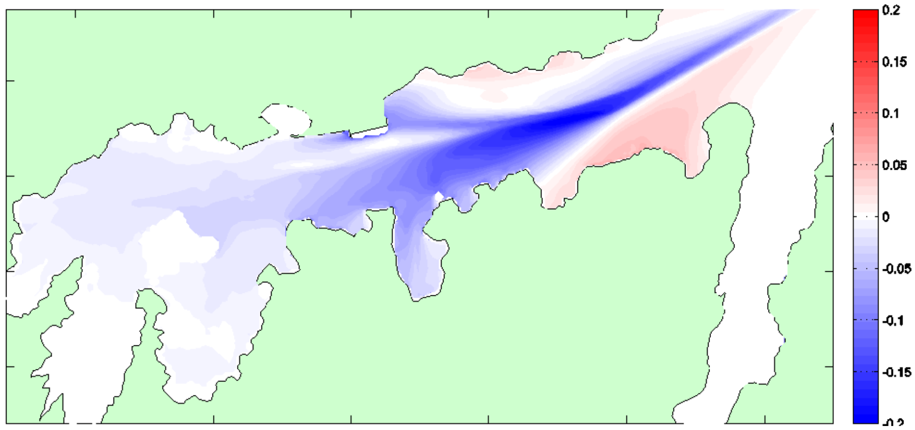


Figure 6.1 (b) Difference in mean wave height (m) for Stage 2: Source: Mulgor Consulting Ltd, 2016.

6.19 Individual sites were also selected and examined for changes to the mean wave height after each project stage. The model predicts that:

a. Waves in the central harbour will decrease by up to 33%;

b. Waves at Livingstone Bay will increase by up to 11%, but this will reduce at the completion of channel deepening and reclamation;

c. Waves in Little Port Cooper and Camp Bay will increase by up to 12%;

d. Waves at Putiki in Port Levy/Koukourārata will not change;

e. At Purau Bay and Diamond Harbour the waves will decrease by up to 38%; and

f. At Rāpaki the mean wave height will reduce slightly.

6.20 Changes were also examined against the three last largest individual weather events which generated very large swells and the pattern of the results was similar. At individual sites the model predicts:

a. A percentage reduction in wave heights in the central Harbour are of the same order as the increases at Livingstone Bay, indicating the refraction of waves towards the northern shoreline;

b. The changes at Camp Bay, Little Port Cooper and Putiki (Port Levy) are small;

c. At Rāpaki there is a small reduction in total waves and in sea waves;

d. At Rāpaki there is a large percentage reduction in swell waves but the swell waves are already small (~ 3 cm), which is close to the limit of precision of the model; and

e. At Diamond Harbour and Purau Bay, there is up to a 62% reduction in swell wave heights, but little change to sea wave heights.

6.21 The reduction in wave heights close to the reclamation is expected because of the blockage to the flow caused by the reclamation and because of the deepening of the ship-turning basin.

6.22 As noted above, in the vicinity of Diamond Harbour the swell waves would reduce and as a consequence the time sediment is disturbed by the swell waves would correspondingly reduce. This may result in a marginal change in depositional environment from that which is now occurring and so it is recommended to monitor this for a longer term.

6.23 The predicted increase in the wave heights along northern and southern bays on the flanks of the deepened shipping channel due to refraction is considered small in absolute terms and the changes in the upper Harbour and in Port Levy/Koukourārata are considered insignificant.

6.24 The differences between the two stages of dredging and reclamation are generally small and this illustrates that changes to wave heights are not particularly sensitive to the overall size of the reclamation and depth of dredging.

6.25 Mulgor Consulting has also assessed the effects on waves should the CDP be completed without the proposed Te Awaparahi Bay reclamation, despite this being a fanciful outcome long-term. It was determined that waves in the Harbour would not be significantly different to those expected once the reclamation is complete. This is because waves are mainly affected by channel deepening, as opposed to the presence or absence of the proposed reclamation.

Currents

6.26 As shown in **Figure 6.2 (a) and (b)** the results of modelling conclude that the differences in speed at mid-ebb tide as a result of the development stages are as follows:

a. In the immediate vicinity of the reclamation, there is a significant reduction in current velocity – up to 0.2 m/s;

b. In the ship-turning basin, the speeds increase after Stage 1 but reduce after Stage 2; and

c. Elsewhere the changes are small and there is little discernible difference between Stage 1 and Stage 2.[61]

6.27 Individual sites were also examined for changes to the mean current wave height after each stage, with the following results:

a. The largest changes occur at the reclamation where the currents speeds increase by up to 24.5% after Stage 1, but this drops back to 11.8% after Stage 2;
b. At Parson Rock, the speeds increase after Stage 1, but decrease after Stage 2 compared to Stage 1;
c. At Diamond Harbour and in the inner Harbour, the speeds decrease up to 9.5% but are still not considered significant in terms of sediment transport; and
d. Elsewhere, the changes are negligible.

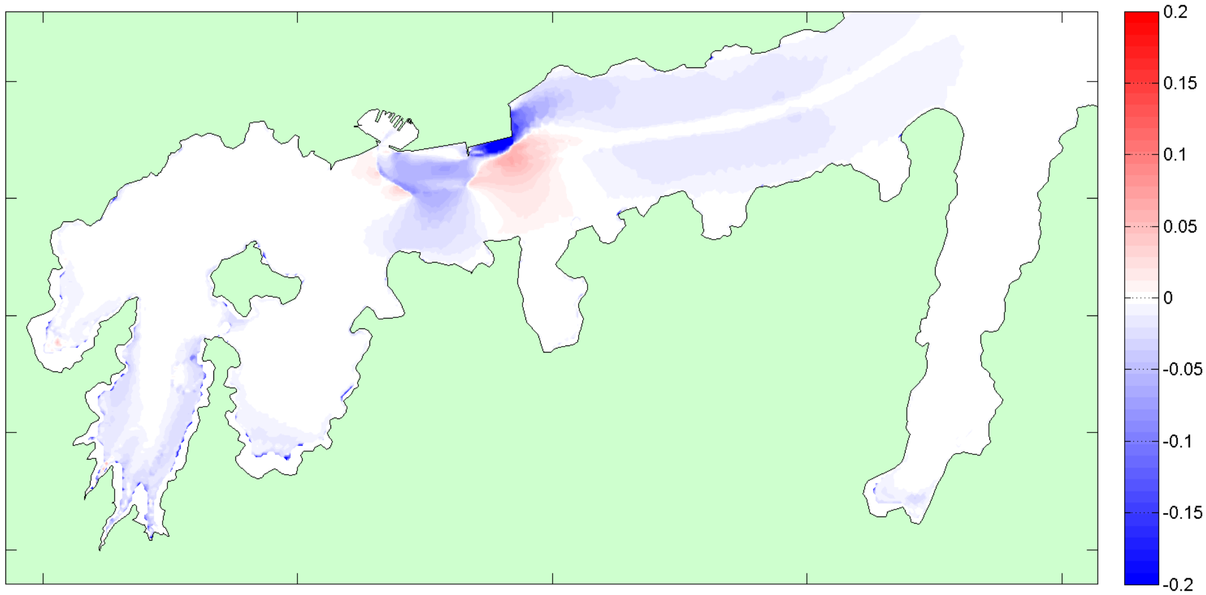


Figure 6.2 (a) Difference in speed in m/s at mid-ebb tide between present and Stage 1 — positive means the stage will result in an increase in speed. Source: Mulgor Consulting Ltd, 2016.

[61] The maps for flood tide are essentially the same and were not shown in the Mulgor Consulting Ltd Report.

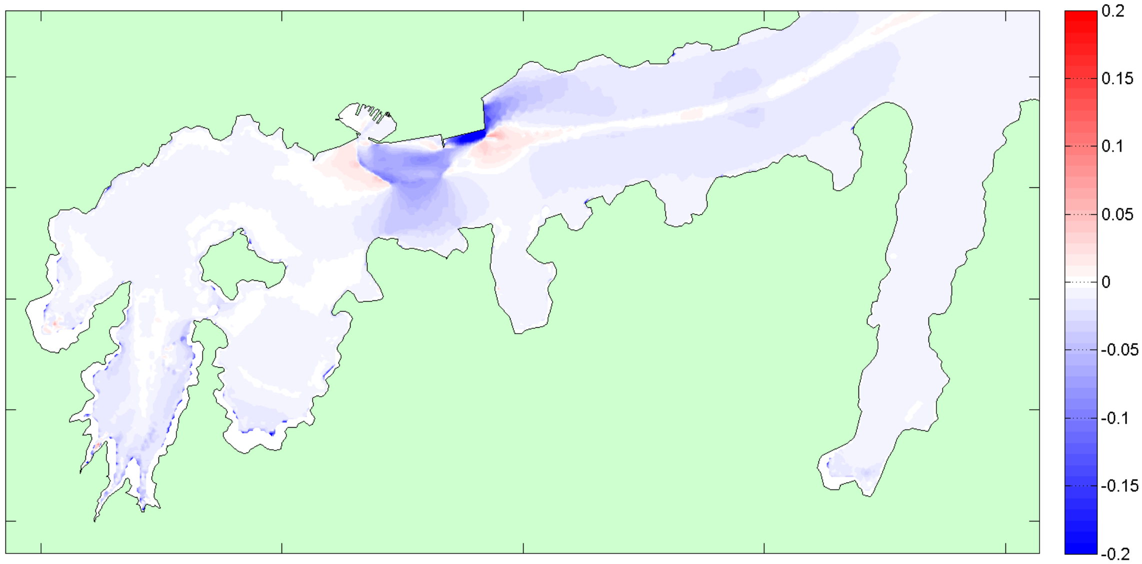


Figure 6.2 (b) Difference in speed in m/s at mid-ebb tide between present and Stage 2 — positive means the stage will result in an increase in speed. Source: Mulgor Consulting Ltd, 2016.

6.28 Overall, the reclamation causes a narrowing of the Harbour width, which increases the tidal currents but conversely deepening of the shipping channel and ship-turning basin will offset the increase, meaning the change in tidal currents will be small.

6.29 Mulgor Consulting has also assessed the effects on currents should the CDP be completed without the proposed Te Awaparahi Bay reclamation, despite, as above, this being a fanciful outcome long-term. It was determined that channel deepening without the proposed reclamation would only have a minor effect on tidal currents.

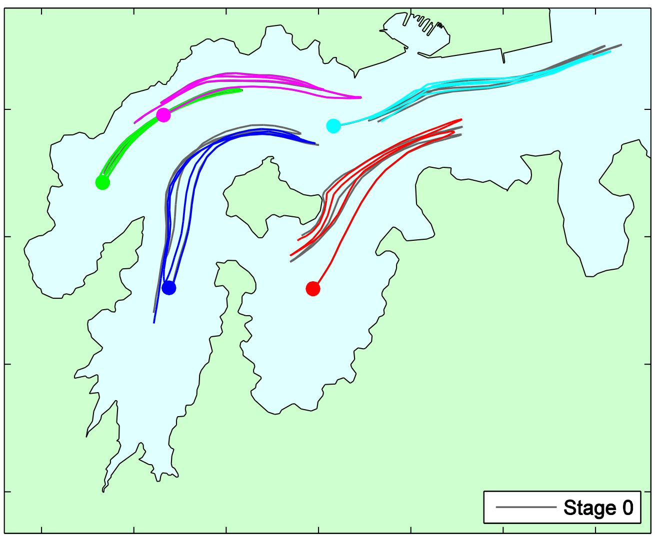
Upper Harbour

6.30 **Chapter 5** describes tidal excursions observed with drogues and then modelled by dropping neutrally buoyant particles into the velocity field of the hydrodynamic model for the primary *M2* tidal current. It was found that tidal excursions over a half-tidal cycle were typically in the range of 2 to 4 km.

6.31 Using the hydrodynamic model, it was tested to see whether these tidal excursions would change in response to channel deepening and construction of the reclamation in Te Awaparahi Bay. **Figures 6.3** and **6.4** show the simulations of the tidal excursions after Stage 1 and Stage 2.

6.32 Results indicate there would be no discernible difference in the trajectories for the different stages, either for particles released in the upper Harbour or at Diamond Harbour. Therefore there is no change to this cyclical pattern, which means that there continues to be no direct mechanism for such particles to exit from their location of origin. Thus, particles that start in the upper Harbour would have difficulty leaving.[62]

6.33 As discussed in **Chapter 5**, this conclusion is also supported by the lack of evidence of any significant quantity of sediment escaping out of the upper Harbour into the central Harbour area. If that was occurring, it would be reflected in the volume of dredge material taken out of the channel and ship-turning basin.



[62] In practice sediment particles will be brought into suspension by waves, then to be transported by tidal currents until it falls to the bottom, whence it will be picked up again in the next wave event and depending on the state of the tide (ebb or flood) will be carried forward or backwards.

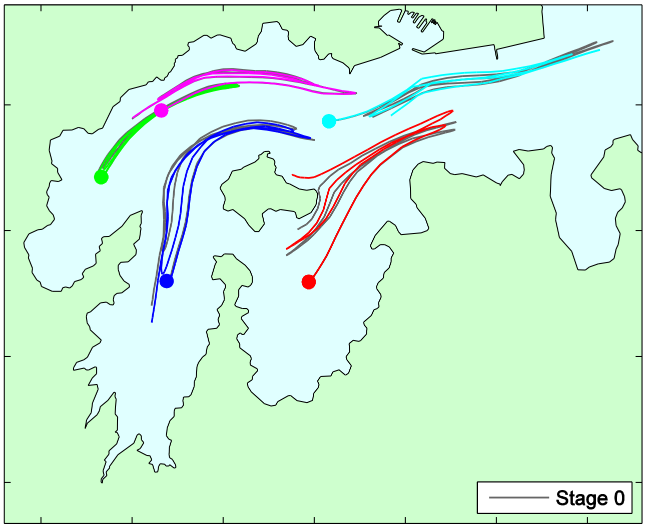
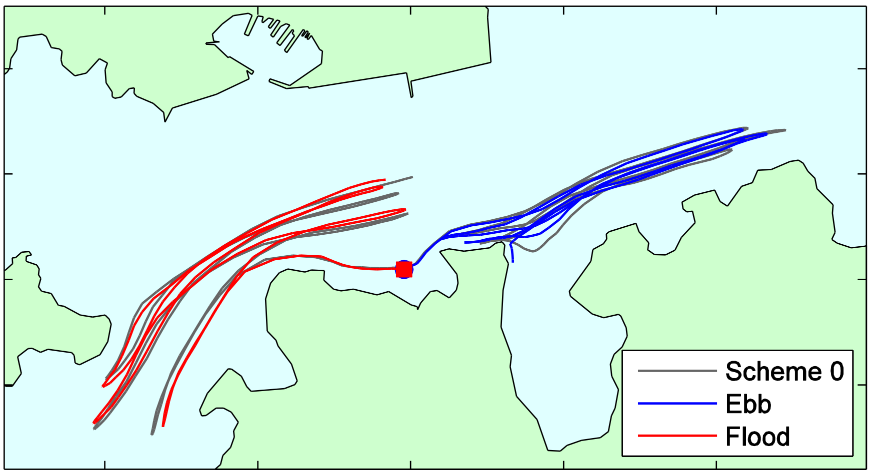


Figure 6.3: Trajectories of neutrally buoyant particles for Stage 1 Stage 2 respectively. The present bathymetry seen today is shown as the dark lines. Source: Mulgor Consulting Ltd, 2016.



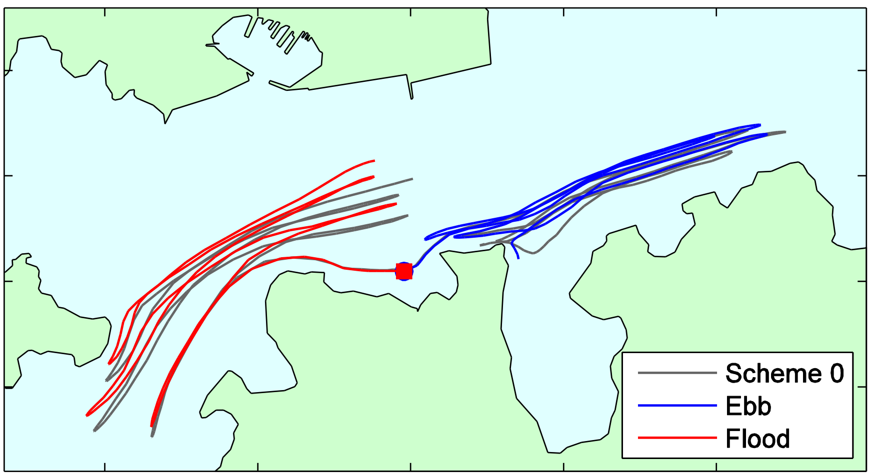


Figure 6.4: Trajectories of neutrally buoyant particles at Diamond Harbour for Stage 1 and 2 respectively. The present bathymetry seen today is shown as the dark lines. Source: Mulgor Consulting Ltd, 2016.

Section 3: Fate of Turbidity (SSC) Plumes Generated during Channel Deepening

Source of Turbidity Plumes during Dredging

6.34 It is anticipated that the channel deepening would involve the deployment of a large trailer suction hopper dredge ('TSHD'), which could range in hopper capacity from 5,000-m^3 up to 18,000 m^3. For the purposes of this assessment three 'design' vessels have been used when modelling the source and fate of turbidity plumes during dredging. They are the vessels 'Olympia', 'Volvox Asia' and the 'Utrecht,' having a hopper volume of 5,000, 10,800, and 18,000 m^3 respectively.

6.35 One of the direct effects of dredging is to mobilise sediment which in turn will lead to an increased concentration of suspended particulate matter in the water column. This increased sediment concentration manifests itself as cloudiness or turbidity. These plumes are known as the suspended sediment concentrations plumes ('SCC' Plumes) or more commonly called turbidity plumes.

6.36 As illustrated in **Figure 6.5**, during dredging (as opposed to during the disposal) most of the turbidity plumes are generated when water and sediment is discharged back overboard via an underwater pipe (overflow mode). The reason for this is to ensure an adequate density of sediment in the hopper load. Small plumes are also generated from sediment being disturbed by the drag-head during dredging and from propeller wash, if the depth is shallow enough.

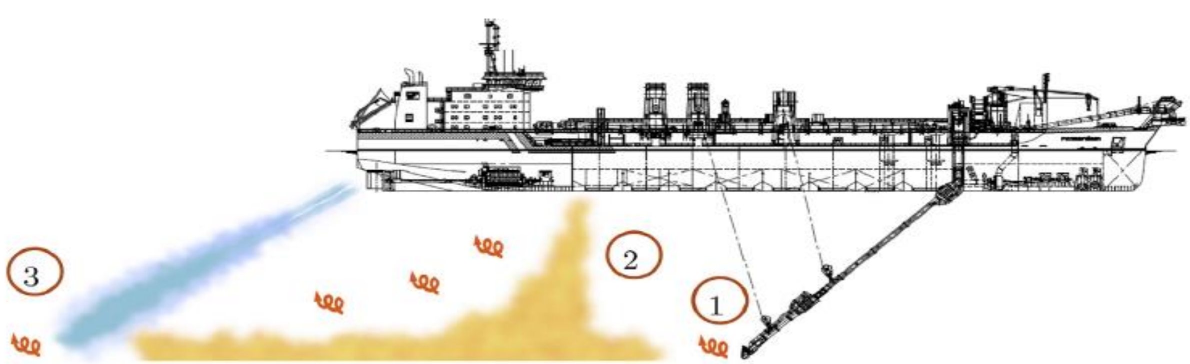


Figure 6.5: Illustration of the sediment plumes generated during dredging using a Trailer Suction Hopper Dredge: 1 = Drag Head, 2 = Overflow, 3 = Propeller wash Source: Met Ocean Solutions Ltd, 2016.

6.37 The overflow sediment loading is typically in the order of 1400-2000 kg/s and will create noticeable plumes whereas the release rates for the drag-head and propeller wash are much less, in the order of 25 kg/s, and not likely to be noticeable.

6.38 As sediment is released from the overflow pipe some 75% will descend rapidly and impact on the bottom (called dynamic collapse). However about 25% of the sediment will remain in the water column to form a plume as the sediment descends from the pipe outlet. Of the 75% of sediment that impacts the bottom some 25% will form a passive plume after a radiating sediment-laden density current subsides.[63]

6.39 In other words, about half of the sediment discharged during dredging is expected to form passive turbidity plumes.

6.40 The same type of process occurs during the disposal of spoil at the spoil disposal grounds although the volumes of sediment involved in deposition are much larger. This is discussed in **Section 7**.

Modelling the Plumes

6.41 Met Oceans Solutions Ltd has modelled the fate of these plumes during dredging using a SELFE model, which is discussed in **Chapter 5**.

6.42 Modelling dredging plumes within a marine environment involves multiple steps. In summary they include:

a. Developing, calibrating and validating a hydrodynamic model of the receiving environment that accurately captures the expected variability in the tidal and non-tidal current velocities;

b. Defining source of sediment, including particle release points within the water column and percentages of the overflow material expected to be entrained into the water column as a passive plume;

[63] The water and sediment descending to the seabed from the overflow pipe is denser than the surrounding water and therefore generates a density current (moving from high pressure or density to a lower pressure or density). Once this density current subsides any particles still in the water column are carried passively by the currents until settling

c. Defining the representative fall velocities for the particles released within a numerical model framework and track these particles over time until they settle out of suspension; and

d. Post-processing the results by adding a specific mass to the particles, and analysing the statistics that provide an overview of the expected plume characteristics.

6.43 To examine any differences in the magnitude or extend of the plume under different forcing conditions, simulations have been undertaken over two complete spring-neap tidal cycles (~ 28 days) both with and without seiche. The full spring-neap[64] tidal cycle simulations captured the entire range of hydrodynamic forcing during a cycle, providing valuable guidance on the extent of the dredging-related plumes.

6.44 The model assumes sediment is generated from the drag-head and the prop wash for the duration of a dredge run although in reality plumes generated from prop wash may or may not occur depending on the depth to the seabed. However, as noted earlier, the major generator of a turbidity plume will be from sediment being discharged during overflow mode. The model has simulated overflow discharges for 10, 20 and 30 minutes to see the differences in the extent of the plumes.

6.45 The model has been run at 12 locations along the channel (**Figure 6.6**), for the three different sized dredges and a full range of tidal conditions. Because future tidal velocities can be calculated, the model can determine an average plume concentration across the full range of tidal conditions.

[64] A spring tide is when there is the greatest difference between high and low water. The opposite applies to a neap tide.

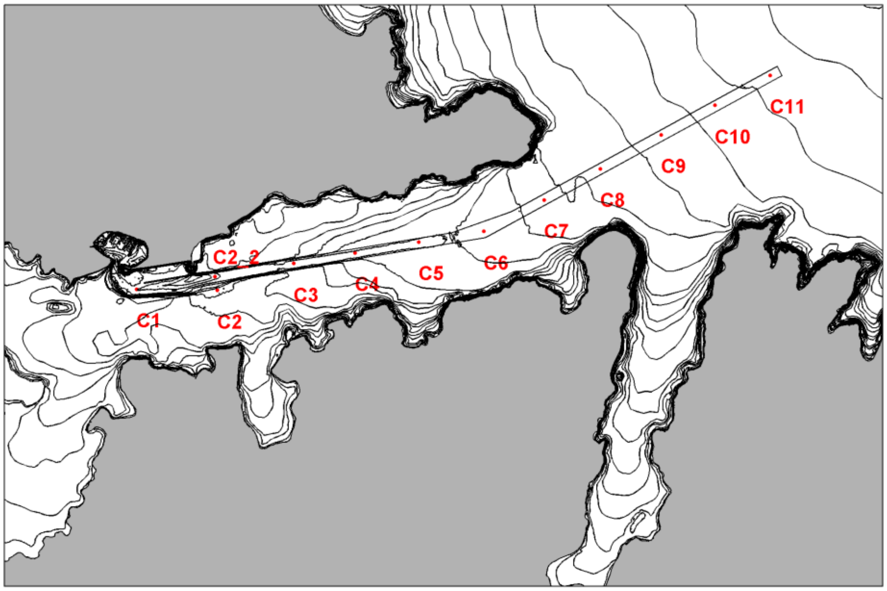


Figure 6.6: Simulated release of sediment at 12 representative locations along the proposed channel. Source: Met Oceans Solutions Ltd, 2016.

6.46 The model needs to assume a particle size distribution for the material dredged in order to calculate the settling velocities of particles contained in a plume. **Figure 6.7** shows the particle size distribution used, which was derived from earlier sampling work of surficial sediments. As illustrated, most sediment falls within clay-silt range (0-63 µm) with most of the rest being very fine to fine sand (63 µm - 256 µm).

6.47 **Figure 6.8** categories particles into various sizes, each with a settling velocity. The less than 44 µm class is grouped together on the assumption that very fine clay particles will flocculate and therefore aggregate and settle out more quickly.

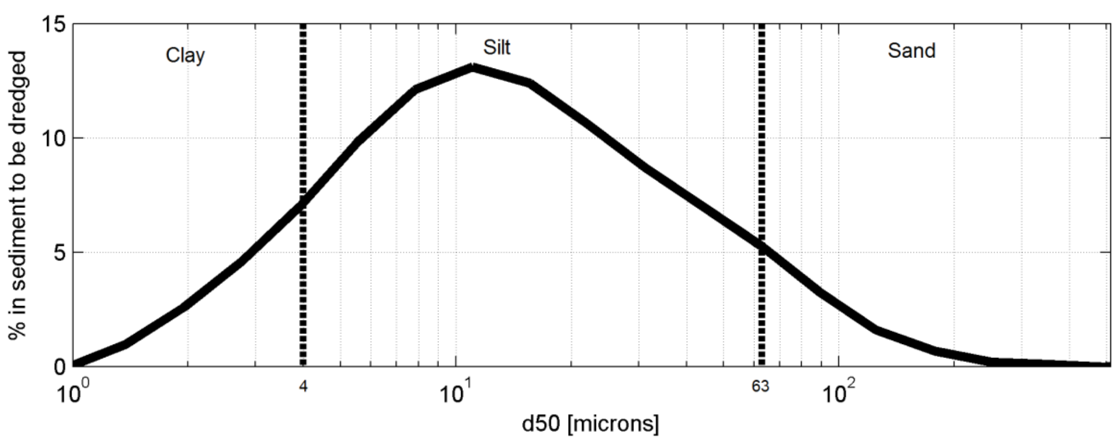


Figure 6.7: Particle size distribution of sediment to be dredged in the Lyttelton Harbour. The vertical dashed lines indicate the clay, silt, and sand size ranges. Source: Met Oceans Solutions Ltd, 2016.

	Representative d50 [microns]	Settling velocity [m/s]	Percentage of total volume [%]
Class 1	Smaller than 44.0	0.0010	81.8
Class 2	44.0	0.0014	7.0
Class 3	62.5	0.0028	5.3
Class 4	118.0	0.0085	5.9

Figure 6.8: Four discrete classes used with representative median grain sizes, settling velocities, and proportions of total volume released from the hopper. Source: Met Oceans Solutions Ltd, 2016.

6.48 Met Oceans Solutions Ltd has modelled several scenarios, as follows:

a. First, plumes are examined when the vessel is dredging without discharge from overflow pipe (dredge mode) and with discharge from the overflow pipe (overflow mode). To get an idea of the range of plumes that can be generated at any one time the dredge mode and overflow mode are investigated at peak flood and peak ebb tidal flows during the spring tide and the neap tide as described earlier;

b. Second, plumes during overflow mode are examined at the very beginning of the project with the existing bathymetry and these plumes are compared to plumes generated in overflow mode at the very end of the project when the channel is about 4m deeper; and

c. Third, the seiche current is factored into (b).

6.49 The discussion below is on the overflow mode operating (which is the worst case) at spring tide, and at the beginning of the project. The other scenarios described above yielded very similar results and are discussed in the Met Ocean Solutions Ltd report (see **Appendix 9**).

Fate of Turbidity Plumes from Dredging

6.50 A snapshot of the plumes operating in overflow mode during peak flood and ebb (spring) tidal flows at sites C1, C5 and C11 is illustrated in **Figures 6.9 (a) and (b)**. As shown on

the drawings, the surface turbidity plume would be sufficiently high in concentration so as to be seen during the overflow mode; although, based on experience during previous maintenance dredging campaigns, such plumes can be expected to dissipate quickly.

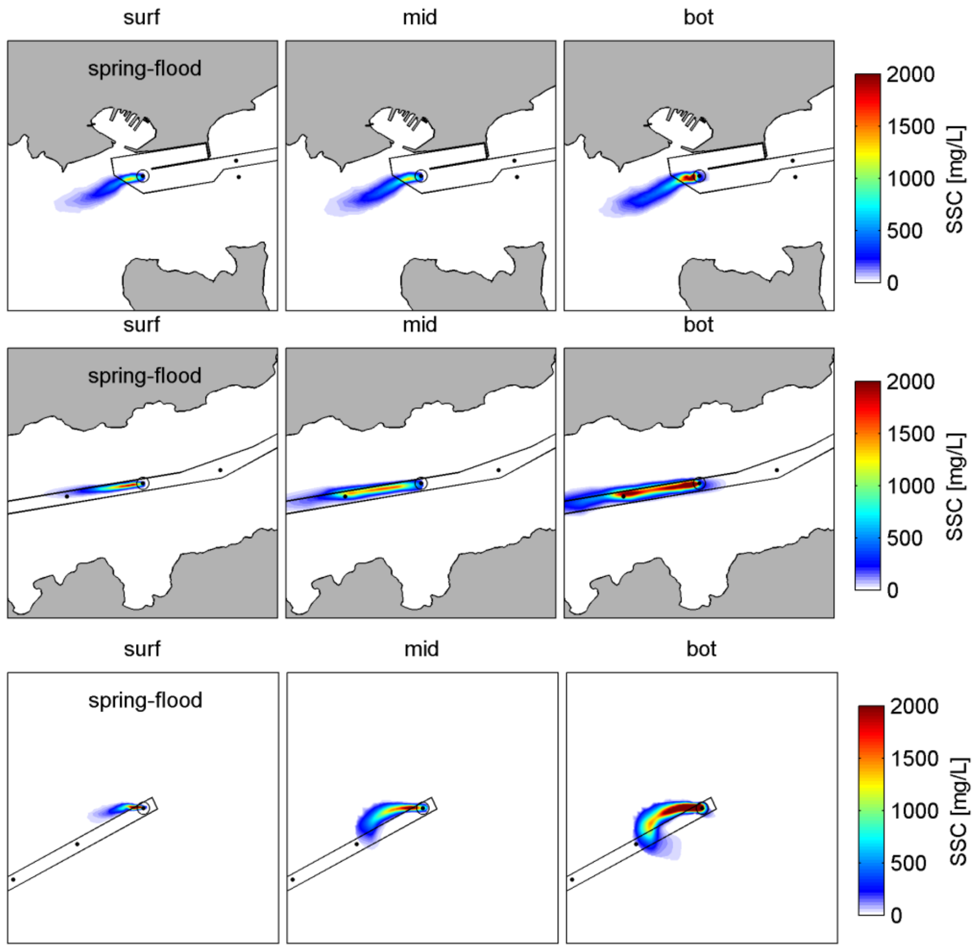
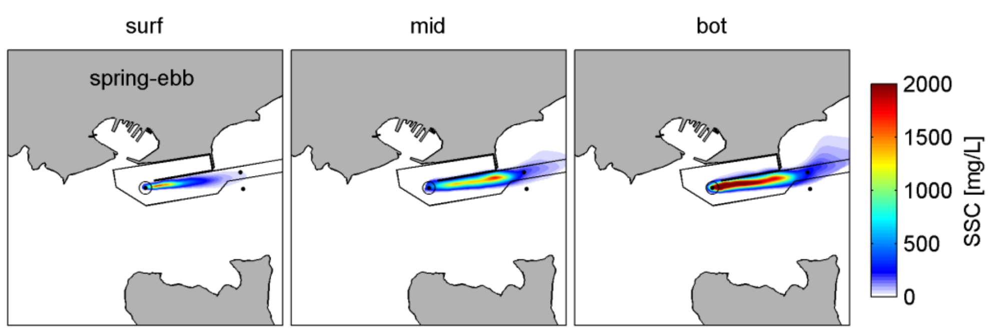


Figure 6.9 (a): Turbidity (SSC) plumes during overflow phases at site C1, C5 and C11 at peak flood flow during spring tides, at the surface, mid-water column and at the bottom - modelled at the commencement of channel dredging. Source: MetOcean Solutions Ltd.



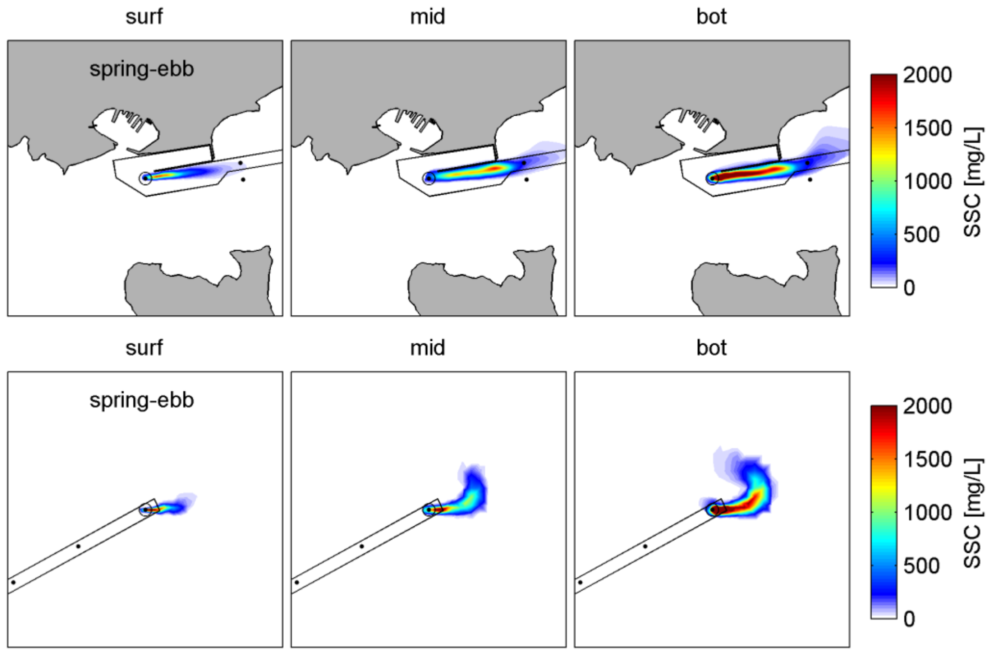


Figure 6.9 (b): Turbidity (SSC) plumes during overflow phases at site C1, C5 and C11 at peak ebb flow during spring tides, at the surface, mid-water column and at the bottom - modelled at the commencement of channel dredging. Source: Met Ocean Solutions Ltd.

6.51 The plumes at sites C1 and C2 are more or less confined to the channel because the currents run along the axis of the Harbour, and because it is more difficult for the plume to escape the channel itself. The plumes hook slightly to the north-west and south-east on the flood and ebb tides respectively at the end of the channel (C11), which is expected given there will be a cross-channel component from the current in Pegasus Bay (see Chapter 5, **Figure 5.12**). No plumes are predicted to reach the rocky shorelines of the Harbour or the outer coast during dredging with the possible exception of Shag Reef.

6.52 Examining the turbidity plumes generated during the peak flood and ebb tides of spring and neap tides provides a good indication of what an individual plume looks like at any one time. It is however equally informative to see what the 'average' plume looks like during the dredge runs over two tidal-cycles (28-days). To do this, the particle clouds generated from each run are laid over each other during the 28-days.[65]

[65] More technically they are called probabilistic SSC plumes and are obtained by overlaying the successive particle clouds throughout the 28-day period and computing the SSC fields based on the combined particle clouds. They were computed for the dredging only phase (i.e. no overflow) and three overflow durations, i.e. 10, 20, and 30 minutes.

6.53 The patterns are similar to those in **Figure 6.9 (a) and (b)** above. The turbidity plumes follow the channel orientations at sites C1 and C5. As shown **Figure 6.10**, the main difference in the pattern is the more elliptical plume that occurs when averaged overtime at site C11 because of the cross-channel component from the current in Pegasus Bay.

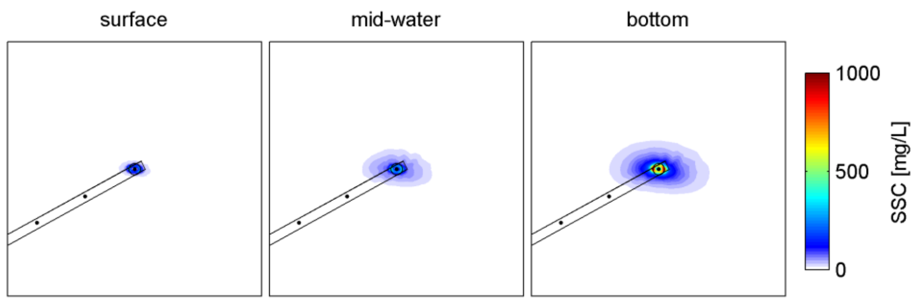


Figure 6.10: Probabilistic *SSC* plumes during overflow from the dredge vessel at site C11, at the surface, mid-water column and at the bottom modelled at the commencement of channel dredging. Source: Met Ocean Solutions Ltd, 2016.

6.54 Another way of examining plumes is to see whether the suspended sediment concentrations associated with the plume exceed typical background levels. Although Lyttelton Harbour/Whakaraupō and Pegasus Bay are naturally turbid, if suspended sediment concentrations exceed typical background levels for long enough some species could be adversely affected and the structure of some of the benthic communities could change.

6.55 The records from Environment Canterbury show that the mean SSCs are typically 10-20mg/L, but often reach up to 50mg/L and on rare occasions reach 100mg/L.[66] This could well be conservative on the assumption that sampling would have been carried out in comparatively calm conditions.

6.56 The SELFE model was used to examine the percentage of time SSC background levels were exceeded by the turbidity plumes generated during dredging. The background levels were taken as 10, 50 and 100 mg/L respectively. The results indicate that the plumes would typically exceed the backgrounds within 500-1000 m of the vessel during dredging at locations C1 and C5 although does extend up to about 2 km in the bottom plume at C5.

[66] Refer to the Met Ocean Solutions Ltd Report contained in **Appendix 10A** for further details.

6.57 It is notable that the plumes at the surface only exceed typical background concentrations 1-2% of the time. This is because most of the sediment at the surface descends rapidly into the mid-layer.

6.58 Again C11, at the outer end of the channel, has an elliptical shape which is consistent with the tidal flows at the site described earlier. The more elliptical nature of the tidal currents at site C11 result in the greater spatial dispersion of the dredging plume and consequently background turbidity is exceeded relatively less frequently than for sites C1-C5, where the dispersion patterns follow the axis of the Harbour. As shown in **Figure 6.11** background turbidity levels are expected to be exceeded for 5-10% of the time near Shag Reef.

