Dredging Management Plan

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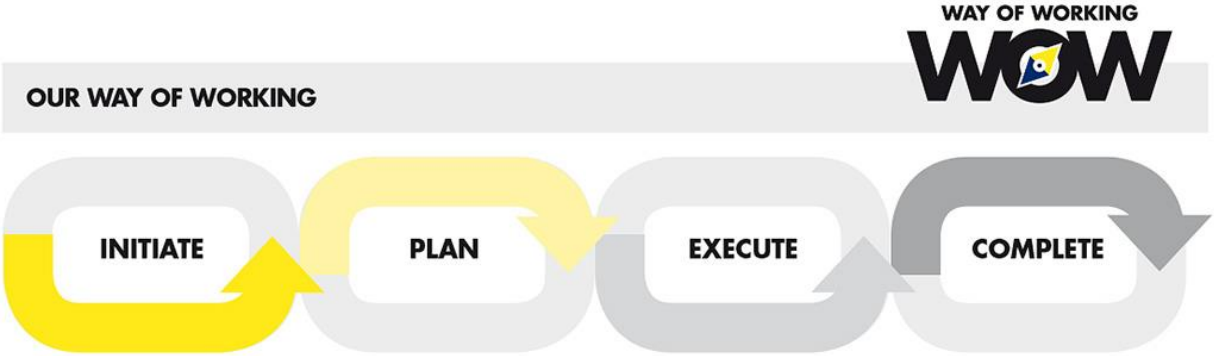
DOCUMENT PREPARATION

This document has been jointly prepared by Boskalis and Lyttelton Port Company. This Dredge Management Plan is required by Condition 4 of the resource consent (CRC 172455/CRC172522 and describes Boskalis' dredging plant, work method, and management systems used for the delivery of the Lyttelton Port of Christchurch Channel Deepening Project Stage 1.

BOSKALIS WAY OF WORKING

This document forms part of the Boskalis Way of Working, the integrated quality management system applicable to all operations in Boskalis. The Boskalis Way of Working is structured around four Phases as pictured below. This Dredging Management Plan is typically prepared in the PLAN Phase, where the main implementation is taking place in the EXECUTION Phase.



More detailed information about the Boskalis Way of Working can be found in the Group Manual and the User Guide. A dedicated website with all supporting materials is available at wow.boskalis.com

Boskalis
Dredging & Marine Experts

Lyttelton Port of Christchurch

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1. INTRODUCTION

1.1. General

Lyttelton Port of Christchurch (the Port) is located on Banks Peninsula on the east coast of the South Island (Figure 1.1). It is the largest port in the South Island and the third largest in New Zealand. Lyttelton Port Company is the operator of the Port and is currently 100% owned by the Christchurch City Council through its investment arm, Christchurch City Holding Limited.

The Port is currently New Zealand's third largest deep-water port, and the largest port in the South Island, and provides a vital link to international trade routes and a key role in the global transport network. The Port Lyttelton Plan (PLP) has been developed and is the first step in developing a 30-year vision for the Port.

As a result of the Canterbury earthquakes in 2010 and 2011, the Port sustained significant and widespread damage to infrastructure. While these events have had a significant impact on the LPC's ability to meet existing service demands in relation to throughput, productivity and customer service it is now the driving force behind the redevelopment program.

The current access channel does not have the draught to cope with the international trend for increasing vessel sizes. Deepening and widening the channel will allow the Port to keep up with international trade demand which is a key facilitator of the regional and national economy.

The existing channel is 180m wide, 11.9m deep and approximately 6.5km in length. Stage 1 of the Channel Deepening Project (CDP) will see the channel widened to 200m, increased in length to approximately 9km and increased in depth by approximately 2m (Figure 1.2). The swing basin is also being deepened and enlarged increasing the width from approximately 450m to 615m. The dredged material will be discharged at a designated dredge spoil ground, located approximately 5 nautical miles offshore of the Harbour Heads.

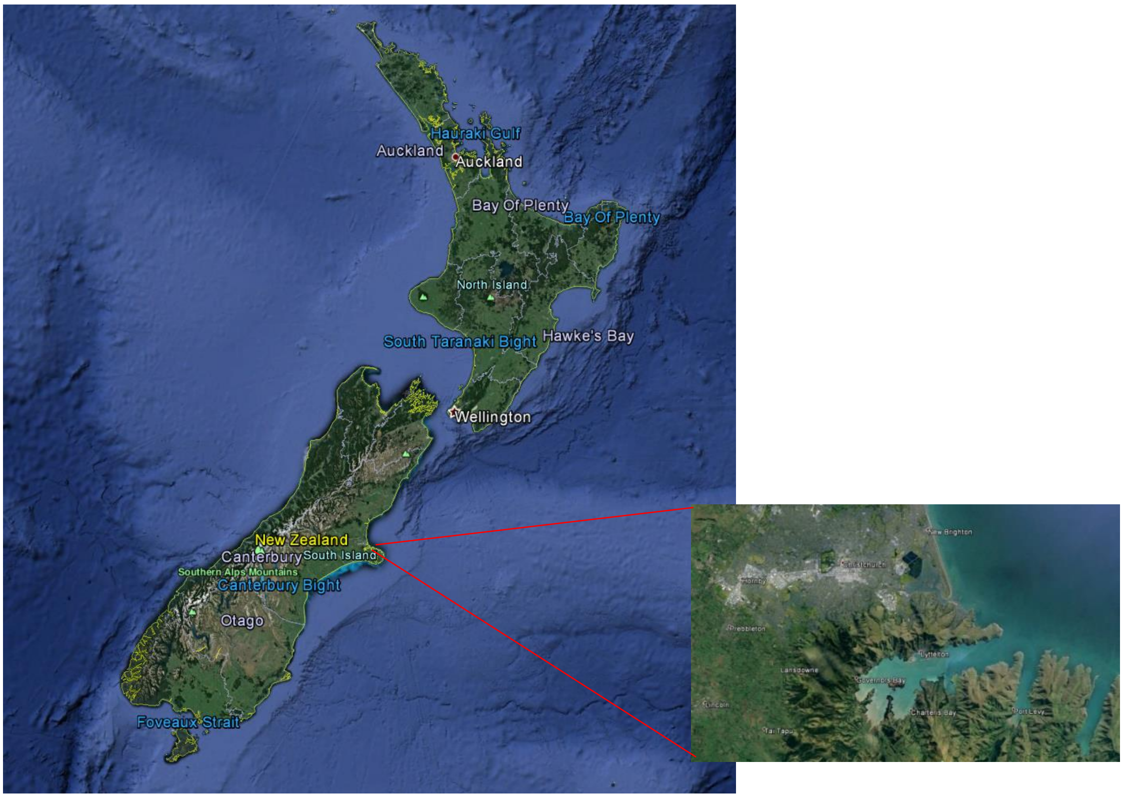


Figure 1.1 Lyttelton Port of Christchuch, South Island, New Zealand

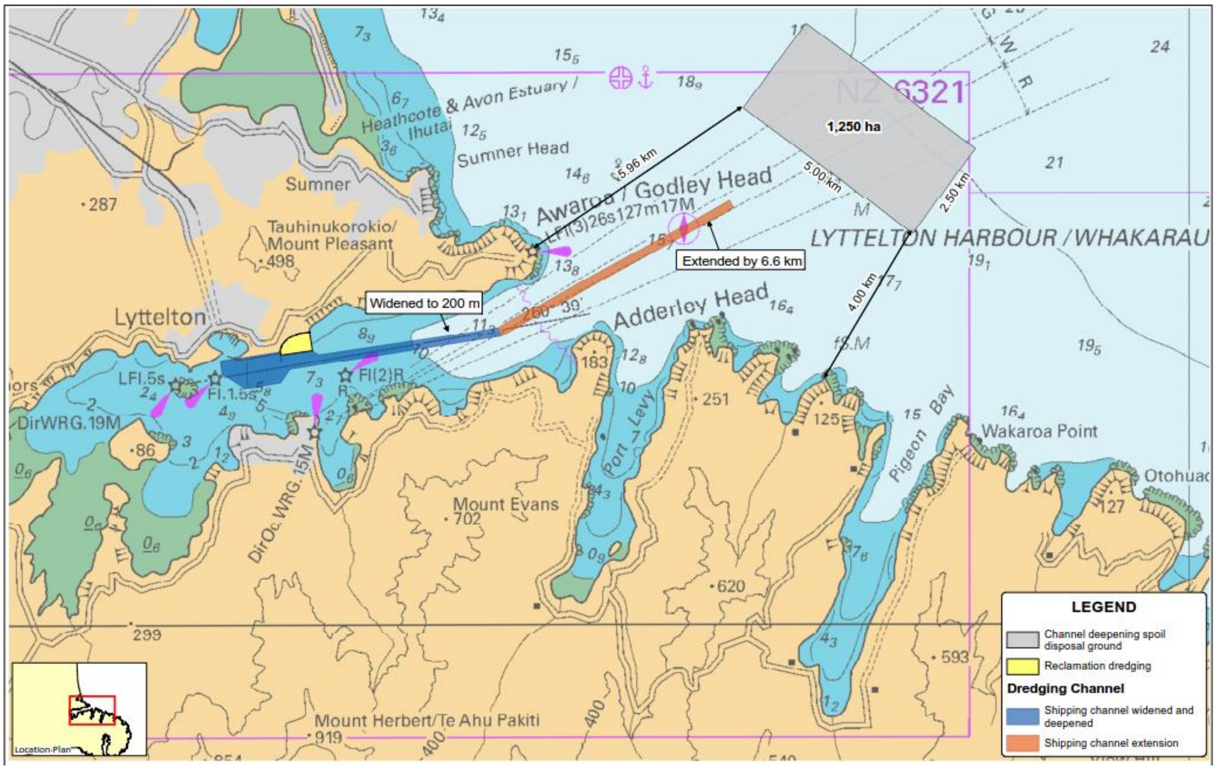


Figure 1.2 Overview Dredging and Dredge Spoil Area

1.2. Purpose

The purpose of this document is to describe Boskalis' dredging plant, work method, and management systems used for the delivery of the Lyttelton Port of Christchurch Channel Deepening Project Stage 1.

