PORT OTAGO LIMITED

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OTAGO REGIONAL COUNCIL RECEIVED DUNEDIN 26 MAY 2010 FILE No pre-app DIR TO MCA

RECEIVED 26 MAY 2010 BY: PC 10:35am cha.

26 May 2010

Mr Chris Shaw
Consents Manager
Otago Regional Council
Private Bag
Dunedin

Dear Chris

RE : Project Next Generation – Application for Resource Consent

Please find enclosed 3 copies of the Application and Assessment of Environmental Effects for Project Next Generation, involving dredging, disposal of spoil and construction of a wharf extension.

In addition I enclose a CD containing copies of all of the supporting reports. The separate document attached is information that is required by Chapter 15 of the Coastal Plan and has been prepared by cross-referencing the main applications and AEE document. I trust this is of assistance.

I look forward to working with you and your team through the statutory process ahead, and if you have any queries, please do not hesitate to contact me directly.

Yours sincerely,

Lincoln Coe
GM Infrastructure

PO Box 8, Port Chalmers, New Zealand. Telephone 03-472-7890, Facsimile 03-472-7891
Email pol@portotago.co.nz

PROJECT NEXT GENERATION

FURTHER INFORMATION REQUIRED BY CHAPTER 15 COASTAL PLAN

1. Name of Applicant:

Port Otago Ltd

2. The address of the Applicant:

PO Box 8, Port Chalmers.

3. Description of the proposed activity and its purpose:

3.1 **Deepening, widening, and dredging works in the channel, swinging areas and berths.**

This application is described in section 2.2 and has the purpose of allowing Port Chalmers to receive the next generation of container ships by permitting the shipping channel to be deepened with some widening, particularly at the bends, the swing basin deepened and extended and the berth areas extended and strengthened and the channel, swinging basin and berths being maintained at the approved depths.

3.2 Deposition of Dredging Spoil and Rock at sea

This application is described in section 2.3 and has three aspects:

(a) Changing the conditions of the existing disposal consent to allow spoil to be deposited at the existing dumping sites when it is taken from depths in excess of that permitted under the Regional Plan: Coast;

(b) Changing the conditions of the existing disposal consent to allow rock from Acheron Head, Rocky Point and the inner basin adjacent to Beach St wharf, to be deposited at the Heywards Point disposal area; and

(c) Permitting disposal to a new disposal ground for the majority of the dredging spoil.

3.4 Extension to Multipurpose Wharf and building of Fishing Platform

This application is described in section 2.4 and is to extend the length of the Multipurpose Wharf and to include a fishing jetty for public recreation.

4. Location of the proposed activity:

4.1 The lower harbour channel up to and including the vessel turning basin at Port Chalmers extends over a distance of some 13 kilometres landward of the "Landfall Tower". Landfall Tower is located at Latitude 45 degrees 24.1 minutes

South, Longitude 70 degrees 43.6 minutes East (chainage 0 metres) marks the start of the approaches to the harbour entrance. These are shown on Drawing 11090.

4.2 The berths are to the east of land owned by Port Otago Ltd being Lot 1 DP 23587 and Lot 1 DP 23008 and are immediately adjacent to the Container Wharf and Multi-purpose Wharf shown on Drawing 10991A.

4.3 The existing disposal grounds are as follows:

(i) Heyward Point

45° 45.07'S	170° 42.09'E
45° 44.95'S	170° 42.27'E
45° 44.44'S	170° 41.78'E
45° 44.63'S	170° 41.60'E

(ii) Spit Beach

45° 46.18'S	170° 42.74'E
45° 46.05'S	170° 42.93'E
45° 45.72'S	170° 42.47'E
45° 46.04'S	170° 42.33'E

(iii) South Spit Beach (Shelly Beach)

45° 46.82'S	170° 42.56'E
45° 46.65'S	170° 42.79'E
45° 46.75'S	170° 42.96'E
45° 46.95'S	170° 42.77'E

4.4 The new disposal site is the area of 2 kilometre diameter from the point located around the distal end of the "Peninsula Spit", centred at or about Latitude 45.735 S, Longitude 170.80 E, being about 6.3 kilometres to the northeast of Taiaroa Head and is shown on Drawing 11142.

4.5 The extensions to the Multipurpose Wharf and the fishing jetty are in that part of the coastal marine area in Otago Harbour to the north of the Multipurpose Wharf at Port Chalmers and directly to the east of land owned by Port Otago Ltd being DP 379968 and DP 23587, contained in CT Identifier 320427 and shown on Drawing 10991A.

5. Identification of proposed location in relation to specified areas in the Plan

5.1 The work on the lower channel at the harbour entrance is alongside Outstanding Natural Feature and Landscape above Mean High Water Springs ONFL8 (Heyward Point) and Coastal Hazard Area CHA5 (The Spit).

5.2 The work on the channel within the lower harbour is adjacent to costal protection areas CPA15 (Aramoana) and CPA17 (Otakou and Taiaroa Head) and Coastal Hazard Area CHA6 (Te Rauone Beach).

5.3 All work within the harbour is within Coastal Development Area CDA4;

5.4 The work on the channel and swinging basin within the harbour is within Coastal Recreation Area CRA9.

5.5 The work on the channel is alongside the following Department of Conservation Administered Land adjacent to the Coastal Marine Are as specified in schedule 6: DCAL28 (Heyward Point), DCAL30 and DCAL 33(Aramoana) and DCAL31 (Taiaroa Head).

5.6 Except as specified above, the proposed location is not within any of the following:

(a) A coastal protection area, coastal recreation area, or coastal development area, as specified in Schedule 2 of the Plan; or

(b) Within or adjacent to any area identified as having outstanding natural features and landscapes, as specified in Schedule 3.2 of the Plan; or

(c) Adjacent to any area identified as having marine mammal or bird conservation values as specified in Schedule 3.1 of the Plan; or

(d) Within or adjacent to any area that is managed under the Conservation Act 1987 or as administered by the Department of Conservation as shown in Schedule 6 of the plan; or

(e) Within or adjacent to any area that has been proposed for protection by the Department of Conservation.

6. Size of the area

6.1 The lower shipping channel extends 13 kilometres and varies in width.

6.2 The swinging basin and berth areas is approximately 35 hectares.

6.3 The berth area to be widened and deepened under and adjacent to the Container and Multipurpose Wharfs is approximately 1.9 hectares (750m long x 25m wide)

6.4 The area required for the extension to the Multipurpose Wharf and fishing jetty is 4500 m^2.

7. Construction Period

7.1 The incremental improvements to the channel will proceed until the major capital dredging is complete which could be a period up to the 20 years sought in the consent.

7.2 The maintenance dredging will continue throughout the term of the consent.

7.3 The expected construction period for the increase in depth and width of berth area and rock placement, as well as the preliminary work on the swinging area and channel is 24 months

7.4 The expected construction period for the major capital dredging is up to 6-8 months although it will depend on the plant used.

7.5 The expected construction period for the Multipurpose berth extensions and the fishing jetty is 16 months.

8. Duration

The intended duration of the proposed activity is indefinite.

9. A description of the possible alternative locations or methods and the reasons for making the proposed choice:

There are no possible alternative locations for the alterations to the channel, swing area, berths or extension to the existing Multipurpose Wharf.

The new disposal site has been assessed as suitable for receiving dredging spoil.

10. An environmental impact assessment is attached & contained in Chapter 6.

11. The following measures will be undertaken to help prevent or reduce any actual or potential effects:

The measures are detailed in chapter 7: Monitoring.

Construction will be undertaken in accordance with the Construction Noise Standard and best practice construction techniques will be utilised.

12. Public Benefit

The public benefit to be derived is the benefit to the community in having a container port that can meet the requirements of vessels visiting New Zealand ports. This will enable suppliers, producers and manufacturers to meet the "just in time" needs of their customers, compete on the global stage and contribute significantly to the economy of Dunedin City and the provinces of both Otago and Southland.

13. The following persons are identified as being interested in the proposal:

The following table outlines a list of particiapants in the Project Consultative group process.

Organisation
Aramoana League
Blue Water Products Ltd
Careys Bay Residents' Assoc.
Chalmers Community Board
Department of Conservation
Dunedin City Council – Consents
Dunedin City Council - Planning Policy
Harbour Cycle Network
Harington Point Community Society (Inc)
Kati Huirapa Runaka ki Puketeraki
Monarch Wildlife Cruises
NZ Marine Studies Centre
Otago Chamber of Commerce
Otago Coastguard
Otago Peninsula Community Board

Otago Regional Council
Otago Yacht Club
Otakou Runanga
Port Chalmers Fishermen's Co-op Society
Port Chalmers Yacht Club
Port Environment Liaison Committee
Port Otago Limited
Quarry Beach Surf Boards
Recreational Fishing
Residents of Port Chalmers, Blueskin Rd, Dunedin and Harwood - as individuals
South Coast Board Riders
Southern Clams Ltd
Surfbreak Protection Society
University of Otago - Department of Marine Science
Yellow-Eyed Penguin Trust

The consultation that has occurred is detailed in Chapter 8: Consultation.

14. Other resource Consents

Three separate resource consents are required to undertake the works, with changes required to Port Otago's existing resource to DOC Consent No. SRCA 3.2 1105, ORC Consent No. 2000.472

No resource consent is required from any other consent authority to undertake the proposed activity.

A small portion of the extension to the Multipurpose Wharf is on the landward side of the boundary of the Coastal Marine Area (within Port 1 Zone) and no resource consent is required as it constitutes a permitted activity under Rule 11.5.1 Dunedin City District Plan.

15. Public Access

The application places no restrictions on public access to the coastal marine area.

Public access to part of the coastal marine area will be enhanced as a result of the construction of the fishing jetty.

16. Monitoring: Refer Chapter 7: Monitoring

17. Natural Hazard

The proposed activity is not located within or adjacent to any area containing a natural hazard.

18. Permanent Structure

The proposed activity will involve the erection of permanent structures, being the extension to the Multipurpose Wharf and the fishing jetty.

19. **Alteration to Seabed**

All activities will alter the seabed as described in the application although the alteration to the seabed as a result of the extension to the Multipurpose Wharf and the fishing jetty is minimal with temporary effects as it is limited to the alteration that will necessarily occur as the result of the driving of the piles for the wharf.

20. **Discharges**

The discharges that will be associated with the proposed activity are minimal and temporary and detailed in the environmental impact assessment. They comprise:

(a) Decant or overflow water from plant (including dredgers, excavators, grabs and barges); and

(b) The discharge of sediment and water containing concrete during construction of the Multipurpose Wharf extensions and the fishing jetty.

21. **Hazardous Substances and Hazardous Waste**

The activity does not involve the storage of any hazardous substance or hazardous waste. The use of explosives for blasting rock is part of the application and detailed within the application.

22. **Coastal Water**

The activity does not involve the taking, use, damming or diversion of coastal water.

23. **Noise is considered in detail in section 6.8**

24. **Exotic Plants**

The proposed activity does not involve the introduction of any exotic plants into the costal marine area. Management of activities to minimise the risk of spreading of invasive plants is discussed in detail within the document.

Lincoln Coe
GM Infrastructure

25 May 2010

PROJECT NEXT GENERATION

Resource Consent Applications

and

Assessment of Environmental Effects

May 2010

APPLICATION FOR RESOURCE CONSENTS UNDER SECTION 88 OF THE RESOURCE MANAGEMENT ACT 1991

[Deepening, widening and dredging works in the channel, swinging areas and berths]

TO: **The Chief Executive**
Otago Regional Council
Private Bag 1954
DUNEDIN

PORT OTAGO LIMITED applies for resource consents to authorise the dredging, deepening and widening of the harbour entrance and channel, inclusive of all ancillary activities, and their operation and maintenance.

1. The type of resource consent sought is as follows:

Coastal permit – to authorise all activities associated with the disturbance of, and removal of natural material from the foreshore and seabed to deepen and widen the entrance channel, lower harbour channel, swinging area and Port Chalmers berths; to maintain the entrance channel, lower harbour channel, swinging area and berths by dredging; the placement of rock on the foreshore and seabed; the discharge of decant water from the plant used for dredging and maintaining the channel, berths and swinging areas; and all ancillary activities.

2. Description of the activity to which these applications relate:

2.1 Port Otago Limited is developing its port facilities for the next generational shift in shipping services ("Project Next Generation"), specifically the use of larger container vessels (6,000 to 8,000 TEU) and/or the increase in number, frequency and duration of all vessels using the Port Chalmers wharfs due to growth in trade.

2.2 The main components of the Project Next Generation include the following:

- **Deepening, widening and maintaining the lower harbour channel, the swinging area and the Port Chalmers berths to allow passage of larger ships to Port Chalmers.**
- **Disposal of dredging spoil at sea.**
- **Extending the Multipurpose Wharf and construction of a new fishing platform at Port Chalmers.**

3. The owners and occupiers of land to which the application relates are:

The land to which the applications relate is owned and occupied by the New Zealand Government (Crown). Port Otago Limited have the right to occupy until September 2026 that part of the coastal marine area identified on the maps annexed to Consent No: 2010:011 (areas adjacent to the Port and navigational aids) for the purposes of operating and managing an existing port.

4. The location to which this application relates are:

The locations to which this application relates are:

(i) The shipping channel and swinging area shown on Drawing No 11090.

(ii) The berths to the east of land owned by Port Otago Ltd (being Lot 1 DP 23587 and Lot DP 23008).

5. The following additional resource consents/processes are being progressed at the time this application has been lodged:

5.1 The other resource consents being sought from the Otago Regional Council are as detailed below:

Coastal permit - to authorise all activities associated with the extension of the multipurpose wharf and construction of a fishing platform and their operation and maintenance; to disturb the foreshore and seabed; to discharge sediment and water; and all ancillary activities, in the general location shown on Drawing 10991A.

Coastal permit – to deposit up to 7.2 million m^3 of sand, shell, shingle or any other natural material other than rock from authorised dredging in Otago Harbour into the sea at the capital disposal site shown in Drawing 11142.

5.2 A change of conditions is being sought in respect of DOC Consent No. SRCA 3.2 1105, ORC Consent No. 2000.472, which relate to the disposal of material from the dredging of the shipping channel and berths areas in and about the Otago Harbour, from activities associated with the operation and maintenance of Port Chalmers and Dunedin facilities.

Change of consent conditions – to allow material dredged as part of Project Next Generation to be disposed of at Port Otago's existing disposal sites.

6. The details of the effects arising as a result of the applications, and other matters required to be addressed pursuant to the Fourth Schedule of the Resource Management Act 1991, and the requirements of the Otago Regional Plan: Coast, are fully described in the Assessment of Environmental Effects accompanying these applications.

Signature: Port Otago Limited
By

____

Lincoln Coe

Date: 25 May 2010

Address for Service: c/- Lincoln Coe
PO Box 8
15 Beach St
PORT CHALMERS

Telephone: (03) 472 7890
Facsimile: (03) 472 7891
Email: lcoe@portotago.co.nz

APPLICATION FOR RESOURCE CONSENTS UNDER SECTION 88 OF THE RESOURCE MANAGEMENT ACT 1991

[Disposal of dredge spoil at sea]

TO: **The Chief Executive**
Otago Regional Council
Private Bag 1954
DUNEDIN

PORT OTAGO LIMITED applies for resource consent to authorise the disposal of material at sea associated with the dredging, deepening and widening of the harbour entrance and channel and their operation and maintenance.

1. The type of resource consent sought is as follows:

Coastal permit – to deposit up to 7.2 million m^3 of sand, shell, shingle or any other natural material other than rock from authorised dredging in Otago Harbour into the sea at the capital disposal site shown in Drawing 11142.

2. Description of the activity to which these applications relate:

2.1 Port Otago Limited is developing its port facilities for the next generational shift in shipping services ("Project Next Generation"), specifically the use of larger container vessels (6,000 to 8,000 TEU) and/or the increase in number, frequency and duration of all vessels using the Port Chalmers wharfs due to growth in trade.

2.2 The main components of the Project Next Generation include the following:

- **Deepening, widening and maintaining the lower harbour channel, the swinging area and the Port Chalmers berths to allow passage of larger ships to Port Chalmers.**
- **Disposal of dredging spoil at sea.**
- **Extending the Multipurpose Wharf and construction of a new fishing platform at Port Chalmers.**

3. The owners and occupiers of land to which the application relates are:

The land to which the applications relate is owned and occupied by the New Zealand Government (Crown).

4. The location to which this application relates is:

The location to which this application relates is centred at or about Latitude 45° 735'S, Longitude 170° 80'E and located about 6.3 kilometres to the northeast of Taiaroa Head, as shown on Drawing 11142.

5. The following additional resource consents/processes are being progressed at the time this application has been lodged:

5.1 The other resource consents being sought from the Otago Regional Council are as detailed below:

Coastal permit – to authorise all activities associated with the disturbance of, and removal of natural material from the foreshore and seabed to deepen and widen the entrance channel, lower harbour channel, swinging area and Port Chalmers berths; to maintain the entrance channel, lower harbour channel, swinging area and berths by dredging; the placement of rock on the foreshore and seabed; the discharge of decant water from the plant used for dredging and maintaining the channel, berths and swinging areas; and all ancillary activities.

Coastal permit - to authorise all activities associated with the extension of the multipurpose wharf and construction of a fishing platform and their operation and maintenance; to disturb the foreshore and seabed; to discharge sediment and water; and all ancillary activities, in the general location shown on Drawing 10991A.

5.2 A change of conditions is being sought in respect of DOC Consent No. SRCA 3.2 1105, ORC Consent No. 2000.472, which relate to the disposal of material from the dredging of the shipping channel and berths areas in and about the Otago Harbour, from activities associated with the operation and maintenance of Port Chalmers and Dunedin facilities.

Change of consent conditions – to allow material dredged as part of Project Next Generation to be disposed of at Port Otago's existing disposal sites.

6. The details of the effects arising as a result of the applications, and other matters required to be addressed pursuant to the Fourth Schedule of the Resource Management Act 1991, and the requirements of the Otago Regional Plan: Coast, are fully described in the Assessment of Environmental Effects accompanying these applications.

Signature:	**Port Otago Limited** **By**
	______________________________
	Lincoln Coe
Date:	**25 May 2010**
Address for Service:	**c/- Lincoln Coe**
	PO Box 8 **15 Beach St** **PORT CHALMERS**
Telephone:	**(03) 472 7890**
Facsimile:	**(03) 472 7891**
Email:	**lcoe@portotago.co.nz**

APPLICATION FOR RESOURCE CONSENTS UNDER SECTION 88 OF THE RESOURCE MANAGEMENT ACT 1991

[Construction of wharf extension and fishing platform]

TO: **The Chief Executive**
Otago Regional Council
Private Bag 1954
DUNEDIN

PORT OTAGO LIMITED applies for resource consents to authorise the extension of the multipurpose wharf and construction of a new fishing platform and their operation and maintenance.

1. The type of resource consent sought is as follows:

Coastal permit - to authorise all activities associated with the extension of the multipurpose wharf and construction of a fishing platform and their operation and maintenance; to disturb the foreshore and seabed; to discharge sediment and water; and all ancillary activities, in the general location shown on Drawing 10991A.

2. Description of the activity to which this application relates:

2.1 Port Otago Limited is upgrading its port facilities for the next generational shift in shipping services ("Project Next Generation"), specifically the use of larger container vessels (6,000 to 8,000 TEU) and/or the increase in number, frequency and duration of all vessels using the Port Chalmers wharfs due to growth in trade.

2.2 The main components of Project Next Generation include the following:

- **Deepening, widening and maintaining the lower harbour channel, the swinging area and the Port Chalmers berths to allow passage of larger ships to Port Chalmers.**
- **Disposal of dredging spoil at sea.**
- **Extending the Multipurpose Wharf and construction of a new fishing platform at Port Chalmers.**

3. The owners and occupiers of land to which the application relates are:

The land to which the applications relate is owned and occupied by the New Zealand Government (Crown). Port Otago Limited have the right to occupy until September 2026 that part of the coastal marine area identified on the maps annexed to Consent No: 2010:011 (areas adjacent to the Port and navigational aids) for the purposes of operating and managing an existing port.

4. The location to which this application relates is:

The location to which this application relates is that part of the coastal marine area in Otago Harbour, to the east of land owned by Port Otago Limited being Lot 1 DP 23587 and Lot 1 DP 379966, and immediately to the north of the Multi-purpose wharf shown on Drawing 10991A.

5. **The following additional resource consents/processes are being progressed at the time this application has been lodged:**

5.1 **The other resource consents being sought from Otago Regional Council are as detailed below:**

Coastal permit – to authorise all activities associated with the disturbance of, and removal of natural material from the foreshore and seabed to deepen and widen the entrance channel, lower harbour channel, swinging area and Port Chalmers berths; to maintain the entrance channel, lower harbour channel, swinging area and berths by dredging; the placement of rock on the foreshore and seabed; the discharge of decant water from the plant used for dredging and maintaining the channel, berths and swinging areas; and all ancillary activities.

Coastal permit – to deposit up to 7.2 million m^3 of sand, shell, shingle or any other natural material other than rock from authorised dredging in Otago Harbour into the sea at the capital disposal site shown in Drawing 11142.

5.2 **A change of conditions is being sought in respect of DOC Consent No. SRCA 3.2 1105, ORC Consent No. 2000.472, which relate to the disposal of material from the dredging of the shipping channel and berths areas in and about the Otago Harbour, from activities associated with the operation and maintenance of Port Chalmers and Dunedin facilities.**

Change of consent conditions – to allow material dredged as part of Project Next Generation to be disposed of at Port Otago's existing disposal sites.

6. **The details of the effects arising as a result of the applications, and other matters required to be addressed pursuant to the Fourth Schedule of the Resource Management Act 1991, and the requirements of the Otago Regional Plan: Coast, are fully described in the Assessment of Environmental Effects accompanying these applications.**

Signature: **Port Otago Limited**
By

____

Lincoln Coe

Date: **25 May 2010**

Address for Service: **c/- Lincoln Coe**

PO Box 8
15 Beach St
PORT CHALMERS

Telephone: **(03) 472 7890**
Facsimile: **(03) 472 7891**
Email: **lcoe@portotago.co.nz**

APPLICATION FOR CHANGE OF CONDITIONS OF RESOURCE CONSENT UNDER SECTION 127 OF THE RESOURCE MANAGEMENT ACT 1991

TO: **The Chief Executive**
Otago Regional Council
Private Bag 1954
DUNEDIN

1. **PORT OTAGO LIMITED applies for changes to the conditions of resource consent Doc Consent No. SRCA 3.2 1105, ORC Consent No. 2000.472, which relate to the disposal of material from the dredging of the shipping channel or within the Otago Harbour from activities associated with the operation and maintenance of Port Chalmers facilities.**

Port Otago Limited is developing its port facilities for the next generational shift in shipping services ("Project Next Generation"), specifically the use of larger container vessels (6,000 to 8,000 TEU) and/or the increase in number, frequency and duration of all vessels using the Port Chalmers wharves due to growth in trade. To allow material dredged as part of Project Next Generation to be disposed of at Port Otago's existing disposal sites, Port Otago is seeking this change to consent conditions.

2. **The proposed change is as follows:**

The specific conditions and wording of conditions of DOC consent No. 3.2 1105 and ORC Consent No. 2000.472 is outlined below.

(a) **Purpose of the Coastal Permit to be amended as follows:**

....for the purpose of disposal of dredging spoil derived from authorised ~~maintenance~~ dredging by Port Otago Limited ~~and incremental improvements to the channel and berth areas~~ in and about the Otago Harbour in accordance with the following specific maximum annual discharge quantities at each location: ....

(b) **The second condition 1 to be amended as follows:**

Material discharged shall only be derived from dredging that is authorised by the Coastal Plan or by a resource consent. ~~dredging of the channel and berth areas necessary to maintain water depths to previously approved levels (being the following depths, based on the Chart Datum on the latest navigation chart NZ6612, of the Otago Harbour published by the Hydrographic Office of the Royal New Zealand Navy:~~
~~(i) The upper berths and swing areas: 10 m~~
~~(ii) The upper channel: 8.5 m~~
~~(iii) Port Chalmers berths and swinging areas: 14.5 m~~
~~(iv) Lower channel: 13m~~

(c) **Condition 3 to be deleted:**

~~This permit does not authorise the discharge of material from capital dredging.~~

(d) **Condition 4 to be replaced as follows:**

Any dredging spoil containing rock material (including spoil derived from removal of rotten rock ridges off Beach Street, Port Chalmers*, Rocky Point or Acheron Head)* shall only be discharged at the ~~*Aramoana Spit*~~ *Heyward Point* site.

(e) **A new condition to be added to read:**

Material from capital dredging over any 12 month period shall contain a minimum of 90% sand.

3. The owners and occupiers of land to which the application relates are:

The land to which the applications relate is owned and occupied by the New Zealand Government (Crown). Port Otago Limited have the right to occupy until September 2026 that part of the coastal marine area identified on the maps annexed to Consent No: 2010:011 (areas adjacent to the Port and navigational aids) for the purposes of operating and managing an existing port.

4. The location to which this application relates is:

The location to which this application relates is as follows:

Area permitted by existing discharge consent DOC Consent No. SRCA 3.2 1105, ORC Consent No. 2000.472:

(i) **Heyward Point**
45° 45.07'S 170° 42.90'E
45° 44.95'S 170° 42.27'E
45° 44.44'S 170° 41.78'E
45° 44.63'S 170° 41.60'E

(ii) **Aramoana Spit**
45° 45.18'S 170° 42.74'E
45° 46.05'S 170° 42.93'E
45° 45.72'S 170° 42.47'E
45° 46.04'S 170° 42.47'E

(iii) **Shelly Beach**
45° 46.82'S 170° 42.56'E
45° 46.65'S 170° 42.79'E
45° 46.75'S 170° 42.96'E
45° 45.95'S 170° 42.77'E

5. The following additional resource consents/processes are being progressed at the time this application has been lodged:

Coastal permit – to authorise all activities associated with the disturbance of, and removal of natural material from the foreshore and seabed to deepen and widen the entrance channel, lower harbour channel, swinging area and Port Chalmers berths; to maintain the entrance channel, lower harbour channel, swinging area and berths by dredging; the placement of rock on the foreshore

and seabed; the discharge of decant water from the plant used for dredging and maintaining the channel, berths and swinging areas; and all ancillary activities.

Coastal permit - to authorise all activities associated with the extension of the multipurpose wharf and construction of a fishing platform and their operation and maintenance; to disturb the foreshore and seabed; to discharge sediment and water; and all ancillary activities, in the general location shown on Drawing 10991A.

Coastal permit – to deposit up to 7.2 million m^3 of sand, shell, shingle or any other natural material other than rock from authorised dredging in Otago Harbour into the sea at the capital disposal site shown in Drawing 11142.

6. The details of the effects arising as a result of the applications, and other matters required to be addressed pursuant to the Fourth Schedule of the Resource Management Act 1991, and the requirements of the Otago Regional Plan: Coast, are fully described in the Assessment of Environmental Effects accompanying these applications.

Signature: **Port Otago Limited**
By

Lincoln Coe

Date: **25 May 2010**

Address for Service: **c/- Lincoln Coe**

PO Box 8
15 Beach St
PORT CHALMERS

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Email: **lcoe@portotago.co.nz**

Assessment of Environmental Effects
TABLE OF CONTENTS

1. INTRODUCTION

1.1 Background

Port Otago Limited ("Port Otago") is readying itself for the next generational shift in shipping services, specifically the use of larger container vessels (6,000 to 8,000 TEU[1]) and/or the increase in number, frequency and duration of all vessels using the Port Chalmers wharves due to growth in trade. To meet these demands Port Otago proposes to upgrade its port facilities ("Project Next Generation") and is seeking the necessary approvals under the Resource Management Act (1991) ("RMA").

Port Otago is making a long-term commitment to Port Chalmers and sees it as an essential element of the local, regional and national infrastructure. Port Otago wants to provide an enduring and sustainable facility and intends that Port Chalmers will be an ongoing and important part of the region.

The major components of Project Next Generation include the following:

- Deepening, widening and maintaining the upper harbour channel, the swinging area, and the Port Chalmers berths to allow passage of larger ships to Port Chalmers.
- Disposal of dredging spoil at sea.
- Extending the Multipurpose Wharf and construction of a new Fishing Jetty at Port Chalmers.

1.2 Resource Consent Requirements

Port Otago is seeking all necessary resource consents for the deepening and widening of the harbour channel swinging area and berths, the disposal of dredged material, and the extension of the Multipurpose Wharf and construction of a new Fishing Jetty at Port Chalmers.

A full description of the consents required, and a description of the relevant rules is provided in Section 9, however a summary is provided below

[1] TEU is an acronym for Twenty-foot Equivalent Unit, which is a measure of cargo capacity for container vessels, based on a volume of a standard-sized 20-foot (~6 m) long shipping container.

The consents required to undertake the proposed dredging comprise:

- **Coastal Permit - to authorise all activities associated with the disturbance of, and removal of natural material from the foreshore and seabed to deepen and widen the entrance channel, lower harbour channel, swinging area and Port Chalmers berths; to maintain the entrance channel, lower harbour channel, swinging area and berths by dredging; the placement of rock on the foreshore and seabed; the discharge of decant water from the plant used for dredging and maintaining the channel, berths and swinging areas; and all ancillary activities.**

The consents required to dispose of dredged material at a new disposal site comprise:

- **Coastal Permit – To deposit sand, silt, clay, shell, shingle or any other natural material other than rock from authorised dredging in Otago Harbour into the sea at a new disposal site.**

The consents required to construct the wharf extension and fishing jetty comprise:

- **Coastal Permit – to authorise all activities associated with the extension of the multipurpose wharf and construction of a fishing platform and their operation and maintenance; to disturb the foreshore and seabed; to discharge sediment and water; and all ancillary activities, in the general location shown on Drawing 10991A.**

The consents required to dispose of dredged material to the existing maintenance disposal sites requires a change of conditions to DOC Consent No. SRCA 3.2 1105, ORC Consent No. 2000.472, which relate to the disposal of material from the dredging of the shipping channel and berths areas in and about the Otago Harbour, from activities associated with the operation and maintenance of Port Chalmers and Dunedin facilities.

- **Change of existing consent conditions – to allow material dredged as part of Project Next Generation to be disposed of at Port Otago's existing disposal sites.**

1.3 Report Structure

This report is set out in the following sections:

Section 1: This introduction

Section 2: Describes the project in detail.

Section 3: Introduces Port Otago Limited, provides background on the history of Port Chalmers, its infrastructure and its regional and national importance. Section 3 also describes how and why Port Chalmers needs to evolve to maintain the social and economic benefits it provides the community and the central role of Project Next Generation in that process.

Section 4: Describes the approach taken to developing the project, including how environmental and engineering imperatives and community consultation have been taken into account during the development of the final project design.

Section 5: Provides a description of the environmental setting for the proposal, including its social, physical and ecological setting.

Section 6: Provides an assessment of the environmental effects associated with the development.

Section 7: Sets out the monitoring proposed for the development. Port Otago anticipates that these measures will form the basis of resource consent conditions.

Section 8: Describes the consultation undertaken with relevant stakeholders, potentially affected parties and interest groups.

Section 9: Provides an assessment of the proposed development against the RMA and planning framework.

Section 10: Conclusion

2. PROJECT DESCRIPTION

2.1 Introduction

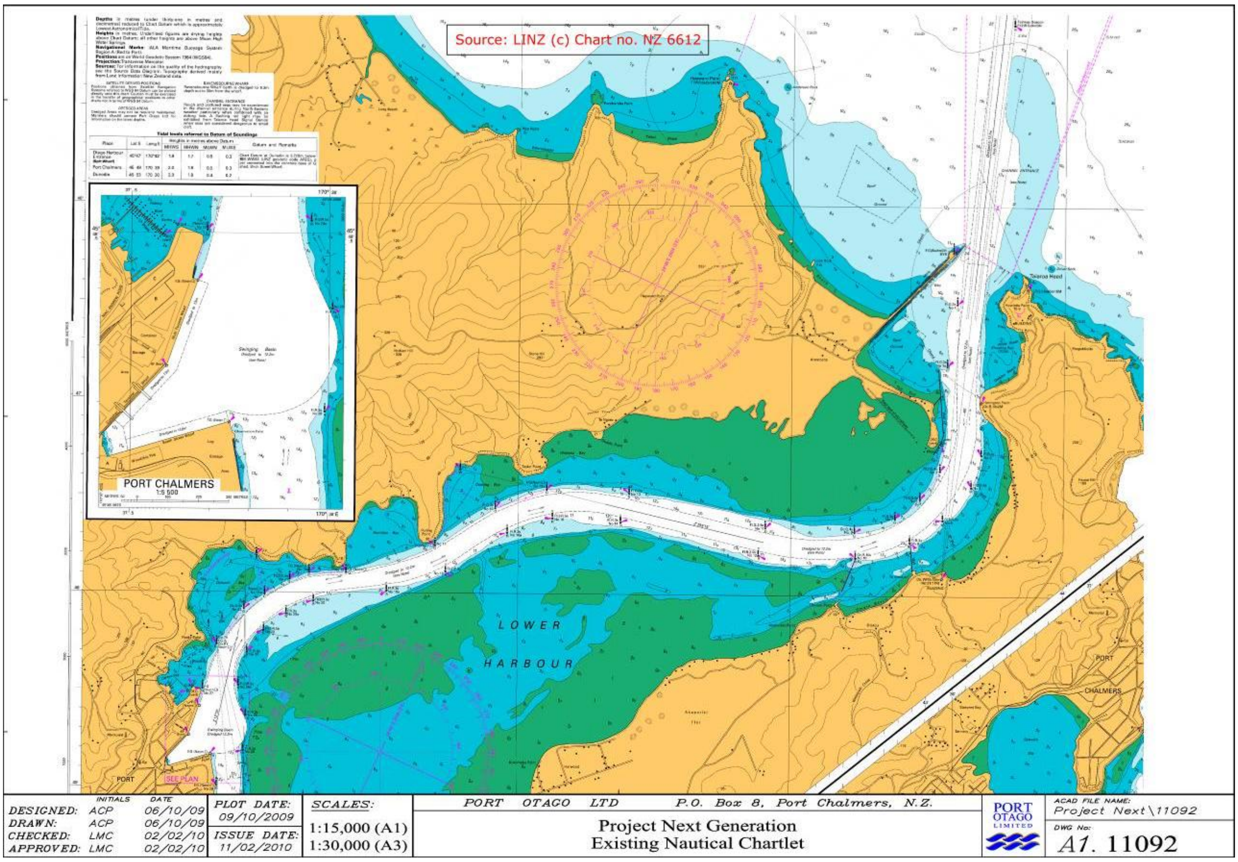
The project comprises two key elements:

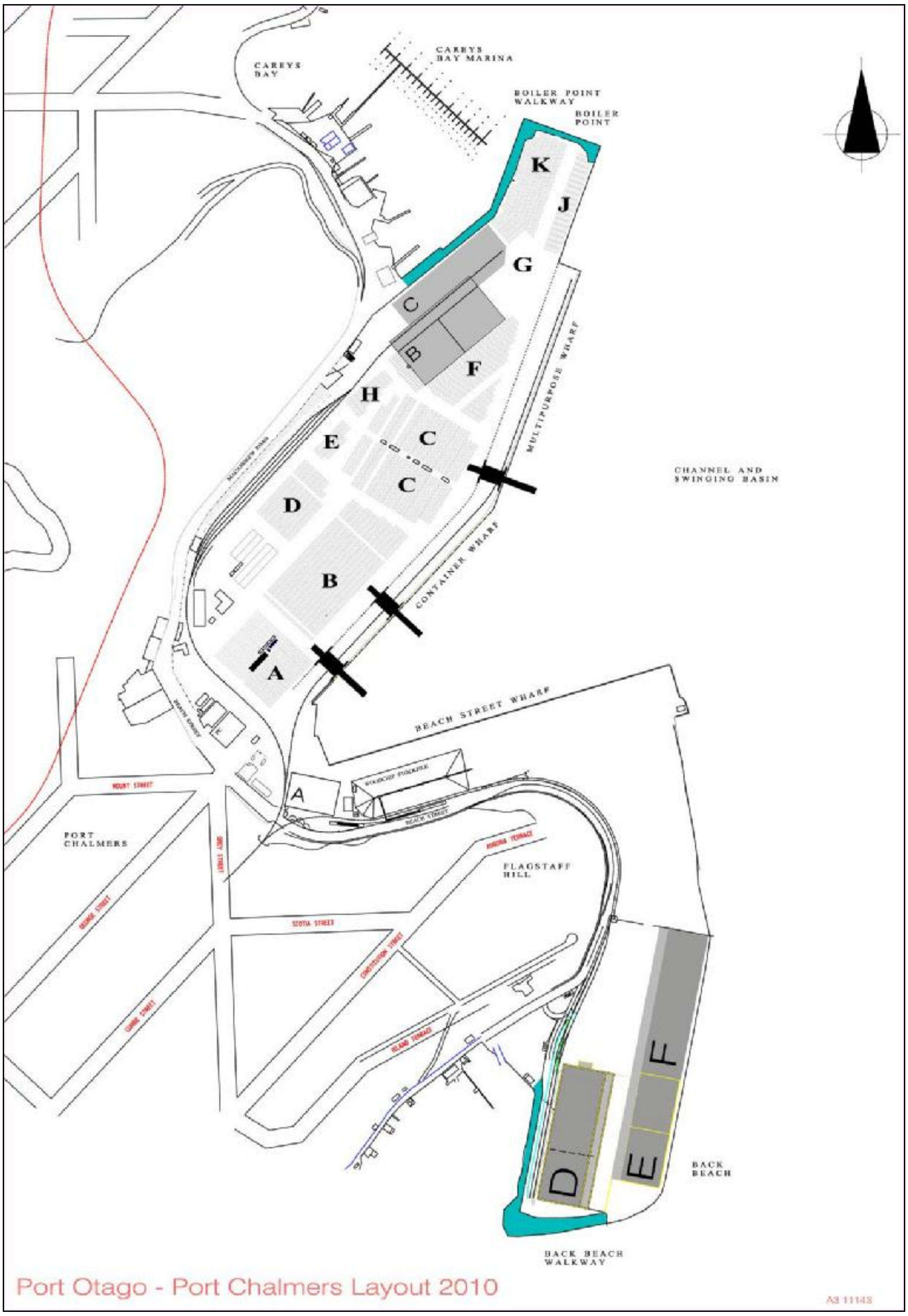
(1) Upgrading (by deepening and widening) the Lower Harbour channel, basin, swinging area and berths for the next generation of container shipping on the New Zealand Coast; and

(2) An extension to the existing Multipurpose Wharf to improve operational flexibility and construction of a new Fishing Jetty.

The Lower Harbour channel to Port Chalmers from the open sea, and the current layout of the wharfs at Port Chalmers are shown on Drawing 11092 and Drawing 11143 as follows:

(Note : For all Drawings referred to in the AEE document, large scale copies are included in Appendix A).





The proposed works are set out in detail in the following sections. Specifically:

- **Section 2.2 provides an overview of the proposed dredging and a description of the construction methodology to be used.**
- **Section 2.3 provides a description of the proposed methodology for the disposal of the dredged material.**
- **Section 2.4 provides a description of the Multipurpose Wharf Extension/new Fishing Jetty and the associated construction methodology.**

2.2 Deepening, Widening and Maintaining Lower Harbour Channel, Swinging Area and Berths

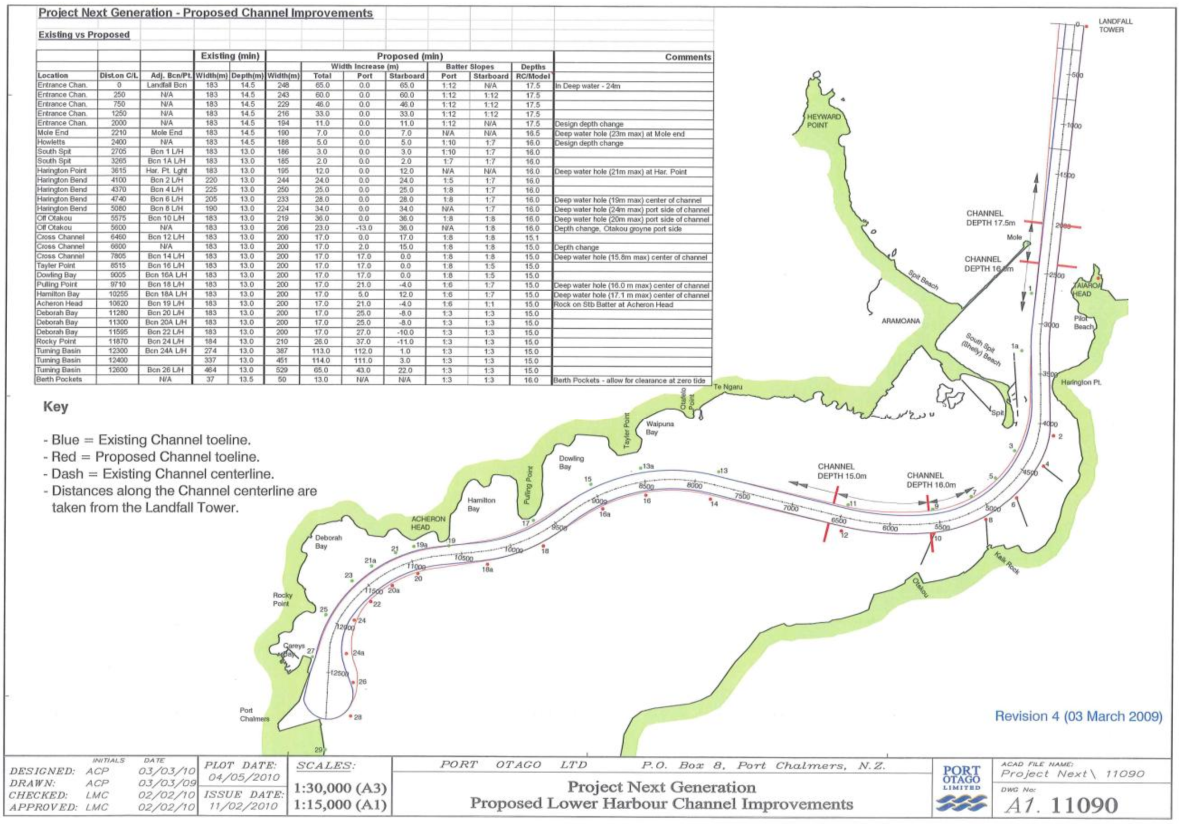
2.2.1 Overview of the Proposed Works

The Lower Harbour Channel

The lower harbour channel up to and including the swinging area (or vessel turning basin) at Port Chalmers is shown on Drawing 11090 (page 6) and extends over a distance of some 13 kilometres landward of the "Landfall Tower". Landfall Tower is located at Latitude 45 degrees 24.1 minutes South, Longitude 70 degrees 43.6 minutes East (chainage 0 metres) and marks the start of the approach to the harbour entrance.

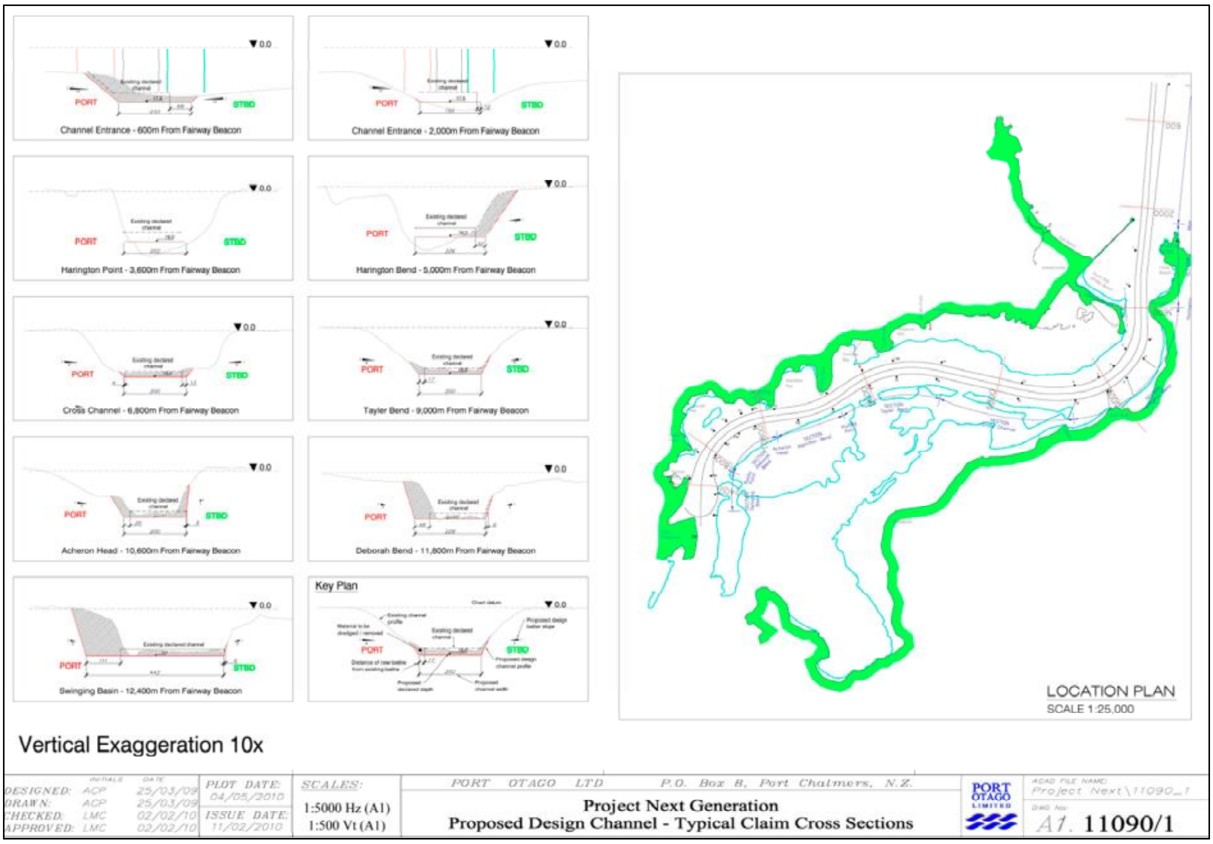
The existing lower harbour channel is currently at a minimum depth of 13.0 metres below chart datum, increasing to a minimum of 14.5 metres north of the Mole End which is situated at the end of Spit Beach. The Mole creates and protects the channel entrance to the Lower Harbour. There are sections along the entire length of the channel that exceed the depths above as a result of natural scouring action.

The upgrading proposed for the lower harbour is detailed on Drawing 11090, with the table in the top left corner showing the differences and variation in alignment and depth relative to the existing channel.



			Existing (min)		Proposed (min)							
						Width Increase (m)			Batter Slopes		Depths	Comments
Location	Dist.on C/L	Adj. Bcn/Pt.	Width(m)	Depth(m)	Width(m)	Total	Port	Starboard	Port	Starboard	RC/Model	
Entrance Chan.	0	Landfall Bcn	183	14.5	248	65.0	0.0	65.0	1:12	N/A	17.5	In Deep water - 24m
Entrance Chan.	250	N/A	183	14.5	243	60.0	0.0	60.0	1:12	1:12	17.5	
Entrance Chan.	750	N/A	183	14.5	229	46.0	0.0	46.0	1:12	1:12	17.5	
Entrance Chan.	1250	N/A	183	14.5	216	33.0	0.0	33.0	1:12	1:12	17.5	
Entrance Chan.	2000	N/A	183	14.5	194	11.0	0.0	11.0	1:12	N/A	17.5	Design depth change
Mole End	2210	Mole End	183	14.5	190	7.0	0.0	7.0	N/A	N/A	16.5	Deep water hole (23m max) at Mole end
Howletts	2400	N/A	183	14.5	188	5.0	0.0	5.0	1:10	1:7	16.0	Design depth change
South Spit	2705	Bcn 1 L/H	183	13.0	186	3.0	0.0	3.0	1:10	1:7	16.0	
South Spit	3265	Bcn 1A L/H	183	13.0	185	2.0	0.0	2.0	1:7	1:7	16.0	
Harington Point	3615	Har. Pt. Lght	183	13.0	195	12.0	0.0	12.0	N/A	N/A	16.0	Deep water hole (21m max) at Har. Point
Harington Bend	4100	Bcn 2 L/H	220	13.0	244	24.0	0.0	24.0	1:5	1:7	16.0	
Harington Bend	4370	Bcn 4 L/H	225	13.0	250	25.0	0.0	25.0	1:8	1:7	16.0	
Harington Bend	4740	Bcn 6 L/H	205	13.0	233	28.0	0.0	28.0	1:8	1:7	16.0	Deep water hole (19m max) center of channel
Harington Bend	5080	Bcn 8 L/H	190	13.0	224	34.0	0.0	34.0	N/A	1:7	16.0	Deep water hole (24m max) port side of channel
Off Otakou	5575	Bcn 10 L/H	183	13.0	219	36.0	0.0	36.0	1:8	1:8	16.0	Deep water hole (20m max) port side of channel
Off Otakou	5600	N/A	183	13.0	206	23.0	-13.0	36.0	N/A	1:8	16.0	Depth change, Otakou groyne port side
Cross Channel	6460	Bcn 12 L/H	183	13.0	200	17.0	0.0	17.0	1:8	1:8	15.1	
Cross Channel	6600	N/A	183	13.0	200	17.0	2.0	15.0	1:8	1:8	15.0	Depth change
Cross Channel	7805	Bcn 14 L/H	183	13.0	200	17.0	17.0	0.0	1:8	1:8	15.0	Deep water hole (15.8m max) center of channel
Tayler Point	8515	Bcn 16 L/H	183	13.0	200	17.0	17.0	0.0	1:8	1:5	15.0	
Dowling Bay	9005	Bcn 16A L/H	183	13.0	200	17.0	17.0	0.0	1:8	1:5	15.0	
Pulling Point	9710	Bcn 18 L/H	183	13.0	200	17.0	21.0	-4.0	1:6	1:7	15.0	Deep water hole (16.0 m max) center of channel
Hamilton Bay	10255	Bcn 18A L/H	183	13.0	200	17.0	5.0	12.0	1:6	1:7	15.0	Deep water hole (17.1 m max) center of channel
Acheron Head	10620	Bcn 19 L/H	183	13.0	200	17.0	21.0	-4.0	1:6	1:1	15.0	Rock on Stb Batter at Acheron Head
Deborah Bay	11280	Bcn 20 L/H	183	13.0	200	17.0	25.0	-8.0	1:3	1:3	15.0	
Deborah Bay	11300	Bcn 20A L/H	183	13.0	200	17.0	25.0	-8.0	1:3	1:3	15.0	
Deborah Bay	11595	Bcn 22 L/H	183	13.0	200	17.0	27.0	-10.0	1:3	1:3	15.0	
Rocky Point	11870	Bcn 24 L/H	184	13.0	210	26.0	37.0	-11.0	1:3	1:3	15.0	
Turning Basin	12300	Bcn 24A L/H	274	13.0	387	113.0	112.0	1.0	1:3	1:3	15.0	
Turning Basin	12400		337	13.0	451	114.0	111.0	3.0	1:3	1:3	15.0	
Turning Basin	12600	Bcn 26 L/H	464	13.0	529	65.0	43.0	22.0	1:3	1:3	15.0	
Berth Pockets		N/A	37	13.5	50	13.0	N/A	N/A	1:3	1:3	16.0	Berth Pockets - allow for clearance at zero tide

Typical cross sections at selected locations of the channel are shown on the following Drawing 11090/1.



The design drawings show the "declared depth" which is the depth that can be relied on for purposes of shipping movements. In order to achieve the declared depth, overdredging will occur of up to 0.5 metres south of the Mole End and up to 1.0 metre north of the Mole End. The greater depth of overdredge allowance north of the Mole End is due to the larger sea-swell in that area increasing the movements of the dredge, which makes accurate depth control of the drag-head more difficult.

The approach channel is to be increased to a minimum declared depth of 17.5 metres below chart datum from the landfall tower (0.00 metres) to chainage 2,500 metres (a point just north of the Mole End).

A slight realignment of the centreline of the direction of approach to the harbour entrance will require up to 65m widening of the channel to be carried out on the western edge of the entrance channel.

From chainage 2,500 metres the depth will be reduced to a declared depth 16.0 metres below chart datum to chainage 5,600 metres, being a point approximately two thirds of the way around Harington Bend.

Over the next 1,000 metres to chainage 6,600 metres the sea bed will gradually slope up to achieve a depth of 15.0 metres and continue at that depth for the remainder of the channel up to and including the Port Chalmers basin.

The alignment of the new channel is centred predominantly on the existing centreline alignment. Widening and realignment along the inner edge of each of the bends at Harington Bend, Taylers Point, Pulling Point, and opposite Deborah Bay up to the Port Chalmers turning basin are required.

Rock Removal

The upgrading of the channel necessitates removal of rock at Acheron Head and Rocky Point at the positions shown on Drawing 11090 (page 6). This work cannot be carried out by a suction dredge and requires the use of explosives and a backhoe dredge or grab dredge.

The Swinging Area

The changes to the Swinging Area are shown in Drawing 11090 (page 6).

The width of the swinging area is to be increased by up to 115m with a significant volume (approximately 710,000m3) of dredging to be carried out along the eastern edge.

The declared depth in the swinging basin area is to be increased to 15.0 metres.

The Alterations to the Berths

The berths alongside the Container and Multipurpose Wharfs are to be deepened to 16 metres and widened from 37 to 50 metres including the area alongside the extension to the Multipurpose Wharf.

2.2.2 The Dredging Program

The volume of material to be removed from the Lower Channel, Swinging area and Berths is up to 7.2 million m^3, this volume includes an allowance for overdredging to an average depth of 0.3m over the whole of the dredged area.

Drawings 11112/1 and 11112/2 (page 9) show the depth that will be dredged from the existing seabed level to achieve the proposed declared depths. They also show the extent of excavation away from the channel.

The channel upgrading will take place in three stages. The reasons for the choice of the proposed methodology are discussed in Section 4 of the proposed AEE.

The stages are:

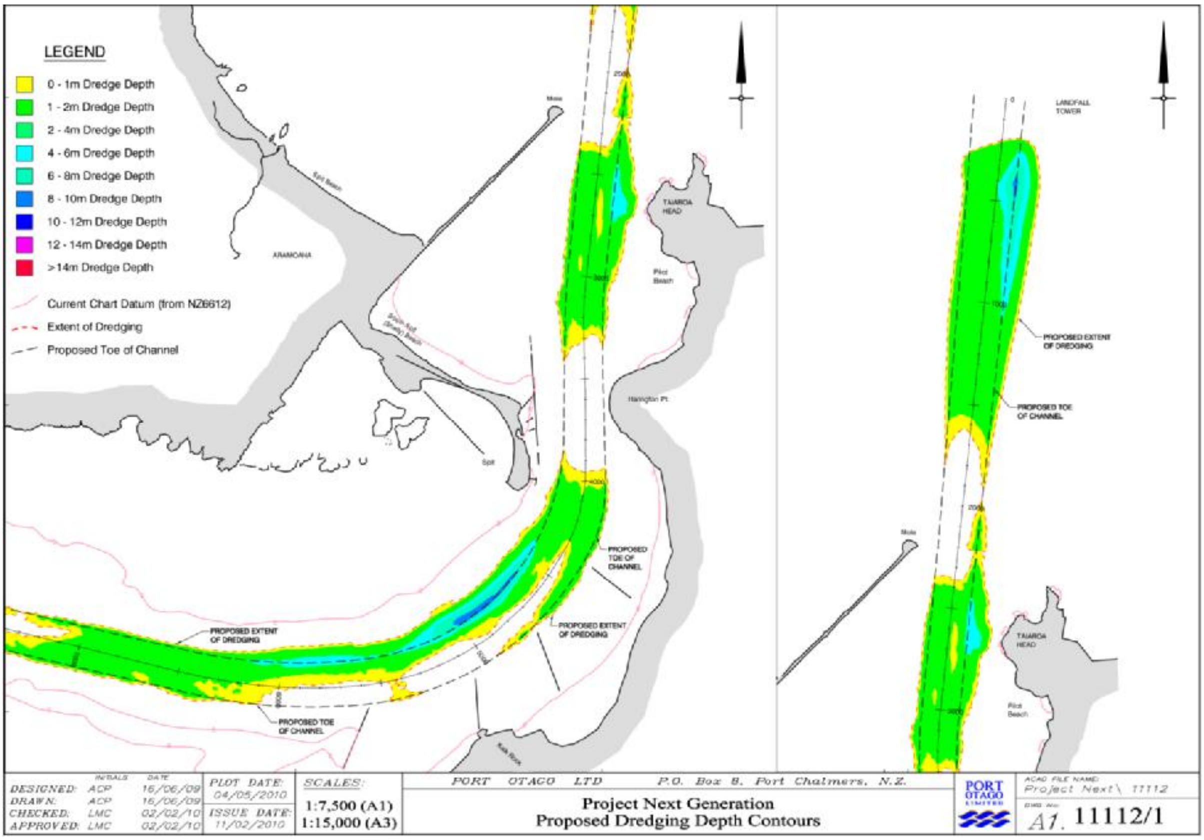
(1) The extension of the current maintenance dredging programme in the whole harbour using existing Port Otago plant (or that of similar size and scale). This will be done by increasing the hours of operation and including development dredging in the lower harbour. This will result in up to 1.45 million m^3 of spoil being removed each year (including the spoil from maintenance dredging);

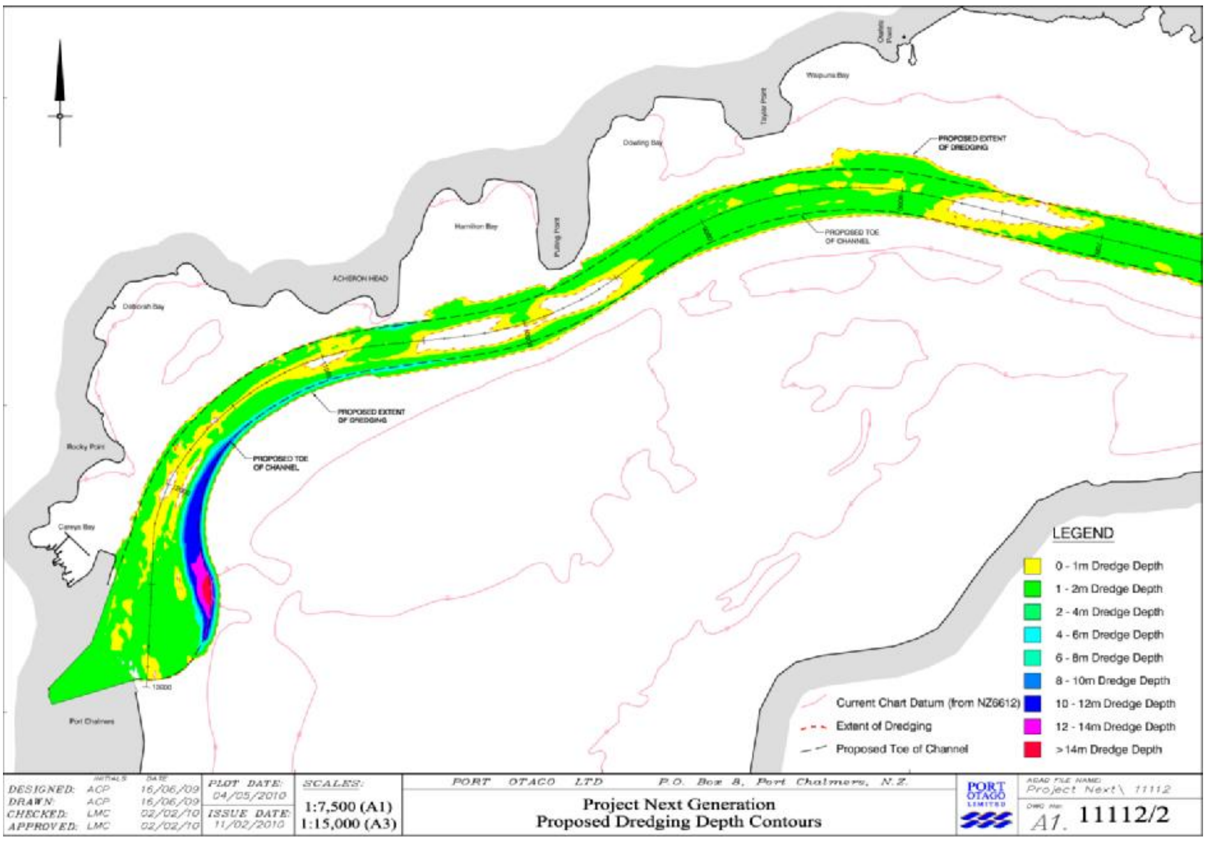
(2) The work requiring a backhoe dredge or grab dredge being:

- **(i) Rock removal and the alterations to the berths;**
- **(ii) The preliminary removal of spoil down to a depth of approximately 9 metres in the swinging area and bends of the channel in order to give the large suction dredge access to those areas. This work is likely to be carried out at the same time as the rock removal because the backhoe dredge or grab dredge can be used for both purposes.**

(3) The completion of the remaining dredging by an international dredging contractor using a large specialist TSHD (Trailer Suction Hopper Dredge). This will likely be undertaken only once shipping companies notify Port Otago of the imminent arrival of the larger ships.

Each stage is discussed in the following sections and further detail is contained in the Dredging Methodology Report (Pullar & Hughes 2009).





2.2.3 Stage 1: Extension of Maintenance Dredging

Port Otago envisages that demand for the upgraded channel could occur anywhere between 2 and 15 years from now. However, it is proposed that some work would begin immediately following the granting of consent using Port Otago's existing dredge plant. The advantage in starting work on the channel then is that it can be carried out at a lower intensity over a longer duration. Once notification is received of the arrival of the new vessels there will be a requirement to complete the upgrading work quickly using the larger contract dredge.

Upgrade work carried out to improve the channel at lower intensity will also benefit existing port operations as it will improve the ability of existing vessels to leave the port fully laden at all stages of the tide.

Port Otago existing plant will be used for this initial work, being its trailing suction dredge "New Era" (used for maintenance dredging and authorised incremental improvements) along with, to a lesser extent, the "Vulcan" grab dredge. Alternatively plant of a similar size and scale of operation may be used. These two items of plant are shown in the following Figures 1 and 2.

Figure 1 – Port Otago Trailer Suction Dredge "New Era"

Figure 2 – Port Otago Grab Dredge "Vulcan"

It is proposed to make a start on the dredging using the New Era by extending its operation from 46 hours per week to one which could operate up to 24 hours a day 7 days a week. The dredge is crewed by full time Port Otago staff and additional crews would be trained to enable these additional hours to be worked.

The work will be done in conjunction with maintenance dredging and is effectively an extension of the work currently being carried out. The New Era is quieter than a large contract dredge and its lesser size results in significantly lower generation of turbidity. The flexibility provided by the smaller scale of dredging using the New Era assists the management of environmental effects and the plant can be operated to ensure the noise from its operations does not exceed construction noise guidelines.

The limitation of using the New Era is its comparatively low capacity and hence the time taken for the work to be carried out. Each load of spoil taken by the New Era is 600 m^3 compared to a load of 11,000 m^3 for a large contract dredge. It would take up to ten years for New Era to solely complete the upgrading work of the channel that does not require the back-hoe or grab dredge but it seems unlikely that Port Otago will have this much time before the deeper channel is required. Hence Port Otago needs to be able to use a large TSHD once the time for completion of the channel becomes critical.

Put another way, while it is possible that the New Era may be utilised for parts of the dredging, its limited size makes it impractical that it undertake all works, the sizeable portion of which would be undertaken by a much larger trailing suction dredge.

2.2.4 Stage 2: Work requiring a backhoe dredge or grab dredge.

The work requiring a backhoe dredge or grab dredge comprises:

(a) The removal of rock from two areas within the lower channel.

(b) Extending and strengthening the container berth areas.

(c) Preliminary work on the extension to the Swinging Area and the bends of the channel to a depth of up to 9 metres to allow the trailing suction dredge to operate in those areas.

The plant is likely to be working 24 hours a day and 7 days a week with two exceptions:

(a) The use of explosives will only take place during daylight hours.

(b) The work that is underneath and adjacent to the Container and Multipurpose Wharfs will be constrained by the tide.

Mitigation measures are proposed where the effect of noise from this work exceeds the construction noise guidelines. These comprise:

- Reducing dredge noise as far as practicable by using mufflers and other related best practice techniques.
- Taking advantage of weather conditions that either raise the background noise, or reduce sound propagation in particular directions.
- Consultation with the local community to inform people of the extent and duration of the dredging activities as it might affect them.
- Programming night-time dredging activity away from residential areas.

Port Otago has extensive experience with blasting of rock in Otago Harbour and the following mitigation measures are proposed to reduce effects:

- **Removal of resident fish prior to blasting (ie crayfish).**
- **Visual observations prior to detonation (ie mammal watch).**
- **Undertaking blasting only during the daytime.**
- **Where appropriate undertaking traffic control during the blast.**
- **Use of best practice blast techniques (ie drilling and use of explosives).**

Figure 3 –Backhoe Dredge *Machiavelli (*Heron Construction Ltd)

Figure 3 shows the Backhoe dredge *Machiavelli* owned and operated by Heron Construction Ltd. It has a 230T backhoe excavator mounted on a floating barge which is loading a 750m3 hopper barge. This shows the backhoe mounted plant on a floating platform loading material into a floating barge.

Additional detail on each of the activities to be undertaken by the Backhoe or Grub dredge is provided below.

(a) Rock Removal

Rock in the Lower Channel at Acheron Head and Rocky Point will be removed from the areas at each end of Deborah Bay as is marked on Drawing 11090 (page 6).

The rock from each area has to be removed using explosives to dislodge the rock into manageable portions, which would then be removed by a backhoe dredge or grab dredge into dumb barges.

(b) Increase of Depth and Width of Berth Areas and Rock Placement

The increase of the depth of the areas underneath and adjacent to the Container Wharf and the Multipurpose Wharf (including the proposed extension to the Multipurpose Wharf) is described on Drawing 11130 (page 14).

There are three elements:

(i) Dredging the buttress areas to a depth of 18 metres and removing silt and clay.

(ii) Placement of two metres of rock to provide toe support to the sloping rock wall revetment that exists beneath the wharf structures.

(iii) The placing of the rock revetment on the slope as an anti scour protection and slope stabilisation.

The rock is required because the deepening of the area underneath and adjacent to the Container and Multipurpose Wharfs risks undercutting the existing piled wharf structure. The front and rear piles of the wharf support the considerable loads generated by the gantry cranes during the vessel loading and unloading, with the remaining central piles of the wharf supporting the main wharf deck which carries straddle carriers and large forklifts. The reclaimed area behind the wharf which forms the operational apron is protected from wave effects and is supported by a sloping rock revetment located beneath the wharfs to a depth of approximately 5.0 metres below chart datum (CD). As a result of the deepening to 18.0 metres below CD, the support at the base of this revetment will effectively be removed. This has the potential, particularly as a result of earthquake excitation, to result in a rotational failure within the reclaim.

To reduce the risk of this rotational failure, the sloping rock revetment is to be extended down to the newly dredged level and any silt or clay material beneath the wharf that is not currently protected by rock will be covered with a protective layer of rock. It is intended that this rock will be sourced from rock excavation at Rocky Point and/or Acheron Head, but rock may also be used from an approved land based quarry (such as Palmers Quarry). This would occur if the rock removed from the channel is unsuitable.

Further support is to be provided at the base of the revetment slope by forming a buttress or mattress of rock at the invert of the berth pocket. This buttress is a minimum of 2 metres thick and 8 metres wide for the full 600 metres of both wharfs. The lower excavated level of this buttress has been designed at 18 metres below CD to allow for the 2 metres of placed rock plus a 1 metre siltation allowance, giving a final berth depth of 15.0m.

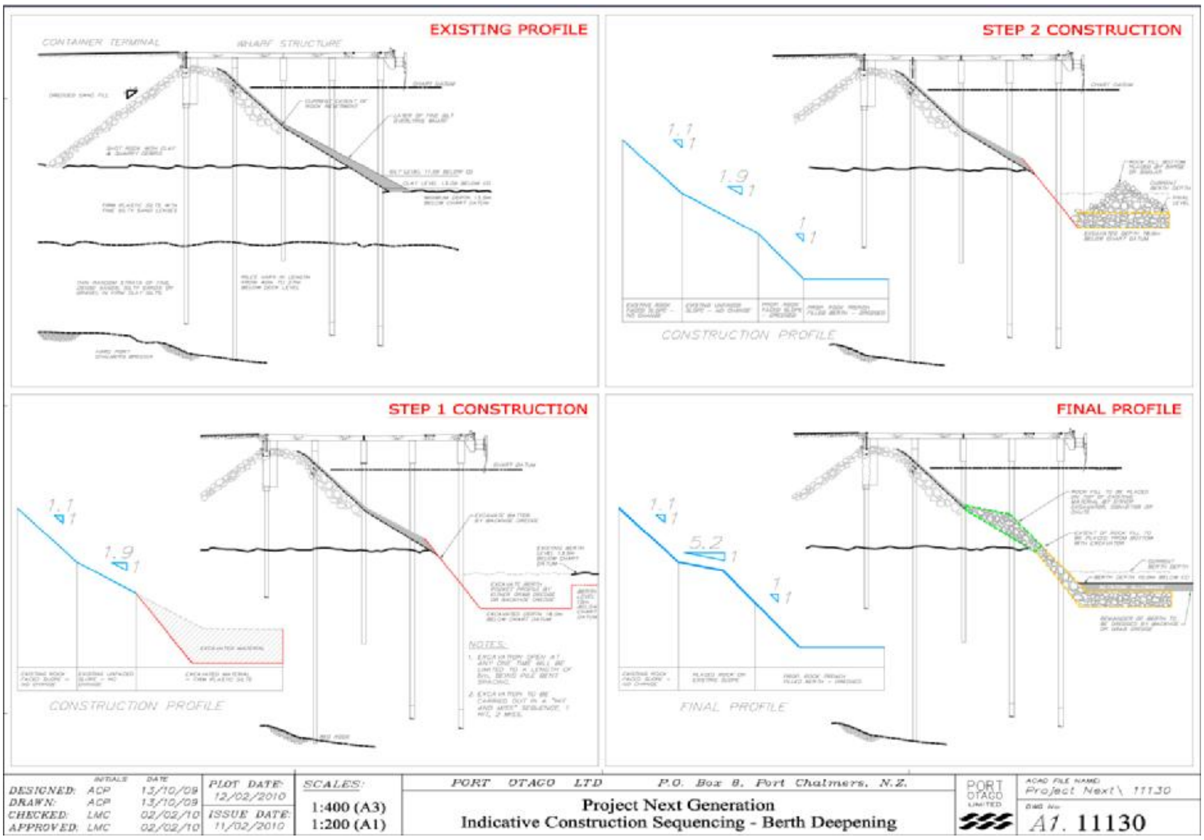
The rock would then be placed on the sloping revetment.

The following Drawing 11130 outlines the details and sequence of the deepening works and slope protection.

The methodology described below may be subject to change after discussion with the successful contractor but is necessary to protect the integrity of the wharf structures while the work is being carried out:

(i) Excavate "buttress" trench at base of slope to a depth of 18.0 metres below CD utilizing either grab dredge or backhoe.

(ii) Excavate revetment trench between piles bents (or bays) to the profile shown using GPS guided long reach backhoe equipment.



(iii) **Buttress and revetment excavation will be limited to one consecutive pile bent open at any one time with excavation sequencing to follow a hit and miss pattern, 1 hit to 2 miss as set out in the following construction sequence:**

Pile Bent No	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Construction Sequence No.	**1**	**7**	**12**	**2**	**8**	**13**	**3**	**9**	**14**	**4**	**10**	**15**	**5**	**11**	**16**	**6**

(iv) **Once the design depth has been reached, rock (preferably sourced from either Rocky Point or Acheron Head) will be placed in the buttress excavation.**

(v) **The excavator will then move material up the revetment slope and be placed in position.**

(vi) **Once the rock has reached the second pile row back from the seaward face of the wharf then further rock can be stacked or placed from the top - this can be achieved by either a long reach excavator, conveyor or chute loaded either from a barge or back tipped off the wharf.**

(vii) **The final profile and extent of rock protection will be checked on completion to ensure compliance with the design.**

The work is complex and includes working in limited space due to tidal restrictions. This means that work will be carried out over an extended period.

(c) Preliminary work on Swinging Area and Channel

This work is a preliminary lowering of the swinging area and other areas where widening is to be undertaken (particularly at the bends) with the work being carried out using a backhoe dredge or grab dredge accompanied by dumb barges.

Lowering the seabed level in shallows and intertidal areas is required to enable the large trailing suction dredge to gain access. Although some advantage can be gained by working these areas at the higher stages of the tide, a water depth of at least 6 metres below chart datum is required for the New Era and a depth of up to 9 metres below chart datum may be necessary for a large contract dredge.

