

Annexure A. Navigational impact assessment

Transport for NSW

Beaches Link and Gore Hill Freeway Connection

Technical working paper: Navigation impact assessment

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Prepared for

Transport for NSW

Prepared by

Royal Haskoning DHV

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Executive summary

The Beaches Link and Gore Hill Freeway Connection project is proposed to include driven tunnels and immersed tube tunnels for the crossing of Middle Harbour. A detailed description of the construction works is provided in Chapter 6 (Construction work) of the environmental impact statement and **Section 5** of this report. Marine construction activities would primarily occur in Middle Harbour with transits of construction vessels through the Outer Harbour.

The impact on navigation in the Outer Harbour during construction would be considered negligible. This is due to infrequent marine construction vessel movements combined with relatively wide waterway widths. Vessel transits would include transportation of the steel shell immersed tube tunnel units likely constructed outside of Middle Harbour.

The impact on navigation in the vicinity of the Spit Bridge during construction would be considered acceptable. A mission simulation has been carried out by Port Authority of NSW to assess the feasibility and impact of transporting the steel shell immersed tube tunnel units past the Spit Bridge and within Middle Harbour. The simulation demonstrated that the construction method proposed in Chapter 6 (Construction work) of the environmental impact statement can be carried out with limited impact to existing harbour operations or infrastructure. However, the waterway is relatively narrow and vessels are required to congregate around the Spit Bridge waiting for the opening. This results in congestion of the waterway. Mitigation measures are proposed to alleviate congestion including special bridge openings for transportation of the steel shell immersed tube tunnel units and other marine construction traffic.

The impact on navigation in the vicinity of the Spit West Reserve construction support site (BL9) and the Middle Harbour crossing during construction would be considered significant for certain user groups. Partial restrictions of Middle Harbour with controlled access through the site would be required. Recreational users, such as boating, sailing, rowing and kayaking would be allowed to travel through the site in a controlled manner ensuring the safety of both the waterway user and the project team. There is minimal commercial traffic in Middle Harbour and the impact on commercial business would be considered negligible. Two community groups (Mosman Rowing Club and Northbridge Sailing Club/Seaforth Moth Sailing Club) have the potential to be substantially impacted by the works. Mitigation measures are proposed to limit the impact on Mosman Rowing Club. Liaison with Northbridge Sailing Club and Seaforth Moth Sailing Club would be carried out to discuss the impact and arrange relocation of their race courses to upstream of the Middle Harbour crossing.

Operational impacts on marine safety and navigation associated with the Middle Harbour crossing would be negligible. The immersed tube tunnels would result in a reduction of water depth in the centre of the Middle Harbour crossing of about 10 metres, but this would not have an impact on navigation.

The potential impacts on safety and navigation during construction would need to be carefully and effectively managed through consultation and liaison during the detailed design and construction planning phase and during construction works. The implementation of safeguards and management measures would assist in avoiding or mitigating the potential impacts. Safeguards and management measures relevant to navigation impacts of the project are identified in **Section 6** of this report.

1 Introduction

This section provides an overview of the Beaches Link and Gore Hill Freeway Connection (the project), including its key features and location. It also outlines the Secretary's environmental assessment requirements addressed in this technical working paper.

1.1 Overview

The Greater Sydney Commission's *Greater Sydney Region Plan – A Metropolis of Three Cities* (Greater Sydney Commission, 2018) proposes a vision of three cities where most residents have convenient and easy access to jobs, education and health facilities and services. In addition to this plan, and to accommodate for Sydney's future growth the NSW Government is implementing the *Future Transport Strategy 2056* (Transport for NSW, 2018), that sets the 40 year vision, directions and outcomes framework for customer mobility in NSW. The Western Harbour Tunnel and Beaches Link program of works is proposed to provide additional road network capacity across Sydney Harbour and Middle Harbour and to improve transport connectivity with Sydney's Northern Beaches. The Western Harbour Tunnel and Beaches Link program of works include:

- The Western Harbour Tunnel and Warringah Freeway Upgrade project which comprises a new tolled motorway tunnel connection across Sydney Harbour, and an upgrade of the Warringah Freeway to integrate the new motorway infrastructure with the existing road network and to connect to the Beaches Link and Gore Hill Freeway Connection project
- The Beaches Link and Gore Hill Freeway Connection project which comprises a new tolled motorway tunnel connection across Middle Harbour from the Warringah Freeway and the Gore Hill Freeway to Balgowlah and Killarney Heights and including the surface upgrade of the Wakehurst Parkway from Seaforth to Frenchs Forest and upgrade and integration works to connect to the Gore Hill Freeway at Artarmon.

A combined delivery of the Western Harbour Tunnel and Beaches Link program of works would unlock a range of benefits for freight, public transport and private vehicle users. It would support faster travel times for journeys between the Northern Beaches and areas south, west and north-west of Sydney Harbour. Delivering the program of works would also improve the resilience of the motorway network, given that each project provides an alternative to heavily congested existing harbour crossings.

1.2 The project

Transport for NSW is seeking approval under Part 5, Division 5.2 of the Environmental Planning and Assessment Act 1979 to construct and operate the Beaches Link and Gore Hill Freeway Connection project, which would comprise two components:

- Twin tolled motorway tunnels connecting the Warringah Freeway at Cammeray and the Gore Hill Freeway at Artarmon to the Burnt Bridge Creek Deviation at Balgowlah and the Wakehurst Parkway at Killarney Heights, and an upgrade of the Wakehurst Parkway (the Beaches Link)
- Connection and integration works along the existing Gore Hill Freeway and surrounding roads at Artarmon (the Gore Hill Freeway Connection).

A detailed description of the project is provided in Chapter 5 (Project description) and Chapter 6 (Construction work) of the environmental impact statement.

The Gore Hill Freeway Connection component of the project is not relevant to this report and is therefore not discussed further.

1.3 Project location

The project would be located within the North Sydney, Willoughby, Mosman and Northern Beaches local government areas, connecting Cammeray in the south with Killarney Heights, Frenchs Forest and Balgowlah in the north.

Commencing at the Warringah Freeway at Cammeray, the mainline tunnels would pass under Naremburn and Northbridge, then cross Middle Harbour between Northbridge and Seaforth. The mainline tunnels would then split under Seaforth into two ramp tunnels and continue north to the Wakehurst Parkway at Killarney Heights and north-east to Balgowlah, linking directly to the Burnt Bridge Creek Deviation to the south of the existing Kitchener Street bridge.

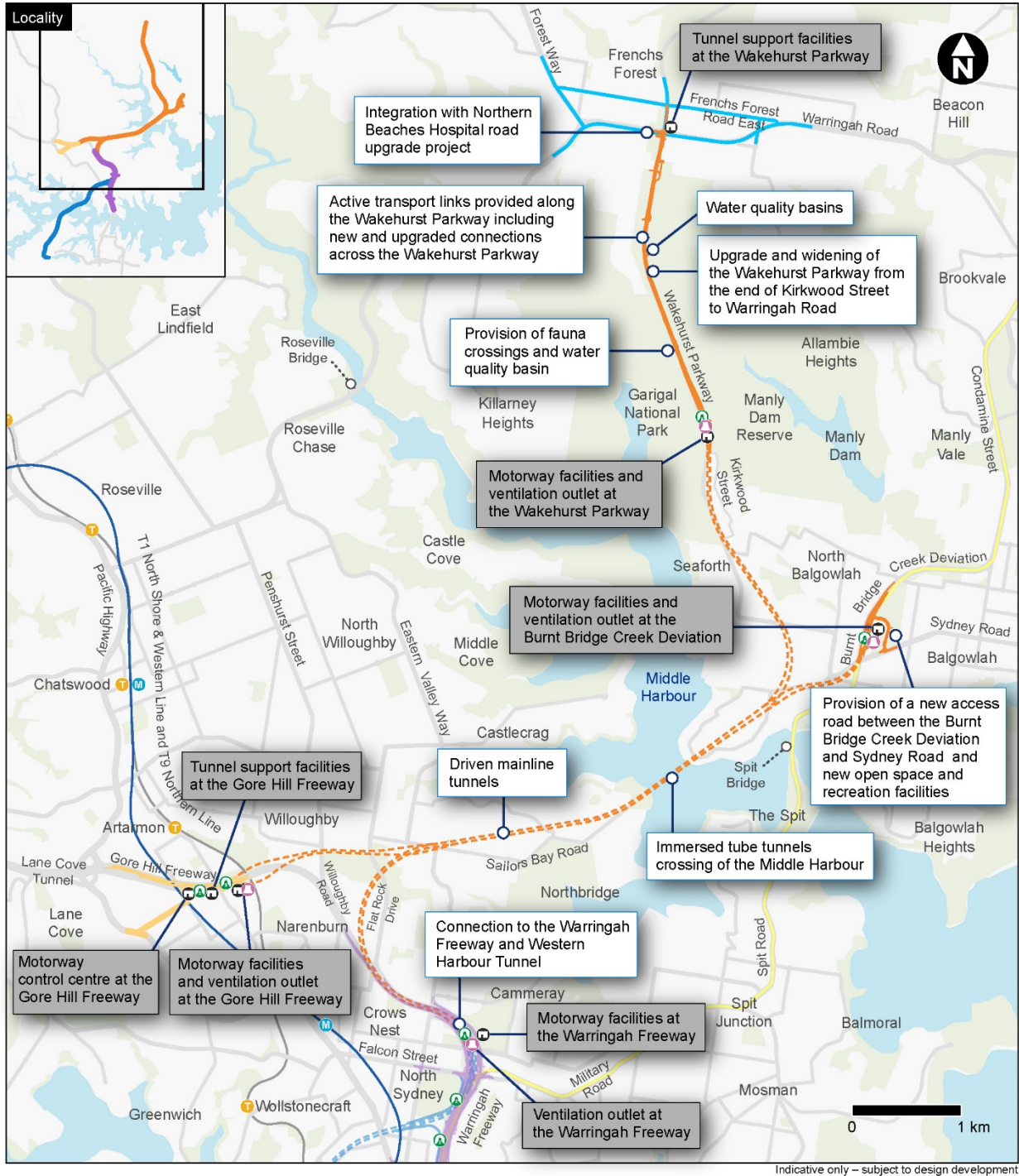
Surface works would also be carried out at the Gore Hill Freeway in Artarmon, Burnt Bridge Creek Deviation at Balgowlah and along the Wakehurst Parkway between Seaforth and Frenchs Forest to connect the project to the existing arterial and local road networks.

1.4 Key features

Key features of the Beaches Link component of the project are shown in Figure 1-1. The key components which are relevant to this report include:

- Twin mainline tunnels about 5.6 kilometres long and each accommodating three lanes of traffic in each direction, together with entry and exit ramp tunnels to connections at the surface. The crossing of Middle Harbour between Northbridge and Seaforth would involve three lane, twin immersed tube tunnels
- Twin two lane ramp tunnels:
 - Eastbound and westbound connections between the mainline tunnel under Seaforth and the surface at the Burnt Bridge Creek Deviation, Balgowlah (about 1.2 kilometres in length)
 - Northbound and southbound connections between the mainline tunnel under Seaforth and the surface at the Wakehurst Parkway, Killarney Heights (about 2.8 kilometres in length)
 - Eastbound and westbound connections between the mainline tunnel under Northbridge and the surface at the Gore Hill Freeway and Reserve Road, Artarmon (about 2.1 kilometres in length).
- Operational facilities, including a motorway control centre at the Gore Hill Freeway in Artarmon and tunnel support facilities at the Gore Hill Freeway in Artarmon and the Wakehurst Parkway in Frenchs Forest
- Other operational infrastructure including groundwater and tunnel drainage management and treatment systems, surface drainage, signage, tolling infrastructure, fire and life safety systems, roadside furniture, lighting, emergency evacuation and emergency smoke extraction infrastructure, Closed Circuit Television (CCTV) and other traffic management systems.

Subject to obtaining planning approval, construction of the project is anticipated to commence in 2023 and is expected to take around five to six years to complete.



Legend

Operational features

- Beaches Link
- Gore Hill Freeway Connection
- ⓐ Surface connection
- ⓑ Permanent operational facility
- ⓐ Ventilation outlet

Connecting projects

- Western Harbour Tunnel
- Warringah Freeway Upgrade
- Northern Beaches Hospital road upgrade project (Completed 2020)

Other projects

- Sydney Metro City & Southwest – Chatswood to Sydneyham (under construction)

Existing transport network

- Northern Beaches B-Line
- Suburban/Metro rail
- ⓐ Train station

Design features

- Surface
- Tunnel

Figure 1-1: Key features of the Beaches Link component of the project

1.4.1 Immersed tube tunnels

The key feature of the Beaches Link component of the project relevant to this report is the crossing of Middle Harbour between Northbridge and Seaforth, which would be constructed as immersed tube tunnels.

The immersed tube tunnels would connect to the driven mainline tunnels in Middle Harbour offshore from Clive Park, Northbridge, and Seaforth Bluff, Seaforth.

The immersed tube tunnels would be installed as a series of pre-cast units. Due to the profile of the harbour bed, the units would sit both partially within in a trench closer to the shore and above the bed of the harbour towards the centre of the harbour crossing. The middle sections would be placed with the tops of the tunnel units being about 9.2 metres above the existing level of the bed of the harbour.

Given the very soft sediments at the bed of Middle Harbour, supporting piles would be required at discrete locations along the immersed tube crossing. A granular locking fill would be placed around the end sections (closer to the shore) of the immersed tube tunnels for stability and protection.

The water depth above the immersed tube tunnels would vary between 16 metres and 22 metres, depending on the distance from the shore.

The immersion of the tube tunnel elements would be performed by two immersion pontoons. Temporary anchors would be placed into the bed of the harbour prior to the immersion process to securely position the immersion pontoons and the tunnel elements.

Indicative cross sections of the immersed tube tunnel crossing of Middle Harbour are shown in Figure 1-2 (end sections) and Figure 1-3 (middle sections). An indicative long section of the immersed tube tunnels is shown in Figure 1-4.

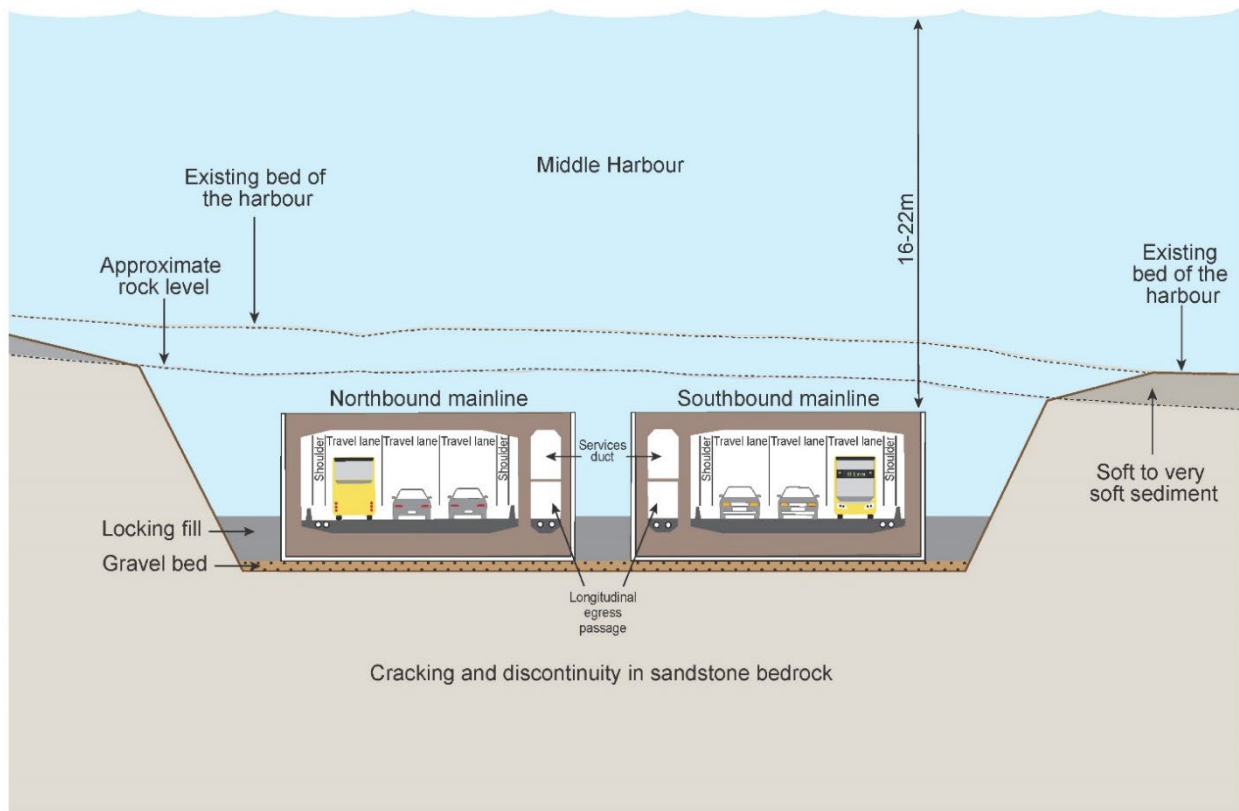


Figure 1-2: Indicative cross-section of the end sections of immersed tube tunnels at Middle Harbour

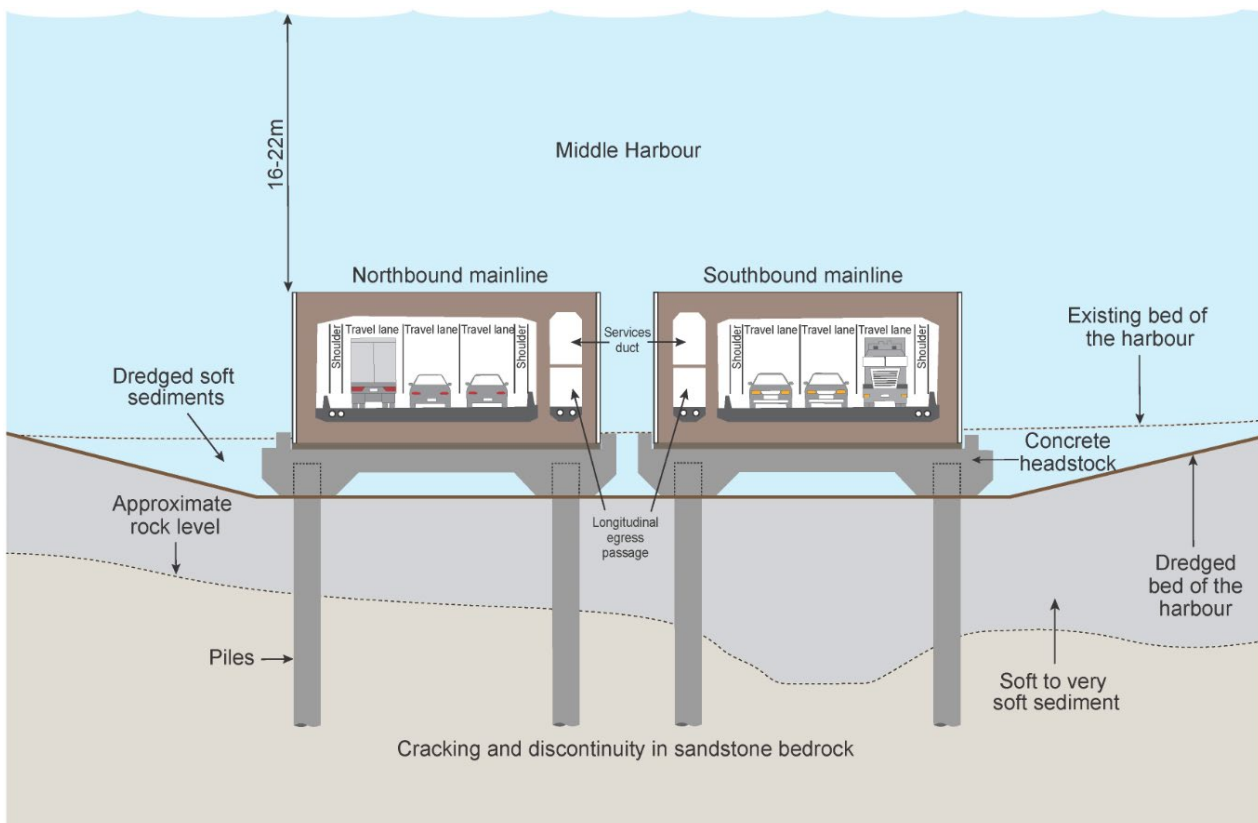


Figure 1-3: Indicative cross section of the middle sections of immersed tube tunnels at Middle Harbour

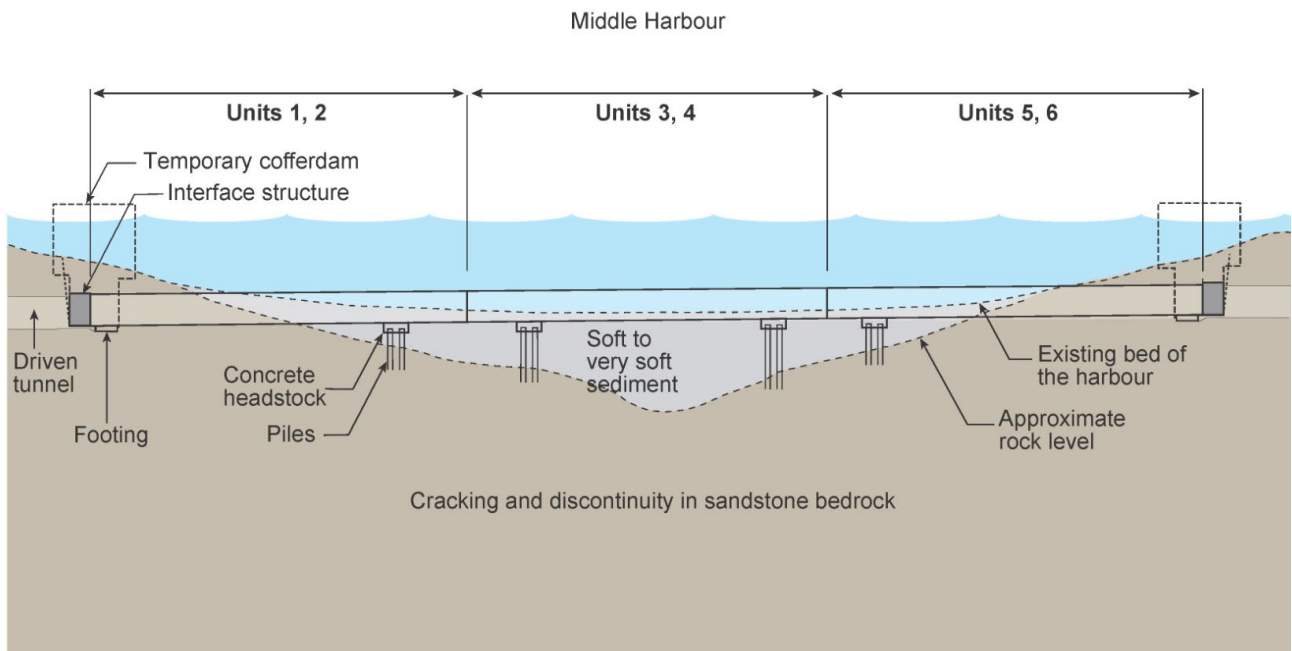


Figure 1-4: Indicative long section of the immersed tube tunnels at Middle Harbour

1.5 Key construction activities

The area required to construct the project is referred to as the construction footprint. The majority of the construction footprint would be located underground within the mainline and ramp tunnels. However, surface areas would also be required to support tunnelling activities and to construct the tunnel connections, tunnel portals, surface road upgrades and operational facilities.

