Infrastructure Victoria
4 May 2017

Infrastructure Victoria Second Container Port Advice

Navigation Study

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Infrastructure Victoria

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Executive summary

The Victorian Special Minister of State has asked Infrastructure Victoria to provide advice on the future capacity of Victoria's ports, focusing on the need for, timing and location of a second container port.

Currently all container shipping into Victoria is through the Port of Melbourne, which is Australia's largest container port. The Infrastructure Victoria Study is preparing advice on the ultimate capacity of Port of Melbourne; when the port will reach capacity and when a second container port will be required.

The Special Minister of State has also asked Infrastructure Victoria to assess two possible sites for the second container port; one at Hastings in Western Port and one at Bay West in Port Phillip Bay.

This navigation study investigates the approach channels in both Western Port and Port Phillip Bay to assess what channel upgrade works are required to cater for the largest container vessels currently in service. Additionally, the largest vessel that could enter the Port Phillip Heads without any channel modifications is assessed, with a review of metocean conditions that would likely limit accessibility to such vessels.

The largest container vessels currently in service in the world fleet have a capacity of approximately 18,500 TEUs (twenty foot container equivalent), a length (LOA) of up to 400 m and a width (beam) of up to 59 m. This class of vessel is known as Ultra Large Containerships. The maximum design draught of these vessels is typically 16 m, however the typical average sailing draught for these vessels visiting Melbourne is expected to be in the range of 12.8-14.4 m or 80-90 percent of the maximum design draught.

The approach for this study encompasses four components:

- concept design of the approach channels in accordance with the design principles outlined in *PIANC Design Guidelines for Harbour Approach Channels 2014* (PIANC 2014)
- real-time navigation simulations to provide proof-of-concept of the channel alignments and pilot operating procedures
- vessel motion simulations to assess the channel availability under a range of metocean conditions, and to determine either the required increase in depth or the percentage channel availability
- channel capacity assessment for the access channels.

This report contains inputs from the Port of Hastings channel design work undertaken by the AECOM + GHD Joint Venture for the Port of Hastings Development Authority (AECOM + GHD Joint Venture, 2015).

All modelling and investigations undertaken for this study are at concept/preliminary level only, and further work will be required prior to any operational or infrastructure changes to either port.

Port Phillip

The key findings for Port Phillip are:

- vessels with a capacity of up to 14,000 TEUs (New Post Panamax class) are able to transit the Port Phillip Heads in its existing configuration to access Webb Dock, albeit with more stringent tidal current speed limitations.
- the West Gate Bridge limits the size of vessels transiting upstream to Swanson Dock to approximately 9,000-9,500 TEU capacity, although the precise capacity limit will vary from ship to ship depending on the sailing draught of the vessel. Notwithstanding, Swanson Dock will remain limited to the existing size of vessels (approximately 7,500 TEU capacity) due to the dimensions of the Swanson Dock swing basin, width of Swanson Dock, vessel generated waves and interaction with moored vessels in the Yarra River.
- To enable Ultra Large Containerships of 18,500 TEU capacity to enter Port Phillip Bay, the critical section for vessel transits – the Great Ship Channel at Port Phillip Heads – will need to be

widened in the order of 180 m to a width of 425 m. This will allow a vessel with a draught of 14 m to enter Port Phillip, however deepening of the Great Ship Channel will be required to enable regular access for these vessels running at a deeper draft, or larger container vessels.

Due to the strong tidal currents that exist at Port Phillip Heads, there are currently limitations on the maximum tidal current speeds for container vessels with a draught of greater than 12.1 m. These tidal current speed restrictions vary if the tide is coming in (flood tide) or going out (ebb tide). They limit the time that the channel is available for these vessels to transit the Great Ship Channel. Table 1 summarises the current restrictions and the percentage of time that a vessel of that size can transit the Great Ship Channel.

Table 1. Summary of tidal current limitations and channel availability

Representative Class	Nominal TEU Capacity	Draught (m)	Inbound Transit (knots)		Inbound Availability	Outbound Transit (knots)		Outbound Availability
			Flood	Ebb		Flood	Ebb	
Existing configuration of the Great Ship Channel								
Old Post Panamax	7,500	14.0	5	5	76%	5	4	65%
Old Post Panamax Plus (8,500 TEU)	8,500	13.0	4	3	65%	3	3	49%
New Post Panamax (14,000 TEU)	14,000	13.5	3	1.5	36%	3	1.5	35%
Widened the Great Ship Channel by 180 m								
Ultra Large Containership	18,500	14.0	3	3	24%	3	3	21%
Widened the Great Ship Channel by 180 m and deepened by 1.5 m								
Ultra Large Containership	18,500	15.0	3	3	41%	3	3	38%

New Post Panamax (14,000 TEU) class vessels can only transit the Great Ship Channel about one third of the time, or eight hours a day on average. A simplified channel capacity assessment of the Great Ship Channel and South Channel was undertaken for a constrained scenario that limited the size of vessels entering Port Phillip to 14,000 TEU New Post Panamax vessels. The channel capacity assessment considered that all vessels greater than 10,000 TEU capacity, and tankers (crude oil and refined fuels), are limited to eight hours per day on average.

The assessment found that the ultimate channel capacity of the Great Ship Channel and South Channel is approximately 24 percent higher than the vessel call forecast for 2066, based on a maximum channel utilisation of 70 percent. For a highly-managed channel with defined periods for inbound and outbound transits, for instance convoys, the ultimate channel capacity is approximately double the vessel call forecast for 2066.

Expansion of Webb Dock to cater for the New Post Panamax class of vessels would result in a 23 percent channel utilisation of the Port Melbourne and Williamstown channels. This is not expected to adversely impact the marine operations of Port of Melbourne.

Table 2 outlines a summary of the existing approach channel constraints for various classes of container vessels beyond the maximum vessel that can currently visit the Port of Melbourne (Old Post Panamax with a 7,500 TEU capacity).

Table 2. Summary of constraints for various container vessel classes based on existing channel configuration

Section	Container Vessel Class					Comment on Existing Limitation
	Old Post Panamax, 7,500 TEU	Old Post Panamax Plus, 8,500 TEU	Old Post Panamax Plus, 9,500 TEU	New Post Panamax, 14,000 TEU	Ultra Large Container-ship, 18,500 TEU	
Great Ship Channel	✓	✓	✓	✓	X	Width of channel
South Channel	✓	✓	✓	✓	✓	
Port Melbourne Channel	✓	✓	~	~	X	Width of channel, may be sufficient subject to simulations
Williamstown Channel	✓	✓	~	~	X	Width of channel beyond Webb Dock Swing Basin only
Webb Dock Swing Basin	✓	~[1]	~[1]	X	X	Size of swing basin
Webb Dock	✓	✓	✓	~[2]	~[2]	Width of northern section; southern section adequate
Yarra River Channel	✓	X	X	X	X	Width of channel
West Gate Bridge	✓	✓	~[3]	X	X	Air draught
Swanson Dock Swing Basin	✓	X	X	X	X	Size of swing basin
Swanson Dock	✓	X	X	X	X	Width of dock

1. These vessels may be able to use the swing basin subject to further investigation
2. Larger vessels would be able to access the southern section of Webb Dock East where the Victorian International Container Terminal (VicT) is located. There will be beam restrictions in the northern section if both sides are used; however this will depend on how Webb Dock is reconfigured/expanded in the future.
3. Depends on the particular vessel air draught and the sailing draught at the time of the transit.

Western Port

To cater for Ultra Large Containerships with a draught up to 14.5 m, the following upgrades will be required to the approach channels for the Port of Hastings:

- widening of parts of Western Channel within the naturally deep area to allow two-way transits
- increasing the declared depth in Western Channel by 2.2 m from -14.8 m CD to -17.0 m CD in the first segment of Western Channel up to McHaffie's Reef, and by 1.7 m from -14.8m CD to 16.5 m CD between McHaffie's Reef and Sandy Point
- widening of North Arm between Sandy Point and Cribb Point from 183 m to 250 m, and adjusting the angle of the channel by two degrees to ease the transit into and out of this segment of the channel
- increasing the declared depth in the North Arm by 1.5 m from -14.2 m CD to -15.7 m CD.

A design vessel draught of 14.5 m represents 90 percent of the maximum design draught of 16 m, which is the typical maximum design draught of the Ultra Large Containership-class vessels expected

to visit Melbourne. Vessels with a deeper draught can still use the approach channels with additional tidal assistance. Most of the dredging in the approach channels will occur in North Arm, while the dredging in Western Channel is largely limited to high points along the channel. The one way section of North Arm will not limit the performance of the port, as its length is relatively short (8 km). Apart from the initial stage, when the number of vessel calls is limited, the multiple swing basins in subsequent stages will allow for flexibility in managing vessel arrivals and departures.

Figure 1 outlines the ‘Along the Shore Alignment’ for the Port of Hastings development, with 5,000 m of quay line for the container terminals. This alignment allows for the continued use of Long Island Jetty and the incorporation of a 200 m long general purpose wharf to replace the BlueScope Steel wharf. The 780 m width of the southern 2,200 m of quay line allows flexibility for concurrent vessel movements and swing manoeuvres, while the 400m width of the remaining 3,000m of quay line allows for vessels to be safely manoeuvred back by tugs past a vessel at berth.

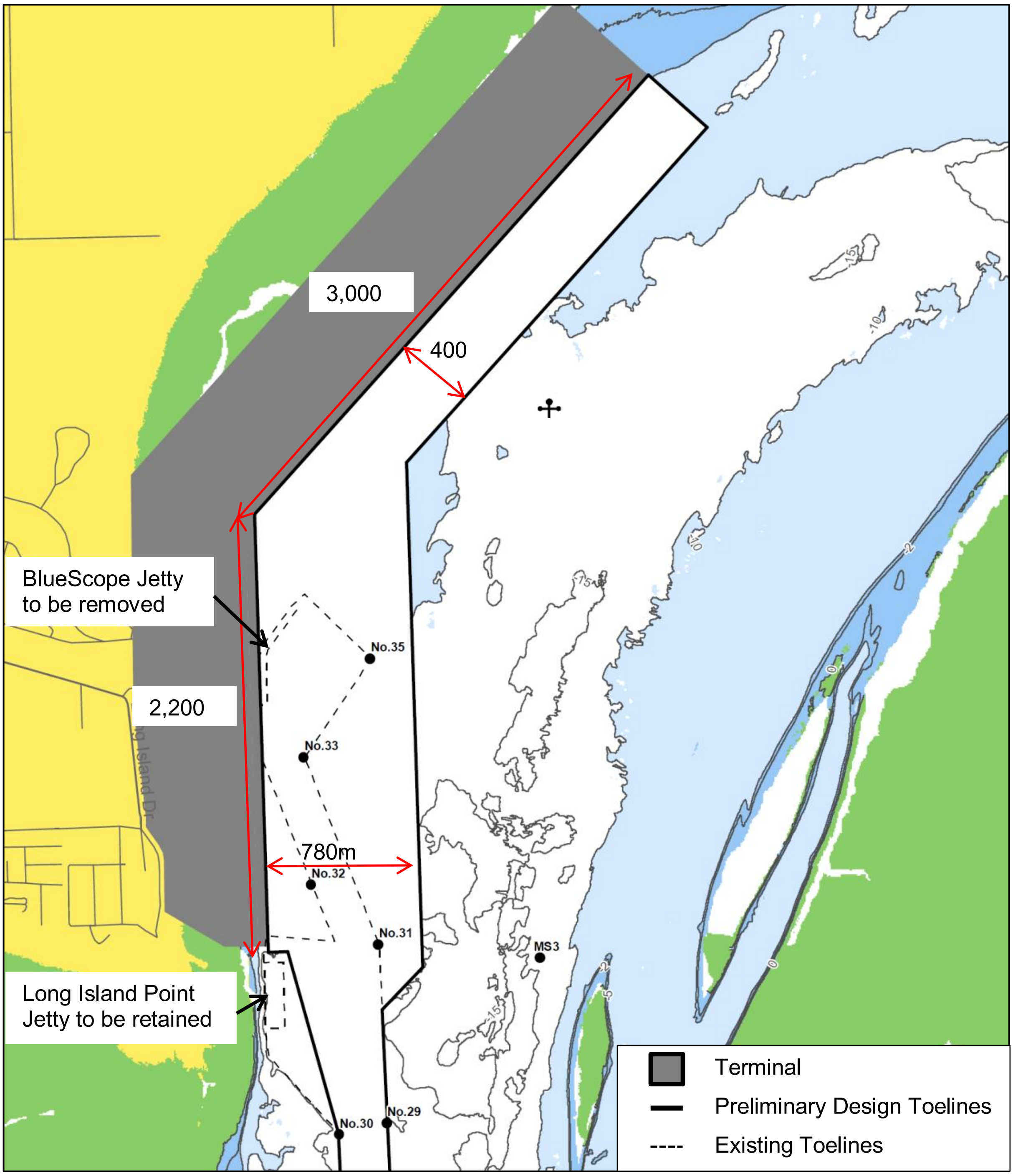

Figure 1. Port of Hastings Along the Shore swing basin alignment - preliminary design

Summary

The navigation study found that Ultra Large Containerships can access proposed port locations in both Bay West and Hastings with widening and deepening works to the existing approach channels to either of these ports. In Port Phillip, vessels with a capacity of up to 14,000 TEU can transit the existing Great Ship Channel at Port Phillip Heads. However vessels of this size will be limited to openings of approximately eight hours on average throughout the day, spread over 3-4 openings per day.

Although not assessed, there are no limitations on designing the Port of Hastings approach channels for the larger container vessels that are currently in international service.

A simplified channel capacity assessment found there is sufficient capacity within the channels for vessel numbers well beyond the 2066 vessel call forecast, however further assessments are required to quantify the delays experienced by each trade.

1.0 Introduction

1.1 Background information

The Victorian Special Minister of State has asked Infrastructure Victoria to provide advice on the future capacity of Victoria's ports, focusing on the need for, timing and location of a second container port.

Currently all container shipping into Victoria is through the Port of Melbourne, which is Australia's largest container port. The Infrastructure Victoria Study is preparing advice on the ultimate capacity of Port of Melbourne, when the port will reach capacity and when a second container port will be required.

The Special Minister of State has also asked Infrastructure Victoria to assess two possible sites for the second container port, one at Hastings in Western Port and one at Bay West in Port Phillip Bay.

1.2 Objectives

The key objectives of this study are to assess:

- the largest container vessels that can transit Port Phillip Heads with the existing shipping channel configuration, and under what metocean conditions this vessel can safely navigate through the approach channels
- channel upgrades required in Port Phillip and Western Port for the largest container vessels currently in international service, and under what metocean conditions these vessels can transit the channels
- changes to channel configurations and rules of operation required to ensure adequate capacity for the forecast future fleet spectrum
- ability to manoeuvrer the largest container vessels currently in international service at the previously planned Port of Hastings Container Terminal, and determine appropriate dimensions for the swing basin
- assess the ultimate channel capacity in terms of number of vessel transits for the forecast period and what capacity there is beyond the forecast period.

1.3 Scope and limitations

The scope of works undertaken includes the following:

- determination of the largest container vessel sizes to meet the objectives in Section 1.2.
- concept design of the approach channel and swing basin for Port of Hastings, and the channel upgrade for the Great Ship Channel and South Channel in Port Phillip; these being the more critical locations of the transits
- real-time navigation simulations to provide proof of concept for navigability of vessels greater than the maximum currently permitted to enter the port and determine what configuration changes and rules of operation may be required
- underkeel clearance (UKC) analysis to determine the limiting metocean conditions for a range of vessels and draughts
- channel capacity assessment for the Port Phillip Bay access channels
- channel availability assessments to assess the depth required or assess the percentage channel availability for the largest container vessels that can:
    - transit the Port Phillip Heads with the existing shipping channel configuration
    - transit the Port Philip Heads in a widened/deepened scenario
    - transit the approach channel to the Port of Hastings.

This report includes the Port of Hastings channel design work undertaken by the AECOM + GHD Joint Venture for the Port of Hastings Development Authority between January 2014 and March 2015 (AECOM + GHD Joint Venture, 2015).

However note that all modelling and investigations undertaken for this study are at concept/preliminary level only, and that further work will be required prior to any operational changes to the management of either port.

A glossary of the terms and acronyms used in this report is outlined in Appendix A.

1.4 Project team

The navigation study was undertaken by AECOM with specialist input from:

- Captain David Shennan of North & Trew Marine Consultancy Pty Ltd – marine operations and port management advice
- Port Phillip Sea Pilots – full-bridge real-time vessel simulations for the entrance to Port Phillip
- OMC International Pty Ltd – fast-time underkeel clearance (UKC) analysis
- HR Wallingford Pty Ltd – Western Port vessel simulations
- Australian Maritime College Search Ltd – Port Phillip vessel simulations
- Cardno – hydrodynamic modelling for vessel simulations

2.0 Study methodology

2.1 Design process and PIANC design methodology

The design of the approach channels has been undertaken in accordance with *PIANC Design Guidelines for Harbour Approach Channels 2014* (PIANC 2014). PIANC 2014 describes two stages in the design development:

- Concept Design involves preliminary design using a series of empirical rules derived from experience of similar conditions to determine the width, depth and alignment
- Detailed Design involves numerical models, physical models and/or simulations to validate, develop and refine the concept design.

PIANC 2014 also recommends the involvement of experienced users (pilots, mariners, etc.) in the design process.

The concept design for this study is based on the alignment of the existing channels being adjusted and widened as per the PIANC 2014 concept design guidelines, to develop potentially feasible channel configuration and dimensions. Given the complex hydrodynamics, metocean conditions and navigational environment within the entrance to Port Phillip, fast-time underkeel clearance analysis and full-bridge navigation simulations have also been employed in this study to provide further refinement and proof of concept. It should be noted that the use of these models does not constitute ‘Detailed Design’ as defined in the PIANC 2014 guidelines. For the purposes of this study, the inclusion of the additional modelling tools usually used for Detailed Design has been termed ‘Preliminary Design’.

2.2 Concept design

The concept design has been undertaken using the PIANC Guidelines. PIANC sets out empirical rules, developed from a review of existing navigation channels world-wide, which enable the estimation of minimum channel dimensions.

2.3 Pilot and harbour master discussions

To inform the Port of Hastings channel design, a workshop was held with the Port Phillip Sea Pilots and the Port of Hastings harbour master. This incorporated practical knowledge of the port and access channels. Discussions included pilotage practices particular to Victoria and general guidance on how pilots navigate the Port of Hastings approach channels.

Input from Port Phillip Sea Pilots was obtained for the Port Phillip Heads and South Channel concept design prior to the navigation simulations.

2.4 Preliminary design

Following concept design and the discussions with the pilots and harbour master, the following works were undertaken to further develop the channel concepts to ‘Preliminary Design’ standard for both ports, including:

- Real-time full-bridge navigation simulations to assess the feasibility of potential layouts and the width required
- update the channel widths and layouts based on the findings of the real-time navigation simulations
- underkeel clearance (UKC) analysis to assess the depth required for a range of metocean conditions
- channel availability assessments to determine the times the channels are accessible to vessels which are limited by their dimensions or sailing draught.

2.4.1 Real-time navigation simulations

The real-time navigation simulations were undertaken to assess the feasibility of the layouts and to provide initial refinement of the horizontal dimensions of the channel and manoeuvring area. The navigation simulations used realistic design vessel performance characteristics and metocean conditions (plus tug operations in the case of Port of Hastings) to create an overlay of vessel track plots. These track plots have been analysed to identify areas where the conceptual channel design has been overly conservative (hence dredge volumes can be reduced), or where geometry or operational design needs to be reconsidered.

2.4.2 Underkeel clearance (UKC) modelling

Underkeel clearance (UKC) is the distance between the vessel's hull and the ocean floor that is required to ensure the vessel hull does not touch, and that there is sufficient water under and around the hull in order for the vessel to manoeuvre. UKC allows for the following:

- uncertainties in the static draught of a vessel
- change in water density
- squat or lowering of the vessel as it moves through the water
- heel-rotation of the vessel as it turns due to inertia or as wind pushes against one side
- movement in the vessel due to waves
- allowance for vessel manoeuvrability
- safety margin between the bottom of the vessel and the ocean floor.

The UKC calculations are based on satisfying either a minimum bottom clearance of 0.25 m where the wave response is greater than 0.65 m (i.e. water depth required = static draught + squat + inertial heel + wind heel + wave response + 0.25 m) or a manoeuvrability margin minimum of 0.9 m (i.e. water depth required = static draught + squat + inertia heel + wind heel + 0.9 m).

The maximum permissible static draught required for safe operations for a particular channel is its declared depth (the vertical distance between shoalest point (highest protuberance) and the sea-level at lowest astronomical tide) less the UKC allowances. This is shown diagrammatically in Figure 2-1:

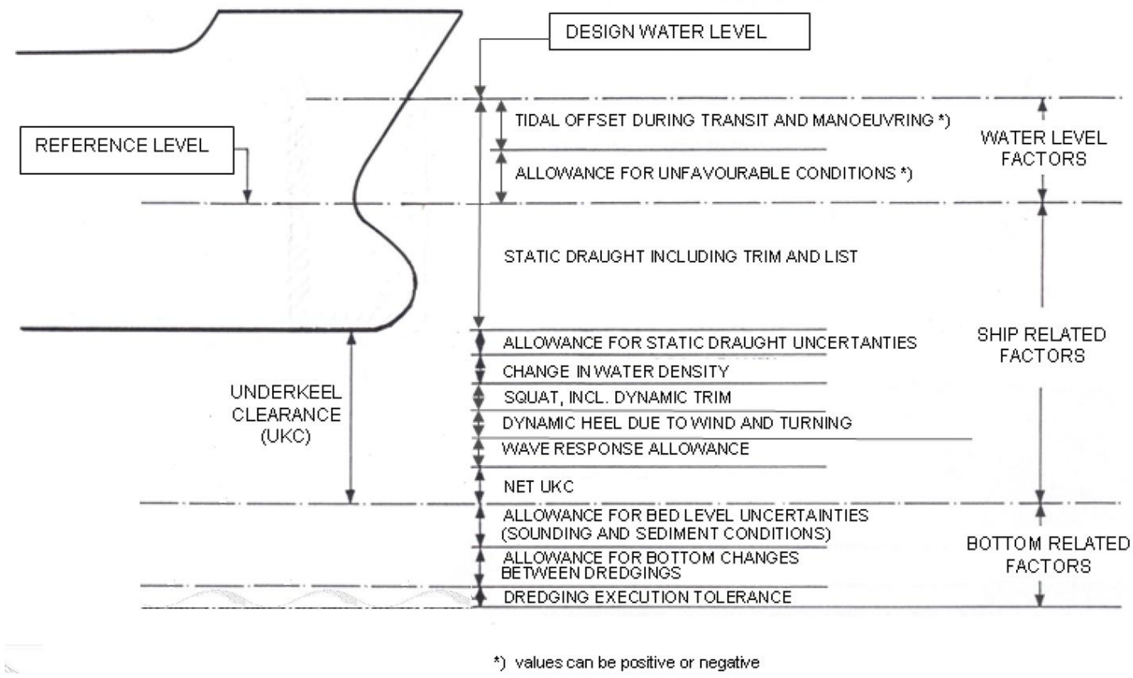

Figure 2-1. Channel depth factors (modified from PIANC 2014, Figure 2.1)

The UKC modelling for this study was undertaken by OMC International using their DUKC methodology, in accordance with PIANC 2014, to define the appropriate channel depths for a range of vessel draughts and accessibility. The DUKC model quantifies vertical wave response, squat and inertial heel for all deep-draught ships within a synthesised shipping schedule for each channel section, based on a typical year of recorded metocean data. Wind heel using meteorological data from the same time period has also been included for this study.

2.4.3 Channel availability

The required depth (vessel sailing draught plus UKC) is calculated for a years' worth of historical metocean and wind data at locations along the approach channel, for a range of scenarios. These scenarios include variations on vessel size (LOA and beam) and draught.

The channel availability model assessed whether the vessel could transit along the channel at hourly intervals. If the vessel was not able to transit at any point along the channel, then the channel would be considered to be closed for that vessel at that draught. The channel availability is then the percentage of time that the channel is open, for the declared depth at that point along the channel and vessel draught, over the course of a year.

For example, if at 0600 on 29 April a 14.5 m draught, 400 m LOA vessel is travelling into the port where there is a declared depth of -16.5 mCD at a given location, and at this point of time the required depth (draught plus UKC for the environmental conditions at that time) exceeded the declared depth, then the channel will be considered closed. Using a channel with a vessel that is unable to transit the channel at all times requires the port to have a UKC system that is able to generate real-time and predictive water depth and/or current data, and relay that information to the vessel.

2.5 Channel capacity

The theoretical channel capacity is assessed by dividing the number of hours per year that the channel is open by the minimum vessel separation (the time required between transits to maintain a safe vessel separation). The average separation time needs to consider separation between vessels travelling in the same direction and vessels travelling in opposite directions through one-way channels. In practice, a channel operating at or near its theoretical capacity would require a very high degree of active management and very tight scheduling, and would result in large vessel queues waiting for a channel slot. As a result a maximum utilisation of 70 percent has been adopted to allow for some flexibility in the scheduling.

3.0 Existing conditions

3.1 Port Phillip

Vessels visiting Port of Melbourne and transiting the waters of Port Phillip are subject to various limitations and constraints on restrictions on their operations, due to the vessel size and dimensions, cargo type, windage, sailing draught and destination terminal.

The applicable rules regarding the transit of all vessels through Port of Melbourne waters - including the Heads, South Channel and Fairway, are listed in The Victorian Ports Corporation (Melbourne) (VPCM) *Harbour Masters Directions* (Victorian Ports Melbourne, 2016). Vessels transiting to and from the Port of Geelong through the Corio Bay approach channels, are subject to additional rules as set out in the *Port Waters of Geelong Operating Handbook* (VRCA, 2016).

There are two Vessel Traffic Service (VTS) sectors covering the approach channels into Port of Melbourne - Melbourne VTS which covers the northern part of the Bay, and Lonsdale VTS covering the southern part of the bay and the approaches to Port Phillip Heads (refer to Figure 3-2).

The 245 m wide Great Ship Channel at the entrance to Port Phillip is used by deep draught vessels to enter Port Phillip (refer to Figure 3-3). The Great Ship Channel traverses Rip Bank, which is the underwater extension of Port Lonsdale and Nepean Bank, which is the underwater extension of Point Nepean. Between these two shallow banks is a deep canyon called Entrance Deep.

Rip Bank, Nepean Bank and Entrance Deep form what is commonly known as The Rip, a complex and dangerous stretch of water for shipping. The relatively narrow entrance to Port Phillip restricts the tidal range within the bay, and as a result the tidal streams in the vicinity of the Heads do not turn at high and low water. The force of the tidal streams depends upon the relative water levels inside and outside Port Phillip. The greatest differences in levels occur at about the time of high and low water at Port Phillip Heads, when the streams run at their strongest. Slack water occurs at about three hours before and after high water, when the levels inside and outside are the same. The incoming stream runs from about three hours before to about three hours after high water and the outgoing stream at other times (Victorian Ports Melbourne, 2016). Figure 3-1 outlines the tide height and current velocity over a 24 hour period at Rip Bank (entrance to Port Philip Heads) and at the entrance to the South Channel (inside Port Phillip).

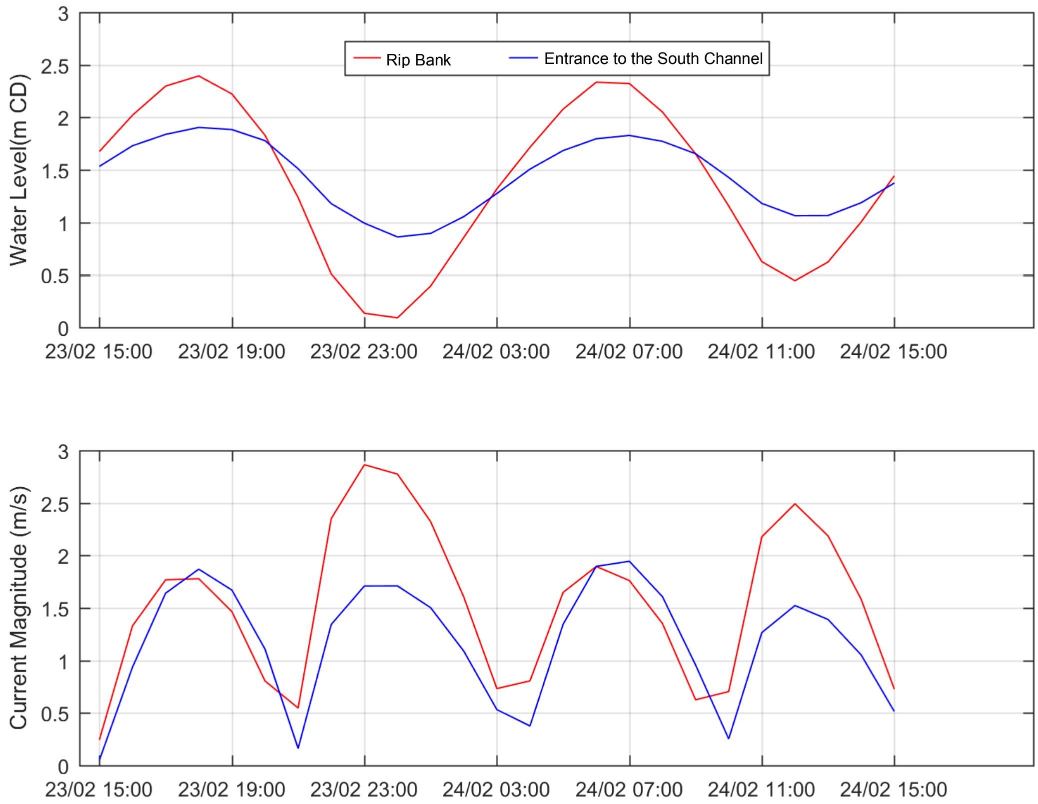

Figure 3-1. Water level and current velocities over a 24 hour period at Rip Bank and at the entrance to South Channel.

The *Harbour Masters Directions* (Victorian Ports Melbourne, 2016) currently limits transits through the Great Ship Channel for vessels with a draught of greater than 12.1 m as follows:

- inbound vessels' transit restricted during periods when the flood and ebb tides are five knots and over
- outbound vessels' transit restricted during periods when the flood tide is five knots and over, or the ebb tide is four knots and over.

Tankers have additional restrictions imposed on their operations due to the risk and consequences of them grounding, as well as their limited manoeuvrability.

Based on modelled currents in the course of one year (2015), the channel is restricted to vessels with a draught of greater than 12.1 m for five percent of the time on the inbound transit, and 18 percent of the time on the outbound transit.

Once through the Great Ship Channel, container vessels are required to immediately turn to starboard to enter South Channel. The width of South Channel varies significantly across its length, with two-way channel operations permitted in the central section.

Once past the bend at Hovell Pile, the 38 km-long Shipping Fairway between South Channel and the Port Melbourne Channel is relatively deep and provides access to anchorage locations. This allows for vessel transits within South Channel and from Port Melbourne Channel to the Port of Melbourne to be managed relatively independently and with minimal constraints.

The channel system between Fawkner Beacon (the point which marks the entrance to the Port Melbourne Channel) and each of the terminals within Port of Melbourne operate as one-way for deep draught vessels including all container ships (refer to Figure 3-4).

The Swanson Dock swing basin has a diameter of 342 m and can currently only accept vessels with a maximum length of 320 m. The Webb Dock swing basin has a minimum diameter of 420 m, with the swing basin extending across the Williamstown Channel-Yarra River Channel junction.

The maximum draught of vessels to Port of Melbourne waters is 14.0 m except with express permission of the harbour master. Vessels with a draught of greater than 11.6 m must use the Port of Melbourne DUKC system. The deepest draught vessels to visit Port Phillip are *Moscow Spirit* on 18 September 2016 and *Ultimate Freedom* on 29 September 2016. These vessels had a recorded draught of 14.5 m. The additional depth achievable by tidal assistance is a case by case assessment at the discretion of the harbour master on the day.

Table 3-1 summarises the width, length and depth of each segment of the existing approach channel that is used by deep draught container vessels.

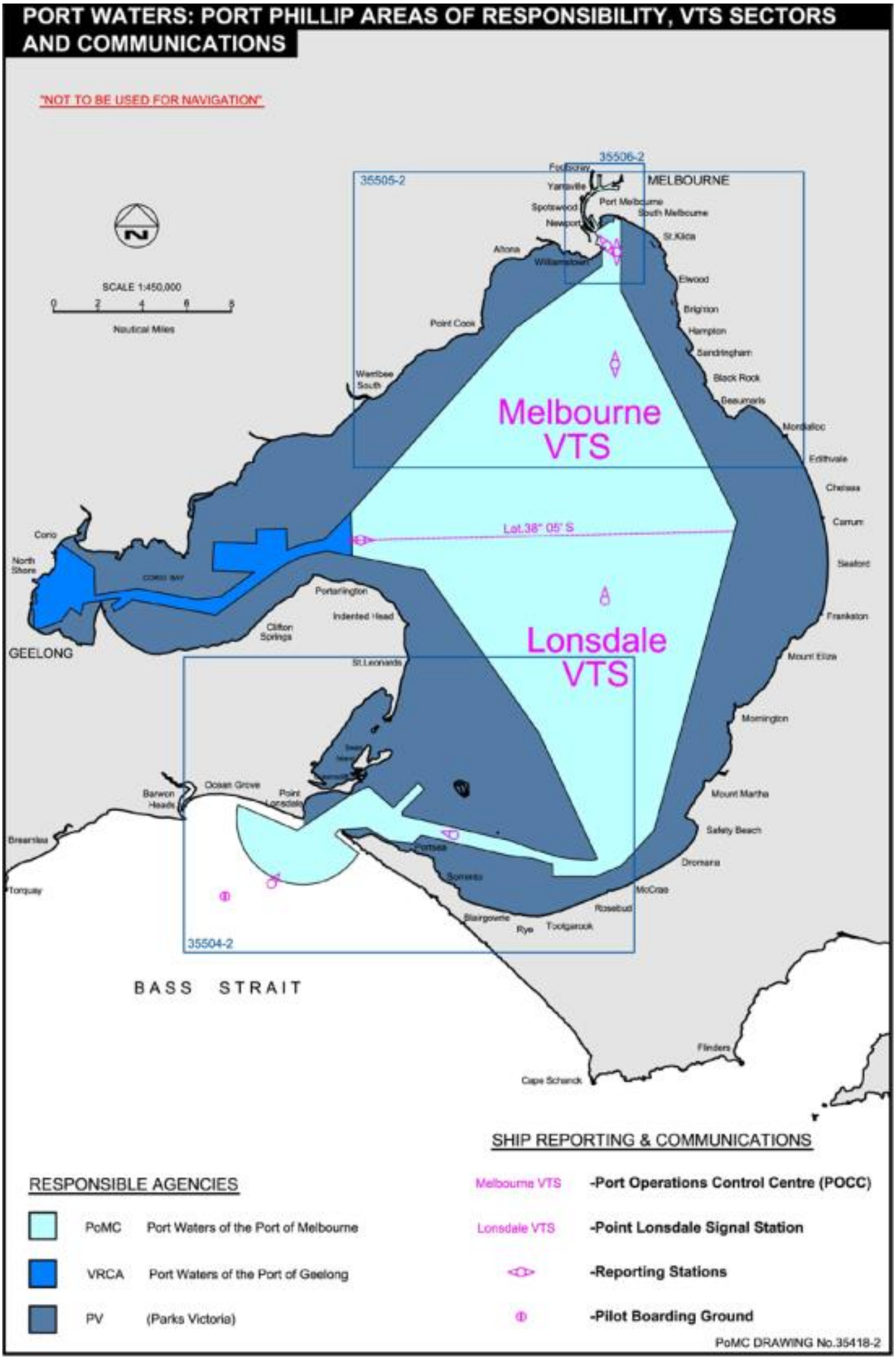

Figure 3-2. Port Phillip port waters (source Victorian Ports Melbourne, 2016)

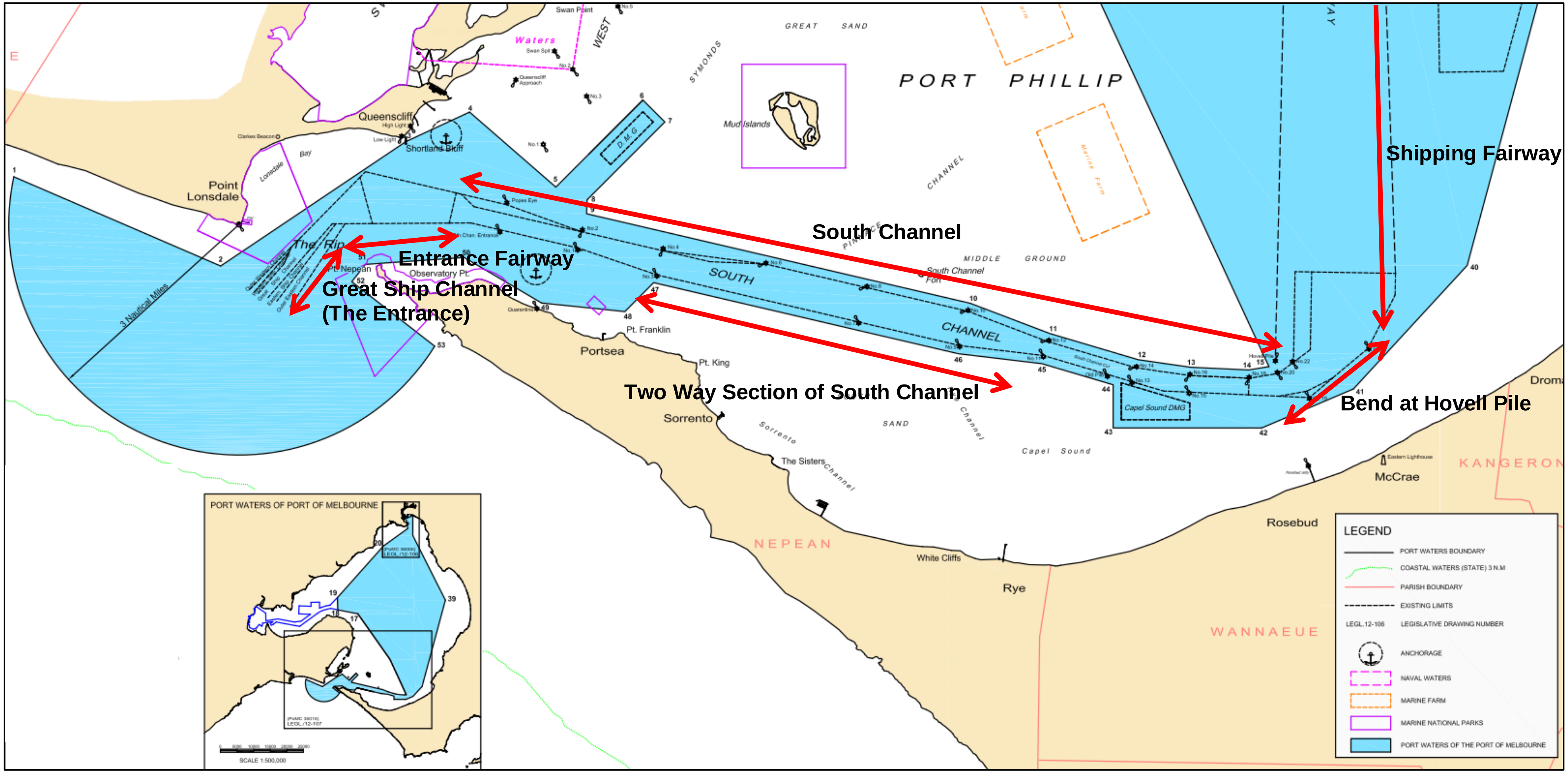

Figure 3-3. Great Ship Channel and South Channel (source Port of Melbourne Corporation Plan 36016)

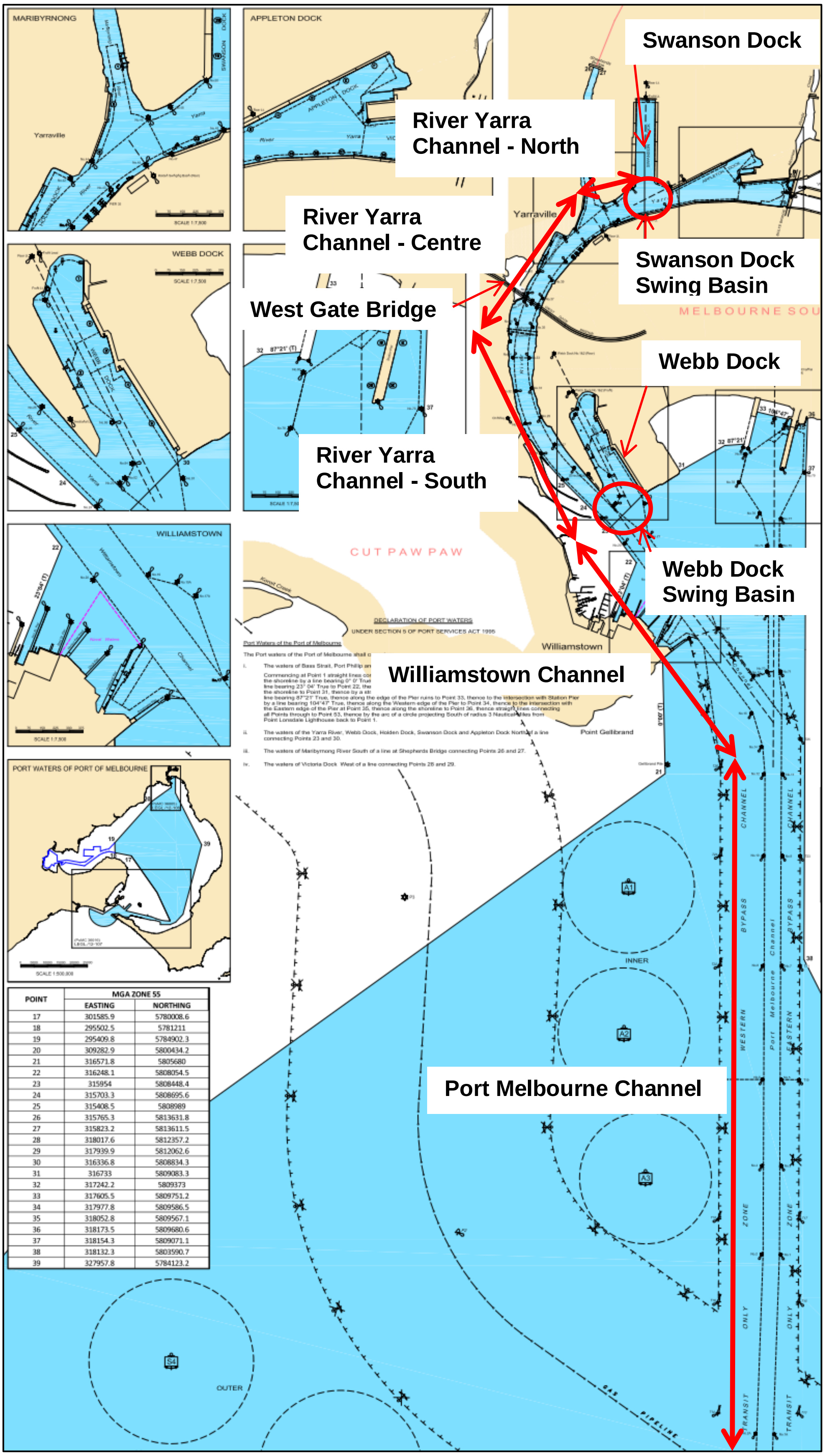

Figure 3-4. Port Melbourne Channel to Swanson Dock (source Port of Melbourne Corporation Plan 36005)

Table 3-1. Port Phillip existing channel segment dimensions for container vessels

Channel Segment	General Description	Navigation Markers	Approx. Length (km)	Approx. Orientation (^{0}N)	Angle of bend into Segment (^{0})	Min Width (m)	1-Way /2-Way	Declared Depth
The Great Ship Channel (The Entrance)	From the pilot boarding ground to due south of Shortland Bluff	Pilot Boarding Ground to the western-most white sector of Shortland Bluff Light, and the red sector of Rocky Point Light	2.4	041-221	-	245	1	17.0
Entrance Fairway	From due south of Shortland Bluff to Popes Eye	The westernmost white sector of Shortland Bluff Light, and the red sector of Rocky Point Light to the South Channel beacons 1 & 2	3.5	090-270	49	310	1	16.5
South Channel-West	From Popes Eye to South Channel Cut	South Channel beacons 1 & 2 to South Channel beacons 9 & 10	11.4	103-283	13	400	1/2	15.5
South Channel-East	South Channel Cut	South Channel beacons 9 & 10 to South Channel beacon 18	7.0	107-287	4	350	1	15.5
Hovell Pile	The waters around Hovell Pile	South Channel beacon 18 to north of Hovell Pile	4.4	359-179	108	400	1	16.0
Shipping Fairway	From north of Hovell Pile to the Port Melbourne Channel Entrance beacons, bns E1 and E2.	North of Hovell Pile to the Port Melbourne Channel Entrance beacons 1A & 2A	38.4	359-179		-	2	15.5
Port Melbourne Channel	From Port Melbourne Channel Entrance bns E1 and E2 to Williamstown Channel-Port Melbourne Channel junction.	Port Melbourne Channel Entrance beacons to WIliamstown Channel beacon 16	5.4	002-182	3	184	1	15.5
Williamstown Channel	From Williamstown Channel-Port Melbourne Channel junction to Webb Dock Entrance (bns 23 and 24)	Williamstown Channel beacon 16 to beacons 23 & 24	2.4	324-144 (at beacon 16)	38	184	1	15.5
River Yarra Channel-South	From Webb Dock Entrance to just south of the utilities that go under the river	Williamstown Channel beacons 23 & 24 to River Yarra Channel beacons 33 & 34	1.8	314-134 (at beacon 23 & 24)	10	153	1	15.5
River Yarra Channel-Centre	From just south of the utilities that go under the river (south of West Gate Bridge) to the entrance of Maribyrnong River	River Yarra Channel beacons 33 & 34 to River Yarra Channel beacons 46 & 47	0.9	001-181 (at beacon 33 & 34)	47	153	1	15.2
River Yarra Channel-North	From the entrance of Maribyrnong River to the entrance of Swanson Dock	River Yarra Channel beacons 46 & 47 to beacon 50	0.4	065-245	64	200	1	14.6

There are a number of key constraints in Port Phillip that restrict the ease of widening or deepening the approach channels to enable larger container vessels to access the port.