The shallow areas will be worked from floating plant moored or mounted on spuds (legs) directly alongside the area to be dredged. The backhoe dredge or grab dredge will remove the material and load this either into dumb barges or a self propelled hopper dredge/barge such as the New Era. Barges will be tied up directly alongside the backhoe or grab platform. Full barges will be towed to the disposal site and self propelled vessels will steam to the disposal site.

The preferred method is to lower the sea bed to approximately 6 metres below chart datum and then use New Era to continue to at least 9 metres as New Era draws considerably less water and can work in shallower depths than the large contract suction dredge. However, if there is insufficient time to allow the New Era to carry out this work then the backhoe or grab dredge may be used to lower the bed level below 6 metres to approximately 9 metres.

2.2.5 Stage 3: Major Capital Dredging

The most efficient method of completing the dredging to the required design depths is through the use of a large trailing suction dredge. This is likely to occur after Port Otago has been notified of the arrival date of the larger vessels that require the increased channel dimensions. It is not possible to predict accurately when this will occur because this depends on the global economy and the commercial considerations the shipping lines need to make prior to committing the larger ships to New Zealand.

This capital dredging program will take several months (6-8) with the plant working 24 hours a day. The actual duration of this dredging will be dependent on the size and specifications of the contractor’s dredge used, whether the preliminary work has been completed and the amount of work that has been able to be carried out using the New Era before the large contract dredge commences work.

Total dredging time, vessel turnaround and the number of transits the vessel needs to make are directly related to hopper size and the dredge’s pumping capacity. Dredging efficiency is further increased if the dredge is able to complete a number of longer runs without the need to turn around. Turning the vessel not only requires the dredge to slow, but also results in the draghead(s) being raised from the surface of the seafloor. With dredging runs of between 2,000 and 3,000 metres the hopper may be filled to capacity (subject to whether the claim is in sand or silt) in as little as two passes.

The detailed method of dredging will be determined during and following the tendering process, and will depend on the available plant and the experience of the international dredging contractor who is awarded the contract. The dredge may be required to work a number of areas concurrently as dredging times may require management in some areas to daytime hours where necessary to reduce the level of noise experienced by the community at night, or for other environmental reasons. The mitigation measures outlined above in section 2.2.4 are also applicable to the large TSHD.

The selection of a suitable contractor will be based on a number of criteria including the condition of their plant, their environmental management procedures, the noise generated by its plant, the method of and ability to minimise adverse effects (i.e. the controlling of overflow by the installation of "green valves"[2]).

The dredging contractor will also be required to undertake the dredging in accordance with a Dredging Environmental Management Plan which is discussed in Section 7.

The contract will ensure technical capability and competence of staff, attention to detail and processes in place to monitor environmental effects.

Figure 5 below shows the dredge Volvox Asia, operated by Van Oord, which is a 10,800m3 hopper capacity trailing suction hopper dredge (TSHD). Dredges of this size are envisaged as the largest TSHD dredges that would be able to be able to undertake the major capital dredging work due to the constraints of the channel and upgrading work required.

Figure 4 – *Volvox Asia*, 10,800m3 TSHD

2.2.6 Maintenance of New Channel Depth after Completion of Capital Works

Once the development is complete then it is intended that the New Era revert to its current maintenance dredging programme with its operation being essentially the same as that which occurs at the present time.

[2] A "green valve" is an adjustable valve which chokes the flow to reduce the air that is taken down in the overflow mixture leaving the hopper. The result is a denser particle stream, causing less turbulence, and taking the overflow sediments more quickly to the sea bottom.

The existing maintenance dredging programme is described below.

There are five main areas that require maintenance dredging in Otago Harbour: the Entrance Channel; the lower harbour channel; the Port Chalmers Inner Basin and Berths; Victoria Channel and the Dunedin Basin and Berths, however, the latter two are not part of this application and will not be mentioned further.

The maintenance dredging in all areas, other than the Port Chalmers basins and berths is able to be carried out with the trailer suction dredge "*New Era*". This dredge has a large suction pump and trailing dredge pipe with a drag-head containing a rotating visor at its base. The operation is similar to that of a vacuum cleaner. The drag-head is lowered to the sea floor and dragged along the bed as the dredge moves forward. A mixture of sand, silt and sea water is pumped up though the dredge pipe and this mixture is deposited into the dredge hopper. In the hopper the solids quickly settle out, and the water and some of the finer material such as silt that remains in suspension flows back overboard through the discharge chute, into the harbour channel. A full load of sand is firm enough to walk on in the hopper and is very close to the natural or in-situ density of undisturbed sand on the sea bed. Port Otago also uses a barge mounted grab dredge "Vulcan" to dredge less accessible areas and for materials which tend to be more difficult to remove including clays and rock.

The time taken to dredge the various channel areas is generally proportional to the amount of silt and clay within the dredge spoil. A load of clean sand from the entrance area can be dredged in 1 hour whereas it may take up to three hours to obtain a full load from the Leith claim near the Dunedin basin, which has higher silt content. The higher proportion of silt results in slower settlement of material in the hopper and more fines flowing overboard during the loading process.

(a) Entrance Channel

The entrance channel is bounded along its eastern edge by a large accumulation of sand forming a bar. The tidal currents on the ebb tide assist greatly in maintaining the position of this channel.

However, once seaward past the outer end of the Mole, the ebb tide strength decreases and sand is constantly being deposited along the eastern channel toe-line. This accretion or build up of sand is further exacerbated during easterly storms as the increased wave height and energy deposit large quantities of material over the bar.

The maintenance dredging of the entrance channel is a significant component of the dredging effort required to maintain the lower harbour with an estimated 60,000 m^3 per annum removed in order to maintain an existing channel toe line design depth of 14.5 metres.

The material dredged from the entrance channel is generally clean fine to medium grained sand.

(b) Lower Harbour Channel

The areas within the Lower Harbour Channel where deposition occurs and which require regular maintenance are located along the inner edge of the bends. This is primarily as the result of the currents being considerably weaker in this region with the result being they are no longer able to transport the sediments either in suspension or as bed load.

The material dredged from the Lower Harbour Channel comprises predominantly fine grained sand, although some areas contain a component of shell. The proportion of silt contained within the spoil increases with distance from the harbour entrance. Floating seaweed is at times collected by the dredge although this tends to be seasonal and is particularly prevalent following a period of strong winds. Sea tulips can become established in the areas that are less frequently dredged.

The areas within the channel that require maintenance dredging amounts to approximately 5% of the total area of the channel invert area, the remaining areas being deeper than the design depth of 13.0 metres as a result of the natural scour of the tidal currents.

(c) Port Chalmers Inner Basin and Berths

The material within the Port Chalmers inner basin and berths varies from clayey silt at the container berths to rock at the Beach Street berth on the eastern side of the basin.

The dredging of these areas is carried out using the heavy digging clamshell bucket suspended off a barge mounted crane. The suction dredge is unable to dredge the silt, clay and rocky bed and has difficulty manoeuvring within the confined areas of the basin.

Deepening adjacent to the Beach Street berth was carried out in the early 1990's. This required drilling and blasting to fracture and dislodge the rock. Some isolated areas that were not taken down to the design depth at that time continue to be worked on using the grab dredge progressively as the rock becomes more weathered.

2.2.7 Dredging Terminology & Effects

The report by Pullar and Hughes (2009), Dredging Methodology and Disposal Alternatives describes in greater detail the various types of dredging activities and the types of effects associated with each type of equipment. In brief summary terms there are 3 separate sources of effects depending on the type of dredging equipment

- **The disturbance of the sea-bed itself whether that be from the draghead of a TSHD of from a grab or bucket of an excavator.**
- **Loss of material from a grab or excavator bucket as the dipper arm is brought up through the water column to be loaded into a barge.**
- **The overflow water from either the hopper of THSD or a dumb barge being loaded mechanically. An alternative technical description that is sometimes used is "decant water".**

2.3 Disposal of Dredged Material

2.3.1 Introduction

The upgrading of the channel, berths and swinging area requires up to 7.2 million m^3 of material to be removed from the harbour. This largely comprises sands (62%) with the balance being silts (34%) and a small component of clays (3%) and rock (1%). These proportions of material were assessed by Opus (2009) in their interpretative report, which used the design channel as well as the factual information from borehole and vibrocores detailed in the report Geotechnical Factual (Opus 2008). Further details of the sediments encountered are contained in Section 5.2.

As discussed in more detail in Section 4, there is no practical alternative to the disposal of this volume of dredged material at sea.

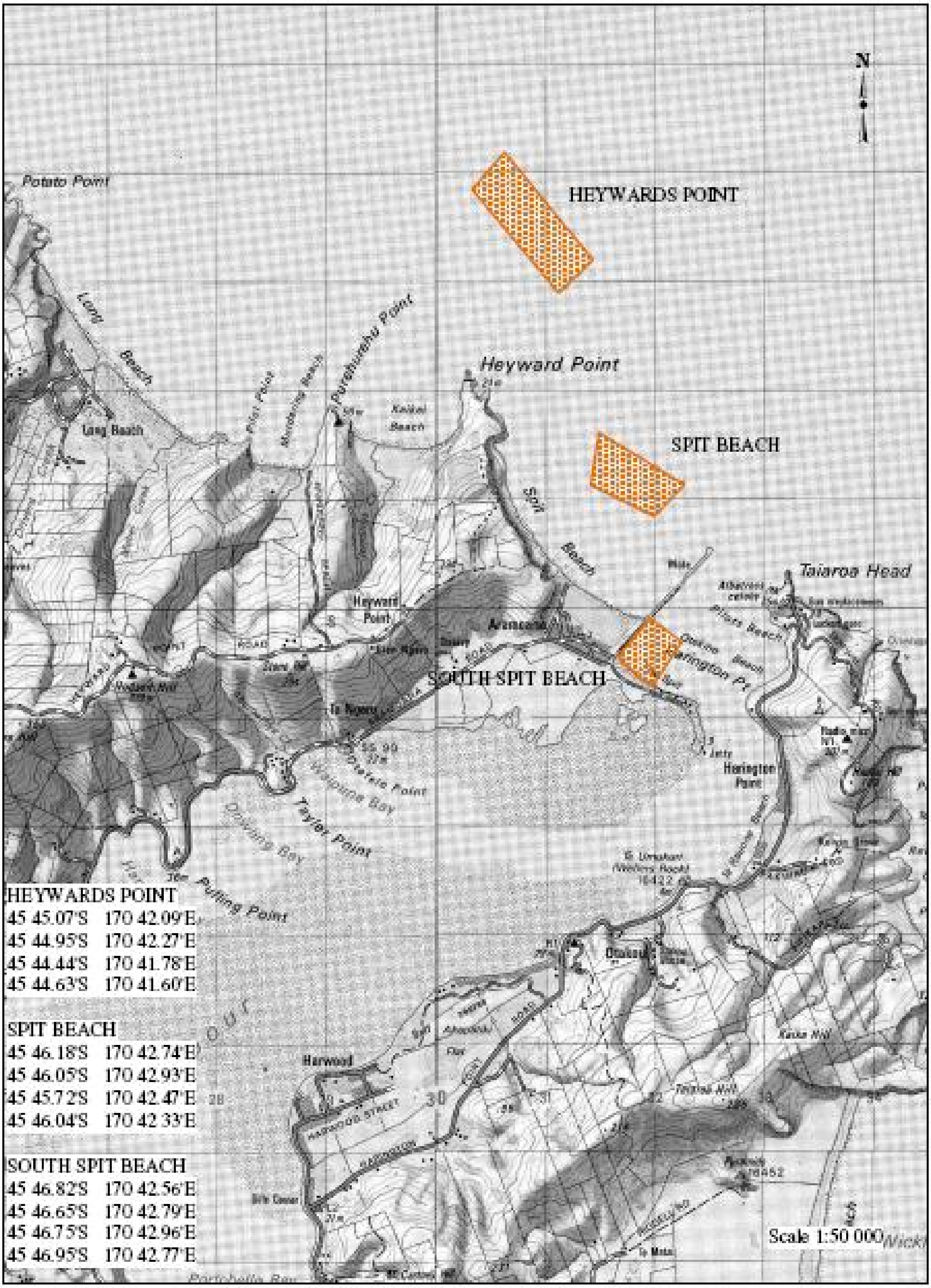
There are detailed records of dredge spoil from the harbour being disposed of at sea since 1914 although it probably occurred at a much earlier date as dredging has been an integral part of the development and maintenance of Otago Harbour since the 1860's. This history is outlined in more detail in Davis (2009), Short History of Otago Harbour Development and Dredging.

Prior to 1985 all dredged material was placed at the Heyward Point site. This included material derived from both development and maintenance dredging. In 1985, the Spit disposal site was first used and this has become the preferred location in recent years because it is closer, resulting in the dredge spending less time going to and from the disposal site. These two sites are shown in Figure 5

The Heyward Pt site tends to be preferred in rough weather as it can often be calmer than the Spit site due to the greater depth of water available.

A third location, South Spit (Shelly) Beach (also see in Figure 5) was added as a further option in 1987. Sediment was placed here to assist in re-nourishing Shelly Beach which was suffering from erosion. The site has a limitation in that only sand from claims seaward of and including Tayler Bend is able to be disposed of to ensure that material moving onto the beach is of similar composition to the sand that already exists there. There is also a limit to the quantity of sand that is able to be disposed of in any one year. Shelly Beach is a particularly useful location when the weather is too rough to take the suction dredge out to sea.

The disposal of the sediment from Project Next Generation requires the dredge or the dumb barges to steam or to be towed to within the boundaries of the disposal site. Once in position the vessel splits open along the entire length of the hopper using an onboard hydraulic system. As the vessel continues moving through the water, the dredged sediment falls from the hopper with any remaining material being washed from the hopper sides by wave action. All of Port Otago's current dredging plant is the split hopper variety which generally discharges the entire load in less than 10 minutes.



Dredge Spoil Grounds

Figure 5: Schedule 5 from the ORC Coastal Plan showing the existing consented disposal grounds.

Both the trailer suction dredges and the tugs used for towing the dumb barges navigate using differential GPS to enable precise positioning within the disposal grounds.

There are three different aspects to spoil disposal for Project Next Generation:

(a) Disposal from authorised dredging (capital and maintenance) will continue to be disposed to the existing disposal sites up to the volumes permitted under the existing consent, including managing the disposal to ensure that 90% of the capital dredging material disposed over any 12 month period is sand.

(b) The rock from Rocky Point and Acheron Head that is not required for the berth areas will be disposed of at the Heyward Point site and will form part of the existing volume permitted to be deposited at that site. This activity is being consented as part of this application.

(c) The balance of the disposal from dredging is to go to a new offshore disposal site "A0".

2.3.2 Disposal to existing disposal sites

Port Otago currently utilises three separate sites to dispose of maintenance dredgings. These are referred to as Heyward Point, Spit Beach and South spit Beach (or Shelly Beach), and are located as follows:

(i) Heyward Point

45° 45.07'S 170° 42.09'E
45° 44.95'S 170° 42.27'E
45° 44.44'S 170° 41.78'E
45° 44.63'S 170° 41.60'E

(ii) Spit Beach

45° 46.18'S 170° 42.74'E
45° 46.05'S 170° 42.93'E
45° 45.72'S 170° 42.47'E
45° 46.04'S 170° 42.33'E

(iii) South Spit Beach (Shelly Beach)

45° 46.82'S 170° 42.56'E
45° 46.65'S 170° 42.79'E
45° 46.75'S 170° 42.96'E
45° 46.95'S 170° 42.77'E

The resource consent for these disposal sites expires in December 2011 and a separate work program of study and assessment is being undertaken at the present time in order to be able to renew that consent. It is important to note that the disposal of sand and silt material from Next Generation capital deepening and widening to the existing disposal grounds, is part of the Next Generation applications. This is achieved by applying to vary the conditions of the existing consent.

As discussed further in Section 2.3.3 the disposal will be managed between the existing sites and the new "A0" disposal site, and also managed to limit the amount of fine material disposed of at these existing disposal grounds. The total volume of material to the existing sites will be within the existing consented volume of 450,000m3 per annum. The only difference between the proposed disposal and that currently undertaken will be that material will be taken from slightly different depths or geographical locations (due to the deepening and widening of the channel, swinging area and berths) than is allowed under the existing consent.

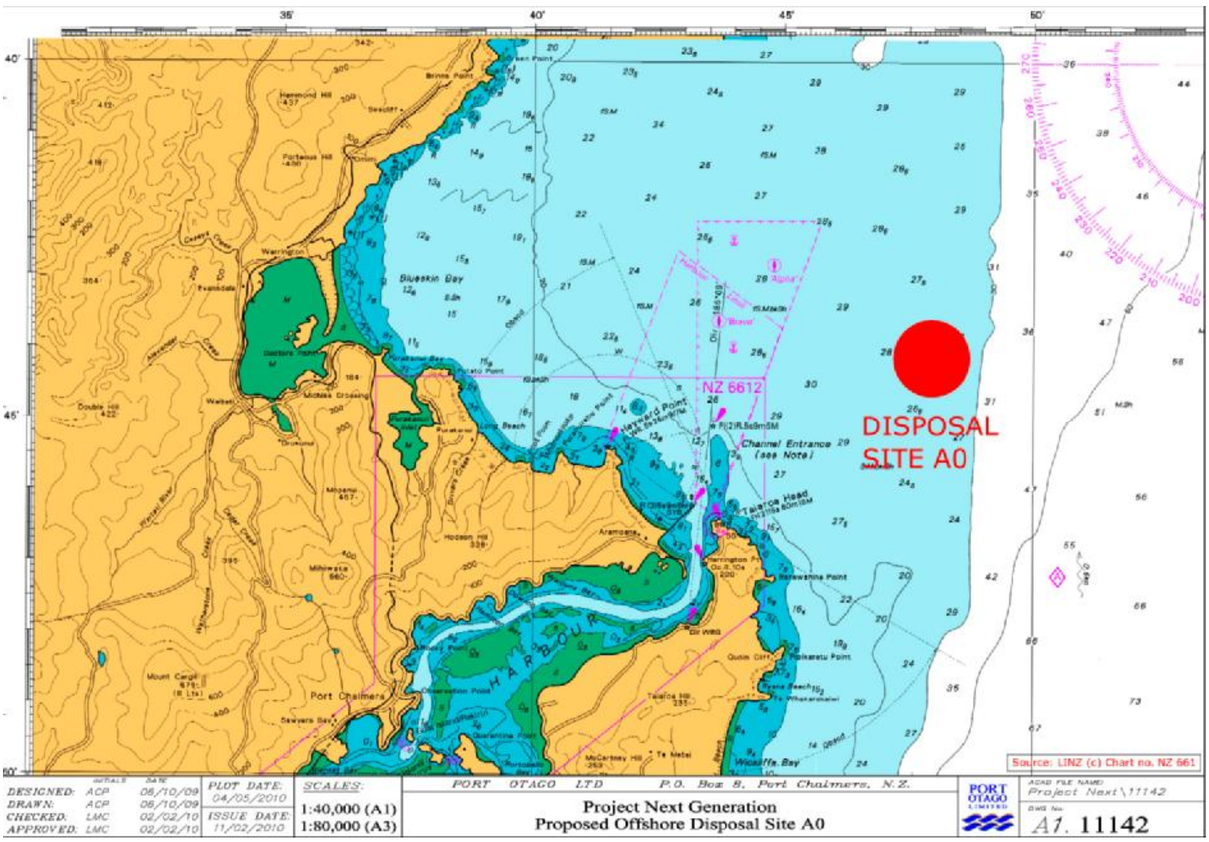
2.3.3 Disposal to new Disposal site

Consent is sought for a new disposal site. The new disposal site is in approximately 27 metres of water (below Chart Datum) at an offshore location on the "Peninsula Spit" sand feature, centred at or about Latitude 45.735 S, Longitude 170.80 E, or about 6.3 kilometres to the northeast of Taiaroa Head as shown on Drawing 11142. This site has been chosen because of its suitability as a receiving environment based on detailed scientific and environmental studies. More detail on the site selection process is provided in Section 4.

The new offshore A0 disposal site will be used as follows:

(a) Until a large contract dredge is used on the project, dredging spoil (other than rock from Acheron Head and Rocky Point) will be divided between the existing disposal grounds and the new "A0" site. There could be up to 1 million m^3 a year disposed of to the new site but generally the disposal is likely to be less than 500,000 m^3 a year.

(b) When the large contract dredge is used then the balance of the total volume of 7.2 million m^3 will be disposed of to this site in a period of less than 6-8 months with the actual volume depending on the progress that has been made by the New Era at the time of arrival of the large contract dredge.



The offshore "A0" would not be used for the disposal of spoil from maintenance dredging once the capital work on the channel is completed as its distance from shore both restricts access by the New Era when seas are rough and also increases the cost of disposal.

2.4 Multipurpose Wharf Extension and Fishing Jetty

2.4.1 Overview

The extension to the Multipurpose Wharf is 135 metres long and varies in width from 28 metres to 37 metres. The variation in this width is due to the change in alignment of the top of the rock slope of the existing reclamation. It is shown in Drawing 10991 (page 25).

The Fishing Jetty extends 30 metres into the Coastal Marine Area ("CMA") and is separated both vertically and horizontally from the Multipurpose Wharf. In addition there will be a fence at the northern end of the Multi-purpose wharf to separate the structures and maintain the required level of port security.

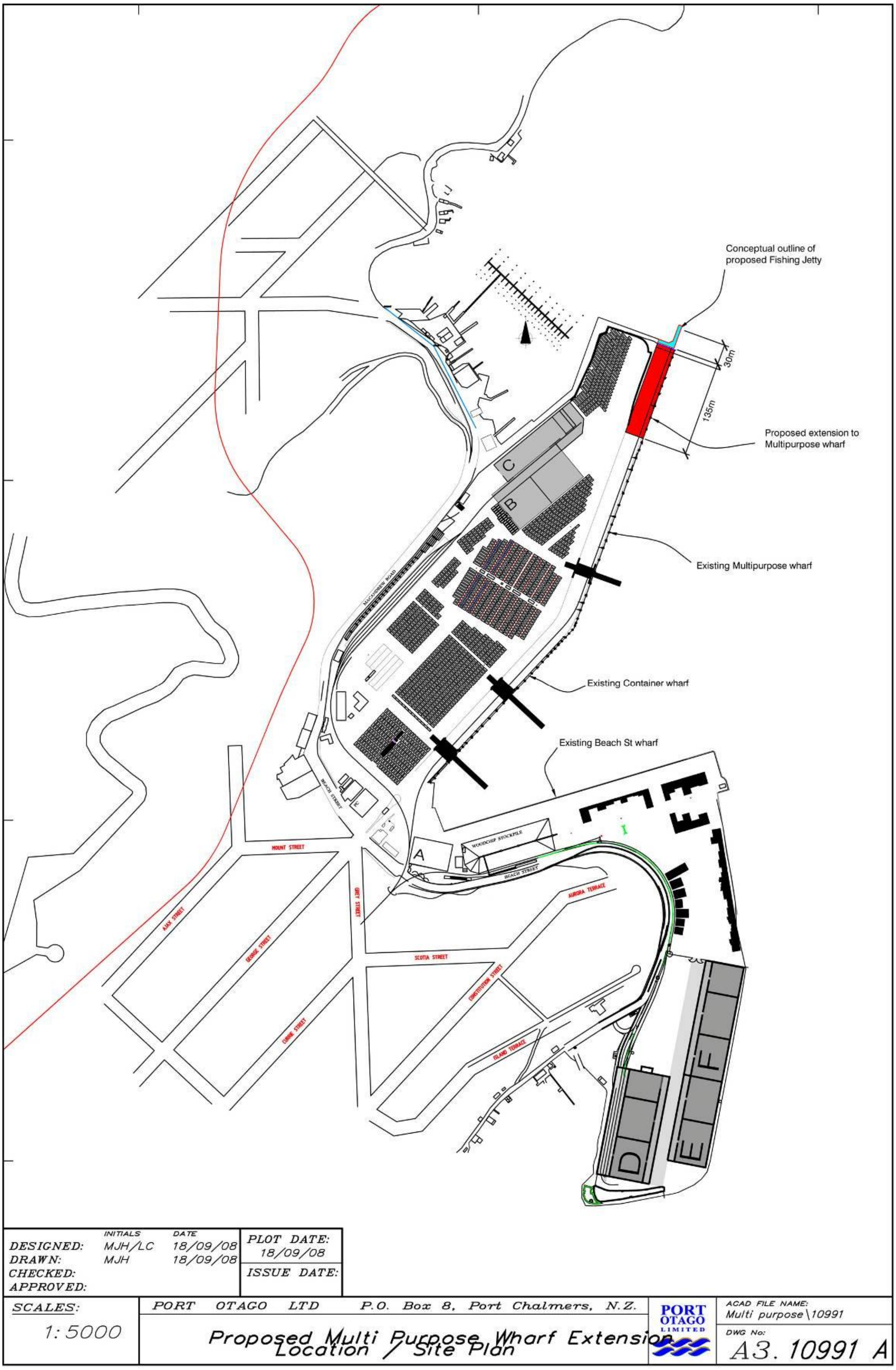
Both the wharf extension and the Fishing Jetty are within the area of the CMA that it is necessary that Port Otago occupy in order to carry out its Port related commercial undertakings.

The final design details and construction methodology may be altered slightly as a result of the tendering process and the contractor's preferred plant and methodologies. It will however be generally as described in this section.

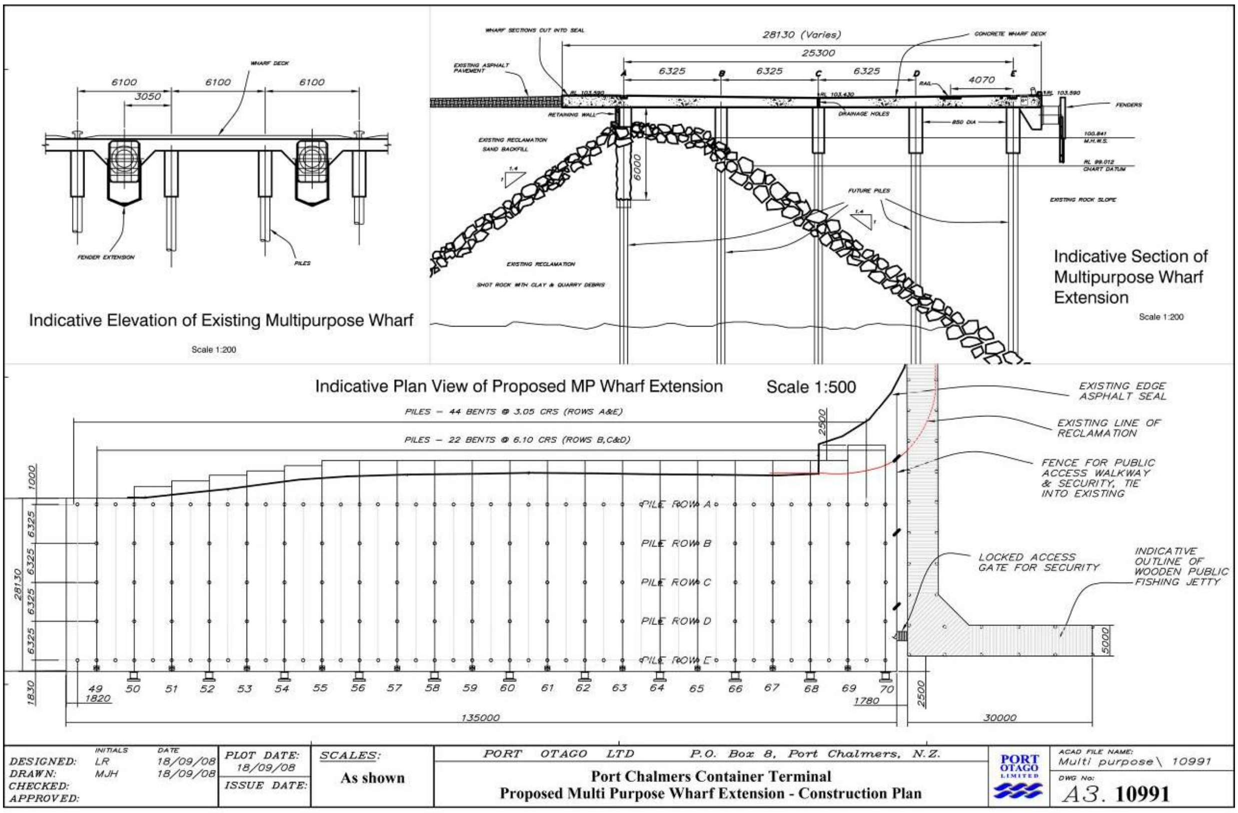
The 135 metres of extra (concrete) workable deck will sit on approximately 165 new piles at centres varying between 3.05 and 6.1 metres as shown on the construction drawings. The construction will allow all port equipment such as straddle carriers, forklifts and cranes to operate on the wharf.

The new Fishing Jetty structure will also be constructed on piles. The loads on this platform will be significantly less than the wharf extension therefore its structure will be of a smaller but appropriate scale of construction.

The following drawing 10991A shows the location of the proposed Multi-purpose wharf extension and Fishing Jetty:


Conceptual outline of proposed Fishing Jetty
30m
135m
Proposed extension to Multipurpose wharf
Existing Multipurpose wharf
Existing Container wharf
Existing Beach St wharf
A
B
C
D
E
F
WOODCHIP STOCKPILE
MOUNT STREET
GREY STREET
SCOTIA STREET
AURORA TERRACE
ISLAND TERRACE
DESIGNED: MJH/LC 18/09/08
DRAWN: MJH 18/09/08
CHECKED:
APPROVED:
INITIALS
DATE
PLOT DATE: 18/09/08
ISSUE DATE:
SCALES: 1:5000
PORT OTAGO LTD P.O. Box 8, Port Chalmers, N.Z.
Proposed Multi Purpose Wharf Extension
Location / Site Plan
PORT OTAGO LIMITED
ACAD FILE NAME: Multi purpose\10991
DWG No: A3. 10991 A

Drawing 10991 shows the construction plan for the wharf extension and fishing jetty.



2.4.2 Method of Construction

(a) Seaward Piles – Preparation / Driving

The piles are similar to those used for the wharf strengthening completed in 2006. Unless there is compelling design or material supply economies it is expected that the steel H piles will be used to support the wharf deck. Alternatively tubular steel piles of 500 mm to 600 mm diameter could be used which are similar to those used in the original wharf construction.

Based on the current wharf concept design it is expected that approximately 165 piles will be required for the wharf. It is noted however that this figure may vary depending on the final selection and availability of the proposed H piles or tubular steel piles.

The piles will be driven either from a floating barge, from land or from the advancing wharf deck.

Piles will initially be welded either on a barge or on the wharf deck. The piles will be lifted plumb into the driving rig and a heavy weight ("dolly") will be used to drive them to their design depth.

Piles will be in the order of 30 metres to 40 metres in length with two to three welds required to achieve the fully driven depth. Once the first 10 metre to 15 metre section is in position then additional lengths will be welded to the top of the driven section of pile.

Each pile will be driven through largely marine silts until the pile reaches the underlying layer of volcanic rock.

The disturbance to the seabed from pile driving is minimal with only the area immediately adjacent to the pile itself affected by the operation.

(b) Landward Piles – Preparation / Driving

For the 20 or so landward piles that are not in the CMA, there will be a need to drive the piles through the existing rock rip–rap material. The pile driving rig will be set up on land. To enable pile driving the rock will be lifted away in the locality of the pile. Any large boulders or cobbles will be shifted by an excavator or crane and then returned to their position once the construction of the pile collar and pile cap has been completed.

Construction of the extension landward of the mean high water springs is within the Port 1 Zone in the Dunedin City District Plan. The construction and use of the berth extension will be undertaken in accordance with the permitted activity provisions of the District Plan

(c) Construction of Reinforced Pile Collar

In the intertidal zone there is a requirement to provide a reinforced concrete pile collar. This is to provide corrosion protection, buckling resistance and mechanical protection for the pile above and below the waterline. The length of the collar will be between 3 metres and 11 metres from the underside of the wharf deck with its diameter approximately 600 mm.

A precast pile cap will be placed on top of this collar to support the wharf deck. Below the pile cap the collar will have a tubular steel former with a base plate cut to the shape of the H pile. This is to allow the former tube to slide over the top of the H pile.

At this stage or just prior to the placement of the collar the piles will have temporary bracing to the adjacent structure and to each other. The bracing is either welded rods or a steel frame to lock the adjacent piles together.

The welding and fitting of the collar formwork and the bracing will either be completed off floating plant (most likely a small barge platform) or off an adjacent deck structure.

Once the collar formwork is braced into position a lean mix of concrete will be used to seal the base of the tube. Once a reasonable seal has been achieved a pre-fabricated reinforcing cage will be positioned inside the collar formwork. The collar will then be filled with 50 MPa concrete up to the level of the precast pile cap. 50 MPa concrete is a very strong stiff mix and there is expected to be minimal amount of float water reaching the seawater directly below. Once the concrete has reached sufficient strength the pre cast pile cap will be lifted into position and concreted to the collar's reinforcing steel.

While it is anticipated that the pile cap will be pre cast, the contractor may also choose to cast the collar in situ, which could result in the discharge of a small amount of concrete float water.

(d) Wharf Deck Construction

The new wharf deck will use 300 mm pre-cast slabs as the formwork with a 500 mm layer of concrete forming the top of the deck. Once the pile caps are concreted in position a crane will be used to lift the pre cast concrete slabs into position. The reinforcing steel will then be placed with formwork used to confine the extent of the concrete pour.

Prior to the placement of the pre cast deck slabs the rock rip rap material removed to enable driving of the landward piles will be placed back into position to provide the required level of wave protection.

The existing rock rip rap wall is not a straight line but is angled away from the western edge of the wharf. The wharf deck is designed to span across and bear on the existing edge of the reclamation embankment.

Once the wharf deck is sufficiently strong the fitting of the bollard, wharf fenders and other fixtures will be progressed. These items will be fitted using a crane from the wharf deck although use of floating plant may also be required.

The installation of the cathodic protection system will follow completion of the wharf deck. Cables will be run along the rear edge of the wharf and at each pile a cable will be connected to a preformed connection on the pile collar. This installation process will be completed from a small floating platform that is able to be manoeuvred between the piles.

(e) Fishing Jetty

The fishing jetty is shown on Drawing 10991 (page 25) and will be wooden decking with railing over a concrete substructure that is light duty with no vehicle loadings designed for or expected.

The jetty will be similar in design to that reconstructed recently at Woody Point in Moreton Bay, Queensland which is shown in Figure 6 and Figure 7.

The substructure construction methodology is relatively simple being reinforced concrete beams and either concrete or steel piles. The decking currently on the Cross Wharf (between the Container wharf and Beach Street wharf) will be recycled and once dressed will be used as decking (refer Figure 8 on page 29 for a photograph). An assessment of the suitability and condition of this timber will be required as not all will be suitable for reuse as decking. Depending on the amount of timber available to be recycled from the Cross wharf, a section of deck may therefore need to be a different timber surfacing.

Figure 6 – Completed Moreton Bay Jetty – Substructure and Handrailing

Figure 7 – Completed Moreton Bay Jetty – Deck and Handrailing

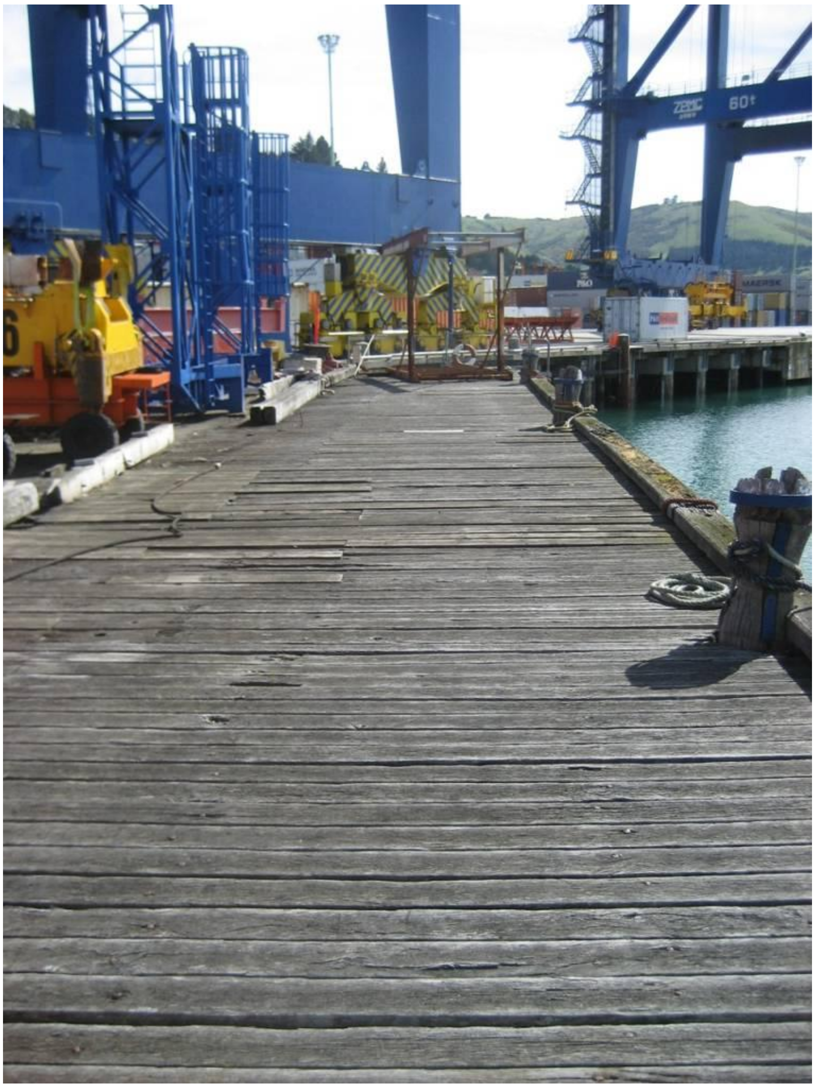


Figure 8 – Existing Cross Wharf Structure

2.4.3 Duration of Construction

The likely period of construction for both the multi-purpose wharf extension and the fishing platform is in the order of 16 months subject to the availability of contractors and plant.

3. PROJECT RATIONALE

3.1 Port Otago Limited

Port Otago Limited is the successor to the elected Otago Harbour Board and is wholly owned by the Otago Regional Council. It owns the land based commercial port infrastructure at both Dunedin and Port Chalmers, and has occupancy rights to the CMA at and adjacent to its berths and commercial port undertakings.

Port Otago currently maintains the commercial shipping channels, berths and swinging area within Otago Harbour in accordance with the permitted activity rules contained within the Otago Regional Council's Regional Plan: Coast.

Figure 9 and Figure 10 show the Otago Harbour which contains the Ports at Dunedin and Port Chalmers, the shipping channels in the upper and lower harbour and the Mole which extends 1.5 km on the seaward and western side of the harbour entrance.

Figure 9: Looking Northeast from above the Upper Harbour Basins, over the Upper Harbour towards the Lower Harbour and Taiaroa Head in the distance.

Figure 10: Looking over Port Chalmers, the Lower Harbour and out towards Taiaroa Head and the Harbour Entrance

The layout of the Port Chalmers Container Terminal including the proposed extensions to the Multipurpose Wharf and the proposed Fishing Jetty are shown on Drawings 11143 (page 5) and 10991A (page 24).

Port Otago's vision is:

> **To provide a timely, competitive, cost efficient and responsible range of port and related services to cargo owners and shipping lines, with a commitment to the success of the region's economy and a focus on adding value to shareholders.**

This is underpinned by its mission:

> **To constantly review the needs of customers, increase (our) capacity, develop new services, improve efficiency and employ research into leading edge technology to become an indispensable link in their supply chain.**

Otago Harbour is important culturally, recreationally and economically and supports commercial and recreational activities including tourism and education. Port Otago recognises the importance of the communities located directly adjacent to the Harbour, as well as the diverse range of ecological and biological species that inhabit the harbour and its surrounds.

Port Otago is committed to managing wisely and sustainably the harbour and harbour resources on which it depends for its operation in combination with the community and other commercial and recreational interests the harbour supports. Port Otago is also committed to sustainable business practices and environmentally responsible operation.

3.2 History of the Port and Dredging at Port Chalmers

3.2.1 General

> **The history of the Port of Otago cannot be fully understood outside the context of wider economic history. The cycles of trade flow in and out of it just as surely as the tides and with just as an immediate impact on those who depend on it for their livelihood. The same with shipping. After all, a port exists solely to serve shipping and as the last decade has shown very clearly, technological changes in the shipping industry are the driving forces behind the whole process of harbour development.**
> ***McLean (1985)***

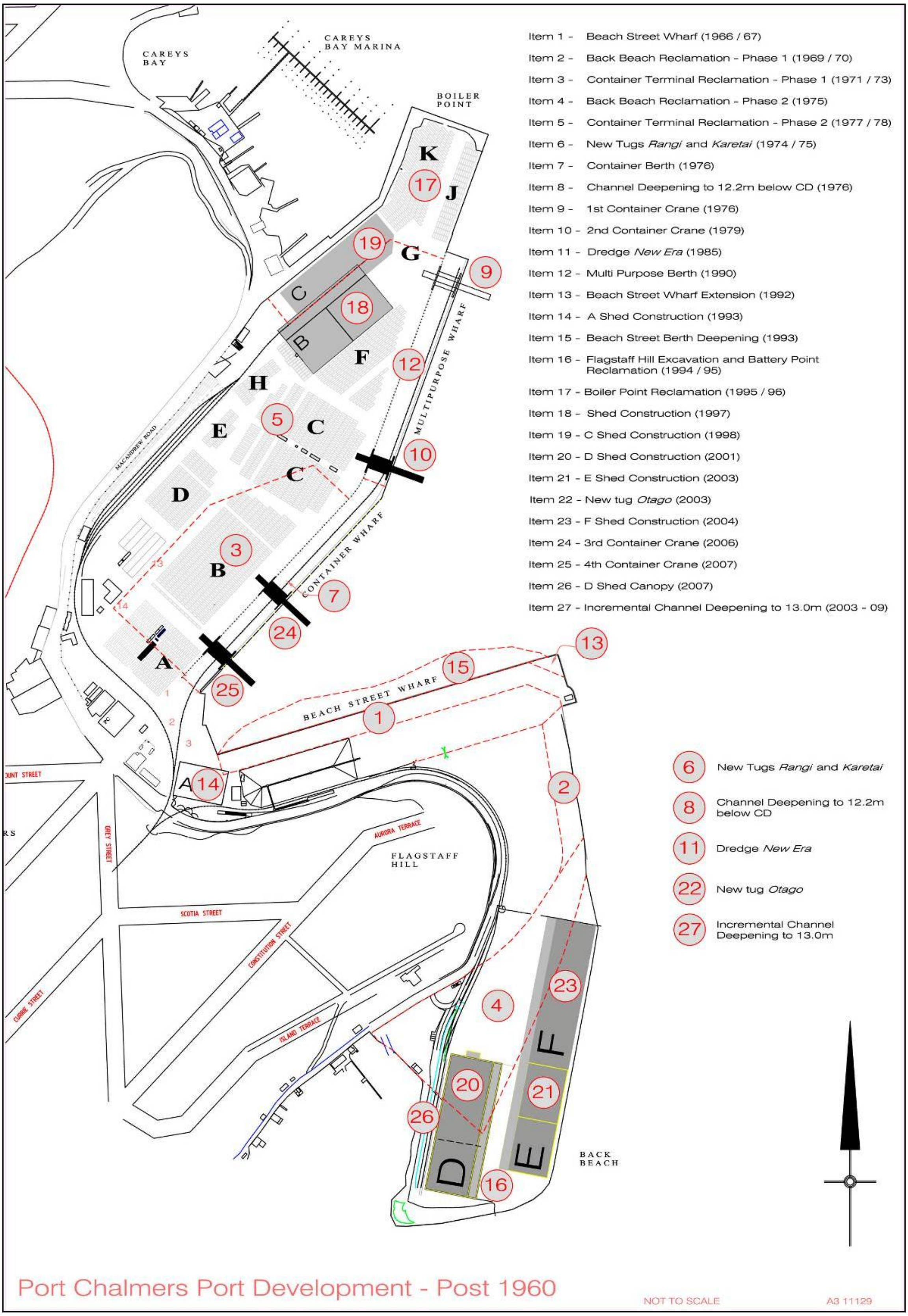
Port Otago and its predecessor the Otago Harbour Board have operated ports at Dunedin and Port Chalmers for well over 100 years. Since New Zealand's first refrigerated meat export sailed from Port Chalmers in 1882, shipping has been the life blood of the New Zealand economy and from the beginning, the Port of Otago has been at the forefront of every new stage of shipping development. This includes the establishment of the country's first container port in the mid 1970's.

Drawing 11129 shows a snapshot of the port development that has occurred at Port Chalmers over the past 50 years.

Port reform in 1988/89 marked the start of significant changes in New Zealand, and those which impacted on the port included:

1. The disbanding of the WIC (Waterfront Industries Commission) in 1989.
2. The Health and Safety in Employment Act 1992.
3. The introduction of the Resource Management Act in 1991.
4. Road transport deregulation in 1983.
5. The ongoing ownership changes of the New Zealand rail network.

With port reform an effective change of ownership focussed attention on the requirement of Port Companies to operate as a successful business (Section 5 Port Companies Act 1988). For the first time ports were free to decide what business they wanted to be in, how to structure that business and the facilities that would be made available either existing or to be developed. They became responsible for the health, welfare and safety of employees, and how user friendly and responsive they wanted to be to customer demands to provide 7 day, 24 hour function, the customer in this case being the cargo owner, the transport operator or the shipping line.


Item 1 - Beach Street Wharf (1966 / 67)
Item 2 - Back Beach Reclamation - Phase 1 (1969 / 70)
Item 3 - Container Terminal Reclamation - Phase 1 (1971 / 73)
Item 4 - Back Beach Reclamation - Phase 2 (1975)
Item 5 - Container Terminal Reclamation - Phase 2 (1977 / 78)
Item 6 - New Tugs *Rangi* and *Karetai* (1974 / 75)
Item 7 - Container Berth (1976)
Item 8 - Channel Deepening to 12.2m below CD (1976)
Item 9 - 1st Container Crane (1976)
Item 10 - 2nd Container Crane (1979)
Item 11 - Dredge *New Era* (1985)
Item 12 - Multi Purpose Berth (1990)
Item 13 - Beach Street Wharf Extension (1992)
Item 14 - A Shed Construction (1993)
Item 15 - Beach Street Berth Deepening (1993)
Item 16 - Flagstaff Hill Excavation and Battery Point Reclamation (1994 / 95)
Item 17 - Boiler Point Reclamation (1995 / 96)
Item 18 - Shed Construction (1997)
Item 19 - C Shed Construction (1998)
Item 20 - D Shed Construction (2001)
Item 21 - E Shed Construction (2003)
Item 22 - New tug *Otago* (2003)
Item 23 - F Shed Construction (2004)
Item 24 - 3rd Container Crane (2006)
Item 25 - 4th Container Crane (2007)
Item 26 - D Shed Canopy (2007)
Item 27 - Incremental Channel Deepening to 13.0m (2003 - 09)
6 New Tugs *Rangi* and *Karetai*
8 Channel Deepening to 12.2m below CD
11 Dredge *New Era*
22 New tug *Otago*
27 Incremental Channel Deepening to 13.0m
CAREYS BAY
CAREYS BAY MARINA
BOILER POINT
MULTIPURPOSE WHARF
CONTAINER WHARF
BEACH STREET WHARF
MACANDREW ROAD
FLAGSTAFF HILL
AURORA TERRACE
SCOTIA STREET
CONSTITUTION STREET
ISLAND TERRACE
GREY STREET
CURRIE STREET
BACK BEACH
Port Chalmers Port Development - Post 1960
NOT TO SCALE
A3 11129

The combination of the Port Companies Act 1988 and the Resource Management Act 1991 added an extra dimension in that it was the first time Port Companies were required to consider resource management issues in the way operations were carried out. At the same time international trade agreements saw New Zealand manufacturers, producers and suppliers facing increasing overseas competition internationally they were also provided with greater opportunities for access to world markets.

3.2.2 Capital Dredging

Dredging has played an important part in the history and development of Dunedin City, beginning in the 1800s when Dunedin was the commercial capital of New Zealand with the placement of dredged materials onshore to reclaim large tracts of waterfront land. Davis (2009) outlines a brief summary of both dredging and harbour development.

Dredging has continued in more recent years to fulfil an important role in the development and maintenance of Otago Harbour as the deepest South Island commercial port.

McLintock (1951) describes dredging being first carried out in 1866 by convicts using spoon dredging methods and hand labour. By the beginning of 1867 a channel 220 feet long and 26 feet wide provided a depth of six feet at low water. Dredging using mechanical means commenced with the construction of the bucket dredge "New Era" in 1868.

Dredging work in the lower harbour (including the development of the Mole at the harbour entrance) the development of the upper harbour channel (also referred to as Victoria Channel) and the formation of the Dunedin basin and berths in the late 1800's, involved dredging some 5.6 million m^3. This is a not dissimilar quantity of material to that required to accommodate the new generation of vessels (7.2 million m^3).

To accommodate larger dedicated container vessels in the 1970's there was a requirement to develop a container terminal, the lower harbour channel and the harbour entrance. Capital dredging, involving some 4 million m^3 of material, was undertaken in stages from 1971 through to 1977 by external dredging contractors, working 24 hours a day when on site. Up until this time dredging had been largely undertaken by Harbour Board owned and operated plant.

The new trailing suction dredge *"New Era"* was commissioned in 1985 with Port Otago also operating a grab dredge for use in the removal of rock or firmly packed silts and clays and in confined areas such as alongside berths or in shallow areas unable to be accessed by the trailing suction dredge.

These dredges have maintained the channels and berths, and at the same time have carried out channel alignment and incremental depth improvements of the harbour channels.

It is estimated that the development of Otago Harbour commencing in the mid to late 1870's has thus far involved dredging some 34 million m^3 of material.

3.2.3 Maintenance Dredging

Sediment naturally builds up in the Otago Harbour and its channels, and requires dredging to maintain channel depth.

Sediment enters the shipping channel as a result of:

(a) Natural coastal processes.

(b) Slope erosion of the hillsides surrounding the harbour.

(c) The discharge from the Leith River as well as the numerous creeks and stormwater pipelines.

(d) The remobilisation of sediment from the intertidal banks, particularly as a result of locally generated wind waves.

This sediment readily settles out in the deeper channel and harbour basins. Port Otago carries out regular Hydrographical Surveys to identify areas of sedimentation which then determine its maintenance dredging program.

Additional detail on the importance of dredging in developing and then maintaining a safe and navigable waterway in Otago Harbour is provided in Davis (2008) and detail of Port Otago's existing maintenance dredging program is provided in Section 2.

3.3 Current Port Facilities

3.3.1 Port Chalmers wharves

There are 3 wharf areas at Port Chalmers as shown in Drawing 11143 (page 5). These comprise:

(a) The Container Wharf

This berth is 300 metres in length and is currently the main berth for container vessel operations. Vessels up to 281 metres long can use this berth and in that situation the container cranes are able to work the full length of the vessel. The water depth alongside the berth is a minimum of 13.5 metres below chart datum.

(b) The Multipurpose Wharf

This berth is located to the north of the main container berth and is principally used for container operations as the secondary berth for container vessels, influenced at times by the need to accommodate the cruise vessels on the inner berth to avoid conflict between passengers and terminal operations.

While this berth is 300 metres in length, the effective working length for container operations is only 240 metres. Although the curved section of crane rail between the 2 wharves enables the container cranes to move across the interface between the 2 wharfs and around the corner, there is a length of wharf at the northern end which is required for the spreading of mooring lines making this area to the extreme north unworkable for the cranes.

The depth alongside this berth is a minimum of 13.5 metres below chart datum.

(c) The Beach Street Wharf

This wharf is 410 metres long and is predominantly used by forestry (logs and woodchip) and cruise ship vessels.

In order for 2 vessels to use this wharf at the same time their combined length must be less than 360 metres.

The depth alongside this berth is a minimum of 11.9 metres below chart datum.

3.3.2 Vessel Berthing Arrangements

Container shipping

The container shipping lines calling at Port Chalmers operate on a weekly service with a pre-determined day of arrival. The vessels actual arrival time will vary as a result of weather conditions on transit and delays in other ports.

Provided the vessel arrives at its scheduled time, Port Otago provides a guarantee as to the availability of the berth and 2 container cranes for the key vessel calls.

Container vessels vary in length from 135 metres for the Trans Tasman services, to 281 metres for the Albatross class (4100) vessels. The time required to complete a container exchange will range from 8 to 36 hours, depending on the number of container lifts required.

It is not unusual to have a vessel alongside both the Container and the Multipurpose berths concurrently.

Cruise Vessels

Shipping lines operating cruise vessels will book a berth for their vessels 2 to 3 years prior to the arrival date. Port Otago currently has bookings through to April 2013, and cruise ship numbers are continuing to rise.

Cruise lines need to plan their schedules years in advance to enable the printing of promotional and marketing material. They tend to arrive on the notified pre-arranged day.

Whilst cruise vessels under 150 metres in length are able to navigate the upper harbour (Victoria) channel to Dunedin, larger vessels ranging in length from 150 metres to 300 metres are required to berth at Port Chalmers. The draft of the vessels is also critical with those having a draft less than 6.7 metres and under 150 metres being able to transit to Dunedin at any time. Vessels over 6.7 metres draft may be restricted by tide.

Port Otago accepts a maximum of 2 cruise ship bookings at Port Chalmers for any particular day.

Forestry

Log and woodchip vessels are chartered on a shipment basis. The vessels are chartered to arrive within a particular window. Log vessels are generally up to 190 metres in length and woodchip vessels slightly longer at 200 metres. A woodchip vessel however requires 320 metres of berth length to enable the vessel to move along the wharf to load different holds.

Log and woodchip vessels are generally in port for 3 to 4 days. With the increasing number of cruise vessels, it can be difficult to find a 3 to 4 day window available for log vessels during the cruise ship season

3.3.3 Infrastructure to Service Vessels

The entry into the New Zealand market of the Albatross class vessels with a capacity to carry 4,100 TEU's (20 foot equivalent unit) introduced to the New Zealand the practice of larger ships calling at fewer ports. This practice has been in existence in other parts of the world for some time.

Since successfully attracting the Albatross class service to Port Chalmers in 2002, Port Otago has invested considerable capital to ensure its facilities are developed and maintained to be able to provide the level of service expected by global operators.

This has included the upgrading of its entire straddle carrier fleet, the purchase of a new 56 Tonne bollard pull tug, and the purchase of 2 new heavy lift ship to shore gantry cranes with twin container lifting capability.

The electrical reticulation supplying the terminal areas dedicated to the storage and care of refrigerated container cargo has been replaced and is supported with backup power supplies and telemetric temperature sensing and monitoring systems.

3.3.4 Channel Depth

Port Chalmers is currently the deepest container port in New Zealand, with a chart datum depth of 13.0 metres.

As part of its maintenance dredging programme, Port Otago has continued to undertake incremental improvements up to its permitted depth in the lower harbour channel. This is to ensure vessel sailing is not unduly delayed, as a vessel draft on departure may be increased by more than a metre from its arrival draft because of the load taken on at Port Chalmers.

3.4 The Importance of Port Chalmers

3.4.1 Importance of Shipping to New Zealand

Some 99.64% of New Zealand's export trade and 99.3 % of imports (both figures by volume) are transported by sea (statistics NZ 2001). In terms of value, 78.5% of all New Zealand's trade is handled by sea ports.

Current annual import/export container throughput at New Zealand ports is estimated to be 2.36 million TEU's (year ended June 2009). This volume has been growing at about 8% per annum for the last 20 years. Additional shipping capacity will be required to carry the increase in container volume, especially during the export season (January to June) when demand for shipping space is at its highest. The other major reason bigger vessels will be introduced to the New Zealand trade routes is the economies of scale they provide.

New Zealand's export trade would become uncompetitive if it did not embrace the economies of scale that the bigger ships provide.

3.4.2 The Place of Port Chalmers

Introduction

Port Otago is New Zealand's third largest port (by cargo value), and in its role as the South Island container export port, Port Otago is the international gateway for some of the country's most important export cargo.

A number of global carriers call at Port Chalmers including Maersk Line (and its consortium partners of Hapag Lloyd, MISC) Hamburg Sud and Mediterranean Shipping amongst others.

These are well established carriers providing largely containerised services. They offer access to markets in North America, the Mediterranean, North and South East Asia, Australia, Europe and the United Kingdom either directly or through hubbing over Singapore. The tendency now is for these liner services to also tranship to other New Zealand ports as well as those in Australia as part of their journey.

Services are available to anywhere in the world at weekly as well as fortnightly intervals from Port Chalmers. The area is similarly served by charter shipping on an as required frequency. High volume bulk products are generally shipped on tramp (or charter) services.

Port Otago's container growth over the last 10 years has exceeded the national average increasing by approximately 12% per annum and almost doubling between 2004 and 2009. This includes gateway cargos generated within the Canterbury, Otago and Southland catchments as well as containers transhipped through the port from (and to) other regions.

Recent forecasts using more conservative base growth figures of between 4-5% indicate that the current container volume of around 218,000 TEU is expected to increase to between 450,000 TEU's and 550,000 TEU by the year 2030.

These forecasts demonstrate the need for the ongoing development of facilities at Port Chalmers to cater for this growth, and it is essential for Dunedin and for the lower half of the South Island, that Port Otago remain a strong and significant part of New Zealand's international trading supply chain.

Role in the Import/Export Supply Chain

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 efficient cost effective transportation of product.

New Zealand's isolation means it has an almost total reliance on sea transport and sea port operations for the importation and in Dunedin's case the export of goods. The transport of goods to and from New Zealand markets is becoming increasingly more competitive. New Zealand exporters are competing internationally with exporters from other countries and New Zealand's economic well being is dependent on all parts of the supply chain being efficient.

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

Cargo Catchment

Port Otago as a service industry is well positioned geographically to provide the lifeline for the suppliers, producers and manufacturers of Dunedin, and the greater Otago, Southland and South Canterbury regions. To a lesser extent Port Chalmers also serves the Mid Canterbury, Christchurch and West Coast cargo catchment areas.

Some 60% of the containerised cargo shipped through Port Chalmers originates either from Dunedin or further south, with the remainder being from other parts of the South Island (particularly Canterbury) and tranships to/from the North Island.

Typical cargo received by Port Otago includes fish, processed timber, whiteware, technical products, wool, and meat and associated products from Dunedin, to medium density fibreboard from Mataura, aluminium from Tiwai Point, pet food and fish from Bluff and wool from Oamaru.

Port Otago receives significant volumes of dairy product into its warehouses located at Port Chalmers which includes in the order of 90% of the Edendale dairy plant production output, as well as cheese from Edendale and the processing facility at Stirling, into its 2 coldstores at Dunedin.

Fonterra has this year added a further 25% production capacity at its plant at Edendale. It is also in the process of establishing a cargo hub at Mosgiel, which will ensure cargo growth through Port Chalmers if the Port is able to satisfy the physical requirements of the shipping company.

Logs, sawn timber and woodchip are also exported in bulk.

The port receives bulk supplies of raw material for the manufacture of fertiliser, oil, fuel and bitumen products, liquefied petroleum gas, cement and motor vehicles.

The breadth of the cargo catchment area for Port Otago includes:

- **Meat processing industry**

  Significant volumes of chilled, frozen and dry cargos arrive from the following meat processing plants:

Processing Plant	Location	Province
Finegand	Balclutha	Otago
Pukeuri	Oamaru	Otago
Silverstream	Mosgiel	Otago
Mataura	Mataura	Southland
Makarewa	Invercargill	Southland
Lorneville	Invercargill	Southland
Belfast	Christchurch	Canterbury
Canterbury Meat Packers	Ashburton	Canterbury
Pareora	Timaru	Canterbury
Smithfield	Timaru	Canterbury
Kokiri	Greymouth	West Coast

- **Processed Timber**

Processing Plant	Location	Province
NZ Wood Mouldings	Mosgiel	Otago
City Forests	Milton	Otago
Wenita	Balclutha	Otago
Craigpine	Winton	Southland
Dongwha Patina NZ Ltd	Mataura	Southland
Niagara	Invercargill	Southland
Southland Veneer	Invercargill	Southland

On-Shore Facilities

Port Chalmers provides these businesses with access to their markets via world class port facilities that are currently designed to accommodate and provide an efficient turnaround for the largest container vessels to service New Zealand.

Port Otago has developed and expanded its warehousing operation at Port Chalmers for processed dairy and sawn timber products to optimise the supply chain, particularly in relation to transport costs and cargo care for the cargo owner.

Dairy products particularly, demand high quality dry storage to regulatory (food standard) requirements, high standards of packing, cargo care and stock management and accounting.

Warehousing provides transient (as opposed to long term) storage and consolidation of product which is then loaded into containers at the port. It provides for the most cost effective and efficient transport of product from the factory gate to ships hold. The product is moved to port warehousing in bulk by road and rail. The container on the other hand never leaves the terminal after arriving on the vessel. It is discharged, checked, repaired and cleaned at the port, moved to the onsite warehouse for packing and is then held on the terminal ready for loading on to the next available vessel. This eliminates a significant transport component and cost to relocate the containers over considerable distances to offsite pack points only for it to be packed and then returned to the port for shipment, reducing congestion on the road and providing savings in fuel consumption and costs in return for extra activity at the port site. Trucks and rail bringing the product to port in bulk on the other hand can then be backloaded.

Port Otago is one of the few port facilities in New Zealand where on port storage and container packing has become well established with in excess of 32,000 square meters of warehousing currently available.

More recently dairy plant processing capacity has been further increased and in the coming dairy season production will exceed the storage available at the port. For that reason, a storage and packing facility is being constructed at Mosgiel by Fonterra.

As well as arriving by road and rail, cargo can also be delivered by feeder services involving smaller vessels to or from other NZ ports, to connect with larger vessels. The port therefore has a significant national role in addition to addressing the needs of the southern South Island region.

Port Otago's Contribution to the Tourism Industry

Otago harbour is also being increasingly seen as a destination for cruise liners and Port Chalmers has become either the first or last New Zealand port call depending on the coastal call rotation selected by the operator. This has seen cruise liner visits grow from a few vessel calls in the mid 1990's to 42 vessel calls in 2007/08, 64 vessel calls in 2008/09 and 50 vessel calls expected for the 2009/10 season and in excess of 60 already booked for 2010/11 season.

This provides a vital boost for tourism with 88,380 passengers visiting Dunedin and its environs in the 2008/09 season.

There is also a trend towards increasing cruise vessel size with the largest being some 300 metres long. Further, it is not uncommon to have 2 vessels arriving on the same day. This creates conflict in demand for berth space, and logistical difficulties when safely transporting 8000 passengers to and from their vessels without compromising the container terminal operations.

Employment

Port Otago currently generates direct economic output of $53 million per annum, $41 million of which is business and household income (including $21 million in wages and salaries) and 300 jobs. The inclusion of downstream multiplier effects means that operation of Port Otago currently generates regional output of $85 million per annum, ($56 million of which is regional business and household income (including $26 million in wages and salaries)) and generates 480 jobs in the region. This does not include the employment and income generated by land freight taking cargo to and from the port.

3.5 The Future of Shipping

3.5.1 Introduction

Shipping lines seek to reduce their costs and increase their competitive edge by maximising the amount of cargo carried and voyages undertaken and minimising the number of ports in which they call. To achieve this, the development of containerships has been characterised by efforts towards the optimisation of ship design in terms of the number of containers to be carried and the efficiency of their loading and unloading.

This competitive pressure naturally translates through to shipping line service providers such as port companies.

Borne out of this desire for efficiency are two key global trends in shipping which will have a significant impact on the future operation of Port Otago and for which Port Otago must ready itself. They are:

- The use of larger ships to transport containers between major shipping "hubs".
- Requirements from shipping companies for shorter turnaround times, and increased schedule integrity.

Each of these is discussed below.

3.5.2 Increasing Ship Size

Over the past 10 years the size of container ships has steadily increased as shipping lines endeavour to move increasing volumes of freight around the world more efficiently and more economically. Shipping is already the most environmentally friendly method of transporting goods over long distances and newer, bigger ships provide even greater efficiencies and will further reduce the carbon footprint.

Since 2000, world TEU carrying capacity of vessels has grown, on average, by 11% per year, whereas the number of containerships has risen by only 6%. This underscores a continuing trend towards larger vessels. The carrying capacity of the world's container fleet of 3,490 ships (July 2005) has more than doubled during the past 10 years and has reached 7.5 million TEU, with the following increases for the different size categories:

- **Up to 1,999 TEU +4%**
- **2,000 to 3,999 TEU +5%**
- **4.000 to 5,999 TEU +12%**
- **Greater than 6,000 TEU +44%**

The current average size of a container ship is 1,228 TEU's but the average size ship under construction is more than three times that size at 3,745 TEU's. This clearly indicates that ships will be bigger in capacity in the years ahead (leaving aside the likes of the "*Emma Maersk*" launched last year and capable of carrying 14,000 TEU's). A large number of Post-Panamax vessels in the range between 5,000 and 6,000 TEU are deployed in world shipping. This group has grown by nearly 40% in the last 3 years. Post-Panamax vessels combine route deployment flexibility on the one hand with operational economies of scale on the other.

Figure 11 provides a comparison of the large number of larger size vessels on order to be deployed once complete as compared with the existing vessels in operation.

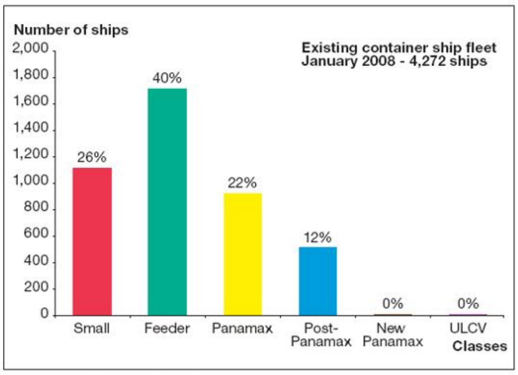


Fig. 3a: Distribution of existing fleet in container ship classes (number of ships)

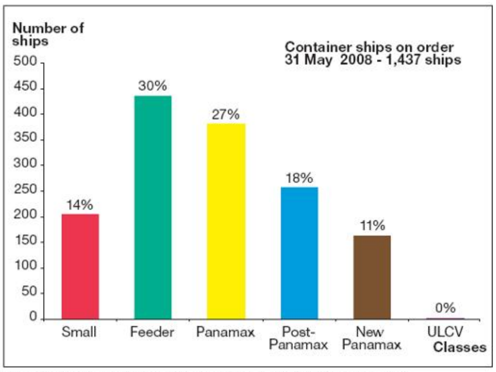


Fig. 3c: Distribution in classes of container ships on order (number of ships)

In Operation **On Order**

Figure 11: Containerships of increasing size in operation and on order (Jan 2008)[3]

[3] http://www.manbw.com/files/news/filesof4672/5510-0040-01ppr.pdf

The Albatross class vessels are the largest ships that currently call at Port Chalmers. They have the ability to nominally carry 4,100 TEU containers and are operated by the world's largest shipping line, "Maersk". Port Chalmers and Auckland are the only 2 ports in New Zealand serviced by the Albatross class vessels on a weekly rotation. These ships are 281 metres long and 32.6 metres wide with a maximum laden draft of 12.5 metres, summarised as follows.

Nominal Size	Max Draught	LOA	Beam	Displacement Tonnage	Typical Vessel Name
4100 TEU	12.5m	281m	32.2m	53,081	Maersk Damascus

The next generation of vessels (6000 TEU) will be longer at up to 320 metres, with a width of up to 43 metres and a laden draft of up to 14.5 metres. Also shown below are the next nominal size of vessels being 8000TEU size increasing in length only.

Nominal Size	Max Draught	LOA	Beam	Displacement Tonnage	Typical Vessel Name
6000 TEU	14.0m	318m	42.8m	84,900	Maersk Karlskrona
6000 TEU	14.5m	300m	40.0m	84,771	Maersk Kendal
8000 TEU	14.5m	347m	43.2m	104,696	Sovereign Maersk

The following pictures in are of both the nominal 6000TEU vessels in the table above being MSC Florentina and Maersk Karlskrona (formerly Regina Maersk).

Figure 12 – 6000 TEU vessels MSC Florentina and Maersk Karlskrona

There is a need to plan and invest in infrastructure to make sure these larger ships can operate effectively in the key New Zealand ports. This is similar to the situation in the 1970's when ports geared up for the start of containerisation.

It will be essential for New Zealand's import/export supply chain to be able to realise the economies of scale that large vessels offer as compared with smaller vessels. Figure 13 shows the unit cost per TEU reducing with increase in vessel size.

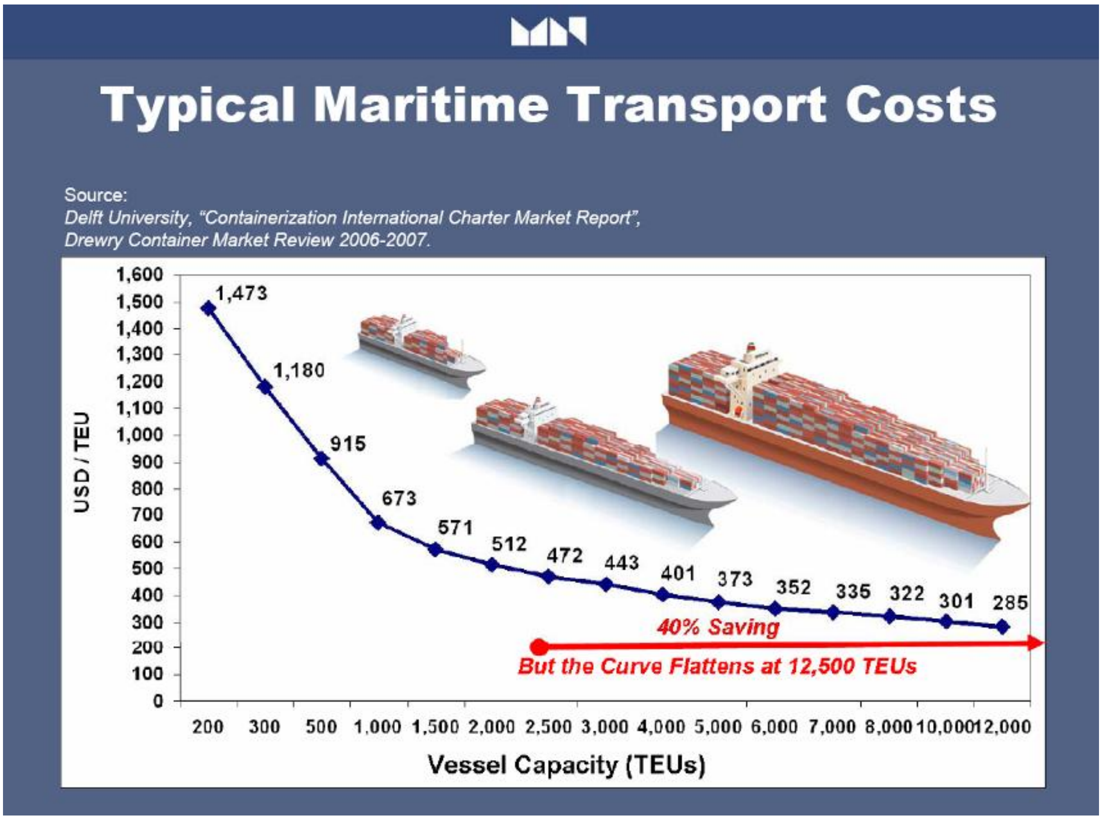


Figure 13: Economies of scale of larger container vessels[4]

The advantage of bigger ships is best realised with the ships travelling between designated "hub" ports where they are being fully loaded and unloaded, without intermediate port calls. This has the added benefit for both the shipping line and the exporter, as larger ships operating costs are spread over a much larger number of containers carried, thus reducing the average freight cost per container significantly (with operational efficiency and reduced turnaround time).

Port Chalmers has a number of clear advantages over other New Zealand ports as it is one of the few ports that are readily able to be upgraded to cater for the new generation of vessels. In particular:

(a) It services a highly productive hinterland supporting an economy that is interlinked with the success of the port and includes a well established land transport network.

(b) It is located within a naturally sheltered harbour.

(c) It is already well on the way to being able to provide the required services as a result of the progressive and incremental development of its channel, berths and cargo areas over its history.

[4] http://aapa.files.cms-plus.com/PDFs/08HARBORS_Horton_Michael.pdf

3.5.3 More Efficient and Reliable Turnaround

To improve efficiency and economics, shipping lines are requiring quicker turnaround of ships, more efficient operations, more effective use of containers, more efficient packing and the use of forty foot containers (which now comprise 40% of the entire exchange of containers on the Maersk 4,100 service compared to 7.59% in 1997).

