THE QUAYS MARINA RECONFIGURATION

AQUATIC ECOLOGY IMPACT ASSESSMENT

Figure 1 Drone View of The Quays Marina Church Point (24 April 24).

REPORT PREPARED FOR THE QUAYS MARINA (CHURCH POINT)

FINAL REPORT NOVEMBER 2024

1 INTRODUCTION

Northern Development Assessment (NDA) is seeking to lodge a development application on behalf of The Quays Marina at Church Point **(Figure 1**) for a reconfiguration of the existing marina facility with an extra Arm C offshore and parallel to the inner Arms A and B (**Figure 2**) and the relinquishment of swing moorings currently under the control of the marina. The proposal is detailed on a plan prepared by Bellingham Marine 4336-02 dated 7 February 24 and a copy of this plan is provided in **Appendix A**.

DPH&I provided SEARs 1960 for the project on 10 July 2024, as the project is designated development under Part 4 of the *Environmental Planning and Assessment Act 1979* and is also integrated development that requires *inter alia* an approval under the *Fisheries Management Act 1994* (FMA). The SEARs include DPI Fisheries assessment requirements, as detailed in the Fisheries SEARs response C24/477 dated 13 June 2024.

NDA on behalf of The Quays Marina requested Marine Pollution Research Pty Ltd (MPR) to prepare an aquatic ecology assessment report to meet the aquatic ecological requirements of the SEARS.

1.1 Site Location and Landscape Description

The Quays Marina is located on generally reclaimed land north of Pittwater Road at Church Point on the southern shore of Pittwater (**Figures 1 & 2**). The Marina is located on a peninsular section bounded by three valleys and the Church Point-Bayview hinterland draining to Pittwater either side of the marina has a relatively rugged topography with steep sandstone hills and incised valleys throughout its residential area. Its soil characteristics are largely derived from Hawksbury Sandstone, where the soils are mainly sandier and shallow overlaying bedrock in some sections.

The entire foreshore along this section of Pittwater and south of the marina is taken up with the public main road, Pittwater Road. This road reclamation is bounded by a block sandstone seawall that also provides a public footpath with ornamental strip planting using mainly native indigenous planting. Storm water from the five valleys and from the road easement are discharged directly to high intertidal sandy shores via three stormwater drains all more than 100 m away from The Quays site (**Figure 2**). Whilst the foreshore bays for these stormwater discharges are primarily broad sandy high to low intertidal beaches, the Marina reclamation footprint is bounded by inshore mangrove growth on both sides. The marina Arm C is located at least 110m offshore from the marine outer reclamation seawall and more than 200m offshore from the inner beach edges.

Figure 2 Site map with 10m contours and Hydrolines. Proposed Arm C shown in red and study site shown in orange.

1.2 Available Information on Aquatic Habitats

In terms of existing aquatic ecological habitat information, the DPI Fisheries NSW marine vegetation habitat mapping in 2019 for Pittwater indicates small beds of *Zostera* seagrass in the shallows north and south of the existing marina footprint, plus mangroves lining the riparian edge both to the north and south of the site (**Figure 3**).

Comparison against earlier Fisheries' mapping in 2000 and 2005 (**Figure 3)** indicate a drastic decrease in seagrass cover, particular for *Posidonia* seagrass, and an overall increase in mangrove cover.

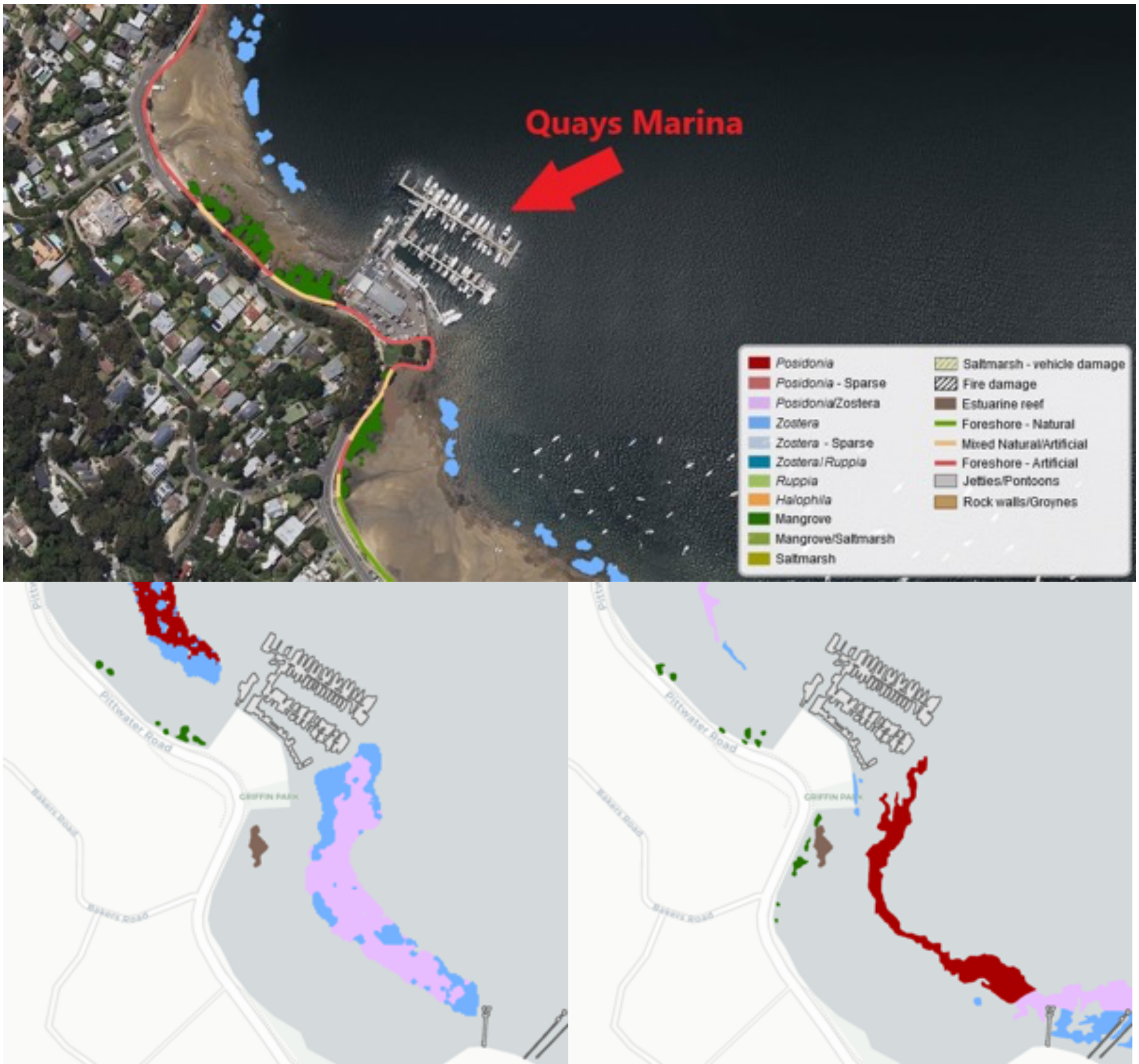

Figure 3 DPI Fisheries mapping 2000 bottom left, 2005 bottom right and 2019 top.