Effect of Dredging Plumes on Marine Ecology and Avifauna

6.59 The benthic communities in the Harbour overall are classified as being turbidity-tolerant. Given only areas near the dredging and along the channel axis are predicted to be exposed to turbidity significantly above the background condition of the Harbour, effects on the benthos are expected to be no more than minor.[67]

6.60 Although the waters around Shag Reef are typically very turbid and a silt-tolerant community assemblage has been documented, an increase in the exposure of turbidity plumes is likely to have an effect on the biota supported by the reef. This is especially so for some species for which present SSC conditions may be marginal. The dredging operation will therefore need to be monitored closely when operating in this locality.

[67] Refer to the Cawthron Institute Report attached in **Appendix 15A.**

4.29

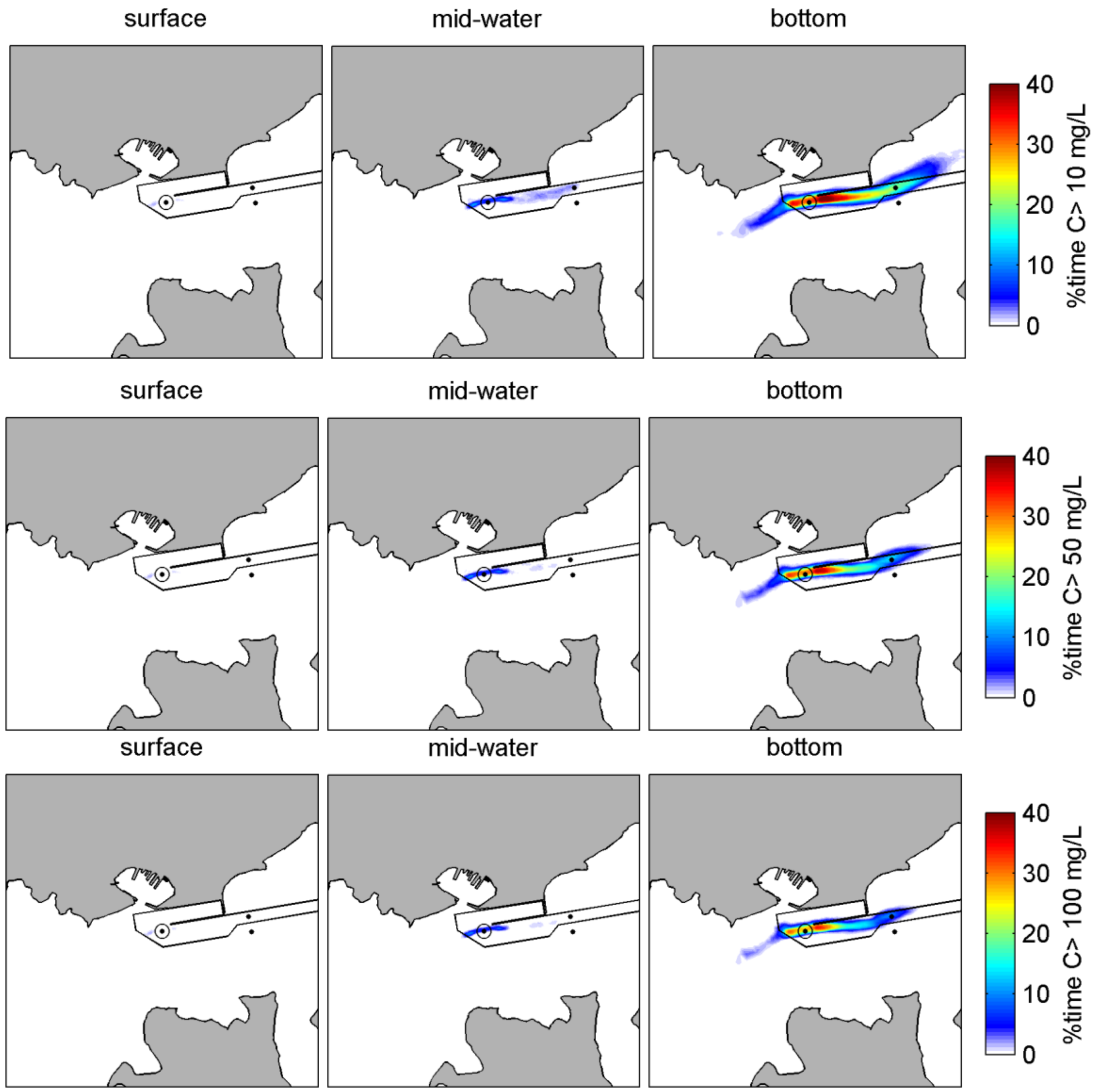


Figure 6.11: Percentage of time *SSC* thresholds of 10, 50, 100 mg/L (top to bottom) are exceeded during dredging activities at site C1, including dredging (25 minutes), overflow (10 minutes) and travel to and from disposal site (85 minutes). The exceedence percentages are computed over a full spring-neap tidal cycle (28-days). Source Met Ocean Solutions Ltd, 2016.

6.61 The plumes would not get close to Ripapa Island which, as discussed in **Chapter 5**, may provide habitat for the small brachiopod (*Pumilus antiquatus*). Even if the plumes did encroach on the shoreline of Ripapa Island, it is speculated that the species would have a reasonable tolerance to variable turbidity based on previous distributions in Lyttelton Harbour.

6.62 In terms of fisheries, the relatively narrow and channel-aligned plumes generated by dredging within the Harbour are not expected to present a barrier to fish movement. Any

exposure of plumes to fish is likely to be intermittent due to reversing tidal currents and changing wind-field influences on surface currents.

6.63 Given no significant effects on the above communities are anticipated from dredging itself, there should be no discernible difference in the food supply available for the associated marine mammals and marine avifauna. Even if there were some effects on food supply, these would be restricted both temporally and spatially and would be avoided by the mammals and birds during that period. Conversely, it cannot be discounted that dolphins or seals may be attracted to the frontal zones created by turbidity plumes to feed on prey.

Section 5: Impacts (other than from plumes) on Marine Mammals and Marine Avifauna during Dredging

6.64 Other impacts during the operation of the dredge vessel on marine mammals and marine avifauna can potentially include vessel strike, auditory damage or avoidance behaviours caused by underwater noise, entanglement from vessel gear or from pollution.[68]

6.65 The risk of vessel strike associated with baleen whales[69] is considered to be low because of the low risk of encounter and because the operating speed of the dredge would be slow enough to enable whales to avoid the vessel. Most odontocete ('toothed' whales or dolphins) and pinniped (seals or sea lions) species demonstrate few avoidance behaviours around ships and boats. Hector's dolphin for example appears curious of boats and often approach and/or bow-ride with numerous vessels. The risk of collision is considered very low, however, because of the dolphin's inherent ability to avoid collision and also because of the speed of the dredge vessel. Nevertheless, because of the threatened status of Hector's it has been recommended that the dredge adopt best boating guidelines for marine mammals to further reduce any chances of mortality from vessel strikes.

[68] Refer to Cawthron Report attached in **Appendix 16** and Boffa Miskell Report attached in **Appendix 17**.
[69] Baleen whales use their baleen plates to filter out food from the water by either lunge-feeding or gulp-feeding.

6.66 The noise from dredging and disposal operations is expected to have a less than minor effect on local or visiting odontocete (dolphins) and pinniped species because of the:

a. Differences in functional frequencies range between species' hearing sensitivities and the lower frequency sounds produced by dredge activities;
b. Relevant environmental factors, such as soft unconsolidated mud substrate, which indicate underwater noise production from dredge activities remains below 1kHz; and
c. Continued year-round occupancy of Lyttelton Harbour and / or nearby Pegasus Bay waters of Hector's dolphins and New Zealand fur seals despite on-going maintenance dredging taking place over many decades.

6.67 Baleen whales hear in the lower frequency ranges and could therefore be affected to a greater degree from an operating dredge due to noise being produced in the lower frequencies. However, given baleen whales only transit through the area and typically only 1-3 individual whales are sighted within or near Lyttelton Harbour each year, any potential adverse effects are expected to be minor.

6.68 Nocturnal birds can strike a vessel when bright, artificial light sources are used at times of poor visibility, particularly when lights are angled outwards or upwards from the vessel and when the vessel is relatively close to large breeding aggregations of seabirds (rather than further offshore). The two species considered potentially at risk based on their known behaviours (i.e. attraction to light and collision with cables) are the sooty shearwater and fairy prion. However the risk of strike in this instance is considered to be low for the following reasons:

d. The species will not be attracted to the dredging vessel as a source of food;
e. The species have large foraging ranges, generally feeding in waters off the New Zealand continental shelf; and
f. Any effect would be of a short term nature (due both to the term of the project and the movement of these species away from the area during the winter months).

6.69 While the probability of vessel strike is very low it is recommended that external lighting should be kept to the minimum required for safe operation and navigation; and deck

lighting, wherever practicable, should be directed downwards and be shielded to reduce light emanating horizontally or vertically from the vessel.

6.70 Penguins may also be at risk from collision with the submerged section of the cable and drag-head. However this risk is also considered to be a low given the mobile nature of penguins and the large foraging area available, as well as the short term nature of the risk.

6.71 Potential adverse effects associated with entanglements from vessel gear or from pollution associated with the dredge vessel are considered negligible for both marine mammals and avifauna.

Section 6: Fate of Turbidity Plumes Generated at the Offshore Disposal Ground

Introduction

6.72 Both measurement and modelling work has been carried out to determine how spoil behaves when released from a hopper at the proposed offshore disposal ground. The reason for this work was to understand how far suspended sediment would be transported away from the release-zone; and to also understand how sediment settles after release from a hopper, i.e. the size and depth of any sediment footprint.

6.73 Met Ocean Solutions Ltd, 2016 (see **Appendix 10A**) has modelled the fate of plumes generated from the disposal of dredge spoil at the offshore disposal ground. The currents are more complex at the offshore disposal ground than within Lyttelton Harbour/Whakaraupō; they are driven by oceanic current flows and winds more than tides. An important driver is the eddy of the Southland current described in **Chapter 5**, which varies in size and strength.

6.74 A ROMS model was used to model 10-years of hindcast (past) tidal and non-tidal current information to investigate the likely plume propagation from the future disposal activities. Long-term simulations to track particles from each corner and the centre of the proposed disposal ground have been run over the 10-year hindcast period. This should capture the range of waves and current which occur at the site. In other words, the model assumes that future conditions will be similar to past conditions.

6.75 The results are conservative because the sediment in practise would be disposed of across the whole of the spoil disposal ground rather than being concentrated at five disposal points.

6.76 The model can estimate how the plumes behave under typical weather conditions and also behave for specific events that have occurred in the past, such as a strong southerly weather event. This enables an understanding of plume behaviour in typical as well as extreme weather events. The data is used to evaluate the concentration and extent of the plumes and the risk of sediment reaching shorelines.

Fate of Sediment after the Release of Spoil from the Vessel Hopper

6.77 The fate of the dredge spoil after release from a hopper is well understood: the majority of spoil descends rapidly and collapses on the seabed, causing a sediment-laden density current to radiate;[70] and, thereafter, a passive plume forms to disperse sediment further.

6.78 As illustrated in **Figure 6.12,** during descent approximately 1% of sediment contained in the hopper is expected to be suspended into the water column near the surface, approximately 5% is expected to be suspended in the mid-part of the water column, and 21% near the seabed. The remaining 73% of sediment deposits on the seabed directly below the vessel.

6.79 The photograph in **Figure 6.13** graphically illustrates the above process with a bucket of spoil being deposited into an aquarium. As can be seen most of the plume spreads out laterally near the seabed bottom rather than at the surface.

6.80 As illustrated in **Figure 6.14**, the modelling of the plume after an individual release of dredge spoil during a strong north-west current predicts that most of suspended-sediment would typically settle within 500 metres of the release site in the 30-45 minutes following disposal. The same pattern is also shown in other current and wind conditions (Refer Figures 3.1 to 3.4 of the Met Oceans Solutions Ltd's Report attached in **Appendix 11**).

[70] Differences in the density of water can cause currents to form and move. In this instance water below the hopper contains higher concentrations of sediment, causing the water to collapse under gravity and forming a density current.

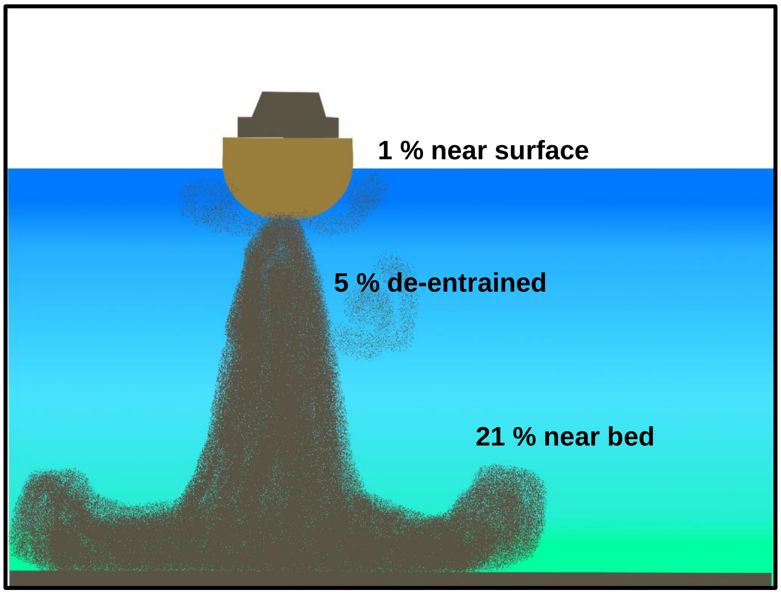


Figure 6.12: The diagram shows the plume descending and collapsing on the seabed, causing a sediment-laden density driven plume. Estimated percentages of sediment transferred from the near-field density driven plume to the passive far-field plume are shown. Source Met Ocean Solutions Ltd, 2016.

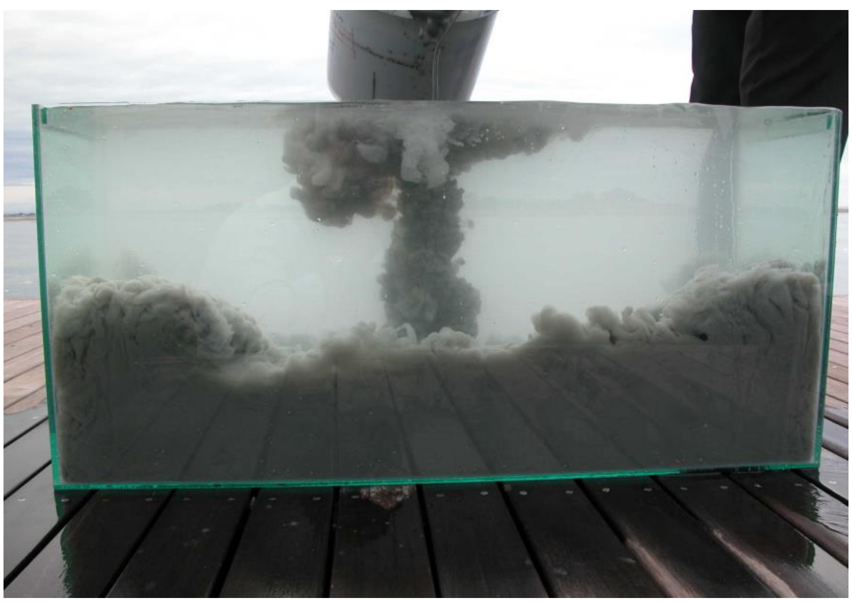


Figure 6.13: Photograph of a bucket of dredge material being deposited into an aquarium. The descending sediment plume hits the bottom of the aquarium and spreads out laterally from the initial release zone. Source: OCEL Consulting NZ Ltd, 2016.

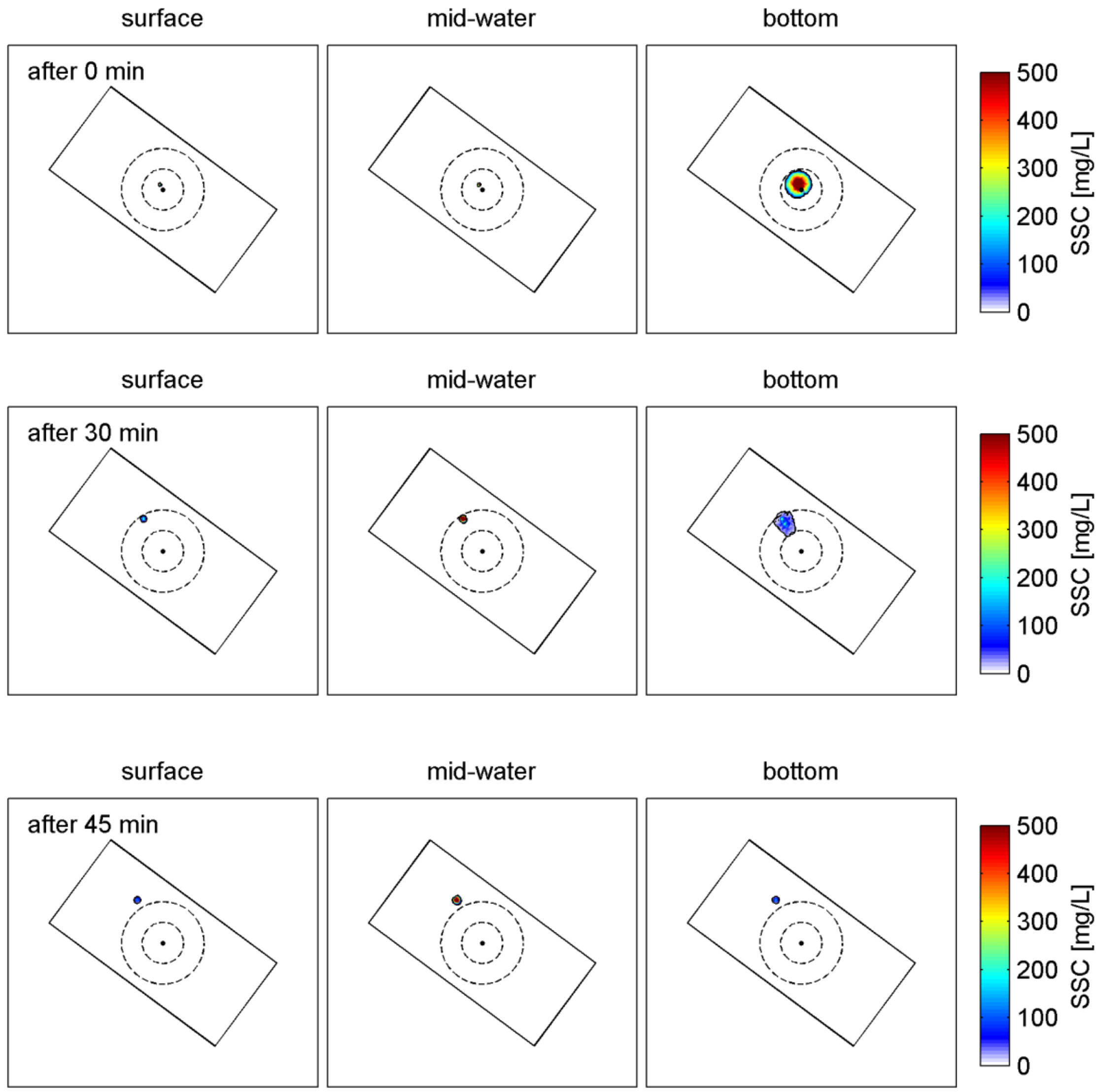


Figure 6.14: Generation of plumes during deposition from a 10,800 m^3 hopper in a strong north-west current. The circles have a radius of 500 m and 1000 m respectively. Source Met Oceans Solutions Ltd, 2016.

6.81 The measurement of plumes following disposal trials using the maintenance dredge vessel the ‘New Era’ is broadly consistent with the results from the modelling. A boat-mounted ADCP was used to detect the leading edge of the density plume, near the seabed bottom, after an individual release of approximately 1000 m^3 of dredge spoil. At Godley Head, the plume became indistinguishable from the background turbidity approximately 300 m from the drop zone in a period of 40 minutes. A similar result was obtained at the proposed offshore deposition ground at a depth of approximately 20 m. Here, the boat-mounted ADCP detected the leading edge of the density plume up to

approximately 200 m from the drop zone before it became indistinguishable from the background turbidity.

6.82 During the offshore trial a bottom-mounted ADCP was also placed on the seabed approximately 1 km towards Godley Head from the proposed offshore deposition ground. There was no detectable response of plumes reaching the bottom-mounted ADCP.

6.83 The fate of the plumes was also modelled under a purposefully unfavourable scenario i.e. three consecutive releases of spoil in very calm (non-dispersive) conditions. The results predict SCC levels will drop below 100-200 $mg.L^{-1}$ within 1 km of the disposal location as illustrated in **Figure 6.15**.

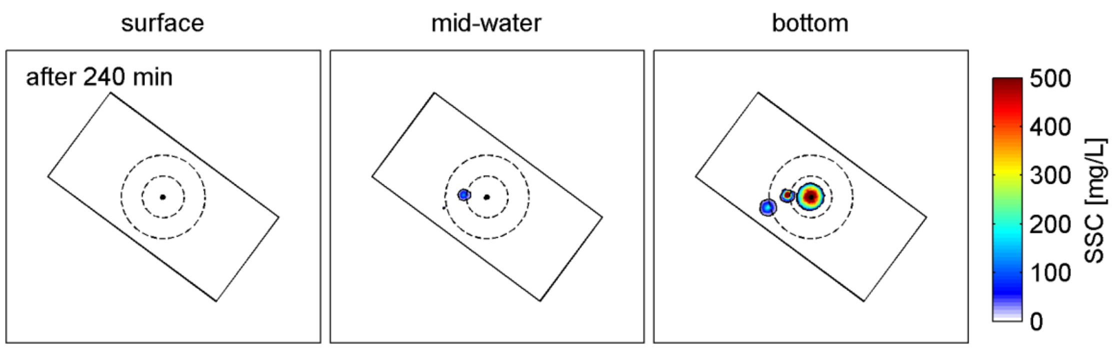


Figure 6.15: Disposal of three successive hopper loads from a 10,800 m^3 hopper during calm conditions. A disposal cycle is assumed to be two-hourly and so the above plume is just after the third release (i.e. 240 minutes after the first release). The circles have a radius of 500 m and 1000 m respectively. Source Met Oceans Solutions Ltd, 2016.

6.84 The modelling was also used to predict how the plumes would behave 'on average' over the 10-year period.10-year simulations within the historical hindcast context were time-averaged to produce a mean SSC associated with the disposal of one hopper load.

6.85 As expected, the plume's main axis was in a northwest-south-east direction which is consistent with the *M2* tidal ellipse (see Chapter 5**, Figure 5.24**). As shown in **Figure 6.16**, for a hopper capacity of 10,800 m^3, the 10 mg/L contour falls within 1 km of the release site for the bottom layer generally and falls within 500 m for the mid-layer of the water column.

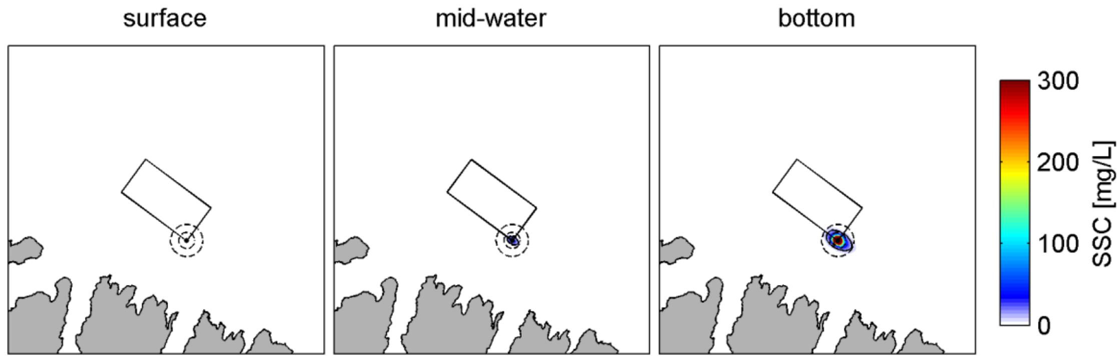


Figure 6.16: Mean SSC after a release from a 10,800 m^3 hopper load (Volvox Asia) at the south/south-east corner of the proposed disposal ground derived from 10-year hindcast simulations. The circles have a radius of 500 m and 1000 m respectively. Source: Met Oceans Solutions Ltd, 2016.

6.86 While the plume from the larger Utrecht dredge increases in size, the 10 mg L^{-1} contour (not shown here) still remains generally within 1 km of the release site for the bottom layer and within 500 m for the plume found in the mid-layer of the water column.

6.87 The ROMS model was also used to investigate where sediment settles out from the passive plumes after disposal (as discussed earlier some 73% of the sediment deposits directly on the seabed, and 21% is entrained back into the water column as a passive plume as the density current radiates and dissipates).

6.88 The results show that, on average, most of the sediment is deposited within 300 m of the release site. The 1 mm deposition contour falls within a 500 m radius around the release site as shown in **Figures 6.17 (a) and (b)**. As expected the thickness of seabed deposition is greater from the Utrecht vessel but the location of the 1 mm contour does not change.

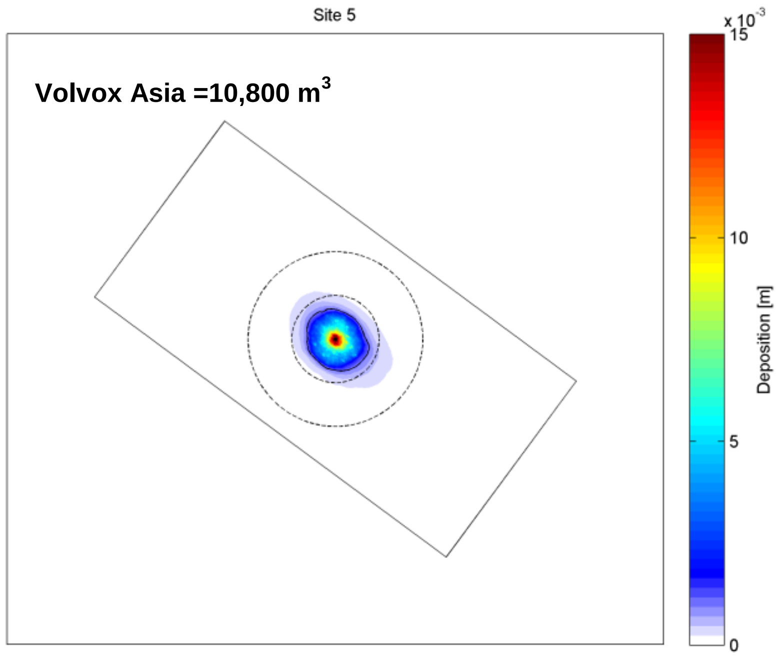


Figure 6.17 (a): Mean deposition field resulting from the disposal of one hopper load at the centre of the grounds from the Volvox Asia. The 1 mm depositional contour line follows the perimeter of the dark blue (but is difficult to see). The dashed circles have a radius of 500 m and 1000 m respectively. Source: Met Oceans Solutions Ltd, 2016.

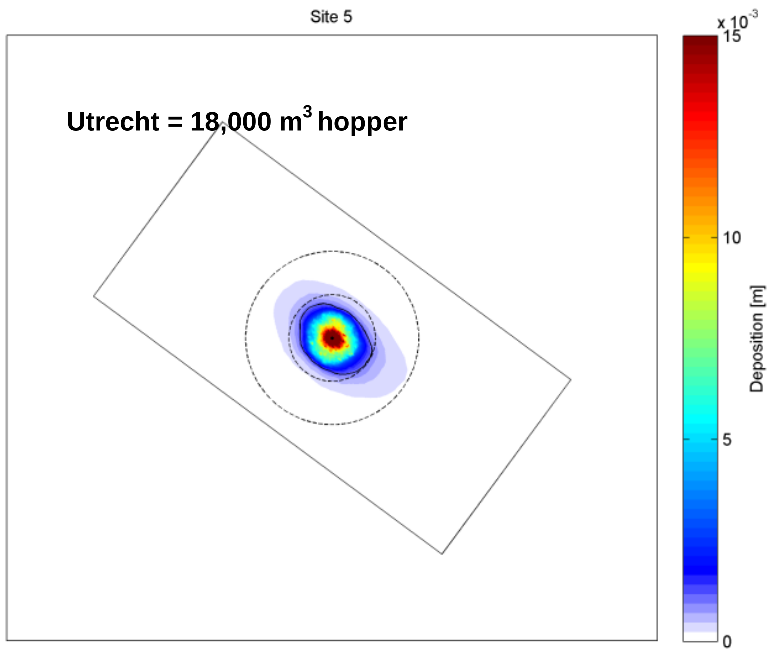


Figure 6.17 (b): As for Figure 6.17 (a) except from the disposal from the Utrecht. Source: Met Oceans Solutions Ltd, 2016.

Shoreline Encroachment of Plumes

6.89 As described earlier, most of suspended-sediment would typically settle within 500 m of the release site or 1 km in conditions favourable for plume propagation. Nevertheless, the model was also interrogated to determine the probability of any 'individual' particles reaching the shoreline, otherwise known as the extreme particle excursion.

6.90 The extreme excursion footprints generated from disposal of spoil at the south-east corner of the disposal ground is shown in **Figure 6.18**. The particle excursions have an elliptic shape elongated to the north-west/south-west which is consistent with plume dispersion modelling. The likelihood (probability) of any particles reaching the shoreline is extremely remote.

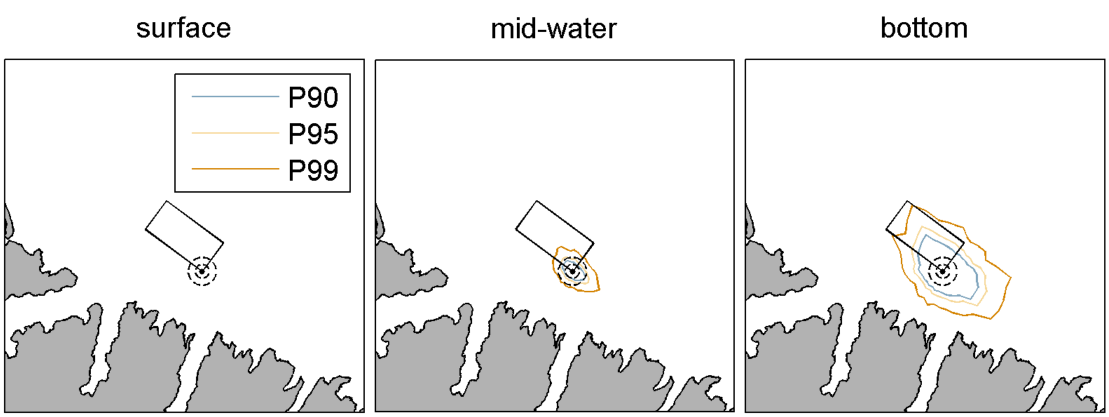


Figure 6.18: Comparison of extreme particle excursions resulting from sediment disposed of at the south/south-east corner of the proposed offshore disposal grounds. The model examines the surface, mid water and bottom layers of the water column and assumes the use of the Volvox Asia (with a hopper capacity of 10,800 m^3). These results are derived from the 10-year hindcast simulations. Dashed circles have radius of 500 m and 1000 m respectively. Source: Met Ocean Solutions Ltd, 2016.

The model was also run with disposal being carried out at all four corners of the disposal ground. Again the particles excursion forms a north-west/south-east ellipse. As shown in **Figure 6.19**, the results indicate that it is very unlikely (5% probability) that any particles would be transported within 1.6 km of the Bank Peninsula shoreline, and it is exceptionally unlikely (1% probability) that particles would be transported within 600 m of the shoreline.

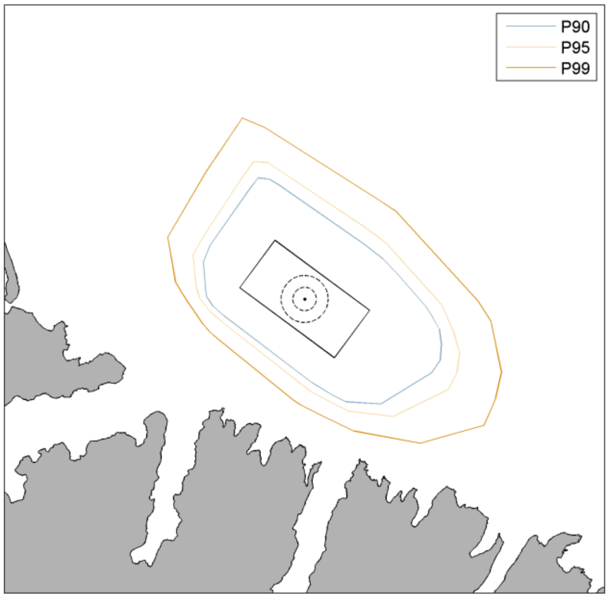


Figure 6.19: Combined extreme excursion footprints of sediment deposition resulting from sediment disposal at the four ground corners for the Volvox Asia vessel. These results are derived from the 10 year hindcast simulations. Dashed circles have radius of 500 m and 1000 m respectively. Source: Met Ocean Solutions Ltd, 2016.

6.91 The overall conclusion from the modelling work is that any measureable plume from disposal at the proposed offshore ground would not impact the coastline.

Plumes Exceeding Background Turbidity Levels

6.92 As discussed in **Section 4**, if suspended sediment concentrations exceed typical background levels for long enough the structure of some of the benthic communities could change. The ROMs model has therefore also been used to examine how long the plumes are likely to exceed background levels of turbidity in the water column.

6.93 The model assumes the disposal of dredge spoil at two-hourly intervals for two 1-month periods, at the centre of the disposal ground and the south/south-eastern which is the corner closest to the coast. One month was January, representing typical summer conditions; and the other was August, representing typical winter conditions. The results are again conservative because a single disposal point within the larger disposal ground is used continuously for the month.

6.94 **Figure 6.20** shows the August results for the south/south-eastern corner. As expected, the exceedance of background is more pronounced in the bottom layer and occurs in a south-east/north-west direction, consistent with the residual current.

6.95 The near-bed layer exceeds the typical mean background (10-20 mg/L) for about 5% of the time beyond 1 km from the disposal point although the area involved is small. In more turbid conditions, the exceedance of background turbidity is largely contained within a kilometre radius, and in naturally high turbid conditions the SSC will exceed background conditions for 5-10% of the time within an approximate 300 m radius of the release point.

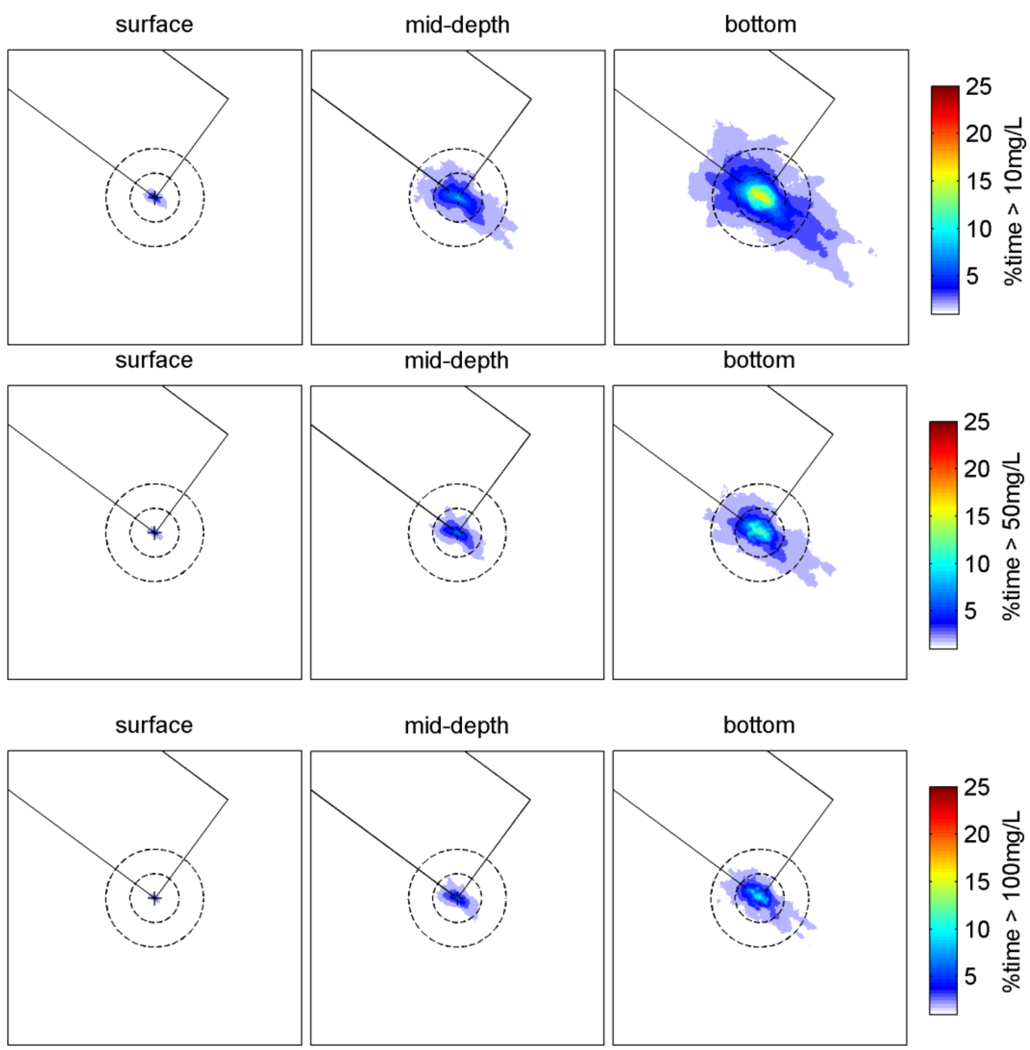


Figure 6.20: Percentage of time *SSC* thresholds of 10, 50, and 100 mg L^{-1} are exceeded during the month of August assuming disposal at two-hourly intervals by the Volvox Asia. Dashed circles have a radius of 500 m and 1000 m respectively. Source: Met Ocean Solutions Ltd, 2016.

6.96 The results between summer and winter are similar although the areas subject to threshold exceedances during January are more circular rather than elliptic. The release

of spoil at the centre of disposal ground indicates no threshold exceedances beyond the disposal footprint.

Section 7: Erosion and Re-deposition of Sediment at the Off Shore Disposal Ground

6.97 The previous section examined the fate the turbidity plumes generated during the release of spoil from the dredge vessel. Given some 73% of sediment released from the hopper deposits directly on the seabed and that the remaining 27% of sediment is expected to settle largely within 500 m radius of the release site, it is useful to examine how this sediment is subsequently disturbed and transported away over time.

6.98 Met Ocean Solutions Ltd applied a coupled wave, current and morphological model system (called Delft3D) to examine how quickly the offshore disposal ground is expected to erode and the sediment disperse and re-deposit.