As well as demanding quicker turnaround times, schedule integrity is also paramount for shipping lines and any reduction in the ability to bring vessels in at any time, commence work on arrival, or any move to restrict the hours of operation or the level of activity would seriously affect the viability of a Port Chalmers call by shipping lines.

3.6 Providing for Bigger Ships

3.6.1 Introduction

Preparing for the new generation of vessel to visit New Zealand is a major undertaking, not dissimilar to that faced and successfully completed for the onset of containerisation in the 1970's.

Port Chalmers is already the deepest container port in New Zealand, with a chart datum of 13.0 metres. Approximately 50% of the harbour channel area is at least 14.0 metres deep, but to accommodate the new generation of vessel, Port Otago will need to deepen and widen the harbour channel further, extend its Multipurpose berth and reconfigure the container terminal layout. There will also be a requirement for investment in additional plant and equipment to handle the increasing volumes of containerised cargo that are anticipated.

A restriction on the ability to service any category of ship that is prepared to visit Port Chalmers is likely to result in the loss of international shipping services at Port Chalmers and also affect Port Otago ability to attract new services. Such restrictions could be through the inability to receive vessels because of their size or the inability to service ships without interruption or in an efficient manner.

In addition to maintaining the current benefits Port Otago provides the region discussed in the previous Section, if Port Otago is developed to enable it to handle these larger ships, then the region will benefit by having lower freight rates than if the cargo is shipped through Lyttelton or Auckland or Tauranga:

(a) At current cargo levels, the net benefits for cargo being shipped from Otago and Southland through Port Chalmers rather than Lyttelton are expected to be $10.6 million per year, and by 2028 the benefits are expected to be $44 million per year;

(b) The Net Present Value of these benefits is estimated to be $202 million;

(c) If the alternative port to Port Chalmers was Auckland or Tauranga, the net reduction in total freight costs for Otago and Southland businesses, by developing Port Chalmers, is expected to be $73 million per year at current volumes, rising to $233 million per year by 2028 and having an NPV of $1,210 million;

(d) There would be associated benefits to the upper South Island if goods could be shipped through Port Chalmers instead of having to be transported to Tauranga or Auckland.

While these benefits may in part be realised by the freight companies and Port Otago, in a reasonably competitive international freight market and with regional ownership of the Port, the vast majority of the benefits will accrue to Otago and Southland producers and residents.

Further details in relation to economic impacts of the projects and alternatives considered can be found in Butcher 2010 – Economic Impacts.

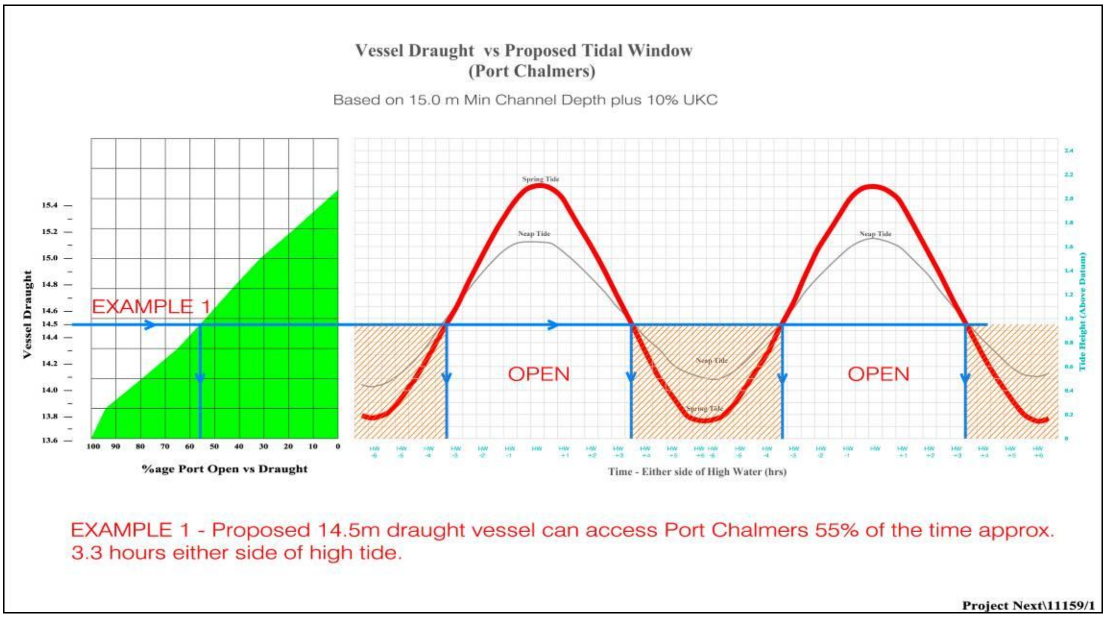
3.6.2 The Channel and Basin Development

To accommodate larger vessels and their increased vessel dimensions (particularly their 14.5 metre draft) an increase in the depth and width of the channel is required.

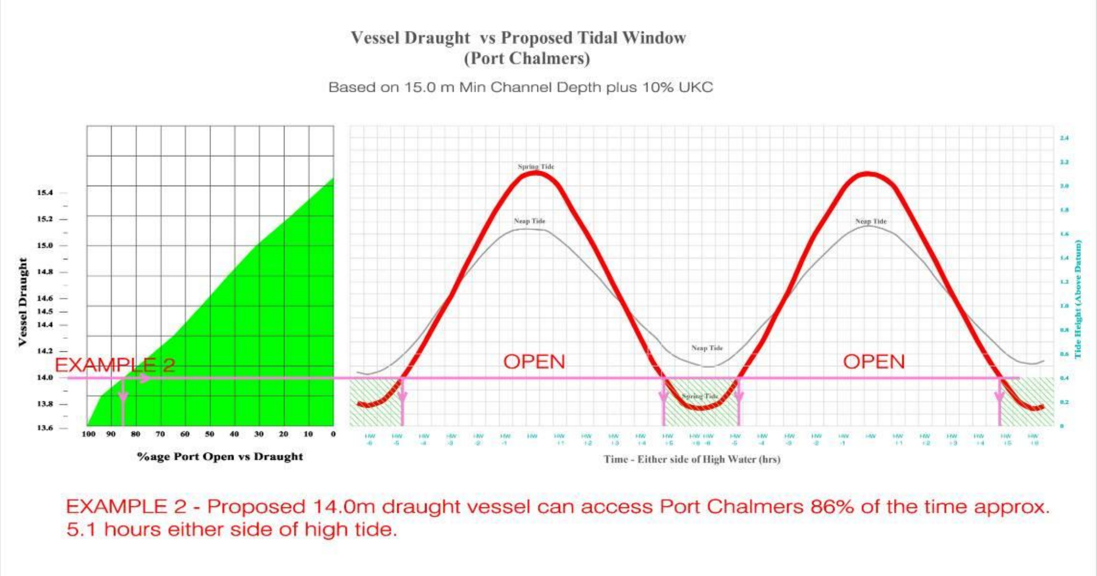
The capital cost of the channel upgrading means that the large trailing suction hopper dredge would not be contracted for the work until confirmation is received from the shipping lines of their intention to bring the larger vessels to Port Chalmers. It is anticipated that from the time of receiving such an undertaking the balance of the deepening will take up to 24 months to be completed, with the two factors that will influence this time period being the amount of work that has previously been carried out and the availability of the larger dredging plant.

The decision as to the required channel depth to service the 14.5 metre draft is a technical as well as a commercial one that strikes a balance between the amount of material to be removed from the channel and the operational window that is then available for the vessel to safely transit the channel.

The nominal channel depth of 15.0 metres is considered a viable commercial depth as it provides a 50% operational window for the 6,000 TEU vessels transiting at their maximum draught of 14.5m. Drawing 11159/1 (Example 1) shows the tidal range of Port Chalmers and the 14.5m draft vessel transit being available for 55% of the time when the tide is above 0.95m.



Drawing 11159/2 (Example 2) shows a 14.0m draft vessel having 5.1hrs either side of high tide available for safe transit during spring tides (ie tide height is greater than 0.4m) hence being available approximately 86% of the time. In neap tides the transits are unrestricted.



The nominal 15.0 metre channel depth is required to be increased to 16.0 metres around Harington Bend to accommodate the roll of the larger vessels as they take the turn. The depth also needs to be increased to 17.5 metres seaward of the northern end of the Mole to allow for swell effects on the vessel as it either approaches from or re-enters the less sheltered open waters. Refer to Drawing 11090 on page 6.

There is a need to obtain approval for the development of the channel ahead of any firm commitment from shipping companies. This is in order to allow for the work to proceed at the earliest opportunity and in response to market demand. It also gives the opportunity for work to commence using Port Otago plant at a lesser intensity than will be the result of the main dredging contract.

The major dredging contract will only proceed once there is a clearly demonstrable need. However, when this need arises then the notice received by the port may be as short as one shipping season.

3.7 Catering For an Increase in Vessel Numbers

3.7.1 Introduction

Vessel arrivals at Port Chalmers have increased from 227 in 1998 to 301 in 2009. However, that in itself does not reflect the significant growth that has been experienced over this time in the number of containers handled as well as the number of passengers that need to be accommodated around the daily container terminal operations as a result of the growth in cruise ship calls

In addition to this existing increase in demand, the use of Port Chalmers as a "hub" for 6000 TEU ships would further increase the number of vessels calling at the port to transfer that cargo to other smaller New Zealand ports.

As vessel calls and time in port increase so will the potential congestion on the wharves.

3.7.2 Limitations on the Use of the Existing Multipurpose Wharf

Although the Container berth is the first choice for container ships, the Multipurpose berth becomes the preferred berth to be used for container ships when a cruise ship is in port with the cruise ship berthing at the container terminal. The Multipurpose berth is also used for container ships when more than one container ship is in port.

The combination of the increasing vessel calls and the current wharf configuration is placing operational constraints on port activity, which will only increase further with the predicted growth in trade. The extension of the wharf and berth will alleviate these constraints.

Two main limitations on the current Multipurpose Wharf mean Port Otago is not able to efficiently service a number of vessel combinations at Port Chalmers. These are:

(i) The inability of the Multipurpose Wharf to fully accommodate vessels in excess of 240 metres (including the Albatross class vessels), and

(ii) The inability to berth cruise ships on the Multipurpose Wharf if a container vessel is working on the Container berth.

The difficulties arise because only 240 metres of the Multipurpose berth is able to be worked, meaning mid-exchange manoeuvring is required when working ships in excess of this length (including the weekly call Albatross class vessels which are 281 metres long). This shifting of an Albatross class vessel during loading and unloading reduces productivity and increases the length of time the vessel is required to stay in port. It results in operational inefficiencies, increases the cost to Port Otago, the shipping operator and exporters and also increases the duration of noise resulting from the verthed vessel.

The necessity to transfer passengers to and from a cruise vessel means it is unsafe to berth a cruise vessel on the Multipurpose Wharf if a container vessel is already berthed at the Container wharf, although two cruise vessels can berth concurrently at the two wharfs. This means that if a container vessel is alongside the container wharf then cruise vessels must be berthed at the Beach Street forestry wharf. This can result in other vessels being required to vacate the Beach Street berth in order for Port Otago to meet its obligations to cruise vessels operators, commitments that may have been made two years previously. This results in considerable inconvenience and added costs to the vessel operator, cargo owner and Port Otago. That added cost includes the cost of moving the vessel from the berth, at times to anchor at sea and back to the wharf again after the cruise ship has departed, as well as the lost productivity by stevedores and log marshallers.

3.7.3 The extension to the Multipurpose Wharf

Without the extension to the Multipurpose Wharf, the present restrictions mean Port Otago is at risk of losing trade as shipping lines consider options at ports which are able to provide guaranteed berthing commitments.

The extension to the wharf will provide some 135 metres of extra workable deck over which to load and unload the vessels and make full use of the adjacent reclamation area, presently used for the storage of empty containers.

The need for this extension would exist irrespective of Port Chalmers receiving 6,000 TEU vessels as it is linked to a requirement to provide greater operational efficiency now.

The extension to the Multipurpose Wharf will allow 1 larger, or 2 small container vessels to be effectively worked or berthed on the Multipurpose Wharf while 1 or 2 other vessels are in port. Ultimately the extended berth will also be capable of servicing the 6,000 TEU vessels. This will provide Port Otago with the flexibility to enable it to provide the required level of berthing commitment and guarantees to its customers as well as overcoming the difficulties that currently exist including allowing an Albatross class container vessel to be efficiently worked on the Multipurpose Wharf while a cruise ship is berthed at the Container wharf.

3.7.4 Proposed Fishing Jetty

The proposed Fishing Jetty is a community amenity being provided by Port Otago and is situated at the end of the public walkway that has been constructed around Boiler Point. It is physically separated from the Multipurpose Wharf.

The Fishing Jetty follows an initiative raised with the "Port Environment Liaison Committee" a number of years ago and was initially included as target 4a at page 10 of the "Port Environment Plan" 2007, and has remained so since.

3.8 Summary

Port Otago owns and operates the land based commercial port infrastructure at both Dunedin and Port Chalmers.

Port Chalmers is the third largest Port (by cargo value) in New Zealand and has been at the forefront of New Zealand shipping history dating back to the 1800s, and including the first refrigerated meat export in 1882 and the establishment of one of New Zealand's first container port in the 1970s. Central to this long history has been ongoing capital and maintenance dredging in Otago Harbour.

Port Chalmers is a fundamentally important part of the import/export supply chain for the lower South Island Region, and its ability to provide the community with a competitive global shipping service is of fundamental importance to the region's social and economic prosperity. Of particular importance, Port Otago is the primary export port for the Regions significant primary production and manufacturing sectors. Port Otago is also playing an increasingly important role in Otago tourism with upwards of 60 cruise vessels a season now stopping in Port Otago.

Global shipping lines are moving towards the use of larger ships to transport cargo, and New Zealand's international cargo going to Singapore and beyond is expected to be carried on larger 6000-8000 TEU ships from some time in the next decade. Global shipping companies are also demanding more efficient and reliable turnaround of their ships when in port.

In order to remain competitive, Port Otago needs to upgrade its port facilities such that it can receive these bigger ships, and so it can provide shipping lines with their desired level of service. This requires deepening and widening the approach to Port Chalmers and its berths. It also requires Port Otago to address current operational inefficiencies by increasing the length of the Multipurpose Wharf. It is these two activities that are the subject to this suite of resource consent applications.

In addition to maintaining the current benefits Port Otago provides to the region, if Port Otago is developed to enable it to handle these larger ships, then the region will benefit by having lower freight rates than if the cargo is shipped through Lyttelton or Auckland or Tauranga.

While these benefits may in part be realised by the freight companies and Port Otago, in a reasonably competitive international freight market and with regional ownership of the Port, the vast majority of the benefits will accrue to Otago and Southland producers and residents.

4. DEVELOPMENT APPROACH

4.1 Introduction

Throughout the design and development phases of this project, environmental and engineering considerations have been integrated in order to ensure that appropriate environmental outcomes are achieved.

Central to this has been close and iterative consultation and interaction between the environmental and engineering work streams, the early and comprehensive consultation with potentially affected stakeholders through the Project Consultative Group (see Section 8) and the utilisation of a staged development process where each stage informs the work undertaken in the next.

The stages in the development of the final project included:

- Project Definition.
- Preliminary Environmental Assessments.
- Project Design.
- Full Assessment of Environmental Effects.

Each of these stages is discussed in the following sections.

4.2 Project Definition

The first stage in the process was to define the objective of the project, and the parameters that needed to be satisfied to achieve that objective.

The objectives for the project are described in detail in Section 3, however, by way of summary they are to:

- Provide safe passage for larger container vessels (6000 – 8000 TEU) to Port Chalmers.
- Improve flexibility in vessel berthing at Port Chalmers to cater for the increasing number, frequency and duration of vessel visits to the Port such that those vessels can be serviced adequately.

As discussed in Section 3, the second matter is required irrespective of the Port being able to service the next generation of larger container ships, due to increases in vessel traffic and container volumes being handled at Port Chalmers.

To achieve these two objectives two engineering imperatives were identified:

- **Upgrading (by deepening and widening) the Lower Harbour Channel, basin, swinging area and berths to between 15 and 17.5 metres.**

- **Extending the existing Multipurpose Wharf by 135 metres.**

4.3 Preliminary Environmental Assessments

Once the initial scope of the project was defined, Port Otago commissioned leading experts in key fields to undertake a preliminary environmental evaluation of the project. This evaluation comprised three general components:

- **Collating and summarising existing information on the receiving environment for the project.**

- **Identifying potential key issues/effects of the project on that environment.**

- **Identifying the further studies required to assess the project in the context of the RMA.**

The collated material was extensive, and had been developed both in support of previous harbour works (including dredging), and also for purely scientific and academic purposes by the University of Otago and other similar or related institutions. This material provided a good understanding of the key values of the environment in which the project is being undertaken.

While these preliminary evaluations indentified several key environmental issues/effects that would need to be addressed, no issues or effects were identified that could not be appropriately avoided, remedied or mitigated through appropriate project design.

Also important at this stage in the project was the establishment of the Project Consultative Group. The Project Consultative Group is discussed in detail in Section 8 of this AEE. However, at this juncture it is important to note the Project Consultative Group played a valuable and significant role in identifying the important community and stakeholder issues, as well as potential issues/effects of the project on the environment that needed to be addressed and potential information gaps.

4.4 Project Design & Alternatives

4.4.1 Introduction

Once the Preliminary Environmental Assessments had confirmed that the project was feasible from an effects standpoint, the information on the surrounding environment, and the potential effects related issues identified in the reports prepared as part of those Preliminary Assessments and identified by the Project Consultative Group was used to undertake more detailed design of the project.

The following sections discuss the key considerations which influenced the design of the main project elements; the channel, dredging methodology, disposal method and location and the wharf extension. The Channel Design Report, and the Dredging Methodology and Disposal Alternatives are the reports that provide the detail associated with these aspects of the project.

4.4.2 Channel Design

In order to minimise the volume of dredging required, thereby reducing and minimising cost and potential adverse environmental effects from the upgrading work, the primary philosophy in designing the upgraded channel was to keep the alignment as close to the alignment of the existing channel as possible. The channel was also designed to avoid sites of significant ecological value such as the Aramoana sand-flats area.

To ensure the efficiency and safety of the channel for its primary purpose, the passage of 6000 – 8000 TEU ships, the proposed channel design alignment has been determined using internationally accepted design guidelines including ship simulation trials.

This simulator based and operated by the Royal New Zealand Navy located at the Devonport Naval Facility has been specifically tailored for the Otago Harbour conditions and allows for the effects of water levels, tidal range and wind and current forces as well as the hydrodynamic response and manoeuvrability of the vessel and speed as it transits the channel. This simulator first set up in 2004, has been used as a pilot training tool, as well as to enable a range of operational procedures to be trialled and refined before being applied in practice in navigating the harbour.

Figure 14 – View of Ship Simulator Bridge, Outbound from Port Chalmers

For the channel design process the ship simulator was used as an iterative channel design tool to determine and confirm the safe alignment and depth of the channel. Port Otago Senior Pilots undertook a large number of transits, making adjustments as they progressed in conjunction with senior engineering staff.

More than 60 separate runs were performed by 6 pilots over 7 days to confirm the adequacy of the selected channel design. Figure 15 shows an output plot from the simulator being a departure manoeuvre from the Multi-purpose wharf. This shows the path of a larger vessel within the proposed swinging basin.

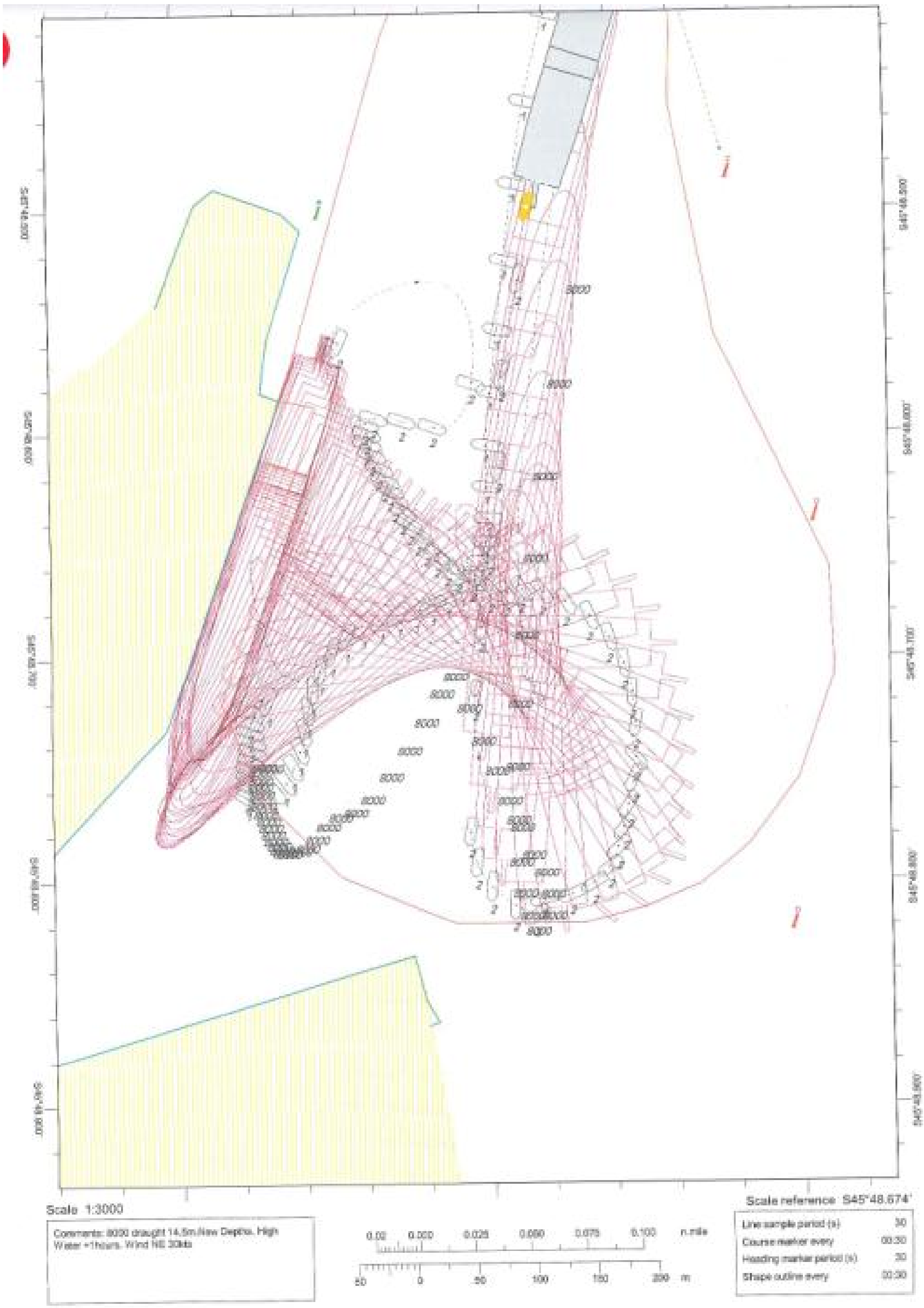


Figure 15: Ship Simulator Plot of Departure Manoeuvre from the Multipurpose Wharf

4.4.3 Dredging Methodology

Environmental, social and economic factors were considered in determining the preferred method of dredging and dredging plant type. The principle environmental concern was minimising the turbidity generated by the operation. Social aspects included project duration, potential effects of turbidity on recreational fishing, noise and vessel safety. Economic factors included project cost, interference with shipping operations and the impact on commercial fishing and aquaculture.

The likelihood that a limited notice period will exist to issue the main dredging contract and mobilise the dredging plant were also important considerations.

In considering these factors and selecting a dredging methodology both in house expertise and knowledge, the knowledge of Port Otago's technical advisors, and New Zealand and international dredging contractors was utilised.

The final dredging methods selected after taking into account the above factors were described in Section 2, and along with more detail on the selection process, are addressed more comprehensively within Pullar and Hughes (2009): Dredging Methodology and Disposal Alternatives Report.

By way of summary, the volume of material required to be removed, the range of sediments involved, the presence of rock outcrops at several locations in the channel and the inaccessibility to larger dredging plant of some shallow areas such as the swinging basin, means the dredging will be carried out in three stages.

1. The first stage is the extension of the existing maintenance dredging programme to include progressive development of the proposed channel improvements using Port Otago Ltd plant or that of similar size and scale. It could transpire that this stage may continue until the project is complete.

2. The second stage which could occur at any suitable time before or during the third stage is the work requiring grab dredge or backhoe, being rock removal and placement or disposal of the rock spoil, the work in the berth areas and preliminary work in the channel and swinging area.

3. The third stage is the removal of the balance of the material. This will be carried out by an international dredging contractor, as and when the demand for the increased channel dimensions exists.

4.4.4 Disposal Method and Location

Method

Several alternative methods for disposing of the dredged material were examined before the preferred marine disposal option was selected. Those alternative methods included using the dredged material:

- As aggregate for construction purposes.
- In reclamation.
- For beach renourishment.

The use of aggregate for construction is considered inappropriate due to the comparatively small amount of material required within the region, relative to that which would be produced by the capital dredging programme. It was also considered that recovery,

unloading and transport costs would make the supply of sand or aggregate to areas outside the Dunedin Region economically unviable.

With respect to reclamation, Port Otago is unaware of any commercial, community or private plans for major reclamation works in the vicinity of Port Chalmers or along the margins of Otago Harbour that would benefit from receipt of significant portions of dredged sand material. There has been interest expressed for additional community land resources along the margin of the harbour in Carey's Bay and Deborah Bay, however, the immediate requirement for reclamation fill is limited. Any reclamation or alternative disposal to land would, of necessity, involve clear justification of the necessity for that development, and detailed assessment of the total effects. Although such reclamations, albeit small, may result in additional community resources, they would also result in associated environmental and economic costs, and disposal of the remaining majority of the dredged material by another means would still be required.

Reclamation was therefore not considered a viable option for Port Otago for the disposal of dredged material from the proposed capital dredging project.

A number of sand beaches in the Dunedin area are subject to either long-term or short-term erosion of sediment volume. At present Port Otago places maintenance dredging material in the nearshore off Shelley Beach to offset losses of sediment from the narrow dune system of the South Spit.

Commencing in July 2007, Dunedin City Council used sand from Port Otago maintenance dredging to nourish Middle Beach after a prolonged period of storm wave induced erosion of the Ocean Beach foreshore and dune system. The Te Rauone Beach community, in conjunction with Port Otago and other agencies, is also investigating the potential to nourish Te Rauone Beach as part of management of erosion of the foreshore and dunes, and other small bays within Otago Harbour have also been replenished with sand in the past to restore and protect local recreational resources and some property. Beach re-nourishment requires sand of an appropriate size, texture, colour and cleanliness to be effective and acceptable to the beach users. In assessing the potential use of the capital dredging material for beach re-nourishment in the Dunedin area, these factors have been considered and areas of suitable sand identified. In addition, the total volume required for possible beach re-nourishment projects has been estimated. The results of those investigations show that the volumes of material that would require disposal during the capital dredging activities would be substantially larger than that required for beach renourishment projects, and it is proposed the requirements for beach renourishment would be better suited to ongoing use of materials from maintenance dredging.

In summary, the main constraint for any beneficial practical use of the dredged material is the significant volume of material, up to 7.2 million m³. Most beneficial uses only require relatively small volumes of material at regular intervals over extended periods. Should this material be required it could more effectively be provided by Port Otago from its maintenance dredging programme.

Therefore disposal in open water was considered the only practical option to dispose of the dredged material. Disposal in open water is the most commonly used international practice especially when there are large volumes of material to dispose of. Offshore disposal has been the method used by Port Otago, and its predecessors, to dispose of about 17.5 million m³ of dredged material over the history of port channel development. The total volume already dredged is estimated to be approximately about 34 million m³ with the bulk of the balance being used in reclamations, refer Davis (2009).

Locating the Disposal Site

Due to the quantity of material involved, disposal in open water requires a new disposal location.

Determining the appropriate location for the new disposal site involved extensive consultation with potentially affected stakeholders to determine areas and effects of interest, as well as extensive and detailed scientific investigations.

The first stage in site selection involved identifying possible sites considering the following key matters:

- Avoiding areas of conservation interest, protected marine areas and areas of significant ecological value.
- Avoiding significant effects on fishing and aquaculture.
- Avoiding effects on recreation including sailing, surfing and boating.
- Avoidance of shipping routes.
- Effects of disposal on currents and waves.
- The likelihood of sediment being re-transported and causing effects on other areas such as beaches and estuaries.
- Distance from dredging work and consequential travelling costs.
- Siting of disposal in areas of similar natural material (i.e disposing of “like onto like”) in order that re-colonisation of existing habitat will occur as quickly as possible following cessation of the disposal activity.

Following the identification of a suite of appropriate sites based on the above criteria, further detailed and iterative modelling was commissioned on a number of sites. That modelling included assessments of the following:

- Short term effects - Tracking sweep zones, concentrations and seabed deposition from suspended-sediment plumes.
- Potential changes to coastal shorelines and margins from differences in waves due to a disposal mound.
- Changes in wave height arising from the physical size and shape of the offshore disposal mound.
- Long term sediment transport from the disposal mound.
- How often, at what rate and where fine sand from the disposal mound moves in the long term.

This early constraints mapping and modelling suggested locations to the NE of Taiaroa Head would have the least impact on a range of activities and this was subsequently narrowed down to Site A0 (~6.5 km NE of Taiaroa Heads) where the potential for disposal material to impact on Blueskin Bay, northern coastline and Otago Peninsula, fisheries and areas with special or unique biological communities would be minimised.

After considering the above and balancing these factors determined that "AO" was the optimal disposal site.

4.4.5 Wharf Extension

The design of the wharf extension was developed such that the flexible operational requirements could be achieved while making best use of the existing wharf infrastructure, and reclamation areas.

There are no other practical alternatives to extending the Multi-purpose wharf.

- **Cruise vessels can not be safely berthed at the MP wharf as the large numbers of passengers and traffic associated with that activity can not be accommodated safely at this in the wharf and land areas to the multi-purpose wharf.**

- **Large container vessels can not work at Beach St due to the lack of water depth alongside at the berth as well as no cranes being present on the wharf. The other reason is the significantly increased distance to take cargo from Beach St around to the main container stacking areas.**

- **Although technically logs could be worked at the Container and Multi-purpose wharves, it is not practical due to the long distance from the log storage area.**

- **The Container Wharf can not be practically extended to the south by more than approximately 15m as a longer extension would impact on the incoming rail line to the port area as well making access around to Beach St more difficult and congested. This relatively small increase in length of the Container Wharf, would also result in little operational benefit to berthing and loading of the larger vessels.**

On this basis the only practical option is to extend the MP wharf.

With respect to the fishing platform, Port Otago has in recent years discussed with the Port Environment Liaison Committee the possibility of constructing such a platform at Port Chalmers to improve public access to the Port Chalmers environment. This option was discussed in more depth as part of this process, and a decision was made to include the platform as part of the work program for Project Next Generation.

4.5 Detailed Environmental Assessments, Studies and Reports

Once the project design was determined Port Otago commissioned a broad range of comprehensive technical reports to fill gaps in knowledge so that the full effects of the project could be comprehensively assessed in the context of the RMA. It is noted that as these detailed assessments were being prepared, additional measures to manage the effects of the project on the environment were proposed and incorporated into the final project design.

These background reports and assessments have informed this AEE, particularly Section 5 "the existing environment" and Section 6 "assessment of effects". These reports and assessments comprise the following:

Biological / Ecological Environment		
Author Reference	**Reference Name**	**Full Report Title**
James et al 2009*	Ecological Environment & Assessment	Biological resources of Otago Harbour and offshore: assessment of effects of proposed dredging and disposal by Port Otago Ltd
Willis et al 2008	Offshore Ecology	Benthic offshore surveys of proposed dredge spoil disposal sites off Otago Peninsula
Paavo, Probert & James 2008	Harbour Ecology	Benthic Habitat Structures and Macrofauna of Lower Otago Harbour
Paavo 2009	Harbour Rocky Shores	Observations of Rocky Shore Habitats in Lower Otago Harbour
Paavo 2010	Te Rauone Latham Bay Ecology	Benthic Habitat Structures and Macrofauna of Te Rauone Beach and Latham Bay, Otago Harbour
Sagar 2008	Bird Foraging	Field study of bird foraging and roosting sites in lower Otago Harbour
Boyd 2008	Fisheries Preliminary	Fisheries resources in Otago Harbour and on the adjacent coast
James et al 2007	Preliminary Summary of Ecological Info	Summary of existing Ecological Information and scoping of further Assessments for Port Otago Dredging Project

Physical Environment		
Author Reference	**Short Title**	**Full Report Title**
Single et al 2010*	Physical Coastal Environment & Assessment	Physical coastal environment of Otago Harbour and offshore: assessment of effects of proposed dredging by Port Otago Ltd
Bell et al 2009*	Hydrodynamic Modelling	Port of Otago Dredging Project: Harbour and Offshore Modelling
Bell & Hart 2008	ADCP Field Report	Offshore ADCP deployments (Otago Peninsula) for Port Otago dredging project
Single & Benn 2007	Preliminary Physical Coastal Environment	Port Otago Project Next Generation Summary of existing physical coastal environment information and scoping for further studies
Bell et al 2008	Preliminary Hydrodynamic	Port of Otago Dredging Project: Preliminary Hydrodynamic Modelling and Scoping Further Work
Benn & Single 2007	Annotated Bibliography	Annotated bibliography: Coastal and continental shelf processes of Otago Harbour and Blueskin Bay. Report for Port Otago Ltd.

Dredging, Design and Other		
Author Reference	**Reference Name**	**Full Report Title**
Davis 2009	Short History of Harbour Dredging	Next Generation - Channel Development Short History of Otago Harbour Development and Dredging
Opus 2008	Geotechnical Factual	Factual Report of Geotechnical Investigations
Opus 2009	Geotechnical Interpretation	Geotechnical Advice "Next Generation" Project - Interpretation of Geotechnical Data and Quantity Survey
Pullar & Hughes 2009	Dredging Methodology	Project Next Generation Dredging Methodology and Disposal Alternatives
Single & Pullar 2009	Vessel Effects	Vessel effects as a result of a deeper channel in the Lower Otago Harbour

General & Related Studies		
Author Reference	**Reference Name**	**Full Report Title**
Butcher 2010	Economic Impacts	Development of lower Otago harbour and channel at Port Chalmers for 6000 TEU Ships - Economic efficiency & Economic Impacts
Traffic Design Group 2008	SH88 Transport Review	SH88 Transport Review
Kiwirail 2009	Rail Infrastructure	Dunedin-Port Chalmers Rail Infrastructure and Future Volume Increase
Port Otago 2009	Port Capacity Assessment	Container Terminal Capacity Assessment
Ballagh 2009	Noise Assessment	Assessment of Noise Effects from Project Next Generation - Dredging and Operation
KTKO 2010	Cultural Impact Assessment	Cultural Impact Assessment - Project Next Generation, Otago Harbour
James, Boyd & Probert 2010	Key Species Ngai Tahu	Information on Key Species of Interest to Ngāi Tahu – Supplementary Paper for Next Generation Project

Note that the reports are categorised into broad subject groups. The references that are contained in Section 11 of this assessment are highlighted with an asterisk* in the author reference column

All of these reports are available on the Port Otago website www.portotago.co.nz / Next Generation / Consent Documentation. In addition to the individual reports themselves the report summaries are zipped as one file to provide a quick reference as to the content of these reports.

5. EXISTING ENVIRONMENT

5.1 Introduction

This document provides a description of Otago Harbour, the Otago coastline either side of the harbour entrance, and the area surrounding the dredge disposal site (A0) off the Otago coast and the values it supports under the following headings:

5.2 Physical Coastal Environment
5.3 Biological Environment
5.4 Human Aspects

Section 6 of this assessment describes the effects of the proposal on this environment.

5.2 Physical Coastal Environment

A comprehensive assessment of the physical coastal environment has been undertaken by Martin Single (Shore Processes and Management Limited), Rob Bell (NIWA) and Peter McComb (MetOcean Solutions Limited). Their assessment is referenced in Section 4.5 as Single et al (2010), Physical coastal environment of Otago Harbour and offshore: assessment of effects of proposed dredging by Port Otago Ltd. The same assessment also provides a detailed analysis of the effects of the proposal on the physical coastal environment.

A comprehensive list of references are contained within Single et al (2010) and reproduced in Section 11.2. Five other reports identified in Section 4.5 were specifically commissioned by Port Otago in order to be able to describe and assess the physical coastal resources as well as effects from the project.

5.2.1 Otago Harbour

General

Otago Harbour is a long and narrow inlet aligned SW-NE, about 21 km long, generally about 2 km wide, with a mean surface area at high spring tides of 46 km2.

Peninsulas at Port Chalmers and Portobello and their adjacent islands divide the Harbour into upper and lower basins (Figure 1). The Harbour is relatively shallow with an average depth of 3.3 m below mean sea level. Outside the main channels water depths are mostly less than 2 m and nearly 30% of the Harbour comprises exposed sediment flats at low spring tides. The main channel between Port Chalmers and Dunedin is maintained to a depth of 7.5 m below Chart Datum but from Port Chalmers to the entrance the channel depth is maintained at 13 m with a 14.5 m depth outside the Mole (depths relative to Chart Datum). The only other naturally deep areas (> 20 m) are several holes in the main navigation channel from Harington Bend to the Mole and between Quarantine and Goat Islands (up to 30 m depth). The shipping channel extends along the western shore for much of the Harbour's length. Otago Harbour is the only large non-estuarine inlet on the

southeast coast of New Zealand and has a number of important sheltered water habitats that are not widely represented elsewhere in this bio-geographic region.

Geology

Otago Harbour is thought to be about 6,000 years old and was formed by volcanism and crustal folding of a syncline during the late Miocene period. Since its formation, the harbour has been subjected to infilling from sand swept in from the continental shelf, and from sediments eroded from the surrounding catchment.

Detailed investigations of the sediment composition of the Lower Harbour were carried out in 2008 to determine the nature of materials to be dredged under this proposal. Sand was found to be the dominant fraction of sediment in the Entrance section of the Lower Harbour and towards Tayler's Bend, with silts and some clay being present at depths greater than 12m up-harbour towards Port Chalmers.

Sediments

Sediment analysis in the shipping channel areas of the Lower Harbour comprised of sub-surface testing using bores and comparing findings with previous studies. From the analysis and interpretation undertaken the following is known about the sediment composition in the Lower Harbour, being summarised from the two Opus geotechnical reports and shown on Drawing 11024 on page 63

a) Sediments in Otago Harbour range from silt to coarse sand containing shell fragments. Finer grained sediments including mud and silts can be found with the fine sand in the Upper Harbour, while coarser sand sizes are found with the fine sand in the Lower Harbour.

b) Sand is most commonly encountered in the channel sections near the entrance to the harbour and beyond, namely from the Harington Bend to the Entrance sections. Laboratory analysis found that sand was generally loosely packed in cores and had a water content of between 20 – 30%.

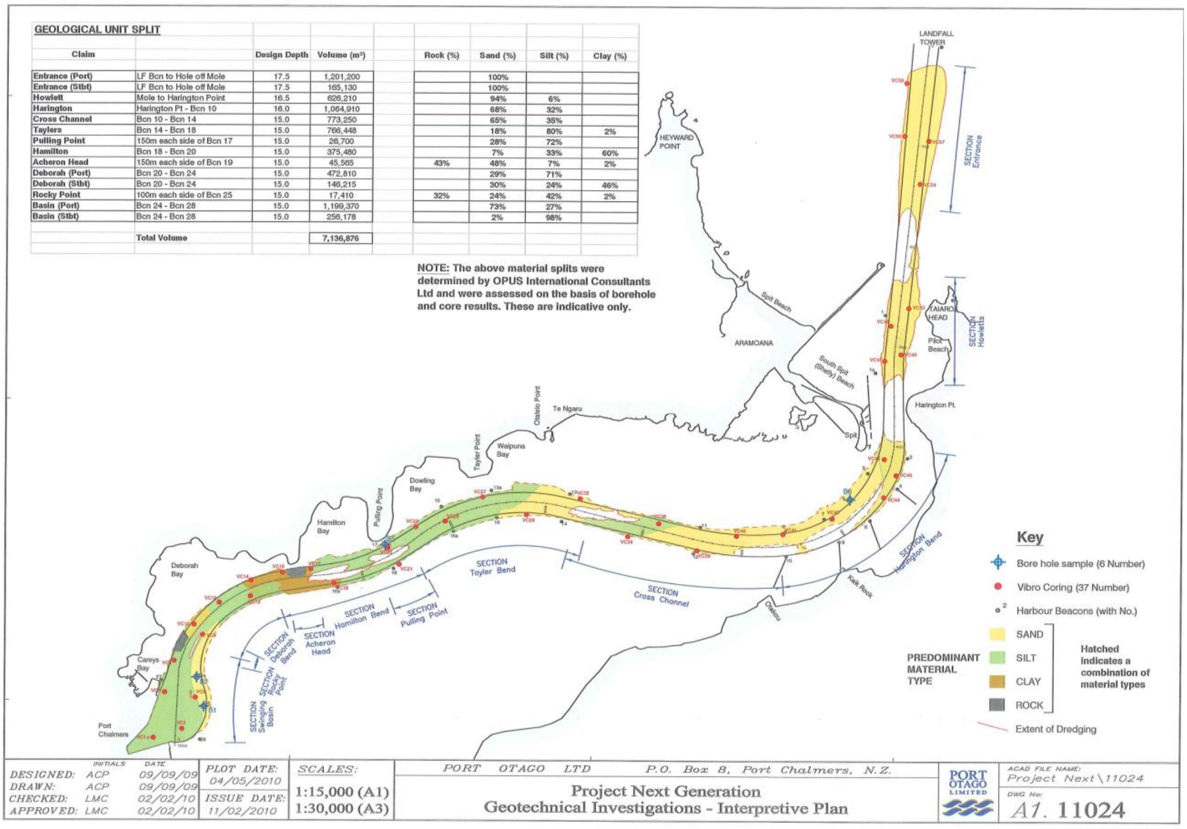
c) Clayey silt is most prominent from the Swinging Basin to the Cross Channel sections. The behaviour of this material is dominated by the high silt content. These sediments were generally soft to very soft and non-plastic. Water content was between 30 – 40% and had a measured shear strength between 14 – 24kPa.

d) Silty clay was the least common sediment type encountered and is most prominent in the area around Acheron Head. The silty clay had a relatively high clay content and sediments were generally soft to very soft, had a high plasticity and water content of approximately 60%. The shear strength of these materials was measured to be between 12 – 22kPa.

e) Rock was only encountered at Rocky Point and Acheron Head, and consisted of completely weathered basalt (cobbles and boulders) near the seabed and moderately weathered basalt at depth. Rock strength ranged from extremely weak to weak within the upper 2 to 4m and became moderately strong to very strong below this.

f) The sediment that is to be dredged is predominantly fine sand, with the secondary volume being clayey silt. There are areas and depths at which the sediment types are relatively uniform and other areas where there are a mix of sediments.

g) Laboratory testing was completed to determine the mechanical and chemical properties of the sediments. The findings were compared to guideline values from the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2000). With regard to chemical testing, none of the parameters analysed exceeded the guideline values used. It has been concluded that the materials to be dredged are not contaminated.



The proposal will result in some sediments being dredged out of the Lower Harbour channel and deposited off the Otago coast at the designated disposal ground (A0). Section 6.2.2 and 6.2.5 of this assessment addresses the environmental effects of removing sediment from the Lower Harbour.

Hydrodynamics

From review of relevant literature, the following observations were made by Single et al (2010) in relation to hydrodynamics.

a) The tidal compartment of the harbour (the amount of water flowing in during a tidal cycle) is between 6.9 x 107m^3 and 7.5 x 107m^3. The spring tidal range is 1.98m at Port Chalmers and 2.08m at Dunedin, while the neap tidal range is 1.25m at Port Chalmers and 1.35m at Dunedin.

b) High tide at Port Chalmers occurs around 10-15 minutes after high tide at the Spit, and there is a tendency for the time difference to be slightly smaller during spring tides and slightly larger during neap tides. The tidal time differences are explained by the tide wave travelling up the harbour faster with increased water depth. Therefore it travels faster during neap low tides than during spring low tides.

c) An ebb tide jet begins to form around 1 hour after high water, narrowing and strengthening to peak around 3 hours after high water. On the ebb tide, a peak flow velocity of 1.36 $m.s^{-1}$ occurs on the eastern side of the channel near the centre of Harington Bend. During flood tide, a peak flow of 1.59 $m.s^{-1}$ occurs at the southern end of the spit on the western side of the channel.

d) The flood tide period is shorter and its flow is stronger than the ebb tide, therefore the harbour is flood dominated and sediment will naturally move into the harbour and infill it.

Section 6.2.2 and 6.2.5 of this assessment addresses the effects of dredging the harbour on the hydrodynamic characteristics listed above.

5.2.2 Offshore

Wave Environment

Very few studies before the work for Project Next Generation had directly measured the wave climate of the offshore or nearshore environment of the Otago coastline. The assessment by Single et al (2010) therefore relied upon data from local studies of directions of deepwater wave approach obtained from ship records. Hindcast modelling of the wave environment has also been used to determine the wave climate of the Otago nearshore area.

For the area offshore of Otago Peninsula and Blueskin Bay the most frequent wind directions are from the north / northeast, and south / southwest. As a result of the local geography, the direction of wave propagation into Blueskin Bay is modified such that waves approach predominantly from the northeast and southeast. With the beaches of Blueskin Bay being situated on the leeward side of Otago Peninsula this section of coastline is also leeward from the dominant southerly swell.

The gradual shelf slope that characterises Blueskin Bay means that shorter period waves undergo little refraction until they are close to the shore. Consequently there is little loss of deepwater wave energy as the northeasterly waves move across the shelf. This results in most of the wave energy from this source being expended at the shore.

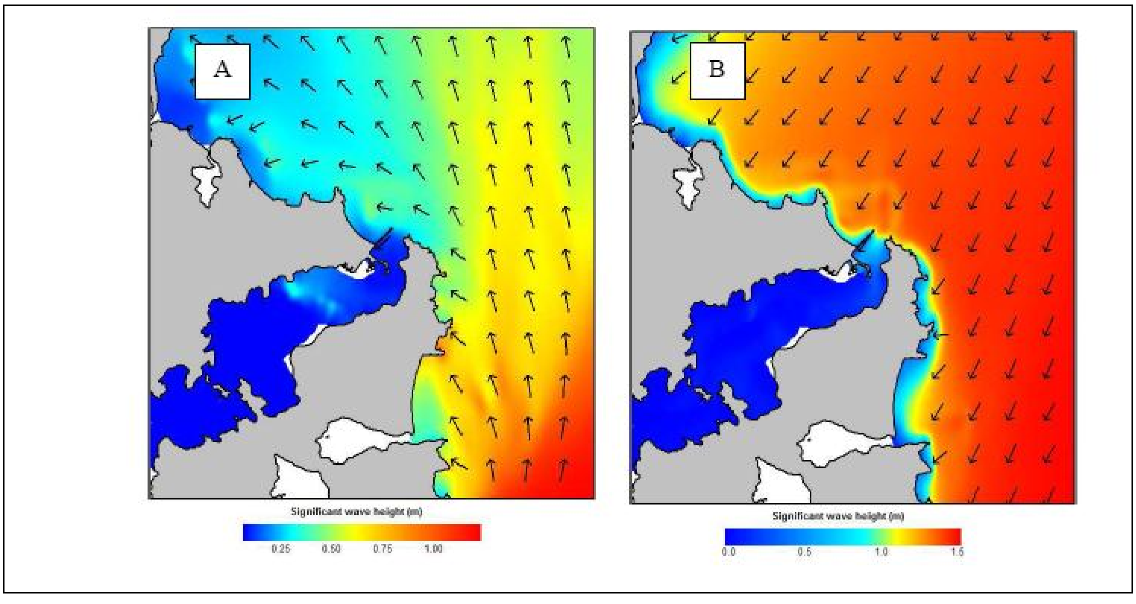


Figure 16: Typical wave height patterns for waves from the Southeast (A) and the northeast (B) (Source Figure 8.6, Bell et al. 2009)

The assessment by Single et al (2010) summarises the wave climate of Blueskin Bay as being 'quieter' than the outer Otago shelf and those beaches south of Otago Peninsula. Of the waves that do enter Blueskin Bay, the strongly refracted southerly swell dominates, but refraction lessens the intensity. The northeasterly waves are unimpeded within Blueskin Bay, although they are generally less powerful than the southerlies. Overall, the regime within Blueskin Bay can be described as a low energy coastal environment that experiences periodic high-energy storm waves propagating from the south. This is shown in Figure 16.

Section 6.2.4 of this assessment addresses the effects of disposing dredged material on the offshore wave environment, and also the role that the wave environment plays in sediment distribution.

Ocean and Tidal Currents

The southern current that moves northwards up the east coast of the South Island is a well-recognised feature along the Otago coast. The Otago Peninsula causes a disruption to this northward current, by forcing an anti-clockwise gyre to form in its lee within Blueskin Bay. Single et al (2010) note in their assessment that recent measurements of currents in Blueskin Bay show variations in the direction and strength of the tidal currents depending on the state of the tide, wind direction and strength, and the strength of the Blueskin Bay gyre.

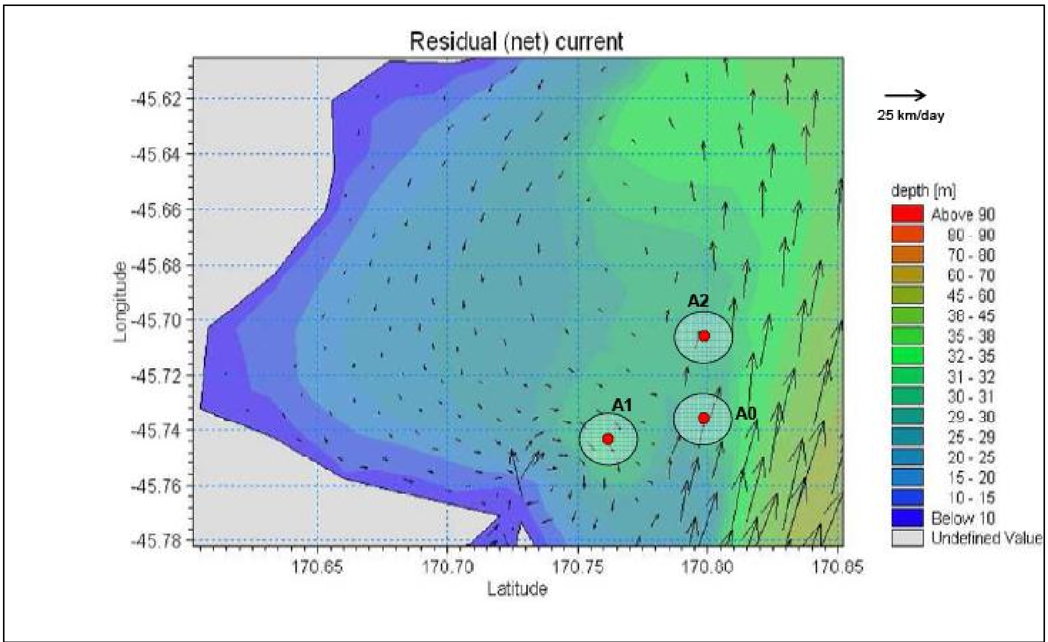


Figure 17: Location and extent of disposal site options investigated during the offshore plume modelling process, with a backdrop of the residual current pattern from Figure 10.4a (Source: Fig 11.2 Bell et al. 2009)

Other studies that informed the assessment by Single et al (2010), examined the tidal currents through the harbour entrance. There is a strong asymmetry between the ebb and flood flow structures. While the ebb flow extends beyond 2km from the harbour entrance, the flood flow is limited to within 500m of the coast. These tidal currents also have an important effect on the general current flows past the harbour entrance, and any resulting sediment transport. The asymmetry of the tidal flow and the flood dominance within the harbour entrance determine the sediment transport pathways across and within the harbour entrance. As a result, maintenance dredging in this area is, and will be, an ongoing activity.

Section 6.2.4 of this assessment addresses the effects of disposing dredged material on the coastal environment, and the subsequent transportation of sediment via tidal currents.

Bathymetry

The width of the continental shelf out from Taiaroa Head is approximately 30km. The seabed slopes gently to depths of 100-250m at the edge of the shelf. A series of drowned Quaternary shorelines have been identified across the shelf. The seabed of Blueskin Bay slopes to a depth of 30m at a distance of about 17km from Warrington Spit. The contour at 30m forms a near straight line from south to north starting from about 5.5km offshore of Taiaroa Head. The 'Peninsula Spit' is located landward of the 30m contour. The crest of the 'spit' slopes from a depth of about 20m at the southern end to a depth of 30m at the distal end. The depth inshore of the 'spit' is about 30m in an area northeast of the dredged channel.

The current dredged sediment disposal grounds at Heyward Point and Aramoana form small sandhills on the general seabed topography. In 2004, the sandhills had an equivalent volume of approximately 44% of the total placed dredged sediment. The accumulation of sediment at these sites includes placed sediment and sediment passing through the area naturally due to nearshore sediment transport processes.

Port Otago proposes to locate the dredged sediment placement site for the capital dredging project at a location around the distal end of the 'Peninsula Spit', centred at or about Latitude 45.735S, Longitude 170.80E, about 6.3km northeast of Taiaroa Head. This site is referred to as A0.

Sediments

Sediment characteristics were summarised as follows by Single et al (2010).

a) The textural characteristics of the nearshore sediments (size, shape and arrangements) can be described as medium to fine sand, with a mean diameter between 0.125mm – 0.14mm, well to very well sorted, and strongly positively (finely) skewed. The only exception to this textural trend is that of the ebb tide delta situated at the harbour entrance. This local area as being very coarsely skewed. The relatively homogenous nature is consistent with a single dominant source for the material.

b) The sediments of Blueskin Bay were generally well consolidated, although fine sands dominate the area, very fine sands and silts dominate the central region of the bay, with slightly coarser fine sand dominating sediments in shallower parts of the bay.

c) The sediment of the nearshore is predominantly very well sorted, although sorting values range from very well sorted to moderately sorted.

d) Sediments of the beaches and nearshore between Taiaroa Head and Karitane range from 0.15mm to 0.33mm, corresponding to descriptive classifications of fine sand to medium sand respectively. Large proportions (85% of all samples) of the sediments are fine sand size (0.17mm to 0.24mm).

e) The textural characteristics of the sediments compare well with historic studies meaning that the physical nature of the sediments of the coastal system between Taiaroa Head and Heyward Point have not changed significantly over a period of 44 years.

The above description of the textural characteristics of the beaches and seabed within Blueskin Bay provides a useful mechanism to aid in the understanding of the processes responsible for the deposition and transportation of sediments. This section of the Otago coastline possesses a relatively homogeneous size range of fine sand. This is likely to be a direct effect of two dominant factors. The first is that the main contemporary source of sediment to the coastal system is from one dominant source, the Clutha River. The second is that a relatively consistent and narrow range of energy is received in the nearshore and at the shore.

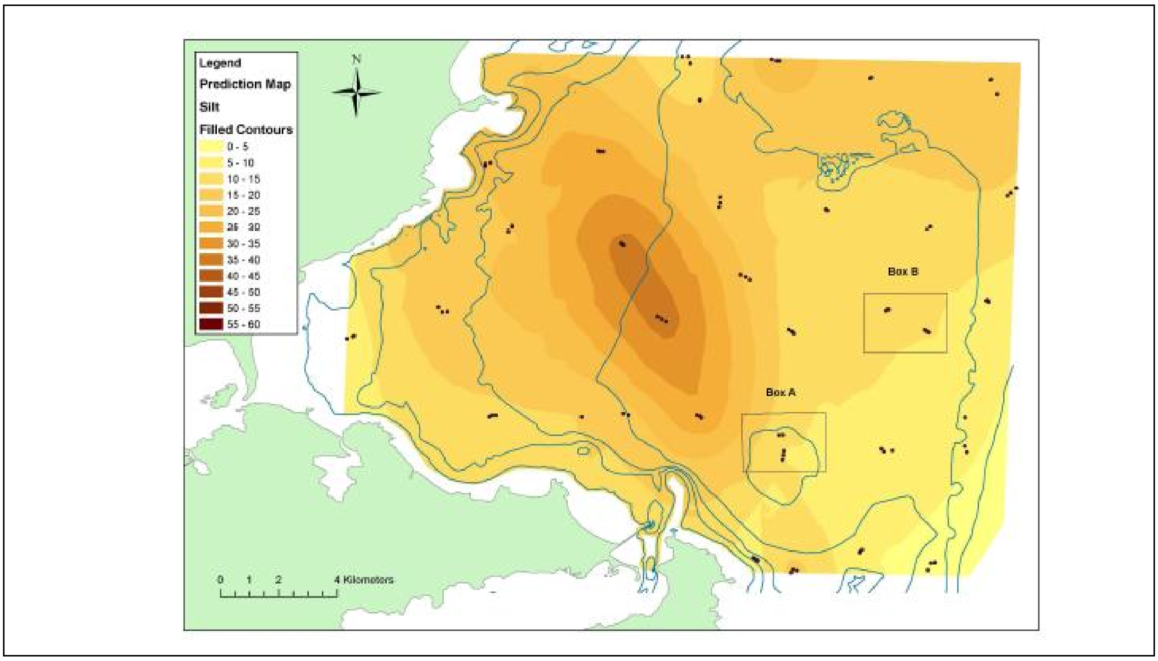


Figure 18: Distribution of silt (grain size < 63 µm) content (%) in the sediments of Blueskin Bay (Source Willis et al. 2008). Depth Contours are at 5m intervals from 10m to 30m.

In terms of sediment transport paths, 'sources' and 'sinks' of sediment are identified to indicate where sediment is travelling from and to, respectively. The results of studies on sediment transportation off the Otago coast from 1980 through to 2008 are relatively consistent in that the main sources and sinks of sediment and major pathways remain the same. The main sediment source areas identified are the shelf south of Taiaroa Head, and areas around Mapoutahi Point, Warrington Spit and Potato Point. The main sink areas are the entrance channel to the harbour, a nearshore area off Aramoana Beach, and the distal end of the Peninsula Spit.

Sediment 'sources' dominate the nearshore between Heyward Point and Karitane Peninsula. Sediment 'sinks' dominate the coastal area south of Heyward Point to Taiaroa Head, including the entrance to Otago Harbour. The analysis has shown that the northern coastal compartment acts as a source of sediment to the southern compartment together with the southern current that delivers sediment up the east coast of the South Island. The three dredged sediment receiving areas (Heyward Point, Aramoana and Shelly Beach) do not appear to supply sediment north into Blueskin Bay Estuary, nor do they appear to supply sediment back into the entrance channel.

Section 6.2.4 of this assessment considers the environmental effects associated with the deposition and dispersion of sediment discharged at A0.

Shoreline Features

The beaches between Taiaroa Head and Karitane are modern (in geologic time) depositional features made up of quartz sands sourced and deposited onshore directly from the Otago shelf.

There are three types of shoreline in Blueskin Bay: bay-head beaches, spit complexes and sea cliffs. Kaikai Beach, Murdering Beach, Long Beach, and Karitane Beach are all bay-head beaches. The morphology of all four of these beaches is very similar. Warrington Spit, Purakanui Beach, Aramoana and Shelly Beach at the entrance of Otago Harbour are all sand-spit complexes. Sea cliffs make up the Headlands of Taiaroa Head, the shore from Warrington to Green Point, and Karitane Peninsula.

Warrington Spit, Purakanui and Long Beach all show a long-term net advance in shoreline position, whilst Murdering and Kaikai beaches show a net decline. These measured rates of change indicate that differential supply of sediment to adjacent beaches is occurring and also different wave energies are spent on the beaches. Storm incidence and onshore winds result in short-term changes to the beach profiles in the form of erosion and accretion.

5.3 Biological Resources

A comprehensive assessment of the biological resources of Otago Harbour and offshore has been undertaken by Mark James (Aquatic Environmental Sciences Limited), Keith Probert (University of Otago), Rick Boyd (Boyd Fisheries Consultants Limited), and Paul Sagar (NIWA). Their assessment is referenced in Section 4.5 as James et al 2009, Biological resources of Otago Harbour and offshore: assessment of effects of proposed dredging and disposal by Port Otago Ltd. The main biological features of interest as described in that assessment are summarised below.

A comprehensive list of references is contained within James et al (2009) and reproduced in Section 11.4. Seven other reports identified in Section 4.5 were specifically commissioned by Port Otago in order to be able to describe and assess the biological resources as well as effects from the project.

5.3.1 Harbour Benthic Communities

Benthic habitats of the wider marine environment include sheltered rocky shores, intertidal sandbanks, and sub tidal soft sediment bottoms within Otago Harbour, and open ocean habitats immediately outside the Harbour.

Habitats/communities of particular interest that were identified through consultation with various interest groups included seagrass distribution, cockle beds, the ecological areas around Aramoana and unmodified areas around Quarantine and Goat Islands. Additional surveys were undertaken in areas of the Upper Harbour (where modelling showed potentially high sedimentation rates) and Te Rauone Beach (where concerns had been expressed about lack of coverage in earlier surveys).

The Lower Harbour is described by James et al (2009) as a mosaic of different benthic habitats. Based on surveys undertaken to date the Lower Harbour can be divided into 11 broad habitat types as follows (see Figure 19):

1. Relict shell on medium sand with sparse patches of algae.
2. Shell hash.
3. Mudstone or consolidated clay pavement with pockets of coarse sand or shell.
4. Relict shell on medium sand with sparse patches of algae but with silty or flocculent layer, no sand ripples, recent bioturbation obvious.
5. Medium sand with ripples.
6. Thick algal mats.
7. Seagrasses on medium sands.
8. Macrofauna burrows/mounds (including ghost shrimp and lugworms), indications of burrowing bivalves minimal.
9. Living cockle beds.
10. Sediment surface dominated by closely packed macro faunal tubes.
11. Deep habitat with cobble-sized stones and mollusc shells fused together, signs of high water flows, with sessile (attached) animals such as sponges, hydroids and tunicates.

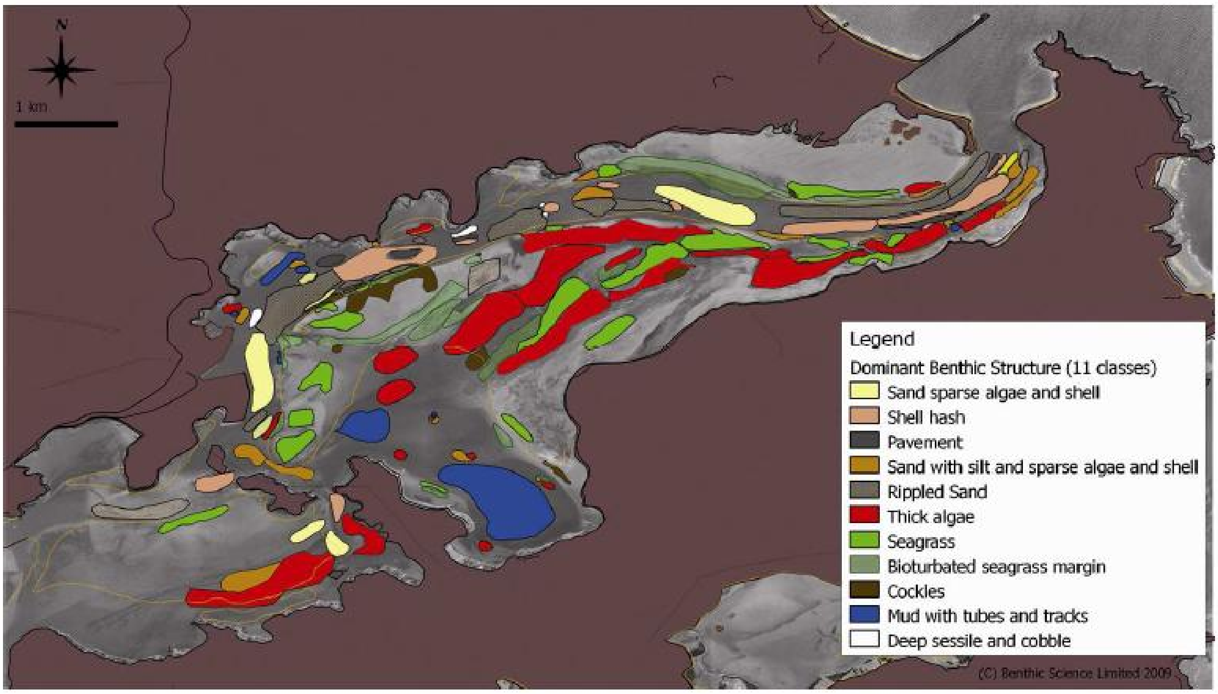


Figure 19: Interpolated map of dominant benthic structures (11 class scheme) from combined 2008 and 2009 photo survey data. (Background LINZ I44/J44 1999-2000 aerial imagery) (Source Fig 5 James et al. 2009)

According to the habitat classification medium sands and relict shells make up 11% of the classified area, rippled sand 13%, extensive intertidal sandflats supporting algal mats 29%, inlet features with seagrasses and cockle beds 28%, macro faunal tube mats 10%, shell hash 8% and mudstone pavement 2 %.

Sampling in the Lower Harbour including rocky shores found 190 benthic taxa. The macrofauna of soft-bottom habitats was dominated numerically by molluscs, annelid worm and arthropod species with larger conspicuous fauna including crabs and mantis shrimp. Also present, but less common were tunicates, sponges, several limpets, chitons, barnacles, serpulid polychaetes attached to shells, and seastars. The fauna was conspicuous for the lack of polychaetes.

James et al (2009) found that the benthic habitat structure classifications do not appear to be a useful proxy for benthic communities, as most species were found across a range of habitats. In this regard, the harbour can essentially be treated as one system.

Additional sampling was undertaken in areas identified as being of special significance by various stakeholders. These included Te Rauone Beach and cockle beds close to the swing basin in Port Chalmers, where it is proposed to widen the channel and remove small areas of some of the banks. Four transects were also sampled at the Ecologically Protected Area of the Aramoana sandflats, which has special significance for birdlife.

Cockles were found at a number of sandflat sites in densities ranging from 15-625 m^{-2}. The highest densities recorded in these surveys were just south of Harwood and on the banks opposite Acheron Point. Densities on channel margins close to the swing basin were very low (<10 m^2) and in the more populated margins opposite Acheron and Pulling Points, abundances were up to 300 m^{-2} and 625 m^{-2} off Harwood.

A small bivalve *Perrierina harrisonae* dominated the fauna on the Aramoana sandflats followed by several species representative of three amphipod families. Few polychaetes were identified in the samples from the sandflats.

A recent survey in the Te Rauone Beach area indicated that pavement-like seabed features extend from the Entrance Spit past Weller's Rock. A medium-sand bank on the southern side of the channel margin forms a retention structure for muddier sand, tube mats, and a sparse patch of horse mussel. Extensive sponge and tunicates communities, similar to those found in the deep sessile habitat in the main channel were found on the northern side of the Weller's Rock groyne.

The Upper Harbour is subject to more anthropogenic inputs and point source pollution from discharges. The fauna in the Upper Harbour is more characteristic of finer, muddier sediments and dominated by capitellid polychaete worms.

The earlier surveys for this project focussed largely on the soft-bottom habitats. Because of the importance of the few remaining naturally rocky shores, additional surveys/transects were carried out in March 2009 off Rocky Point, Acheron Point, Pulling Point and Quarantine Island (Paavo 2009a). Small periwinkles were present at Rocky Point amongst the barnacles in the upper shoreline, but littorinids were not recorded at the other sites. Barnacles were very abundant at Acheron Point along with snails and crabs in the upper 6m of transects. Schools of yellow-eyed mullet and triplefins were commonly observed.

The sites on Quarantine Island were more sheltered from prevailing winds than the other sites. Dense algal beds were found at 4m below chart datum along with *Undaria* and the bladder kelp which were attached to hard surfaces. The most numerous animals at this site were snails, limpets, chitons and tubeworms, found mostly in the upper shore or mid-littoral.

All species identified in the latest survey of rocky shores were species commonly found in shallow sheltered inlets of southern New Zealand estuaries and have been observed in Otago Harbour before. No rare or unusual species or communities were identified during these surveys.

Section 6.3.1 of this assessment addresses the environmental effects of the proposed dredging on the benthic communities within Otago Harbour.

5.3.2 Offshore Benthic Resources

To gain a better understanding of the different habitats and benthic communities in the area offshore of Otago Peninsula and Blueskin Bay, an offshore benthic survey was carried out in April/May 2008 at the proposed dredge spoil disposal sites and the wider area to the east and north to Cornish Head (Willis et al. 2008). The aim of these surveys was to determine the spatial distribution of habitat types and macro faunal assemblages, identify any species or assemblages of unique or particular biological interest and to understand what factors may be driving the current distributions of animals, with a view to predicting what the likely consequences of spoil disposal may be.

The benthic fauna in the area surveyed was numerically dominated by the gastropod snail *Antisolarium egenum*, followed by three polychaete worms and the ubiquitous bivalve *Nucula nitidula*. Depth and type of sediment appeared to be the main determinant of faunal groupings.

Total faunal densities were highest in the area just north of the Otago Harbour entrance, were lower in the middle of the bay and lowest in close to the coast in Blueskin Bay and offshore. The most species-rich area was also that which contained the highest densities (just north of the Harbour entrance), and the most species-poor area was right in Blueskin Bay and east of Taiaroa Head.

The coarser gravelly sediments of the middle and outer shelf provide habitat for attached epifauna, notably several species of bryozoans (lace corals). Surveys and mapping of their distribution have found that large colonies form reef-like thickets at depths of about 70-110m. Also distinctive of the outermost shelf is the queen scallop, the basis of a local fishery. These communities are found well offshore and generally south of the proposed disposal grounds, so will not be impacted by the proposed dredging and disposal. Beyond the outer shelf break, the continental slope is incised by submarine canyons with a diverse benthos, but this habitat is unlikely to be affected by the proposed activities.

Section 6.4.3 of this assessment addresses the environmental effects of the proposed disposal of dredged material on the offshore benthic community.

5.3.3 Planktonic Communities

The Upper and Lower Harbour support different zooplankton communities reflecting distance from the open ocean. Copepod species were the most abundant members of the permanent zooplankton community. Temporary larvae from a diverse range of benthic species are found in the Harbour, particularly in spring and summer. These include the euphausiid *Nyctiphanes australis* and the krill *Munida gregaria* which are an important source of food for birds when they reach high abundances in summer.

The hydrological regime off the Otago coast is complex and dynamic and includes three major water masses and associated plankton communities. Inshore waters have neritic characteristics with communities in the middle of Blueskin Bay comprising mainly meroplantonic larvae and a mixed fauna of oceanic and neritic species over the mid-shelf and north of Blueskin Bay. Physical processes rather than biological processes appear to determine the spatial structure of zooplankton in the region with the eddy systems acting as a recruitment and retention mechanism for coastal species.

Refer to Section 6.3.1 for an assessment of effects on the inner harbour zooplankton community, and Section 6.4.2, which addresses the effects on the offshore planktonic communities.

5.3.4 Birds – Coastal and Harbour

The Lower Harbour and the adjacent offshore marine environment support a diverse array of bird life. These species, and other birds reported from the area, inhabit two major ecosystems within the area of interest to this study – coastal (including the lower Otago Harbour and the offshore area where dredged material may be disposed) and intertidal within Otago Harbour. The area around Taiaroa Head is nationally significant and is the only breeding site on the mainland for the northern royal albatross and Stewart Island shag (James et al. 2007). Thirty four species of seabirds are reported from, or are likely to occur frequently in Otago coastal waters. Thirteen of these species breed on the Otago coast and another six commonly frequent the intertidal zone in the Lower Harbour. Those species present that have special conservation status include the following:

- Grey-headed mollymawk
- Black-fronted tern
- Black-billed gull
- Banded dotterel
- Caspian tern
- White-fronted tern
- Red-billed gull
- Yellow-eyed penguin
- Stewart Island shag
- Hutton's shearwater
- Flesh-footed shearwater
- Sooty shearwater
- Southern blue penguin
- NZ pied oystercatcher
- NZ Black-browed mollymawk
- Northern royal albatross
- Erect-crested penguin

Sagar 2008 presented the results of a field study of bird foraging and roosting sites in lower Otago Harbour. The observations undertaken on 27 March 2008 as part of that study observed the following species at Aramoana:

- Black shag
- White-faced heron
- Black swan
- Paradise shellduck
- Mallard
- Grey teal
- Pied oystercatcher
- Pied stilt
- Banded dotterel
- Spur-wined plover
- Bar-tailed godwit
- Black-backed gull
- Black-fronted tern
- White-fronted tern

Also presented in Sagar 2008 was a summary of observations undertaken on 4 separate occasions in 2008 of birds observed roosting or feeding on shellbanks between Port Chalmers and Ravensbourne. The sand banks off Port Chalmers were used by a wide variety of birds as roost sites during high tide and as feeding grounds at lower tides. At low tide on the afternoon of 9 July 2008 there were 46 pied oystercatchers, 6 variable oystercatchers, 2 spur-winged plovers, 4 Australian shovelers, plus many mallards, black shags, little shags, red-billed gulls and black-backed gulls roosting or feeding on the shellbank east of Ravesnbourne (at the end of Athol Place). In addition, 2 white-faced

herons, 58 pied oystercatchers, 4 spurwinged plovers, plus many mallards, little shags, black shags, spotted shags, black-billed gulls, red-billed gulls, and black-backed gulls were feeding or roosting on the shellbank south of St Leonards. Also, a black-fronted tern was foraging over the shellbanks. (Sagar 2008)

Section 6.3.2 of this assessment considers the environmental effects of the proposed dredging on birdlife and habitat within Otago Harbour, whilst Section 6.4.5 assesses the impacts of the proposal on coastal birdlife. Both of these sections also contain additional, more detailed information and discussion in relation to prevalence and distribution of local species.