2 AQUATIC HABITATS AND ECOLOGY

A dive survey and drone photography of the site was undertaken on 24 April 2024 with an additional confirmation dive on 20 June 2024. On both survey days waters were clear with good underwater visibility. **Figures 4 and 5** shows the main aquatic habitats. Aquatic habitats at the site are described as follows:

- The riparian edge of the existing marina land site is lined by a sandstone block seawall above clean marine sands and some sections of rock rubble. Grey mangroves are located inshore on both the eastern and western edges of the site (**Figure 5**).
- Scattered rock rubble inshore adjacent the wall supported Neptune's necklace *Hormosira Banksii* and *Sargassum sp* (**Figure 6**).
- Seabed sediments grade from clean marine beach sands inshore to silt sands offshore, increasing in silt fraction with depth.
- Multiple *Zostera* beds are located to the east of the site and line parts of the shallow bay infill sandbar sections (**Figure 7**), and the slightly deeper seagrass beds either side of the marina are predominantly mixed *Halophila* seagrass with the invasive pest algae species *Caulerpa* and very small amounts of *Zostera* seagrass throughout (**Figures 8 & 9**).
- Most of the seagrass areas were smothered in a thick filamentous brown algae (winter weed) at the time of the survey.
- The intertidal sections of the marina piles supported a sparse band of Sydney rock oysters, *Saccostrea glomerata,* and subtidal pile sections supported barnacles, *Dictyota sp*, tubeworms, sponges, tunicates, branching bryozoans and large encrusting bryozoa (mainly *Schizoporella sp.*).
- The wetted surfaces of the marina floating pontoons supported a similar assemblage of marine growth including barnacles, *Dictyota sp*, *Padina sp,* some encrusting sponges, tunicates, encrusting bryozoa (mainly *Schizoporella sp.*) (**Figure 10**).
- Sediments underneath the existing marina structure consisted of silty sands with some scattered rock and rubble supporting small amounts of *Sargassum sp* (**Figure 11**). Sparse *Caulerpa* was also found in some areas underneath the existing structure (**Figure 12**), particularly on the western side. The inshore eastern side seabed had large amounts of leaf litter and overlaying organic material (**Figure 13**), likely deposited from the eastern stormwater outlets.
- Seabed sediments underneath the marina Arm C proposal footprint were bare silty sands with an abundance of infaunal burrows (**Figure 14**).
- There was no marine vegetation found in the areas proposed for the new berths or under (or in the vicinity of) the new floating Arm C pens
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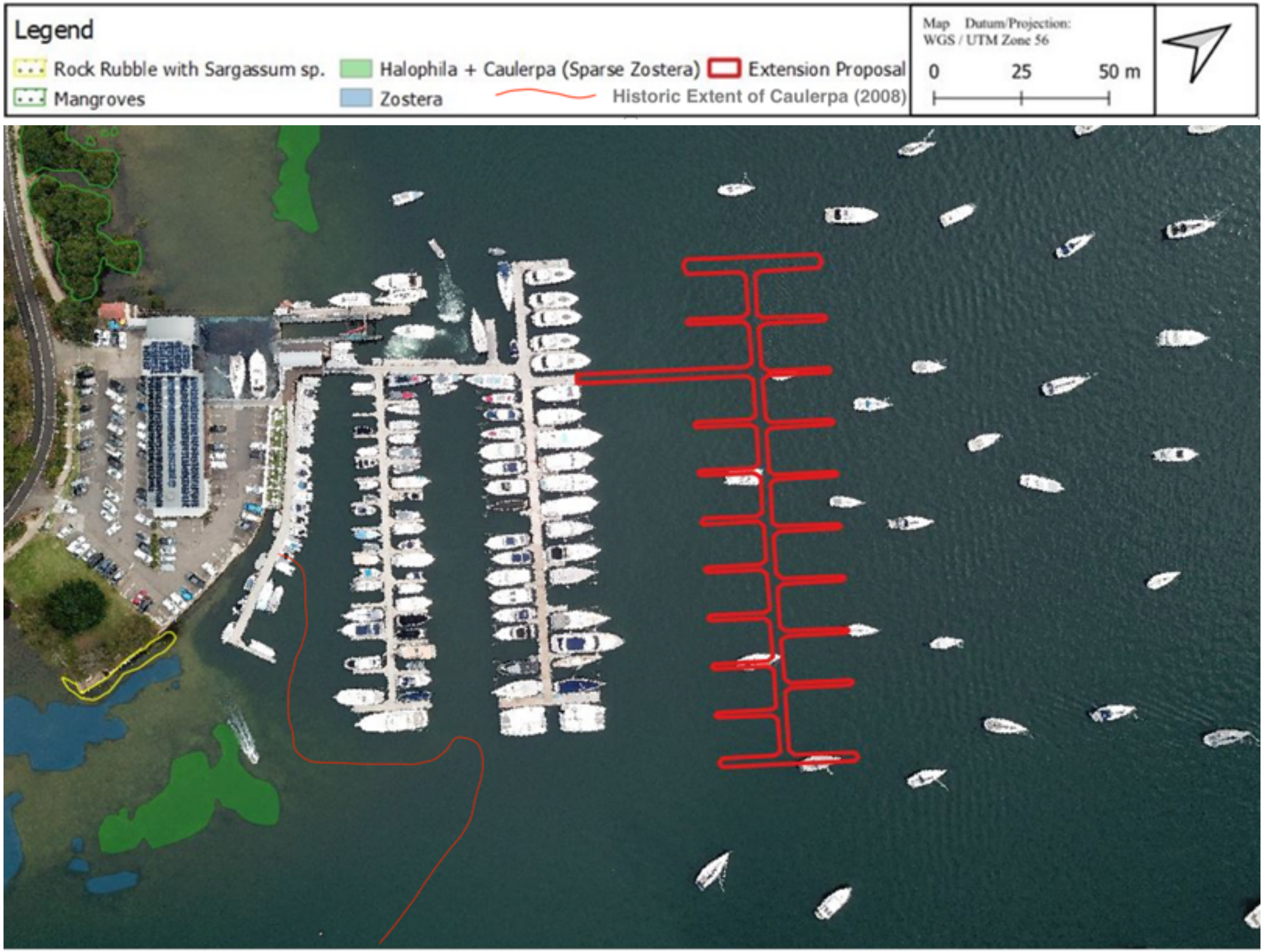

Figure 4 Drone image of the site showing the main aquatic habitats and the proposed new Arm C shown in red.

Figure 5 SixMap View of site showing the extent of the intertidal sand flats either side of the marina and the inshore Grey Mangrove distribution.