6.99 The model conservatively assumes that spoil is spread evenly throughout the spoil disposal ground at the same time, which results in an even sediment thickness of 1.44 m across the ground. This is a conservative assumption given:

a. Spoil will be disposed over many months which results in continuous dispersion occurring and not all at once; and
b. The channel deepening will occur over at least two stages.

6.100 Furthermore, sensitivity testing of the model also strongly indicates that the erosion rate assumed in the model is likely to be considerably less in reality and therefore the rate of dispersion from the grounds is likely to be less than that shown in the results. Nevertheless, the work provides a useful picture of dispersion from all parts of the ground. The model in this instance cannot be specifically calibrated and validated due to limited empirical information on underlying sediment texture and historical information on how the seabed morphology changes over time after receiving sediment. Therefore the models are used to identify 'qualitatively' the patterns of morphological changes and key pathways of sediment transport. In other words, the models provide only guidance on how sediment disposed of at offshore disposal ground is eroded and re-deposited in the marine environment. (For further detail of the model see Section 2.4 of the Met Ocean Solutions Ltd's Report contained in **Appendix 12**.)

6.101 Figure **6.21** shows the eroded sediment being re-deposited to the south and to the north-west of the proposed disposal ground. It is thought that the majority of the suspension and associated transport of sediment is caused by infrequent but large waves in a north-west direction (see wave rose in Chapter 5, **Figure 5.11b**). In other words, wave-induced residual currents to the north-west, which operate during large weather events, are now thought to be the predominant driver of sediment transport rather than residual currents just generated by the Southland current.

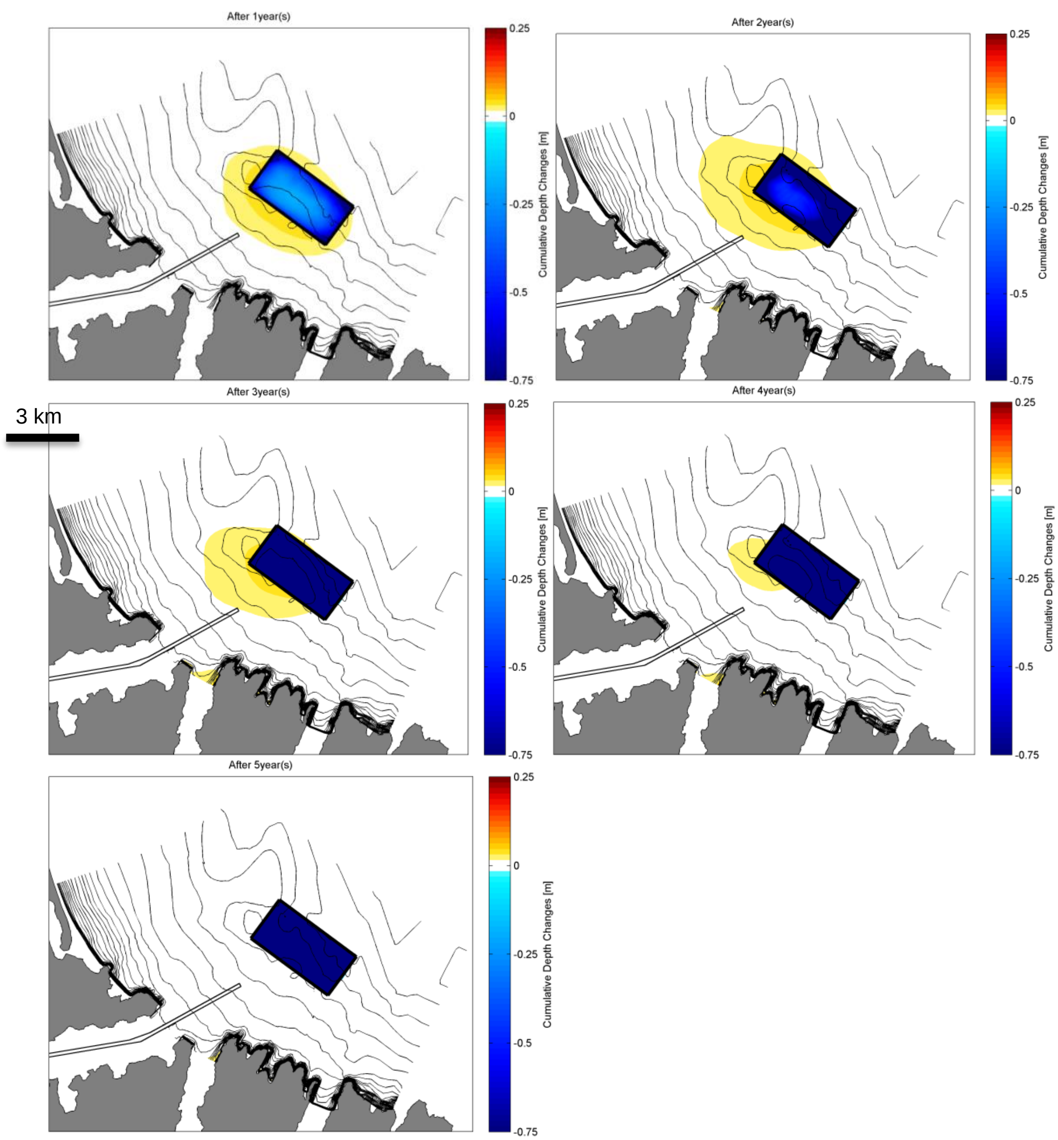


Figure 6.21: Cumulative morphological changes after each year over a 5-year morphological simulation of the disposal ground. The initial post-disposal bathymetry was obtained by adding 1.44 m of sediment throughout the entire ground (~12.5 km^2) i.e. the entire 18 million m^3 of

sediment. Initial bathymetric contours are shown in black. A positive magnitude (yellow) indicates sedimentation. Source: Met Ocean Solutions Ltd, 2016.

6.102 The erosion of the mound is illustrated in **Figure 6.22**. Within approximately 5 years the mound is reduced to surrounding seabed level.

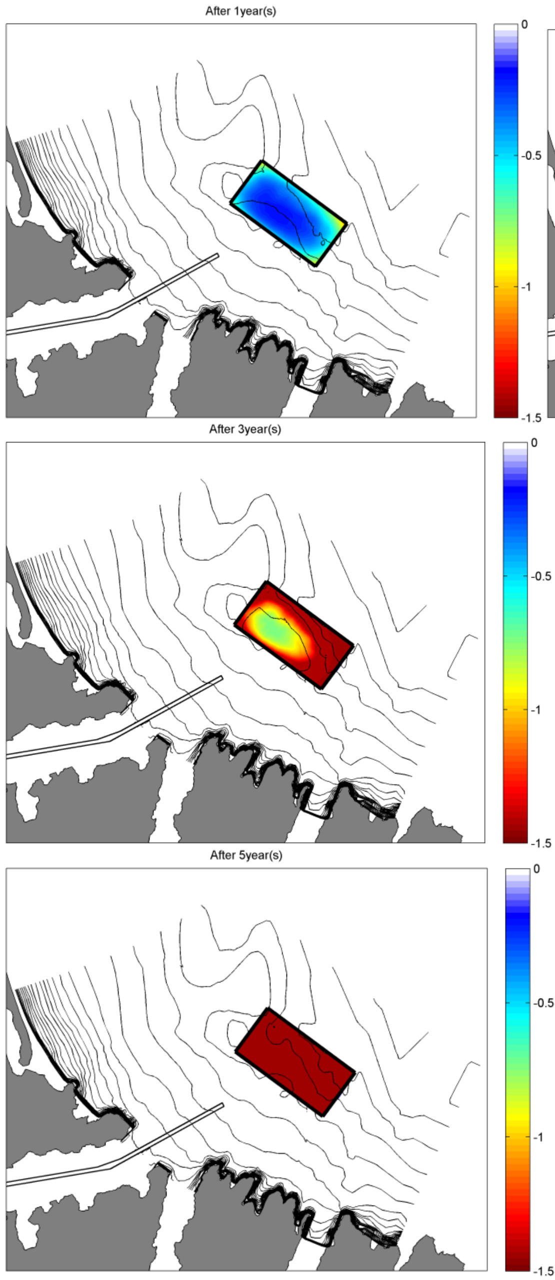


Figure 6.22: Cumulative erosion patterns of the sediment volume initially present in the disposal ground. The initial post-disposal bathymetry was obtained by adding 1.44 m of sediment throughout the entire ground (~12.5 km^2) i.e. the entire 18 million m^3 of sediment. Initial bathymetric contours are shown in black. The dark red colour indicates a cumulative loss (erosion) of some 1.5 m i.e. the mounds would have completely eroded.

6.103 In practice, it would impossible to measure the re-deposited sediment far beyond the boundary of the spoil grounds. This is for two reasons. Firstly, the grain size distribution of the sediment to be dredged is similar to that at the offshore grounds and therefore any re-deposited sediment would merge with the fluid mud layer, making it virtually indistinguishable. Secondly, as noted earlier, the disposal of dredge material will occur over many months, not all at once, and so the amount of sediment eroded and re-deposited would occur incrementally rather than all at once.

6.104 Assuming a uniform elevated disposal ground of 1.44 m, the model also examines whether the waves will change behaviour in response to the shallower seabed up until the mound is eroded.

6.105 A temporary change in wave transmission is expected as waves focus (increase height) in the lee of the disposal ground mound and defocus (reduce) on either side. **Figure 6.23** shows the difference in the weighted mean significant wave height (m) over all weather events and indicates that the waves focus up to 4% along South New Brighton with mean reductions between Sumner and Lyttelton Harbour/Whakaraupō of up to 2%.

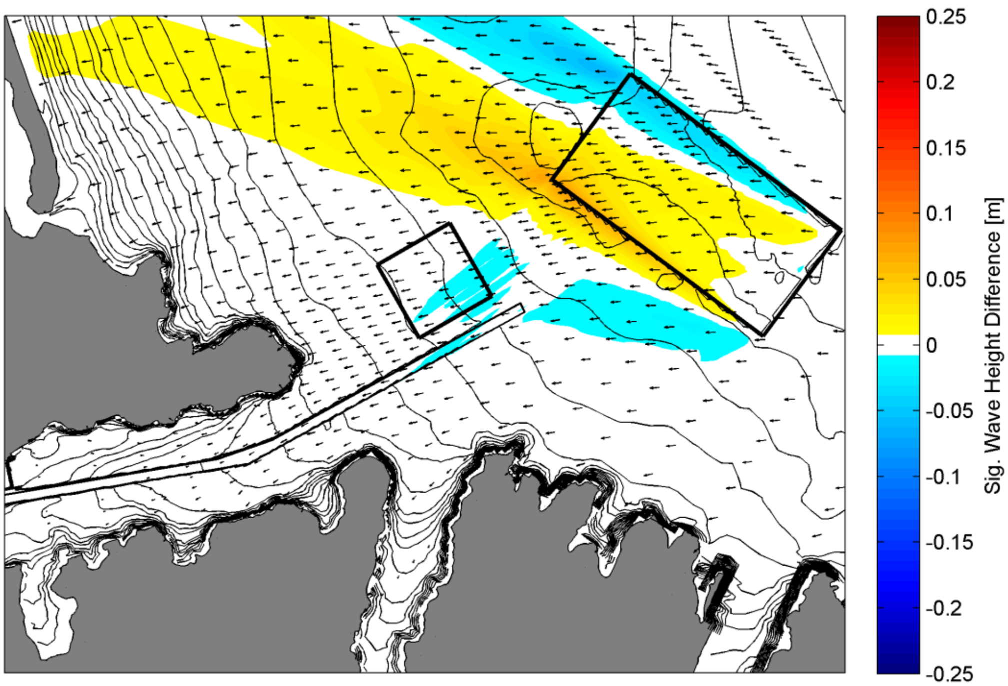


Figure 6.23: Difference of weighted mean significant wave height (m) between the existing environment and with the elevated disposal ground. Source: Met Ocean Solutions Ltd, 2016.

6.106 As shown in the Met Ocean Solutions Report attached in **Appendix 12** (see Figure 3.10) the areas where waves focus is dependent on weather conditions and the associated wave direction. Waves from north-east quarter for example tend to focus on Godley Head and Taylors Mistake area, whereas waves from the east to south-east tend to focus on South New Brighton Beach with reduced waves in the Taylors Mistake and Godley Head area (although these differences are typically less than 1-2%).

Section 8: Ecological Response to Deposited Sediment and Turbidity Plumes at the Offshore Disposal Ground

Deposited Sediment and Effects on the Seafloor Communities

6.107 The following assessment on ecology is summarised from the Cawthron Institute Report attached in **Appendix 15A**. For the benthic habitat within the spoil ground, the deposition of dredge spoil over an extended period (for each stage) is equivalent to a series of extreme sedimentation events, significantly exceeding those of natural occurrences such as from periodic swell events. This will lead to substantial smothering effects to the existing benthic community. However, lasting structural and ecological impacts in the vicinity of the proposed spoil ground are considered unlikely. This is due to a number mitigating factors, the main ones being that:

a. The disposal would occur in not less than two stages;
b. The deposition would be incremental over many months;
c. The spoil has a high degree of similarity with the native sediments at the spoil disposal ground;
d. There are low levels of contaminants; and
e. The benthic communities of the spoil disposal ground are dominated by small-bodied invertebrate taxa with generally short life-cycles and adapted to a dynamic sediment environment with major habitat-forming species being absent.

6.108 The type of benthic community is a particularly important consideration. At the proposed disposal ground the benthic community is characterised by species adapted to a dynamic sedimentary environment, where the benthic assemblages are fast-growing, small, opportunistic, and can readily re-establish themselves under conditions of high frequency disturbances.

6.109 For the proposed disposal ground, the processes of re-colonisation and recovery would begin almost immediately after the spoil has been released. This means recovery in any one part of the disposal ground will be occurring after being subject to deposition. Furthermore, many benthic infaunal organisms such as burrowing polychaetes, amphipods and molluscs can colonise newly deposited sediments through vertical migration. Therefore, if deposited sediment depths and/or rate of deposition are within the vertical migration capacity of these organisms (20-30 cm), recovery rates may be quicker than if colonisation is dependent solely upon lateral migration from adjacent areas and larval settlement.

6.110 On this basis, populations of many of the actively burrowing species identified by the survey (including many of the polychaetes, crustaceans and some of the bivalve molluscs) are unlikely to completely disappear, even temporarily, from the spoil ground.

6.111 The recovery of benthic communities at the spoil ground is likely to proceed in a similar manner to that of maintenance dredging spoil disposal sites within Lyttelton Harbour. Changes to benthic communities in the maintenance spoil grounds, while observable, are found to be relatively subtle within a few months of the cessation of deposition activities.

6.112 Therefore, and notwithstanding the scale of the proposed spoil deposition (18 million cubic metres), a complete recovery of the benthic habitat is expected over time.

Turbidity Plumes

6.113 The severity of ecological effects from turbidity plumes depends on a number of factors, including:

a. The nature of the suspended matter i.e. composition, size range and reactivity;
b. The concentration within the water column;
c. The duration of the turbidity event and rate of dilution and dispersion;
d. The rate of settlement of suspended particulates out of the water column; and
e. The level of background turbidity to which ecological communities are naturally adapted.

6.114 As discussed in **Section 7**, the model suggests that most of the bottom layer plume will settle within 500 m of the release site in the 30-45 minutes following disposal and simulations indicate that a plume concentration contour of 10 mg/L (above background) would stay within 1 km of the disposal location in the bottom layer and within 500 m in the mid-water layer.

6.115 Depending on the rate of consolidation of the sediments after disposal, there is potential for bottom layer plumes to remain above background SSC levels for a time. This could reduce the rate of benthic recovery in parts of the disposal ground although the effects from SSC are expected to be secondary and more transient compared with the effects from smothering.

6.116 The soft-sediment benthic areas of southern inshore Pegasus Bay contain a persistent near-bed layer of higher turbidity. Hence the soft-sediment benthic communities are inherently tolerant of sustained conditions of high suspended sediment loadings, including the increased deposition rates which this engenders. This is consistent with the relatively sparse benthic epifauna identified by trawl sampling.

6.117 Light penetration at the seabed is expected to be naturally very low in offshore areas, so elevated surface and mid-water turbidity following spoil deposition is not expected to result in significant effects to the benthic environment 15-20 m from the surface. In contrast, reef communities at the shoreline may be less tolerant, especially at sites where clear water is more prevalent. Much depends on the levels and ranges of turbidity to which communities are naturally accustomed.

6.118 The modelling indicates that it is extremely unlikely that any sediment particles, let alone concentrated plumes, would reach the shoreline. If any old age plumes did reach the shoreline it is considered that any observable changes to the shoreline ecosystem would be subtle, manifesting as changes in community structure which may include the following:

a. An increase in the prevalence of taxa less sensitive to suspended sediments;
b. A decrease in the cover of erect canopy-forming macrophyte species;
c. A decrease in the depth to which canopy-forming and other macrophytes extend; or
d. Changes to the prevalence and community structure of grazers.

6.119 It is noted that the shifts described above, should they occur, are reversible with a return to normal background conditions after dredging.

Release of Contaminants, Nutrients and Organic Matter

6.120 Samples from the benthic stations discussed in **Chapter 5** revealed that trace metals at the offshore stations are essentially low and uniform and likely to be representative of natural background concentrations. All were well below the trigger levels listed in the Australian and New Zealand Environment and Conservation Council (ANZECC) sediment quality guidelines. Stations along the proposed channel extension exhibited similarly low trace metal levels.

6.121 A substantial proportion of the dredge spoil would come from strata unaffected by anthropogenic inputs. While some surficial sediments in the central Harbour may contain contaminants at concentrations slightly above background, release of these to the water column through re-suspension (either during dredging or at the spoil ground) is expected to be minimal.

6.122 The release of significant quantities of nutrients and organic matter from re-suspended sediments can deplete oxygen within the water column. Although nutrients were not specifically analysed in sediment samples from the channel extension area, the relatively low sediment organic content and the absence of symptoms of anoxia in the surficial cores indicate that the re-suspension of sediments would not result in rapid or extensive oxygen depletion.

Effects on Finfish

6.123 The impact on finfish and the associated commercial fishing of finfish has been examined both in terms of seabed areas directly impacted by disposal at the offshore ground and from related turbidity plumes.

6.124 As discussed in **Chapter 5**, there is a small but significant fishery specifically targeting flatfish (principally *Rhombosolea leporine* and *Rhombosolea plebeian*) that occurs in shallow near-shore waters over the whole length of Pegasus Bay. In addition, elephant fish, rig and gurnard is likely to represent a high value by-catch. Of these species, only

elephant fish are limited to the near-shore zone for critical life stages, in this case breeding and egg-laying.

6.125 Flatfish and other inshore fisheries species are highly mobile and will avoid the immediate area if stressed by the effects of dredging and spoil deposition. Spoil deposition may result in an additional short-term food supply although in general, the disturbance to the seabed by this activity is likely to represent a temporary loss of suitable habitat.

6.126 It is likely that the immediate vicinity of the capital spoil ground will be lost as a fishing ground for the duration of the project and a subsequent period of habitat recovery. Recovery after disturbance is likely to be rapid, encouraging the rapid return of bottom-foraging fish.

6.127 There is no information indicating that the proposed off-shore disposal ground is an important spawning or nursery area for finfish with species such as flounder and gurnard and cod reportedly spawning in deeper waters. While elephant fish egg cases were not found during surveys it is possible that the disposal of dredge spoil could disrupt breeding or egg-laying in this area of the Pegasus Bay environs.

6.128 Turbidity plumes with high concentrations of suspended sediment can cause gill clogging and abrasion as well as egg smothering and abrasion in finfish species. Such plumes can also reduce foraging success and for some species increase their vulnerability to predation. The plumes being generated from the proposed offshore disposal ground of potential concern are not expected to extend more than a few hundred meters from the point of suspension. It is expected finfish species are likely to avoid these area in response to increasing stress.

Effects on Marine Mammals

6.129 Given the effects on marine ecology are not expected to be significant, are limited in spatial extent, and only a small portion of fish would be displaced temporarily from disposal sites, it is concluded that any short or long-term flow-on effects to local marine mammals would be negligible.

6.130 The assessment is premised on:

a. Expected low contaminant levels in the dredge spoil;
b. Insolubility of some contaminants and others that are not expected to be bio-available (i.e. bound in mineral forms with very limited solubility);
c. Rapid settlement of dredge spoil resulting in limited spatial exposure to individual prey species; and
d. The mammals having a generalist diet and therefore roving for food.

6.131 Similarly, it is expected that any effect from the turbidity plumes would not have any significant effect on marine mammals, based on the following:

a. The turbidity plumes are expected to settle out relatively quickly and are not expected to impact on shoreline habitats; and
b. The local marine mammal species being regularly exposed to highly turbid waters when seeking prey.

6.132 Notwithstanding, it is recommended that a combination of visual sightings from dredging vessels and simultaneous passive underwater acoustic monitoring be carried out prior to, during and after dredging and disposal activities, to assist in understanding:

a. Which species of marine mammals are present within the vicinity of works;
b. Potential seasonality and relative frequency of species within the vicinity of works; and
c. Continued presence both prior to, during and after activities have ceased.

6.133 This information would assist in testing the effectiveness of any mitigation measures put in place and enable them to be revisited and amended, if necessary. Such information may also inform the maintenance dredging concerning marine mammal response to dredging and spoil disposal operations and seasonal use of the area by particular species.

Effects on Marine Avifauna

6.134 As for marine mammals, the effect of disposal activities on marine avifauna is expected to be insignificant because there should be no discernible difference in the food supply available.

6.135 Even if there were some effects on food supply, these would be restricted both in the temporal and spatial extent associated with the disposal activities. Marine avifauna present within the Lyttelton Harbour and wider Banks Peninsula area are highly mobile with wide foraging ranges and reportedly can adjust foraging strategies in response to changes in food availability.

6.136 The effects of turbidity plumes likewise are considered insignificant perhaps with the exception of the little (white-flippered) penguin. The more limited foraging behaviour together with the location of the breeding birds (particularly in the upper Lyttelton Harbour/Whakaraupō means the species is potentially the most vulnerable to turbidity plumes. While the potential impact is still considered low, because of its rare status the overall effect is evaluated as being potentially moderate.

Effects on Key Mahinga Kai Species and Effects on Mussel Farms

6.137 Mahinga kai refers to iwi or hapū interests in food and other natural resources, and the sites, habitats and practices associated with those resources (see the CIA - **Appendix 3**). Therefore, not only is there an interest in the individual species that may be taken for food but also an interest in protecting the wider marine ecology that supports and underpins mahinga kai. For that reason, the assessments discussed earlier are also relevant and fundamental to protecting mahinga kai.

6.138 Locally important mahinga kai have been identified in collaboration with local representatives of the Runanga as shown in **Figure 6.24**.

Maori name	**English or common name**	**Species name**
Pāua	Abalone	*Haliotis iris*
Kina	Sea urchin	*Evechinus chloroticus*
Kutai	Blue mussel	*Mytilus edulis*
	Green-lipped mussel	*Perna canaliculus*
Koura	Spiny crayfish	*Jasus edwardsii*
Tio	Oyster	*Ostrea lutaria*
	Rock oyster	*Saccostrea commercialis*
Tipa	Scallop	*Pecten novaezelandiae*
Tuaki	Cockle	*Austrovenus stutchburyi*

Pipi	Pipi	*Paphies australis*
Pupu (or boo boos)	Cat's eye	*Lunella smaragdus*
	Scorched monodont	*Diloma aethiops*
	Mudflat snail	*Amphibola crenata*
Tuatua	Tuatua	*Paphies subtriangulata*
Wheke	Octopus	*Pinnoctopus cordiformis* and other species
Kaeo	Sea tulip	*Pyura pachydermatina*
Karengo	Seaweed	*Porphyra, Pyropia,* and *Clymene* species

Figure 6.24: Mahinga kai species of local importance. Source: Tonkin Taylor, 2016.

6.139 The report from Tonkin Taylor attached in **Appendix 6** notes that while it appears that soft-substrate species such as Pipi, Tuaki (cockles), and Tipa (scallops) are not present within the works area, they could be displaced, both by removal from dredge areas and by the disposal of spoil.

6.140 Any effect on intertidal mahinga kai outside of the direct works footprint will depend on the suspended sediment concentration in the sediment plume, its physical extent in relation to these mahinga kai resources, and the duration that the plume is present in the vicinity of these resources. The modelling data indicates that there is negligible chance of disposal material being transported onto the shoreline and therefore there should be no impact on these resources.

6.141 There are healthy populations of key mahinga kai species in close proximity to existing maintenance dredge disposal activities on the northern-side of Lyttelton Harbour. For instance, there are Green-lipped Mussels (*Perna canaliculus*) at Livingstone Bay and Breeze Bay, both located on the immediate shoreline of the existing consented maintenance dredge spoil grounds. The mussel beds at these two sites covered an average area of more than 55% of the inter-tidal habitat. Another important mahinga kai species, the Pāua (*Haliotis iris*) was also present in reasonably high densities at these sites.

6.142 In another recent survey of 20 Lyttelton Harbour/Whakaraupō sites, it was observed that the highest mussel bed densities are at two sites in Gollans Bay, the bay immediately to the west of Livingstone Bay. It appears that the healthy state of these species is evidence that they are not negatively impacted by the existing channel maintenance dredging and/or disposal activity.

6.143 The Cawthron Institute (see **Appendix 15A**) also examined the potential effects on Pāua and lobster. It concluded that any significant effects on Pāua, including juvenile Pāua, would be unlikely because again plumes are not predicted to reach shoreline. Even in the event any particulates did reach the shoreline areas they would not settle due to significant water movement at these sites. As noted above, there are apparent healthy populations of Pāua along the northern shoreline of outer Lyttelton Harbour within the existing maintenance dredging spoil disposal grounds despite spoil disposal occurring within 100 m of shore.

6.144 Lobsters inhabit a broad range of natural turbidity conditions. While information regarding the effects of suspended solids on this species is very sparse, the direct effects of turbid plumes on adult individuals are likely to be minimal. This is because high strength plumes (which would cause a reduction in the photic zone) are not predicted to occur on their rocky reef habitats.

Mussel Farms

6.145 One of the key mahinga kai species, the filter-feeding green-lipped mussel (*Perna canaliculus*), is also farmed. As discussed in **Chapter 5** there are a number of mussels in the area and the aquiculture industry is considered to be important to the local economy.

6.146 Green-lipped mussels have evolved in near-shore environments and are inherently tolerant of elevated levels of suspended sediments. They have been experimentally tested in their ability to extract food from water with high suspended sediment concentrations. Reportedly, the mussels were able to cope, and regulate their feeding, at suspended sediment concentrations greater than 1000 mg/L. As discussed above, the plumes generated from dredging and disposal activities are not predicted to reach shoreline but even if they did, they would not be of sufficient concentration to affect the mussels.

6.147 Nevertheless, because of the importance of these mussel farms to the local economy, real-time turbidity plume monitoring is to be carried out during the works, to confirm the actual extent of plume movement, and if necessary, to allow the dredge and disposal activities to be modified in real time, if the potential for any unforeseen adverse effects arise. This is discussed further **Chapter 7**.

Section 9: Assessment on Effects Recreation, Navigation and Noise

6.148 The actual or potential adverse effects of dredging and disposal activities on recreational activities are quite limited and confined. The presence of the dredging vessel will be an additional consideration for boats using the outer Harbour, as will the increase in duration of attendance of the maintenance dredge. The activities will also be noticeable to people engaging in recreation around Lyttelton Harbour/Whakaraupō. However, any change sits within an existing environment of commercial vessel traffic using the Port. Turbidity plumes may also be noticeable, but they are confined and temporary and have been assessed as not affecting recreation settings or resources.[71]

6.149 In terms of navigation, maintenance dredging vessels have operated in the harbour for years and there have not been any documented safety issues associated with other craft. The larger dredging vessel would be visible and would not constitute a hazard to other ships.

6.150 A consequence of channel deepening is that larger vessels will arrive. These vessels can be noisier depending on the types of refrigerator units used. The change in the levels of noise associated with servicing larger vessels was modelled as part of the assessments prepared for the Port Recovery Plan.[72] A copy of the report is contained in **Appendix 18** and it concludes that there will be an insignificant change to the port-noise contours in the Lyttelton township. Furthermore, the level predicted at the nearest house located at Diamond Harbour is to be below 55dBA L_{dn}, which is the level where the port noise would have any negative effects on the residential community.

Section 10: Marine Biosecurity

6.151 Lyttelton Port has a range of exotic marine organisms. Three of them are considered to be high-profile harmful marine organisms (HMOs): the Asian kelp *Undaria pinnatifida*, the clubbed tunicate *Styela clava* (a type of 'sea squirt') and the Mediterranean fanworm *Sabella spallanzanii*. The Ministry for Primary Industries initiated responses to *Styela* and *Sabella* in Lyttelton Port when these species were first detected, but these

[71] Refer to the Rob Greenaway & Associates Report attached in **Appendix 5.**
[72] 347 x 43 m s class Maersk container ship

programmes are no longer ongoing, reflecting the difficulties in marine pest population management.

6.152 Three risk factors have been identified with the channel deepening project:

a. The introduction of new harmful marine organisms ('HMOs') associated with a dredge deployed from overseas;
b. Increase HMO risk due to dredging and disposal activities; and
c. Increased HMO risk due to large vessels entering the port and possibly vessels arriving from new overseas ports.

6.153 The most significant of the above risk factors is considered to be associated with a dredge being deployed from overseas. The risk arises from:

a. Discharge of ballast water;
b. Sediment left on the dredge; and
c. Biofouling (marine plants and animals that are attached to, or associated with, submerged surfaces).

6.154 Section 9 of the Cawthron Institute report contained in **Appendix 15A** evaluates the level of risk posed by these activities. It considered the risk would be at an acceptable level provided the dredge vessel adheres to the Ministry for Primary Industries' mandatory Import Health Standard ('IHS') for ballast water and sediment[73] and adheres to the currently voluntary Craft Risk Management Standard ('CRMS'). The CRMS requires that vessels coming to New Zealand arrive with a 'clean hull' which is defined in relation to thresholds of 'allowable biofouling' and will greatly mitigate the potential for HMO introductions.

6.155 The CRMS will become mandatory in 2018 but given it is likely that the dredge vessel would be deployed by then it is suggested that a management plan be adopted that details how bio-fouling is to be managed. Cawthron Institute recommends that a Biosecurity Management Plan ('BMP') be developed for the vessel, and that it includes a description of:

a. The dredge and its attributes that affect risk;

[73] Ballast water is exchange mid-ocean *en route* to New Zealand. Ballast water management systems that can include the use of substances to treat ballast is shortly to be ratified and will apply to a third of the global shipping fleet.

b. Key sources of potential marine biosecurity risk from ballast water, sediments and biofouling;

c. Risk mitigation prior to arrival in New Zealand, including:

   i. Routine preventative treatment measures;

   ii. Specific treatments for submerged and above-water surfaces that will be undertaken to address IHS and CRMS requirements prior to departure for New Zealand;

   iii. Additional risk mitigation planned during transit to New Zealand, including expected procedures for ballast water management;

   iv. Expected desiccation period of above-water surfaces prior to departure and during transit to New Zealand;

   v. The nature and extent of pre-border inspection that will be undertaken at the overseas port of departure) to verify compliance with IHS and CRMS requirements; and

   vi. Record keeping and documentation of all mitigation undertaken prior to and during transit to New Zealand.

6.156 It is also anticipated that the BMP will be submitted to MPI and the MPI reporting requirements will be completed as required by law.

Conclusions

6.157 The modelling, measurement and assessment work in summary concludes:

During Dredging

- The change of habitat associated with channel deepening and widening is not considered to be significant in the context of near-shore Pegasus Bay;
- No features of ecological significance have been observed;
- The benthic communities are adapted to turbid environments – recovery is expected to occur quickly;
- Waves heights will increase and decrease in different parts of the Harbour, with the largest change involving swell waves in the vicinity of Diamond Harbour reducing in height further;

- Reclamation would cause an increase in the tidal currents, but deepening of the shipping channel and ship-turning basin would offset this effect, meaning the overall change in tidal currents would be small;
- Sediment is not expected to accumulate in the upper Harbour as a consequence of channel deepening or dredging activities;
- Overall, the deepening of the channel (together with future reclamation) would change the Lyttelton Harbour/Whakaraupō hydrodynamics but in absolute terms most of the changes would be small;
- Turbidity plumes generated during dredging are largely confined to the channel Harbour and no plumes are remotely predicted to reach the shoreline;
- Visually, the plumes during overflow mode will be noticeable at the surface although background turbidity means the plumes should dissipate quickly; and
- The plumes are not predicted to cause any significant effects on the marine ecology.

During disposal:

- The most significant turbidity (density) plumes occur at the seabed and are contained within a 300 m radius from the release point;
- The turbidity plumes are predicted to propagate in a northwest-southeast direction, consistent with the dominant currents at the disposal site;
- In the bottom layer, the 10 mg/L contour line generally stays within 1 km of the disposal point and within 500 m in the mid-water layer. In the surface layer, SSC plumes are very limited, with typical magnitudes below 10 mg/L;
- The turbidity plumes and the associated deposition footprints remain 2 to 3 km from the nearest shoreline;
- It is extremely unlikely that individual sediment particles will be transported any closer than 600 m from the coastline;
- Even if any sediment particles did make the shoreline any change to shoreline ecosystem are unlikely because of the high energy environment not enabling sediment to settle;

- The spoil ground is typical of Pegasus Bay habitat and no features of ecological significance have been observed;
- Impacts from smothering are expected to be extensive but mitigated because the benthic communities are dominated by small-bodied invertebrate taxa with generally short life-cycles, which are adapted to turbid environments. Recovery is expected to occur quickly;
- Consequently, the impacts on finfish, marine mammals and avifauna is expected to be low to negligible;
- Staging of the project would reduce the degree of impact; and
- The green-lipped mussel that is farmed is reportedly very tolerant of turbid conditions and is not expected to be effected.

6.158 However, given the scale of dredging and disposal is significant, even with staging, a comprehensive monitoring programme is proposed and a framework established to manage dredging and disposal operations should unforeseen effects become apparent. This is discussed in **Chapter 7**.

PART C: MAINTENANCE DREDGING

Effects during Dredging

6.159 It is anticipated that the maintenance dredging campaign would continue to deploy a small trailer suction hopper dredge, with a hopper capacity of approximately 1,840 m^3. The maintenance dredge would generate smaller plumes that than larger dredge being used for channel deepening for the following reasons:

a. The vessel has a smaller drag-head;
b. The pumps are of a smaller capacity and hence the rate of sediment being discharge in overflow mode is less; and
c. The sediment is easily removed because it is relatively unconsolidated.

6.160 The plumes would be of a smaller size and concentration than those discussed in Section 3 earlier. This means the plumes would remain more or less confined to the channel because the currents run along the axis of the Harbour, and because it is more

difficult for the plume to escape the channel itself. No plumes are predicted to reach the rocky shorelines of the Harbour or the outer coast during dredging.

6.161 Effects on the benthos are also expected to be no more than minor given only areas in the vicinity of the dredging activity and along the channel axis are predicted to be exposed to turbidity above the background condition of the Harbour. Maintenance dredging has been carried out for many decades and Harbour wide monitoring has not revealed any significant effects on biota.

6.162 The maintenance dredge vessel would pose the same types of risks to marine mammals and marine avifauna discussed in Section 5 earlier although the risk profile of the vessel is less because it is smaller, travels slower than a larger dredge vessel, and would be less noisy.

Effects of Deposition at the Proposed Offshore Maintenance Disposal Ground

Introduction

6.163 Similar modelling and investigative work was carried out at the proposed offshore maintenance ground disposal as that completed for the larger offshore (capital) ground described earlier: LPC examined:

d. The fate of turbidity plumes;
e. The erosion and fate of re-deposited sediment at the ground; and
f. The ecological response to deposited sediment and turbidity plumes at the offshore disposal ground.

6.164 The conclusions reached are in essence the same as those described earlier in Sections 6, 7 and 8, and will accordingly not be repeated at the same level of detail. Further details of the modelling and ecological assessment work undertaken, however, can be found in the following reports:

g. Met Ocean Solutions Ltd's Report on plumes attached in **Appendix 11**;
h. Met Ocean Solutions Ltd's Report on the modelling of sediment dynamics **Appendix 13**;
i. Cawthron Institute's Report on the assessment of impacts to benthic ecology and marine ecological resources attached in **Appendix 15A**; and
j. Cawthron Institute's Report on the assessment of effects on marine mammals attached in **Appendix 16**.

The fate of turbidity plumes

6.165 **Figure 6.25** illustrates how the plumes would behave 'on average' over a one year period. The figure represents a time-averaged mean SSC associated with the disposal of one hopper load in the historical hindcast context. The largely circular plume shows the 10 mg/L contour falling well within 1 km of the release site for the bottom layer and the plume for the surface and min-water layers is not registered (less than 10 mg/L).

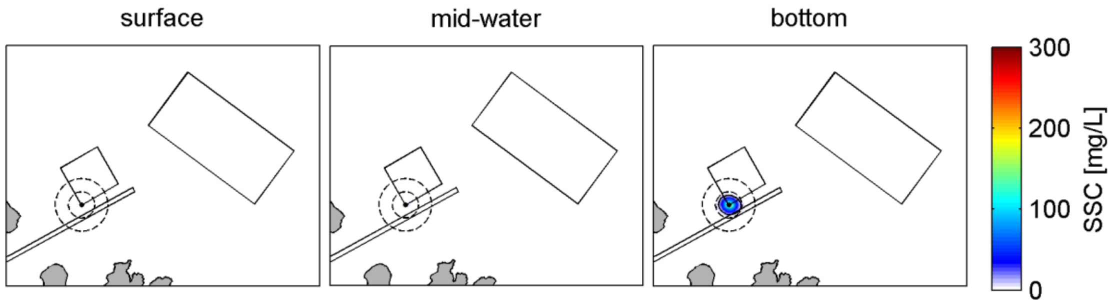


Figure 6.25: Mean SSC after a release from a 1,840 m^3 hopper load (Mahury) at the south/south-east corner of the proposed disposal ground derived from 10-year hindcast simulations. The circles have a radius of 500 m and 1000 m respectively. Source: Met Oceans Solutions Ltd, 2016.

6.166 The fate of the plumes was again modelled under a purposefully unfavourable scenario i.e. three consecutive releases of spoil in very calm (non-dispersive) conditions. In those circumstances, the plumes are predicted to drop below 100-200 $mg.L^{-1}$ within 1 km of the disposal location as illustrated in **Figure 6.26**.