3.1.1 Depth

Most of the Port of Melbourne container terminals with vessel draught limits less than 14 m can potentially be deepened to enable larger vessels. The constraints on deepening below the existing maximum declared depth in the Port of Melbourne are:

- River Yarra Channel is constrained by utilities, including sewer and gas pipelines, that lie south of the West Gate Bridge. While it is possible to lower these services, it would be a very complex and costly exercise
- River Yarra Channel is heavily contaminated and further dredging beyond the Channel Deepening Project design depth would be costly, and environmental approval would be difficult to obtain
- Further deepening of the Port of Melbourne access channels north of Fawkner Beacon is constrained by both the Ethane and the Westernport/Altona/Geelong (WAG) Pipelines, which both lie across Hobsons Bay. Lowering these pipelines where they traverse the access channels will be technically complex and costly.

3.1.2 Width

Swanson Dock’s capacity is limited by the ‘post panamax constraint’. The Post Panamax constraint refers to the limit on the number and location of Post Panamax vessels that can berth at Swanson Dock at any one time. Due to the 214m width of Swanson Dock, it is not desirable to navigate a Post-Panamax ship between two Post-Panamax ships on opposite sides of the dock. Consequently the maximum number of Post-Panamax vessels in Swanson Dock at any time is three:

- Two at the northernmost berths (one each side)
- A third vessel at one of the berths immediately to the south of the first two Post Panamax vessels.

Width increases through the Yarra River are possible but are currently constrained by the existing infrastructure along the banks and contaminates in the Yarra River (as outlined in Section 3.1.1).

The width of the confirmed channel means that increases to vessel sizes will displace more water around the vessel. A simplified assessment found that vessel induced current speeds well in excess of 2 m/s (4 knots) are likely and in excess of 3.5 m/s (7 knots) are possible with the wider vessels. These currents would be manifest as a significant “surge” as the ship passes and may cause problems for moored vessels (Cardno, 2017), particularly at Holden Dock and Pier 35.

3.1.3 Length

The main vessel length constraint at the Port of Melbourne is the Swanson Dock swing basin, which limits all ships that use the berths north of the West Gate Bridge to 320 m length. As currently designed, the Webb Dock swing basin will cater for vessels up to 300 m, however greater lengths may be achievable.

Aside from the swing basin constraints, all vessels entering Port Phillip Bay are limited by the difficult manoeuvre into and out of Port Phillip, however there is no ‘hard limit’ published for this constraint.

3.1.4 Air draught

The air draught is the keel-to-mast height (KTMH) less the sailing draught of the vessel. The actual air draught for vessels depend on cargo and trade characteristics, plus sailing patterns of the vessels in terms of how laden the vessels are at each port call and transit.

The West Gate Bridge across the lower River Yarra Channel limits the height of vessels to 50.1 m (47.5 m during bridge maintenance) from the Highest Astronomical Tide (1.04 m CD) to the top mast. There is a two metre exclusion zone from the West Gate Bridge. With a maximum draught of 14.0 m, the maximum allowable keel-to-mast height is 65.14 m, or 62.54 m during bridge maintenance.

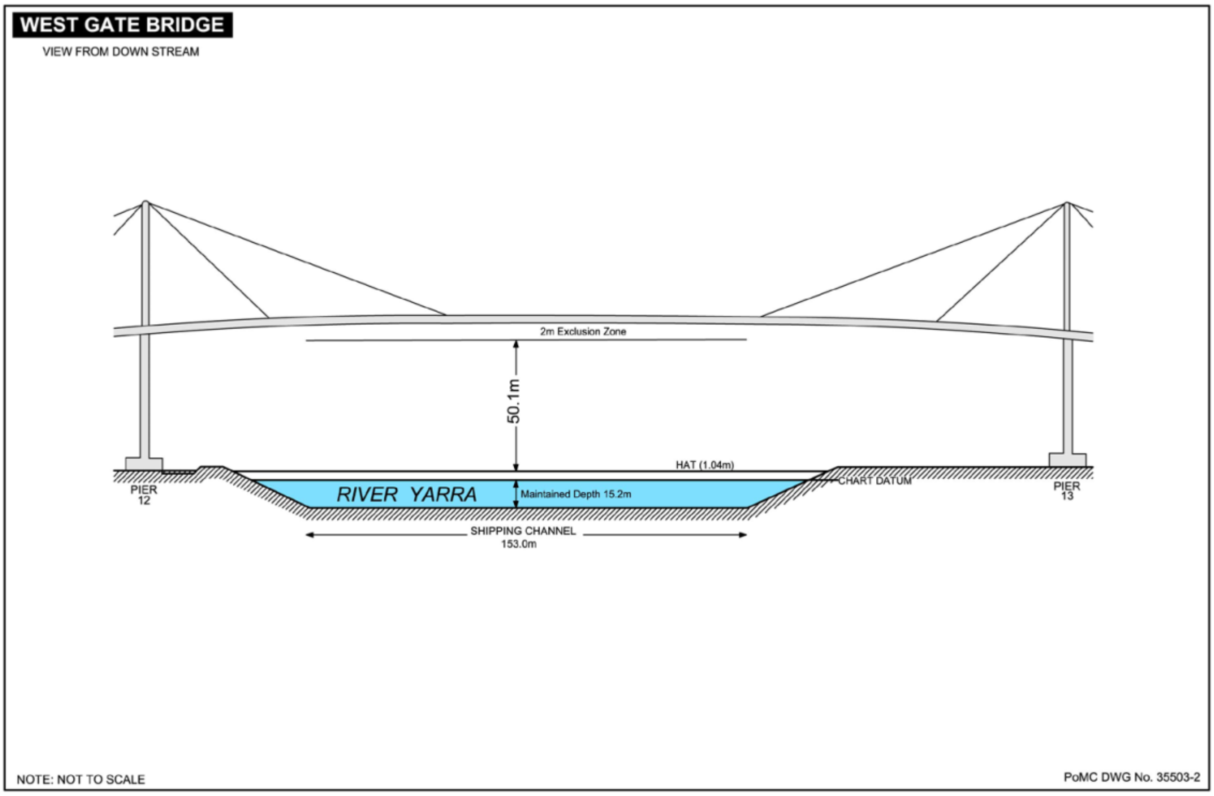

Figure 3-5. West Gate Bridge air draught (source Port of Melbourne Corporation Drawing No. 35503-2)

The keel-to-mast height is not well reported in the shipping databases. The IHS Sea-web database has the keel-to-mast height for a very small percentage of the container vessels. A study undertaken (US Army Corp of Engineers, 2009) for the raising of the Bayonne Bridge for vessels visiting the Port of New York and New Jersey, surveyed 15 of the 17 major carriers that visited the port. When taking into account the varying loading pattern, the analysis showed that once container vessels get beyond 9,000-9,500 TEU capacity, they are unable to fit under the West Gate Bridge. Even for container vessels beyond 6,000 TEU capacity, there are situations when these vessels will not be able to fit under the West Gate Bridge. Their ability to get under the West Gate Bridge will depend on maximising their sailing draught to lower their air draught.

3.2 Western Port

The Port of Hasting approach channel provides access to the Esso and BlueScope facilities at the Long Island Point precinct and to Crib Point Oil Terminal Jetty and Stony Point to the south.

The existing Western Channel up to Sandy Point is located in an area of Western Port with naturally deep water along the north-western shoreline of Phillip Island. Actual water depths along the Western Channel are generally significantly greater than the declared depths indicated on the charts. The existing navigation channel along the North Arm of Western Port extends from the Western Channel south of Sandy Point, to the northern end of the existing BlueScope facility, where it terminates (refer Figure 3-6 and Figure 3-7).

3.2.1 Depth

The channel is declared to a depth of -14.8 mCD along the Western Channel, reducing to -14.2 mCD north of Sandy Point. The declared depth of -14.2 mCD extends all the way to Long Island Point, only reducing further to -9.1 mCD at the northern end of the Long Island Jetty for the remainder of the channel to the BlueScope steel wharves from the Secondary Channel.

According to the Port of Hastings Handbook (Patrick Ports – Hastings, 2013), the approach channel, with a declared depth of -14.2 mCD, may be used by vessels drawing 13 m draught unassisted by tide, or vessels up to 15.2 m draught with tide assistance, allowing for a static under-keel clearance of 1.3 m. Tide assistance of up to 2.2 m is allowed in the Port of Hastings Handbook based on the neap

tidal range. In addition, vessels of up to 6 m draught and 100 m overall length are able to utilize the water space within 200 m of the west side of North Arm, providing additional means for passing vessels.

The handbook states that the channel between the Long Island Point Jetty and BlueScope Steel Wharves, with declared depth of -9.1 mCD, may be used by vessels drawing 8.5 m draught unassisted by tide, or by vessels up to 10.7 m draught with tide assistance, allowing for an underkeel clearance of 0.6 m.

3.2.2 Width

The Western Channel has a width of between 400 m and 560 m and caters for two-way traffic. North Arm between Hanns Inlet (south of Stony Point) and Crib Point is 183 m wide for one-way traffic. The channel along North Arm between Crib Point and Long Island Point is 250 m wide and is also limited to one-way traffic. Departing deep draught vessels have priority, with incoming vessels typically waiting in East Arm anchorage until outbound deep draught vessels have departed. Further north, the channel reduces to 200 m between the Long Island Point Jetty and BlueScope wharves, and is one way, with departing vessels also taking priority.

Table 3-2 summarises the width, length and depth of each segment of the existing approach channel.

Table 3-2 Western Port existing channel segment dimensions

Channel Segment	Description	Approx. Length (km)	Approx. Orientation (^{o}N)	Angle of bend into Segment (^{o})	Min Width (m)	1 way /2 way	Declared Depth[1]
Western Channel 1	Fairway Buoy to buoys 7 & 8	8.0	046-226	-	400	2	14.8
Western Channel 2	Buoys 7 & 8 to 13 & 14	5.8	061-241	15	500	2	14.8
Western Channel 3	Buoys 13 & 14 to 17 & R	3.6	040-220	21	500	2	14.2
Western Channel 4	Buoys 17 & R to 19 & 20	2.4	359-179	41	183	1/2	14.2
North Arm 1	Buoys 19 & 20 to 23 & 24	3.4	345-165	14	183	1	14.2
North Arm 2	Buoys 23 & 24 to 29 & 30	4.8	358-178	13	250	1	14.2
Between Long Island Jetty and BlueScope Steel wharf	Buoys 31 to 35	1.0	338-158	20	205	1	9.1

1. Declared depth source Chart AUS 150 – Western Port (Edition No. 2 dated 4 Jun 2010)

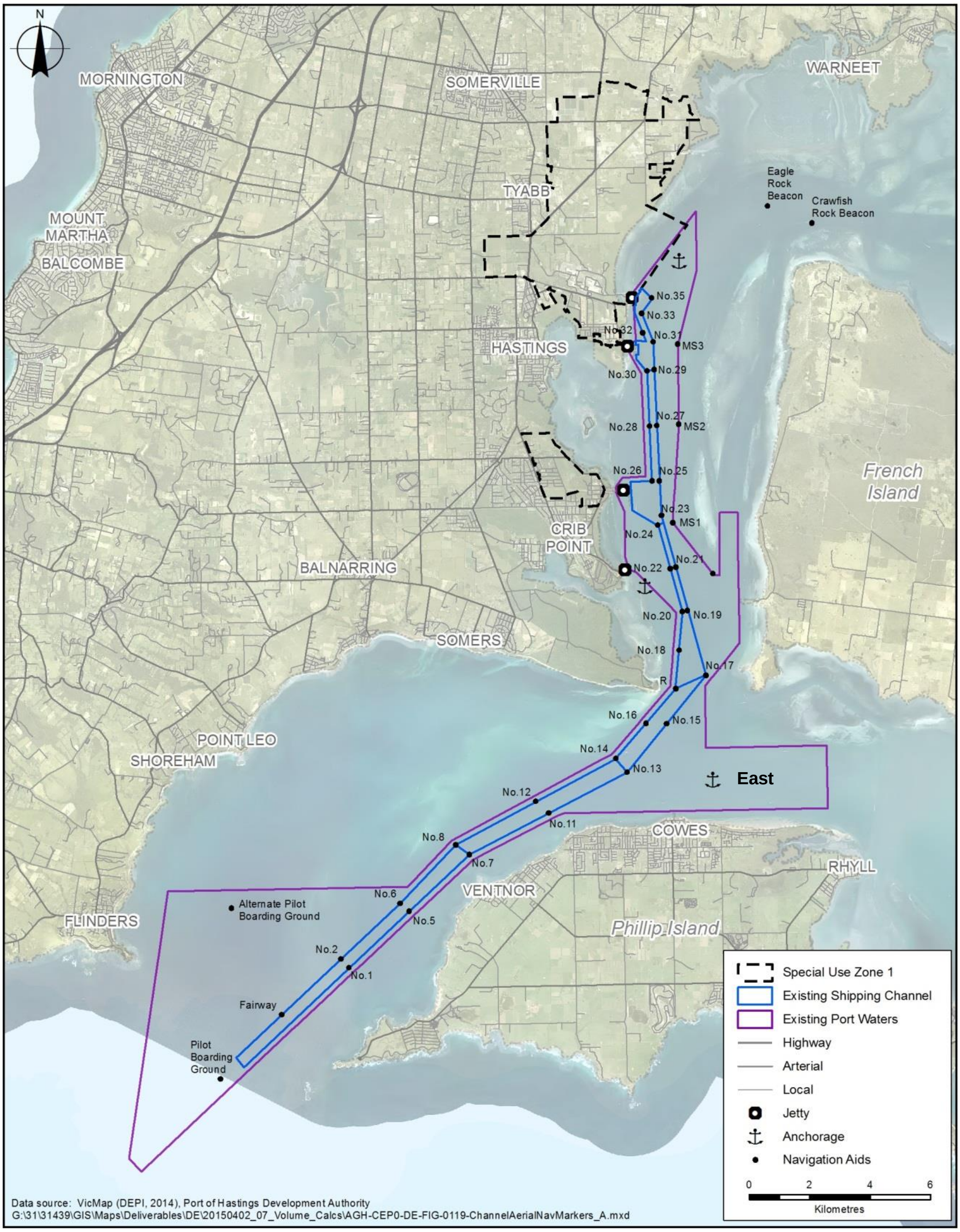

Figure 3-6. Existing Port of Hastings approach channel

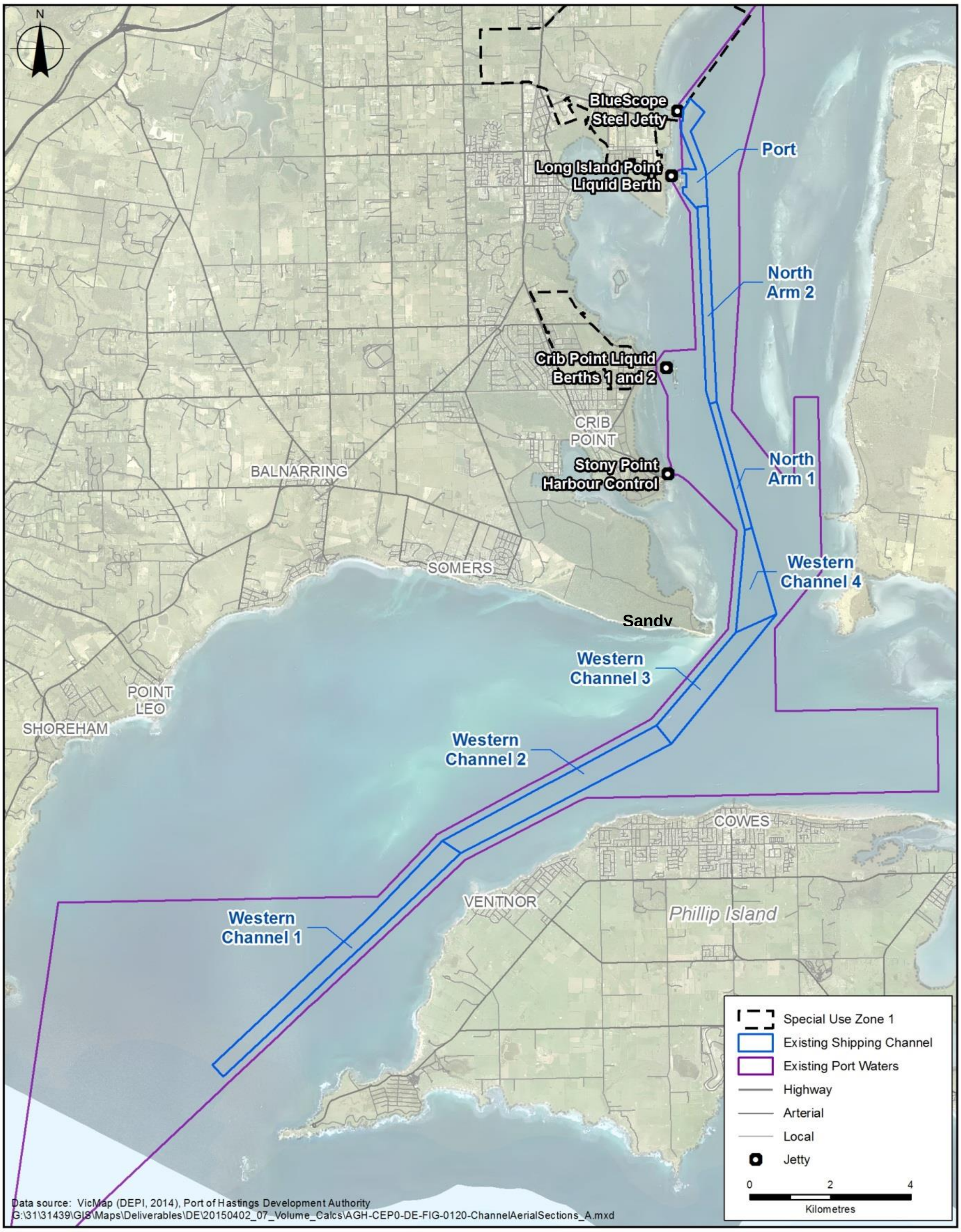

Figure 3-7. Port of Hastings channel segments

4.0 Design vessel and fleet forecast

4.1 Design container vessel

This section profiles the design container vessels used for the channel design.

4.1.1 Primary dimensions

International container vessels are broadly characterised as outlined in Table 4-1.

Table 4-1. Container vessel classifications

Vessel Classification	Nominal TEU Capacity	Typical Maximum LOA (m)	Typical Maximum Beam (m)	Typical Maximum Design Draught[1] (m)	Typical Minimum Air Draught[2] (m)
Small / feeder	100-2,999 TEU	222	30	11.5	38.5
Old Panamax	3,000-4,999 TEU	294	32	13.5	41.5
Old Post Panamax	5,000-7,499 TEU	300	43	14	45.0
Old Post Panamax Plus	7,500-9,999 TEU	337	46	15	48.5
New Panamax	10,000-12,999 TEU	366	48	15	51.0
New Post Panamax	13,000-15,999 TEU	398	56	15.5	52.0
Ultra Large Containership (ULC)	16,000+ TEU	400	59	16	57.0

Notes:

1. The maximum design draught is the maximum draught at which the vessel can safely sail with respect to classification rules and load line regulations. Typically, the actual sailing draught is less than maximum design draught.
2. The minimum air draught is calculated as the keel-to-mast height (KTMH) less the maximum design draught. As the actual sailing draught is typically less than maximum design draught, the typical air draught will therefore be greater than the minimum air draught. For example, 90 percent of 14 m maximum design draught adds an extra 1.4 m to the minimum air draught.

4.1.2 Vessel call forecast scenarios

A number of international container scenarios have been developed for this study (GHD, 2017). The key relevant scenarios are:

1. Unconstrained Scenario, where there are no restrictions on the size of vessel that can visit either Port Phillip or Western Port (Figure 4-1).
2. Constrained Scenario, which includes a 7,500 TEU vessel limitation on calls to Swanson Dock due to Yarra Channel and Swanson Dock Width, and a 14,000 TEU vessel limitation on calls to Port Phillip Bay (Figure 4-2). This scenario is only relevant to Port Phillip.

Both of these scenarios include some service with service consolidation on the North, East and Southeast Asian routes as defined in the GHD report (GHD, 2017).

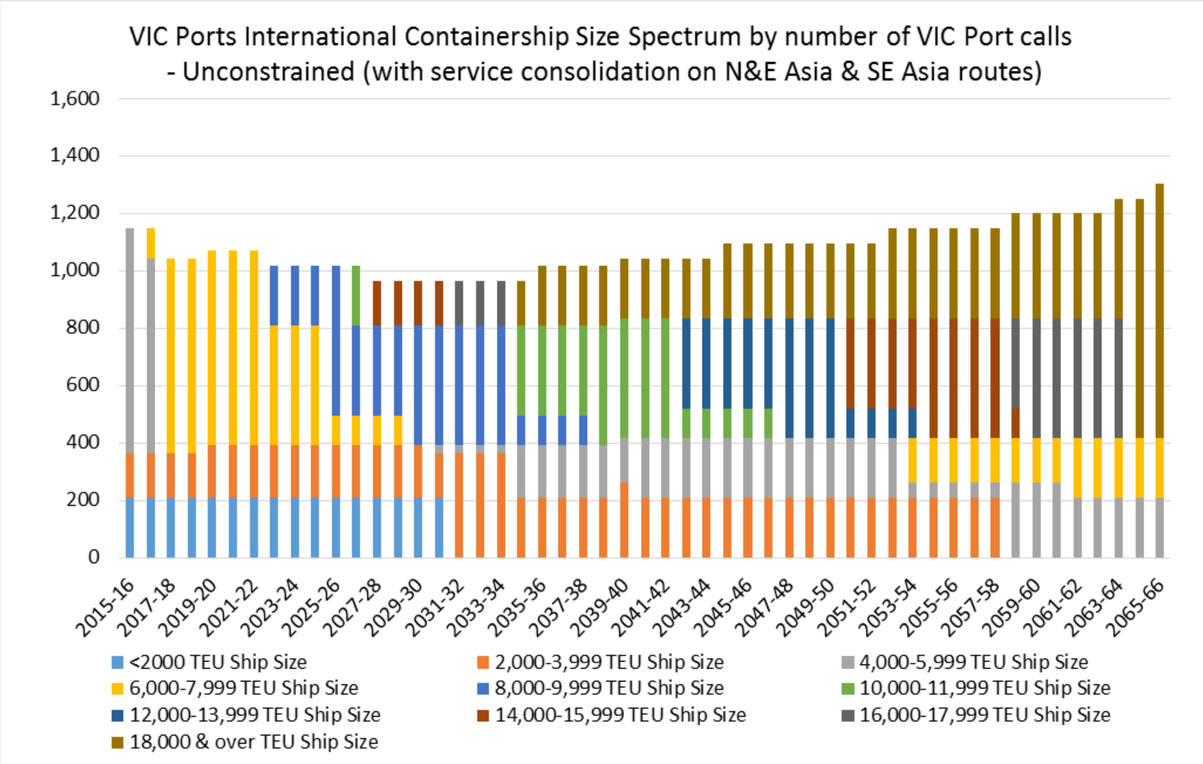

Figure 4-1. Unconstrained vessel call forecast

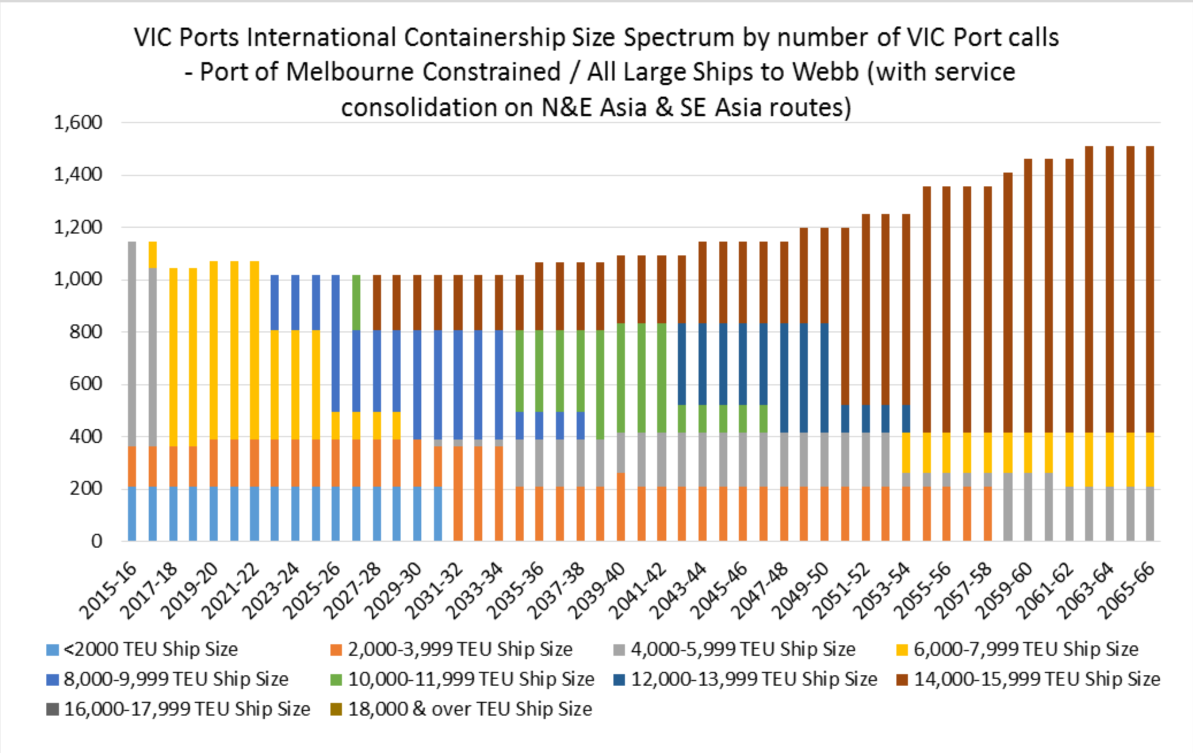

Figure 4-2. Constrained vessel call forecast

4.1.3 Design vessels

For Western Port, the Ultra Large Containership is selected as the design vessel, as this represents the largest container vessel currently in service that has the potential to visit the Port of Hastings within the forecast period.

For Port Phillip, the design vessel in the constrained case is largely limited by the existing constraints of the Great Ship Channel. The design vessel was chosen to meet the objectives of assessing the existing capacity of the channel, and assessing a widened/deepened channel for the Ultra Large Containership class vessel. The design vessels selected are:

- Old Post Panamax Plus (8,500 TEU, 334 m LOA, 42.8 m beam) – existing channel
- New Post Panamax (14,000 TEU, 366 m LOA and 51.2 m beam) – existing channel
- Ultra Large Containership (18,500 TEU, 400 m LOA, 59 m beam) – widened/deepened channel

The Ultra Large Containership category represents the largest container vessels currently in service. This vessel has a quoted maximum capacity of 19,200 TEUs, length overall (LOA) of 400 m and a beam of 59 m.

4.1.4 Sailing draughts

The draught of a particular vessel most often quoted is the maximum design draught. The maximum design draught is the maximum draught at which the vessel can safely sail with respect to classification rules and load line regulations. The maximum level is set by the Plimsoll line, which is a reference mark located on a ship's hull that indicates the maximum depth to which the vessel may be safely immersed when loaded with cargo. This depth varies with a ship's dimensions, type of cargo, time of year, and the water densities encountered in port and at sea. The draught is measured vertically from the lowest point on the hull to the water level.

Container vessels rarely sail at the maximum design draught, due to the number and weight of containers (including empties), distribution of these containers on the vessel, the unloading and loading that occurs at each port of call and the consumption of fuel between ports.

A review of sailing draughts for the ports of Botany (Sydney), Brisbane and Singapore over a 1-2 year span is outlined in the following sections.

4.1.4.1 Sydney and Brisbane sailing draughts

This section summaries the findings of the analysis of the recorded running draughts of all container ships (700 to 6,500 TEU or 140 to 300 metres in length) calling over the last 24 months at Brisbane and Sydney, and through the analysis of these three ports the implied running draughts at Melbourne.

Arrivals at Sydney from Melbourne

Figure 4-3 outlines the recorded draughts for 959 container ship calls at Sydney where the previous port call was the Port of Melbourne. The majority of sailing draughts are below 12.5 m (>99%), with a maximum of less than 13.5 m. Vessels with a length overall (LOA) of between 275 to 300 metres (or 4,000 to 6,500 TEU) had an average 10.7 m draught or around 82% of their average maximum design draught.

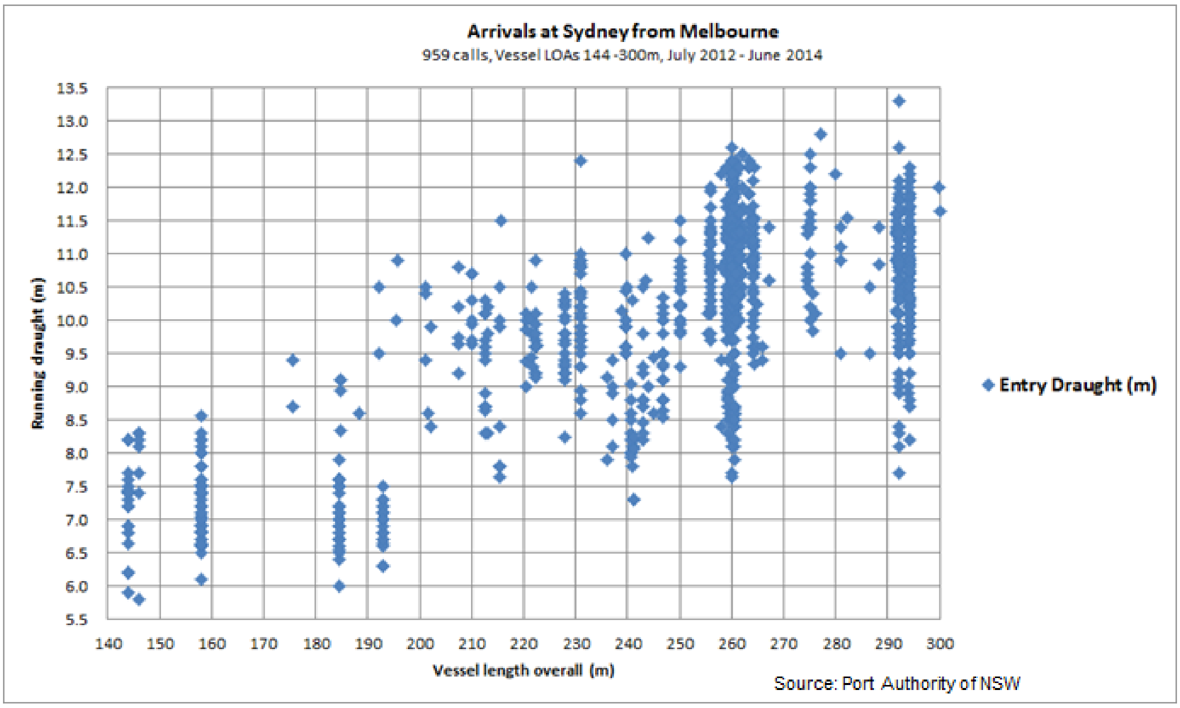

Figure 4-3. Arrivals at Sydney from Melbourne

Departures from Sydney to Melbourne

Figure 4-4 outlines the recorded draughts for 1,120 container ship calls at Sydney where the next port call was the Port of Melbourne. The majority of sailing draughts are below 12.5 m (>99%), with a maximum of less than 13.0 m. Vessels with an LOA of between 275 to 300 metres (or 4,000 to 6,500 TEU) had an average 10.7 m draught or around 82% of their average maximum design draught.

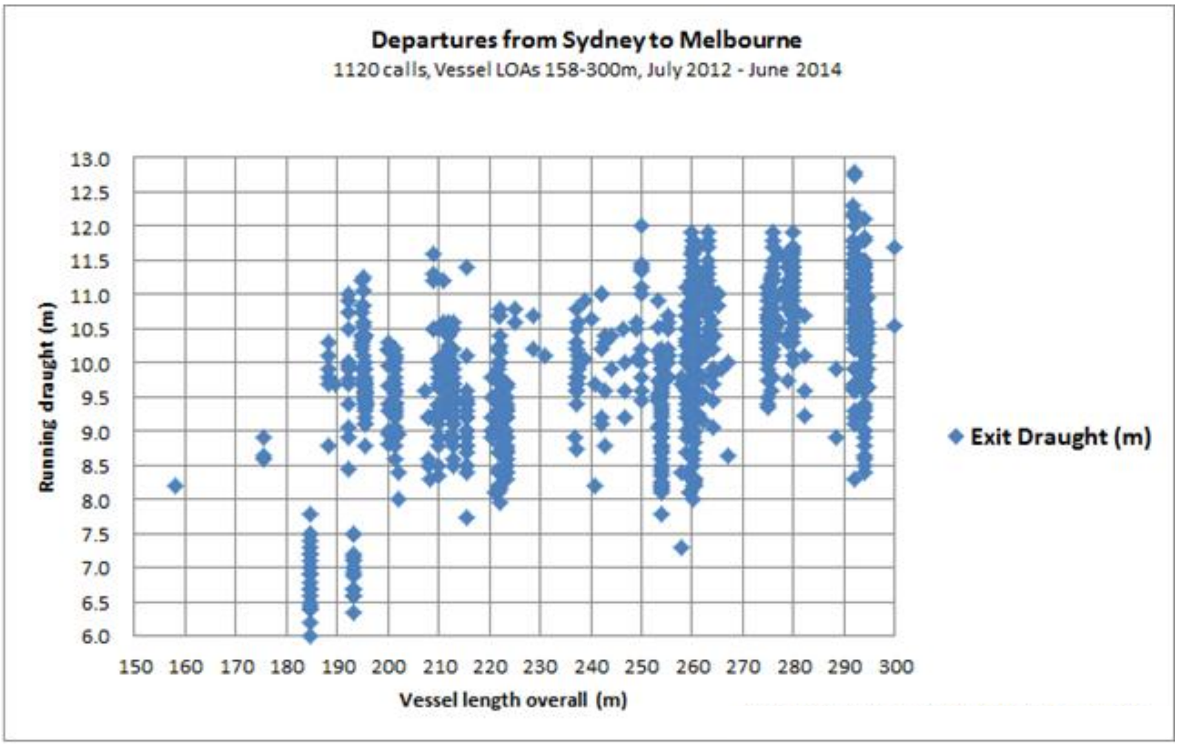

Figure 4-4. Departures from Sydney to Melbourne

Arrivals at Sydney as first port call to Australia

Figure 4-5 outlines the recorded draughts for 380 container ship calls at Sydney as the first Australian port call for services southbound from Asia and Europe. This is likely to be similar for Melbourne, which currently has four out of 13 services calling Melbourne as the first port of call.

The majority of sailing draughts are below 12.5 m (>95%), with a maximum of less than 13.5 m. Vessels with an LOA of between 275 to 300 m (or 4,000 to 6,500 TEU) had an average 11.6 m draught or around 89% of their average maximum design draught.

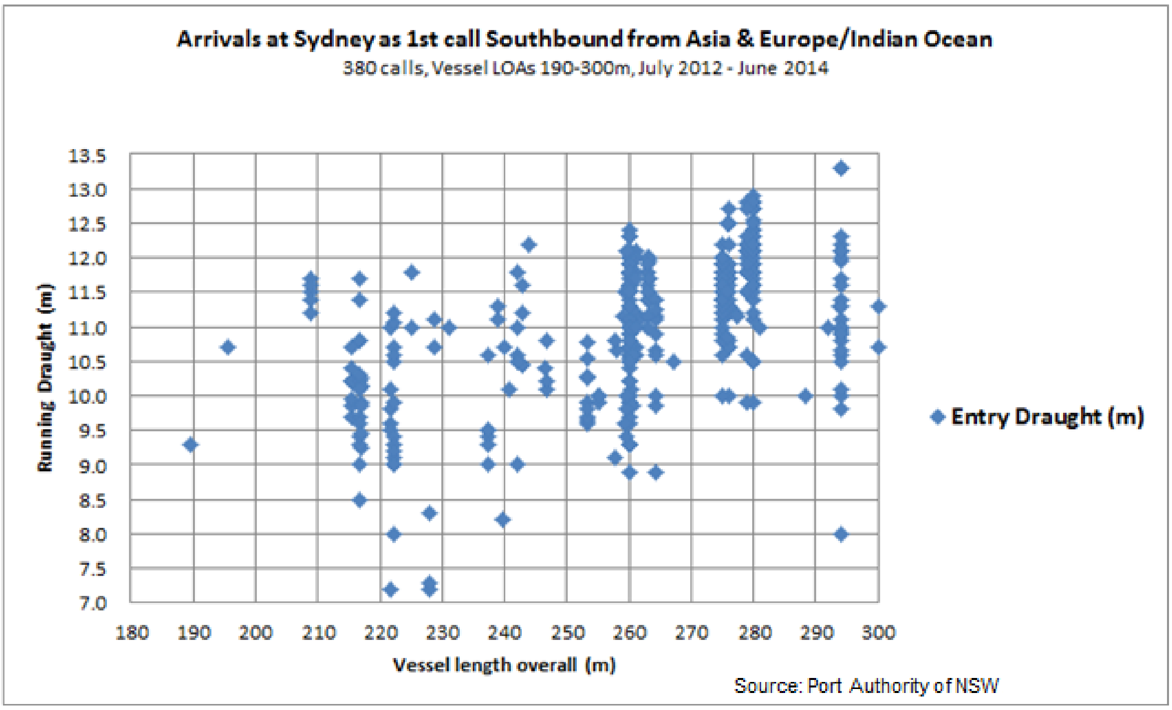

Figure 4-5. Arrivals at Sydney as first call southbound from Asia

Arrivals at Brisbane as first port call to Australia

Figure 4-6 outlines the recorded draughts for 747 container ship calls at Brisbane as the first Australian port call for services southbound from Asia. This is likely to be similar for Melbourne which currently has four out of 13 services calling Melbourne as the first port of call.

The majority of sailing draughts are below 12.5 m (>95%), with a maximum of less than 13.5m. Vessels with an LOA of between 275 to 300 m (or 4,000 to 6,500 TEU) had an average 11.7 m draught or around 90% of their average maximum design draught.