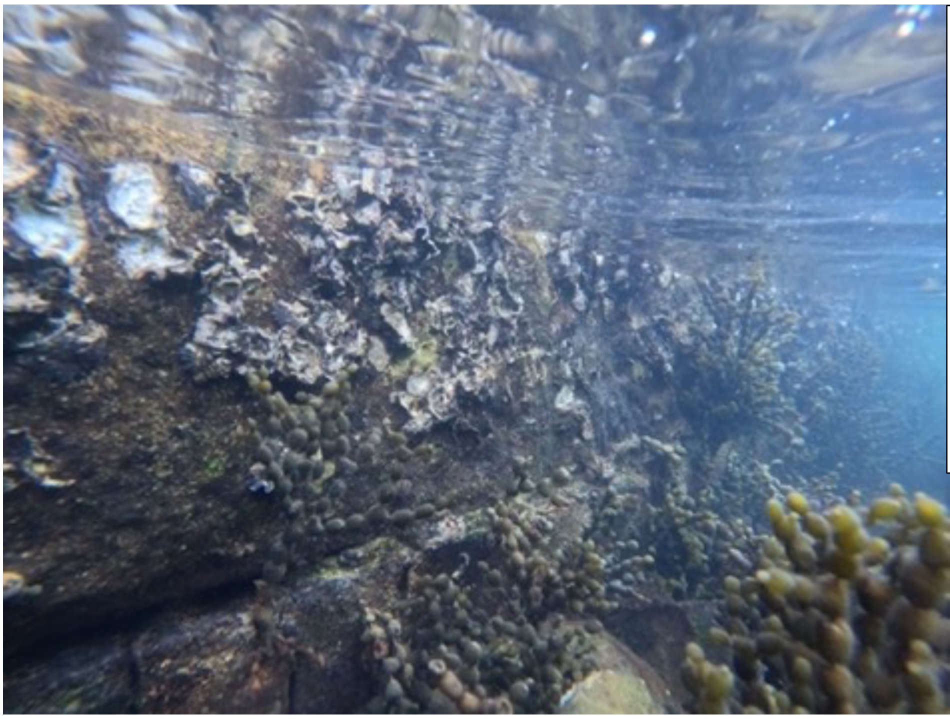

Figure 6 Sandstone seawall with intertidal oyster growth and rock rubble with Neptune's necklace.

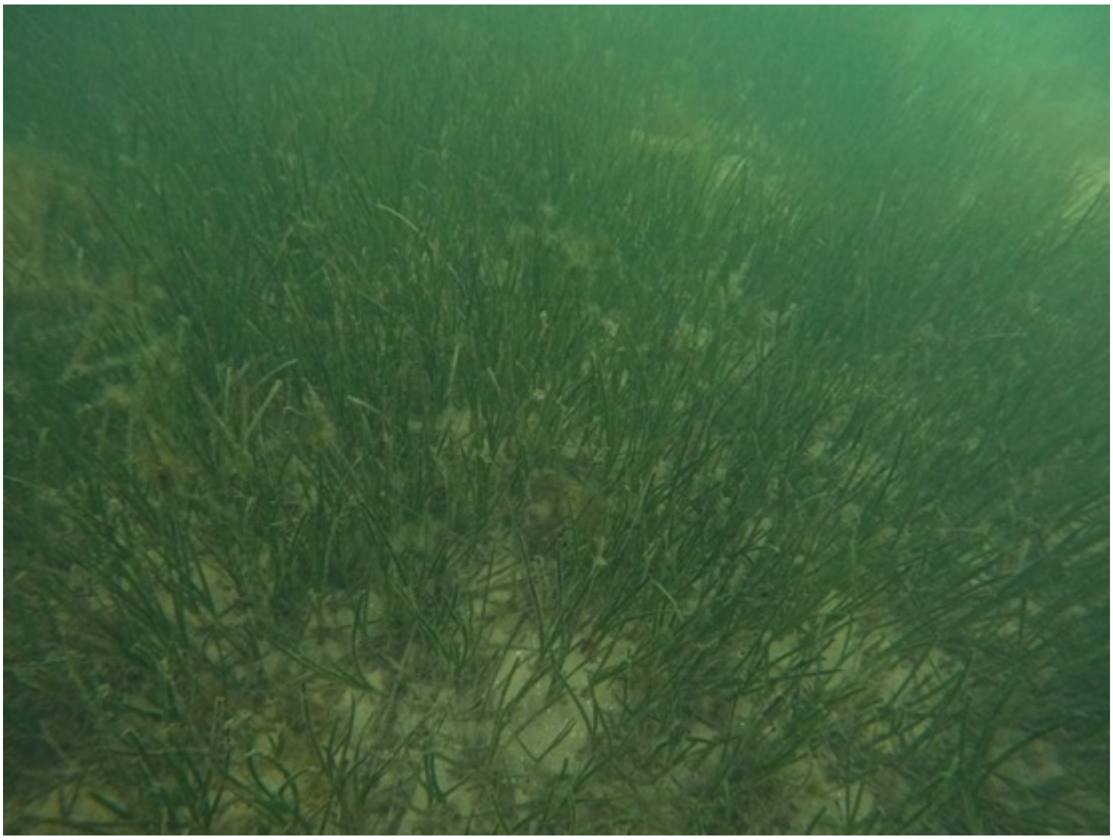

Figure 7 *Zostera* seagrass bed on sand bar edges east of marina.

Figure 8 Thick brown algal cover across *Halophila/ Caulerpa* bed, with sparse *Zostera* to the east of the marina.

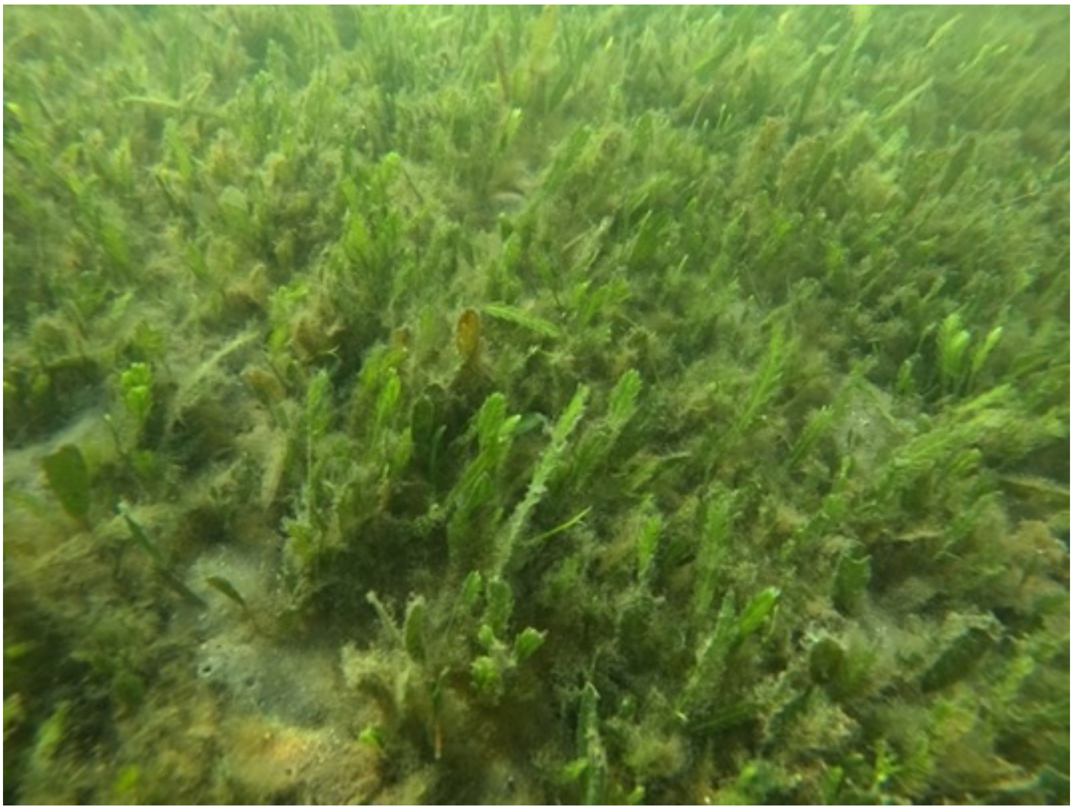

Figure 9 Inshore *Halophila/ Caulerpa* bed. This mixed bed does not extend offshore beyond Arm A and the *Caulerpa* bed does not extend beyond the Arm A to Arm B fairway.