This Dredging Management Plan (DMP), together with the Environmental Monitoring and Management Plan (EMMP) [14], the Marine Mammal Management Plan (MMMP) [15] and the Biosecurity Management Plan (BMP) [16], specify how Dredging practices and procedures will ensure that any actual or potential adverse effects on the marine receiving environment are avoided or otherwise mitigated to the greatest extent practicable.

The content and scope of the DMP has been guided by Boskalis's normal best practise dredge management and the scope and requirements for the DMP as set out in condition 4.4 of Resource Consent CRC 172455 and CRC 172522.

This DMP has been prepared by Boskalis, with input from LPC. The Boskalis personnel who prepared and reviewed this DMP have significant experience in both the operation of the proposed dredge equipment and the management of environmental effects of dredging.

1.3. Scope of Document

This document entails:

- The Scope of Work, including dredge and disposal locations, dredge tolerances and quantities (Chapter 2)
- The Work Method, including number and type of dredges used, dredge methodology, mobilisation and demobilisation (Chapter 3)
- Equipment maintenance (Chapter 4)
- Safe Implementation of Simultaneous Operations (SIMOPS) (Chapter 5)
- Environmental management (Chapter 6)
- Dredging control & Survey method (Chapter 7)

More detail on the environmental management and adaptive management approach is given in the EMMP [14]. Detail on monitoring and mitigation measures for marine mammals is given in the MMMP [15]. For detail on the biosecurity management, reference is made to the BMP [16]. For more detail on the Health and Safety management reference is made to the HSE Plan [29]. Finally, a detailed description of the Survey method is given in the Survey Method Statement [32].

2. SCOPE OF WORK

2.1. Project Overview

The Works require the Contractor to widen and deepen the existing channel and swing basin as outlined in the Drawings.

The existing channel is 180m wide, 12.2m deep and approximately 6.5km in length. Stage 1 of the Channel Deepening Project will see the channel widened to 200m, increased in length to approximately 9km and an increase in depth by approximately 2m. The swing basin is also being deepened and enlarged which will increase the width from approximately 450m to 615m. All dredged material is to be transported to and disposed of within the designated dredge spoil ground.

Areas to be dredged and the applicable design depths required are shown in Table 2.1, Figure 2.1 and Figure 2.2.

Table 2.1 Dredge Areas and Design Depths

Dredge areas		
Description	**Area**	**Design Depth (m below CD)**
Swing Basin	A	-13.3 (note Cruise Berth Pocket is -11.5)
Te Awaparahi Bay	B	-13.3
Inner Channel Areas	C to G	-13.6 to -15.0
Outer Channel Areas	H to J	-14.5 to -14.0

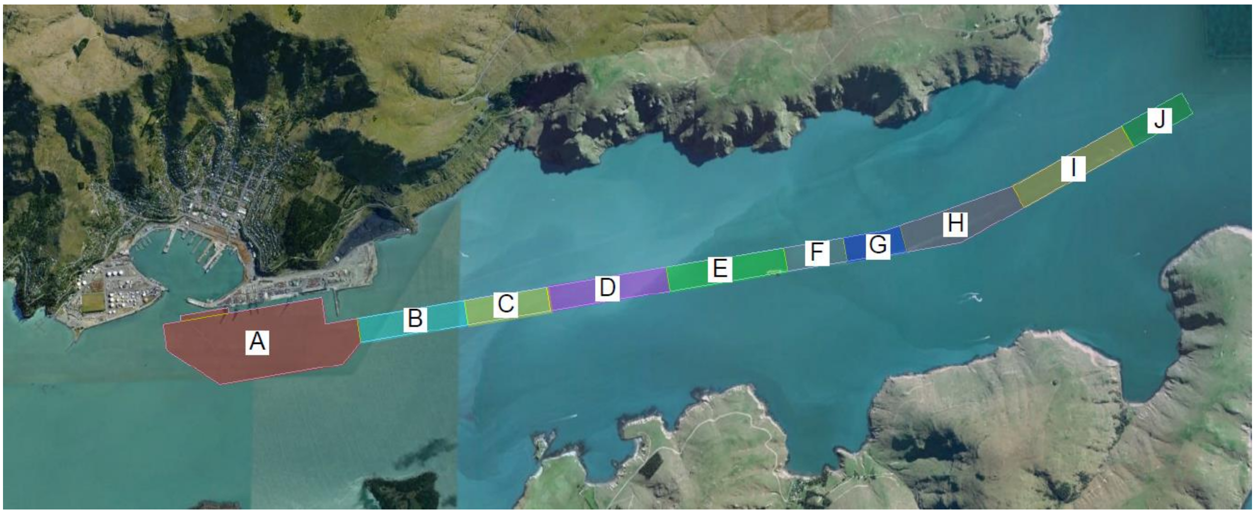


Figure 2.1 Overview of dredging areas

Figure 2.2 Overview of dredge area and spoil ground

2.2. The Works

2.2.1. Dredging Limits and Depths

The dredging limits are defined on the Drawings. The dredge depths specified on the Drawings are the minimum depths, which are to be achieved over the entire extent of the various dredge areas for clearance sounding purposes.

2.2.2. Batters

Batters shall be constructed to the slopes as detailed on the Drawings. If during the execution of the Works, material is encountered which requires batter slopes flatter or steeper than specified, the Employer may issue a written direction to carry out the dredging to other slopes. Batters shall be formed as follows:

Table 2.2: Proposed Batter Slopes per Dredge Area

Batter Slope	
Area	**Batter Slope**
A	1:4 to 1:5
B to D	1:3
E to J	1:2

2.3. Tolerances

The Contractor shall achieve the required design depth and profile at all locations. The Contractor shall dredge all areas so as to leave the seabed surface as level as possible.

Maximum permitted tolerances to achieve design depth for the different dredge areas are given in Table 2.3 and Figure 2.3.

Table 2.3 Dredge Tolerances

Dredge Tolerances		
Dimensions	**Location**	**Tolerance To Dredge Design**
Vertical	All areas	Deeper: 0.5 m
		Shallower: 0.0 m
Horizontal	All areas	Plus: 5.0 m (i.e. outside design line)
		Minus: 0 m

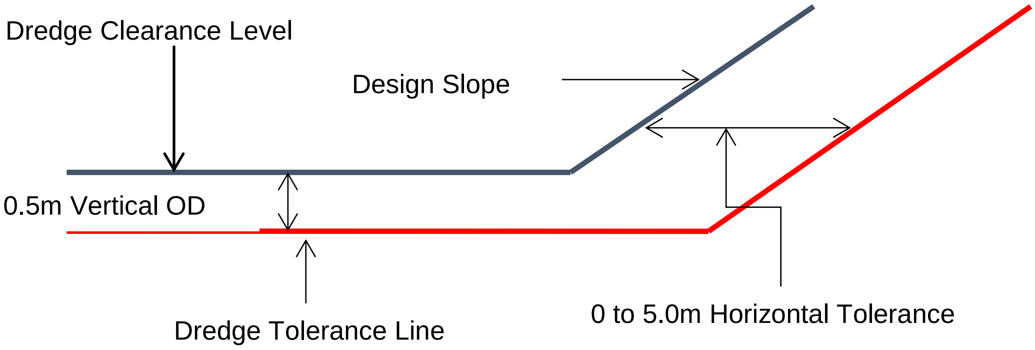


Figure 2.3 Dredging Tolerances

2.4. Dredging Quantities

The dredge volumes per area are given in Table 2.4.

Table 2.4 Dredge Volumes per Dredge Area

Dredge Volumes		
Dredge Area	**Net Volume (m^3)**	**Gross Volume (m^3)**
A	1,812,500	2,277,160
B	237,900	354,456
C	294,400	393,240
D	446,000	583,332
E	501,600	629,486
F	253,100	316,672
G	312,600	377,486
H	634,600	798,537
I	245,800	377,346
J	33,100	104,145
TOTAL	**4,771,600**	**6,211,860**

3. WORK METHOD

3.1. Mobilisation and Preparation
Mobilisation of all dredging equipment will be in accordance with the requirements of the relevant authorities such as the Ministry for Primary Industries, Customs, legislation that is in force in New Zealand and the Consent Conditions. The requirements of the Consent Conditions and the management thereof are outlined in the BMP.

3.2. Pre-Dredge Survey
Prior to start of works the survey system will be set up and a pre-dredge survey will be done of the dredge and disposal area to assess the actual depths. For more detail reference is made to section 7.2 and the Survey Method Statement [32].

3.3. Selection of Work Method
The proposed work method is based, amongst others, on the following:

- Our interpretation of available information (geotechnical, metocean conditions);
- The need to complete works in accordance with environmental approvals (the Resource Consents) for the works;
- Accessibility;
- Sailing distance to the spoil ground;
- The date for Practical Completion;
- Environmental objectives and limitations on the dredging process;
- Prevailing metocean conditions and their effect on the workability of proposed equipment.

With this in mind the optimal work method for the works consists of a large Trailing Suction Hopper Dredge (TSHD) installed with draghead side jetting nozzles supported by a Sweeping Vessel. Additionally, areas consisting of hard soil may be dredged with the use of a Backhoe Dredge (BHD).

3.4. Equipment

3.4.1. Primary Dredging Equipment
The primary dredging equipment selected for the works is a Trailing Suction Hopper Dredger (TSHD) as shown in Figure 3.1. A large or medium-sized hopper dredge will be used with a capacity of respectively 35,500 m^3 or 15,961 m^3. Specifications of the TSHDs which may be used, or similar, are given in section 9.1 and 9.2.