Key construction activities would include:

- Early works and site establishment, with typical activities being property acquisition and condition surveys, utilities installation, protection, adjustments and relocations, installation of site fencing, environmental controls (including noise attenuation and erosion and sediment control), traffic management controls, vegetation clearing, earthworks, demolition of structures, building construction support sites including acoustic sheds and associated access decline acoustic enclosures (where required), construction of minor access roads and the provision of property access, temporary relocation of pedestrian and cycle paths and bus stops, temporary relocation of swing moorings and/or provision of alternative facilities (mooring or marina berth) within Middle Harbour
- Construction of the Beaches Link, with typical activities being excavation of tunnel construction access declines, construction of driven tunnels, cut and cover and trough structures, construction of surface upgrade works, construction of cofferdams, dredging and immersed tube tunnel piled support activities in preparation for the installation of immersed tube tunnels, casting and installation of immersed tube tunnels and civil finishing and tunnel fitout
- Construction of operational facilities comprising:
 - A motorway control centre at the Gore Hill Freeway in Artarmon
 - Tunnel support facilities at the Gore Hill Freeway in Artarmon and at the Wakehurst Parkway in Frenchs Forest

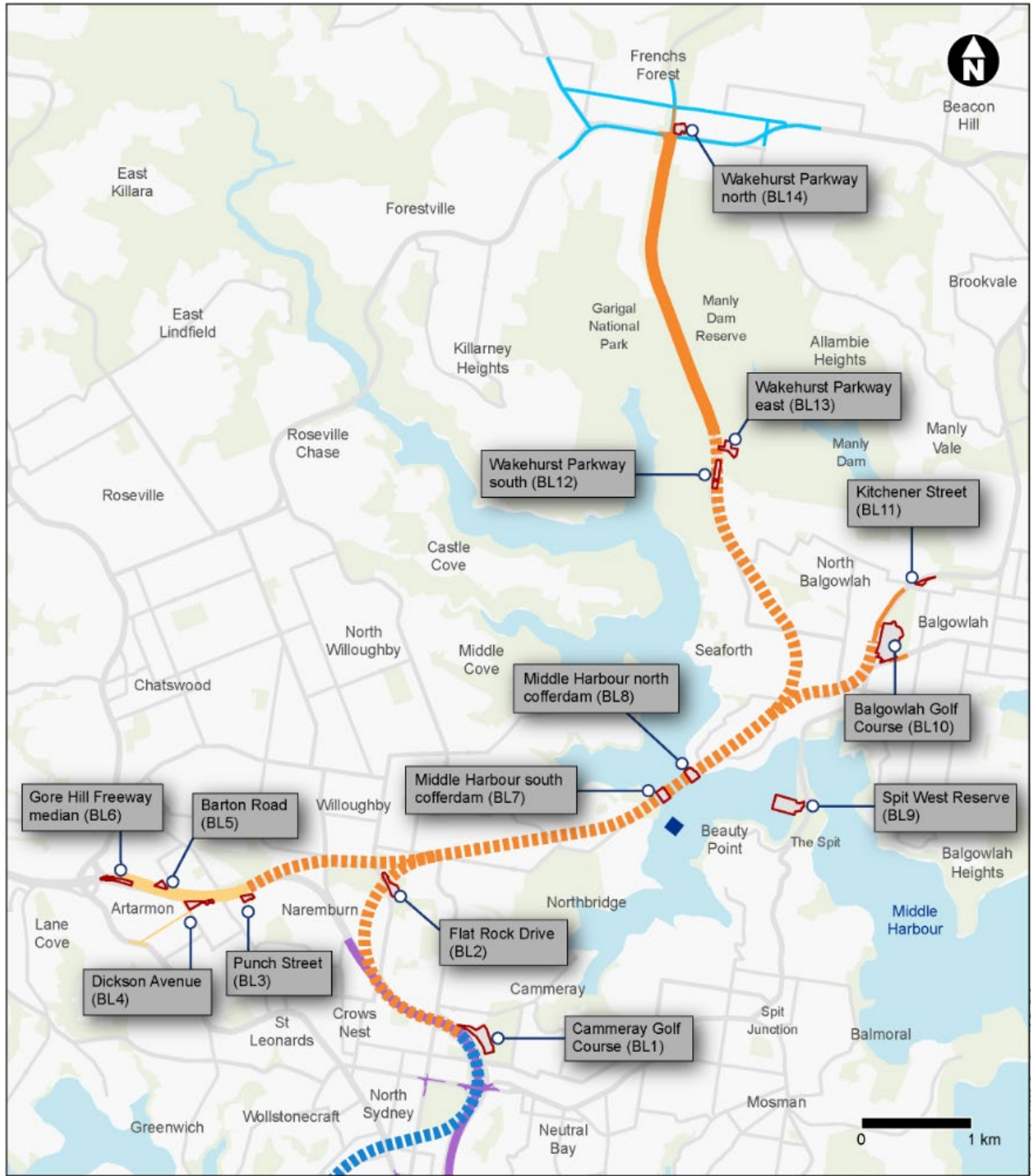
- Motorway facilities and ventilation outlets at the Warringah Freeway in Cammeray (fitout only of the Beaches Link ventilation outlet at the Warringah Freeway (being constructed by the Western Harbour Tunnel and Warringah Freeway Upgrade project), the Gore Hill Freeway in Artarmon, the Burnt Bridge Creek Deviation in Balgowlah and the Wakehurst Parkway in Killarney Heights
- A wastewater treatment plant at the Gore Hill Freeway in Artarmon
- Installation of motorway tolling infrastructure
- Upgrade and integration works at Balgowlah and along the Wakehurst Parkway with typical activities being earthworks, bridgeworks, construction of retaining walls, stormwater drainage, pavement works and linemarking and the installation of roadside furniture, lighting, signage and noise barriers
- Testing of plant and equipment and commissioning of the project, backfill of access declines, removal of construction support sites, landscaping and rehabilitation of disturbed areas and removal of environmental and traffic controls.

Temporary construction support sites would be required as part of the project (refer to Figure 1-5), and would include tunnelling and tunnel support sites, civil surface sites, cofferdams, mooring sites, wharf and berthing facilities, laydown areas, parking and workforce amenities.

Only three construction support sites are relevant to this report. These are:

- Middle Harbour south cofferdam (BL7)
- Middle Harbour north cofferdam (BL8)
- Spit West Reserve (BL9).

A detailed description of construction works for the project is provided in Chapter 6 (Construction work) of the environmental impact statement.



Indicative only – subject to design development

Figure 1-5: Overview of the construction support sites

1.6 Purpose of this report

Transport for NSW has commissioned Haskoning Australia Pty Ltd, a company of Royal HaskoningDHV (RHDHV), to prepare a Navigation impact assessment to support the environmental impact statement for the project and to address the environmental assessment requirements of the Secretary of the NSW Department of Planning, Industry and Environment.

The scope of this study involves:

- Review of background information including site conditions
- Establish existing waterway navigation and commercial and recreational usage
- Determine likely occupation of the waterway during construction including number, type, frequency and duration of marine construction traffic
- Assessment of potential navigation impacts and proposed mitigation measures
- Preparation of a Navigation impact assessment report.

1.7 Secretary's environmental assessment requirements

Key Issue 1 and Key Issue 8 of the Secretary's environmental assessment requirements identified potential impacts that relate to marine safety and navigation. The key issues and the desired performance of the project were stated as:

- Key Issue 1 – Transport and Traffic
 - Desired performance outcome:
 - Network connectivity, safety and efficiency of the transport system in the vicinity of the project are managed to minimise impacts
 - The safety of transport system customers is maintained
 - Impacts on network capacity and the level of service are effectively managed
 - Works are compatible with existing infrastructure and future transport corridors.
- Key Issue 8 - Socio-economic, land use and property
 - Desired performance outcome:
 - The project minimises adverse social and economic impacts and capitalises on opportunities potentially available to affected communities
 - The project minimises impacts to property and business and achieves appropriate integration with adjoining land uses, including maintenance of appropriate access to properties and community facilities, and minimisation of displacement of existing land use activities, dwellings and infrastructure.

The Secretary's environmental assessment requirements relating to the Navigation impact assessment, and where these requirements are addressed in this report are outlined in **Table 1-1**.

Table 1-1: Secretary's environmental assessment requirements - Navigation impact assessment

Secretary's environmental assessment requirements	Where addressed
Key Issue 1 – Transport and Traffic	
<p>1. The Proponent must assess construction transport and traffic (vehicle, marine, pedestrian and cyclists) impacts, including, but not necessarily limited to:</p> <ul style="list-style-type: none"> a) a considered approach to route identification and scheduling of marine and land transport movements, particularly outside standard construction hours; b) the number, frequency and size of construction related vehicles (passenger, marine commercial and heavy vehicles, including spoil management movements); c) construction worker parking; d) the nature of existing traffic (types and number of movements) on construction access routes (including consideration of peak traffic times and sensitive road users and parking arrangements); e) access constraints and impacts on public transport, pedestrians and cyclists; f) how construction of the project affects the capacity of, and the need to close, divert or otherwise reconfigure elements of, the road, cycle and pedestrian network; g) details of how construction and scheduling of works are to be coordinated in regard to public events and cumulative traffic impacts resulting from concurrent work on the project and other major projects, under or preparing for or commencing construction in the vicinity of the proposal; h) alternatives to road transport of construction spoil including marine and rail options as well as potential re-use in existing land reclamation areas or in association with Resource Recovery Exceptions (if obtained from the EPA) to minimise traffic impacts on the road network; i) the likely risks of the project to public safety, paying particular attention to pedestrian safety and users of Middle Harbour; and j) impacts to water based traffic on Middle Harbour. 	Section 5
<p>2. The Proponent must assess impacts from construction and operation on potentially affected properties, businesses, recreational users and land and water users (including from cumulative and extended construction time frames and construction fatigue), property acquisitions/adjustments, future land uses, access, relevant statutory rights, and community severance and barrier impacts resulting from the project.</p>	Section 5
Key Issue 8 - Socio-economic, land use and property	
<p>3. Where an immersed tube method of construction is proposed for use in Middle Harbour, the Proponent must:</p> <ul style="list-style-type: none"> a) provide details of how reductions to current Harbour depths will be avoided; b) provide details confirming the level of protection for the immersed tube tunnels will be similar to or better than that of the existing Sydney Harbour Tunnel; c) identify impacts to ship scheduling in consultation with the Harbour Master; and d) provide details of full mission simulation which takes in account, movement of tunnel units past the Spit Bridge and within Middle Harbour. 	Section 5

The report herein provides an assessment of the impact on marine navigation resulting from construction of the immersed tube tunnels. An assessment of the impact on marine navigation during operation of the project is also provided. In doing so, the report partially or completely addresses the following key issues and requirements of the Secretary's environmental assessment requirements:

- Key Issue 1, Requirement 1a, 1b and 1j
- Key Issue 8, Requirement 3.

A mission simulation as per Requirement 3d has been carried out by Port Authority of NSW to assess the feasibility and impact of transporting the steel shell immersed tube tunnel units past the Spit Bridge and within Middle Harbour. Findings from the simulation are documented in the *Simulation Report Movement of Beaches Link Tunnel Units* (Port Authority of NSW, 2018). The simulation demonstrated that the construction method proposed in Chapter 6 (Construction work) of the environmental impact statement can be carried out with limited impact to existing harbour operations or infrastructure.

2 Description of Port Jackson

Port Jackson (Sydney Harbour) is a drowned river valley that was formed during a period of natural sea level rise about 10,000 years ago. It is typically a well-mixed estuary due to low freshwater discharges from the catchment and significant tidal turbulence.

The *Transport for NSW Regional Boating Plan for the Sydney Harbour Region* (Transport for NSW, 2015) divides Port Jackson into five main areas, with each area characterised by different physical attributes and usage patterns. The five main areas are:

- Outer (Sydney) Harbour, a wide waterway between Sydney Heads, the Opera House at Bennelong Point and Admiralty House at Kirribilli Point
- Inner (Sydney) Harbour, a high traffic area between the Outer Harbour extending upstream to Yurulbin Point and Manns Point. The Inner Harbour encompasses Circular Quay, Darling Harbour and the Bays Precinct comprising Blackwattle Bay, White Bay, Johnstons Bay and Rozelle Bay
- Parramatta and Lane Cove Rivers, which extend upstream of Yurulbin Point. The rivers merge at Greenwich Point
- North Harbour, bordering the northern side of Outer Harbour and extending north of Cannae Point and Dobroyd Head
- Middle Harbour, bordering the western side of the Outer Harbour and extending west of Middle Head and Grotto Head.

The location of the Middle Harbour crossing stretches from Clive Park (Northbridge) in the south to Seaforth Bluff in the north, a distance of about 440 metres. The crossing transits the main maritime navigation channel. Construction activities for the project require occupation and navigation through other parts of Port Jackson, including Pearl Bay, Spit West Reserve and the Outer Harbour.

Relevant maps for the site and relating to various aspects of the Navigation Impact Assessment are attached in the appendices. These are listed below.

Appendix A contains maps displaying relevant spatial data and comprises:

- Map 1 – Middle Harbour Overview and Mooring Areas
- Map 2 – Maritime and Navigation Features of Middle Harbour
- Map 3 – Proposed Construction Plan and Navigation Restrictions
- Map 4 – Community Groups and Clubs
- Map 5 – Commercial Operators, Government Organisations, Boat Launching Ramps and Marina Facilities
- Map 6 – Proposed Marine Construction Traffic Route for Civil Works
- Map 7 – Draft Marine Construction Management Plan.

Appendix B contains the Roads and Maritime Services Boating Maps covering the works area including:

- Map 1 – Port Jackson – Middle Harbour and North Harbour.

3 Existing site conditions

3.1 Bathymetry

The bed of the harbour of Port Jackson comprises numerous deep holes, shoals, basins, rocky islands and reefs. The bathymetry of the Outer Harbour and seaward portion of Middle Harbour is illustrated in Navigation Charts AUS201 (Port Jackson Eastern Sheet) (refer **Map 2** in **Appendix A**).

The Outer Harbour is relatively deep and wide with water depths exceeding 20 metres Chart Datum (CD) (-20 metres CD)¹ between South Head and North Head, decreasing to -8 metres CD between Grotto Point and Middle Head.

The water depths in Middle Harbour are highly variable. A flood tide delta known as The Bar is located near the entrance to Middle Harbour between Wy-ar-gine Point and Castle Rock/Grotto Point. While the waterway is relatively wide, the water depths through the deepest part of the channel are about -3 metres CD. Immediately upstream of The Bar, the water depth increases with two deep basins (-24 to -26 metres CD) located on the eastern side of The Spit. The water depth between the basins -15 metres CD, between Parriwi Point and Clontarf Reserve. The water depth under the Spit Bridge is approximately -9 metres CD. Upstream of The Spit, the water depth is generally in excess of -20 metres CD. The depth of the waterway decreases towards the head of the bays within Middle Harbour including Pearl Bay, Long Bay, Sailors Bay, Powder Hulk Bay and Sugarloaf Bay. However, the foreshore of Middle Harbour is relatively steep and water depth in excess of -10 metres CD is typically available close to the shoreline.

A detailed bathymetric map in the vicinity of the Middle Harbour crossing has been produced. The map is based on the latest available bathymetric soundings, provided by Transport for NSW. This available bathymetry data is presented in **Figure 3-1**.

The bathymetry at the proposed crossing location is best described as a relatively deep defined symmetrical channel. The depth of the channel at the proposed crossing location is particularly deep being up to -32 metres CD at its deepest point.

¹ Chart Datum is the zero reference point from which tidal heights and chart soundings are calculated and is an approximation of the Lowest Astronomical Tide (LAT). Chart Datum is about 0.925 m below Australian Height Datum (AHD).

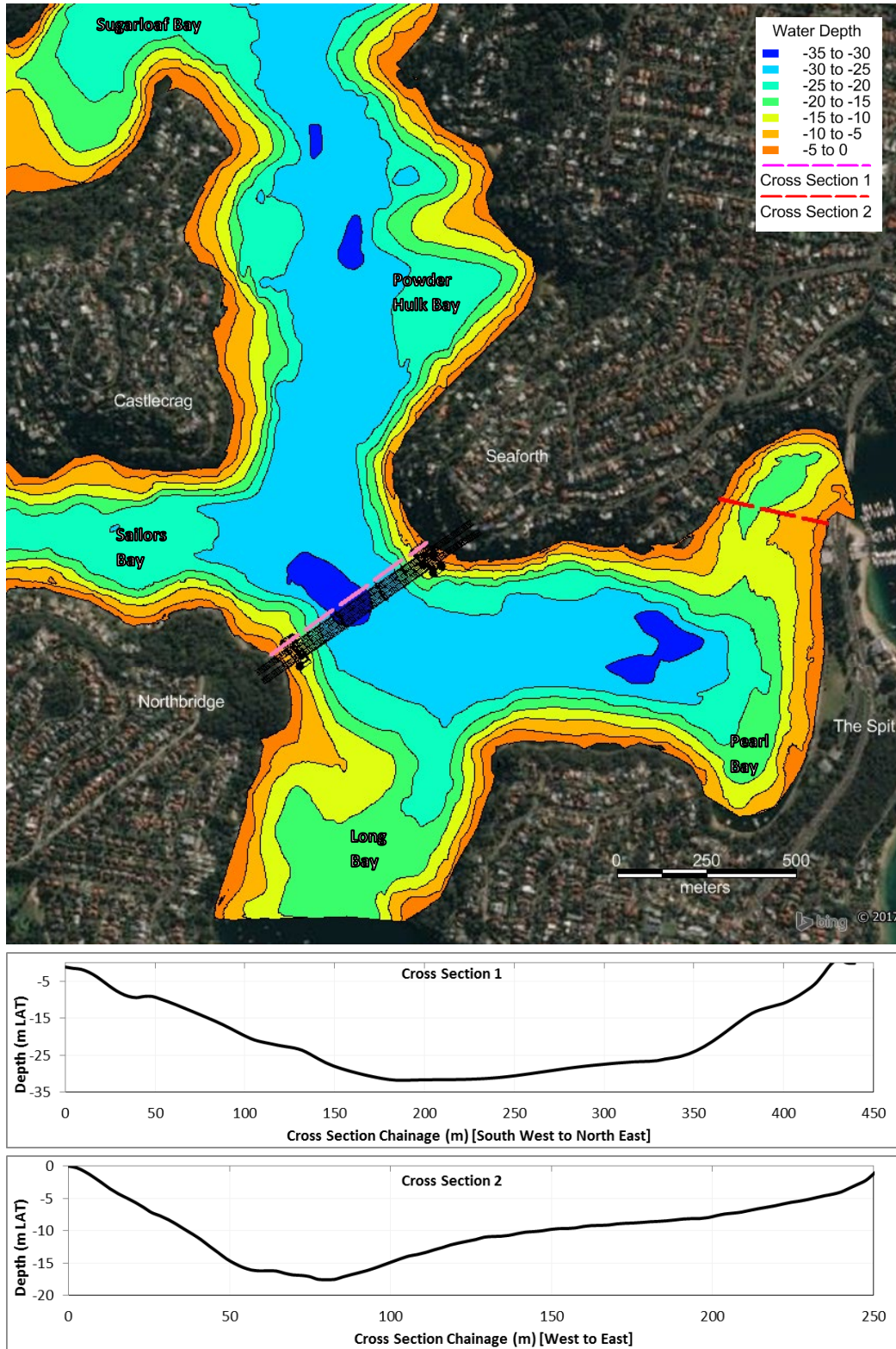


Figure 3-1: Local bathymetry at the study site. Based on the latest available bathymetric soundings, provided by Transport for NSW

3.2 Tides

Port Jackson is a semi-diurnal, micro-tidal (one metre on neaps and two metres on spring tides) estuary. The channel constriction at The Spit and The Bar acts to limit the volume of tidal waters able to propagate upstream. The constriction results in high current speeds at the Spit Bridge with greatly reduced current speeds upstream.

Tidal water levels in Port Jackson are represented by tidal planes at the Fort Denison tide gauge, and are summarised in **Table 3-1**.

Table 3-1: Port Jackson tidal planes (Manly Hydraulics Laboratory, 2012)

Tidal plane	Chart Datum (metres)	Australian Height Datum (metres)
Highest Astronomical Tide (HAT)	2.1	1.18
Mean High Water Springs (MHWS)	1.57	0.65
Mean High Water (MHW)	1.45	0.53
Mean High Water Neaps (MHWN)	1.33	0.41
Mean Sea Level (MSL)	0.95	0.03
Mean Low Water Neaps (MLWN)	0.56	-0.37
Mean Low Water (MLW)	0.44	-0.49
Mean Low Water Springs (MLWS)	0.32	-0.61
Lowest Astronomical Tide (LAT)	0	-0.93

3.3 Waves

The wave climate upstream of The Spit in Middle Harbour is contributed to primarily by wind waves and boat-generated waves. Ocean swells that enter Middle Harbour are shoaled and diffracted by the complex bathymetry and shoreline configuration such that most of the waterway upstream of The Bar is beyond the extent of ocean swell penetration. In certain conditions, ocean swell would propagate upstream to The Spit. However, the constriction of The Spit and change in direction of the waterway eliminates ocean swell penetration beyond this point.

Wind waves and boat-generated waves combine to generate the incident wave conditions.

3.3.1 Wind waves

Wind waves are generated when the wind blows across a body of water. The size and period of these waves depends on the wind speed, the distance over which the wind blows (fetch) and the water depth. Design wind velocities for the site were obtained from *Australian Standard Structural Design Action Part 2: Wind Actions (AS/NZS1170.2:2011)*. Wind wave hindcast procedures set out in the *Coastal Engineering Manual* (USACE, 2008) were used to predict the incident wind wave climate in Port Jackson.

Wind waves are typically defined at primary directions separated by 45 degrees. The fetch is defined as the average length of eight radials separated by three degrees, centred on the primary direction (SPM, 1984).

Westerly winds result in the highest design wind velocity and corresponding wave height and as such, this wind direction has been adopted for assessment of wave heights in Port Jackson. Wave heights for

varying fetches and Average Recurrence Intervals (ARIs) are summarised in **Table 3-2**. This table can be used to predict maximum wave heights at other locations

Table 3-2: Incident wave height for a westerly wind direction

Fetch	0.5 km		1 km		2 km	
	H_s (m)	T (s)	H_s (m)	T (s)	H_s (m)	T (s)
Average Recurrence Interval						
1 year	0.3	1.3	0.4	1.6	0.5	2.0
50 year	0.4	1.4	0.5	1.7	0.7	2.2
100 year	0.4	1.4	0.5	1.8	0.7	2.2

Notes: significant wave height H_s is the average of the highest one third of waves in a wave train (in metres). $H_{max} \sim 1.86H_s$

T = period (seconds)

The maximum fetch at the location of the Middle Harbour crossing is about two kilometres to the north, and at Spit West Reserve it is about 1.8 kilometres to the north-west. The significant wave height at these locations for a one year ARI event is about 0.4 metres with a period of 1.8 seconds, and 0.45 metres with a period of 1.9 seconds respectively.

3.3.2 Boat waves

Boat generated waves are governed by the submerged shape of the boat hull, the boat speed and the water depth. Typically boat waves exhibit a divergent component that emanates from the bow, and a transverse component that follows behind the stern.

The boat speed relative to the water depth and boat length can affect the form of the waves. This is conveniently considered in relation to the:

1. Depth Based Froude number F_d , where:

$$F_d = \frac{V}{\sqrt{gd}}, \text{ where:}$$

V = vessel speed (m/s)

g = acceleration due to gravity (9.81 m/s²)

d = water depth (m)

2. Length Based Froude number F_{nl} (applicable to deepwater) where:

$$F_{nl} = \frac{V}{\sqrt{gL}}, \text{ where:}$$

V = vessel speed (m/s)

g = acceleration due to gravity (9.81 m/s²)

L = water line length of vessel (m)

When F_d is less than one, the vessel speed is defined as sub-critical, and when it is greater than one it is defined as supercritical. The "critical speed", ie when $F_d=1$, is associated with maximum wash generation. Similarly, $F_{nl}=0.5$ corresponds to maximum resistance of a moving vessel and corresponding maximum wave height.

$F_d=1$ and $F_{nl}=0.5$ should, therefore, be avoided as far as possible. Acceleration and deceleration phases by vessels should also be considered to minimise effects caused by passage through the critical threshold speeds.

The depth limited vessel speed corresponding the maximum wash generation ($F_d=1$) in the vicinity of the project (water depth of 30 metres) is 17 to 18 metres per second (m/s) (33 to 35 knots). The deep water vessel speed corresponding the maximum wash generation ($F_{nl}=0.5$) in the vicinity of the project is tabulated in **Table 3-3** for vessels of varying length.

Table 3-3: Critical vessel speed in deep water

Vessel length (m)	Critical speed (m/s)	Critical speed (knots)
4	3	6
8	4	9
12	5	11
16	6	12
20	7	14
25	8	15
30	9	17
40	10	19
50	11	22

Typical maximum boat wave heights and periods about 50 to 100 metres from the vessels' sailing line are set out in **Table 3-4**. These wave heights could occur at the location of the Middle Harbour crossing.

Table 3-4: Maximum boat wave height and period 50 to 100 metres from the sailing line

Vessel type	Average H_{max}^1 (metres)	Period (sec) ¹	Power (W/m) ²
Power boat	0.5	2 to 3	736
High speed catamaran ferries	0.3	5 to 7	618
15 metre motor cruiser	0.7	3 to 4	1923

Note:

1. Based on RHDHV Database
2. Power is measure in watts per metre.

Boat waves attenuate with distance from the sailing line. It is noted that there is no reduction in wave period from the sailing line. NSW Maritime Authority (2005) note that the wash height from a high speed catamaran ferry in deep water and at a distance from the sailing line of 400 to 450 metres is about 0.15 metres, representing a decrease of about 50 per cent. It is assumed the attenuation of power boat and motor cruiser wash would be similar.

Pearl Bay lies within a 'No Wash' zone, which extends downstream from Beauty Point and Seaforth Bluff. The boat wave climate at Spit West Reserve/Pearl Bay is estimated to be 0.3 metres with a period of four seconds. This assumption is based on the attenuation of far field waves and production of waves by vessels operating near the site.

3.3.3 Combining boat waves and wind waves

Boat waves and wind waves travel across a body of water at varying velocities, which depends on a range of factors. As a result of the varying wave velocities, there is a possibility that the wind waves and boat waves would be superimposed. It is overly conservative to simply sum the design wind wave heights in **Table 3-2** with the design boat wave heights in **Table 3-4** to describe a design combined wave climate (Department of Environment and Climate Change (DECC), 2009). One reason why it is conservative is that it is highly improbable that either commercial or recreational boating vessels would be operating in conditions coincident with the defined average return period. The different wave periods must also be accounted for.

There are very few guidelines available for combining separate wave climates. A simplified approach adopted in DECC (2009) to account for the reduced likelihood of joint occurrence of the waves becoming superimposed is to sum half the incident wind wave energy and the total boat wave energy and then solve for the combined wave height.

Table 3-5 presents the equivalent combined design wave conditions. The period adopted for the combined conditions has been assumed based on the period of the wind wave climate and boat wave conditions. This is considered to be the upper bound and lower bound of expected design wave periods and as such, the resolved design wave heights are considered sufficiently conservative.

Table 3-5: Equivalent combined design wave conditions

Location	Average Return Period	Wind wave maximum power (W/m)	Boat wave maximum power (W/m)	Total Power (W/m)	Condition 1		Condition 2	
					Period (sec)	Height (m)	Period (sec)	Height (m)
Middle Harbour crossing	1 year	283	1923	2064	1.8	1.08	4.0	0.73
	50 year	491	1923	2168	1.8	1.11	4.0	0.74
Spit West Reserve/Pearl Bay	1 year	378	353	542	1.9	0.54	4.0	0.37
	50 year	742	353	724	1.9	0.62	4.0	0.43

It follows from the above that the largest combined boat and wind wave height expected to occur once a year on average at the site of the Middle Harbour crossing and Spit West Reserve/Pearl Bay would be 1.08 metres and 0.54 metres respectively.

A similar assessment could be carried out for other return periods and locations in Middle Harbour.