Figure 10 Pontoon wetted surfaces areas support an assemblage including encrusting bryozoa, sponges and marine algae.

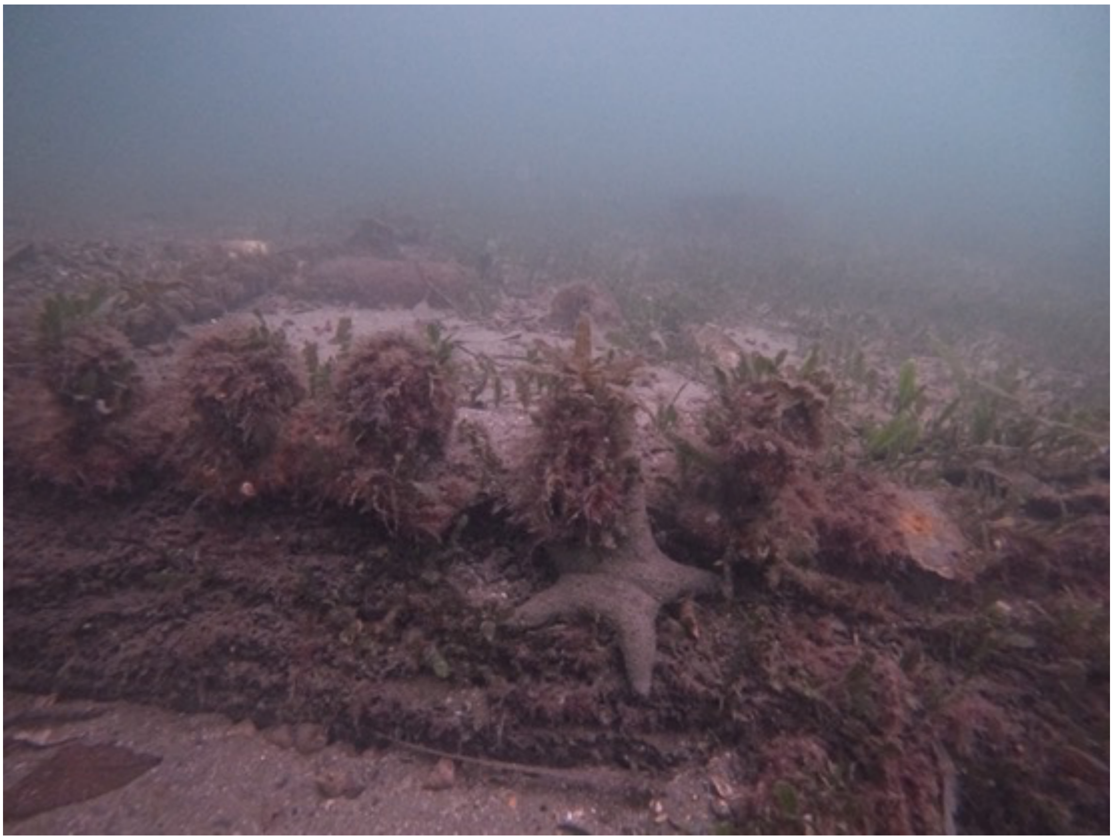

Figure 11 Small amount of *Sargassum sp* and algal growth on rubble under existing marina inner arm.

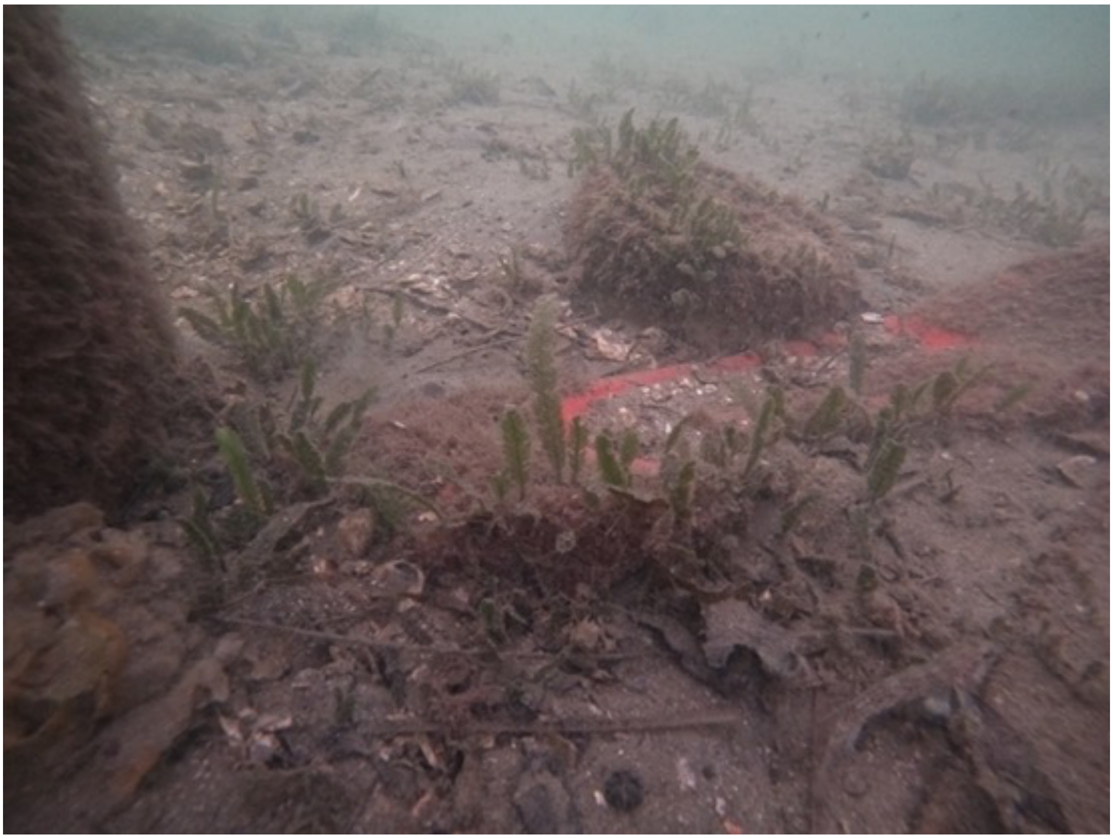

Figure 12 *Caulerpa* on silt sediments and on rubble underneath existing marina inner arm.

Figure 13 Thick cover of leaf litter and organic matter on eastern side of marina arm B.