5.3.5 Marine Mammals

Four seal and six cetacean species have been reported from the Otago coast. All species spend time in the coastal waters off Otago, and several species of seal use sites on the Otago Peninsula as haul-out areas and breeding grounds. Mammals with special conservation status are listed as the southern elephant seal, Hector's dolphin, Southern Right whale, New Zealand sea lion and the Bottlenose dolphin. James et al (2007) provides a more detailed summary of the existing desktop information that was available and used as part of the assessment.

Section 6.3.3 addresses the impacts associated with noise and blasting on marine mammals within Otago Harbour, as well as other aquatic animals and birds. Section 6.4.6 assesses the impacts of the deposition of dredged material on offshore marine mammals. Both of these effects or impacts sections also contain greater background and more detailed information and discussion in relation to prevalence and distribution of local species.

5.3.6 Fish Resources

There is a diverse range of coastal fish and shellfish fauna in Otago Harbour and the waters adjacent to Otago Peninsula. Both the fish and shellfish fauna present in these waters are predominantly comprised of common species that are widely distributed throughout New Zealand coastal waters.

The extensive intertidal areas of Otago Harbour contain a significant population of cockles. Customary, recreational and commercial fishing and seafood gathering takes place in Otago Harbour and along the Otago coast. Recreational salmon fishing is a significant activity along the lower Otago Harbour channel and around the Harbour entrance during the summer months. The waters of Blueskin Bay and the adjacent coast are important to Otago commercial fishing vessels that fish for flatfishes, rock lobster and a range of other inshore fish species.

Section 6.5 addresses the effects of the proposal on fisheries resources and recreational and commercial fishing within Otago Harbour and the adjacent coastal area offshore from the Harbour.

5.4 Human Aspects

5.4.1 Human Modification

Otago Harbour

The assessment by Single et al (2010) made the following observations in relation to aspects of human modification within the Otago Harbour.

a) The harbour has been substantially modified by human activity through reclamation, causeway and groyne construction, dredging and channel stabilisation, catchment modification and lining the harbour shoreline with seawalls. Reclamation has resulted in a reduction of the harbour tidal compartment. Most of the shoreline of the Upper Harbour has been modified, and is comprised of placed rock. Training walls and groynes also play an important role in determining the hydrodynamic flow of the harbour, stability of the position of the navigation channel and sediment movement on the shores and harbour bed.

b) Inflows from modified urban and rural catchments have resulted in changes to the sediment supply and chemistry in parts of the harbour.

c) Sediment samples from along the Lower Harbour shipping channel were tested for contaminants including Heavy Metals and Metalloids, Organic and Inorganic Compounds. Concentrations for all contaminants were found to be well below Australian and New Zealand guidelines for fresh and marine water quality.

Otago Harbour has a number of residential settlements located along its coastline, the most notable being Port Chalmers, though many other settlements including; Deborah Bay, Te Ngaru, Aramoana, Harington Point, Otakou, and Harwood are located adjacent to the Lower Harbour. The likely impacts on these settlements from the proposed activity are largely associated with the potential noise effects, which are addressed in Section 6.8 of this assessment. Many of these settlements also have an interest in terms of coastal erosion and deposition and this has also been addressed in Section 6.2.

Offshore

Single et al (2010) have summarised three human activities that have modified the offshore physical coastal environment and approaches to Otago Harbour:

a) By modification of the harbour inlet form and stability through construction of the Mole and Long Mac, and by dredging of the harbour channel,

b) Disposal of dredged sediment at the Heyward and Spit sites,

c) Disposal of dredged sediment at Shelly Beach.

Between 1846 and 1994, shoreline position and sediment transport at Aramoana was significantly altered by coastal engineering structures. Progradation of Aramoana Beach after the Mole construction (from 1884) indicates sediment has accumulated on the updrift side. The beach area between the Mole and Harington Point (Shelly Beach) retreated rapidly after the construction of the Mole, indicating the beach is on the downdrift side of the Mole and starved of sediment.

Maintenance and development dredging of the shipping channel in Otago Harbour has been carried out since 1865. About 34 million m^3 of sediment has been dredged from the harbour in that time. Disposal of dredged sediment has occurred off Heyward Point, the Spit and at Shelly Beach

Analysis of historical data shows that Aramoana Beach has been accreting since the construction of the Mole. Accumulation of sediment on the disposal site has also occurred during years when no dredged sediment has been placed there. Accordingly, it is likely that a combination of natural and human sediment inputs are occurring at Aramoana. At Shelly Beach, sediment placement has been carried out to provide sand as nourishment to the eroding beach. Retention of placed dredged sediment on Shelly Beach and in the nearshore south of the Mole has assisted in mitigating the erosion hazard to the beach.

These aspects of human modification within Otago Harbour and off the Otago coast were considered in determining what impacts the proposal will have on the existing physical environment. Section 6 of this assessment makes numerous references to these human modifications.

5.4.2 Cultural

During early discussions and consultation with Te Rūnanga o Ōtākou and Kāti Huirapa Rūnanga ki Puketeraki, the suggestion was made that a specific Cultural Impact Assessment ("CIA") should be prepared for Project Next Generation. Port Otago therefore commissioned Kāi Tahu Ki Otago Ltd (KTKO) to prepare the CIA. This process was a collaborative one involving Port Otago, and their advisors as well as the Kai Tahu Whanui, being interrelated Tangata Whenua Groups whose interests are potentially affected by the proposed capital dredging programme within the Otago Harbour.

In relation to describing the existing environment, the following quotation taken directly from section 4.2 of the CIA provides a brief outline of the cultural and spiritual association with the harbour and offshore environs. (Note: for simplicity the footnotes and references from the CIA have not been included).

> ***4.2 Maori Association with the Otago Harbour***
>
> ***Waitaha, Kāti Mamoe and Kāi Tahu made use of the Otago Harbour as a food resource (mahika kai), as a means of travel and as a realm of Papa-tū-ā-nuku to be respected.***
>
> ***Rangiriri (Goat Island) was the abode of Takaroa, the atua or guardian spirit of all that lives in the sea, in southern mythology. Takaroa would be acknowledged in karakia (prayer / incantation) before and after each fishing voyage. Food would not be taken on a fishing trip for fear of invoking the wrath of Tangaroa. All sea life was likened to the children of Takaroa.***
>
> ***The tūpuna used numerous methods of catching fish in the harbour and the estuaries and creeks, including netting, trolling, spearing and line fishing. Barracouta, Red Cod (Moka), Patiki (Flounder), Kokiri/Puamorua (Leather Jacket), Koura (Crayfish), and Kaio were collected. In addition, middens show the evidence of the gathering of kai moana, including pipi, cockle (Tuaki), mussel, pāua, toheroa, oyster, pūpū and kina (Sea Egg).***
>
> ***Ducks (Pateke), other birdlife including weka, and Sea Lions (the female and male sealion, Kake and Whakahao respectively), were also food sources. Whalebone was used for making weapons, tools, and ornaments.***
>
> ***Waka would travel from the kaik (villages) that were scattered around the harbour to various tauraka waka (canoe landing sites). Koputai (Port Chalmers) was one such landing site where hunting parties would venture into the bush clad Kapukataumahaka (the slopes of Mihiwaka / Mt Cargill) in search of woodhen (weka) a favourite food.***

By the 19th Century settlement was focused on the Coast from Taieri Mouth to Moeraki, around the Lower Harbour and on Muaupoko (Otago Peninsula). There were tangata whenua settlements on the Taieri Plain (including Maitapapa at Henley) and at Taieri Mouth; along the western edge of the Otago Harbour from Koputai to Te Waiparapara on the Aramoana Spit; in the northern bays and inlets, including Whareakeake (Murdering Beach) and Purakaunui; around Puketeraki / Waikouaiti (now Karitane) area; and at Moeraki.

The kaik (villages) on Muaupoko (Otago Peninsula) included Okia (Flat), Takiharuru (Pilots Beach), Little Papanui, Te Rauone (Te Rauone Beach), Te Ruatitiko (Harington Point), Tahakopa (bottom of Pipikaretu Road), Omate (in front of the marae), Waipepeka (south end of the flat in front of marae), and a settlement at Harwood. In addition, Pukekura (Taiaroa Head) was an important fortified pa. Its position had been strategically important in times of political unrest.

Further details in relation to the CIA are contained in the assessment of effects section in Section 6.9

5.4.3 Recreational Activity

Otago Harbour and the coastal environment are used for a number of water-based recreational activities, including: boating, fishing, diving and surfing.

Recreational boating activity within Otago Harbour includes (although is not limited to) sailing, motor boats, kayaking and rowing, all of which feature prominently at various locations within the Harbour, though in terms of the Lower Harbour these activities are more prevalent at Port Chalmers. Boats of sufficient size also venture outside of the harbour into the coastal environment more often for recreational fishing than any other activity. There are 7 yacht clubs within the harbour each of which undertake their own activities locally based around their respective club's location. However the main harbour channel areas and most secondary channel and bay areas with greater than 2 - 3m water depth are all commonly used for club events such as regatta and racing circuits as well as sailing in general. The facilities that support these recreational activities fall under jurisdiction of the Otago Regional Council and the Dunedin City Council. Potential project issues identified by representatives of these clubs related to shallowing up of harbour areas, effects of the commercial use of the deepened cannel on recreational boating, as well as effects at moorings or on slips.

Fishing from boats occurs within the harbour though the Entrance Channel is a particularly popular site for salmon and other species. Fishing from the Mole and Taiaroa Head near the Entrance Channel is also popular as is surfcasting from many beaches and rocky headlands.

Recreational diving is very popular at the Mole which is a voluntary marine reserve. The Mole is also used on a regular basis for people learning to scuba dive. Various other locations along the Otago coast and within the harbour are also popular diving spots, although the Mole is considered to be one of the more accessible locations.

Surfing is a popular pastime at many locations along the Otago coastline including a number of beaches from Aramoana through to Karitane. Of particular note are Murdering Beach (Whareakeake) which is nationally renowned as one of the best and longest right-hand breaks in NZ, as well as Aramoana beach. Surfing takes place throughout the year when conditions suit, and swimming at many of the coastal beaches and sites within the Harbour also takes place during the summer months. Beaches as well as other coastal and harbour areas are popular general community resources which are enjoyed by many.

Potential effects of Project Next Generation on these values have been considered and are addressed in Section 6.6 of this AEE.

5.4.4 Commercial Activity

A number of commercial operations are evident within Otago Harbour and along the immediate coastline. These include: commercial shipping, fishing (including the harvesting of cockles for research purposes), and eco-tourism, which has its predominant focus at Taiaroa Head.

Shipping operations are the most prominent of these commercial activities and the importance of Project Next Generation to these commercial port activities was outlined in Section 3.

Offshore commercial fishing and cockle harvesting are recognised activities within the areas affected by and adjacent to this proposal. The fisheries resource is described in more detail in Section 6.5 which also includes the assessment of potential effects on this resource.

Eco-tourism activity within the Lower Harbour focuses on wildlife activity at and in the vicinity of Taiaroa Head, but also includes other areas within the lower harbour. The Monarch has been taking tourists out to Taiaroa Head for over 10 years and in more recent times similar trips by sea kayak have become popular. The Royal Albatross Centre operated by the Otago Peninsula Trust is based at Taiaroa Head, while Natures Wonders is a smaller privately owned commercial operation based south of Taiaroa Head on open coast of the peninsula. Both are commercial operations based on eco-tourism. The assessment of effects in relation to the resources on which these operations rely on is considered further under Sections 6.3 and 6.4 of this assessment.

5.5 Summary

Detailed Scientific investigation and consultation has been undertaken including the most comprehensive ecological surveys to date which have enabled a good understanding of the surrounding environment to be developed. This includes detail on important physical processes and the significant ecological values the environment supports. It also includes the significant history of human interaction, use and modification of the environment that characterises the area.

The effects of Project Next Generation on these values are assessed in Section 6.

6. ENVIRONMENTAL EFFECTS

6.1 Introduction

This Section addresses the actual and potential environmental effects associated with Project Next Generation. The assessment takes an expansive view of the potential effects and where necessary draws on a number of expert reports specifically prepared to inform this proposal and consenting process.

The assessment of effects has been informed by analysis of the existing environment, as described in Section 5. The assessments of actual and potential effects of the proposal are covered under the following headings:

6.1 Introduction
6.2 Effects on the Physical Coastal Environment
6.3 Effects on Harbour Ecology
6.4 Effects on Offshore Ecology
6.5 Effects on Fisheries Resources and Commercial Fishing
6.6 Recreation
6.7 Navigation
6.8 Noise
6.9 Cultural Effects
6.10 Other Matters

6.2 Effects on the Physical Coastal Environment

6.2.1 Introduction

This Section addresses the effects of the proposed dredging activity and the resulting deeper channel on the physical coastal environment. This includes the effects on hydrodynamics, sediment transport and shore processes in Otago Harbour and in the wider Blueskin Bay area.

Assessment of the effects has used an approach consistent with international practice.

A review of literature on coastal and continental shelf processes of Otago Harbour and Blueskin Bay (Benn and Single 2007) was undertaken in order to summarise the main understandings of coastal and shelf processes in the study area, and to identify any significant gaps in the current knowledge base. A further report by Single and Benn (2007) considered the feasibility of the proposed dredging activity and resulting deeper channel.

The main effects on the physical coastal environment identified in the feasibility study concerned possible changes to the hydrodynamics of the harbour, and the transport of sediment in the harbour and from a possible dredged-sediment disposal site in Blueskin Bay. The report also identified gaps in the information required to fully assess the effects

of the dredging activity, and identified additional studies required to address the gaps in information.

Subsequently, a number of studies have been carried out to augment the knowledge base and to investigate specific aspects of coastal processes in the area as well as specific effects associated with dredging, disposal, a deeper harbour channel and vessel effects. Refer to Section 4.5 for full details of these reports.

These studies include :-

- *Hydrodynamic factors within Otago Harbour*

  Modelling of the tidal propagation was carried out by NIWA to assess the effects of a deeper channel on tide height, currents and timing of the tide into and out of the harbour. The results are reported in Bell et al. (2009).

  Met Ocean Solutions Ltd assessed the wave environment of the harbour with regard to the deeper channel. The results are reported in Bell et al. (2009).

- *Hydrodynamic factors outside the harbour between Taiaroa Head and Karitane Point*

  Measurements of currents outside the harbour were carried out to determine the magnitude and directions of currents with regard to possible dredged material placement sites. The results are reported in Bell and Hart (2008).

  Modelling of the currents and wave processes was carried out by NIWA and Met Ocean Solutions Ltd to assess the wider coastal environment for receiving dredged material. The results are reported in Bell et al. (2009).

  Met Ocean Solutions Ltd assessed the wave environment in the vicinity of the outer channel to identify changes to the wave propagation across the deeper channel and into the nearshore and beaches. The results are reported in Bell et al. (2009).

- *Sediment characteristics of material to be dredged from the main harbour channel.*

  Opus International Consultants Ltd carried out an investigation of the geotechnical aspects of the harbour seabed to identify the types and quantities of different sediments that would be dredged in deepening the channel. The results are reported in Opus (2008). Opus also undertook an interpretative evaluation of the data to determine the types and locations of the materials, as well as the validity of interpreted data supplied by Port Otago. These results are reported in Opus (2009).

- *Sedimentological factors of potential dredge spoil receiving sites, including sediment characteristics of the seabed and potential dispersal of placed dredge sediments.*

  NIWA carried out seabed surveys and modelling of sediment transport in the area offshore of Otago Peninsula between Taiaroa Head and Karitane Point in order to identify sediment characteristics and sediment transport paths from potential dredged sediment placement sites. The results are presented in Willis et al. (2008) and Bell et al. (2009).

- ***Vessel wake from existing and larger ships using the dredged channel, and the effects on the shores of the harbour.***

  Port Otago staff carried out observations of vessel wakes and assessed the potential changes of wake characteristics based on theoretical analysis of ship waves and the effects of the deeper channel. This work is presented in Single and Pullar (2009).

Significant portions of this section are taken from the comprehensive assessment of effects undertaken by Martin Single (Shore Processes and Management Limited), Rob Bell (NIWA) and Peter McComb (MetOcean Solutions Limited) referred to as Single et al 2010. Similarly Bell et al 2009 is also an important reference document. Comprehensive lists of references are contained within both Single et al 2010 and Bell et al 2009, and are reproduced in Sections 11.2 and 11.3.

The work on the physical coastal environment was carried out in conjunction with work on ecological and biological matters (see James et al. 2007, James et al. 2009 and Willis et al. 2008).

6.2.2 Hydrodynamic Modelling

A hydrodynamic model of the harbour was generated to simulate relative hydrodynamic changes before and after dredging and to provide supporting current flow fields for plume dispersion modelling. The model was calibrated using tides and currents from a previous field investigation carried out for the Otago Harbour Board in 1988 (Barnett et al., 1988), and tuned to match the field data. The match with tide heights was satisfactory (with differences between measurements and the model predictions of up to 0.1 m). A reasonably good match was obtained between modelled and measured currents in the main channels, particularly in the central core of the channel flow.

The Harbour model was also validated on two different sets of data: a) S4 current-meter measurements during the 2008 field programme from the eastern side of the Harbour; b) vessel-mounted ADCP survey currents measured by the University of Otago in the period 1998–2000. There was a reasonable fit to the overall pattern of flows and balance between ebb and flood currents, particularly in the Eastern Channel (south-west of Grassy Point).

At two sites there were some differences between the model results and the field measurements, especially for the flood tide. These can mostly be explained by localised effects on currents, including wind or rapid changes in seabed bathymetry that are picked by a current meter at a "point", whereas the current velocities in the model are depth-averaged and spatially averaged over a 30 m × 30 m model cell. Validation of the model using the boat-mounted ADCP currents from the main channel shows a good visual match between the modelled and measured boat-mounted ADCP current vectors - both in the magnitude and direction of the vectors and also the overall pattern of flows within the channels.

Overall, the Harbour hydrodynamic model performed well in predicting the tide height and more-importantly, tidal currents. The good calibration also leads to a dependable modelling platform whereby the assessment of suspended-sediment plume transport can be achieved with reasonable confidence.

6.2.3 Effects on Otago Harbour Processes

Tidal Range, Timing and Speed

The comparison of the calibrated hydrodynamic model runs for the existing situation and the 15-m dredged channel option provided an estimate of the relative changes in tide heights and current speeds from the dredging. The main focus in the comparison between before and after dredging was on spatial differences for a mean (average) tide.

Tidal range

Deepening of the shipping channel leads to a slightly larger tidal range within the Harbour as a deeper channel means the tide wave travels with less dampening from seabed friction. However these tidal range differences due to the 15-m dredged channel are relatively small (i.e., less than 1% of the average 1.6-m tide range). Along the deepened part of the channel, the increase in mean tide range (twice the half-range) is almost negligible in the Harbour Entrance (up to 0.004 m) and between 0.004 and 0.006 m increase over the existing situation from Harington Bend to Tayler Point. The highest increases in tide range of 0.006 to 0.008 m would occur around Port Chalmers, Portobello Bay and Harwood areas of the Lower Harbour and in the Upper Harbour, with the highest change at Dunedin. These changes amount to a difference of no more than 0.6% of the existing average 1.6 m tidal range.

High-water phase

High and low water will arrive slightly earlier due to the channel deepening. In the Upper Harbour, Deborah Bay, Port Chalmers and Portobello Bay, the advance would be up to 3 to 4 minutes. Between the Harbour Entrance and the commencement of Harington Bend the difference in the timing of the tide would be less than 1 minute, with a negligible change in the Mole area of the Entrance and beyond. This would occur as the tide wave travels faster in deeper water, and then levels off as it propagates up the Victoria Channel of the Upper Harbour, which will not be subject to the capital-dredging programme. Similar, but slightly smaller advances in the timing of low water would also occur.

Tidal currents

Overall there are likely to be only small changes of less than ±0.01 m/s (±0.02 knot) in the speeds of tidal currents following dredging. This change is not perceptible to human users of the harbour. The dredging results mainly in reductions rather than increases in speed, and largely within the Lower Harbour. There would be localised increases in the average major (peak) current of up to 0.02-0.05 m/s (0.04-0.1 knot) off the groyne at Beacon No. 10 on south side of Harington Bend and decreases in peak current (negative) of up to 0.10 m/s off Carey's Bay, just north of Port Chalmers as a result of the tidal flow being channelled into the wider Turning Basin. Much of the main shipping channel will experience reduced peak velocities. Smaller changes would occur in peak velocities in the side channel north of Quarantine Island (an increase of 0.01–0.02 m/s), with decreases of 0.02 to 0.04 m/s generally over the eastern side of the Lower Harbour between Harwood and Ohinetu Point. Most of the significant changes in current speeds (e.g., magnitudes >0.06 m/s) would only occur in localised patches, mainly on channel bends (Harington Bend, Port Chalmers Turning Basin) or around the groyne at Harington Bend (Beacon No. 10). It is in these areas, where dredging the intertidal or shallow flanks of the existing channel (to accommodate a wider and deeper channel) would have the most effect on currents compared to the existing situation. The change in phasing (timing) of the peak mean-tide current would be 2 and 4 minutes earlier in the Lower Harbour with the

deepened channel. These differences are in the same range as the advances to the high and low tide timing.

Mostly the inclination (or direction) of the peak-tide currents would be similar to the existing situation (within ±2°). The main change in inclination would be in outer Portobello Bay, and the connecting shallow subsidiary channel through the intertidal bank to the main shipping channel. This arises from dredging required to widen and deepen the Port Chalmers Turning Basin and lead-in transition on the eastern side of the shipping channel. The changes in peak current inclination would be up ± 7–8° in magnitude, arising from changes in eddies that form later in the flooding tide in northern Portobello Bay as a result of deepening and shortening of the entrance to the subsidiary channel.

Hydrodynamic changes before and after dredging were also considered for 20-knot southwest and northeast wind scenarios in an earlier feasibility report (Oldman et al. 2008). Similar high-water phase changes and differences in velocities and tide ranges to the tide-only situation (with no winds) were obtained, indicating the tide dominates the Harbour hydrodynamics. Consequently, no further analysis was undertaken on extending the analysis of changes for different wind and tide combinations.

Wave Environment

Lower Harbour

Harbour wind-wave modelling was undertaken for the purposes of characterising the wave climate within the Lower Harbour, and identifying the influence of various wind directions and speeds on wave generation. SWAN (Simulating Waves Nearshore) was used for all the wave modelling. The modelling was only undertaken on the existing channel bathymetry grid, as changes in significant wave heights would be small (less than a few cm) for a deeper channel. The reasoning is that short-period wind waves are not limited or influenced much by the larger depths (e.g., >12 m as in the existing channel or dredged channel option) for the relatively short wind fetches that occur in the Lower Harbour.

The resulting wave information for different wind velocities was used to assess ship handling by Port Otago. However the model results also provide insights into the influence the Harbour orientation, channel alignment and varying depths have on the spatial distribution of waves within the Lower Harbour.

Example wave model results for significant wave height for the 99th percentile northerly wind conditions are presented in Figure 20, and the westerly condition in Figure 21.

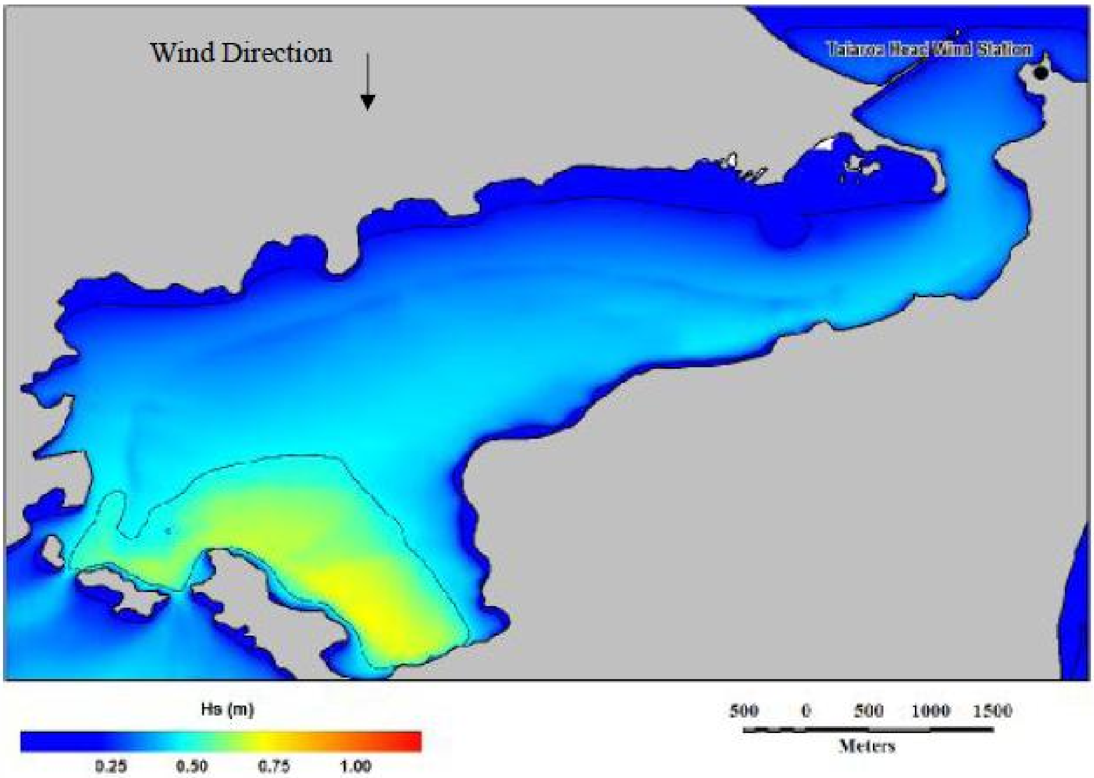


Figure 20: **Wind-generated significant wave heights from the 99th percentile northerly winds (Source: Figure 9.3 Bell et al. 2009).**

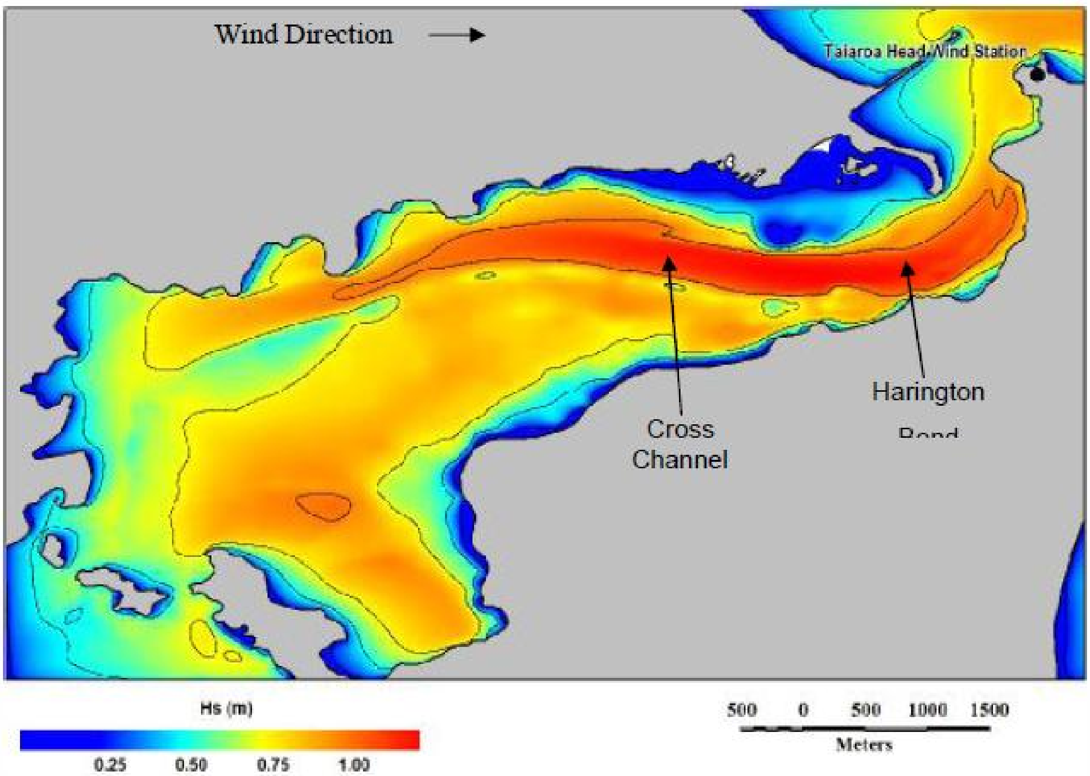


Figure 21: **Wind-generated significant wave heights from the 99th percentile westerly winds (Source: Figure 9.4 Bell et al. 2009).**

These results clearly show the fetch-limitations to wave growth and the attenuation that occurs over the shallow intertidal areas. The highest waves in the Lower Harbour originate from westerly winds (highest waves) and south westerlies (next highest). These are also the directions associated with the strongest winds. These predominant winds, combined with the geographical alignment of the Lower Harbour and shipping channel and the associated wind fetches over open-water pathways, result in the largest wind-generated waves occurring in the channel reach from Cross Channel through to and around Harington Bend. The largest significant wave height reaches approximately 1.2 m in the Harington Bend area for a 99- percentile wind (25 m/s or 49 knots) from due west (as can be seen in Figure 21).

Entrance Channel

The Entrance Channel crosses an ebb-tidal bar formation located between Taiaroa Head and the Landfall Tower, as shown on Figure 22. The current flows over the ebb-tide bar are complex and are affected by the oceanic currents (the Southland Current) and by tidal currents. There is a westerly flood flow through Transect 2 (right to left in Figure 22), while the ebb flow is biased towards the north. Residual flows are slightly biased towards the north due to the dominant ebb-tide jet and weak flood-tide currents. These flows in combination with wave induced processes have fashioned the geomorphic shape and orientation of the ebb-tide sandbar.

The computer generated models determined that the tidal currents were not strong enough to transport sand sized sediments alone, but that the initial entrainment of the sediments was likely due to wave currents.

It is the shape of the ebb tidal bar in relation to the predominant alongshore sediment transport system that results in a long interception distance for sediment moving north and west along the seabed. The cross-sectional shape and location of the channel margins in this location is therefore influenced by sediment spilling into the channel from the south and east.

In cross-section the channel is asymmetrical with a steeper side on the east and a flatter bank to the west. As a result, the dredging demand for this area of the channel is quite high in comparison to other sections of the channel, and the eastern channel margin requires 'shaving' to maintain the channel position. In summary, the hydrodynamic processes of the tide are working at right angles to the sedimentation processes relating to oceanic and wave induced currents, resulting in sediment being transported across from east to west, and along the channel towards and out of the harbour.

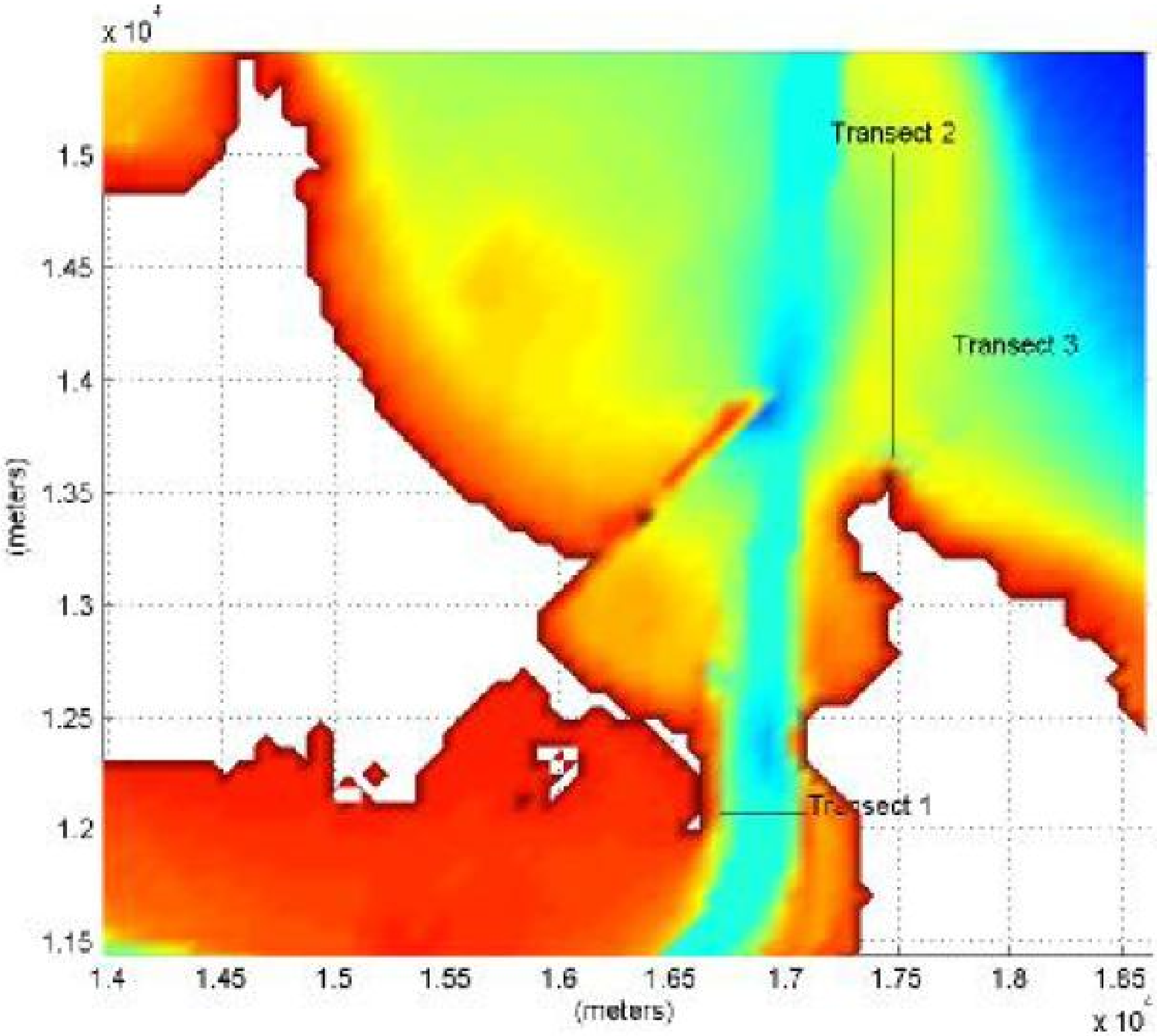


Figure 22: Depth shading of the Entrance Channel area, showing locations of transects modelled for currents before and after dredging (Source: Bell et al. 2009, Figure 5.9).

Sediment Dispersal

With the proposed dredging programme, it can be expected that there will be changes to patterns and processes of sedimentation in Otago Harbour and the offshore area from Taiaroa Head to Karitane Peninsula. These changes will result from:

- Additional fine sediment put into the active sedimentation environment in the harbour during the dredging activity (excavation in the channel and deposition at the receiving ground).
- Changes to the channel form as the sides and margins of the deepened channel "relax" into an equilibrium condition.
- The addition of the dredged sediment onto the offshore seabed.

The hydrodynamic and wave modelling was used to identify patterns of plume dispersion through application of Harbour and offshore plume dispersion models. The MIKE-21 Particle tracking model was applied inside the harbour. The DHI Particle Tracking (PT) module for the Flexible Mesh (FM) version of MIKE-3 was used to simulate the transport and fate of suspended material outside the harbour. This model is commonly used

worldwide for modelling or monitoring of dredging and disposal works. The models were tested for sensitivity and found to be relatively insensitive to the effects of winds, the choice of dispersion coefficients and the use of different quartile silt distributions examined for a sand-dredging claim within the Port Chalmers Turning Basin. This means that for discharged sediments, dispersion and mixing processes (excluding settling of silts versus sands) and wind-driven effects on currents play a relatively minor role in determining the fate of sediment discharges from the trailing suction dredging operation. Discharge sources well below the water surface i.e., near the bed (nominally 1 m) and 5 m below the surface for the overflow, also contribute to constraining the settling sediments within the channel systems, rather than leading to substantial spreading out across the adjoining intertidal flats, with the only opportunities for wider spreading occurring around high tide. Insensitivity to the effects of winds and wind modifications to the tidal currents emphasizes that the to and fro tidal advection in the channel is a dominant factor in determining the transport of suspended-sediment plumes.

In addition, due to the plume model characteristics, the resulting suspended-sediment concentrations (SSC) are presented in terms of saturated-weight of sediment rather than dry weight per volume. This means that the actual SSC would be about 70-80% of that predicted (Bell et al. 2009).

Key results from the MIKE-21 modelling of suspended-sediment concentration simulations show:

- **The dredger discharges in the Turning Basin would have the most influence on elevating average SSC above background levels in the Upper Harbour, in contrast to dredging at Harington Bend and beyond, which would have little influence on SSC in the Upper Harbour beyond Goat and Quarantine Islands.**

- **The highest depth-average SSC values (e.g., over 100 mg/L with some patches up around 1000 mg/L) would occur in the main shipping channel, subsidiary side channels e.g., channel north of Quarantine Island through to Portobello Peninsula, and on the intertidal banks adjacent to these channels e.g., the mid-harbour intertidal banks from discharges at Harington Bend.**

- **Discharges from predominantly-silt claims generally show a wider spread of affected areas onto intertidal flats and side channels than discharges of silt-sized material from predominantly sand areas. This difference is related directly to the magnitude of the discharge or flux of silt-sized material, which was set to 1000 kg/s for "silt" claims compared to 60 kg/s for "sand" claims, even though the latter discharge would run for much longer. However, there wouldn't be widespread dispersion of these finer silt-sized sediments over large tracts of the Harbour, as the channel tidal streams dominate the transport of suspended sediments rather than dispersion/spreading processes. Also there would be only limited opportunities around the more quiescent period either side of high tide when diluted plumes from the overflow sources – that discharge most of the time at 5 m below the surface (except at Turning Basin - east) - can spread out further over adjacent intertidal or shallow sub-tidal areas.**

- **While there is only a short distance separating the two Turning Basin source locations (east and west sides), there would be a substantial divergence in areas affected by suspended-sediment plumes due to the strong flow divergence at Quarantine Island. From the "west" source location, discharge plumes would be transported up the Victoria Channel partway into the Upper Harbour while plumes from the "east" source location would be preferentially transported and dispersed to areas around the Portobello Peninsula and into the Latham Bay area of the Upper Harbour.**

- **Most of the eastern side of the Lower Harbour from Te Rauone Beach to Harwood would be largely unaffected by discharge sources (from the dredge while in operation or during transit to the receiving ground) other than the Harington Bend discharge location, and then only in patches.**

- **The eastern side of the Upper Harbour from Grassy Point to Dunedin would be also largely unaffected by sediment discharge sources.**

- **Average SSC will be low in the plume that emanates from the Mole to Taiaroa Head channel section for dredging claims in the Turning Basin, but will gradually increase up to a depth-average SSC of 100–200 mg/L for discharge sources at Harington Bend. These average SSC levels offshore from the Mole would reduce somewhat as the dredger works the Howlett claim (between Harington Point and the Mole) and further reduce in the Outer Channel claim as the silt content of the sandy seabed sediments reduces considerably to virtually nil.**

A period of 100 days was selected as the most likely length of time required to carry out the dredging (not counting down time). Due to the differing capacities of dredging vessels, the contracted operator could take longer or shorter than the 100 days to complete the dredging. However, the volumes of the dredging claims predominantly govern the values of total deposition. For example, this means the total deposition thicknesses wouldn't change much for a 120-day period of dredging. However, daily rates of deposition could change somewhat depending on the capacity of the dredger that is contracted.

Key results for predicted sediment deposition accumulated over an entire 100-day dredging season (assuming no subsequent resuspension of settled silts) show:

- **A marked difference in silt deposition between the predicted deposition in the main shipping channel and all other Harbour sub-areas, with deposition values much higher within the main channel. However these high predicted deposition values exclude subsequent resuspension by tidal currents and/or wind waves, so are mostly unrealistic. They occur in the model when sediments settle out eventually in more quiescent periods of the ebb or flood tide periods, and remain fixed to the bed in the simulations. In practice, these sediments will be re-mobilised frequently, until eventually a proportion is flushed through the main channel system, while some material re-settles in areas of the channel and consolidates into the fabric of sands on the channel floor;**

- **Other Harbour sub-areas which would exhibit accumulated deposition of over 10 mm in the 100-day dredging period, in the 1% of model cells with the highest deposition for that sub-area, would be in: a) the reach of Victoria Channel to Kilgours Point (99% of cells would have less than 14 mm deposition over the dredging programme); b) the side channel off Quarantine Point at the tip of Portobello Peninsula (99% of cells would have below 10 mm deposition); c) the southern side of the central intertidal bank and adjacent shallows that separate the shipping channel from the side channel through Ohinetu Point, which would arise primarily from discharge sources in the Harington Bend and The Spit areas (99% of cells would have less than 24 mm deposition); d) the sequence of central intertidal banks adjacent to the shipping channel, with the highest likely to occur in the sandbank opposite Port Chalmers (99% cells would have below 82 mm of deposition), arising mostly from dredging of the eastern side of the Turning Basin; e) the subsidiary channel from Quarantine Island through to Latham Bay, again from dredging the eastern side of the Turning Basin (99% of cells would have less than 13 mm deposition over the dredging period);**

- **Outside the main shipping channel, the highest median deposition in any sub-area of the Harbour would occur on the intertidal sandbank opposite Port Chalmers, with half the model cells in this sub-area showing deposition of nearly 4 mm or more. In** most other sub-areas outside the main channels, the median deposition is small at less than 1 mm over the dredging programme.

The long-term fate of silts within the Harbour is difficult to address with suspended–sediment modelling, as it would involve very long computer simulations with a combination of wave, tide and silt-transport models. However, some general tendencies can be inferred from the plume modelling results and our understanding of silt transport in harbours.

Firstly, the plume modelling shows that only the main channel and the side channel between Quarantine Island and Portobello Peninsula would be subject to the highest initial deposition thicknesses. These channel silts would be reworked regularly by tidal currents, especially on spring tides, and spread throughout the entire shipping channel, preferentially settling in more quiescent sections of the channel system and also with a sizeable proportion being exported out the Entrance. In the shallower sub-tidal areas, and intertidal banks, some of the initially settled silts are likely to be remobilized by wind waves rather than by currents, and will then be transported elsewhere in suspension by the current until settling again. For a typical 3-second wave, and a upper-range significant wave height of 0.6 m, the threshold for mobilizing non-cohesive medium silts (0.01 mm) would be exceeded in depths less than about 7 m, which includes most of the Harbour outside the main shipping channels, except a small part of the basin in Portobello Bay. Consequently, during moderate to high waves, silts available for reworking will be winnowed from the seabed surface, especially off exposed shallow areas and intertidal flats where wave orbital velocities can be high.

Silts in the long-term would be dispersed further and more thinly throughout the Harbour, eventually finding their way into the main channel system to be exported to the ocean or preferentially settle "permanently" in quiescent areas where wave activity and currents are low or sporadic such as Dunedin Basin, inlets in the Upper Harbour behind the railway embankments, sheltered sub-tidal embayments (e.g., Careys Bay and the inner Port Chalmers berths), the deep basin in Portobello Bay, and in the lee of groynes or half-tide training walls.

6.2.4 Effects on the Offshore Environment Processes

Hydrodynamics

The 3-dimensional DHI MIKE-3 Flexible Mesh (FM) model was used to simulate current flows on the Otago shelf (Figure 23). The model was calibrated against field data measurements at a number of sites (shown in Figure 24).

The model shows that the inshore component (Subtropical Waters) of the Southland Current is strong and persistent, peeling off from Cape Saunders to the NE, with the net residual current gradually reducing in velocity as it moves more northwards over the submergent Peninsula Spit in outer Blueskin Bay.

On the inner shelf, there is an anticlockwise eddy in Blueskin Bay (Figure 3.1a) as deduced by Murdoch et al. (1990), but it is relatively weak and it sweeps down through the outer part of Blueskin Bay in depths of greater than 20 m, rather than moving along the coastline.

The main feature on the inner shelf, hitherto not documented, is a relatively small clockwise eddy of about 5 km in diameter off Taiaroa Head, juxtaposed between the ebb-tide jet from the Harbour entrance and the Southland Current flow to the NE offshore. The current-meter mooring site at A1 was located towards the outer edge of the Taiaroa Head eddy, giving rise to a persistent residual current to the SE (Bell et al. 2008).

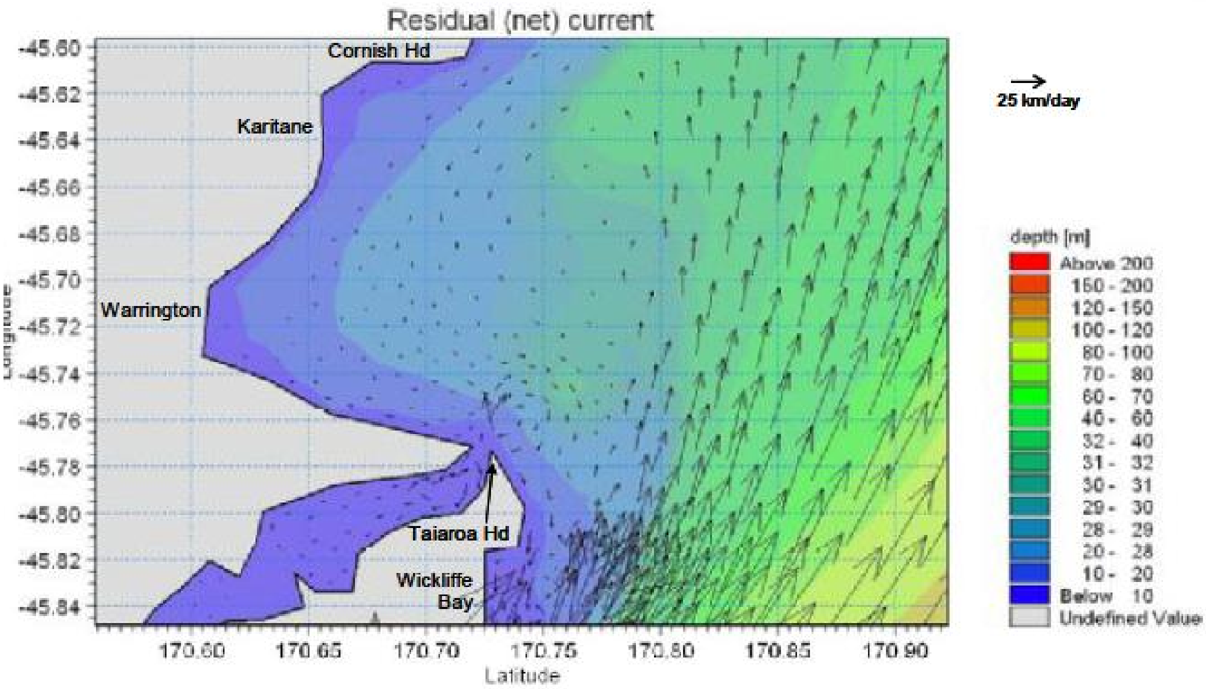


Figure 23: **Residual depth-averaged current pattern over the initial two field deployments at A1 from the calibrated Run10 of the offshore hydrodynamic model. [Note: residual currents inside Otago Harbour should be ignored] (Source: Figure 10.4a Bell et al. 2009).**

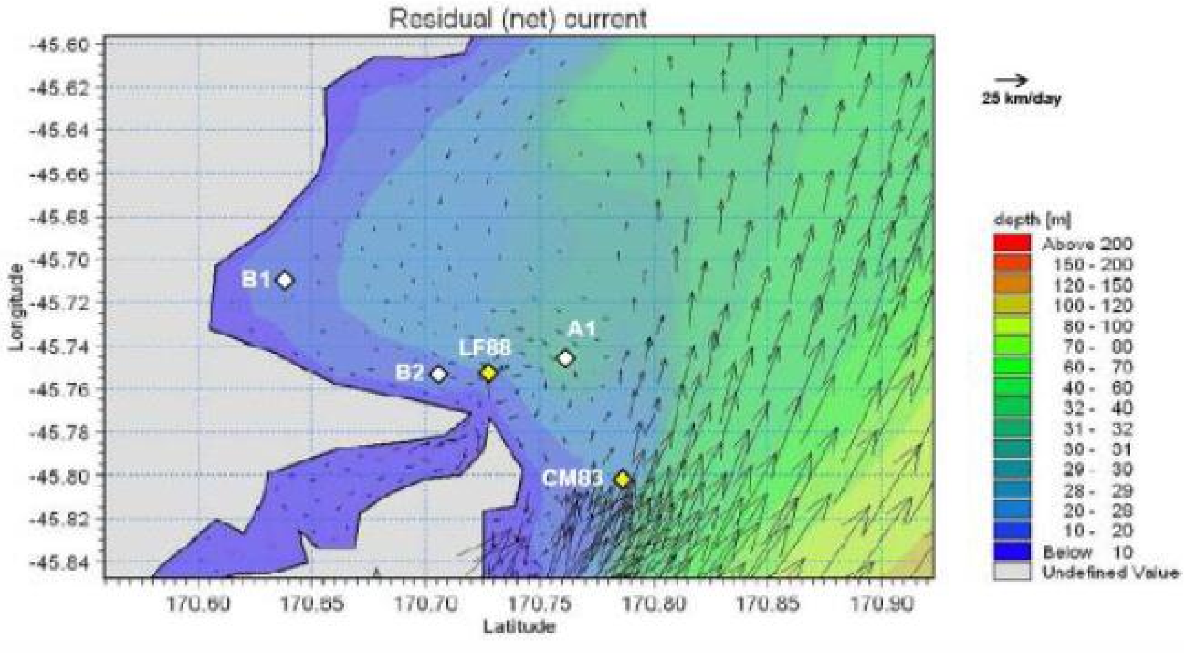


Figure 24: **Current-meter mooring sites plotted on the backdrop of the residual depth averaged current pattern over the initial two field deployments at A1 from the calibrated Run10 of the offshore hydrodynamic model. White diamonds are from the 2008 field programme, and yellow diamonds from previous moorings in the 1980s (Source: Figure 10.4b Bell et al. 2009).**

In the nearshore zone south of Taiaroa Head, including Wickliffe Bay, the depth-averaged current residual is to the south (Figure 24), which is driven by the return flow of the separation eddy off Cape Saunders. This residual current only includes the influences of winds, tides and the Southland Current. Waves and swell also generate current drift in the nearshore region, with stronger swells arriving from the SE (compared with local seas from the NE) likely to generate a nearshore wave drift to the north in the opposite direction to the current residual.

A reasonable calibration of the 3-layer offshore hydrodynamic model was achieved focusing on obtaining a good match with net or residual currents. Residual current patterns and behaviour are more important for longer- and larger-scale plume and sediment transport processes offshore, than tides and responses to winds over short time scales. Critical to the success in achieving a realistic match of the modelled residual current to that measured at the offshore site A1 (30 m depth) was the ability to derive a realistic southern boundary condition to drive the model by quantifying the spatial variation along a shore-normal transect of the mean flow of the Southland Current from NIWA's ocean circulation models.

While the chosen field mooring location (A1) proved eventually to be unsuitable as dredged sediment receiving ground option, it proved to be an excellent location to test and verify the offshore model because of the complexities that exist there in the circulation pattern.

In this locality, a small-scale clockwise eddy off Taiaroa Heads interacts with the ebb-tide jet from the Harbour Entrance, local offshore winds and the Southland Current further offshore. At A1, the SSE residual or drift current was reasonably well predicted after tuning the hydrodynamic model, the boundary conditions and its associated irregular bathymetry grid. If the mooring site had been located further offshore within the Southland Current, the subtleties within the inshore flows may not have been well resolved, particularly the Taiaroa Head eddy, which preferentially transports material towards the coastline of Otago Heads. Not having a mooring further offshore within the main Southland Current flow was not critical in this project. Sensitivity tests of the offshore model using realistic variations in the spatial distribution and strength of the Southland Current boundary condition showed the results on the shelf were relatively insensitive compared to the situation of using the mean or average flow of the Southland Current. Local winds play a role in modifying the underlying residual currents offshore that are generated or influenced by the Southland Current, which the model was also able to mimic.

Overall, the MIKE-3 FM offshore hydrodynamic model is performing well in predicting residual or net currents that specifically include the Southland Current, tides and local offshore winds. Therefore simulating transport of suspended sediment and long-term sand transport from the preferred dredge disposal site can be achieved with reasonable confidence.

Wave Environment

A detailed analysis of the wave climate was undertaken for two representative locations between Taiaroa Head and Karitane Peninsula; an offshore site in the vicinity of the A1 receiving ground option, and a location near the fairway beacon on Landfall Tower. The numerical wave hindcast model was used to generate information about the long-term wave climate in the area. Annual, seasonal and monthly significant wave height statistics for each site were calculated. The Landfall Tower receives more sheltering of waves than the offshore A1 location; the mean annual significant wave height (Hs) at A1 is 1.06 m while at the Landfall Tower it is 0.85 m. The largest waves tend to have peak periods in the range 10–13 seconds, and the height–period distribution is similar for both locations.

The winter and autumn months are more energetic, while November is the least energetic month. At location A1, two directional modes are evident from the NE and the SE. Wave directions are constrained near the entrance region.

Effects of disposal mound on the offshore wave climate

Waves refract, shoal and dissipate as they approach the shore, and the nearshore wave climate will respond to changes to the offshore bathymetry. The dredging proposal will result in a deeper entrance channel and the creation of a mound in the dredged sediment receiving ground. These changes have the potential to influence the adjacent wave climate. The numerical wave hindcast model was used to simulate waves over a 5-year period (2003–2007) using the modified bathymetry, so that the model outputs could be compared directly with the existing bathymetry simulation.

The comparisons between the mean and maximum significant wave heights over the 5-year hindcast are shown on Figures 3.7 and 3.8, respectively. The furthest offshore receiving ground option (A2) would have little discernable impact on the wave patterns, especially mean wave height (Figure 4.6), while the option closer to Taiaroa Head (A1) has a minor focussing effect in the lee of the mound (to the NW). The dredging programme for maximum significant wave heights would result in a maximum of 3-5% change to the wave heights for the existing situation. The model results show no evidence of change to the wave environment at the shoreline, and there is no evidence that the changes would be detrimental to surfing conditions or give rise to adverse coastal change.

Detailed analysis of the time-series of wave hindcast data (existing versus modified) at discrete locations along the coast further quantified the changes that would result from the disposal mound and deeper channel. Annual, seasonal and monthly significant wave height statistics were assessed. It was found that there would be a very slight reduction in wave heights at some locations near the harbour entrance. For example, in the middle of

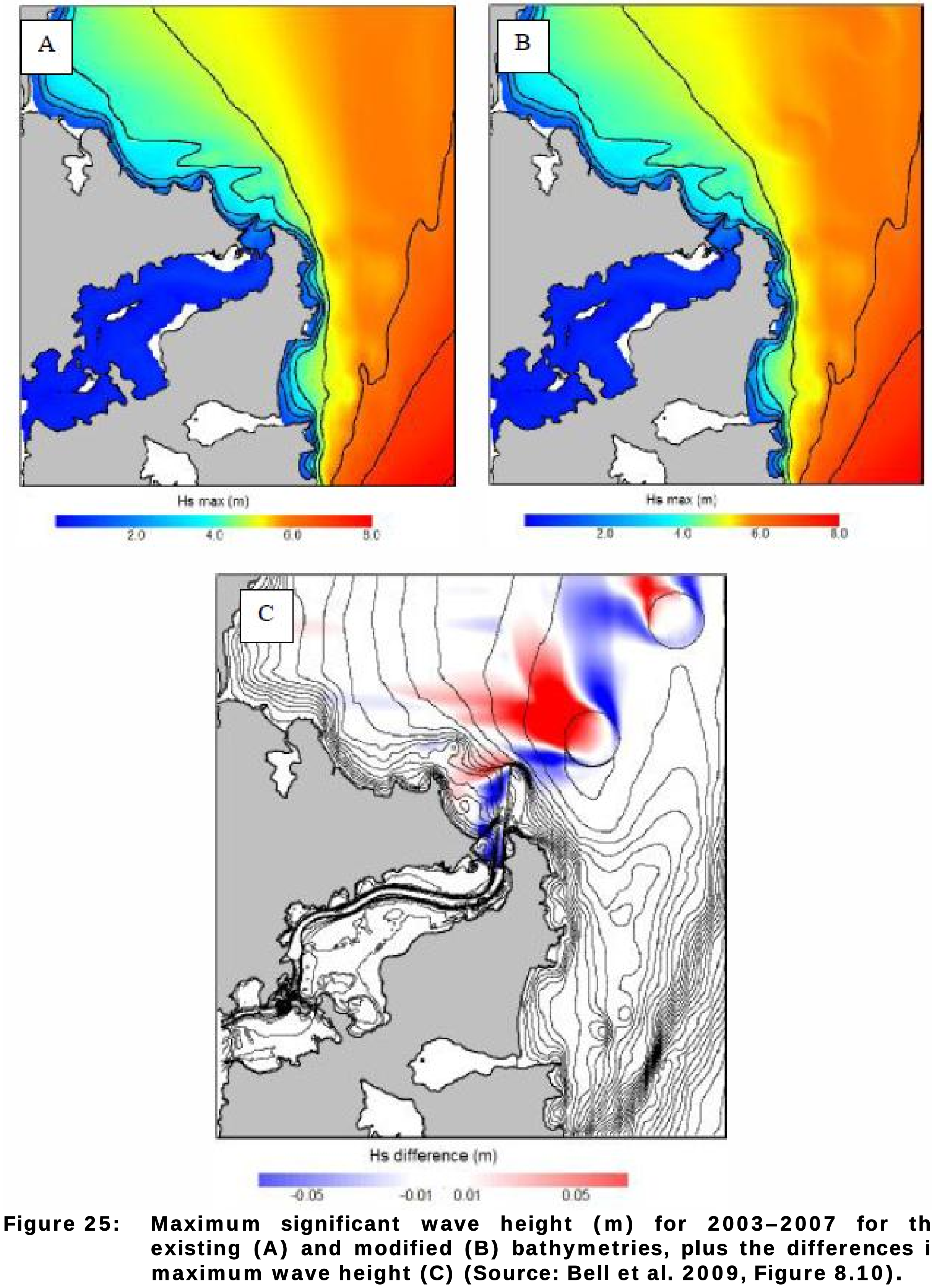


Figure 25: Maximum significant wave height (m) for 2003–2007 for the existing (A) and modified (B) bathymetries, plus the differences in maximum wave height (C) (Source: Bell et al. 2009, Figure 8.10).

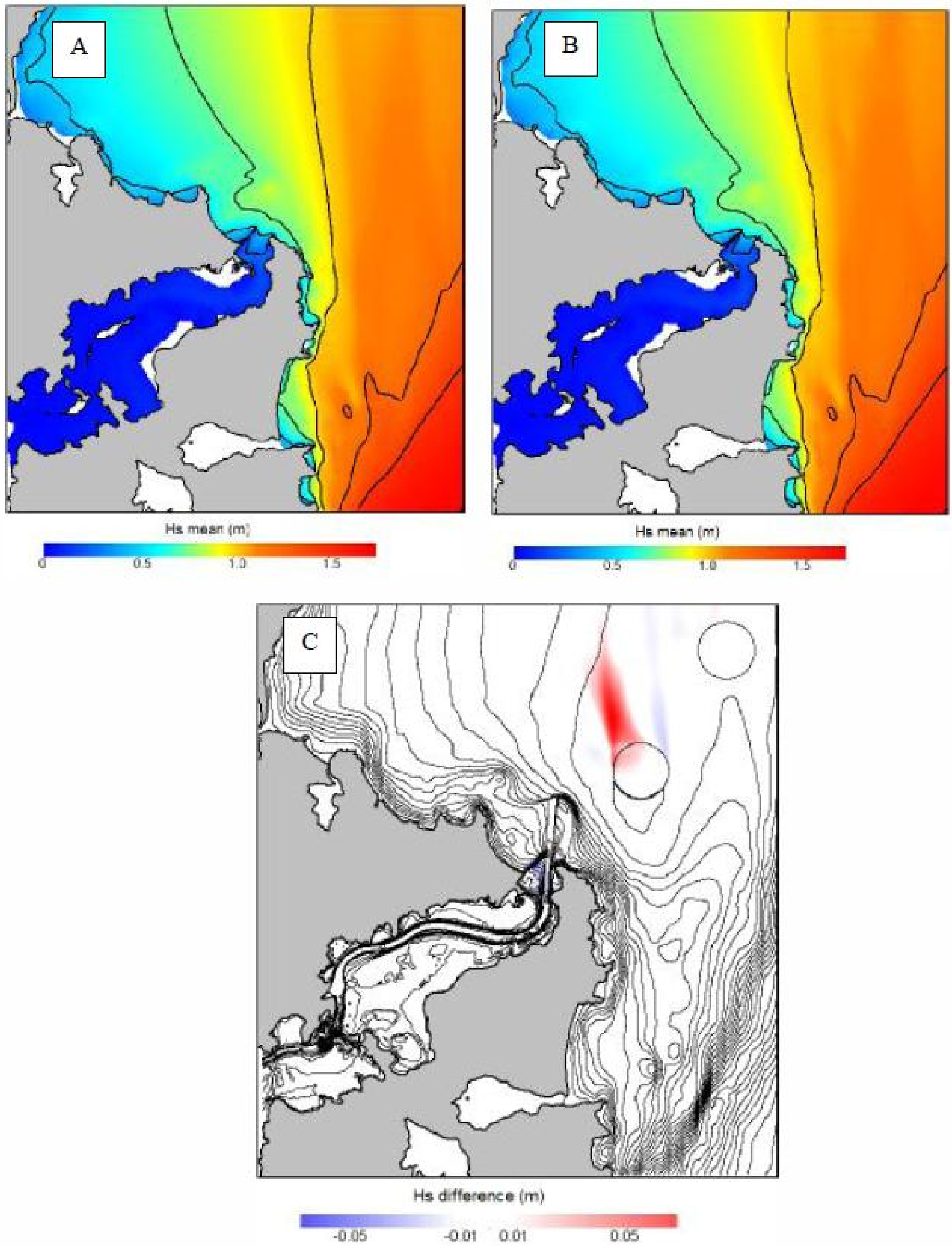


Figure 26: Mean significant wave height (m) over 2003–2007 for the existing (A) and modified (B) bathymetries, plus the predicted differences in mean wave height (C) (Source: Bell et al. 2009, Figure 8.9).

Aramoana Beach the reduction in height would be around 0.01 m, while at Shelly Beach the wave height reduction would be around 0.02–0.04 m. These effects are due to changes to the shoaling of waves crossing the proposed dredged approach channel and wave refraction over the A1 receiving ground option.

Although the preferred receiving ground option (A0) was not modelled, changes to the wave environment would be of a similar to lesser magnitude and type as those found for sites A1 and A2. The wave environment at the shore would be less modified than under the A1 option.

Sedimentation

Offshore Plume Dispersal

During the disposal operation, when the dredge hopper is emptied at the offshore disposal site, the following processes would occur (as shown in Figure 27):

- A major portion of the released sediment load descends rapidly en masse to the seabed and deposits itself there;

- A minor portion of the sediment load goes directly into suspension (especially finer size fractions), increasing the concentration of suspended material in the water column and drifts off with the current, dispersing and gradually settling with time;

- Finer material (e.g., silts) within the mass that falls directly to the seabed will spread out radially along the seabed away from the impact zone;

- Deposited material can be subsequently re-suspended when wave conditions are sufficient strength to mobilise the seabed surface sediments and transported by currents before settling again when conditions allow.

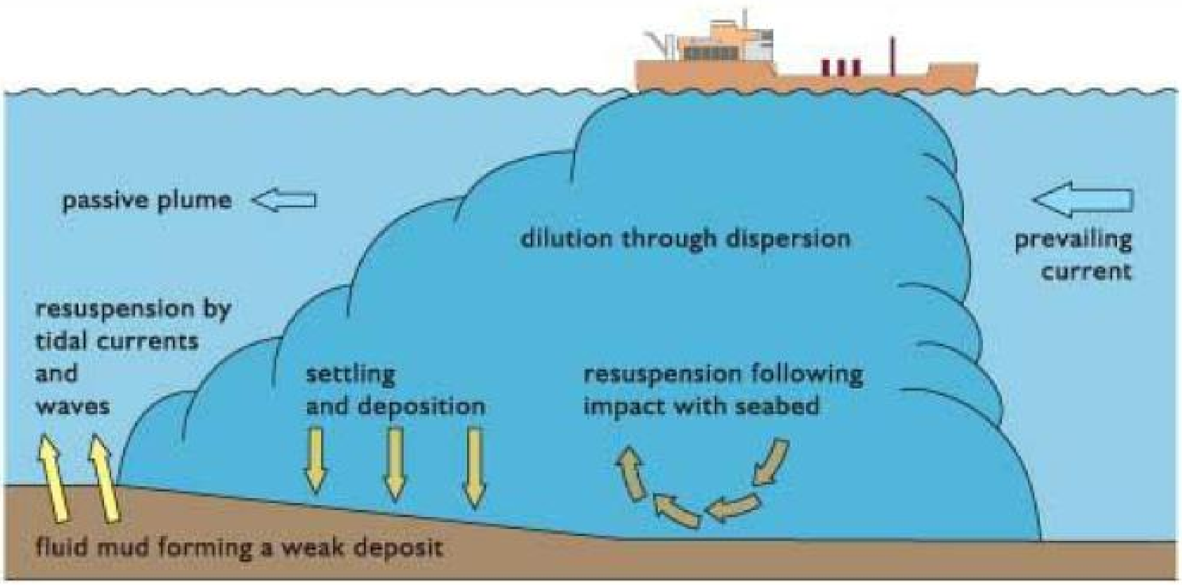


Figure 27: Schematic of a dynamic sediment plume discharged from a dredge hopper. [Source: CIRIA (2000)].

Suspended-sediment concentrations were analysed from single simulations of each of six 48- hour wind scenarios from either NNE or from WSW, applied for each of five selected placement sub-sites within the 2 km disposal area at A0. Each hopper load was assumed to contain an average mix of dredgings from “silt” and “sand” sources in proportion to their respective total volumes from all dredging claims. Mean and maximum composite plots for each sediment-size component and depth-layer of the plume simulation were generated for the 48-hour wind sequence.

Key results for the A0 receiving ground for an average hopper mixture were:

- **Suspended-sediment concentrations (SSC) would be highest in the bottom near-bed layer (bottom 20% of the water depth) due to the settling of sediment towards the bed and having commenced discharge from the hopper at 5 m below the water surface.**

- **Medium silts cause the higher local elevations in SSC in the bottom layer within a few kilometres of the receiving ground, but the fine silts are more dispersive spreading over a wider area (due to their lower settling rate).**

- **In the vicinity of the receiving ground, considering both fine and medium silts, moderate WSW winds are the most adverse wind conditions for the maximum bottom layer SSC, which would be up to 160 to 220 mg/L (excluding coarse silts and sands). The highest maximum surface-layer concentrations reached in the vicinity of the disposal site would be in the range 30–60 mg/L for each of the size classes and across all six wind scenarios, with the higher surface-layer values occurring during light NNE winds when combining all size classes, the maximum total surface-layer SSC would be around 185 mg/L.**

- **Average SSC would be substantially lower than the maximum values, because the 2- hour gap between discharge from the dredging vessel would allow the concentrations to reduce from settling and dispersion.**

- **The dilute edge of the near-bed plume could occasionally reach coastal areas between Taiaroa Head and Wickliffe Bay but not under stronger winds from the WSW or NNE. SSC would be elevated above background surface SSC by up to only 0.7–1.5 mg/L, for fine and medium silts (with a total SSC increase of only 2.2 mg/L) under light NNE winds. In the bottom layer, maximum total SSC increase would be somewhat higher at around 2.8 mg/L above background concentrations for the same wind conditions.**

- **The dilute edge of the plume could reach areas of the coast north of Karitane and beyond but would elevate the total surface SSC by only about 0.02 mg/L in the Karitane area, and up to only 0.9 mg/L further north towards Stony Creek and Shag Rock under light NNE winds. In the bottom layer, maximum increase in total SSC north of Cornish Head would only reach 0.41 mg/L above background concentrations under strong WSW winds.**

- **In the bottom layer, the highest excess concentrations occur at the receiving ground where the fine sand (class 4) concentrations would reach around 1600–1700 mg/L for light wind conditions, and less for stronger wind events. Of the silt-size classes, medium and coarse silts would contribute similar maximum excess concentrations in the bottom layer of up 200–230 mg/L "downstream" in the vicinity of the receiving ground, with the higher values occurring during a moderate WSW wind. For this moderate WSW wind scenario, the total maximum SSC in the bottom layer combining all size classes would be around 2100 mg/L in the vicinity of the receiving ground.**

- **For coastal areas likely to be reached occasionally by the dilute plume, excess surface SSC would be highest for light NNE winds, which are conducive to wider spreading (dispersion) of the plume and less vertical shear in the water column (which occurs in stronger winds). In terms of the bottom layer, light NNE winds would cause the highest SSC off Otago Heads, but strong WSW winds would cause the highest SSC off the northern coast. In all coastal cases, the maximum SSC would remain quite small and occur periodically depending on the winds.**

- In the vicinity of the receiving ground, the highest excess concentrations in the surface water would most likely occur on light NNE winds, with the highest concentrations in the bottom layer for sands also likely to occur during light winds (any direction), while for silts, it would be reached during moderate WSW winds.

- Overall, winds don't appear to substantially affect the plume characteristics and movement from site A0 as much as plume simulations for option A1 closer inshore. This is because site A0 is located on the inner edge of the periphery of the Southland Current that drives a persistent residual current to the north and tends to dominate the flow regime.

Summary of results for the bottom layer for a predominantly silt hopper load:

- Maximum bottom-layer concentrations in the vicinity of the receiving ground are considerably higher for the predominantly-silt hopper discharge compared with the average sand/silt hopper loads reported above. For class 1 (fine silts), the increase would be 130% and 145% for light WSW and light NNE winds respectively, with equivalent increases of 140% and 150% for class 2 sediment size (medium silts) and 150% higher in both cases for class 3 sediment size (coarse silts).

- Combining all the "silt" size classes, the maximum silt-derived SSC in the bottom layer in the vicinity of the receiving ground, for the worst wind scenario (a moderate WSW wind), would increase from around 620 mg/L for an average sand/silt hopper load to around 910 mg/L for a smaller, but predominantly-silt hopper load—an increase of around 145%.

- Combining all size classes including sands, the total maximum SSC in the bottom layer in the vicinity of the receiving ground, for a moderate WSW wind, would actually decrease from around 2100 mg/L for an average sand/silt hopper load to around 1150 mg/L for a smaller, but predominantly silt hopper load—because of the much smaller sand volume in the latter.

- For shoreline areas (e.g., Otago Heads, north of Cornish Head) when the edge of the dilute edge of the plume makes contact, the maximum increase in SSC for each silt size class in the bottom layer is unlikely to be any higher for the predominantly-silt hopper discharge for light WSW or NNE wind conditions, but the area over which the silts disperse at very low concentrations is somewhat more widespread. Both these findings are indicative of the highly dispersive processes for suspended silt that operate on the Otago shelf, once they leave the receiving area.

Total Sediment Deposition on the Seabed

Given the distribution of winds during the actual dredging programme are not known ahead of time, a Monte Carlo approach was used to randomly select one of the six 48-hour wind scenarios, where the chance of selection for a wind scenario is governed by the likelihood of that wind occurring. The analyses of dredge volumes and dredge turnaround times by Port Otago indicate a continuous dredging season of around 100 days, not including downtime and weather contingencies. Therefore a sequence of 51 lots of 48-hour plume simulations was required to replicate the dredging season. The deposition pattern and magnitude from each 48-hour plume simulation is accumulated to arrive at an estimate of the total deposition.