Figure 3.1 TSHD Fairway

These TSHDs are selected based on their hopper capacity, twin pipe configuration and proven draghead design leading to the following advantages/benefits:

1. The large hopper capacity and the relatively short sailing distance to the spoil ground virtually negates the need to overflow during hopper loading as overflow will result in no or little production advantage in the anticipated material. This also proves beneficial from an environmental perspective. Regardless, any overflow water from the hopper will be via the “green valve”, explained in detail in section 3.4.2;
2. The twin pipe configuration will allow greater accessibility to areas regardless of sailing direction;
3. The dragheads on the TSHD can be installed with side jetting nozzles, shown in Figure 3.2, to assist with dredging alongside quay walls and also for dredging channel batters.

Figure 3.2 Draghead with side jetting nozzle

The TSHD will be used to dredge all materials encountered within the dredging envelope. These are generally expected to be predominantly fine grained sediments, comprising clayey silt with lesser silty clay which are of low to medium plasticity that can be dredged relatively easily. The TSHD will be used to gradually deepen and widen the channel and basin as per the specifications and drawings.

The TSHD will be supported by a Sweeping Vessel and, if required a Backhoe Dredge as described in sections 3.4.2 & 3.4.3 respectively.

3.4.2. TSHD overflow with 'Green valve'

The TSHD hopper overflows are fitted with 'green valves'. 'Green valves' are devices installed on the overflow that reduce turbidity by preventing entrainment of air into the overflow. When dredging in normal mode, the overflows are fully open and the water mixture including fine sediments, which have not settled in the hopper, makes more or less a free fall down the overflow until it reaches seawater level. During this free fall, air gets entrained. The main part of the fine sediments will settle directly to the seabed due to differences in density. However, a part of the mixture will be pulled towards the water surface by the rising air bubbles creating a visible plume.

When using a green valve, the overflow is partly closed (right picture in Figure 3.3), preventing the free fall of the water sediment mixture. This results in hardly any air being entrained, bringing less fine sediments in suspension in the upper part of the water column. Because a larger part of the fine sediments in the mixture settles to the seabed more rapidly with the use of a green valve, the turbid plumes are smaller, of shorter duration, and mostly confined to the lower parts of the water column where currents have less power for sediment dispersion.

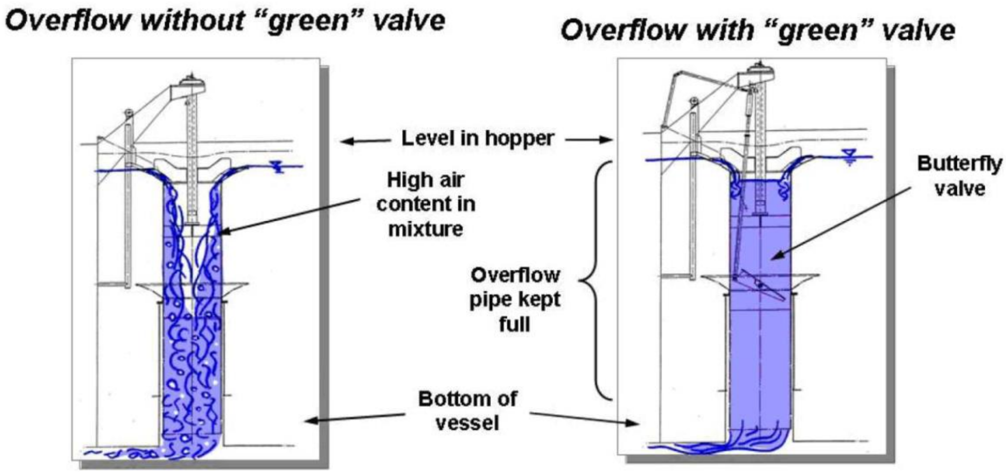


Figure 3.3 the 'Green valve'

3.4.3. Supporting Dredging Equipment

A Sweeping Vessel will be utilised to assist the TSHD by moving materials from areas that are difficult to access with the TSHD as described in further detail in section 3.5.3. It will also be used to level any ridges remaining from the TSHD dredging process.

At some locations within the Dredge Area the soil may be too hard to dredge with the use of a TSHD. In these areas a Backhoe Dredge (BHD) may be required.

In addition, various auxiliary craft will be used to support the dredging operations including a crew transfer vessel (CTV) and a hydrographic survey vessel. Typical crew/survey vessels are available locally and will be chartered for the duration of the works.

Specifications of a Sweeping Vessel, BHD and crew/survey vessel which will be used, or similar, are given in section 9.3, 9.4 and 9.5.

3.5. Dredging Method

3.5.1. TSHD dredging works

To start dredging operations, the TSHD will sail to the dredging area. Dredging area for that time will be selected based upon the construction programme, metocean conditions and current turbidity regime in the harbour/offshore. Once in the dredging area, the suction pipe(s) are lowered to the seabed, the dredge pump(s) are started and dredging commences.

While dredging, the draghead(s) scrape over the seabed and loosens the sediments. The sediment-water mixture is brought up through the suction pipe and pumped into the hopper well. During loading with its draghead(s) on the seabed, the TSHD sails fairly slow. The trailing speed depends on local conditions and the material being dredged and will generally not exceed 1-3 knots. Figure 3.4 shows the TSHD during the loading process.

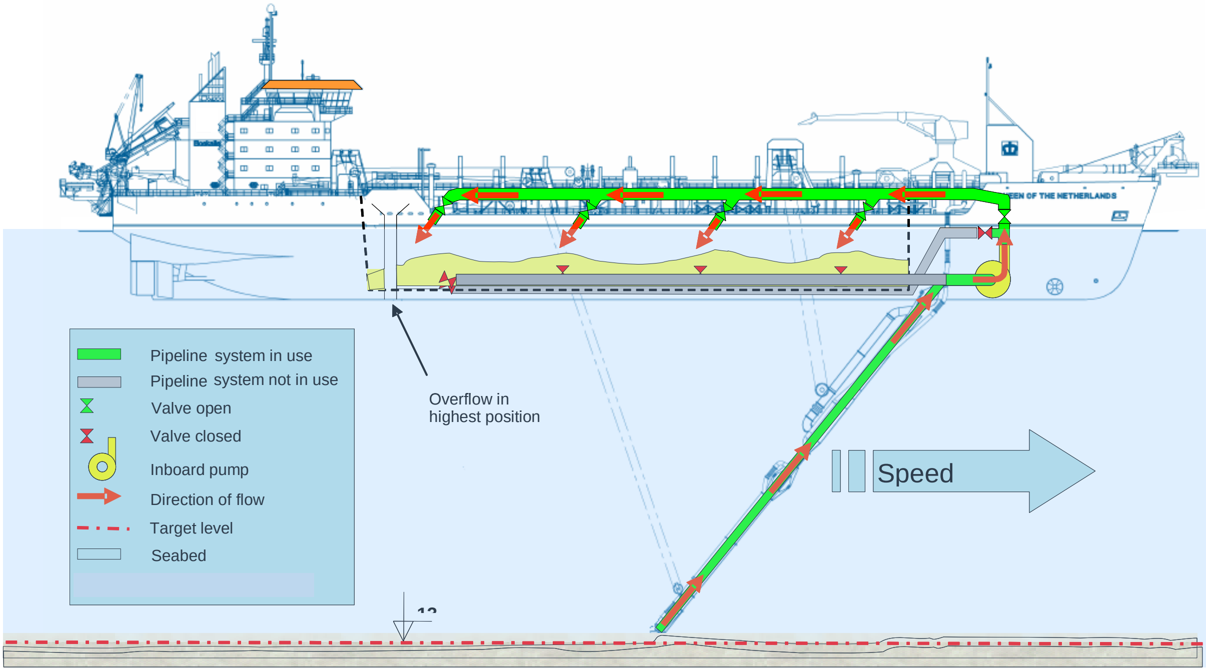


Figure 3.4 TSHD loading process

The dredged material settles out in the hopper and the excess transport water is evacuated through the overflow system. This overflow system can be adjusted, in order to optimise production and minimise losses. In the cases where use of the overflow is not advantageous (e.g. no increase in production) or not permitted, the hopper is only filled up to the overflow level.

When the draught of the vessel reaches the dredging load mark or when circumstances do not allow further loading, dredging will be suspended and the suction pipe(s) will be hoisted on deck. The vessel then sails loaded with dredged material to the approved disposal ground.

The general sequence of actions when dredging in the work areas are described below and will depend on actual current directions, wind speed and direction and at the Dredge Master's discretion:

- TSHD will approach its pre-planned dredge target location;
- THSD will reduce speed within 2000 meters from the dredging area;
- TSHD will reduce speed to 6 knots within 1000 meters from the dredging area;
- TSHD will further reduce her speed to 3 knots within 500 meters from the dredging area;
- TSHD will have reduced her speed to 0 -3 knots upon arrival at the dredging area;
- Upon arrival at the dredging area, the dredge pipes, fitted with a 'normal' multi-purpose draghead, will be put overboard and lowered to the seabed by the winches;
- When the draghead has reached a depth of 5 meters above the seabed, the pumps will be started;
- The TSHD will start "trailing" in Dynamic Positioning and Dynamic Tracking (DP/DT) mode with an operating speed of 0.5 – 3knots;
- Simultaneously the draghead will be lowered onto the seabed and dredging commences;
- The TSHD will continue "trailing" until the draghead has reached the end of a particular stretch, after which the draghead will be hoisted clear above the seabed and the "trailing" will be stopped;

- The TSHD will then go astern to the starting position, or turn around, or proceed to different area.
- If loading has not been completed yet the TSHD will relocate to an appropriate stretch for completing the loading;
- Draghead will be lowered on the seabed again;
- Sequence will be repeated as described above.

3.5.2. Channel Widening
Channel widening of the designated areas will take place by dredging along the toe line of the proposed channel alignment allowing materials to progressively flow down the slope and form a natural batter. Widening of the channel and the creation of batter slopes will be with the assistance of draghead side jets to loosen and encourage material to flow down the slope for retrieval by the draghead as shown in Figure 3.5.