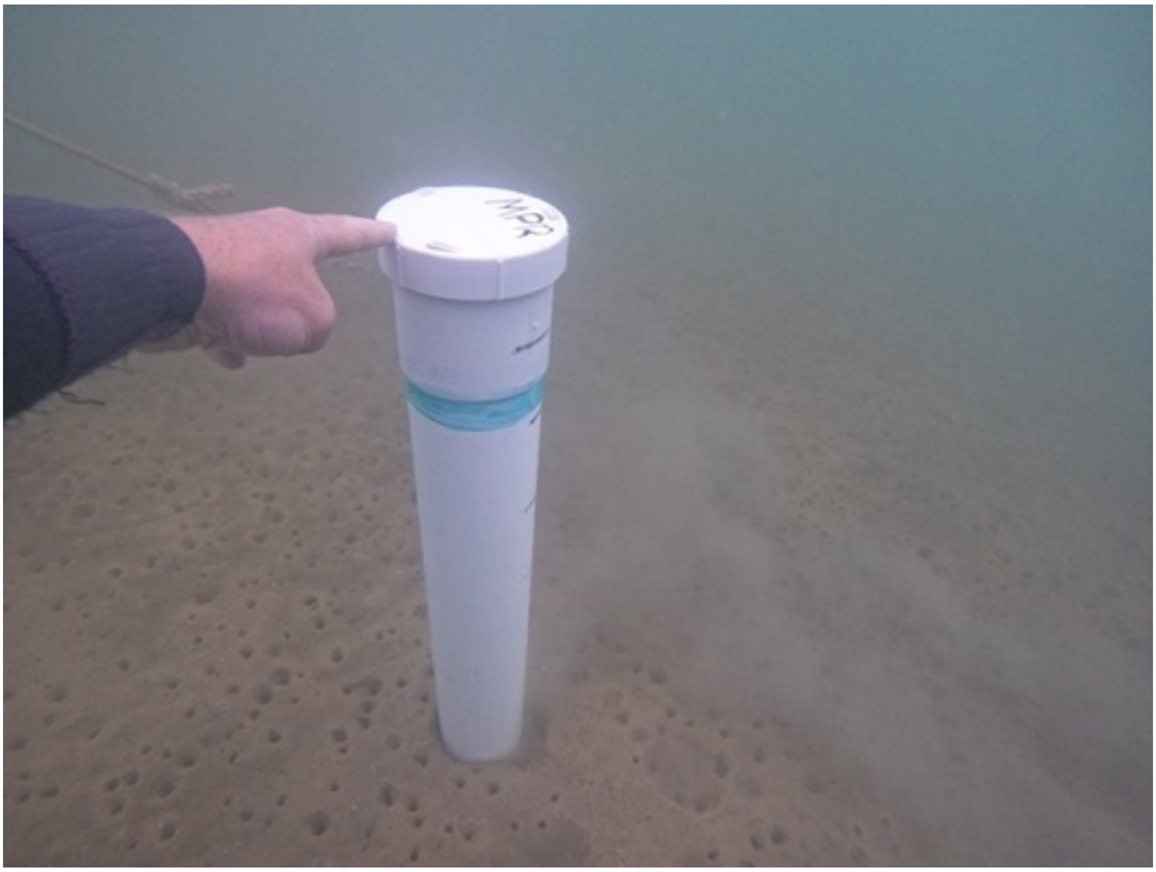

Figure 14 Soft silt sands offshore from the marina with abundant infauna burrows

2.1 Threatened Species, Endangered Ecological Communities & Protected Species

The NSW *Fisheries Management Act 1994* (FMA), NSW *Biodiversity Conservation Act 2016* (BCA) and the Commonwealth *Environment Protection Biodiversity Conservation Act 1999* (EPBC) require that any proposed activity be assessed with respect to its potential impact on species or ecological communities listed as threatened under the Threatened Species Schedules of the Acts or listed as migratory species under the EPBC Act. The FMA and EPBC Act list a number of marine and estuarine shark and teleost fish species as Vulnerable Species under Schedule 5 of the Act. Syngnathiformes (seahorses, sea-dragons, pipefish, pipe-horses and sea-moths) are protected, under both the EPBC Act and the FMA, with Whites Seahorse *Hippocampus whitei* listed as *endangered* under the FMA. Seagrasses are protected under the FMA, and *Posidonia australis* seagrass is listed under both the FMA and EPBC Act as an *Endangered Ecological Community* in Pittwater.

- There are three FMA threated species (Grey Nurse Shark, Great White shark plus Black Rock Cod) known from coastal waters at the mouth of Pittwater and White's Seahorse (listed as Threatened under the FMA) is known from the Pittwater Estuary.
- The two shark species could conceivably visit the outer estuary from time to time, and would only be expected in the estuary when in pursuit of mobile prey species. They are unlikely to penetrate the estuary to the Pittwater southern shores.
- The Black Rock Cod *Epinephelus daemelli* has been recorded from the outer estuary, however there was no suitable rock cave or crevice habitat found at or near the site.
- At least two seahorse species (White's Seahorse *Hippocampus whitei,* Bigbelly Seahorse *Hippocampus abdominalis*) and three pipefish (Wide-body Pipefish *Stigmatopora nigra*, Stick Pipefish *Trachyrhamphus bicoarctatus* and Hairy Pipefish *Urocampus carinirostris* are expected or known from Pittwater. White's Seahorse was listed as *Endangered* under the FMA in 2019 and under the Commonwealth EPBC Act in 2020:
  - Whilst the *Zostera* seagrass beds to the east of the existing marina are of sufficient size to provide potential habitat for White's Seahorses, they are unlikely to occur within the *Halophila/ Caulerpa* beds closer in and around the marina due to lack of camouflage habitat from these species and they would not occur offshore on the bare sandy sediment habitats at the proposed Arm C site.
  - Whilst seahorses could conceivably colonise and reside on vessel mooring blocks if these blocks supported sufficient encrusting and branching biota to provide adequate food plus shelter and camouflage protection from predatory fish, it is considered unlikely for the combined reasons that most mooring blocks and associated tackle have to be properly maintained as part of the licence conditions that require annual inspections which means that they are both disturbed and cleaned to the extent that there is unlikely to be appropriate habitat available to support seahorses. This is particularly so for commercial moorings that have an

overall higher insurance-based incentive to lift, check and clean mooring tackle on a timely basis.

  - Given the spacing required for the laying out of mooring blocks to allow vessels to swing freely on the surface with the wind without colliding with other vessels, each mooring block becomes, in effect, an isolated rocky outcrop on a sandy seabed - which severely limits the ability of seahorses, which are poor swimmers and depend almost entirely on camouflage to protect them from predatory fish - to find and colonise these isolated habitats.

- There are three seagrass species recorded from Pittwater; *Zostera capricorni* and *Halophila ovalis*, are both protected under the FM Act and *Posidonia australis* seagrass is listed under both the FM and EPBC Acts as an Endangered Ecological Community in Pittwater. Both *Zostera* and *Halophila* seagrass was located inshore around the existing marina structure but there are no seagrass or any other marine vegetation on the seabed under the proposed Arm C walkways and mooring pens.

With regard to other aquatic species or ecological communities listed under the NSW *BCA* and the Commonwealth *EPBC Act:*

- Little Penguins that are likely to be associated with the breeding colony on Lion Island are observed fishing and feeding throughout Pittwater and would likely visit the site from time to time.
- Various listed cetaceans (whales and dolphins), marine mammals (seals and sea lions), marine reptiles (turtles and sea-snakes) and sea-birds (ocean birds and waders) are known from the area and are known to penetrate the estuary to and beyond the study area. Seals are more commonly seen in southern Pittwater waters as there is a developing colony at Barrenjoey headland.
- Whilst the intertidal sand flats either side of the marina development provide valuable potential feeding habitat for a variety of sea- and wading birds, the utilisation of this resource is limited due to the overall urbanisation of the area that results in there being very little safe roosting habitat that is essential for these birds during high tides. Accordingly, the utilisation of this resource is sporadic and infrequent.