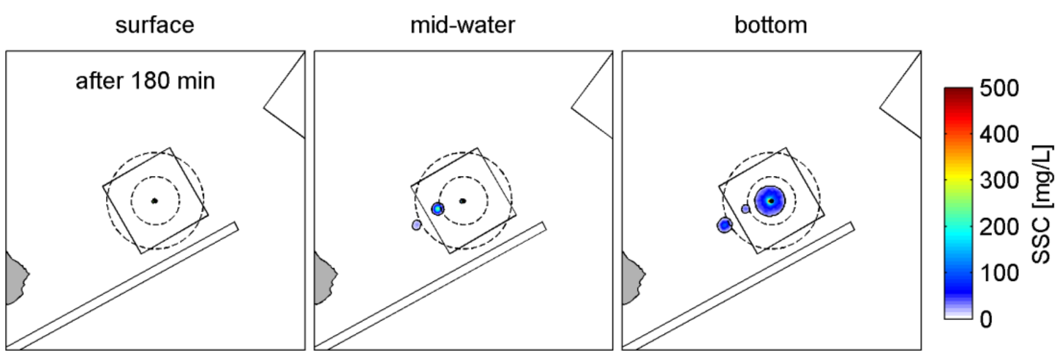


Figure 6.26: Disposal of three successive hopper loads from a 1,840 m^3 hopper during calm conditions. A disposal cycle is assumed to be 1.5 hours and so the above plume is just after the third release (i.e. 180 minutes after the first release). The circles have a radius of 500 m and 1000 m respectively. Source Met Oceans Solutions Ltd, 2016.

6.167 Extreme excursion footprints were also generated by running the model with disposal occurring at all four corners of the disposal ground. As shown in **Figure 6.27**, the particles excursion forms a north-west/south-east ellipse, and the results indicate that it is very unlikely (5% probability) that any sediment would be transported within 400m of the Banks Peninsula shoreline. The results also indicate that it is possible but exceptionally unlikely (1% probability) that individual particles might reach Godley Head and Baleine Point.

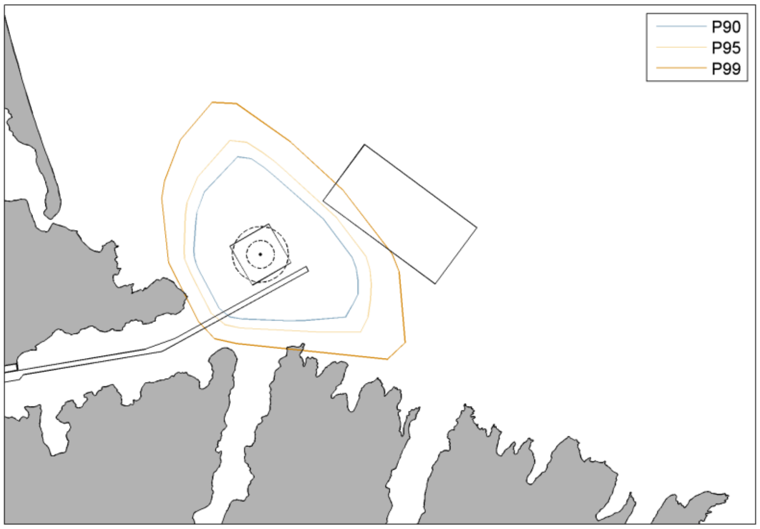


Figure 6.27: Combined extreme excursion footprints of sediment deposition resulting from sediment disposal at the four ground corners for the Mahury vessel. These results are derived from the one year hindcast simulation. Dashed circles have radius of 500m and 1000m respectively. Source: Met Ocean Solutions Ltd, 2016.

6.168 The overall conclusion from the modelling work is that any measureable plume from disposal at the proposed offshore ground would not impact the coastline.

6.169 The model was again used to examine how long the plumes are likely to exceed background levels of turbidity in the water column.

6.170 The model assumes the disposal of dredge spoil at 1.5 hour intervals for a 1-month period, at the centre of the disposal ground and the southern corner closest to the coast. One month was January, representing typical summer conditions; and the other was August, representing typical winter conditions. The results are again conservative because a single disposal point is used continuously for the month.

6.171 As shown in **Figure 6.28** at the southerly corner for the month of August the bottom layer exceeding the typical mean background (10-20 mg/L) for up to 5% of the time occurs generally within 500m and tapers off up to 1 km of the release site. In more turbid conditions, the exceedance of background turbidity is largely contained within a 500m radius.

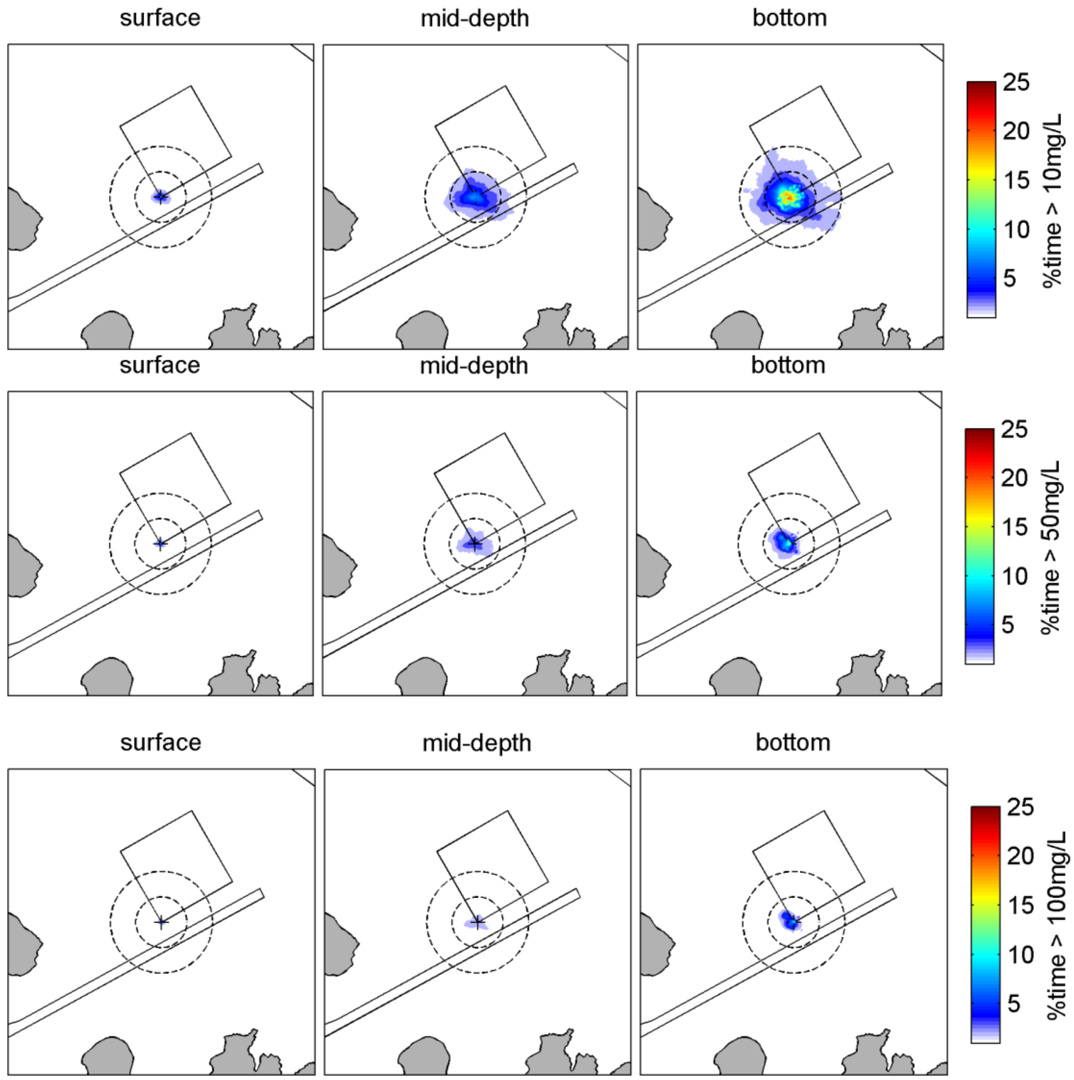


Figure 6.28: Percentage of time *SSC* thresholds of 10, 50, and 100 mg L^{-1} are exceeded during the month of August assuming disposal at 1.5 hour intervals by the Mahury. Dashed circles have a radius of 500 m and 1000 m respectively. Source: Met Ocean Solutions Ltd, 2016.

6.172 Given the nature of seabed habitats within the area encompassed by the plume contours and the information available regarding background turbidity in near-shore Pegasus Bay, neither the plumes or their subsequent depositional footprints are expected to result in significant adverse ecological effects.

6.173 Cawthron Institute notes that the predicted absence of effects on shoreline reef habitats from deposition-derived plumes is consistent with observations and surveys of intertidal and sub-tidal communities within the current maintenance dredge spoil grounds that have been carried out since the mid-1990s.

6.174 The visual amenity from the numerous vantage points was also assessed[74] and it is concluded that all will receive either low or very low visual effects of the operation except for some residents in Smugglers Cove. The effects may be moderate to low due in that location due to an easterly outlook enabling the dredge to be seen at the proposed maintenance spoil disposal ground and to a lesser extend the plume after disposal.

Erosion and Re-deposition of Sediment at the Off Shore Disposal Ground

6.175 Met Ocean Solutions Ltd applied a coupled wave, current and morphological model system (called Delft3D) to examine how quickly spoil disperses from the offshore maintenance spoil disposal ground. The model assumes that spoil is spread evenly throughout the spoil ground at a height of approximately 0.35 m although this is a conservative assumption given spoil will be disposed over many weeks.

6.176 As for the assessment of the larger offshore ground for channel deepening, the model cannot be specifically calibrated and validated due to limited empirical information on underlying sediment texture and historical information on how the seabed morphology changes over time after receiving sediment. Therefore the models are used to identify 'qualitatively' the patterns of morphological changes and key pathways of sediment transport. For further detail of the model see Section 2.4 of the Met Ocean Solutions Ltd's Report contained in **Appendix 13**.

6.177 As shown in **Figure 6.29** after one year the layer of sediment is expected to be thin and roughly circular in shape around the spoil ground.

[74] Boffa Miskell report on natural character, landscape and visual amenity assessment attached in **Appendix 4.**

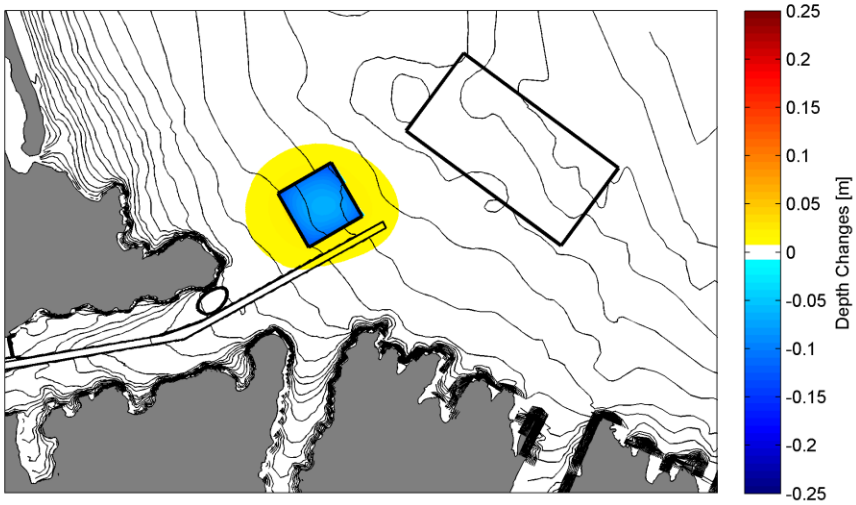


Figure 6.29: Predicted bathymetric changes after an accelerated one-year morphological simulation for the scenarios showing an elevated maintenance ground only. The erosion rate parameter used in the simulations was 1e^{-6} kg/m^2/s. Source: Met Ocean Solutions Ltd, 2016.

6.178 The model also examined the use of Godley Head and the proposed maintenance spoil ground at the same time as shown in **Figure 6.30**. The model has assumed half of the estimated average quantity of spoil would go to both grounds (i.e. 450,000 m^3 each) whereas the proposal is for the majority of spoil is to be directed to the offshore maintenance spoil ground and Godley Head used as backup.

6.179 Models show that sediment disposed at both grounds will find its way into the channel, although it is estimated that if both grounds were used evenly (which will not be the case) then the channel would accumulate approximately two to three times that compared with just using the offshore maintenance spoil ground. One reason for this is the shipping channel further out is shallower and would act less as a sediment trap.

6.180 The ease of which sediment is eroded from the seabed depends on the nature of the seabed material i.e. grain size and cohesiveness. Based on previous work with similar sediments the predicted erosion rate for the project area is at the upper end 1e x 10^{-5} kg/m^2/s and at the lower end 1e x10 $^{-6}$ kg/m^2/s. If the upper end (or bound) is applied to the model and is operating on both fully mounded disposal fields (see **Figure 6.31**) then a very thin layer of sediment would reach for example the eastern side of Port Levy/Koukourārata.

6.181 Given this prediction, the model was further interrogated to determine what would happen if the upper and lower bounds of the erosion rate were applied without any

disposal mounds. In other words, the model was examining how the seabed eroded and consequently deposited in natural background conditions.

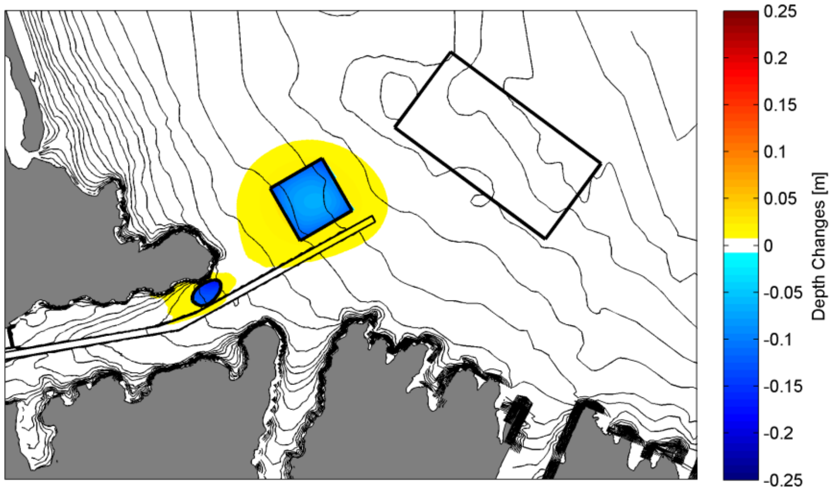


Figure 6.30: Predicted bathymetric changes after an accelerated one-year morphological simulation which assumes 0.45 M m^3 being split between both grounds. The erosion rate parameter used in the simulations was $1e^{-6}$ $kg/m^2/s$. Source: Met Ocean Solutions Ltd, 2016.

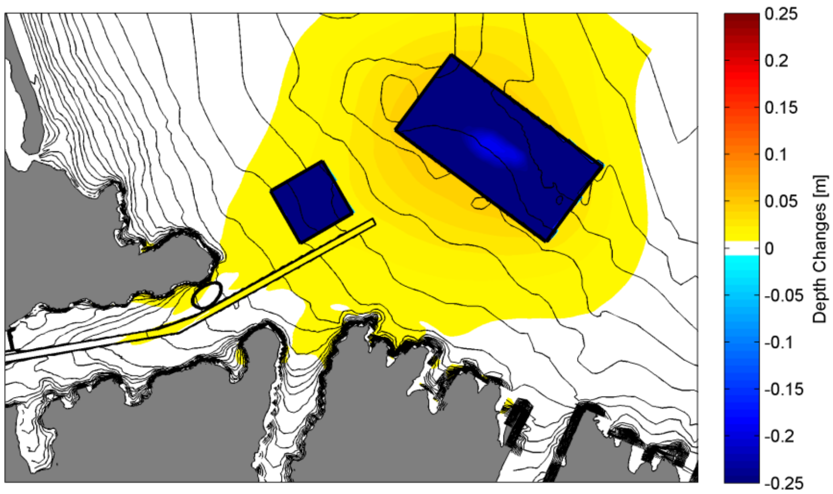


Figure 6.31: Predicted bathymetric changes with a 1.44 m across the large disposal area and 0.35 m across the smaller maintenance spoil ground. The erosion rate parameter used in the simulations was $1e^{-5}$ $kg/m^2/s$. Source: Met Ocean Solutions Ltd, 2016.

6.182 As shown in **Figure 6.32**, the model predicts sedimentation within the entrance to Port Levy/Koukourārata at the lower or upper erosion rate in natural conditions. Erosion for example is observed at the entrance of Lyttelton Harbour/Whakaraupō. Therefore, it is concluded that if the lower erosional rate occurs then the dispersion of sediment from the

disposal mounds reaching any inlet is not measurable but if the higher rate occurs then a thin layer of sediment may reach the inlets settle in a measurable amount however the amount would be negligible in terms of rates of natural background deposition.

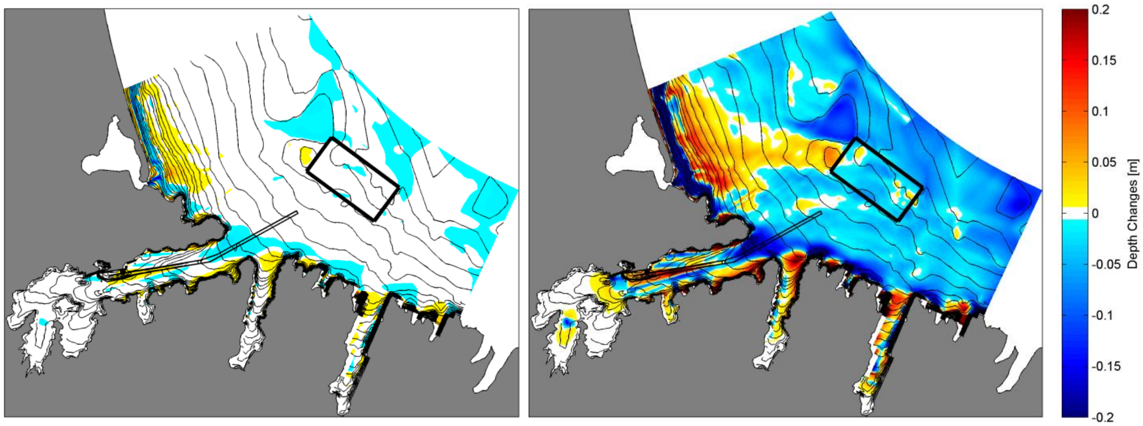


Figure 6.32: Sensitivity testing of the user defined Erosion Parameter (M) assuming a constant depth of available sediment (0.25 m) within the entire domain and assuming the existing environment without the proposed channel or the proposed offshore spoil grounds. Erosion parameter of $1x10^{-6}$ is shown on the left, while Erosion Parameter of $1x10^{-5}$ is shown on the right. Source: Met Ocean Solutions Ltd, 2016.

6.183 The response of waves to the shallowing of the maintenance spoil disposal ground was examined. Assuming a uniform elevated disposal ground of 0.35m, a change in wave transmission is expected as waves focus (increase height) in the lee of the disposal ground mound and defocus (reduce) on either side. **Figure 6.33** shows the difference in a weighted mean significant wave height (m) over all weather events and predicts that the waves may focus up to 3% near Taylors Mistake with mean reductions around the mouth of Lyttelton Harbour/Whakaraupō of up to 2%. These changes would generally be undetectable compared to daily to seasonal changes in wave height, although they would be cyclical as long as material continues to be placed on the disposal site on a regularly (i.e. annual) basis.

6.184 Wave from north-east quarter tend to focus on Godley Head while waves from the east to south-east tend to focus on the Sumner to Taylor's Mistake Area.

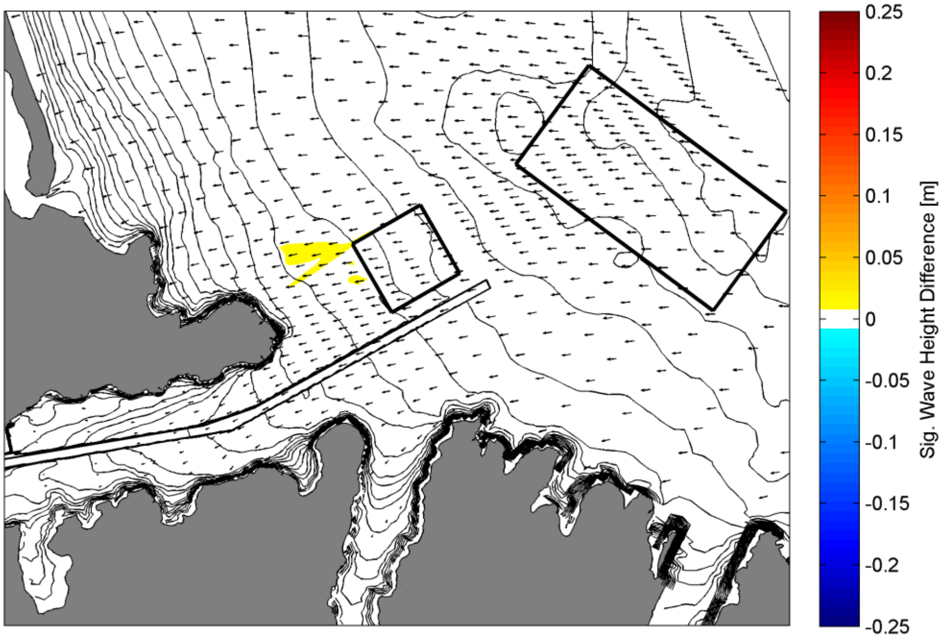


Figure 6.33: Difference of weighted mean significant wave height (m) between the existing environment and with the elevated maintenance spoil disposal ground. Source: Met Ocean Solutions Ltd, 2016.

Ecology

6.185 The Cawthron Institute expects that any longer-term changes to the benthic environment and communities within the maintenance spoil disposal ground will be minor for the following reasons:

a. Significant changes in bed level outside the offshore maintenance spoil ground boundary are not predicted because the site sufficiently dispersive;

b. There is a high degree of physical similarity between the maintenance spoil and the native sediments, and so any dispersion of the spoil mound over time will have no significant implications for the surrounding areas;

c. The risk of contamination issues is less than minor; and

d. Significant smothering impacts to the benthic community are unavoidable at the site, but relatively rapid rates of recovery are predicted and the benthic community will be held in an intermediate successional stage because of annual campaigns.

6.186 With respect to the latter, Cawthron states that the monitoring of the current maintenance spoil grounds has shown that differences in community structure between

areas within and outside the grounds are relatively subtle even months following deposition.

6.187 Plume impacts are not expected to result in significant adverse ecological effects, due to the nature of seabed habitats within the area encompassed by the plume contours together with known background turbidity in near-shore Pegasus Bay. The predicted absence of effects on shoreline reef habitats from deposition-derived plumes is consistent with observations and surveys of intertidal and sub-tidal communities within the current maintenance dredge spoil ground that has been carried out since the mid-1990s.

6.188 The marine mammal assessment undertaken in respect of channel deepening applies similarly to maintenance dredging. While the use of the offshore maintenance spoil disposal ground will be ongoing, the effects from turbidity and risks from contamination are likely to be very low. Since the majority of the spoil taken to the offshore ground will come from the outer Harbour channel, its contamination status is likely to be near background levels for inshore Pegasus Bay. The use of a smaller dredge vessel during maintenance dredging is likely to result in the generation of correspondingly lower levels of both turbidity plumes.

6.189 The assessment of impacts on finfish is also described in earlier in the assessment for channel deepening. It is however noted that the offshore maintenance spoil ground is within an area where flatfish are targeted more intensively than elsewhere in Pegasus Bay.

6.190 As shown in **Figure 6.35**, the catch data for the years 2011-2014 indicates that an area immediately offshore from Godley Head yields a significantly higher catch weight of flatfish than other areas in Pegasus Bay. The reason for this is not immediately clear, although the movement of fish in and out of the Lyttelton Harbour/Whakaraupō may be a factor. Both the channel extension and the proposed offshore maintenance spoil disposal ground coincide with this area of relatively higher flatfish catches.

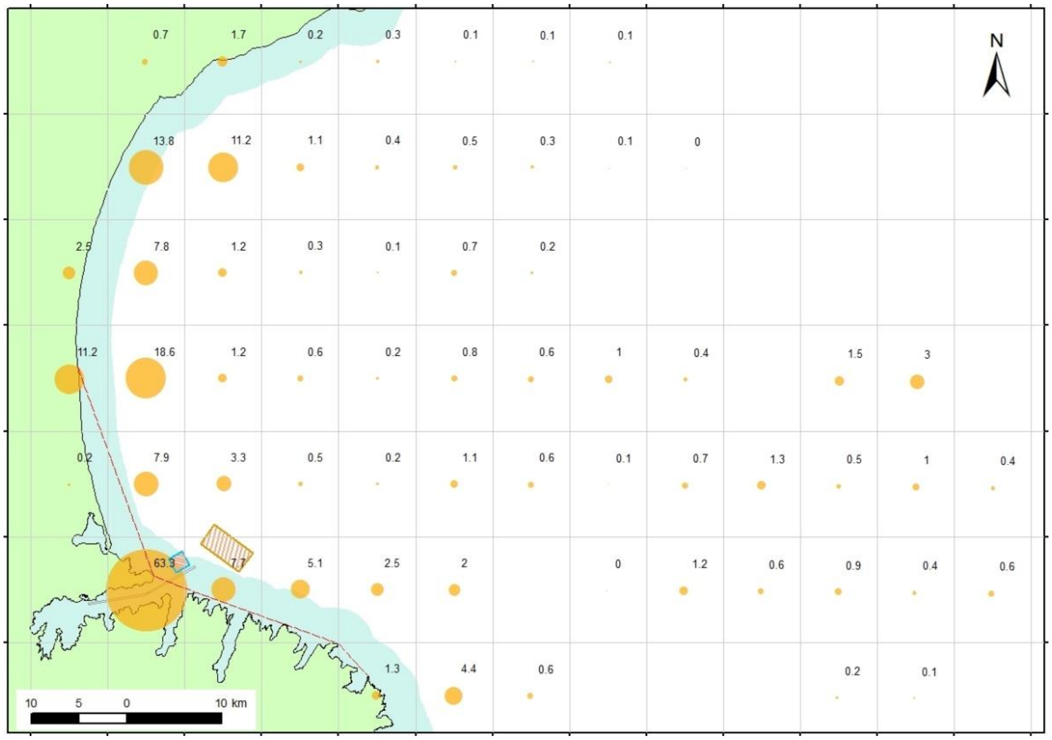


Figure 6.35: Recorded commercial catch weight (tonnes) for aggregated flatfish species in Pegasus Bay (1 Oct 2011 to 14 Aug 2014) for 0.1 degree grid squares. Shaded area designates 2 Nm trawl height restriction. Red line designates inshore trawl prohibition boundary. Source: Cawthron Institute, 2016

6.191 Longer-term changes in the seabed area in the approaches to the Harbour may have local implications for the commercial flatfish fishery. Bottom contact trawl methods would potentially be compromised by the bathymetric discontinuity of the extended channel off Godley Head and possibly also by changes to the degree of consolidation of the seabed within the offshore maintenance spoil ground.[75] However, there is insufficient information to provide a robust assessment of the impact of maintenance spoil disposal on the ongoing suitability of the area off Godley Head as habitat for flatfish. The available information concerning historical spoil disposal at Godley Head suggests that yellow-belly founder are resilient to such disturbances occurring in relatively close proximity.

[75] Noting that bottom-contact trawling of-itself contributes to the on-going disturbance of the seabed especially in areas fished relatively intensively.

Conclusion

6.192 In summary, the modelling, measurement and assessment work concludes:

During dredging:

- Turbidity plumes generated during maintenance dredging will be smaller than those associated with the deepening of the channel and therefore largely confined to the channel within the Harbour. No plumes would reach the shoreline;
- Visually, the plumes during overflow mode will be noticeable at the surface although background turbidity means they should dissipate quickly; and
- The plumes are not predicted to cause any significant effects on marine ecology.

During disposal:

- On average the 10 mg/L contour associated with the bottom-layer plumes generally stay within 500 m of the disposal point and plumes at the surface or mid water-layer do not register;
- In an unfavourable scenario (i.e. very calm conditions) the plumes drop below 100-200 mg/L1 within 1 km from the disposal point;
- It is very unlikely that individual sediment particles will be transported any closer than 400 m from the coastline;
- Even if any sediment particles did make the shoreline any changes to the shore ecosystem are unlikely because the high energy environment prevents sediment from settling;
- The spoil ground is typical of Pegasus Bay habitat and no features of ecological significance have been observed;
- Benthic communities are expected to recover rapidly from smothering associated with the disposal of maintenance spoil, but because deposition would be cyclical the community structure would be held in an intermediate successional state;
- Any effects on marine mammals are expected to be very low. The impact on finfish is also expected to be low although the area where the maintenance spoil disposal ground is proposed is presently targeted commercially for flatfish.

PART D: EFFECTS ON MANAWHENUA RIGHTS, VALUES AND INTERESTS

6.193 A Cultural Impact Assessment (CIA) was completed in April 2014 for the Channel Deepening Project. In June 2016 Te Hapū o Ngāti Wheke and Te Rūnanga o Koukourārata identified the need to update the CIA before consent lodgment, given that two years had passed since the CIA was prepared and because:

a. The scale of the proposed project has increased, resulting in a wider and deeper channel and an increase in the proposed volume of dredged spoil from 12 million m^3 to 18 million m^3, and the proposed disposal site has been rotated anticlockwise;
b. LPC undertook additional technical work in response to issues raised in the CIA and changes to the project;
c. The disposal site for ongoing maintenance dredging is proposed to shift from the existing in-harbour spoil grounds to a new offshore site;
d. LPC and Manawhenua have made progress giving effect to the agreements and actions coming out of the 2014 CIA;
e. The Lyttelton Port Recovery Plan added a new chapter to the Regional Coastal Environment Plan with provisions that apply to capital dredging; and
f. There is improved understanding of the project and how it fits with the long-term plans for port recovery and development.

6.194 The update report has therefore been prepared recognising the commitment of Te Hapū o Ngāti Wheke, Te Rūnanga o Koukourārata and Te Rūnanga o Ngāi Tahu to work together, and with LPC, to achieve outcomes desired by Manawhenua for both harbours.

6.195 The 2014 CIA is included in the application because for the Manawhenua it is important to provide a record of 'where we started' as the context for 'where we are now and all the work in between'.

6.196 The 2014 CIA and 2016 update are attached in **Appendix 3**. They include a record of engagement, noting that includes on-going engagement with the Manawhenua Advisory Group and the formation of a Technical Advisory Group ('TAG') over the last year, which has been made up primarily of experts appointed by the Manawhenua, the aquiculture industry and by LPC. The purpose of the TAG was to examine the relevant expert

reports and assist in the development of a monitoring and management response program.

6.197 The executive summary in the CIA update encapsulates the key themes in the document:

"Summary of findings:

- The key values that manawhenua seek to protect are water quality and mahinga kai. Mahinga kai includes natural kaimoana stocks and the customary rights associated with these, and also marine farm interests. These values are integral to the relationship between manawhenua and the coastal environment.

- Manawhenua understand LPC's desire to widen, deepen and extend the existing navigation channel in Whakaraupō to enable larger vessels. However, there are concerns about the localised and cumulative sediment-induced effects on mahinga kai. Te Hapū o Ngāti Wheke and Te Rūnanga o Koukourārata are actively working to protect and restore their harbours as mahinga kai. Assessing how and where specific activities occur is critical to achieving this goal.

- Capital dredging and the disposal of dredge spoil have the potential to increase turbidity[76] and sediment movement in the water and across the seabed, and this can result in adverse effects on water quality and the health, abundance, or diversity of mahinga kai species, and the ability to access and gather these.

- Manawhenua want to be satisfied, with a high degree of confidence, that their values, rights and interests associated with the coastal environment will be protected. For many, shifting the capital dredging disposal activity further offshore from Koukourārata into deeper water is the best way to achieve this.

- Manawhenua will continue to work with LPC to develop an Environmental Monitoring and Management Plan (EMMP) to monitor and adaptively manage the dredging activity. However, the ability to move the offshore disposal grounds further away from the coastline must remain on the table.

- Manawhenua are looking for LPC to adopt a precautionary approach to managing the dredging activity, favouring environmental protection and mahinga kai. Effective turbidity trigger levels, and knowing that specific actions will be taken by LPC if these are exceeded, are critical to this.

- Lodging a resource consent application without turbidity trigger levels remains a concern. Manawhenua are still uncertain around how the trigger levels will be set, and the ability of manawhenua to influence these.

[76] Turbidity is a measure of water quality, and in this case the amount of suspended sediment in the water and therefore how clear or transparent the water is.

- Manawhenua are seeking a reduced duration of consent, and support proposed consent conditions requiring a formal review of the EMMP following Stage 1 of the project, and of baseline monitoring if Stage 2 occurs more than 5 years after Stage 1.

- The proposed removal of the majority of maintenance dredge spoil disposal from Whakaraupō to a new offshore site is an opportunity for positive effects on the harbour environment and mahinga kai. However, manawhenua want to see capital and maintenance dredge spoil consolidated at the proposed capital dredging disposal grounds, rather than creating another disposal site in the coastal environment. There is also a strong expectation that LPC will discontinue use of the existing Awaroa/Godley Head disposal grounds."

6.198 The summary concludes by stating:

> "LPC, Te Hapū o Ngāti Wheke, Te Rūnanga o Koukourārata and Te Rūnanga o Ngāi Tahu have invested significant time and resources to engage on this project, and will continue to do so. While there are varying levels of confidence around effects and how these can be managed, the willingness to work together to get to a place of agreement is a shared goal. The focus of the engagement and cultural impact assessment process is on how the project occurs rather than if it occurs. Ultimately, the response of manawhenua to the project will depend on the outcomes of this process."

6.199 There are a large number of recommendations provided in the CIA (pages 26 to 32) and are not repeated here. A key point, however, is that there is an acceptance of an adaptive management approach in principle (recommendation 15) subject to a number of provisos, including that:

a. The adaptive management framework (contained in the EMMP)[77] should reflect a precautionary approach to managing effects on water quality and mahinga;

b. There is adequate baseline monitoring;

c. There are agreed conditions setting out the nature and extend for Te Hapū o Ngāti Wheke, Te Rūnanga o Koukourārata and Te Rūnanga o Ngāi Tahu involvement;

d. Adaptive management responses to adverse effects are enforceable via consent;

e. The '*stop and re-assess'* management response is consistent with a precautionary approach; and retains the ability to move the offshore site into deeper water further offshore (as per the 2014 CIA);

f. Assurance and adaptive monitoring is integrated;[78] and

[77] Environmental Monitoring and Management Plan

[78] Adaptive Monitoring is based upon the proposed real-time monitoring for turbidity and the setting of trigger levels for management response measures. Assurance monitoring consists of bathymetric, ecological, physical beach shore surveys and water and sediment quality sampling.

g. There is ability for Manawhenua, on the advice from a technical advisory group, to request additional monitoring sites and methods to the monitoring programme following baseline monitoring.

6.200 There are also a number of specific recommendations around the development of the EMMP, the monitoring of baseline data and the setting of triggers for response management, and how the Technical Advisory Group and an Independent Peer Review Group are to be constituted in the conditions of consent. All the recommendations are made on the basis that the disposal of dredge spoil at the channel deepening disposal ground must be managed to avoid sediment transport into Whakaraupō, Koukourārata and/or the coastline and bays along the northern side of Banks Peninsula, particularly given the potential challenges with linking the disposal activity with effects on mahinga kai (recommendation 10). A 15-year consent duration for is recommended in the CIA (recommendation 27).

6.201 With respect to maintenance the preferred/only option for manawhenua is that there are two disposal grounds; one at Gollans Bay and one at the offshore (capital) dredge disposal ground. This is in contrast to the four grounds proposed by LPC (Gollans Bay, Godley Head and the two offshore grounds (recommendations 28 and 29).

6.202 This reflects that the proposed offshore maintenance spoil disposal ground is closer to shore and therefore poses a greater risk to cultural values.

6.203 Notwithstanding the above, the maintenance dredging disposal site should be located, managed and monitored to avoid various impacts (recommendation 30) and a monitoring and management plan reflecting an adaptive and precautionary approach to effects be developed (recommendation 31). Te Hapū o Ngāti Wheke, Te Rūnanga o Koukourārata and Te Rūnanga o Ngāi Tahu would also like to discuss a maximum dredge volume limit (recommendation 33). A 25-year consent duration for maintenance dredging is recommended with a review being carried out every 5-years (recommendation 35).

6.204 Finally, the updated CIA (page 32) records that these documents provide the basis for the manawhenua and LPC to continue working together in a collective and constructive way, and to align the development aspirations for Lyttelton Port with the long term vision

of manawhenua to protect and restore the coastal environment, mō tātou, ā, mō kā uri ā muri ake nei.

7. MITIGATION AND MONITORING

7.1 Chapter 7 is set out in two sections. **Section 1** discusses mitigation and monitoring associated with the proposed deepening and extension of the channel and includes a discussion on conditions. **Section 2** assesses mitigation and monitoring associated with the proposed maintenance dredging. The maintenance dredging of the inner Harbour is outside the scope of this application, as it will continue to operate under existing coastal permit CRC135318.

Section 1: Channel Deepening

Design of the Offshore Disposal Ground

7.2 The assessment work for the channel deepening project has focused on understanding the coastal processes and ecology in the project area. In particular, studies have focused on the nature of the wave climate, the ocean currents, the associated transportation of sediment in the project area, and also confirming that the seabed communities at the proposed offshore deposition ground are similar to elsewhere in Pegasus Bay. The assessment work shows that the proposed offshore deposition ground is of an appropriate size and location to accept spoil during channel deepening. In other words, the deposition ground selected should avoid any adverse effects on sensitive receptors and otherwise should not give rise to any unacceptable adverse effects.

7.3 Nevertheless, because of the scale of the project and stakeholder values, a comprehensive monitoring programme is proposed to enable a timely management response should effects become apparent. The primary issue is how to respond to any unforeseen turbidity plumes that could have potential effects on the coastal marine ecosystems, which in particular are providers of mahinga kai.

Management of Suspended Sediment (Turbidity) Plumes

7.4 As detailed in **Chapter 6**, sediment transport modelling indicates that any turbidity plumes are broadly confined to within 2 km of the dredging or disposal discharge point and do not reach the shoreline. LPC intends to monitor these predictions by proposing a suite of monitoring stations that capture turbidity (NTU) in real-time (i.e. are telemetered).

If the stations detect elevated turbidity then a series of management responses are activated, depending on the degree of elevation.

7.5 The initial response would be to determine whether the reported elevation is the result of a problem with the monitoring equipment. If not, then it needs to be determined whether the elevation is attributed to turbidity plumes generated from dredging or disposal activities or from other environmental factors (i.e. the Waimakariri River in flood). If it is attributable to dredging or disposal activities then the activity will need to be adjusted until turbidity levels return to a normal background range.