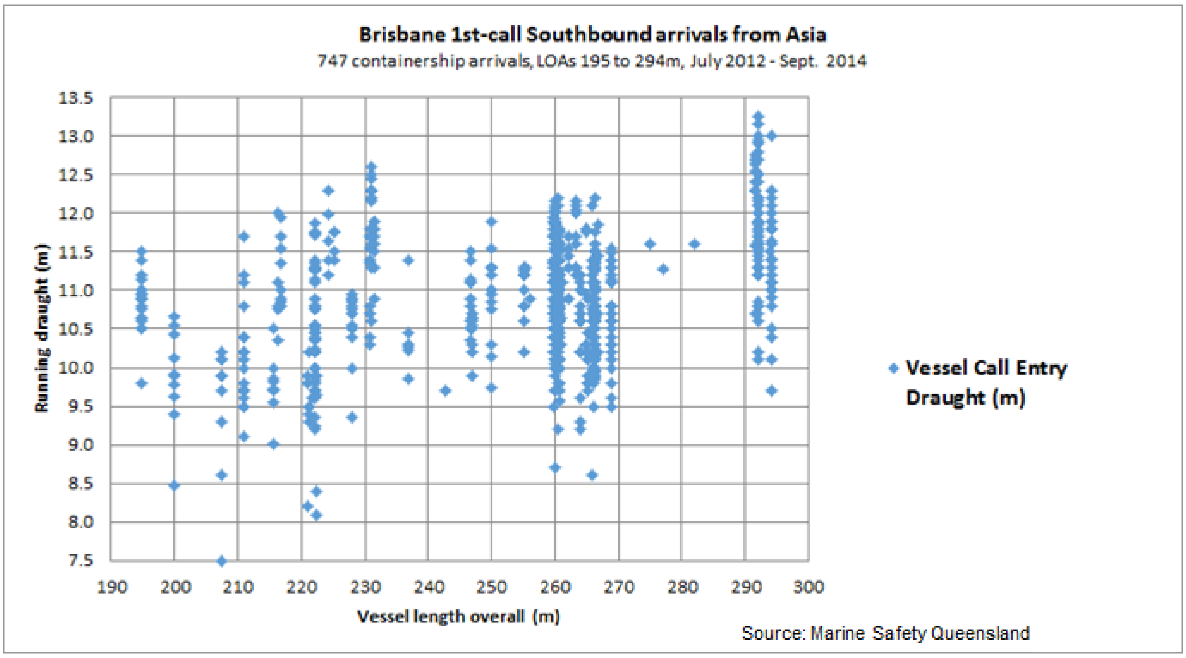

Figure 4-6. Arrivals at Sydney as first call southbound from Asia

4.1.4.2 Singapore Sailing Draughts (8,000+ TEU Containerships)

This section summaries the findings of the analysis of the recorded running draughts of 8,000+ TEU container ships calling over the last 12 months at the Port of Singapore, which may be indicative of the situation on larger container ships when they start calling in Australia (data procured from Lloyds Shipping Intelligence).

Sailing draughts of 8,000+ TEU vessels departing Singapore as last Asian port call westbound

Figure 4-7 outlines the recorded draughts for 573 containership calls at Singapore as last Asian port call westbound. The average draughts range from 13.3 m for 8,000 TEU vessels to 14.6 m for 12-13,000 TEU vessels and 15.5 m for 14,000 TEU vessels. The average draughts are around 95% of their average maximum design draught.

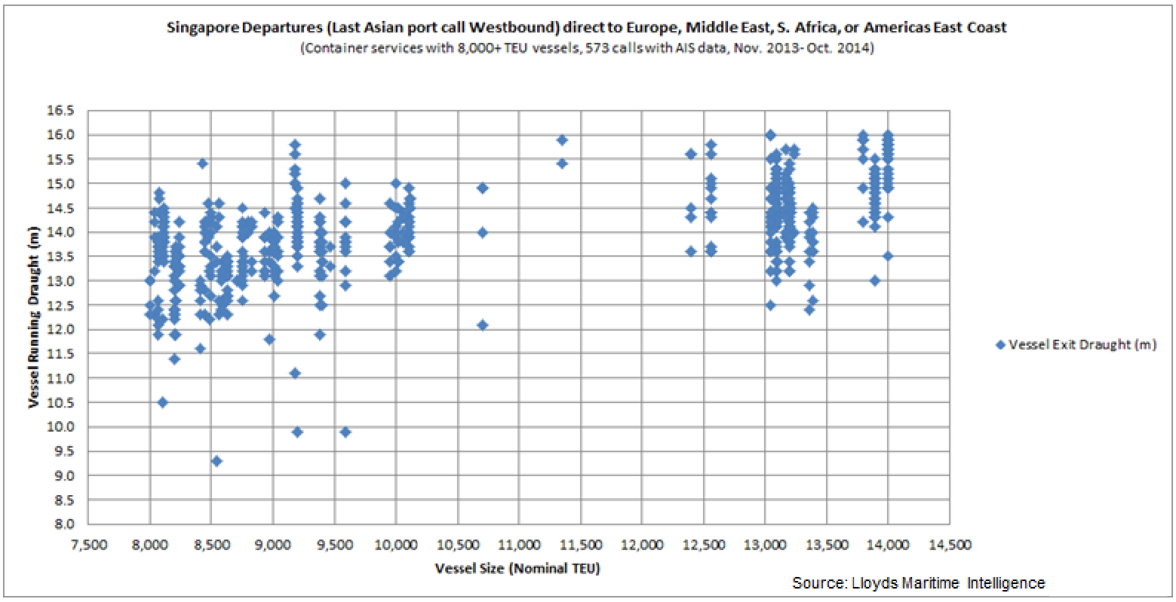

Figure 4-7. Singapore departures as last Asian port call westbound

Sailing draughts of 8,000+ TEU vessels arriving at Singapore as first call eastbound:

Figure 4-8 outlines the recorded draughts for 944 containership calls at Singapore as first Asian port call eastbound with recorded draughts via ship AIS data. The Maersk Triple E class vessels (18,270 TEU capacity) call at Singapore, however only nine visits are in the data set. The average draughts range from 12.5 m for 8,000 TEU vessels to 13.8 m for 12-13,000 TEU vessels and 14.5 m for the 18,270 TEU vessels. The average departure draughts are around 90 percent of their average maximum design draught.

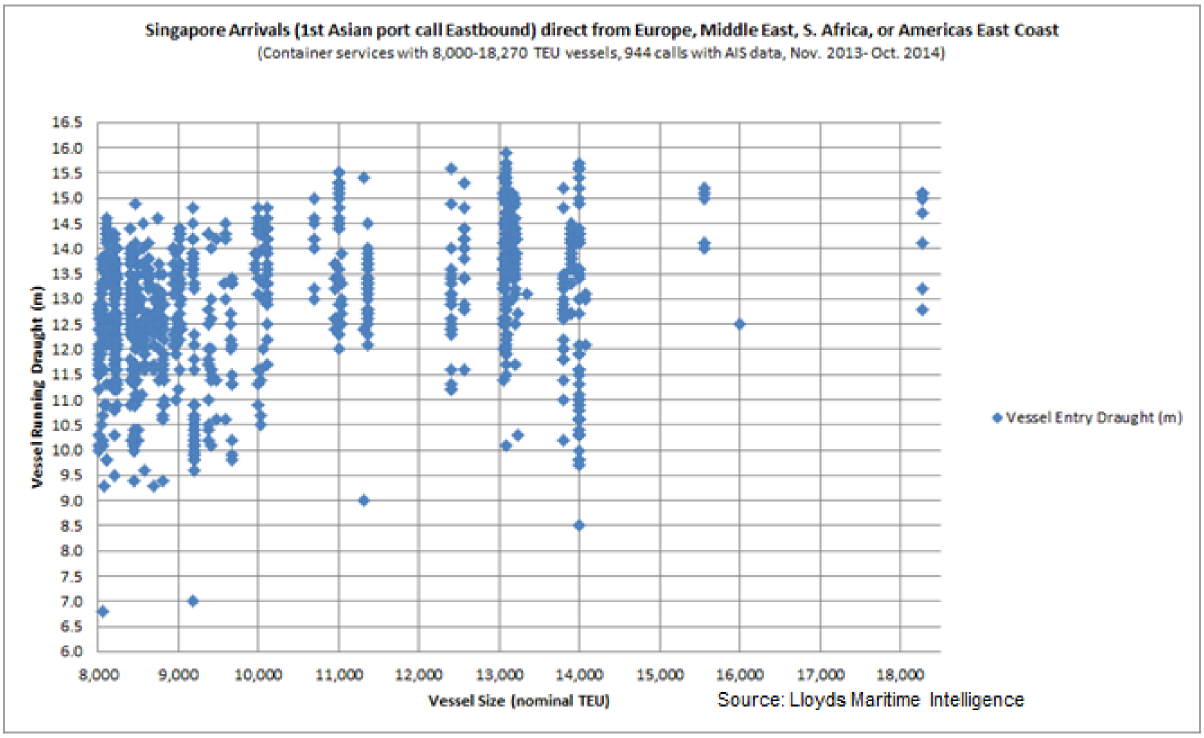

Figure 4-8. Singapore arrivals as first Asian port call eastbound

4.1.4.3 Summary

The actual running or operational draughts and the actual percentage of maximum summer draught are specific to each ship design, as well and the cargo, fuel and supplies carried per ship voyage. Given the high-level scope of this analysis, the findings can be considered typical for Victoria. The key findings from this data are:

- Following current shipping patterns, Victoria is unlikely to be either the first or last Australian port of call for the majority of services – this implies that the 95-plus percent of maximum summer draught experienced by Singapore as a typical last port of call (westbound), and 90-plus percent for typical first port of call (eastbound) is unlikely to be repeated for Victoria.
- Melbourne's current estimated percentage of maximum summer draught for 4,000-6,500 TEU ships of 80-90 percent appears to be a realistic indicative percentage for large (8,000+ TEU) ships calling at Victoria in the future.

Table 4-2 outlines typical sailing draughts based on the typical maximum design draught of each vessel.

Table 4-2. Expected sailing draughts

Vessel Classification	Nominal TEU Capacity	Draught (m)			
		Typical Maximum Design Draught	80% of Typical Maximum Design Draught	90% of Typical Maximum Design Draught	95% of Typical Maximum Design Draught
Small / feeder	100-2,999 TEU	11.5	9.2	10.4	10.9
Old Panamax	3,000-4,999 TEU	13.5	10.8	12.2	12.8
Old Post Panamax	5,000-7,499 TEU	14.0	11.2	12.6	13.3
Old Post Panamax Plus	7,500-9,999 TEU	15.0	12.0	13.5	14.3
New Panamax	10,000-12,999 TEU	15.0	12.0	13.5	14.3
New Post Panamax	13,000-15,999 TEU	15.5	12.4	14.0	14.7
Ultra Large Containership (ULC)	16,000+ TEU	16.0	12.8	14.4	15.2

4.2 Vessel fleet forecasts

For the assessment of the Port Phillip channel capacity, the vessel fleet forecast for the study period has been derived from a variety of sources as outlined in this section.

4.2.1 Container vessels

The container vessel call forecast is based on the constrained scenario with a 7,500 TEU capacity vessel limitation at Swanson Dock, and a 14,000 TEU capacity vessel limitation for Port Phillip Heads (GHD, 2017). The 2066 forecast for the total international container vessel calls is 2,642 calls per annum. This is an increase of approximately 50 percent over the current number of international container vessel calls.

4.2.2 Other trades

Forecasts for other trades have been compiled using various publically available sources, and interpolated and extrapolated to cover five-yearly intervals up to 2066. Total trade volumes are disaggregated through the existing and proposed Melbourne range gateway ports - Geelong, Melbourne and Hastings - for all trades based on existing terminal configurations, publically available and current port planning studies and assumed port developments. It should be noted that the high level forecasts presented here have been prepared specifically for the purpose of assessing the channel capacity. Due to the limitations of the publically available information, the forecasts should not be relied upon for other purposes. It is understood that more detailed forecast information is held by other parties. However, this information was not available for use in this project.

Data for this assessment has been gathered from the following sources:

- *Port of Melbourne Corporation's Port Development Strategy 2035 Vision* (Port of Melbourne Corporation, 2009). This document provided data for forecasted growth in trade for major commodities between 2010 and 2035. These values have been interpolated to forecast for years between 2010 and 2035, as well as extrapolated beyond 2035
- *Geelong Shipping Forecasts* (Thompson Clarke Shipping, 2009), provided forecast fleet spectra for bulk vessels visiting Geelong under un-deepened and deepened Geelong Channel scenarios. Only the un-deepened scenario was considered
- *Automotive Trade Relocation Study* (Department of Transport, 2011). Both the automotive trade forecasts and the fleet spectra have been used from this report
- *GHD Forecasts* (GHD, 2017): Bass Strait container vessels, excluding the ferry.

The fleet forecast were assessed by interpolating and extrapolating total expected trade volumes by commodity, reviewing average commodity parcel sizes and combining to obtain ship calls per annum. No speculative future trades have been included. Figure 4-9 outlines the vessel forecast for all vessels entering Port Phillip and Figure 4-10 outlines the vessel forecast for all vessels entering the Port of Melbourne.

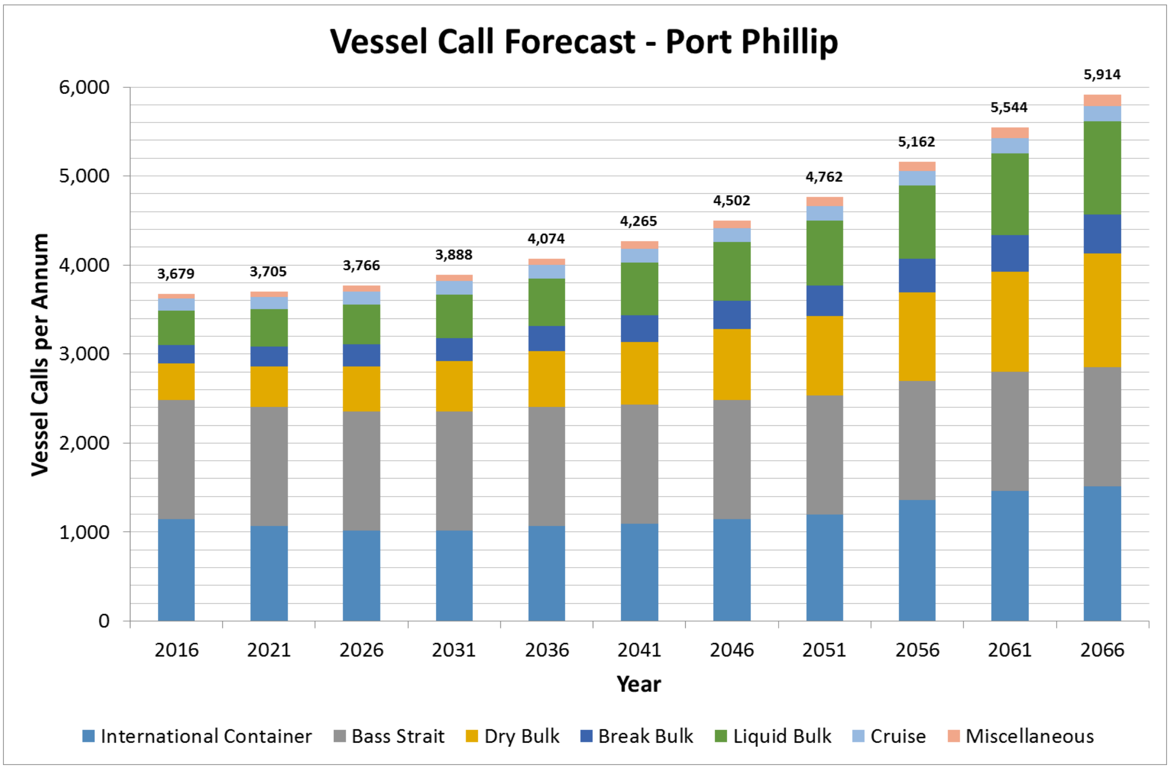

Figure 4-9. Vessel call forecast for Port Phillip

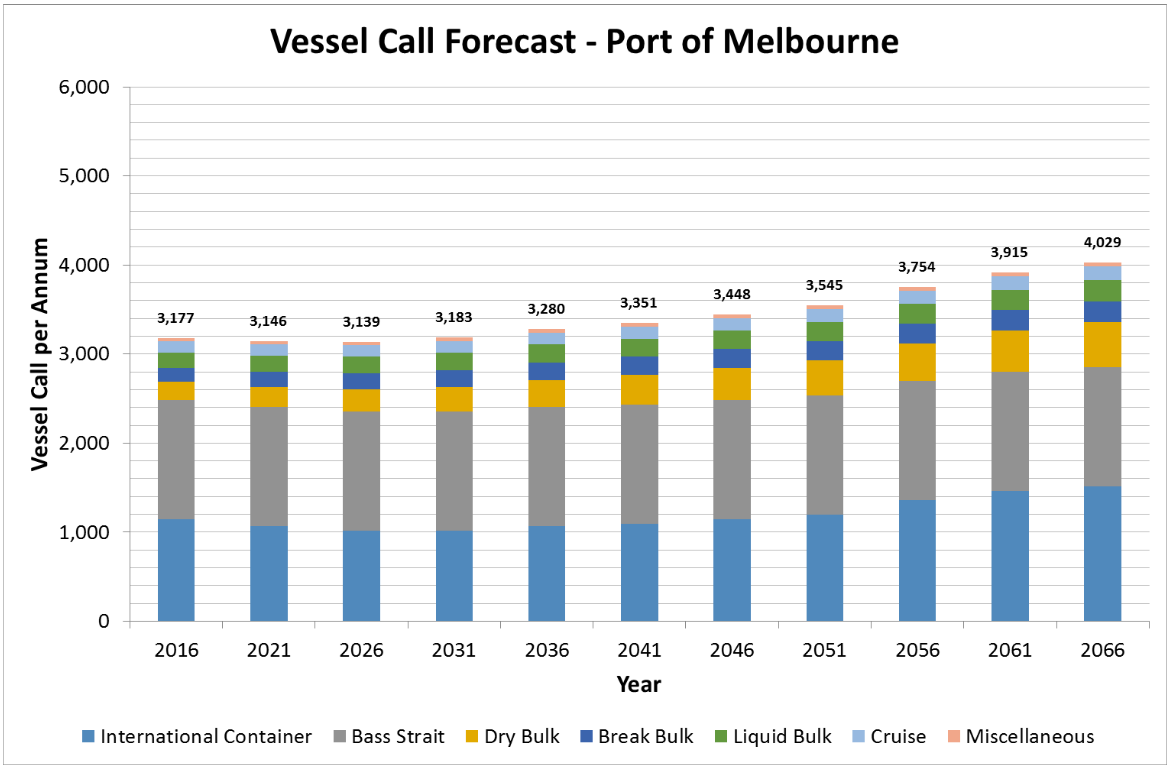

Figure 4-10. Vessel call forecast for the Port of Melbourne

5.0 Port Phillip

5.1 Channel width and layout concept design

The width of the channel was determined using the concept design method in PIANC 2014. PIANC 2014 sets out empirical rules, developed from a world-wide review of existing channels, which enable the width of the channel to be estimated. This is based on multiples of the design vessel beam taking into account vessel speed, prevailing crosswind, cross and longitudinal currents, waves, aids to navigation, bottom surface and the depth of the waterway.

The existing channel has been broken into segments outlined in Table 5-1. This table also summarises the required channel widths based on the concept design methodology in PIANC 2014; the calculations and rationale are included in Appendix B. Values highlighted in red are where the concept design width is greater than the existing width.

The concept design results show that South Channel has sufficient width to cater for larger vessels. The Harbour Masters Directions regarding passing in the South Channel would need to be reviewed to consider larger container vessels.

The existing radius and width of the bend at the Fairway and Hovel Pile are deemed adequate for all larger container vessels considered.

The concept design results for the Great Ship Channel show that the existing width is not adequate for even the existing maximum container vessel, let along larger container vessels. The PIANC 2014 concept design methods are intended to be conservative in most cases, and the design needs to be confirmed by using real-time navigation simulation.

In order to assess whether the existing width was satisfactory for larger container vessels, two scenarios were developed for the navigation simulations:

1. Great Ship Channel (245 m wide) and South Channel unmodified in its existing configuration
2. Great Ship Channel widened to 425 m with the depth unchanged. South Channel width unchanged with the depth increased by 1.5 m in the South Channel.

Table 5-1. Concept design channel widths

Segment	Existing Width (m)	Concept Design Width (m)			
		Current Maximum (320m LOA, 40m Beam)	Old Post Panamax Plus (337m LOA, 46m Beam)	New Post Panamax (366m LOA, 49m Beam)	Ultra Large Containership (400m LOA, 59m Beam)
Great Ship Channel	245	288	331	353	425
South Channel West (one way)	400	180	207	221	266
South Channel West (two way)	850	396	455	485	584
The Cut (one way)	350	180	207	221	266
South Channel East (one way)	400	180	207	221	266
Port Melbourne Channel Williamstown Channel	185	160	184	196	236
Yarra River Channel	153	160	184	196	236

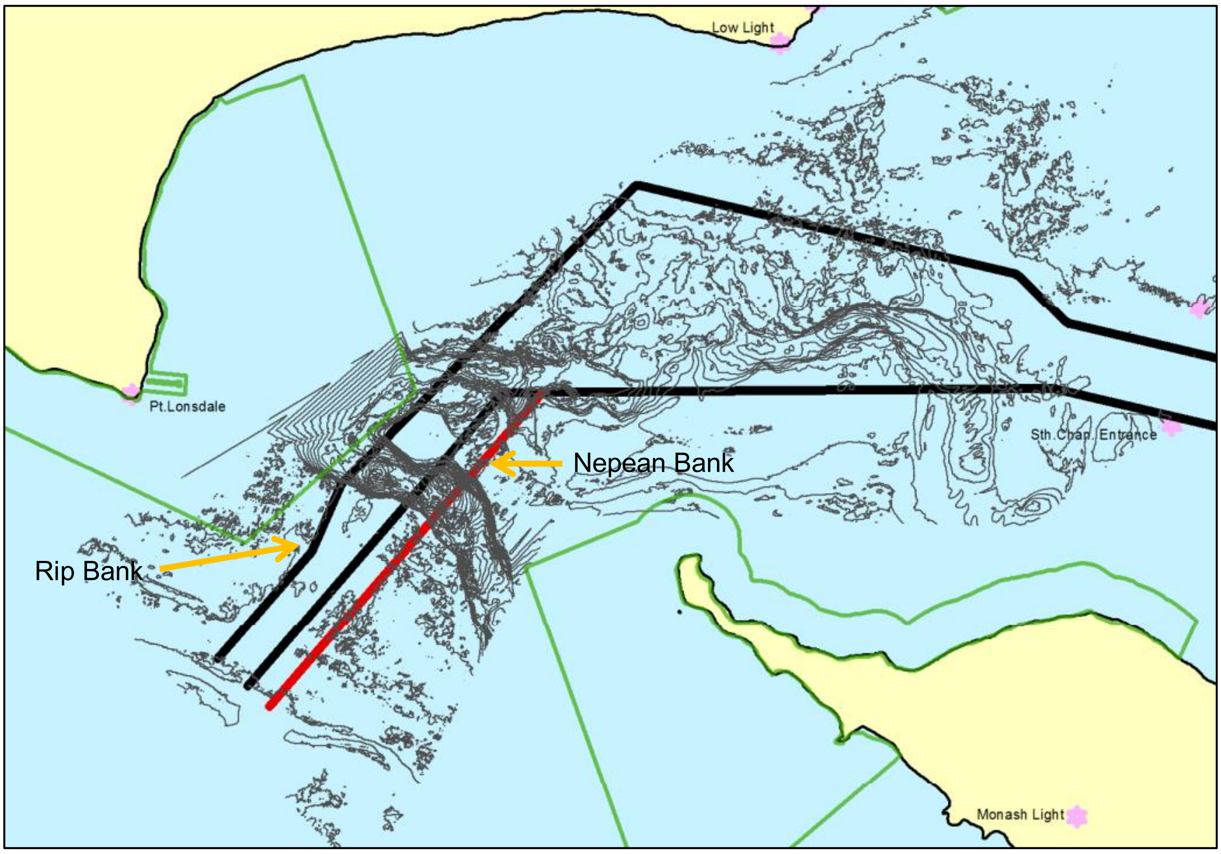

Figure 5-1. Great Ship Channel widening to 425 m (Red Line)

5.2 Navigation simulations

The real time navigation simulations were undertaken to assess the feasibility of the layouts and to undertake initial refinement of the horizontal dimensions of the channel and assess the operating conditions.

The navigation simulations only focused on the Great Ship Channel. This area is environmentally very sensitive to dredging, and so greater accuracy was warranted in assessing the need for widening or deepening of the channel. It was also identified in the Concept design as needing widening.

5.2.1 Objectives

The key objectivities of the navigation simulations were:

- Determine the largest container vessel that can transit the Great Ship Channel in its existing configuration without deepening or widening.
- Determine whether the largest container vessels currently in service can transit the Great Ship Channel, and find the likely width and depth that would be required.

5.2.2 Methodology

The real-time navigation simulations were undertaken at Australian Maritime College Search's (AMCS) facility in Launceston. The simulation facility comprised a full mission bridge with wrap-around projection, with a horizontal field of view of 240 degrees and two 15 degree fields of view to the aft of the vessel.

The simulations were undertaken by pilots from the Port Phillip Sea Pilots that have considerable experience navigating the Great Ship Channel and piloting simulations in the AMCS simulator.

The navigation simulations utilised the hydrodynamic and bathymetry model that AMCS has developed for the Port of Melbourne Corporation. For the widened channel, hydrodynamic data was prepared by Cardno utilising an existing model (Cardno, 2017). The hydrodynamic model included the widening of the Great Ship Channel and the deepening of the South Channel by 1.7 m, however only the section between the sandbar and the entrance to the South Channel was incorporated into the navigation simulation model. A suitable tide period, that closely matched a spring tide, was selected for the simulations.

Wind and wave conditions were varied according to the tide and direction of transit, based on discussions with the pilots, to assess the more adverse conditions. It was found that tidal currents were the dominating factor affecting vessel handling, and for the majority of the runs the wind and wave conditions were kept constant in order not to mask differences between runs.

The draught of the vessel was decreased in a number of scenarios by artificially increasing the water depth to simulate additional underkeel clearance.

For the outbound transits through the Great Ship Channel, the pilots position the vessel at the end of the South Channel near Popes Eye. The vessel is positioned to the north side of the channel rather than placed in the centre of the channel. This is to replicate the existing operations, where the pilots position the vessel on the northern side of the channel at Popes Eye (as far as they are able to, draught allowing) to give themselves the best chance of making the outward turn successfully. The run ends once the vessel is within the green sector from the Point Lonsdale Lighthouse.

Inbound transits start near the offshore sandbar to give the pilot sufficient time to position the vessel for the transit through Great Ship Channel. The run ends once the pilot has confidence that they will successfully make the entrance to South Channel.

A run is considered successful when the pilot confirms the vessel was able to be kept under control at all stages of the turn or transit. The pilot takes into consideration the ability to make further adjustments during the transit if the unexpected occurs. If the vessel is regularly at hard-over helm and/or at full throttle through the turn between Great Ship Channel and South Channel, there is little margin for error and the run is considered to be a failure.

5.2.3 Vessels characteristics for simulation

Table 5-2 outlines the vessel models used for the simulations. The *Ital Cortesia 334* and *MSC Daniela* were used with the existing channel alignment. The CNTNR19L and *Superium Maersk* were used for the widened channel to represent the largest container vessels currently in service.

The CNTNR19L model was developed prior to the Maersk E Class vessels; however the hull shape is more typically of the standard container vessel construction. It was found that the rudder response was very poor and the model was abandoned after two runs, as it was not considered representative of an Ultra Large Containership.

The *Superium Maersk* model was developed based on typical characteristics of a 201,300 displacement tonnage container vessel in a loaded condition, rather than a specific Maersk Triple E Class hull shape. The rudder area to wetted hull surface area ratio of *Superium Maersk* was 2.5 percent, as compared to a range of 1.6 percent to 2.6 percent for other vessels in AMC Search's library that have a LOA of greater than 300 m.

It is considered that *Superium Maersk* is a typical representation of an Ultra Large Containership. Further details of the vessels are outlined the in Port Phillip Heads Container Ship Simulation Study in Appendix C.

Table 5-2. Vessel model particulars

Vessel Name	Representative Class	LOA (m)	Beam (m)	Draught (m)	Typical TEU Capacity
Ital Cortesia 334	Old Post Panamax Plus	334	42.8	13	8,500
MSC Daniela	Large Post Panamax	366.1	51.2	14.48	14,000
CNTNR19L	Large Post Panamax	398	55	15	16,000
Superium Maersk	Ultra Large Containership	398	58.2	15	18,500

5.2.4 Results

This section outlines the results of the navigation simulation runs undertaken for each of the vessels and layouts that were assessed. Further details are provided in the Port Phillip Heads Container Ship Simulation Study in Appendix C.

5.2.4.1 Ital Cortesia

Table 5-3 outlines the summary of the findings from the runs undertaken for *Ital Cortesia* and Figure 5-2 outlines the vessel swept path for the acceptable runs. These runs were undertaken using the existing channel configuration.

Table 5-3. *Ital Cortesia* run summaries for the existing channel configuration

Run	Direction	Draught (m)	Tidal Current	Acceptable	Key Pilot Post Run Comments
1	Inbound	13	2.5 knots flood	OK	Familiarisation run, standard arrival
2	Inbound	13	2.5 knots ebb	OK	Familiarisation run, standard arrival
3	Inbound	13	4 knots ebb	NO	Vessel slow to respond to hard-over helm at full ahead
4	Inbound	13	4 knots ebb	NO	Vessel slow to respond to hard-over helm at full ahead
5	Inbound	13	3 knots ebb	Marginal	Changed from half to full-ahead a couple of times to start rotation
6	Inbound	13	4 knots flood	OK	Acceptable run
7	Outbound	13	3 knots flood	OK	Hard-over helm required at times, but acceptable
8	Outbound	13	3 knots ebb	OK	Standard departure

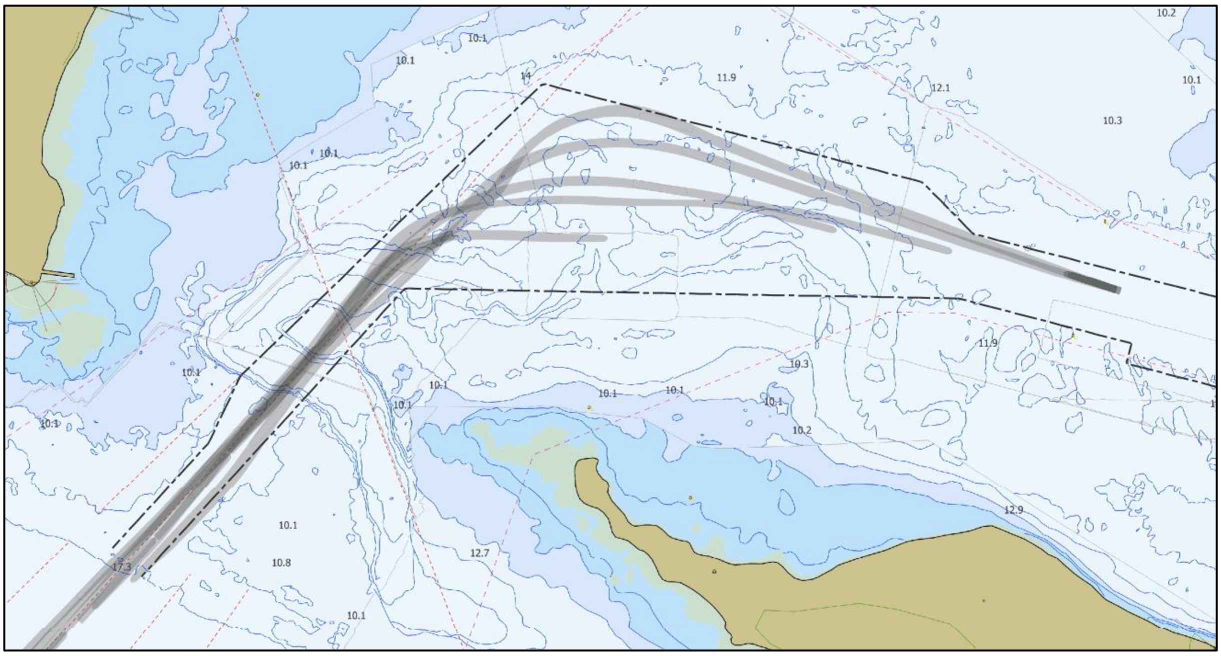

Figure 5-2. *Ital Cortesia* vessel successful swept paths

These limited runs show that *Ital Cortesia* can successful transit the Great Ship Channel, and that there are acceptable tidal current window for inbound and outbound transits during both the flood and ebb tides. Based on these results, and for the purposes of the channel availability assessment, Table 5-4 outlines the current limitations that have been adopted for an Old Post Panamax Plus class vessel with a draught of 13 m.

Table 5-4. Proposed tidal current limitations for Old Post Panamax Plus class vessel based on *Ital Cortesia* (draught 13 m)

Transit	Tide	Tidal Current Limitations (knots)	Basis
Inbound	Flood	4	Successful run 6
	Ebb	3	Run 1 successful for 2.5 knots and run 5 marginal but acceptable for 3 knots
Outbound	Flood	3	Successful run 7
	Ebb	3	Successful run 8

5.2.4.2 MSC Daniella

Table 5-5 outlines the summary of findings from the runs undertaken for *MSC Daniela* and Figure 5-3 outlines the vessel swept path for the acceptable runs. These runs were undertaken using the existing channel configuration.

Table 5-5. *MSC Daniela* run summaries for the existing channel configuration

Run	Direction	Draught (m)	Tidal Current	Acceptable	Key Pilot Post Run Comments
9	Outbound	14.5	3 knots flood	Marginal	30 degrees of helm used, with engine speed increased to improve manoeuvrability.
10	Inbound	14.5	3 knots flood	OK	Vessel sluggish to respond, Manoeuvre still achievable.
11	Outbound	14.5	3 knots ebb	NO	Significant shallow water effect hampered vessel manoeuvrability at this draught.

Run	Direction	Draught (m)	Tidal Current	Acceptable	Key Pilot Post Run Comments
12	Outbound	14.5	3 knots flood	NO	Combination of wind on port quarter and reduced manoeuvrability due to shallow water effect meant port rotation could not be checked and vessel grounded on eastern bank of Great Ship Channel.
13	Outbound	13.5	1.5 knots flood	OK	Vessel sluggish to respond, requiring considerable effort to commence rotating. However acceptable conditions for this transit.
14	Outbound	13.5	3 knots flood	OK	Noticeable difference with increase in underkeel clearance. Hard-over helm only used to commence rotation. Manageable in these conditions.
15	Outbound	13.5	1.5 knots ebb	OK	Standard departure. Vessel responded to helm much better at this draught.

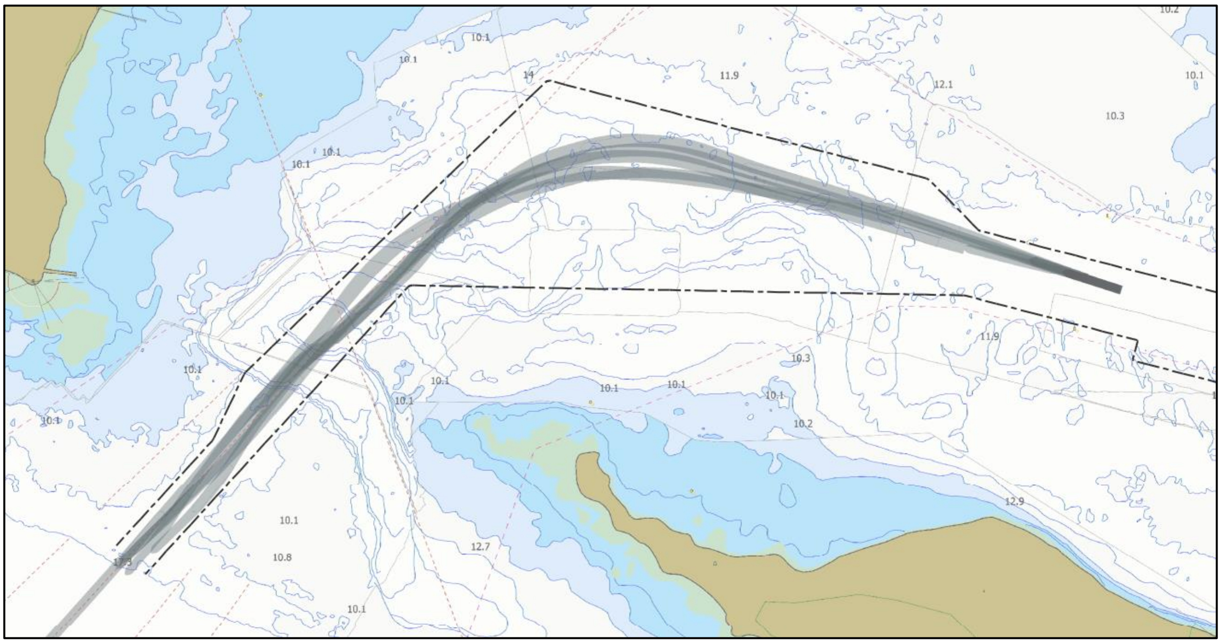

Figure 5-3. *MSC Daniela* successful swept paths

The four runs for the 14.5 m draught vessel found that the reduction in UKC under the vessel resulted in a significant decrease in the responsiveness of the vessel to the rudder. The draught was decreased to 13.5 m and these limited runs show that the *MSC Daniela* can transit Great Ship Channel and that there are acceptable current speeds for inbound and outbound transits during both the flood and ebb tides for this draught. Based on these results, and for the purposes of the channel availability assessment, Table 5-6 outlines the current limitations that have been adopted for a New Post Panamax-class vessel with a draught of 13.5 m.

Table 5-6. Proposed tidal current limitations for the New Post Panamax class vessel based on *MSC Daniela* (draught 13.5 m)

Transit	Tide	Tidal Current Limitations (knots)	Basis
Inbound	Flood	3	Successful run 10 (draught 14.5)
	Ebb	1.5	Not attempted, 1.5 knots acceptable outbound on the ebb which is considered a more difficult transit
Outbound	Flood	3	Successful run 14
	Ebb	1.5	Successful run 15

5.2.4.3 *Superium Maersk* (widened channel)

Table 5-7 outlines the summary of findings from the runs undertaken for the *Superium Maersk*, and Figure 5-4 outlines the vessel swept path for the acceptable runs. These runs were undertaken using the widened existing channel configuration.

Table 5-7. *Superium Maersk* run summaries for the widened channel configuration

Run	Direction	Draught (m)	Tidal Current	Acceptable	Key Pilot Post-Run Comments
20	Outbound	14.5	3 knots flood	NO	Vessel hampered in manoeuvrability due to shallow water effect. Vessel within 30 m of eastern toe line.
21	Outbound	14	1.5 knots flood	OK	Vessel responded much better to the change in the rudder at this draught and state of tide. Vessel experienced unexpected sheer upon approach to Rip Bank, requiring hard-over helm to counter.
22	Outbound	14	1.5 knots ebb	OK	Standard departure.
23	Outbound	14	3 knots ebb	OK	Hard-over helm used, however vessel responded well.
24	Outbound	14	3 knots flood	Marginal but manageable	Experiencing sheer passing over Nepean Bank, pushing the bow out, and had to go hard-over helm through the Great Ship Channel to maintain course. Marginal result.
25	Inbound	14	3 knots flood	OK	Vessel carried 20 degrees of helm through Great Ship Channel.

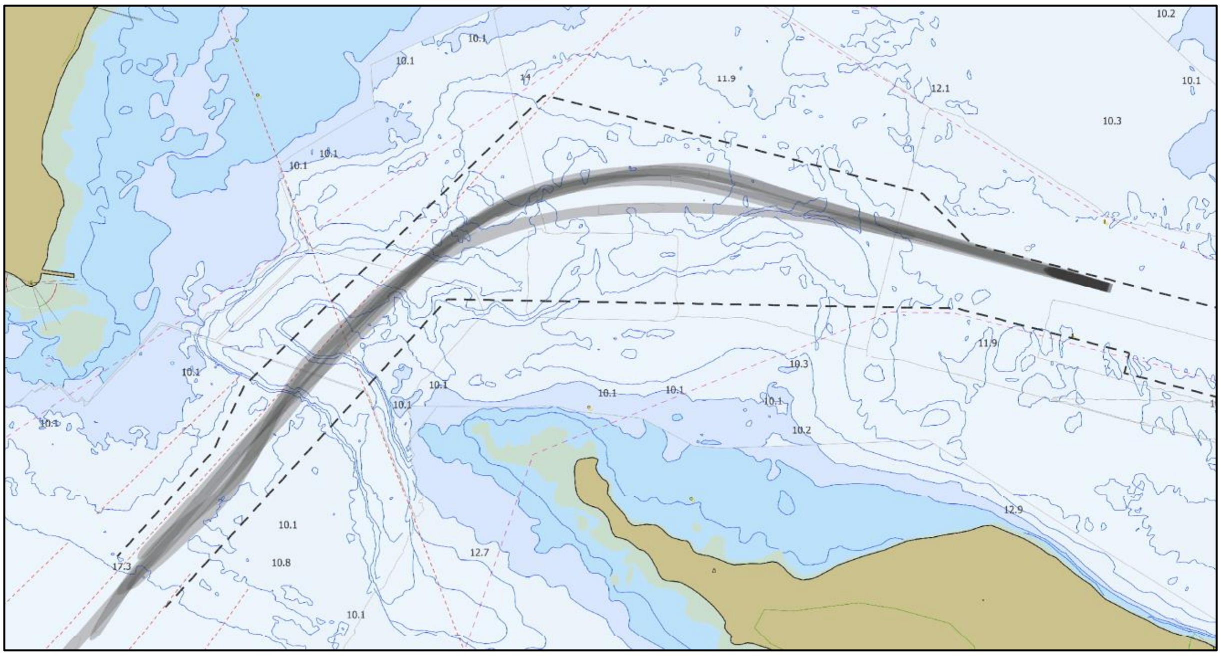

Figure 5-4. *Superium Maersk* successful swept paths for the widened channel configuration

The initial run with a 14.5 m draught was unsuccessful, and the draught was changed to 14 m for the remaining runs. These runs concluded that the widened channel of 425 m was adequate for this vessel. Based on these results, and for the purposes of the channel availability assessment, Table 5-8 outlines the current limitations that have been adopted for an Ultra Large Containership-class vessel with a draught of 14 m.