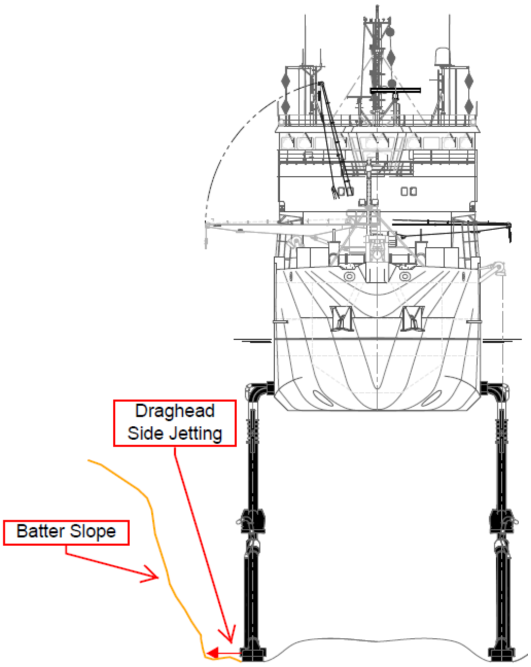


Figure 3.5 Dredging slopes with side jetting

3.5.3. Sweeping method
When an area is dredged by the TSHD or has a small amount of material above the design level, the area will be bed levelled by a Sweeping Vessel. The Sweeping Vessel will also be used to assist the TSHD by moving materials from areas that are difficult to access with the TSHD.

The Sweeping Vessel consists of a tug on which an A-frame and bed leveller are installed. By lowering the bed level bar to a certain level (Figure 3.6), the tug will start to sail and the material above the cutting edge of the bar will be gathered and will be swept and deposited in lower areas.

Onboard the Sweeping Vessel, Boskalis inhouse DV2 survey system will be installed to enable accurate positioning and operation of the bed levelling vessel.

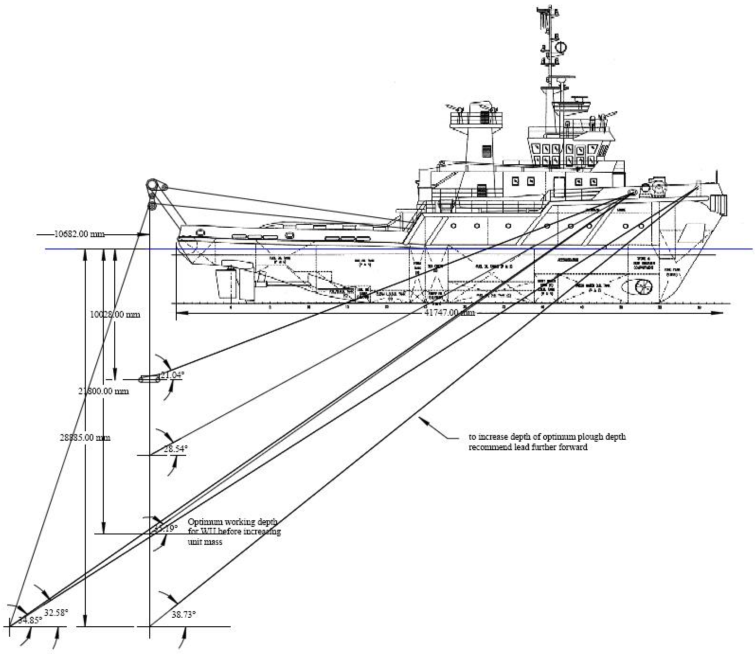


Figure 3.6 Typical Tug and Bed leveller Setup

3.6. Dredge Spoil Method

Dredged materials will be transported in the TSHD from the dredging locations to the spoil deposition site. During the discharge of the hopper the speed of the hopper will be kept to a minimum in order to accurately place the material. The hopper doors will only be opened once above the designated area of the deposition site and will be closed prior to departing this area. The opening of the bottom doors will generally take around 5 to 10 minutes.

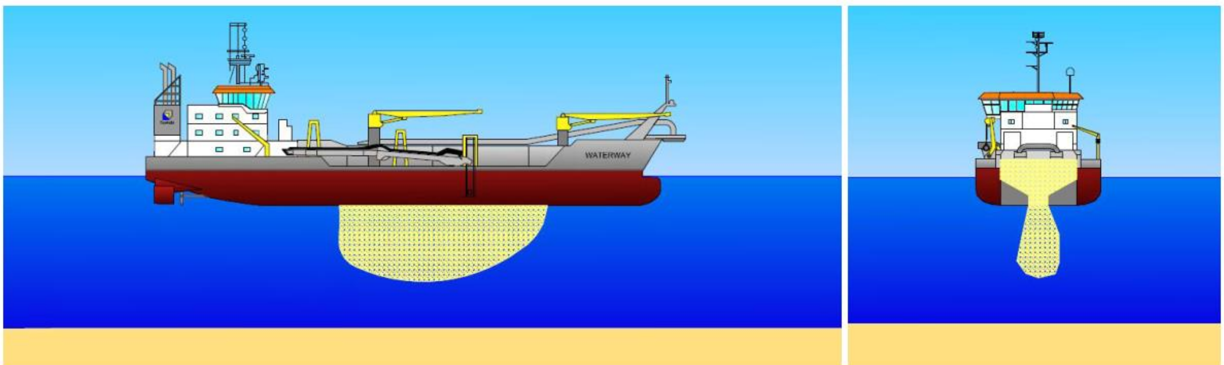


Figure 3.7 TSHD discharging through bottom doors

The TSHD will be equipped with:

- ship-borne automated identification system (AIS);
- a DGPS system enabling monitoring and registering of the status and location of the vessel. (open or closed).

Dredge spoil plans will be based upon a grid of boxes (see Figure 7.2) representing the size of a hopper load.

For the placement of the material the following will be reported:

- trip number;
- date and time of discharge;

- dredging plant;
- dredged location;
- name of vessel;
- coordinates of the discharge location;
- estimate of the amount of material in m^3.

3.7. Regulations for Dredging Equipment

During the Channel Deepening and Widening works the following documents/ procedures (beyond that set out in the Resource Consent) will be applicable:

- LPC Inductions
- Port Operations Harbour Masters Directions
- Notices to Mariners
- Admiralty Charts
- Local knowledge and pilot exemptions
- Communication with LPC Port Control
- Priority of commercial shipping
- Restrictions for cruise shipping
- Caution with recreational craft
- AIS requirements.

3.8. Plant Operating Hours

Dredging equipment utilised on the project will operate on a 7 day x 24 hour basis, stopping only for maintenance and bunkering requirements. Auxiliary vessels will operate on an as and when required schedule.

3.9. Demobilisation

Specific equipment will be demobilised from site after it has completed its tasks for the Works. Demobilisation will be in accordance with the procedures and regulations of the relevant authorities and contract conditions.

4. EQUIPMENT MAINTENANCE

During the works, regular maintenance will take place of all equipment. The purpose of the maintenance is to ensure proper and efficient operation of the dredger and to minimise potential effects on the environment (i.e. underwater noise and possible leakage of hazardous substances).

Boskalis vessels and equipment follow the Boskalis Fleet Management System (FMS), which is based on the International Safety Management Code for the Safe Operation of Ships and for Pollution Prevention (ISM-code). All main vessels and equipment of Boskalis are managed centrally by Fleet Management Dredging (FM). To keep track of repair, maintenance and stock of each vessel in the fleet Boskalis uses IBM Maximo Asset Management software. Required intervals of routine inspections, repairs and refits are shown in the system. This also helps plan necessary quantity of assets to stock on the vessels before they leave the port.

Specific attention is made to ‘Critical Equipment’, which is defined as equipment that is vital for the safety of the Fleet and its crew. FM-430 ‘Critical Equipment’ describes the control, preventive maintenance, purchasing and logistics of these Critical Equipment. For each vessel a general criticality assessment matrix is made for each equipment based on seven parameters:

1. Class
2. Environmental
3. Risk failure start-up
4. Risk failure in operation

5. Effect on production
6. Complexity
7. Cost re-install/change-out

Scores per parameter are based on the next table:

Analyse - Critical value of equipment					
Definition		Score = 1	Score = 2	Score = 3	Score = 4
Class	Is the equipment under Class?	N			Y
Environmental	What is the impact of the failure of the equipment on the environment?	N	Moderate	Considerable	Extremely
Risk failure start up	Are there safety risks for the installation/personnel when the equipment fails to start	N	Low	High	Extremely high
Risk failure in operation	Are there safety risks for the installation/personnel when the equipment fails during operation	N	Low	High	Extremely high
Effect on production	What is the influence of the equipment on the production ?	N	Moderate reduction of production	Considerable reduction of production	Stop of production
Complexity	How complex is the installation?	Simple	Moderate complex	Considerable complex	Extremely complex
Cost re-install / change-out	How high are the costs of repair/ replacement in case the installation fails?	Minor	Moderate	Considerable	Extremely high

For all equipment, a critical value is calculated:

1. Based on the 4 first parameters, all equipment with a critical value **above 80% is considered as ISM critical.**
2. Based on the 4 last parameters, all equipment with a critical value **above 50% is considered as Operational critical.**
3. Based on all 7 parameters, all equipment with a critical value **below 50% is considered as non-critical.**

For all ISM Critical Equipment, a Preventive Maintenance Schedule has to be implemented to increase the reliability of the equipment. This schedule includes planned maintenance, corrective maintenance and a planned testing and inspection regime. For Operational Critical Equipment, the Preventive Maintenance scheme is based on regular inspections, experience and wear & tear.

Defining the criticality of each equipment on board of the vessel allows to assess the critical equipment of each vessel and the required maintenance. The critical value of the equipment is displayed in Maximo and all maintenance activities on Critical Equipment is registered in Maximo. In case of failures of Critical Equipment, the Captain shall directly inform the Fleet Management Team. The Fleet Management Team and the Captain shall jointly and as soon as possible initiate the necessary mitigating actions to limit the risks involved.

As an example, equipment for the TSHD Fairway assessed as ISM critical (critical value above 80%) are i.a.: CO_2 system, Foam Fire Fighting System, Water Mist Installation, Engine, Rudder, Propulsion, Thruster, Oil Pollution Prevention, Pilot ladder, Radar and Magnetic Compass.