7.6 If turbidity concentrations continue to climb, however, a Technical Advisory Group[79] ('TAG') will meet to examine the situation in further detail and provide advice to LPC's project group and the dredging operator. The group would examine factors such as:

a. The wider sediment transport patterns in Lyttelton Harbour and Banks Peninsula;
b. The turbidity trends and levels at all monitoring locations to determine whether there is a trend of increasing turbidity at all locations (and thus could be contributed to a wider environment factor such as weather conditions); and
c. The proximity of the stations showing elevated results to the shoreline or the mussel farms.

7.7 The use of real-time monitoring also enables the operator to respond by changing the dredging process, including for example the timing of dredging within the tidal phase or the use of the overflow. If turbidity concentrations climb past the highest trigger (tier 3), unless the reasons for the elevated levels are demonstrably not caused by dredging activities:

a. the dredging activity must cease at that location and relocate to somewhere else in the channel; or
b. the disposal activity must cease and recommence somewhere else in the disposal ground.

7.8 An important component of this process is determining just when turbidity is considered sufficiently elevated to trigger a management response. The trigger values developed need to balance the rate of 'false-triggering' with the need for an 'early-warning'

[79] This is a group of technical people tasked with examining the results of monitoring and providing advice to LPC. Further details of the group composition can found in the suggested conditions attached with this application in **Appendix 23**.

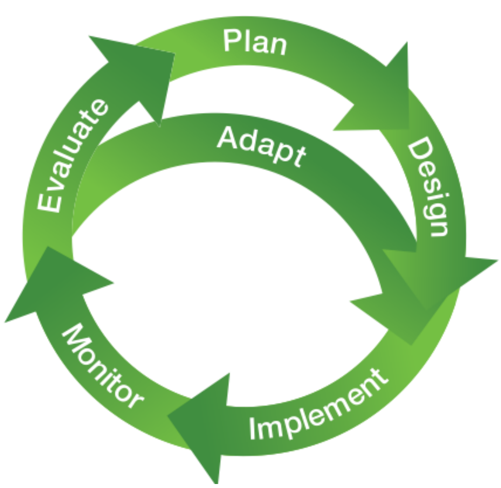
capability. If the triggers are too low then there will be a continual need to instigate a management response to what are normal fluctuations in turbidity, and if the triggers are too high then the appropriate management response may not be achieved in time thereby resulting in the potential for an adverse effect.

7.9 There are also challenges involved with collecting and processing data in an appropriate manner given the environment is naturally highly turbid and can fluctuate rapidly. The report by Environmetrics Australia and attached in **Appendix 19** discusses the statistical methodology which in summary is shown in **Figure 7.1**.

Figure 7.1: Illustration of the process to capture data and smooth it so can be assessed against a trigger value.

7.10 The adaptive management of the dredging operation in response to continuous monitoring and evaluation of real-time data is recognised practice in the dredging industry and its principle is set out in **Figure 7.2**.

7.11 The turbidity feedback loop enables the dredge operator to continually examine the real-time turbidity data and adjust its operation accordingly so as to avoid the trigger values being exceeded which activates the more formal response procedures.



- **Figure 7.2**: Adaptive management cycle. Source: CEDA, 2015.[80]

7.12 This is only a brief summary of the management response process and further details (including relating to setting the trigger values, the functions of a TAG and also a Peer Review Group ('PRG')) are detailed in the Draft Environment Monitoring and Management Plan ('EMMP') attached in **Appendix 22**.

Staged Dredging

7.13 The division of the channel deepening project into two or more stages is in itself a form of mitigation. If continued monitoring after dredging does reveal an ecological effect then monitoring information can be can be examined to determine whether the effect was due to natural causes or due to dredging and disposal activities. If results attribute an effect to dredging then there is an opportunity to review the conditions of the resource consent and re-examine the appropriateness of the management response triggers or the statistical methodology used.

Dredge Vessel Mitigation

7.14 Dredging is a comparatively simple activity, with roughly a 2-hour cycle of sediment being removed from the seabed, placed in the vessel's hopper, released at the disposal grounds, and the steaming time between the channel and the disposal ground.

7.15 Nevertheless, there are some mitigation measures that can apply to the vessel. The first is to ensure the overflow pipe outlet, described in Chapter 2, is placed underwater. This will reduce the significance of the surface plumes when the overflow mode is on.

7.16 The second is the introduction of procedures to avoid or mitigate any potential adverse effects on marine mammals and marine avifauna. The measures for marine mammals are as to:

a. Ensure there is a designated crew member that keeps a look out for any whales over daylight hours;

[80] Refer to the Central Dredging Association (CEDA). CEDA is an established authority and the leading independent forum for the professional dredging community, and associated industries, in Europe, Africa and the Middle East. It represents dredging professionals and organisations, from government, academia and business and aims to foster and promote the understanding and advancement of dredging to the wider community.

b. Record and report the type and frequency of any whale sighting;

c. Use common sense behaviour to reduce the risk of collision with a whale, including keeping the speed to 14 knots or below; and

d. Avoid loose rope and minimise potential for loss of rubbish and debris.

7.17 The measures for avifauna are to minimise the potential for bird strike by:

a. Keeping external lighting to the minimum required for safe operation and navigation;

b. Directing deck lighting downwards and shielding it to reduce light emanating horizontally or vertically from the vessel; and

c. Investigating the deployment of bird scaring lines if birds strike the aerial portion of the cable which lowers the dredge head.

7.18 The above measures are to be addressed in a Dredge Management Plan ('DMP') and a Marine Mammal Management Plan ('MMMP') which are referred to in the proposed conditions attached in **Appendix 23**.

Monitoring

7.19 The proposed monitoring programme is described in the Draft EMMP attached in **Appendix 22** and is based on the recommendations made by:

a. Vision Environment on water quality matters (see **Appendix 21**);

b. Cawthron Institute on ecology matters (see **Appendix 15A** and **Appendix 16**); and

c. Tonkin Taylor on physical shoreline monitoring (see **Appendix 7**).

7.20 Fifty seven monitoring stations in total are proposed, made up of:

a. 15 stations to monitor water quality parameters;

b. 19 stations to monitor the benthic community[81];

c. 6 stations to monitor the sub-tidal communities;

d. 4 stations to monitor the intertidal community; and

e. 13 stations to monitor the physical shoreline.

[81] 14-stations during dredging and 19 stations during the baseline and after a dredging stage.

7.21 Monitoring is to be carried out prior to dredging commencing so at least one year of baseline information is obtained, which is particularly critical for turbidity monitoring. Monitoring would then be carried out during dredging and for no less than 6-months after a dredging stage has been completed.

7.22 As discussed in the report by Vision Environment the water quality stations will have specialist equipment that can monitor more than one parameter. Of the 15 stations proposed to monitor water quality shown in **Figure 7.3**, 13 will be able to monitor turbidity in real-time, that is, each 15-minutes with the information being telemetered to Vision Environment and LPC. Total suspended solids (TSS) would also be monitored, noting that increased sediment concentration manifests itself as cloudiness or turbidity which is measured in NTU. The monitoring of TSS ensures the suspended sediment concentrations can be correlated with NTU. TSS is also used to validate the model predictions described in **Chapter 6**.

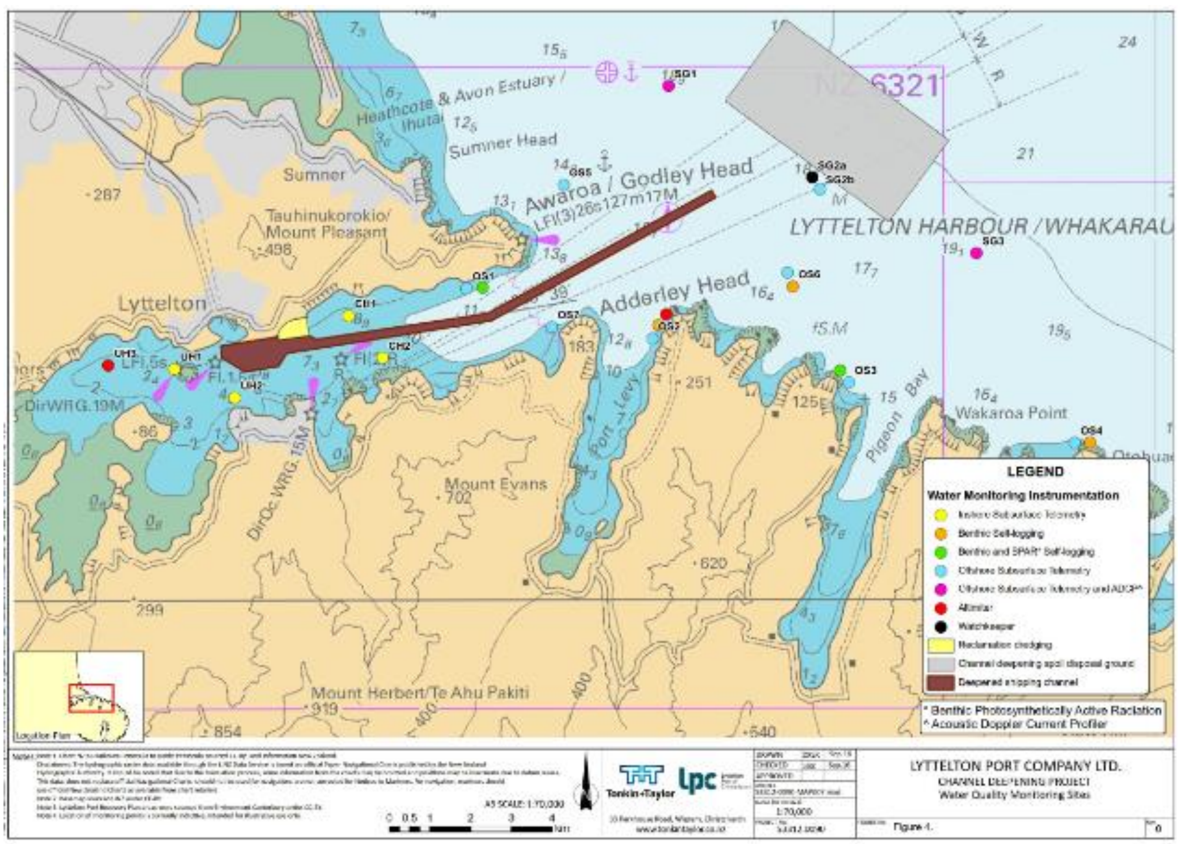


Figure 7.3: Location of the water quality stations selected for baseline monitoring. An A4 Plan is contained in Appendix 1.

7.23 It is possible the stations shown in **Figure 7.3** may need to be relocated if the results indicate a problem, for instance anomalous data being collected from a particular site. The location of the water quality stations and the parameters to be monitored at each station along with the methodology and equipment to be used is to be detailed in the EMMP, although the instruments must be located within the zones the on map attached in **Appendix 1**.

7.24 The proposed benthic stations are to be placed in a gradient away from the disposal ground as a means to monitor the direct and indirect effects from disposal with comparison against the reference (control) stations as shown on **Figure 7.4**.

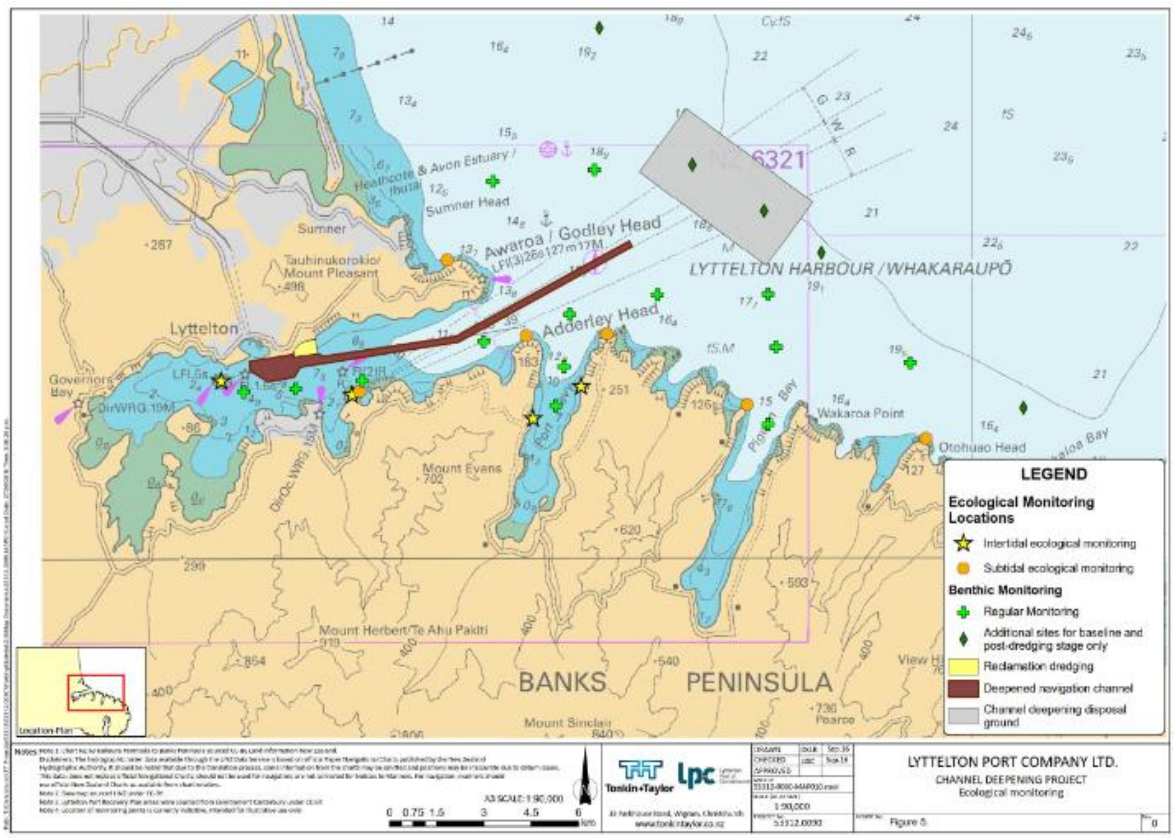


Figure 7.4: Location of the benthic monitoring stations selected for baseline monitoring. An A4 Plan is contained in Appendix 1.

7.25 LPC also proposes that a network of stations is located within the sub tidal and intertidal zones (see again **Figure 7.4**). It is not expected that there will be any adverse effects on these communities and so the purpose of the monitoring is to check that these predictions are correct. The same also applies to the monitoring of a number of other

water quality parameters. For example, the sampling work has not revealed any significant contaminants in the sediments but there would be stations monitoring trace metals and organics.

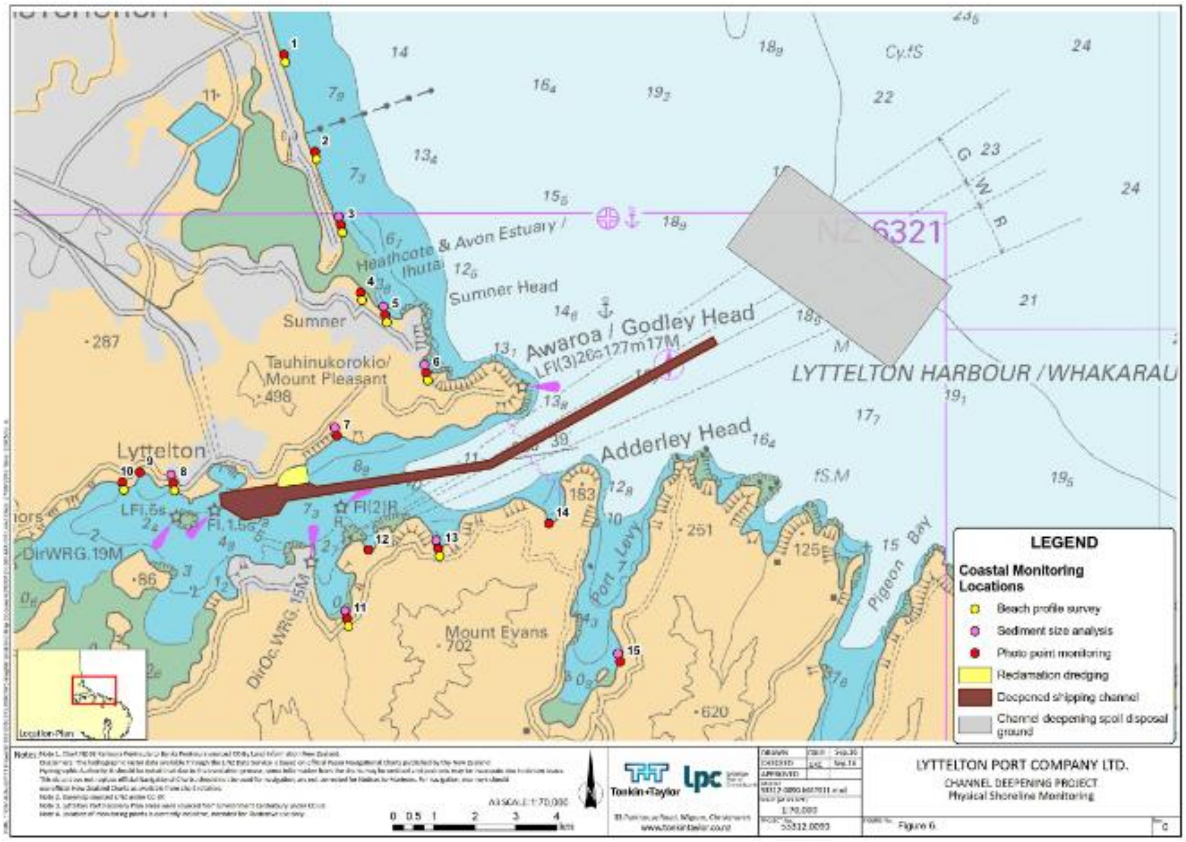


Figure 7.5: Location of the physical shoreline monitoring stations selected for baseline monitoring. An A4 Plan is contained in Appendix 1.

7.26 Bathymetric monitoring at the disposal ground is also proposed. This is to assess the rate of erosion at the disposal ground and should be able to pick up a re-deposition gradient at the margins of the disposal ground. There will be also two altimeters installed to examine whether net flux of sediment changes; and, if so, whether this could be attributed to dredging activities.

7.27 A description of the parameters to be monitored, the frequency of monitoring and the frequency of data collection are contained in Tables 1 and 2 of **Figure 7.6**. For example some of the water quality parameters are monitored by the instruments regularly (no less than every 30 minutes) with it being delivered to LPC at the same time in most instances (telemetered) while other stations log the data at the same frequency but the logged data

needs to be collected by boat each month. Other water quality parameters are measured after the manual collection of water samples.

Table 1: Type of parameters to be monitored and the frequency of data collection

Parameter	Monitoring Frequency	Collection Frequency	Purpose
Turbidity (NTU)	At least every 30 minutes	Telemetered or Logged and collected monthly	Turbidity is an important parameter to measure during dredge operations because suspended sediments in the water column can increase. Real-time monitoring of turbidity enables management response measures to be implemented in a timely manner.
TSS mg/L	Monthly	Monthly	Another measure of water clarity, this is an important parameter to measure during dredge events. TSS is used by hydrodynamic modellers to evaluate the model predictions.
Benthic PAR (Mol/m^2/d)	At least every 30 minutes	Monthly	Benthic primary producers (such as kelp and other algae) have high ecological value, having a role in providing food resources and habitat for many species. Coastal fringing reef habitats have been identified in the near offshore environment of Lyttelton Harbour/Whakaraupō and Port Levy/Koukourārata. Due to their sensitivity to reduced light (i.e. decreased water clarity) benthic primary producers are considered sensitive indicators for measuring potential effects from turbidity plumes.
Bed Level (altimeter)	At least every 30 minutes	Monthly	Resuspension and resettlement of sediments can cause potential adverse effects on benthic organisms, and have impacts on nutrient cycling and contaminant release. Measuring the net flux may assist in determining net sediment transport and for validation of model predictions.
pH	At least every 30 minutes	Telemetered or Logged and collected monthly	A change in pH can potentially have a direct toxic effect on aquatic biota and may also alter metal bioavailability to aquatic organisms. While this parameter does not measure a potential dredge-related impact, it does provide information on natural conditions.

Parameter	Monitoring Frequency	Collection Frequency	Purpose
• Temperature • Conductivity • Dissolved Oxygen	At least every 30 minutes	Telemetered or Logged and collected monthly	An unnatural change in temperature or conductivity (stressors rather than toxicants) can have a direct adverse impact on aquatic organisms. Conductivity can also provide an indication of the degree of catchment rainfall entering the system. A lack of dissolved oxygen results in asphyxiation of respiring organisms Measurements of dissolved oxygen can assist in the validation of the presence of algal blooms. While these parameters do not measure potential dredge-related impacts, they can provide information on natural and anthropogenic effects which may be causing underlying stress to the ecosystem.
Nutrients (phosphorus and nitrogen) and chlorophyll *a* (µg/L)	Monthly	Monthly	Analysed nutrients include phosphorus and nitrogen, as well as their different forms, including orthophosphate, ammonia, nitrate and nitrite. Phosphorus and nitrogen are essential for the growth of organisms including algae. Nutrients are not necessarily considered to be directly toxic to aquatic organisms, but can directly affect the ecosystem and biota. Excessive nutrients can result in algal blooms which can lead to increased TSS and turbidity and thus decreased light attenuation. Therefore these are important parameters to measure during dredge activities.
Total and dissolved metals (µg/L)	Monthly	Monthly	Some metals are essential to plant and animal growth but can become toxic at elevated concentrations. Dissolved metals are considered to be the potential bio-available fraction. Both total and dissolved metals are important to measure during any water quality program but particularly during dredge events, due to disturbance of the benthic sediments, which can result in the addition of total metals to the water column.
Organic chemicals - 22 individual acid herbicides - 179 individual multiresidue pesticides - Total petroleum hydrocarbons and BTEX	6-Monthly	6-Monthly	Potential sources of some of these compounds such as herbicides and pesticides are generally related to agricultural and farming sources. Increased industrial and anthropogenic activity indirectly associated with development may contribute to an increase in hydrocarbon compounds and can be present in sediment.
Water dynamics (current speeds and direction and waves)	At least every 30 minutes	Telemetered (Sent 6-hourly)	Current speeds, direction and shear bed stress can be used by hydrodynamic modellers to predict the speed and direction of dredge plumes. This information is to be used to manage the dredge programme in differing weather and tidal scenarios.

Parameter	Monitoring Frequency	Collection Frequency	Purpose
Soft-Sediment Benthic	4-Monthly (subject to whether conditions)	4-Monthly (subject to whether conditions)	These community types will be directly affected by dredge-derived activities. Information will be obtained to assess whether there is a spatial gradient of effect from the spoil disposal ground and also assess recovery at the spoil ground.
Shoreline Ecology - Sub-tidal - Inter-tidal	4-Monthly (subject to whether conditions)	4-Monthly (subject to weather conditions)	This information is to be used to evaluate the predicted absence of effects of suspended or deposited sediment on sub-tidal and inter-tidal communities.
Bed Level (Bathymetric Survey)	Monthly	Monthly	This information is to be used to evaluate model predictions.
Underwater Acoustic Monitoring	At least every 30 minutes	4-Monthly	To provide a qualitative assessment prior, during and after dredging and disposal activities to record the types, and presence, of marine mammals.

Table 2: Type of shoreline parameters to be monitored to be carried out

Name	Frequency of Monitoring			Purpose
	Baseline	During	After	
Photo-point monitoring	Quarterly	Monthly	3-monthly for first 2 years 6-monthly for following 3 years	To visually assess beach level change or fine sediment deposition from fixed locations and aspects.
Sediment size analysis	6-monthly	6-monthly	6-monthly for first 2 years Annually for following 5 years	To quantify sediment size on beach to determine changes in texture and composition
Beach profile survey	6-monthly	6-monthly	6-monthly for 5 years	To quantify changes in profile geometry and/or location from an established benchmark
Shoreline analysis	Baseline assessment of historical shoreline (Lyttelton harbour only)	Annually for five years as aerial photographs/satellite imagery become available		To determine changes in shoreline position using aerials photographs or satellite imagery

Figure 7.6: Type of parameters to be monitored and monitoring frequency

7.28 The above monitoring information will be assessed in monthly and 4-monthly reports for dissemination as detailed in the conditions on reporting attached in **Appendix 23**.

7.29 In conclusion, a comprehensive monitoring programme is proposed. The monitoring of turbidity is a critical parameter, which would enable the dredging operator to continuously monitor, evaluate and adjust the dredging activity as necessary. The ecological monitoring is to confirm the rates of recovery for the benthic communities impacted from disposal activities or otherwise to validate the predicted absence of effect in the sub-tidal and inter-tidal zones and along the shorelines. The staging of the dredging campaigns would enable the conditions to be reviewed if any unforeseen effects did emerge that were attributable to dredging and disposal activities. The mitigation measures discussed have been incorporated into the EMMP and referenced in the proposed conditions discussed further below.

Proposed Conditions

7.30 A set of proposed condition is attached in **Appendix 23**. In summary, the conditions set a framework that requires:

a. The preparation of management plans that detail measures and procedures on how to monitor the environment and how any actual or potential adverse effects are to be avoided or mitigated (conditions 6-9);
b. The preparation of a comprehensive monitoring programme that enables the dredging operator to carry out any management responses as required and otherwise to evaluate any actual or potential effects (conditions 10); and
c. The establishment of a TAG and an independent PRG which are respectively to provide advice to the consent holder's project team and provide independent and objective oversight of the operation (conditions 12 and 13). The composition and function of these groups are specified in the conditions.

7.31 There are also a number of specific conditions covering matters such as:

a. The methodology used to set the turbidity trigger values required to elicit a management response from the consent holder project team and dredge operator (condition 11);
b. The location of dredging and disposal footprints, the in situ volume limits and the staging of dredging (condition 1);
c. Obligations to disseminate information to the public (condition15);
d. The recoding of complaints (condition 16); and

e. The requirement to certify the EMMP (condition 4) and means to amend the other management plans (condition 5).

7.32 The methods referred in condition 11 are contained in the Environmetrics Australia Report Attached in **Appendix 20**.

Section 2: Maintenance Dredging

7.33 The discussion in paragraph 7.2 equally applies to the proposed offshore maintenance spoil ground. The assessment work shows that the proposed maintenance offshore deposal ground is of an appropriate size and location to accept spoil during channel deepening and otherwise should not give rise to any unacceptable adverse effects. In other words, the mitigation is effectively incorporated into the site selection process.

7.34 As discussed in **Chapter 6**, the long-term benthic monitoring of the existing maintenance spoil grounds on the north side of the Harbour has shown that the benthic communities experience rapid recovery after spoil deposition and exhibit minimal longer-term change compared to adjacent undisturbed areas. Nevertheless, monitoring of the spoil grounds is recommended.

7.35 Godley Head is proposed to be used as a backup spoil disposal ground. The proposal is to continue with the 5-yearly monitoring surveys of Lyttelton Harbour/Whakaraupō currently required under LPC's existing coastal permit CRC135318. Additional benthic monitoring stations are also proposed for the offshore maintenance spoil disposal ground and surveys would also be 5-yearly, consistent with the Harbour monitoring program. The stations are shown in **Figure 7.7**.

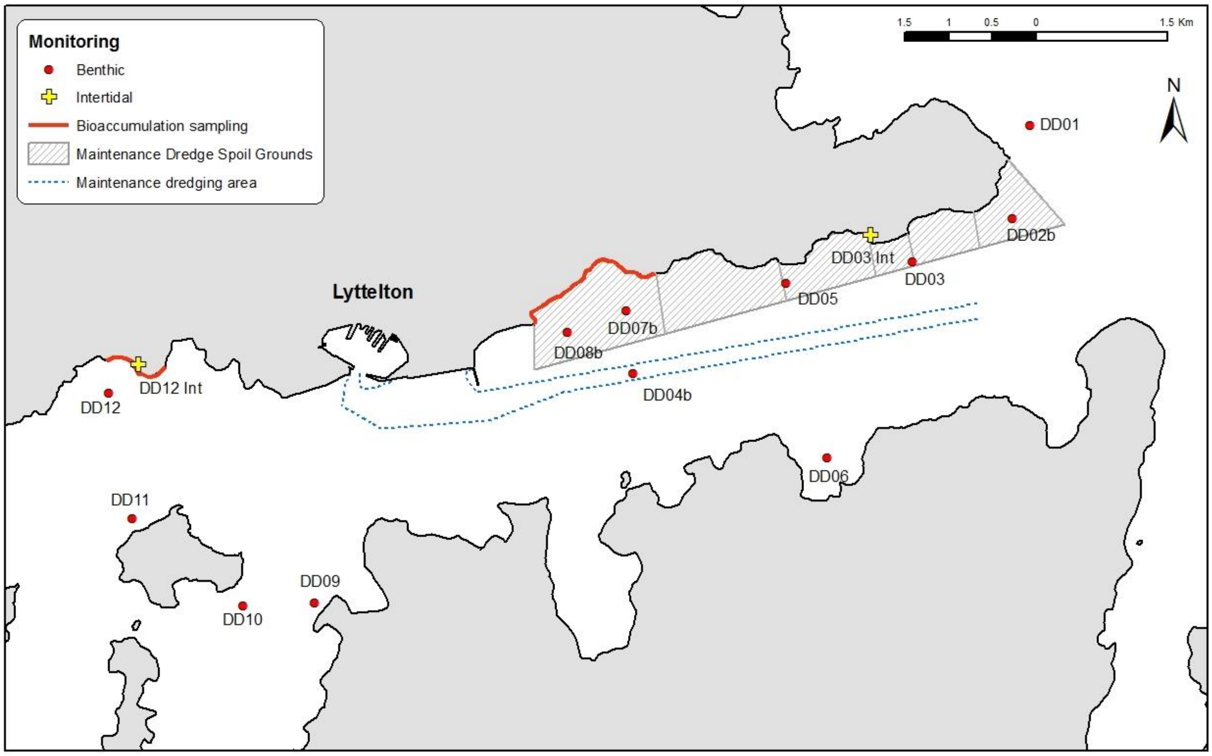


Figure 7.7: Location of the monitoring stations following that of CRC135318.

7.36 It is anticipated that there will also be monitoring of turbidity associated with the disposal of spoil at the proposed maintenance disposal ground. The nature and scope of that monitoring is continuing to be developed, and whether any management response actions are necessary. LPC has been working with a TAG[82] for a year on monitoring and management response actions for channel deepening and envisages this work will continue as these applications progress (refer to the Draft EMMP in **Appendix 22**).

7.37 Conditions will be developed as this work progresses.

Conclusion

7.38 The channel deepening project is to involve a network of instruments that measure key environmental parameters, including water currents, turbidity, and the deposition of sediment. The instrument capability will include real-time telemetry of data that will be made publicly available so that, for example, the public can observe the turbidity situation in real time. The planned monitoring will include 12-months of baseline monitoring before the dredging begins, followed by monitoring during and after dredging.

[82] Refer to the CIA attached in **Appendix 3.**

7.39 Real-time data gathered during the dredging and disposal activities will form the basis of an active response process where the activity can be modified real-time. For example, disposal could be moved to a site within the designated disposal area that is further away from sensitive receiving environments if turbidity measurements go above designated trigger values and are attributable to dredging activities rather than natural events.

7.40 Augmented to this will be the monitoring of the sub-tidal and intertidal communities, marine mammals, or the physical shoreline to confirm that these receptors have not been affected by dredging activities.

7.41 The establishment of a TAG and the establishment of an independent PRG is proposed to provide the community with confidence in the monitoring and management response measures being carried out.

7.42 Mitigation measures during dredging will otherwise be managed in a number of management plans which are set out in the proposed conditions.

7.43 The monitoring of the proposed offshore maintenance spoil disposal ground is expected to follow the same approach as the channel deepening project although monitoring needs to be tailored to reflect that it is likely to be an annual activity involving a smaller vessel and smaller volumes of spoil. It is expected that the 5-yearly survey work of the Harbour will continue, and include the proposed offshore maintenance spoil disposal ground.

8. CONSULTATION

Introduction

8.1 Consultation is a process of communicating with affected and interested parties about any proposal requiring resource consent. Whilst it is not a prerequisite that consultation be undertaken before lodging resource consents, the RMA requires the identification of persons affected by the proposal, and that any consultation undertaken with those people is reported on as part of an assessment of environmental effects.

8.2 LPC believes that engaging in discussion and consultation on issues of interest to the local community or Port users is a beneficial exercise to all involved as information can be shared as well as sought. The company maintains links with and regard for its local community and therefore works proactively with that community's members to address issues of potential concern.

LPC's Consultation Objectives

8.3 LPC's consultation objectives for the channel deepening project were to:

a) Be transparent and open about the project, process and related information;
b) Inform stakeholders about the proposed project (e.g. the scope, methods and consent process);
c) Identify stakeholder values and any information gaps in the project proposal or effects assessment work;
d) Develop and refine foundation assessment work (e.g. hydrodynamic modelling and marine ecology) with key stakeholders;
e) Develop and refine the adaptive management approach, including monitoring, with key stakeholders; and
f) Provide an opportunity for engagement prior to and during the consenting process.

Affected persons

8.4 Due to the scale and large geographic area of the project, LPC was aware there were a number of potential affected persons who might have an interest in the process, project methods and outcomes. To identify the affected persons LPC relied on its existing database of stakeholders and a review of the project scope against local and national stakeholder groups. This resulted in a database of "key stakeholders" which was used

for all direct consultation and engagement. As the project developed this database was modified and updated.

8.5 The key stakeholders can be broadly grouped as follows (noting that most of these have multiple organisations or individuals within them):

a) Tangata Whenua:
   i. Te Hapū o Ngāti Wheke;
   ii. Te Rūnanga o Koukourārata; and
   iii. Te Rūnanga o Ngāi Tahu;
b) Commercial fishers:
   i. Local inshore and coastal commercial fishers and industry groups;
   ii. Pāua/crayfish fishers and industry groups; and
   iii. Quota holders;
c) Aquaculture:
   i. Individual local farmers/operators (including Te Rūnanga o Koukourārata); and
   ii. Larger commercial operators (i.e. Sanfords, Ngāi Tahu Seafoods);
d) Tourism operators (e.g.Black Cat, Tug Lyttelton)
e) Recreation Groups:
   i. Boating clubs;
   ii. Recreational fishing groups/clubs;
   iii. Diving club; and
   iv. Surfing/ Surf Lifesaving;
f) Harbour/coastal residents and associations;
   i. Residents' associations (Harbour and Sumner);
   ii. Business Associations; and
   iii. Harbour and Christchurch residents;
g) Environmental interest groups:
   i. Local environmental groups (i.e. Lyttelton Harbour Issues Group, Lyttelton Environment group);
h) Local and central Government agencies (i.e. DOC, Environment Canterbury, Maritime NZ, Members of Parliament, Ministers etc.).

Project timeline

8.6 The channel deepening project (previously known as the Capital Dredging Project) was first considered in 2007. As outlined in Chapter 1, the project and associated consent application work has been modified and refined a number of times since. These changes (channel design etc.) were primarily in response to changes in the container trade and projected deep draught vessel arrivals.

8.7 Refinements were also made throughout this time in response to stakeholder concerns and effects assessment work. The 2010/2011 earthquakes and subsequent focus on the recovery of the Port also necessitated some delays to the channel deepening project.

8.8 In order to clearly set out the project evolution and related consultation and engagement, the remainder of this Chapter is split into the following phases:

a) **2007 to 2010**, which covered project initiation and definition, exploration of options and channel requirements, and early outline concept designs. Technical assessments and consultation began.
b) **2012 to early 2013**, which included the project re-start, review of channel requirements, progress on concept design, development of further technical assessments and the re-commencement of consultation.
c) **2013 to 2015**, during which further detailed effects assessments were undertaken, the project was refined, the concept channel design was further detailed and further consultation was undertaken. The Lyttelton Port Recovery Plan (LPRP) also commenced and was finalised in this period.
d) **2015 to 2016**, during which LPC developed and finalised the concept channel design, and included reclamation dredging into project. Detailed assessment work was undertaken, and there was regular engagement with key stakeholders, along with the preparation of this consent application.

Stakeholder consultation and engagement activities

8.9 The consultation and engagement was built upon two methods; direct engagement with key stakeholders as well as advertised ‘open invite’ events for the general public. In order to provide a logical summary, the consultation and engagement undertaken by LPC has been grouped into the key time periods of the project:

2007 to 2010: Project Initiation

8.10 From late 2007 through to early 2008 the project was being defined, scoped and early designs worked through. During this time LPC consulted with a large range of stakeholders to discuss the proposed capital dredging project (as it was then known). This consultation included a number of meetings to present the findings of various investigations completed by experts engaged by LPC. The project was then put on hold in 2010. The consultation undertaken in this period is summarised in Figure 8.1 below.

Stakeholder:	Information Letter/Phone Discussions	Meeting	Further Meeting(s)
Te Hapū o Ngāti Wheke	√	√	√
Te Rünanga o Koukourärata	√	√	√
Port Levy Residents Association/ Local Marine Farmers/Members of the	√	√	√
Lyttelton Harbour Issues Group	√	√	√
Lyttelton Community Association	√	√	√
Department of Conservation	√	√	√
Lyttelton Environment Group	√		
Maritime NZ	√		
Inshore Commercial Fishing fleet	√	√	√
Independent Fisheries etc.	√		
Ministry of Fisheries	√		
Forest and Bird	√	√	
Fish and Game	√		
Lyttelton Harbour Business Association	√		
Black Cat	√		
Tug Lyttelton	√		
Surfrider Environmental Advocacy	√		
Naval Point Yacht Club	√		
Canterbury Sport fishing Club	√	√	√
Christchurch City Council Lyttelton Mt Herbert Community Board	√		

Figure 8.1: Stakeholders consulted with in 2008

2012 to early 2013: Project re-commencement

8.11 After the immediate period following the 2010/2011 earthquakes was worked through, LPC recommenced efforts on the channel deepening project. The aim of this phase was to explore stakeholders' issues and understand their concerns so that necessary alterations to the project design/methodology could be made early on. Consequently this phase focused on open invite public meetings and further specific key stakeholder meetings to ensure all potentially affected parties could attend and provide their views on the proposals. The consultation was undertaken by LPC staff and consultants employed within the Project team.

8.12 Key activities are summarised below:

a) In August of 2012, LPC sent out letters to the twenty groups or organisations contacted during 2008 consultation to inform them that LPC was initiating consultation in preparation for submitting resource consent applications for both capital and maintenance dredging in 2013.
b) A public meeting in August 2012 at Lyttelton provided an overview of the proposal, reviewed existing work and proposed future work. Identified key stakeholders received a direct mail out, and the meeting was also advertised in a local newsletter (the Lyttelton Review). Te Hapū o Ngāti Wheke was specifically invited.
c) An LPC community newspaper article in October 2012 provided key aspects of the proposed project.
d) A public meeting was held in December 2012 at Governors Bay. An overview of the proposal was provided, and a review provided of existing and proposed further work. It was advertised in the Lyttelton Review weekly newsletter and Bay Harbour News. Rūnanga were specifically invited.
e) A public meeting was held in February 2013 at Sumner. It was organised with the Sumner Residents Association. This meeting presented the findings of the investigation work with a focus any actual or potential effects on Taylors Mistake Bay or Sumner.
f) There was a meeting with Te Rūnanga o Koukourārata, local marine farmers and the Port Levy Residents Association in March 2013.This meeting presented the findings of the investigation work with a focus any actual or potential effects on Port Levy.

g) There was a meeting in March 2013 with Department of Conservation. LPC presented a project overview, along with findings from the investigation work etc.
h) In 2013 project information was placed on LPC's corporate website.