Table 5-8. Proposed tidal current limitations for the Ultra Large Containership class vessel based on the *Superium Maersk* (draught 14 m) – widened Great Ship Channel

Transit	Tide	Tidal Current Limitations (knots)	Basis
Inbound	Flood	3	Successful run 25
	Ebb	3	Not attempted; 3 knots acceptable outbound on the ebb, which is considered a more difficult transit
Outbound	Flood	3	Successful run 24. It is considered that the sheer experienced is a result of the model setup and further design refinement would reduce this sheer force.
	Ebb	3	Successful run 23

5.2.4.4 *Superium Maersk* (widened and deepened channel)

Additional scenarios were undertaken to consider an extra 1.5 m of deepening for deeper draught. This was undertaken by raising the water level to simulate additional depth; however the tidal currents were unchanged.

Table 5-9 outlines the summary of the findings from the runs undertaken for the *Superium Maersk,* and Figure 5-5 outlines the vessel swept path for the acceptable runs.

Table 5-9. *Superium Maersk* run summaries for the widened and deepened channel configuration

Run	Direction	Draught (m)	Current	Acceptable	Key Pilot Post-Run Comments
18	Outbound	14	3 knots flood	OK	Hard-over helm required briefly, but no need to supplement with engine.
19	Outbound	14.5	3 knots flood	Marginal	More pronounced effect of shallow water due to reduced tidal height. Hard-over helm and full ahead required to transit the vessel through the Great Ship Channel. Marginal result.
26	Outbound	15	3 knots flood	OK	Acceptable departure.
27	Outbound	15	3 knots ebb	OK	Sheer effect at the bow over Nepean Bank requiring considerable correction, vessel slow to respond to rudder, manageable.
28	Outbound	15	4 knots flood	NO	Sheer effect at the bow over Nepean Bank requiring hard over held and full ahead, not able to keep vessel within the channel.

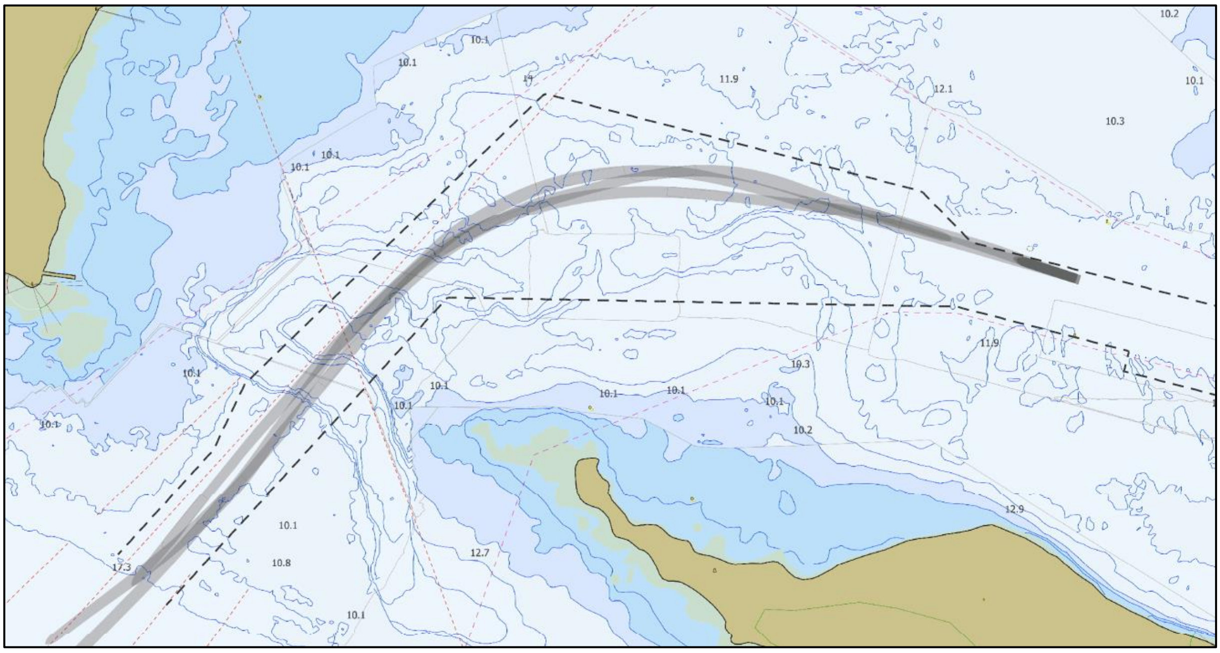

Figure 5-5. *Superium Maersk* successful swept paths for the widened and deepened channel configuration

These results indicated that there are channel upgrade scenarios including deepening and widening where Ultra Large Containership class vessels with a 15 m draught could transit the Port Phillip Heads. Based on these results and for the purposes of the channel availability assessment Table 5-8 outlines the current limitations that have been adopted for an Ultra Large Containership class vessel with a draught of 14 m.

Table 5-10. Proposed tidal current limitations for the Ultra Large Containership class vessel based on *Superium Maersk* (draught 15 m) – widened and deepened Great Ship Channel

Transit	Tide	Current Limitations (knots)	Basis
Inbound	Flood	3	Assumed based on results of the widened only runs
	Ebb	3	Assumed based on results of the widened only runs
Outbound	Flood	3	Successful run 26
	Ebb	3	Successful run 27

5.2.5 Findings

The key findings from the navigation simulations are:

- Old Post Panamax Plus (*Ital Cortesia*) and New Post Panamax (*MSC Daniela*) vessels are able to transit Port Phillip Heads with restrictions on the current velocities for the existing channel configuration
- Widening of the Great Ship Channel from the existing 245 m to 425 m is sufficient for Ultra Large Containership (*Superium Maersk*) class vessels to transit Port Phillip Heads (Great Ship Channel) with restrictions on the current velocities.

Based on the acceptable runs, the initial conclusion drawn from this study for the purposes of the channel availability assessment, are summarised in Table 5-11. Included are the current tidal limitations for the maximum vessel that is currently able to visit the Port of Melbourne.

Table 5-11. Summary of tidal current limitations for the channel availability assessment

Vessel	Representative Class	Nominal TEU Capacity	Great Ship Channel Configuration	Draught (m)	Inbound Transit (knots)		Outbound Transit (knots)	
					Flood	Ebb	Flood	Ebb
Current Maximum	Old Post Panamax	7,500	Existing	14.0	5	5	5	4
Ital Cortesia	Old Post Panamax Plus (8,500 TEU)	8,500	Existing	13.0	4	3	3	3
MSC Daniela	New Post Panamax (14,000 TEU)	14,000	Existing	13.5	3	1.5	3	1.5
Superium Maersk	Ultra Large Containership	18,500	Widened by 180 m	14.0	3	3	3	3
Superium Maersk	Ultra Large Containership	18,500	Widened by 180 m and deepened by 1.5 m	15.0	3	3	3	3

The ability to successfully transit the Great Ship Channel is mostly due to the tidal current velocity and the amount of water under the vessel (UKC). With sufficient UKC the vessel responded much better to the change in the rudder, and the pilots were able to complete the transit without needing to position the rudder at hard-over helm, or put the engine to full ahead. Where there was not sufficient UKC, the pilots had to have the rudder at hard-over helm and put the engine to full ahead to initiate the turn.

The results indicate that it is feasible to bring larger container vessels into Port Phillip under given tidal current restrictions. It should be noted that although the pilots state a run is acceptable, this does not imply that this would form a satisfactory operating condition to the satisfaction of the harbour master.

Multiple successful runs with multiple pilots under a range of conditions and vessel types would be required. Alternatively, there may be situations where the current restrictions are relaxed once the pilots become familiar with these vessels in the conditions and the risk profile is reduced.

5.3 Channel depth and availability

5.3.1 Methodology

Channel availability in respect to minimum depth requirements has been assessed with a UKC analysis.

This does not account for rising sea levels due to climate change. At Williamstown, sea level has risen by an average of 2.3 m each year for the period 1965 to 2013 (Cardno, 2015). The *Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (IPCC, 2007) outlines a sea level rise of 0.5 m by 2070 and 0.8 m by 2100 for the upper end scenario. CSIRO & BoM (2015) classify this as a medium scenario, and have a high-end scenario of 0.7 m by 2070 and 1.1 m by 2100, based on more recent research that explore the impacts of recent warming trends on ice sheet dynamics beyond those already included in the IPCC projections. CSIRO & BoM (2015, p152 (caption for Figure 8.1.7)) also note that *"If a collapse in the marine based sectors of the Antarctic ice sheet were initiated, these projections could be several tenths of a metre higher by late in the century"*

The UKC analysis is based on the model outputs from a years' worth of historical data (2015) based on model data from OMC International's Dynamic UnderKeel Clearance (DUKC) system, which is currently in operation for deep draught vessels that transit the Great Ship Channel.

Figure 5-6 outlines the points along the channel where the UKC is calculated. The speed at each of the UKC locations is based on the speed profiles developed for the Port of Melbourne DUKC system in consultation with Port Phillip Sea Pilots.

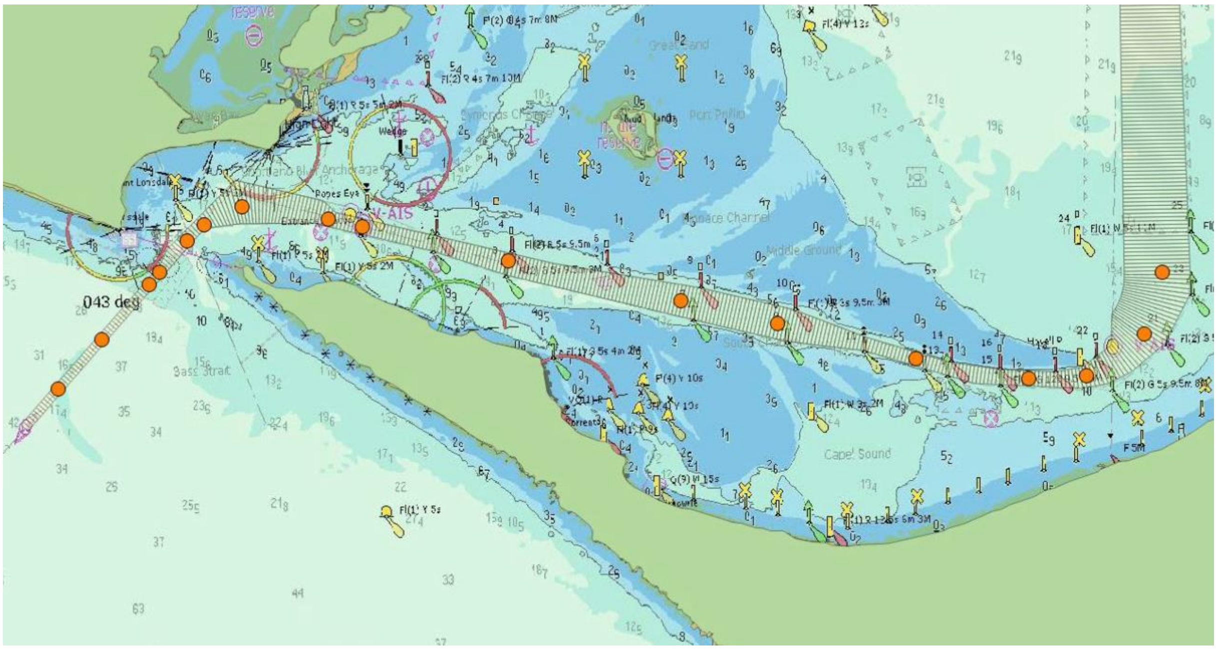

Figure 5-6. UKC calculation points

The wind heel calculations are based on wind data from the South Channel Island Bureau of Meteorology weather station from the same period as the hydrodynamic data used by OMC International, and have been added to OMC International's results. On average the wind heel contributed about 0.05-0.1 m to the overall required depth, although in high winds, with winds perpendicular to the side of the vessel, this increased to 0.4-0.8 m depending on the scenario. No limit on wind was set in accordance with current practice.

5.3.2 Scenarios

Table 5-12 outlines the scenarios that have been developed for the assessment of channel availability. Scenario 1 matches the existing maximum vessel size at its maximum draught, and scenarios 2, 4, 6 and 8 match those assessed as part of the navigation simulations. For these scenarios the tidal current limitations findings from the navigation simulations have been used.

Table 5-12. Scenarios for assessment of channel availability

Scenario	Vessel Classification	Nominal TEU Capacity	Comparison Vessel in the Simulations	Draught (m)
1	Old Post Panamax	7,000	N/A - current maximum (304 m LOA and 40 m beam)	14.0
2	Old Post Panamax Plus	8,500	*Ital Cortesia* (334 m LOA and 42.8 m beam)	13.0
3				14.0
4	New Post Panamax	14,000	*MSC Daniela* (366 m LOA and 51.2 m beam)	13.5
5				14.0
6	Ultra Large Containership	18,500	*Superium Maersk* (400 m LOA and 59 m beam used in the UKC model)	14.0
7				14.5
8				15.0

5.3.3 Channel availability results

5.3.3.1 Current maximum vessel (7,000 TEU)

Table 5-13 outlines the results for the current maximum vessel for the Port of Melbourne (304 m LOA, 40 m beam) at the maximum permissible draught of 14.0 m, based on the existing tidal current restrictions.

In the current situation, the channel closures are almost entirely caused by the tidal current limitations. The average time the channel is open each day is 18.3 hours per day, or 11.2 hours per opening on the inbound transit and 15.5 hours per day, or 7.3 hours per opening on the outbound transit.

Table 5-13. Scenario 1 channel availability for Old Post Panamax vessel (7,000 TEU, 304 m LOA and 40 m beam) at 14.0 m draught

Scenario 1 – 7,000 TEU Vessel at 14 m Draught	Unit	Inbound	Outbound
Channel availability	%	76%	65%
Total number of intervals per year that the channel is available	No.	595	775
Average number of intervals per day that the channel is available	No.	1.6	2.1
Average duration of each channel opening	Hours	11.2	7.3
Average hours per day that the channel is open	Hours/day	18.3	15.5
Maximum duration of a channel closure during a year	Hours	25	33

5.3.3.2 Old Post Panamax Plus vessel class (8,500 TEU)

Table 5-14 outlines the results for an Old Post Panamax Plus vessel based on tidal current limitation findings for *Ital Cortesia* (334 m LOA, 42.8 m beam and 13.0 m draught) simulation runs as outlined in section 5.2.4.1. In this scenario the channel closures are almost entirely caused by the tidal current limitations. The average time the channel is open each day is 15.5 hours per day, or 6.4 hours per

opening on the inbound transit, and 11.7 hours per day or 3.4 hours per opening on the outbound transit.

Table 5-14. Scenario 2 channel availability for Old Post Panamax Plus vessel (8,500 TEU, 334 m LOA and 42.8 m beam) at 13.0 m draught

Scenario 2 – 8,500 TEU Vessel at 13 m Draught	Unit	Inbound	Outbound
Channel availability	%	65%	49%
Total number of intervals per year that the channel is available	No.	886	1251
Average number of intervals per day that the channel is available	No.	2.4	3.4
Average duration of each channel opening	Hours	6.4	3.4
Average hours per day that the channel is open	Hours/day	15.5	11.7
Maximum duration of a channel closure during a year	Hours	13	13

If the same tidal current restrictions are considered for a 14 m draught, the channel availability decreases to 56 percent on the inbound transit and 40 percent on the outbound transit as outlined in Table 5-15. The average time the channel is open each day is 13.5 hours per day, or 5.3 hours per opening on the inbound transit, and 9.7 hours per day, or 2.9 hours per opening on the outbound transit. In this scenario the UKC is reduced by 1 m and the tidal current restrictions used in Scenario 2 may need to be more onerous; channel availability would reduce to that stated in Table 5-15.

Table 5-15. Scenario 3 channel availability for Old Post Panamax Plus (8,500 TEU, 334 m LOA and 42.8 m beam) at 14.0 m draught

Scenario 3 – 8,500 TEU Vessel at 14 m Draught	Unit	Inbound	Outbound
Channel availability	%	56%	40%
Total number of intervals per year that the channel is available	No.	934	1202
Average number of intervals per day that the channel is available	No.	2.6	3.3
Average duration of each channel opening	Hours	5.3	2.9
Average hours per day that the channel is open	Hours/day	13.5	9.7
Maximum duration of a channel closure during a year	Hours	23	23

5.3.3.3 New Post Panamax vessel class (14,000 TEU)

Table 5-16 outlines the results for a New Post Panamax vessel based on tidal current limitations findings for *MSC Daniela* (14,000 TEU, 366 m LOA and 51.2 m beam) simulation runs as outlined in section 5.2.4.2. In this scenario the channel closures are almost entirely caused by the tidal current limitations. The average time the channel is open each day is 8.7 hours per day, or 2.5 hours per opening on the inbound transit, and 8.5 hours per day, or 2.5 hours per opening on the outbound transit.

Table 5-16. Scenario 4 channel availability for New Post Panamax vessel (14,000 TEU, 366 m LOA and 51.2 m beam) at 13.5 m draught

Scenario 4 – 14,000 TEU Vessel at 13.5 m Draught	Unit	Inbound	Outbound
Channel availability	%	36%	35%
Total number of intervals per year that the channel is available	No.	1262	1245
Average number of intervals per day that the channel is available	No.	3.5	3.4

Scenario 4 – 14,000 TEU Vessel at 13.5 m Draught	Unit	Inbound	Outbound
Average duration of each channel opening	Hours	2.5	2.5
Average hours per day that the channel is open	Hours/day	8.7	8.5
Maximum duration of a channel closure during a year	Hours	21	22

If the same tidal current restrictions are considered for a 14 m draught, the channel availability decreases to 29 percent on the inbound transit and 26 percent on the outbound transit as outlined in Table 5-17. The average time the channel is open each day is 6.9 hours per day or 2.3 hours per opening on the inbound transit and 6.3 hours per day or 2.2 hours per opening on the outbound transit.

In this scenario the UKC is reduced by 0.5 m and the tidal current restrictions used in Scenario 4 may need to be more onerous, and channel availability would reduce to that stated in Table 5-17.

Table 5-17. Scenario 5 channel availability for New Post Panamax vessel (14,000 TEU, 366 m LOA and 51.2 m beam) at 14.0 m draught

Scenario 5 – 14,000 TEU Vessel at 14.0 m Draught	Unit	Inbound	Outbound
Channel availability	%	29%	26%
Total number of intervals per year that the channel is available	No.	1115	1062
Average number of intervals per day that the channel is available	No.	3.1	2.9
Average duration of each channel opening	Hours	2.3	2.2
Average hours per day that the channel is open	Hours/day	6.9	6.3
Maximum duration of a channel closure during a year	Hours	23	24

5.3.3.4 Ultra Large Containership vessel class (18,500 TEU)

Great Ship Channel widened to 425 m

Table 5-18 outlines the results for an Ultra Large Containership based on tidal current limitation findings for *Superium Maersk* (18,500 TEU, 398 m LOA and 58.2 m beam) simulation runs as outlined in section 5.2.4.3. In this scenario the channel closures are caused by the tidal current limitations, along with the Great Ship Channel and South Channel depth restrictions. The average time the channel is open each day is 5.8 hours per day, or 2.5 hours per opening on the inbound transit, and 5.1 hours per day, or 2.3 hours per opening on the outbound transit.

Table 5-18. Scenario 6 channel availability for Ultra Large Containership (18,500 TEU, 400 m LOA and 59 m beam) at 14.0 m draught

Scenario 6 – 18,500 TEU Vessel at 14 m Draught	Unit	Inbound	Outbound
Channel availability	%	24%	21%
Total number of intervals per year that the channel is available	No.	854	801
Average number of intervals per day that the channel is available	No.	2.3	2.2
Average duration of each channel opening	Hours	2.5	2.3
Average hours per day that the channel is open	Hours/day	5.8	5.1
Maximum duration of a channel closure during a year	Hours	61	62

Great Ship Channel widened to 425 m and deepened

Table 5-18 and Table 5-20 outlines the results for an Ultra Large Containership based on tidal current limitation findings for *Superium Maersk* (398 m LOA and 58.2 m beam) simulation runs as outlined in section 5.2.4.4. In these scenarios the declared depths have been adjusted, as outlined in Table 5-19. In both of these scenarios, the tidal current limitations reduce the channel availability to 50 percent. Other deepening scenarios that would increase the channel availability are possible, however the improvements are minimal. In these scenarios the channel would be open 9-10 hours per day or about three hours during each open period on average.

Table 5-19. Scenario 7 and 8 channel deepening

Channel Segment	Deepening and Adjusted Declared Draught	
	Scenario 7 – 14.5 m draught	Scenario 8 – 15 m draught
Great Ship Channel	0.5 m to -17.5 mCD	1 m to -18.0 mCD
Entrance Fairway	1 m to -17.0 mCD	1 m to -17.5 mCD
South Channel	1.5 m to -17.0 mCD	2 m to -17.5 mCD
Hovell Pile & Transit Fairway	1.0 m to -17.0 mCD	1.5 m to -17.5 mCD

Table 5-20. Scenario 7 channel availability for Ultra Large Containership (18,500 TEU, 400 m LOA and 59 m beam) at 14.5 m draught

Scenario 7 – 18,500 TEU Vessel at 14.5 m Draught	Unit	Inbound	Outbound
Channel availability	%	44%	42%
Total number of intervals per year that the channel is available	No.	1209	1190
Average number of intervals per day that the channel is available	No.	3.3	3.3
Average duration of each channel opening	Hours	3.2	3.1
Average hours per day that the channel is open	Hours/day	10.5	10.1
Maximum duration of a channel closure during a year	Hours	23	23

Table 5-21. Scenario 8 channel availability for Ultra Large Containership (18,500 TEU, 400 m LOA and 59 m beam) at 15 m draught

Scenario 8 – 18,500 TEU Vessel at 15 m Draught	Unit	Inbound	Outbound
Channel availability	%	41%	38%
Total number of intervals per year that the channel is available	No.	1173	1132
Average number of intervals per day that the channel is available	No.	3.2	3.1
Average duration of each channel opening	Hours	3.0	3.0
Average hours per day that the channel is open	Hours/day	9.8	9.2
Maximum duration of a channel closure during a year	Hours	36	35

5.3.4 Summary

Table 5-22 summarises the channel availability percentage for each of the scenarios considered. The primary factor for channel availability is the current restrictions that are in place. The current restrictions used are based on limited real-time navigation simulations. With further simulations to define the operations rules, and once pilots become familiar with these operations, there may be opportunities to relax the current restrictions.

To maximise these channel opening windows, a system that allows for real-time measurements and modelling of the currents will be required, to ensure that the pilots stay within the parameters set out by the harbour master.

Table 5-22. Summary of channel availability assessments

Scenario	Percentage Available	
	Inbound	Outbound
1 - Old Post Panamax vessel (7,000 TEU, 304 m LOA and 40 m beam) at 14.0 m draught	76%	65%
2 - Old Post Panamax Plus vessel (8,500 TEU 334 m LOA and 42.8 m beam) at 13.0 m draught	65%	49%
3 - Old Post Panamax Plus (8,500 TEU, 334 m LOA and 42.8 mb) at 14.0 m draught	56%	40%
4 - New Post Panamax vessel (14,000 TEU, 366 m LOA and 51.2 m beam) at 13.5 m draught	36%	35%
5 - New Post Panamax vessel (14,000 TEU, 366m LOA and 51.2 m beam) at 14.0 m draught	29%	26%
6 - Ultra Large Containership vessel class (18,500 TEU, 400 m LOA and 59 m beam) at 14.0 m draught (Great Ship Channel widened to 425 m)	24%	21%
7 - Ultra Large Containership vessel class (18,500 TEU, 400 m LOA and 59 m beam) at 14.5 m draught (Great Ship Channel widened to 425 m, deepened to -17.5 m)	44%	42%
8 - Ultra Large Containership vessel class (18,500 TEU, 400 m LOA and 59 m beam) at 15 m draught (Great Ship Channel widened to 425 m, deepened to -18.0 m)	41%	38%

5.4 Channel capacity

5.4.1 Great Ship Channel and the South Channel

The capacity of the South Channel can be assessed using a simplified approach, considering the average separation between vessels and an allowance for channel unavailability. The assessment considers the following assumptions:

- Separation between vessels is 15 mins
- Channel availability due to metocean conditions (waves, tides, currents) is 90 percent
- Vessels greater than 10,000 TEU capacity, and tankers (crude oil and refined fuels), limited to eight hours per day on average.

Based on the vessel call forecast outlined in Section 4.2, the channel utilisation for vessels greater than 10,000 TEU capacity, and tankers is 35 percent at 2066. For all transits the channel utilisation is 37 percent at 2066. Based on a maximum utilisation of 70 percent to allow for some flexibility in the scheduling, the number of vessel transits could potentially be almost double the number of forecast transits in 2066. Table 7-1 summarises these results.

Table 7-1. Theoretical channel capacity for 15 minute average separation

	2016	2026	2036	2046	2056	2066	Capacity
Total >10,000 TEU and tanker Transits	563	651	1903	2384	3023	3632	7358
8hr/day Utilisation for >10,000 TEU and tanker vessels	5%	6%	18%	23%	29%	35%	70%
Total transits	7355	7530	8147	9001	10322	11826	22075
Utilisation for all vessels	23%	24%	26%	29%	33%	37%	70%

Another scenario to assess the sensitivity considers a vessel separation of 22.5 mins. This accounts for a scenario that is the average separation for two vessels heading in the same direction (15 mins) and two vessels heading in the opposite direction (30 mins through the Great Ship Channel to the two way section of South Channel). Under this scenario the channel utilisation for vessels greater than 10,000 TEU capacity, and tankers is 52 percent at 2066, or 56 percent at 2066 for all transits. Based on a maximum utilisation of 70 percent, the number of vessel transits could potentially increase by 24 percent from the number of transits in 2066. Table 7-2 summarises these results.

Table 7-2. Theoretical channel capacity for 22.5 minute average separation

	2016	2026	2036	2046	2056	2066	Capacity
Total >10,000 TEU and Tanker Transits	563	651	1903	2384	3023	3632	4906
8hr/day Utilisation for >10,000 TEU and Tanker Vessels	8%	9%	27%	34%	43%	52%	70%
Total Transits	7355	7530	8147	9001	10322	11826	14717
Utilisation for all Vessels	35%	36%	39%	43%	49%	56%	70%

Based on this analysis there would be sufficient capacity in Great Ship Channel and South Channel up to 2066. This will require improved management procedures to ensure it is possible to manage this number of vessel movements.

5.4.2 Port of Melbourne

Future expansion of Webb Dock will increase the utilisation of the Port Melbourne and the Williamstown Channel. This is not due solely to the increased number of vessels visiting the port, but also the location of the Webb Dock Swing Basin in the Williamstown Channel. Due to the complex nature of movements in and out of the port, only the utilisation of container vessels at Webb Dock has been assessed. Vessels being swung at the Webb Dock swing basin lock all movements out of the port except for Gellibrand and Station Piers. On the inbound transits, vessel would not be able to enter the Williamstown Channel until the vessel being swung in the Webb Dock swing basin is clear of the Williamstown Channel. Movements to Gellibrand and Station Piers could still occur while a vessel is being swung at Webb Dock.

Based on the transit time from the entrance to the Webb Dock swing basin (30 minutes), the time to swing a container vessel at the Webb Dock swing basin (30 minutes) and allowing another vessel to come up the Port Melbourne Channel (20 minutes), the time separation between vessels is 40 minutes on an inbound transit and 60 minutes on an outbound transit. Based on an average separation of 45 minutes for container vessels, the channel utilisation assuming 95 percent availability and 1,876 container vessel transits to/from Webb Dock (2066) would be 23 percent for container vessels using Webb Dock

This is not expected to adversely impact the marine operations of the Port of Melbourne.

5.4.3 Potential future operational improvements

While the decrease in channel performance will be gradual and the initial impact small, it will be necessary to ensure that a satisfactory level of navigation and environmental safety, as well as associated commercial performance, is maintained over the forecast period. The following provides high-level suggestions for future work and initiatives that may be required extend the capacity of existing channel sets. All the suggestions made below are considered best practice in well-run international ports.

5.4.3.1 Port operating guidelines

In order to maximise the efficient use of the waterway, it will be necessary to introduce agreed procedures for prioritising vessel movements. This prioritisation will include consideration of vessel destination, berth availability, tidal conditions and cargo type, amongst others.

A full end-to-end port management system (including scheduling, navigation, berthing, cargo management and invoicing) is a tool for improving efficiency. This can allow for slot times to be planned further in advance, which can allow for arrival planning methods such as slow steaming to be used.

5.4.3.2 Vessel traffic management

A Vessel Traffic Service provider (VTS Authority) will schedule vessels against the agreed priorities and manage vessel traffic through the channel system on a fair and reasonable basis, ensuring compliance with the agreed procedures. This service is now provided by the Victorian Ports Corporation for vessels proceeding into Port Phillip to both Melbourne and Geelong. The service is governed by the *Marine (VTS Standards) Determination 2008* (VTS Determination), which is regulated by Transport Safety Victoria.

Under the VTS Determination, auditing arrangements are in place to ensure the VTS Authority responsible for vessel traffic management to the new terminals is suitably equipped for the task in terms of hardware, software and trained personnel. As the forecast increase in number, size and type of vessel occurs, the channel system scheduling priority should be reconsidered and adjusted as necessary. Existing first-come-first-use of the entrance channel system may need to be revised.

Efficiencies in channel usage can be achieved by introducing a convoy system for vessel transits and reducing time and distance separation where navigational safety permits.

The extent of the efficiencies which can be achieved using a convoy system can only be determined through review of the scheduling procedures and cargo prioritisation. This needs to be done on an ongoing basis to ensure that in changing economic climates the most effective prioritisation is in place.

5.4.3.3 Port resources

Steps will need to be taken, through stakeholder consultation and legislation if necessary, to ensure sufficient port resources are available to meet the increased demand. Pilotage, towage and mooring service providers must be in a position to meet the requirements of the shipping lines.

In most cases market forces will result in the appropriate services being available. Good early liaison between the port operator and service providers will normally result in the business opportunities being clearly appreciated and the vessels and expertise being available when needed.

Alternatively, some jurisdictions put legislation in place which requires service providers to provide certain equipment/services. This usually takes the form of conditions on the service providers' licensing regime.

5.4.3.4 Ongoing review

As trade levels increase it will be prudent to conduct a reassessment of navigational risk for the bay and channel systems. This will enable the existing operational parameters and procedures to be reviewed in the light of the changing commercial and environmental landscape. The channel design, bathymetry and effectiveness of dredging programs will all come under consideration. Larger and deeper vessels will be subject to the Dynamic Under Keel Clearance (DUKC) system currently used as the primary risk mitigation tool against grounding in the entrance to Port Phillip and along the South Channel. This system could be updated to include more accurate current predictions if larger container vessels have more onerous current restrictions.

These reviews are essential in maintaining navigational safety, but can also help identify where modifications to operating guidelines, or even minor channel design changes, would achieve further efficiencies within the channel system.

5.4.3.5 Navigation improvements

Pressure on the channel system will increase as larger vessels with deeper draughts enter Port Phillip. Detailed simulation studies will be required to confirm the operational procedures. These simulations will also indicate the placement of any additional navigational aids and marks (leading lights/marks, mid-channel buoys, virtual aids etc) that may improve the efficiency of vessel transits.

There are limited options for safe anchorage off the southern coast of Victoria, and masters of vessels are advised of this through nautical publications and radio communication. Port of Melbourne currently

offers a number of charted anchorage positions within Port Phillip offering depths of up to 16 m. Additional anchorage positions with sufficient underkeel clearance may need to be identified to cope with the larger and deeper-draught vessels.

There is space available within the bay of the required depth to accommodate as many new anchorages as are forecast to be required. This space is currently in Victorian Ports Corporation waters. The responsible port authority can gazette new anchorages. Depending on what future decision is made as to the redesignation of port waters, some coordination may be necessary between ports.

It is common for anchorages to be shared by different ports and this works particularly well where there is one VTS authority, as anchorage allocations are based on pre-set priorities.

5.4.4 Emergency management

With increased vessel numbers comes an increase in risk. The additional risk controls put in place can address this to a certain extent. Marine accidents and incidents can be expected to occur on occasions, and contingency plans must be in place to deal with the additional risk exposure. Emergency management response and business continuity plans will need to be produced covering key risks such as channel blockage, fire, collision and grounding.

There is potential for the temporary closure of a navigational channel for a variety of reasons including:

- collision between vessels, resulting in a grounding and channel obstruction
- collision or grounding of a vessel due to human or mechanical error, or a combination of both
- loss of cargo, reducing channel depth
- adverse environmental conditions, preventing vessel transits due to reduction in visibility or severe sea and swell conditions
- loss of channel depth due to siltation.

Risk mitigation strategies are put in place to address these hazards and reduce the risk to as low as reasonably practicable.

Mitigation strategies in common use include:

- one-way traffic in specified channels
- compulsory pilotage for specified vessels
- setting of parameters for wind, tide and current
- vessel traffic service (VTS) monitoring
- use of underkeel clearance systems
- harbour masters directions and operational procedures
- escort towage
- proximity of salvage assets
- classification and certification of vessels

5.4.4.1 Entrance to Port Phillip (The Heads)

There are five channels available to shipping entering and leaving Port Phillip Heads (refer to Figure 5-7, namely:

- Great Ship Channel
- Inner Eastern Channel
- Outer Eastern Channel
- Inner Western Channel
- Outer Western Channel

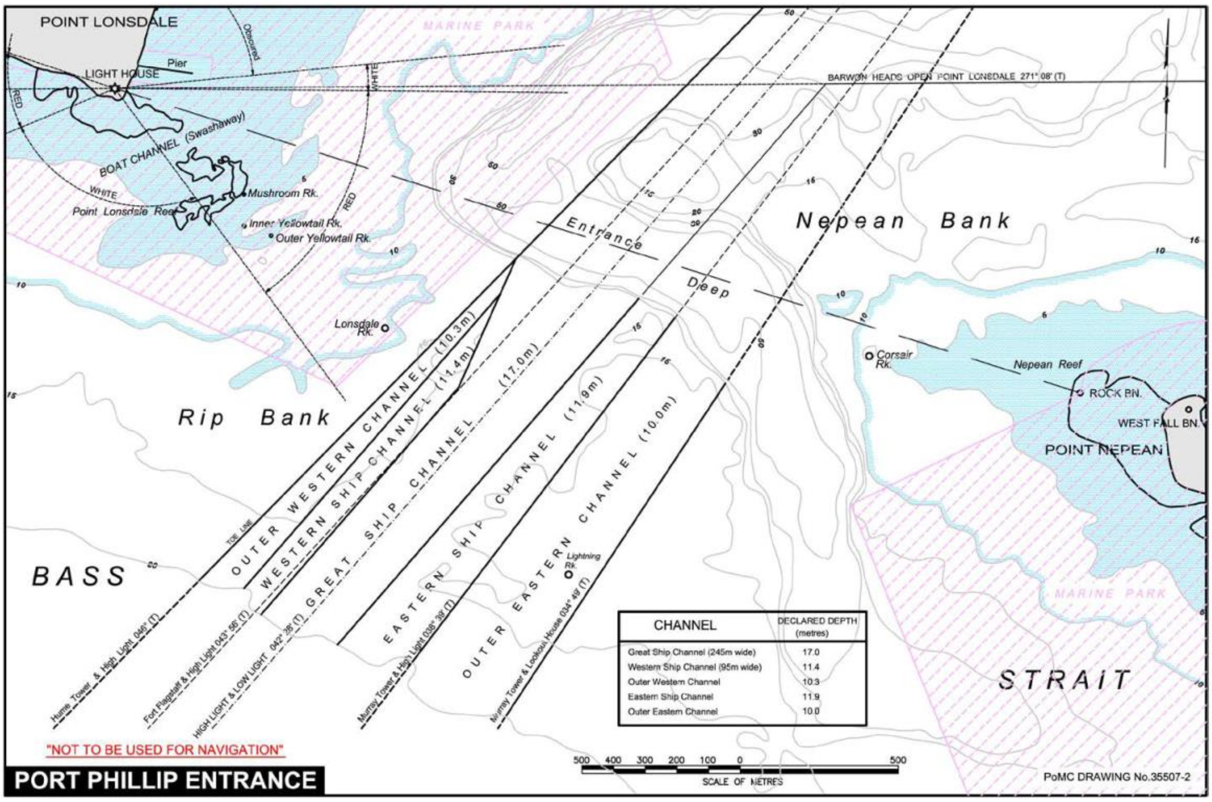

Figure 5-7. Port Phillip entrance channels (Source Port of Melbourne Corporation drawing No. 35507-2)

Specific controls are in place to ensure the safety of navigation of vessels transiting the heads:

- larger vessels are restricted to using the Great Ship Channel where one-way traffic is required
- vessel traffic rules are in place to ensure that no conflict occurs between vessels transiting the heads
- compulsory pilotage is required for all vessels over 35 m in length
- standards of training and certification of pilots and VTS officers are in place to ensure continued competence
- pilots' ongoing professional performance is maintained through the use of comprehensive safety management systems
- deep draught vessels transiting the Heads are to use the dynamic underkeel clearance system (DUKC)
- vessel transits are monitored by Lonsdale VTS and warnings of potential conflict provided to masters and pilots
- channel depths are maintained through regular survey and maintenance dredging as required
- classification societies ensure vessels are maintained 'in class' by regular survey
- AMSA oversees national port state control requirements, conducting targeted vessel inspections and detaining vessels found to have defects requiring rectification
- all ships have safety management systems, which are subject to regular inspection
- ship vetting services, eg Rightship, provide services to charterers needing to ensure ships are fit for purpose
- emergency response and management plans are in place.

The most likely cause of an incident occurring in one of the channels into Port Phillip would be a vessel grounding on the channel edge, due to human error or mechanical defects, or human error causing mechanical failure.

Examples of human error may be:

- an incorrect helm or engine order given by the master or pilot
- the helmsman or engineer not following the order given
- malfunction of steering or propulsion systems due to poor design, lack of preventative maintenance or not following correct procedures.

Likelihood

The risk controls mentioned previously ensure that loss of vessel control is rare. The best defence for ports is for them to have appropriate and robust procedures and guidelines.

With the introduction of safety management systems, a greater emphasis on training, improved maintenance systems, better vessel design, provision of backup systems and improved auditing, the risk of failure has reduced significantly in recent years.

Outcome

Should a vessel ground on the channel edge in one of the channels into Port Phillip, there are a number of strategies that can be employed to minimise the effect of restriction to port access:

- vessels with a smaller draught can continue to use the adjacent channels to the east or west if the Great Ship Channel is affected
- tugs can be used to hold the vessel in position if conditions are suitable to allow access to vessels past the stranded vessel
- salvage experts can be called in to re-float the vessel by ballasting, de-ballasting or cargo removal.

The time taken to clear the blocked channel will depend entirely on the nature of the incident, and can in extreme circumstances take weeks, although several days is far more likely. The Australian Maritime Safety Authority (AMSA) retains capability in the form of Svitzer tugs suitable for deep sea towage in Port Phillip that could be used to assist the vessel in moderate conditions. Any additional plant such as heavy lift crane barges and larger towage assets would need to be brought in from elsewhere, possibly Singapore, if there were none available on the Australian coast. Additional salvage assets would take approximately a week to arrive, depending on location.

However the availability of adjacent channels right through the heads and into the bay ensures vessels of a shallower draft will be able to continue to supply the greater Melbourne region unhindered and with no increase in risk profile.

A complete blockage of the Heads has not to the knowledge of the project team ever happened since the introduction of the five existing channels. The likelihood of it occurring in the future, with the improved processes outlined above, is unlikely, and more likely to be the result of an extreme natural event (such as seismic activity affecting all the channels simultaneously).

6.0 Western Port

6.1 Channel width and layout concept design

6.1.1 Approach channel

The required width of the channel using the concept design method in PIANC 2014 is based on multiples of the design vessel beam, taking into account vessel speed, prevailing cross wind, cross and longitudinal currents, waves, aids to navigation, bottom surface and the depth of the waterway.

The existing channel has been broken into segments by each straight length of channel as outlined in Figure 3-7. Table 6-1 summarises the required widths given by PIANC 2014, the calculations and rationale are included in Appendix A.

Table 6-1. Concept design channel widths (m)

Segment	Existing Width (m)	Concept Design Width (m) using PIANC 2014	Concept Design Widths Adopted (m)
Western Channel 1	400	519	519
Bend of Western Channel 1 and 2	560	581	581
Western Channel 2	536	460	536
Bend of Western Channel 2 and 3	592	534	592
Western Channel 3	536	448	536
Bend of Western Channel 3 and 4	1,112	536	1,112
Western Channel 4	183*	230	230
Bend of Western Channel 4 and North Arm 1	183	267	267
North Arm 1	183	212	212
Bend of North Arm 1 and 2	605	243	605
North Arm 2	250	212	250

Red text indicates that the required dimension is larger than the existing width.

** This segment is trapezoidal in shape and the dimension corresponds to the minimum width, which is located at the junction with North Arm 1*

Where the concept design widths using PIANC 2014 are less than those existing, the channel dimensions have not been reduced. Widening or realignment of the existing channel is required at the following locations:

- For a two-way transit along the full length of Western Channel 1 and the bend of Western Channel segments 1 and 2. High spots are located near the bend of Western Channel 1 and 2 near McHaffie's Reef at Ventnor on Phillip Island, and along the north of the channel at the southern entrance to Western Channel 1. To avoid these high spots the intersection of Western Channel 1 and 2 has been moved 300 m to the west and the angle at this corner increased by two degrees as outlined in Figure 6-1. This results in a marginally tighter approach into the first bend along the Western Channel.