In accumulating the deposition thicknesses, the assumption is made that once sediment is placed it remains there. This is a conservative assumption, especially for the finer sizes, which will be regularly mobilised by wave action and moved on in an ever-increasing dispersive manner. Also a conservative assumption was made that the bulk density of

settled sediments would be only 1300 kg/m3, thus erring on the higher side of deposition depths. Finally, losses of silts and sands that may overflow from the hopper into the Harbour waters during dredging were not deducted from the volumes discharged over the receiving ground. Consequently on all counts, the offshore deposition plots provide a conservative upper bound on deposition depths on which to assess environmental effects, bearing in mind the dispersive behaviour of fine sediments on an active, exposed shelf system.

The key results from the deposition distributions are:

- **For the A0 receiving ground option, the deposition is predominantly on the site and to the north of it, arising from the persistent northerly residual current.**

- **The small degree of deposition to the south-east mainly occurs at times during light NNE breezes.**

- **Fine silt deposition occurs over the widest area as expected in a highly dispersive environment with slowly settling sediments. This contrasts with sand, where deposition is much more confined, occurring well offshore and to the north and northeast of the receiving ground.**

- **Deposition is low along coastal areas where the diluted suspended-sediment plume edge comes in occasional contact, such as Otago Heads (north of Wickliffe Bay) and the northern coast from Cornish Head north. Where deposition is predicted to occur, it would be <0.5 mm thick over the dredging programme. This is an upper-bound estimate, but in reality these "deposited" sediments, being fine and medium silts, will be mobilised by wave activity in shallow coastal waters and continue to be dispersed over a wide area. The modelling also shows that no deposition of silts or sands would occur in Blueskin Bay or at Karitane within 48 hours of disposal.**

- **All silt sizes would be dispersed further north than the northern boundary in the hydrodynamic model at Shag Rock, but deposition would be very small at <0.1 mm.**

- **The area influenced by various deposition rates is shown in Figure 28. The area where a deposition rate of more than 0.08 mm per day would occur (as an upper bound) extends approximately 18 km in N-S direction (mainly to the north) and 5 km in width (Figure 28) covering 77 km^2. The area in which the deposition rate would be 0.4 mm per day would extend only to the northern terminus of the Peninsula Spit (–45.655°N) covering up to 29 km^2 while smaller areas where accumulated deposition rates would exceed 0.8 and 1.7 mm/day (Figure 28) could cover 18 km^2 and 11 km^2 respectively (including the disposal mound). This deposition pattern is closely aligned with the results from the sand transport modelling.**

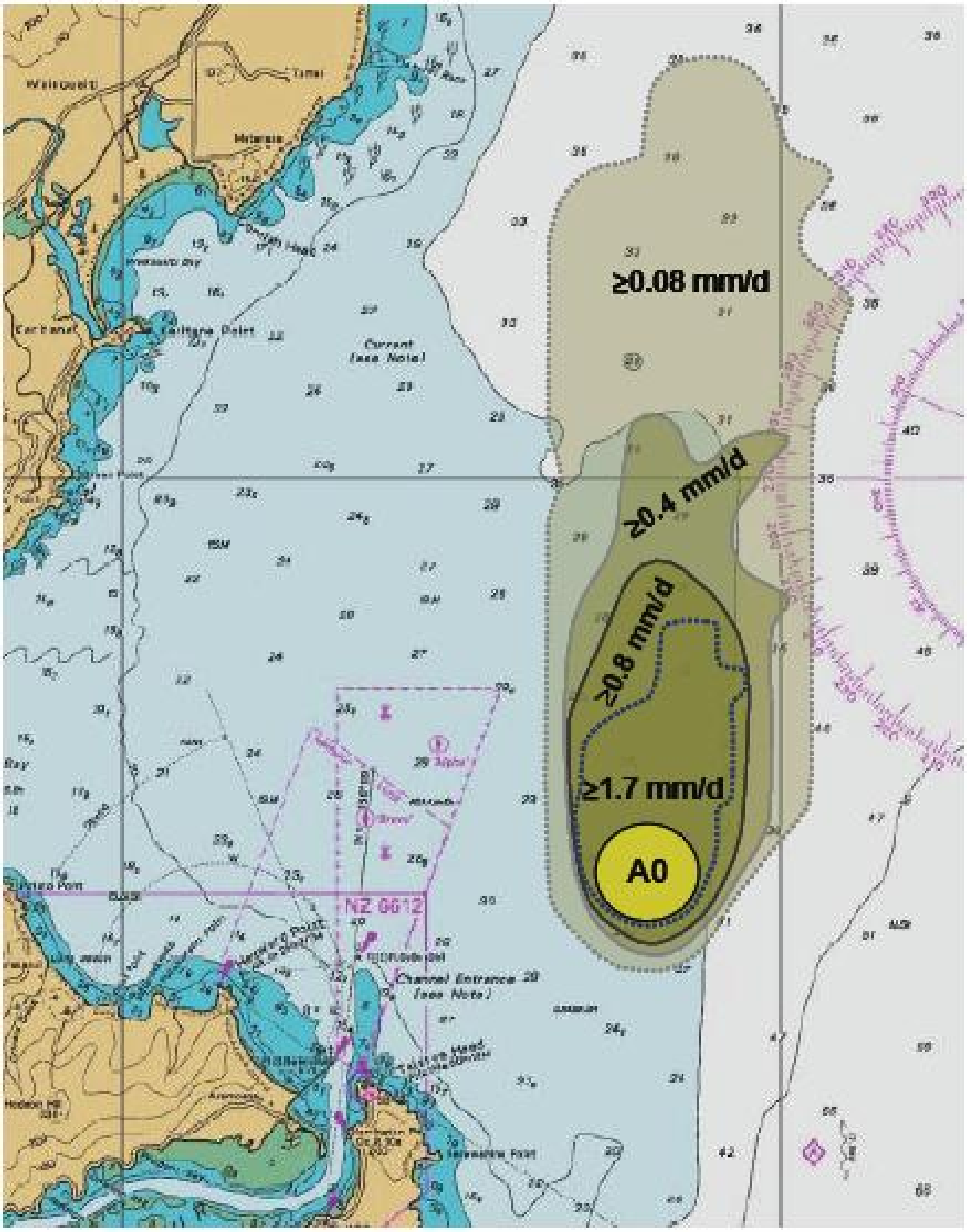


Figure 28: Figure 3.10: Zones within which various average deposition rates (mm per day) are exceeded for all sand/silt fractions over the entire dredging programme. The deposition rates are conservative, being applicable to a mid-size TSHD of 10,800 m3 capacity where the dredging extends for 120 days continuously. The inner zones out to the 0.5 mm/d zone boundary are indicative of the transport pathway and extent of sand transported through the disposal mound at A0. The transport pathway also matches closely with the alignment of the incumbent geomorphological feature (Peninsula Spit) that is marked out by the light-blue 30-m depth contour shading, providing further confidence that the modelled net sediment transport direction is reliable. [Source of background map: Chart NZ661, LINZ] (Source: Bell et al. 2009, Figure 13.2).

Long term sediment transport from the receiving ground A0

Transport rates and deflation of the disposal mound

Based on analysis of near-bed currents and wave from the 4-month field monitoring programme at site A1 (30 m depth), currents acting alone are insufficient most of the time to resuspend fine sands with grain sizes of 0.1 mm or more. This mostly applies also to site A0, although there will be some occurrences when stronger currents are present to mobilize sands independent of waves. Therefore generally sand transport on the seabed is only possible when waves (particularly swell) generate orbital motions of sufficient strength to resuspend sands from the mound and surrounding seabed, which can then be subsequently carried short distances by the near-bed current until they settle again. Based on a 10-year hindcast of the wave climate offshore, waves are capable of suspending 0.1 mm fine sands for 55% of the time at the preferred receiving ground A0, reducing to 23% of the time for coarser 0.5 mm sands (from all wave directions). There is also a seasonal variation, with the most energetic season being winter (waves were capable of resuspending fine sand at A0 for 68% of the time) followed by autumn (61%), spring (53%) and summer (42%). These frequencies of sand mobilization will be somewhat higher again at the top of any mound at A0.

Based on an estimated height of 1.6m and bulk density of 1600 kg/m^3, a mass of approximately 8×10^6 tonnes of sediment is likely to form the initial mound. This total should be considered with regard to the estimated "net" sediment transport through a 2-km section at the A0 site. Based on Rouse and Nielsen models respectively, this would be in the range of 4,000 to 92,000 tonnes over the 2008 4-month field period for the median sand size (0.2 mm).

However it should be noted that the field period was more energetic than normal in terms of significant wave height.

An analysis of potential upper and lower bounds on the deflation of the initial mound was undertaken based on transport rates determined for the 4-month 2008 field period at A0 and using the mass continuity equation, with various input and output rates relative to the mound height. The differential in local sediment transport rates on the top of the mound (in this case 1.6 m) relative to the surrounding "native" seabed at A0 are around 30% higher for the Rouse model and 37% higher for the alternative Nielsen model, which holds for all sand grain sizes.

While the estimates of the upper and lower-bound estimates of the mound deflation time vary substantially between the Rouse and Nielsen sediment models, the key result from this overview of upper and lower bounds is that the mound will take many years to fully deflate back to the present seabed level at A0, based on using the median sand size of 0.2 mm. This deflation period could be as short as 21 - 580 years or 120 - 3490 years depending on the calculation method).

Direction of sediment movement

One of the key findings of the sediment transport analysis for sand sized sediments placed at the A0 receiving ground is that there is very little sediment transport that would occur in any other direction apart from towards True North. There is more surety of the direction of long-term sediment transport for this site compared with sites such as A1 closer to the coast, because it would be predominantly to the north along the axis of the Peninsula Spit submarine feature. The submarine spit, has evolved over the Holocene from the prevailing sediment and hydrodynamic processes that operate in this offshore zone transporting major sediment sources from the Clutha River and to a much lesser extent the Taieri River (Carter, 1986), and will continue to build out to the north.

A conservative indication of where sand-sized sediments (sourced from the receiving ground at A0) could move to can be inferred from the suspended-sediment plume modelling of the dredged sediment placement. After being initially deposited on the receiving ground, sand-sized material, particularly the finer sands (0.1–0.2 mm), will be re-mobilized again only by waves of sufficient height and period and then transported short distances by the near-bed current velocity operating at the time, before settling again. The larger deposition zones (50+ mm and 100+ mm) will be where most of the sands deposit, and therefore are indicative of the long-term (months to year timescales) transport pathway and extent of transported sand that has been sourced and re-mobilized from the seabed off any mound at A0. It also needs to be noted that remobilization and transport of sand particles occurs ubiquitously on the seabed during moderate to high wave events, irrespective of whether they are from the dredgings or “native” sands.

Over time periods of months and years, the mound at A0 will smooth out and deflate gradually from both consolidation and differential erosion (due to higher local wave-orbital and current velocities over the top of the mound). The evolving shape of the mound is likely to show an elongated “tail” on the northern side of the mound from the prevailing “net” sediment transport to the north, but also a smoothing of the southern side-slope of the mound as the bedload fraction of sand transport from upstream (south) is deposited on the flanks of the mound.

An optimal time of year for placement of dredged material is not obvious since the predominant transport direction to the north is independent of time or season.

Given the results from the sediment transport analysis and the above reasoning based on inferences from the plume modelling for sand-sized material and the morphology of the offshore Spit, it is very unlikely that sand-sized material, other than isolated grains from the dredgings deposited at A0 would move westwards to reach the nearshore zone (depths <15 m).

Sand already moving on the seabed in the vicinity of A0 will be indistinguishable from the placed sand sized sediment. Sand moving from A0, either the placed sand or sand moving through the area, will be subject to the same sand transport processes and will move in the same way. In essence, the placed sand sized sediment will behave the same as sand moving through the area from the surrounding seabed.

Comments on long-term silt transport offshore

Modelling the long-term fate of silt-size material (<0.0625 mm), especially the finer fractions (<0.02 mm), is inordinately difficult to achieve. These “deposited” sediments, especially fine and medium silts, will often continue to be re-mobilized by wave activity in shallow coastal waters and further disperse in very low concentrations over a wide area of the Otago shelf, particularly to the north.

The ultimate fate of these widely dispersed silts in terms of “permanent” deposition will be mainly in deeper waters and canyons offshore as exemplified by the deposition of fine terrigenous material from catchment run-off including the Clutha River. There are also preferential natural deposition areas for fine to coarse silts on the shelf such as off Blueskin Bay, which possibly arise from the combination of the weak counter-clockwise gyre in outer Blueskin Bay and the loss of momentum in ebb-tide sediment plumes emanating from Otago Harbour towards the north, and hence enhanced settling of coarser silts from the Harbour.

Some of the silt material from the receiving ground A0 could be deposited in this preferential silt zone, but as shown by the disposal plume modelling, most of the silt material would be dispersed to the north and north-east, with virtually no suspended-sediment plumes sweeping across this preferential silt zone in central Blueskin Bay over a 48 hour period.

6.2.5 The direct and indirect effects of the proposed works

Introduction

The changes to the physical coastal environment due to the proposed dredging activity and the deeper shipping channel in Otago Harbour have been assessed in order to identify the potential effects on the physical coastal environment. These effects are discussed with regard to the following areas:

- The potential effects of the dredging operation on the hydrodynamics of Otago Harbour and the area offshore of Otago Peninsula between Taiaroa Head and Karitane Point as a result of the proposed dredging operation.

- The potential effects of changes to the wave environment on the physical coastal environment of Otago Harbour and the area offshore of Otago Peninsula between Taiaroa Head and Karitane Point as a result of the proposed dredging operation.

- The potential effects of the dredging operation and placement of dredged sediment on the sedimentation processes of Otago Harbour and the area offshore of Otago Peninsula between Taiaroa Head and Karitane Point.

Effects of hydrodynamic changes

Hydrodynamics within the harbour

The deepened channel results in three types of changes to the hydrodynamics of the harbour.

These are the tidal range, the timing of the tidal wave, and the speed of tidal currents. The tidal range will increase by up to 0.004 m in the Harbour Entrance, between 0.004 and 0.006 m from Harington Bend to Tayler Point, by 0.006 to 0.008 m in the vicinity of Port Chalmers, and around Portobello Bay and Harwood in the Lower Harbour, and in the Upper Harbour.

The effect of the deeper channel on the tidal range is negligible, especially when considered against the background of natural variability. The change in range will not result in an increase in the incidence of inundation hazards of the harbour margins, nor expose inter-tidal areas to a significantly greater degree than at present.

The timing of the tidal wave travelling into and out of the harbour will advance, resulting in high tide arriving by up to 3 minutes earlier between the Harbour Entrance and Harington Bend, 3 to 4 minutes earlier at Port Chalmers and in the Upper Harbour. Similar but slightly smaller advances in the timing of low water would also occur. This is not a significant effect on the tide phase, but would require recalculation of tidal tables for Otago Harbour after the completion of the dredging.

There are likely to be only small changes to the speeds of tidal currents. These changes are mainly reductions in speed of less than 0.1m/s and will occur in the Lower Harbour, including within the deeper channel. Localised increases in average peak current of up to 0.02 to 0.05 m/s would occur off the groyne at Beacon 10 on the south side of Harington Bend and there would be decreases in peak current of up to 0.1 m/s in areas along the channel margins at Harington Bend and near Port Chalmers where the channel will be made wider.

These changes are less than 6% of the existing current speeds and would not result in changes to the transport of sediment within the harbour due to tidal currents. The changes in current speed would also not affect boating conditions within the shipping channel, side channels or across the shallow areas of the harbour. These small changes in velocity will have no noticeable effect.

The effects of the deeper channel on the tidal hydrodynamics would not be significantly different for different wind and tide combinations.

Hydrodynamics in the area offshore of Otago Peninsula between Taiaroa Head and Karitane Point

There will be small changes to the current flows in the vicinity of the Entrance Channel after dredging. There would be a resultant slight enhancement of the flood-tide flows, particularly for the mean and spring tide cycles. There would also be a slight increase in the amount of time that the flows exceeded a threshold speed such that they could mobilise fine sand. On the ebb tide sand bar, the existing bias of a dominant ebb-tide flow to the north up the axis of the sand bar would be slightly enhanced by the deepened channel. Tidal currents acting alone will still be insufficient to mobilise fine sands on the inner half of the sand bar, so wave processes play the dominant role is mobilising and transporting sediment on the bar in tandem with the net northerly tidal-flow residual.

The net result may be that there is less flushing of sediments on the peak flows, and there will be preferential deposition of sediment in the dredged channel. Therefore, there may be an increase in the maintenance dredging volumes and/or frequency, and an increased need for maintaining the shape and position of the side of the channel on the eastern margin, as sediment will spill over from the east and south into the channel.

Effects of changes to the wave environment

Wave environment within the harbour and near the Harbour Entrance

Increases in significant wave height for a 15m channel will be small (less than a few cm) in the main channel, with negligible change outside of the proposed widened channel.

There will be a slight reduction in wave heights at some locations near the entrance. At Shelly Beach, the wave height reduction would be around 0.02-0.04m. There would be negligible effect on ship handling through the Entrance Channel, and no noticeable changes to wind waves or swell penetration in the area shoreward of the channel towards Taiaroa Head, Pilots Beach and Te Rauone.

Vessel wake within the harbour

Single and Pullar (2009) present an assessment of the effects of vessel movements resulting from the use of the proposed 15 m shipping channel. The assessment is based on the existing wave environment including observations of wake events at Te Rauone Beach and measurements of wake waves, and the results of studies carried out for the Ports of Melbourne comparing wake from container ships in Port Phillip Bay.

Port Otago's proposal to deepen and widen the existing navigable channel in the Lower Otago Harbour will enable vessels of a larger size and displacement to transit the channel. Concerns have been raised that this could potentially lead to increased magnitude and instances of wake from vessels that cause public nuisance and create safety concerns for fellow users of the Harbour. Wake from the largest ships (4100 class container vessels) has been measured at up to 0.150 m high. The observation program of vessel wake experienced at Te Rauone beach undertaken in 2009, showed that for 22 vessel transits the highest single event resulted in a "stranding wave" of 0.35 m in height with the remainder being all less than 0.25 m. Analysis of the spit tide gauge undertaken as part of the same work showed that the maximum 1minute change in the tidal level as a result of vessels passing was 0.110 m with 99% being less than 0.040 m.

It is likely that deepening and widening of the channel will result in a reduction in the magnitude of wake generated by current commercial vessels. This is due to the reduction in blockage ratio of the vessels in relation to the channel depth and cross-sectional area.

There will also be a reduction in the seabed scour beneath the vessels due to the lower blockage ratio and the greater clearance beneath the existing vessels and the proposed base of the channel.

The wake waves created by 6000 TEU vessels that could use the deeper channel will be potentially larger than those from the 4100 TEU vessels due to the greater displacement and blockage ratio of the larger vessels on a typical transit of the harbour channel. It is difficult to quantify this increase with any certainty although based on vessel observations and studies in Port Phillip Bay in Melbourne it is likely to be in the order of 10 – 15%, this range is well within the natural variability within the existing wave environment. However with the introduction of a service utilising 6000 TEU vessels, the number of transits of container vessels will be less than at present due to the larger capacity of the vessels. This will mean that the same volume of containers will be moved for less container vessel transits. Therefore the cumulative effect of wake waves in the harbour will be reduced.

There are no documented effects on the harbour ecology from wake generated by the passage of the present vessels using the harbour channel. This situation is not likely to change following the deepening and widening of the channel. Any effects from existing vessels that may exist are likely to be reduced. The wakes of the 6000 TEU vessels may disturb surficial sediments and biota but to no greater degree than current wind waves, tidal currents or existing vessels.

The wake events that are more likely to be adverse at the shore are those that occur within an hour or two either side of high tide. The effects on the water are limited to within two or three boat lengths away from the sailing line. As the shipping channel is "one way", the interaction of boats with wake does not occur between ships, and smaller vessels are advised to sail at a distance from larger ones.

In conclusion, the effects of vessel passage following widening and deepening of the existing navigable channel will be similar or less than that currently existing. The cumulative effect of vessel wake, both current and in the future, is likely to be much less than the effects of natural waves and tidal currents occurring in the dynamic environment of Otago Harbour.

Wave environment offshore of Otago Peninsula between Taiaroa Head and Karitane Point

There is likely to be a minor focusing effect on wave patterns in the lee of the receiving ground at A0. The biggest changes would be an increase in wave height of about 3 to 5% of the wave heights for the existing situation in the vicinity of the receiving ground. There would also be a small reduction (about 0.01m) in height of waves at Aramoana Beach due to the deeper Entrance Channel.

These changes will have no persistent effects at the shoreline. There will be no noticeable effect on surfing conditions and there will be no changes to existing patterns of beach response to changes in the wave environment. In particular, there will be no increase in erosion or inundation hazards at the shore, and there will no increase in accretion due to changes in the wave environment.

Effects of changes to sedimentation processes

Sedimentation process effects include turbidity in the harbour, at the dredged sediment placement site and areas in-between, changes to wave refraction and sediment movement on the seabed as a result of placement of dredged sediment, and changes to maintenance dredging operations as a result of the deeper channel. The modelling and assessment of sediment transport and the inshore wave environment show that there will be no effects on coastal erosion and beach deposition from the proposal. Specifically in relation to areas nearest the harbour entrance channel, at the distal end of The Spit and at Te Rauone. Similarly, because of the very small changes in currents, tidal heights and wave climate from the deeper channel, there would not be significant changes (i.e. shallowing or deepening of other secondary channel or harbour areas) as a result of the project.

Turbidity

The dredging activity will result in suspended sediments being added to the water column resulting in turbidity. The immediate effect of the turbidity is to discolour the water.

However suspended sediment will also travel within flowing water and disperse and settle along the harbour channel and across the inter-tidal flats, within secondary channels and shallow areas.

The modelling (suspended sediment concentrate simulation) shows that different source areas of discharges of silt from overflow and during dredging will result in areas close to the source being affected by suspended sediment plumes. Most of the deposition of fine sediment from dispersed plumes will occur in the main channel. Currents will remobilise this sediment causing some of it to flow through the main channel system up and down the harbour, and some to consolidate into the fabric of sands on the channel bed.

Turbidity resulting from transport of dredged sediment and placement at the receiving ground will be widespread but is unlikely to have an effect on the physical coastal environment.

Deposition of fine sediments

Modelling of deposition of fine sediments shows that deposition of up to 14 mm thick over an entire 100-day dredging season could occur within the reach of Victoria Channel to Kilgours Point, within the side channel off Quarantine Point, the southern side of the central intertidal bank and adjacent shallows that separate the shipping channel from the side channel through Ohinetu Point, the sequence of central intertidal banks adjacent to the shipping channel, and the subsidiary channel from Quarantine Island through to Latham Bay. The highest median values of deposition are likely to occur on the intertidal sandbank opposite Port Chalmers.

Deposition could be as much as 82 mm at Port Chalmers over the entire dredging period, however it is intended that the management of the dredging operation will reduce these levels of deposition.

The modelling also shows that only the main channel and side channel between Quarantine Island and Portobello Peninsula would be potentially subject to high depositional thicknesses (> 10 mm). These channel silts would be reworked regularly by tidal currents and spread throughout the shipping channel. Settlement of the fine sediment will occur in quiescent sections of the channel system, but much of the fine sediment will be transported out of the harbour entrance. Wind waves will remobilise sediments deposited on the intertidal sandbanks. Currents will then transport fine sediments until further dispersed to settle elsewhere within the harbour system. Preferential settlement will occur in quiescent areas where wave activity and currents are low or sporadic such as Dunedin Basin, inlets in the Upper Harbour behind the railway embankments, sheltered sub-tidal

embayments (e.g., Careys Bay and the inner Port Chalmers berths), the deep basin in Portobello Bay, and in the lee of groynes or half-tide training walls.

Although the modelling shows potential settlement of small fractions of fine sediments on broad highly elevated intertidal areas such as the Aramoana flats, this material is easily remobilised and is likely to have a short residence time before moving back into, and being redistributed via the main channel.

Fine sediments will be carried for long distances from the receiving ground, with the northern dilute edge of the suspended sediment plume reaching areas north of Karitane, and the south-western dilute edge of the plume occasionally reaching coastal areas between Taiaroa Head and Wickliffe Bay. This fine sediment is unlikely to settle on beaches and rocky coastal areas, as it will be readily remobilised by wave action, wind and tidal currents in the nearshore.

Deposition of sand in the vicinity of the receiving ground

The ideal offshore receiving site would have the same sediment in situ characteristics as the dredged material to be placed. From the investigations of the seabed sediments and the geotechnical investigations in the harbour, the modern sand and mud facies offshore of Otago Harbour, and in particular in the vicinity of the distal end of the "Peninsula Spit" are of the same character as the sediments to be dredged. Willis et al. (2008) do not consider the seabed in the vicinity of site A0 to be unusual nor ecologically significant. Placement of the dredged sediment would not change the composition of the seabed sediments in the long term.

The deposited sand will result in a mound being built on the seabed, and this mound will intercept and transfer sand moving on the seabed. The wave and current energy at the disposal site is not sufficient to cause mass movement of the deposited sand away from the site.

Sand transport patterns from receiving ground

The ideal sediment disposal site would not result in sediment transport back into the dredged channel, into Blueskin Bay estuary, or onto the rocky coast north of Warrington or south of Taiaroa Head.

Movement of sediment on the seabed was determined from seabed observations, and by assessing the predominant current directions and known sediment transport paths in the wider Blueskin Bay environment. The bed is mantled by highly mobile fine to medium sands and there is a zone in the middle of Blueskin Bay that is mantled in predominantly finer sediment (silts and mud).

The modelling studies have shown that sediment from the receiving ground would move predominantly to the north and would be masked by the existing sediment transport from south of Otago Peninsula to the north.

Bunting et al. (2003a) show that the beach systems from Kaikai north to Purakanui Bay have not been adversely affected by nearly 30 years of disposal of maintenance dredged sediment, and capital dredged sediment from the 1970s placed near Heyward Point. The modelled movement of the sediment from the disposal site, AO, does not indicate any change to the present situation.

Effects on the present pattern of maintenance dredging

The design of the channel sides and batter slopes replicates the existing slopes to minimise adjustment of the channel and margins after the capital-dredging programme is complete. Changes to tidal currents and waves in the harbour are unlikely to increase sedimentation from scouring of the channel margins or from erosion of the intertidal banks.

Sediment will not move from the receiving ground back towards the Harbour Entrance. However the deeper channel across the ebb-tide delta is likely to result in additional capture of sand in the Entrance Channel and will possibly result in an increase of dredging demand seaward of Harington Bend. The quantity and the duration of this increase are unknown.

It is unlikely that the total maintenance dredging demand will increase to more than the existing consent of 450,000 m^3 per year.

6.2.6 Conclusion

Otago Harbour is a robust, dynamic environment subject to variable wave energy and sediment supply, and to a history of human modification to the shores, the main channel and the entrance configuration. The area of Blueskin Bay between Taiaroa Head and Karitane Peninsula is subject to high-energy waves, strong tidal and oceanic currents, and a large but variable volume of sediment transfer on the continental shelf and nearshore seabed.

As noted in Section 4 feasibility studies were carried out on the proposal to deepen the shipping channel through the lower Otago Harbour, and to identify the most suitable method of sediment disposal and the offshore disposal site with the least adverse effect.

The main considerations for the effects on the physical coastal processes were:

- Potential changes to the hydrodynamics of the harbour and the entrance channel,
- Potential changes to the wave environment of the harbour, the entrance channel and the disposal site,
- Changes to patterns of sedimentation within the harbour, the entrance channel and the wider Blueskin Bay area, and
- The dispersal of fine sediments due to the dredging operation.

Studies carried out to investigate these effects have shown that they are mostly negligible, and of magnitudes within the variability of the natural environment.

Apart from the physical change to the seabed topography in and along the margins of the channel, and at the disposal site, the effects of the dredging operation on the physical coastal environment are considered to be minor.

6.3 Effects on Harbour Ecology

Prediction of the potential effects that might be caused by dredging and disposal in a marine environment require a good understanding of the general processes associated with dredging disturbance. As noted in the previous section, this is the case here. These need to be combined with site-specific data on the existing environment, dredging and disposal operations and sediment type to be dredged, changes as a result of dredging and sensitivity of communities. Generally, the potential major impacts of dredging and disposal can be summarised as follows:

- Direct impacts through removal of benthic species and communities in the channel itself.
- Suspended sediments and turbidity. Short-term increases in the level of suspended sediment can give rise to changes in water quality (including clarity), which can in turn affect marine flora and fauna, both favourably and unfavourably, such as clogging of gills and feeding apparatus, reduced light levels for benthic and water column plants, feeding by birds and fish.
- Release of contaminants, organic matter and nutrients, depending upon the nature of the material in the dredging area.
- Settlement of suspended sediments can result in the smothering or blanketing of subtidal/channel communities and adjacent intertidal communities.
- Effects on the benthic community (plants and animals) can indirectly affect higher trophic levels through impacts on food resources and foraging.

The impact of the dredging and disposal of dredged material largely depends on the nature of the material to be dredged (sediment type, degree of organic enrichment, presence of contaminants) and the characteristics of the disposal area (sediment type, accumulative or dispersive areas for sediment). In this case the potential impacts of the disposal of dredged material on the marine environment have been minimised through careful consideration of the disposal site.

It is proposed a robust monitoring programme be set up to monitor turbidity during the operation and to follow the recovery of biota and ensure there are no long-term effects. This is discussed in Section 7.

The evaluation of the environmental effects of dredging and disposal must take account of the severity, the short-term and long-term effects that may occur both at the site of dredging or disposal (near-field) and the surrounding area (far-field).

For dredging operations near-field short-term effects include removal of organisms, increased turbidity, smothering of organisms, reduced faunal densities/biomass and diversity, reduced water quality and potential chemical toxicity/anoxia in extreme cases, while potential long-term effects include removal of contaminated sediments, change to substrate type and community structure, accumulation of deposits, bioaccumulation and chemical toxicity.

Generally far-field effects ‘occurring more than approximately 1 km from the activity' are not expected to be significant short or long-term but there can be dispersal of some fine sediments, chemicals and pollutants if they are present and changes to geomorphology and hydrodynamics.

This section is based predominantly on the comprehensive assessment of effects undertaken by Mark James (Aquatic Environmental Sciences Limited), Keith Probert (University of Otago), Rick Boyd (Boyd Fisheries Consultants Limited), and Paul Sagar (NIWA) referred to as James et al (2009). A comprehensive list of references are contained within James et al (2009) and reproduced in Section 11.4.

Sections 6.3.1 – 6.3.5 provide a summary of the key findings in relation to the potential effects on the ecological environment of Otago Harbour. Sections 6.4.1 – 6.4.7 provide a similar summary in relation to offshore ecological effects.

6.3.1 Benthic Communities and Rocky Shore Environments

Physical Disturbance and Recovery

Dredging operations involving removal of material from the seabed also remove or heavily disturb the animals and plants living on and in the sediments. With the exception of some very deep burrowing animals or mobile surface animals that may in some cases be able to avoid dredging operations, dredging will result in the complete removal of most of the animals and plants from the dredging site (some smaller animals may be returned via overflow pipes but most will be removed).

The impact will be site specific but most of the benthic animals in the channel from Port Chalmers to the entrance, where it is to be dredged, will be removed or heavily disturbed by the proposed dredging operation. This is likely to result in loss or modification, at least temporarily, of all benthic assemblages and processes within the channel and areas that are widened. While some parts do not require dredging approximately 48% of the channel to Port Chalmers will be directly impacted. While the dredging operations could be expected to directly affect small areas of intertidal benthic habitat it is unlikely that new habitat types would be created or existing habitat types would be eliminated.

The intertidal area including cockle beds will only be directly physically disturbed at the channel margins in areas to be widened close to the Port. Most of the intertidal habitat that will be impacted by the widening would be classified as medium sand with sparse patches of algae, relict shells and evidence of recent bioturbation. Cockles are typically found in shallow inter-tidal areas and occasionally down to 6-8 m.

Assuming that up to 8,000 m^2 of intertidal area around the Port will be dredged during the widening then this represents less than 0.15% of the area of the Lower Harbour between 0.0 and 1.0 m above chart datum (~6,000,000 m^2). Densities of cockles on the margins of the channel where it is to be widened close to the Port basin were less than 10 m^{-2} (Paavo, Probert and James 2008).

Highest cockle densities were found on the flats on the intertidal banks opposite Acheron Point, and close to Harwood. Thus although there will be a very localised direct effect, the widening of the channel is likely to have a minimal direct impact on the overall extent of similar intertidal habitats and cockle beds in the Lower Harbour. The effects of increased turbidity and settlement are discussed in following sections.

Few soft sediment fauna were found in the channel areas due to high tidal flows. However, the sensitivity and types of communities still need to be taken into consideration. For example dense mats of compacted tubeworms and some deep sessile communities prevail in areas of the channel from Port Chalmers out to the entrance despite maintenance dredging. The deep sessile communities are generally found in deeper pockets or channels embedded in the main channel. While some of these species and

communities will be lost, the existence of these communities now with maintenance dredging suggest that in the medium to longer term they would recover (several years). Similar communities of sponges and tunicates were found on the northern side of the Weller's Rock Groyne where there will be no direct disturbance. It must also be noted that most sediments in the channel region are already highly modified and disturbed.

The recovery of disturbed habitats and benthic communities following dredging depends on the extent of the disturbance, nature of sediment and potential for recolonisation. Recovery is most rapid where the channel is predominantly silt/muds as they tend to be occupied by opportunistic/early succession species and communities.

Recovery usually takes longer in habitats with coarser sediments and for longer lived benthic animals such as cockles. Recovery often depends on recolonisation by larval stages (from the water column) but can also be through horizontal bed transport of juveniles and adults in highly mobile environments which can recover quicker.

Published rates of recovery vary considerably from a few weeks/months for the likes of polychaete worms in disturbed muds/clay/silt, 1-2 years for communities in sands/gravel and up to 10 years for shell/sand habitats (Nedwell & Elliot 1998; Newell et al. 1998). Impacts and recovery with the proposed dredging will vary with the deeper areas around the Port, which are mostly silt, likely to recover quicker and in the short-term (months) while for the sandy areas that will be widened and lower reaches of the main channel, recovery is likely to be medium term (1-5 years). A highly mobile sand habitat such as that near the entrance will likely recover more quickly through dispersion of larvae and bed transport than isolated and fragmented sand habitats.

Discrete benthic assemblages were not evident in this study of the Lower Harbour but rather the same or similar species were found across a range of habitats supporting a "one-harbour" system i.e., there does not appear to be discrete communities associated strictly with one habitat type. This means that local disturbances (e.g., the area to be widened) will be recolonised by neighbouring fauna relatively quickly unless a totally new habitat type was created. An example of new habitat creation would be the exposure of rock or cobbles via the removal of existing overlying soft sediments. However, there is no evidence that this will occur.

The deep sessile, diverse communities (tunicates, sponges etc.) found in patches, and rippled sand areas in the primary channel, exists because of strong tidal flows (~1% of channel area has this habitat). Some of these habitats in the outer part of the channel will not be directly physically impacted by the dredging because they are below the level to be dredged but sediment will be washed into and through these areas. While the communities in these habitats are mostly filter feeders and likely to be very sensitive to increased sediment loads, the areas will be flushed of finer sediment and will be recolonised in time. This could take several years however, because the fauna found here tend to be long-lived and slow colonisers.

Suspended Sediments and Turbidity

As noted in the previous section the proposed dredging will cause an increase in suspended sediments and water turbidity as a result of physical disturbance of the seabed, release of sediment/water mix during dredging and disposal and subsequent resuspension of settled sediments during periods of high wave activity. These increased levels of suspended sediments and turbidity will impact on marine fauna and flora through direct physical effects and indirectly through changes to water clarity and light availability.

In assessing the effects of suspended sediments in the area being dredged there are a number of considerations. The most obvious one is the resulting plume of water/fine sediment mix that is released during the operation. Material that settles out on the seabed

can also subsequently be resuspended. The degree of resuspension of sediments from dredging depends on the type of sediments being dredged, methods of dredging, hydrodynamic regime, geomorphology, and weather conditions.

Direct physical effects of suspended sediments include clogging of gills, and impairment of respiration and feeding via filtration. Suspension feeding animals such as some polychaete worms, cockles, mussels and zooplankton are particularly vulnerable to high sediment levels and persistent high turbidities can result in changes in assemblages from dominance by suspension feeding fauna to ones dominated by deposit feeders (e.g., some polychaete worms, gastropod snails). Impacts of increased turbidity are likely to be greatest in low energy areas where water exchange and wave action are limited.

Considerable work has been done overseas and some work in New Zealand on the effects of high sediment levels at which condition and suspension feeding processes of benthic animals are potentially impacted. Experiments in the laboratory and observations in the field suggest that like a number of molluscs, cockles and mussels benefit from small amounts of suspended sediments and in the case of the cockle *Austrovenus stutchburyi*, Hewitt and Norkko (2007) found they benefitted at suspended sediment concentrations up to 400 mg/l and even higher in field observations, before condition started to decline. Persistent high levels and very high levels of suspended sediments dominated by clays for more than a week however, were found to have a significant impact. Field transplants showed that small cockles can withstand similar levels but mortality tends to be higher than for adults.

Development of oyster eggs was found to be impacted at suspended sediments concentrations of 188 mg/l of silt and larvae at 750 mg/l of silt (Clarke and Wilber 2000). Similarly Hawkins et al. (1999) found the filtering rate for the Green-shell mussel, *Perna canaliculus*, did not start decreasing until suspended sediments levels were above 1000 mg/l. The horse mussel (*Atrina*) appears to be more sensitive with filtering rate declining at 120 FTU (Formazin Turbidity Unit) and condition of *Atrina* and pipi were affected if suspended sediments concentrations were over 80 mg/l (Ellis et al. 2002).

Patches of *Atrina* were recorded in muddy-sands in the Te Rauone beach area but are generally uncommon in the harbour. Other taxa which have been shown to show some adverse effects when exposed to concentrations above 80 mg/l for several days to a few weeks include some deposit feeding polychaetes, heart urchins (Nicholls et al. 2003) and pipis (Hewitt et al. 2001). Other taxa are more robust, for example, the wedge shell (*Macomona liliana*) only showed effects when exposed to concentrations over 300 mg/l after 9 days and the snail *Zeacumantus lutulentus* showed no response up to 750 mg/l after 14 days (Nicholls et al. 2003).

Taking 100 mg/l as the level of SSC (suspended sediment concentrations) that would start to impact on most benthic invertebrates then other than the main channel the only areas where dredging could have a significant impact would be the margins close to the channel around the Port (including around Goat and Quarantine Islands) for most of the dredging period and the margins opposite Pulling Point and Tayler Point when the dredge was operating in the Harington Bend areas. It should be noted that apart from the immediate area near the Port these intertidal areas would be subjected to very high levels (400 mg/l or ~320 mg/l dry-weight) for less than 8% of the time, a time period that most invertebrates could survive relatively high SSC conditions. The intertidal area immediately opposite the Port could be subjected to greater than 400 mg/l for less than 8% of the time, except when the dredge was operating on the eastern side of the basin, and then these concentrations could be for up to 24% of the time. The main cockle beds in this area are opposite Acheron and Pulling Points and thus the largest population would be unlikely to be subjected to these high levels for long periods.

Increased suspended sediments will cause decreases in water clarity and the availability of light for phytoplankton in the water column, benthic plants and microphytobenthos

(benthic microalgae like diatoms). The most sensitive communities to the indirect impacts of the proposed dredging are likely to be the seagrass communities, particularly those close to where the channel is to be dredged and widened. The aerial extent of the plumes of higher turbidity will partly be determined by wind direction and state of tide but generally the most significant impacts of increased turbidity and smothering will be restricted to the channel areas in the nearfield area to the east of the Port (<1km), and far field (few kms) to the southeast of the Port and south towards Latham Bay where seagrasses are not common (although beds have been recorded on the north-east side of Quarantine Island- Jim Fyfe, DOC, pers. comm.).

Dispersion means that the plumes will be diluted away from the dredging activity and will be considerably lower away from the channel. Predictions are that most of the tidal flats would be largely unaffected except close to the channel where concentrations could be up to 100-200 mg/l (likely to be 80-160 mg/l dry-weight SSC). Concentrations above 1000 mg/l (800 mg/l dry-weight SSC) could occur in patches immediately adjacent to dredging but would only be for brief periods during actual dredging (i.e., less than 10% of the time or very short-term). In areas like Harwood and the intertidal flats well away from the channel margins, increased suspended sediment concentrations would be undetectable for most of the time during the dredging and there would only be very short episodic periods when concentrations were above 20 mg/l.

Environmental limits have been placed on a number of dredging operations overseas. In most cases there is a two stage approach if these are exceeded, with the first being an investigation of what caused the exceedance and if necessary a mitigation stage which could involve changes to the dredging operation as a last resort. An impact matrix was devised by Doorn-Groen (2007) for reclamation works in Singapore and included sensitivity of seagrass beds, corals and mangroves. Based on relatively high suspended sediments backgrounds in the Singapore case excesses of 5 mg/l for more than 20% of time and in excess of 10 mg/l for less than 20% of the time would be termed a "slight impact" on seagrass, with over 75 mg/l for less than 1% of the time termed "moderate" in severity.

The recent Port of Melbourne dredging programme (Port of Melbourne 2008a) set site-specific environmental limits which ranged from 15-35 NTU (Nephelometric turbidity units) above background levels for benthic invertebrates (including 35 NTU or 50 mg/l to prevent impacts on a Pyura sea tulip species), 15 NTU for seagrasses, and 15-70 NTU above background for fish (some sites had seasonal limits). These limits are generally based on a 2 week moving average with higher levels based on a 6 hourly average and were site specific, depending on the sensitivity of local communities.

Most of the seagrass beds in Otago Harbour appear to be intertidal rather than subtidal (Mark Morrison, NIWA, unpublished, pers comm.). These habitats have been shown to be very important as nursery areas for juvenile fish and thus there can be significant flow-on effects if these beds are significantly impacted although surprisingly Miller (1998) found no differences in macroinvertebrate abundance or diversity at sites with and without seagrasses.

Plants respond to reduced light levels rather than suspended sediment concentrations and the relationship between these two depends on the sediment properties. Overseas studies and recent ones for the New Zealand *Zostera* species (Schwarz 2004, Anne- Maree Schwarz, World Fish, pers comm.) indicate that 15-40% of surface light is required, on average, to protect these seagrass beds, with 15% being a minimum.

Measurements of Kd in the Harbour vary naturally between 0.1 and 0.3 m^{-1} and can reach over 2 m^{-1} during storms with corresponding suspended sediment concentrations over 6 mg/l. Based on Kd values of 0.1 and 0.3 then the depth at which 15% of surface light would reach is approximately >6 m and 3.5 m respectively. A Kd of 2 m^{-1} is likely to result in the depth of 15% of surface irradiation being at or less than 1 m.

Aside from areas very close to the main channel the tidal flats in the Lower Harbour will be subjected to no increase in SSC most of the time (often 90% or more of the time), as a result of the dredging. Parts of the intertidal area opposite the Port and Acheron Point could be subject to concentrations above 75 mg/l (50-60 dry-weight SSC) for 1-5% of the time particularly when dredging the channel nearby. Seagrasses are likely to be able to tolerate levels these levels but only for very short times so the impact is likely to be "moderate" in intertidal areas close to the main channel opposite the Port, around Quarantine Island, Acheron and Pulling Points when dredging close to these areas but "slight" in most other areas, such as Harwood where extensive mats do occur.

It must be remembered that these environments are naturally turbid relative to open waters as they are subject to episodic high sediment turbidity and settling events and the communities, including seagrasses, are adapted to these conditions. As demonstrated above however, beyond a critical threshold even the hardiest communities can be impacted if levels are high for extended periods. The predicted levels are within the natural range that these communities may be subjected to (5.6- 215 mg/l in Lower Harbour – Currie and Robertson (1987)) and large inter tidal areas will not be subject to increases in concentrations at all. In terms of recovery after the dredging, Miller (1998) found that when surface stems of *Zostera* are removed new shoots were observed within two months so as long as the whole plant was not impacted, recovery will depend on the time of year when dredging takes place but should be in the short-term (<1 year). If whole plants were impacted then recovery could be in the medium term (i.e., few years).

As noted in Section 7 it is proposed that monitoring of turbidity be undertaken during the dredging operation in Otago Harbour and that environmental limits be set in key areas such as the extensive seagrass beds off Harwood.

Zooplankton

Many benthic species and most fish have a larval phase which is critical for dispersion and recruitment. These larval stages, along with permanent zooplankton (mostly copepods) and crustaceans, are generally adapted to episodic high levels of suspended sediments that occur in estuaries and harbours. Experiments over two weeks with different zooplankton have shown that mortality is high at levels over 10,000 mg/l but generally studies have not shown any significant impact at the levels experienced from dredging (Clarke & Wilbur 2000). Many larval stages are only in the plankton for short periods and other groups have short life cycles which mean recovery can be relatively quick (less than a year) depending on the time of year when dredging takes place.

Contaminants and Nutrients

Contaminants released from benthic sediments during dredging could potentially bioaccumulate and become concentrated in species at the top of the food chain (large benthic fauna like cockles and eventually large fishes, birds, marine mammals). If not managed properly this can ultimately affect human health and the value of commercial fish catches if there were persistent high levels of contaminants.

However, testing of cores from the Port Chalmers area and channel for contaminants indicated that there were no sites with levels above the ANZECC guidelines for acceptable levels in sediments that will protect aquatic ecosystems. State of the environment reporting by Otago Regional Council (ORC 2005) also indicates that water quality in areas such as that around Ravensbourne and Portobello have improved in recent years. Much of the improvement in water quality in the Harbour will have resulted from closure of sewage works and reduction or closure of industrial discharges such as the tannery in Sawyers Bay (Grove and Probert 1999).

The guidelines also recognise that some ecosystems like those commonly found in harbours servicing major cities and around shipping ports, are already highly disturbed. Bioaccumulation can result in higher levels further up the food web but at the levels found in the sediments we would not expect there to be a significant effect at higher levels.

Nutrients are necessary for the growth of primary producers (e.g., phytoplankton and aquatic plants), but excess nutrients can cause algal blooms and periphyton growths. Zooplankton and filter-feeding benthos might benefit from excess food resources associated with increased phytoplankton, but could be negatively affected by hypoxia or toxicity associated with some phytoplankton blooms. Darker sediments indicative of organically enriched sediments and low oxygen were only recorded in cores from one site, close to the port itself. Dredging will disturb these sediments but this is unlikely to cause significant issues when dredged due to dilution from high flows and the restricted area where this occurred. Although increased nutrients would quickly be diluted and flushed out of the harbour dredging outside spring and summer could help avoid adding to the potential for algal blooms and any anoxia issues.

Settlement of Suspended Sediments

When sediments settle out in the vicinity of a dredged area, they can smother benthic organisms and depending on the amount of sediment settling, can change the sediment characteristics and community structure and in extreme cases cause mortality of fauna and flora. Small and recently settled life-stages of many species are especially vulnerable to smothering, as are organisms that must maintain contact with the sediment-water interface.

Estuaries and harbours are naturally turbid and macrofauna are probably conditioned to deal with episodic sediment deposition. Understanding potential impacts requires some knowledge of background turbidity conditions and animal sensitivities. Beyond a critical threshold, sediment will have a negative influence on even the hardiest estuarine benthic communities.

Generally, habitats with fine silt and sediments, such as those found in the Port Chalmers area and out towards Cross Channel, have lower abundance of most macroinvertebrate taxa and can be dominated by deposit feeders. Settling of silts in these areas is unlikely to cause a shift in community structure. In the lower regions of the channel which are characterised by sand substrates there could be a temporary shift in benthic food webs from suspension- (e.g., bivalves) to deposit-feeding species (e.g., snails and polychaete worms). However, high flows in these areas would quickly flush the fine sediment out towards the entrance and eventually offshore with the Lower Harbour community reverting back to its original state.

The sessile communities with sponges and tunicates are very patchy and are susceptible to high sedimentation. Some of these communities would not be directly physically impacted because they are in channels and holes that are deeper than depths to be dredged but they will be covered in sediment during the operation. These communities would be impacted at least in the short to medium-term until the sediment is flushed out and the areas can be recolonised. Doorn-Groen (1998) suggested that less than 1.7 mm/14 days would not have an impact on corals and similar levels could be applied to the deep sessile communities and some colonial animals found on soft sediments and rocky shores in the harbour. These communities are likely to experience short-medium term impacts from the proposed dredging.

Cockles, other bivalves and benthic animals and plants found in intertidal flats of habitats in Otago Harbour are exposed to high turbidity and sediment loads from storms and catchment runoff. Experiments with clay deposits in the Whitford area of Auckland have demonstrated that clay layers as thin as 0.3 to 0.7 cm had some impacts on macrofauna,

but they were relatively short-term. Rapid accumulations on the other hand (over 2 cm in one event) were found to smother entire benthic communities (Norkko et al. 1999, Lohrer et al. 2004). Recovery of sediment properties and benthic communities was found to take a few months for opportunistic species like many polychaete worms, but several months to a few years for larger taxa like some gastropod molluscs.

Shrimps and some crab species have been shown to survive up to 9 cm of deposition (Norkko et al. 1999). Cockles can only survive short periods of burial under these fine sediments and generally molluscs responded at lower levels with 2-3 cm the critical depth of deposits for many taxa (Lohrer et al. 2004). Many crab species on the other hand actually show a strong preference for finer silt/mud habitats and are less sensitive.

Norkko et al. (2001) carried out a comprehensive study of macroinvertebrates and their sensitivity to increasing silt/clay sediments in the Whitford embayment. Benthic species found in the recent surveys of Otago Harbour span a range of responses with species like the limpet *Notoacmea helmsi* (found on rocky shores) and the whelk *Cominella glandiformis* being highly sensitive and other species such as the common polychaete *Boccardia syrtis*, cockle *Austrovenus stutchburyi* and Syllid and Cirratulid polychaete worms being sensitive to silt and clay content. Norkko et al. (2001) found that once the silt/clay content reached over 60% cockles tend to decrease in abundance. Large bivalves tend to be more resilient than smaller ones.

As would be expected surface grazing animals like the gastropod snail *Zeacumantus lutulentus* are relatively robust, at least in the short-term, to increased sedimentation of fine material (Nicholls et al. 2003). Although *Zeacumantus lutulentus* is not common in Otago Harbour, we would expect similar taxa to also be robust to sedimentation events. It should be noted that most experiments on New Zealand species were conducted with clay sediments.

Deposits of up to 3-7 mm can have a negative effect on microphytes and, although responses vary, repeated additions of 3 mm over several months can have a cumulative effect at these levels of deposition (Gibbs and Hewitt 2004).

While most of the fine sediment being disturbed or dredged up with the proposed dredging will initially settle in the channel area, fine silt and clay particles that are presently found in the inner reaches of channels have slow fall velocities and are thus likely to be transported much further than sand particles before settling out. The sediment plume with highest concentrations of suspended sediment is confined to the channel area and margins but the plume does spread out after several tidal cycles and some material would initially settle out on the tidal flats. Most areas away from the margins would be subject to little or no deposition with the rate of deposition on the intertidal flats predicted to average less than 0.01 mm/d for most areas with up to 0.05 mm/d around Goat and Quarantine Islands and higher rates (over 0.2 mm/d) largely confined to the shipping channel.

Over the period of the dredging the impact in the channel would be localised and medium-high severity but in non-channel areas the impact is likely to generally be low, and short-term with less than 10% of these areas receiving 6 mm or more. An exception is the intertidal area opposite the Port which could receive 23 mm or more but this is likely to be only in a limited area of ~10 ha and for a short time after the dredging operation.

Deposition in areas like Aramoana, Te Rauone beach and inner Harwood would mostly receive less than 1 mm over the dredging period with only a few patches over 4 mm. The greatest abundance of annelids (worms), molluscs and arthropods (amphipods etc.) occurs in the intertidal areas away from the main channel and close to Harwood. Less than 10% of the area around Portobello would receive more than 2.4 mm over the dredging period. The levels that would be experienced in these areas are unlikely to have significant adverse effects on the benthic community.

In summary the highest potential impacts to soft-sediment communities would be relatively localised, short-term and on the immediate margins around the Port, within the main channel itself and side channel between Quarantine Island and Portobello Peninsula, but most of the material is likely to eventually be resuspended and flushed out in time. There are likely to be short-medium term impacts on the deep-sessile community in the channel but these would recover in time once the fine sediment had been flushed out.

The faunal community in the Upper Harbour is dominated by polychaete worms and the small bivalve *Nucula*. The habitats are characterised by finer silt/mud sediments and are subject to episodic events with high runoff and constant point source discharges. The average deposition in the intertidal area of the Upper Harbour over the whole dredging period has been estimated through modelling as less than 2 mm over the dredging period (Bell et al. 2009) so there is likely to be little impact on these communities.

Although there were no surveys before and after the capital works dredging in 1976, unpublished data from University of Otago (see Raffaelli 1979) indicated that suspended material in the Harbour increased by a factor of three during the operation in some parts of the Harbour. Experiments being run at the time however, found that grazing molluscs were able to keep the substrate clean of mud which is consistent with the observations above (settlement being in the order of a few mm).

Settlement of fine material may result in smothering and burial of seagrasses. Smothering can have direct physical effects and can also reduce light availability and thus photosynthesis. Most seagrasses can survive moderate levels of settlement. Although there is no data for New Zealand seagrasses, overseas studies of similar species suggest that they can grow through 2 cm in 4 months and thus to maintain seagrass beds short-term sedimentation over time spans less than 2 months should not exceed 5 cm (Vermaat et al. 1997). From the modelling to date areas occupied by seagrasses should not exceed this sedimentation threshold except perhaps the beds around Quarantine Island. As long as seagrass in this area was not completely destroyed it should gradually recover in time once the fine sediment had been flushed out.

In general the deleterious direct impacts of sedimentation for macroalgae and rocky shore communities are associated with settlement, recruitment, growth and survival and indirect effects of loss of photosynthetic capacity with a film of a few millimetres of sediment potentially reducing photosynthesis of plants. In extreme cases anoxia can have an impact through interference with diffusion of gases for plants (both for respiration and for photosynthesis). While most established alga can survive burial for short periods attachment of germlings can be impacted by a light dusting of sediment while relatively heavy settlement (2 mm) can prevent attachment altogether (Schiel et al. 2006). Most of the rocky areas in the Lower Harbour would receive less than 1 mm of sedimentation over a 14 day period when dredging was taking place nearby. Grazing invertebrates are generally not affected by small amounts of sediments and in some cases it can aid with ingestion of algae (James et al. 2000). Limpets and some gastropods are very effective at moving sediment around so that they can access the algae below (Schiel et al. 2006).

With respect to the levels of sediment that macroalgae can tolerate some open coast species of macroalgae can survive extended periods of burial with cycles of beach building and erosion. For example, the open coast species of *Gracilaria* can be buried for days/weeks and photosynthetic capacity can re-activate once the plants are uncovered through scouring and wave activity. Some intertidal algae can remain intact after 3 months of burial but growth is inhibited, while others do not survive burial under thick sediments for a month (D'Antonio 1986). Coralline crusts were found to be unaffected by burial in sand for a few months but there was significant mortality of the sea lettuce *Ulva*. The invasive *Undaria* can compete with other macroalgae such as *Macrocystis*, particularly at low light levels (Fyfe 2000) but as it is already established in the harbour the relatively short period of dredging is unlikely to alter the distribution of these species in the Harbour. Recruitment for macroalgae such as *Macrocystis* relies on adequate light reaching the seabed. Fyfe (2000) observed recruitment of *Macrocystis* in spring and summer months following substantial thinning over winter thus spring and summer is likely to be a critical period for recruitment. Overall impacts on macroalgae are likely to be low-moderate, nearfield and with recovery being in the short-term (less than one year), depending on the time of year when dredging takes place and recruitment processes.

6.3.2 Birds within Otago Harbour

The effects of dredging on birds within Otago Harbour could occur as a result of the:

- direct removal of invertebrates as a food source during widening of the channels;
- settlement of sediments in intertidal areas;
- increased turbidity levels throughout the Harbour; and
- removal of roosting sites.

Otago Harbour and the area around Taiaroa Head are of particular importance as a breeding and feeding ground for a number of species including some that are endangered or vulnerable. The Harbour and inlets on the Peninsula are likely to operate as a network of feeding and roosting sites for many species.

Removal of invertebrates during channel widening – effects on birdlife

Dredging activity would result in a relatively small amount of mortality of sessile shellfish such as cockles, especially where they occur along the edge of the Harbour channel that is being widened. Observations of feeding wading birds over a tidal cycle (Sagar 2008) show that generally these birds feed along the water's edge of the receding tide. Consequently, a small area of feeding habitat will be lost at the lower tidal levels as a result of channel widening but this would be confined to a very small area close to the port. Shellfish and other macrofauna would be expected to recolonise the banks within a few years and smaller benthic animals (e.g., polychaete worms) within a few months of the completion of the operation.

The species of most conservation concern that tended to feed along the water line were pied oystercatchers and bar-tailed godwits. In Otago Harbour, the latter have been identified as a species of particular concern because of their declining population worldwide and need to ensure that they are able to accumulate sufficient reserves to undertake their extreme migration to their northern hemisphere breeding grounds. No detailed studies of the feeding of bar-tailed godwits have been made in Otago Harbour. However, they have been studied elsewhere in New Zealand, particularly the Firth of Thames and Farewell Spit. Bar-tailed godwits use their long bills to probe into soft substrate to obtain their prey; female godwits have longer bills than males – females 97-129 mm, males 69-97 mm (Battley & Brownell 2007) which allows resource partitioning within the species. For example, on firmer substrates including rocky tidal flats near Kaiaua, foraging godwits are almost exclusively males whilst in soft mud such as off Miranda it is almost invariably females that feed deeply on the outgoing and incoming tides (Battley & Brownell 2007). Godwits feed mainly on large polychaetes (Battley et al. 2005), but they are also capable of feeding on hard-shelled prey such as crabs and bivalves (Battley 1996). On Farewell Spit, Battley et al. (2005) calculated that the relevant prey for godwits in the invertebrate community were the bivalves *Paphies australis* and *Macoma liliana* ($\leq$ 15 mm), the bivalve *Austrovenus stutchburyi*, the small black mussel *Xenostrobus pulex* ($\leq$ 10 mm), the bivalve *Nucula hartvigiana*, all polychaetes $\geq$ 10 mm, and all crabs. In the Firth of Thames the polychaetes *Aonides oxycephala*, *Nicon aestuariensis* and *Orbinia papillosa*, plus crabs and small *Nucula* and *Austrovenus* are likely to be godwit prey (Battley & Brownell 2007).

The level of any impact on these species through the reduction in feeding habitat will depend upon the proportion of area lost as a result of channel widening and the time taken for sessile invertebrates to recolonise areas. The area likely to be directly impacted is very small compared with the area of similar habitats (e.g., ~8,000 m2 or 0.8 ha of intertidal area would be removed). In areas that are impacted directly or indirectly smaller polychaete worms are likely to recolonise rapidly (months) with larger molluscs and other invertebrates taking longer, with timing depending on the time of year that dredging takes place.

Settlement of sediments in intertidal areas – effects on birdlife

Overall, the degree and duration of any adverse effects on fish and shellfish resources, and the birds that feed upon them, from dredging activity in Otago Harbour, will depend on the duration of dredging, the quantity and particle size of material to be removed and the ultimate fate of suspended sediments as they settle out of the water column. In addition to pied oystercatcher and bar-tailed godwit, the main species of conservation concern, feeding over intertidal areas, is the banded dotterel. Cockles and other sessile organisms that are filter feeders would be potentially affected by high suspended sediment concentrations or a significant depth of sediments over them on the seabed as the sediments settle out of the water column.

Modelling indicates that deposition is likely to be at a level that will enable the benthic communities in most cases to avoid suffocation, and so avoid disruption.

Increased turbidity levels – effects on birdlife

Dredging activity will have some potential short term effects on fishery uses of the Harbour. Migrating fish are likely to avoid high suspended sediment levels and this may have some effect on the birds that feed on the fish. Gulls, terns, and shags (particularly black, little and Stewart Island shags) are of conservation concern and the ones most likely to be affected by reduced occurrence of small fish and reduced ability of the birds to see the fish because of turbid water. These birds feed primarily upon planktonic crustaceans and larval and small fish, which they locate visually and obtain particularly from sheltered waters such as harbours and estuaries, and at sea within a few km of the shore. Large aggregations of *Munida* are often stranded on beaches in the harbour predominantly in summer and can cover up to 10 ha attracting large numbers of gulls and other species such as pied oystercatchers and spotted shags (Zeldis 1985, McClatchie et al. 1991). Little blue penguins are also found feeding in the harbour particularly around the entrance (Jim Fyfe, DOC, pers. comm.) and could be impacted when suspended sediment levels are high there.

The turbidity levels predicted for the proposed dredging operations are within the natural range reported from Otago Harbour. Consequently, the level of any impact of the dredging operation will depend mainly upon whether dredging extends the duration of high suspended sediment levels that are avoided by small fish, and so both reduce the availability of prey to the birds and inhibit the ability of the birds to see their potential prey. In terms of prey the levels of suspended sediments predicted, are unlikely to be at a level that would significantly impact on the filtering by benthic animals such as cockles, other bivalves and polychaete worms away from the channel margins (see above). Levels of suspended sediments that could impact on bivalves (>400 mg/l for more than 5% of the time) would be confined to areas very close to the Port.

In the Port of Melbourne case 25 mg/l and 17 NTU above background were set as the thresholds to protect seabirds (crested terns and gannets). The predicted levels on the Aramoana flats and other intertidal areas (e.g., Harwood) during dredging would only be

above this level for less than 0.5% of the time. A flock of up to 26 godwits were observed during the survey in late March but numbers are considerably higher over summer before their migration north. Monitoring and management of dredging adjacent to the Aramoana area just prior to migration would help mitigate impacts on godwits if they were to occur.

Removal of roost sites

Large numbers of a variety of birds use the sand islands opposite Port Chalmers for roosting at high tide. Such roosting sites are important because they provide refuge from terrestrial predators and disturbance. A number of other locations in the Lower Harbour are also used for roosting (Hamel 1991) but the removal of any sand islands opposite the Port during the dredging operation could have had a negative impact on the birds that use this part of Otago Harbour.

As previously outlined, the only area of intertidal habitat that would be lost as a result of the dredging activity is approximately 8,000m^2 in the vicinity of the Port Chalmers swinging basin. This area is all below 0.5m Chart Datum, being exposed only on low spring tides. This is not considered a significant loss of roosting habitat as the main exposed shell bank in the area will not be affected.

6.3.3 Noise and Blasting Effects on Aquatic Animals and Birds

There are small areas of rock on the edge of the channel which may have to be removed by blasting as a last resort. Depending on the charges used blasting can impact on some aquatic animals. Invertebrates are unlikely to be impacted by blasting, except those in immediate vicinity, as they do not have gas filled organs. Impacts through pressure waves are considered to be negligible on shellfish and crustaceans (Wright and Hopky 1998). Animals with swim bladders (many fish and marine mammals) and other sensitive organs will be impacted by sudden pressure waves as a result of explosives, causing rupture and possible mortality. Some fish species are more susceptible than others, with those living on the bottom often not having swim bladders and thus being less susceptible.

Localised fish kills would be unavoidable with greatest impact within 30-50m, depending on the type of charge used. A Port of Auckland study provides an indication of the potential area affected by blasting and suggest an LR50 of 36m for a charge of 50kg and 50m for 100 kg charge (Ports of Auckland 2001).

Similarly marine mammals within 100m could be impacted. Dolphins enter the Harbour and may be disrupted temporarily by the dredging process if they are close to operations. New Zealand sea lions can be found around some of the rocky areas in the harbour and one or more were observed at Acheron Point and the small kelp patches near Wellers Rock and Te Rauone Beach walls during recent surveys. Direct impact on whales from dredging activities within the Harbour is unlikely, although increased avoidance of inner coastal areas close to centres of human and vessel activity is possible. Many mammals rely on sound for navigation/feeding and have sensitive hearing apparatus. These animals are large enough to swim away from bothersome background dredging noises, but sudden high-decibel blasts could harm them if they were in close proximity.

Ongoing noise and disturbance from machinery may also affect fish movements or migrations in and out of the Harbour. The Harbour channel acts as a migration path for the likes of salmon with most migration being over summer when they are targeted by recreational fishers.

The main effects on birds during the dredging phase would be excess noise, lights and the appearance of large machinery. Birds in the Harbour are acclimatised to regular ship movement and maintenance dredging and showed little response to ship movement during

observations at Aramoana (Sagar 2008). There is no documented evidence that operation of the existing maintenance dredge or operational shipping within the harbour channels is affecting bird foraging or roosting behaviour.

Surveys before and after blasting by Port Otago Ltd at the Beach Street Wharf, Port Chalmers were carried out in 1993 (Stewart 1993). The presence and effects on marine mammals, shags, penguins, fish and shellfish were monitored over the three months of operation and concluded that the blasting appeared to have had little effect on the marine fauna and flora except in the immediate vicinity where small schooling fish and a small number of larger fish were affected. Marine bird life appeared to be totally unaffected and no marine mammals were seen in the vicinity during blasting.

Several mitigation measures are proposed to reduce the effect of blasting and these are summarised in Section 2. They include visual monitoring for presence of mammals so that operations can be stopped if they are in close proximity (thus blasting would only take place during daylight hours). Blasting should be timed to reduce potential impact on fish breeding/recruitment or migrations and to avoid nesting time or other key periods in the life cycle of birds (October/November being the most critical time). In respect of dredging noise, and similar to the community exposure discussed in more detail in Section 6.8, selection of equipment and best practice operation to minimise noise at source will be important in reducing adverse impacts on aquatic animals and birds.

6.3.4 Spread of Invasive and Biofouling Species

Surveys of invasive species carried out in Port Otago and Port Chalmers in 2003 did not find the sea-squirt *Styela* but *Undaria* and 25 other species, not previously described from New Zealand waters, were recorded from the Otago region (Gust et al. 2006). These invasions include 23 species of sponge, an amphipod and a polychaete worm. *Undaria pinnatifida* was first identified in the Harbour in 1990 and has since spread along much of the hard shoreline. The most recent survey in Feb 2009 provides the first record of *Styela* in Otago Harbour. It was found in the Town Basin and as yet, hasn't been found elsewhere in the harbour (Graeme Inglis, NIWA, pers. comm.).

Transferring and disturbing sediment during dredging can potentially spread invasive and biofouling species through fragmentation and removal of whole plants/animals. Invasive species are already present in the port areas and no new species would be likely to invade as a result of this operation. The sea tulip is already spread throughout the harbour where ever it can gain a holdfast. Strong water flows in the channel and maintenance dredging over a number of years would have already resulted in any potential spread within the harbour thus any further impacts as a result of the proposed dredging would be considered to be low.

6.3.5 Conclusion

The main effects of dredging on ecology of the Otago region will be direct impacts through removal and disturbance, smothering of benthic communities, increased suspended sediments and turbidity, reduced water clarity, release of contaminants, effects of blasting and potential for spread of invasive species. Each of these potential impacts have been considered for the benthic communities, fish, birds and mammals. The most significant effects are likely to be through direct removal of organisms, and the increase in suspended sediment and sediment deposition. These could potentially be of high severity but would be restricted in extent and duration.

Habitats and communities in the channel are already modified through maintenance dredging. However, most of these communities will be removed in areas that are dredged and marginal areas where the channel is to be widened. Most of these communities are

well represented elsewhere in the Harbour except for the deep, sessile communities in the deeper sub-channels and hollows and a small area near the entrance. Recovery of animals like polychaete worms could be on a timescale of months while longer lived species could take 2-3 years and deep sessile communities several years to recover. The area to be removed by widening is less than 0.15% of the intertidal habitat (0.0 to 1.0 m above chart datum) in the Lower Harbour and will thus only have a very localised effect.

Harbours are naturally turbid at times and most communities can tolerate periods of high suspended sediment concentrations and low water clarity but many for only short periods. Modelling indicates that levels could reach over 1000 mg/l but only for short periods and only in patches in the immediate vicinity close to the main channel. Most intertidal areas would experience less than 200 mg/l (high only on channel margins near the Port) and concentrations in sensitive areas like off Harwood would be undetectable most of the time with only small areas experiencing over 20 mg/l.

Fish and mammals are very mobile and can avoid areas of high suspended sediments while zooplankton and larval fish can tolerate the levels predicted. The highest levels predicted could have a moderate effect on seagrasses but this would be for less than 5% of the time and would be very localised in extent. The communities would be expected to recover when dredging ceases.

Most animals and plants found in harbours and estuaries can survive small amounts of sediment deposition (generally <20 mm in an event for benthic animals and seagrasses). Modelling indicates that for non-main channel areas, less than 10% of the areas would receive 6 mm or more over the period of dredging, except the intertidal area opposite the Port where 10% of this sub-area would receive 23 mm or more. In the intertidal area around Portobello and off Harwood less than 10% of the sub-area would receive more than 2.4 mm and 0.1 mm respectively over the period of dredging. Deposition in areas like Aramoana, Te Rauone beach and inner Harwood would be less than 1.0 mm over the dredging period with only a few patches over 4 mm. The levels of contaminants and potential for water quality issues are low. If water quality issues did occur any impact would be for a very short period due to rapid flushing. Levels of contaminants in sediments to be dredged were below ANZECC guidelines for protection of biological communities.

There may be limited areas of rock substrate (<1% of area) that will require blasting. It is expected that only fish in the immediate vicinity of the blasting will be impacted. With appropriate mitigation most mobile species can avoid the blasting. Only macroinvertebrates at the site itself would be impacted.

The effects of dredging on birdlife can occur through direct effects on foraging ability (physical disruption during feeding and turbidity) and indirect effects through impacts on food sources. Otago Harbour is particularly important as a breeding and feeding ground for a number of species including some that are endangered or vulnerable. Impacts on food sources, if they were to occur would be low and only short term. Most areas would be subjected to turbidity levels below that recommended to protect seabirds.

Some of the invertebrates that fish feed on will be smothered or impacted by high levels of suspended sediments but these effects will be very localised and short term. It is only in localised parts of the channel and margins that cockles and food resources for fish would be significantly affected. Eggs and larvae of a number of fish species are found in the harbour with peak spawning occurring in early spring. A number of rocky reefs and the area around the Mole are important for recreational divers and fishers. Waves and currents will disperse material that settles in these areas so any impacts on fish communities and fishers in these areas are likely to be localised and short term.

Noise associated with potential blasting of small areas of rock and dredging operations could potentially impact on a range of species. Localised fish kills would be unavoidable

but impacts could be mitigated by minimising charges and carrying out these activities outside fish breeding, recruitment and migration periods. Monitoring for presence of mammals during blasting will be essential and is proposed. Excess noise and the presence of dredging machinery could have an effect on birdlife but this is unlikely to be significant or more than a temporary effect as they are already acclimatised to such activities.

6.4 Effects on Offshore Ecology

6.4.1 Introduction

Depending on the type and quantity of dredged material being disposed of it can impact on the ecology of an area in a number of ways:

- **Fine material can stay in the water column and disperse creating a plume that can have a direct impact on suspension feeding planktonic animals, and reduce water clarity and thus light availability for phytoplankton and benthic algae.**
- **Fine material can be dispersed and depending on the extent of the plume can impact on inshore areas and sensitive offshore communities.**
- **Material which reaches the seafloor can blanket and smother benthic organisms in the immediate disposal site.**
- **Changes in sediment characteristics can result in changes to benthic community structure. Generally muddy sediments have low species richness compared with sandy sediments and are dominated by small surface associated taxa.**
- **Impacts on benthic and planktonic fauna can in turn impact on food resources and foraging of birds, mammals and fish.**

Each of these potential effects is discussed in the following section.

6.4.2 Offshore Plankton Communities

As the dredge material is released at the disposal site there will be an increase in turbidity as sediments settle through the water or disperse with the currents. Heavier sediments will settle in the immediate vicinity of the disposal site but finer silts and clays will disperse as a plume with duration and direction depending on prevailing currents. Some of the material that reaches the seabed may subsequently be resuspended into the water column under certain hydrodynamic conditions.

Although coastal plankton communities are subject to episodic turbid events as a result of increased runoff and riverine input, elevated suspended sediment concentrations as a result of the disposal of dredge material can impact on both phytoplankton and zooplankton. Lower water clarity can mean less light reaching the water column and reducing photosynthetic capacity. Primary production in offshore areas is predominantly associated with phytoplankton in the water column. Effects on larger benthic plants offshore are likely to be minor because submerged aquatic vegetation is rare in offshore sand habitats (see later in this section re kelp beds along the northern coast).