8.13 The majority of questions at the meetings related to the capital dredging project although some were on the maintenance dredging of the existing navigation channel. The key issues raised by stakeholders at the meetings were:

a) Effects on sedimentation rates in the Upper Harbour;
b) Plumes and sediment entering Koukourārata and effects on shellfish;
c) Depth of turbid layer (dredging related and naturally);
d) Effects on waves, tides and currents;
e) Effects of larger vessels, more vessels;
f) Hydrodynamic model and what it includes;
g) Type of dredge used and where would it come from;
h) Location and effects of offshore disposal ground;
i) Ongoing maintenance dredging;
j) Ecological effects (including marine mammals);
k) Monitoring and consent requirements;
l) Biosecurity risks; and
m) Unforeseen risks.

2013 to 2015: Consultation

8.14 In this period of the project, LPC were undertaking more detailed technical work to assess effects and inform the overall project design. Some of this technical work was undertaken in response to issues previously raised by stakeholders. Consultation in this phase focussed more on the detail of the effects assessments and project proposals.

8.15 Key activities are summarised below:

a) A Lyttelton harbour field trip in November 2013 provided Environment Canterbury staff with a chance to familiarise themselves with the location of the dredging and disposal and to see "first hand" a dredging operation in progress.
b) Another field trip was undertaken in March 2014 with Te Hapū o Ngāti Wheke and Te Rūnanga o Koukourārata. Representatives were taking to view the location of the

dredging and disposal sites.

c) A pre ‘consent lodgement’ workshop was undertaken in March 2014 with Environment Canterbury staff. LPC and technical advisors gave presentations on the proposal.

d) There was a meeting with Sanford Ltd in Auckland in June 2014, at which there was an overview and discussion of the proposed dredging and disposal.

e) There was a meeting with aquaculture operators Sanford Ltd, Ngai Tahu Fisheries Ltd, and Koukourārata in July 2014. We discussed the project and its effects. The principal concern identified was impacts on their marine farms resulting from degradation of water quality (suspended sediment and contaminants) and biosecurity issues from marine invaders.

f) LPC met with the Department of Conservation in July 2014. There was a discussion of the project and effects, and concerns were raised about the potential impact of the activity on the benthic biota, including brachiopods, fish and marine mammals.

g) There was a meeting with Pegasus Fishing Ltd in August 2014. LPC provided a project overview and discussion, and it was recognised that dredging disposal sites were likely to be more of an issue for the inshore fishers.

h) There was a further Lyttelton Harbour field trip with Environment Canterbury and DOC staff in August 2014.They were taken to the dredging and disposal sites and saw “first hand” a dredging operation in progress.

i) There was a workshop with key stakeholders (DOC, ECan, Te Rūnanga o Ngāi Tahu, Sanford Ltd) in August 2014, to develop a monitoring plan. The workshop was coordinated by Graham Fenwick of NIWA and was attended by LPC and their experts.

j) LPC met with Southern Inshore Fisheries in October 2014, in Nelson. They discussed the proposed dredging and disposal operation, and responded to questions.

k) A meeting with the Pāua Industry was held in October 2014.The proposed dredging and disposal operation was discussed. Monitoring the potential sediment plume was a key issue.

l) A meeting with Lyttelton Inshore Fisherman was held in October 2014, Christchurch. The proposed dredging and disposal operation was discussed. Monitoring the potential sediment plume and potential impact on the flat fish fishery at the entrance to Lyttelton Harbour were key issues.

m) LPC met with Aquaculture operators in October 2014 at Koukourārata. Again, the proposed dredging and disposal operation was discussed. Monitoring the potential sediment plume was a key issue.

2015 onwards

8.16 Following the completion of the LPRP process, additional focus was placed on the channel deepening project. During this period, significant advances were made in some of the technical work, particularly the hydrodynamic and sediment transport modelling.

8.17 As a result, LPC made some changes to the way it was engaging with stakeholders, particularly the key stakeholders. One of the key aspects of this was the development of a Technical Advisory Group (TAG). The purpose and operation of the TAG is summarised in following sections.

8.18 In addition to the TAG, LPC continued to engage with other key stakeholders with written communication, face to face meetings and conversations. The key points of consultation are summarised below:

a) A letter was sent in April 2016 to an expanded list of 47 key stakeholders to provide an update of project progress including changes to the project scope (principally the greater volume of dredging);
b) A number of phone discussions were held with a range of the identified key stakeholders over the period April to September 2016;
c) A project page on LPC's website was developed to provide information to the general public;

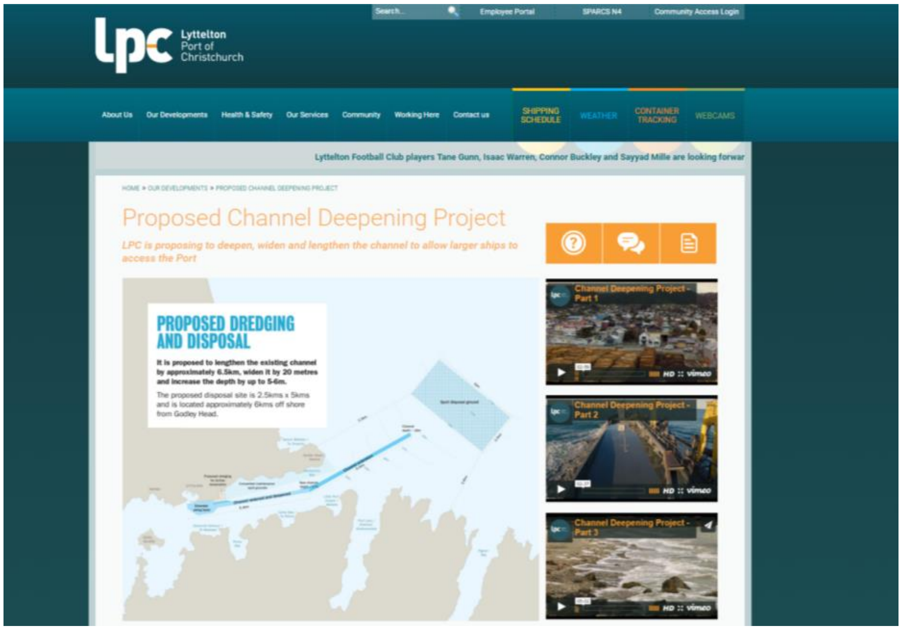


Figure 8.2 Image of the project page on LPC's website

d) Meetings were held to present and discuss the project with the following stakeholders:
   i) Pāua 3 AGM in Kaikoura, May 2016;
   ii) Carol Scott (Southern Inshore Fisheries), June 2016;
   iii) Tony Threadwell (Pegasus Fishing) May 2016;
   iv) DOC, May 2016;
   v) Eugiene Sage (Green Party), June 2016;
   vi) ECan (Harbour Master, science and planning staff), June 2016;
   vii) Lyttelton-Mt Herbert Community Board, June 2016;
   viii) Jan Evelens (Charteris Bay Yacht Club), June 2016;
   ix) Banks Peninsula Mussel Farmers, Aquaculture NZ, July 2016;
   x) Koukourārata Matatai Committee, July 2016;
   xi) Naval Point Club Lyttelton, a number of discussion, May-September 2016;
   xii) DOC September 2016;
   xiii) Inshore Fisheries Ltd, September 2016; and
   xiv) Archie Laird (fisherman) September 2016;

e) A Port Talk event in June 2016 followed the same format as that used in the Lyttelton Port Recovery Plan (Saturday mornings during the Lyttelton Market). It was advertised in the Bay Harbour News, the Press and on LPC's website. The Project

Team and members of LPC's management team, including the Chief Executive, were in attendance to answer the public's questions.

Figure 8.3 Port Talk event

f) A project brochure was produced in June 2016 to provide information on the project and potential effects. It was available to the public at Port Talk and distributed at meetings;

g) Three project videos were produced in June 2016 to set out the reason dredging is required, how dredging is undertaken and how LPC was assessing potential effects. These videos were available online as well as played at Port Talk;

h) Port Talk is also opening every Friday from 11.00am-1.00pm so members of the public can discuss aspects of the ports operations or developments with an LPC staff member;

i) In order to involve the Canterbury Regional Council in the early stages of the consent application and ensure the resulting application documents were complete, the following engagement was undertaken:

- Regular (fortnightly to monthly) meetings with the planning staff assigned to the project (commenced April 2016) to discuss the project and process; and
- A series of meetings with ECan planning staff, Mahaanui Kurataiao Ltd (MKT) and LPC to discuss conditions and linkages with the Environmental Monitoring and Management Plan. This group also attended a TAG meeting to link with the technical experts.

Technical Advisory Group

8.19 The TAG was set up to provide a mechanism for the key stakeholders to provide advice to LPC on further marine ecological investigations, hydrodynamic modelling as well as

advice on appropriate turbidity monitoring and adaptive management methods. The TAG also enabled LPC to gain a good understanding of the range of issues and concerns that the TAG members may have with the project and related technical work. The roles and functions of the TAG were set out in a Terms of Reference document agreed to by all TAG members.

8.20 Regular full day TAG meetings were held in Lyttelton, either monthly or fortnightly, depending on workload. LPC chaired the meetings, took minutes and prepared agendas. In total sixteen meetings were held between October 2015 and August 2016.

8.21 The TAG comprised representatives from Te Rūnanga o Koukourārata, Te Hapū o Ngāti Wheke (Rāpaki), Ngāi Tahu Fisheries, Te Rūnanga o Ngāi Tahu, Sanfords Ltd as well as LPC and their experts.

8.22 Key outcomes from the TAG were:

a) Providing advice on, and assistance with, the development of methodology and scope for the reef and shoreline ecology survey work undertaken by Cawthron Institute. This included specific survey methods, locations of surveys, number of sites/areas of interest;
b) Advice on the appropriate types and location of water quality monitoring to underpin the adaptive management framework;
c) Advice on the hydrodynamic and sediment transport modeling work undertaken, including additional work to address uncertainties;
d) Advice on how the technical work and monitoring can protect the rights, values and interests of manawhenua; and
e) Advice on the development and framework of the adaptive management plan and associated trigger level system.

Consultation with Tangata Whenua

8.23 As described earlier, LPC began consulting with Tangata Whenua in late 2007. The main issues raised at that time were:

a) Whether sediment could be transported to upper Whakaraupō and increase the rate of sedimentation of the upper Harbour, and more specifically whether the channel

can act as conduit for sediment;

b) Whether dredge spoil from the proposed offshore ground could adversely affect the Koukourārata maitatai, marine farms and shoreline generally; and

c) Whether sediment suspended during dredging could propagate into Koukourārata.

8.24 Although the project was then put on hold, in the intervening period LPC did carry out further investigation work. In particular a hydrodynamic model was developed which served to validate the measurement work carried out. LPC also continued to use its best endeavours to try and secure an appropriate person to complete a cultural impact assessment (CIA) for the capital dredging project.

8.25 Following some difficulty in getting a CIA commissioned, Mahaanui Kurataiao Ltd (MKT)[83] and LPC jointly contracted the National Institute of Water and Atmosphere (NIWA) in 2011 to provide a desk-top specialist technical evaluation of the likely impacts of developments proposed by LPC on matters of particular interest to local Rūnanga.

8.26 The report determined that LPC's investigative work and associated conclusions appeared to be sound.[84] The report was originally circulated as a draft for discussion and comment. The NIWA report was intended to form the basis of a truncated CIA but that did not eventuate.

From 2012 onwards the following consultation was undertaken:

a) An informal meeting was held in July 2012 with representatives from Lyttelton Harbour/Whakaraupō Issues Group (LHWIG) and Rāpaki. The meeting discussed the projects in general. It was agreed that a formal meeting would be organised by LPC but facilitated through LHWIG. As detailed earlier, this meeting was held in August 2012.

b) LPC invited a representative of Rapaki to participate in work to better understand sediment transport pathways in outer Whakaraupō. A representative from Te Hapū o Ngāti Wheke was involved in the field work and also attended the webinar presentation of the results to LPC in the beginning of October.

c) There was a Hui in October 2012 at Rapaki Marae which Te Hapū o Ngāti Wheke

[83] MKT represents the interests of the Rūnanga.

[84] It was noted by NIWA that no verification of the hydrodynamic model in Whakaraupō was presented. However, since then there have been deployments inside the Harbour.

(Rāpaki), Te Rūnanga o Koukourārata and Mahaanui Kurataiao Ltd attended. LPC provided an overview of the projects and discussed tidal currents, residual currents, waves and the associated transport of dredge spoil. While there was discussion on the investigative work completed by LPC there were no specific issues raised although it was suggested that wetland at head of Whakaraupō could be restored.

d) A meeting was held in March 2013 at Koukourārata Marae with Te Rūnanga o Koukourārata, local marine farmers and the Port Levy Residents Association. Te Rūnanga o Koukourārata reiterated that the issue for the Rūnanga concerned dredge spoil getting into Koukourārata and adversely affecting mahinga kai.

e) Another Hui was held in April 2013 at Rāpaki Marae, with Te Hapū o Ngāti Wheke and Te Rūnanga o Koukourārata. Both the capital and maintenance projects were discussed as well as a general discussion about the harbour environments generally. Questions raised were related to sediment transport into Koukourārata, management of biosecurity risks, dredge vessel noise, sediment plume effects on shellfish, monitoring requirements and the need for a CIA. There was also wider discussion on the need for continuing research in Whakaraupō to better under the effects of various activities, including past and present port-related activities and structures.

f) The process of preparing the 2014 CIA involved a range of engagement activities, which are summarised in the 2014 CIA included in **Appendix 3**.

g) The Manawhenua Advisory Group (MAG) was set up in April 2014. The purpose of this group was to provide a forum for LPC and Te Hapū o Ngāti Wheke to work together on harbour issues. More details are set out in Section 2 of the Cultural Impact Assessment (**Appendix 3**).

h) In June 2016, due to the period of time and changes in the project, it was decided by Te Hapū o Ngāti Wheke Te Rūnanga o Koukourārata that the CIA needed to be updated. The 2016 CIA summarises the engagement undertaken since the 2014 CIA and includes the following table of activities.

Date	**Activity**
May 2014	Capital Dredging Project CIA
June 2014	LPC, manawhenua and Te Rūnanga meet to discuss CIA and agree on way forward.
November 2014	Lyttelton Port Recovery Plan CIA. Includes issues related to capital dredging.
December 2014	Stakeholder workshops and NIWA report identifying monitoring options.
September 2015	LPC forms Technical Advisory Group (TAG) to provide advice on ecological monitoring programme and Adaptive Management Plan.

October 2015	LPC communicates changes to the Capital Dredging project to manawhenua.
October 2015	Whakaraupō trip by vessel to view and discuss maintenance dredging operations.
March 2016	LPC/Manwawhenua/Te Rūnanga Hui - project scope, plume modelling results and approach monitoring and adaptive management.
May 2016	LPC/Manwawhenua/Te Rūnanga Hui - assessment of progress on key issues and discuss proposed changes to maintenance dredging disposal.
June 2016	LPC/Manwawhenua/Te Rūnanga Maintenance Dredging Hui - discussion of site options for offshore disposal and identify manawhenua preferences.
July 2016	CIA update Hui
August 2016	CIA update Hui
August 2016	Manawhenua/Te Rūnanga review and endorsement of CIA update report.
August 2016	LPC/Manwawhenua/Te Rūnanga Maintenance Dredging Hui - discussion of site options for offshore disposal
September 2016	LPC/ Manwawhenua/Te Rūnanga 'wrap-up' Capital Dredging Hui
September 2016	CIA update Hui

Figure 8.4 – Summary of engagement 2014-2016

9. STATUTORY CONSIDERATIONS

Introduction

9.1 This chapter sets out the relevant statutory provisions and then sets out an assessment of those provisions against this proposal.

9.2 The following activities, associated with capital and maintenance dredging, require resource consent under the Regional Coastal Environment Plan for the Canterbury Region (RCEP):

a. To dredge (disturb) seabed material for purposes of deepening, extending and widening a shipping (navigation) channel that includes a ship-turning basin, and berth pockets; and to dredge (disturb) seabed material for the purposes of construction of a reclamation in Te Awaparahi Bay;
b. To discharge contaminants (dredge spoil and water) into water;
c. To discharge contaminants (seabed material and water) into water associated with dredging described in (a) above; and
d. To deposit seabed material on the seabed associated with (a) to (c) above.

9.3 The application is to be assessed as a discretionary activity. The details of the rules and status of the disturbance, deposition and discharge activities associated dredging is discussed later.

Summary of the Relevant Statutory Framework

9.4 The Resource Management Act 1991 ('RMA') and the Resource Management (Marine Pollution) Regulations 1998 ('Marine Pollution Regulations') provide the statutory framework under which this application is processed.

9.5 Section 12 of the RMA regulates activities to be carried out in the coastal marine area. In summary, no person may disturb the seabed or deposit any substance on the seabed in a manner that is likely to have an adverse effect on the seabed unless expressly allowed by a rule in a regional coastal plan. Section 12(6) states that this section does not apply to anything to which section 15A or section 15B applies.

9.6 Section 15(1)(a) provides that no person may discharge any contaminant or water into water unless the discharge is expressly allowed by a national environmental standard or other regulations, a rule in a regional plan, or a resource consent. Section 15 does not apply to anything to which section 15A or section 15B applies.

9.7 Section 15A specifically regulates the dumping of waste from any ship in the coastal marine area and provides that no dumping shall occur unless expressly allowed by a resource consent. The definition of waste under the RMA means materials or substances of any kind, form or description and therefore includes the dumping of dredge spoil.

9.8 Regulation 4(2) of the Marine Pollution Regulations states that the dumping of dredge material is deemed to be a discretionary activity in a regional coastal plan.

Information Requirements

9.9 Section 88(2) of the RMA states that an application must include information relating to the activity, including an assessment of the activity's effects on the environment as required by Schedule 4.

9.10 Clause 2 of Schedule 4 sets out the information required in all applications, and Clause 6 sets out what information is required in an assessment of environmental effects. Clause 7 further details the matters which must be addressed by an assessment of environmental effects.

9.11 In addition, Regulation 5 of the Marine Pollution Regulations states that every application for the dumping of dredge material must include the information specified in Schedule 3.

9.12 Schedule 3 states that an application must include a detailed description and characterisation of the waste to enable a proper assessment to be made of its potential impacts on human health and the environment. This relevantly includes the following:

a. The identification of any sources of contamination associated with the sediment and waste prevention strategies that may be pursued to control that contamination (Clause 4);

b. Details of the physical, chemical and biological characteristics of a proposed dump site (Clause 6 [a]);

c. An assessment of constituent fluxes associated with dumping in relation to existing fluxes of substances in the marine environment and integration this information with the proposed disposal techniques; (Clause 6 [b]);

d. The economic and operational feasibility (Clause 6 [c]); and

e. Specify the potential effects on the environment and define the nature, temporal, and spatial scales and duration of expected effects and state any assumptions (Clause 8).

9.13 The RCEP also provides guidance on the information to be provided (Chapter 12). It includes the types of information that might need to be included in an assessment of effects and relevantly includes effects on:

a. Navigation;
b. Marine habitat;
c. Coastal processes;
d. Water quality;
e. Temporal effects;
f. Conservation values;
g. Displacement of users;
h. The type, content and volume of any discharge; and
i. The volume and type of material to be deposited.

Decision-Making

9.14 Section 104 of the Resource Management Act sets out the matters to which a consent authority must have regard when considering applications for resource consents. In particular, section 104(1) provides:

> “(1) When considering an application for a resource consent and any submissions received, the consent authority must, subject to Part 2, have regard to –
> (a) any actual and potential effects on the environment of allowing the activity; and
> (b) any relevant provisions of –
> (i) a national policy statement:
> (ii) a New Zealand coastal policy statement:
> (iii) a regional policy statement or proposed regional policy statement:
> (iv) a plan or proposed plan; and
> (c) any other matter the consent authority considers relevant and reasonably necessary to determine the application.”

9.15 The Ngāi Tahu Claims Settlement Act 1998 and Mahaanui Iwi Management Plan ('MIMP') are relevant and consideration of the same is reasonably necessary to determine the application.

9.16 Section 108 enables the Commissioners to impose conditions on any consent that is granted.

9.17 Notwithstanding Sections 104 and 108 above, Section 107(1) of the Act states that a consent authority shall not grant a discharge permit if, after reasonable mixing, the contaminant is likely to give rise to all or any of a number of effects in the receiving waters identified under clauses (c)-(g) except in those circumstances identified under subsection (2).

9.18 Section 138A contains special provisions relating to coastal permits for dumping and incineration. It states:

> "(1) Without limiting section 104, when considering an application for a coastal permit to do something that would otherwise contravene section 15A(1), the consent authority shall, in having regard to the actual and potential effects of allowing the activity, have regard to—
>
> (a) The nature of any discharge of any contaminant which the dumping or incineration may involve and the sensitivity of the receiving environment to adverse effects and the applicant's reasons for making the proposed choice; and
>
> (b) Any possible alternative methods of disposal or combustion including any involving discharge into any other receiving environment,—
>
> and, without limiting the powers of the consent authority under section 92, it may, at any reasonable time before the hearing (or, if there is no hearing , the determination) of the application, by written notice to the applicant, require the applicant to provide, by way of further information, an explanation of those matters.
>
> (2) Without limiting section 108, but subject to subsection (5), a coastal permit to which subsection (1) applies may include a condition requiring the holder to adopt the best practicable option to prevent or minimise any actual or likely adverse effect on the environment of any discharge of any contaminant which may occur in the exercise of the permit; provided that before a consent authority decides to grant a coastal permit subject to such a condition, it shall be satisfied that, in the particular circumstances, and having regard to—
>
> (a) The nature of any discharge of a contaminant and the receiving environment; and
>
> (b) Other alternatives, including any condition requiring the observance of minimum standards of quality of the receiving environment,—
>
> the inclusion of the condition is the most efficient and effective means of preventing or minimising any actual or likely adverse effect on the environment.

(3) In respect of a coastal permit to do something that would otherwise contravene section 15A(1), a consent authority may, at any time specified for that purpose in the permit, in accordance with section 129, serve notice on the holder of the permit of its intention to review the conditions of the permit for the purpose of requiring the holder to adopt the best practicable option to remove or reduce any adverse effect on the environment.

(4) Subject to subsection (5), sections 129 to 133 shall apply to any review of a coastal permit under subsection (3) and the powers conferred on a consent authority by that subsection are in addition to the powers conferred by section 128.

(5) Before deciding to grant a coastal permit subject to a condition described in subsection (2) and before deciding to change the conditions of a coastal permit pursuant to subsections (3) and (4), the consent authority shall be satisfied, in the particular circumstances, and having regard to—

(a) The nature of any discharge of a contaminant and the receiving environment; and

(b) The financial implications for the holder of including that condition; and

(c) Other alternatives, including a condition requiring the observance of minimum standards of quality of the receiving environment—

that including a condition in the permit requiring the holder to adopt the best practicable option to remove or reduce any adverse effect on the environment is the most efficient and effective means of removing or reducing that adverse effect.

(6) In every coastal permit to do something that would otherwise contravene section 15A(1), there shall be implied a condition that the holder shall, in the prescribed form and at the cost of the holder in all respects, keep such records and furnish to the Director of **[[**Maritime New Zealand**]]** such information and returns as may from time to time be required by regulations."

9.19 Those matters set out 104 and 138 are subject to Part 2 (Purpose and Principles) of the Act.

9.20 The purpose of the RMA is to promote the sustainable management of natural and physical resources. Sustainable management is defined as:

" …managing the use, development, and protection of natural and physical resources in a way or at a rate that enables people and communities to provide for their social, economic and cultural wellbeing, and for their health and safety, while

(a) Sustaining the potential for natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations;

(b) Safeguarding the life supporting capacity of air, water, soil and ecosystems; and

(c) Avoiding, remedying or mitigating any adverse effects of activities on the environment".

9.21 Matters of national importance (Section 6) relevant to this application (which must be recognised and provided for) include the following:

> “(a) the preservation of the natural character of the coastal environment (including the coastal marine area), wetlands and rivers and their margins and the protection of them from inappropriate subdivision, use and development;
> (c) (c) the protection of areas of significant indigenous vegetation and significant habitats of indigenous fauna; and
> (e) the relationship of Maori and their culture and traditions with their ancestral lands, water, sites, waahi tapu and other taonga.”

9.22 Relevant matters to which regard must be had (Section 7) include the following:

> “(a) kaitiakitanga
> (aa) the ethic of stewardship
> (b) the efficient use and development of natural and physical resources
> (c) the maintenance and enhancement of amenity values
> (d) intrinsic values of ecosystems
> (e) [Repealed]
> (f) maintenance and enhancement of the quality of the environment
> (g) any finite characteristics of natural and physical resources.”

9.23 Section 8 requires that the principles of the Treaty of Waitangi must be taken into account by all persons exercising functions and power under the Act in relation to managing the use, development and protection of natural and physical resources.

9.24 In addition to the above RMA matters, the Consent Authority is also required to have regard to the following matters under Schedule 3 of the Marine Pollution Regulations:

> “9. Consideration of an application must have regard to the avoidance, remedying, or mitigation of environmental disturbance and detriment. Consideration of an application must also have regard to the imposing of conditions specifying—
> (a) The types and sources of materials to be dumped:
> (b) The location of the dump-site(s):
> (c) The method of dumping:
> (d) Monitoring and reporting requirements.
>
> 10. Consideration of an application must have regard to the imposition of monitoring programmes as a condition of a resource consent.”

9.25 The Canterbury Earthquake Recovery Act, 2011 (‘CER Act’) is also relevant to the decision made under the RMA. Section 23 of the CER Act states that on and from the notification of a Recovery Plan in the *Gazette*, any person exercising functions or powers under the Resource Management Act 1991 must not make a decision or recommendation that is inconsistent with the Recovery Plan on any of the following relevant matter under the Resource Management Act 1991:

"(a) an application for a resource consent for a restricted discretionary, discretionary, or non-complying activity……"

9.26 The Lyttelton Port Recovery Plan was notified in the Gazette on 19 November 2015. Chapter 3 sets out the key considerations for Lyttelton Port. Consideration 3.3 states:

"To accommodate larger ships, Lyttelton Port requires deeper and longer shipping channels. If Lyttelton Port is only serviced by relatively small, old and costly ships, it could disadvantage Christchurch and Canterbury in terms of economic efficiency and growth.

Lyttelton Port Company Limited is seeking to deepen and widen the main navigational channel and to create and deepen ship-turning basins adjacent to Te Awaparahi and Cashin Quay reclamations."

9.27 **Figure 1** shows that geographic extent of the Recovery Plan, which includes the enlarged main navigation channel and existing spoil dumping grounds located along the north side of the Lyttelton Harbour.

9.28 The proposed offshore grounds are not included in Port Recovery because it is outside the geographical area covered by the Recovery Plan although the offshore grounds are needed for the channel deepening project to proceed.

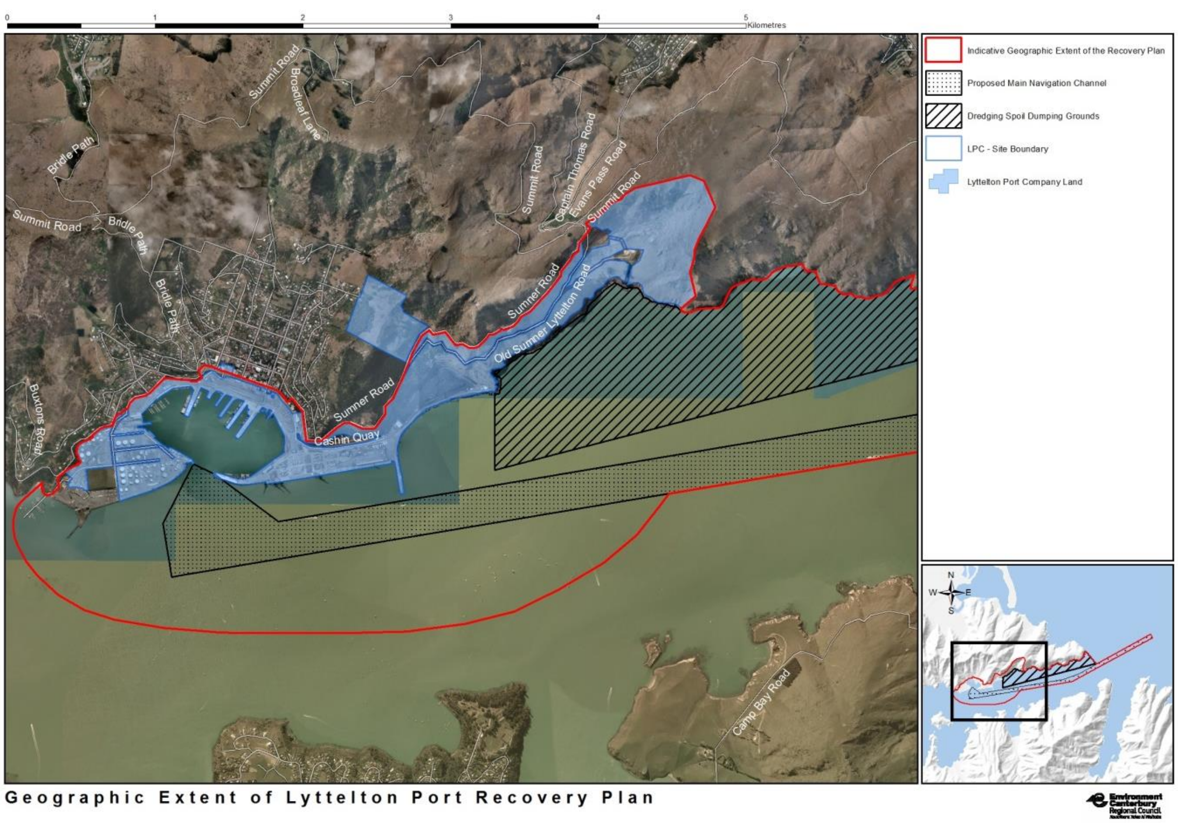


Figure 2: Area covered by the Lyttelton Port Recovery Plan: Source CERA, 2015.

Assessment of the Application against the Statutory Framework

Assessment of the Rules

9.29 Chapter 10 of the RCEP contains rules on activities in and occupation of the Coastal Marine Area required for the recovery of the Lyttelton Port. This includes dredging and deposition/discharge of dredge spoil shown on Planning Maps 10.1, 10.3 and Map 10.5.

9.30 Because the proposed offshore deposition ground is outside the geographic extent of Port Recovery, then the existing rules in the other chapters of the RCEP apply.

9.31 Details of the rules and an assessment of the rules are set out in the **Table 1** at the end of this chapter.

9.32 In summary, the rules regulate activities associated with the proposal as shown in the following table:

Permitted Activities
Rule 10.9 - Disturbance of the seabed associated with maintenance dredging of the navigation channel and the operational area of Lyttelton Port
Rule 10.9 - Disturbance of the seabed associated with the deepening of the berth pockets at Cashin Quay
Rule 10.29 – Discharge of sediment already present on the seabed which is the result of disturbance that is directly associated with Dredging of the main navigation channel or within the operational area of Lyttelton Port
Controlled Activities
Rule 10.17 - Deposition of dredge spoil associated with the deepening of the berth pockets at the Harbour spoil dumping grounds
Restricted Discretionary Activities
Rule 10.12 - Disturbance of the seabed associated with the deepening and/or extending the main navigation channel, ship-turning basin and approach to the inner Harbour.
Rule 10.18 - Deposition of dredge spoil associated with maintenance dredging of the main navigation channel or the operational area of Lyttelton Port at the Harbour spoil dumping grounds
Discretionary Activities
Rule 10.33 – Discharge of dredge spoil associated with dredging of the main navigation channel or the operational area of Lyttelton Port at the Harbour spoil dumping grounds
Rule 7.2 – Discharge of dredge spoil associated with dredging of the main navigation channel or the operational area of Lyttelton Port at the proposed offshore grounds for channel deepening and for maintenance dredging
Rule 8.13 – Deposition of dredge spoil associated with dredging of the main navigation channel or the operational area of Lyttelton Port at the proposed offshore grounds for channel deepening and for maintenance dredging

9.33 As discussed earlier, Section 4(2) of the Marine Pollution Regulations states that the dumping of dredge material is deemed to be a discretionary activity in any regional coastal plan. Consistent with the regulations, the above rules classify the discharge of spoil as a discretionary activity.

9.34 Therefore the application as a whole is to be considered a discretionary activity unless there is a reason to unbundle the disturbance and deposition activities from the discharge (dumping) of dredge material. Both capital and maintenance dredging is reliant on the discharging of dredge material from the hopper of the dredge vessel into the water column and so the activities cannot be unbundled.

9.35 Nevertheless, it is relevant that various disturbance and deposition activities associated with channel deepening and maintenance dredging are expressly anticipated by the RCEP because they are classified as permitted, controlled or restricted discretionary activities (other than the proposed discharges and deposition at the offshore grounds).

9.36 As described earlier, Schedule 4 (Clause 7) of the RMA and the Marine Pollution Regulations and the RCEP set out matters that must be assessed and the RCEP (Chapter 12) also provides guidance on the matters that should be assessed when making an application for resource consent. The AEE and the associated supporting documents have addressed the various matters.

Assessment of Objectives and Policies contained in the Relevant Statutory Documents

Objectives and Policies relating to Port Recovery

9.37 A general assessment of the policies is provided below while further comment is provided on individual objectives and policies is contained in **Table 1** at the end of this Chapter.

9.38 Chapter 10 of the RCEP is concerned with the recovery of the Lyttelton Port. The integration with the rest of the RCEP is explained at the beginning of the chapter:

> "The policies and rules in this chapter implement not only the specific recovery objectives for the Lyttelton Port in this chapter, but also the region-wide objectives in the RCEP. Where the RCEP

contains objectives, policies and rules in Chapter 10 that are on the same subject matter as in other chapters, the provisions of Chapter 10 will prevail.

In considering an application for a resource consent in accordance with the rules in this chapter, the consent authority is also obliged to have regard to relevant objectives and policies in other chapters of the plan."

9.39 Objective 10.1 (Recovery of Lyttelton Port) recognises that the expedited recovery of Lyttelton Port, including its repair, rebuild and reconfiguration, is provided for as a matter of priority, while recognising the relationship with and managing any adverse effects of recovery activities on the ecological, recreational, heritage, amenity and cultural values of Lyttelton Harbour/Whakaraupō.

9.40 Policy 10.1.1 (Elements of recovery) states than an expedited recovery of Lyttelton Port is enabled by undertaking a range of activities including "*increasing shipping capacity, including deepening berth pockets, ship turning basins and the Main Navigation Chanel to allow for larger vessels*."

9.41 Policy 10.1.2 recognises that Lyttelton Port is essential to the regional economy and that its continued operation is essential for the recovery of greater Christchurch. The deepening of vessel access to the Port is part of Port Recovery.

9.42 Policy 10.1.8 enables maintenance dredging for the continued operation of Lyttelton Port, and dredging to create, or deepen and widen, the Main Navigational Channel, ship-turning basins and berth pockets, provided that dredging is undertaken in accordance with best practice methods that minimise adverse effects on the environment. This proposal is consistent with the enlarged shipping (navigation) channel shown on Map 10.3 and best practice is proposed to promulgated using a Dredge Management Plan ('DMP'), a Marine Mammal Management Plan ('MMMP') and a Biosecurity Management Plan ('BMP').

9.43 Objective 21.8.1.1 of the proposed Christchurch Replacement District Plan also states that recovery of Lyttelton Port is to be enabled in a timely manner so as to restore its efficient and effective operation, and enable growth and development to support its role as strategic infrastructure in the recovery of greater Christchurch.

9.44 The above objectives and policies anticipate and are supportive of the proposal as it is an integral part of Port Recovery.

9.45 The proposed offshore spoil disposal grounds are outside the geographic extent of the Lyttelton Port Recovery Plan. However, the above objectives and policies carry considerable weight given that the deepening of the shipping channel cannot proceed without such grounds (refer to **Chapter 4**).

9.46 Policy 10.1.4 states that the relationship between Lyttelton Port and the values of Whakaraupō/Lyttelton Harbour are to be recognised by minimising as far as far as practicable any adverse effects on the ecological, recreational, heritage, amenity and cultural values of Whakaraupō/Lyttelton Harbour; and that effort is made to achieve a net gain in mahinga kai.

9.47 The ecological and recreational and visual amenity assessments have concluded no significant adverse effects are anticipated during dredging in Whakaraupō/Lyttelton Harbour.[85] While no significant adverse effects on the marine ecology and mahinga kai has been evidenced from the previous monitoring of maintenance spoil disposal at the existing spoil ground on the north-side of the harbour, the shifting of the primary spoil ground offshore would substantially remove one anthropogenic activity from the Harbour and would be in accord with Manawhenua wishes.[86]

9.48 Policy 10.1.9 recognises and anticipates the continued use of the existing spoil disposal grounds as shown on Planning Map 10.5, subject to ensuring that any adverse effects of dredge spoil removed during maintenance dredging or capital dredging are avoided, remedied or mitigated; and, that the deposition area is monitored so that any adverse effects on the environment, including mahinga kai, can be identified and managed appropriately. The proposal to restrict the use of Godley Head temporary periods when the proposed primary ground cannot be used means that turbidity generated during disposal and the re-circulating of sediment would be largely removed compared to the exclusive use of grounds now occurring. The proposal is therefore consistent with policy. Notwithstanding, monitoring of Whakaraupō/Lyttelton Harbour is proposed.

[85] Refer to the reports on ecological related matters (**Appendices 15A, 15B, 16** and **17**), recreation matters (**Appendix 5**) and Visual Amenity (**Appendix 4**).
[86] Accepting Te Hapū o Ngāti Wheke (Rāpaki) would not like to see any disposal at Godley Head at all.

Other Objectives and Policies

9.49 There are a range of other objectives and policies contained in the RCEP and other higher levels documents that need to be considered.

9.50 The RPS lists Lyttelton Port as ‘strategic infrastructure’ and by definition strategic infrastructure is deemed to be regionally significant infrastructure (page 198).

9.51 Policy 9 of the New Zealand Coastal Policy Statement (‘NZCPS’) states that a sustainable national transport system requires an efficient national network of safe ports, servicing national and international shipping, with efficient connections with other transport modes. The proposal is consistent with this objective because as discussed in **Chapter 3** the port is the largest in the South Island, servicing national and international shipping.