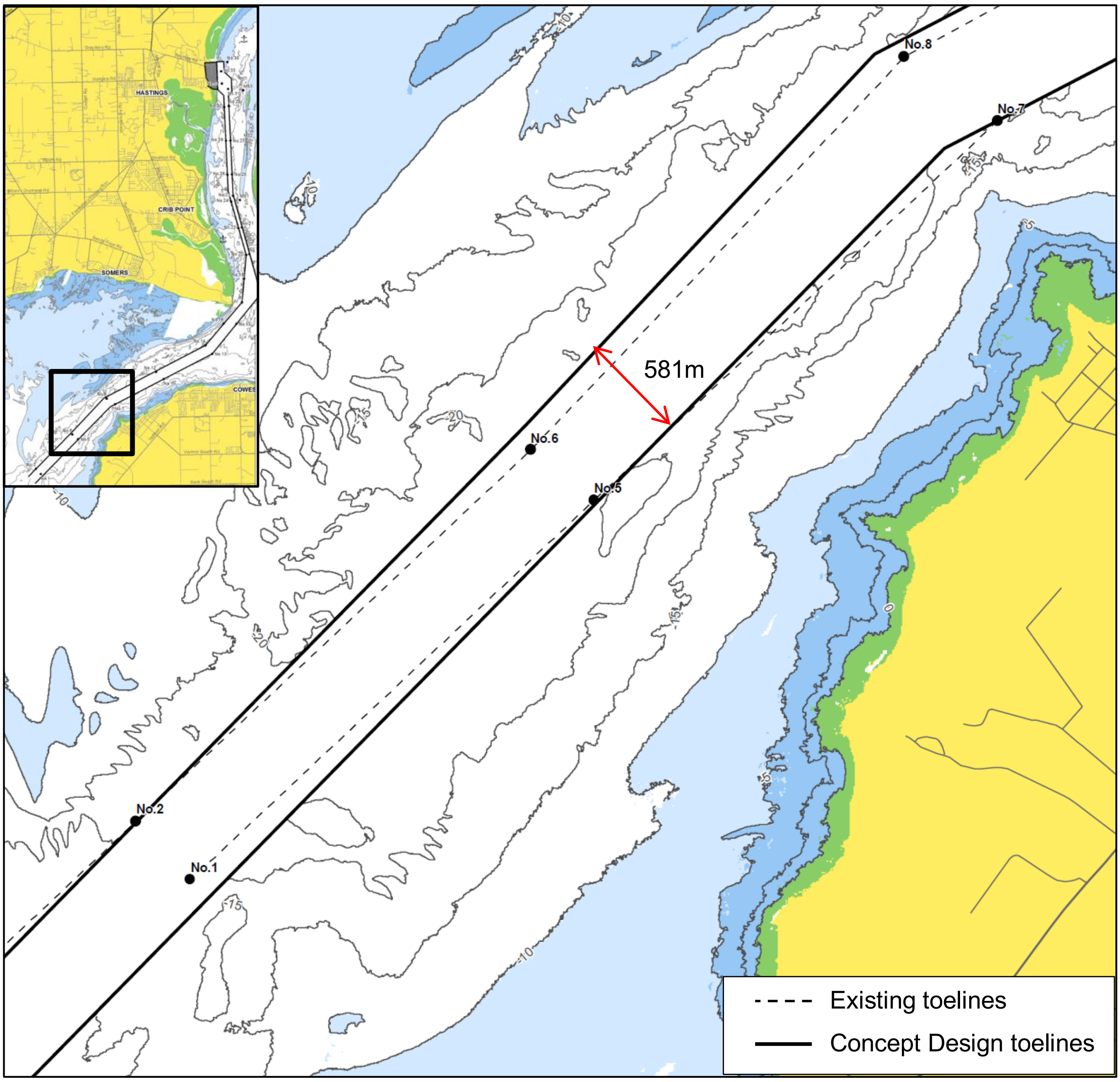

Figure 6-1. Western Channel 1 alignment concept design

- At the entrance to the North Arm (the northern end of the Western Channel). At this location beacon No. 19 has been moved eastward to accommodate the additional width. The eastern side was selected for adjustment because it is slightly deeper, resulting in a lower dredge volume, however the operational impacts of this change will need to be confirmed in the simulation studies. The alignment is outlined in Figure 6-2.

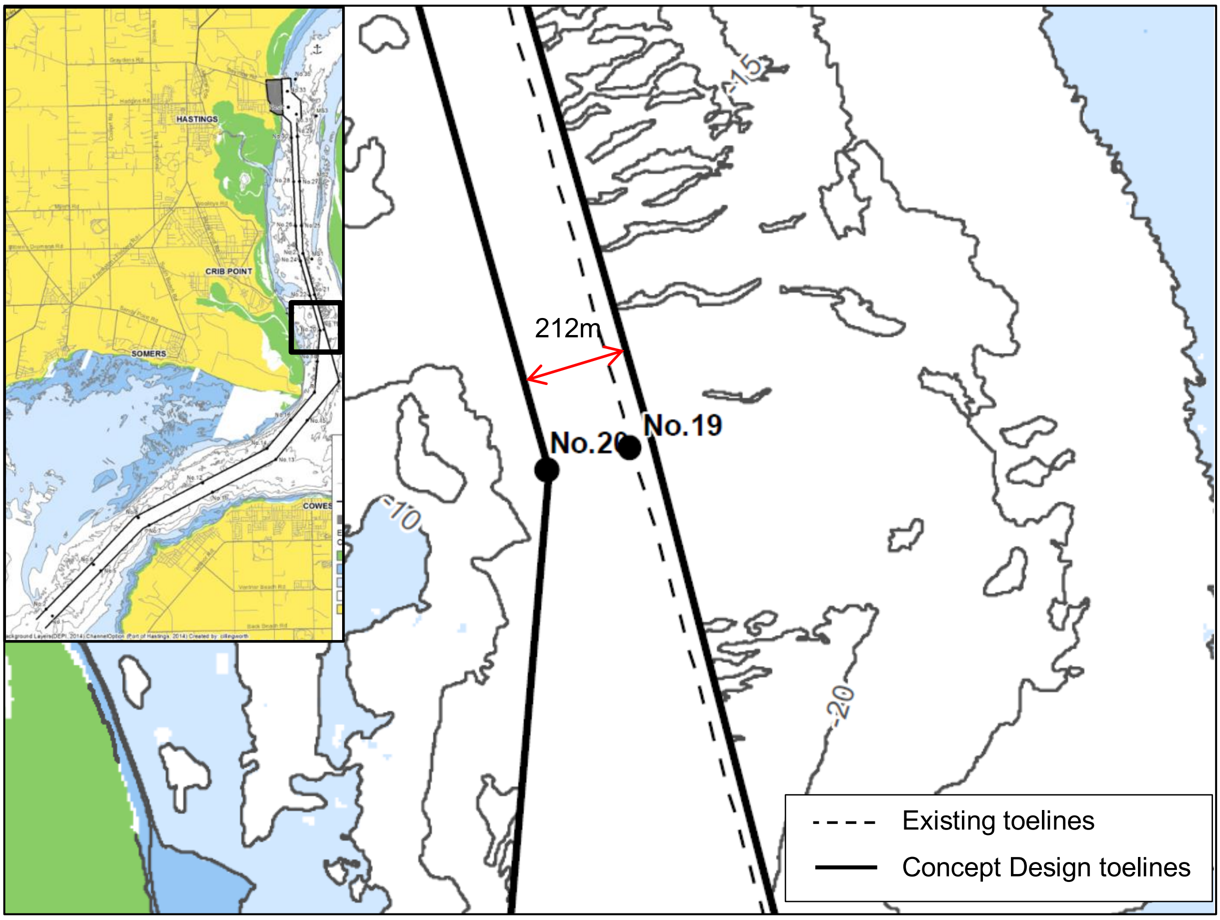

Figure 6-2. Entrance to North Arm

6.1.2 Port area

Within the port area, two berth alignment options developed as part of the Port of Hastings Development Project have been considered in the channel design. The berth alignment options are:

- Along the Shore option - berth line follows the general shape of the shoreline and bed level contours
- Basin Option - A basin is excavated in from the shore line with berths potentially located on both sides.

Both alignments start at the same location, which is 250 m north of the centre point of the Long Island Point Jetty, and are on the same alignment as the Long Island Point and BlueScope RoRo jetties.

The Stage 1 development is the same for both alignments and consists of 1,450 m of berth length between the existing Long Island Point and BlueScope RoRo jetties. The Long Island Point Jetty and the BlueScope general purpose berth are to remain in operation, while the BlueScope RoRo Jetty is to be demolished as part of the Stage 1 development. Refer to Figure 6-3.

The Along the Shore alignment is aligned with the existing Long Island Point Jetty and BlueScope RoRo wharf berth line over the first 2,200 m. At this point the berth alignment changes by approximately 44 degrees to the east, with a potential length of up to 3,000 m, which would bring the total berth length up to 5,200 m. Refer to Figure 6-4.

The Basin Option follows the same alignment as Along the Shore t for the first 2,200 m. At this point the berth alignment changes by approximately 46 degrees to the west, and the length of the basin is 2,500 m with an additional 800 m of berths on the northern side of the basin. Refer to Figure 6-5.

For the port area the following dimensions have been considered:

- swing basin – PIANC 2014 recommends a width up to two times LOA and an additional vessel length in the direction of current flow. A width of less than two times LOA perpendicular to the current flow is used safely in many ports, and this particular clause of the PIANC recommendations is generally considered conservative where there is a good tug fleet. A swing basin width of 1.75 times LOA has been adopted. In the direction of the current flow, a width of three times LOA has been used for the concept design, due to the unknowns at that stage about the impact of the current on the movement of vessels.
- berth pocket – a width of two times beam has been adopted
- drag area (where vessels are manoeuvred to the berth after being swung – a width of 282 m (400 m from the berth line) has been adopted based on practice in other ports.
- basin – a width of 450 m has been used based on a review of worldwide ports that cater for the design container vessel.

Figure 6-3 to Figure 6-5 show these dimensions on the Stage 1, Along the Shore and Basin alignments.

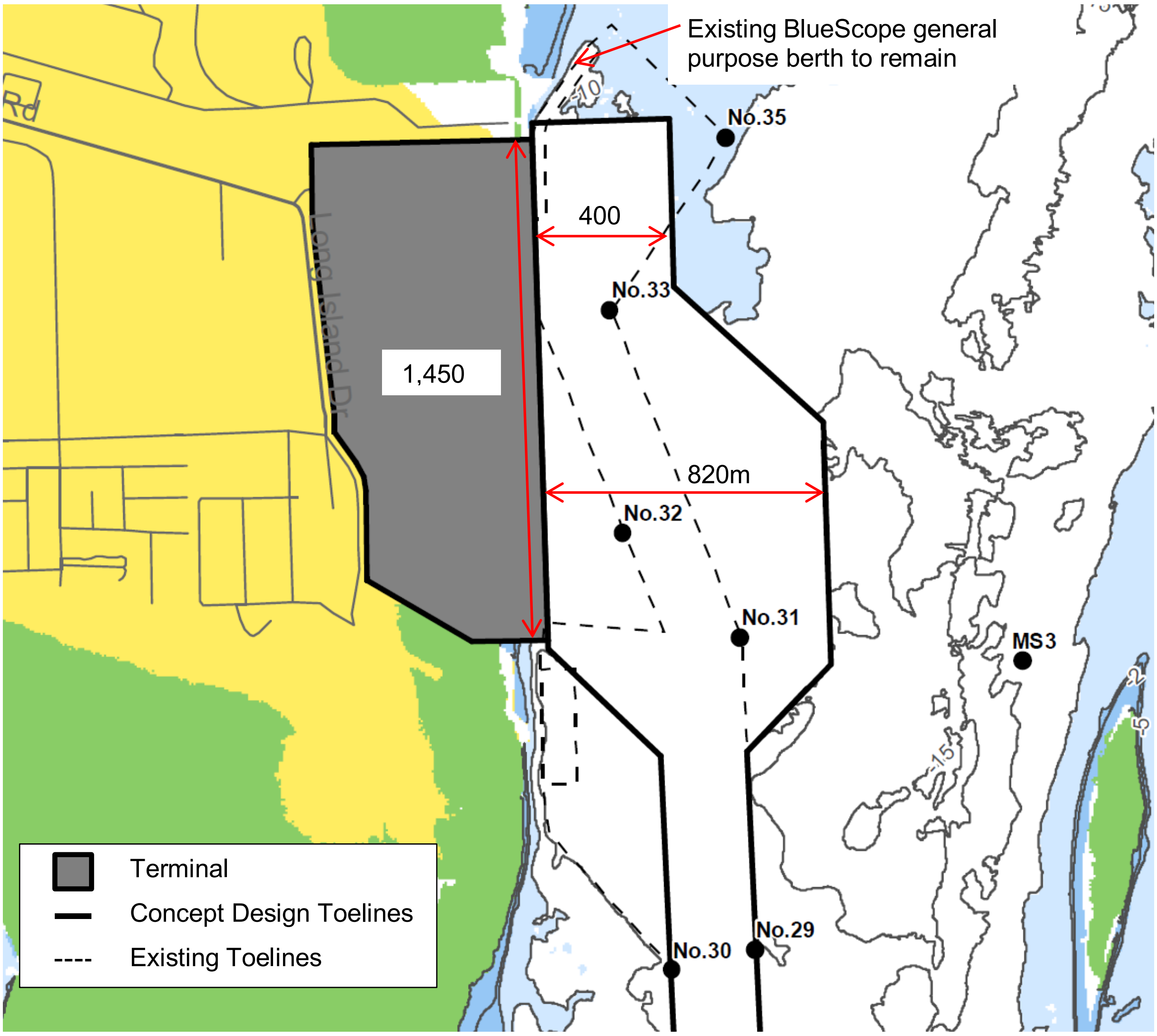

Figure 6-3. Concept design - Stage 1 Development (common to both Along the Shore and Basin alignments)

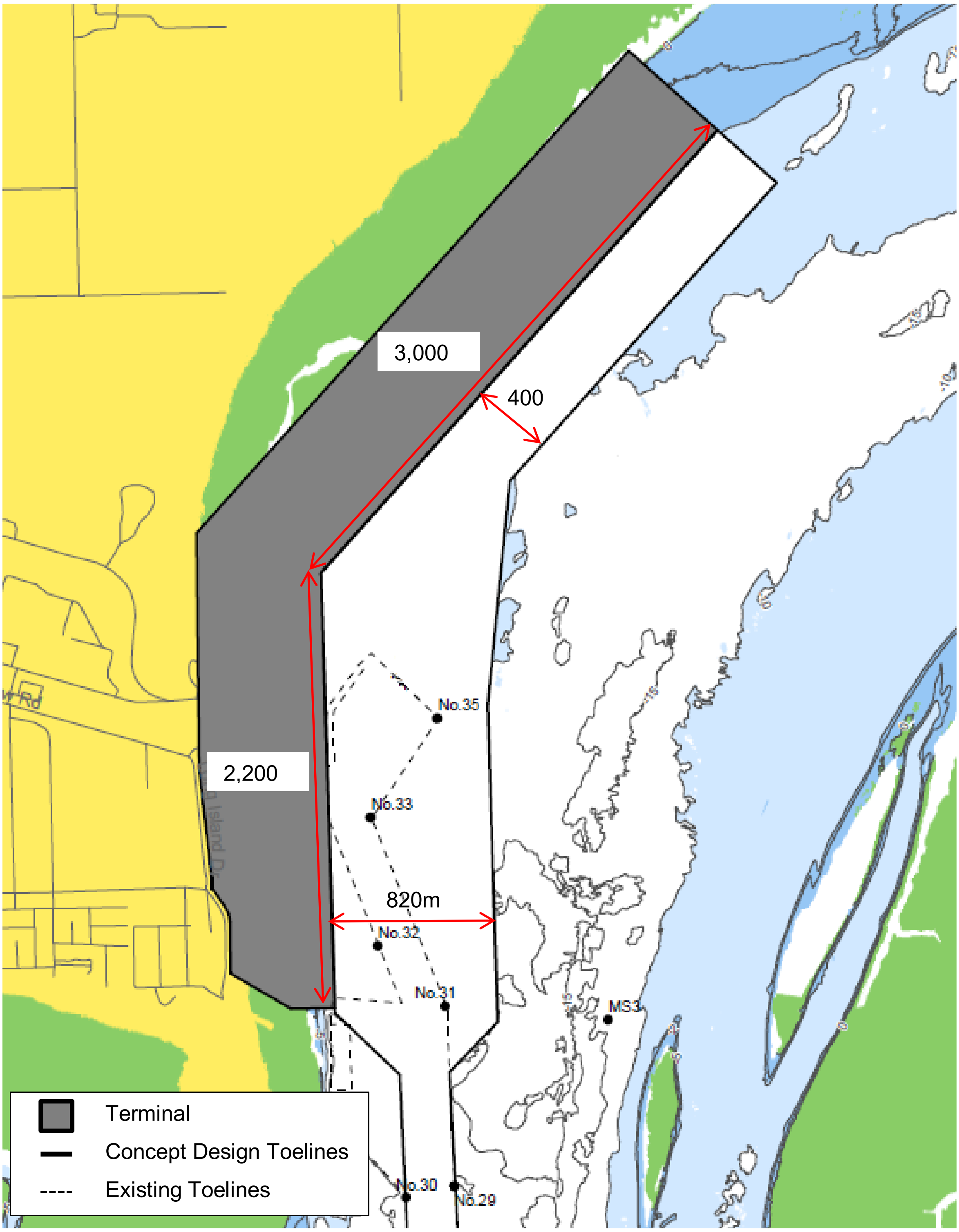

Figure 6-4. Concept design - Along the Shore alignment

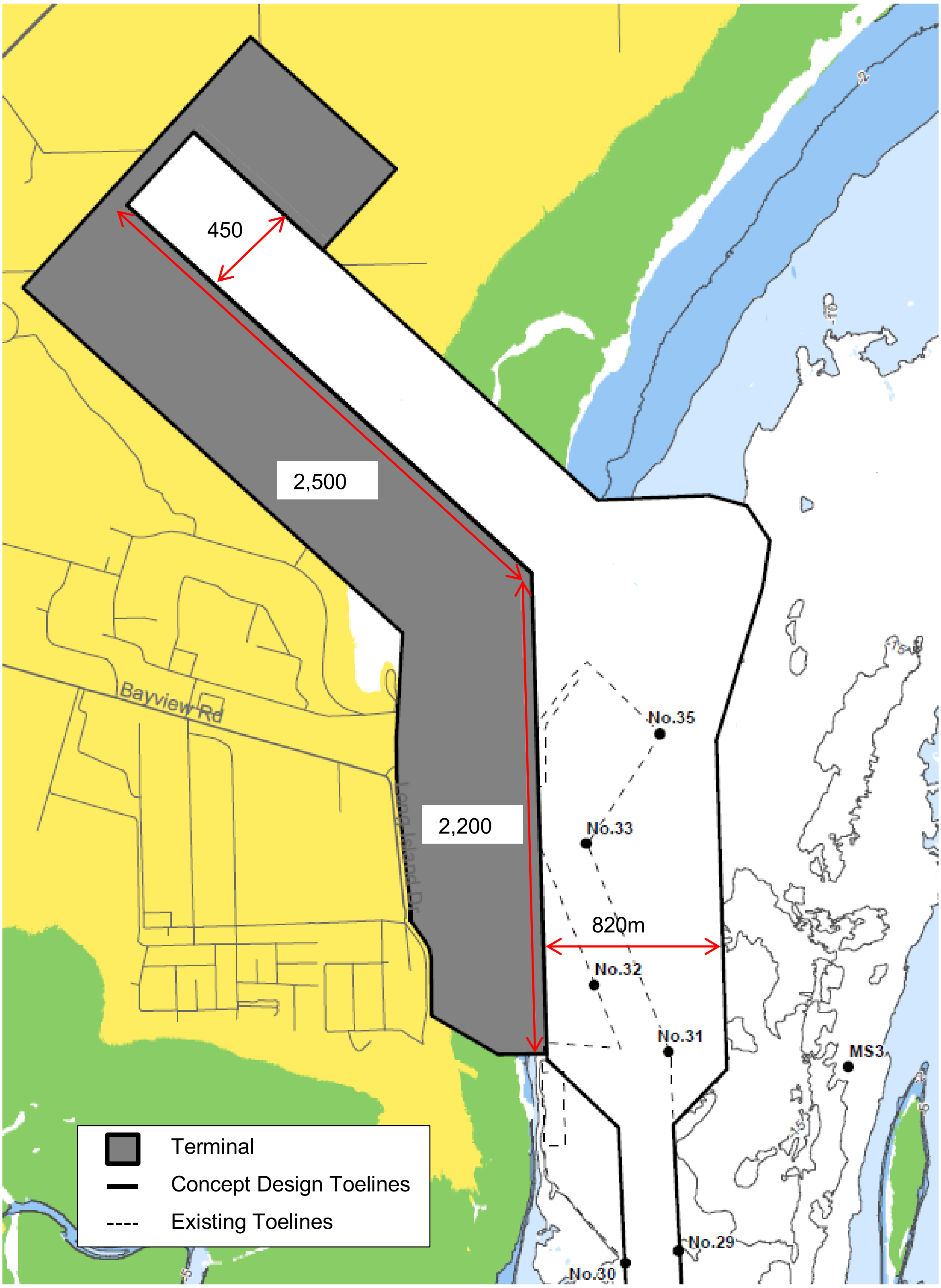

Figure 6-5. Concept design - Basin alignment

6.2 Navigation simulations

6.2.1 Objectives

The key objectivities of the navigation simulations were to:

- refine the concept design for the approach channels
- confirm the size of the swing basin for the Stage 1 development
- confirm that the Along the Shore option is feasible for manoeuvring large container vessels back along the berth quay after the bend
- confirm that vessels (Ultra Large Containerships and 115,000 DWT bulk vessels) can be manoeuvred into and out of the basin in the Basin option, and assess if a training wall is required to reduce the effect of cross currents while the vessel is being swung
- confirm that the existing berthing operations at the Long Island Point Jetty would not be compromised by the container terminal development to the north.

6.2.2 Methodology

The real time navigation simulations were undertaken at HR Wallingford's facility in Fremantle. The simulation facility comprises wrap-around screens with a continuous visual angle of 280 degrees, and a 42" TFT monitor for the astern view. A 'look-around' facility is also incorporated that allows the pilot's viewpoint to be moved from the centre of the bridge to either bridge wing, and all around the ship. In addition, the pilot is able to look down the ship's side.

The simulations were undertaken by Captain Ian Simpson. Captain Simpson has considerable pilotage experience, including bringing the first 400 m LOA container vessels into Port of Felixstowe, United Kingdom. Port of Felixstowe has some similarities to Port of Hastings in that there is a run of tide along the face of the berths. The River Stour joins the River Orwell just opposite the main berths at Felixstowe, giving a complex pattern of tidal currents. Most vessels arriving at Felixstowe are turned in the current and then moved astern to reach their berths. Captain Simpson's experience therefore has direct relevance to Western Port.

Hydrodynamic data was prepared using a DELFT-3D model which has 2D (depth averaged) flow (Haskoning, 2015). The model comprised a 20 m fine grid in the port area, North Arm and Western Channel down to buoys 1 and 2. Beyond this the model comprises a 150 m coarse grid that extends just past the port limits. A suitable tide period that closely matched a spring tide was selected.

6.2.3 Vessel characteristics for simulation

The vessel for the real time simulations was a 400 m (nominal length) LOA, 59 m beam Ultra Large Containership. The *CSCL Globe* model was chosen over the Maersk E Class model as it more closely represents the hull shape and fitout of the majority of the 400 m LOA container vessels that are currently in service or on order. For the bulk vessels, a ship that closely represented the dimensions of an Aframax vessel (which currently uses Long Island facility) was adopted.

The tugs used in the navigation simulations were centrally controlled. For the 400 m LOA vessel, tugs with an 80 tonne bollard pull were used. For the existing layout the current tugs, which have a rated bollard pull capacity of 52 tonnes, were downgraded to 40 tonnes as it is understood they are not able to provide the rated capacity. The tugs were subject to realistic delays and loss of effectiveness due to speed and movement in waves.

Details of the vessels are outlined in Table 6-2, and further details are provided in *Port of Hastings Real Time Navigation Simulation Report* in Appendix E.

Table 6-2. Vessel models

Vessel Name	LOA (m)	Beam (m)	Draught (m)	Comments
399 m container ship	399	58.6	14.5	*CSCL Globe* verification model
250 m products tanker	250	44	8.0	Ballast
250 m products tanker	250	44	14.5	Laden
115,000 DWT bulker	255	43	7.0 forward 8.0 aft	Ballast
115,000 DWT bulker	255	43	13.2 forward 14.5 aft	Laden

6.2.4 Results

The following sections outline the results of the navigation simulation runs undertaken for each of the layouts that were assessed. Further details are provided in *Port of Hastings Real Time Navigation Simulation Report* in Appendix E.

6.2.4.1 Approach channel

Table 6-3 outlines the summary of the findings from the runs undertaken in the approach channel. All runs were undertaken during the peak spring ebb or flood tide.

Table 6-3. Approach channel run summary

Run	Direction & Transit	Current	Wind	Key Pilot Post Run Comments
01	In - entire channel	Ebb	15 knot easterly	No issues in the Western Channel; the depth and width allows for speeds to be kept high. Entrance to North Arm (Buoy 19 and 20) is difficult, clearance to toelines about 20-30 m.
02	In – North Arm only	Ebb	30 knot westerly	Very difficult to assess the position of the vessel at the entrance to the North Arm (Buoy 19 and 20). Heading of vessel was always out of the channel in the North Arm with both buoys on the one side of the vessel.
03	In – North Arm only	Flood	30 knot westerly	Entrance to North Arm (Buoy 19 and 20) was difficult.
04	In – North Arm only	Flood	30 knot easterly	Entering the manoeuvring area the vessel was set toward Buoy 32, requiring aggressive manoeuvring to clear Buoy 32, resulting in difficulty reducing speed within the manoeuvring area. Unable to maintain satisfactory clearance from port infrastructure during the swing. More space in proximity to Buoy 32 is required.
05	In – North Arm only	Ebb	30 knot easterly	Better than previous run but difficult to gauge what is having a bigger effect, wind or current. Once past buoy 19 and 20 at the entrance to the North Arm aimed for buoy 21

Run	Direction & Transit	Current	Wind	Key Pilot Post Run Comments
				but went too far in order compensate for the wind and ended up close to buoy 22. Straight forward up North Arm 2 but still having to do regular changes to maintain course.
07	Out – entire channel	Ebb	30 knot westerly	A cross current component was evident past McHaffie reef but the vessel speed and width of the channel meant that for these vessels this is not an issue. Went slow ahead though North Arm 2 as he was worried about having too much speed at the corner to North Arm 1. In the North Arm the difficulty is that the sight lines are always out of the channel and the pilot has no visual reference that he is in the channel. Additional buoys will not necessarily help.

6.2.4.2 Stage 1 layout

Table 6-4 summarises the findings from the runs undertaken from the end of the approach channel to-and-from the berth for the Stage 1 layout. All runs were undertaken during the peak spring ebb or flood tide unless otherwise noted.

Table 6-4. Stage 1 layout run summary

Run	Direction	Current	Wind	Key Comments/Findings
01	In	Ebb	15 knot easterly	No issues with the swing manoeuvre.
02	In	Ebb	30 knot westerly	The speed passing through the end of the narrow channel influences where the swing basin is. To successfully transit past buoys 31 and 32 the pilot needed to maintain speed and was not able to initiate the turn until he had successfully passed these buoys. This and the direction of the current was why the turn was so high up in the swing basin. The vessel did not get to within 100 m of the toelines between buoys 33 and 35 and the toelines between buoys 35 and 37.
03	In	Flood	30 knot westerly	The pilot only stopped the engine to reduce the speed when he was satisfied that he could successfully enter into the swing basin. However the length of the swing basin was adequate despite the flood tide making it more difficult to slow the vessel down. The vessel did not get to within 150 m of the toelines between buoys 33 and 35 and was about 100 m from the toelines between buoys 35 and 37.
04	In	Flood	30 knot easterly	When entering the swing basin the pilot had to straighten up the vessel to miss buoy 32. This resulted in the vessel being in a worse position for the swing and very close to the berth (approx. 75 m from the berth) during the swing. Without buoy 32 the stern could have been pushed out earlier and

Run	Direction	Current	Wind	Key Comments/Findings
				the swing would have been undertaken in a more central position. When the vessel was close to the berth the pilot was solely focused on moving it away from the berth and essentially stopped the swing.
05	In	Ebb	30 knot easterly	No issues with the swing manoeuvre, however the pilot noted that three tugs would be required for berthing. The vessel did not get to within 150 m of the toelines between buoys 33 and 35.
06	In	Flood	30 knot south-westerly	Entered basin under control and swung to starboard because the pilot was unsure that he would have full control going in the other direction, however next time he would consider going bow into the berth. When backing up the current got on the wrong side (on the starboard side of the bow) and then to get control again he had to force the vessel around by having a tug on the bow with a bow thruster and then to put the ship engine ahead to keep away from the toelines between buoys 35 and 37. The vessel did not get to within 150 m of the toelines between buoys 33 and 35.
07	Out	Ebb	30 knot westerly	Entering the channel at buoys 31 and 32 was problematic. As soon as the pilot could see the buoy on the starboard side he increased the speed to provide more control.

6.2.4.3 Along the Shore layout

Table 6-5 summarises the findings from the runs undertaken from the end of the approach channel to-and-from the berth for the Along the Shore layout. All runs were undertaken during the peak spring ebb tide.

Table 6-5. Along the Shore layout run summary

Run	Direction	Current	Wind	Key Comments/Findings
08	In	Ebb	30 knot northerly	No issues. The pilot swung the vessel at buoy 35 and backed the vessel up away from the toeline between buoys 35 and 37 in order to assess if it was possible to assess the drag back area. The drag back area width was considered adequate. Clearance at the swing position to the toelines was 163 m.
26	In	Ebb	30 knot north-westerly	It was not possible to hold the vessel against this combination of tide and wind with three tugs, which resulted in the vessel crossing the toelines at buoy 37.

6.2.4.4 Basin layout

Table 6-6 summarises the findings from the runs undertaken from the end of the approach channel to and from the berth for the Basin layout. All runs were undertaken during the peak spring ebb or flood tide unless otherwise noted.

All runs except run 15 where undertaken using a layout that includes a vertical wall along the north side of the basin that extends out to the 0 m CD contour. Run 15 used a layout with a vertical ‘training’ wall along the north side of the basin that extended out to Buoy 37. This layout was for an assessment of whether a training wall is required to reduce the effect of cross currents while the vessel is being swung.

Table 6-6. Basin layout run summary

Run	Direction	Current	Wind	Key Comments/Findings
09	In	Ebb	10 knot northerly	No issues with the swing manoeuvre; adequate space and the area east of buoy 33 was not used. Vessel navigated stern first through the basin and kept safe distances from the berth.
10	In	Ebb	30 knot northerly	Swing effected with adequate clearances. The stern first manoeuvre up the basin required more tug power in these conditions.
11	Out	Ebb	30 knot northerly	Vessel successfully transited straight out of the basin without stopping to swing. Minimum clearance to the berth was 120 m. Vessel entered the channel at buoy 30 under control but at high speed, and it was difficult to control the speed in these conditions.
12	Out	Flood	30 knot south westerly	Vessels successfully transited straight out of the basin without stopping to swing. Minimum clearance to the berth was 100 m. Stern tug used to control speed, however ground speed was 6.5 knots when entering the channel.
13	In	Flood	30 knot south westerly	Swung the vessel further south due to the environmental conditions, and the pilot was successfully able to position the vessel stern first for the transit up the basin, with a minimum clearance of 120 m from the berth.
14	Out	Flood	30 knot south westerly	Stern first exit from the basin. The swing manoeuvre was initiated too soon and as a result the vessel got to within 30m of buoy 39. More effective use of the available area is expected to give a better outcome.
15	In	Ebb	30 knot northerly	Vessel swung and berthed about halfway along the southern berths. No problems identified on the ebb tide.
16	In	Flood	30 knot south westerly	Bulk vessel inbound swung at the entrance to the basin and transited stern first into the basin. Manoeuvre completed successfully and maintained adequate clearance to port infrastructure.
17	Out	Flood	30 knot north westerly	Bulk vessel outbound stern first out of the basin and swung successfully, while maintaining adequate clearance to port infrastructure.
23	Out	Ebb	30 knot northerly	Alternative strategy to that used in run 11 for the same conditions. The vessel speed was reduced when exiting the basin, with lateral control maintained by the tugs. Swing completed successfully, however it was difficult to keep the speed low when entering the channel and the vessel was within 33 m of buoy 29.

6.2.4.5 Existing operations at Long Island Point Jetty

Table 6-7 summarises the findings from the runs undertaken to-and-from the Long Island Point Jetty. The runs were undertaken during a state of tide that was known to replicate the current operations. Buoy 32 is considered to be a virtual navigation marker for container vessels only and was ignored for these runs.

Table 6-7. Long Island Point Jetty run summary

Run	Direction	Current	Wind	Key Comments/Findings
24	In	Ebb	25 knot north westerly	Routine berthing manoeuvre

Run	Direction	Current	Wind	Key Comments/Findings
25	Out	Flood	25 knot south-westerly	This state of the tide is possibly the issue that the pilots have reported at this berth, in that there is a flood current about 1-2 beams off the berth which reduces to nothing at the berth, and the ebb slowly moves out from the berth while there is still a flood tide in the middle of the swing area. Routine unberthing manoeuvre.

6.2.5 Findings

The key findings from the navigation simulations are that the both the Along the Shore and Basin alignment options are feasible for the Ultra Large Containerships, and the width of North Arm 1 (between buoys 19/20 and 23/24) needs to be increased. Furthermore a number of opportunities to reduce the width of the swing basin on all layouts have been identified. The findings from the navigation simulations undertaken are as follows:

- Approach Channel
  - the Western Channel was found to be adequate, although two-way transits were not assessed
  - the bend east of Sandy Point was found to be adequate
  - The width of North Arm 1 (212 m between buoys 19 & 20 and 23 & 24) was found not to be adequate, however the width of North Arm 2 (250m between buoys 23 & 24 and 29 & 30 was found to be adequate
  - the deflection of the channel at buoys 23 & 24 is a significant navigational feature and consideration should be given to widening the channel and/or easing the bend in this area
  - an additional set of lateral navigation marks was recommended for North Arm 2 (between buoys 23 & 24 and 29 & 30)
  - the width of the channel at the entrance to the swing basin at 31/32 is inadequate. Widening the entrance to the swing basin will allow the vessel to slow down earlier while maintaining control. The vessel speeds in the navigation simulation past Long Island Point and on the entry to the swing basin were considered to be too high.
- Stage 1 Development swing basin
  - the length of the swing basin is adequate
  - the width of the swing basin could be reduced as the closest a vessel was to the eastern toelines was approximately 100 m.
  - the drag back area is adequate for vessels to manoeuvre stern-first.
- Along the Shore Alignment swing basin;
  - the manoeuvring area at the change in direction of the berths is more than adequate and the width could be reduced
  - the drag back area is adequate for vessels to manoeuvre stern-first
- Basin Alignment swing basin;
  - the manoeuvring area at the entrance of the basin is more than adequate and its width could be reduced for both the Basin Short and Basin Long layouts. It was found that a training wall is not required as the current velocities are lower at the entrance to the basin compared to the current velocities at Long Island Jetty.
  - the width of the basin is adequate for the entrance of vessels stern-first into the basin and the exit of vessels either stern or bow first from the basin.

One of the runs on the Along the Shore layout identified a scenario where the wind and current conditions were too strong to be safely controlled with the use of three 80 tonne tugs. This may result in some 30 knot wind conditions, where either four tugs may be required or berthing/unberthing activities restricted.

The simulations were undertaken over a period of five days under a range of environmental conditions for a range of layouts, and all simulations where undertaken using the same pilot. Typically this involved one run for each scenario. To be able to confirm the channel dimensions, multiple runs with different pilots would need to be undertaken. Additionally the simulations did not consider high swell conditions or poor visibility due to night or fog conditions. Notwithstanding the above, there are a number of recommendations from these simulations which can be used to develop a preliminary design.

It should be noted that although the pilots noted that a run was acceptable, this does not imply that this would form a satisfactory operating condition to the satisfaction of the harbour master. To achieve this multiple successful runs with multiple pilots under a range of conditions and vessel types would be required.

6.3 Preliminary channel width and layout design

6.3.1 Approach channel

Following the real time vessel navigation simulations and based on the findings outlined in Section 6.2.5 the following changes have been made to the approach channel layout.

- the width of North Arm 1 between buoys 19 & 20 and 23 & 24 has been increased to the same width as North Arm 2 (250 m)
- the angle into and out of North Arm 1 has been reduced by two degrees by keeping buoys 19 and 24 in the same place and moving buoys 20 and 23 to achieve the required width
- the angle between North Arm 1 and 2 (at buoys 23 & 24) has been further reduced by straightening the toelines between buoys 23 and 25, and 24 and 26.

These changes are outlined in Figure 6-6.

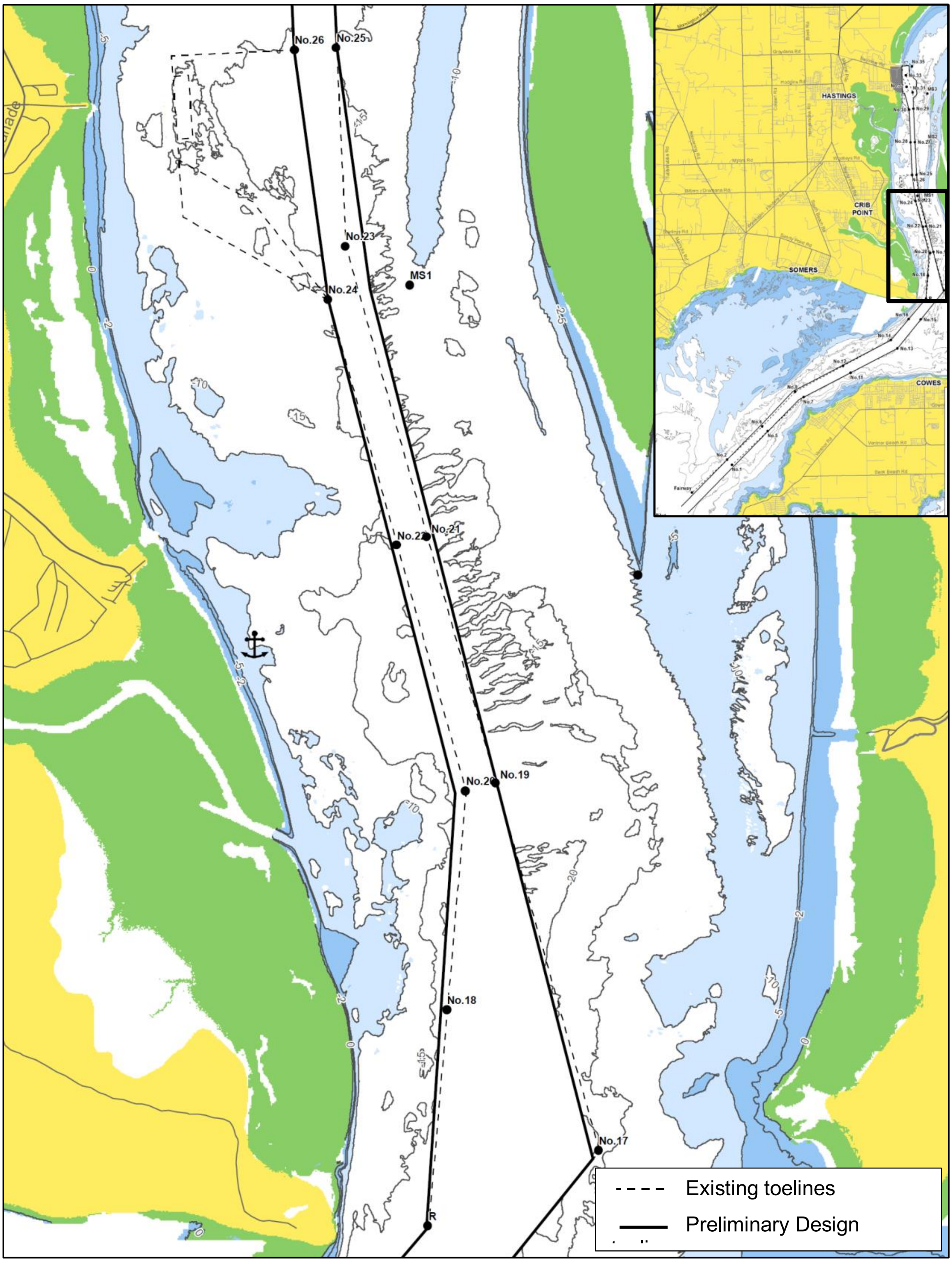

Figure 6-6. North Arm preliminary design

6.3.2 Port area

Following the real time vessel navigation simulations, and based on the findings outlined in Section 6.2.5, the following changes have been made to the port area layouts.

- all layouts
  - buoy 32 (virtual marker due to the presence of the adjacent Long Island Point Jetty) has been removed and the toeline from buoy 30 runs up to a point that is 30 m south and 100 m east of the southernmost end of the berths. This location has been chosen so that the toeline does not extend through the berth pocket for the Long Island Point Jetty. Refer Figure 6-7 to Figure 6-9
  - the berth pocket width has been reduced to 1.5 times the vessel beam.
- Stage 1 Development swing basin
  - reduced the width of the swing basin by 40 m in order to maintain a beam width (60 m) gap between the vessel and the toelines based on the vessel track plots for the navigation simulations. Refer to Figure 6-7
- Along the Shore alignment swing basin
  - The reduction in the width of the Stage 1 Development swing basin by 40 m has been extended up to the start of the drag back area which has resulted in the corner between the swing basins along the southern berths and the drag back area moving by 270 m to the southwest. Refer to Figure 6-8.
- Basin alignment swing basin
  - the reduction in the width of the Stage 1 Development swing basin by 40 m has been extended up to the toeline at the edge of the swing basin at the entrance to the basin. Refer to Figure 6-9.