Of the listed species that may occur in the vicinity of the site, most would be utilising the resources of the inshore intertidal sand flats or the adjacent waters as transients or opportunistic feeders, and it is concluded that, other than the Whites seahorse and other Syngnathiformes within the inshore seagrass to the east of the marina, it is unlikely that there would be any threatened species listed under the FMA, BCA and EPBC Act residing within the locality.

2.2 Key Fish Habitat Assessment

With regard to the Fisheries NSW waterway classification scheme as shown in Table 2 of the NSW Fisheries 2013 Policy and Guidelines document, Pittwater is a Class 1 "Major key fish habitat" (KFH) by virtue of it being an estuarine waterway. In regard to the sensitivity classification of the specific habitats at the site (as defined in Table 1 of Fisheries NSW 2013):

- The *Zostera and Halophila* seagrass beds to the east of the Quays Marina site as indicated in **Figures 3 and 4** are Type 1 "highly sensitive KFH".
- The mangrove stands shown in **Figure 5** and the rock and rubble habitats with marine Sargassum algal growth at the base of the Marina seawall are Type 2 "moderately sensitive KFH.
- The remaining shallow inshore un-vegetated marine sand and shell that support the pest algae *Caulerpa* are Type 3 "minimally sensitive" KFH.
- The inshore sand flats either side of the marina (**Figure 5**) plus the offshore seabed sediments under the existing Arm B and proposed marina arm C (**Figure 14**) are considered Type 2 "moderately sensitive KFH, due to the relatively high density of infauna burrows.

3 SEDIMENT AND WATER QUALITY ANALYSIS

MPR collected sediment and water samples from four sites located under existing and proposed marina arms (**Figure 15**) on 24 April 2024 to provide an assessment of present sediment and water quality. Water depths on the day were: 6.3m at EO, 7.8m at WO, 7.1m at WI and 4.5m at EI

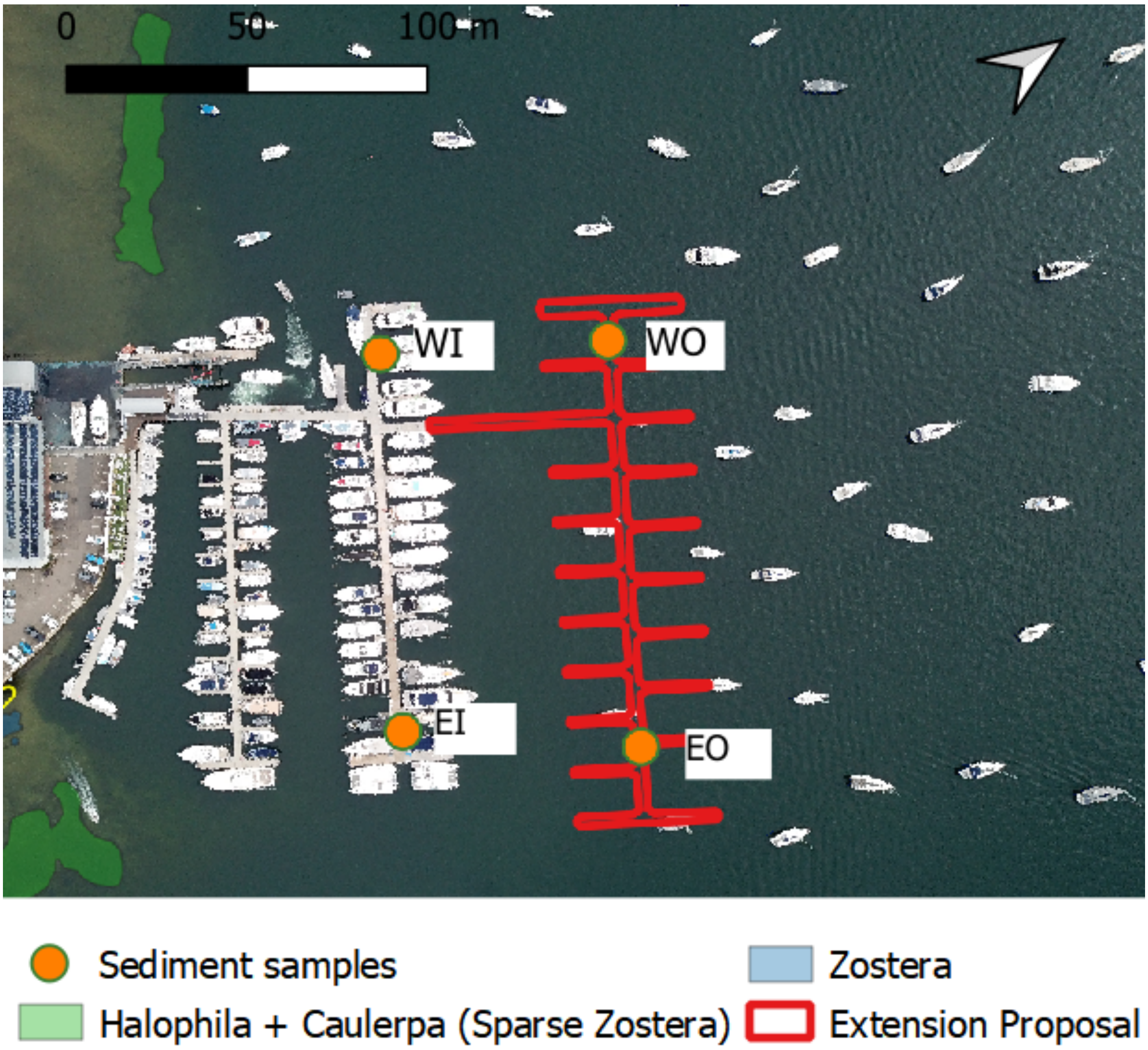

Figure 15 Sediment and water quality sampling site map.

3.1 Sediment Sampling Results

MPR divers collected four core samples using a 100mm diameter by 0.75m long PVC corer (**Figure 11**). At each site, the corer was pushed to retrieve a 500mm deep core, the corer cap was then screwed into place and the core was removed intact. Once collected and brought to the surface, the cap was removed and the cores were layered out into a pre-washed white polythene tray, photographed and measured. The core samples were then each divided into two equal parts – an upper (surface) part and a lower (bottom) part.