Routine maintenance activities conducted on the dredge vessels to prevent biofouling will be elaborated further in the BMP [16].

5. SAFE IMPLEMENTATION OF SIMULTANEOUS OPERATIONS

The Channel Deepening and Widening works require interaction with multiple port users. Maintaining a safe environment for the current port users and operators is paramount. This includes but not limited to onshore operations, shipping, associated ancillary vessels and labour.
A SIMOPS plan will be used to illustrate the measures that will be taken to ensure safe implementation of Simultaneous Operations (SIMOPS) and Interface Management during the works.

The document serves the following main functions:
- To prevent any incidents/ near misses from occurring as a result of dredging activities.
- To prevent any delays from occurring for commercial operators in and around the port as a result of the dredging activities.
- To describe the measures to be taken for the coordination, cooperation, and communication of multiple contractors/operators working in close proximity to each other.
- To act as a controlling document, highlighting the responsibilities and timetable for the completion of all aspects of the SIMOPS for Marine Construction Activities.

5.1. Voyage Planning – Commercial Traffic

Voyage planning will be an integral component of the SIMOPS plan to ensure continuous and open passage for commercial vessels entering and leaving port. Hopper transits between the dredging and deposition sites will be planned around shipping movements.

The TSHD will sail under its own power and will therefore be able to relocate relatively easily to an alternate dredging area or sail to the deposition site prior to the arrival or departure of traffic.

5.2. Voyage Planning - Recreational Traffic

Recreational sailing/boating and yacht races are conducted in Lyttelton Harbour/ Whakaraupō on a regular basis (typically Wednesday nights 5:30-8pm and Saturday/Sunday afternoons) mainly during summer months. It is expected that during the Project execution period (winter 2018) the recreational traffic activity in the harbour will be minimal with formal yacht racing only likely on some Sundays.

However, prior to the start of the Project the Employer and Contractor will meet with the Naval Point Club Lyttelton and Charters Bay Yacht Club to ensure that the Project activities will not intervene with any yachting events in the Project Area. Notices will also be placed on the local boat ramps to provide project information and navigations recommendations for the general boating public. The local fishing fleet and general Port users will also be provided information on the project and navigation hazards via LPC's normal customer communications and formal central government Notices to Mariners.

6. ENVIRONMENTAL MANAGEMENT

It is the Employer and Contractor's aim to minimise any negative impacts of the dredging and associated discharge of dredged materials on the marine receiving environment. This includes measures related to minimising turbidity as described in detail in the EMMP [14], monitoring of marine mammals as described in the MMMP [15], biofouling as described in the BMP [16] and management of waste, hazardous substances and refuelling as described in the HSE plan [29]. This section describes environmental measures related to dredging in line with the Consent conditions for the DMP which are not covered in the aforementioned plans.

6.1. Contractor's corporate statement with respect to environment

As Boskalis operates in environmentally sensitive areas, we adhere to:

- Complying with the applicable statutory environmental provisions and regulations and, wherever possible, going further than required;

- Focusing policy on the permanent prevention or limitation, as far as possible, of pollution of soil, water and air, sound creation, creation of waste products and use of dangerous materials;
- Collecting and having waste processed separately, and using water and energy efficiently;
- Translating policy into clear practical guidelines and, furthermore, ensuring that the policy and the guidelines are implemented in practice;
- Permanently ensuring that the environmental awareness and motivation of the employees and others who work on the premises of Boskalis is such that environmental protection - although primarily the management's responsibility - is everybody's concern;
- Optimising our environmental management system according to ISO 14001 standard, to achieve continuous improvement of our environmental performance SHE-Q structure.

6.2. Adaptive Management

The Project's environmental philosophy is based on an adaptive management approach. An adaptive management approach seeks to develop strategies to assess the system, predict the impact and cater for uncertainties (Figure 6.1). In general, levels of uncertainty about the construction-related impacts will decrease over the course of the Project as more accurate information is collected.

By monitoring throughout the construction activities in combination with reviewing the process (for example dredging cycle, production rates, bathymetric surveys etc.) opportunities can be identified d to amend the activities to reduce impacts and increase efficiency.

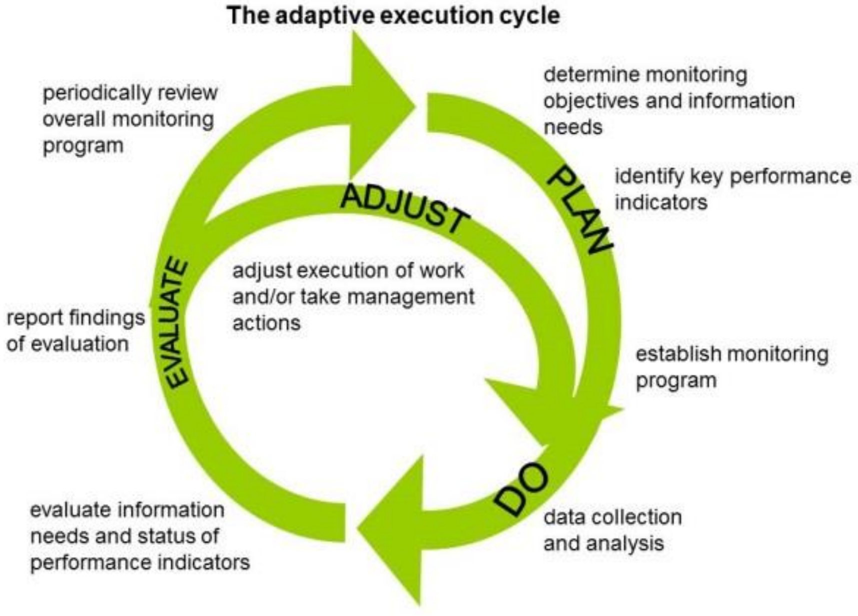


Figure 6.1 Adaptive Management

The adaptive management approach and mitigation measures for this Project consist of:

- Continuous real-time turbidity monitoring and associated trigger/compliance levels as described in detail in the EMMP [14].
- Use of a 'green valve' to reduce turbulence in the overflow system, described in section 3.4.2.
- Assurance monitoring, undertaken by LPC, to monitor potential longer term effects, by a comprehensive set of ecological monitoring prior, during and post-Dredging as described in detail in the EMMP [14].
- Marine mammal monitoring to prevent collision with marine mammals and impact from underwater noise, as described in detail in the MMMP [15].
- Management of biofouling as described in [16].
- Minimisation of outdoor lighting to reduce the potential for bird strike as described in section 6.3.
- Waste management and handling and storage of hazardous wastes, as described in section 6.5 and in further detail in the HSE Plan [29].

- Training to relevant personnel consisting of general environmental induction, marine mammal monitoring and identification of potential archaeological material as described in section 6.4.
- Measures to prevent any conflicts between the Dredging program and organized sporting events in the Lyttelton Harbour/ Whakaraupō as described in section 5.2.

6.3. Outdoor lighting

As part of the application process for the Consent Order a study has been carried out on the effects of dredging on marine avifauna [19]. The following marine birds have been identified in the area: Little Blue Penguin, the Yellow-Eyed Penguin, the Spotted Shag, Pied and Little Shags, Gulls, various types of Oystercatchers, Reef Heron and White-faced Heron.

The effect of the Project on marine avifauna is assessed to be low to very low for most species, due to the mobile nature of these species, the large foraging area available, the restricted spatial extent and short-term nature of any effects.

However, to minimise any effects of bird strike associated with vessel lights, lighting on the vessels will be kept to the minimum required to ensure safe operations and navigation. As a standard all lighting will be faced downwards, whenever practicable. Lighting on the vessel will comprise of:

- Deck lighting;
- Navigational lights;
- Lighting on the trailing arm and draghead such that the Dredge Master can visually locate the dredging equipment during deployment and retrieval.

6.4. Environmental training

The following environmental will be provided during the project:

- General induction will be given to all project personnel including environmental awareness specific to the Project.
- Operational staff will be trained in the contents and operation of the EMMP, particularly the use of the online monitoring website and trigger level system.
- Marine mammal monitoring induction to all dredge and auxiliary vessels in the harbour, described in detail in the MMMP [15].
- Training to a crew member on board the dredge vessel dedicated as marine mammal observer, described in detail in the MMMP [15].
- Training to a dedicated person on board the dredge vessel to recognise any potential archaeological material including koiwi tangata or taonga. Training will be provided by a local runanga representative and a trained archaeologist from LPC's archaeological consultant (Underground Overground).

6.5. Waste Management & Hazardous Substances

All Contractor vessels, owned or chartered will be fitted with proper disposal containers for segregation and collection of on-board wastes. The containers are fitted with lids to prevent material being blown overboard during either storage or handling. A licensed contractor will be appointed to collect and dispose of project waste materials.

The various types of solid and liquid wastes that may be generated during the dredging activities are:

- Liquid waste;
- Hazardous waste;
- General solid waste (putrescible);
- General solid waste (non-putrescible);
- Recyclables.

6.5.1. Hazardous waste

No bulk hazardous materials are planned to be used during the course of the Project. The Contractor Project Manager will ensure that any hazardous materials used during the project are controlled and appropriately managed. An inventory of any hazardous materials will be maintained on the respective vessels.

The Contractor will ensure that the Employer is provided with details of chemicals and hazardous substances proposed to be used in execution of the project. Information on all chemical and hazardous substances will be provided by reference to the appropriate Safety Data Sheets (SDSs).

Physical storage, handling/transport and usage shall comply strictly with the procedures as defined in the product MSDS guidelines and New Zealand legislative requirements. Personal Protective Equipment (PPE) will be provided to the workers and extra precautionary measures shall be taken where necessary. Welding, cutting or grinding operations will not be permitted in the vicinity of flammable substances storage.

All project personnel are responsible for making themselves aware of and applying the controls and precautions as per manufacturer's instructions/recommendations when working with hazardous materials, this includes Environmental controls.