9.52 Policy 8.3.6 provides for the efficient and effective development, operation, maintenance and upgrade of regionally significant infrastructure in the coastal environment and the Lyttelton Port Recovery Plan amended the Policy 8.3.6 so that it now provides for the expedited recovery of Lyttelton Port, including its repair, rebuild and reconfiguration as described earlier.

9.53 **Chapter 3** of this application document sets out the rational for the proposal and the economic consequences are discussed in the assessment of economic effects prepared by Brown, Copeland & Co Ltd, 2016 (Refer **Appendix 2**). The project would enable the Lyttelton Port to develop and operate in an effective and efficient manner would assist the Port’s Recovery, consistent with these particular policy outcomes sought in the NZCPS, and the RPS and the recovery-related policies discussed above. The proposal is consistent with and supported by these policies.

9.54 There are also a large number of often overlapping objectives and policies that seek to manage environmental effects in the coastal environment, including the need to:

a. Avoid adverse effects on rare or threatened taxa and avoid significant adverse effects on other important ecosystems generally;
b. Maintain or enhance biological and physical processes in the coastal environment generally;
c. Maintain water quality or enhance it where deteriorated;

d. Control activities that could introduce harmful aquatic organisms;

e. Avoid or mitigate adverse effects on amenity, cultural and recreational values;

f. Adopt a precautionary approach towards proposed activities whose effects on the coastal environment are uncertain, unknown, or little understood, but potentially significantly adverse;

9.55 The details of the relevant objectives and policies are set out in **Table 1**. The actual or potential effects of the proposed dredging or disposal activities are not anticipated to be of a significance that would render the proposal contrary to any of these policies.

9.56 Considerable investment has been made on using the latest modelling techniques to better understand and predict the effects of the dredging on the waves and currents and on the transport of suspended sediment. There is a good degree of confidence in the results given they are largely consistent with the previous modeling and empirical work carried out. Notwithstanding, a monitoring program and a management response actions are being proposed as a precautionary approach.

Assessment of any other matter the consent authority considers relevant and reasonably necessary to determine the application under Section 104 (1) (c) of the RMA

Ngāi Tahu Claims Settlement Act 1998

9.57 Lyttelton Harbour lies within the Statutory Acknowledgement Area for Te Tai o Mahaanui (Banks Peninsula and Selwyn). The Crown has acknowledged the statements by Te Rūnanga o Ngāi Tahu of the particular cultural, historic, spiritual and traditional association with Te Tai o Mahaanui. When considering resource consent applications, section 95E(2)(c) of the RMA requires consent authorities to have regard to the statutory acknowledgements when forming a view on Te Hapū o Ngāti Wheke, Te Rūnanga o Koukourārata and Te Rūnanga o Ngāi Tahu are affected by an application.

9.58 Te Tai o Mahaanui covers the coastal marine area around Banks Peninsula and down to, and just past, the mouth of the Rakaia River.

9.59 The majority of Koukourārata (Port Levy) is also identified as a Mataitai area. A Mataitai is a traditional fishing ground that has special status under the Fisheries Act 1996 to protect customary food gathering values. Commercial fishing is prohibited in this area.

9.60 Te Hapū o Ngāti Wheke (Rāpaki) have also sought a Mataitai be established for much of Lyttelton Harbour/Whakaraupō although this has yet to be confirmed by the Minister.

Ngāi Tahu Resource Management Strategies for the Canterbury Region

9.61 The Mahaanui Iwi Management Plan (MIMP) was released February 2013. This Iwi Management Plan (IMP) is a manawhenua planning document reflecting the collective efforts of six Papatipu Rūnanga that represent the hapū who hold manawhenua rights over lands and waters within the takiwā from the Hurunui River to the Hakatere River and inland to Kā Tiritiri o Te Moana. This relevantly includes the takiwā of Te Hapū o Ngāti Wheke (Rāpaki) and Te Rūnanga o Koukourārata.

9.62 The IMP is the principal manawhenua planning document for the six Papatipu Rūnanga identified, although Te Whakatau Kaupapa is noted to be taonga in its own right and remain valuable sources of information on values and history. Part 3 of the IMP (Wāhi Tuatoru) also provides a brief introduction to the marae, history and takiwā of each of the six Rūnanga. The relevant Issue, objective and policies are discussed in Chapter 4 of the IMP.

9.63 A Cultural Impact Assessment (CIA) prepared for LPC in 2014 and attached in **Appendix 3** sets out in further detail the relevant policies.

Assessment of any Restriction on the Grant of Certain Discharges contained under Section 107 of the RMA

9.64 Section 107 states that a consent authority shall not grant a coastal permit to dump matter that is a contaminant into the coastal marine area from any ship, if, after reasonable mixing, the contaminant is likely to give the effects to all or any of the following effects in the receiving waters:

(c) the production of any conspicuous oil or grease films, scums or foams, or floatable or suspended materials:

(d) any conspicuous change in the colour or visual clarity:

…

(g) any significant adverse effects on aquatic life.

9.65 However, the consent authority may grant a discharge permit or a coastal permit to do something that would otherwise contravene section 15A that may allow any of the effects described in subsection (1), if it is satisfied—

(a) that exceptional circumstances justify the granting of the permit; or

(b) that the discharge is of a temporary nature; or

(c) that the discharge that the discharge is associated with necessary maintenance work—

and that it is consistent with the purpose of this Act to do so.

9.66 Determining an appropriate mixing zone is challenging for the following reasons:

a. The discharge during dredging and during disposal occurs at different locations along the shipping channel or at the disposal grounds;
b. The plumes vary in concentration in different parts of the water column;
c. The tidal and non-tidal currents vary in time and in space; and
d. The receiving environment is naturally turbid and fluctuates depending on the sea-states.

9.67 Any mixing zone would have to allow for such spatial and temporal variation both from the activity and from the natural background. As discussed in **Chapter 7** a best practice methodology has been established to address this complexity. An important component of this process is identifying when turbidity is considered sufficiently elevated to trigger a series of management response actions. If turbidity concentrations climb past the highest trigger (tier 3) then the dredging activity must cease at that location and relocate to somewhere else in the channel or the disposal activity cease and recommence somewhere else in the disposal ground unless the reasons for the elevated levels are demonstrably not caused by dredging activities. In other words, this trigger, in effect, establishes a reasonable mixing zone although it is important to recognise that even a tier 3 trigger exceedance does not mean that there will be a significant adverse effect on aquatic life or there will be any plumes that are ‘conspicuous’ because the largest

plumes occur near the seabed. The point is to establish tiers of triggers to avoid such effects from developing.

9.68 To achieve the triggers the following is to be undertaken:

a. A network of telemetered turbidity monitoring stations are being established, at least a year of baseline information is to be obtained; and

b. A statistical methodology (refer to **Appendix 20**) is to be used to monitor for the triggers at any one monitoring station and at any one time (taking into account background and predicted dredging plumes).

9.69 On this basis it is considered that an acceptable 'reasonable mixing zone' for the production of conspicuous suspended sediment plume or a conspicuous change in colour or visual clarity, or in terms of any significant adverse effects on aquatic life is defined as that area beyond which adaptive management responses are triggered. That is, when suspended sediments concentrations exceed the threshold triggers and require a response through the management response actions.

Assessment of Part 2 of the RMA

9.70 Lyttelton Port is the major gateway for importers and exporters in the Canterbury Region and is by far the most significant port in the South Island in terms of total tonnages of cargo and containers, the value of exports and the value of imports. It is identified as Regionally Significant Infrastructure in the Canterbury Regional Policy Statement.

9.71 If Lyttelton Port becomes big ship capable it is estimated that freight costs will decrease by greater than 10% for Canterbury and West Coast shippers of overseas containerised cargo. If it does not become big ship capable, it is estimated that freight costs will increase by between 11 and 50% for Canterbury shippers of overseas cargo and between 50 and 100% for West Coast shippers of overseas cargo. The proposal would enable local residents and businesses to provide for their economic and social wellbeing under Section 5(2) of the RMA and is consistent with the efficient use of resources under Section 7(b) of the RMA.

9.72 In terms of Section 5(2)(b) and (c) of the RMA, the investigation work expects that the life supporting capacity of the marine ecosystems will be safeguarded and any actual or

potential effects otherwise will appropriately avoided, remedied or mitigated. This will be reflected in conditions of consent and associated management plans.

9.73 The proposed dredging and deposition activities are located in the coastal marine area of the takiwā (traditional territory) of Te Hapū o Ngāti Wheke (Rāpaki) and Te Rūnanga o Koukōurārata.

9.74 The coastal marine area is known as Te Tai o Mahaanui, and is identified in the Ngāi Tahu Claims Settlement Act (NTCSA) 1998 as a Statutory Acknowledgement site, reflecting the particular cultural, spiritual, historical and traditional associations of Ngāi Tahu to this area and established Mātaitai Therefore sections 6(e) and 7(a) and (b) are relevant to the proposal.

9.75 LPC has consulted with Manawhenua as described in the CIA attached in **Appendix 3**. The formation of a Technical Advisory Group ('TAG'), which has been made up primarily of experts appointed by Manawhenua, the aquiculture industry and LPC, was part of this consultation process. The purpose of the TAG was to examine the relevant expert reports and to assist in the development of a monitoring and management response program. The CIA states that the implementation of turbidity triggers and associated adaptive management responses is supported by Manawhenua in principle, subject to a number technical matters being resolved and subject to appropriate processes being put in place for the implementation of the consent.

9.76 The CIA sets out a large number of recommendations that include:

a. The ceasing of any maintenance spoil disposal at Godley Head;
b. Maintenance dredge spoil instead being directed to the channel deepening (capital) offshore disposal ground;
c. An ability to move the offshore grounds to deeper water should be retained in case of any issues;
d. Setting appropriate consent durations; and
e. Any proposed technical advisory group or independent panel are set up and can operate in an appropriate manner.

9.77 Section 6(c) is relevant because the proposal area is part of wider habitat used by Hector's Dolphin and a number of marine avifauna classified as threatened nationally

vulnerable. The assessment of the direct effects on Hector's Dolphin and on marine avifauna is considered to be negligible except for the little (white-flippered penguin) where the direct effect could be low[87] due to the project area being located within the (restricted) foraging range of the Quail Island population in particular.[88] The proposed management plans set out the measures to further reduce any potential risk to these species.

9.78 In terms of Section 6(a) the Port area is considered to be of very low marine natural character, increasing to moderate for the Harbour generally, and moderate to high for Pegasus Bay, with experiential attributes considered to be high in Pegasus Bay. It is concluded that any natural character effects will be low, and in landscape terms the perceptual values of the adjacent outstanding natural features and landscapes along the coast and on land will be very low and neutral.[89]

9.79 In terms of Section 7(c) it is not expected that the proposed dredging and disposal of spoil will adversely affect amenity values. The proposed offshore spoil grounds or the existing spoil grounds are not known to be used to any great extent for recreational purposes. The project is not anticipated to cause any significant visual effects. As far as LPC is aware there have been no complaints relating to any adverse effects on amenity values from maintenance dredging. Likewise there is no evidence to indicate that the quality of the environment is likely to deteriorate in the longer term in terms of Section 7(f) because the effects associated with channel deepening would be temporary. The extent to which the quality of the existing maintenance spoil dumping grounds has deteriorated is difficult to evaluate because the activity has been occurring for over 100 years. The monitoring of the existing spoil grounds has not shown there to be any significant adverse effects on the benthic or intertidal communities in Lyttelton Harbour.

9.80 In terms of section 7(d), the marine ecosystems impacted from the proposal are adapted to turbid conditions and are typical of Pegasus Bay. As noted above the on-going disposal of spoil associated with maintenance dredging has resulted in observable

[87] The level of potential adverse effects is raised from negligible to low and from low to moderate, in the case of the little (white-flippered) penguin, by virtue of their threatened status.
[88] For further detail refer to **Chapter 6** or to the reports contained in **Appendix 16** (marine mammals) and **Appendix 17** (marine avifauna).
[89] For further detail refer to the report contained in **Appendix 4** (Natural Character, Landscape and Visual Amenity Assessment).

shift in the composition of benthic communities within the grounds but this is not considered to represent a significant adverse effect.

9.81 In terms of section 7(g), there are no species or biological communities which could be impacted from the dredging or dumping activities that only occur in the vicinity of the proposal. While the largest population of Hector’s dolphin is around Banks Peninsula, the highest population densities have been observed around the eastern part of the Peninsula. Although a sheltered, deepwater port of a similar scale to Lyttelton Port could be established elsewhere to serve the Christchurch and the Canterbury Region, realistically this is unlikely to happen and to that extent it could be seen a finite resource.

TABLE 1: Assessment of Application Against Relevant Provisions of a Document Referred To in Section 104(1)(b)

Rules – Regional Coastal Environment Plan (for the Canterbury Region)

Chapter 10

RCEP Rule	Description	Comment
Rule 10.9 Permitted Activities – Disturbance associated with maintenance dredging and deepening berth pockets	The disturbance of the foreshore or seabed, including the removal of material that is associated with: a) Maintenance dredging of the Main Navigational Channels shown on Planning Map 10.3 or within the Operational Area of Lyttelton Port shown on Planning Map 10.1; or b) Dredging to deepen the berth pockets adjacent to Wharf Structures in Area B shown on Planning Map 10.7; is a permitted activity, provided that for seabed material to be dredged from the Inner Harbour shown on Planning Map 10.8: a) An Inner Harbour Sediment Analysis Plan is prepared and implemented; and b) Pre-characterisation surveys are carried out; and c) A Sediment Analysis Report is prepared and implemented.	Disturbance of the seabed associated with dredging to maintain depths within the channel and the port operational area can be carried out as-of-right. The same applies to disturbance associated with any deepening of the seabed at any berth pocket at Cashin Quay and in the inner Harbour. However, within the inner Harbour the sediment needs to be firstly pre-characterised so as to ascertain the contamination status of the sediment prior to disposal. There are conditions in CRC135318 that address the management of contamination.
Rule 10.11 Controlled Activities – Disturbance associated with activities adjacent to and including the Te Awaparahi Bay Reclamation	The disturbance of the foreshore or seabed (including by excavating, drilling or tunnelling), where the disturbance is directly associated with the following activities: a) The construction of the reclamation in Area A shown on Planning Map 10.10; and c) Dredging to create and deepen the berth pocket(s) within Area C shown on Planning Map 10.7. is a controlled activity. Control is reserved over the following matters: a) The preparation and content of a Construction Environmental Management Plan that deals with the methods of construction and dredging; and b) Methods to mitigate adverse effects of the activity on	Disturbance associated with construction of the reclamation and the deepening of the berth pockets is classified as a controlled activity. A Dredge Management Plan (DMP) and an Environmental Monitoring and Management Plan (EMMP) are to be prepared that detail methods of dredging. In terms of Clauses (b) to (d), the EMMP contains the turbidity and assurance monitoring program, the setting of the trigger values and management response actions to manage effects on water quality and, including propagation of sediment plumes, and as a consequence reduce the risk of unforeseen effects on the marine ecosystems.

	water quality, including methods to manage the propagation of sediment; and c) Methods to manage effects on marine ecology; and d) Monitoring requirements; and e) The matters set out in Rule 10.35. Notification Pursuant to section 95A of the Resource Management Act, an application for resource consent under this rule will be publicly notified.	
Rule 10.12 Restricted Discretionary Activities – Disturbance associated with dredging within the Operational Area of Lyttelton Port and Main Navigational Channel	Except as provided for by Rules 10.9 and 10.11, the disturbance from dredging associated with the deepening of the foreshore or seabed within the Operational Area of Lyttelton Port shown on Planning Map 10.1, including dredging to create or deepen a ship turning basin adjacent to the Te Awaparahi Bay and Cashin Quay reclamations, or to deepen and widen the Main Navigational Channels shown on Planning Map 10.3, is a restricted discretionary activity. The exercise of discretion is restricted to the following matters: a) The effects of the disturbance on harbour hydrodynamics; and b) The effects of the disturbance on sediment transport in Lyttelton Harbour; and c) The preparation and content of a Construction Environmental Management Plan; and d) Dredging methods; and e) The effects of the disturbance on marine ecology; and f) Effects on cultural values, particularly mahinga kai; and g) The potential benefits of the activity to the applicant or community; and h) Monitoring requirements; and i) The matters set out in Rule 10.35.	Dredging to deepen and widen the ship-turning basin, the approach into the Inner Harbour and to widen the main channel is classified as restricted discretionary activity. In terms of clause (a), the effects of the disturbance (deepening) on harbour hydrodynamics is described in the report prepared by Mulgor Consulting Ltd in **Appendix 14**. In terms of clause (b), the effects of the disturbance in terms of the generation of plumes during dredging is described in the report by Met Ocean Solutions Ltd (**Appendix 9**) and is also assessed in the Cawthron Report (**Appendix 15A**) In terms of clause (c), a DMP, MMMP, BMP and an EMMP are to be prepared. In terms of clause (d), the dredging methods are described in chapter 2 and will be further detailed in the DMP. In terms of Clause (e) the effects on marine ecology are evaluated in Chapter 6 and detailed in the Cawthron institute and Boffa Miskell reports contained in **Appendices 15A, 15B, 16 and 17**. In terms of clause (f), the effects on cultural values are described in the CIA attached in **Appendix 3** and the effects on key mahinga kai species as well as on mussel farms is described in the Tonkin Taylor report in **Appendix 6**.

		In terms of clause (g), the monitoring programs are recommended in a range of supporting reports and is consolidated and described in **Chapter 7**.
Rule 10.17 Controlled Activities – Deposition of seabed material at the Spoil Dumping Grounds generated from construction activities and dredging	The deposition of seabed material in, on or under the foreshore or seabed at the Spoil Dumping Grounds shown on Planning Map 10.5 is a controlled activity, provided the following conditions are met: ………… c) The material has been removed from the foreshore or seabed during dredging of a berth pocket which is either permitted under Rule 10.9 or for which a resource consent is obtained under Rule 10.11. Control is reserved over the following matters: a) The preparation of and content of a Construction Environmental Management Plan that deals specifically with dredging operations and the deposition of sediment; and b) The establishment of a monitoring programme in the Spoil Dumping Ground and surrounding area to monitor any adverse effects of the dumping of dredge spoil on the receiving environment; and c) Methods to mitigate any adverse effects on aquatic and benthic ecology; and d) The effects on cultural values, particularly mahinga kai; and e) The volume of spoil to be deposited; and f) For seabed material to be dredged from the Inner Harbour shown on Planning Map 10.8; i) Preparation of an Inner Harbour Sediment Analysis Plan; and ii) Pre-characterisation surveys; and iii) Preparation of Sediment Analysis Reports; and iv) Monitoring of the relevant disposal areas; and g) The establishment of a monitoring programme at the Spoil Dumping Ground; and h) The matters set out in Rule 10.35. Notification Pursuant to section 95A of the Resource Management Act, an application for resource consent under this rule that relates	For completeness this rule has been included but is not relevant to this application because the dredging spoil from the berths is to be disposed of at the large offshore channel deepening ground.

	to the Te Awaparahi Bay Reclamation located in Area A on Planning Map 10.0 will be publicly notified.	
Rule 10.18 Restricted Discretionary Activities – Deposition of seabed material generated from maintenance dredging at the Spoil Dumping Ground	The deposition of seabed material in, on or under the foreshore or seabed, at the Spoil Dumping Grounds shown on Planning Map 10.5, which is removed from the foreshore or seabed during maintenance dredging of the Main Navigational Channels or within the Operational Area of Lyttelton Port, is a restricted discretionary activity. The exercise of discretion is restricted to the following matters: a) The preparation of and content of a Construction Environmental Management Plan that deals specifically with dredging operations and the deposition of sediment; and b) The establishment of a monitoring programme at the Spoil Dumping Grounds and surrounding area to monitor any adverse effects of the dumping of dredge spoil on the receiving environment; and c) Methods to mitigate any adverse effects on aquatic and benthic ecology; and d) The volume of spoil to be deposited; and e) The effects on cultural values, particularly mahinga kai; and f) For seabed material that has been dredged from the Inner Harbour, including from areas of known or potential contamination shown on Planning Map 10.8, the following is required: i) The preparation of a Sediment Management Plan which sets out the practices and procedures to manage Dredge Spoil from this location; and ii) An assessment of whether any contaminated sediment is suitable for unconfined open sea disposal, and if so	The proposal involves using a part of the existing spoil grounds (100ha Godley Head area) and only as a backup to the offshore ground for temporary periods as needed. Clauses (a), (b), (c), (d) have been discussed under Rule 10.12. The volume of material is unknown but it will be minor compared to the volumes currently disposal of at Godley Head.

	what type of conditions, including monitoring conditions, are needed for unconfined open sea disposal; and g) The potential benefits of the activity to the applicant and community; and h) The matters set out in Rule 10.35.	
Rule 10.19 Discretionary Activities – Deposition of seabed material	The deposition of seabed material in, on, under or over the foreshore or seabed, at the Spoil Dumping Grounds shown on Planning Map 10.5, that is removed from the foreshore or seabed within the Operational Area of Lyttelton Port shown on Planning Map 10.1, or the Main Navigational Channels shown on Planning Map 10.3 that is not provided for or does not comply with Rules 10.14, 10.15, 10.16, 10.17 or 10.18 is a discretionary activity.	For completeness this rule has been included but is not relevant to this application.
Rule 10.29 Permitted Activities – Discharge of sediment during the erection, placement, reconstruction, alteration, extension, removal or demolition of structures or maintenance dredging within the Operational Area of Lyttelton Port	The discharge into water, or onto or into land in the Coastal Marine Area of sediment already present in, on or under the foreshore or seabed is a permitted activity, provided the following conditions are met: …….. b) The discharge is the result of disturbance that is directly associated with Dredging of the Main Navigational Channel or within the Operational Area of Lyttelton Port; or …….	The discharge is the result of disturbance that is directly associated with Dredging of the Main Navigational Channel or within the Operational Area is a permitted activity. It is interpreted that this includes all aspects of dredging including the discharge of sediment during overflow mode for example. However for avoidance for doubt this discharge is also being applied for.
Rule 10.33 Discretionary Activities	The discharge at the Spoil Dumping Grounds shown on Planning Map 10.5 of dredge spoil derived from dredging the Main Navigational Channels shown on Planning Map 10.3 or dredging within the Operational Area of Lyttelton Port shown on Planning Map 10.1 is a discretionary activity.	Consistent with the Marine Pollution Regulations which require the discharge (dumping) of dredge spoil to be listed a full discretionary activity.

Chapter 7

RCEP Rule	Description	Assessment
Rule 7.2 Discretionary Activities	Except as provided for by Rules 7.1, 7.3 7.4, 7.5 or 7.6, the discharge of any water or any contaminant, into water, or onto or into land, in the Coastal Marine Area, is a Discretionary Activity and shall comply with the standards and terms set out below. This rule shall not apply to the discharges of contaminants from ships or offshore installations that are subject to section 15B of the Act and associated regulations. Standards and Terms for Rule 7.2 (1) Except as specified in (2) below, the activity shall comply with the following standards and terms: (a) The relevant water quality standards contained in the water quality classes set out in Schedule 4 shall be observed. The standards apply after reasonable mixing of any discharge of contaminants or water to water and disregard the effect of any natural perturbations that may affect the receiving water. (b) The discharge, (either by itself or in combination with the same, similar, or other contaminants or water), and disregarding the effect of any natural perturbations that may affect the receiving water, shall not, after reasonable mixing of the contaminant with the receiving water, give rise to any of the following effects in the receiving waters: (i) the production of conspicuous oil or grease films, scums or foams, or floatable or suspended materials; or (ii) within areas classified as Coastal AE water or Coastal CR water: a change in the colour of the receiving water by greater than ten points, as measured using the Munsell Scale, or a reduction in the visual clarity of	This rule applies to the discharge of dredge spoil at the offshore disposal grounds either associated with channel deepening or for maintenance dredging. The areas are shown as 'natural state' in the RCEP and therefore the Schedule 4 water quality standards do not apply. A series of turbidity triggers are being proposed that in effect establish a reasonable mixing zone although the exceedance of the trigger does not mean that there will be a significant adverse effect on aquatic life or there will be any plumes that are 'conspicuous' because the largest plumes occur near the seabed. The point is to establish tiers of triggers to avoid such effects from developing. See the discussion earlier in this chapter. The rule does not classify the status of a discharge that cannot meet those standards set out in Clause (b) (i) and (ii). In other words a proposed discharge would be classified as a full discretionary activity regardless. The standards and terms expressly exclude reference of these standards to the discharge of dredge material at the existing spoil grounds in Lyttelton Harbour.

	the receiving water by greater than 50 %; within any other area: a change in the colour of the receiving water by greater than five points, as measured using the Munsell Scale, or a reduction in the visual clarity of the receiving water by greater than 20 %; or (iii) any emission of objectionable odour. (2) The discharge of dredged material by or on behalf of the Lyttelton Port Company within the spoil dumping grounds in Lyttelton Harbour/Whakaraupo shown in Map 5.5 is a Discretionary Activity for which no standards and terms are set by this Rule. **Effect of Rule 7.2 on Existing Resource Consents** This rule shall affect, under Section 130 of the Act, the exercise of existing coastal permits for discharges of water or contaminants. The holders of resource consents shall comply with the terms of this rule from the date at which the new conditions on their resource consent commence in accordance with Section 116 of the Act. This compliance may be required in stages or over specified periods. When this rule becomes operative, Environment Canterbury may serve notice, under Section 128 of the Act, on the holders of all such resource consents of its intention to review the conditions of their resource consent, where, in Environment Canterbury's opinion, it is appropriate to do so in order to enable the standards set by this Rule to be met.	

Chapter 8

RCEP Rule	Description	Assessment
Rule 8.13 Discretionary Activities	Except as provided for by Rule 8.15, the deposition of more than 50,000 cubic metres of any material on the foreshore or seabed by any person at any site in any twelve month period, is a Discretionary Activity.	The rule applies to the deposition of dredge spoil at the offshore disposal grounds associated with channel deepening and with maintenance dredging.

	Financial Contribution A financial contribution, in the form of money, land, or any combination thereof, may be required as a condition of any resource consent granted in accordance with Rule 8.14 (sic) a financial contribution shall not be required for disturbance within the Operational Areas of the Ports of Lyttelton and Timaru. The financial contribution shall be made for the purposes of: (a) restoring, at the same location or in close proximity, any natural or physical resources which suffer damage or loss as a result of the activity; or (b) ensuring that there are positive effects on the environment, at the same or any other location in the region, to offset any adverse effects of the activity on natural or physical resources. The financial contribution shall be determined as follows: (a) Where the environment can be restored, the financial contribution shall be limited to: (i) the costs of measures of restoration actually undertaken or to be undertaken; or (ii) the costs of restoring the environment to a pre-activity state. (b) Where the environment cannot be restored, the financial contribution shall be limited to an amount calculated by the consent authority as if the environment could be restored to a pre-activity state. (c) Where a financial contribution is received for damage to the environment that cannot be restored, the contribution shall, if possible, be used for the purposes of environmental enhancement or maintenance in the Coastal Marine Area, or in parts of the coastal environment, that are adjacent to where the environmental damage has occurred. If this is not possible the financial contribution shall be applied in other parts of the CMA in the Canterbury Region. (d) Notwithstanding paragraphs (a), (b) and (c) above, a financial contribution shall be no greater than: the lesser of: (i) 100% of the cost of the deposition of material on the foreshore or seabed for which the resource consent is granted, or	A financial contribution may be taken in the form of money, land or combination thereof. The benthic community at the depositions grounds will be affected primarily by smothering as discussed in **Chapter 6** and in the Cawthron Institute report in **Appendix 15A**. The offshore channel deepening disposal area is expected to recover completely overtime. The maintenance dredge spoil disposal grounds will recover but because the area would receive periodic, usually annual, inundations the benthic communities will shift to that which is of an intermediate successional stage. The actual or potential effects on the benthic communities are not considered significant and no consequential effects on marine mammals, marine avifauna or the fisheries are predicted and so financial compensation is necessary.

	(ii) the estimated costs of restoring, at the same location or in close proximity, any natural or physical resources which suffer damage or loss as a result of the activity.	

New Zealand Coastal Policy Statement, 2010

Objectives and Policies

Objective	**Objective Detail**	**Assessment**
Objective 1	To safeguard the integrity, form, functioning and resilience of the coastal environment and sustain its ecosystems, including marine and intertidal areas, estuaries, dunes and land, by: • maintaining or enhancing natural biological and physical processes in the coastal environment and recognising their dynamic, complex and interdependent nature; • protecting representative or significant natural ecosystems and sites of biological importance and maintaining the diversity of New Zealand's indigenous coastal flora and fauna; and • maintaining coastal water quality, and enhancing it where it has deteriorated from what would otherwise be its natural condition, with significant adverse effects on ecology and habitat, because of discharges associated with human activity.	LPC commissioned a large number of experts to assess the actual or potential effects of the proposal. The reports contained in **Appendices 7 – 14** address the physical processes associated with the project and the receiving environment and the reports contained in **Appendix 6** and **Appendices 15-17** address the biology associated with the project and the receiving environment.
Objective 2	To preserve the natural character of the coastal environment and protect natural features and landscape values through: • recognising the characteristics and qualities that contribute to natural character, natural features and landscape values and their location and distribution; • identifying those areas where various forms of subdivision, use, and development would be inappropriate and protecting them from such activities; and • encouraging restoration of the coastal environment.	The report in **Appendix 4** assesses the natural character, landscape and visual amenity within the project area and concludes the proposed activities are not inappropriate.
Objective 3	To take account of the principles of the Treaty of Waitangi, recognise the role of tangata whenua as kaitiaki and provide for tangata whenua involvement in	In terms of bullet point one and bullet point four, the CIA in **Annexure 3** sets out the relationship between Te Rūnanga o Ngāti Wheke (Rāpaki) and Te Rūnanga o Koukōurārata

	management of the coastal environment by: • recognising the ongoing and enduring relationship of tangata whenua over their lands, rohe and resources; • promoting meaningful relationships and interactions between tangata whenua and persons exercising functions and powers under the Act; • incorporating mātauranga Māori into sustainable management practices; and • recognising and protecting characteristics of the coastal environment that are of special value to tangata whenua.	and sets out the relevant provisions of the Mahaanui Iwi Management Plan. The CIA identifies the consultation undertaken with the Manawhenua Advisory Group and the establishment of a Technical Advisory Group which included experts representing Manawhenua to examine the supporting documents and assist in the development of the proposed monitoring and management response processes.
Objective 4	To maintain and enhance the public open space qualities and recreation opportunities of the coastal environment by: • recognising that the coastal marine area is an extensive area of public space for the public to use and enjoy; • maintaining and enhancing public walking access to and along the coastal marine area without charge, and where there are exceptional reasons that mean this is not practicable providing alternative linking access close to the coastal marine area; and • recognising the potential for coastal processes, including those likely to be affected by climate change, to restrict access to the coastal environment and the need to ensure that public access is maintained even when the coastal marine area advances inland.	LPC commissioned an assessment of effects from the project on recreational values. The report prepared by Rob Greenaway & Associates can be found in **Appendix 5**. It concludes that the net effect on recreation and tourism of the dredging proposal is likely to be similar to the status quo.
Objective 6	To enable people and communities to provide for their social, economic, and cultural wellbeing and their health and safety, through subdivision, use, and development, recognising that: • the protection of the values of the coastal environment does not preclude use and development in appropriate places and forms, and within appropriate limits; • some uses and developments which depend upon the use of natural and physical resources in the coastal environment are important to the social, economic and cultural wellbeing of people and	Lyttelton Port functionally depends on the coastal environment and it is a nationally significant infrastructure that is important to the social and economic wellbeing of the Canterbury Region as discussed in the assessment of economic effects prepared by Brown Copeland & Co Ltd and attached in **Appendix 2**.

	communities; • functionally some uses and developments can only be located on the coast or in the coastal marine area; • the coastal environment contains renewable energy resources of significant value; • the protection of habitats of living marine resources contributes to the social, economic and cultural wellbeing of people and communities; • the potential to protect, use, and develop natural and physical resources in the coastal marine area should not be compromised by activities on land; • the proportion of the coastal marine area under any formal protection is small and therefore management under the Act is an important means by which the natural resources of the coastal marine area can be protected; and • historic heritage in the coastal environment is extensive but not fully known, and vulnerable to loss or damage from inappropriate subdivision, use, and development.	
Policy Title	**Policy Detail**	**Comment**
Policy 1 Extent and characteristics of the coastal environment	(1) Recognise that the extent and characteristics of the coastal environment vary from region to region and locality to locality; and the issues that arise may have different effects in different localities. (2) Recognise that the coastal environment includes: (a) the coastal marine area; (b) islands within the coastal marine area; (c) areas where coastal processes, influences or qualities are significant, including coastal lakes, lagoons, tidal estuaries, saltmarshes, coastal wetlands, and the margins of these; (d) areas at risk from coastal hazards; (e) coastal vegetation and the habitat of indigenous coastal species including migratory birds; (f) elements and features that contribute to the natural character, landscape, visual qualities or amenity values; (g) items of cultural and historic heritage in the	LPC commissioned experts to assess the receiving environment that is potentially affected by the project. All matters set out in Clause 2 have been assessed.

	coastal marine area or on the coast;, (h) inter-related coastal marine and terrestrial systems, including the intertidal zone; and (i) physical resources and built facilities, including infrastructure, that have modified the coastal environment.	
Policy 2 The Treaty of Waitangi, tangata whenua and Māori heritage	In taking account of the principles of the Treaty of Waitangi (Te Tiriti o Waitangi), and kaitiakitanga, in relation to the coastal environment: (a) recognise that tangata whenua have traditional and continuing cultural relationships with areas of the coastal environment, including places where they have lived and fished for generations; (b) involve iwi authorities or hapū on behalf of tangata whenua in the preparation of regional policy statements, and plans, by undertaking effective consultation with tangata whenua; with such consultation to be early, meaningful, and as far as b)practicable in accordance with tikanga Māori; (c) with the consent of tangata whenua and as far as practicable in accordance with tikanga Māori, incorporate mātauranga Māori in regional policy statements, in plans, and in the consideration of applications for resource consents, notices of requirement for designation and private plan changes; (d) provide opportunities in appropriate circumstances for Māori involvement in decision making, for example when a consent application or notice of requirement is dealing with cultural localities or issues of cultural significance, and Māori experts, including pūkenga, may have knowledge not otherwise available; (e) take into account any relevant iwi resource management plan and any other relevant planning document recognised by the appropriate iwi authority	While the policy is focused on policy and plan preparation, in terms of clause (a) the CIA attached in **Appendix 3** sets out the relationship between Te Rūnanga o Ngāti Wheke (Rāpaki) and Te Rūnanga o Koukōurārata and sets out the relevant provisions of the Mahaanui Iwi Management Plan. In terms of clause (b), the CIA identifies the consultation undertaken with the Manawhenua Advisory Group and the establishment of a Technical Advisory Group that included experts representing Manawhenua described earlier.

	or hapū and lodged with the council, to the extent that its content has a bearing on resource management issues in the region or district; and (i) where appropriate incorporate references to, or material from, iwi resource management plans in regional policy statements and in plans; and (ii) consider providing practical assistance to iwi or hapū who have indicated a wish to develop iwi resource management plans; (f) provide for opportunities for tangata whenua to exercise kaitiakitanga over waters, forests, lands, and fisheries in the coastal environment through such measures as: (i) bringing cultural understanding to monitoring of natural resources; (ii) providing appropriate methods for the management, maintenance and protection of the taonga of tangata whenua; (iii) having regard to regulations, rules or bylaws relating to ensuring sustainability of fisheries resources such as taiāpure, mahinga mātaitai or other non commercial Māori customary fishing; and (g) in consultation and collaboration with tangata whenua, working as far as practicable in accordance with tikanga Māori, and recognising that tangata whenua have the right to choose not to identify places or values of historic, cultural or spiritual significance or special value: (i) recognise the importance of Māori cultural and heritage values through such methods as historic heritage, landscape and cultural impact assessments; and (ii) provide for the identification, assessment, protection and management of areas or sites of significance or special value to Māori, including by historic analysis and archaeological survey and the development of methods such as alert layers and predictive methodologies for identifying areas of high potential for undiscovered Māori heritage, for example coastal pā or fishing villages.	