3.4 Wind

Wind has an influence on wave formation and the manoeuvrability of a vessel. The annual wind roses for Sydney at 9am and 3pm are displayed in **Figure 3-2**.

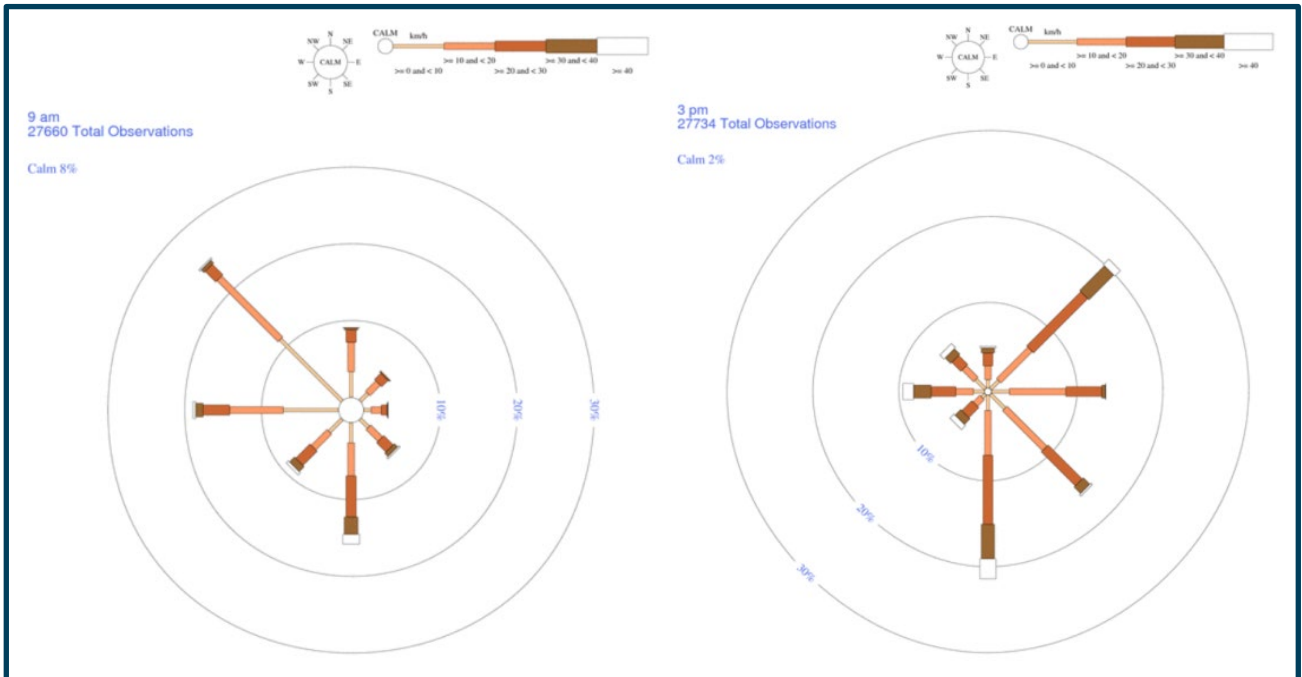


Figure 3-2: Annual wind roses for Sydney at 9am and 3pm

3.5 Daylight hours

The summer solstice is the day that receives the most daylight hours of any day in a year. It occurs between the 21st and 23rd December. The day length between sunrise and sunset is about 14 hours and 25 minutes with sunrise at 5.41am and sunset at 8.06pm.

The winter solstice is the day that receives the least daylight hours of any day in a year. It occurs between the 21st and 23rd June. The day length between sunrise and sunset is about 9 hours and 54 minutes with sunrise at 7.00am and sunset at 4.54pm.

4 Existing navigation

4.1 Acts and regulations

The legislation to be observed when navigating on NSW waterways includes:

- Commonwealth Government legislation
 - *Navigation Act 2012*
 - *Shipping Registration Act 1981*
 - *Maritime Safety (Domestic Commercial Vessel) National Law Act 2012*
 - Marine Safety (Domestic Commercial Vessel) National Law Regulation 2013
 - *Maritime Transport & Offshore Facilities Security Act 2003*
 - Maritime Transport & Offshore Facilities Security Regulations.
- NSW Government legislation
 - *Marine Safety Act 1998*
 - Marine Safety Regulation 2016
 - *Ports and Maritime Administration Act 1995*
 - Port and Maritime Regulation 2012
 - *Work Health and Safety Act 2011*
 - Work Health and Safety Regulation 2011.

The *Navigation Act 2012* is legislation that covers international ship and seafarer safety. The *Navigation Act 2012* applies to 'regulated Australian vessels', which includes vessels registered under the *Shipping Registration Act 1981* and vessels proceeding on an overseas voyage or for use on an overseas voyage. The *Navigation Act 2012* provides the legislative power for Australia to implement the following treaties developed by the International Maritime Organisation, the International Labour Organisation and United Nations Conferences:

- International Convention for Standards of Training, Certification and Watchkeeping for Seafarers (STCW)
- Maritime Labour Convention (MLC)
- International Convention on Load Lines (Load Lines)
- International Convention for the Safety of Life at Sea (SOLAS)
- Convention on the International Regulations for Preventing Collisions at Sea 1972 (COLREGS)
- International Convention for Safe Containers (CSC)
- International Convention on Tonnage Measurement of Ships
- International Convention for the Prevention of Pollution from Ships (MARPOL)
- Convention of Limitation of Liability for Maritime Claims
- International Convention on Salvage
- United Nations Convention on the Law of the Sea (UNCLOS) - in certain parts.

The *Marine Safety (Domestic Commercial Vessel) National Law Act 2012* is the regulatory framework for certification, construction, equipment, design and operation of domestic commercial vessels in Australia. The Marine Safety (Domestic Commercial Vessel) National Law Regulation 2013 is made under authority of the *Marine Safety (Domestic Commercial Vessel) National Law Act 2012* and dictates how its provisions are to be applied. A domestic commercial vessel is defined as any vessel that is for use in

connection with commercial, governmental or research activities, including construction activities. However, a vessel is not a domestic commercial vessel if the vessel is a 'regulated Australian vessel' whereby safety requirements are outlined in the *Navigation Act 2012*.

The *Marine Safety Act 1998* sets out the broad legal policy relating to marine safety and other matters in NSW. The Marine Safety Regulation 2016 is made under authority of the *Marine Safety Act 1998* and dictates how its provisions are to be applied.

The Marine Safety Regulation 2016 makes provisions with respect to:

- Safety of navigation
- Marine safety licences, including the following:
 - Vessel registration
 - Aquatic licences (including for commercial aquatic activities)
 - Boat driving licences
- Safety equipment that must be carried on vessels including requirements for the wearing of lifejackets.

With regards to safety of navigation in NSW, the Marine Safety Regulation 2016 adopts the Convention on the International Regulations for Preventing Collisions at Sea 1972 (COLREGS) with modifications. The COLREGS applies to all vessels upon the high seas and in all waters connected therewith navigable by seagoing vessels. It is an international document that defines the navigation rules to be followed to prevent collisions between two or more vessels.

4.2 Regulatory authority

The Australian Maritime Safety Authority (AMSA) is the Australian Government authority with responsibility for operational activities of the *Navigation Act 2012* and administers the *Marine Safety (Domestic Commercial Vessel) National Law Act 2012*, Marine Safety (Domestic Commercial Vessel) National Law Regulation 2013 and marine orders.

Transport for NSW is the NSW Government authority with responsibility for marine safety and regulation of commercial and recreational boating, including enforcement of the *Marine Safety Act 1998* and Marine Safety Regulation 2016. Transport for NSW (formerly Roads and Maritime Services) produced the *NSW Boating Handbook* (Roads and Maritime, 2016), which is an interpretation of the law and legislation to assist the general public in understanding the navigation rules and requirements.

The NSW Police Marine Area Command also has the authority to enforce the Marine Safety Regulation 2016 in addition to additional duties they perform, particularly drug and alcohol testing of skippers.

In addition to the authority granted to Transport for NSW, within the Sydney Harbour Port Limits, the Harbour Master, who is an employee of the Port Authority of NSW, has the authority to issue directions to vessel operators under Part 7 of the *Marine Safety Act 1998* and the Master of any vessel shall comply with direction given by the Harbour Master. Sydney Harbour Port Limits is defined as:

'the waters of Sydney Harbour and of all tidal bays, rivers and their tributaries connected or leading to Sydney Harbour bounded by mean high water mark together with that part of the Tasman Sea below mean high water mark enclosed by the arc of a circle of radius four nautical miles having as its centre the navigation light at Hornby Lighthouse (South Head) (Port Authority of NSW, 2016).'

4.3 Safety of navigation – key rules

The key navigation rules applying to the assessment of navigation in relation to the Middle Harbour crossing are outlined below.

4.3.1 Look Out and Safe Speed

Two key rules in the COLREGS are:

- Rule 5 – Look-Out
Every vessel shall at all times maintain a proper look-out by sight and hearing as well as by all available means appropriate in the prevailing circumstances and conditions so as to make a full appraisal of the situation and of the risk of collision.
- Rule 6 – Safe Speed
Every vessel shall at all times proceed at a safe speed so that she can take proper and effective action to avoid collision and be stopped within a distance appropriate to the prevailing circumstances and conditions.

In determining a safe speed, the following factors shall be among those considered:

- a) the state of visibility
- b) the traffic density including concentrations of fishing vessels or any other vessels
- c) the manoeuvrability of the vessel with special reference to stopping distance and turning ability in the prevailing conditions
- d) at night, the presence of background light such as from shore lights or from back scatter of her own lights
- e) the state of wind, sea (waves) and current, and the proximity of navigational hazards
- f) the draught in relation to the available depth of water.

The Marine Safety Regulation 2016 provides additional requirements for a minimum distance to be maintained between vessels and other objects. The minimum distance is specified as:

- 30 metres from a vessel, towing equipment or person being towed to any vessel, land, structure and other things when travelling at a speed of six knots or more
- 60 metres from a vessel, towing equipment or person being towed to a person in the water or a dive flag.

If these distances are not practical then a safe distance and speed must be maintained, which is defined as a distance and speed that will ensure the vessel will not cause danger or injury to the person, or damage to the thing, having regard to all relevant safety factors, including:

- Weather conditions at the time
- Visibility
- Speed of the vessel
- Obstructions to navigation that are present.

4.3.2 Collision avoidance

The conduct of vessels in sight of one another is established in the COLREGS, which sets out international 'rules of the road' to avoid a collision. These rules are summarised in the *NSW Boating Handbook* (Roads and Maritime, 2016). The general rules of navigation are that a power vessel must give way to:

- Sailing vessels
- Vessels restricted in their ability to manoeuvre
- Vessels approaching head on, by altering course to starboard
- Vessels approaching from the right (starboard) hand side (ie crossing)
- Any vessel being overtaken.

Additional rules apply to a sailing vessel underway, including a requirement for sailing vessels to keep out of the way of a vessel restricted in their ability to manoeuvre.

Vessels restricted in their ability to manoeuvre include:

- A vessel engaged in dredging, surveying or underwater operations
- A vessel engaged in a towing operation (ie tug assisted) where the towing vessel and her tow are severely restricted in their ability to deviate from their course.

Vessels restricted in their ability to manoeuvre must display special lights and signals. In addition, in narrow waterways such as Sydney Harbour, power vessels less than 20 metres in length and sailing vessels must give way to a vessel which can safely navigate only within a narrow channel or fairway (ie large ships). These vessels are not required to display special lights and signals.

The Marine Safety Regulation 2016 modifies Rule 18 of the COLREGS to include a clause that vessels displaying an orange diamond shape have priority over all other vessels (sail and power). It is understood that a number of ferries on Sydney Harbour display the orange diamond shape, including the First Fleet and Freshwater Fleet ferries.

4.3.3 Wash

The Marine Safety Regulation 2016 includes a provision to minimise wash and notes that the operator of a vessel must not cause wash that damages or impacts unreasonably on:

- a) Any dredge or floating plant
- b) Any construction or other works in progress
- c) Any bank, shore or waterside structure, or
- d) Any other vessel, including a vessel that is moored.

This provision impacts the way in which a vessel is operated.

4.4 Site specific navigation requirements

4.4.1 Harbour Master directions

Supplementary to the navigation rules identified in **Section 4.3**, the Harbour Master, under Part 7 of the *Marine Safety Act 1998*, directs that:

- All vessels of length overall 30 metres or over are required to participate in the Vessel Traffic Service. The Sydney Harbour Vessel Traffic Service area is defined as:
From Port limits to Longnose Point (commonly referred to as Yurulbin Point) excluding Middle Harbour west of Dobroyd Head (Port Authority of NSW, 2016)
- Pilotage is compulsory for vessels of length overall 30 metres or over unless the vessel is exempt under the *Marine Safety Act 1998*
- Vessels must not exceed four knots within 100 metres of:
 - Any dredger or floating plant
 - Any construction or any works in progress
- The minimum under keel clearance (UKC)² for all seagoing vessels must be of 10 per cent of the vessel's deepest draught while in transit to the seaward limit of the berth box and 0.5 metres in the berth box and at all times whilst alongside. Passage planning tankers are required to maintain under keel clearance of 10 per cent of deepest draught plus 0.2 metres
- Tug assistance from one or more tugs is required for all vessels greater than 30 metres in length (increased to 75 metres if a bow thruster is fitted)
- Seagoing ships greater than 100 metres in length must be escorted by an Authority vessel displaying red and blue flashing lights. Vessels must not pass between the escort vessel and seagoing vessel or within 30 metres of the seagoing vessel.

4.5 Navigation restrictions

Navigation restrictions in the vicinity of the project include:

- HMAS Penguin, an Australian Defence Force facility. The exclusion zone is noted on the Middle Harbour and North Harbour boating map (Roads and Maritime, 2016) found in **Appendix B**
- A four knots zone between Clontarf Point and Parriwi Point extending upstream to d'Albora Marina and the eastern end of Peach Tree Bay. The four knot zone encompasses the Spit Bridge
- All land and structures including moorings. Vessels traveling at more than six knots are required to maintain a distance of 30 metres from vessels, land or structures.

4.5.1 NSW Marine Safety Regulation 2016

The NSW Marine Safety Regulation 2016 specifies speed limits for certain areas. This includes waters between a line from Inner South Head to Inner North Head, and a line from the stone pillar at Bradley's Head to Hermit Point and including Middle Harbour and North Harbour. The speed limit for vessels exceeding 30 metres is 12 knots.

4.5.2 Aquatic Events and licencing

Additional restrictions may be imposed by an Aquatic Event such as a race, competition or exhibition. An aquatic licence is issued by Transport for NSW under the *Marine Safety Act 1998*, and may be required for organised activities on navigable waters that restrict the availability of those waters for normal use by

² UKC is the distance between the bed of the harbour and the keel (deepest point) of a vessel.

the public. Transport for NSW may elect to establish an exclusion zone around the activity. This would typically only occur for major events such as the New Year's Eve fireworks display or the start of the Sydney to Hobart Yacht race.

4.5.3 The Spit Bridge

The Spit Bridge is a concrete and steel girder bridge with a bascule lift span. The bridge comprises seven spans with a total length of 227 metres. The navigation channel between the piers of the lifting span (ie when the bridge is open) is 24.3 metres. The piers are protected by fendering.

The clearance under the bridge is:

- 4.7 metres at Highest Astronomical Tide (HAT) under the opening span (when closed)
- 5.7 metres at HAT under the first fixed span at the northern end.

Scheduled bridge opening times are listed in **Table 4-1**.

Table 4-1: The Spit Bridge opening times (Roads and Maritime, 2018)

Weekday opening times	Weekend and public holiday opening times
	8.30am
10.15am	10.00am
11.15am	11.30am
1.15pm	
2.15pm	2.30pm
	4.30pm
	6.30pm
8.15pm	8.30pm
9.15pm (during daylight saving only)	9.30pm

4.6 Navigation widths

The entrance to Middle Harbour is relatively wide at about 750 metres. This decreases to a waterway width of 165 metres at the end of The Spit (location of Spit Bridge). However, the navigable width between the piers of the opening span of the Spit Bridge is 24.3 metres.

Upstream of The Spit, the width of the waterway is generally about 400 metres and decreases towards the head of the bays within Middle Harbour including Pearl Bay, Long Bay, Sailors Bay, Powder Hulk Bay and Sugarloaf Bay.

At the location of the project crossing, the navigation width between the headland at Northbridge and the moorings and jetties near Seaforth Bluff is about 350 metres.

4.7 Waterway users

The *Transport for NSW Regional Boating Plan for the Sydney Harbour Region* (Transport for NSW, 2015) noted that Middle Harbour is generally used for:

- Swimming in Hunters Bay, Chinamans Beach and Clontarf Baths and Beach
- Rowing between Spit West Reserve/Pearl Bay and the Roseville Bridge

- Water skiing and wakeboarding upstream of the Spit Bridge
- Sailing typically between Hunters Bay and The Spit
- General cruising
- Kayaking and canoeing, especially in the vicinity of the Roseville Bridge
- On water storage in large mooring fields in Pearl Bay, Quakers Hat Bay, Willoughby Bay and Sailors Bay (refer **Map 1** in **Appendix A**)
- Other activities including:
 - Marinas and clubs
 - Hire and drive operations
 - Marine Rescue NSW.

The Outer Harbour is generally used for:

- Sailing and yachting
- Leisure boating
- Non-powered craft use such as kayaks and stand-up paddle boards in the sheltered bays
- Recreational fishing typically in the sheltered bays
- On water storage in large mooring fields
- Swimming and diving in the Camp Cove area and in Chowder Bay
- Major events such as New Year's Eve fireworks display, Australia Day celebrations and the start of the annual Sydney to Hobart yacht race
- Other activities including:
 - Commercial and private marinas
 - Ferries, water taxis, commercial adventure vessel operations
 - Navigation access for international cruise ships, commercial tankers and bulk carriers accessing the Inner Harbour
 - Naval activities at Garden Island
 - Seaplane operations at Rose Bay.

Waterway users can be grouped into three main sectors, comprising community groups and clubs, commercial operators and government organisations. These three sectors are discussed in the following sections and the location of various user groups are shown in **Map 4** and **Map 5** in **Appendix A**.

4.7.1 Community groups and clubs

4.7.1.1 Paddle craft groups and clubs

Recreational paddle craft users frequent Middle Harbour. Paddle craft include rowing skulls, kayaks, surf and ocean skis and stand up paddle boards.

Mosman Rowing Club is the only rowing club located in Middle Harbour. Located in Spit West Reserve/Pearl Bay on the western side of The Spit, the club comprises two sheds, a gymnasium and two low freeboard pontoons. In addition to providing amenities for club members, Mosman Rowing Club services five Sydney Schools. It is understood training squads conducted from the sheds at Spit West Reserve/Pearl Bay typically row towards Roseville Bridge.

Several commercial companies offer paddle craft hire and tours in the Middle Harbour. Ocean Paddler, located in Manly, organises group training sessions for surf ski and ocean ski paddlers. The training sessions are conducted on Monday and Friday mornings and depart Clontarf Beach at 5.30am. Sydney

Harbour Kayaks at The Spit offer kayak tours and offer paddle craft for hire. Balmoral Water Sports Centre also offer hire craft including kayaks, stand up paddle boards, windsurfers and sailing boats³.

4.7.1.2 Fishing clubs

There are no fishing clubs located on the foreshore of Middle Harbour. Furthermore, the Department of Planning, Industry and Environment (Regions, Industry, Agriculture and Resources) (formerly Department of Primary Industries (Fisheries)) recommends that for fish and crustaceans caught east of the Sydney Harbour Bridge, no more than 150 grams of fish should be consumed per month. The recommendation is a precautionary measure due to elevated levels of dioxins in fish and crustaceans across the harbour. It is assumed that the recommendation applies to Middle Harbour.

Fishing is a popular activity in Middle Harbour, particularly around The Spit as the complex nature of the seafloor and high currents attract numerous fish species. Fishing is also popular in the Outer Harbour and offshore of Sydney, particularly around the Sow and Pigs Reef. However, there are no known clubs located on the foreshore of the harbour that frequently fish in the area.

4.7.1.3 Sailing clubs

A number of sailing clubs are located in Middle Harbour. These clubs include:

- Balmoral Sailing Club
- Middle Harbour Amateur Sailing Club
- Middle Harbour Yacht Club
- Middle Harbour 16' Skiff Club
- Northbridge Sailing Club
- Seaforth Moth Sailing Club.

Seaforth Moth Sailing Club has effectively merged their sailing activities with Northbridge Sailing Club and partake in racing organised by Northbridge Sailing Club. However, they have retained their own premises and should be treated as a separate entity for the purposes of consultation.

The race courses of these clubs are laid out to achieve a good competitive outcome given prevailing wind conditions at race time. The days of the week that the various clubs regularly sail are documented in **Table 4-2**. With the exception of Northbridge Sailing Club and Seaforth Moth Sailing Club, all of the race courses are located downstream of the Spit Bridge. Maps of the race courses for Northbridge Sailing Club are included in **Appendix C**.

In addition to weekly club racing, some of the clubs hold interclub regattas including State and National Championships. Such regattas are typically conducted over a weekend, or during a week long period in late December or January.

A number of the clubs run training camps or training days throughout the year, particularly for juniors and learn to sail groups in 'off the beach' dinghies. In addition, some teams train mid-week, particularly leading up to interclub regattas and championships. Training sessions are more common for 'off the beach dinghies' than yachts.

³ Note: Sydney Harbour Kayaks and Balmoral Water Sports Centre are commercial operators. However they have been grouped with paddle craft clubs herein.

Table 4-2: Sailing calendar for clubs in Middle Harbour

Club	Yachts	Off the beach sailing dinghies
Balmoral Sailing Club		Saturdays during summer
Middle Harbour Amateur Sailing Club		Sundays during summer
Middle Harbour Yacht Club	Saturday all year Wednesday all year Thursday during summer	Sunday all year
Middle Harbour 16' Skiff Club		Saturdays and Sundays during summer
Northbridge Sailing Club	Sundays during winter	Sundays during summer
Seaforth Moth Sailing Club		Merged with Northbridge Sailing Club for racing activities

Note: Summer sailing is generally between September and April and winter sailing is generally May to August. The start and finish date of the season for each club varies. Not all clubs sail every weekend during the defined period.

In addition, there are also a number of sailing clubs that are located around the Outer Harbour and North Harbour that sail in The Sound between South Head, Middle Head and North Head. These clubs include but are not limited to:

- North Harbour Sailing Club
- Manly Yacht Club
- Manly 16 ft Skiff Sailing Club
- Royal Sydney Yacht Squadron
- Sydney Amateur Sailing Club
- Vaucluse Yacht Club
- Royal Motor Yacht Club of NSW
- Royal Prince Edward Yacht Club
- Royal Australian Navy Sailing Association
- Cruising Yacht Club of Australia.

An aquatic license is issued by Transport for NSW for the start of the Sydney to Hobart yacht race organised by Cruising Yacht Club of Australia. The race is held annually and starts on Boxing Day (26th December). The exclusion zone occupies the Outer Harbour and Inner Harbour extending upstream to around Nielsen Pak.

4.7.1.4 Scout and Guide clubs

A number of Sea Scout and Girl Guide groups are located on Port Jackson. Activities carried out by Sea Scouts and Girl Guides may include kayaking, paddling and sailing.

There are two Sea Scout groups located on the foreshore of Middle Harbour at Northbridge and Sailors Bay.

4.7.1.5 Marine Rescue NSW

Marine Rescue NSW is a not-for-profit, community-based organisation supported by the NSW Government. Marine Rescue was established in 2009 and is an amalgamation of the Australian Volunteer Coast Guard Association, Royal Volunteer Coastal Patrol and Volunteer Rescue Association. The Marine Rescue base for Middle Harbour is located at The Spit. In conjunction with Marine Rescue Port Jackson (Sydney Harbour) at Birkenhead Point, the organisation services the closed and open waters around Sydney.

4.7.2 Commercial operators

The vast majority of the commercial operations in Port Jackson are located in the Inner Harbour around the Bays Precinct, or nearby at Darling Harbour and Balmain. These commercial operations would transit the Outer Harbour. However, they would not typically enter Middle Harbour. The commercial operators include:

- Cruise, Container and Bulk Shipping Terminals including Overseas Passenger Terminal, White Bay and Glebe Island, and Gore Bay. These operators transit the Outer Harbour. However, they are physically restricted from navigating in Middle Harbour due to water depths
- Harbour City Ferries, the operator of Sydney Ferries on behalf of the NSW Government. The ferry fleet along with the maintenance facility at Balmain is leased by Harbour City Ferries on a seven year term. Ferry services transit the Outer Harbour and North Harbour en route between Circular Quay and Manly Wharf. There are no Harbour City Ferries services that operate in Middle Harbour
- Captain Cook Cruises operate sight-seeing tours and ferry services in the Outer Harbour and North Harbour. The ferry services do not operate in Middle Harbour. The map of routes for the sight-seeing or dining cruises do not traverse Middle Harbour. However, it is understood that private charters do occasionally enter Middle Harbour and navigate up to the Spit Bridge
- Commercial fishing fleet located in Blackwattle Bay that would mostly fish offshore. Fishing is not permitted in Sydney Harbour, including Parramatta River and connected tidal waterways. It is understood this includes Middle Harbour. The restriction on fishing was introduced as a precautionary measure in 2006 due to elevated levels of dioxins in fish and crustaceans across the harbour.

4.7.2.1 Water taxis

A number of water taxi companies operate on Port Jackson and its estuaries. To increase business, a number of the water taxis offer more than a taxi service, including providing private tours of the harbour and exclusive New Year's Eve fireworks cruises or Vivid light display cruises. Some of the vessels are also available for private charter.

4.7.2.2 Charter companies

A limited number of yacht charter and boat hire companies are located in Middle Harbour. These include:

- Champagne Sailing, Clontarf. It is unclear where the vessels are moored. However, pick up locations include Balmoral, Clontarf and Middle Harbour Yacht Club amongst others
- Eco Boats Hire, Northbridge.