6.5.2. Waste Management Measures

- Where practicable, Contractor will separate waste streams and re-use, reduce and recycle waste to minimise the impact on the environment.
- Only approved and licensed waste contractors will be employed for waste disposal.
- Any chemicals and hazardous substances used during all phases of the Project will be selected and managed to minimise the potential adverse environmental impact associated with their transport, transfer, storage, use and disposal.
- Safety data sheets (SDSs) will be available at the facilities to aid in the identification of appropriate spill clean-up and disposal methods.
- Waste will be stored in the designated waste stations and appropriately segregated into categories as specified in the EPA waste classification guideline.
- Bins or other putrescible wastes will be covered to prevent scavenging by animals or infestation by flies.
- All hazardous liquid wastes will be stored over a bund in leak-proof sealed containers.
- All waste receptacles will be clearly labelled as to the nature of the materials that may be placed in them in order to avoid contamination

Dredge vessels adhere to i.e. the following Standard Code of Practices:

- International Convention on the Prevention of Marine Pollution by Dumping of Wastes or Other Matter 1972 [9]
- International Convention for the Pollution of Pollutions from Ships (MARPOL) 2005 [10]
- International Ships Management (ISM) Code
- Maritime New Zealand Code of practice for health and safety in port operations, published by Occupational Safety and Health Service – Department of Labour. Dated May 2004 [4]
- Occupational Health & Safety Policy Statement.

For more detail on waste management and storage and handling of Hazardous substances reference is made to the HSE plan [29].

7. DREDGING CONTROL & SURVEY

7.1. Dredging Control TSHD

Controlling the dredging process is supported by means of the TSHD's Dredge View 2.0 – Hopper Monitoring System (DV2-HMS), a Boskalis' in-house development. The computer system monitors and displays all the dredging processes such as the position and level of the draghead, pump settings, power control and bottom doors.

Input variables for DV2-HMS are:

- Positioning in vertical and horizontal planes, based on a commercially available DGPS signal or using more accurate RTK-DGPS signal (see chapter survey);
- Tide signal receiver, providing the real-time water level;
- Heading of the TSHD, derived from a gyro-compass.
- List, trim and draft measurements on the TSHD;
- Suction tube position monitoring system (STPM); this is a system comprising of pressure sensors and angle transducers, which enable calculation of horizontal and vertical co-ordinates of the draghead(s), relative to the vessel;
- The Digital Terrain Model (DTM) comprising at least of the following layers:
    - Design, which is the desired situation, as defined by the Contract;
    - In-survey, which is the initial situation of the seabed as observed at the start of the works;
    - Intermediate survey, which is the situation of the seabed at regular intervals during the actual dredging campaign.

The positioning system determines the actual vessel and draghead position(s) and presents the results, relative to the area to be dredged, on navigational displays. The vessel and draghead position results are derived by calculation from the X, Y, Z inputs from the RTK-DGPS positioning and tide gauge systems together with the data from the angle transducers, the pressure sensors and the vessel's gyro compass.

The position of the vessel and draghead(s) are visualised on screen against a background of bathymetric data, obstacles, buoys and special features such as the presence of existing cable(s) or pipeline(s). For example a plan view is displayed with a coloured differential chart showing the areas to be dredged, together with a longitudinal and cross sectional profile indicating the seabed level and design. The graphical display can also visualise the tracks the TSHD has sailed previously.

DV2-HMS allows the operator maximum control over the dredge area, both in the horizontal and vertical planes. Impressions of the DV2-HMS's operator's displays are given below.

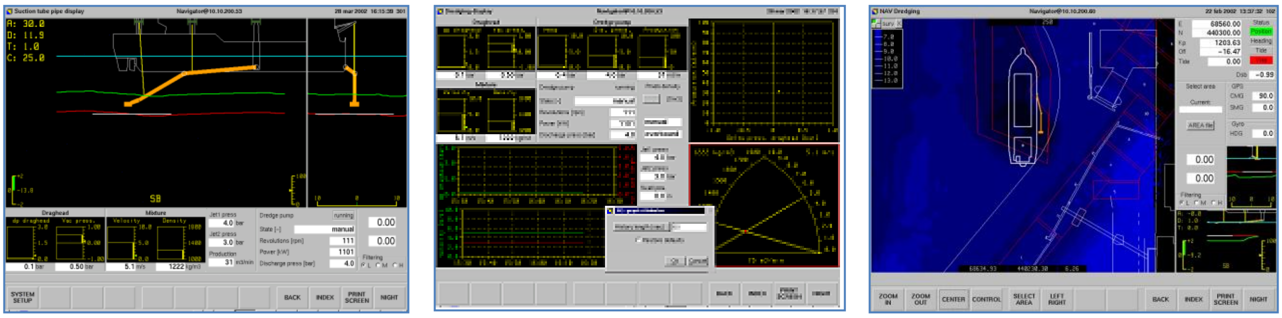


Figure 7.1 DV2-HMS TSHD control displays. Suction tube display, suction production display and main navigation display

Dredging tolerances are an accumulation of positioning and tracking accuracy, soil characteristics, swell, tide, data errors and operator's skills.

For discharging via the bottom doors, it is possible to pre-define so called 'discharge-boxes' in the DV2-HMS module. These boxes enable the helmsman to accurately position the TSHD above a specific target, in order to discharge the dredged material in that particular box. This is illustrated in the figure below. The location of the boxes can be defined during preparation of the works by the surveyor, superintendent and TSHD's Captain.

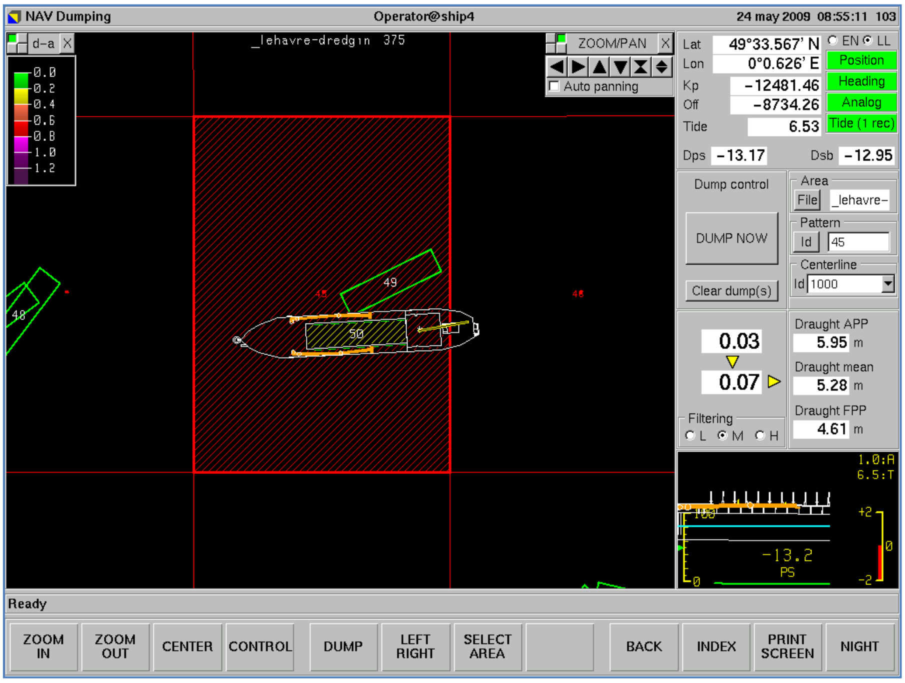


Figure 7.2 DV2-HMS TSHD control display of discharge boxes

7.2. Survey

Dredged spoil material will be discharged in the designated disposal ground by means of TSHD bottom dumping as described in section 3.6. The disposal ground is located approximately 5 NM offshore of the Harbour Heads, located as shown in Figure 1.2.

The disposal area will be subdivided by the Contractor into various disposal boxes as described in the previous section. To ensure the dredged material is always discharged within the boundaries of the Dredge Spoil Disposal Area each box will be subdivided into smaller disposal boxes. The size of each individual disposal box will be adjusted to the discharge footprint of the vessel, therefore ensuring that the TSHD has disposal boxes suitable for its specific dimensions. The additional subdivision of the main boxes will allow for control of distribution and gradual build-up of the material within the disposal area. A 100m buffer zone where disposal will not occur will be maintained along the edge of the Dredge Spoil Disposal Area as a safeguard.

The disposal location of each load will be logged and recorded. Regular progress surveys will be undertaken to ensure all vessels are provided with accurate bathymetrical data. The vessel will discharge its load evenly across the dedicated discharge boxes. In practice this means that the vessel will be discharging at slow speed to ensure the load is spread and no unwanted high spots are created. Based on the sediment behaves during disposal (informed by the progress surveys) the disposal process may be further optimised to ensure even deposition by altering the vessel speed whilst depositing the load.