These were individually homogenised with sub-samples placed into pre-washed sample jars or bags supplied by the analysis laboratory (Australian Laboratory Services – ALS). Samples were then placed into a chilled esky and delivered to the ALS sample receipt depot that same afternoon. The lab was requested to undertake particle size analysis, Total Organic Carbon concentrations, plus metal analysis for metals that are commonly associated with urbanised and industrialised estuarine localities, following a recommendation by Birch and Olmos (2008) who found that the correlation between three metals (Copper, Lead, and Zinc) with other contaminants, including Organochloride pesticides (OCPs), Polychlorinated Biphenyls (PCBs) and Polynuclear Aromatic Hydrocarbons (PAH), from 103 sites in Port Jackson and nearby estuaries was significant ($r^2 = 0.63$, $p < 0.05$), and concluded that sediment-bound heavy metals data can provide the spatial extent and magnitude of chemical change, as well as the risk of biological stress attributable to contamination in estuarine ecosystems

Sediment sample photography and field notes are provided in **Appendix Table 1 and Appendix Figures 3 & 4**.), Results of the MPR sediment sample program are provided in **Appendix Table 3,** and the full laboratory analysis reports are appended to this report:

- Particle size analysis confirmed that the seabed sediments under the existing Arm B western end and at both the proposed Arm C sampling locations are uniformly sandy (85 to 94% with very little fines content (6 to 14%) for both the surface and sub-surface samples (**see Figure 12**). This is far less than the modelled piling plume calculations provided by Stantec (2024), who assumed a uniform 54% fines content based on studies off Scotland Island to the north.
- The shallowest Inner East site which is located in a slight depression that concentrates organic debris (**Figure 11)** derived from urban stormwater runoff not associated with the Marina had siltier sands (43% average fine silt).
- Whilst all metal concentrations across all sites were well below their respective lower ANZG 2018 Default Guideline Values (DGV) for the protection of aquatic life for the most part, the results for sediments samples at the Inner Eastern stormwater runoff site (**Figure 11**) were elevated compared to other sites:
    - The East Inner Site (EI) Arsenic concentration was double the mean background concentration of 1.3mg/kg for all other sites.
    - Cadmium, Silver and Nickel concentrations were all below detection with above detection results for Cadmium and Nickel at site EI.
    - Mean Copper concentrations for the four outer Arm C area samples was 9mg/kg and Inner sample results mean was 19mg/kg and varied between 13mg/kg at WIbottom to 24 g/kg at EIbottom.

- Mean Lead concentrations for the four outer Arm C area samples was 3.8mg/kg and Inner sample results mean was.7mg/kg, and varied between 3.4mg/kg at EIbottom) to 8.6 g/kg at WIbottom
- Mean Zinc concentrations for the four outer Arm C area samples was 12.6mg/kg, with lower surface concentrations, and the Inner sample results mean was 27.5mg/kg, and varied between 17mg/kg at EIbottom) to 36mg/kg at EIsurface.

The sediment sampling results indicate that the presence and operation of the Quays Marina at this site has not resulted in an adverse impact on sediment quality for the protection of benthic biota and that for the most ;art elevated metal results were associated with accumulated urban stormwater runoff sediments and debris.

3.2 Water Quality Sampling Results

Surface and Bottom water samples were collected from the sediment sampling sites to establish existing dissolved copper concentrations as a surrogate for antifouling contaminants. Depth profiling of water quality was also undertaken at each site using a submersible Yeo-Kal 618 water quality data logger which records water depth, temperature, dissolved oxygen concentration and saturation, pH, conductivity and turbidity. Water samples were analysed for Dissolved Copper (Cu) and Dissolved Organic Carbon (DOC) as DOC reduces copper bioavailability, allowing DOC modified DGV's to be calculated where DOC concentrations are greater than 1mg/L. The ALS laboratory analysis report is appended to this report and the results are provided in **Table 1** below.

Table 1 The Quays Marina Water Quality Sampling Results

Analyte	LOR	Units	ANZG 18	WO-S	WO-B	EO-S	EO-B	WI-S	WI-B	EI-S	EI-B
Cu	1	µg/L	1.3	2	2	2	2	2	2	3	3
DOC	1	mg/L	DTV	2	2	2	1	1	1	1	1
Modified Cu DTV (if DOC>1mg/L)				2.27	2.27	2.27	1.3	1.3	1.3	1.3	1.3

- Dissolved Organic Carbon results were low, between 1 and 2 mg/L with the higher values offshore.
- Application of the DOC modified triggers indicated that the Copper concentrations in the Outer Arm C waters are suitable for the protection of 95% of aquatic biota.
- Although the copper concentrations for inner West site waters offshore from

the marina travel lift and workshops are above the default ANZG 2018 guideline value of 1.3µg/L they are nevertheless within the range of estuarine dissolved copper values for the Sydney urbanised estuaries (1.68±0.37) Hatje et al (2003).

- The higher Inner East water Dissolved Copper values are most likely related to shallow water wave action mobilisation of the overall higher silt copper concentrations in the stormwater derived sediments at this location.

Results of the MPR metered depth profiling water quality results are presented in **Appendix Table 5** and summarised as follow**:**

- Water temperature was relatively uniform (mean 21.3°C) with slightly warmer waters inshore and a slight decrease in temperature with depth.
- Water salinity at a mean ± standard deviation of 33.5 ± 0.2 ppt was completely marine with a very slight indication of some freshwater influence for surface waters.
- Water pH varied between 7.98 to 8.07 pH units with very slight increases with depth at all sites. Offshore water mean pH was 8.01 whilst inshore waters had slightly lower means but all within the overall Mean ± SD range of 8.03 ± 0.02 pH units These are all within the ANZG2018 guideline range of 7 to 8.5 pH units.
- Mean site dissolved oxygen (DO) % saturation values were between 111 and 111.5 % saturation with an overall mean of 111.7 ± 1.7 % saturation, just above the ANZG 2018 range of 80 to 110 % saturation. DO saturation values reduced with depth at all sites with bottom waters for all sites except E1 . ranged between 108.1%sat and 113.5%sat and decreased with depth.
- Waters were very clear throughout the area and the majority of turbidity readings were below 1NTU. Site WI recoded 4.1NTU on the bottom, however this iwas likely due to a small bottom disturbance with the probe.

The results indicated that the waters at Quays Marina were well mixed clean estuarine waters with the majority of water quality parameters within the limits for physical parameters for the protection of aquatic life (ANZG 2018).

4 IMPACT ASSESSMENT

The redevelopment proposal includes a reconfiguration of the marina which would include a new Arm C located 73m to the northeast (see **Figure 4** above) for 40 vessels and the relinquishing and removal of 40 swing moorings (**Figure 16** below) for no net increase in marina capacity. With regard to the assessment of possible impacts on aquatic ecological aspects, the following elements are considered:

- Removal of the 40 swing-moorings - average 40 foot (±12m) length vessels:
  - Some 11 of these moorings are located in shallow waters that could support seagrass growth or may currently support pest algae *Caulerpa taxifolia* growth.
- Provision of floating arm Arm C to provide 40 berths for the marina.
  - Arm C would require some 38 piles to be installed.
  - From the Hydrographic Survey prepared by Adam Clarke Surveyors (2024) the estimated minimum depth of Marina Arm C would be -7.5m AHD at the eastern end (about -6.5m chart datum or 6.5m water depth at Lowest Astronomical Tide (LAT). Accordingly, there is no dredging required for the project.