Vessels from charter companies further afield may enter Middle Harbour.

4.7.2.3 Jungle Float Mobile Water Park

Jungle Float is a floating mobile water park that is 11 metres long and three metres wide. It is anchored about 20 metres off Clontarf Beach when in use. Jungle Float is the only waterpark attraction on Port Jackson and includes six attractions which allow participants to swing, jump and/or slide into the water. It is tailored to suit all ages (typically teenagers) and can accommodate groups of up to 40 people. Participants are required to swim to the floating barge from Clontarf Beach and the attractions require participants to enter the water and swim around the barge.

The floating barge is stored upstream of the Spit Bridge and would transit the project.

4.7.3 Government organisations

4.7.3.1 Royal Australian Navy

HMAS Penguin is located at Balmoral in Middle Harbour. The primary purpose of the facility today is to provide trained personnel to the fleet. It caters for the:

- Australian Defence Force Diving School
- Royal Australian Navy Hydrographic School
- Royal Australian Navy Medical School.

A naval water exclusion zone is established around the facility.

The navy also operates facilities in Inner Harbour and Outer Harbour. These include Fleet Base East (Garden Island/HMAS Kattabul) and HMAS Waterhen at Waverton. Vessels from these facilities typically transit the Outer Harbour but rarely enter Middle Harbour.

4.7.3.2 Other organisations

The NSW Police Marine Area Command, Department of Planning, Industry and Environment (Regions, Industry, Agriculture and Resources) and Transport for NSW are located in the Inner Harbour. These organisations require access to the waterway in order to perform their duties.

Transport for NSW Boating Safety Officers are employed to patrol discrete regions throughout NSW in order to ensure compliance of waterway users with the relevant legislation. In addition to their responsibility as a regulatory authority, Transport for NSW is the owner of Sydney Harbour and its tributaries. The property boundary between the land and water is typically defined as the Mean High Water Mark. As such, Transport for NSW is the owner of a number of seawall assets in Port Jackson and is responsible for managing leases of the bed of the harbour, which may be held by private residence or commercial organisations such as marinas.

4.8 Vessel use

4.8.1 Recreational vessels

The *Transport for NSW Regional Boating Plan for the Sydney Harbour Region* (Transport for NSW, 2015) identifies about 20,000 registered recreational vessels in the Sydney Harbour region. However, it is noted that Transport for NSW's licence and registration data does not capture vessels that do not require registration including non-powered craft such as kayaks, canoes and 'off the beach' sail craft and power craft less than a specified engine power (currently 4.0 kW [about five horsepower]).

About 60 per cent (12,000) of registered vessels are between two and six metres in length, which are defined as trailerable. The average registered vessel length is 6.6 metres and 14 per cent (2800) of all registered vessels are greater than 10 metres.

The report noted that over one million people annually use boats as a form of recreation on the harbour. Additionally, more than 15 million passengers used the ferry service across Sydney Harbour and the rivers in 2019 (Transport for NSW, 2020).

Kitesurfers and personal watercraft are prohibited in Sydney Harbour.

4.8.2 Boat storage facilities

A number of boat storage and boat launching facilities are located in Middle Harbour that provide storage for recreational seagoing vessels. These include:

- Marina facilities
- Moorings
- Boat ramps.

4.8.2.1 Marina facilities

Commercial marina facilities generally offer a wide range of premium services for the boating community. As such, they generally attract larger vessels and represent a high density of boat storage for the area of occupation. Boat ramp facilities attract smaller trailable craft and often attract users from a larger geographical area.

The larger marinas located in Middle Harbour are as follows:

- Middle Harbour Yacht Club, The Spit
- Smiths Boatshed Marina, The Spit
- Fergusons Boat Shed, The Spit
- D'Albora Marina, The Spit
- Cammeray Marina, Cammeray
- Northbridge Marina, Northbridge
- Castlecrag Marina, Castlecrag
- Roseville Bridge Marina, Roseville
- Clontarf Marina; Clontarf.

Generally speaking, the majority of the yachts in the marinas around the Spit Bridge (particularly Middle Harbour Yacht Club) and in the nearby mooring fields are used for racing and would be registered with Middle Harbour Yacht Club. They would be used relatively frequently (once per week on average) with the majority of activity occurring downstream of the Spit Bridge. Other moored vessels including motor cruisers and cruising yachts would be used less frequently, would not typically belong to a community group or club and activity would occur both upstream and downstream of the Spit Bridge.

The larger vessels berthed at the marinas around The Spit are up to 35 metres in length with a beam of eight metres. A review of 2020 aerials on Nearmap indicates there are about 13 vessels berthed at these marinas in excess of 25 metres.

4.8.2.2 Moorings

In addition to marinas, numerous mooring fields are located throughout Middle Harbour (refer **Map 1** in **Appendix A**). These include Sandy Bay, Pearl Bay and the area around Seaforth Bluff. A number of the moorings are commercially leased by local marinas from Transport for NSW with a lease arrangement for occupants. Some of the marinas offer a tender service to commercial and/or privately leased moorings within a defined area for vessels registered with the club or marina.

The largest vessels moored and berthed upstream of the project are up to 25 metres in length.

4.8.2.3 Boat ramps

There are two boat ramps located in Middle Harbour, which can be found at:

- Tunks Park, Cammeray
- Roseville Bridge, Killarney Heights.

These ramps are generally in good condition and are protected from wind and waves, providing an ideal location for boat launching. The facility at Roseville Bridge provides excellent parking while Tunks Park is somewhat limited in the number of parking spaces. Both ramps provide relatively close access to the Outer Harbour and offshore compared to other boat launching ramps in Port Jackson. They attract a range of users from a wide geographical area that would navigate through all parts of Middle Harbour and the Outer Harbour. These vessels would typically not be registered with a community group or club.

In addition, a sand ramp for informal launching is located in Clontarf Reserve, Clontarf. It is understood this ramp is infrequently used. Users would include surfboat rowers from nearby Surf Life Saving Clubs and other small craft.

4.8.3 Commercial vessels

The *Transport for NSW Regional Boating Plan for the Sydney Harbour Region* (Transport for NSW, 2015) notes that Sydney Harbour has a large commercial vessel fleet, with 20 per cent of the State's commercial vessels based in the harbour. Commercial activities include charter vessels, work boats and barges, adventure vessels, water taxis, passenger ferries, and seagoing commercial ships. These vessels typically operate in the Inner Harbour and Outer Harbour. However, access to Middle Harbour for deep draft vessels is restricted by the water depth over The Bar.

Cruise ships, tankers and bulk carriers transiting the Outer Harbour have historically been up to 348 metres long. Vessels of a similar length could be expected in the future.

The Freshwater class ferry operating between Circular Quay and Manly are up to 70 metres in length. The ferry service is run by Harbour City Ferries.

Captain Cook Cruises own and operate a number of vessels including the Sydney 2000 at 63 metres long. However, the Captain Cook 3 that is used for sight-seeing and dining cruises is 35 metres in length.

Water taxis, yacht charter and boat hire companies operating in Middle Harbour typically offer vessels less than 12 metres in length.

Jungle Float operates a vessel 11 metres long and three metres wide, which is frequently moored near Clontarf Beach.

4.8.4 Government vessels

4.8.4.1 Royal Australian Navy

Fleet Base East (Garden Island/HMAS Kattabul) is the home port for 11 vessels in the Royal Australian Navy between 118 and 230 metres in length. The largest of these is HMAS Adelaide (III) and HMAS Canberra (III), which are both 'Canberra Class' Amphibious Assault Ships. These vessels transit the Outer Harbour.

Larger vessels may be moored at the Man of War Anchorage, HMAS Penguin or other naval waters. However, this would generally only occur during periods of war.

4.8.4.2 Water Police

The NSW Police Marine Area Command operate a number of vessels, the largest of which is Nemesis, an offshore patrol vessel. It is reported to be the largest purpose built police boat in the southern hemisphere. The vessel is 32 metres long and transits the Outer Harbour.

4.8.4.3 Transport for NSW

The majority of Transport for NSW vessels are trailerable craft and jet skis. However, Transport for NSW does maintain a fleet of vessels at Rozelle for a range of activities. These vessels are generally less than 10 metres in length.

4.9 Summary of vessel use and waterway users

On the basis of the above, the largest vessels to navigate through the Outer Harbour would be commercial cruise ships accessing the Offshore Passenger Terminal (OPT) at Circular Quay and White Bay. These vessels have historically been up to 348 metres in length.

The Bar at the entrance to Middle Harbour physically restricts larger vessels from entering. Vessels that would transit past the project would be up to 25 metres in length. However, the vast majority of vessels would be less than 10 metres in length.

The Outer Harbour and Middle Harbour near Hunters Bay and The Bar is relatively wide and uncongested. There is minimal vessel storage in this area. However, there are a number of transits by relatively large vessels.

Immediately downstream of the Spit Bridge, the waterway is relatively congested. Within 650 metres of the Spit Bridge, there are:

- Four marinas plus numerous moorings
- Three sailing clubs (one of which is also a marina)
- A paddle tour and hire operator (Sydney Harbour Kayaks) and organised group training sessions for surf ski and ocean ski paddlers twice a week (Ocean Paddler)
- A floating mobile water park
- An informal sand launching ramp
- Marine Rescue Middle Harbour.

These users would typically use the waterway downstream of the Spit Bridge.

Upstream of the Spit Bridge, there are:

- Five marinas plus numerous mooring fields and private land based structures
- Two boat ramps
- Two sea scout groups
- Mosman Rowing Club
- Northbridge Sailing Club
- Seaforth Moth Sailing Club.

Recreational vessels berthed at the marinas, moored in Middle Harbour and launched at the boat ramp, would use the waterway upstream and downstream of the Spit Bridge. The latter three groups would exclusively use the waterway upstream of the Spit Bridge and would regularly traverse the location of the Middle Harbour crossing.

4.10 Foreshore recreation

Downstream of the Spit Bridge, a number of foreshore reserves and sandy beaches offer public recreation for swimming and bathing. The most accessible beaches include Cobblers Beach, Balmoral Beach, Edwards Beach, Chinamans Beach and Clontarf Reserve. Baths (swimming enclosures) have been installed at Balmoral and Clontarf. However, sand has accreted in the Clontarf Baths that limits its use as a swimming enclosure. A shark net was located at Edwards Beach and while it still appears on boating maps, the shark net was removed in 2008.

Upstream of the Spit Bridge, the foreshore is generally steep and rocky or privately owned. The head of the bays are generally shallow and comprise estuarine sands and silts. As such, foreshore recreation is limited. Clive Park Pool, a heritage tidal rock swimming enclosure, is located at the eastern end of a small sandy beach in Northbridge. The pool is relatively small at about 30 metres by 15 metres.

Spit West Reserve offers public amenity for walking and cycling. However, the foreshore is lined by a revetment that offers minimal access to the water for public recreation.

4.11 Private foreshore structures

With the exception of Seaforth Bluff, Long Bay and Sailors Bay, the foreshore of Middle Harbour is relatively undeveloped. The Spit is lined by a revetment on the eastern and western side that extends along Spit West Reserve to the head of Pearl Bay. Three houseboats with permanent land access are located near the head of Pearl Bay. A number of jetties, pontoons and mooring pens adjoining private residence are located on the foreshore of Seaforth Bluff, Long Bay and Sailors Bay. The bed of the harbour occupied by the private foreshore structures is leased from Transport for NSW.

5 The project

The project includes a crossing of Middle Harbour, which would comprise three immersed tube tunnel units for the northbound lanes and three immersed tube tunnel units for the southbound lanes. Each unit would be between 121.3 metres and 125.6 metres in length, 18.85 metres wide and 9.2 metres high (to accommodate three lanes of traffic in each direction). Two separate tunnels have been specified to ensure the units are sufficiently narrow to pass between the Spit Bridge pylons when being transported to Middle Harbour. When in place, the units would be separated by a distance of four metres to allow sufficient space for diving works.

The immersed tube tunnels would join excavated tunnels at either end that would be constructed using roadheaders. Temporary cofferdams would be constructed to allow construction of permanent interface structures at the interface between the driven tunnels and immersed tube tunnel units.

5.1 Summary of methodology and program

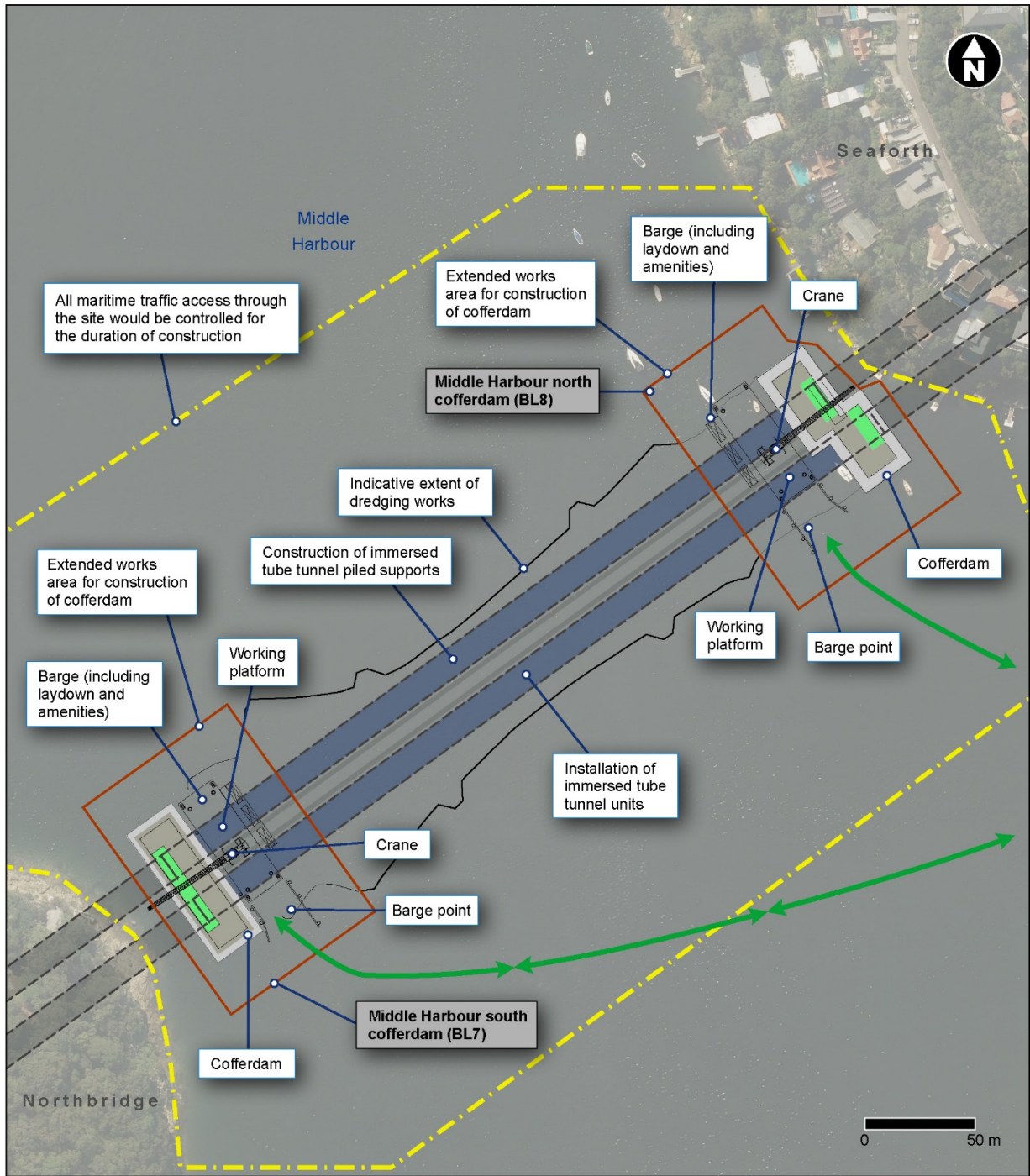
A brief summary of the construction methodology is provided below. The construction plan is attached in **Map 3 in Appendix A**. A detailed construction method is provided in Chapter 6 (Construction work) of the environmental impact statement. The construction method would be refined during the detailed design phase of the project.

1. Spit West Reserve construction support site (BL9)
 - a) Construction of facility for casting and fit out of immersed tube tunnel units and supply of all other materials including cofferdam piles and interface structure concrete.
2. Immersed tube tunnel transportation and immersion (six immersed tube tunnel units)
 - a) Transport steel shell immersed tube tunnel units to Spit West Reserve construction support site (BL9) from external fabrication site outside of Middle Harbour
 - b) Completion of casting and fit out of immersed tube tunnel units at Spit West Reserve construction support site (BL9)
 - c) Storage of completed units at the Temporary Mooring Facility east of Clive Park in Middle Harbour
 - d) Transport to Middle Harbour crossing location and immersion.
3. Middle Harbour south (BL7) and Middle Harbour north (BL8) cofferdams
 - a) Construction of two temporary cofferdams about 63 metres by 25 metres. Top of the cofferdam would be at about +3 metres AHD
 - b) Excavation inside cofferdam with excavators loading material into barges and transported to the designated offshore disposal site or approved licensed land-based facility
 - c) Formation of concrete interface structures linking the immersed tube tunnels and driven land based tunnels.
4. Dredging
 - a) Installation of 'moon pool' localised floating silt curtains around dredger, primary deep draft (10 to 12 metre) silt curtains around the broader dredging site and secondary shallow silt curtains to protect sensitive fringing aquatic habitats
 - b) Dredging of soft sediments not suitable for offshore disposal with a backhoe dredge with a closed environmental clamshell. Material that is not suitable for offshore disposal would be barged to a load out facility for disposal at an approved land-based licenced facility
 - c) Dredging of soft sediments and soft rock suitable for offshore disposal with a backhoe dredge with a closed clamshell or an open bucket, and barged to the designated offshore disposal site for disposal
 - d) Dredging of rock suitable for offshore disposal with a backhoe dredger and rotating drum cutter, and barged to the designated offshore disposal site for disposal.

5. Pile foundations
 - a) Installation of 24 piles and eight associated precast concrete headstocks with a barge and crane.
6. Foundation, locking fill and back fill
 - a) Placement of locking fill and backfill in tunnel trench after immersion of immersed tube tunnel units.

An indicative program for the construction activities mentioned above is outlined in Chapter 6 (Construction work) of the environmental impact statement.

The location of work items and vessel movements associated with the Middle Harbour crossing (including Middle Harbour south (BL7) and Middle Harbour north (BL8) cofferdams) and Spit West Reserve construction support site (BL9) are displayed in **Figure 5-1** and **Figure 5-2**.



Indicative only – subject to design development

Legend








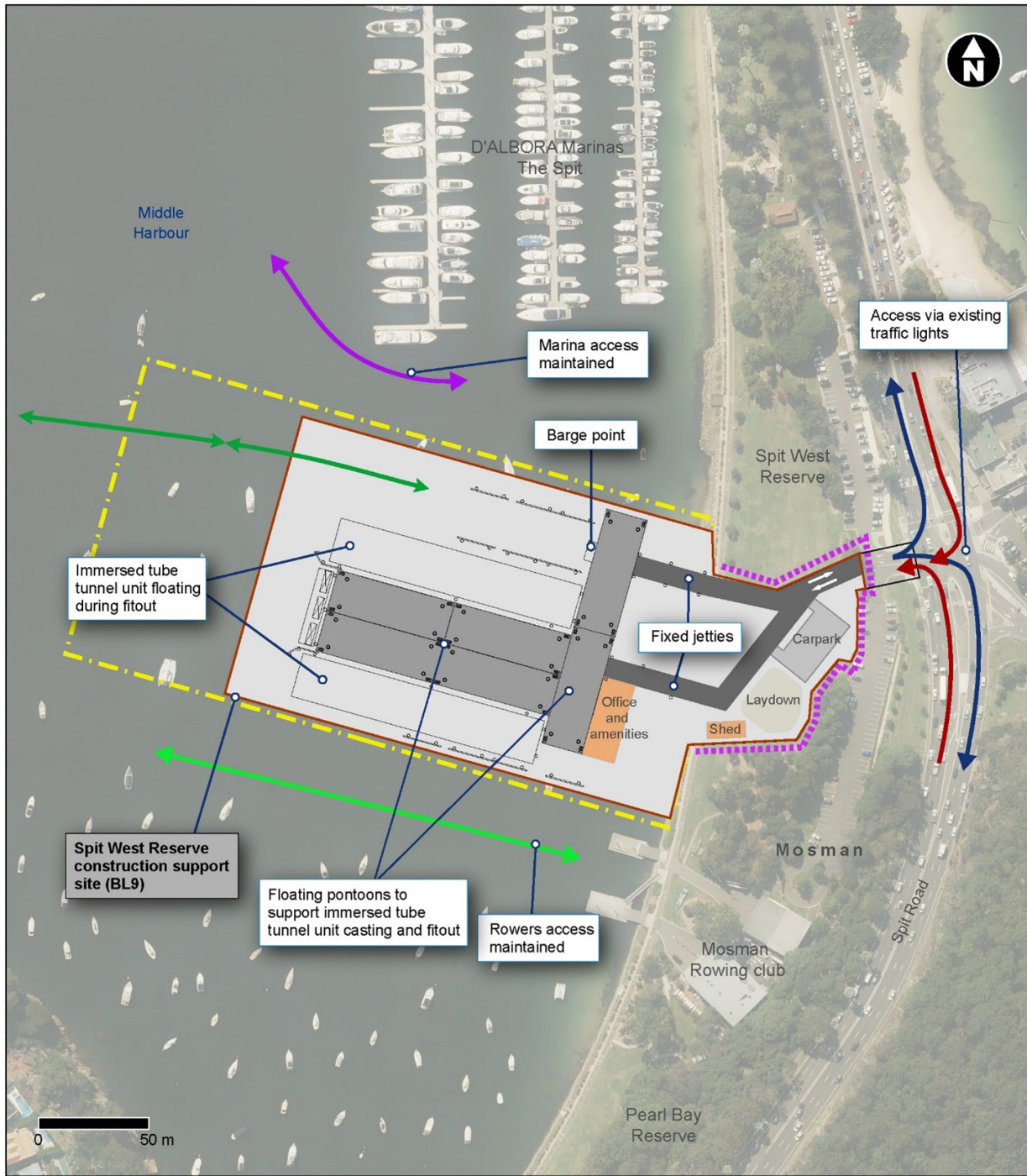
- | | | |
|---|--|---|
|  Construction footprint |  Beaches Link driven tunnel |  Construction support from Spit West Reserve (BL9) |
|  Construction support site |  Immersed tube tunnel |  Interface structure |
| |  Indicative Marine traffic control zone | |

Figure 5-1: Construction activities associated with Middle Harbour crossing including Middle Harbour north cofferdam (BL8) and Middle Harbour south cofferdam (BL7)



Indicative only – subject to design development

Legend

- | | | |
|---|--|---|
|  Construction footprint |  Temporary site access |  Site access - in |
|  Construction support site |  Construction support site buildings |  Site access - out |
| |  Indicative Marine traffic control zone |  Marina access |
| |  Temporary shared user path diversion |  Mosman rowing club access |
| | |  Construction support to immersed tube tunnel site |

Figure 5-2: Construction activities associated Spit West Reserve construction support site (BL9)

5.2 Summary of marine traffic

The peak period for marine traffic would be during construction of the interface structures where there may be up to 68 barge and workboat movements between Spit West Reserve construction support site (BL9) and the cofferdams and dredging works per day. However, the duration of these works would be relatively short.

The route of the vessel movements is shown in Map 6 in Appendix A. Note that vessel movements are each way (ie arriving at a site and leaving a site counts as two movements).

Prolonged periods of high marine construction activity would occur over three months of the construction program. During this period, the following construction activities would be underway:

1. Concreting of interface structures
2. Dredging of sediment and rock
3. Transport of steel shell immersed tube tunnel units and completed immersed tube tunnel units.

Daily vessel movements during this period may be about:

- Twelve small boats movements for transporting construction workforce
- Four barge movements for support of cofferdam dredging, piling and tube tunnel immersion
- Three barge movements for disposal of dredged material to sea
- 48 barge movements for concrete deliveries.

5.3 Waterway occupation

Marine activities would occupy certain parts of the waterway for the majority of the construction period. The affected areas would include:

1. Spit West Reserve construction support site (BL9)
2. Temporary Mooring Facility east of Clive Park in Middle Harbour that would occupy an area of 120 metres by 160 meters
3. Location of the two cofferdams, Middle Harbour south (BL7) and Middle Harbour north (BL8) and adjacent primary silt curtains for dredging operations.

Occupation of the waterway would require relocation of moorings near Spit West Reserve, on the approach to the Spit West Reserve construction support site (BL9) and around the Middle Harbour north cofferdam (BL8). In addition, the Temporary Mooring Facility for the immersed tube tunnel units would occupy part of the waterway and create a navigation restriction.

6 Assessment of impacts and mitigation measures

This section of the assessment assesses the likely impacts of the intended construction work on navigation in the study area. Where impacts are noted, measures to mitigate their severity or avoid them altogether are proposed. These measures can be investigated further within the environmental impact statement process and the relevant licences and permits, subject to final incorporation within the construction environmental management plan, which would be implemented during construction.

The program for construction activities is outlined in Chapter 6 (Construction work) of the environmental impact statement. The size and number of registered vessels in NSW is progressively increasing over time (Transport for NSW, 2014). However, at the end of the construction period, the increase in vessel size, distribution of the size of vessels and the frequency of navigation traffic in Port Jackson is likely to be similar to the existing demand analysis in **Section 4**. As such, the assessment of waterway users and vessel use in **Section 4.7** and **Section 4.8** is expected to remain similar until the end of the construction period.