8. REFERENCES, ABBREVIATIONS, DEFINITIONS

8.1. References

Controlled Legislation		
No.	**Document No.**	**Document Title**
[1]	CRC172455	Coastal Permit under section 12 of the Resource Management Act 1991
[2]	CRC172522	Discharge Permit under section 15, 15A and 15B of the Resource Management Act 1991.
[3]		Canterbury Regional Council Navigation Safety Bylaw 2016 and Controls
[4]		Maritime New Zealand Code of practice for health and safety in port operations, published by Occupational Safety and Health Service – Department of Labour. Dated May 2004
[5]		Maritime Transport Act 1994
[6]		Health and Safety in Employment Act 1992
[7]		Resource Management Act 1991
[8]		Resource Management (Marine Pollution) Regulations 1998
[9]		International Convention on the Prevention of Marine Pollution by Dumping of Wastes or Other Matter 1972.
[10]		International Convention for the Pollution of Pollutions from Ships (MARPOL) 2005

Client Documents		
No.	**Document No.**	**Document Title**
[11]	LYT263462 5982618.6	Request for Tender – Channel Deepening Project Stage 1 - September 01, 2017
[12]	LYT263462 5982619.6	Contract 1892 - Channel Deepening Project Stage 1 - September 01, 2017
[13]	301311-09433-CS-SPC-001-0	Channel Deepening Technical Specification – Dredging and Spoil Disposal – September 01, 2017
[14]	Enviser 1006	Environmental Monitoring and Management Plan
[15]	TBA	Marine Mammal Management Plan
[16]	TBA	Biosecurity Management Plan
[17]		Application CPDW Coastal Marine Area Lyttelton Harbour Appendix 9 - Plumes During Dredging, May 2016
[18]		Application CPDW Coastal Marine Area Lyttelton Harbour Appendix 10A – Plumes During Disposal

Client Documents		
No.	**Document No.**	**Document Title**
		(Capital), March 2016
[19]		Application CPDW Coastal Marine Area Lyttelton Harbour Appendix 17 – Effects on Marine Birds, September 2016
[20]	GEOPLCOV00220AA-AB	Coffey 2015, Te Awaparahi Bay - Marine Geophysical Survey - Land Reclamation at Te Awaparahi Bay - Stage 1
[21]	GEOPLCOV00220AC-AC	Coffey 2016, Proposed Deepening and Extension of Lyttelton Port Approach Channel - Report of A13 Capital Dredge Geophysical Investigation
[22]	GENZCHRI15656AL	Coffey 2017, Lyttelton Port of Christchurch Te Awaparahi Bay Ground Investigation - Factual Report
[23]		OCEL 2006, Geotechnical Investigation of the Hard Layer in the Lyttelton Harbour Navigation
[24]		OCEL 2009, Deepening and Extension of the Navigation Channel - Capital and Maintenance Dredging Impact on the Physical Environment
[25]		OCEL 2016, Geotechnical Investigation for the Dredging Required to Extend and Deepen the Lyttelton Navigation Channel – Preliminary Results Summary
[26]		OCEL 2016, Capital Dredging Geotechnical Investigation Report
[27]	301311-09433–SS-REP-001	Worley Parsons 2017, Channel Deepening Geotechnical 2016/2017 Site Investigation Factual Report
[28]	301311-09433–SS-REP-002	Worley Parsons 2017, Channel Deepening Geotechnical Interpretive Report

Boskalis Documents		
No.	**Document No.**	**Document Title**
[29]	554-10023-02-01	Health, Safety, Environment Management (HSE) Plan
[30]	554-10023-02-02	Quality Management Plan
[31]	554-10023-02-03	Emergency Response Plan
[32]	554-10023-14-01	Survey Method Statement

8.2. Abbreviations

Abbreviation	Full meaning
ADP	Accidental Discovery Protocol
AIS	Automatic Identification System
BHD	Backhoe Dredge
BKA	Boskalis Australia Pty Ltd (Contractor)
BMP	Biosecurity Management Plan
CD	Chart Datum
Consents	Consent CRC172455 and CRC172522
Consent Authority	Canterbury Regional Council
CTV	Crew Transfer Vessel
DGPS	Differential Global Positioning System
DMP	Dredging Management Plan
DP/DT	Dynamic Positioning & Dynamic Tracking
DTM	Digital Terrain Model
DV2-CMS	Dredge View 2.0 Monitoring System
EMMP	Environmental Monitoring and Management Plan
HSE	Health, Safety & Environment
ISM	International Ships Management
km	Kilometre
LOA	Length Over All
LPC	Lyttelton Port Company
m	Metres
MARPOL	International Convention for the Prevention of Pollution from Ships
MMMP	Marine Mammal Management Plan
NM	Nautical Mile
NTU	Nephelometric Turbidity Units
PLP	Port Lyttelton Plan
PPE	Personal Protective Equipment
rev	Revision
SHE-Q	Safety, Health, Environment and Quality
SIMOPS	Safe Implementation of Simultaneous Operations
TSHD	Trailing Suction Hopper Dredge
WoW	Way of Working

8.3. Definitions

Definition	Full meaning
Employer	Lyttelton Port Company
Contract number	1892
Contractor	Boskalis Australia Pty. Ltd.
Project	Channel Deepening Project Stage 1
Project number	554-10023
Subcontractor	Companies contracted by Contractor to perform a specific portion of the work.
Supplier	A company that is requested to supply (temporary) materials or services on behalf of Contractor

9. ATTACHMENTS

9.1. Specifications TSHD Oranje

Boskalis
Dredging & Marine Experts

EQUIPMENT SHEET

ORANJE
TRAILING SUCTION HOPPER DREDGER

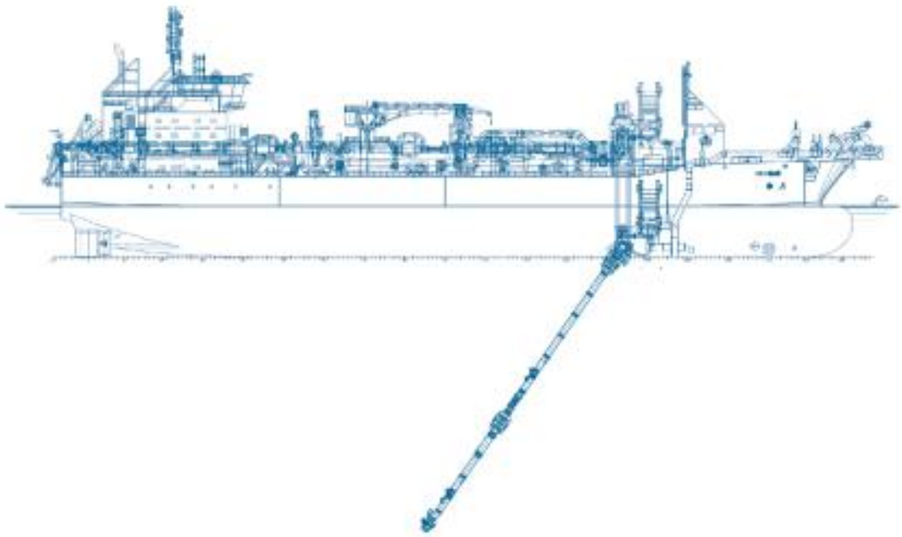
CONSTRUCTION/CLASSIFICATION	
Built by	Merwede Shipyard
Year of construction	2004
Classification	B.V. I ✠ HULL ✠ MACH ✠ AUT-UMS, hopper dredger, unrestricted navigation, dredging over 15 miles from shore, MON-SHAFT.

FEATURES
Long suction pipe with underwater pump.
3 gravity-gantries.

MAIN DATA	
Gross tonnage	18,091
Length overall	156.00 m
Breadth	28.00 m
Moulded depth	15.00 m
Max. draught empty	4.63 m
Max. draught Int. load line	9.24 m
Max. draught dredging load line 1	12.02 m
Max. draught dredging load line 2	12.84 m
Carrying capacity (D.W.)	30,445 t
Hopper capacity	15,961 m³
Suction pipe diameter	2 x 1.00 m
Max. dredging depth	90.0 m
Discharge systems	bottom doors/pump ashore/ rainbow installation
Sailing speed loaded	16.2 kn
Total installed power	19,500 kW
Sand pump output	5,000 kW
Jet pump output	3,000 kW
Pump ashore output	8,800 kW
Propulsion power sailing	14,000 kW
Bow thruster	1,400 kW

ORANJE

TRAILING SUCTION HOPPER DREDGER



SIDE VIEW

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| 01 – 2012

9.2. Specifications TSHD Fairway

Boskalis
Dredging & Marine Experts

EQUIPMENT SHEET

FAIRWAY
TRAILING SUCTION HOPPER DREDGER

CONSTRUCTION/CLASSIFICATION

Built by	Verolme Shipyard Heusden B.V.
Year of construction	1997
Year of modification	2013
Classification	B.V. I ✠ HULL ✠ MACH ✠ AUT-UMS Hopper dredger Dredging within 15 miles from shore, or within 20 miles from port, dredging over 15 miles from shore with H.S. ≤ 3.5m Unrestricted navigation Mon-shaft

FEATURES

- Optional dredging depth 83 m at PS, with submergible dredge pump.
- 2 independent flad-rudders
- Extended in 2002 with 54 m
- Equiped with DP/DT system
- Equiped with TDM - measurementsystem

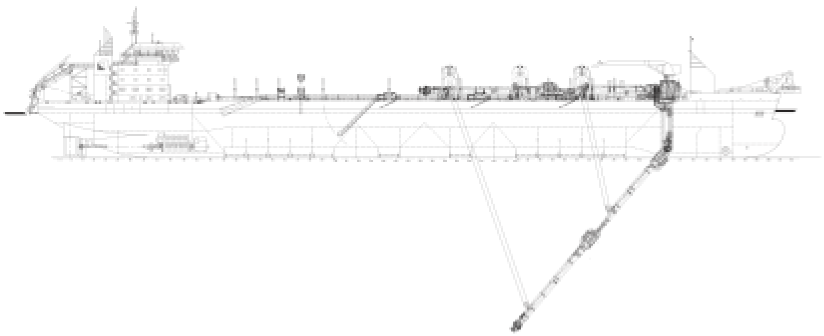
MAIN DATA

Gross tonnage	33,423
Length overall	230.71 m
Breadth	32.00 m

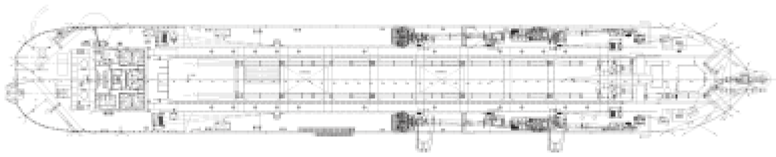
MAIN DATA (CONTINUED)

Moulded depth	15.90 m (Aft ship)/ 16.85 m (Mid ship)
Max. draught Int. load line	13.50 m
Max. draught dredging load line	13.50 m
Carrying capacity (D.W.)	58,298 t
Hopper capacity	35,500 m³
Displacement D.L.L.	82,910 t
Suction pipe diameter	2 x 1,200 mm
Max. dredging depth	70 m
Discharge systems	24 Bottom door sections Pump ashore Rainbow installation Back filling
Sailing speed loaded	16.0 kn
Total installed power	27,550 kW
Dredge pump output	SB: 6,000 kW (inboard dredge pump only) PS: 6,000 kW (inboard dredge pump only)
Jet pump output	3 x 1,000 kW
Pump ashore output	2 x 6,000 kW
Propulsion power sailing	23,000 kW
Bow thruster	2,650 kW