Turbidity associated with dredged material disposal would reduce light penetration at the disposal site with potential effects on primary producers (plants) both planktonic and on the seabed. The predicted suspended sediment concentrations are up to 2100 mg/l in bottom waters and 185 mg/l in surface waters at the disposal site but are likely to be less than 100 mg/l in the plume once you get a few km away from the site and rapidly dilutes to less than 20 mg/l. Surface layer concentrations off the Taiaroa Heads and other northern coastal areas are predicted to be less than 3 mg/l. It should be noted that these are conservative estimates and dry-weight which is commonly used for environmental limits is about 70-80% of these values. To put this into context, recent measurements of background levels at Site A0 and in the middle of Blueskin Bay varied from 0.3 to 4.1 mg/l (Kim Curry, NIWA, pers. comm.) and the human eye has been shown to detect increases above ~15 mg/l (Longmore 2007).

Suspension and filter-feeding zooplankton can be affected by clogging of feeding apparatus. Surface concentrations of suspended sediments are predicted to reach a maximum of 185 mg/l, even close to the site, which is well below the level that is known to have a significant impact on zooplankton communities, fish eggs and larvae (>500 mg/l, Wilber and Clarke 2001). Any impact, if it was to occur would be short-term as zooplankton are short-lived (days to months) so recovery would be relatively rapid through recruitment, depending on the time of year, as well as advection from other areas.

Generally the impacts on planktonic communities are expected to be moderate right at the disposal site but low away from the site, and short-term.

6.4.3 Offshore Benthic Communities

Effects on benthic communities, due to the disposal of dredged material, are inevitable. Sudden 20-30 cm thick deposits accumulating up to 1.4-1.8 m on average across the 2 km diameter of the site will cause mortality of most underlying benthos, with the possible exception of a few large bivalves and active macroinvertebrates that are adapted for rapid burrowing and movement in mobile sediments. Consequences of species loss depend on the species removed with large long-lived organisms often controlling community structure and ecological functioning.

Recovery will be fastest when dredged sediments and spoil area sediments are well matched (i.e., similar grain size and similar biotic composition). Once disposal ceases, recovery could still take up to a year for early pioneering species but several years for large animals that take years to mature.

Maintenance and development dredging has been in place in Otago Harbour since 1865. Three dredge material disposal sites are currently in use and Port Otago Ltd has a coastal permit to dispose of dredged material from its ongoing maintenance dredging at these sites until December 2011. The Heyward Point site was relocated 600 metres to the north-east in 1977 following the disposal in 1976 of 3.7 million m^3 from a major dredging programme in the Harbour. Unfortunately there is no data on the impacts of this large capital dredging but surveys in 2002/03 found benthic assemblages of similar composition, diversity and abundance inside the present Heyward Point site as that found outside (Paavo and Probert 2005) and presumably including the 1976 disposal site to south-west. It is difficult to assess whether the coarser sediment (pebbles/rocks) encountered off Heyward Point is the result of extension of reefs from the point or an active hydrodynamic environment creating a coarser substrate (Paavo and Probert 2005).

As part of the most recent consent Port Otago was required to undertake a study of the effects of disposal on the biota at the present maintenance dredging disposal sites. The direct impacts on the inner shelf benthos from the disposal of this dredged material, was examined, in particular at the Spit Beach (Aramoana) disposal site, by Paavo (2006). Macrofauna inside the Spit Beach disposal site was found to have lower species richness and abundance compared to adjacent sediments. Disposal related effects beyond the disposal area boundaries appear, at least in part, to be due to the accumulation mound influencing wave and tidal currents.

In order to better understand the environmental effects of disposal at the Spit Beach site, the site was protected from dredge material disposal for an extended period followed by experimental disposal of sandy and muddy dredge material. Macrofaunal samples were collected before disposal and at nine sites within 120 days after disposal.

Disposal site samples were depauperate in individuals and taxa compared to an area protected from disposal, for greater than 180 days. A drop in abundance and a dissimilar community coincided with muddy sediments, but fine sediments were dispersed within 26 days and macrofaunal assemblages recovered to the pre-existing state. Disposal of sandy material, while not altering native sediment textures, had a more prolonged impact due to transplantation of macrofauna (polychaetes, amphipods, molluscs) from the dredged area. These animals survived the transplant and persisted for more than 40 days after disposal thus increasing diversity and abundance of some animals (Paavo 2006).

Paavo et al. (subm) also demonstrated that 50% of the common snail *Zethalia zelandica*, one of the commonest benthic animals in the inshore sandy region off Otago, did not survive 24 hrs after burial under 17 cm of sand. If buried under only 3.8 cm of mud the same level of mortality occurred demonstrating the differential effects based on sediment type. The threshold at which only 10% of bivalves such as *Nucula* and *Macomona* may escape burial and re-establish is up to 50 cm (Kranz 1974) and a few polychaete worms 20-30 cm, but most soft-bottom species can only escape maximum burial of up to 2-10cm.

No sensitive or rare species or communities were identified in the surveys around the proposed disposal sites, at the level of taxonomic details used here. Of the alternative sites considered, Site A1 was more turbid and possessed little epifauna but large numbers of the small gastropod *Antisolarium egenum*. Site A2 had higher densities of large tubeworms and epifauna despite all sites having similar sediment characteristics. The site finally chosen (Site A0) is located in between these two sites but would be expected to have similar characteristics to Site A2. Other than a few bivalves, few species encountered at the site itself would be likely to survive smothering by sediment of over 10-20 cm. Based on the predictions of deposition (Bell et al. 2009) these levels could impact on an area up to ~5-6 km in a footprint to the north/northeast of the disposal site and the area receiving over 1.7 mm/d on average (20 cm accumulated over the disposal period) would be ~11 km^2. The material that is dispersed to the north is likely to be fine sand and silt which could change, at least in the short-term, the present sandy community by potentially reducing grain size, altering water clarity for benthic algae, and affecting suspension feeders. The impact in this area is likely to be short to medium term as the dispersive processes will continue to remobilise the finer sediments to deeper waters and canyons offshore.

In terms of recovery at the site and further north the likes of polychaete worms and amphipods can recover on a time scale of a few months to a year but for longer-lived species recovery could be in the medium term (up to several years). Constant remobilisation for a few years at least could keep some communities in more of an early successional stage although there would be constant migration and recruitment into the area.

It should be noted that deposition is likely to be gradual so the area to the north of the disposal site receiving 20 cm would average less than 1.7 mm/day which many animals could tolerate and manage to burrow through the deposited sediment as it gradually built up during disposal. The high impact area is likely to be confined to the site itself or within a km or so where sedimentation could average over 10 mm/d, with larger amounts depending on the disposal methods.

Some offshore locations have biogenic habitats (bryozoan thickets, horse mussel beds, sponge gardens, soft-corals) that are ecologically very important for their biodiversity and as settlement habitat for commercially valued finfish and shellfish species. The potential disposal sites have been carefully chosen so that these communities will not be affected. The proposed dredging site is well inshore and to the north of areas where they occur (75-110m depth) and modelling at Site A0 indicates dispersion will be to the north with no dispersion of sediments towards those habitats.

The coastline north of the Otago Peninsula has extensive areas of benthic algal and kelp beds which are a very important habitat for a range of invertebrates (including the likes of paua and kina) and fish. Recruitment processes are important in determining the distribution and abundance of these communities. Although seasonal patterns of growth are not considered important the kelp *Macrocystis pyrifera* has a "recruitment window" when light and temperature requirements are met and allow the establishment of sporophytes (Fyfe 2000). Recruitment has been observed along the coastline near Pleasant River through spring and summer months following thinning of the canopy during winter storms. Based on modelling it is unlikely that the benthic community in the Blueskin Bay area and northern coastline will be impacted by the plume of fine material. The coastal area on the outside of Otago Peninsula and north would receive negligible amounts of sediment on occasions (<0.1 mg/l SSC in surface waters, <0.5 mm over dredging period). These levels are well below thresholds that would be likely to impact on biota (see Section 6.1.5 above). Material that may be resuspended and flushed out of the harbour would be well spread out in Blueskin Bay and deposition would be unlikely to be more than a few mm after settling out in the middle of the Bay.

In terms of mitigation of the effects of disposal, systematic disposal (starting at one end of the disposal area and progressing toward the other) rather than haphazard/random disposal would probably help to limit impacts. Repeated disposal in an area would be worse than one-off disposals, especially for communities dominated by large long-lived "climax" species (see comments above).

6.4.4 Spread of Invasive and Biofouling Species Offshore

As discussed in earlier sections recent surveys of invasive species carried out in Port Otago and Port Chalmers have now recorded both the sea-squirt *Styela* and *Undaria* as well as 25 other species not previously described from New Zealand waters (Gust et al. 2006, Graeme Inglis, NIWA, pers. comm). These invasions include 23 species of sponge, an amphipod and a polychaete worm. *Undaria pinnatifida* was first identified in the Harbour in 1990 and has since spread along much of the hard shoreline. *Styela* was first recorded in early 2009 in the Town Basin, Port of Dunedin.

It is highly unlikely that species like Undaria would colonise at the proposed disposal site because of the lack of hard substrate, depth and exposure. Undaria has already spread to northern coasts such as off Cornish Head and Omini Point (Jim Fyfe, DOC, pers. comm.). The three invasive species that were found exclusively at Port Chalmers were algae or sponge species which would be unlikely to survive offshore because of a lack of hard substrate. Viable algal cysts and sediment microbes could be transported offshore but their survival and proliferation in offshore waters is unlikely. The sea tulip also requires a hard substrate and would soon die at the disposal grounds. Dead sea tulips have been found around maintenance dredge disposal sites but until recent discussions with local fishermen, Port Otago were not aware they were established in offshore areas. Recent discussions with local fishermen indicated that there are some locations within Blueskin Bay that sea-tulips are present there at times.

Contaminants that are present in sediments at the dredge site are at very low levels but some contaminants will remain bound to sediments and be transported to the disposal site. These contaminants could potentially affect the offshore biota through direct toxic effects

and bioaccumulation into the food web. However, sediments at the dredging sites have been tested and are below the ANZECC guidelines for levels that are known to impact on biota. Any contaminants that were released into the water column would be rapidly diluted and dispersed.

The dilution of nutrients in the open coastal sea (and the sporadic nature of the disposal schedule) will mean the formation of phytoplankton blooms and associated issues are unlikely to occur.

6.4.5 Offshore and Coastal Birds

Disposal of the dredged material could have a number of potential short- and long– term effects on fisheries resources (see section on effects on fisheries below). Fish, squid and swarm-forming crustaceans such as *Munida gregaria* and *Nyctiphanes* are the principal prey of seabirds off the Otago coast. Consequently, disposal of dredge material that affects these prey would also have flow-on effects to seabirds.

A sediment plume will develop in the water column as each load of dredged material is released at the disposal site. The finer sediments in this plume will be dispersed away from the site by any prevailing water currents at the time of disposal and may cause a short term reduction of water clarity, depending on where the plume disperses.

Such effects would be limited to the duration of dredging and disposal but could affect seabirds close to the site that detect their prey visually. The concentrations of suspended sediments are low enough once you get a few kilometres away from the disposal site that they would be unlikely to affect foraging by these birds except in the immediate area. The main sediment plume also disperses to the north rather than towards Taiaroa Heads and the Otago Peninsula where a number of rare and endangered birds nest and raise their young.

The critically endangered grey-headed mollymawk is rare off the Otago coast and is considered to forage mainly off the continental shelf, over deep (>500m) water (Marchant & Higgins 1990), and so is unlikely to be directly affected by disposal of dredge material.

The one mainland breeding colony of northern royal albatrosses is situated on Taiaroa Head, Otago Harbour. The location of the breeding colony, high on the promontory, ensures that it will not be affected directly by dredging activity. The important foraging areas off the Otago coast of 18 Northern royal albatrosses from the Taiaroa Head colony, during the incubation stage of their breeding season, was monitored using global positioning system (GPS) loggers (Waugh et al. 2005). This study showed that waters within 100 km of the breeding colony were extremely important for the albatrosses (tagged individuals spent 28% of their time, on average within this area). This area is also frequented by albatrosses from Campbell Island, making it an important feeding habitat for this species. A large amount of foraging also occurred in areas much farther off shore. Birds spent multiple days at sea and travelled over large distances when searching for food (2-19 days at sea, travelling on average 2000 km). Consequently, because of the ability of the birds to forage over such a large area and mostly right at the surface, potential impacts to the albatrosses due to dredging and spoil disposal, if they were to occur, are likely to be minimal and confined to when they are traversing the disposal site and immediately downstream.

Sooty shearwaters breed in colonies on Otago Peninsula (Sagar et al. 2002). Birds from these colonies forage widely, obtaining their food by diving to depths of over 40 m and have the ability to cover large areas of ocean rapidly. They feed mainly on small fish, squid, krill and other small crustaceans. Spatial distribution of sitting and flying sooty shearwaters off the Otago Peninsula in surveys in 1994-96 indicates that the area of the proposed disposal site is likely to be a pathway to deeper water but a number of birds were observed to either be resting or feeding in the vicinity of the site (O'Driscoll 1997, O'Driscoll et al. 1998). Feeding and passage in the vicinity of the disposal site and immediately downstream could be affected during the actual disposal operation but the ability of these birds to cover large areas of ocean rapidly should ensure that they are not significantly affected by the disposal of spoil.

Yellow-eyed penguins and southern blue penguins breed in coastal areas outside the Harbour. They are predominantly pelagic feeders, foraging for food near the ocean floor (Marchant & Higgins 1990). Off the Otago Peninsula, Moore (1999) and Mattern et al. (2007) suggested that yellow-eyed penguins foraged mostly in waters over the continental shelf at depths between 40-80 m. Individuals were shown to retain foraging patterns throughout the breeding season; some birds were markedly inshore feeders, with centres of activity less than 5 km from the coast. Breeding success was related to foraging time. Failed breeders and non-breeders travelled further and for longer periods of time than breeding individuals. In addition, breeding birds that later failed took longer trips during incubation than successful breeders.

Both species of penguin breeding on Otago Peninsula are likely to forage at some stage within the proposed offshore dredge material disposal zone. Disruption of benthic communities and associated food sources in this zone could mean that birds will be forced to forage over larger distances. However, yellow-eyed penguins tend to forage on small fish such as sprat, red cod, silverside, blue cod, and mostly at depths greater than 40-80 m and up to 160 m, which is well offshore from the proposed disposal area. Blue penguin feed on a variety of surface schooling fish, squid and crustaceans which could be impacted for a short time in the immediate vicinity of the disposal site. Effects on penguins, if they were to occur, are likely to be restricted in extent and time.

Four species of shag inhabit the Otago Harbour and the adjacent coastline. Howlett Point is the only mainland breeding location of the Stewart Island shag. The Otago population of Stewart Island and spotted shags represents about 20% of the species around New Zealand. Disposal of dredging material may interrupt habitats and feeding grounds of fish species that make up the majority of the diet of Otago shag species, and so reduce the abundance of prey species, but only in a small area relative to the foraging area available. The diet of these shags was analysed allowing the foraging habits of the birds to be deduced from the habits of their prey (Lalas 1983). Black and little shags generally forage close to shore in shallow water feeding on small fish (mostly yellow-eyed mullet, thornfish, red cod for black shag and cockabullies, flounder and sole for little shags). Stewart Island and spotted shags feed up to 15 km offshore and mainly on small fish with Stewart Island shags feeding on inshore and harbour cockabullies, flounder and sole. Spotted shags feed on the deepwater ahuru, and sprats, gudgeon and red cod. Little shags and Stewart Island shags are considered demersal or bottom feeders, spotted shags pelagic (water column) and black shags both demersal and pelagic.

Stewart Island shags have a more restricted feeding range and their breeding season is Sept – Jan (Lalas 1983). Although the potential effects of disposal of dredge material on shags are likely to be short-term and restricted in spatial extent, monitoring during this period could be used to inform dredging management if an adverse effect was encountered. The same would apply to other species such as sooty shearwaters and penguins which have not had good breeding seasons lately (Graeme Loh, DOC, pers. comm.). The most critical time to monitor dredging impact on bird nesting, and potentially manage dredging activity would be in the locations where birds are nesting during October/November.

White-fronted terns breed in colonies on the outer coasts of Otago Peninsula (Sagar et al. 2002), while Caspian terns and black-fronted terns do not breed in the area. Thus breeding of these terns should not be affected by dredging. However, Lalas (1977, 1979) reported that 50-70, and occasionally almost 200 birds, of black-fronted tern roosted in

Otago Harbour and foraged in adjacent coastal waters on planktonic larvae, taken from the surface or just below the surface.

The preferred prey of Caspian and white-fronted terns are fish and crustaceans which they capture by diving. Consequently, even though they forage over a large area, dredging and disposal could temporarily interrupt habitats and feeding grounds of the terns and their prey species in the immediate vicinity of the disposal site, particularly by reducing the ability of the terns to detect their preferred prey.

In addition to white-fronted terns and sooty shearwaters a number of other pelagic feeding bird species are known to use the disposal area for passage or for resting and feeding. Observations along transects up to 14 km off the Otago Peninsula (McClatchie et al. 1989, O'Driscoll 1997, O'Driscoll et al. 1998,) indicate that this region (including the disposal area) is also important for passage, resting and feeding by black-backed gulls, Buller's mollymawks, red and black-billed gulls and Stewart Island shags. In this region red-and black-billed gulls feed mostly on euphausiids while black-backed gulls feed mainly on fish and *Munida*. These birds often aggregate along salinity fronts where krill and other plankton can be abundant, particularly in summer when krill form swarms. The distribution of *Munida* postlarvae are very patchy and tend to be highest along the inner to middle shelf from Blueskin Bay to Moeraki (Zeldis 1985). Larvae are found offshore in June/July with the post-larvae shoaling inshore over summer. Most of the pelagic feeding seabird species observed by O'Driscoll et al. (1998) occurred throughout the ~130 km2 area studied with little change in seabird assemblage observed with increasing distance out to at least 14 km.

Modelling to date does indicate that the concentrations of suspended sediments in surface waters are likely to be less than 185 mg/l (wet weight) at the disposal site itself (2 km diameter) and less than 20 mg/l at distances more than a few km to the north of the disposal site (As a guide the human eye may detect increases above ~15 mg/l, Longmore 2007). The threshold set by Port of Melbourne to protect terns and gannets was 25 mg/l thus the levels likely to be encountered by birds foraging off the Otago coast during disposal of dredge material event could have a medium to high impact but only in the very localised area around the disposal site and a small distance to the north. Direct impacts on foraging would be short-term and mostly during the disposal period itself. Recovery of the immediate area of disposal as a feeding ground could take a few years as described above but again this is likely to be only a small part of their foraging area.

6.4.6 Offshore and Coastal Mammals

Fur seals forage on the likes of squid, octopus, barracouta and mackerel in depths greater than 22m and up to 78 km from Otago rookeries while sea lions are known to spend several days at sea foraging and completing dives as great as 474m (Harcourt et al. 1995; Gales and Mattlin 1997). Consequently, because of the ability of these species to forage over such a large area, potential impacts due to dredging and dredge material disposal, if they were to occur, are likely to be minimal.

The southern elephant seal (*Mirounga leonine*) and leopard seal (*Hydrurga leptonyx*) are also occasionally sighted on the Otago coast. This area represents the most northern extent of their ranges (although stragglers are found further north) and both species are more commonly found off the Subantarctic Islands and over the Antarctic ice shelf (Sagar et al. 2002) and thus are unlikely to be impacted by the proposed dredging and disposal of dredged material.

The New Zealand (Hookers) sealion (*Phocarctos hookeri*) was declared a threatened species in 1997 and its status is presently being reviewed. The Otago breeding population in 2002 consisted of four breeding females and the Otago Peninsula is the only mainland breeding site of this species (Jim Fyfe, DOC, pers. comm.). Over 95% of the breeding

occurs at the Auckland Islands and Campbell Island and they tend to forage outside the proposed disposal area and to the south and east (Jim Fyfe, DOC, pers. comm.) so possible effects of the dredging operation are related more to the potential for disturbance when dredging near the Harbour entrance. A few sealions have recently taken up residence in this area and are one of the attractions for visitors on the Monarch during summer (Sean Heseltine, M.V. Monarch, pers. comm.). The New Zealand sea lion feeds on small fish, squid and invertebrates which are found over a wide area. It needs to be kept in mind that these animals have taken up residence close to regular boat and ship traffic and maintenance dredging operations with no obvious effects.

Four dolphin species are found off the Otago coast – Hector's dolphin, (*Cephalorhynchus hectori hectori*), dusky dolphin (*Lagenorynchus obscurus*), bottlenose dolphin (*Tursiops truncates*) and common dolphin (*Delphinus delphis*).

Dusky and common dolphins occasionally enter the Otago Harbour, often staying for several days at a time, and travelling as far as the inner basin (Dunedin City Council 2006; Würsig et al. 2007). Hector's dolphins are endemic to New Zealand, and are considered to be at very high risk of extinction in the wild. Hector's dolphins inhabit inshore coastal waters and are generally restricted to local areas, with little movement between areas.

About 20 Hector's dolphins are resident in Blueskin Bay out to Taiaroa Head and are generally found in pods of 3-4 animals (Steve Dawson, University of Otago, pers. comm.). Hector's dolphins in this area spend winter at depths of 60-70m. Although they are found close inshore in summer (3-4km off the coast) they generally forage opportunistically (both pelagic and demersal) to the north and west of Taiaroa Head so are unlikely to be significantly affected by the disposal operation. The plume resulting from disposal is predicted to head north and indications are it will avoid the inshore Blueskin Bay area occupied by Hectors dolphins. It should also be noted that concentrations in the plume will be diluted to less than 20 mg/l above background within a few kms of the disposal site, thus will be unlikely to impact on the planktonic or larger animals in the water column of Blueskin Bay.

The Humpback whale (*Megaptera novaeangliae*) can be sighted off the Otago coast in autumn during their northward migration to breed. The distance from shore and depth of their main migration routes are unknown, however a juvenile Humpback whale was sighted feeding within the Otago Harbour. Sightings of the Southern Right whale (*Eubalaena australiis*) off the Otago coast are also frequently recorded at various locations close to shore. The coastline is part of their migration route, and they probably feed over the entire continental shelf. Direct impact on whales from dredging and disposal activities is highly unlikely as they can avoid areas of activity.

6.4.7 Summary of Effects on Offshore Ecology

The main effects at the disposal site are predicted to be the direct effects of smothering of the benthic community, increased levels of suspended sediments and reduced water clarity.

Virtually all benthic plants and animals in the immediate disposal area would not survive smothering (1.4 to 1.8 m depth on average). Recovery could take up to a year for some animals and longer for some larger animals, depending on the disposal operations. Careful consideration has gone into the selection of a site to avoid important biogenic sites offshore (bryozoan community) and the potential for significant dispersal inshore to Blueskin Bay and the outer Otago peninsula. No unique or special communities were identified within the footprint of the disposal site, at the level of taxonomic detail used.

The increased levels of suspended sediments and reduced water clarity will affect the immediate disposal site but the levels of suspended sediments will be rapidly diluted away

from the site. North of the disposal site (~2 km in diameter) suspended sediment concentrations will be less than 20-30 mg/l, within a few kilometres, which is a level which should not affect plankton or fish and is similar to the level set to protect birds like terns and gannets. Most seabirds found in the area feed well offshore (e.g., endangered grey-headed mollymawk and northern royal albatross) or are predominantly bottom feeders at depths over 40m (e.g., sooty shearwaters and yellow-eyed penguins). However some birds such as shags and gulls may feed in the disposal area and along with some fish species may be affected in the immediate area over the short-medium term. Most birds and fish however, could avoid areas of high suspended sediments. Monitoring of dredging effects and management if necessary should be particularly focussed on the critical part of the breeding period (October/November). Similarly mammals generally feed over very large areas and could avoid the short-term disruption associated with the disposal. Hectors dolphins tend to forage to the west and north of the disposal grounds and would be unlikely to be impacted.

Because of the low levels of major contaminants at the dredging sites the effects from release of contaminants at the disposal site is likely to be low and very short-term.

A number of invasive species have been reported from Otago ports with 25 species (mostly sponges) not previously described from New Zealand waters. The seaweed *Undaria* has been present since at least 1990 the seasquirt *Styela* has only recently been recorded. It is highly unlikely that species like *Undaria* would become established at the proposed disposal site because of the lack of hard substrate, depth and exposure.

6.5 Effects on Fisheries Resources and Commercial Fishing

6.5.1 Introduction

The fisheries resources present at any particular location and effects on these resources are influenced by various local environmental factors, such as substrate material, benthic and pelagic resources and various physical factors. . As such, while this section focuses on fisheries and fishing, reference should also be made to earlier sections, where much of the contextual environmental information is presented. Sections 6.3.1 – 6.3.5 provide a summary of the key findings in relation to the potential effects on the ecological environment of Otago Harbour. Sections 6.4.1 – 6.4.7 provide a similar summary in relation to offshore ecological effects.

Further information on habitats, diets and potential effects on key fish and shellfish species of interest to Ngai Tahu is provided in a supplementary report prepared in March 2010 (James, Boyd & Probert 2010). The initial discussions and review of existing information with the Tangata Whenua working party highlighted the importance of fish and shellfish species to the Tangata Whenua. Key species include flatfish (flounders and sole), barracouta, blue cod, blue moki, butterfish, hapuka, ling, red cod, re gurnard, tarakihi, rock lobster, paua, cockles (tuaki), pipi and tuatua.

Nature of Fisheries Resources

Most fish species are highly mobile meaning that the populations of most species are very widely distributed along the New Zealand coast, with in many cases no clear boundaries to their spatial distribution. The specific distribution of individual fish species in each area is largely dependent on the presence of its preferred habitat. Many fish species aggregate or

migrate seasonally along the coast for feeding or spawning, with catches of some species limited to a few months each year when they are most easily caught. There is also considerable inter–annual variation in the abundance and spatial distribution of fishes, driven by factors such as water temperature, salinity, and plankton and prey abundance.

Because of the wide and variable distribution of fishes in time and space, there is almost no part of the New Zealand coast that is not fished commercially or for personal use, either throughout the year or at certain times of the year. Both fisheries research data and fishing use patterns show that some areas of the coast are clearly much more important than others, although it is frequently difficult to identify specific sites where a particular fish species or fishing activity is especially important or not because these may change from season to season or year to year. Given these factors and the mobility of the resource, the boundaries of most fish populations and any fishing activities are indistinct and may vary over time.

Shellfish are generally less mobile, being either sedentary such as the cockle, or exhibiting very limited movement over a scale of several metres such as the paua. However, many crustacean species such as the rock lobster and swimming crab are very mobile and may move considerable distances along the coast, but usually not on the scale of fish movements or migrations.

Character of Otago Fisheries Resources

Coastal Otago has a diversity of fisheries habitats including hard and soft shores and exposed and protected coasts and harbours supporting all types of fish and shellfish. Otago Peninsula and Otago Harbour are major coastal features of the east coast of the South Island. There is a diverse fish and shellfish fauna on the coast and within Otago Harbour and the other harbours of Otago Peninsula with in excess of 200 fish and shellfish species known to occur. Paulin & Roberts (1990) found that the fishes of Otago Harbour, Otago Peninsula and adjacent waters consist primarily of species that are widespread in central New Zealand waters, with a small component of cooler water species plus a few warm water species that are occasionally present. The marine fish and shellfish fauna of the Otago coastal area is not known to be unique, presently at risk or of special ecological significance.

6.5.2 Fish and shellfish resources within Otago Harbour

As Otago Harbour is an extension of the sea rather than an estuarine environment, most of the fish and shellfish species present in the Harbour are also found on the open coast. The shallow and protected waters of the Harbour also serve both as a habitat and a nursery area for a range of fish and shellfish species, especially flatfishes and cockles. Significant cockle beds are found in the Lower Harbour especially opposite Acheron Point, near Harwood and at Aramoana (Breen et al. 1999). In the recent surveys undertaken for Port Otago Ltd, Paavo et al. (2008) also found cockles to be abundant opposite Acheron Point but greatest abundance was found southwest of Harwood (up to 625m^{-2}).

The main environmental effects arising from dredging and disposal potentially affecting fish species are associated with suspended sediments and increases in turbidity. Otago Harbour is a naturally turbid environment as local sediments are frequently suspended due to wind, wave and tidal flows. Fish and shellfish that live in or visit this environment are reasonably tolerant of the naturally relatively high levels of suspended sediments.

As noted in section 6.5.1 above, the potential effects of dredging on harbour ecology have been discussed in sections 6.3.1 – 6.3.5. Some of these potential effects will also impact fish and shellfish.

Sediments mobilised during the dredging programme are the main environmental effect potentially affecting fish and shellfish resources within Otago Harbour. There will also be a loss of some fisheries habitat and shellfish in the areas that are dredged. In particular, widening of the approach to the Port will result in the loss of some shellfish, mainly cockles and possibly pipis, along the margins of the channel and turning basin. This loss in the context of the wider and harbour are considered negligible.

Mobile fishes, swimming crabs and rock lobster are more able to avoid effects of the dredging than sessile shellfish species such as cockles, which are part of the benthic community. Fishes are well adapted to avoid potential threats and typically swim away from any disturbance or noise in their vicinity. They will avoid high suspended sediment levels that occur during dredging activity. Fishes can be expected to immediately return to the vicinity of newly dredged areas to forage for benthic organisms exposed during dredging whenever the dredger ceases operation. Some of the benthic organisms that fishes feed on will be smothered by sediment deposition in the newly dredged channel and immediate margins around the Port but the mobility of fish means that they are able to move away from the small areas of highest deposition to less impacted areas to feed in the short–term before the affected areas are recolonised again.

High suspended sediment levels can interfere with gas exchange in fishes as well as causing gill abrasion and clogging of gills at high concentrations but fish will avoid areas of high suspended sediment concentrations by moving into unaffected or less affected areas.

Larval fishes in the sediment plume downstream from the dredger may not survive high levels of sedimentation as they do not have sufficient ability to swim away. The fisheries literature indicates that the majority of common fishes for which data is available spawn on the open coast outside of the Harbour, although research has also shown that some fish larvae are transported into the Harbour by tidal currents. Larvae of three species of flounder (sand flounder, speckled sole, and greenback flounder) are common in Otago Harbour in late winter to early summer when there is often an abundance of juveniles of these species (Robertson 1980, Roper and Jillett 1981). Hurst et al. (2000) found that harbours and protected coastal waters along the east coast of the South Island tend to be the main areas where the greatest numbers of eggs, larvae or juveniles of many inshore species are found – these areas include protected harbours and estuaries as well as semi–protected areas such as Pegasus Bay and Blueskin Bay.

Robertson (1980) found late stage eggs of ahuru in July as well as eggs of lemon sole in Otago Harbour but suggested they came in on the tide from Blueskin Bay. Eggs of the southern pigfish were also found in the Harbour and may have been spawned there while spotty eggs were present in the Harbour from November–December although spawning is thought to mostly occur during August–September. Based on egg surveys, September–October was the period when the greatest numbers of species in the Otago area were found to spawn (Robertson 1980). The planktonic eggs and larval phase of sessile shellfish species such as the cockle are more likely to remain largely contained within Otago Harbour waters and are therefore more at risk from high suspended sediment levels than fish species that spawn on the open coast.

In the Port of Melbourne assessment it was suggested that 100 mg/l of SS and 70 NTU was necessary to protect fish eggs and larvae. Appleby and Scarratt (1989) summarised a number of studies that have assessed the effects of suspended sediments on fish. Most fish eggs and larvae do not show a significant effect until concentrations get above 500 mg/l and adult fish can tolerate at least 2000 mg/l for extended periods before mortality occurs. Larval bivalves have shown a similar level of response with no significant effect on pacific oyster larvae at concentrations up to 500–800 mg/l (Cardwell et al. 1976).

The physical disturbance or loss of benthic biota as a result of dredging could have some short term indirect impacts on fishes that normally reside within the impacted areas and feed on benthic organisms in these locations. As described earlier there is a mosaic of

benthic habitats and biota within the Harbour. A small area of these benthic habitats will be altered as a result of dredging or sedimentation but replacement populations of benthic organisms will begin to establish in affected areas almost immediately. Any impacts of physical disturbance or loss of benthic biota on the availability of feeding areas for fish will therefore be localized and temporary. There will be some loss of cockles that lie immediately adjacent to the Harbour channel due to the widening of the turning basin and channel. However, the affected areas represent a small part of the extensive cockle beds present in Otago Harbour. Other effects on benthic shellfish from turbidity and suspended sediments are covered in Section 6.3.1.

There is potential for sediments to adversely affect rocky habitats of importance to fish or shellfish within Otago Harbour if significant sedimentation occurs as a result of the dredging activity. Most of the benthic habitats within Otago Harbour are comprised of soft sediments, but there are a few rocky areas such as around Pulling Point and Quarantine Island. The Mole at the Harbour entrance is a rocky habitat supporting kelp beds and a number of reef dwelling fish and shellfish species, including paua. The Mole is very important for recreational divers and is a voluntary marine reserve because of its abundant marine life. The Mole is exposed to wave action on its northern side and waves and tidal currents on its southern side should disperse any sediment that settle there. Modelling predicts that sediment deposition around the Harbour entrance will be low (<0.2 mm/d).

Some sediment will be deposited on rocky habitats around Quarantine Island/Kamau Taurua and Portobello. These habitats could be at risk of adverse effects from sedimentation but they are also exposed to strong tidal currents. The predicted rate of sedimentation around Goat Island/Rakiriri is less than 1.5 cm over the whole dredging period with no re–suspension taken into consideration. Sedimentation effects in these areas are predicted to be short–term as the area will be flushed by wave, tidal and current activity and low–moderate in impact.

Overall, physical disturbance or loss of fish or shellfish and their habitats and any indirect effects on fish feeding in Otago Harbour are expected to be minor and short–term based on the results of hydrodynamic modelling and the scientific literature. Most of the effects will cease when the dredging programme is complete.

6.5.3 Fish and shellfish resources on the open Otago coast

As noted in section 6.5.1, the fish and shellfish fauna of coastal Otago is comprised of species that are mostly common and widespread throughout most of central New Zealand. The presence of individual fish and shellfish species is largely dependent on habitat preferences with hard shore and reef dwelling species mainly confined to the coastal fringes and rocky reefs and benthic feeding species found in areas of soft seabeds comprised of sands and silts.

Disposal of the dredged material will have potential short and medium–term effects on fish and shellfish resources at or near the disposal site. The most immediate biological impact will be the smothering of any benthic fauna at the disposal site including any shellfish and benthic organisms on which fish may feed. Site surveys indicate that the seabed sediments at the proposed disposal sites are predominantly fine sands with a benthic fauna typical of waters of this depth along the Otago Coast (tubeworms, gastropods and small bivalves). There are no known shellfish resources of fisheries significance at or in the vicinity of Site A0 or the other potential disposal sites considered in the area. Any impacts of the loss of the benthic fauna on fish feeding in the area is expected to be short–term (but could be medium term at the disposal site itself) and minor in the wider context as the proposed disposal areas represents a small fraction of the available benthic habitats at these depths within or near Blueskin Bay. The fishes that utilise these habitats are distributed over much of the east coast of the South Island and many make seasonal migrations along the coast and offshore.

Mapping of fish distributions at the scale of Blueskin Bay or the disposal site is problematic. Site specific data on fish presence has limited value due to their temporal and spatial variability. Therefore knowledge of fish distributions is generally presented on a population wide or regional basis (see Anderson et al. 1998, Beentjes and Cole 2002). The dredged material that will be disposed of consists mainly of similar fine sands (62% sand) to those already present at the disposal sites but there is a significant component of fine silt (37%). Following cessation of the disposal activity benthic biota is expected to re–establish itself at the disposal site. Once the biota is fully established, the seabed habitat and biota is expected to be similar to that currently present, restoring opportunities for fish to feed. There will be no permanent loss of fisheries habitat off the Otago coast.

Foraging by planktivorous fish such as barracouta, jack mackerel and slender tuna which occur off the Otago coast could be impacted by a turbid plume, particularly at and immediately downstream of the disposal site. O'Driscoll and McClatchie (1998) found krill were common in stomach contents of these fish and fish schools often occurred in areas with high krill densities. Krill tend to aggregate at salinity fronts, mainly over summer. These salinity fronts originate from northward flows of low salinity water from rivers to the south.

Robertson (1980) examined spawning areas and seasons of local fish species off the Otago coast. Prevailing hydrological conditions play a big part in the distribution and abundance of fish eggs. Some spawning occurs year round but the highest number of fish species spawning occurs in spring (September and October). Most species appear to spawn over a wide geographical area in coastal Otago, with Blueskin Bay and the area to the northeast of Taiaroa Head being included in the areas where eggs of sprat, ahuru, sole and lemon sole have been observed.

A sediment plume will develop in the water column as each load of dredged material is released onto the disposal site. The sediments in this plume will be dispersed away from the site by any prevailing water currents at the time of disposal and may cause a short term reduction of water clarity. Modelling indicates this effect is likely to be restricted to a plume extending to the north of the disposal site and would be insignificant by the time it reaches the coastline. Any turbidity effects from the plume would be limited to the duration of dredging and disposal and a short time after. Indications are that concentrations of suspended sediments in the plume would be well below levels likely to impact directly on fish or shellfish eggs, larvae or adults.

There may also be a sediment plume around the entrance to Otago Harbour as a result of tidal outflows from the Harbour during or shortly after dredging activity. This plume is likely to be dispersed over a large area off the entrance to the Harbour. Water clarity will be reduced by the suspended sediments until they are sufficiently diluted through dispersion or settle out.

Some of the sediments that initially settle at the disposal site will be dispersed away from the site over time. The long term fate of sediments at the disposal site will depend on the volume and particle size of the dredged material that is deposited and the direction and velocity of currents along this part of the coast. The existing seabed types along this part of the coast probably give the best indication of where any sediment transported from the disposal site are most likely to permanently settle.

Offshore from the proposed disposal site the Southland Current moves northward along the coast indicating that transported sediments should generally move from the disposal site in the same direction. This is consistent with the modelling results.

Current meters deployed at disposal Site A1 indicated that the prevailing drift is to the SE due to the more frequent winds from the SW and NE. This site has now been discarded in favour of a site further offshore which ensures any plume reaching the coast and sensitive fish and shellfish habitats there would have very low levels of suspended sediments.

6.5.4 Effects on Recreational Fishing

Bell (1998) provided a detailed study of recreational fishing in Otago Harbour and its approaches. The report showing areas fished, methods used and species caught gives a comprehensive picture of recreational fishing in the Harbour and its approaches. The salmon fishery is a major focus of recreational fishing in Otago Harbour in the summer months (Jan-Feb). Recreational fishing for other species in the Harbour is mainly focused on set netting and hand gathering of cockles. Set netting is concentrated at a number of locations: between the Mole and Aramoana Spit; off Wellers Rock and Harwood, around Quarantine Island and in Macandrew Bay. Spearing for flatfish occurs on the flats between Harwood and Otakou and at a number of sites in the upper Harbour. Hand gathering of paua takes place at Taiaroa Head and near the Mole. Cockle harvesting occurs around Aramoana, near Wellers Rock and along the sand banks adjacent to the shipping channel.

Dredging activity has the potential to have short term and localised effects on recreational fishery uses of the Harbour. Although modelling suggests only low levels of sediment are expected in areas of cockle beds, part of the suggested monitoring regime is to assess the impact. Fish may be attracted to benthic organisms exposed during dredging activity which may provide opportunities for recreational fishers to target them, but fishes are likely to avoid the sediment plume itself when suspended sediment levels are highest. Diving is a popular activity around the Mole and Taiaroa Head and this activity may be affected by the sediment plume that is likely to be generated at the entrance to the Harbour. The turbidity may also have short term adverse effects on visibility for recreational divers in some areas within the Harbour and at the entrance.

As noted earlier in the AEE, sediment deposition on the cockle beds in the Harbour is expected to be within tolerance limits for this species, although small numbers of cockles will be lost along the margins of the Harbour channel. These minor potential effects on recreational fishing activity will be limited to the period of dredger activity and a short duration after.

6.5.5 Effects on Commercial Fishing

There is a long history of commercial fishing in Otago Harbour and coastal Otago, although commercial fishing within the Harbour largely ceased after the 1940s and there is presently no active commercial fishery inside the Harbour. Southern Clams Limited currently has a special fisheries permit to undertake scientific investigations in relation to commercial cockle fishery potential in certain areas of the Harbour.

As recently as the late 1970s there were between 70 and 80 commercial fishing vessels operating out of Otago Harbour plus about 15 from Oamaru, 30 from Moeraki, 20 from Karitane and 20 from Taieri Mouth (Fenaughty and Bagley 1981). However, since the mid 1980s, there has been a steady decline in the number of Otago domiciled fishing vessels to very low numbers today. Beentjes & Cole (2002) give a recent description of the commercial fishery in Otago within the Otago Regional Council's jurisdiction (Waitaki River to the Sisters and out to the 12 nm limit of the territorial sea). There are five fishing ports in the region, Oamaru, Moeraki, Karitane, Port Chalmers and Taieri Mouth. At the time of the Beentjes & Cole's (2002) report, 38 commercial vessels were operating out of these five ports, including 12 out of Port Chalmers. It is believed that less than half that number are operating in 2010 but there are no official statistics. Many of the smaller commercial vessels are multi-purpose, fishing for rock lobster seasonally and switching to trawling, line fishing, set netting or cod potting at other times of the year.

Within the general coastal area of Blueskin Bay and offshore from the proposed disposal site, commercial trawling, set-net fishing, line fishing, cod potting, rock lobster potting and paua diving all occur with fishing effort and fishing areas dependent on species, season and method. Overall, only a small number of vessels operate in the area. Rock lobster

potting and trawling are the most important and valuable Otago coastal fisheries. Rock lobster potting occurs near the coast on rocky shores or seabed. About 100t of rock lobster with a landed value in the order of $5-6 million is taken annually from the CRA7 area (Waitaki River to Long Point). About 10 rock lobster vessels operate between Waitaki River and Nugget Point. Trawling occurs on soft seabeds throughout the coastal area, including adjacent to the disposal site. The value of the trawl fishery is more difficult to ascertain, no statistics are available, but the main target of inshore vessels in fishery statistical area 024 (which extends from Oamaru to Taieri and out to 173 deg E) is flatfish. A wide variety of other species is also taken. While inshore trawl vessels operate through or near the disposal site from time to time there is no indication that the area of the disposal site is more important for commercial fishing than other areas in Blueskin Bay or the general vicinity.

There are less than 5 full time inshore trawl vessels currently working out of Port Chalmers. Rock lobster vessels tend to base themselves closer to the main rock lobster fishing areas to the north (Karitane, Moeraki), with some of the rock lobster vessels converting to inshore trawling, cod potting, lining or set netting in the off season for lobsters. A handful of larger trawlers from other ports visit the Otago coast seasonally and may fish the coastal area within or offshore from Blueskin Bay, targeting a range of species such as barracouta or red cod if these species appear in the area. Recent fishery statistics indicate that up to 40 trawlers may visit fisheries statistical area 024 at some time over the course of any given year, but this includes vessels fishing in deeper waters for offshore species. Site specific data giving fishing locations of inshore vessels has not historically been collected by the Ministry of Fisheries, although for the past three years inshore trawlers have been required to provide the starting position of each trawl.

Dredge disposal activity and its associated effects may impact on trawling, line fishing, set netting or cod potting where it occurs in the immediate vicinity of the proposed disposal site. As noted in sections 6.4.3 and 6.5.3 above, the main direct impacts of the disposal of dredge material will be on suspended sediment levels in the water column and on the benthic organisms on which fish feed. These effects are predicted to be of short–medium term duration and localised. It is probable that in the very short term, some fish will be attracted to forage on benthic organisms exposed in the dredged material at the time of each release at the disposal site. Overall, it is expected that disposal will cause only minor effects on trawling and other commercial fishing methods due to the widespread distribution of fishes, the dispersed nature of inshore commercial fishing activity along the coast and the rapid re-establishment of benthic communities at the disposal site after dredging ceases.

Rock lobster fishing occurs around patches of rocky habitat along the coast from Pipikaretu Point to Te Whakarekaiwi, around Hydra Rock outside Wickliffe Bay and around Cape Saunders. However the main rock lobster fishing areas in the Otago area are north of Blueskin Bay and south of Brighton. Modeling indicates very little of the sediment from the disposal site will reach rocky habitats along the coastal fringe and wave activity will prevent sediment from settling on the coast.

Paua diving occurs in very shallow waters south and west of Site A0 along the coastal fringe. Along this exposed coastline wave activity should also prevent any sediment from settling on the rocky habitats, if it were to reach this area. However, low concentrations of the sediment plume that will form around the entrance to the Harbour may temporarily reduce visibility at times for short periods during dredging.

Periodically and based on stock surveys, a fishery for queen scallops occurs offshore along the edge of the continental slope. This is well offshore from the disposal area.

6.5.6 Conclusions

Overall, the effects of dredging and disposal on fishery resources and fishing activity are expected to be minor. There are a number of reasons for this conclusion. Fishes are widespread and mobile and will avoid the effects of high suspended sediment levels during the dredging and disposal activity itself. While there will be some short to medium term loss of benthic organisms on which fish feed at the dredging and disposal sites, these benthic organisms are widespread both within Otago Harbour and on the open coast. The benthos will re-establish relatively quickly on the disposed sediments which are similar to those currently at the disposal site. Once the benthos is re-established, the fisheries habitat is expected to be similar to that now present.

Shellfish are not mobile. Within Otago Harbour, cockles are the main shellfish resource and there will be some loss of habitat and cockles along the margins of the channel and turning basin. However the area affected is very small relative to the size of this resource. Some minor effects on cockles in small localised areas are possible due to the higher levels of sedimentation and suspended sediment levels from dredging immediately adjacent to the Port Chalmers swinging basin. Cockles are well adapted to both, and losses are expected to be minor relative to the overall distribution and abundance of this resource.

At the disposal site offshore, there are no shellfish resources with fishery potential at or near the disposal site. Modeling of sediment dispersal from the disposal site indicates that rock lobster and paua that occur on the rocky coastline will be exposed to very low levels of suspended sediments and sedimentation.

Any effects on both recreational and commercial fishing activities are also expected to be minor, localised and temporary. Recreational fishing is likely to be affected only in areas near where the dredger is operating or very shortly after. Commercial fishing effort is dispersed relatively thinly throughout the coastal area in Blueskin Bay and around the area of the disposal site. The short-term loss of benthic biota at and near the disposal site is likely to affect the opportunity for fish to feed in the short to medium term, but as the benthic biota rebuilds, fish and fishing should return to pre-disposal conditions.

The predicted levels of sedimentation and their distribution and consequent assessment of effects on fisheries largely depend on the results of the modelling reported by Bell et al. (2009). During the dredging and disposal programme, monitoring will be needed to confirm the accuracy of the modeling predictions, and management of the disposal activity may be required if monitoring indicates a significant adverse effect on the resource.

6.6 Recreation

6.6.1 Introduction

The Otago Harbour and coastline is an important area for recreational activities including boating, fishing, diving and surfing. Accordingly, it is important to recognise the potential impact of the proposed dredging and disposal of dredged material on these recreational activities, given that the Port Otago operations share this natural resource with other users.

6.6.2 Recreational Fishing and Diving

A number of Rocky reefs and the area around the Mole are important for recreational divers and fishers. Waves and currents will disperse material that settles in these areas so any impacts on fish communities and fishers in these areas are likely to be localised and short term. More detail is included above in Section 6.5.2.

6.6.3 Recreational Boating

The main potential impact of the proposal in terms of recreational boating relates to navigational matters, as well concerns expressed about sedimentation associated with shallowing of secondary areas of the harbour. These matters are addressed in more detail within Sections 6.2.5 and 6.7. Given that dredging, and vessel movements already occur in the channel the proposed dredging operation and management of commercial port related vessel traffic will not result in any change in navigational procedures compared to the status quo. When the dredging is completed a wider harbour channel will be available allowing for greater separation distances between recreational and commercial users of the channel. Therefore effects on recreational users are expected to be similar or less than is currently experienced.

6.6.4 Surfing and Swimming

The assessment of effects on the physical coastal environment concluded that there will be a small reduction in wave height at Aramoana Beach (approximately 0.01 metres). This will be a direct result of deepening the adjacent Entrance Channel to Otago Harbour. The assessment by Single et al (2010) concluded that the effects of the proposal on the offshore wave environment will be negligible at the shoreline. Patterns of beach response to the wave environment will remain unchanged, with no increase in erosion or accretion.

Sediment dispersal from the A0 disposal ground has already been assessed with the vast majority of sediment dispersing to the north as a result of the Southland current which travels up the eastern side of the South Island. Any sediment that reaches the Otago coastline will not be discernible to beach users. Accordingly, the surfing and swimming environment along the Otago coast will remain unchanged in giving effect to this proposal.

The effects on recreation from giving effect to this proposal will be no more than minor.

6.7 Navigation

Maintenance dredging operations already occur within the Channel and are managed by Port Otago and the Harbour Master. Accordingly, it is not expected that the proposed dredging operations will require any changes to the current navigational arrangements in Otago Harbour, and normal harbour operations will continue.

The end result of the proposed dredging includes a wider shipping channel through the harbour. This will result in an overall safer navigational environment, particularly for recreational and commercial fishing vessels that currently share a narrower channel with larger ships servicing both Port Chalmers and the Fryatt Street wharf.

With the widening of the channel the current navigation aids along the Harbour Channel will need to be shifted out to the new channel edge. This will either occur progressively as the channel is being widened or once the dredging operation is complete. Land Information New Zealand (LINZ) who is responsible for amending hydrographic charts will be informed of the changes made and will amend and re-issue the charts and almanacs which container this information. Similarly once the new channel depth are achieved and confirmed, this information would be included in updates of charts and almanacs published by LINZ.

Deepening of the channel will have an effect on the hydrodynamics of Otago harbour, although the assessment of effects on the physical coastal environment has concluded that the changes in hydrodynamics are not significant enough to impact on vessels using the channel as a transportation route.

The effects on navigation from giving effect to this proposal will be no more than minor.

6.8 Noise

Marshall Day Acoustics has prepared an Assessment of Noise Effects for Project Next Generation, being Ballagh 2009. The assessment addresses the potential noise effects associated with the dredging operation and also the future operation of the Port, taking into consideration the wharf extension and larger vessels utilising the Port facilities. The assessment focuses on the impact of noise on the community adjacent to Otago Harbour. Noise effects on aquatic animals and birds have already been addressed in Section 6.3.3 of this assessment.

At Port Chalmers the noise associated with port activities is well documented and a number of measures have been taken by Port Otago to address the adverse noise effects on the local community. For this latest proposal, Marshall Day Acoustics undertook ambient noise surveys at representative locations along the harbour. It was found that the noise environment was typical of a rural coastal location. At times when the weather is calm the ambient noise level can be as low as 25 dBA particularly at night. But when the weather is more unsettled the noise levels can be 50 dBA or higher right through the day and night.

The ambient noise environment has been taken as the background noise upon which to assess likely effects from the dredging activity. The assessment has used as a worst case scenario the noise generated from the Trailing Suction Hopper Dredge (TSHD). Noise associated with operating the TSHD will be generated from the diesel motor providing propulsion to the dredge, and also secondary noise from generators and gear boxes. Dredging will be undertaken on a 24 hour basis and the noise generated across this time period will remain relatively constant.

As noted in Section 2, a suite of management practices are proposed to manage dredge related noise, for each type of activity or equipment. With the adoption these measures, it is considered that noise effects from dredging are likely to be minor. The assessment also notes that the nature of the noise would be similar to existing noise sources such as shipping and is therefore, less likely to be disturbing.

The noise assessment has also considered the noise effects associated with the proposed 6,000 TEU class container ship using both the container terminal wharf and the extended multi-purpose wharf. In regards to the former it is predicted that there would be no discernable change in noise effects compared to the current situation and no adjustments would be required to the programme of house insulation that is currently in progress. For the latter scenario there will be a noticeable increase in noise only at Careys Bay. This would require up to 12 houses in Harbour Terrace to be included in the sound insulation programme, with 2-3 of these being in the 60-65 dBA zone which could involve significant upgrading of the dwellings. Port Otago is committed to undertaking these works.

6.9 Cultural Effects

As outlined in Section 5.4.2 and following early suggestions from tangata whenua groups to complete a Cultural Impact Assessment, Port Otago Ltd engaged Kai Tahu Ki Otago Ltd in May 2009 to complete this work in order to further inform the decision making process.

The development of the CIA involved setting up of a working party of the 5 represented parties of the Kai Tahu Whanui, identification and scoping of issues following meetings and interviews with working party members as well as working meetings with Port Otago representatives and professional advisors. KTKO and the working party were provided project information from Port Otago gradually as well as on request further supplementary information of specific interest. Both technical and general peer reviews of the document were undertaken.

In addition to the participation in the CIA process, as part of the more general consultation for the project, representatives of some of the working party members were active participants in many of the PCG meetings and on the mailing list for PCG agenda's and minutes. Some separate face to face meetings were held with individual groups as well.

The following conclusion is copied quoted directly from Section 8 (pages 60-61) of the CIA assessment report (Note: for simplicity the footnotes and references from the CIA document have not been included) :-

8. Conclusion

> ***Ahakoa kia pā te upoko o Te moana-Tāpokopoko-a-Tāwhaki ki ngā takutai o Te Waka-o-Aoraki, Engari, i tākekea te kupenga a Tahu kia oioi i roto i te nekeneke o te tai***
>
> **Although the shores of Te Waipounamu may be buffeted by the turbulent currents of the great waves of the southern oceans, the fishing net of Tahu has been made flexible so as to move at one with the tide. (*Source Maaire Goddall)***

Kāi Tahu Whānui are tangata whenua within Otago and have a responsibility as tangata tiaki (kaitiaki) of the environment to assess how Project Next Generation will impact upon their cultural values.

The Otago Harbour and Te Tai O Arai Te Uru (the Otago Coast) has a cultural and spiritual meaning for tangata whenua signified through layers of tradition, association and use, and reinforced by place names.

The coastal waters and processes were integral to the way of life that our tūpuna (ancestors) enjoyed, and are as important today for Waitaha, Kati Māmoe and Kāi Tahu. The whole of the coastal area offered a bounty of Mahika Kāi, including a range of kaimoana (sea food), and marine and freshwater fish.

The centrality of Takaroa in our cultural beliefs also influences the way we relate to and manage our marine resources. The marine environment is a moving force, a reminder of the power of Takaroa.

This cultural impact assessment ensures that the spiritual and cultural significance of the Otago Harbour and Te Tai o Arai Te Uru is recognised and provided for in the management of Project Next Generation. The outcomes of this assessment reflect an open and

collaborative engagement between Manawhenua and Port Otago Ltd over the effects of capital dredging.

The assessment benefited from the ecological review undertaken by Eco-Dynamic Systems Ltd, the technical advice provided by Port Otago's consultants, and from the peer review of the final report by Dr Gail Tipa.

The assessment concludes that monitoring and a flexible dredging programme is required to ensure that the Otago Harbour and Te Tai o Arai Te Uru is healthy and will continue to support Kāi Tahu ki Otago customs. Specifically, monitoring of the effects of dredging on key species and ecosystems of importance to Kāi Tahu, including tuaki, flat fish, seagrass and kelp, is a recommendation of this assessment.

The recommendations of this assessment are set out in full in Section 9.

Finally, it is noted that Project Next Generation offers an opportunity for Manawhenua to work in partnership with Port Otago Ltd in managing the effects of port activities, and of maintenance and capital dredging, on the cultural and spiritual values of the Otago Harbour and Te Tai O Arai Te Uru (the Otago Coast).

The recommendations from the CIA are contained in Section 9, as outlined in the above quotation, and total 15 separate recommendations covering general, hydrodynamic, physical coastal environment, sedimentation as well as ecology aspects of the project.

It is anticipated that these matters will be articulated further by tangata whenua during the statutory process and at any hearing, and Port Otago welcomes that input.

6.10 Other Matters

6.10.1 Visual Effects

The proposal will require a vessel to be located within the harbour channel, either dredging by suction, or mechanical grabbing means. Given that maintenance dredging already occurs in the channel, the visual effects of having a dredge operating will be similar to the status quo. Furthermore, boating and shipping traffic is an anticipated and expected activity within the lower harbour channel.

At Port Chalmers, the visual context of the container terminal and its two wharves is dominated by the combination of the cranes and container ships (unrestricted height), storage sheds (not exceeding 15 metres high), and stacked containers (5 high on a short term basis at Boiler Point). This is the permitted environment and is unaffected by the proposal to develop an additional wharf.

The extended multi-purpose wharf, would introduce cranes and vessels into the view of Carey's Bay residences along Aramoana Rd and also residences along Harbour Tce at times. That is an inevitable consequence of the expansion of the port, within the area that is zoned for that purpose.

6.10.2 Road and Rail Capacity

During early consultation concerns were been raised as to the ability of the road and rail network to service the Port in the future, given the larger 6,000 TEU container ships that will frequent the Port, if the channel is deepened and widened as proposed.

Port Otago commissioned Traffic Design Group to prepare a report on the capacity of State Highway 88 connecting Dunedin with its North/South links to State Highway 1 and Port Chalmers. The review concludes that: the existing transport environment has shown that additional heavy vehicle transport could be accommodated on SH88 without affecting the capacity or safety of the network for other motorised road users.

Rail continues to be an important means of connecting Port Chalmers to the cargo catchment for distributing both full and empty containers and for the receipt of high volume bulk products. While it may be possible to develop additional capacity at the terminals at the Dunedin and Port Chalmers ends of the rail corridor, this may not be as simple to achieve along the corridor itself.

Advice sought from the rail operator "Kiwi Rail" confirmed that there are a number of ways that the currently underutilised rail capacity can be further enhanced to accommodate additional growth in rail traffic.

In the case of both road and rail capacity it is important to note that regardless of larger container vessels, growth in the port over time without further port or channel development could and would result in increasing traffic volumes. In this respect, both the capacity of road and rail to service the port are independent of the project. Secondly the responsibility and jurisdiction for road and rail lie with NZTA and Kiwirail respectively, hence these matters falling outside the scope of this assessment.

6.10.3 Te Rauone Beach

There have been a number of reports and speculation as to the causes of erosion at Te Rauone Beach, with vessel wake being suggested as one of the contributing factors. Vessel wake is unlikely to be significant in comparison to the naturally generated waves as referred to earlier in this assessment (Section 6.2.2).

Independent of Project Next Generation, Port Otago commissioned Dr. Martin Single in 2007 to undertake a review of the information that was available on the physical processes affecting Te Rauone Beach and the shoreline changes that had been observed over time. A report was prepared on possible mitigation and management options to overcome the long term effects of erosion at the beach. The report identified that nourishment of the beach in combination with structures to encourage sand retention is the most appropriate option for addressing erosion.

Port Otago is proceeding with the shoreline restoration at Te Rauone Beach separately and independent from Project Next Generation, and is currently undertaking consultation with the affected parties. A resource consent application will likely be lodged in the next few months.

7. MONITORING

7.1 Introduction

This section outlines the monitoring which could be carried out to confirm the effects associated with the proposed works in conceptual terms as appropriate for this AEE. Port Otago anticipates discussion with the Consent Authority will be ongoing through the consenting phase regarding the detail of monitoring.

As part of detailed monitoring design effects based environmental limits or trigger levels and corresponding management responses will need to be developed.

It is proposed a Dredging Environmental Management Plan will be the principle guiding document for managing the proposed activities and that a detailed monitoring program will be a cornerstone of that Plan. The detailed monitoring program will ensure not only that resource consent conditions are being met, but also that should unexpected adverse effects be detected, require adjustments to the Dredging Environmental Management Plan and dredging practices

Proposed monitoring is as follows.

7.2 Harbour

Bathymetric Surveys

Issue

Physical changes could occur to the seabed within the channel and adjacent flanks of the channel as dredging work is undertaken.

Proposed Actions

- Regular bathymetric surveys undertaken to monitor the changes in depth.

Beach & Nearshore Changes (Harbour Entrance)

Issue

Degradation of rock groynes and harbour structures and beaches.

Proposed Actions

- Condition surveys of rock groynes and harbour structures pre-dredging and post-dredging and at intervals following to ascertain their effectiveness.
- Beach / nearshore profiles pre-dredging, during and post-dredging to monitor changes. (Identified areas are :- Shelly Beach, Te Rauone, Aramoana Flats)

Turbidity and Sedimentation

Issue

Dredging plume contains increased turbidity which can directly or indirectly affect aquatic biota.

Proposed Actions

- Plume tracking / monitoring during the capital dredging operation and a set of measurements during continuous dredging.
- Monitoring of turbidity levels at representative and key sites (including control sites away from the dredging operation) before, during and post-dredging.
- Monitoring of sedimentation levels at representative and key sites before, during and post-dredging.

Water quality

Issue

Suspension of dredged material in the water column can alter water quality (assessments have predicted these effects to be no more than minor for Project Next Generation).

Proposed Action

- Identify and test specific sites of concern to the Consent Authority prior to commencement of dredging and on occasions during the dredging (ongoing if required).

Aquatic Communities

Issue

The dredging operation and widening in some locations will have unavoidable direct physical effects on the benthic habitat. Specific locations include:

- Small areas of intertidal and inlet communities close to the Port.
- Habitats and communities in the main channel.
- Small areas of subtidal habitat at the Port, Harington Bend and close to Aramoana subject to widening.

Proposed Actions

The recolonisation of these areas could be monitored at representative sites over 3-5 years to follow recovery, with reviews after one and three years.

Issue

Increases in turbidity, suspended sediments and settled sediments can impact on habitats and communities in the channel itself and some marginal and intertidal flat areas close to the main channel.

Proposed Action

Representative sites with key assets, plus control sites, will be chosen and monitored at appropriate frequencies before, during and post-dredging. These should be chosen in consultation with appropriate parties.

Key indicators / sites could include:

- **Seagrass – general mapping as well as mapping at specific sites. Measurements of light attenuation during the dredging undertaken at appropriate frequency and sites. It is proposed the programme be designed so that significant areas of these sensitive communities are protected and to follow recovery of beds if they were to be impacted.**

- **Cockle beds – areas disturbed through widening would be assessed for the opportunity to remove cockles prior to dredging commencing. Areas identified to receive potentially high levels of suspended solids or deposition should be monitored before, during and post-dredging along with a few representative intertidal sites (including major beds opposite Acheron and Pulling Points).**

- **Monitoring of the general habitats and communities at representative locations (channel, deep sessile communities) and in sensitive areas, or specific areas of major concern to authorities (such as Aramoana, Te Rauone Bay etc….)**

Birdlife

Issue

A number of sites have been identified in the harbour and along the coastline as important to bird feeding, roosting and nesting. While birds can be very mobile, sensitive areas have been identified (e.g. Aramoana).

Proposed Actions

In conjunction with OSNZ surveys of birds feeding, resting at sensitive sites during and post-dredging.

Noise

Issue

Construction Noise can adversely affect amenity values.

Proposed Actions

- **Assess (measure and monitor noise levels) dredging equipment once confirmed.**
- **If construction noise guidelines are exceeded, manage dredging activities or consider mitigation measures as outlined in section 2.2.4**

7.3 Offshore

Monitoring of the offshore region should be done in conjunction with, and complimentary to the monitoring being undertaken and recommended by the Maintenance Dredging Working Party for Port Otago's existing disposal sites.

Bathymetric Surveys

Issue

Physical changes to the seabed within the channel and adjacent flanks of the channel will alter as disposal of dredged material continues, and the currents and waves transport material away from the disposal sites.

Proposed Actions

Monitoring would include:

- **Regular bathymetric surveys to monitor the changes in depth.**
- **Pre-dredge, during dredging and then post-dredging surveys to confirm sediment movement away from the disposal site.**

Turbidity and sedimentation

Issue

The disposal of large volumes of sediment at the offshore site (A0) during capital dredging will result in a sediment plume, settling of large volumes of sediment onto the seabed and subsequent dispersion along the seabed.

Proposed Actions

- **Monitoring of turbidity levels at representative and key sites (including control sites away from the dredging operation) before, during and post-dredging.**
- **Monitoring of sedimentation levels at representative and key sites before, during and post-dredging.**

Offshore Benthic Community

Issue

Offshore deposition of dredged material could affect offshore benthic communities:

Proposed Actions

- **Monitor macrobenthic fauna at the capital dredge disposal site (A0) when and if it occurs, plus downstream at varying distances and at control sites. Monitoring**

would include enough sites and be a frequency to detect significant changes if they were to occur. The programme would include the ability to detect changes in sediment type, as well as composition and abundance of macrobenthic community (or at least indicator species) and their recovery following the disposal operation.

Northern Coastline

Issue

Effects on key sensitive coastal areas should be avoided (modelling predicts the suspended solids levels that would be experienced in these environments will be very low).

Proposed Actions

Suspended solids and sedimentation levels experienced in sensitive coastal areas identified in consultation with stakeholder groups would be monitored prior to, during and after the dredging operation. An example would be representative sites in the kelp beds between Warrington and Matanaka.

Birdlife and Fish

Issue

There will be some disruption to birdlife and fish in the immediate vicinity of the disposal site. However, they are very mobile and difficult to survey thus it would be very difficult to design a programme that would be meaningful and able to detect changes that could be attributed to the dredging operation.

Proposed Action

Consideration could be given to pre-dredge and during-dredge surveys of bird activities along transects at the disposal site and a control site.

8. CONSULTATION

8.1 Introduction

The general principles of consultation that have been applied for Next Generation are as follows:

- Consultation is initiated as early as possible.
- Consultation is transparent and open.
- Consultation is on the basis of a two-way process and not a means to a particular end.
- Consultation does not necessarily mean reaching agreement.

For all its major capital projects Port Otago has over the years taken the approach of engaging with the community in order to provide the background and rationale supporting any project as well as to seek feedback and input where appropriate.

For most projects and indeed as part of its ongoing port operational activity the consultation with the local community is aided considerably through the Port Environment Liaison Committee. This committee was established in 1999, at which time a formal "Port Environment Plan" was developed and ratified, and continues to be updated on an annual basis. The Port Environment Liaison Committee meets on a regular basis to review activities of the port, not the least of which includes reporting the results of noise monitoring and the implementation of the "Port Noise Management, and Port Noise Mitigation Plans" which are a requirement of the Dunedin City District Plan.

On this occasion as project "Next Generation" involved the entire lower harbour channel as well as offshore coastal areas there was the potential to affect a wider sector of the community, hence the decision was made to form a dedicated "Project Consultative Group".

8.2 Project Consultative Group

The first meeting was called on 27 August 2007 and over the course of the first 2 meetings, terms of reference were developed and adopted, and an independent Chairman introduced. Twelve consultative group meetings in all have been held to date, as summarised in the following table.

Meeting Number	Meeting Date
#1	29 August, 2007
#2	18 September 2007
#3	9 October 2007
#4	12 November 2007
#5	17 December 2007
#6	11 February 2008
#7	31 March 2008
#8	30 June 2008

#9	25 August 2008
#10	8 December 2008
#11	25 February 2010
#12	18 March 2010

Invitations to attend the consultative meetings were open and extended to all members of the community and statutory organisations that were considered to have an interest in the project. No restrictions or limitations were placed on who could attend and at every meeting the request was made to all those attending to bring along others who it was felt may have an interest in the project. During the passage of time of the project, the membership of the PCG mailing list and those attending the meetings grew. A summary table of the groups represented and on the mailing list as at the final 2010 meeting is summarised as follows.

Organisation
Aramoana League
Blue Water Products Ltd
Careys Bay Residents' Assoc.
Chalmers Community Board
Department of Conservation
Dunedin City Council – Consents
Dunedin City Council - Planning Policy
Harbour Cycle Network
Harington Point Community Society (Inc)
Kati Huirapa Runaka ki Puketeraki
Monarch Wildlife Cruises
NZ Marine Studies Centre
Otago Chamber of Commerce
Otago Coastguard
Otago Peninsula Community Board
Otago Regional Council
Otago Yacht Club
Otakou Runanga
Port Chalmers Fishermen's Co-op Society
Port Chalmers Yacht Club
Port Environment Liaison Committee
Port Otago Limited
Quarry Beach Surf Boards
Recreational Fishing
Residents of Port Chalmers, Blueskin Rd, Dunedin and Harwood - as individuals
South Coast Board Riders
Southern Clams Ltd
Surfbreak Protection Society
University of Otago - Department of Marine Science
Yellow-Eyed Penguin Trust

There was no restriction placed on the discussions and while there was an agenda circulated before each meeting, opportunity was provided on each occasion for attendees to raise any concerns followed then by the opportunity to further debate the matter raised, should this prove to be necessary.

At each meeting detailed notes of the discussion were prepared and confirmed at subsequent meetings. Once agreed these notes were circulated as well as being placed on

the Port Otago website. The website acted as a repository for both the PCG notes as well as technical reports being added to the site.

The detailed notes form a good record of the discussions but also of the issues raised by stakeholders, Port Otago's response to those issues, as well as reference to isseus being incorporated into the relevant technical studies, assessment documents or this AEE document. It is not intended to replicate or summarise all of the issues raised and responded to in this document, however reference to the PCG notes highlights the consultative nature of the process.

Also as requested meetings were held with many stakeholder groups on a one-on-one basis in order that specific feedback and input could be sought. These meetings provided the opportunity to discuss specific areas of concern and as appropriate to enable Port Otago to incorporate them into the research work and assessment of effects.

The consultative approach taken, as well as the staged manner in which the scientific and detailed assessment work was undertaken has provided for the ability for feedback from the consultation process to be integrated into the project, and the assessment of effects.

The consultation process has been ongoing since the start of the project and during that time matters raised have been gradually incorporated into the background research and finally into the AEE. It is therefore not possible to summarise the key issues or aspects from the consultation that have been raised and acted upon. However all significant issues have been considered and stakeholders who have been involved in the process will be able to identify their input in the AEE documentation.

8.3 Media Coverage

At milestone times during the project there has been media coverage in the Otago Daily Times (ODT) or Star, specifically in the relation to the project. These occasions being :-

- **7th August 2007 (ODT)**
- **13th December 2007 (Star)**
- **1st February 2008 (ODT)**
- **6th March 2008 (ODT)**
- **26th February 2009 (ODT)**

On other occasions when Port Otago generally has been in the media, the project has been alluded to or referred to.

Following most of these occasions there has always been some new contact from members of the public seeking further information or wishing to be involved in the PCG group.

8.4 Draft Applications / AEE

As a final phase in the consultative process and prior to submission of the final application, draft copies of applications and the AEE were made available on the 25th of February 2010. This was widely publicised and a PCG meeting was held on that date. Since that time a further PCG was held feedback has been received as well as many individual stakeholder group meetings held.

During the period, final amendments to some of the supporting documentation was being undertaken as well as final improvements to the applications and AEE.

8.5 Conclusion

The consultation process has been undertaken throughout the whole of project over a long period of time. A number of different mediums of communication have been used to engage with stakeholders and significant resource and effort invested in that consultation. This has assisted in allowing completion of a comprehensive and detailed AEE document that more accurately conveys and reflects the effects articulated by stakeholder groups involved.

There have been occasions where it has not been possible to agree with all parties in relation to the level of detail of research undertaken or the relevance of certain issues. In these instances Port Otago has met with these groups to discuss these issues and the scope and outcomes from the research work.

Although lodging of the application and acceptance by the ORC will commence the statutory RMA process, Port Otago encourages continuing discussions with specific groups who wish to engage in further dialogue during that statutory process.

9. RESOURCE MANAGEMENT ACT MATTERS

9.1 Planning Framework

9.1.1 RMA 1991

The RMA is the principal guiding statutory document governing the use of land, air and water. The purpose of the RMA, as set out in section 5, is to "promote the sustainable management of natural and physical resources". The method of applying section 5 involves an overall broad judgement, which allows for the comparison of conflicting considerations, the scale of them and their relative significance or proportion in the final outcome.

This section of the AEE sets out the RMA framework for the resource consents that are sought from the Otago Regional Council.

9.1.2 Section 88

Section 88 of the RMA requires that an application for a resource consent be made in the prescribed form, and include in accordance with Schedule 4, an assessment of environmental effects in such detail as corresponds with the scale and significance of the effects that the activity may have on the environment.

The resource consent applications for Project Next Generation accompanying this AEE are in the prescribed form, as set out in Form 9 of Schedule 1. The requirements of the Fourth Schedule are set out in the remainder of this section. By way of summary it is concluded that the AEE meets the requirements of the Fourth Schedule, and the requirements of section 88.

9.1.3 Fourth Schedule Requirements

The Fourth Schedule to the RMA provides the key statutory guidance in terms of the content of an assessment of effects on the environment. The Fourth Schedule reads as follows:

> 1. Matters that should be included in an assessment of effects on the environment
>
> Subject to the provisions of any policy statement or plan, an assessment of effects on the environment for the purposes of section 88 should include—
> (a) A description of the proposal;
> (b) Where it is likely that an activity will result in any significant adverse effect on the environment, a description of any possible alternative locations or methods for undertaking the activity;
> (c) Repealed.
> (d) An assessment of the actual or potential effect on the environment of the proposed activity;

(e) Where the activity includes the use of hazardous substances and installations, an assessment of any risks to the environment which are likely to arise from such use;

(f) Where the activity includes the discharge of any contaminant, a description of—

  (i) The nature of the discharge and the sensitivity of the proposed receiving environment to adverse effects; and

  (ii) Any possible alternative methods of discharge, including discharge into any other receiving environment;

(g) A description of the mitigation measures (safeguards and contingency plans where relevant) to be undertaken to help prevent or reduce the actual or potential effect;

(h) Identification of the persons affected by the proposal, the consultation undertaken, if any, and any response to the views of any person consulted;

(i) Where the scale or significance of the activity's effect are such that monitoring is required, a description of how, once the proposal is approved, effects will be monitored and by whom.