6.1 Marine construction equipment requirements

Vessel movements would be conducted by the following personnel:

- Vessels of length overall 30 metres or more including barges and dredgers should be conducted by a licensed marine pilot unless the master holds a Certificate of Local Knowledge or Marine Pilotage Exemption Certificate
- Immersed tube tunnel movements should be conducted by a licensed marine pilot
- All other vessel movements should be conducted by a master and crew holding a commercial qualification or certificate of competency.

Furthermore, it is a requirement of the Port Authority of NSW Harbour Master that vessels of length overall 30 metres or over when east of Dobroyd Head participate in the Vessel Traffic Service (refer to **Section 4.4.1**).

It would be a requirement of Port Authority of NSW that all construction equipment including stationary barges and transport vessels be fitted with automatic identification system that is turned on at all times. This recommendation limits the requirement to report the vessels position under the Vessel Traffic Service.

Notwithstanding the above, Port Authority of NSW requires all vessels, irrespective of size, to seek approval from the Harbour Master before moving from all construction sites.

All marine construction equipment and immersed tube tunnel units should be fitted with operational navigation lights at all times, including while moored or anchored at a location other than their registered (everyday) mooring location. These navigation lights should be turned on between sunset and sunrise.

6.2 Wave climate

6.2.1 Marine construction traffic

During the construction of the project, there is expected to be a substantial increase in construction related boating traffic in Middle Harbour. The construction vessels would primarily include:

- Barges for delivering material, removing dredged material, or for other construction activities
- Tugboats for manoeuvring barges
- Transport vessels for workers.

The waterway from Beauty Point to Clontarf Point is a 'No Wash' zone. As such, all marine construction traffic in this area must be operated in a manner that minimises vessel wash. If speeds are kept to a minimum, then it would be expected that there would be no additional resulting boat wash.

West of Beauty Point, a formal 'No Wash' zone is not enforced. In addition, there is no speed restriction for vessels less than 30 metres provided they are more than 30 metres from moored vessels or fixed structures.

The *Roads and Maritime Boating Handbook* (Roads and Maritime, 2016) states that:

'The operator of a vessel must not cause wash that damages or impacts unreasonably on:

- *Any dredge or floating plant*
- *Any construction or other works in progress*
- *Any bank, shore or waterside structure,*
- *Any other vessel, including a vessel that is moored.'*

Therefore, in order to ensure that marine construction traffic does not create wash that would have an impact on the wave climate, a speed limit is recommended to ensure that vessels do not operate at or near the critical threshold speed (refer to **Section 3.3.2**), particularly for smaller transport vessels (up to eight to 10 metres). It is noted that the critical threshold speed for wash in deep water is about nine knots for a vessel length of eight metres.

A speed limit of six knots (about 11 km/hr) for all vessels between the existing four knot speed zone at the Spit Bridge and 100 metres upstream of the Middle Harbour crossing is recommended. This speed is consistent with the speed limit within 30 metres of a mooring or fixed structure. At this speed, the time to reach the Middle Harbour crossing from Spit West Reserve construction support site (BL9) would be about 6.5 minutes.

6.2.2 Other waterway users

Port Authority of NSW states that vessels must not exceed four knots within 100 metres of:

- Any dredger or floating plant
- Any construction or any works in progress.

This restriction is in addition to requirements in the Marine Safety Regulation 2016 that states the operator of a vessel must not cause wash that damages or impacts unreasonably on dredgers, floating plant or

construction works in progress. These restrictions would have an influence on the potential impact of the proposed works on navigation.

It is recommended to impose the same speed restriction on all other motorised waterway users. This recommendation would not apply to sailing vessels and rowing skulls. In addition to reducing the wave climate, this recommendation would reduce the risk of collisions, damage to construction equipment and spillages.

Furthermore, there is a requirement for vessels to slow to less than four knots in the vicinity of dredging or construction activities. As a result, the wave climate created by recreational and commercial vessels in the vicinity of the Middle Harbour crossing would decrease. Conversely, as vessels accelerate beyond the construction zone on the upstream side of the crossing, the critical threshold speed would be attained whereby the maximum theoretical wave height is produced. Therefore, a higher wave climate may be produced upstream of the construction works. Transport for NSW may wish to implement a speed restriction upstream of the Middle Harbour crossing subject to further investigations. The speed restriction would be about 10 knots so that not all vessels accelerate through the critical threshold speed at the same location. This would distribute boat wash over a larger area.

6.2.3 Transport of immersed tube tunnel units

A vessel simulation for marine transport of the steel shell immersed tube tunnel units from the Outer Harbour to Spit West Reserve construction support site (BL9), transiting the Spit Bridge, was carried out by Port Authority of NSW (2018). The simulation found that the transportation of the steel shell immersed tube tunnel elements to the Spit West Reserve construction support site (BL9), and transportation of the completed immersed tube tunnel elements subsequently to the temporary mooring location before immersion, would be feasible and could be carried out safely based on the proposed methodology. The model also identified that a temporary pile may be required about 20 metres east of the Spit Bridge to assist with lining up the steel shell immersed tube tunnel units and tugboats before passing through the bridge. This would be confirmed as project construction planning develops further.

The maximum advised conditions for local transportation of the steel shell immersed tube tunnel units are significant wave height (H_s) approximately less than one metre and peak period (T_p) less than six seconds.

The 100 year average return period wind waves outlined in **Section 3.3.1** are less than 0.7 metres with a period less than two seconds. However, the one year average return period combined wind waves and boat waves exceed the maximum conditions for local transport. Limiting the boat waves in Middle Harbour would ensure that the wave conditions for local transport of the immersed tube tunnel units would not be exceeded. However, it is noted that it is extremely unlikely that the steel shell immersed tube tunnel units would be transported in a one year average return period wind wave event.

6.2.4 Wave impact on the shoreline

There is not expected to be an appreciable increase in the vessel wash resulting from the construction activities. However, during certain construction activities, marine construction vessels or other vessels may navigate close to a shoreline. Vessel wash would not attenuate to the same degree and therefore, a higher localised wave climate could potentially be experienced near the shoreline. Due to the presence of the cofferdams near the edges of the navigation channel vessels would generally be required to navigate near the centre of the channel.

The potential increase in the wave climate near the shoreline would be negligible. However, the project should avoid arrangements that require navigation close to a shoreline. This would ensure that the wave impact on the shoreline or on shoreline infrastructure would be similar to existing.

6.3 Water depths

The central portion of the Middle Harbour crossing would be founded on piles which would be level with the existing bed of the harbour. The immersed tube tunnels would, therefore, result in a reduction of water depth in that area of about 10 metres. The water depth at the location of the Middle Harbour crossing is up to -32 metres CD and typically greater than -20 metres CD. A reduction in the water depth of 10 metres would not have an impact on navigation.

The maximum water depth over The Bar at the entrance to Middle Harbour is about 5.1 metres (bathymetry -3 metres CD and HAT +2.1 metres CD). Assuming an under keel clearance of 0.5 metres, the absolute maximum vessel draught in Middle Harbour, upstream of The Bar, would be 4.6 metres.

During construction, piling works would be carried out for construction of the immersed tube tunnel foundations. The piles would be either marked with a navigation aid or cut off at least -10 metres CD to ensure sufficient water depth for navigation during construction.

6.4 Navigation restrictions

6.4.1 Obstructions to navigation

Nearshore water depths near the vicinity of the Middle Harbour crossing are relatively deep resulting in a wide existing navigable waterway. The proposed construction works, however, would impact on this ease of navigation through the need to impose restrictions to minimise risk of collision and other impacts (ie increased wash). These restrictions are likely to include:

- Reduced width of navigable channels due to the construction of the cofferdams. The cofferdams would be about 40 metres from the shoreline and 25 metres wide. They would be constructed with flat top barges 50 metres by 20 metres and it is recommended that a marine exclusion zone be established around the cofferdam. The exclusion zone would be a minimum of 25 metres from the flat top barge (about 110 metres from the shoreline). The navigable width between each of the cofferdams would be about 220 metres when the safety zones are in place
- Reduced navigation width due to the use of the primary silt curtains. It is assumed that the silt curtains would only be required for the duration of the dredging activities (about 34 weeks). The navigation channel between the primary silt curtains would be about 100 metres
- Obstruction to navigation caused by the driving and socketing of the foundation piles, which would be completed with a barge and crane. The anchored barge is not readily relocatable once operations commence and a safety zone is also recommended around this whilst operational
- Obstruction to navigation caused by construction vessels waiting to pass under the Spit Bridge (selected number of opening times per day). A temporary mooring area and a vessel movement plan that minimises wait time at the Spit Bridge would be developed
- Obstruction to navigation caused by the Spit West Reserve construction support site (BL9) and reduced navigation width for vessels accessing d'Albora Marina at The Spit
- Obstruction to navigation caused by temporary storage of completed immersed tube tunnel units, which would be east of Clive Park. The Temporary Mooring Facility would be about 160 metres by 120 metres

- Obstruction to navigation through the use of six, 24 to 48 hour partial or full navigation restrictions that are proposed during the immersion/placement of the immersed tube tunnel units.

It is likely that the immersion of the central two immersed tube tunnel units would require full closure of the navigation channel over two, 24 to 48 hour periods. During these closures, no boating traffic would be able to pass the location of the Middle Harbour crossing. The closures should occur midweek to minimise the impact on other waterway users including recreational boating traffic. The greatest impact on navigation would be associated with the closures of Middle Harbour. However, these impacts would be short term and would be unavoidable in order to deliver the long term benefits that would be provided by the project.

The outer two immersed tube tunnel units on either side of the channel could be immersed without full closure of the channel. Navigation restrictions would apply that would prohibit larger vessels but would allow smaller vessels to pass during the immersion process. Escort vessels should be provided to ensure safe passage of recreational vessels. However, this requirement would depend on the type of equipment utilised for the immersion process.

Immersion of the immersed tube tunnel elements would occur on six occasions being about once every two weeks (refer Chapter 6 (Construction work) of the environmental impact statement). This immersion should take place during weekdays to limit the disturbance on recreational boating.

During all other days of the construction, partial restrictions of Middle Harbour with controlled access through the site would be required. Recreational users, such as boating, sailing, rowing and kayaking would be allowed to travel through the site in a controlled manner ensuring the safety of both the waterway user and the project team.

6.4.2 Special Event Marine Notices and Marine Traffic Management Plan

Special Event Marine Notices should be issued in accordance with Section 12 of the *Marine Safety Act 1998* notifying all marine users of the navigation restrictions. It is recommended that exclusion zones are formed around the construction works area to separate the public from construction works and navigation channels are delineated to indicate safe passage for recreational vessels through the exclusion zones.

As part of the Special Event Marine Notices, it is recommended that a Marine Traffic Management Plan is prepared and approved by Transport for NSW that specifically notes exclusions zones delineated by special marks and navigation channels delineated by navigation marks. The plan should indicate distance from the works area, marker spacings and the like. The discussion herein and the Draft Marine Construction Management Plan provided in **Map 7** in **Appendix A** are based on the information available to date and should be amended as the project develops.

It is recommended that exclusion zones are formed by placing yellow special marks at the following locations:

- About 75 metres from the seaward face of the Spit West Reserve construction support site (BL9) and about 10 metres from the side of the construction support site. A larger exclusion zone would be preferable around the Spit West Reserve construction support site (BL9). However, it is constrained by the location of d'Albora Marina and Mosman Rowing Club. Further, additional space outside of the exclusion zone would be required to manoeuvre immersed tube tunnel units
- About 50 metres upstream of the primary silt curtain at the Middle Harbour crossing and 100 metres downstream of the primary silt curtain at the Middle Harbour crossing.

The special marks should be located such that the exclusion zone is clearly visible and delineated. However, the spacing should not be such that they create unnecessary waterway obstructions. A spacing of about 50 metres is recommended, which would be refined following selection of construction equipment.

Due to congestion of the waterway resulting from relocated moorings and marine construction traffic, it is recommended that vessel speed is restricted to six knots (about 11 km/hr) between the existing four knot speed zone at the Spit Bridge (near d'Albora Marina) and 100 metres upstream of the Middle Harbour crossing. The speed restriction zone would extend to a line due west of Beauty Point.

Where possible, manoeuvring of marine construction equipment should take place within the exclusion zones. Transits between the Middle Harbour crossing exclusion zone and construction site exclusion zone should be as direct as possible and approximately perpendicular to the main channel of Middle Harbour. There would be vessel interactions within this zone that would be tolerable given the width of the waterway. It is recommended that a navigation warning is issued (refer to **Section 6.6**) and additional measures are implemented to mitigate the impact on rowers (refer to **Section 6.7.1**).

The special marks around the Spit West Reserve construction support site (BL9) should allow for a safe navigation channel into d'Albora Marina. The width of the channel should be measured from the outside of the berths at the end of the marina arms and the preferred width should be about 50 metres (1.75 times the length of the largest vessel in the Marina) in accordance with *AS3962 - Guidelines for the design of Marinas*.

The current navigation channel leading to Mosman Rowing Club is about 50 metres wide. The width of the navigation channel should be retained.

In addition to the special marks, a navigation channel delineated by port (red) and starboard (green) buoys should be formed between the primary silt curtains and any other fixed navigation restrictions at the location of the Middle Harbour crossing, for the duration of the works. The channel is to provide safe passage of vessels through the construction zone. Construction vessels would be required to give way to recreational vessels in the defined navigation channel. This is contrary to normal right of way protocols where recreational power vessel must give way to:

- Vessels displaying the special lights and signals
- Large vessels restricted in their manoeuvrability (refer to **Section Error! Reference source not found.**).

The navigation markers should not be displayed during immersion of the middle two immersed tube tunnel units where it is likely that temporary full closure of Middle Harbour would be required. During these full closures, additional exclusion zone markers should be placed and it is recommended that Transport for NSW and the Waterway Police undertake additional patrols to manage boating traffic.

All structures occupying part of the waterway or any exclusion mark or navigation mark placed in the water should be adequately lit. Where necessary, cardinal markers and/or navigation aids should be fixed to any structure or exclusion marker to clarify the side that vessels should pass. The position, colour and light characteristic of all buoyage used for the works must be agreed in advance with the Harbour Master and Transport for NSW.

6.5 Relocation of moorings

Moorings in the following locations would be impacted by the project:

- About 55 swing moorings would be impacted by the project, including 45 in Pearl Bay near the Spit West Reserve construction support site (BL9) and 10 at Seaforth Bluff near the Middle Harbour north cofferdam (BL8). These moorings would be relocated elsewhere in Middle Harbour in consultation with the licence holder(s). All efforts would be made to relocate moorings as close to their original locations as possible. Impacted mooring licence holders may be entitled to a fee waiver or fee reimbursement where appropriate
- Access to three jetties at Seaforth Bluff would also be restricted while construction is underway. Alternative arrangements would be determined in consultation with the lease holder(s)
- A small number of additional swing moorings may require short term temporary relocation while the immersed tube tunnel units are delivered to the Spit West Reserve construction support site (BL9). If required, arrangements would be determined in consultation with the licence holder(s).

The proposed temporary mooring relocation zones are shown in **Figure 6-1**.

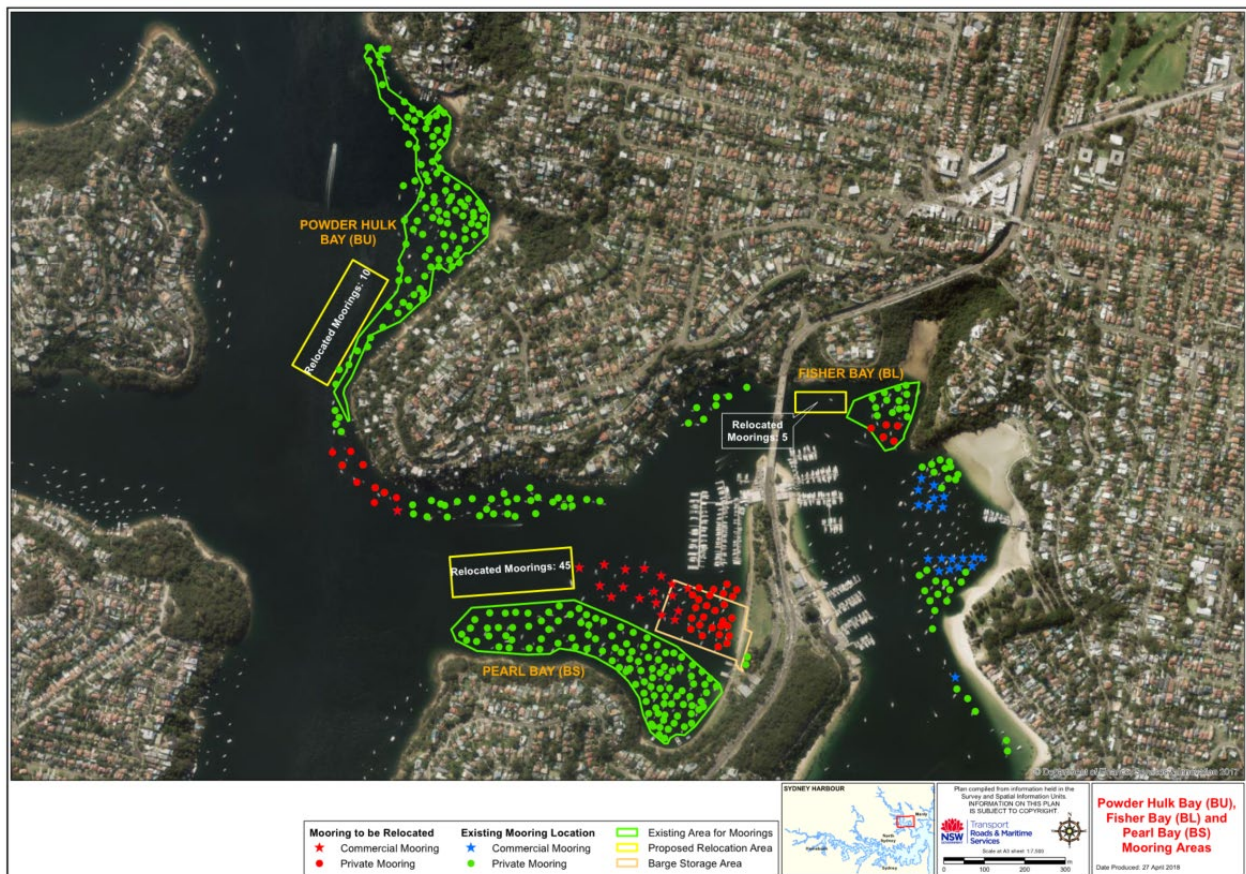


Figure 6-1: Proposed mooring relocation zones.

6.6 Vessel interaction

Vessel interactions in the Outer Harbour and lower reaches of Middle Harbour would be considered tolerable. The waterway in the vicinity of The Spit is currently congested and recommendations for this area are made herein. The majority of the marine construction traffic would be upstream of The Spit, between Spit West Reserve construction support site (BL9) and the Middle Harbour crossing. Specific recommendations to minimise the impact on waterway users are discussed in **Section 6.7**.

Passage of the steel shell immersed tube tunnel units under the Spit Bridge should only be carried out when the bridge gantry is raised due to height restrictions. Typically, vessels arrive at the Spit Bridge 10 minutes before the bridge opening time in accordance with Transport for NSW recommendations. Two public courtesy moorings are available on either side of the Spit Bridge to service vessels queuing/waiting to pass under the bridge. However, the number of moorings is usually insufficient for the number of vessels queuing for the bridge opening and the surrounding area on the downstream side of the Spit Bridge is a 'No Anchoring' zone. As such, vessels typically remain under motor and slowly move in a large circular/elliptical pattern waiting for the bridge to open.

Despite the requirement that power vessels must give way to large vessels restricted in their manoeuvrability, it is recommended that the transit of marine construction traffic under the Spit Bridge should not unreasonably restrict recreational vessels from accessing the public moorings or limit the movement of vessels waiting for the bridge to open. This is particularly important for vessels fitted with a rudder, such as sail yachts, that require continuous forward movement to maintain steering and manoeuvrability.

The steel shell immersed tube tunnel units and other marine construction traffic waiting for the bridge to open would be anchored between Bradys Point and Parrawi Head (refer to **Map 6** and **Map 7** in **Appendix A**). These locations are recommended due to the relatively wide waterway width, adequate water depth and suitable distance from marinas and moored vessels. With the exception of the steel shell immersed tube tunnel units, marine construction traffic should only approach the bridge when it is open, and a clear transit is available (ie after the passage of recreational vessels through the bridge transit). This would limit the impact on other waterway users queuing to pass under the bridge.

Due to the length, draught, limited speed and limited manoeuvrability of the steel shell immersed tube tunnel units, it is recommended to arrange for special bridge opening times to coincide with:

- High water slack tides to minimise currents through the bridge
- Daylight off-peak road traffic periods, such as 6am on a weekend morning.

Transport for NSW would liaise with Mosman Rowing Club as transport of the steel shell immersed tube tunnel units may impact their activities. The bridge transits may occur outside of standard construction hours and special arrangements and permits would need to be put in place.

It is also recommended that a navigation warning is issued for Middle Harbour between Grotto Point and Sugarloaf Point. The navigation warning would encompass the Spit Bridge and the waterway between Seaforth Bluff and Beauty Point where marine traffic would increase leading to higher vessel interactions. These warnings form part of Transport for NSW's risk management approach to safe navigation. The warning should remind waterway users of the requirement that power vessels give way to larger vessels restricted in their manoeuvrability.

6.7 Waterway users

The waterway users identified in **Section 4.7** downstream of the Spit Bridge would not be substantially impacted by the construction activities. Marine construction vessel movements through this part of Middle Harbour would be considerably less than vessel movements upstream of the Spit Bridge. Vessel transits would require marine construction traffic and other waterway users to give way in accordance with the navigation rules (refer **Section** Error! Reference source not found.). Congestion and obstruction of the narrow channel on the approach to the Spit Bridge should be avoided and mitigation measures are suggested (refer to **Section 6.6**).

Upstream of the Spit Bridge, the construction activities would impose speed restrictions around construction equipment. Additional speed restrictions are proposed between Middle Harbour crossing and the Spit Bridge. These speed restrictions would result in increased transit times for recreational, commercial and government vessels. On occasion, transit past the Middle Harbour crossing would be prevented altogether, although this would be temporary.

Prior to construction, a vessel travelling at a typical speed of 20 knots would take one minute and 40 seconds to travel from d'Albora Marina (upstream end of existing four knot zone) to 100 metres upstream of the Middle Harbour crossing. This is considered a relatively fast speed for many vessels such as yachts that typically have a maximum speed of eight knots.

During construction, vessels would take four minutes and 20 seconds to travel from d'Albora Marina to 100 metres downstream of the primary silt curtain at the Middle Harbour crossing, through the proposed six knot zone. The increased transit time in this area could be avoided by removing the speed restriction. However, the speed restriction is proposed to improve safety and minimise wash.

In the vicinity of the Middle Harbour crossing, vessels would be required to travel additional distance to avoid construction plant and equipment and would be restricted to four knots for a distance of about 350 metres. Transiting the crossing would take about two minutes and 50 seconds. While minor, the increased transit time is unavoidable.

The resultant journey from d'Albora Marina (upstream end of existing four knot zone) to 100 metres upstream of the Middle Harbour crossing would be seven minutes and 10 seconds compared to the transit time of one minute and 40 seconds in the absence of construction activities.

Specific clubs, groups and operators that are impacted by construction activities are discussed in the following sections.

6.7.1 Community groups and clubs

6.7.1.1 d'Albora Marina, The Spit

The Spit West Reserve construction support site (BL9) would be in close proximity to d'Albora Marina. A navigation channel on the approach to the marina's interior channels and fairways would be retained (refer to **Section 6.4.2**). Commercial moorings leased by d'Albora Marina, in the vicinity of the Spit West Reserve construction support site (BL9) would be relocated. The marina currently offers a tender service to these moorings. Relocation of the moorings would impact the marina's patrons that rent the moorings and would increase the distance traversed by the marina's tender service.

6.7.1.2 Mosman Rowing Club

The proposed construction works have the potential to impact Mosman Rowing Club. These potential impacts would be mitigated wherever practical. Mitigation measures are outlined in **Section 6.9**.

Furthermore, Transport for NSW should liaise with Mosman Rowing Club to discuss a route for rowers and marine construction vessels between the Middle Harbour crossing and Spit West Reserve. The rowing and marine construction vessel routes would be separated where possible. It is envisaged the two routes would be near parallel up to the Middle Harbour crossing (refer to Draft Marine Construction Management Plan provided in **Map 7** in **Appendix A**). Construction vessels accessing the Middle Harbour south cofferdam (BL7) would need to cross the rowing route near the Middle Harbour crossing (refer to **Figure 6-2**). It is understood that the typical training speed for rowing skulls would be between four and eight knots. Therefore, the speed difference between rowing skulls and construction vessels, recommended as six knots in **Section 6.2**, would be similar and there would be sufficient time for the vessels to avoid a collision. If deemed necessary during a review of construction risks, the rowing route and route for construction vessels should be delineated by marks. The marks could be safe water marks that are distinguishable from special marks used to outline exclusion zones.