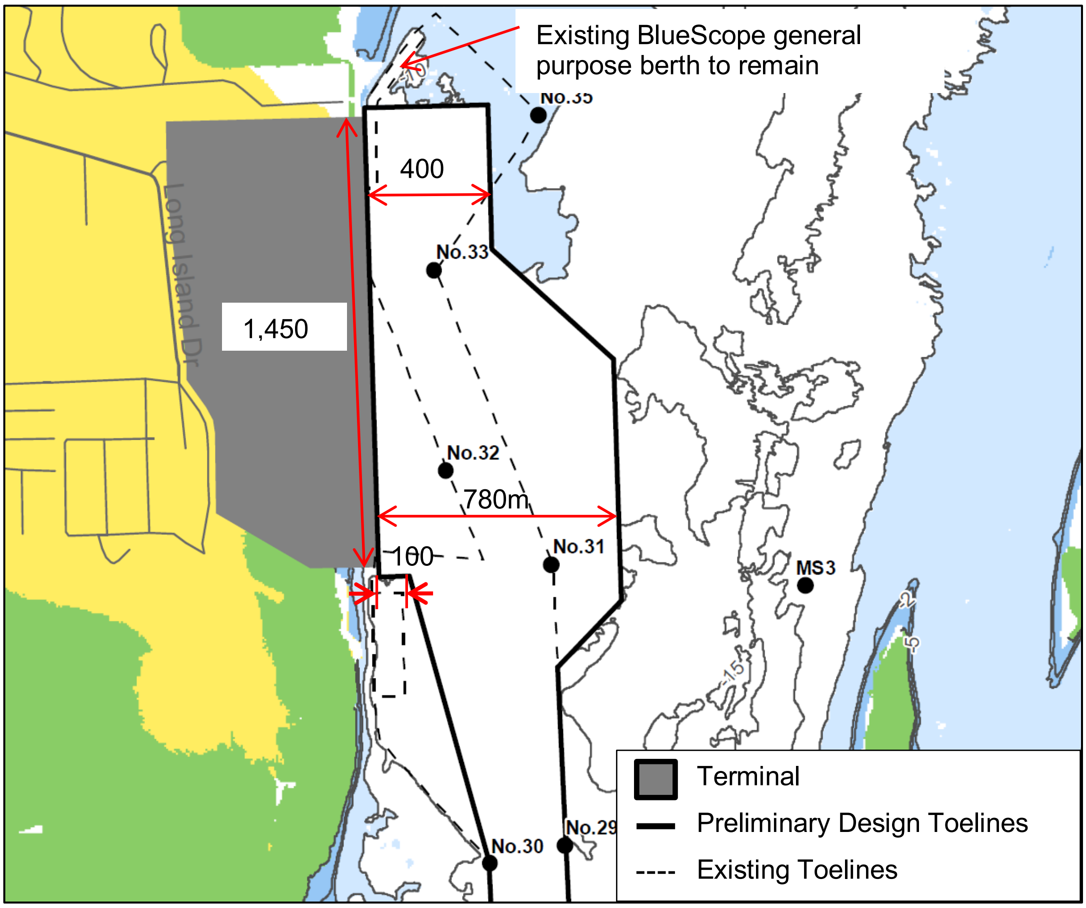

Figure 6-7. Stage 1 development preliminary design swing basin alignment

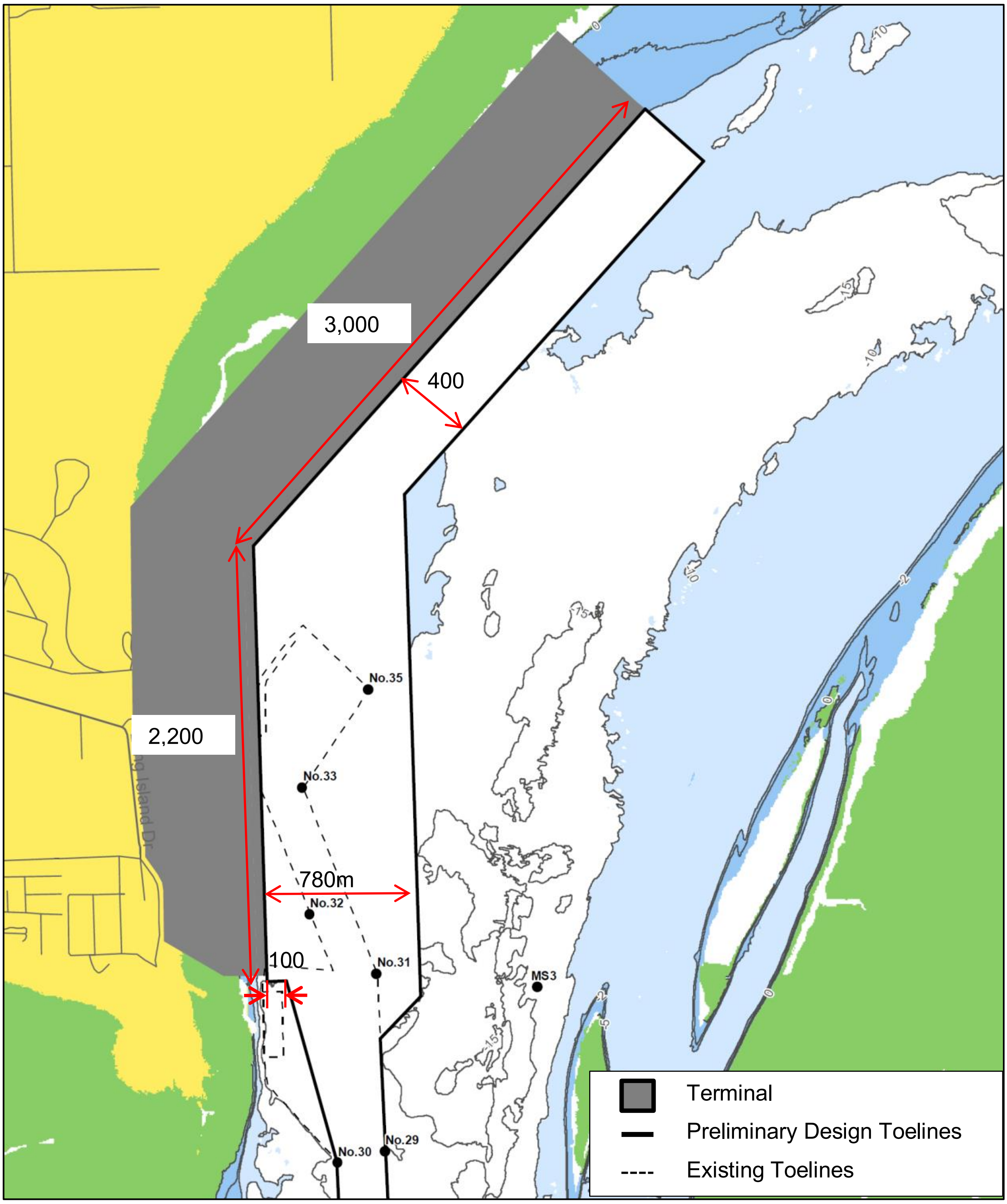

Figure 6-8. Along the Shore preliminary design swing basin alignment

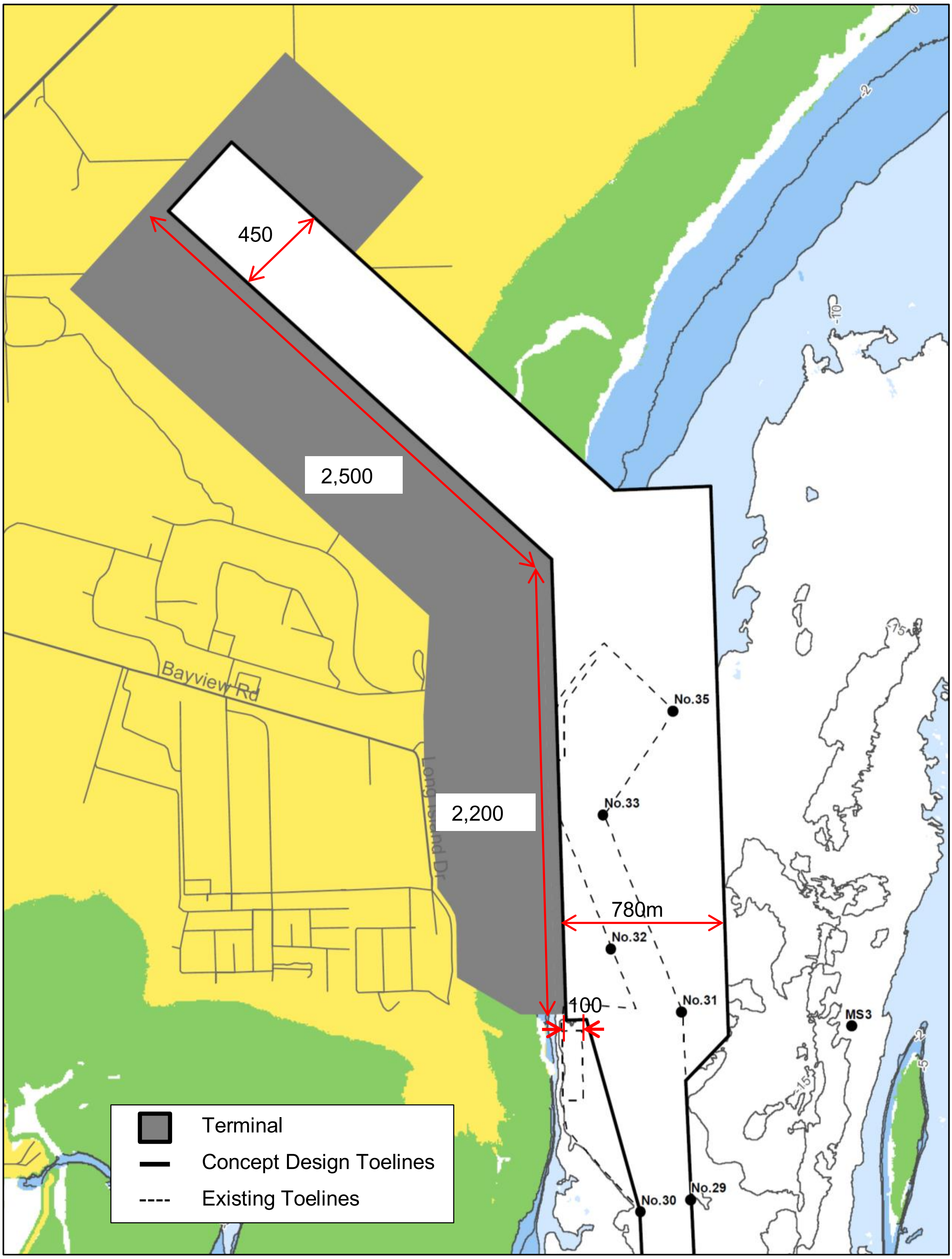

Figure 6-9. Basin preliminary design swing basin alignment

6.4 Channel depth and availability

6.4.1 Methodology

6.4.1.1 Underkeel clearance (UKC)

The UKC analysis is based on the model outputs from a years' worth of historical data (2006) and modelled using OMC International's Dynamic UnderKeel Clearance (DUKC) system. The 2006 data was considered the most comprehensive and suitable data available for this exercise. The tide data is based on historical records and includes tide residuals. This analysis was undertaken for the 400 m LOA, 59 m beam Ultra Large Containership at draughts of 14 m, 15 m and 16 m. Results for 14.5 m were extrapolated between the 14 m and 15 m results.

Figure 5-6 shows the points along the channel where the UKC is calculated. Two vessel speed scenarios were assessed, and following the navigation simulation the 'Fast Transit Speed' scenario was chosen for the analysis.

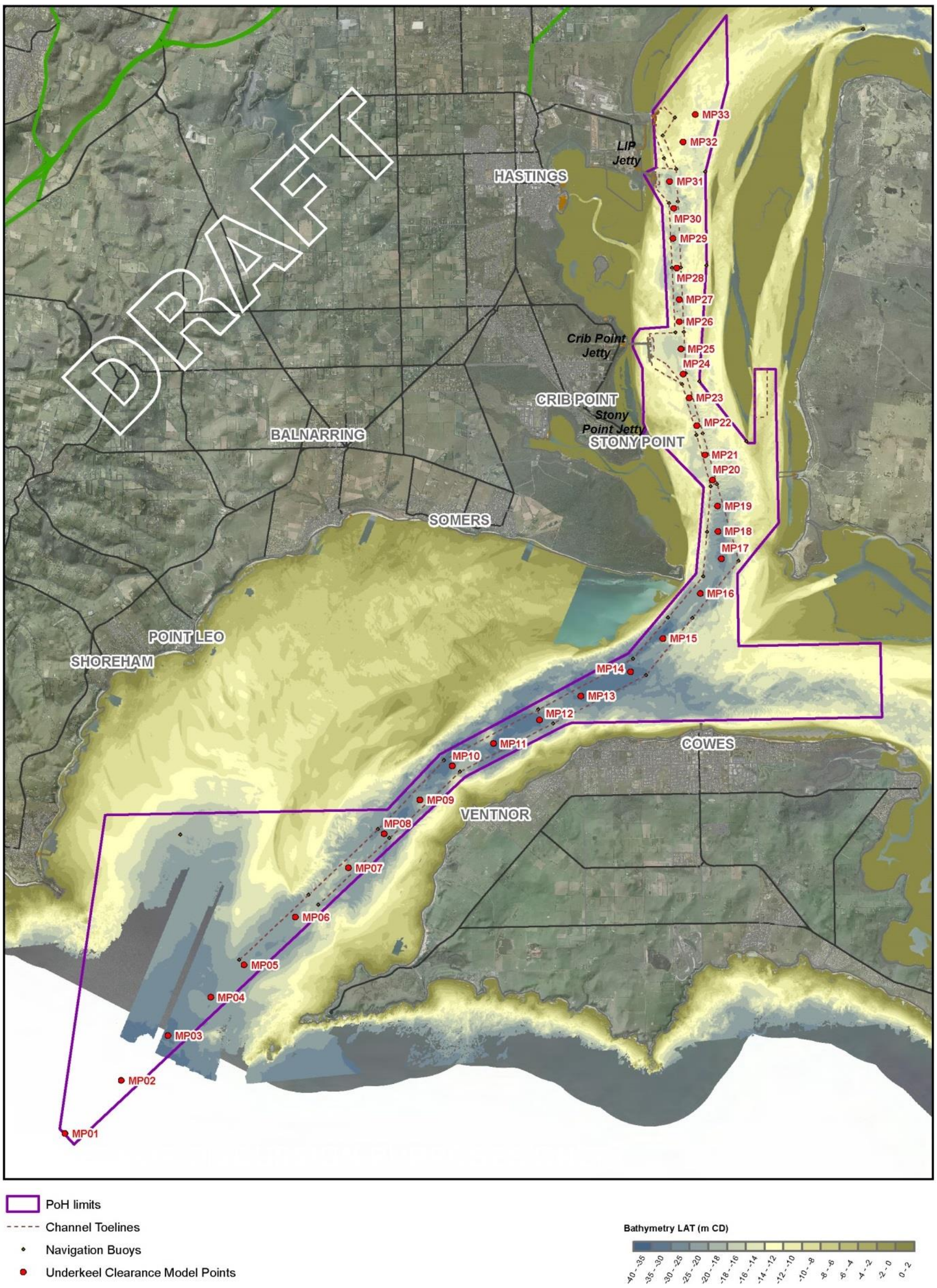

Figure 6-10. UKC calculation points

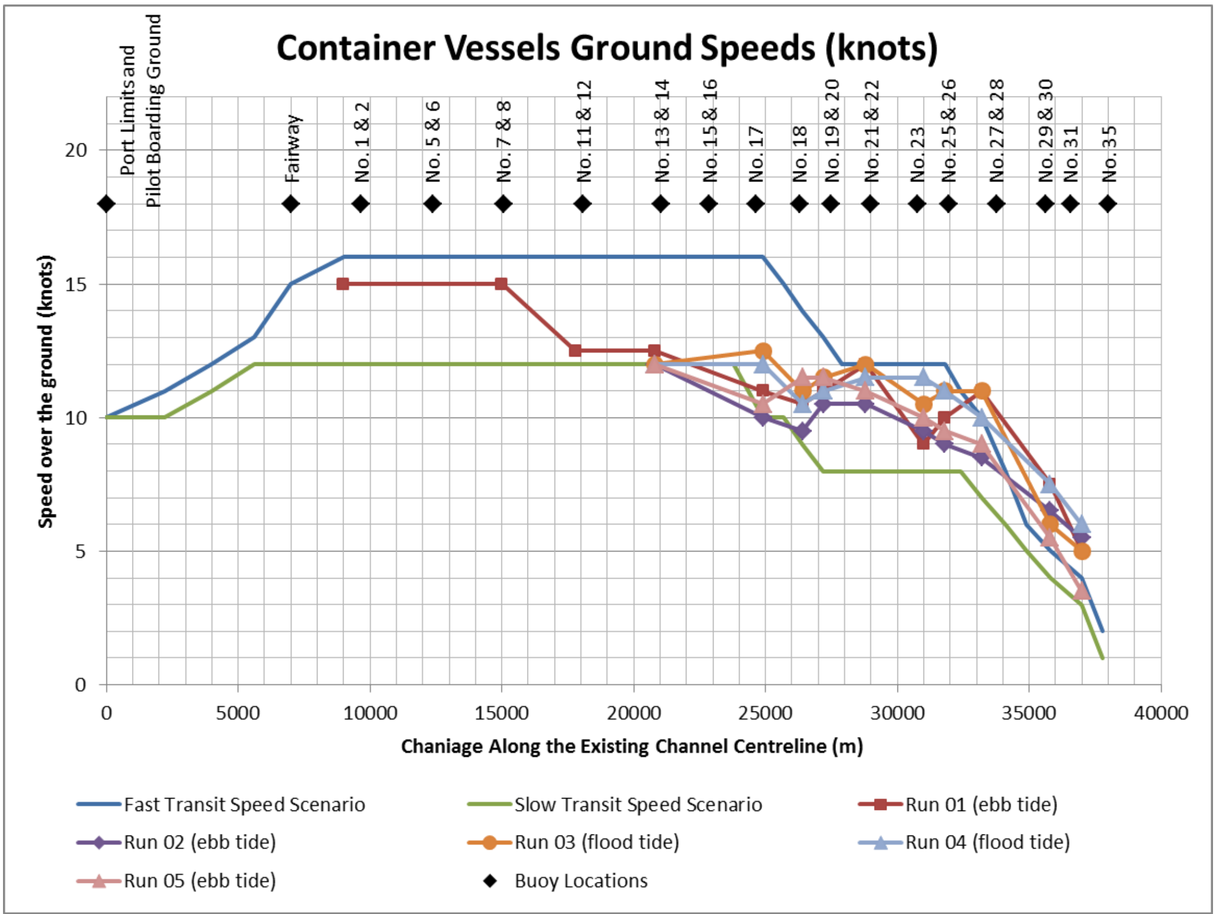

Figure 6-11. Container vessel transit speed scenarios

The wind heel calculations are based on wind data from the same period as the hydrodynamic data used by OMC International, and have been added to OMC International's results. On average the wind heel contributed about 0.03-0.05 m to the overall required depth, although in high winds acting perpendicular to the side of the vessel this increased to 0.3-0.4 m.

The limiting wind speed for berthing and unberthing operations at Swanson Dock is a 30 knot steady state wind, or a wind gusting to 35 knots. This was selected as an appropriate limit for berthing and unberthing operations in the Port of Hastings and, given that there is no anchorage between North Arm and the berth, it is considered that this limit would also apply to the approach channels.

6.4.2 Channel depth criteria

Unlike Port Phillip, Western Port has a large tidal range right up to the berth. This means that designing the approach channel for access at a given level means that the advantages of higher tides are not considered and the design can be overlay conservative. Therefore a channel availability percentage is used as the basis for determining appropriate depths for the channel.

If a vessel knows sufficiently far in advance that the channel will not be available at the planned time of arrival, the master can adjust the planned arrival time by either speeding up or slowing down. Using a higher steaming speed carries a fuel penalty, so the tendency is to slow the vessel so that she arrives as the channel reopens. This strategy also protects the ship against a lower than expected tide, or severe wave action, causing further delays. To make use of adjusted steaming speeds to mitigate the effect of channel windows of closure, the port must have a modern VTS system that monitors the position of ships at least 12 hours out (usually by AIS live services) and integrates information on tides, waves and weather. These procedures are standard in modern deep sea ports. In practice, adjusting steaming speeds to Melbourne can be used to adjust arrival times by up to 3-4 hours. Based

on this an average closure time of less than three hours is being considered for the Port of Hastings approach channels.

A design vessel draught of 14.5 m is selected as this represents 90 percent of the maximum design draught of 16 m that is typical of the Ultra Large Containership. Vessels with a deeper draught can still use the approach channels with additional tidal assistance.

In summary, the criteria used for the determination of appropriate channel depth at the Port of Hastings is that the average channel closure is to be below three hours for a 14.5 m draught Ultra Large Containership.

6.4.3 Channel depths

Table 6-8 and **Table 6-9** outline the channel availability for various draughts using the criteria outlined in section 6.4.2.

Table 6-8. Channel availability for various draughts – inbound transits

Channel Segment	Declared Depth	Availability (%) - Inbound				
		14 m	14.5 m	15 m	15.5 m	16 m
Western Channel 1	17.0	94%	85%	71%	57%	43%
Western Channel 2	16.5	96%	85%	70%	55%	40%
Western Channel 3	16.5	96%	84%	68%	54%	39%
Western Channel 4	16.5	97%	85%	68%	52%	38%
North Arm 1	15.7	95%	83%	65%	49%	32%
North Arm 2	15.7	97%	87%	70%	53%	37%
Channel availability		**92%**	**79%**	**61%**	**46%**	**29%**
Channel unavailability statistics (excluding visibility delays)						
Total hours per year that the channel is unavailable	Hrs/year	593	1787	3293	4622	6110
Total number of intervals per year that the channel is unavailable	No.	254	556	707	706	661
Average number of intervals per day that the channel is unavailable	No.	0.7	1.5	1.9	1.9	1.8
Average duration of each channel closure	Hours	2.3	3.2	4.7	6.5	9.2
Average hours per day that the channel is closed	Hrs/day	1.6	4.9	9.0	12.7	16.7
maximum duration of a channel closure	Hours	7	11	32	33	48

Table 6-9. Channel availability for various draughts – outbound transits

Channel Segment	Declared Depth	Availability (%) - Outbound				
		14 m	14.5 m	15 m	15.5 m	16 m
Western Channel 1	17.0	99%	99%	96%	79%	49%
Western Channel 2	16.5	99%	95%	80%	55%	32%
Western Channel 3	16.5	99%	95%	80%	56%	36%
Western Channel 4	16.5	99%	93%	78%	54%	33%
North Arm 1	15.7	96%	84%	62%	42%	18%
North Arm 2	15.7	98%	92%	75%	53%	34%
Channel availability		**96%**	**84%**	**61%**	**41%**	**17%**
Channel unavailability statistics (excluding visibility delays)						
Total hours per year that the channel is unavailable	Hrs/year	257	1329	3299	5040	7159
Total number of intervals per year that the channel is unavailable	No.	157	461	704	710	555
Average number of intervals per day that the channel is unavailable	No.	0.4	1.3	1.9	1.9	1.5
Average duration of each channel closure	Hours	1.6	2.9	4.7	7.1	12.9
Average hours per day that the channel is closed	Hrs/day	0.7	3.6	9.0	13.8	19.6
Maximum duration of a channel closure	Hours	3	5	8	10	88

For each segment of the channel for the 14.0 and 14.5 m sailing draught vessels, the inbound transit has the lower channel availability and hence the higher average closure time. Therefore the inbound transits have been used when calculating the average closure times. Table 6-10 summarises the channel availability for a 14.5 m draught Ultra Large Containership.

Table 6-10. Results

Segment	Declared Depth	Channel Availability (Ultra Large Containership, 14.5 m draught)		Comment on inbound transits delays (excluding poor visibility delays)
		Inbound	Outbound	
Western Channel 1	17	85%	99%	1.2 closures per day of 2.8 hours on average
Western Channel 2	16.5	85%	95%	1.3 closure per day of 2.6 hours on average
Western Channel 3	16.5	85%	93%	1.3 intervals per day of 2.7 hours on average
Western Channel 4	16.5	85%	93%	1.3 intervals per day of 2.6 hours on average
North Arm 1	15.7	83%	84%	1.4 closures per day of 2.8 hours on average
North Arm 2	15.7	87%	92%	1.2 closures per day of 2.4 hours on average
TOTAL		**79%**	**84%**	

6.4.4 Port area

6.4.4.1 Swing basin

There are no anchorages along North Arm and if delays or high winds occur on an inbound transit, the swing basin is the only point of refuge. Therefore the swing basin will need to cater for all except the most extreme conditions. A transit speed of 6 knots has been considered in the swing basin, although for the Stage 1 development the entry speed into the swing basin may be only 4 knots. Table 6-11 outlines the availability in the swing basin for varying draughts and depths.

Within the Port Area (MP31-33) about 1 percent of the time the water level is below LAT. Basing the analysis on a water level of 0mCD as the criteria for the swing basin, then the required depth which could regularly accommodate vessels up to about 14.5 m draught, would be 15.7 m.

Table 6-11. Swing basin availability

Swing Basin Declared Depth	Swing Basin Availability for a Vessel Draught of				
	14 m	14.5 m	15 m	15.5 m	16 m
16.2	99.8%	99.8%	99.0%	91.5%	75.7%
16.1	99.8%	99.8%	98.2%	88.9%	71.7%
16.0	99.8%	99.7%	97.0%	85.8%	67.9%
15.9	99.8%	99.6%	95.5%	82.7%	64.2%
15.8	99.8%	99.4%	93.7%	79.3%	60.8%
15.7	99.8%	99.0%	91.5%	75.7%	57.4%
15.6	99.8%	98.2%	88.9%	71.7%	53.5%
15.5	99.7%	97.0%	85.8%	67.9%	50.4%

6.4.4.2 Berth pocket

The berth pocket would need to provide safe water to cater for all environmental conditions. As outlined in Section 6.4.4.1, within the port area (MP31-33) about 1 percent of the time series data had a water level of below LAT (at Stony Point) with the lowest tides being about -0.5 mCD. The normal maximum ship out-of-trim during loading is 1.5 degrees. This equated to a UKC of 0.7 m, or 0.95 m with a bottom clearance of 0.25 m. A value of 1 m has been adopted, which will allow for a roll angle of 1.6 degrees in normal conditions, and up to 2.1 degrees in extreme conditions.

Based on a design draught of -14.5 m, the declared depth of the berth pocket would be -16 mCD. It would be expected that deeper draught vessels could be accommodated subject to an assessment by the harbour master.

6.4.5 Summary

Table 6-12 outlines the declared depths for the Port of Hastings approach channels that will allow an Ultra Large Containership with a sailing draught of 14.5 m access to the port for approximately 80 percent of the time, with an average channel closure of less than three hours.

Table 6-12. Declared depth summary

Segment	Declared Depth
Western Channel 1	17
Western Channel 2	16.5
Western Channel 3	16.5
Western Channel 4	16.5
North Arm 1	15.7

Segment	Declared Depth
North Arm 2	15.7
Swing Basin	15.7
Berth Pocket	16.0

6.5 Channel capacity

Limitations of the channel capacity of the Port of Hastings are in the North Arm and the port area. These limitations will change as the port is expanded.

With the single swing basin in Stage 1, the North Arm is locked from when a vessel departs the berth until it leaves the North Arm and enters the Western Channel on the outbound transit. On the inbound transit, the channel is locked from when the vessel approaches the turn into the North Arm until the vessel arrives at the berth. The transit time when the channel is locked is 80 minutes on the inbound transit and 45 minutes on the outbound transit.

Based on a channel availability of 80 percent and a maximum channel utilisation of 70 percent, the theoretical channel capacity is over 2,000 calls per year. Given that there are only three berths plus the existing Long Island Jetty and the BlueScope Jetty during this initial stage, the channel can more than cater for the maximum number of vessels the berths could accommodate.

Once the berths are expanded further to the north and additional swing basins are created, additional flexibility is generated. A vessel can be swung in the northern section of the swing basin while another vessel is approaching, and the vessels can pass at the southern section of the swing basin. This reduces the time that the channels are locked to the transit time of the North Arm, unless a vessel is being swung in the southern most section of the swing basin. The theoretical channel capacity is over 3,000 calls per year, and well beyond the number of calls that the port would expect.

7.0 Conclusions

7.1 Port Phillip

Key conclusions from the navigation study for bringing larger container vessels into Port Phillip are:

- the critical navigable section of the channel for vessels transiting to and from Port of Melbourne is the Great Ship Channel
- large Post Panamax vessels up to 14,000 TEU (366 m LOA, 51.2 m beam) can transit the Great Ship Channel in its current configuration. However, tidal current restrictions will need to be imposed and will reduce the channel availability when compared to the current maximum vessel (7,500 TEU, 304 m LOA and 40 m beam) allowed
- the tidal current restrictions in the Great Ship Channel will place limitations on the times when the larger container vessels can transit in and out of the Great Ship Channel. The 14,000 TEU vessel will be able to transit the Great Ship Channel for 6-7 hours per day on average for a 14 m draught, and 8.5 hours per day on average for a 13.5 m draught. The average opening duration would be 2-5.5 hours
- channel availability in the Great Ship Channel reduces considerably once the vessel draught exceeds 14 m for all vessel sizes. This suggests that even with deepening of only South Channel, the channel availability will only increase marginally
- Ultra Large Containerships require widening of the Great Ship Channel in order to safety transit the channel. It was found that widening the channel from 180 m to 425 m is likely to be adequate, however with more detailed assessments it may be possible to reduce that width
- Ultra Large Containerships with a draught of more than 14 m also require deepening of the Great Ship Channel and other approach channels into the port
- South Channel is unlikely to require any widening based on the concept design, although this is subject to further assessments, including navigation simulations
- Port Melbourne Channel will require widening in the order of 11 m for the 14,000 TEU Large Post Panamax vessel and 50 m for the Ultra Large Containership vessel. This could be reduced with further assessments, including navigation simulations

The key findings for the existing approach channel to Port of Melbourne are that vessels with a capacity of up to 14,000 TEU (New Post Panamax class) are able to transit the Port Phillip Heads to access Webb Dock. The West Gate Bridge limits the size of vessels to approximately 9,000-9,500 TEU capacity, although this will depend on the sailing draught of the vessel. Swanson Dock is limited to the existing size of vessels (approximately 7,500 TEU capacity) due to the dimensions of the Swanson Dock swing basin, width of Swanson Dock, vessel generated waves and interaction with moored vessels in the Yarra River.

Due to the strong tidal currents that exist at the Port Phillip Heads, there are currently limitations on the maximum allowable current speeds for when container vessels with a draught of greater than 12.1 m can pass through Port Phillip Heads. These current speed restrictions vary for whether the tide is coming in (flood tide) or going out (ebb tide). These tidal current restrictions limit the time the channel is available for these vessels to transit the Great Ship Channel. Table 7-1 summarises the current restrictions and the percentage of time that a vessel of that size can transit the Great Ship Channel.

Table 7-1. Summary of tidal current limitations and channel availability

Representative Class	Nominal TEU Capacity	Draught (m)	Inbound Transit (knots)		Inbound Availability	Outbound Transit (knots)		Outbound Availability
			Flood	Ebb		Flood	Ebb	
Existing configuration of Great Ship Channel								
Old Post Panamax	7,500	14.0	5	5	76%	5	4	65%
Old Post Panamax Plus (8,500 TEU)	8,500	13.0	4	3	65%	3	3	49%
New Post Panamax (14,000 TEU)	14,000	13.5	3	1.5	36%	3	1.5	35%
Widened Great Ship Channel by 180 m								
Ultra Large Containership	18,500	14.0	3	3	24%	3	3	21%
Widened Great Ship Channel by 180 m and deepened by 1.5 m								
Ultra Large Containership	18,500	15.0	3	3	41%	3	3	38%

New Post Panamax (14,000 TEU) class vessel can only transit the Great Ship Channel about one third of the time, or eight hours a day on average. A simplified channel capacity assessment of the Great Ship Channel and South Channel was undertaken for a constrained scenario that limited the size of vessels entering Port Phillip to 14,000 TEU New Post Panamax vessels. The channel capacity assessment considered that all vessels greater than 10,000 TEU capacity and tankers (crude oil and refined fuels) are limited to 8 hours per day on average.

The assessment found that the ultimate channel capacity of the Great Ship Channel and the South Channel is approximately 24 percent higher than the vessel call forecast for 2066 based on a maximum channel utilisation of 70 percent. For a highly managed channel with defined periods for inbound and outbound transits i.e. conveys, the ultimate channel capacity is approximately almost double the vessel call forecast for 2066.

Expansion of Webb Dock to cater for the New Post Panamax would result in a 23 percent channel utilisation of the Port Melbourne and Williamstown Channel. This is not expected to adversely impact the marine operations of the Port of Melbourne.

Table 7-2 outlines a summary of the existing approach channel constraints for various classes of container vessels beyond the maximum vessel that can currently visit the Port of Melbourne (Old Port Panamax with a 7,500 TEU capacity).

Table 7-2. Summary of existing channel constraints for larger container vessels

Section	Container Vessel Class					Comment on Existing Limitation
	Old Post Panamax 7,500 TEU	Old Post Panamax Plus 8,500 TEU	Old Post Panamax Plus 9,500 TEU	New Post Panamax 14,000 TEU	Ultra Large Container-ship 18,500 TEU	
Great Ship Channel	✓	✓	✓	✓	X	Width of channel
South Channel	✓	✓	✓	✓	✓	
Port Melbourne Channel	✓	✓	~	~	X	Width of channel, may be sufficient subject to simulations
Williamstown Channel	✓	✓	~	~	X	Width of channel, beyond Webb Dock swing basin only
Webb Dock swing basin	✓	~[1]	~[1]	X	X	Size of swing basin
Webb Dock	✓	✓	✓	~[2]	~[2]	Width of northern section, southern section adequate
Yarra River Channel	✓	X	X	X	X	Width of channel
West Gate Bridge	✓	✓	~[3]	X	X	Air draught
Swanson Dock swing basin	✓	X	X	X	X	Size of swing basin
Swanson Dock	✓	X	X	X	X	Width of dock

1. *These vessels may be able to use the swing basin subject to further investigation*
2. *Larger vessels would be able to access the southern section of Webb Dock East where VicT are located. There would be beam restrictions in the northern section if both sides are used, however this will depend on how Webb Dock is reconfigured/expanded in the future.*
3. *Depends on the particular vessel air draught and the sailing draught at the time of the transit.*

7.2 Western Port

Key conclusions from the navigation study for upgrading the approach channels to enable Ultra Large Containerships with a draught of 14.5 m to access Port of Hastings in Western Port are:

- widening of parts of the Western Channel within the naturally deep area to allow two-way transits
- increasing the declared depth in the Western Channel by 2.2 m from -14.8 mCD to -17.0 mCD in the first segment of the Western Channel up to McHaffie's Reef, and by 1.7 m from -14.8 mCD to 16.5 mCD between McHaffie's Reef and Sandy Point
- widening of the North Arm between Sandy Point and Cribb Point from 183 m to 250 m and adjusting the angle of the channel by two degrees to ease the transit into and out of this segment of the channel
- increasing the declared depth in North Arm by 1.5 m from -14.2 mCD to -15.7 mCD
- both the Basin and the Along the Shore layouts are feasible for combinations of peak spring tidal currents and wind speeds up to 30 knots, although a 30 knot wind speed may require additional

tug capacity for certain manoeuvres. For operations in a 30 knot wind, three 80 t tugs are required, and in some circumstances a fourth tug may be needed

- For the Basin layout, the currents across the entrance are not an issue for swinging the vessel or transiting into or out of the basin
- The construction of the berths between Long Island Point Jetty and the BlueScope berths has no significant impact on the berthing/unberthing of vessels at the Long Island Point Jetty.

Although not assessed, there are no limitations on designing the Port of Hastings approach channels for larger container vessels that what are currently in international service.

A design vessel draught of 14.5 m represents 90 percent of the maximum design draught of 16 m, which is the typical maximum design draught of the Ultra Large Containership class vessels. Vessels with a deeper draught can still use the approach channels with additional tidal assistance. Most of the dredging in the approach channels will occur in the North Arm while the dredging in the Western Channel is largely limited to high points along the channel.

Table 7-3, Channel availability for various sailing draughts – inbound and outbound transits

Channel Segment	Declared Depth	Channel Availability (%)							
		14m Draught		14.5m Draught		15m Draught		15.5m Draught	
		In	Out	In	Out	In	Out	In	Out
Western Channel 1	17.0	94%	99%	85%	99%	71%	96%	57%	79%
Western Channel 2	16.5	96%	99%	85%	95%	70%	80%	55%	55%
Western Channel 3	16.5	96%	99%	84%	95%	68%	80%	54%	56%
Western Channel 4	16.5	97%	99%	85%	93%	68%	78%	52%	54%
North Arm 1	15.7	95%	96%	83%	84%	65%	62%	49%	42%
North Arm 2	15.7	97%	98%	87%	92%	70%	75%	53%	53%
Channel availability		**92%**	**96%**	**79%**	**84%**	**61%**	**61%**	**46%**	**41%**

The one way section of the North Arm will not limit the performance of the port as its length is relatively short (8 km), and apart from the initial stage when the number of vessel calls is limited, the multiple swing basins in subsequent stages will allow for flexibility in managing vessel arrivals and departures. Table 7-4 summarised the changes to the existing declared depth and width of the approach channels in Western Port to provide access to the Port of Hastings for Ultra Large Containerships.

Table 7-4. Summary of changes to the declared depth and width of the Port of Hastings approach channels

Segment	Declared Depth			Width		
	Existing (-mCD)	Upgrade (-mCD)	Change (m)	Existing (m)	Upgrade (m)	Change (m)
Western Channel 1	14.8	17	+2.2	400	519	+119
Western Channel 2	14.8	16.5	+1.7	536	536	0
Western Channel 3	14.8	16.5	+1.7	536	536	0
Western Channel 4	14.8	16.5	+1.7	183-536	250-536	0 to +67
North Arm 1	14.2	15.7	+1.5	183	250	+67
North Arm 2	14.2	15.7	+1.5	250	250	0

Figure 7-1 outlines the Along the Shore alignment for the Port of Hastings development with 5,000 m of quay line for container terminals. This alignment allows for the continued use of the Long Island Jetty and the incorporation of a 200 m-long general purpose wharf to replace the BlueScope steel wharf. The 780 m width of the first 2,200 m of quay line allows flexibility for concurrent vessel movements and swing manoeuvrers, while the 400 m width of the next 3,000 m of quay line allows for vessels to be dragged back by tugs past a vessel at berth.

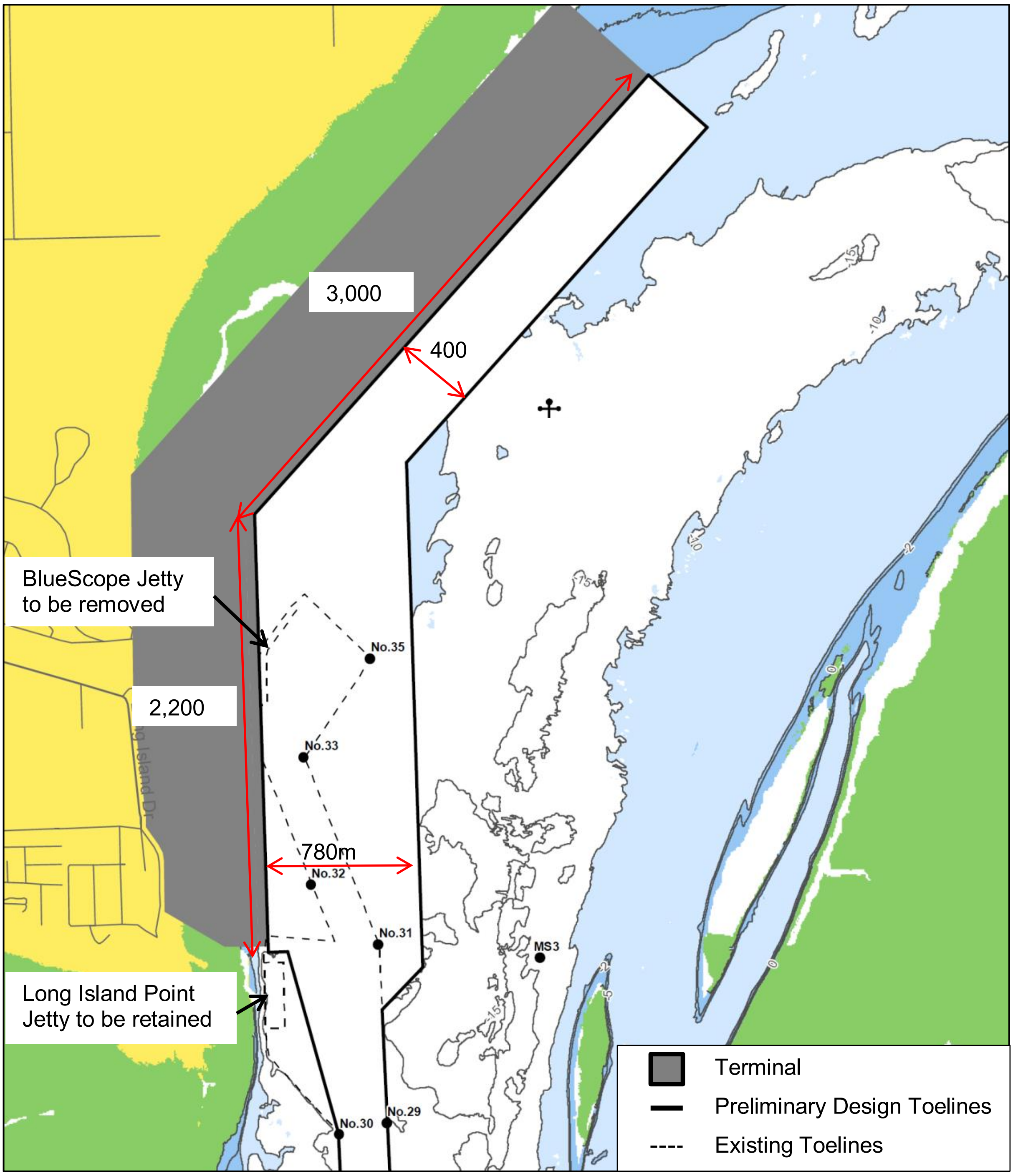

Figure 7-1. Port of Hastings Along the Shore swing basin alignment - preliminary design

8.0 Reference documents

Key reference documents used in this report are:

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Appendix A

Glossary

The acronyms and terminology used in this document are further defined in the following table.