FAIRWAY
TRAILING SUCTION HOPPER DREDGER



SIDE VIEW



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9.3. Specifications Sweeping Vessel

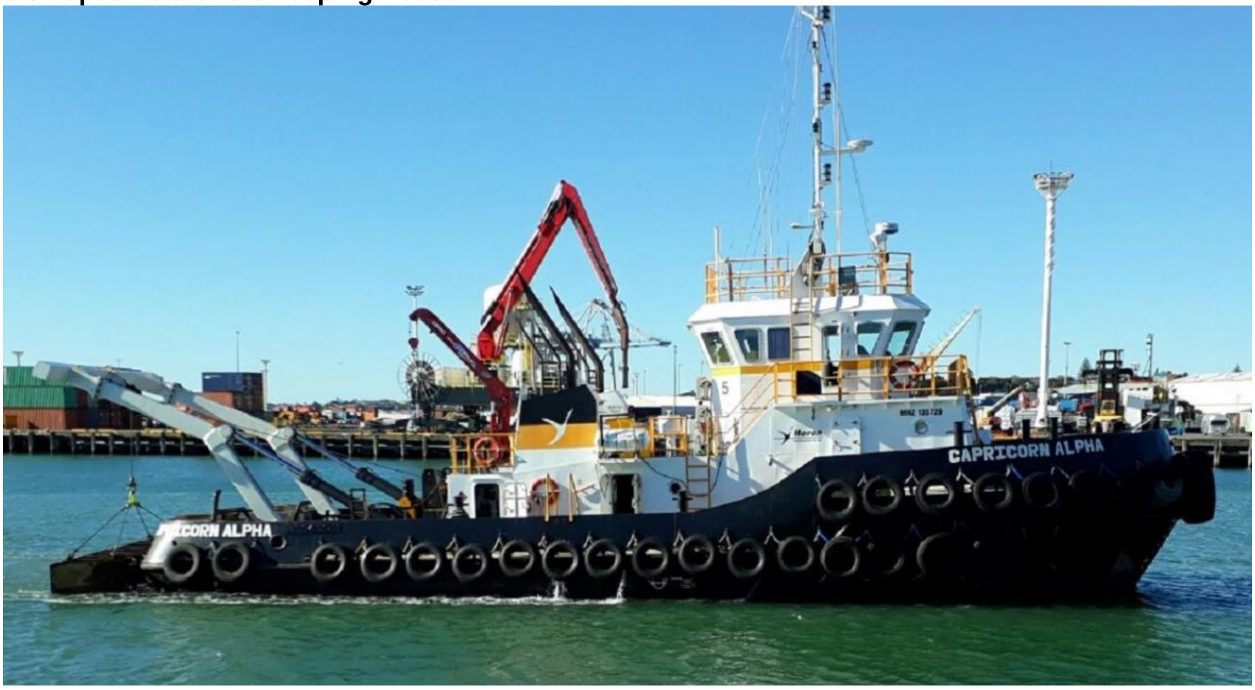


Figure 9.1 Sweeping Vessel "Capricorn Alpha"

Name	Capricorn Alpha
Type	Ocean Going Tug
Class	BV – Tug, Unrestricted navigation - MNZ – Restricted Coastal
Official and MNZ	876460 MNZ135729
Operators	Heron Construction Company Ltd
Port of registry	Auckland, New Zealand
Call Sign	ZMG 3155
Gross tonnage	196
Nett tonnage	59
Length overall	26.0m
Breadth	8.0m
Max draft	3.0m
Main engines	2 x Yanmar 6AYM-WET
Power	2 x 610Kw (1220Kw)
Auxiliaries	1 x 6BT Cummins, 1 x 4BT Cummins.
Propellers	Twin screw, 4 blade + kort nozzles
Bollard pull	22.5 tonne
Towing specifications	Tow winch 500m x 32mm IWC Wire
Hydraulic A-frame	20 tonne SWL – suitable for anchor recovery, bed levelling (blading)
Compass	Furuno Satellite Compass, Saura Keiki Magnetic Compass
GMDSS Equipment	Furuno
Radar Transponder	Kannad Rescuer
Radar	Furuno 24 Nm
Plotter	TMQ GPS Plotter (C Plot)

Name	Capricorn Alpha
Echo Sounder	Furuno LS 6100
Auto Pilot	TMQ Auto Pilot

9.4. Specifications Backhoe Dredge

Boskalis
Dredging & Marine Experts

Lyttelton Port of Christchurch

Boskalis
Dredging & Marine Experts

EQUIPMENT SHEET

STORKEN
BACKHOE DREDGER

CONSTRUCTION/CLASSIFICATION

Built by	De Donge
Year of Construction	1985/2001

FEATURES

Equipped with a computerised excavation monitoring system (CMS)

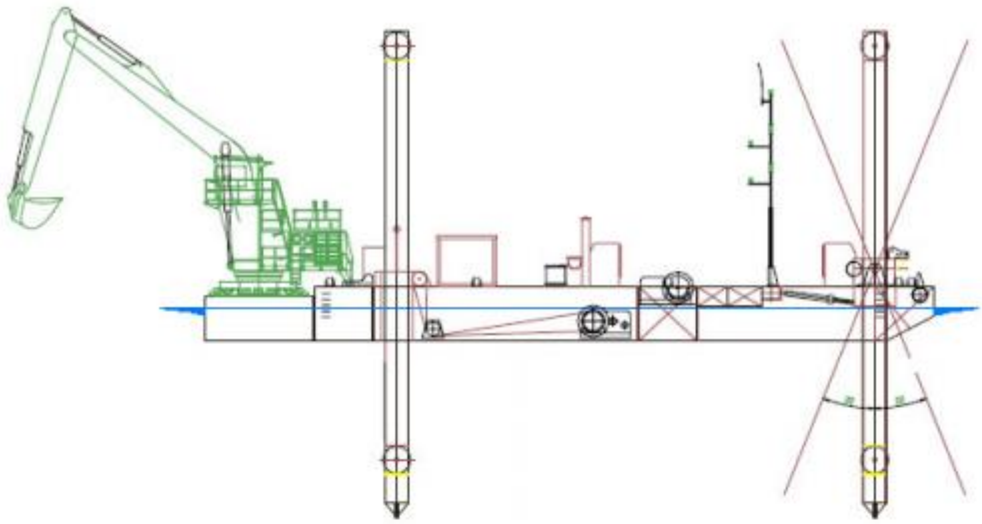
Crane barge consists of 12 individual pontoons

Spuds remotely controlled from operator's cabin

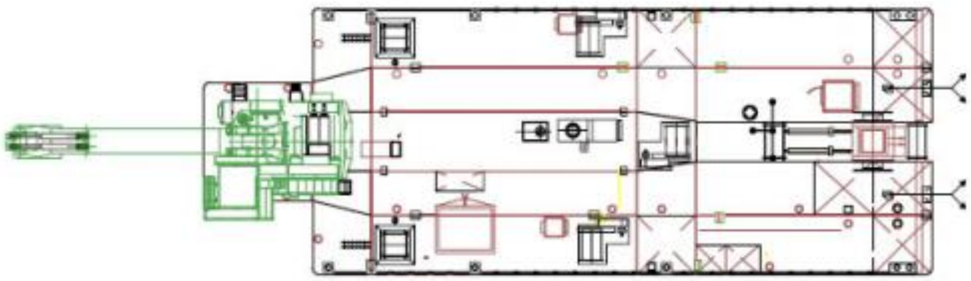
MAIN DATA

Length	37.02 m
Breadth	13.52 m
Depth	2.5 m
Draft Dredging	2.2 m
Service Capacities	Fuel 40,000 l, Hydraulic Oil 3,000 l
Gross tonnage	323 t
Nett tonnage	97 t
Mooring System	3 Spuds
Excavator	Komatsu PC-1400 (Aquadigger Version)
Weight	115 t
Installed Power	565 kW
Service Capacities	Fuel 1,800 l Hydraulic Oil 1,610 l
Boom Length	12 m & 14 m
Stick Length	8.5 m
Bucket Capacity	3.3, 3.8, 5.0, 6.0 m³
Dredging Depth	16.5 m

STORKEN
BACKHOE DREDGER



SIDE VIEW



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9.5. Specifications Crew/Survey Vessel

Figure 9.2 Typical Crew Transfer/Survey Vessel "Star Keys"

Table 9.1 Specifications Typical Crew Transfer/Survey Vessel "Star Keys"

Classification	Survey/Patrol/Crew/Research
Year built	1998
Length O.A.	19.10 m
Beam	5.4 m
Draft	1.9 m
Builder	Image Marine Group WA
Construction	Aluminium
Maximum Speed	24 knots
Transit Speed	10 knots
Fuel	6,000 litres
Fresh Water	600 litres + Water Maker
Deck Area	45m2
Tender	IBC RIB, 25HP
Navigation	Radar, Autopilot, Depth Sounder, Radios, Magnetic Compass, GPS, SSB, Plotters, AIS.
Other	Towing Post, Survey Pole
Main Engines	Caterpillar C32 Total 1,099 HP
Generators	1 x Onan 27 kVA
Deck Power Outlet	3 Phase, 400V/20A/5 Pin

Classification	Survey/Patrol/Crew/Research
Propulsion	Single Screw 4 Blade, Bowthruster
Deck Machinery	Palfinger PK 11001 crane (aft), Pot Hauler
Bollard Pull	5 T
Helm Stations	Bridge/Fly Bridge/Deck
Enclosed & Inshore (12 miles)	42 POB, Passenger
Coastal (50 miles)	10 POB, Non-Passenger
Offshore (200 miles)	10 POB, Non-Passenger