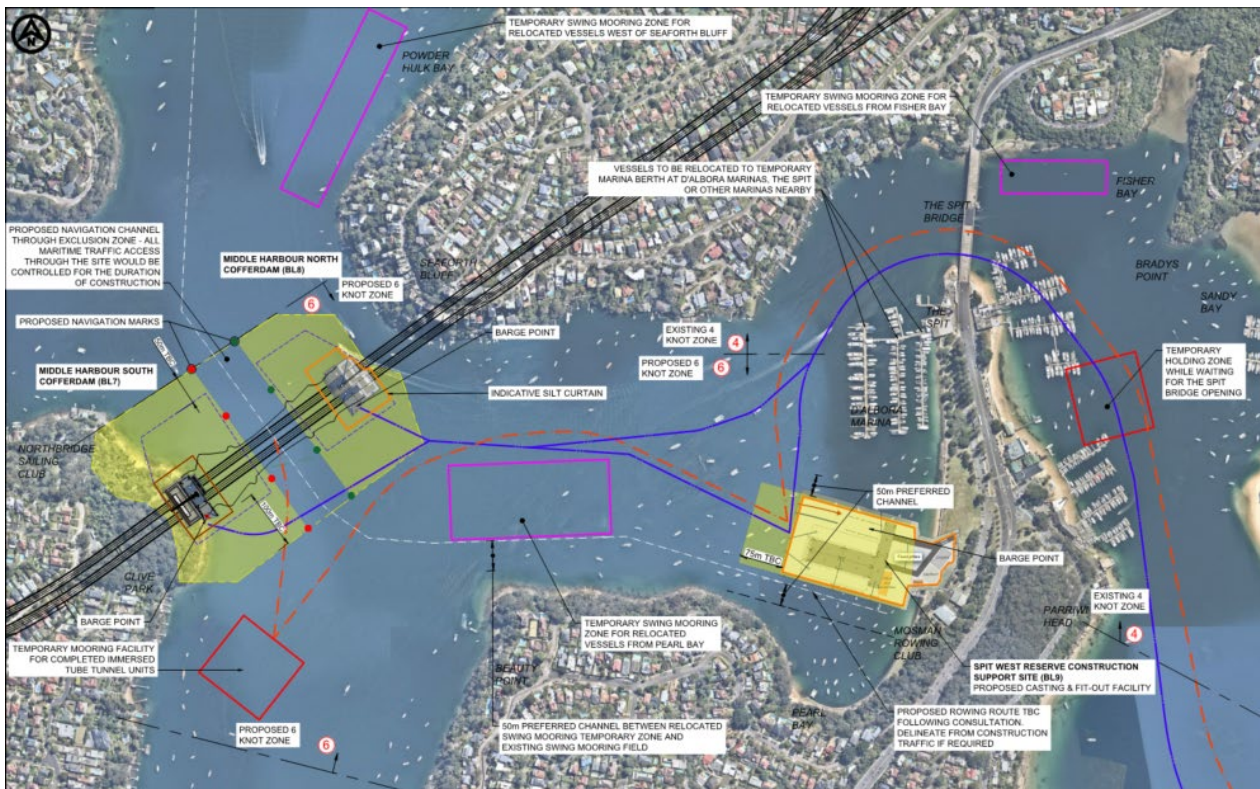


Figure 6-2: Marine construction traffic routes and envisaged route of rowing craft during construction of the immersed tube tunnels

Mosman Rowing Club would be consulted during construction planning of the project to address any additional concerns and develop additional mitigation measures as may be deemed necessary.

6.7.1.3 Northbridge Sailing Club and Seaforth Moth Sailing Club

Northbridge Sailing Club and Seaforth Moth Sailing Club would be substantially impacted by the proposed works. Northbridge Sailing Club provides racing primarily for 'off the beach' dinghies and has a strong group of junior sailors as young as seven years of age. Northbridge Sailing Club's race courses are attached in **Appendix C**. The courses typically occupy the waterway in the immediate vicinity of the

project. The courses are orientated to achieve a good competitive outcome given prevailing wind conditions at race time and avoid the variable wind in the lee of the higher hills and headlands towards Roseville Bridge.

Unlike other waterway users including rowing skulls and power vessels, the direction of travel of a sail craft is dependent on the wind direction. Sail craft cannot sail any closer than about 45 degrees to the direction of the wind. This limitation means that the route of a sail craft is rarely a straight line from one mark of the course to the next.

Construction of the immersed tube tunnels, particularly the primary silt curtains for dredging, would have a substantial impact on the layout of the Northbridge Sailing Clubs race courses. Northbridge Sailing Club and Seaforth Moth Sailing Club would be consulted and advised of the works and proposed mitigation measures during the detailed design phase of the project. The clubs would be consulted on feasible and reasonable mitigation measures including the measure to relocate their race courses to upstream of the Middle Harbour crossing.

Northbridge Sailing Club, Seaforth Moth Sailing Club, and other community groups, would be consulted during construction planning of the project to address any concerns and develop additional mitigation measures as may be deemed necessary.

6.7.2 Commercial operators

With the exception of Eco Boat Hire at Northbridge and Jungle Float Mobile Water Park, there is minimal commercial boating traffic that would traverse the Middle Harbour crossing. Furthermore, Eco Boat Hire charter small vessels and the Jungle Float Mobile Water Park consists of a relatively small single barge. These vessels could traverse the Middle Harbour crossing at all times except for the full closure for immersion of the middle two immersed tube tunnel units.

Marine construction equipment affiliated with the project would need to give way to larger commercial vessels in the Outer Harbour or offshore. Harbour Master directions including the requirement that vessels must not pass between an escort vessel and a seagoing vessel, or within 30 metres of the seagoing vessel (refer to **Section 4.4.1**) would apply to construction equipment.

6.7.3 Government organisations

Vessels associated with construction of the project would transit past HMAS Penguin. The width of Middle Harbour in the vicinity of HMAS Penguin is relatively wide and a low number of vessels access the naval facility, which is primarily used for training and education purposes and does not provide a permanent berth for naval ships. Construction activities associated with the project would have a negligible impact on navigation to and from HMAS Penguin.

It is understood that Transport for NSW infrequently patrol the waterway upstream of the Middle Harbour crossing. This is due to the low volume of marine traffic in this area, which is a result of only one boat launching facility and minimal on-water vessel storage. Transiting the Middle Harbour crossing at high speed would be restricted during construction. However, these speed restrictions would not apply to Water Police in an emergency. It is recommended that Transport for NSW and the Water Police increase patrols in the vicinity of the project during construction to ensure compliance of waterway users.

6.8 Impacts during operation

As discussed in **Section 6.3**, the project would lead to a reduction in water depth. However, this is inconsequential as the draught of vessels in this part of the Harbour is constrained by shallow water depths downstream.

A 'No Anchoring' area would need to be defined around the Middle Harbour crossing to ensure anchors do not become snagged or damage the immersed tube tunnel segments. This zone should be marked on boating maps and signs should be displayed near Clive Park and Seaforth Bluff. The impact of 'No Anchoring' is relatively minor given the opportunities elsewhere in Middle Harbour.

Reinstatement of moorings near the project may be restricted. However, it should be possible for the moorings to be reinstated in close proximity to their existing location.

6.9 Summary of mitigation measures

The following is a summary of mitigation measures discussed herein.

Vessel interaction and requirements for marine construction vessels

- All movements of large construction equipment including barges, steel shell immersed tube tunnel units and fully completed immersed tube tunnel units and dredgers should be conducted by a master and crew holding a commercial qualification or certificate of competency
- All marine construction equipment, steel shell immersed tube tunnel units and fully completed immersed tube tunnel units should be fitted with operational navigation lights at all times, including while moored or anchored at a location other than their registered (everyday) mooring location
- Transport of the steel shell immersed tube tunnel units and fully completed immersed tube tunnel units shall comply with directions of the Harbour Master. Port Authority of NSW (2018) has carried out a vessel simulation for the marine transport of immersed tube tunnel units
- All construction vessels including stationary barges and transport vessels should be fitted with automatic identification systems that are turned on at all times
- Construction equipment affiliated with the project would need to give way to larger vessels under escort in the Outer Harbour or offshore
- Special Spit Bridge opening times, specifically for transiting of the immersed tube tunnel units, should be arranged during off-peak road traffic periods
- All structures occupying part of the waterway or any exclusion marker placed in the water should be adequately lit. This includes wharves, jetties, cofferdams etc
- Marine construction traffic should avoid queuing near the Spit Bridge and should avoid congesting this part of the waterway
- A navigation channel on the approach to d'Albora Marina at The Spit should be formed alongside the Spit West Reserve construction support site (BL9).

Special Event Marine Notices and Marine Traffic Management Plan

- A speed limit of six knots for all marine traffic should be implemented between the Spit Bridge and 100 metres upstream of the Middle Harbour crossing to minimise the impact of vessel wash and reduce vessel speed to ensure the safety of mariners
- A Special Event Marine Notice(s) should be issued in accordance with Section 12 of the *Marine Safety Act 1998* notifying of the navigation restrictions. A navigation warning should be issued for the broader waterway where construction vessels would frequently transit
- A Marine Construction Management Plan should be prepared that notes exclusion zones, navigation channels and the like to provide safe passage of commercial and recreational vessels. A Draft Marine Construction Management Plan is provided in **Map 7** in **Appendix A**.

Impact on Mosman Rowing Club

- The Spit West Reserve construction support site (BL9) should not impact the land based approach or water based approach to the Mosman Rowing Club
- The existing navigation channel between the moorings on the approach to the Mosman Rowing Club should be maintained at its current width. Relocated moorings should not be placed in this navigation channel
- Construction works should avoid wash around any rowing skulls
- Due to the minimal noise produced by a rowing skull and low level of the skull, vessel operators associated with the project should maintain a good lookout for these craft
- Transport for NSW should liaise with Mosman Rowing Club to discuss a route for rowers and construction vessels between the Middle Harbour crossing and the Spit West Reserve construction support site (BL9). The routes should be separate where possible and delineated by special markers if required
- Rowers and sailing craft would have right of way over maritime construction vessels in the vicinity of the project
- Transport for NSW would liaise with Mosman Rowing Club to discuss and arrange relocation of their race courses to upstream of the Middle Harbour crossing.

Northbridge Sailing Club and Seaforth Moth Sailing Club

- Rowers and sailing craft would have right of way over maritime construction vessels in the vicinity of the project
- Construction works should avoid wash around any rowing skulls
- Due to the minimal noise produced by a rowing skull and low level of the skull, vessel operators associated with the project should maintain a good lookout for these craft
- Transport for NSW would liaise with Northbridge Sailing Club and Seaforth Moth Sailing Club to discuss and arrange relocation of their race courses to upstream of the Middle Harbour crossing.

7 References

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Appendix A – Maps

Map 1 – Middle Harbour Overview and Mooring Areas

Map 2 – Maritime and Navigation Features of Middle Harbour

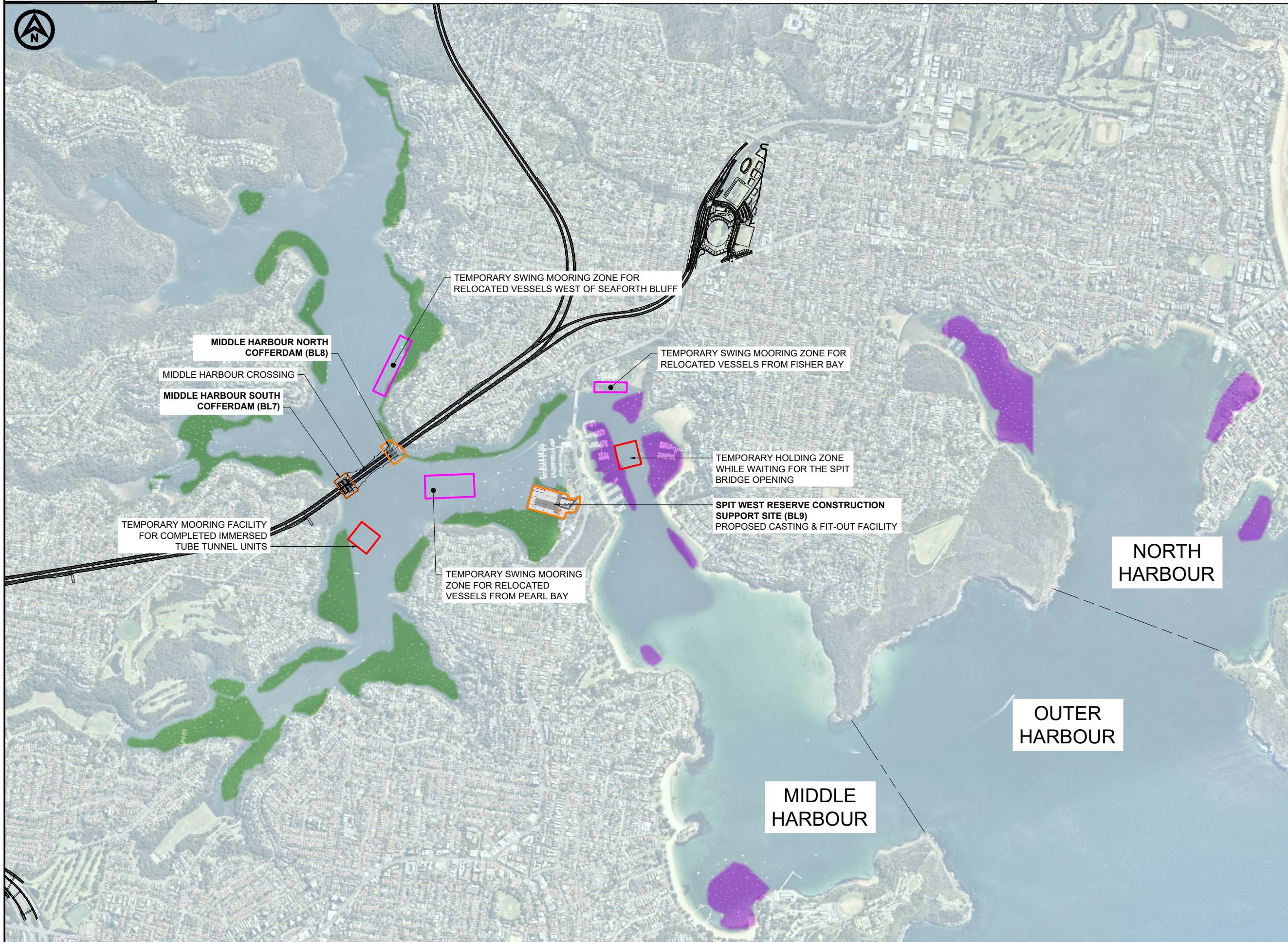
Map 3 – Proposed Construction Plan and Navigation Restrictions

Map 4 – Community Groups and Clubs

Map 5 – Commercial Operators, Government Organisations, Boat Launching Ramps and Marina Facilities

Map 6 – Proposed Marine Construction Traffic Route for Civil Works

Map 7 – Draft Marine Construction Management Plan



NOTES

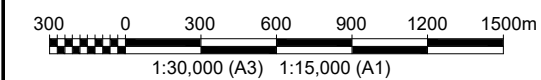
1. AERIAL OBTAINED FROM NEARMAP ON 26.09.2020
2. BEACHES LINK TUNNEL SITE PLAN PROVIDED BY TRANSPORT FOR NSW
3. MOORING MAP OF SYDNEY HARBOUR OBTAINED FROM ROADS & MARITIME SERVICES 05.02.2016

LEGEND

- BEACHES LINK TUNNEL CONSTRUCTION SUPPORT SITES REQUIRED FOR MARINE ACTIVITIES
- BEACHES LINK TUNNEL PROPOSED PROJECT
- PROPOSED TEMPORARY HOLDING ZONES REQUIRED FOR MARINE ACTIVITIES
- TEMPORARY SWING MOORING ZONE

LEGEND MOORINGS

- SYDNEY B
- SYDNEY C



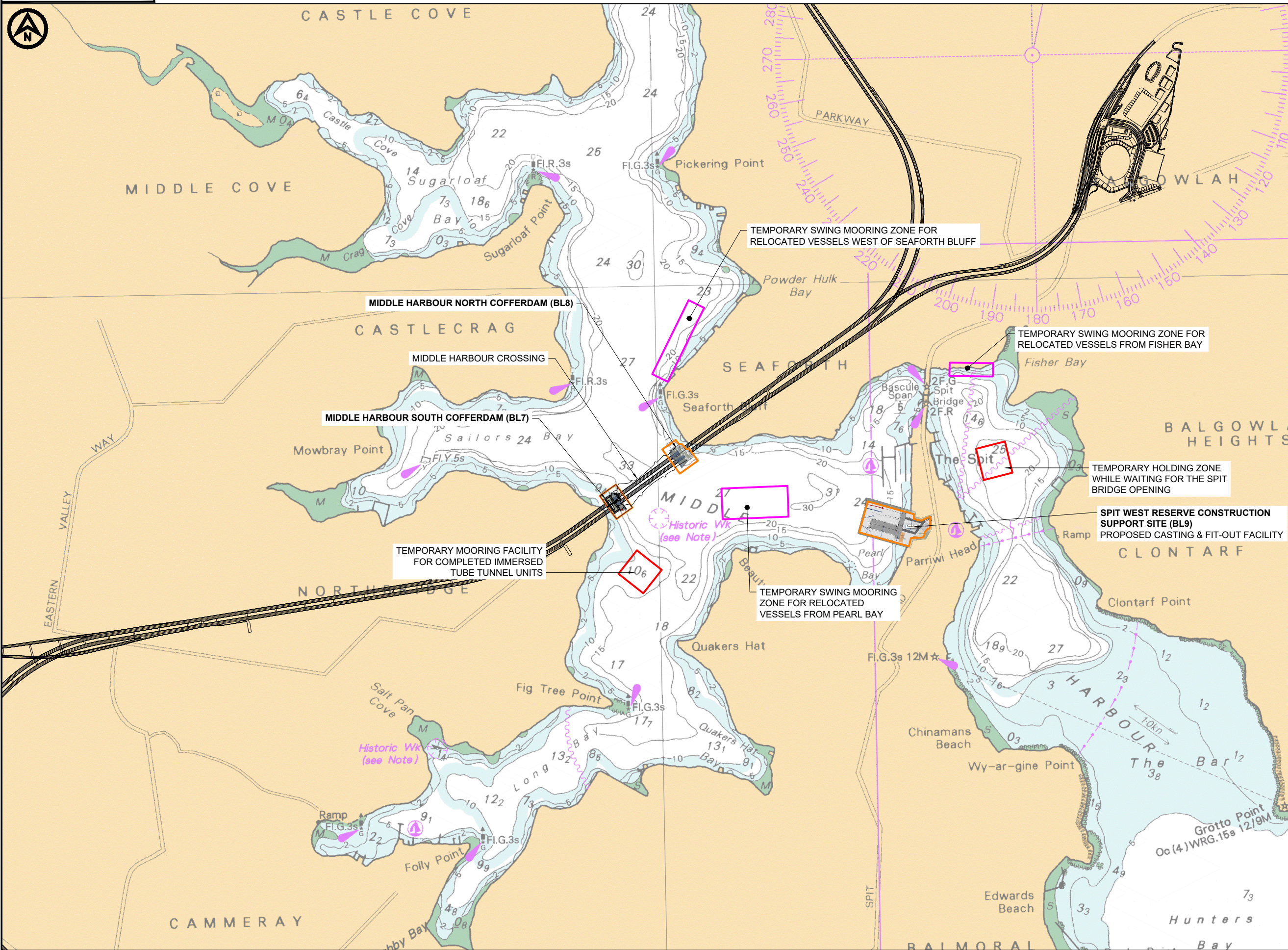
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PROJECT
BEACHES LINK TUNNEL
NAVIGATIONAL IMPACT
ASSESSMENT

TITLE
MAP 1
MIDDLE HARBOUR OVERVIEW
& MOORING AREAS

Level 14, 50 Berry Street
North Sydney NSW 2060
Australia
Tel +61 2 88545000
Fax +61 2 95290960
Email: project.admin.australia@rhdhv.com
Website: www.royalhaskoningdhv.com

DRAWN JFC	COORD. SYSTEM MGA ZONE 56	DATUM AHJD	DATE 03.12.2020
SCALE AT A1 AS SHOWN	REF. PA1694-RHD-BL-M2-MA-0001-CONSTRAINTS		
DRAWING No. PA1694-RHD-BL-MP-MA-0100	REVISION		



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2. NAUTICAL CHART AUS 200

LEGEND

- BEACHES LINK TUNNEL CONSTRUCTION SUPPORT SITES REQUIRED FOR MARINE ACTIVITIES
- BEACHES LINK TUNNEL PROPOSED PROJECT
- PROPOSED TEMPORARY HOLDING ZONES REQUIRED FOR MARINE ACTIVITIES
- TEMPORARY SWING MOORING ZONE

MIDDLE HARBOUR NORTH COFFERDAM (BL8)

MIDDLE HARBOUR CROSSING

MIDDLE HARBOUR SOUTH COFFERDAM (BL7)

TEMPORARY MOORING FACILITY FOR COMPLETED IMMERSED TUBE TUNNEL UNITS

TEMPORARY SWING MOORING ZONE FOR RELOCATED VESSELS WEST OF SEAFORTH BLUFF

TEMPORARY SWING MOORING ZONE FOR RELOCATED VESSELS FROM FISHER BAY

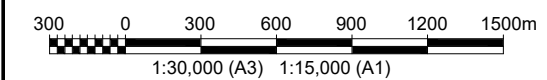
TEMPORARY HOLDING ZONE WHILE WAITING FOR THE SPIT BRIDGE OPENING

SPIT WEST RESERVE CONSTRUCTION SUPPORT SITE (BL9) PROPOSED CASTING & FIT-OUT FACILITY

TEMPORARY SWING MOORING ZONE FOR RELOCATED VESSELS FROM PEARL BAY

Historic Wk (see Note)

406



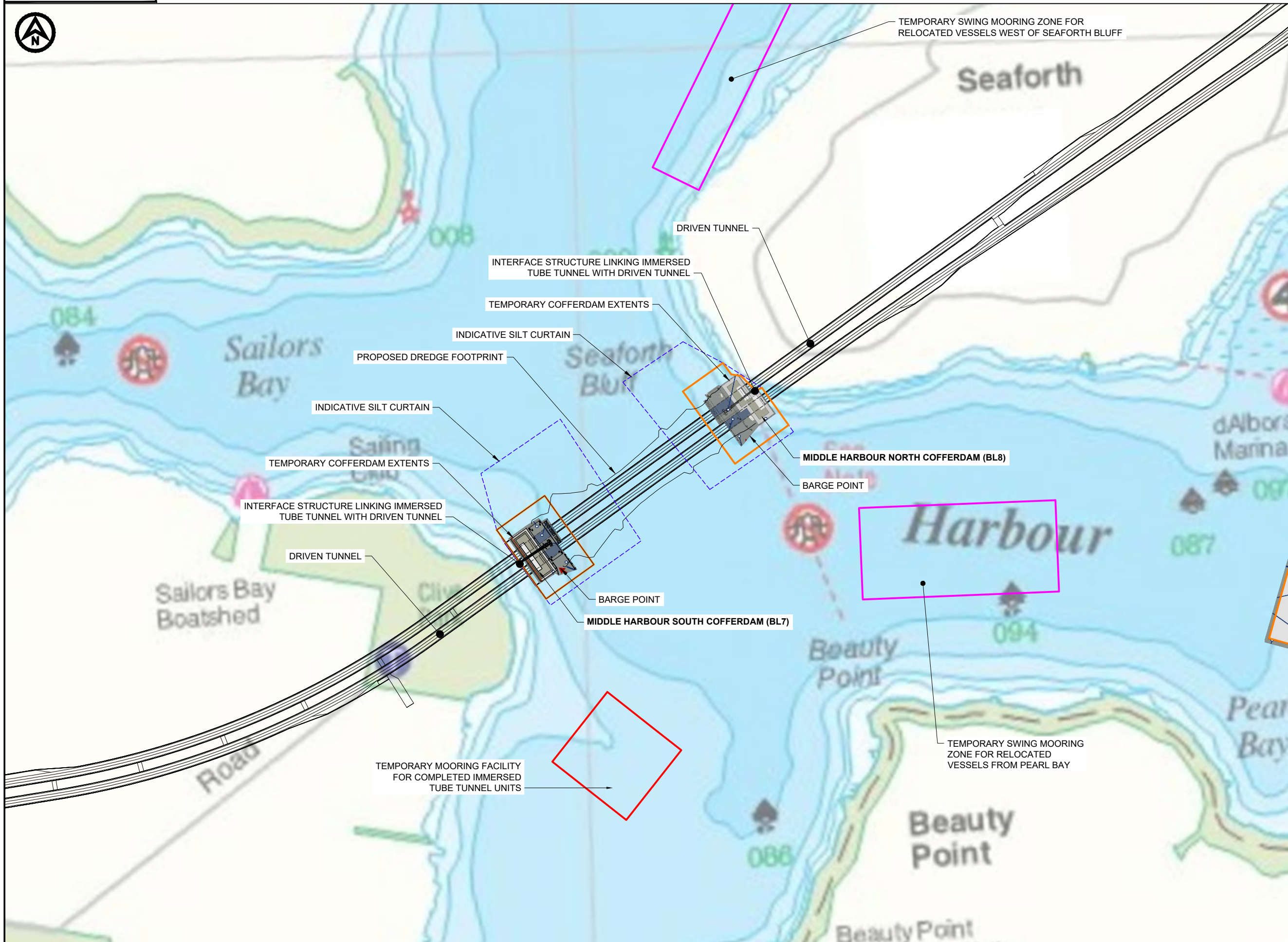
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PROJECT
BEACHES LINK TUNNEL
NAVIGATIONAL IMPACT
ASSESSMENT

TITLE
MAP 2
MARITIME & NAVIGATION
FEATURES OF MIDDLE
HARBOUR



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SCALE AT AS SHOWN	REF: PA1694-RHD-BL-M2-MA-0001-CONSTRAINTS		
DRAWING No. PA1694-RHD-BL-MP-MA-0200	REVISION		

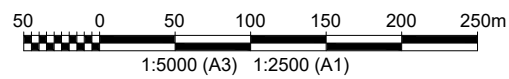


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1. ROADS & MARITIME SERVICES BOATING MAP OF MIDDLE HARBOUR 04.2016
2. BEACHES LINK TUNNEL SITE PLAN PROVIDED BY TRANSPORT FOR NSW

LEGEND

- BEACHES LINK TUNNEL CONSTRUCTION SUPPORT SITES REQUIRED FOR MARINE ACTIVITIES
- BEACHES LINK TUNNEL PROPOSED PROJECT
- PROPOSED TEMPORARY HOLDING ZONES REQUIRED FOR MARINE ACTIVITIES
- TEMPORARY SWING MOORING ZONE



NOT FOR CONSTRUCTION

PROJECT
BEACHES LINK TUNNEL
NAVIGATIONAL IMPACT
ASSESSMENT

TITLE
MAP 3
PROPOSED CONSTRUCTION PLAN
AND NAVIGATION RESTRICTIONS

Level 14, 50 Berry Street
North Sydney NSW 2060
Australia
Tel +61 2 95545000
Fax +61 2 95209660
Email: project.admin.australia@rhdhv.com
Website: www.royalhaskoningdhv.com

DRAWN JPC	COORD. SYSTEM MGA ZONE 56	DATUM AHJD	DATE 03.12.2020
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DRAWING No. PA1694-RHD-BL-MP-MA-0300	REVISION		

1. AERIAL OBTAINED FROM NEARMAP ON 26.09.2020
2. BEACHES LINK TUNNEL SITE PLAN PROVIDED BY TRANSPORT FOR NSW

LEGEND

- BEACHES LINK TUNNEL CONSTRUCTION SUPPORT SITES REQUIRED FOR MARINE ACTIVITIES
- BEACHES LINK TUNNEL PROPOSED PROJECT
- PROPOSED TEMPORARY HOLDING ZONES REQUIRED FOR MARINE ACTIVITIES
- TEMPORARY SWING MOORING ZONE



NORTH HARBOUR

OUTER HARBOUR

MIDDLE HARBOUR

LEGEND

PADDLE CRAFT CLUBS, TOURS AND HIRE CENTRES:

- 1 BALMORAL WATER SPORTS CENTRE
- 2 SYDNEY HARBOUR KAYAKS
- 3 MOSMAN ROWING CLUB
- 4 OCEAN PADDLER TRAINING SQUAD

NOTE: BALMORAL WATER SPORTS CENTRE AND SYDNEY HARBOUR KAYAKS ARE COMMERCIAL OPERATORS.