Table 8-1. Glossary of terms

Acronym / Term	Definition
Air draught	The maximum vertical distance measured from the ship's waterline to the highest point on the ship at the prevailing draught.
Along the Shore alignment	A Port of Hastings port alignment that generally followings the contours of the Western port Bay north of Long Island Point Jetty.
Approach channel	The defined navigation channel from the open sea to the port area.
Australian Height Datum	A geodetic datum for altitude measurement in Australia. According to Geoscience Australia, "In 1971 the mean sea level for 1966-1968 was assigned the value of 0.000m on the Australian Height Datum at thirty tide gauges around the coast of the Australian continent.
Basin alignment	A Port of Hastings port alignment that includes a 2,500 m-long basin after the Stage 1 development.
Bay West	A potential future port site located in Port Phillip somewhere between Werribee South and Point Wilson.
Beam (B)	Maximum width of a vessel.
Berth pocket	Dredged area along each side of the Wharf, with depth sufficient to accommodate the design vessel at all states of the tide.
Bottom clearance	The clearance between the lowest point of the vessel and the highest point of the channel under any part of the vessel.
Channel availability	The percentage of time over the period of a year that the channel is open for a vessel of a given draught.
Chart datum	The level of water that charted depths displayed on a nautical chart are measured from. A chart datum is generally a tidal datum, which is a datum derived from some phase of the tide. Common chart datums are lowest astronomical tide and mean lower low water.
Declared depth	The minimum depth guaranteed available to vessels as declared by the harbour master. This is referred to as 'maintained depth' on navigation charts.
Deep draught vessel	Refers to a vessel with a draught of 11.6 m or over when transiting the Port of Melbourne channels.
Dynamic Under Keel Clearance (DUKC)	A proprietary computer package that integrates key vessel information with channel bathymetry and environmental conditions to calculate real-time under keel clearance predictions for a specific vessel transit within a forecast period, thus assisting vessel loading and sailing scheduling.
Ebb tide	The outgoing or falling tide, generally occurring between high tide and low tide. At Port Phillip Heads the outgoing tide runs from about three hours before to about three hours after low water.
Entrance Fairway	The fairway north of Port Phillip Heads marked by the boundary of the High Light White Sector extending to Point Nepean, and the fairway south of Port Phillip Heads between the eastern boundary of the Outer Eastern Channel and the western boundary of the Outer Western Channel extending two nautical miles to seaward.
Flood tide	The incoming or rising tide, generally occurring between low tide and high tide. At the Port Phillip Heads the incoming tide runs from about three hours before to about three hours after high water.
Hampered vessel	A vessel not under command or a vessel restricted in its ability to manoeuvre and therefore unable to keep out of the way of another vessel. The term 'vessel not under command' means a vessel which through some exceptional circumstance is unable to manoeuvre as required by these Rules

Acronym / Term	Definition
	and is therefore unable to keep out of the way of another vessel. The term 'vessel restricted in her ability to manoeuvre' means a vessel which from the nature of her work is restricted in her ability to manoeuvre as required by these Rules and is therefore unable to keep out of the way of another vessel. These include a vessel engaged in laying, servicing or picking up a navigation mark, submarine cable or pipeline, dredging, surveying or underwater operations; replenishment or transferring persons, provisions or cargo while underway; launching or recovery of aircraft; mine clearance operations; a towing operation such as severely restricts the towing vessel and her tow in their ability to deviate from their course.
Inertia heel	Rotation of a vessel about its longitudinal axis during a turn.
Keel-to-mast-height (KTMH)	Distance from the lowest part of the keel at the bottom of the vessel to the top of the highest mask on the vessel
LOA	Length over all, or the maximum length of a vessel.
Manoeuvrability margin	The term used to define the time-averaged clearance under a vessel. Vessel manoeuvrability may be defined as the vessel's ability to perform the manoeuvres intended by the pilot/master without the assistance of tugs. The ability of a vessel to manoeuvre at its design speed will decrease when the clearance between the channel bottom and the ship's keel is reduced, and may become insufficient if it is less than a certain critical value that maintains sufficient flow under and around the ship.
Maximum design draught (T_{Design})	The maximum draught at which the vessel can safely sail with respect to classification rules and load line regulations. The draught is measured vertically from the lowest point on the hull to the water level when at the maximum permissible summer load line.
North Arm	The approach channel in Western Port between the existing buoys 19 & 20 to buoys 29 & 30.
PIANC	Permanent International Association for Navigation Congresses.
Port Area	The area north of existing buoys 29 & 30 that encompasses the port, including the swing basin and berth pockets.
Port Phillip	Port Phillip covers 1,930 square kilometres and the shore stretches approximately 264 km. The deepest portion is only 24 metres and half the region is shallower than 8 m. The Port of Melbourne and the Bay West site are located in Port Phillip. Also commonly known as Port Phillip Bay or just The Bay.
Port Phillip Heads (the Heads)	An imaginary line joining Point Lonsdale and Point Nepean.
Sailing draught (T)	The draught of the vessel at arrival or departure from a port when it is at rest. Typically this is measured at the bow, amidships and stern prior to departure to confirm that the vessel can leave the port and enter the next port safely. This is sometimes referred to as the running draught.
Shipping Fairway	The unmarked shipping route across Port Phillip Bay that runs south from the Transit only Zone (TOZ) entrance beacons, Beacons T1 and T2, to South Channel Beacons 24 and 25, as marked on approved navigational charts.
South Channel	The navigable channel marked by beacons in the south of Port Phillip which is bound by Entrance beacon and Popes Eye beacon in the west and beacons 24 and 25 in the east.

Acronym / Term	Definition
South Channel Cut or 'The Cut"	The section of the East South Channel between beacons 12 and 14.
Squat	The steady downward displacement consisting of a translation and rotation due to the flow of water past the moving hull.
Stage 1 Development	A port development with a berth length of 1,450 m between the existing Long Island Point Jetty and the BlueScope general purpose wharf.
Static draught	Equal to the sailing draught.
Swing basin	Designated area for turning vessels prior to berthing or following unberthing.
TEU	Twenty-Foot Equivalent Unit.
UKC	Underkeel clearance is the depth requirement between the bottom of the keel of the vessel and the channel bed level.
UKC calculation point, MP or BNID	Points along the channel where the UKC analysis has been undertaken.
Vessel Traffic Service (VTS)	A marine traffic monitoring system established by harbour or port authorities. Typical VTS systems use radar, closed-circuit television (CCTV), VHF radiotelephony and automatic identification system to keep track of vessel movements and provide navigational safety in a defined geographical area.
Wave response	The response of the vessel in the six degrees of freedom due to wave actions on the vessel.
Western Channel	The approach channel in Western Port from the existing buoys 1 & 2 to buoys 19 & 20.
Western Port	A large tidal bay in southern Victoria, Australia, opening into Bass Strait. Geographically, it is dominated by the two large islands, French Island and Phillip Island. The waters of Western Port cover an area of 680 km² of which 270 km² are exposed as mud flats at low tide. Also commonly known as Western Port Bay
Wind heel	Rotation of a vessel due to the action of wind against the vessel.

Appendix B

Port Phillip concept channel design

Channel width factors

PIANC 2014 provides the following formula for determining the channel width for concept design:

- One-Way Channel Width (W) = W_{BM} + 2ΣWi + W_{Br} + W_{Bg}
- Two-Way Channel Width (W) = 2W_{BM} + 2ΣWi + W_{Br} + W_{Bg} +ΣW_p

Where:

- W_{BM} is the width of basic manoeuvring lane as a multiple of the design ship's beam
- ΣWi additional widths to allow for the effect of wind, current, waves etc
- W_{Br}, W_{Bg} is the bank clearance on the 'red' and 'green' sides of the channel
- ΣWp is the passing distance, comprising the sum of a separation distance between both manoeuvring lanes and an additional distance for traffic density.

A number of the criteria are subjective and the following sections discuss the rationale behind the criteria that has been used. This assessment draws on the assessment used for the Channel Deepening Project.

Inner/Outer channel

PIANC 2014 gives the following description for outer and inner channels:

- An outer channel in open water and exposed to waves that can produce significant vertical ship motions of heave, pitch, and roll.
- An inner channel that lies in relatively sheltered waters and is not subject to wave action of any significance to large ships.

The Great Ship Channel has been assessed as an outer channel while all other channels within the bay have been assessed as inner channels

Basic manoeuvring lane

PIANC 2014 recommends moderate manoeuvring characteristics (1.5B) for container vessels.

Vessel speed

PIANC 2014 characterises vessel speed into the following categories:

- Fast - Vs ≥ 12 kts
- Moderate - 8 kts ≤ Vs < 12 kts
- Slow - 5 kts ≤ Vs < 8 kts

The existing speeds through the approach channels are in excess of 12 knots this speed has been used for all channel segments.

Prevailing cross wind

Figure 8-1 a wind rose based on half-hourly 10 Minute Averages for 2015 from the South Channel Island Bureau of Meteorology Weather Station. The data indicates that winds in the PIANC 2014 Strong Category (33 kts ≤ Vcw < 48 kts) occur less than 2% of the time. Currently there are no wind speed limits on the operation of the channels and it is not proposed to introduce any as part of this study. Therefore the strong category has been used.

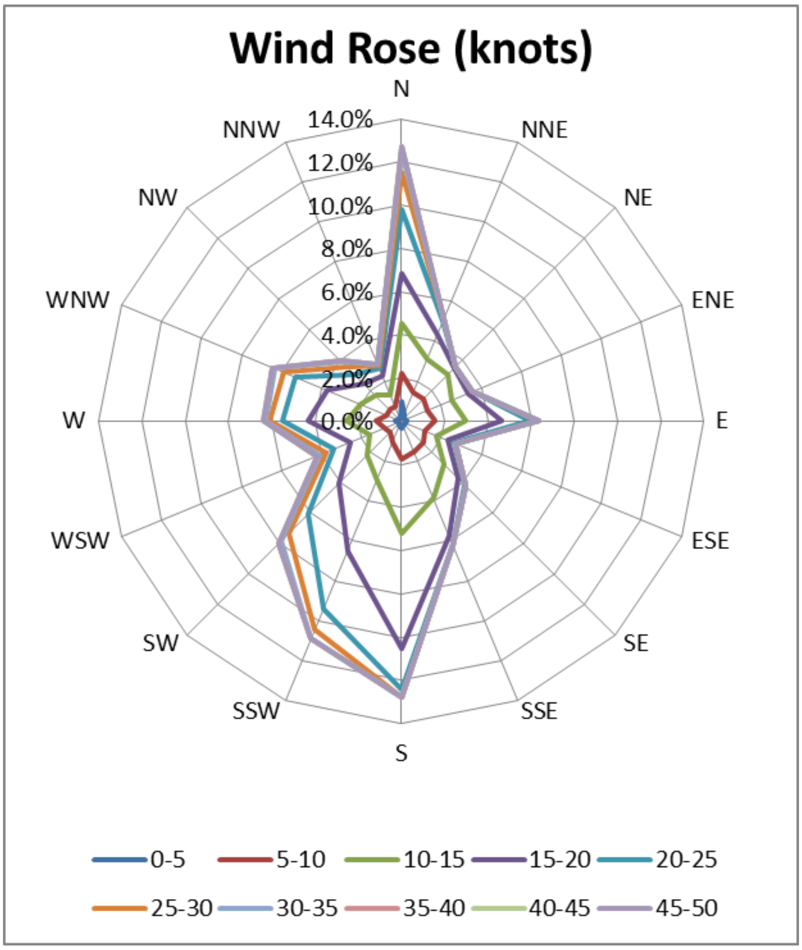


Figure 8-1. Wind rose based on half-hourly 10 minute averages for 2015 from the South Channel Island Bureau of Meteorology weather station

Prevailing cross current

PIANC 2014 categories the prevailing cross current as follows:

- Negligible Vcc < 0.2 kts
- Low 0.2 kts ≤ Vcc < 0.5 kts
- Moderate 0.5 kts ≤ Vcc < 1.5 kts
- Strong 1.5 kts ≤ Vcc < 2.0kts

The prevailing cross current has been considered be strong in the Great Ship Channel, moderate in the South Channel and negligible elsewhere in Port Phillip.

Prevailing longitudinal current

PIANC categories the prevailing longitudinal current as follows:

- Low V_{lC} < 1.5 kts
- Moderate 1.5 kts ≤ V_{lC} < 3 kts
- Strong V_{lC} ≥ 3 kts

The prevailing cross current has been considered be strong in the Great Ship Channel, moderate in the South Channel and low elsewhere in Port Phillip.

Beam and stern quartering wave height

PIANC categories the beam and stern quartering wave height as follows:

- $H_s \leq 1$ m
- 1 m < H_s < 3 m
- $H_s \geq 3$ m

The beam and stern wave height has been considered to be greater than 3m for the Great Ship Channel and less than 1m within Port Phillip

Aids to navigation

The existing and future aids to navigation are categorised as excellent. Excellent corresponds to paired lit buoys with radar reflectors, lit leading lights and VTS along with the availability of pilots, DGPS and ECDIS.

Bottom surface

PIANC categories the bottom surface as follows:

- if depth h > 1.5T
- if depth h < 1.5T then
  - smooth and soft
  - rough and hard

The depth of waterway is less than 1.5T for deep draught vessels. The bottom surface of the Great Ship Channel is rock (rough and hard) while the remainder of the channels are sand (smooth and soft).

Depth of waterway

PIANC categories the bottom surface as follows:

- Outer Channel
  - h ≥ 1.5 T
  - T > h ≥ 1.25 T
  - h < 1.25 T
- Inner Channel
  - h ≥ 1.5 T
  - 1.5 T > h ≥ 1.15 T
  - h < 1.15 T

For deep draught vessels, the depth of the waterway was assessed as follows:

- Great Ship Channel (outer channel) - less than the 1.25T.
- Remainder of the channel (inner channel) - less than the 1.15T

Width for bank clearance

PIANC categories the width for bank clearance as follows:

- Gentle underwater channel slope (1:10 or less steep)
- Sloping channel edges and shoals
- Steep and hard embankments, structures

The slopes in the Great Ship Channel are considered to be similar to the steep and hard embankments description.

The slopes in the remainder of the channel are considered to be similar to the sloping channel edges and shoals description.

Traffic density

The average traffic density throughout the forecast period is more than 3 vessels per day throughout the forecast period.

Appendix C

Port Phillip Heads large container ship simulation report

AUSTRALIAN MARITIME COLLEGE

Australian Maritime College

Infrastructure Victoria Second Container Port Advice

Port Phillip Heads Large Container Ship Study

From

21 November 2016

To

22 November 2016

SUMMARY OF SIMULATION

PROJECT NO. 16/S/26

AMC Search Ltd

Infrastructure Victoria Second Container Port Advice

Port Phillip Heads Large Container Ship Study

From **21 November 2016** To **22 November 2016**

PARTICIPANTS

Name	Position
Ben Gray	Senior Engineer - AECOM
Austin Kennedy	Associate Director - AECOM
Christian Taylor	Principal Adviser - Infrastructure Victoria
Andrew Varga	Director Ports Team - Infrastructure Victoria
Capt. Rob Buck	Managing Director - Port Philip Sea Pilots
Capt. Gavin Barry	Marine Pilot
Capt. Tim Fitzgerald	Marine Pilot

AMC PERSONNEL

Name	Position
Matt Best	Commercial Simulation Manager - AMC Search
Louis Lam	Simulation Technical Support

FORMAT OF REPORT

The format of this report is in 5 sections:

1. Program Summary
2. Ship Details
3. Navigation Warning
4. Run Summary
5. Run Plots

AIMS OF THE PROJECT

To determine feasibility and operational parameters for the arrival of large Container vessels through Port Phillip Heads.

Section 1

Program Summary

AUSTRALIAN MARITIME COLLEGE

PROGRAM SUMMARY

The total number of exercise runs conducted over the duration of the program was 28

AREA MODEL

The following simulation area model(s) were used for this study.

Melbourne - Standard Area, Melbourne - Modified Bathymetry and Currents

SHIP MODELS

The following ship models were used during the study:

Vessel	Type of Ship	Model Codes			
Ital Cortesia 334	Container Ship	CO334LDA			
MSC Daniela	Container Ship	CT364L			
CNTNR19L	Container Ship	CNTNR19L			
Superium Maersk	Container Ship	CNTNR32L			

Wheelhouse posters and or pilot cards of the ship models are included in this report.

TUGS

Tug powers deployed were implemented after consultation with the participants and a consensus agreed to.

Adequate compensation and loss of tug power was deployed to account for winds, seas and ships speed.

TUG NAME	BOLLARD PULL [TON]	ORDER				
		FULL	3/4	1/2	1/4	WEIGHT

INTRODUCTION TO THE SIMULATOR

Before the commencement of the simulation exercise runs the participants were shown around the simulator and the bridge equipment. When requested by the participants, the simulator instructor gave look out distances from the vessel of required objects eg. Distance from bow to berth ahead etc. The simulator's ECDIS with docking mode was turned on as requested.

A person was employed as a helmsman to steer the ship as ordered.

LIMITATIONS

SHIP MODEL:
The behaviour of a vessel or vessels in the simulator may vary from that experienced in reality. This is due to a number of factors that are not able to be simulated, and/or data that is not available, or is sparse. AMC does not guarantee that the behaviour of a vessel or vessels in the simulator will be precisely that as experienced in reality.

PORT AREA MODEL:
AMC does not update the simulated area model, unless contracted to do so by the client.
This may result in the ENC and Visual model differing from the actual area as seen by participants

SIMULATIONS:
Results of manoeuvres from simulations are meant as a guideline only and should not be considered to be an absolute. These results are meant to complement other studies and knowledge.

DISCLAIMERS:
This summary is prepared solely for the use of AECOM. No responsibility to any third party shall be accepted, as the report will not be prepared, and shall not be intended for any other purpose.

AECOM acknowledges that it is, and will continue to be, solely responsible for making management decisions and functions when implementing any advice or recommendations in this summary.

We believe the summary is accurate and precise, but no warranty is given for the accuracy or reliability of information given from AECOM that may affect the outcome in actual conditions.

EXPLANATION OF REPORT FORMAT

1) Ship Details

General information for each ship used during the program is given by the wheelhouse poster and or pilot card of the ship.

2) Run Summary

The Run Summary contains a list of runs conducted on each day of the program. The list gives the following information:

- Run number - The run number is allotted consecutively.
- Name of the participant conducting the run.
- The area model.
- Comments

3) Navigational Warning

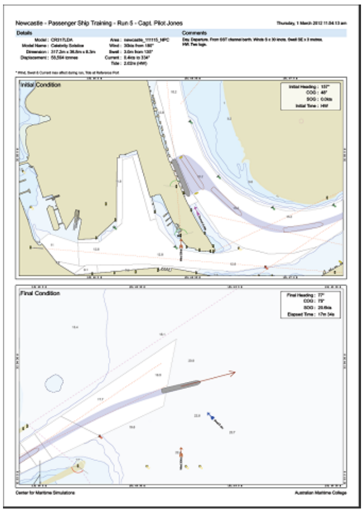
The Hydrographic Office requires this because we change the Hydrographic Office chart data to include engineering data and other external data to create a simulated area model.

4) Run Plots

During the exercise, the simulator records the information compiled into this summary of simulations.

The Run Plot can be divided into two sections :

Situation Plot



The Situation Plot typically spans two pages. At the top of the first page, details of the senario are outlined, including the ship model used and and environmental conditions in effect. A description of the exersice and any comments are also provided.

Three plan views are then presented. The first and second show the ship and surrounds at the start and the end of the run respectivly.

The third plan view shows the full run including breakout boxes detailing time, heading, turnrate & speed.

Each plan view shows the swept path of the ship and a shipshape indicator spaced at 3 minute intervals.

Parameter Graphs

Several pages show graphs of ship and environmental parameters as they vary with time over the course of the run. Various parameters can be plotted, and the choice of the parameters is set after consultation with the participants, and relevance to the program.

Vertical lines (light red) are shown on the graph at 3 minute intervals that match the shipshape positions found on the situation plots.

Section 2

Ship Details

AUSTRALIAN MARITIME COLLEGE

Centre for Maritime Simulations
Vessel Data

Container Ship

Ital Cortesia 334

CO334LDA

Ship Details		Drafts	
Length:	334.0 m	Draft Fwd:	12.53 m
Breadth:	42.8 m	Draft Aft :	13.6 m
Displacement:	117,663 t	Mean Draft:	13.065 m
Capacity:	6,100		

PILOT CARD
Ital Cortesia 334
CO334LDA
Version 2

Ship's name Ital Cortesia 334 **Date** ______

Call Sign DDYY2 **Deadweight** 100863 tonnes **Year built** 2005

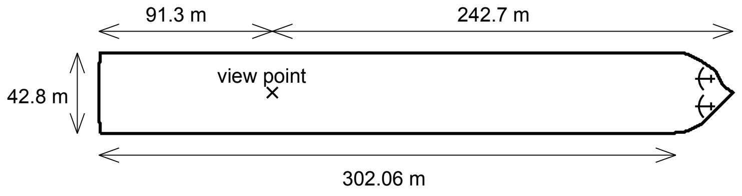
Draught aft 13.6 m / 44 ft 7 in **Forward** 12.53 m / 41 ft 1 in **Displacement** 117663 tonnes

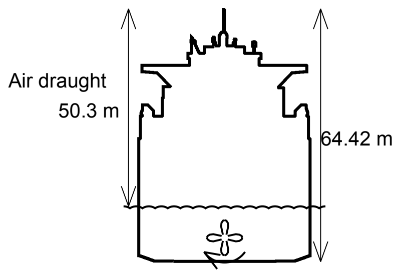
SHIP'S PARTICULARS

Length overall 334 m **Anchor chain:** **Port** 14.0 shackles **Starboard** 14.0 shackles

Breadth 42.8 m **Stern** ______ shackles

Bulbous bow No **(1 shackle = 27.432 m = 15 fathoms)**





PROPULSION PARTICULARS

Type of engine Diesel **Maximum power** 69621 kW (93369 hp)

Manoeuvring engine order		RPM	Pitch	Speed (knots)	
				Loaded	Ballast
Full sea speed	**1**	102.0		25.7	
Full Ahead	**0.8**	65.0		17.0	
Half Ahead	**0.5**	50.0		13.1	
Slow Ahead	**0.25**	35.0		9.1	
Dead Slow Ahead	**0.125**	25.0		6.4	
Dead Slow Astern	**-0.125**	-25.0			
Slow Astern	**-0.25**	-35.0			
Half Astern	**-0.5**	-50.0			
Full Astern	**-1**	-65.0			

Time limit astern ______ min:sec

Full ahead to full astern ______ min:sec

Max. No. of consecutive starts ______

Minimum RPM ______ ______ knots

Astern power ______ % ahead

STEERING PARTICULARS

Type of rudder	Normal	**Maximum angle**	35 °
Hard-over to hard-over	12.1 s		
Rudder angle for neutral effect	0 °		
Thruster: **Bow**	2500 kW (3353 hp)	**Stern**	kW (hp)

CHECKED IF ABOARD AND READY

Anchors		☐	**Indicators:**	☐
Whistle		☐	**Rudder**	☐
Radar	☐ 3 cm	☐ 10 cm	**Rpm/pitch**	☐
ARPA		☐	**Rate of turn**	☐
Speed log	☐ **Doppler:**	Yes / No	**Compass system**	☐
Water speed		☐	**Constant gyro error ±**	°
Ground speed		☐	**VHF**	☐
Dual-axis		☐	**Elec. pos. fix. system**	☐
Engine telegraphs		☐	**Type**	
Steering gear		☐		
Number of power units operating		☐		

OTHER INFORMATION:

WHEELHOUSE POSTER

Ital Cortesia 334

CO334LDA
Version 2

Ship's name Ital Cortesia 334 **Call Sign** ______ **Gross tonnage** ______ **Net tonnage** ______

Max. Displacement 117663 tonnes, and **Deadweight** 100863 tonnes, and **Block coefficient** 0.643 at summer full load draught

Draught at which the manoeuvring data were obtained

Loaded	Ballast
Trial / Estimated	Trial / Estimated
12.53 m forward	m forward
13.6 m aft	m aft

STEERING PARTICULARS

Type of rudder(s) Normal

Maximum rudder angle 35 °

Time hard-over to hard-over

with one power unit 24.1 s

with two power units 12.1 s

Min. speed to maintain course propeller stopped ______ knots

Rudder angle for neutral effect 0 °

ANCHOR CHAIN

	Chain length	Max. rate of heaving
	shackles	min / shackle
Port	14.0	0.894
Starboard	14.0	0.894
Stern		

(1 shackle = 27.432 m = 15 fathoms)

Windage 10554 m^2

PROPULSION PARTICULARS

Type of engine Diesel , 69621 kW (93369 hp) **Type of propeller** Propeller

Engine order		RPM	Pitch	Speed (knots) Loaded	Speed (knots) Ballast
Full sea speed	**1**	102.0		25.7	
Full Ahead	**0.8**	65.0		17.0	
Half Ahead	**0.5**	50.0		13.1	
Slow Ahead	**0.25**	35.0		9.1	
Dead Slow Ahead	**0.125**	25.0		6.4	
Dead Slow Astern	**-0.125**	-25.0			
Slow Astern	**-0.25**	-35.0			
Half Astern	**-0.5**	-50.0			
Full Astern	**-1**	-65.0			

Critical revolutions 25 rpm

Minimum RPM **25** **6.4** knots

Time limit astern ______ min:sec

Time limit at min. revs. ______ min:sec

Emergency

full ahead to full astern ______ s

stop to full astern ______ s

Astern power ______ % ahead

Max. No. of consecutive starts ______

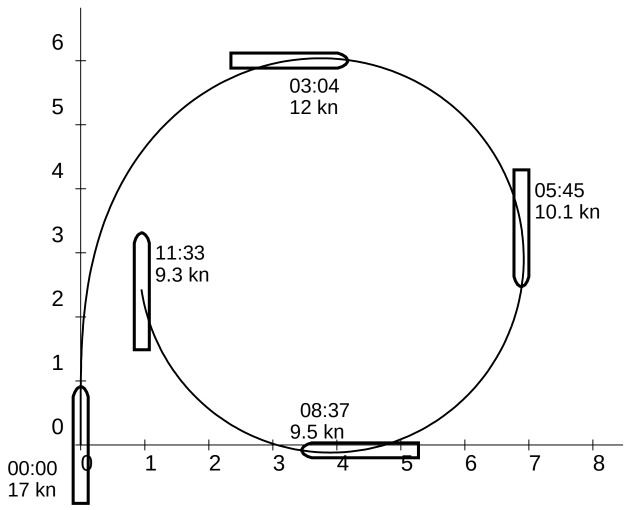
THRUSTER EFFECT at trial conditions

Thruster	kW	hp	Time delay for full thrust	Turning rate at zero speed	Time delay to reverse full thrust	Not effective above speed
Bow	2500	3353	3 s	14.77 °/min	2.5 s	
Stern						
Combined	2500	3353	3 s	14.77 °/min	2.5 s	

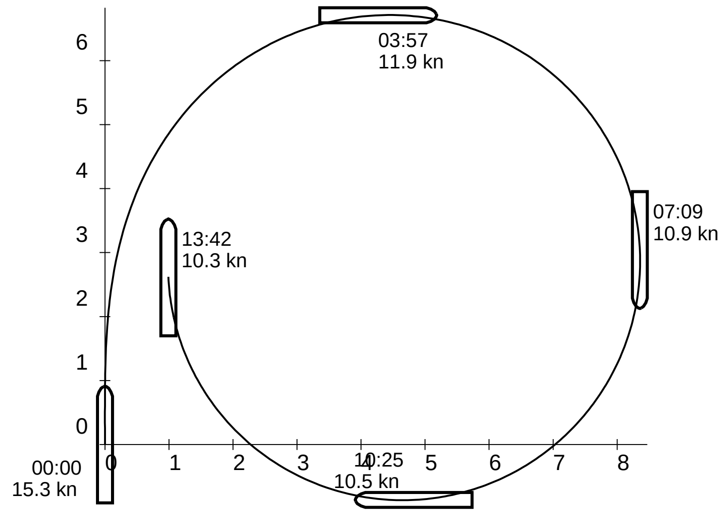
DRAUGHT INCREASE (LOADED)

Estimated squat effect			Heel Effect	
Under keel clearance	Ship's speed (knots)	Max bow squat estimated (m)	Heel angle (degree)	Draft increase (m)
26.1	8.8	0.28		
	12.3	0.55		
	21.5	1.68		
19.6	8.8	0.36		
	12.2	0.68		

TURNING CIRCLES AT MAX. RUDDER ANGLE (35 °)

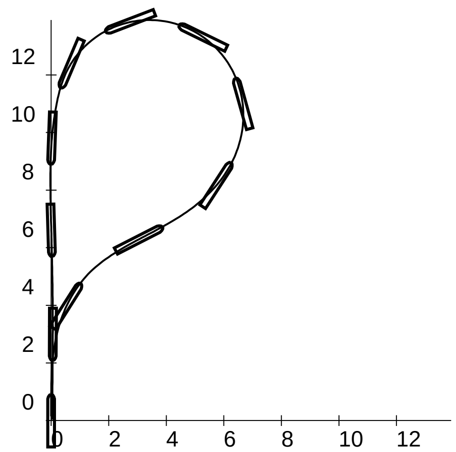


Distance (cables)
Deep Water



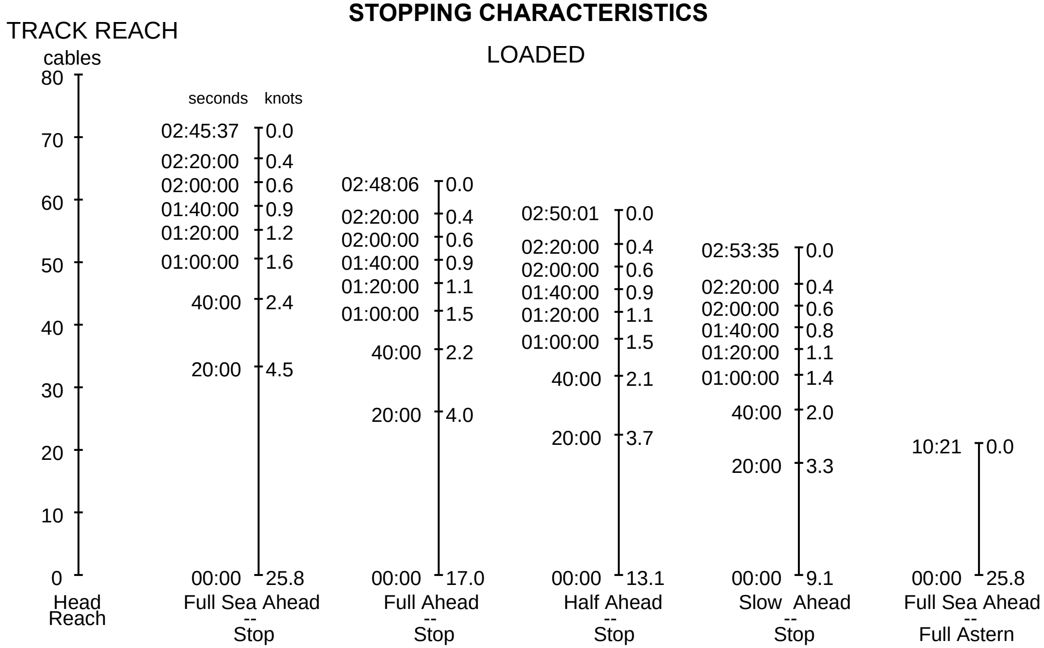
Distance (cables)
Shallow Water (Depth = 19.6 m)

WILLIAMSON TURN



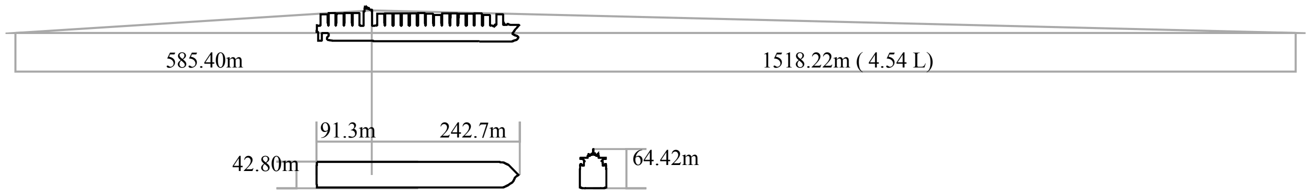
Distance(cables)
Rudder = 35.0 deg
Committed heading = 48.7 deg

STOPPING CHARACTERISTICS



PERFORMANCE MAY DIFFER FROM THIS RECORD DUE TO ENVIROMENTAL, HULL AND LOADING CONDITIONS

BLIND ZONE



Container Ship

MSC Daniela

CT364L

Ship Details		Drafts	
Length:	366.1 m	Draft Fwd:	14.48 m
Breadth:	51.2 m	Draft Aft :	14.48 m
Displacement:	183,969 t	Mean Draft:	14.48 m
Capacity:	13,798 TEU		

PILOT CARD

CT364L2
Version 2

Ship's name MSC Daniela **Date** ______

Call Sign 3FIA2 **Deadweight** 162867 tonnes **Year built** 2008

Draught aft 14.48 m / 47 ft 6 in **Forward** 14.48 m / 47 ft 6 in **Displacement** 183969 tonnes

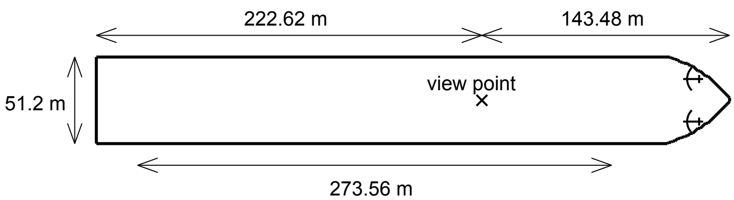
SHIP'S PARTICULARS

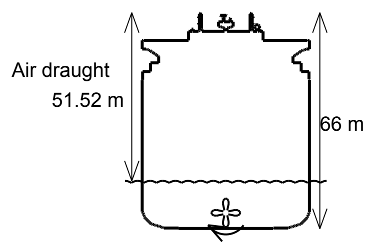
Length overall 366.1 m **Anchor chain:** **Port** 14.0 shackles **Starboard** 14.0 shackles

Breadth 51.2 m

Bulbous bow Yes

(1 shackle = 27.432 m = 15 fathoms)





PROPULSION PARTICULARS

Type of engine Diesel **Maximum power** 72203 kW (98168 hp)

Manoeuvring engine order		**RPM**	**Pitch**	**Speed (knots)**	
				Loaded	**Ballast**
Full sea speed	**1**	98.0	N/A	24.1	N/A
Full Ahead	**0.8**	65.0	N/A	16.6	N/A
Half Ahead	**0.5**	50.0	N/A	12.7	N/A
Slow Ahead	**0.25**	39.0	N/A	9.8	N/A
Dead Slow Ahead	**0.125**	31.0	N/A	7.8	N/A
Dead Slow Astern	**-0.125**	-31.0	N/A		
Slow Astern	**-0.25**	-39.0	N/A		
Half Astern	**-0.5**	-50.0	N/A		
Full Astern	**-1**	-65.0	N/A		

STEERING PARTICULARS

Type of rudder	Normal	**Maximum angle**	35 °
Hard-over to hard-over	13.2 s		
Rudder angle for neutral effect	0 °		
Thruster: **Bow**	3400 kW (4623 hp)	**Stern**	N/A kW (N/A hp)

CHECKED IF ABOARD AND READY

Anchors ☐

Whistle ☐

Radar ☐ 3 cm ☐ 10 cm

ARPA ☐

Speed log ☐ **Doppler:** Yes / No

Water speed ☐

Ground speed ☐

Dual-axis ☐

Engine telegraphs ☐

Steering gear ☐

Number of power units operating ☐

Indicators: ☐

Rudder ☐

Rpm/pitch ☐

Rate of turn ☐

Compass system ☐

Constant gyro error ± ______ °

VHF ☐

Elec. pos. fix. system ☐

Type ______

OTHER INFORMATION:

WHEELHOUSE POSTER

CT364L2
Version 2

Ship's name MSC Daniela **Call Sign** 3FIA2 **Gross tonnage** 151559 **Net tonnage** 83151

Max. Displacement 183969 tonnes, and **Deadweight** 162867 tonnes, and **Block coefficient** 0.693 at summer full load draught

Draught at which the manoeuvring data were obtained

Loaded	Ballast
Trial / Estimated	Trial / Estimated
14.48 m forward	N/A m forward
14.48 m aft	N/A m aft

STEERING PARTICULARS

Type of rudder(s) Normal

Maximum rudder angle 35 °

Time hard-over to hard-over

with one power unit 26.5 s

with two power units 13.2 s

Rudder angle for neutral effect 0 °

ANCHOR CHAIN

	Chain length	Max. rate of heaving
	shackles	min / shackle
Port	14.0	0.894
Starboard	14.0	0.894
(1 shackle = 27.432 m = 15 fathoms)		

PROPULSION PARTICULARS

Type of engine Diesel , 72203 kW (98168 hp) **Type of propulsion** Propelle

Engine order		RPM	Pitch	Speed (knots)	
				Loaded	Ballast
Full sea speed	**1**	98.0	N/A	24.1	N/A
Full Ahead	**0.8**	65.0	N/A	16.6	N/A
Half Ahead	**0.5**	50.0	N/A	12.7	N/A
Slow Ahead	**0.25**	39.0	N/A	9.8	N/A
Dead Slow Ahead	**0.125**	31.0	N/A	7.8	N/A
Dead Slow Astern	**-0.125**	-31.0	N/A		
Slow Astern	**-0.25**	-39.0	N/A		
Half Astern	**-0.5**	-50.0	N/A		
Full Astern	**-1**	-65.0	N/A		

Critical revolutions ______ rpm

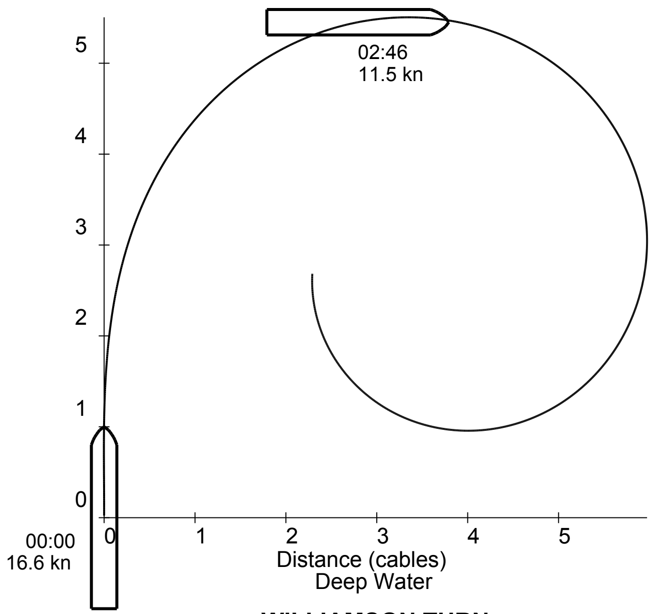
THRUSTER EFFECT at trial conditions

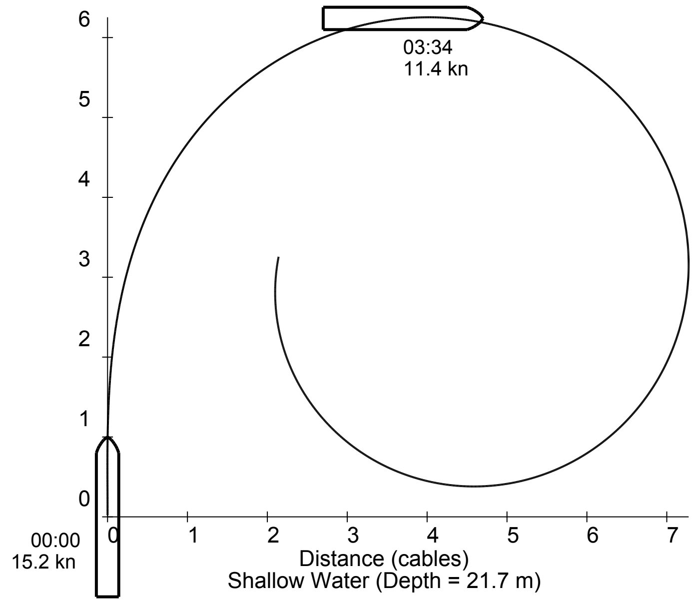
Thruster	kW	hp	Time delay for full thrust	Turning rate at zero speed	Time delay to reverse full thrust
Bow	3400	4623	19.2 s	12 °/min	20 s
Stern	N/A	N/A	N/A	N/A	N/A
Combined	N/A	N/A	N/A	N/A	N/A

DRAUGHT INCREASE (LOADED)

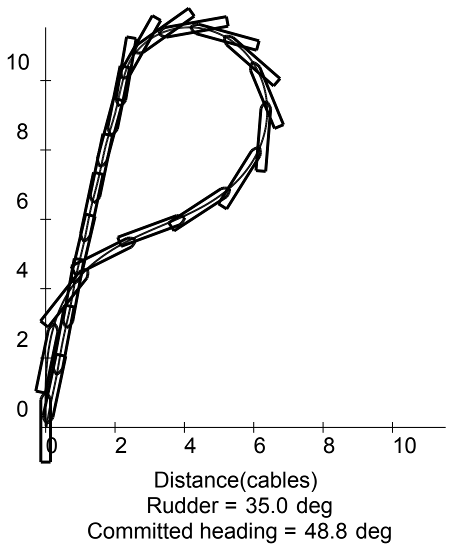
Estimated squat effect		
Under keel clearance (m)	Ship's speed (knots)	Max bow squat estimated (m)
14.5	9.9	0.59
	12.6	0.99
	22.0	1.26
7.2	9.6	0.58
	12.1	0.94

TURNING CIRCLES AT MAX. RUDDER ANGLE (35 °)