2. Matters that should be considered when preparing an assessment of effects on the environment

Subject to the provisions of any policy statement or plan, any person preparing an assessment of the effects on the environment should consider the following matters:

(a) Any effect on those in the neighbourhood and, where relevant, the wider community including any socio-economic and cultural effects;

(b) Any physical effect on the locality, including any landscape and visual effects;

(c) Any effect on ecosystems, including effects on plants or animals and any physical disturbance of habitats in the vicinity;

(d) Any effect on natural and physical resources having aesthetic, recreational, scientific, historical, spiritual, or cultural, or other special value for present or future generations;

(e) Any discharge of contaminants into the environment, including any unreasonable emission of noise and options for the treatment and disposal of contaminants;

(f) Any risk to the neighbourhood, the wider community, or the environment through natural hazards or the use of hazardous substances or hazardous installations.

Set out below is a summary of how these requirements have been addressed in this document.

Clause 1(a) Description of the Proposal

A description of the proposal is provided in Section 2 of this AEE.

Clause 1(b) Possible Alternatives

Section 4 set out the development philosophy, and the reasons for the proposed choice of channel design, dredging methodology, and disposal methodology and location. Section 4 also included a discussion of the alternatives that were considered and discounted.

By way of summary, in each case the proposed works were considered the best available means of undertaking the proposed activities when considering engineering requirements and environmental effects.

Clause 1(d) Actual or Potential Effects on the Environment

The actual and potential effects of the proposed development are described in detail in Section 6 of this AEE.

Clause 1(e) Use of Hazardous Substances and Installations

Explosives required for the blasting of rock associated with the proposed development were outlined in Section 2. Appropriate mitigation measures will be undertaken to reduce potential effects from this activity.

Clause 1(f) Discharge of Contaminants

The discharges of contaminants associated with the proposed development were outlined in Sections 2 and 6, and the effects of those discharges were discussed in Section 6. These discharges included:

- Decant water from the dredging plant.
- Sediment and concrete laden water from pile construction for the wharf extension and fishing jetty.

Clause 1(g) Mitigation Measures

Adverse effects of the proposed development will be avoided, remedied or mitigated through the strategic selection of channel design, dredging method, disposal method and location, and the use of a dredging environmental management plan. Details on each are provided in Section 2, Section 4 and Section 7.

Clause 1(h) Interested or Affected Parties

Port Otago has undertaken early, continuous and extensive consultation with potentially interested stakeholders leading up to the submission of this application. This is discussed in Section 8. By way of summary, those parties Port Otago have been part of the consultation process by way of the Project consultative Group are summarised in the following table :

Organisation
Aramoana League
Blue Water Products Ltd
Careys Bay Residents' Assoc.
Chalmers Community Board
Department of Conservation
Dunedin City Council – Consents
Dunedin City Council - Planning Policy
Harbour Cycle Network
Harington Point Community Society (Inc)
Kati Huirapa Runaka ki Puketeraki
Monarch Wildlife Cruises
NZ Marine Studies Centre
Otago Chamber of Commerce
Otago Coastguard
Otago Peninsula Community Board
Otago Regional Council
Otago Yacht Club
Otakou Runanga

Port Chalmers Fishermen's Co-op Society
Port Chalmers Yacht Club
Port Environment Liaison Committee
Port Otago Limited
Quarry Beach Surf Boards
Recreational Fishing
Residents of Port Chalmers, Blueskin Rd, Dunedin and Harwood - as individuals
South Coast Board Riders
Southern Clams Ltd
Surfbreak Protection Society
University of Otago - Department of Marine Science
Yellow-Eyed Penguin Trust

Clause 1(i) Proposed Monitoring

Section 7 sets out the monitoring measures adopted and proposed for Project Next Generation. Port Otago anticipates that these measures will form the basis of resource consent conditions.

Clause 2(a) Wider Effects

The proposed development will have positive effects to the wider Otago and South Island Region as detailed in Section 3. Potential adverse effects of the proposal on those in the neighbourhood, and the wider community, are also discussed in Section 6 of this AEE.

Clause 2(b) Physical Effects

The primary physical effects associated with the proposed development are discussed in Section 6 of this AEE.

Clause 2(c) Effect on Ecosystems

The potential effects of the proposed development on the surrounding ecosystem are discussed in Section 6 of this AEE.

Clause 2(e) Discharge of Contaminants

The discharges of contaminants associated with the project were outlined in Section 2, and the effects of those discharges were discussed in Section 6.

Clause 2(f) Risks to Neighbourhood and Wider Community

Effects on natural hazards were addressed in Section 6. The use of explosives for blasting activities will be undertaken in a controlled manner using best practise blast techniques that minimise risks to the neighbourhood and the wider community. By way of summary no adverse effects are expected.

9.2 Consent Requirements and Activity Status

9.2.1 The Relevant Planning Document

All the works subject to this consent application will be located within the CMA of the Otago Region. The Regional Plan: Coast for Otago ("the Coastal Plan") contains the relevant rules which determine the consent requirements for Project Next Generation.

The Coastal Plan became operative on 1 September 2001.

It is understood there are plans for a full review of the Coastal Plan, however, that this has been postponed pending the outcome of the New Zealand Coastal Policy Statement Review.

9.2.2 Consents Required

The consents required from the Regional Council for the Project are summarised in Table 1 and Table 2

Deepening and Widening the Channel, Swinging Area and Berths

The consents required for the dredging and disposal works are as follows.

Table 1: Consents required for the dredging and disposal works

Activity	Activity Status	Rule Number
Coastal Permit - to authorise all activities associated with the disturbance of, and removal of natural material from the foreshore and seabed to deepen and widen the entrance channel, lower harbour channel, swinging area and Port Chalmers berths; to maintain the entrance channel, lower harbour channel, swinging area and berths by dredging; the placement of rock on the foreshore and seabed; the discharge of decant water from the plant used for dredging and maintaining the channel, berths and swinging areas; and all ancillary activities.	Discretionary & Restricted Coastal Activity	9.5.2.2 9.5.3.3 9.5.4.3 10.5.6.2
Coastal Permit - to deposit up to 7.2 million m^3 of sand, shell, shingle or any other natural material other than rock from authorised dredging in Otago Harbour into the sea at the capital disposal site shown in Drawing 11142.	Discretionary & Restricted Coastal Activity	9.5.4.2
Change of consent conditions – to allow some material dredged as part of Project Next Generation to be disposed of at Port Otago's existing disposal sites.	Discretionary	

With respect to the dredging, it is noted that a portion of the work could be undertaken under Rule 9.5.3.2 as a permitted activity. Rule 9.5.3.2 permits the dredging of berths and existing swinging areas to 14.5 metres and the lower channel to 13 metres respectively. However, for simplicity, a conservative approach is preferred and a single resource consent has been sought to undertake all the capital and maintenance dredging work.

It is noted that a separate coastal permit has been sought for the works associated with the deepening of the berths adjacent to the Container and Multipurpose Wharfs. This is because the activities required for this work are slightly different to those associated with the deepening and widening of the harbour channel and swinging area. However, for simplicity the ongoing maintenance dredging of the harbour berths is combined in the consent application to maintain the harbour channel and swinging area.

A change of conditions to DOC Consent No. SRCA 3.2 1105, ORC Consent No. 2000.472, which relate to the disposal of material from the dredging of the shipping channel and berths areas in and about the Otago Harbour, from activities associated with the operation and maintenance of Port Chalmers and Dunedin facilities, is required to allow some material dredged as part of Project Next Generation to be disposed of at the existing maintenance disposal sites.

Extending the Multipurpose Wharf and Constructing the Fishing Platform

The consents required for the Multipurpose Wharf extension and construction of the new Fishing Jetty are as follows.

Table 2: Resource Consents required for the extension of the Multipurpose Wharf and construction of the Fishing Jetty.

Activity	Activity Status	Rule Number
Coastal Permit - - to authorise all activities associated with the extension of the multipurpose wharf and construction of a fishing platform and their operation and maintenance; to disturb the foreshore and seabed; to discharge sediment and water; and all ancillary activities, in the general location shown on Figure 10991A.	Discretionary	8.5.1.9 8.5.2.5 9.5.3.6 10.5.6.2

It is noted that the occupation of the CMA by the wharf extension and the fishing platform would be authorised by Port Otago's existing coastal permit 2010:011 and therefore no additional Coastal Permits are required for that purpose.

9.3 Section 104

Section 104 of the RMA lists the matters that the Consent Authority has to consider in determining whether an application should be granted, and if it is to be granted, what conditions should be included.

Section 104(1) states:

(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 environmental standard:
    (ii) other regulations:
    (iii) a national policy statement:
    (iv) a New Zealand coastal policy statement:
    (v) a regional policy statement or proposed regional policy statement:
    (vi) a plan or proposed plan; and

(c) any other matter the consent authority considers relevant and reasonably necessary to determine the application.

Section 104 does not give any of the matters to which a consent authority is required to have regard primacy over any other matter. All the matters are to be given such weight as the consent authority sees fit in the circumstances and all provisions are subject to Part II.

The actual and potential effects on the environment (clause a) are set out in Chapter 6.

No national environmental standards (clause b(i)) or operative national policy statements (clause b(iii)) are directly relevant to the project.

The project is located within the CMA therefore the New Zealand Coastal Policy Statement ("NZCPS") is relevant and is discussed below.

The Otago Regional Policy Statement ("RPS") is relevant (clause b(v)) and is discussed below.

With respect to clause 1(b)(vi) the Regional Coastal Plan is relevant, and its objectives and policies are discussed below.

9.3.1 The National Coastal Policy Statement

The NZCPS sets out the framework for managing New Zealand's coastal environment and is therefore of particular relevance to this project.

The NZCPS contains policies addressing the following issues that are expressly relevant to the project:

- Preservation of the natural character of the coastal environment (including protection from inappropriate subdivision, use and development) (Policies 1.1.1 to 1.1.5).
- Protection of the characteristics of the coastal environment of special value to tangata whenua in accordance with tikanga maori (Policy 2.1.2).
- Maintenance and enhancement of amenity values (Policy 3.1.1).
- Provision for appropriate subdivision use or development of the coastal environment while avoiding or mitigating adverse effects (Policy 3.2.2) avoiding significant cumulative effects (Policy 3.2.4) and protecting habitats which are important for commercial, recreational, traditional or cultural purposes (Policy 3.2.8).
- Maintenance and enhancement of public access to and along the coastal marine area, except where restriction is necessary (Policy 3.5.1).
- Taking into account the principles of the Treaty of Waitangi in land of the Crown in the CMA (Policies 4.2.1 and 4.2.2).

The effects of Project Next Generation on those elements which comprise natural character were addressed in Section 6. In each case, it was concluded that effects will be no more than minor.

With respect to Policy 2.1.2 and Policies 4.2.1 and 4.2.2, Port Otago has undertaken extensive consultation with representatives of Otakou Runanga and Huirapa Runanga and a CIA has been commissioned from Kai Tahu Ki Otago.

Effects on amenity values (Policy 3.1.1) were assessed in Section 6, with the main conclusion being that effects on those values as a result of undertaking Project Next Generation would be no more than minor. Amenity values will thus be maintained.

With respect to Policy 3.2.2, Policy 3.2.4 and Policy 3.2.8, as was noted in Section 4 the project was designed to avoid adverse effects on the surrounding environment. Effects on those matters listed in Policy 3.2.2, Policy 3.2.4 and Policy 3.2.8 were assessed in Section 6. As noted in Section 6 any effects would be of short duration and as is noted in Section 9.3.4 below, they will be appropriately avoided, or mitigated. With respect to protecting habitats that are important for commercial, recreational, traditional or cultural purposes, extensive consultation with commercial fishing and aquaculture stakeholders, commercial tourism operators, recreational users and cultural representatives was undertaken early in the process and has helped shape the final design of the project. This has ensured that, where practicable, the project avoids adverse effects on their interests.

With respect to Policy 3.5.1, the only area to which public access will be restricted is immediately adjacent to the dredge plant, and this will be temporary and only as necessary for safety purposes.

Overall, the project undertaken as proposed in Section 2 is consistent with the provisions of the NZCPS. When drafted the RPS and the Coastal Plan were required not to be inconsistent with the NZCPS and those documents apply the principles set out in the NZCPS to the local environment. The provisions of the RPS and in particular the Coastal Plans are discussed in more detail below.

9.3.2 The Otago Regional Policy Statement

The RPS is prepared by the Otago Regional Council as a requirement of Section 60 of the RMA. The RPS for the Otago Region became operative on 1 October 1998.

The RPS provides an overview of the resource management issues of the region, and contains the objectives, policies and methods to achieve the integrated management of the natural and physical resources of the whole region.

In that context there are objectives and policies that seek to enable the community to provide for their social, economic and cultural wellbeing and objectives and policies which seek to safeguard environmental quality. When considered in the broad the project is generally consistent with those provisions.

The objectives and policies of the RPS are also given effect to within the Coastal Plan which is discussed in the following section.

9.3.3 Regional Plan: Coast for Otago

The Coastal Plan contains the policy framework for the management of the CMA in the Otago Region.

The Coastal Plan contains 17 chapters:

- **Chapter 1 – Introduction.**
- **Chapter 2 – Legislative and Policy Framework.**
- **Chapter 3 – Otago Coastal Description.**
- **Chapter 4 – Kai Tahu Perspective.**
- **Chapter 5 – Coastal Management.**
- **Chapter 6 – Cross Boundary Issues.**

- Chapter 7 – Public Access and Occupation of Space.
- Chapter 8 – Structures.
- Chapter 9 – Alteration of the foreshore and seabed.
- Chapter 10 – Discharges.
- Chapter 11 – Taking, Use, Damming or Diversion.
- Chapter 12 – Noise.
- Chapter 13 – Exotic Plants.
- Chapter 14 – Natural Hazards.
- Chapter 15 – Information Requirements.
- Chapter 16 – Financial Contributions.
- Chapter 17 – Review and Monitoring.

Of these, Chapters 5 to 14 contain a description of the coastal management issues that face Otago, and objectives, policies, methods and, where appropriate rules to address those issues, and are most relevant to this assessment.

Chapters 1 to 4 contain an introduction to the Plan, a description of the legislative framework applying to the coast, and background information on both Otago's CMA and the perspective of Kai Tahu, Otago's Manawhenua. Chapters 15 to 17 identify the main administrative issues that affect the use of the CMA, specify the information required with any resource consent application, the circumstances where a financial contribution may be required, and the processes to be used to review and monitor the Coastal Plan.

Chapter 5 – Coastal Management

Chapter 5 contains one overarching objective. It states:

> **Objective 5.3.1**
> To provide for the use and development of Otago's coastal marine area while maintaining or enhancing its natural character, outstanding natural features and landscapes, and its ecosystem, amenity, cultural and historical values.

This objective recognises that there are a variety of activities undertaken within Otago's CMA that provide substantial benefit to people and communities and seeks to enable those activities provided their effects on the natural and amenity values of the CMA are sustainable. Objective 5.3.1 also recognises that there are some areas of the CMA that support significant natural or amenity values and that those values should be maintained or enhanced.

The overarching framework contained in the Coastal Plan to achieve Objective 1 is based on identifying and scheduling areas of the CMA which contain a specific group of values, be it significant infrastructure such as a port, or natural values such as an ecologically significant estuary, and setting a policy framework to manage those individual areas accordingly.

The Coastal Plan identifies four specific types of area which require specific management. They are:

Coastal Protection Areas
These areas have been identified on the basis of their significant biological, physical or cultural values.

Coastal Development Areas
These areas have been developed to varying degrees. The classification of coastal development areas recognises the important facilities and infrastructure contained in those areas.

Coastal Recreation Areas
These areas have been identified because of their accessibility by the public, their frequency of use, and the facilities and infrastructure such as yachting clubs, surf life saving clubs and navigational markers associated with them.

Coastal Harbourside Areas
These areas have been developed to varying degrees. While traditionally developed for port activities and some recreational activity, their function is identified as shifting towards increased recreational and public access opportunities that utilise and enhance existing structures. The Coastal Plan proposes that improved public access and recreational opportunities in these areas of the CMA will create a quality waterfront that integrates with, and supports, development and activities on the adjacent land. There is only one such area, Steamer Basin, which is not affected by Project Next Generation.

The Coastal Plan also identifies Coastal Boundary Areas. The inclusion of these areas recognises that the effects of an activity within the CMA can be felt in adjacent areas, outside of the immediate vicinity of the activity or process, including land above the line of mean high water springs.

Three types of Coastal Boundary Areas are identified in the Coastal Plan. They are:

- **Marine Mammal and Bird Sites.**
- **Outstanding Natural Features and Landscapes.**
- **Coastal Hazard Areas.**

Both Coastal Protection Areas ("CPA"), Coastal Development Areas("CDA"), Coastal Recreation Areas ("CRA"), Marine Mammal and Bird Sites ("MMB"), Outstanding Natural Features and Landscapes ("ONFL") and Coastal Hazard Areas ("CHA") are located in the vicinity of the project as shown in Figure 29 and Figure 30

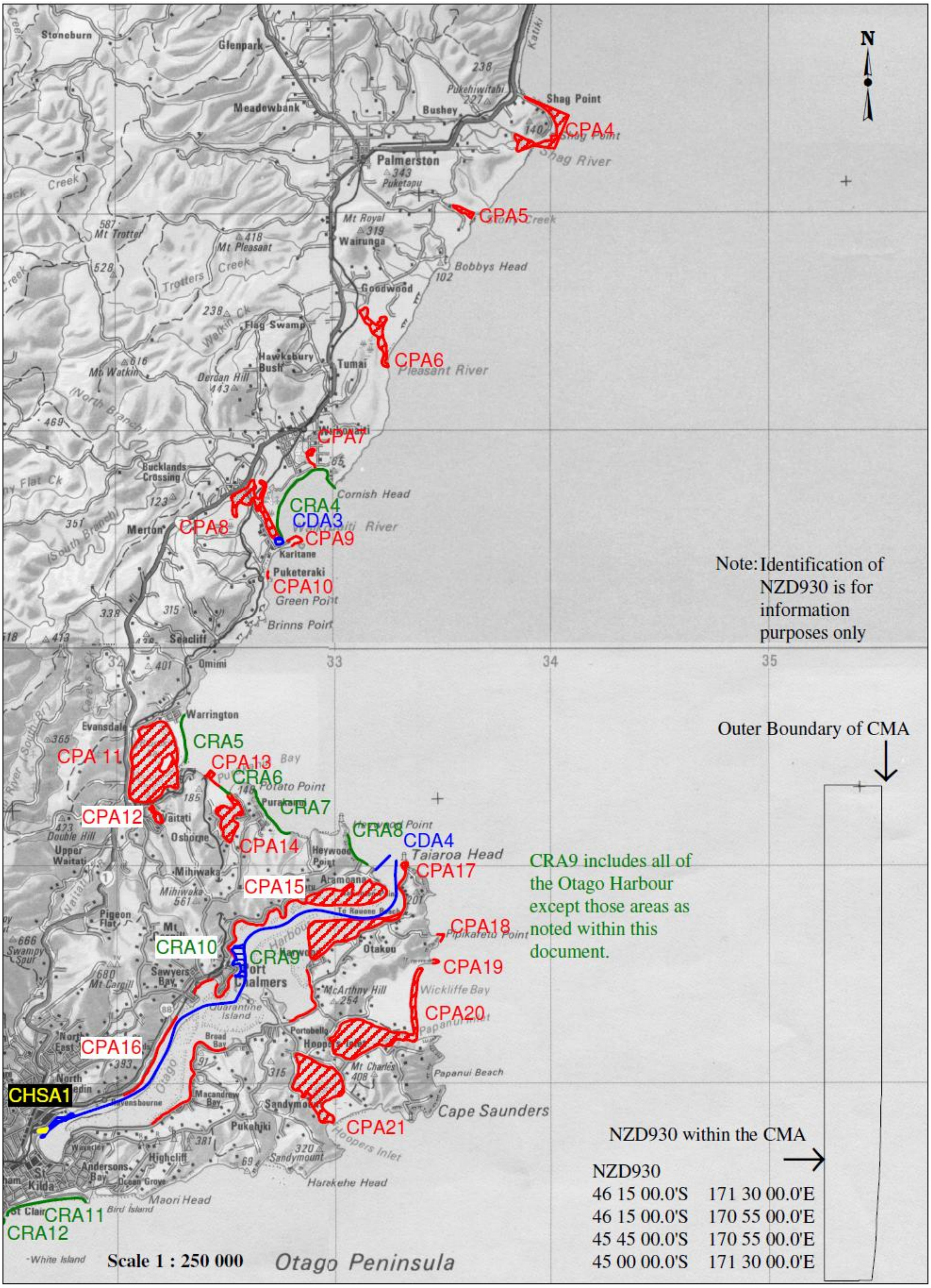


Figure 29: Coastal Management Areas in the vicinity of the project.

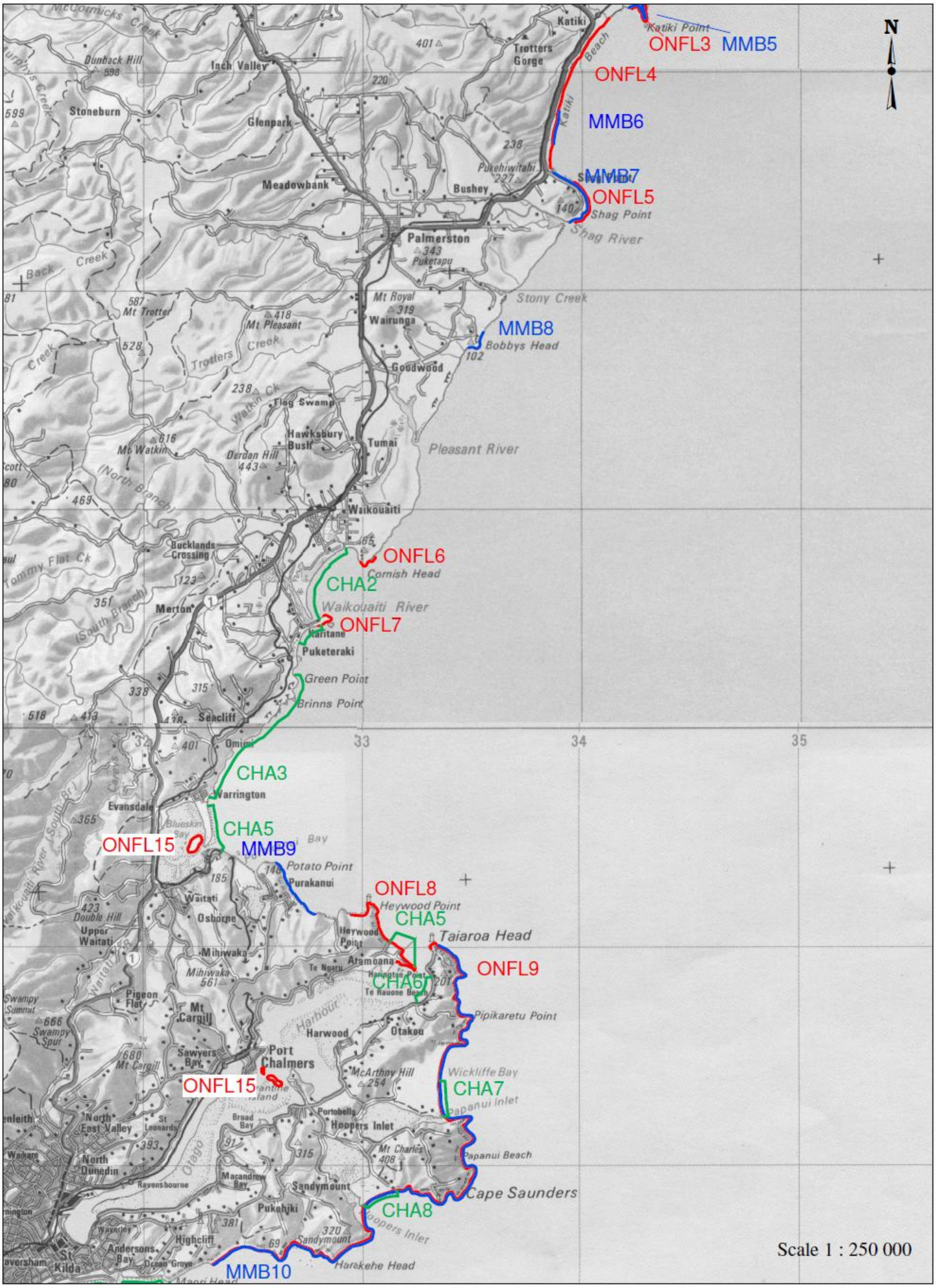


Figure 30: Coastal Boundary Areas in the vicinity of the project.

Policy 5.4.1 and Policy 5.4.2 address the management of CPA and MMB. They state:

> **Policy 5.4.1**
> To recognise the following areas, as identified in Schedule 2.1, as coastal protection areas within Otago's coastal marine area:
>
> ...
>
> CPA 11 Blueskin Bay
> CPA 12 Orokonui Inlet
> CPA 13 Mapoutahi
> CPA 14 Purakanui Inlet
> CPA 15 Aramoana
> CPA 16 Historic Otago Harbour walls.
> CPA 17 Otakou & Taiaroa Head
> CPA 18 Pipikaretu Point
> CPA 19 Te Whakarekaiwi
> CPA 20 Papanui Inlet
> CPA 21 Hoopers Inlet
>
> ...
>
> **Policy 5.4.2**
> Priority will be given to avoiding adverse effects on:
>
> (a) The values identified in Schedule 2.1, associated with any coastal protection area; and
>
> (b) The habitat and movement of marine mammals and birds in the coastal marine area adjacent to any marine mammal and bird site identified in Schedule 3.1;
>
> when considering the use, development and protection of Otago's coastal marine area.

Section 6 discussed the effects of the project on the values of the CPA and MMA areas indentified in Schedule 2.1 and 3.1 respectively. By way of summary in each case, any adverse effects predicted were of short duration and localised, and not identified as significant.

As noted in Section 4 when designing the project, specific effort was made to avoid effects on those values contained within the nearby CPA and MMA. In particular, the channel was designed to avoid CPA 15 (Aramoana) and CPA 17 (Otakou and Taiaroa Head) and to avoid adverse effects on their physical processes, while the choice of dredging method and plant sought to avoid effects on the ecological values of those CPA by reducing the release of turbidity.

As also noted in Section 3 the disposal site was selected after considerable technical work assessing the movement of disposed material, and seeking to avoid the movement of disposed material into CPA's and MMB's on the surrounding coastline as identified in Figure 29 and Figure 30.

Policy 5.4.3 and Policy 5.4.4 address coastal development areas. They state:

> **Policy 5.4.3**
> To recognise the following areas, as identified in Schedule 2.2, as coastal development areas within Otago's coastal marine area:
> ...
> CDA 4 Otago Harbour
> ...

Policy 5.4.4
Regard will be given to the need to provide for the values associated with any coastal development area when considering the use, development and protection of Otago's coastal marine area.

The harbour channel is identified in Schedule 2.2 as CDA 4 – Otago Harbour. Policy 5.4.4 notes that the consideration of activities within the Otago Harbour CDA must be set within the context of the existing use, the developed nature of the area, and the purpose of the channel itself. The project is entirely consistent with the purpose of the CDA, and as is outlined in Section 4, Project Next Generation is essential for the port facilities to continue to fulfil their important role in supporting the social and economic wellbeing of people and communities.

Policy 5.4.5 and Policy 5.4.6 address coastal recreation areas. They state:

Policy 5.4.5
To recognise the following areas, as identified in Schedule 2.3, as Coastal Recreation Areas:
...
CRA 5 Warrington Beach
CRA 6 Purakanui Inlet
CRA 7 Potato Point & Long Beach
CRA 8 Spit Beach
CRA 9 Otago Harbour
CRA 10 Careys Bay
....

Policy 5.4.6
Priority will be given to the need to provide for and protect the values associated with the coastal recreation areas when considering the use, development and protection of Otago's coastal marine area.

CRA 5 (Warrington Beach), CRA 6 (Purakanui Inlet), CRA 7 (Potato Point & Long Beach), CRA 8 (Spit Beach), CRA 9 (Otago Harbour) and CRA 10 (Careys Bay) are located in the vicinity of the project. Surfing, fishing, boating, diving, walking and swimming are the main recreational uses of these areas. Yachting, surfing, recreational fishing / boating interests, as well as members of the local community were involved in the Project Consultative Group and as was discussed in Section 4, a consideration of their interests contributed to the overall design of the project. Section 6 discussed the effects of the project on recreational interests, with the overall conclusions being adverse effects on those values will be minor.

The following policies contained within Chapter 5 are also relevant:

Policy 5.4.9
To take into account the values associated with a management area when considering an activity in any adjacent management area.

Policy 5.4.10
To recognise and provide for the following elements which contribute to the natural character of Otago's coastal marine area:
(a) Natural coastal processes;
(b) Water quality;
(c) Landforms, seascapes; and
(d) Coastal ecosystems.

Policy 5.4.11
To have particular regard to the:

(a) Amenity values;
(b) Cultural values;
(c) Scenic values;

(d) Ecological values; and
(e) Historical values, including those identified in Schedule 8;

associated with Otago's coastal marine area when considering its subdivision, use or development.

With respect to Policy 5.4.9, throughout this assessment the values associated with the management areas adjacent to confines of the project area have been considered.

Effects on those elements listed in Policy 5.4.10 and those values listed in Policy 5.4.11 were discussed in Section 6. By way of summary, any adverse effects on ecological values were predicted to be of short duration and localised, and not identified as significant, while effects on all other matters listed in Policies 5.4.10 and 5.4.11 were considered to be no more than minor.

Overall, Project Next Generation is entirely consistent with, and is a fundamentally important part of providing for the values of the Otago Harbour CDA, and the means in which the project manages its effects on adjacent Coastal Management Areas is consistent with direction provided in Chapter 5.

Chapter 6 - Cross Boundary Issues

Chapter 6 recognises that the effects of an activity within the CMA can be felt in adjacent areas, outside of the immediate vicinity of the activity or process, including land above the line of mean high water springs.

Chapter 6 contains one objective and five policies relevant to project. They state:

> **Objective 6.3.1**
> To avoid, remedy or mitigate the adverse effects of activities crossing the boundary line of mean high water springs.
>
> **Policy 6.4.1**
> Regard will be had to the effects of any activity in the coastal marine area on any values associated with areas located on the landward side of the line of mean high water springs, and to the provisions of any relevant district plan.
>
> **Policy 6.4.2**
> To recognise and provide for the following elements which contribute to the natural character adjacent to Otago's coastal marine area:
> (a) Natural coastal processes;
> (b) Landscapes and landforms; and
> (c) Coastal ecosystems.
>
> **Policy 6.4.3**
> Priority will be given to avoiding any adverse effect on the habitat of, and movement of any marine mammal or bird between the coastal marine area and any coastal protection area, or any of the following areas specified in Schedule 3.1 of this Plan, which are above the line of mean high water springs, and the coastal marine area:
>
> ...
> MMB 9 Potato Point and Long Beach
> MMB 10 Otago Peninsula
> ...
>
> **Policy 6.4.4**
> To recognise the following coastal hazard areas, as identified in Schedule 3.3:
> ...
> CHA 3 Puketeraki - Warrington

CHA 4 Warrington Spit/Doctor's Pt
CHA 5 The Spit
CHA 6 Te Rauone Beach
CHA 7 Victory Beach
...

Policy 6.4.6
To recognise the action of natural physical coastal processes within the coastal marine area which could have the potential for adverse effects on adjacent land.

In accordance with Objective 6.3.1, Policy 6.4.1 and Policy 6.4.2 the effects of Project Next Generation on the values associated with areas adjacent to the CMA were assessed and are discussed in Section 6.

As was discussed earlier with respect to Policy 5.4.2, several areas identified in Policy 6.4.3 as MMB are located in the vicinity of project, and the same comments made with respect to Policy 5.4.2 apply equally here.

CHA 2 (Waikouaiti – Karitane), CHA 3 (Puketeraki – Warrington), CHA 3 (Spit/Doctor's Pt), CHA 5 (The Spit) and CHA 6 (Te Rauone Beach) are located in the vicinity of the project. The effects of the project on natural physical coastal processes, and coastal erosion were discussed in Section 6. By way of summary that assessment concluded that effects would be minor.

Overall, Project Next Generation and the means by which effects on Coastal Boundary Areas are addressed in consistent with direction provided in Chapter 6.

Chapter 7 – Public Access and Occupation of Space

During the construction phase of the project, for safety reasons public access will be restricted in the immediate vicinity of the dredging and disposal activities.

Chapter 7 contains the following relevant objectives and policies.

Objective 7.3.1
To maintain and as far as practical enhance public access to Otago's coastal marine area.

Objective 7.3.2
To provide for activities requiring the occupation of the coastal marine area.

Policy 7.4.2
For activities seeking the right to occupy land of the Crown, consideration will be given to the reasons for seeking that occupation, whether or not a coastal location is required, and to any other available practicable alternatives.

Policy 7.4.3
Public access to and along the margins of the coastal marine area will only be restricted where necessary:

(a) To protect areas of significant indigenous vegetation and/or significant habitats of indigenous fauna; or
(b) To protect Maori cultural values; or
(c) To protect public health or safety; or
(d) To ensure a level of security consistent with the purposes of a resource consent; or
(e) In other exceptional circumstances sufficient to justify the restriction.

In explaining these provisions the Coastal Plan explicitly recognises that within Otago Harbour the restriction of public access may be required for health and safety and navigation reasons in the areas surrounding the commercial port areas. The proposed

dredging is explicitly related to Port Operations and it is entirely reasonable and consistent with the intentions of this chapter of the Coastal Plan. For safety reasons public access be restricted in the immediate vicinity of the dredging and disposal activities.

Chapter 8 - Structures

Chapter 8 contains objectives and policies of relevance to the extension of the Multipurpose Wharf and construction of the new Fishing Jetty. Of particular relevance to this application are policy 8.4.3 and policy 8.4.5:

> **Policy 8.4.3**
> **To recognise and have regard for the values associated with coastal development areas when considering activities involving structures in and adjacent to coastal development areas.**
>
> **Policy 8.4.5**
> **New and existing structures will be required to be maintained in a structurally sound and tidy state, and should blend as far as is practicable with the adjoining landscape to minimise the visual impact of that structure on the character of the area.**

The Multipurpose Wharf extension and the new Fishing Jetty are both located within the Otago Harbour Coastal Development Area and are entirely consistent with the values of that area as required by policy 8.4.3.

In accordance with policy 8.4.5, both structures will be maintained in a structurally sound and tidy state, and their presence will be entirely in accordance with the character of the surrounding commercial port area.

Chapter 9 – Alteration of the Foreshore and Seabed

Chapter 9 addresses the alteration of the foreshore and seabed and contains objectives and policies that are relevant to all aspects of the project. Those objectives and policies state:

> **Objective 9.3.1**
> **To recognise and provide for values associated with:**
> **(a) Areas of cultural significance; and**
> **(b) Areas of conservation value; and**
> **(c) Areas of public amenity;**
> **when considering any alteration of the foreshore or seabed within the coastal marine area.**
>
> **Objective 9.3.2**
> **To preserve the natural character of Otago's coastal marine area as far as practicable from the adverse effects associated with any alteration of the foreshore or seabed.**
>
> **Objective 9.3.3**
> **To take into account the effects of natural physical coastal processes when considering activities which alter the foreshore or seabed in the coastal marine area.**
>
> **Objective 9.3.4**
> **To restrict the disturbance of the foreshore and seabed to those activities which require a coastal location.**
>
> **Policy 9.4.1**
> **In order that any proposed alteration of the foreshore or seabed that will, or is likely to, have an adverse effect on cultural values, can be identified by kaitiaki runanga, Kai Tahu will be:**

(a) Treated as an affected party for non-notified resource consent applications to alter the foreshore or seabed within areas, or adjacent to such areas, identified in Schedules 2 and 3 of this Plan as having cultural or spiritual values to Kai Tahu; and be
(b) Notified about notified resource consent applications to alter the foreshore or seabed within the coastal marine area.

Policy 9.4.2
For activities involving the alteration of the foreshore or seabed, priority will be given to avoiding adverse effects on values associated with any area identified in Schedules 2 and 3 of this Plan as being a coastal protection area, a coastal recreation area, an area of outstanding natural features and landscapes or an area important to marine mammals or birds.

Policy 9.4.3
To recognise and have regard for the values associated with coastal development areas when considering activities involving alterations of the foreshore and seabed in and adjacent to coastal development areas.

Policy 9.4.5
The area to be disturbed during any operation altering the foreshore or seabed will be limited as far as practicable to the area necessary to carry out that operation.

Policy 9.4.6
The integrity of natural features such as beaches, sand dunes, salt marshes, wetlands, and barrier islands, and their ability to protect areas above the line of mean high water springs from natural physical coastal processes will be maintained and enhanced wherever practicable.

Policy 9.4.8
For the following activities, consideration will be given to the reasons for undertaking the activity in the coastal marine area, the public benefit to be derived and to any other available alternatives:
(a) Any reclamation; or
(b) The removal of sand, shingle, shell or other natural materials for commercial purposes; or
(c) Any deposition of material.

Policy 9.4.10
Alterations of the foreshore and seabed should blend as far as is practicable with the adjoining landscape to minimise the visual impact of the alteration on the character of the area.

As noted in Section 4 in designing the project effort was made to avoid effects on the values listed in Objective 9.3.1. The effects on the values listed in Objective 9.3.1 are also summarised in Section 6.

With respect to Objective 9.3.2, as noted in Section 4 the project has been designed to minimise the extent to which it disturbs the seabed, and as is addressed in Section 6, effects on those values that comprise natural character will be no more than minor.

With respect to Objective 9.3.3 effects on natural and coastal processes are addressed in Section 6 and are expected to be no more than minor.

It is beyond question that the proposed activities require a coastal location and they are entirely consistent with the type of activities anticipated in the CMA by Objective 4.3.4.

The extensive consultation Port Otago has undertaken with Kai Tahu, including the commissioning of a CIA is consistent with Policy 9.4.1.

With respect to Policy 9.4.2, priority was afforded during the design of the project to avoiding adverse effects on CPA's and CRA's.

The fundamental importance of Project Next Generation in enabling Port Otago to remain in the position to provide for the social and economic wellbeing of the Otago and greater South Island communities was addressed in Section 3. In that regard, the proposed project is entirely consistent with Policy 9.4.3.

Consistent with Policy 9.4.5, and as noted in Section 4, the area of seabed disturbance was limited as much as practicable during the design of the channel, and through the choice of dredging method.

The design of the project sought to avoid effects on those values listed in Policy 9.4.6, and as stated in Section 6 effects of the project on those values would be no more than minor.

With respect to Policy 9.4.8 the reasons for choosing the open sea deposition of the dredged material were addressed in Section 4, as were the other options considered.

The visual effects of the project were addressed in Section 6. Consistent with Policy 9.4.10 they would be no more than minor.

Overall, the project and the design and management of the bed disturbance is consistent with the direction provided by the objectives and policies of Chapter 9.

Chapter 10 - Discharges

As noted in Section 2 decant water will be discharged from the dredge plant, and a small amount of concrete laden water and sediment will also be discharged when constructing the wharf extension and new fishing platform.

Chapter 10 contains objectives and policies relevant to these activities. They state:

> **Objective 10.3.1**
> **To seek to maintain existing water quality within Otago's coastal marine area and to seek to achieve water quality within the coastal marine area that is, at a minimum, suitable for contact recreation and the eating of shellfish within 10 years of the date of approval of this plan.**
>
> **Objective 10.3.2**
> **To take into account community, cultural and biological values associated with Otago's coastal marine area when considering the discharge of contaminants into Otago's coastal waters.**
>
> **Objective 10.3.3**
> **To safeguard the life-supporting capacity of Otago's coastal marine area.**
>
> **Objective 10.3.4**
> **To enhance water quality in:**
> **(a) Coastal protection areas; and**
> **(b) Coastal recreation areas; and**
> **(c) Areas adjacent to marine mammal or bird sites; and**
> **(d) Areas where there is a direct discharge containing human sewage; and**
> **(e) Areas where there is a direct discharge of wastes from commercial, industrial or production activities.**
>
> **Policy 10.4.1**
> **In order that any proposed discharge, into the coastal marine area that will, or is likely to, have an adverse effect on cultural values, can be identified by kaitiaki runanga, Kai Tahu will be:**
> **(a) Treated as an affected party for non-notified resource consent applications to discharge water or contaminants into areas, or adjacent to such areas,**

identified in Schedules 2 and 3 of this Plan as having cultural or spiritual values to Kai Tahu; and be

(b) Notified about notified resource consent applications to discharge water or contaminants into the coastal marine area.

Policy 10.4.2

For activities involving the discharge of water or contaminants, priority will be given to avoiding adverse effects on values associated with any area identified in Schedules 2 and 3 of this Plan as being a coastal protection area, a coastal recreation area, an area of outstanding natural features and landscapes or an area important to marine mammals or birds.

Policy 10.4.4

To require an effective mixing zone for discharges of water or contaminants into the coastal marine area which takes account of:

(a) The sensitivity of the receiving environment; and
(b) The particular discharge, including contaminant type, concentration, and volume; and
(c) The physical processes acting on the area of discharge; and
(d) The community uses and values associated with the area affected by the discharge; and
(e) The ecological values associated with the area.

Policy 10.4.5

To not include intertidal areas within the mixing zones of particular discharges unless the discharge is treated so as to reduce the contaminant loading to an extent that any adverse effects on any intertidal areas can be shown to be minor.

Policy 10.4.7

The discharge of a contaminant (either by itself or in combination with other discharges) into the coastal marine area will only be allowed where:

(a) It can be shown that the adverse effects of the discharge to any area, other than the coastal marine area, would create greater adverse effect than the discharge to the coastal marine area; or
(b) There are no practicable alternatives to the discharge occurring to the coastal marine area; and
(c) The discharge is of a standard which will achieve a water quality suitable for contact recreation and shellfish gathering within ten years of approving this Plan.

As noted in Section 4, an important criteria for choosing the proposed dredging method and plant will be the amount of turbidity it generates. Green valves or similar modern best practice technologies will be required to be installed in any large dredge used to undertake the capital works. As was noted in Section 6, the effects of the turbidity generated by the decant water will be localised, and in combination with the turbidity generated by the dredging process itself, will largely be confined to the channel and immediately adjacent flanks, and similar to that currently experienced during maintenance dredging. As also noted in Section 6, where elevated levels of turbidity are experienced they will be localised and of short duration, causing no more than minor effects on benthic communities, birds, fish and mammals in the harbour.

With respect to the discharge of sediment and concrete laden water discharged during the construction of the wharf extension and fishing platform, they cannot be practicably avoided but will be localised and readily assimilated within a short distance.

Overall the proposed activities and management of discharges are consistent with the objectives and policies of Chapter 10.

Chapter 12 – Noise

Chapter 12 contains objectives and policies of relevance to noise in the CMA. They state:

Objective 12.3.1
To manage and control noise levels within the coastal marine area to minimise any adverse effect on amenity values, conservation values and the use of the coastal marine area.

Policy 12.4.1
In managing and controlling noise levels within the coastal marine area:

(a) Particular regard will be had to ensuring consistency with any noise control provisions or standards in any district plan for adjacent land; and
(b) Regard will be had to the New Zealand Standards NZS 6801 (1991), NZS 6802 (1991), NZS 6803P (1984) and NZS 6807 (1994); and
(c) Regard will be had to any other relevant information relating to the emission and effects of noise, and the measures which may be taken to avoid, remedy or mitigate those effects; and
(d) Regard will be had to the duration and nature of noise produced.

As noted in Section 2 a suite of noise management measures are proposed, and with the implementation of those measures the effects on noise as a result of undertaking the project will be no more than minor. The project is consistent with Objective 12.3.1 and Policy 12.4.1.

Chapter 13 – Exotic Plants

Chapter 13 contains objectives and policies relevant to the project. They state:

Objective 13.3.1
To recognise and provide for values associated with:
(a) Areas of cultural significance; and
(b) Areas of conservation values;
when considering the introduction of exotic and introduced plants into the coastal marine area.

Objective 13.3.2
To prevent exotic and introduced plants from adversely affecting the natural character of the coastal marine area.

Objective 13.3.3
To prevent exotic and introduced plants from having any adverse effect on natural physical coastal processes.

Policy 13.4.1
In order that any proposed introduction of exotic or introduced plants that will, or is likely to, have an adverse effect on cultural values, can be identified by kaitiaki runanga, Kai Tahu will be:
(a) Treated as an affected party for non-notified resource consent applications to introduce any exotic or introduced plants into areas, or adjacent to such areas, identified in Schedules 2 and 3 of this Plan as having cultural or spiritual values to Kai Tahu; and be
(b) Notified about notified resource consent applications to introduce any exotic or introduced plants into the coastal marine area.

Policy 13.4.2
For activities involving the planting of any exotic plant, priority will be given to avoiding adverse effects on values associated with any area identified in Schedules 2 and 3 of this Plan as being a coastal protection area, an area of outstanding natural features and landscapes, or an area important to marine mammals or birds.

Policy 13.4.3
To consider potential adverse effects of, and the need for, any proposed introduction or planting of any exotic or introduced plant into Otago's coastal marine area.

Policy 13.4.4
When restoration plantings take place, preference will be given to the use of indigenous species with a further preference for the use of local genetic stock.

As noted in Section 6 a number of invasive species are known to exist in the harbour and transferring and disturbing sediments by dredging can potentially spread these species, while the disposal of dredge material will inevitably transfer some organisms, including invasive species offshore.

However, given that maintenance dredging has been carried out for a number of years, the potential for further impacts within the harbour is considered to be low, while it is considered highly unlikely any species would become established at the disposal site due to its lack of hard substrate, depth and exposure.

Overall the project would be consistent with the objective and polices of Chapter 13.

Chapter 14 – Natural Hazards

Chapter 14 contains several objectives and policies. With respect to Project Next Generation Policy 14.4.2 is particularly relevant:

Policy 14.4.2
The potential effect of activities on natural physical coastal processes operating within the coastal marine area, and the potential for those effects to result in adverse effects within other areas of the coastal marine area will be recognised and taken into account.

As noted in Section 6, the effects of the project on natural and coastal processes have been comprehensively assessed with the primary conclusion being effects will be no more than minor, and the project is consistent with Policy 14.4.2.

9.3.4 Part 2 Considerations

The provisions of section 104 are all "subject to Part 2", which means that the single purpose and principles of the Act are paramount.

The purpose of the RMA (section 5) is to promote the sustainable management of natural and physical resources. The Act defines "sustainable management" as:

"managing the use, development, and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic, and cultural wellbeing and for their health and safety while—
(a) Sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations; and
(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."

Applying section 5 involves an overall judgement of whether a proposal would promote the sustainable management of natural and physical resources, and that judgement allows for the comparison of conflicting considerations and the scale and degree of them and their relative significance or proportion in the final outcome.

In the context of section 5, Port Otago is a physical resource which must be sustainably managed. Section 3 addressed the means by which Project Next Generation will enable the people and communities of the Otago and broader South Island Region to provide for

their social, economic and cultural wellbeing and health and safety, by enabling Port Chalmers to continue to remain a strong and significant part of New Zealand's international trading supply chain, and also a growing component of Otago's tourism industry.

Section 4 addressed how Project Next Generation has been designed to sustain the potential of natural and physical resources (including Otago Harbour and its surrounds) to meet the reasonably foreseeable needs of future generations, and Section 6 outlined how the life supporting capacity of the environment will be safeguarded.

Requirement to Avoid, Remedy or Mitigate

Section 5(2)(c) of the RMA requires that adverse effects of activities on the environment are "avoided, remedied or mitigated".

Case law has established that it is not required that all effects be avoided, or that there is no net effect on the environment, or that all effects are compensated for in some way. This was summarised by the then Planning Tribunal in Treble Tree v Marlborough District Council W103/96 which stated that:

> "The idea of mitigation is to lessen the rigour or severity of effects. We have concluded that the inclusion of the word "mitigation" in section 5(2)(c) of the Act, contemplates that some adverse effects from developments such as those we have now ascertained may be considered acceptable no matter what attributes the site may have. To what extent the adverse effects are acceptable is however, a question of fact and degree."

It is clear that section 5(2)(c) is about doing what is reasonably necessary, given the circumstances of the particular case, to lessen the severity of effects. Some flexibility is also necessary when exploring mitigation measures that can be used to reduce the impact of adverse effects, to ensure that the mitigation itself is sustainable.

In this context, the effects of Project Next Generation have been comprehensively studied and assessed, and any adverse effects have been identified and appropriately avoided, remedied or mitigated. Port Otago anticipates the measures proposed to avoid, remedy of mitigate adverse effects will form the basis of consent conditions.

Sections 6, 7 and 8

Sections 6, 7 and 8 of the RMA set out the principles to be applied in achieving the purpose of the Act. It is important to note that the principles contained in sections 6, 7 and 8 of the RMA are subordinate to the overriding purpose of the Act as set out in section 5. Each plays a part in the overall consideration of whether the purpose of the Act has been achieved in a particular situation. These matters are not an end in themselves, but an accessory to the principal purpose.

There are no matters within these sections that would suggest the proposed development undertaken in accordance with appropriate conditions to be inappropriate.

9.3.5 Conclusion

The overall broad judgement required by Part 2 and the relevant matters set out in section 104, lead to the conclusion that granting the resource consents as sought would promote the purpose of the Act and would constitute sustainable management of natural and physical resources.

9.4 Section 105

With respect to the discharges associated with Project Next Generation, in addition to the matters set out above under section 104(1), section 105 requires the Consent Authority to have regard to:

(a) The nature of the discharge and the sensitivity of the receiving environment to adverse effects; and

(b) The applicant's reasons for the proposed choice; and

(c) Any possible alternative methods of discharge, including discharge into any other receiving environment.

With respect to these three matters, Sections 2, 5 and 6 outlined the nature of the discharges and the sensitivity of the receiving environment to adverse effects. Chapter 4 discussed Port Otago's reasons for the proposed choice of discharge method and location, and the alternative methods of discharge considered. Considering all these factors, in each case the proposed method of discharge is appropriate.

9.5 Conclusion

The project requires the following consents associated with the proposed dredging and disposal program from the Otago Regional Council:

- Coastal Permit – To disturb and to take natural material from the foreshore and seabed associated with the capital dredging to deepen and widen the harbour channel and swinging area, and maintenance dredging to maintain the harbour channel, swinging area and berths.
- Coastal Permit – To disturb, to take natural material from, and to deposit rock on the foreshore and seabed associated with the deepening of the berths adjacent to the Multipurpose and Container Wharfs.
- Coastal permit – To discharge decant water from dredging plant.
- Coastal Permit – To deposit dredged material at a new disposal ground.

The project also requires the following consents associated with the extension of the Multipurpose Wharf and new fishing platform:

- Coastal Permit – To extend the Multipurpose Wharf.
- Coastal Permit – To disturb the bed associated with the construction of the Multipurpose Wharf.
- Coastal Permit - To erect the fishing platform.

- **Coastal Permit – To disturb the bed associated with the construction of the fishing platform.**

- **Coastal Permit – To discharge sediment and concrete laden water during the extension of the Multipurpose Wharf and construction of the new fishing platform.**

The project also requires changes to the consent conditions of Otago Regional Council Coastal Permit 2000.472 and Department of Conservation Consent No SRCA 3.2 1105. When considering the applications under section 104 it is clear that the project would result in demonstrable benefits to the Otago and greater South Island community by enabling Port Chalmers to continue to operate effectively as a major and fundamentally important link in the regions import/export supply chain and tourism industry, while appropriately avoiding, remedying or mitigating its effects on the environment. The project also fits comfortably within the policy framework of the relevant RMA planning documents; and there is no reason why the resource consents cannot be granted as sought.

10. CONCLUDING COMMENTS

Port Chalmers is a fundamentally important part of the import/export supply chain for the lower South Island Region, however, its continued ability to provide the community with a competitive global shipping service is contingent on upgrading its port facilities and access channel to meet the future requirements of international shipping lines, specifically, being able to accommodate 6000-8000 TEU vessels, and the provision of efficient and reliable vessel turn around.

This requires deepening and widening the approach to Port Chalmers and its berths. It also requires Port Otago to address current operational inefficiencies by increasing the length of the Multipurpose Wharf. It is these two activities that are the subject to this suite of resource consent applications.

Port Otago has been committed throughout the development of this project to ensuring that the works associated with Project Next Generation will be undertaken to a very high standard, and that the Councils and community are actively involved in its planning and development. Considerable effort has also been made to integrate the proposed works into the sustainable development of the Otago Harbour and its surrounds, affording appreciation to the physical, ecological, recreational, commercial and social values it supports.

Detailed analysis of the potential effects has been presented in this AEE. These assessments demonstrate that the effects of Project Next Generation are either minor, or can be appropriately avoided, remedied or mitigated.

Port Otago wishes to record its appreciation to the many organisations and individuals who have been involved in the consultation process, for their various contributions, their thoughtful comments and their time. These relationships are important to Port Otago, who look forward to these continuing, in the spirit of partnership, in the years ahead.

11. REFERENCES

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The scientific studies, reports and assessments that Port Otago Ltd commissioned in order to support this application for consent and AEE are outlined in Section 4.5 of this document.

This section contains references from selected reports in Section 4.5 which reference other documents as secondary references. In order these reports are

- **Single et al (2010): Physical coastal Environment & Assessment**
- **Bell et al (2009): Hydrodynamic Modelling.**
- **James et al (2009): Biological Environment & Assessment**

11.2 Single et al 2010: Physical Coastal Environment & Assessment

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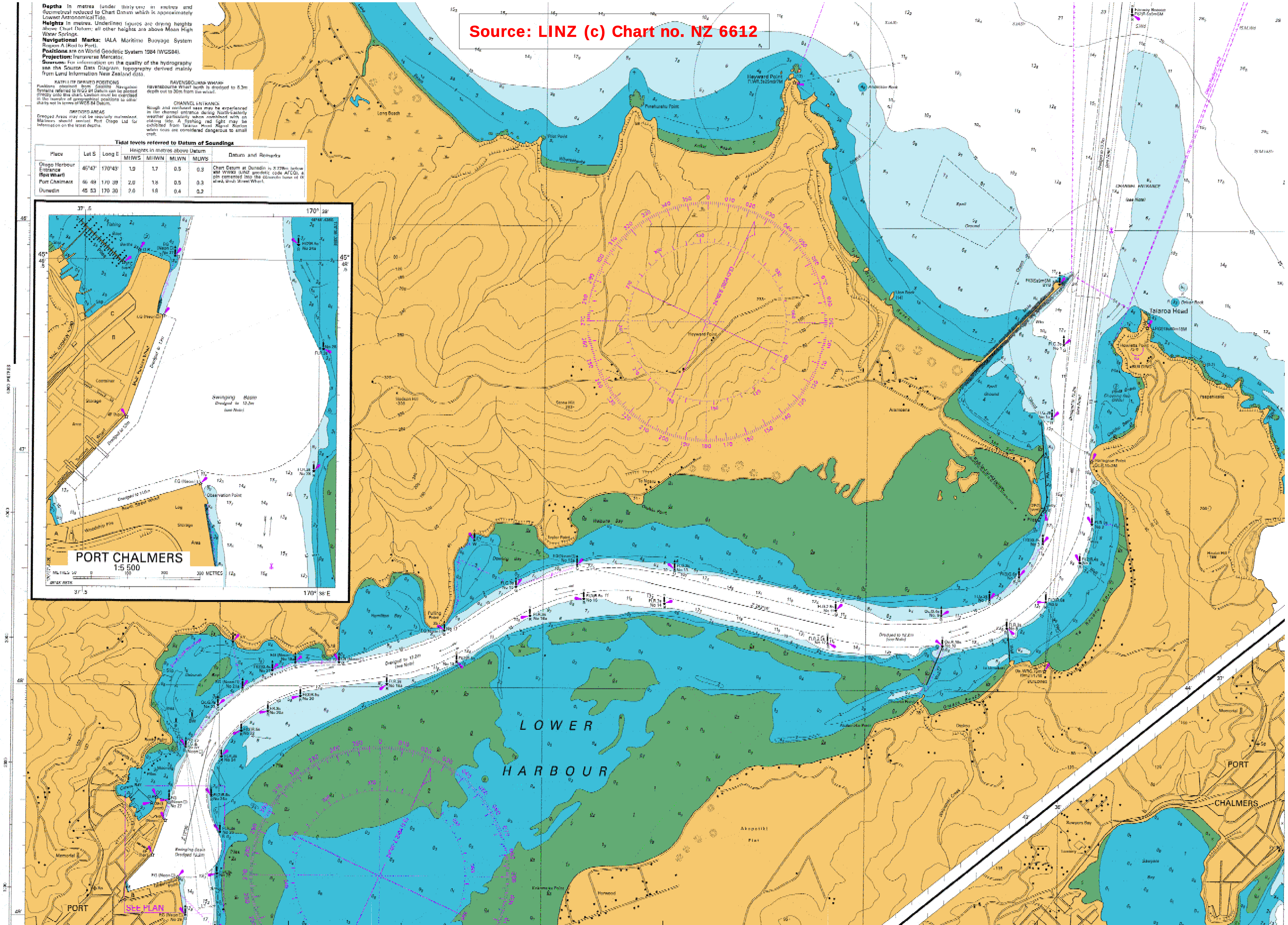
APPENDIX A - Drawing List

The following drawings are included as thumbnails in the AEE document, and they appear in the same order as that in the AEE. It is not however a comprehensive list of all drawings that Port Otago have completed for the project.

Dwg No	Title
11092	Existing Nautical Chartlet
11143	Port Chalmers Container Terminal Layout
11090	Proposed Lower Harbour Channel Improvements
11090/1	Proposed Design Channel – Typical Claim Cross Sections
11112/1-2	Proposed Dredging Depth Contours
11130	Indicative Construction sequence Berth Deepening
11142	Proposed Offshore Disposal Site
10991A	Proposed Multipurpose Wharf Extension – Location / Site Plan
10991	Proposed Multipurpose Wharf Extension – Construction Plan
11159/1-2	Vessel Draft vs Tidal Window for 15.0m Channel.
11129	Port Chalmers Port Development – post 1960
11011A	Geotechnical Investigations – Site Locations
11024	Geotechnical Investigations – Interpretative Long Section
11024/1	Geotechnical Investigations – Interpretive Plan



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CHECKED:	LMC	02/02/10
APPROVED:	LMC	02/02/10

PLOT DATE: 09/10/2009

ISSUE DATE: 11/02/2010

SCALES:
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PORT OTAGO LTD P.O. Box 8, Port Chalmers, N.Z.

Project Next Generation
Existing Nautical Chartlet

PORT OTAGO LIMITED

ACAD FILE NAME: Project Next\11092

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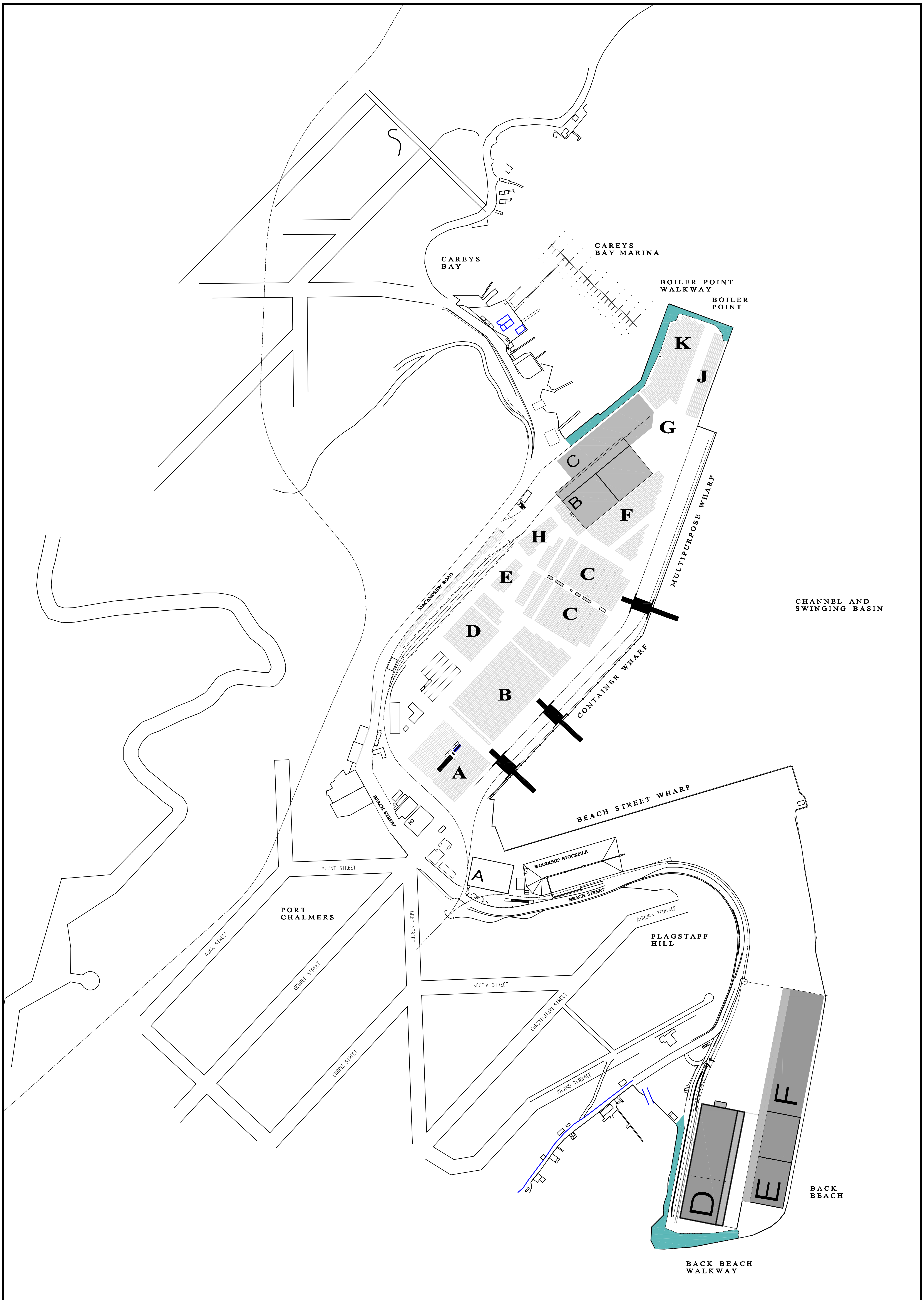


Port Otago - Port Chalmers Layout 2010

A3 11143

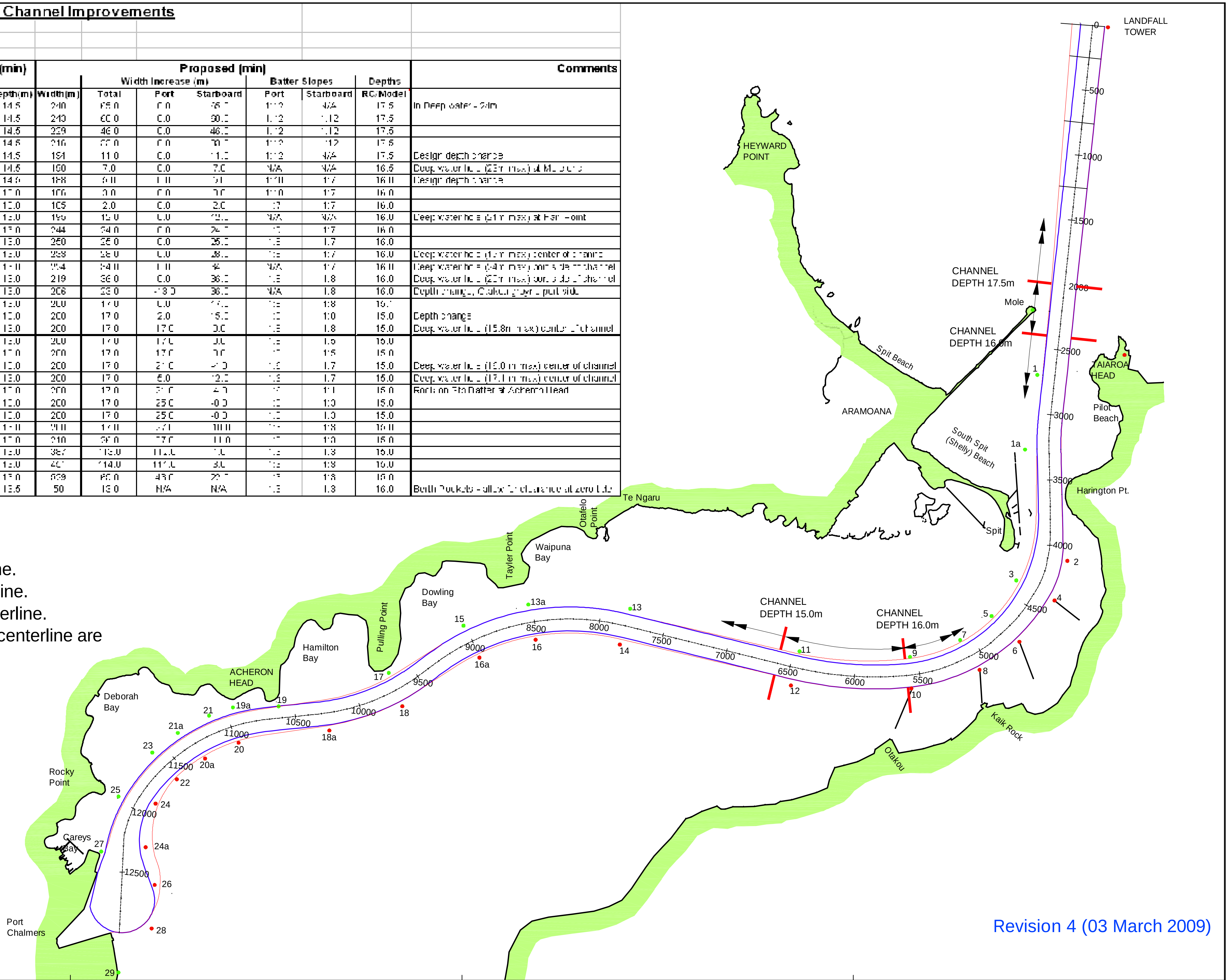
Project Next Generation - Proposed Channel Improvements

Existing vs Proposed

Location	Dist.on C/L	Adj. Bcn/Pt.	Existing (min) Width(m)	Existing (min) Depth(m)	Proposed (min) Width(m)	Width Increase (m) Total	Width Increase (m) Port	Width Increase (m) Starboard	Batter Slopes Port	Batter Slopes Starboard	Depths RC/Model	Comments
Entrance Chan	0	Landfall Bcn	100	14.5	240	65.0	0.0	[illegible]	1:12	N/A	17.5	In Deep water - 24m
Entrance Chan.	250	N/A	100	14.5	240	60.0	0.0	60.0	1:12	1:12	17.5	
Entrance Chan.	750	N/A	183	14.5	229	46.0	0.0	46.0	1:12	1:12	17.5	
Entrance Chan	1350	N/A	100	14.5	210	[illegible]	0.0	[illegible]	1:12	1:12	17.5	
Entrance Chan.	2200	N/A	100	14.5	191	11.0	0.0	11.0	1:12	N/A	17.5	Design depth change
Mole End	2210	Mole End	183	14.5	190	7.0	0.0	7.0	N/A	N/A	16.5	Deep water hole (23m max) at Mole end
Hoopers	2400	N/A	188	14.0	188	0.0	0.0	[illegible]	1:10	1:7	16.0	Design depth change
South Spit	2705	Bcn 1 L/F	100	13.0	106	3.0	0.0	3.0	1:10	1:7	16.0	
South Spit	3205	Bcn 1A L/F	100	13.0	105	2.0	0.0	2.0	1:7	1:7	16.0	
Harington Point	3310	Har. Pt. Light	183	13.0	195	12.0	0.0	12.0	N/A	N/A	16.0	Deep water hole (21m max) at Har. Point
Harington Bend	4100	Bcn 2 L/F	220	13.0	244	24.0	0.0	24.0	[illegible]	1:7	16.0	
Harington Bend	4370	Bcn 4 L/F	225	13.0	250	25.0	0.0	25.0	1:5	1.7	16.0	
Harington Bend	4?40	Bcn 3 L/F	205	13.0	233	28.0	0.0	28.0	1:5	1:7	16.0	Deep water hole (2?m max) center of channel
Harington Bend	[illegible]	Bcn 3 L/F	190	14.0	224	34.0	0.0	[illegible]	N/A	1:7	16.0	Deep water hole (24m max) port side of channel
Off Otakou	5575	Bcn 10 L/F	183	13.0	219	36.0	0.0	36.0	1:5	1.8	16.0	Deep water hole (20m max) outside of channel
Off Otakou	5900	N/A	183	13.0	206	23.0	-13.0	36.0	N/A	1.8	16.0	Depth change, Otakou groyne port side
Cross Channel	6460	Bcn 12 L/F	183	13.0	200	17.0	0.0	17.0	1:5	1:8	16.0	
Cross Channel	6900	N/A	100	13.0	200	17.0	2.0	15.0	[illegible]	1:0	15.0	Depth change
Cross Channel	7305	Bcn 14 L/F	183	13.0	200	17.0	17.0	0.0	1:5	1.8	15.0	Deep water hole (15.8m max) center of channel
Tayler Point	8515	Bcn 16 L/F	183	13.0	200	17.0	17.0	0.0	1:5	1.5	15.0	
Dowling Bay	8705	Bcn 16A L/I	100	13.0	200	17.0	17.0	0.0	[illegible]	1:5	15.0	
Pulling Point	9710	Bcn 16 L/F	100	13.0	200	17.0	21.0	-4.0	1:5	1.7	15.0	Deep water hole (16.0m max) center of channel
Hamilton Bay	10255	Bcn 18A L/F	183	13.0	200	17.0	5.0	12.0	1:5	1.7	15.0	Deep water hole (17.1m max) center of channel
Acheron Head	10620	Bcn 19 L/F	100	13.0	200	17.0	21.0	-4.0	[illegible]	1:1	15.0	Rock on Stb Batter at Acheron Head
Deborah Bay	11200	Bcn 20 L/F	100	13.0	200	17.0	25.0	-8.0	[illegible]	1:0	15.0	
Deborah Bay	11300	Bcn 20A L/I	100	13.0	200	17.0	25.0	-8.0	[illegible]	1.0	15.0	
Deborah Bay	[illegible]	Bcn 2? L/F	188	14.0	200	14.0	[illegible]	10.0	[illegible]	1:8	16.0	
Rocky Point	11?70	Bcn 24 L/F	104	13.0	210	36.0	77.0	11.0	[illegible]	1:0	15.0	
Turning Basin	12300	Bcn 24A L/F	2?4	13.0	387	113.0	110.0	1.0	1:5	1.3	15.0	
Turning Basin	12400		397	13.0	4?1	114.0	111.0	3.0	1:5	1:8	15.0	
Turning Basin	12600	Bcn 26 L/F	464	13.0	529	65.0	43.0	22.0	1:5	1:8	15.0	
Berth Pockets		N/A	37	13.5	50	13.0	N/A	N/A	1:3	1.3	16.0	Berth Pockets - allow for clearance at zero tide

Key

- Blue = Existing Channel toeline.
- Red = Proposed Channel toeline.
- Dash = Existing Channel centerline.
- Distances along the Channel centerline are taken from the Landfall Tower.



Revision 4 (03 March 2009)

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CHECKED:	LMC	02/02/10
APPROVED:	LMC	02/02/10

PLOT DATE: 12/02/2010

ISSUE DATE: 11/02/2010

SCALES: 1:30,000 (A3) 1:15,000 (A1)

PORT OTAGO LTD P.O. Box 8, Port Chalmers, N.Z.