SAILING AND YACHT CLUBS:

- 1 BALMORAL SAILING CLUB
- 2 MIDDLE HARBOUR AMATEUR SAILING CLUB
- 3 MIDDLE HARBOUR YACHT CLUB
- 4 MIDDLE HARBOUR 16' SKIFF CLUB
- 5 NORTHBRIDGE SAILING CLUB
- 6 SEAFORTH MOTH SAILING CLUB

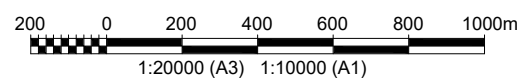
NOTE: ONLY SAILING CLUBS IN MIDDLE HARBOUR ARE RECORDED.

SEA SCOUT AND GUIDE GROUPS:

- 1 NORTHBRIDGE SEA SCOUTS
- 2 SAILORS BAY SEA SCOUTS

MARINE RESCUE:

- 1 MARINE RESCUE MIDDLE HARBOUR



NOT FOR CONSTRUCTION

PROJECT
BEACHES LINK TUNNEL
NAVIGATIONAL IMPACT
ASSESSMENT





TITLE
MAP 4
COMMUNITY GROUPS & CLUBS

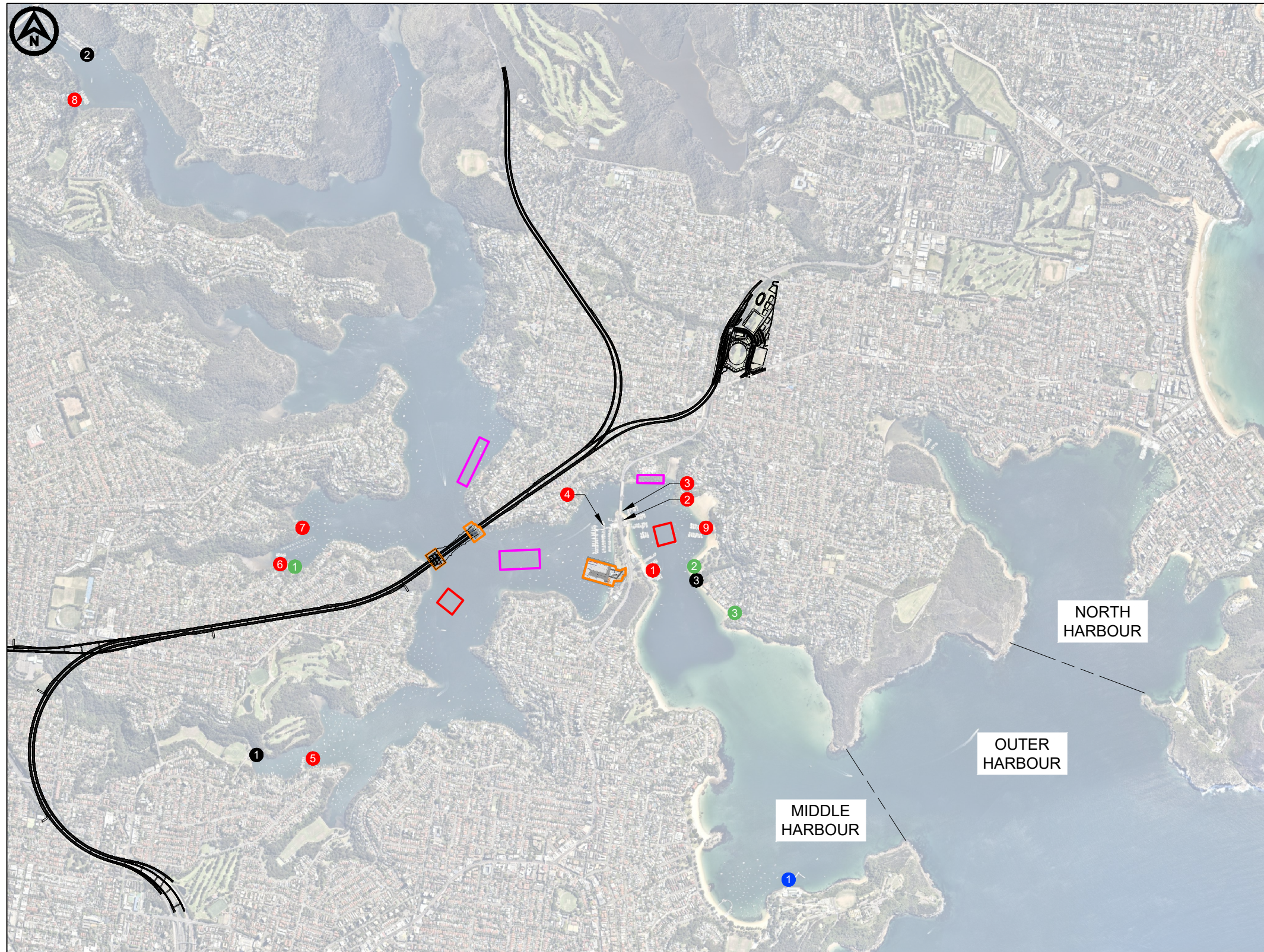
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DRAWING No. PA1694-RHD-BL-MP-MA-0400	REVISION		

NOTES

1. AERIAL OBTAINED FROM NEARMAP ON 26.09.2020
2. BEACHES LINK TUNNEL SITE PLAN PROVIDED BY TRANSPORT FOR NSW




LEGEND

-  BEACHES LINK TUNNEL CONSTRUCTION SUPPORT SITES REQUIRED FOR MARINE ACTIVITIES
-  BEACHES LINK TUNNEL PROPOSED PROJECT
-  PROPOSED TEMPORARY HOLDING ZONES REQUIRED FOR MARINE ACTIVITIES
-  TEMPORARY SWING MOORING ZONE




LEGEND










COMMERCIAL OPERATORS:

-  ECO BOAT HIRE SYDNEY
-  JUNGLE FLOAT MOBILE WATER PARK
-  CHAMPAGNE SAILING SYDNEY




GOVERNMENT ORGANISATIONS:

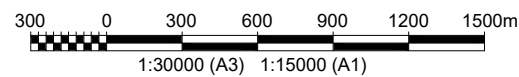
-  H.M.A.S. PENGUIN

PRIVATE AND COMMERCIAL MARINAS:

-  MIDDLE HARBOUR YACHT CLUB, THE SPIT
-  SMITHS BOATSHED MARINA, THE SPIT
-  FERGUSONS BOAT SHED, THE SPIT
-  D'ALBORA MARINA AT THE SPIT
-  CAMMERAY MARINA, CAMMERAY
-  NORTHBRIDGE MARINA, NORTHBRIDGE
-  CASTLECRAG MARINA, CASTLECRAG
-  ROSEVILLE BRIDGE MARINA, ROSEVILLE
-  CLONTARF MARINA; CLONTARF

BOAT LAUNCHING FACILITIES:

-  TUNKS PARK, CAMMERAY
-  ROSEVILLE BRIDGE, KILLARNEY HEIGHTS
-  CLONTARF RESERVE SAND RAMP, CLONTARF



NOT FOR CONSTRUCTION

PROJECT
BEACHES LINK TUNNEL
NAVIGATIONAL IMPACT
ASSESSMENT

TITLE
MAP 5
COMMERCIAL OPERATORS



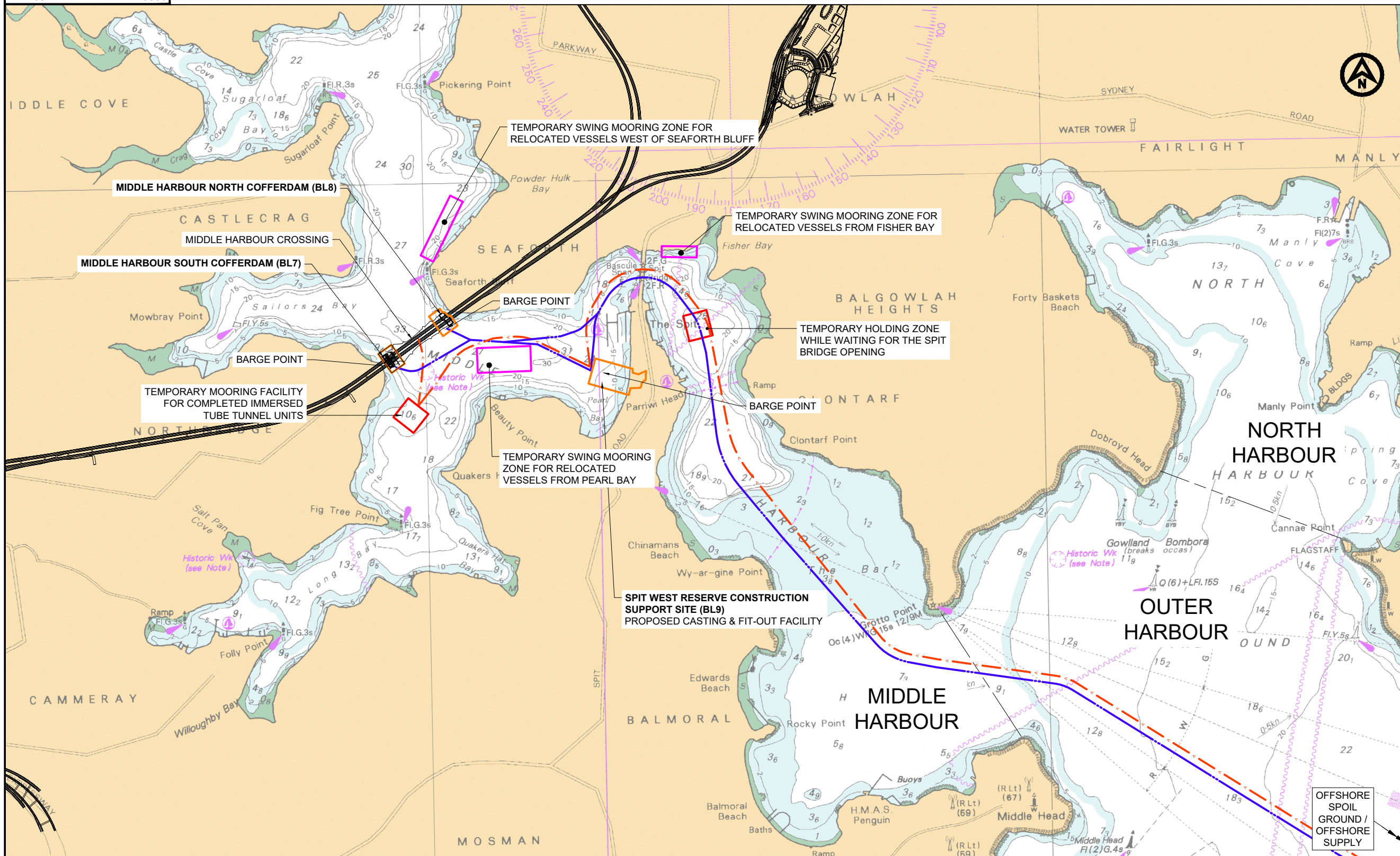
DRAWN JPC	COORD. SYSTEM MGA ZONE 56	DATUM AHJD	DATE 03.12.2020
SCALE AT A1 AS SHOWN	REF. PA1694-RHD-BL-M2-MA-0001-CONSTRAINTS		

DRAWING No. PA1694-RHD-BL-MP-MA-0500 REVISION

1. BEACHES LINK TUNNEL SITE PLAN PROVIDED BY TRANSPORT FOR NSW
2. NAUTICAL CHART A200

LEGEND

- BEACHES LINK TUNNEL CONSTRUCTION SUPPORT SITES REQUIRED FOR MARINE ACTIVITIES
- BEACHES LINK TUNNEL PROPOSED PROJECT
- PROPOSED TEMPORARY HOLDING ZONES REQUIRED FOR MARINE ACTIVITIES
- TEMPORARY SWING MOORING ZONE



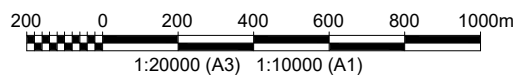
LEGEND

IMMERSED TUBE TUNNEL UNIT TRANSPORT - - - - - -

1. OFFSHORE SUPPLY TO SPIT WEST RESERVE CONSTRUCTION SUPPORT SITE (BL9) (VIA TEMPORARY MOORING FACILITY) - POTENTIAL ROUTE FOR SUPPLY OF OTHER MATERIALS AND EQUIPMENT
2. SPIT WEST RESERVE CONSTRUCTION SUPPORT SITE (BL9) TO STORAGE LOCATION
3. STORAGE LOCATION TO MIDDLE HARBOUR CROSSING - FOR IMMERSION

MARINE CONSTRUCTION TRAFFIC - - -

1. SPIT WEST RESERVE CONSTRUCTION SUPPORT SITE (BL9) TO/FROM MIDDLE HARBOUR CROSSING - FOR SUPPLY OF EQUIPMENT/MATERIALS TO MIDDLE HARBOUR CROSSING FOR CONSTRUCTION OF COFFERDAMS, PILING ACTIVITIES AND REMOVAL OF DREDGED MATERIAL
2. MIDDLE HARBOUR CROSSING TO/FROM OFFSHORE SPOIL GROUND (VIA TEMPORARY MOORING FACILITY) - FOR DISPOSAL OF SUITABLE DREDGED MATERIAL AT THE DESIGNATED OFFSHORE DISPOSAL SITE



NOT FOR CONSTRUCTION

PROJECT
BEACHES LINK TUNNEL
NAVIGATIONAL IMPACT
ASSESSMENT

TITLE
MAP 6
PROPOSED MARINE
CONSTRUCTION TRAFFIC ROUTE
FOR CIVIL WORKS

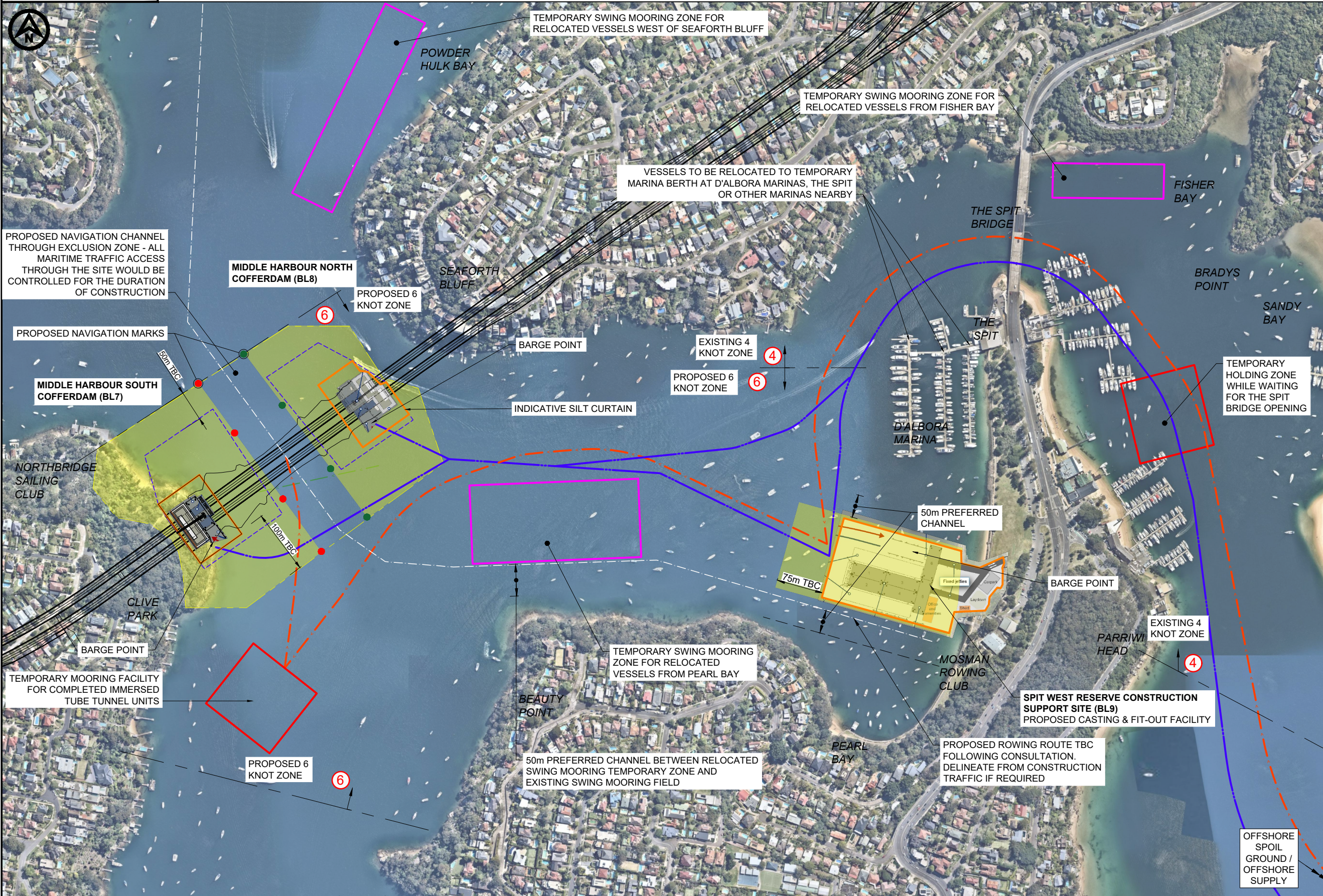
Level 14, 50 Berry Street
North Sydney NSW 2060
Australia
Tel +61 2 98545000
Fax +61 2 95209600
Email: project.admin.australia@rhdhv.com
Website: www.royalhaskoningdhv.com

DRAWN JPC	COORD. SYSTEM MGA ZONE 56	DATUM AHJD	DATE 03.12.2020
SCALE AT 1: AS SHOWN	REF. PA1694-RHD-BL-M2-MA-0001-CONSTRAINTS		
DRAWING No. PA1694-RHD-BL-MP-MA-0600	REVISION		

1. AERIAL OBTAINED FROM NEARMAP ON 26.09.2020
2. BEACHES LINK TUNNEL SITE PLAN PROVIDED BY TRANSPORT FOR NSW

LEGEND

- BEACHES LINK TUNNEL CONSTRUCTION SUPPORT SITES REQUIRED FOR MARINE ACTIVITIES
- BEACHES LINK TUNNEL PROPOSED PROJECT
- PROPOSED TEMPORARY HOLDING ZONES REQUIRED FOR MARINE ACTIVITIES
- PROPOSED EXCLUSION ZONE DELINEATED BY SPECIAL MARKERS AT 50m SPACING TBC
- TEMPORARY SWING MOORING ZONE

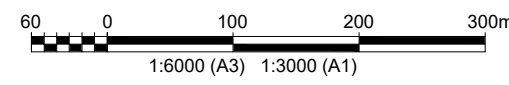


LEGEND

- IMMERSED TUBE TUNNEL UNIT TRANSPORT**
1. OFFSHORE SUPPLY TO SPIT WEST RESERVE CONSTRUCTION SUPPORT SITE (BL9) (VIA TEMPORARY MOORING FACILITY) - POTENTIAL ROUTE FOR SUPPLY OF OTHER MATERIALS AND EQUIPMENT
 2. SPIT WEST RESERVE CONSTRUCTION SUPPORT SITE (BL9) TO STORAGE LOCATION
 3. STORAGE LOCATION TO MIDDLE HARBOUR CROSSING - FOR IMMERSION

MARINE CONSTRUCTION TRAFFIC

1. SPIT WEST RESERVE CONSTRUCTION SUPPORT SITE (BL9) TO/FROM MIDDLE HARBOUR CROSSING - FOR SUPPLY OF EQUIPMENT/MATERIALS TO MIDDLE HARBOUR CROSSING FOR CONSTRUCTION OF COFFERDAMS, PILING ACTIVITIES AND REMOVAL OF DREDGED MATERIAL
2. MIDDLE HARBOUR CROSSING TO/FROM OFFSHORE SPOIL GROUND (VIA TEMPORARY MOORING FACILITY) - FOR DISPOSAL OF SUITABLE DREDGED MATERIAL AT THE DESIGNATED OFFSHORE DISPOSAL SITE



NOT FOR CONSTRUCTION

PROJECT
BEACHES LINK TUNNEL
NAVIGATIONAL IMPACT
ASSESSMENT

TITLE
MAP 7
DRAFT MARINE
CONSTRUCTION
MANAGEMENT PLAN

Level 14, 50 Berry Street
North Sydney NSW 2060
Australia
Tel +61 2 95545000
Fax +61 2 95509660
Email: project.admin@haskoningdhv.com
Website: www.haskoningdhv.com

Royal HaskoningDHV
Enhancing Society Together

DRAWN JFC	COORD. SYSTEM MGA ZONE 56	DATUM AHJD	DATE 03.12.2020
SCALE AT A1 AS SHOWN	REF: PA1694-RHD-BL-M2-MA-0001-CONSTRAINTS		
DRAWING No. PA1694-RHD-BL-MP-MA-0700	REVISION		

Appendix B – Roads and Maritime Services Boating Map – Middle Harbour and North Harbour



ROADS & MARITIME
Boating MAP FOR
Port Jackson Sydney, Middle and North Harbours

Boat licence and registration:
13 77 88
services.gov.au
• Boat licence
• Registration
• Change of address
• Registration transfer
• Licence payments
• Boat registration payments
• Recycled boating weather information.
13 12 36 100 or 02 9545 8556 (outside NSW)
rms.nsw.gov.au/nautical

Boat licence and registration:
13 12 36 100 or 02 9545 8556 (outside NSW)
rms.nsw.gov.au/nautical

Other maritime products:
• Boat licence
• Boat registration
• Licence payments
• Boat registration payments
• Recycled boating weather information.
13 12 36 100 or 02 9545 8556 (outside NSW)
rms.nsw.gov.au/nautical

Official charts and nautical publications
The Australian Hydrographic Service is the Commonwealth authority responsible for the production and distribution of official nautical charts and other publications. Commercial vessels over 12 metres in length are required to carry up-to-date official nautical charts. Contact the Australian Hydrographic Service
• Commercial charts
• Environmental complaints
• Hydrographic services
• Professional services
• Boat clubs
• Boat hire
• Boat insurance
• Boat maintenance
• Boat repair
• Boat safety
• Boat storage
• Boat transport
• Boat washing
• Boatyard
• Boatyard services
• Boatyard supplies
• Boatyard tools
• Boatyard waste
• Boatyard equipment
• Boatyard materials
• Boatyard services
• Boatyard supplies
• Boatyard tools
• Boatyard waste
• Boatyard equipment
• Boatyard materials

MANLY VISITOR INFORMATION
Forecast: Manly What?
www.manlywhat.com.au
Phone: (02)976-1430

CAUTION: No Anchoring inside line of Country Moorings

CAUTION: Vessels should use extreme caution when navigating in the vicinity of Cahill's Tree Bay Aquatic Reserve due to swimming and diving activities. Control Swimming Zone - Police Craft only in the vicinity of Manly Beach.

CAUTION: Vessels should use extreme caution when navigating in the vicinity of Cahill's Tree Bay Aquatic Reserve due to swimming and diving activities. Control Swimming Zone - Police Craft only in the vicinity of Manly Beach.

Note: Aquatic Reserve. For further information visit www.environment.nsw.gov.au/nationalparks

NOTE: Critical Habitat between July and February for Fairy Penguins. Special fishing and boating restrictions apply. No anchoring or any part of vessels within 50 metres of the shore.

WARNING: Commercial shipping in Port Jackson is often restricted by draft and operating requirements for narrow channels or special courses when blue buoys are shown. Small craft must not impede the passage of these ships.

SEE NAUTICAL CHARTS
AIS: 107, 202, 203 and RMS Coastal Boating Map No 9 for further information.

WARNING: Commercial shipping in Port Jackson is often restricted by draft and operating requirements for narrow channels or special courses when blue buoys are shown. Small craft must not impede the passage of these ships.

NOTE: It is compulsory to carry certain safety equipment including a lifejacket (one for all on board, while navigating in the creek etc.). It is also recommended that lifejackets be worn while crossing the entrance to Sydney Harbour.