Policy 3 Precautionary approach	(1) Adopt a precautionary approach towards proposed activities whose effects on the coastal environment are uncertain, unknown, or little understood, but potentially significantly adverse. (2) In particular, adopt a precautionary approach to use and management of coastal resources potentially vulnerable to effects from climate change, so that: (a) avoidable social and economic loss and harm to communities does not occur; (b) natural adjustments for coastal processes, natural defences, ecosystems, habitat and species are allowed to occur; and (c) the natural character, public access, amenity and other values of the coastal environment meet the needs of future generations.	The understanding of the hydrodynamic processes in the project area has improved significantly in the last 10-15 years with the advent of sophisticated measurement equipment and also the ability to carry out hydrodynamic and sediment transport modelling. As consequence there is a significant improvement in the understanding of the receiving environment and the effects of dredging and spoil disposal would have on the receiving environment. Although the dredging and disposal activities are not expected to cause any significant adverse effects, a comprehensive monitoring programme and associated management response actions are proposed.
Policy 6 Activities in the coastal environment	(1) In relation to the coastal environment: (a) recognise that the provision of infrastructure, the supply and transport of energy including the generation and transmission of electricity, and the extraction of minerals are activities important to the social, economic and cultural well-being of people and communities; (b) consider the rate at which built development and the associated public infrastructure should be enabled to provide for the reasonably foreseeable needs of population growth without compromising the other values of the coastal environment; (c) encourage the consolidation of existing coastal settlements and urban areas where this will contribute to the avoidance or mitigation of sprawling or sporadic patterns of settlement and urban growth; (d) recognise tangata whenua needs for papakāinga, marae and associated developments and make appropriate provision for them;; (e) consider where and how built development on land should be controlled so that it does not compromise activities of national or regional	Clause (1)(a) recognises that infrastructure (which includes the Lyttelton Port by definition) is important to the social, economic and cultural well-being of people. In terms of Clause the rational for the project (Chapter 3) is highly relevant is the Assessment of Economic Effects prepared by Brown, Copeland & Co Ltd, 2016 and contained in **Appendix 2**. In terms of Clause 1(e), the Port has a functional need to locate and operate in the coastal marine area. Larger vessels can only access the Port if the channel is deepened and design depths are subsequently maintained. In terms of Clause (2)(b) the issue of open space and recreation is addressed in the report contained in **Appendix 5** described earlier. In terms of Clause 2(c), Port has a functional need to locate and operate in the coastal marine area.

	importance that have a functional need to locate and operate in the coastal marine area; (f) consider where development that maintains the character of the existing built environment should be encouraged, and where development resulting in a change in character would be acceptable; (g) take into account the potential of renewable resources in the coastal environment, such as energy from wind, waves, currents and tides, to meet the reasonably foreseeable needs of future generations; (h) consider how adverse visual impacts of development can be avoided in areas sensitive to such effects, such as headlands and prominent ridgelines, and as far as practicable and reasonable apply controls or conditions to avoid those effects; (i) set back development from the coastal marine area and other water bodies, where practicable and reasonable, to protect the natural character, open space, public access and amenity values of the coastal environment; and (j) where appropriate, buffer areas and sites of significant indigenous biological diversity, or historic heritage value. (2) Additionally, in relation to the coastal marine area: (a) recognise potential contributions to the social, economic and cultural wellbeing of people and communities from use and development of the coastal marine area, including the potential for renewable marine energy to contribute to meeting the energy needs of future generations: (b) recognise the need to maintain and enhance the public open space and recreation qualities and values of the coastal marine area; (c) recognise that there are activities that have a functional need to be located in the coastal marine area, and provide for those activities in appropriate places; (d) recognise that activities that do not have a functional need for location in the coastal marine	

	area generally should not be located there; and (e) promote the efficient use of occupied space, including by: (i) requiring that structures be made available for public or multiple use wherever reasonable and practicable; (ii) requiring the removal of any abandoned or redundant structure that has no heritage, amenity or reuse value; and (iii) considering whether consent conditions should be applied to ensure that space occupied for an activity is used for that purpose effectively and without unreasonable delay.	
Policy 9 Ports	Recognise that a sustainable national transport system requires an efficient national network of safe ports, servicing national and international shipping, with efficient connections with other transport modes, including by: (a) ensuring that development in the coastal environment does not adversely affect the efficient and safe operation of these ports, or their connections with other transport modes; and (b) considering where, how and when to provide in regional policy statements and in plans for the efficient and safe operation of these ports, the development of their capacity for shipping, and their connections with other transport modes.	**Chapter 3** of this application document sets out the rational for the channel deepening project. It explains the trend towards larger vessels globally and Lyttelton Port is identified by the New Zealand Shippers' Council as is the logically the first South Island port to become bigger ship capable. This is further discussed in the assessment of economic effects prepared by Brown, Copeland & Co Ltd, 2016 attached in **Appendix 2**. The Canterbury Regional Policy Statement and the Regional Coastal Environment Plan for the Canterbury Region provide further policy direction for the port's development.
Policy 11 Indigenous biological diversity (biodiversity)	To protect indigenous biological diversity in the coastal environment: (a) avoid adverse effects of activities on: (i) indigenous taxa that are listed as threatened or at risk in the New Zealand Threat Classification System lists; (ii) taxa that are listed by the International Union for Conservation of Nature and Natural Resources as threatened; (iii) indigenous ecosystems and vegetation types that are threatened in the coastal environment, or are naturally rare; (iv) habitats of indigenous species where the species	Clause (a) states that adverse effects of activities on threatened or naturally rare indigenous taxa are to be avoided. Hector's dolphin and several species of marine avifauna are listed as threatened and the project area is part of their habitat. The actual or potential effects caused by the dredging and disposal activities have been identified as negligible or low (refer to **Appendices 16** and **17**). Measures to reduce the risk of injury to vessel strike are to be addressed in a DMP and a MMMP. With respect to Clause (b) benthic, sub-tidal and intertidal communities, and the fisheries, has been characterized and the actual or potential effects assessed (Refer to **Appendix**

	are at the limit of their natural range, or are naturally rare; (v) areas containing nationally significant examples of indigenous community types; and (vi) areas set aside for full or partial protection of indigenous biological diversity under other legislation; and (b) avoid significant adverse effects and avoid, remedy or mitigate other adverse effects of activities on: (i) areas of predominantly indigenous vegetation in the coastal environment; (ii) habitats in the coastal environment that are important during the vulnerable life stages of indigenous species; (iii) indigenous ecosystems and habitats that are only found in the coastal environment and are particularly vulnerable to modification, including estuaries, lagoons, coastal wetlands, dunelands, intertidal zones, rocky reef systems, eelgrass and saltmarsh; (iv) habitats of indigenous species in the coastal environment that are important for recreational, commercial, traditional or cultural purposes; (v) habitats, including areas and routes, important to migratory species; and (vi) ecological corridors, and areas important for linking or maintaining biological values identified under this policy.	**15A**). While no significant adverse effects are expected a monitoring and management response programme is proposed. The deposition of maintenance dredge spoil would mean that the benthic communities in these locations would change to one which is dominated by rapidly colonising taxa, representing an intermediate successional community. However, the shift in species composition is likely to subtle based on previous monitoring work and in the context of the wider Harbour and Pegasus the change is not considered a significant effect on biodiversity.
Policy 12 Harmful aquatic organisms	(1)Provide in regional policy statements and in plans, as far as practicable, for the control of activities in or near the coastal marine area that could have adverse effects on the coastal environment by causing harmful aquatic organisms to be released or otherwise spread, and include conditions in resource consents, where relevant, to assist with managing the risk of such effects occurring. (2) Recognise that activities relevant to (1) include: (a) the introduction of structures likely to be contaminated with harmful aquatic organisms; (b) the discharge or disposal of organic material from dredging, or from vessels and structures, whether during maintenance, cleaning or otherwise; and	The report from the Cawthron Institute also addressed the issue of marine biosecurity (Refer **Appendix 15A**). The most significant risk is associated with the introduction of unwanted organisms arriving with the dredge vessel for channel deepening. A BMP is recommended and contents of the Plan are attached in the proposed conditions.

	whether in the coastal marine area or on land; (c) the provision and ongoing maintenance of moorings, marina berths, jetties and wharves; and (d) the establishment and relocation of equipment and stock required for or associated with aquaculture.	
Policy 13 Preservation of natural character	(1) To preserve the natural character of the coastal environment and to protect it from inappropriate subdivision, use, and development: (a) avoid adverse effects of activities on natural character in areas of the coastal environment with outstanding natural character; and (b) avoid significant adverse effects and avoid, remedy or mitigate other adverse effects of activities on natural character in all other areas of the coastal environment; including by: (c) assessing the natural character of the coastal environment of the region or district, by mapping or otherwise identifying at least areas of high natural character; and (d) ensuring that regional policy statements, and plans, identify areas where preserving natural character requires objectives, policies and rules, and include those provisions. (2) Recognise that natural character is not the same as natural features and landscapes or amenity values and may include matters such as: (a) natural elements, processes and patterns; (b) biophysical, ecological, geological and geomorphological aspects; (c) natural landforms such as headlands, peninsulas, cliffs, dunes, wetlands, reefs, freshwater springs and surf breaks; (d) the natural movement of water and sediment; (e) the natural darkness of the night sky; (f) places or areas that are wild or scenic; (g) a range of natural character from pristine to modified; and (h) experiential attributes, including the sounds and smell of the sea; and their context or setting.	The policy seeks to avoid adverse effects of activities on natural character in areas of the coastal environment with outstanding natural character. The report contained in **Appendix 4** as described earlier assesses both the abiotic, biotic and experiential attributes of natural characters and concludes the effects on natural character from the dredging and disposal activities would be low and any potential for significant adverse effects would be avoided.

Policy 21 Enhancement of water quality	Where the quality of water in the coastal environment has deteriorated so that it is having a significant adverse effect on ecosystems, natural habitats, or water based recreational activities, or is restricting existing uses, such as aquaculture, shellfish gathering, and cultural activities, give priority to improving that quality by: (a) identifying such areas of coastal water and water bodies and including them in plans; (b) including provisions in plans to address improving water quality in the areas identified above; (c) where practicable, restoring water quality to at least a state that can support such activities and ecosystems and natural habitats; (d) requiring that stock are excluded from the coastal marine area, adjoining intertidal areas and other water bodies and riparian margins in the coastal environment, within a prescribed time frame; and (e) engaging with tangata whenua to identify areas of coastal waters where they have particular interest, for example in cultural sites, wāhi tapu, other taonga, and values such as mauri, and remedying, or, where remediation is not practicable, mitigating adverse effects on these areas and values.	The policy is concerned with improvement of water quality that has deteriorated and is having a significant adverse effect on various activities including cultural activities. The project area within Lyttelton Harbour/Whakaraupō involves three different water classifications. These are shown on in the Regional Coastal Environment Plan (Map 1.5). The outer Harbour is classified 'Shell Fish Gathering' (SG) while the rest apart the Operational Area of Lyttelton Port is classified 'Contact Recreation' (CR). The Port Operational Area is classified 'Aquatic Ecosystem' (AE). Port Levy/Koukourārata is classified 'Shell Fish Gathering' (SG). The proposal to shift the majority of maintenance spoil disposal outside of the Lyttelton Harbour/Whakaraupō should result in reduced turbidity levels and re-circulation of sediment although as noted in **Chapter 6** it appears the disposal activities at the existing spoil ground is having little recognisable effects on the inter-tidal communities.
Policy 22 Sedimentation	(1) Assess and monitor sedimentation levels and impacts on the coastal environment. (2) Require that subdivision, use, or development will not result in a significant increase in sedimentation in the coastal marine area, or other coastal water. (3) Control the impacts of vegetation removal on sedimentation including the impacts of harvesting plantation forestry. (4) Reduce sediment loadings in runoff and in stormwater systems through controls on land use activities.	The sediment transport models are not predicting turbidity plumes to reach the shoreline or inlets, and the re-deposition of sediment after disturbance is predicted to be insignificant in the context of the natural erosional and depositional processes that occur in the receiving environment. The monitoring program includes the monitoring of the bathymetry and the use of altimeters to examine sediment flux to confirm predictions.
Policy 23 Discharge of	(1)In managing discharges to water in the coastal environment, have particular regard to:	In terms of Clause (a), the Cawthron Institute Report contained in **Appendix 15A** describes the sensitivity of the

contaminants	(a) the sensitivity of the receiving environment; (b) the nature of the contaminants to be discharged, the particular concentration of contaminants needed to achieve the required water quality in the receiving environment, and the risks if that concentration of contaminants is exceeded; and (c) the capacity of the receiving environment to assimilate the contaminants; and: (d) avoid significant adverse effects on ecosystems and habitats after reasonable mixing; (e) use the smallest mixing zone necessary to achieve the required water quality in the receiving environment; and (f) minimise adverse effects on the life-supporting capacity of water within a mixing zone. (2) In managing discharge of human sewage, do not allow: (a) discharge of human sewage directly to water in the coastal environment without treatment; and (b) the discharge of treated human sewage to water in the coastal environment, unless: (i) there has been adequate consideration of alternative methods, sites and routes for undertaking the discharge; and (ii) informed by an understanding of tangata whenua values and the effects on them. (3) Objectives, policies and rules in plans which provide for the discharge of treated human sewage into waters of the coastal environment must have been subject to early and meaningful consultation with tangata whenua. (4) In managing discharges of stormwater take steps to avoid adverse effects of stormwater discharge to water in the coastal environment, on a catchment by catchment basis, by: (a) avoiding where practicable and otherwise remedying cross contamination of sewage and stormwater systems; (b) reducing contaminant and sediment loadings in stormwater at source, through contaminant treatment and by controls on land use activities; (c) promoting integrated management of catchments	receiving environment. That report notes: • There is a uniformity between the sediments in the Harbour that are to be dredged and the sediments located in the proposed offshore deposition grounds; • The benthic and aquatic communities are adapted to turbid conditions; • The relevant intertidal zones are characterised as high energy environments with little opportunity for sediment to settle; • To date there has been no evidence of smothering from sediment in the intertidal zones located in the existing maintenance spoil grounds on the north-side of the Lyttelton Harbour. In terms of clause (b), the dredge spoil is defined as a contaminant because when it is released into the water column from the dredge hopper it will change the physical, chemical and biological condition of the water column, albeit for temporary period until the plume becomes indistinguishable from the background turbidity. There is a contamination gradient in the surficial sediments sampled from the channel although the levels were low and well below guidelines. The underlying sediment is not expected to have any contaminants. Sediment that is known to have elevated levels of metals in parts of the inner Harbour not applicable and is instead addressed under CRC135318. In terms of clause (c), the size of the offshore deposition grounds have been calculated so that it has capacity to receive the dredge spoil. In terms of establishing a reasonable mixing zone, this matter was discussed earlier under s107 of Act.

	and stormwater networks; and (d) promoting design options that reduce flows to stormwater reticulation systems at source. (5) In managing discharges from ports and other marine facilities: (a) require operators of ports and other marine facilities to take all practicable steps to avoid contamination of coastal waters, substrate, ecosystems and habitats that is more than minor; (b) require that the disturbance or relocation of contaminated seabed material, other than by the movement of vessels, and the dumping or storage of dredged material does not result in significant adverse effects on water quality or the seabed, substrate, ecosystems or habitats; (c) require operators of ports, marinas and other relevant marine facilities to provide for the collection of sewage and waste from vessels, and for residues from vessel maintenance to be safely contained and disposed of; and (d) consider the need for facilities for the collection of sewage and other wastes for recreational and commercial boating.	

Canterbury Regional Policy Statement

The RPS's glossary (page 198) defines regionally significant infrastructure. It does not list the Port of Lyttelton specifically but the Port is captured by Clause 15 which refers to "Infrastructure defined as 'strategic infrastructure' in this regional policy statement".

The definition of "Strategic Infrastructure" (page 204) means: "those necessary facilities, services and installations which are of greater than local importance, and can include infrastructure that is nationally significant."
The following examples of strategic infrastructure include the "Port of Lyttelton."

The Port also falls within the definitions of "Strategic Transport Network" which means: "transport networks and operations of national or regional significance. These include the strategic road network including State Highway and major arterial roads as defined in district plans and the rail network, along with the region's core public passenger transport operations and significant regional transport hubs such as Christchurch International Airport and the Port of Lyttelton."

The Port also falls within the definitions of "essential infrastructure" and "critical infrastructure" but the only direct policy references to essential and critical infrastructure are found in Chapter 10 (Beds of Rivers and Lakes and their Riparian Zones) and Chapter 11 (Natural Hazards) respectively.

Chapter 8: Coastal Environment

Objective	Objective Detail	Assessment
Objective 8.2.3 – Regionally significant infrastructure and commercial maritime facilities	Subdivision, use or development in the coastal environment does not adversely affect the efficient development and use of regionally significant infrastructure and other commercial maritime activities.	The objective recognises that the efficient development and use of regionally significant infrastructure is important for wider social and economic reasons. The explanation to the objective states that ports will need to be developed in response to future growth of population and economic activity in the region. The provision for larger ships will enable Lyttelton Port to receive vessels directly from other international ports and therefore pass these efficiencies onto exporters and importers and ultimately the wider community. Refer to the assessment of economic effects prepared by Brown, Copeland & Co Ltd, 2016 for further detail in **Appendix 2**.
Objective 8.2.4 – Preservation, protection and enhancement of the coastal environment	In relation to the coastal environment: (1) Its natural character is preserved and protected from inappropriate subdivision, use and development; and (2) Its natural, ecological, cultural, amenity, recreational and historic heritage values are restored or enhanced.	Refer to the discussion under Objective 1 of the NZCPS with respect to the preservation of natural character. In terms of clause (2) there is a requirement to restore or enhance natural, ecological, cultural, amenity, recreational, and historic heritage values. The explanation states that adverse effects of past activities have in places degraded the coastal environment and in these places enhancement to restore the coastal environment may be appropriate. No degraded areas are identified in the RPS. Refer to the previous comments made under NZCPS Policy 21 concerning the water quality classes. The assessment of the actual or potential effects has concluded that the dredging and deposition of dredge spoil would maintain those natural, ecological, amenity and recreational values held by the community. The CIA contained in **Appendix 3** discusses the cultural values and the issues and recommendations from Manawhenua in relation to the project.
Objective 8.2.6 – Protection and improvement of	Protection of coastal water quality and associated values of the coastal environment, from significant adverse effects of the point and non-point discharge of	Refer to discussion under Policy 21 of the NZCPS.

coastal water	contaminants; and enhancement of coastal water quality where it has been degraded.	
Policy Title	**Policy Detail**	**Comment**
Policy 8.3.3 – Management of activities in the coastal environment	Within the coastal marine area provide a framework for: (1) the use and occupation of coastal space; (2) the use and development of the natural and physical resources of the coastal marine area; (3) the extraction of sand, shingle, shell, or other natural materials; (4) the emission of noise; (5) activities on the water and on the foreshore and seabed. (6) protecting the values of the coastal environment while avoiding, or where this is not practicable, remedying or mitigating adverse effects within the coastal environment on: (a) the life-supporting capacity and/or mauri of coastal ecosystems and the natural processes that sustain them; (b) indigenous species, areas of significant indigenous vegetation and significant habitats of indigenous fauna; (c) natural character (including associated natural processes), outstanding natural features and outstanding natural landscapes; (d) amenity, cultural and recreational values; (e) coastal areas of cultural significance identified in consultation with Ngāi Tahu as tāngata whenua; (f) the health and safety of people; (g) historic heritage values, including historic heritage and historic cultural landscapes; (h) surf breaks of national significance; (i) the efficient and effective operation, maintenance and development of regionally significant infrastructure or other commercial maritime facilities.	This policy sets the general framework for managing activities in the coastal marine area. It provides for both the use and development of the coastal marine area providing activities seek to avoid adverse effects but where this is not practicable then to remedy or mitigate adverse effects. The nature of this project means not all avoid adverse effects can be avoided. However, it has been assessed that the adverse effects will not be significant and temporary for the channel deepening project. Maintenance dredging is likely to be carried out annually however the actual or potential effects of maintenance dredging are not considered to be significant (Refer to the reports contained in **Appendices 4, 5, 6, 7**, and **15** to**17**). Clauses (a) to (e) have been addressed in the assessment of the objectives and policies contained in the NZCPS described above. With respect to clause (f), the dredge vessels should not pose any safety risks to other users of the coastal marine area due to their size and operating speed. Clauses (g) and (h) are irrelevant and clause (i) is relevant to the extent that it is implicit that regionally significant infrastructure is expected to be able to be developed.
Policy 8.3.4 – Preservation of the natural character of the coastal	To preserve and restore the natural character of the coastal environment by: (1) protecting outstanding natural features and landscapes including seascapes from	Refer to the assessment of NZCPS Objective 2.

environment	inappropriate occupation, subdivision, use and development; (2) protecting and enhancing indigenous ecosystems and associated ecological processes; (3) promoting integrated management of activities that affect natural character in the coastal environment and the coastal marine area, in particular coastal landforms and landscapes that are significant, representative or unique to the region; (4) avoiding new development adjacent to the coastal marine area that will compromise areas of high natural character; and (5) in appropriate situations, imposing or reviewing restoration or rehabilitation conditions on resource consents and designations.	
Policy 8.3.6 – Regionally significant infrastructure	In relation to regionally significant infrastructure in the coastal environment: (1) provide for its efficient and effective development, operation, maintenance and upgrade; (2) provide for a range of associated activities that have an operational requirement to be located in that environment; (3) recognise the potential of renewable resources in the coastal environment, such as energy from wind, waves, current and tides; (4) avoid development that may result in reverse sensitivity effects that constrain the ability of the infrastructure to be developed and used (because of the imposition of time or other operational constraints); and (5) provide for the expedited recovery of the Lyttelton Port, including its repair, rebuild and reconfiguration. Such provisions should avoid, remedy or mitigate the adverse effects on that environment and take into account:	**Chapter 3** of this application sets out the rational for the project as discussed under NZCPS Policy 9. In terms of clause (1), the provision for larger ships would enable Lyttelton Port to receive vessels directly from other international ports, and therefore pass these efficiencies onto exporters and importers and ultimately the wider community. In terms of maintenance dredging, clause (a) recognises that the ports of Lyttelton and Timaru need to dredge and deposit spoil in the coastal marine area outside the port areas to remain operational. This is within the context of the port being able to provide for its efficient and effective operation while avoiding, remedying or mitigating adverse effects. In terms of Clause (a), refer to the previous comments made under Policy 10.1.4 in the body of Chapter 9.

	(a) the integrated management of Whakaraupō/ Lyttelton Harbour in the recovery and further development of the Lyttelton Port, including provision for the many ecological, cultural, recreational and amenity values and sues of that area. (b) that the ports of Lyttelton and Timaru need to dredge and deposit spoil in the coastal marine area outside the port areas to remain operational. (c) that the recovery of the Lyttelton Port includes a container terminal being established in Te Awaparahi Bay on up to 34 hectares of reclaimed land; (d) that regionally significant infrastructure may need to be further developed in response to commercial opportunities and community needs. (e) that the operators of regionally significant infrastructure need to have their own controls over access to operational areas, and that public access to such areas is not always appropriate. (f) national port noise standards. (g) the effects of coastal erosion, climate change and sea level rise.	
Policy 8.3.7 – Improve water quality in degraded areas	To improve the quality of Canterbury's coastal waters in areas where degraded water quality has significant adverse effects on natural, cultural, amenity and recreational values.	Refer to the discussion under Policy 21 of the NZCPS.

Chapter 9: Biodiversity

Objective	Objective Detail	Comment
Objective 9.2.1 – Halting the decline of Canterbury's ecosystems and indigenous biodiversity	The decline in the quality and quantity of Canterbury's ecosystems and indigenous biodiversity is halted and their life-supporting capacity and mauri safeguarded.	Refer to discussion under Policy 11 of the NZCPS.
Objective 9.2.3 – Protection of significant indigenous vegetation and habitats	In relation to the coastal environment: Areas of significant indigenous vegetation and significant habitats of indigenous fauna are identified and their values and ecosystem functions protected.	Refer to discussion under Policy 11 of the NZCPS.
Policy Title	**Policy Detail**	**Comment**
Policy 9.3.1 – Protecting significant natural areas	Significance, with respect to ecosystems and indigenous biodiversity, will be determined by assessing areas and habitats against the following matters: (a) Representativeness (b) Rarity or distinctive features (c) Diversity and pattern (d) Ecological context The assessment of each matter will be made using the criteria listed in Appendix 3. 2) Areas or habitats are considered to be significant if they meet one or more of the criteria in Appendix 3. 3) Areas identified as significant will be protected to ensure no net loss of indigenous biodiversity or indigenous biodiversity values as a result of land use activities.	The project area is considered to be significant natural area because it is part of a habitat that supports the rare and threatened Hector's dolphin and marine avifauna. Refer to discussion under Policy 11 of the NZCPS. Clause (3) only refers to a no net loss of biodiversity or indigenous biodiversity values as a result of land use activities and so is not relevant.

Regional Coastal Environment Plan (for the Canterbury Region)

The Minister for Canterbury Earthquake Recovery directed that a Lyttelton Port Recovery Plan be developed following the sequence of earthquakes that struck Canterbury in 2010 and 2011. The Port suffered extensive damage and it will take many years to complete the recovery of the Port.

The LPRP was notified in November 2015. The LRRP has amended the Regional Coastal Environment Plan (RCEP), and introduced a new Chapter 10 that has policies and rules to implement the specific recovery objective for the Lyttelton Port.

Where the plan contains objectives, policies and rules in Chapter 10 that are on the same subject matter as in other chapters, the provisions of Chapter 10 are to prevail.

In considering an application for a resource consent in accordance with the rules in this chapter, the consent authority is also obliged to have regard to relevant objectives and policies in other chapters of the plan.

Chapter 10: Lyttelton Port of Christchurch

Objective	Objective Detail	Assessment
Objective 10.1 – Recovery of Lyttelton Port	**Objective 10.1 – Recovery of Lyttelton Port** The expedited recovery of Lyttelton Port, including its repair, rebuild and reconfiguration, is provided for as a matter of priority, while recognising the relationship with and managing any adverse effects of recovery activities on the ecological, recreational, heritage, amenity and cultural values of Whakaraupō/Lyttelton Harbour.	Refer to the general discussion of this objective in the body of Chapter 9.
Policy Title	**Policy Detail**	**Assessment**
Policy 10.1.1 – Elements of recovery	An expedited recovery of the Lyttelton Port is enabled by undertaking the following activities: 1) The progressive phased movement east of port operations including: a) Establishing a container terminal on a maximum of 34 hectares of reclaimed land in Te Awaparahi Bay; and b) Shifting some general cargo from the Inner Harbour to Cashin Quay; and c) Redeveloping Dampier Bay to provide for a marina and associated activities, commercial development, as well as enhanced public access and amenity in the coastal environment, including parking and access facilities for the marina activities and commercial development. 2) The erection, placement, reconstruction, alteration, demolition and removal of structures located in the Operational Area of Lyttelton Port, including new wharves to service the container terminal and a new wharf to service cruise vessels.	Refer to the general discussion of this policy in the body of Chapter 9.

	3) Quarrying at Gollans Bay and the construction of a new haul road, and works to widen and improve the existing haul road. 4) Increasing shipping capacity, including deepening berth pockets, ship turning basins and the Main Navigational Channel to allow for larger vessels.	
Policy 10.1.2 – Role of Lyttelton Port	Recognise that Lyttelton Port is essential to the regional economy and that its continued operation is essential for the recovery of greater Christchurch.	**Chapter 3** sets out the rational for the channel deepening project. Refer to the discussion under Policy 9 of the NZCPS and Policy 8.3.6 of RPS.
Policy 10.1.4 – Lyttelton Harbour Relationships	Recognise that the recovery of Lyttelton Port, including reconfiguration, will result in some adverse effects on the environment that cannot in all circumstances be avoided or mitigated, but that the owner or operator of Lyttelton Port will undertake recovery activities while ensuring that: 1) The relationship between Lyttelton Port and the values of Whakaraupō/Lyttelton Harbour are recognised; and 2) Any adverse effects on the ecological, recreational, heritage, amenity and cultural values of Whakaraupō/Lyttelton Harbour are minimised as far as practicable; and 3) Best practice methods are used during construction; and 4) Effort is made to achieve a net gain in mahinga kai.	Refer to the general discussion of this policy in the body of Chapter 9.
Policy 10.1.8 – Deposition of dredge spoil	Enable maintenance dredging for the continued operation of Lyttelton Port, and dredging to create, or deepen and widen, the Main Navigational Channel, ship turning basins and berth pockets, provided that dredging is undertaken in accordance with best practice methods that minimise adverse effects on the environment.	Refer to the general discussion of this policy in the body of Chapter 9.
Policy 10.1.9 – Dredging	Subject to Policy 10.1.10, manage effects of the deposition of dredge spoil at the Spoil Dumping Grounds shown on Planning Map 10.5 by: 1) Enabling the deposition of dredge spoil removed	Refer to the general discussion of this policy in the body of Chapter 9.

	during construction activities and the creation of berth pockets; and 2) Ensuring that any adverse effects of the deposition of dredge spoil removed during maintenance or capital dredging are avoided, remedied or mitigated; and 3) Requiring monitoring of the deposition area so that any adverse effects on the environment, including mahinga kai, can be identified and managed appropriately.	

Chapter 6: Natural Character and Appropriate Use of the Coastal Environment

Objective 6.1	To protect, and where appropriate enhance, the following areas, sites and habitats of high natural, physical, heritage or cultural value: a) Areas of Significant Natural Value (identified in Schedule 1, and shown on the Planning Maps in Volume 2); b) Those Areas listed in Schedules 2 and 3; c) Areas within the intertidal or subtidal zone that contain unique, threatened, rare, distinctive or representative marine life or habitats (including coastal wetlands) or are significant habitats of marine species generally; d) Areas used by marine mammals as breeding, feeding or haul out sites and breeding, roosting or feeding areas of indigenous bird species; e) Areas, including adequate buffer zones, that contain locally, regionally, nationally or internationally significant: ecosystems, vegetation, individual species, or habitat types, (for example coastal lakes, wetlands, lagoons, estuaries); f) Historic, archaeological, and geo-preservation sites in the coastal marine area; g) Coastal landforms and landscapes, submerged platforms and seascapes that are regionally, nationally or internationally representative or unique, including the Kaikoura coast, Banks Peninsula, Kaitorete Spit, and the Timaru reefs; h) Areas identified in consultation with Tangata	Schedule 1 lists 'Scarborough Cliffs and Godley Head' as an ASNV although the maps include the associated coastal marine area adjoining these features. The upper part of Lyttelton Harbour, south-west of Quail Island/Otamahua is identified as ASNV as is Ripapa Island and the harbour waters around the Island. Schedule 1 includes eight broad criteria that may contribute to an area being identified although no further details are provided in the schedule. For example, Scarborough Cliffs and Godley Head has been is considered relevant to four of the eight criteria i.e. • Protected Area • Marine Mammal and birds • Ecosystems, Flora and habitats • Scenic site. The tidal flats of the upper Harbour are relevant to all eight criteria listed in Schedule 1 while Ripapa Island is relevant to six of the criteria. The waters around Ripapa Island were known to harbour a rare brachiopod as discussed in the Cawthron Institute report (**Appendix 15A**). The matters set out in Objective 6.1 have been discussed in the expert reports that have been referred to under the NZCPS objectives and policies.

	Whenua including wahi tapu, urupa, tauranga waka and mahinga kai; i) Areas of significant amenity value, including recreational attributes; j) Areas having high natural character in the coastal environment; k) Areas having significant heritage values; and l) Habitats of species which are important for commercial, recreational, traditional, or cultural purposes.	
Objective 6.2	To protect, and where appropriate enhance, natural character and amenity values of the Banks Peninsula coastal environment including: a) Volcanic and coastal landforms and features; b) Estuarine and coastal vegetation and habitat; c) Coastal processes and ecosystems; d) Areas of high water quality; e) Areas of high visual amenity value, and/or otherwise unmodified by structures or other activities, in particular the outer bays and open coast.	The natural character, landscape, and visual amenity assessment report (**Appendix 4)** and recreation assessment report (**Appendix 5**) consider that the effects of the project are negligible to low.
Policy 6.1	(a) Within the Coastal Marine Area Environment Canterbury will: (i) control activities and development to remedy or mitigate adverse effects on: • coastal ecosystems and processes, • the identified values of Areas of Significant Natural Value, • the identified values of areas of high natural, physical, heritage or cultural value, and • natural character in areas of the coastal environment where natural character predominates; and (ii) control activities and development to avoid any significant adverse effects on: • coastal ecosystems and processes, • the identified values of Areas of Significant Natural Value, • the identified values of areas of high natural, physical, heritage or cultural value, and • natural character in areas of the coastal environment where natural character predominates;	The policy seeks to avoid any significant adverse effects on coastal ecosystems and processes and various identified values or otherwise to remedy and mitigate effects. This policy appears to focus on or around the coast rather than the coastal marine area. There are no adverse effects anticipated at the coast as a result of the project although turbidity and management response actions are being proposed to further reduce any risk of any unforeseen effects and assurance monitoring is to be completed along the coast to evaluate the predicted absence of effects. In terms of clause (iii), refer to the discussion under Policy 3 of the NZCPS.

	unless there are special or extraordinary and unique reasons why those adverse effects cannot be avoided; and (iii) adopt a precautionary approach10 when considering applications for resource consents where the effects, including cumulative effects, are as yet unknown or little understood, or where the functioning of marine ecosystems and coastal processes is poorly understood.	

Chapter 7: Coastal Water Quality

Objective 7.1	Enable present and future generations to gain cultural, social, recreational, economic, health and other benefits from the quality of the water in the Coastal Marine Area, while: (a) maintaining the overall existing high natural water quality of coastal waters;. (b) safeguarding the life-supporting capacity of the water, including its associated: aquatic ecosystems, significant habitats of indigenous fauna and areas of significant indigenous vegetation; (c) safeguarding, and where appropriate, enhancing its value for providing mahinga kai for Tangata Whenua; (d) protecting wahi tapu and wahi taonga of value to Tangata Whenua; (e) preserving natural character and protecting outstanding natural features and landscapes, where water quality is an aspect of their value, from reductions in water quality; (f) maintaining, and where appropriate enhancing, amenity values; and (g) recognising the intrinsic values of ecosystems and any finite characteristics of the coastal environment.	Objective 7.1 focuses on ensuring that high natural water quality of the coast environment is maintained and the life-supporting capacity of the water is safe-guarded including safeguarding and where appropriate enhancing its value for provided mahing kai. These matters are to an extent are a re-packing of the NZCPS policies discussed above. The turbidity generated from dredging and disposal activities is not predicted to cause any significant adverse effects on the benthic, sub-tidal, intertidal communities (including mahinga kai) nor is it expected to cause any significant adverse effects on Hector's dolphins or marine avifauna.
	Policy 7.1 In areas where water quality classes for parts of the Coastal Marine Area have not been established in this plan, the granting of a resource consent to discharge a contaminant or water into water, or onto or into land in the Coastal Marine Area: (a) shall not unreasonably restrict existing lawful uses of the coastal water; and	Policy 7.1 is relevant because the proposed disposal grounds are not subject to any water quality classes (i.e. natural state). Refer to the discussion earlier in this Chapter that addresses the use of a reasonable mixing zone under s107 of the Act. The receiving environment is naturally turbid especially near the seabed, and so any suspended sediment plumes are not predicted to have any significant adverse effects generally beyond the boundary of the grounds.

	(b) shall provide that, after reasonable mixing, the discharge shall not have any more than a minor adverse effect on the quality of the water existing prior to the granting of the resource consent.	Within the grounds the most significant effect is due to depositional smothering rather than affecting water quality and impacting on the biotic communities (Refer to the Cawthron Institute Report in **Appendix 15**).
	Policy 7.4 Before being granted a resource consent for a point source discharge of a contaminant or water into water, or onto or into land in the Coastal Marine Area in circumstances where the discharge, after reasonable mixing, would not achieve the water classification purposes for which the water quality standards set in this plan, the applicant must satisfy Environment Canterbury: (a) that exceptional circumstances justify the granting of the consent; or (b) that the discharge is of a temporary nature; or (c) that the discharge is associated with necessary maintenance work; or (d) that practicable alternatives to avoid such a discharge are not available.	While Lyttelton Harbour/Whakaraupō involves three different water classifications, the standards contained Schedule 4 are not particularly relevant to discharge of dredge spoil. It noted by the Cawthron Institute that the sediments sampled are not observed not to be anoxic.
Policy 7.6	In setting conditions on a resource consent to discharge a contaminant or water into water, or onto or into land in the Coastal Marine Area, a reasonable mixing zone should be determined by considering, amongst other matters, the following: (a) the volumes, contaminant loading and contaminant concentrations involved with the discharge; (b) factors such as sea conditions, tides, wave action, water depths, water velocity, and flushing characteristics that will normally affect the assimilative capacity of the receiving water and the dispersion of the contaminants or the discharge water; (c) the presence of an Area of Significant Natural Value at the site or in close proximity; (d) the existing use of the immediate area, including the presence of other discharges; (e) if in any area within which a water quality standard is set, the size of the area in relation to the mixing zone; and (f) the proximity of adjacent areas where water quality standards have been set; and	A discussion on the mixing can be found in the body of this Chapter when evaluating s107 of the Act.

	(g) the natural values of the receiving environment.	
Policy 7.7	Ensure that discharges of water or contaminants into water, or onto or into land in the Coastal Marine Area avoid significant adverse effects on cultural or spiritual values associated with sites, (e.g. areas covered by controls such as taiapure or mahinga mataitai), of special significance to the Tangata Whenua.	The modelling, measurement and assessment work conclude that the turbidity plumes generated from the dredging and disposal activities would not do not reach the coast and adversely affect mahinga kai. The turbidity monitoring and management response actions and the assurance monitoring have been developed to reduce the risk of any unforeseen effects from occurring and otherwise to confirm predictions.

Chapter 8: Activities and Occupation in the Coastal Marine Area

Objective 8.1	(1) To enable people to use the Coastal Marine Area and its resources while avoiding, remedying or mitigating the adverse effects of that use on the environment, including avoiding, remedying or mitigating the adverse effects: (a) of conflicts between these uses and people's well-being, health, safety and amenity; and (b) on natural character, and other (natural, ecological, amenity, Tangata Whenua, historic and cultural) values of the coastal environment. (2) ……..	The objective is at a reasonably high level of generality and the matters have been discussed in other objectives and policies described earlier with the exception of safety issues. In this regard navigation safety is not considered to be an issue to the size and comparatively low speed of the dredging vessels. No navigation incidents during maintenance dredging have been reported before.
ePolicy 8.3	In considering applications for resource consents to undertake activities in the Coastal Marine Area, Environment Canterbury will have regard to: (a) the existing level of use and development in the area and the national priority in the New Zealand Coastal Policy Statement to preserve the natural character of the coastal environment; and (b) the need to protect characteristics of the coastal environment of special value to Tangata Whenua; and (c) effects on the public use and enjoyment of the coast, including public access to and along the Coastal Marine Area, and the contribution of open space to the amenity value of the coast; and (d) cumulative effects of such activities on the coastal environment both within and outside the immediate location; and (e) existing agricultural and other use and development of the adjacent land area, and any adverse effects on that activity; and	The matters raised in the policy again have been dealt with previously or are not relevant. In terms of clause (d), dredging and disposal activities are discrete activities undertaken by LPC. There is no evidence to suggest that the activities including on-going maintenance dredging will generate effects that are cumulative over-time. However there are a range of marine and land-based activities that occurring in the inlets that are affecting the receiving marine environment. It was agreed under the Lyttelton Port Recovery Plan that the Canterbury Regional Council, Lyttelton Port Company Limited, Te Hapū o Ngāti Wheke, Christchurch City Council and Te Rūnanga o Ngāi Tahu with Tāngata Tiaki will work together to develop a catchment management plan for the Whakaraupō/Lyttelton Harbour in accordance with the philosophy of ki uta ki tai (from the mountains to the sea).

	(f) the status of any lands or areas administered by the Department of Conservation that are affected; and (g) the publicly notified purpose of any proposal for protected status, if the application affects an area proposed for protection under a statute administered by the Department of Conservation; and (h) the possibility of natural features migrating inland as the result of dynamic coastal processes, including sea level rise, and the ability of natural features to protect subdivision, use and development from erosion and inundation; and (i) the need to protect existing network utility infrastructure where such infrastructure is located adjacent to or within the Coastal Marine Area.	The shifting of the primary maintenance spoil disposal offshore, outside the Harbour, would substantially remove one anthropogenic activity from the Harbour.
Policy 8.7	Activities in the Coastal Marine Area should not take place where they have, or have the potential to have, a significant or irreversible adverse effect on the natural or cultural values of an Area of Significant Natural Value, or on the natural or cultural values of areas of the coastal environment adjacent to an Area of Significant Natural Value; unless: (a) there are special or extraordinary and unique reasons why the activity should be sited in the area; and (b) any adverse effects on areas of significant indigenous vegetation or significant	As discussed under previous policies the assessment work does not indicate that there will be any significant adverse effects or any irreversible adverse effects associated with dredging and disposal activities.

Christchurch Replacement District Plan

Objective	Objective Detail	Assessment
21.8.1.1Objective – Recovery and growth of Lyttelton Port	a. The recovery of the Lyttelton Port is enabled in a timely manner: i. to restore its efficient and effective operation, and enable growth and development to support its role as strategic infrastructure in the recovery of greater Christchurch; and ii. to recognise its significance in the recovery of greater Christchurch, including economic growth within the township of Lyttelton, Christchurch District and the wider region.	Channel deepening and associated maintenance dredging is a project that will enable growth and development, in turn enabling the Port to support its role as strategic infrastructure in the recovery of greater Christchurch.