Project Next Generation
Proposed Lower Harbour Channel Improvements

PORT OTAGO LIMITED

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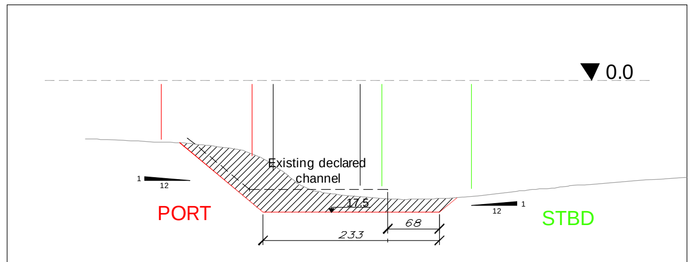
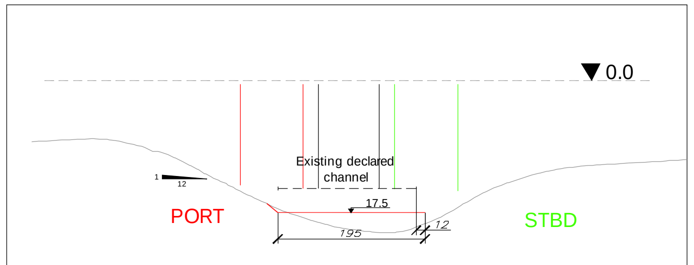


Channel Entrance - 600m From Fairway Beacon



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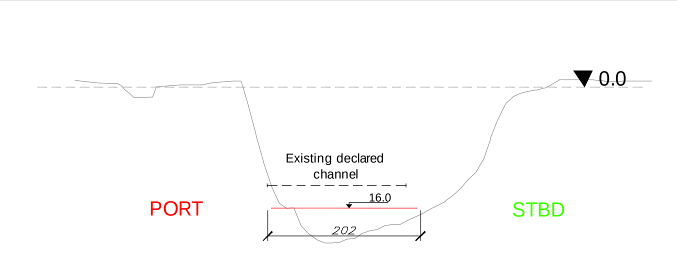

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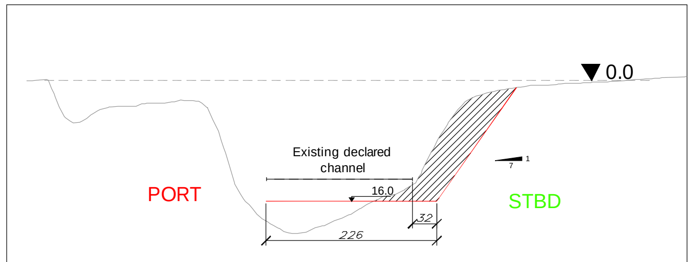
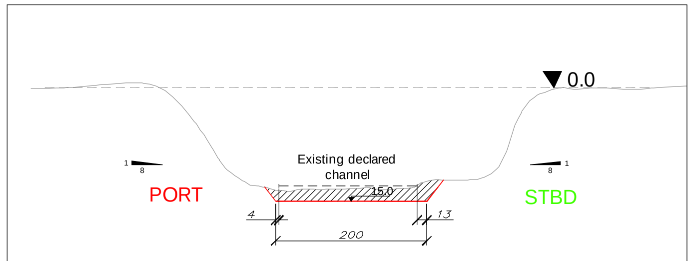
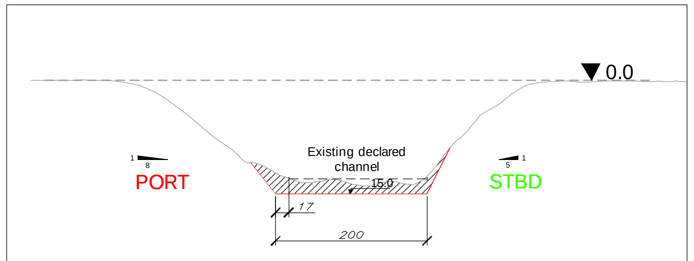


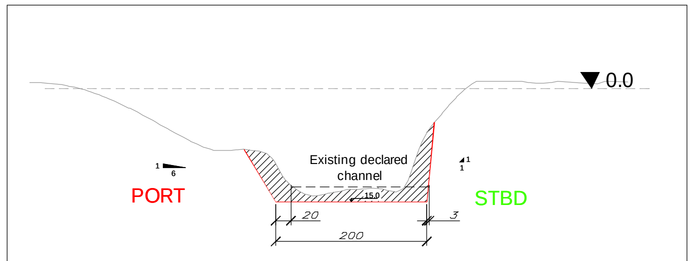
Harington Bend - 5,000m From Fairway Beacon



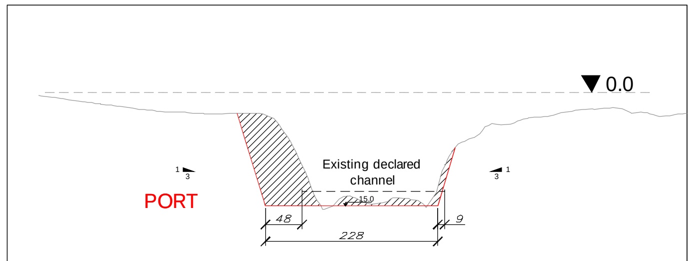
Cross Channel - 6,800m From Fairway Beacon



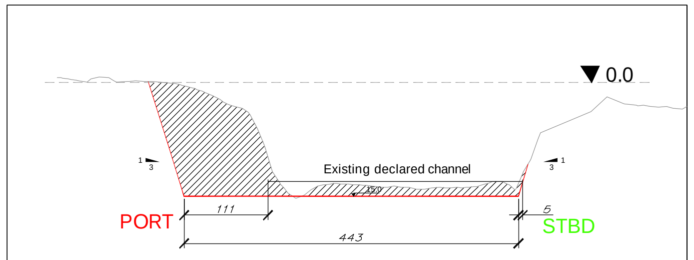
Tayler Bend - 9,000m From Fairway Beacon



Acheron Head - 10,600m From Fairway Beacon

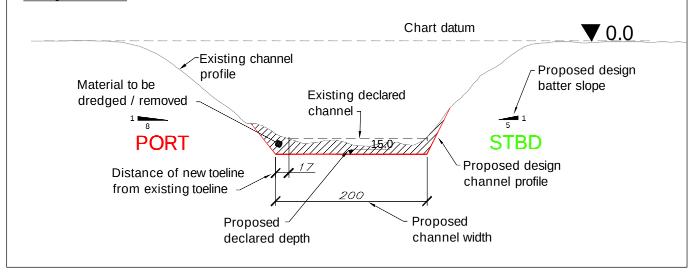


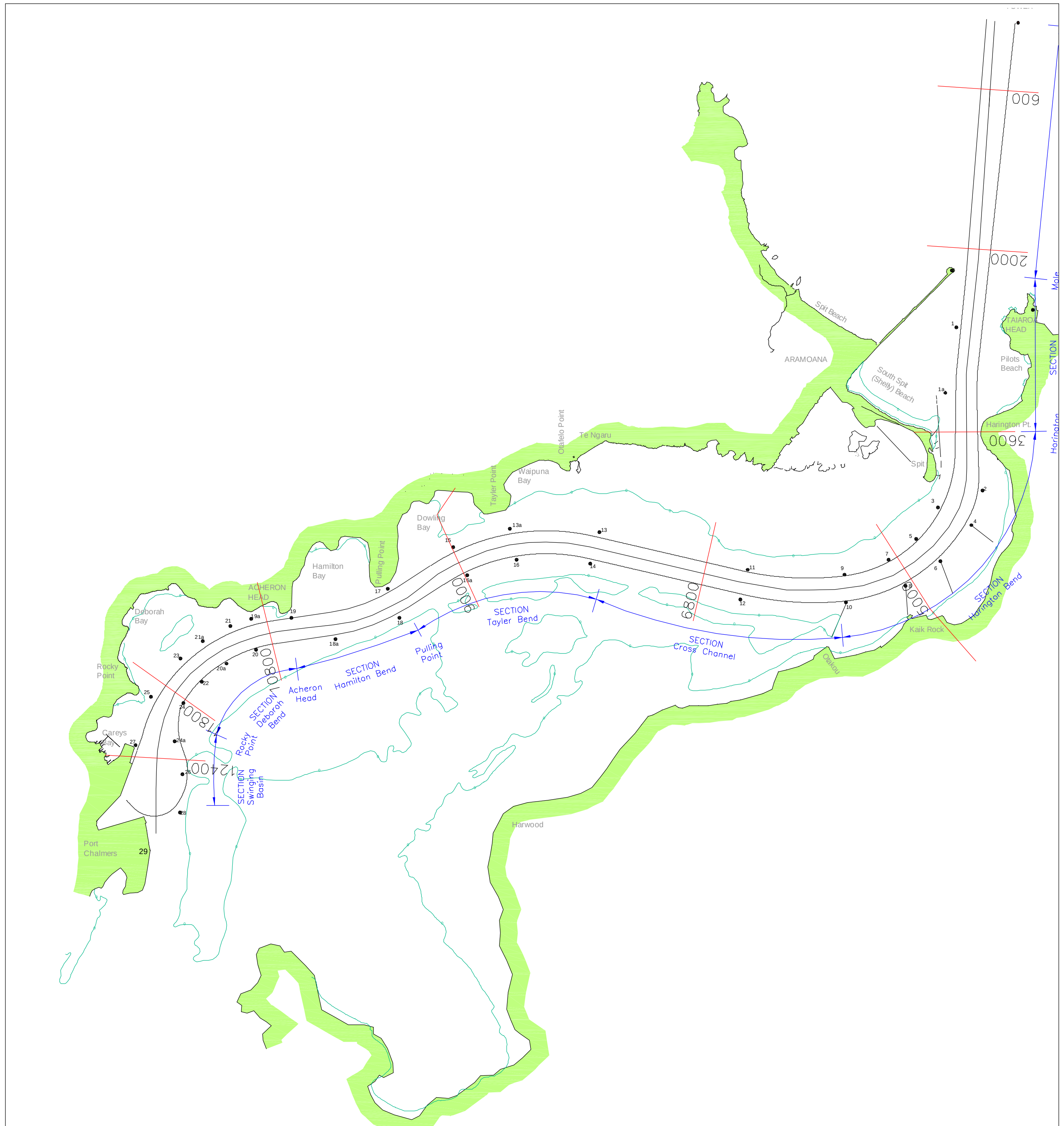
Deborah Bend - 11,800m From Fairway Beacon



Swinging Basin - 12,400m From Fairway Beacon

Key Plan





LOCATION PLAN
SCALE 1:25,000

Vertical Exaggeration 10x

	INITIALS	DATE
DESIGNED:	ACP	25/03/09
DRAWN:	ACP	25/03/09
CHECKED:	LMC	02/02/10
APPROVED:	LMC	02/02/10

PLOT DATE: 12/02/2010
ISSUE DATE: 11/02/2010

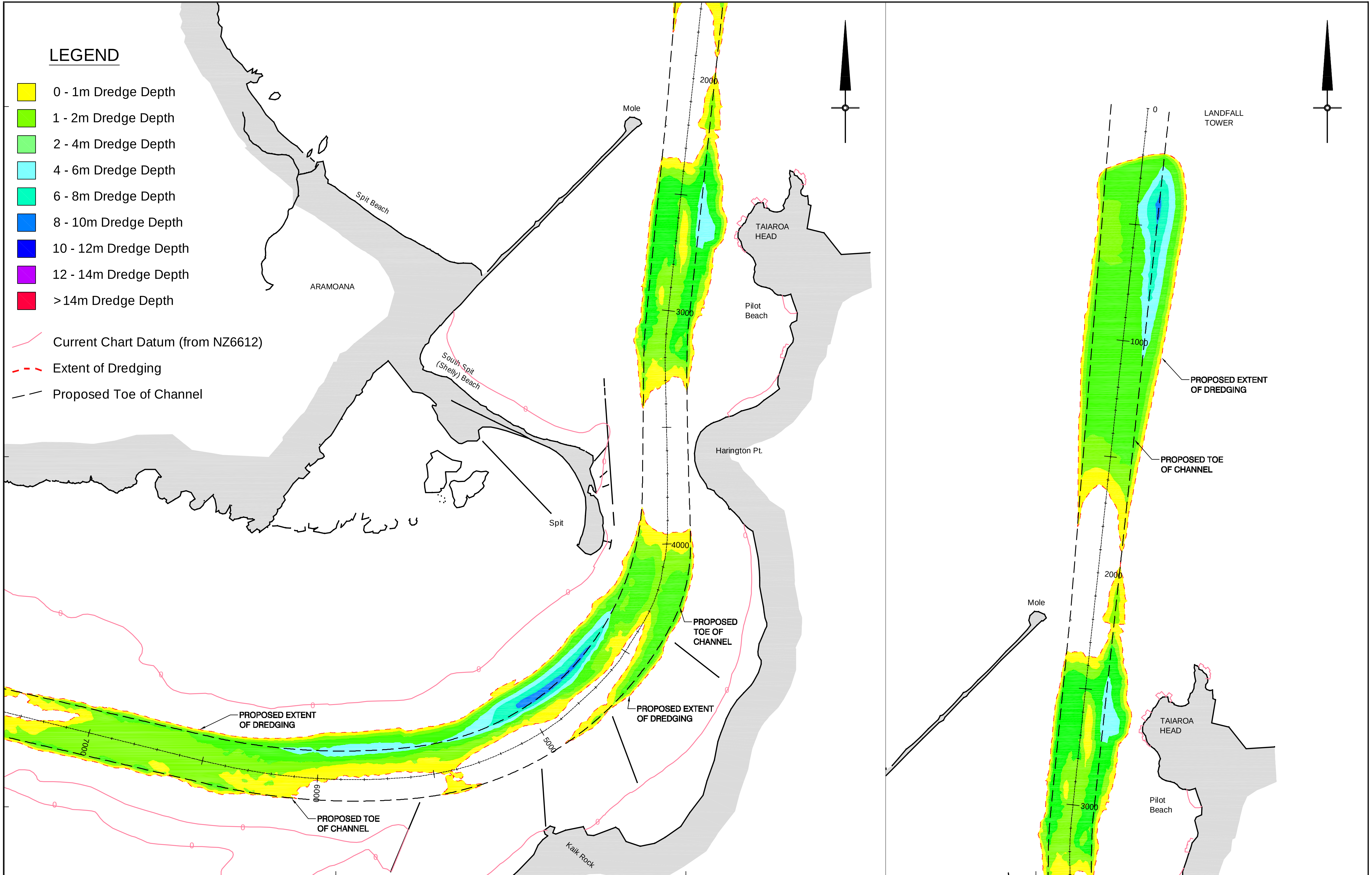
SCALES:
1:5000 Hz (A1)
1:500 Vt (A1)

PORT OTAGO LTD P.O. Box 8, Port Chalmers, N.Z.

Project Next Generation
Proposed Design Channel - Typical Claim Cross Sections

PORT OTAGO LIMITED

ACAD FILE NAME: Project Next\11090_1
DWG No: A1. 11090/1



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DRAWN:	ACP	16/06/09
CHECKED:	LMC	02/02/10
APPROVED:	LMC	02/02/10

PLOT DATE: 16/06/2009

ISSUE DATE: 11/02/2010

SCALES:
1:7,500 (A1)
1:15,000 (A3)

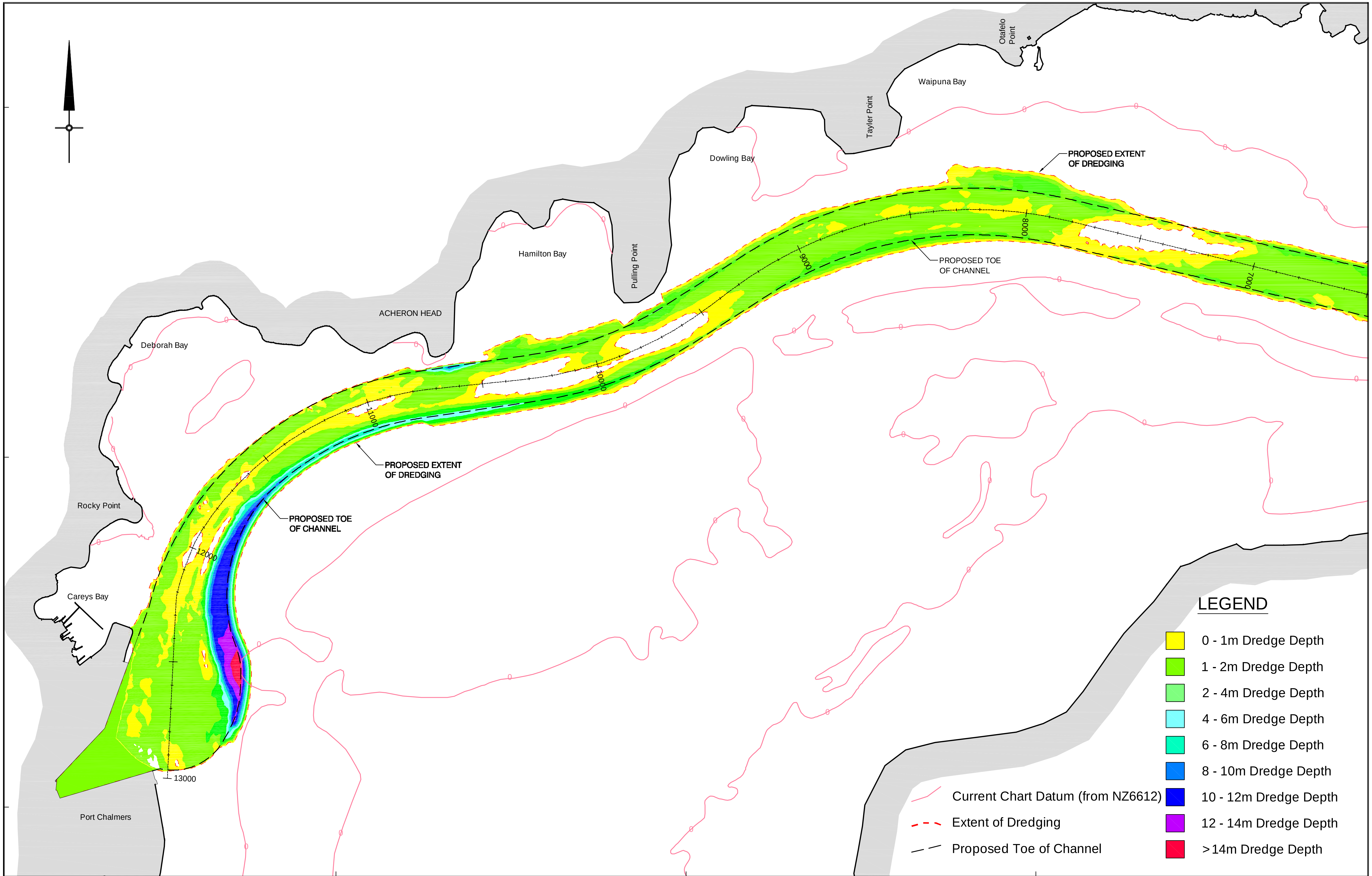
PORT OTAGO LTD P.O. Box 8, Port Chalmers, N.Z.

Project Next Generation
Proposed Dredging Depth Contours

PORT OTAGO LIMITED

ACAD FILE NAME: Project Next\ 11112

DWG No: A1. 11112/1



	INITIALS	DATE
DESIGNED:	ACP	16/06/09
DRAWN:	ACP	16/06/09
CHECKED:	LMC	02/02/10
APPROVED:	LMC	02/02/10

PLOT DATE: 16/06/2009

ISSUE DATE: 11/02/2010

SCALES:
1:7,500 (A1)
1:15,000 (A3)

PORT OTAGO LTD P.O. Box 8, Port Chalmers, N.Z.

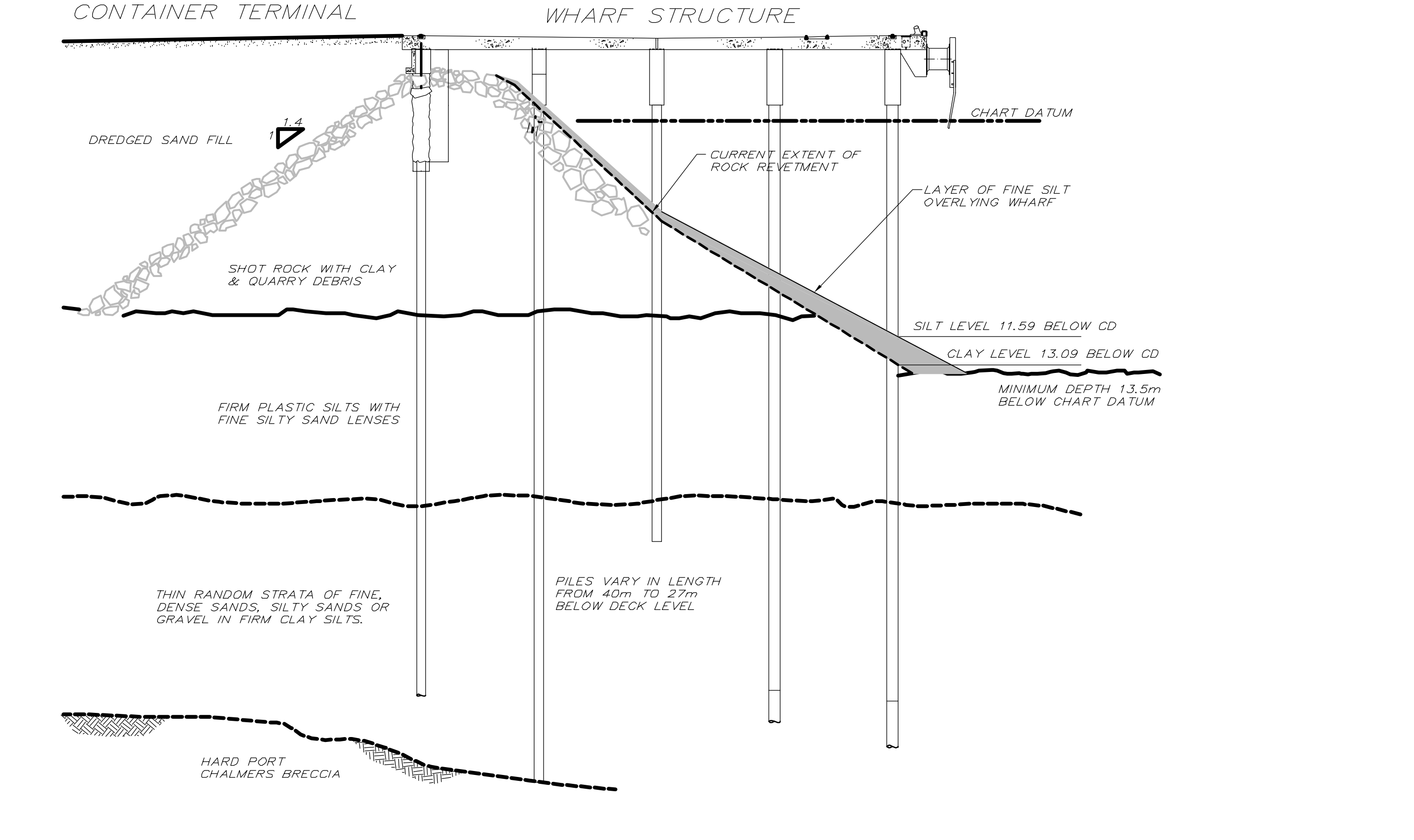
Project Next Generation
Proposed Dredging Depth Contours

PORT OTAGO LIMITED

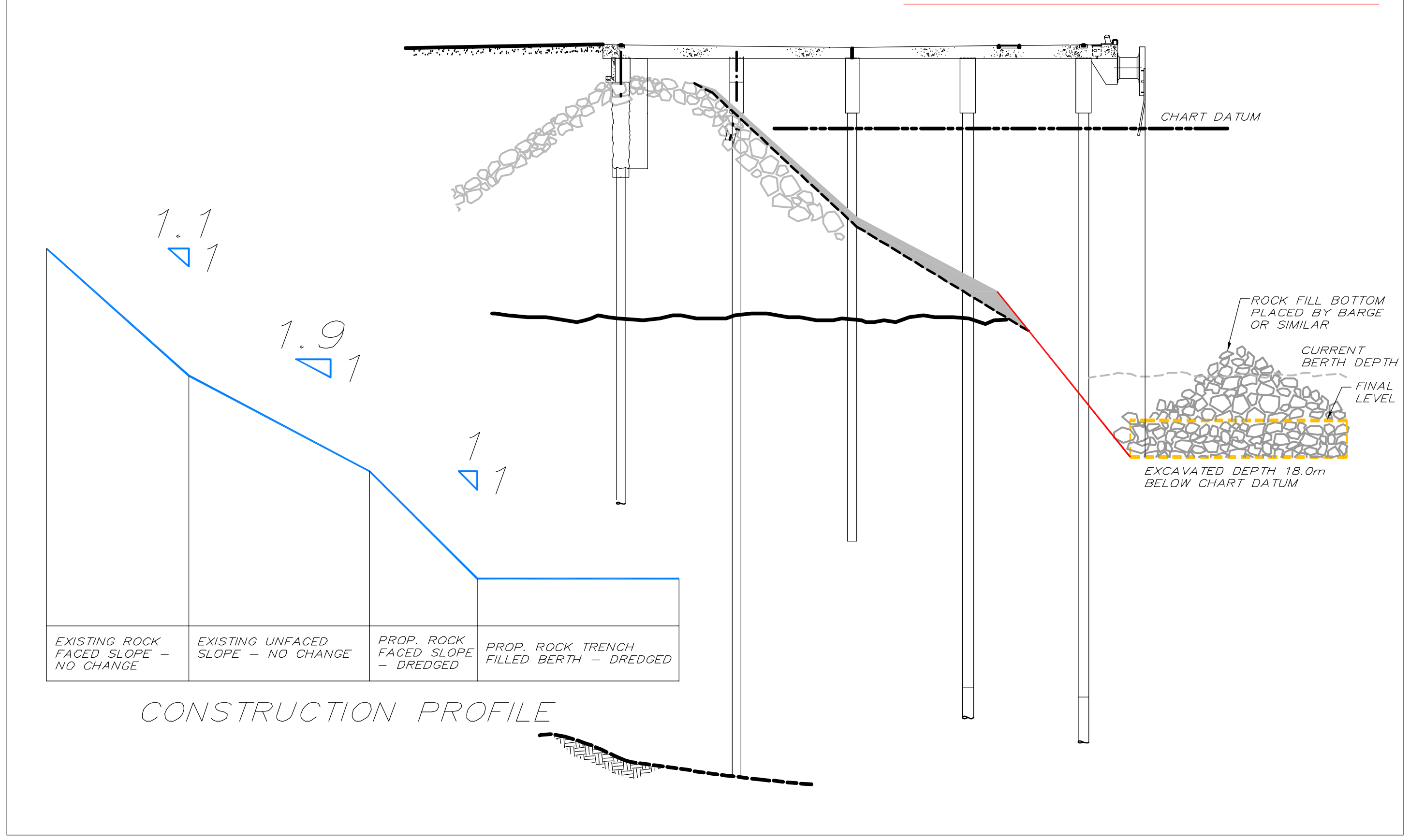
ACAD FILE NAME: Project Next\ 11112

DWG No: A1. 11112/2

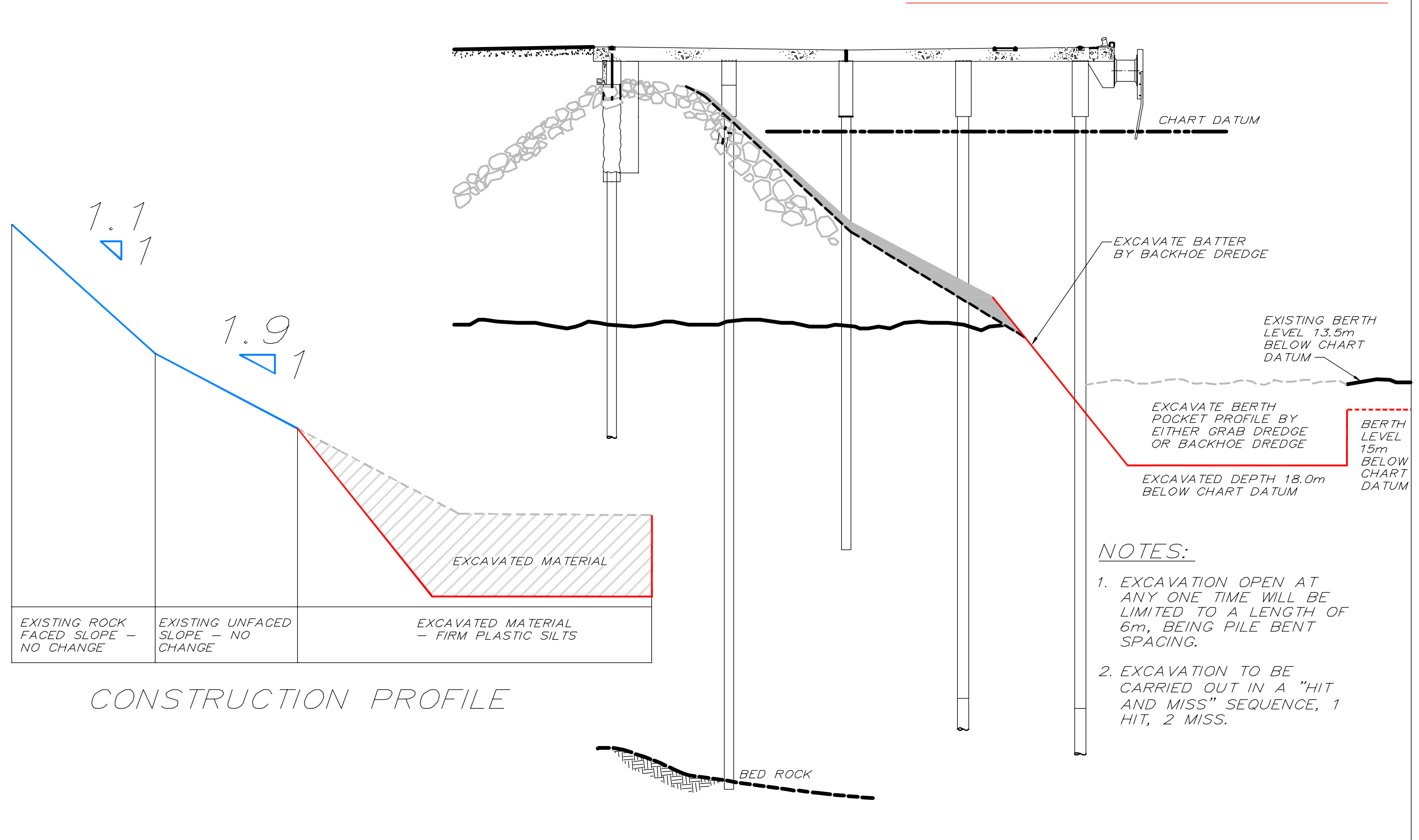
EXISTING PROFILE



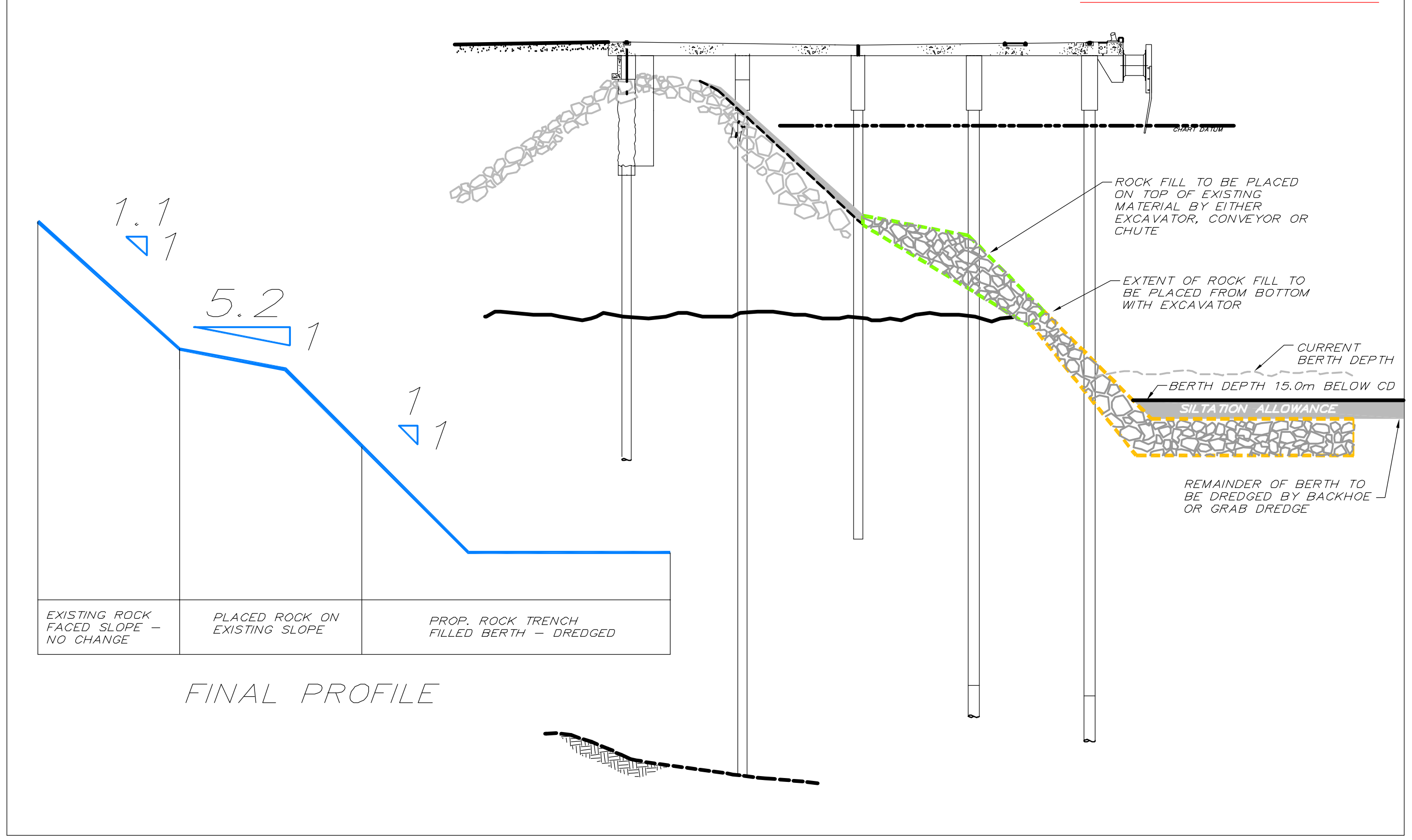
STEP 2 CONSTRUCTION



STEP 1 CONSTRUCTION



FINAL PROFILE



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DESIGNED:	ACP	13/10/09	PLOT DATE: 12/02/2010	SCALES: 1:400 (A3) 1:200 (A1)
DRAWN:	ACP	13/10/09		
CHECKED:	LMC	02/02/10	ISSUE DATE: 11/02/2010	
APPROVED:	LMC	02/02/10		

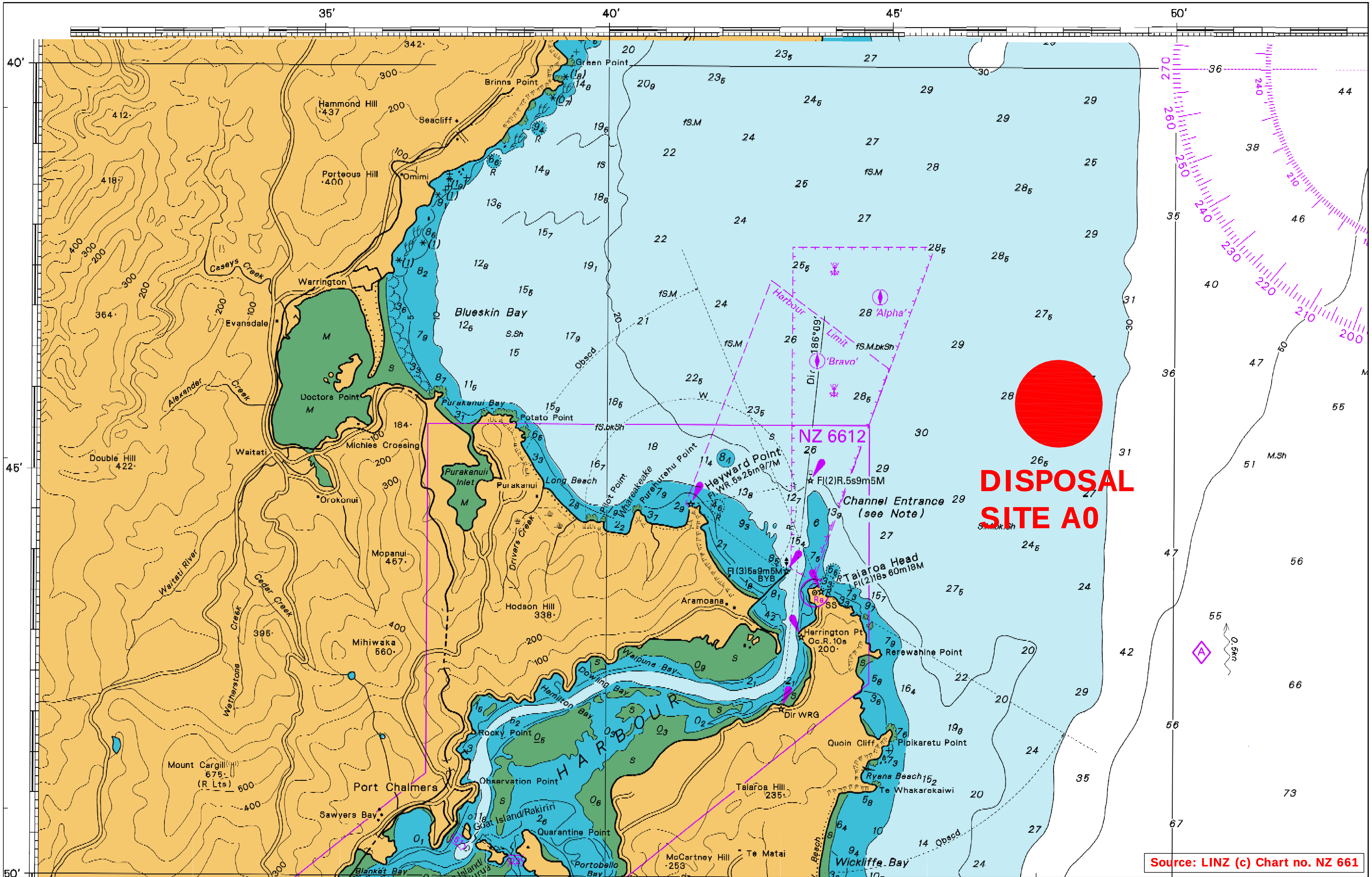
PORT OTAGO LTD P.O. Box 8, Port Chalmers, N.Z.

Project Next Generation
Indicative Construction Sequencing - Berth Deepening

PORT OTAGO LIMITED

ACAD FILE NAME: Project Next\ 11130

DWG No: A1. 11130



	INITIALS	DATE
DESIGNED:	ACP	06/10/09
DRAWN:	ACP	06/10/09
CHECKED:	LMC	02/02/10
APPROVED:	LMC	02/02/10

PLOT DATE: 09/10/2009

ISSUE DATE: 11/02/2010

SCALES:
1:40,000 (A1)
1:80,000 (A3)

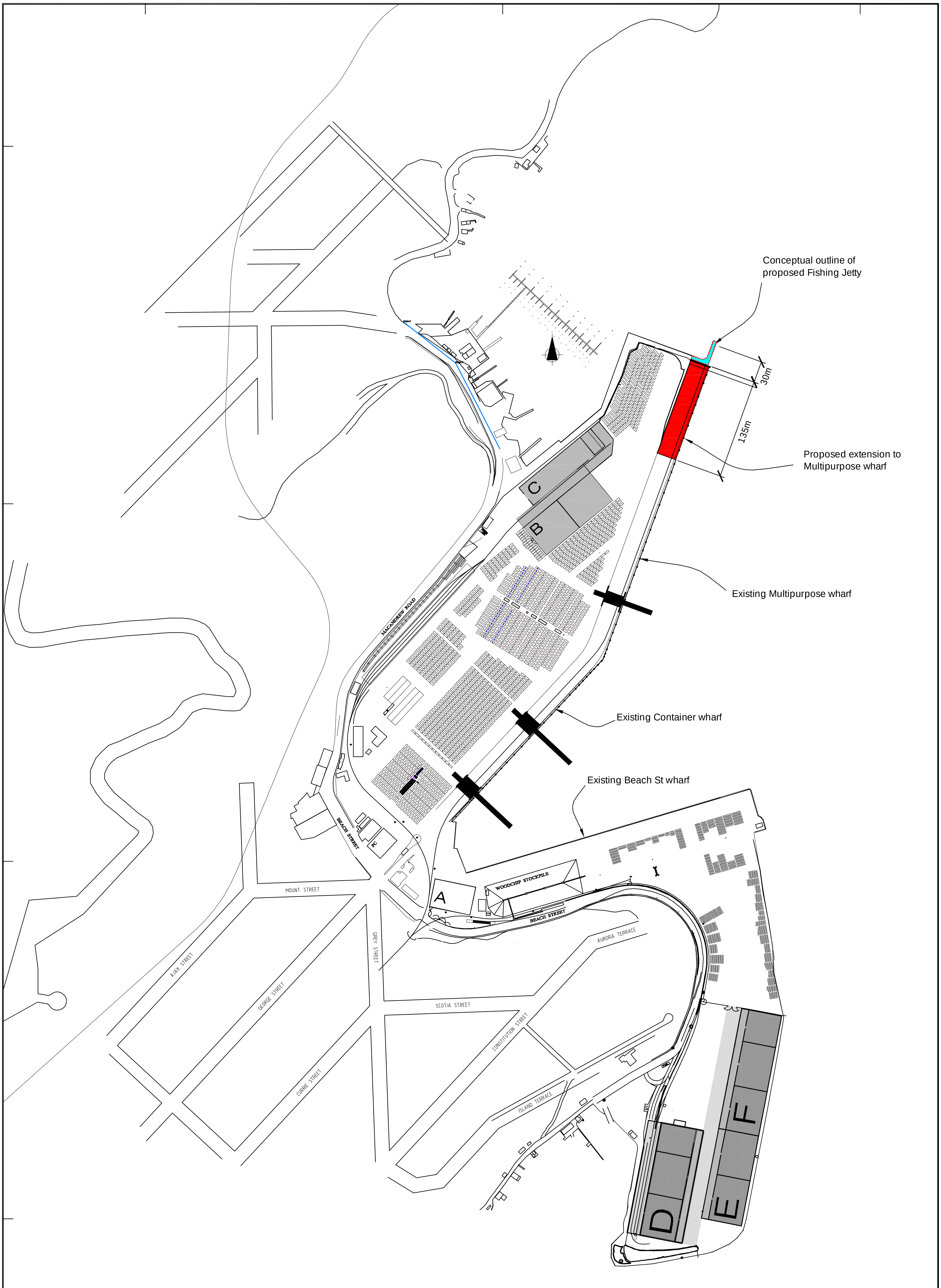
PORT OTAGO LTD P.O. Box 8, Port Chalmers, N.Z.

Project Next Generation
Proposed Offshore Disposal Site A0

PORT OTAGO LIMITED

ACAD FILE NAME: Project Next\11142

DWG No: A1. 11142



	INITIALS	DATE
DESIGNED:	MJH/LC	18/09/08
DRAWN:	MJH	18/09/08
CHECKED:		
APPROVED:		

PLOT DATE: 18/09/08

ISSUE DATE:

SCALES: 1:5000

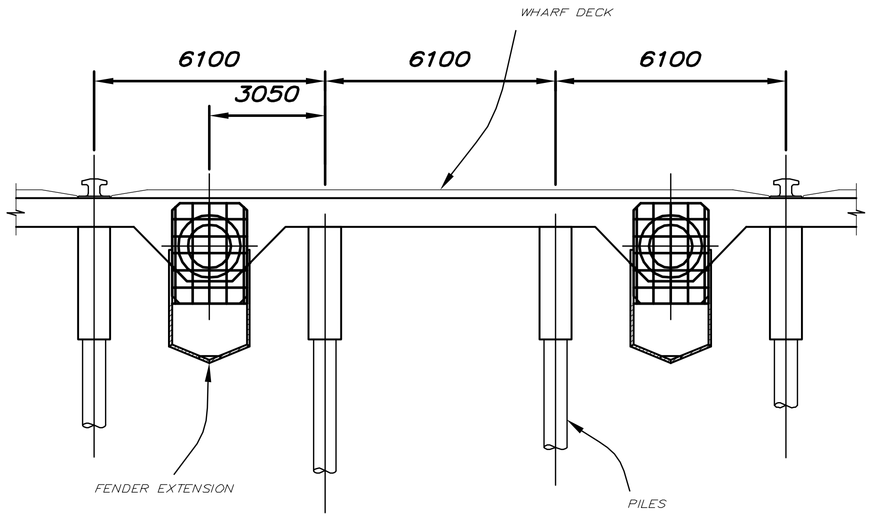
PORT OTAGO LTD P.O. Box 8, Port Chalmers, N.Z.

Proposed Multi Purpose Wharf Extension Location / Site Plan

PORT OTAGO LIMITED

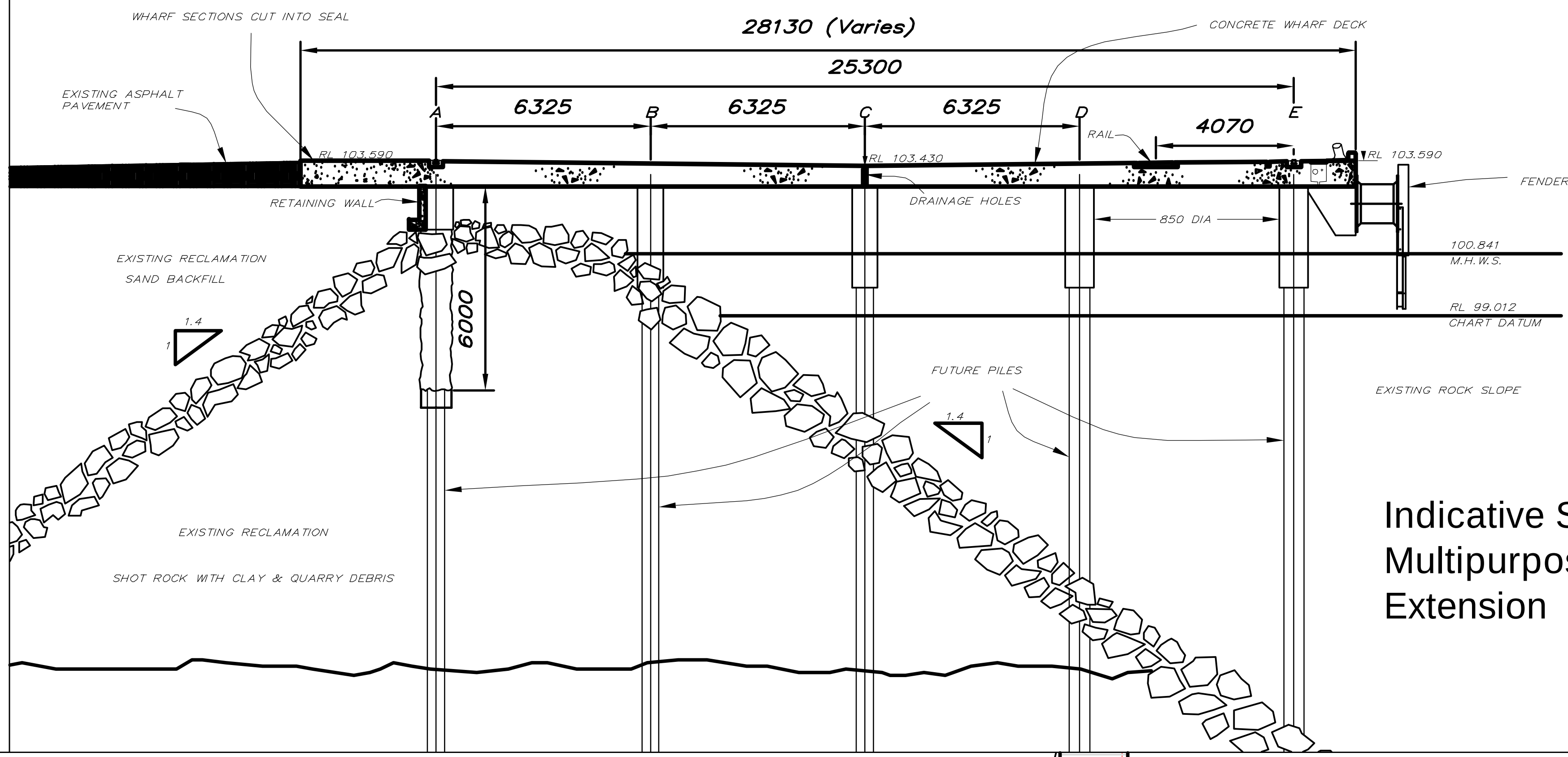
ACAD FILE NAME: Multi purpose\10991

DWG No: A3.10991 A



Indicative Elevation of Existing Multipurpose Wharf

Scale 1:200

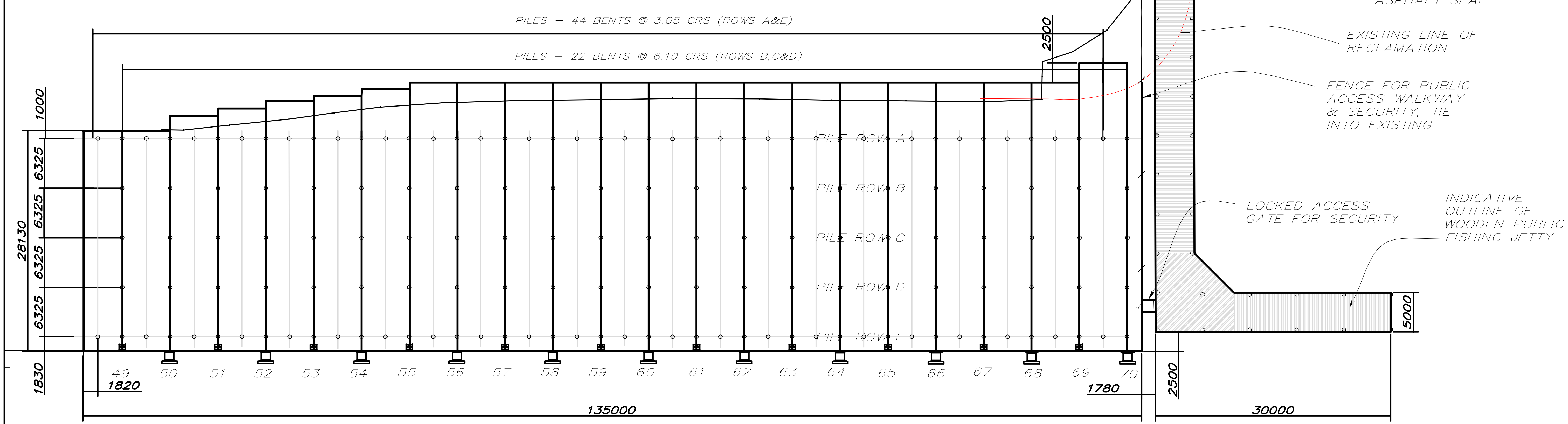


Indicative Section of Multipurpose Wharf Extension

Scale 1:200

Indicative Plan View of Proposed MP Wharf Extension

Scale 1:500



	INITIALS	DATE	PLOT DATE: 18/09/08	SCALES:	PORT OTAGO LTD P.O. Box 8, Port Chalmers, N.Z.
DESIGNED:	LR	18/09/08		As shown	**Port Chalmers Container Terminal**
DRAWN:	MJH	18/09/08	ISSUE DATE:		**Proposed Multi Purpose Wharf Extension - Construction Plan**
CHECKED:					
APPROVED:					

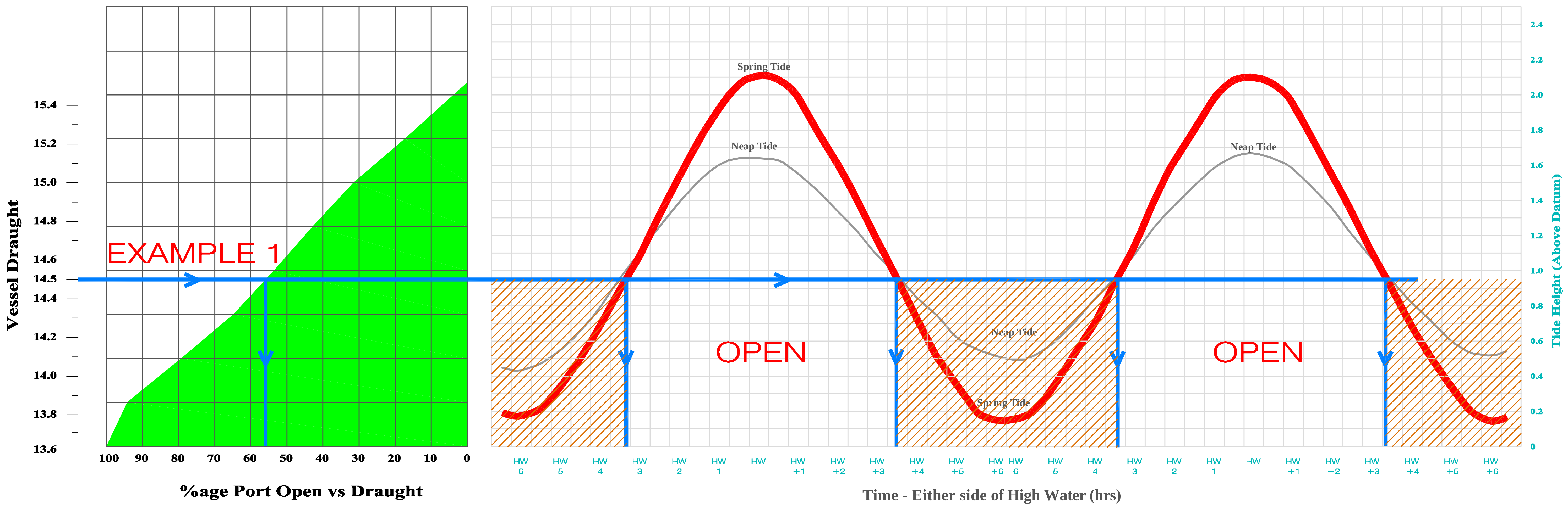
PORT OTAGO LIMITED

ACAD FILE NAME: Multi purpose\ 10991

DWG No: A3. **10991**

Vessel Draught vs Proposed Tidal Window
(Port Chalmers)

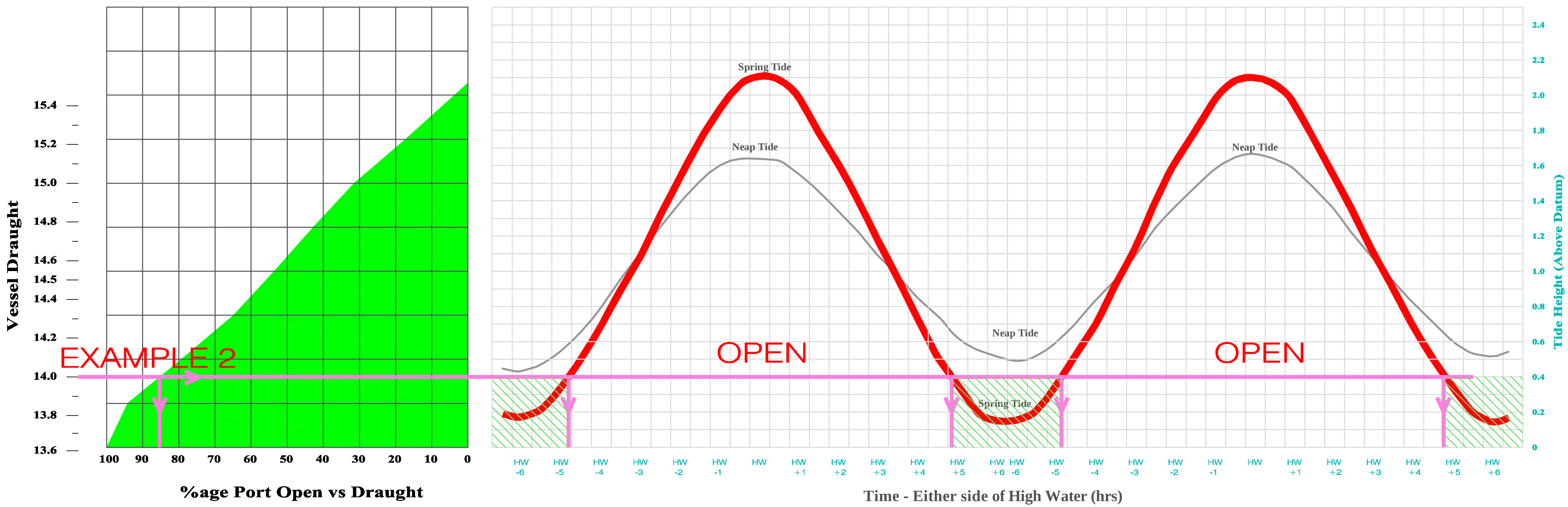
Based on 15.0 m Min Channel Depth plus 10% UKC



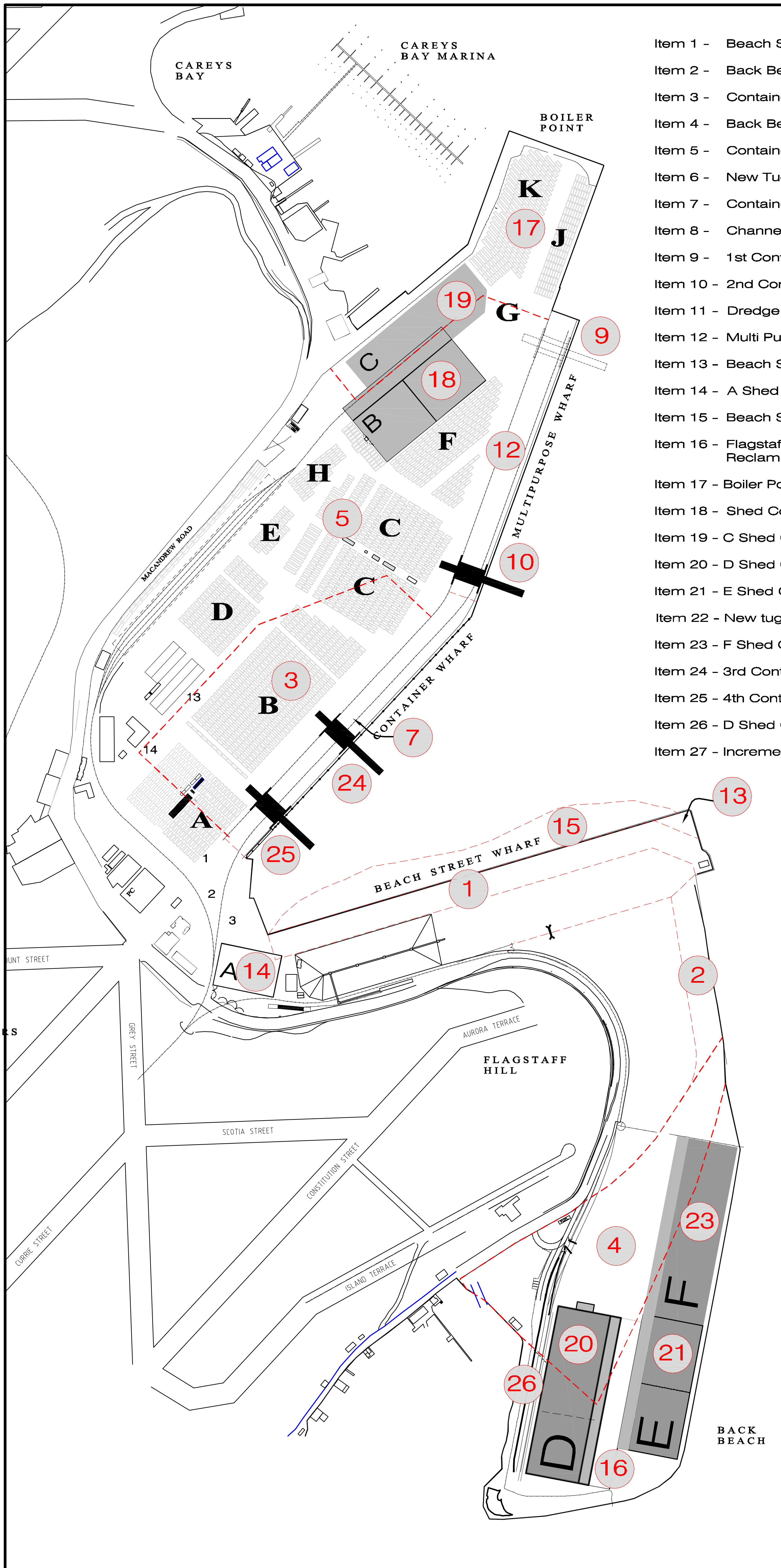
EXAMPLE 1 - Proposed 14.5m draught vessel can access Port Chalmers 55% of the time approx. 3.3 hours either side of high tide.

Vessel Draught vs Proposed Tidal Window (Port Chalmers)

Based on 15.0 m Min Channel Depth plus 10% UKC



EXAMPLE 2 - Proposed 14.0m draught vessel can access Port Chalmers 86% of the time approx. 5.1 hours either side of high tide.



Item 1 - Beach Street Wharf (1966 / 67)
Item 2 - Back Beach Reclamation - Phase 1 (1969 / 70)
Item 3 - Container Terminal Reclamation - Phase 1 (1971 / 73)
Item 4 - Back Beach Reclamation - Phase 2 (1975)
Item 5 - Container Terminal Reclamation - Phase 2 (1977 / 78)
Item 6 - New Tugs *Rangi* and *Karetai* (1974 / 75)
Item 7 - Container Berth (1976)
Item 8 - Channel Deepening to 12.2m below CD (1976)
Item 9 - 1st Container Crane (1976)
Item 10 - 2nd Container Crane (1979)
Item 11 - Dredge *New Era* (1985)
Item 12 - Multi Purpose Berth (1990)
Item 13 - Beach Street Wharf Extension (1992)
Item 14 - A Shed Construction (1993)
Item 15 - Beach Street Berth Deepening (1993)
Item 16 - Flagstaff Hill Excavation and Battery Point Reclamation (1994 / 95)
Item 17 - Boiler Point Reclamation (1995 / 96)
Item 18 - Shed Construction (1997)
Item 19 - C Shed Construction (1998)
Item 20 - D Shed Construction (2001)
Item 21 - E Shed Construction (2003)
Item 22 - New tug *Otago* (2003)
Item 23 - F Shed Construction (2004)
Item 24 - 3rd Container Crane (2006)
Item 25 - 4th Container Crane (2007)
Item 26 - D Shed Canopy (2007)
Item 27 - Incremental Channel Deepening to 13.0m (2003 - 09)

6 New Tugs *Rangi* and *Karetai*
8 Channel Deepening to 12.2m below CD
11 Dredge *New Era*
22 New tug *Otago*
27 Incremental Channel Deepening to 13.0m

Port Chalmers Port Development - Post 1960

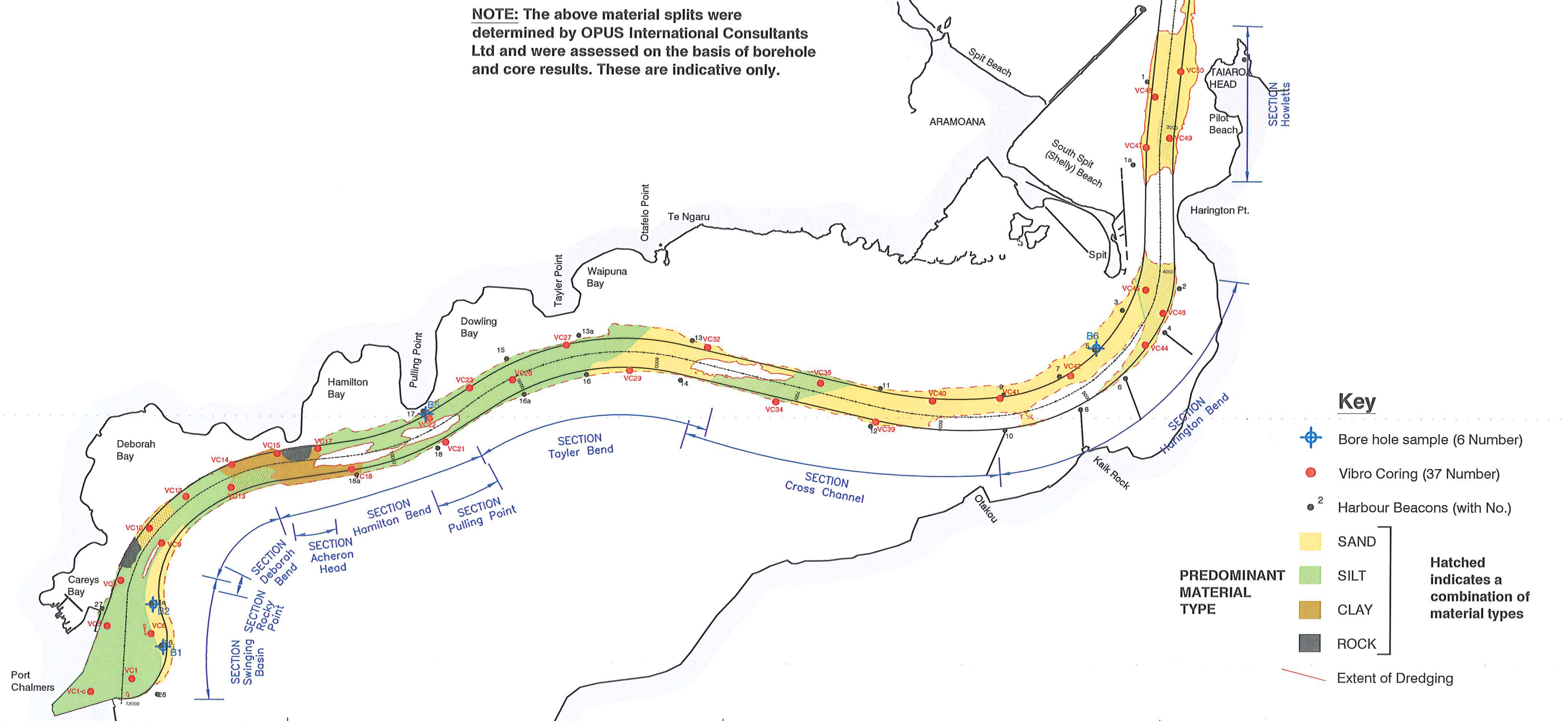
NOT TO SCALE

A3 11129

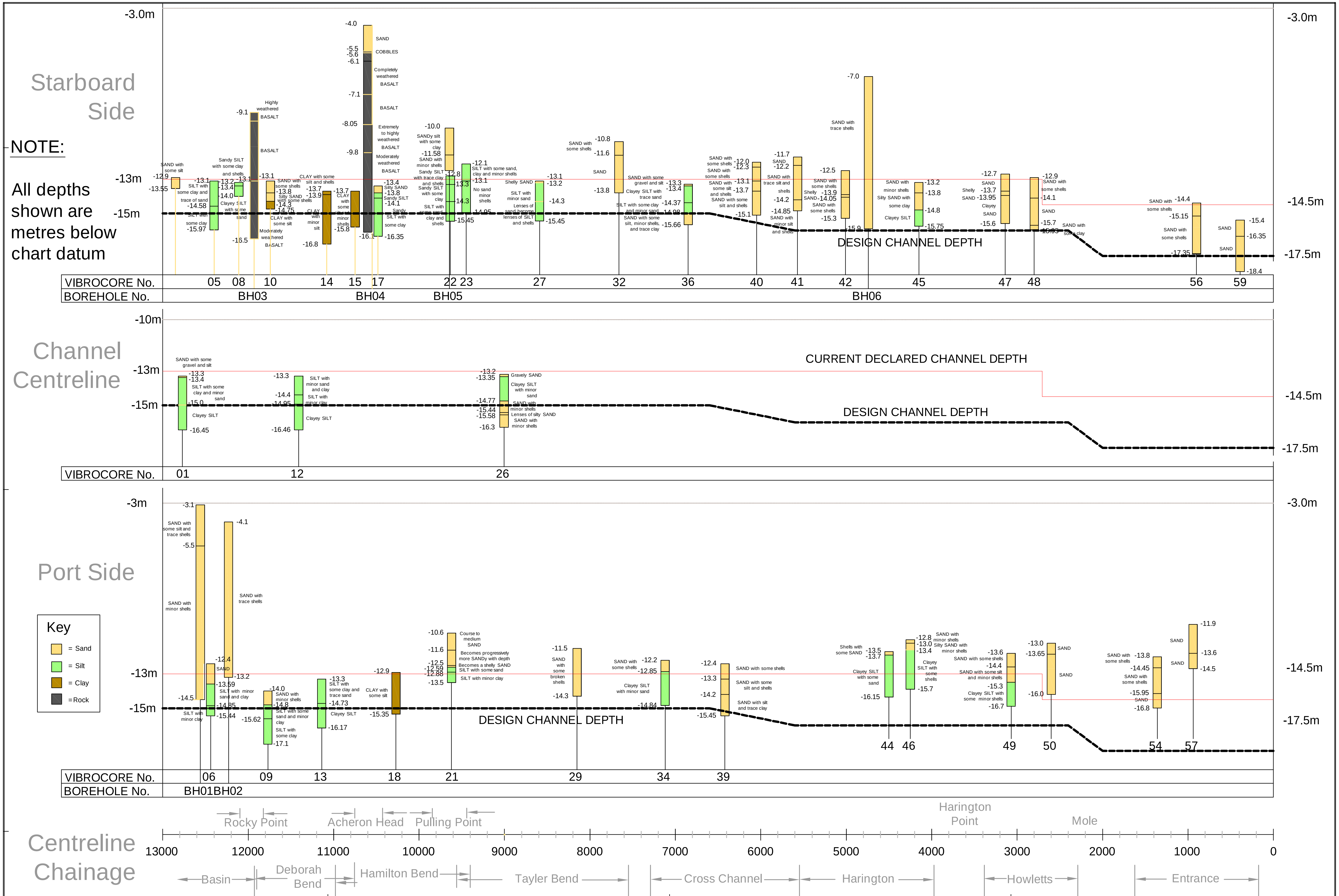
GEOLOGICAL UNIT SPLIT

Claim		Design Depth	Volume (m³)	Rock (%)	Sand (%)	Silt (%)	Clay (%)
Entrance (Port)	LF Bcn to Hole off Mole	17.5	1,201,200		100%		
Entrance (Stbt)	LF Bcn to Hole off Mole	17.5	165,130		100%		
Howlett	Mole to Harington Point	16.5	626,210		94%	6%	
Harington	Harington Pt - Bcn 10	16.0	1,064,910		68%	32%	
Cross Channel	Bcn 10 - Bcn 14	15.0	773,250		65%	35%	
Taylers	Bcn 14 - Bcn 18	15.0	766,448		18%	80%	2%
Pulling Point	150m each side of Bcn 17	15.0	26,700		28%	72%	
Hamilton	Bcn 18 - Bcn 20	15.0	375,480		7%	33%	60%
Acheron Head	150m each side of Bcn 19	15.0	45,565	43%	48%	7%	2%
Deborah (Port)	Bcn 20 - Bcn 24	15.0	472,810		29%	71%	
Deborah (Stbt)	Bcn 20 - Bcn 24	15.0	146,215		30%	24%	46%
Rocky Point	100m each side of Bcn 25	15.0	17,410	32%	24%	42%	2%
Basin (Port)	Bcn 24 - Bcn 28	15.0	1,199,370		73%	27%	
Basin (Stbt)	Bcn 24 - Bcn 28	15.0	256,178		2%	98%	
	Total Volume		**7,136,876**				

NOTE: The above material splits were determined by OPUS International Consultants Ltd and were assessed on the basis of borehole and core results. These are indicative only.



DESIGNED:	ACP	09/09/09	PLOT DATE: 12/02/2010	SCALES: 1:15,000 (A1) 1:30,000 (A3)	PORT OTAGO LTD P.O. Box 8, Port Chalmers, N.Z.	PORT OTAGO LIMITED	ACAD FILE NAME: Project Next\11024
DRAWN:	ACP	09/09/09			Project Next Generation		
CHECKED:	LMC	02/02/10	ISSUE DATE: 11/02/2010		Geotechnical Investigations - Interpretive Plan		DWG No: A1. 11024
APPROVED:	LMC	02/02/10					



	INITIALS	DATE
DESIGNED:	ACP	09/09/09
DRAWN:	ACP	09/09/09
CHECKED:	LMC	02/02/10
APPROVED:	LMC	02/02/10

PLOT DATE: 12/02/2010

ISSUE DATE: 11/02/2010

SCALES:
1:100 Vt (A1)
1:2000 Hz (A1)

PORT OTAGO LTD P.O. Box 8, Port Chalmers, N.Z.

Project Next Generation
Geotechnical Investigations - Interpretive Long Section

PORT OTAGO LIMITED

ACAD FILE NAME: project next\11024_1

DWG No: A1. 11024/1