Further information on what you should carry can be found in the RMS Safe Boating Handbook available from all RMS offices or by visiting www.rms.nsw.gov.au



WARNING: OVERHEAD AND SUBMARINE CABLES AND PIPES CROSS THESE WATERWAYS AT VARIOUS LOCATIONS AND ARE USUALLY INDICATED BY WARNING NOTES ON THE SHORE. CAUTION SHOULD BE EXERCISED AT ALL TIMES WHILE NAVIGATING IN THE VICINITY OF THESE CROSSINGS.



YOU'RE THE SKIPPER YOU'RE RESPONSIBLE!



CAUTION: ROWERS USE THESE WATERWAYS. PLEASE AVOID CREATING UNNECESSARY WASH.



CAUTION: ROWERS USE THESE WATERWAYS. PLEASE AVOID CREATING UNNECESSARY WASH.

NOTE: Bridge clearance heights shown in RED are in metres above the Highest Astronomical Tide (HAT).

CONTINUES ON other side

Appendix C – Northbridge Sailing Club Courses

7 NSC SAILING COURSES

TASAR, NS14

WHITE NW	GREEN SE-E	BLUE NE	RED E-NE	YELLOW W	BLACK S
Start – SL (P)	START	START	START	START	START
CL (P)	SP (P)	PH (P)	SP (P)	SB (S)	LB (P)
BP (S)	BL1 (P)	WI (S)	SB (S)	CL (S)	BL1(P)
LB (S)	QH (S)	SL (S)	SL (S)	BP (P)	CC1 (S)
SL (P)	BL2 (P)	LB (P)	CP (P)	BL2 (S)	PH (P)
CL (P)	SB (GATE)	SP (P)	SP (P)	SP (S)	CC2 (P)
PH (P)	SP (P)	CL2 (S)	BL1 (P)	SB (S)	LB(P)
SL (P)	BL1 (P)	PH (P)	FP (S)	SP (S)	BL1(P)
CL (P)	QH (S)	CL2 (S)	SB (S)	SB (S)	CC1(S)
BP (S)	BL2 (P)	PH (P)	SP(P)	CL (S)	PH(P)
LB (S)	SB (GATE)	WI (S)	SB(S)	BP (P)	CC2(P)
SL (P)	SP (P)	SL (S)	FINISH	BL2 (S)	LB(P)
BP (S)	SB (GATE)	LB (P)		SP (S)	CC2(P)
FINISH	SP (P)	SP (P)		FINISH	LB(P)
	BL1 (P)	CL2 (S)			BL1(P)
	QH (S)	FINISH			CC1 (S)
	BL2 (P)				PH (P)
	SB (GATE)				CC2 (P)
	FINISH				FINISH

LASER

WHITE NW	GREEN SE-E	BLUE NE	RED E-NE	YELLOW W	BLACK S
Start – SL (P)	START	START	START	START	START
CL (P)	SP (P)	PH (P)	SP (P)	SB (S)	LB (P)
BP (S)	BL1 (P)	WI (S)	SB (S)	CL (S)	BL1(P)
LB (S)	QH (S)	SL (S)	SL (S)	BP (P)	CC1 (S)
SL (P)	BL2 (P)	LB (P)	CP (P)	BL2 (S)	PH (P)
CL (P)	SB (GATE)	SP (P)	SP (P)	SP (S)	CC2 (P)
PH (P)	SP (P)	CL2 (S)	BL1 (P)	SB (S)	LB(P)
SL (P)	SB (GATE)	PH (P)	FP (S)	SP (S)	CC2(P)
CL (P)	SP (P)	CL2 (S)	SB (S)	SB(S)	LB(P)
BP (S)	BL1 (P)	PH (P)	SP(P)	SP (S)	BL1(P)
LB (S)	QH (S)	WI (S)	SB(S)	FINISH	CC1(S)
SL (P)	BL2 (P)	SL (S)	FINISH		PH(P)
BP (S)	SB (GATE)	LB (P)			CC2(P)
FINISH	SP	SP (P)			LB (P)
	SB (GATE)	CL2 (S)			CC2(P)
	FINISH	FINISH			FINISH



MOTH/OPEN

WHITE NW	GREEN SE-E	BLUE NE	RED E-NE	YELLOW W	BLACK S
Start – SL (P)	START	START	START	START	START
CL (P)	SP (P)	PH (P)	SP (P)	SB (S)	LB (P)
BP (S)	BL1 (P)	WI (S)	BL1 (P)	CL (S)	BL1(P)
LB (S)	QH (S)	SL (S)	LB (S)	BP (P)	CC1 (S)
SL (P)	BL2 (P)	CL2 (S)	SB (S)	BL2 (S)	PH (P)
CL (P)	SB (GATE)	SP (P)	SL(S)	SP (S)	CC2 (P)
PH (P)	SP (P)	LB (P)	CP (P)	SB (S)	LB (P)
SL (P)	BL1 (P)	CL2 (S)	SP(P)	CL (S)	BL1(P)
CL (P)	QH (S)	PH (P)	SB(S)	BP (P)	CC1 (S)
BP (S)	SB (GATE)	WI (S)	SP(P)	BL2 (S)	PH (P)
LB (S)	SP (P)	SL (S)	BL1(P)	SP (S)	CC2 (P)
SL (P)	BL1 (P)	CL2 (S)	LB(S)	FINISH	LB (P)
BP (S)	QH (S)	FINISH	SB(S)		BL1(P)
FINISH	BL2 (P)		FINISH		CC1 (S)
	SB (GATE)				PH (P)
	FINISH				CC2 (P)
					FINISH

FLYING 11

WHITE NW	GREEN SE-E	BLUE NE	RED E-NE	YELLOW W	BLACK S
Start – SL (P)	START	START	START	START	START
CL (P)	SP (P)	PH (P)	SP (P)	SB (S)	LB (P)
BP (S)	SB (GATE)	LB (P)	BL1 (P)	CL (S)	BL1(P)
LB (S)	SP (P)	SP(P)	LB (S)	BP (P)	CC1 (S)
SL (P)	BL1 (P)	CL2 (S)	SB (S)	BL2 (S)	PH (P)
CL (P)	QH (S)	PH (P)	SP (P)	SP (S)	CC2 (P)
PH (P)	BL2 (P)	LB (P)	BL1 (P)	SB (S)	LB (P)
SL (P)	SB (GATE)	SP (P)	LB (S)	SP(S)	BL1(P)
CL (P)	SP (P)	CL2 (S)	SB (S)	FINISH	CC1 (S)
BP (S)	SB (GATE)	FINISH	FINISH		PH (P)
FINISH	FINISH				CC2 (P)
					FINISH

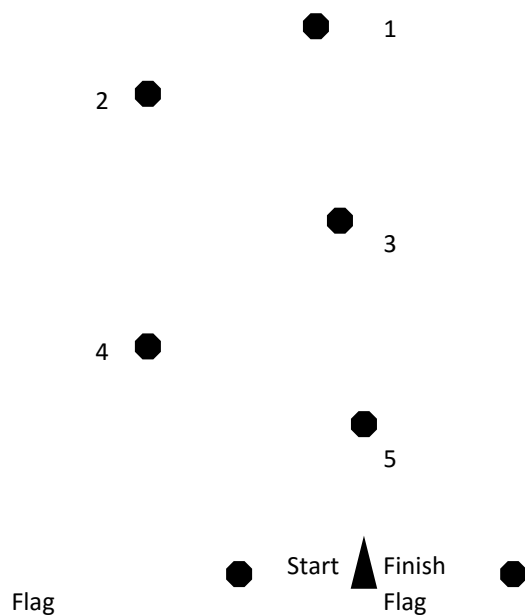
OPTIMIST

Optimist courses are as decided by the Junior Captain.

A briefing will be held in the Clubhouse each race day.



COMMODORE'S CUP, PRESIDENT'S PLATE & WILLOUGHBY SHIELD COURSES and AFTERNOON SPRING & SUMMER 2 RACE DAYS (if later designated as such)



A red or green flag will be flown from the start boat indicating a port or starboard course respectively. A numerical number board will indicate either a 3 or 4 lap course.

3 Lap Course

Start-1-2-3-4-5* -1#-5-1-2-3-4-Finish

4 Lap Course

Start-1-2-3-4-5-1-5* -1#-2-3-4-5-1-Finish

Port Course

All marks except mark 3 to be left to port

Starboard Course

All marks except mark 3 to be left to starboard

*Optimists to sail from this mark to finish

Flying 11s to sail from this mark to finish

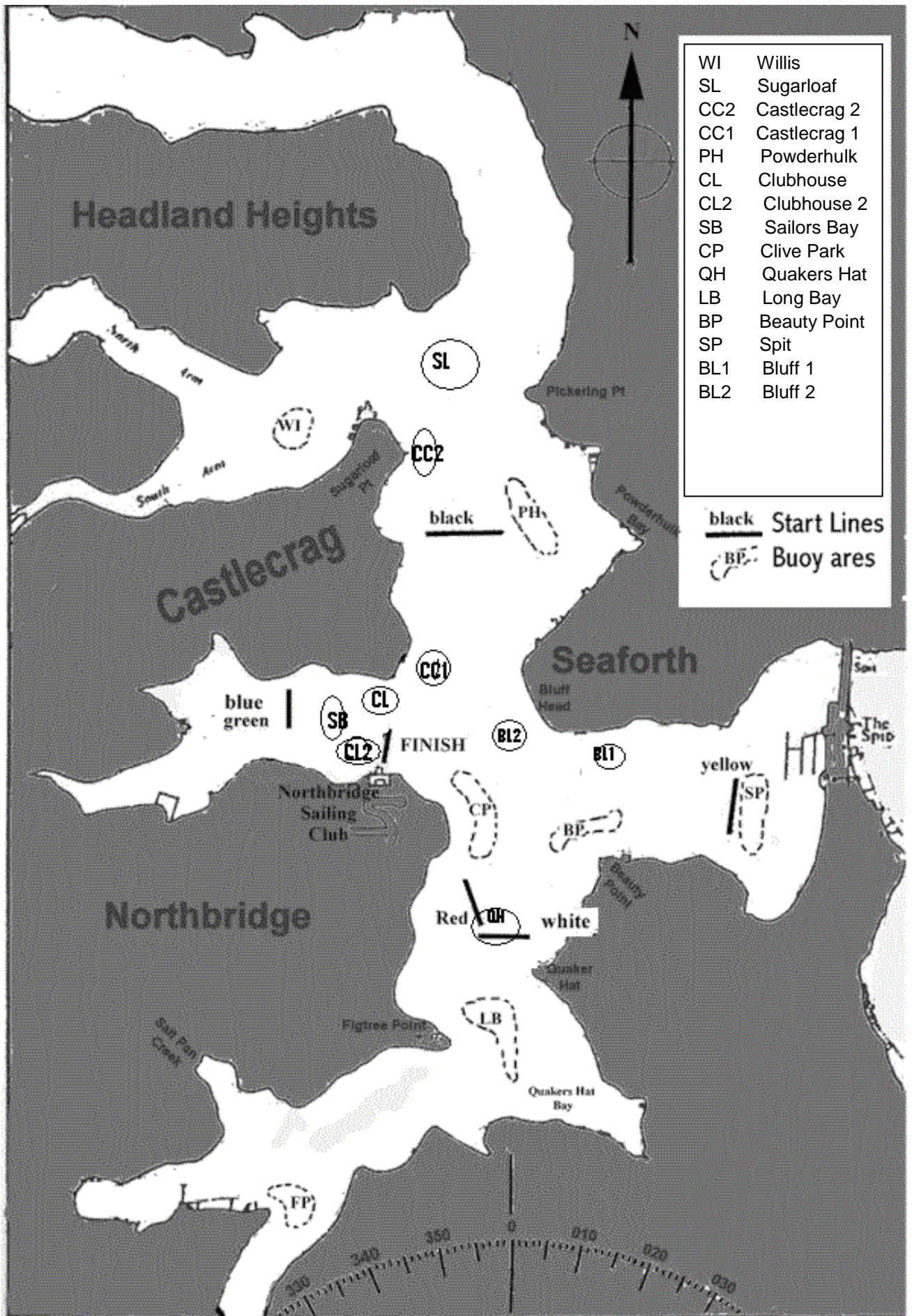
Note: Port Course Shown

8 BOUY POSITIONS AND MAP

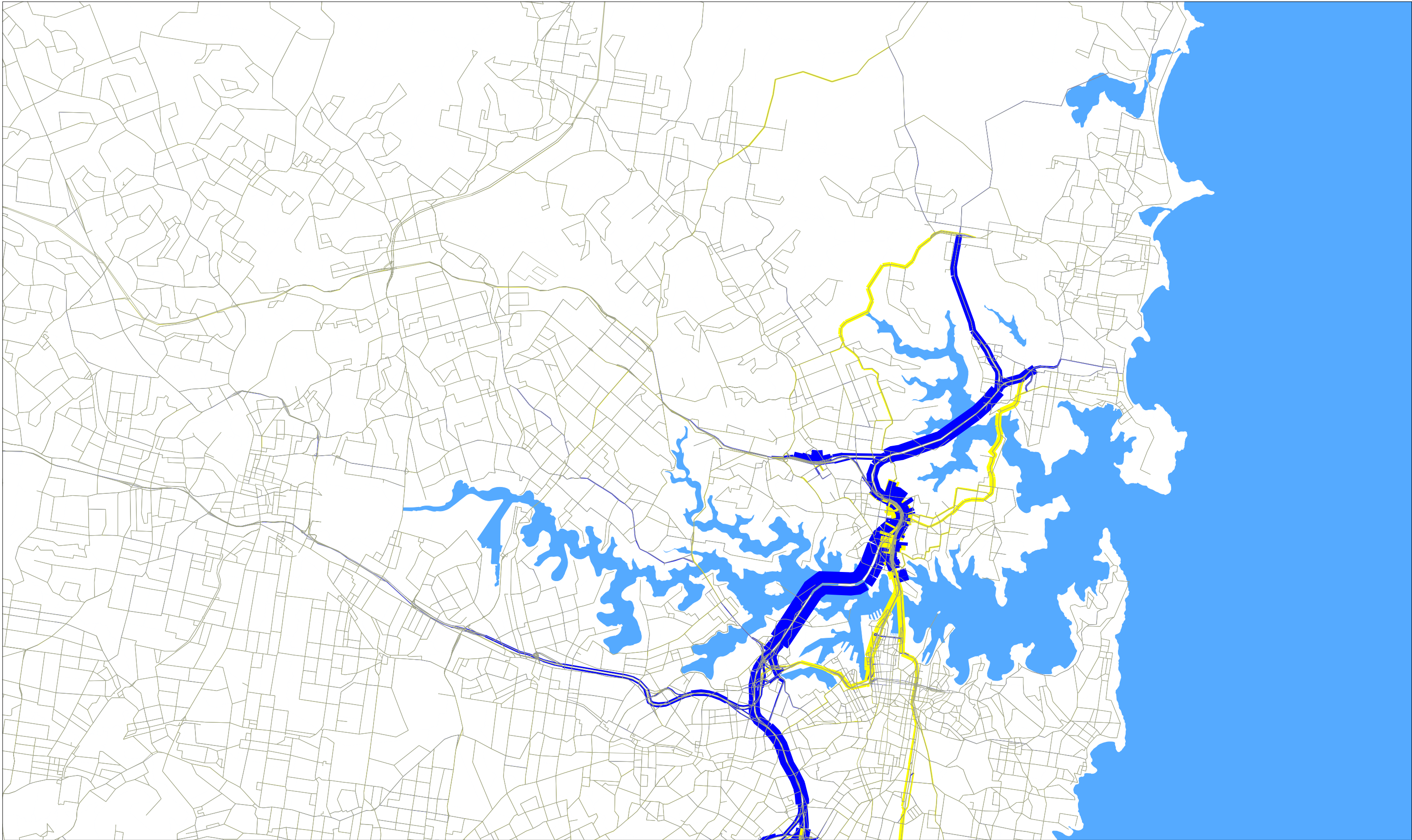
(In ringed area, according to wind direction)

SL	Sugarloaf in line with beacon
WI	Deep in Sugarloaf
SB	South of Castlecrag shore
CP	North-East of Clive Park Pool
BL1	100 m. off the Bluff, 25m towards Spit
BL2	100m off the Bluff, 25m towards Sailors Bay
SP	150 m. off Spit Marina
BP	At Beauty Point
PH	In Powder Hulk Bay off Seaforth Moth Sailing Clubhouse
CC1	Off Castlecrag opposite Seaforth bluff
CC2	Off Castlecrag near entry to sugarloaf
CL	Clubhouse
CL2	50m off scout pontoon (shallow SB on close to southern shore)
FP	Folly Point
FIN	150 m. North of Northbridge Sailing Clubhouse
LB	Long Bay
QH	Quakers hat (Shallow Long Bay)
Starting Line Shown e.g. ----- Black	







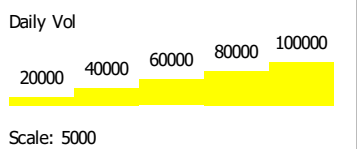
Annexure B. Forecast traffic volume difference plots

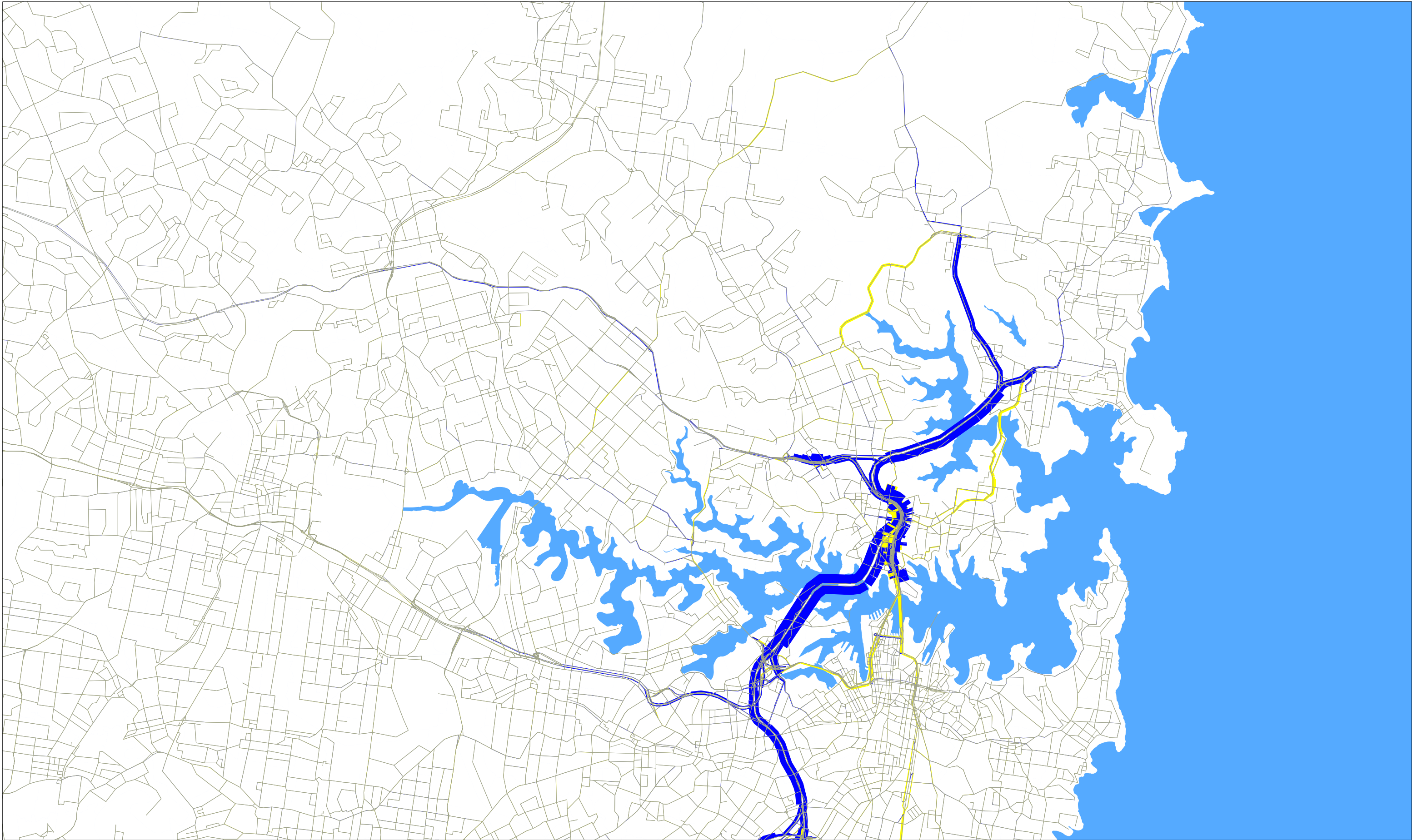


Average Weekday Daily Total Vehicle Volume Comparison
SMPM1.0 - LU16
2037 M1406 Cumulative Case Dec 2018 Design
(WCX + Gateway + F6 Ext + WHT + BL + WFU)
vs
2037 M0808 Base Case (WCX only)

LEGEND
 Difference in Daily Vehicle Volumes Average Weekday Traffic
 (Scenario 1 - Scenario2)

 Decrease in flows
 Increase in flows

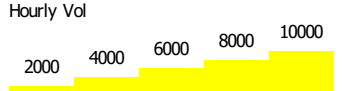




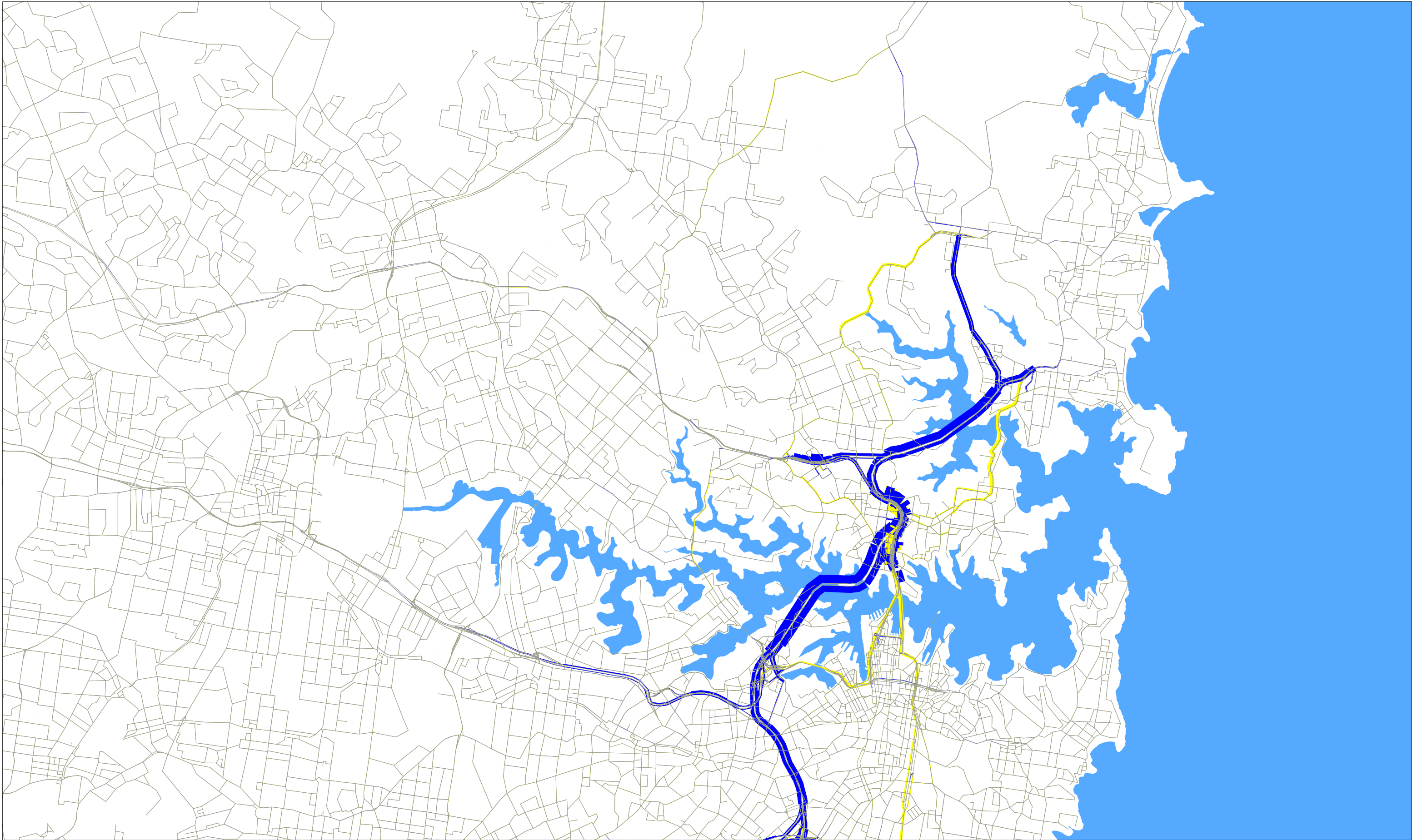
**Total AM Hourly Volumes Comparison
 SMPM1.0 - LU16
 2037 M1406 Cumulative Case Dec 2018 Design
 (WCX + Gateway + F6 Ext + WHT + BL + WFU)
 vs
 2037 M0808 Base Case (WCX only)**

LEGEND
 Difference in AM Hourly Vehicle Volumes Average Weekday Traffic
 (Scenario 1 - Scenario2)

Decrease in flows
 Increase in flows





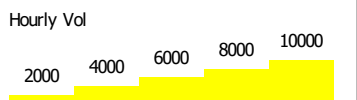
Scale: 500



Total PM Hourly Volumes Comparison
SMPM1.0 - LU16
2037 M1406 Cumulative Case Dec 2018 Design
(WCX + Gateway + F6 Ext + WHT + BL + WFU)
vs
2037 M0808 Base Case (WCX only)

LEGEND
 Difference in PM Hourly Vehicle Volumes Average Weekday Traffic
 (Scenario 1 - Scenario2)

 Decrease in flows
 Increase in flows



Scale: 500