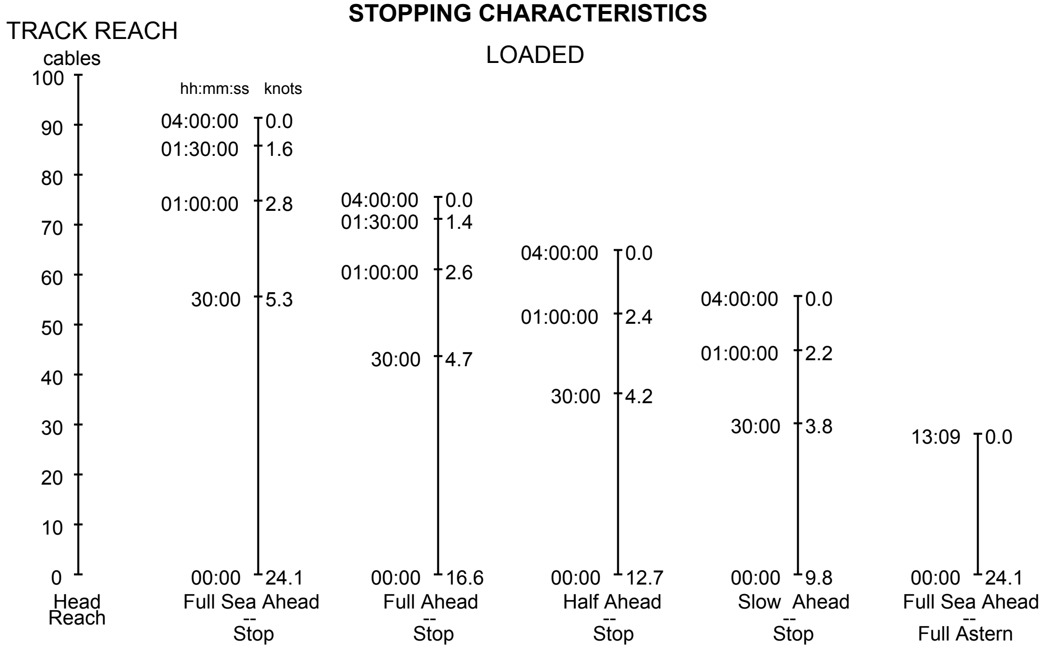




WILLIAMSON TURN

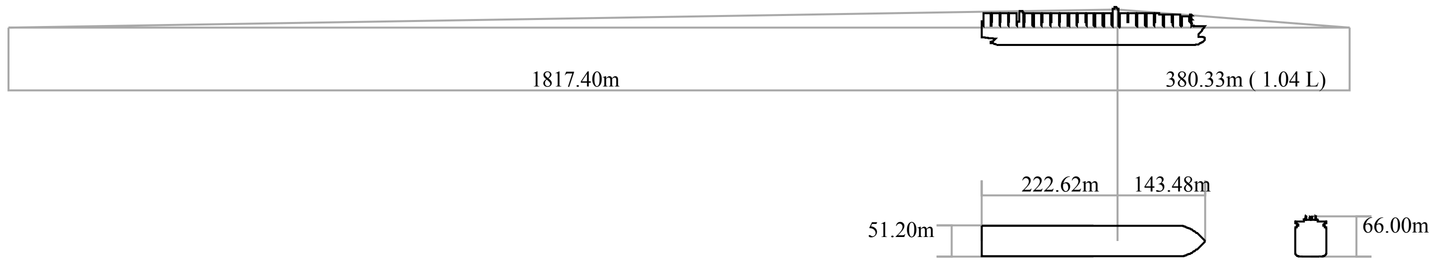


STOPPING CHARACTERISTICS



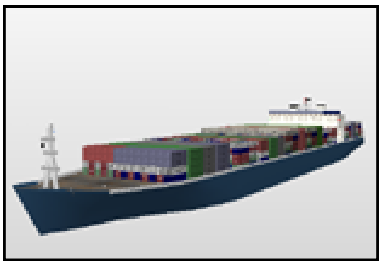
PERFORMANCE MAY DIFFER FROM THIS RECORD DUE TO ENVIRONMENTAL, HULL AND LOADING CONDITIONS

BLIND ZONE



Centre for Maritime Simulations
Vessel Data

Container Ship



CNTNR19L

CNTNR19L

Ship Details		Drafts	
Length:	398.0 m	Draft Fwd:	15.0 m
Breadth:	55.0 m	Draft Aft :	15.0 m
Displacement:	201,300 t	Mean Draft:	15.0 m
Capacity:	12,000 TEU		

PILOT CARD

CNTNR19L
Version 7

Ship's name CNTNR19L **Date**

Call Sign **Deadweight** 140000 tonnes **Year built**

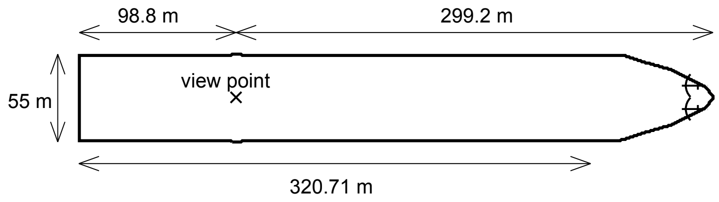
Draught aft 15 m / 49 ft 3 in **Forward** 15 m / 49 ft 3 in **Displacement** 201300 tonnes

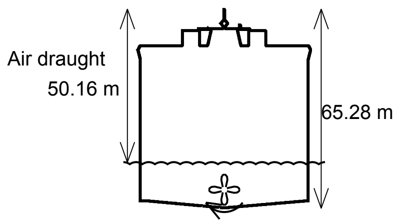
SHIP'S PARTICULARS

Length overall 398 m **Anchor chain:** **Port** 13.0 shackles **Starboard** 14.0 shackles

Breadth 55 m **Stern** shackles

Bulbous bow No **(1 shackle = 27.432 m = 15 fathoms)**





PROPULSION PARTICULARS

Type of engine Diesel **Maximum power** 85024 kW (114024 hp)

Manoeuvring engine order		RPM	Pitch	Speed (knots)	
				Loaded	Ballast
Full sea speed	1	82.0		26.5	
Full Ahead	0.8	42.5		14.0	
Half Ahead	0.5	34.8		11.4	
Slow Ahead	0.25	27.0		8.8	
Dead Slow Ahead	0.125	20.0		6.4	
Dead Slow Astern	-0.125	-20.0			
Slow Astern	-0.25	-27.0			
Half Astern	-0.5	-34.8			
Full Astern	-1	-55.0			

Time limit astern min:sec

Full ahead to full astern min:sec

Max. No. of consecutive starts

Minimum RPM knots

Astern power % ahead

STEERING PARTICULARS

Type of rudder	Normal	**Maximum angle**	35 °
Hard-over to hard-over	23 s		
Rudder angle for neutral effect	0.1 °		
Thruster: **Bow**	4000 kW (5364 hp)	**Stern**	kW (hp)

CHECKED IF ABOARD AND READY

Anchors		☐	**Indicators:**	☐
Whistle		☐	**Rudder**	☐
Radar	☐ 3 cm	☐ 10 cm	**Rpm/pitch**	☐
ARPA		☐	**Rate of turn**	☐
Speed log	☐ **Doppler:**	Yes / No	**Compass system**	☐
Water speed		☐	**Constant gyro error ±**	°
Ground speed		☐	**VHF**	☐
Dual-axis		☐	**Elec. pos. fix. system**	☐
Engine telegraphs		☐	**Type**	
Steering gear		☐		
Number of power units operating		☐		

OTHER INFORMATION:

WHEELHOUSE POSTER

CNTNR19L
Version 7

Ship's name CNTNR19L **Call Sign** ______ **Gross tonnage** ______ **Net tonnage** ______

Max. Displacement 201300 tonnes, and **Deadweight** 140000 tonnes, and **Block coefficient** 0.626 at summer full load draught

Draught at which the manoeuvring data were obtained

Loaded	Ballast
Trial / Estimated	Trial / Estimated
15 m forward	m forward
15 m aft	m aft

STEERING PARTICULARS

Type of rudder(s) Normal
Maximum rudder angle 35 °
Time hard-over to hard-over
with one power unit 46.1 s
with two power units 23 s
Min. speed to maintain course propeller stopped ______ knots
Rudder angle for neutral effect 0.1 °

ANCHOR CHAIN

	Chain length	Max. rate of heaving
	shackles	min / shackle
Port	13.0	0.894
Starboard	14.0	0.894
Stern		
(1 shackle = 27.432 m = 15 fathoms)		

PROPULSION PARTICULARS

Type of engine Diesel , 85024 kW (114024 hp) **Type of propeller** Propeller

Engine order		RPM	Pitch	Speed (knots) Loaded	Speed (knots) Ballast
Full sea speed	1	82.0		26.5	
Full Ahead	0.8	42.5		14.0	
Half Ahead	0.5	34.8		11.4	
Slow Ahead	0.25	27.0		8.8	
Dead Slow Ahead	0.125	20.0		6.4	
Dead Slow Astern	-0.125	-20.0			
Slow Astern	-0.25	-27.0			
Half Astern	-0.5	-34.8			
Full Astern	-1	-55.0			

Critical revolutions 19 rpm
Minimum RPM ______ ______ knots
Time limit astern ______ min:sec
Time limit at min. revs. ______ min:sec
Emergency
full ahead to full astern ______ s
stop to full astern ______ s
Astern power ______ % ahead
Max. No. of consecutive starts ______

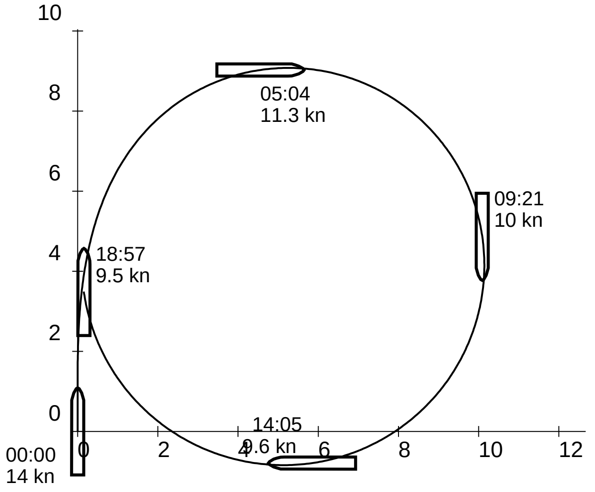
THRUSTER EFFECT at trial conditions

Thruster	kW	hp	Time delay for full thrust	Turning rate at zero speed	Time delay to reverse full thrust	Not effective above speed
Bow	4000	5364	10 s	13.37 °/min	2.4 s	
Stern						
Combined	4000	5364	10 s	13.37 °/min	2.4 s	

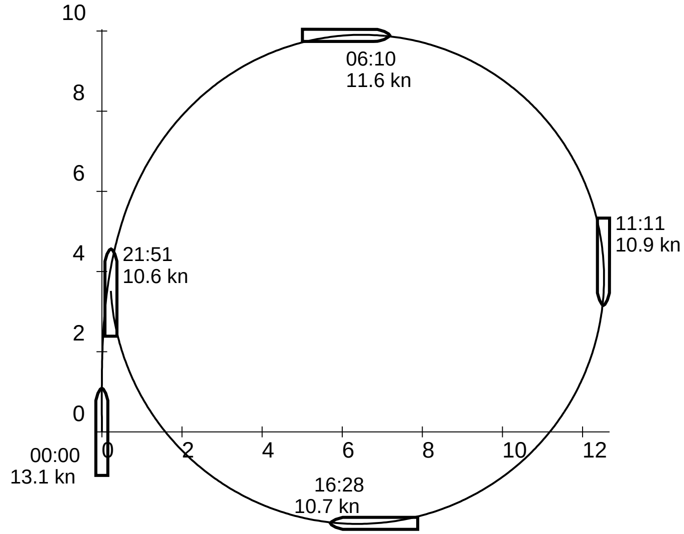
DRAUGHT INCREASE (LOADED)

Estimated squat effect			Heel Effect	
Under keel clearance	Ship's speed (knots)	Max bow squat estimated (m)	Heel angle (degree)	Draft increase (m)
30.0	8.4	0.26		
	10.9	0.44		
	23.6	2.07		
22.5	8.3	0.32		
	10.8	0.54		

TURNING CIRCLES AT MAX. RUDDER ANGLE (35 °)

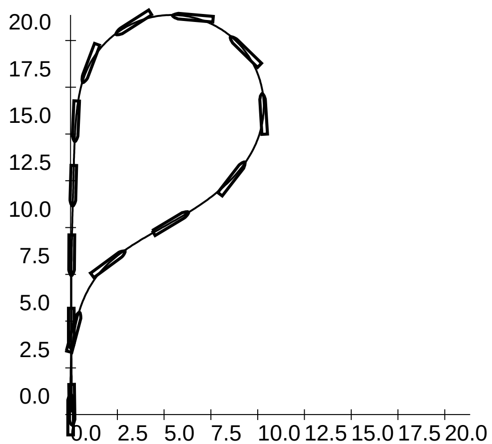


Distance (cables)
Deep Water



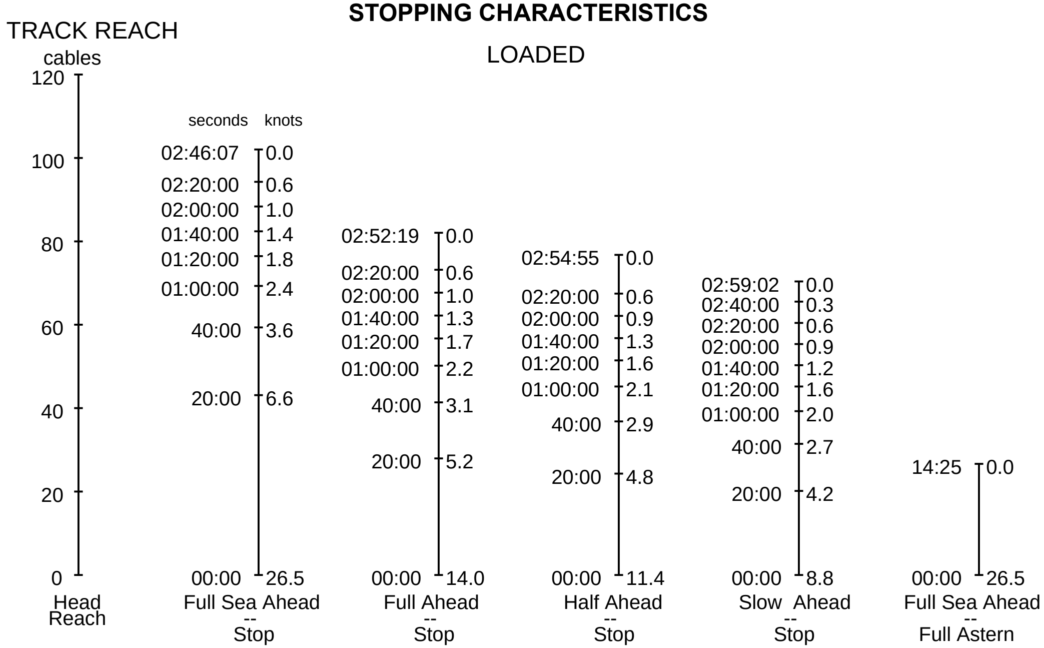
Distance (cables)
Shallow Water (Depth = 22.5 m)

WILLIAMSON TURN



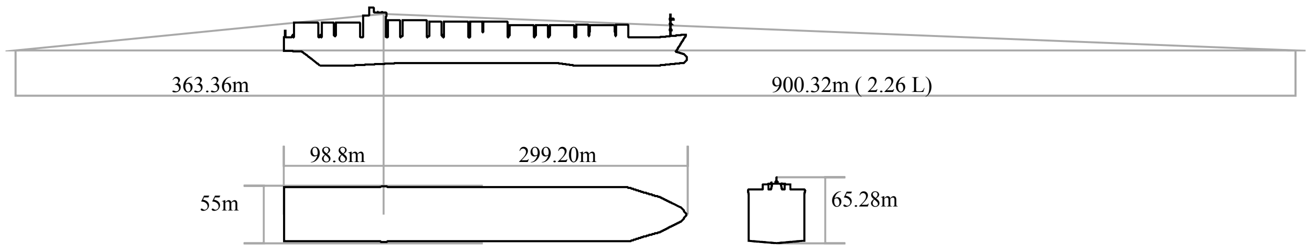
Distance(cables)
Rudder = 35.0 deg
Committed heading = 37.9 deg

STOPPING CHARACTERISTICS



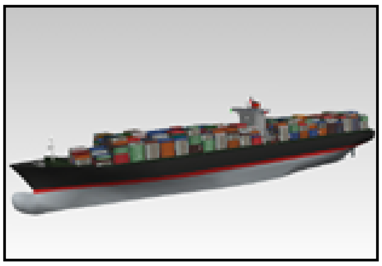
PERFORMANCE MAY DIFFER FROM THIS RECORD DUE TO ENVIROMENTAL, HULL AND LOADING CONDITIONS

BLIND ZONE



Centre for Maritime Simulations Vessel Data

Container Ship



Superium Maersk

CNTNR32L

Ship Details		Drafts	
Length:	398.0 m	Draft Fwd:	15.0 m
Breadth:	58.2 m	Draft Aft :	15.05 m
Displacement:	201,300 t	Mean Draft:	15.025 m
Capacity:	13,400 TEU		

PILOT CARD

CNTNR32L
Version 3

Ship's name Superium Maersk **Date**

Call Sign **Deadweight** 141500 tonnes **Year built**

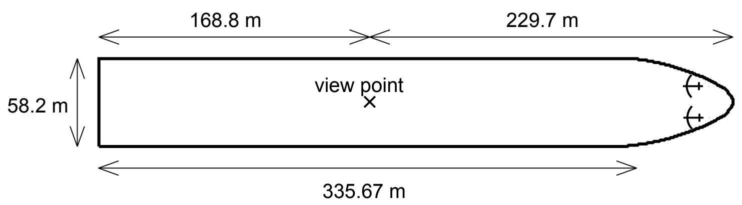
Draught aft 15.05 m / 49 ft 5 in **Forward** 15 m / 49 ft 3 in **Displacement** 201300 tonnes

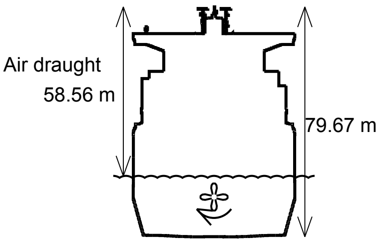
SHIP'S PARTICULARS

Length overall 398.5 m **Anchor chain:** **Port** 28.1 shackles **Starboard** 28.1 shackles

Breadth 58.2 m **Stern** shackles

Bulbous bow No **(1 shackle = 27.432 m = 15 fathoms)**





PROPULSION PARTICULARS

Type of engine Diesel **Maximum power** 74985 kW (100562 hp)

Manoeuvring engine order		RPM	Pitch	Speed (knots)	
				Loaded	Ballast
Full sea speed	**1**	95.0		24.7	
Full Ahead	**0.8**	83.7		21.8	
Half Ahead	**0.5**	62.0		16.0	
Slow Ahead	**0.25**	36.2		9.0	
Dead Slow Ahead	**0.125**	21.0		5.0	
Dead Slow Astern	**-0.125**	-19.3			
Slow Astern	**-0.25**	-36.8			
Half Astern	**-0.5**	-61.3			
Full Astern	**-1**	-87.8			

Time limit astern min:sec

Full ahead to full astern min:sec

Max. No. of consecutive starts

Minimum RPM knots

Astern power % ahead

STEERING PARTICULARS

Type of rudder Normal **Maximum angle** 35 °

Hard-over to hard-over 14 s

Rudder angle for neutral effect 0 °

Thruster: Bow 3280 kW (4399 hp) **Stern** 3280 kW (4399 hp)

CHECKED IF ABOARD AND READY

Anchors	☐	**Indicators:**	☐
Whistle	☐	**Rudder**	☐
Radar ☐ 3 cm	☐ 10 cm	**Rpm/pitch**	☐
ARPA	☐	**Rate of turn**	☐
Speed log ☐ **Doppler:**	Yes / No	**Compass system**	☐
Water speed	☐	**Constant gyro error ±**	____ °
Ground speed	☐	**VHF**	☐
Dual-axis	☐	**Elec. pos. fix. system**	☐
Engine telegraphs	☐	**Type**	____
Steering gear	☐		
Number of power units operating	☐		

OTHER INFORMATION:

WHEELHOUSE POSTER

CNTNR32L
Version 3

Ship's name Superium Maersk **Call Sign** ______ **Gross tonnage** ______ **Net tonnage** ______

Max. Displacement 201300 tonnes, and **Deadweight** 141500 tonnes, and **Block coefficient** 0.6 at summer full load draught

Draught at which the manoeuvring data were obtained

Loaded	Ballast
Trial / Estimated	Trial / Estimated
15 m forward	m forward
15.05 m aft	m aft

STEERING PARTICULARS

Type of rudder(s) Normal

Maximum rudder angle 35 °

Time hard-over to hard-over

with one power unit 28 s

with two power units 14 s

Min. speed to maintain course propeller stopped ______ knots

Rudder angle for neutral effect 0 °

ANCHOR CHAIN

	Chain length	Max. rate of heaving
	shackles	min / shackle
Port	28.1	0.894
Starboard	28.1	0.894
Stern		
(1 shackle = 27.432 m = 15 fathoms)		

PROPULSION PARTICULARS

Type of engine Diesel , 74985 kW (100562 hp) **Type of propeller** Propeller

Engine order		RPM	Pitch	Speed (knots)	
				Loaded	Ballast
Full sea speed	**1**	95.0		24.7	
Full Ahead	**0.8**	83.7		21.8	
Half Ahead	**0.5**	62.0		16.0	
Slow Ahead	**0.25**	36.2		9.0	
Dead Slow Ahead	**0.125**	21.0		5.0	
Dead Slow Astern	**-0.125**	-19.3			
Slow Astern	**-0.25**	-36.8			
Half Astern	**-0.5**	-61.3			
Full Astern	**-1**	-87.8			

Critical revolutions 15 rpm

Minimum RPM ______ ______ knots

Time limit astern ______ min:sec

Time limit at min. revs. ______ min:sec

Emergency

full ahead to full astern ______ s

stop to full astern ______ s

Astern power ______ % ahead

Max. No. of consecutive starts ______

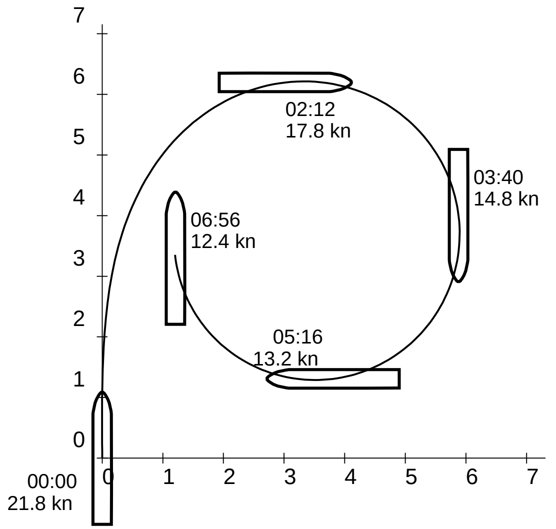
THRUSTER EFFECT at trial conditions

Thruster	kW	hp	Time delay for full thrust	Turning rate at zero speed	Time delay to reverse full thrust	Not effective above speed
Bow	3280	4399	10 s	14.41 °/min	3.6 s	
Stern	3280	4399	10 s	14.01 °/min	2 s	
Combined	6560	8798	20 s	20.66 °/min	3.6 s	

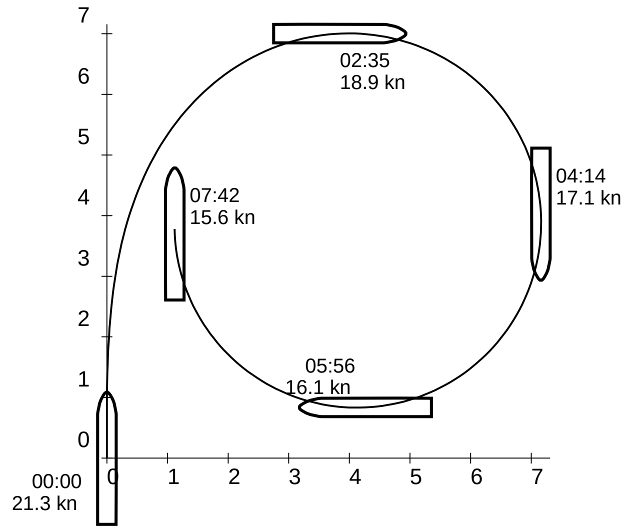
DRAUGHT INCREASE (LOADED)

Estimated squat effect			Heel Effect	
Under keel clearance	Ship's speed (knots)	Max bow squat estimated (m)	Heel angle (degree)	Draft increase (m)
30.2	8.9	0.40		
	15.8	1.30		
	24.1	1.22		
22.7	8.8	0.39		
	15.7	1.35		

TURNING CIRCLES AT MAX. RUDDER ANGLE (35 °)

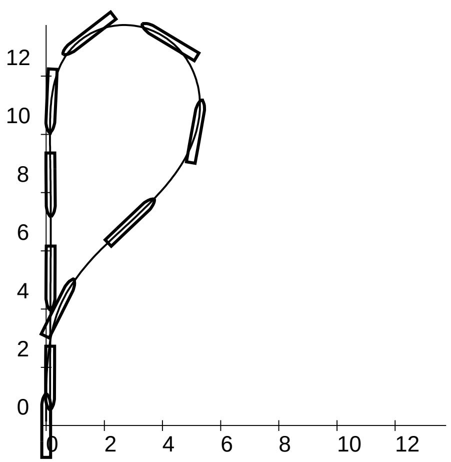


Distance (cables)
Deep Water



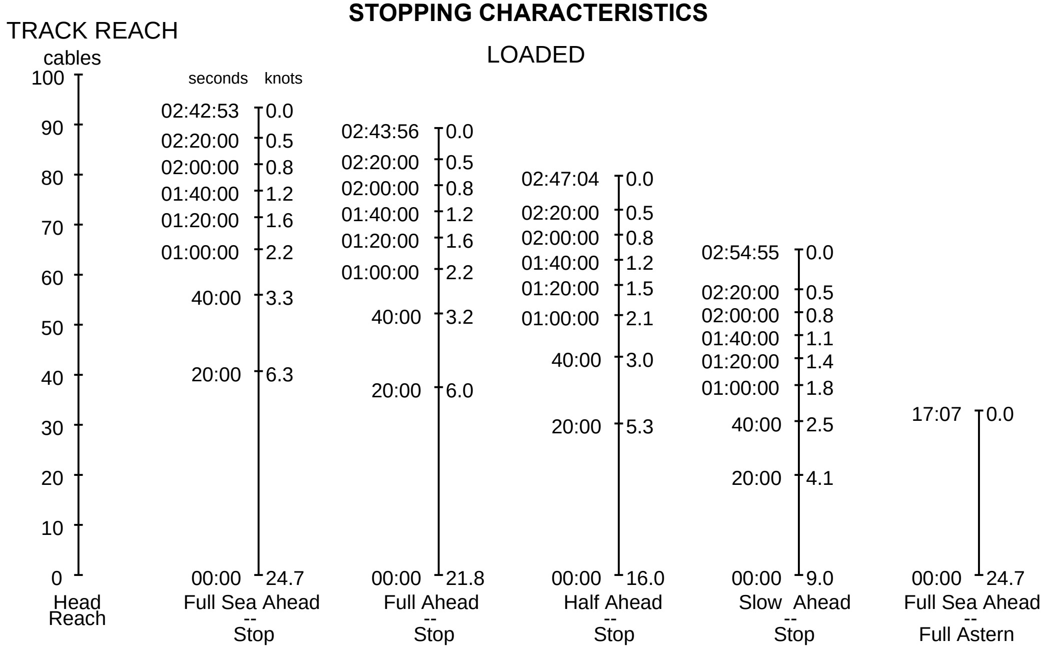
Distance (cables)
Shallow Water (Depth = 22.7 m)

WILLIAMSON TURN



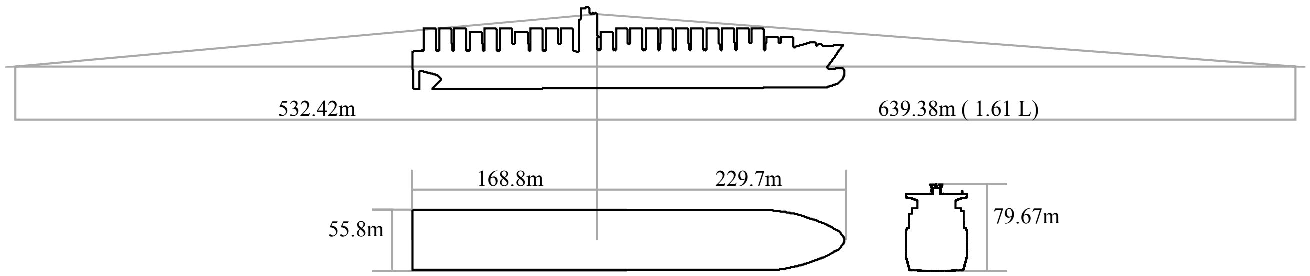
Distance(cables)
Rudder = 35.0 deg
Committed heading = 24.2 deg

STOPPING CHARACTERISTICS



PERFORMANCE MAY DIFFER FROM THIS RECORD DUE TO ENVIROMENTAL, HULL AND LOADING CONDITIONS

BLIND ZONE



Section 3

Navigation Warning

AUSTRALIAN MARITIME COLLEGE

WARNING: Not to be used for navigation

The Australian Hydrographic Office does not check the information in this product and the Commonwealth accepts no liability for the accuracy of copying or for any modifications that may have been made to the material which it has supplied. Furthermore, the Commonwealth does not warrant that this product meets any regulations as an appropriate product for navigation or that it contains the latest hydrographic information available.

Section 4

Run Summary

AUSTRALIAN MARITIME COLLEGE

Summary of Runs: Day 1, 21 November 2016

<table>
<tr><th>Run</th><th>Pilot</th><th>Wind</th><th>Tide</th><th>Current</th></tr>
<tr><td rowspan="2">1</td><td>Gavin Barry</td><td>10kts from 270°</td><td>1.58m (HW -03:00)</td><td>1.9kts to 17°</td></tr>
<tr><td colspan="4">Ital Cortesia 334 Inbound from Sea.Wind: W x 10kts. Swell: SW x 2.0m @ 10s. Tide: HW -03:00. Current: 2.5 knots Flood. Standard Model Familiarisation Run</td></tr>
<tr><td rowspan="2">2</td><td>Rob Buck</td><td>10kts from 270°</td><td>1.14m (HW +04:30)</td><td>2.7kts to 220°</td></tr>
<tr><td colspan="4">Ital Cortesia 334 Inbound from Sea. Wind: W x 10kts. Swell: SW x 2.0m @ 10s. Tide: HW +04:30. Current: 2.5 knots Ebb. Standard Model Familiarisation Run</td></tr>
<tr><td rowspan="2">3</td><td>Tim Fitzgerald</td><td>10kts from 270°</td><td>0.68m (HW +06:30)</td><td>4.7kts to 220°</td></tr>
<tr><td colspan="4">Ital Cortesia 334 Inbound from Sea. Wind: W x 10kts. Swell: SW x 2.0m @ 10s. Tide: HW +06:30. Current: 4.0 knots Ebb. Standard Model Familiarisation Run</td></tr>
<tr><td rowspan="2">4</td><td>Rob Buck</td><td>10kts from 270°</td><td>0.68m (HW +06:30)</td><td>4.5kts to 199°</td></tr>
<tr><td colspan="4">Ital Cortesia 334 Inbound from Sea. Wind: W x 10kts. Swell: SW x 2.0m @ 10s. Tide: HW +06:30. Current: 4.0 knots Ebb. Standard Model Vessel speed restricted to 13 knots (Half Ahead) to simulate vessel constrained by DUKC</td></tr>
<tr><td rowspan="2">5</td><td>Gavin Barry</td><td>33kts from 235°</td><td>1.06m (HW +04:50)</td><td>3.6kts to 220°</td></tr>
<tr><td colspan="4">Ital Cortesia 334 Inbound from Sea. Wind: SW x 30kts. Swell: SW x 3.0m @ 12s. Tide: HW +04:50. Current: 3.0 knots Ebb. Standard Model Vessel speed restricted to 13 knots (Half Ahead) to simulate vessel constrained by DUKC</td></tr>
<tr><td rowspan="2">6</td><td>Tim Fitzgerald</td><td>33kts from 131°</td><td>1.91m (HW -02:15)</td><td>4.3kts to 15°</td></tr>
<tr><td colspan="4">Ital Cortesia 334 Inbound from Sea. Wind: SE x 30kts. Swell: SW x 3.0m @ 12s. Tide: HW -02:15. Current: 4.0 knots Flood. Standard Model Vessel speed restricted to 13 knots (Half Ahead) to simulate vessel constrained by DUKC</td></tr>
<tr><td rowspan="2">6a</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="4">Chart of full plot of Run 6</td></tr>
<tr><td rowspan="2">7</td><td>Rob Buck</td><td>33kts from 274°</td><td>0.49m (HW -02:45)</td><td>3.1kts to 15°</td></tr>
<tr><td colspan="4">Ital Cortesia 334 Outbound from Popes Eye. Wind: W x 30kts. Swell: SW x 3.0m @ 12s. Tide: HW -02:45. Current: 3.0 knots Flood. Standard Model</td></tr>
<tr><td rowspan="2">8</td><td>Gavin Barry</td><td>33kts from 276°</td><td>0.50m (HW +04:45)</td><td>3.6kts to 219°</td></tr>
<tr><td colspan="4">Ital Cortesia 334 Outbound from Popes Eye. Wind: W x 30kts. Swell: SW x 3.0m @ 12s. Tide: HW +04:45. Current: 3.0 knots Ebb. Standard Model Vessel speed restricted to 13 knots (Half Ahead) to simulate vessel constrained by DUKC</td></tr>
<tr><td rowspan="2">9</td><td>Tim Fitzgerald</td><td>23kts from 269°</td><td>0.50m (HW -02:45)</td><td>3.4kts to 14°</td></tr>
<tr><td colspan="4">MSC Daniela Outbound from Popes Eye. Wind: W x 20kts. Swell: SW x 2.0m @ 10s.Tide: HW -02:45. Current: 3.0 knots Flood. Standard Model Vessel speed restricted to 13 knots (Half Ahead) as vessel constrained by DUKC. (14.5m draft)</td></tr>
<tr><td rowspan="2">10</td><td>Rob Buck</td><td>23kts from 217°</td><td>1.73m (HW -02:40)</td><td>3.1kts to 18°</td></tr>
<tr><td colspan="4">MSC Daniela Inbound from Sea. Wind: SW x 20kts. Swell: SW x 2.0m @ 10s.Tide: HW -02:40. Current: 3.0 knots Flood. Standard Model Vessel speed restricted to 13 knots (Half Ahead) as vessel constrained by DUKC. (14.5m draft)</td></tr>
<tr><td rowspan="2">11</td><td>Gavin Barry</td><td>23kts from 235°</td><td>0.53m (HW +04:50)</td><td>3.7kts to 221°</td></tr>
<tr><td colspan="4">MSC Daniela Outbound from Popes Eye. Wind: SW x 20kts. Swell: SW x 2.0m @ 10s.Tide: HW +04:50. Current: 3.0 knots Ebb. Standard Model Vessel speed restricted to 13 knots (Half Ahead) as vessel constrained by DUKC. (14.5m draft)</td></tr>
</table>

12	**Tim Fitzgerald**	23kts from 96°	0.45m (HW -02:45)	3.3kts to 16°
	MSC Daniela Outbound from Popes Eye. Wind: E x 20kts. Swell: SW x 2.0m @ 10s.Tide: HW -02:45. Current: 3.0 knots Flood. Standard Model Vessel speed restricted to 13 knots (Half Ahead) as vessel constrained by DUKC. (14.5m draft)			
13	**Rob Buck**	23kts from 95°	1.50m (HW -03:10)	1.8kts to 15°
	MSC Daniela Outbound from Popes Eye. Wind: E x 20kts. Swell: SW x 2.0m @ 10s.Tide: Manually increased by 1.0m to replicate shallower draft. Current: 1.5 knots Flood. Standard Model Vessel speed restricted to 13 knots (Half Ahead) as vessel constrained by DUKC.			
14	**Gavin Barry**	33kts from 280°	1.50m (HW -02:45)	3.3kts to 17°
	MSC Daniela Outbound from Popes Eye. Wind: W x 30kts. Swell: SW x 2.0m @ 10s.Tide: Manually increased by 1.0m to replicate shallower draft. Current: 3.0 knots Flood. Standard Model Vessel speed restricted to 13 knots (Half Ahead) as vessel constrained by DUKC.			
15	**Tim Fitzgerald**	33kts from 265°	0.60m (HW +04:00)	1.8kts to 221°
	MSC Daniela Outbound from Popes Eye. Wind: W x 30kts. Swell: SW x 2.0m @ 10s.Tide: Manually increased by 1.0m to replicate shallower draft. Current: 1.5 knots Ebb. Standard Model Vessel speed restricted to 13 knots (Half Ahead) as vessel constrained by DUKC.			

Summary of Runs: Day 2, 22 November 2016

Run	Pilot	Wind	Tide	Current
16	**Gavin Barry**	15kts from 270°	2.01m (HW -02:10)	2.9kts to 26°
	CNTNR19L Inbound from Sea. Wind: W x 15kts. Swell: SW x 2.0m @ 10s.Tide: HW -02:10. Current: 3.0 knots Flood. Amended Bathymetry and Current Vessel speed restricted to Half Ahead as vessel constrained by DUKC (Draft 15m) .			
17	**Rob Buck**	15kts from 270°	3.00m (HW -02:10)	2.8kts to 27°
	CNTNR19L Inbound from Sea. Wind: W x 15kts. Swell: SW x 2.0m @ 10s. Tide:Manually increased by 1.0m to replicate shallower draft. Current: 3.0 knots Flood. Amended Bathymetry and Current Vessel speed restricted to Half Ahead as vessel constrained by DUKC (Draft 15m) .			
18	**Tim Fitzgerald**	15kts from 270°	3.00m (HW -02:10)	3.0kts to 24°
	Superium Maersk Inbound from Sea. Wind: W x 15kts. Swell: SW x 2.0m @ 10s. Tide: Manually increased by 1.0m to replicate shallower draft. Current: 3.0 knots Flood. Amended Bathymetry and Current Vessel speed restricted to Half Ahead as vessel constrained by DUKC (Draft 15m) .			
19	**Gavin Barry**	15kts from 270°	2.50m (HW -02:10)	3.1kts to 24°
	Superium Maersk Outbound from Popes Eye. Wind: W x 15kts. Swell: SW x 2.0m @ 10s. Tide: Manually increased by 0.5m to replicate shallower draft. Current: 3.0 knots Flood. Amended Bathymetry and Current Vessel speed restricted to Half Ahead as vessel constrained by DUKC (Draft 15m) .			
20	**Tim Fitzgerald**	15kts from 270°	2.20m (HW -02:10)	3.0kts to 25°
	Superium Maersk Outbound from Popes Eye. Wind: W x 15kts. Swell: SW x 2.0m @ 10s. Tide: Manually increased by 0.5m to replicate shallower draft (14.5m). Current: 3.0 knots Flood. Amended Bathymetry and Current - Tide reduced by 1.5m to account for vertical sounding datums Vessel speed restricted to Half Ahead as vessel constrained by DUKC.			
21	**Rob Buck**	15kts from 270°	2.70m (HW -02:45)	1.8kts to 23°
	Superium Maersk Outbound from Popes Eye. Wind: W x 15kts. Swell: SW x 2.0m @ 10s. Tide: Manually increased by 1.0m to replicate shallower draft (14.0m). Current: 1.5 knots Flood. Amended Bathymetry and Current - Tide reduced by 1.5m to account for vertical sounding datums Vessel speed restricted to Half Ahead as vessel constrained by DUKC			
22	**Gavin Barry**	15kts from 270°	2.20m (HW +03:00)	1.5kts to 210°
	Superium Maersk Outbound from Popes Eye. Wind: W x 15kts. Swell: SW x 2.0m @ 10s. Tide: Manually increased by 1.0m to replicate shallower draft (14.0m). Current: 1.5 knots Ebb. Amended Bathymetry and Current - Tide reduced by 1.5m to account for vertical sounding datums Vessel speed restricted to Half Ahead as vessel constrained by DUKC			
23	**Tim Fitzgerald**	15kts from 270°	1.90m (HW +03:30)	3.2kts to 205°
	Superium Maersk Outbound from Popes Eye. Wind: W x 15kts. Swell: SW x 2.0m @ 10s. Tide: 0.9m then manually increased by 1.0m to replicate shallower draft (14.0m). Current: 3.0 knots Ebb. Amended Bathymetry and Current - Tide reduced by 1.5m to account for vertical sounding datums Vessel speed restricted to Half Ahead as vessel constrained by DUKC			
24	**Rob Buck**	15kts from 270°	3.00m (HW -02:00)	3.4kts to 26°
	Superium Maersk Outbound from Popes Eye. Wind: W x 15kts. Swell: SW x 2.0m @ 10s. Tide: 2.0m then manually increased by 1.0m to replicate shallower draft (14.0m). Current: 3.0 knots Flood. Amended Bathymetry and Current - Tide reduced by 1.5m to account for vertical sounding datums Vessel speed restricted to Half Ahead as vessel constrained by DUKC			

25	**Gavin Barry**	15kts from 270°	1.50m (HW -02:00)	3.3kts to 26°
	Superium Maersk Inbound from Sea. Wind: W x 15kts. Swell: SW x 2.0m @ 10s. Tide: 2.0m then manually increased by 1.0m to replicate shallower draft (14.0m). Current: 3.0 knots Flood. Amended Bathymetry and Current - Tide reduced by 1.5m to account for vertical sounding datums Vessel speed restricted to Half Ahead as vessel constrained by DUKC			
26	**Tim Fitzgerald**	15kts from 270°	1.69m (HW -02:00)	3.3kts to 26°
	Superium Maersk (15m Draft) Outbound from Popes Eye. Wind: W x 15kts. Swell: SW x 2.0m @ 10s. Tide: HW -02:00. Current: 3.0 knots Flood. Amended Bathymetry and Current - with bathymtery deepened by 1.5m. Vessel speed restricted to Half Ahead as vessel constrained by DUKC			
27	**Rob Buck**	15kts from 270°	1.40m (HW +03:30)	3.1kts to 204°
	Superium Maersk (15m Draft) Outbound from Popes Eye. Wind: W x 15kts. Swell: SW x 2.0m @ 10s. Tide: HW +03:30. Current: 3.0 knots Ebb. Amended Bathymetry and Current - with bathymtery deepened by 1.5m. Vessel speed restricted to Half Ahead as vessel constrained by DUKC			
28	**Gavin Barry**	15kts from 270°	1.83m (HW -01:00)	4.7kts to 26°
	Superium Maersk (15m Draft) Outbound from Popes Eye. Wind: W x 15kts. Swell: SW x 2.0m @ 10s. Tide: HW -01:00. Current: 4.0 knots Flood. Amended Bathymetry and Current - with bathymtery deepened by 1.5m. Vessel speed restricted to Half Ahead as vessel constrained by DUKC			