4.1 Habitat Losses and Gains

In terms of habitat losses and gains from removal of 40 swing-moorings, this will result in the removal of hard substratum mooring block surfaces that provide some habitat for encrusting biota and will also result in the removal of associated mooring chain attached to the blocks that allow for attached vessels to swing freely with the breeze:

- In relation to potential use of mooring blocks for Syngnathid (seahorse) colonisation, the statutory maintenance requirements for mooring apparatus limits the actual amount of fouling biota that can grow on the blocks, so removal of mooring blocks does not represent a significant loss of potential deep water hard substratum fish habitat and is highly unlikely to result in the loss of seahorse habitat.
- Further, removal of the associated mooring tackle, especially heavy chain will remove a significant seabed and benthic faunal disturbance mechanism that is significant in shallow marine vegetation areas where the swinging chain scours out a circle of marine vegetation and is also a significant benthos disturbance mechanism as the gouging chain continually disturbs and infills benthic burrows

as the chain is dragged around by the vessel realigning with the wind resulting in overall less burrow density in the mooring circle.
- From **Figure 16** below, removal of up to 11 swing moorings inshore of the east-west alignment of the existing marina would lower the risk of these existing swing moorings disturbing patchy pest algae *Caulerpa* that occurs in these shallows from time to time. These shallows could support *Zostera* seagrass habitat from time to time, generally associated with prolonged droughts and enhanced water clarity.

In terms of habitat losses and gains from piling and pontoon placement works:

- The proposal does not include the removal of any piles or pontoons from the existing marina structure, and the proposed Arm C infrastructure plus pens are not located over any marine vegetation or rocky reef. Therefore, the proposal will only result in an overall habitat gain via the added wetted surface areas provided by the proposed locator piles and pontoons. There will be approximately 555m lineal pontoon length installed as part of the reconfiguration which will provide additional and valuable shallow wetted surface area for marine growth.
- All the piles are to be placed into bare sediment habitat offshore from any seagrass and well also offshore from the pest *Caulerpa* algae depth limits, so there are no losses of sediment-based marine vegetation and no risk of disturbing the pest algae arising from piling activities.
- Piling will result in existing benthic fauna either displaced laterally as the pile is driven or screwed into the sediments or pumped out of the sediments by the lateral, pressure of piling works. Whilst this will result in a loss of overall benthic habitat, this loss is considered negligible in terms of the overall extent of benthic habitat available on the south Pittwater seabed and the loss of infaunal habitat will be well offset by the gain of pile wetted surfaces that will be colonised by encrusting and attached biota.
- Placement of the pontoon walkways and new floating berth fingers will introduce additional shallow sub-tidal wetted surface habitats for a diversity of mainly fringing zone biota including algae (Connell 2000).
- As there is no marine vegetation on these deeper sediments there is no shading risk for marine sediment vegetation arising from the placement of the additional arm or from vessels moored in the new arm pens.

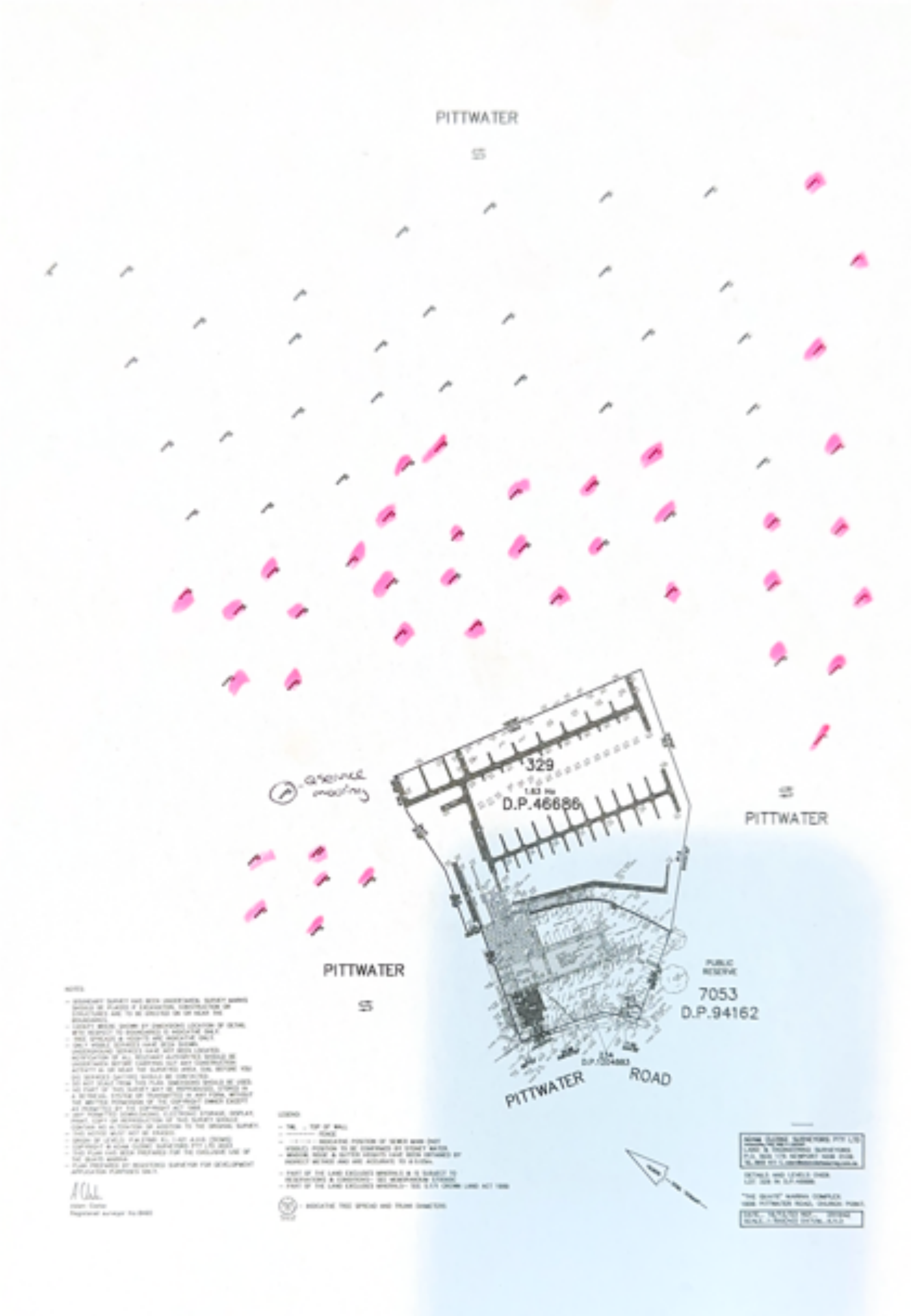

Figure 16 Existing 40 Marina Swing Moorings proposed to be relinquished.

The relinquishing of 40 swing moorings will require the removal of 40 mooring blocks plus associated chain, rope and buoys. As the mooring apparatus are required to be regularly maintained, including cleaning, there will be little or no loss of any significant hard substratum fouling or encrusting assemblages, and the removal of chain will lessen the disturbance of the seabed that occurs when vessels turn on their moorings with wind and tide variations. For some of the inshore moorings this may also include cessation of disturbance of some deeper water past *Caulerpa* algae.

In summary, the proposed works will result in a high net gain in pile and pontoon wetted surface areas suitable for colonisation by a variety of marine biota, as described for the present existing marine in **Section 2** above. and that habitat gain will adequately offset the loss of benthic infaunal habitat lost to pile placement.

4.2 Potential for ASS Soil Disturbance

Acid sulphate soils (ASS) include naturally occurring marine sediments that contain iron sulphides which have the potential to harm marine plants and animals. ASS are common throughout NSW coastal estuaries and found throughout Pittwater. **Figure 17** provides the ASS risk mapping for the locality that identifies the marine sediments as High probability ASS potential.

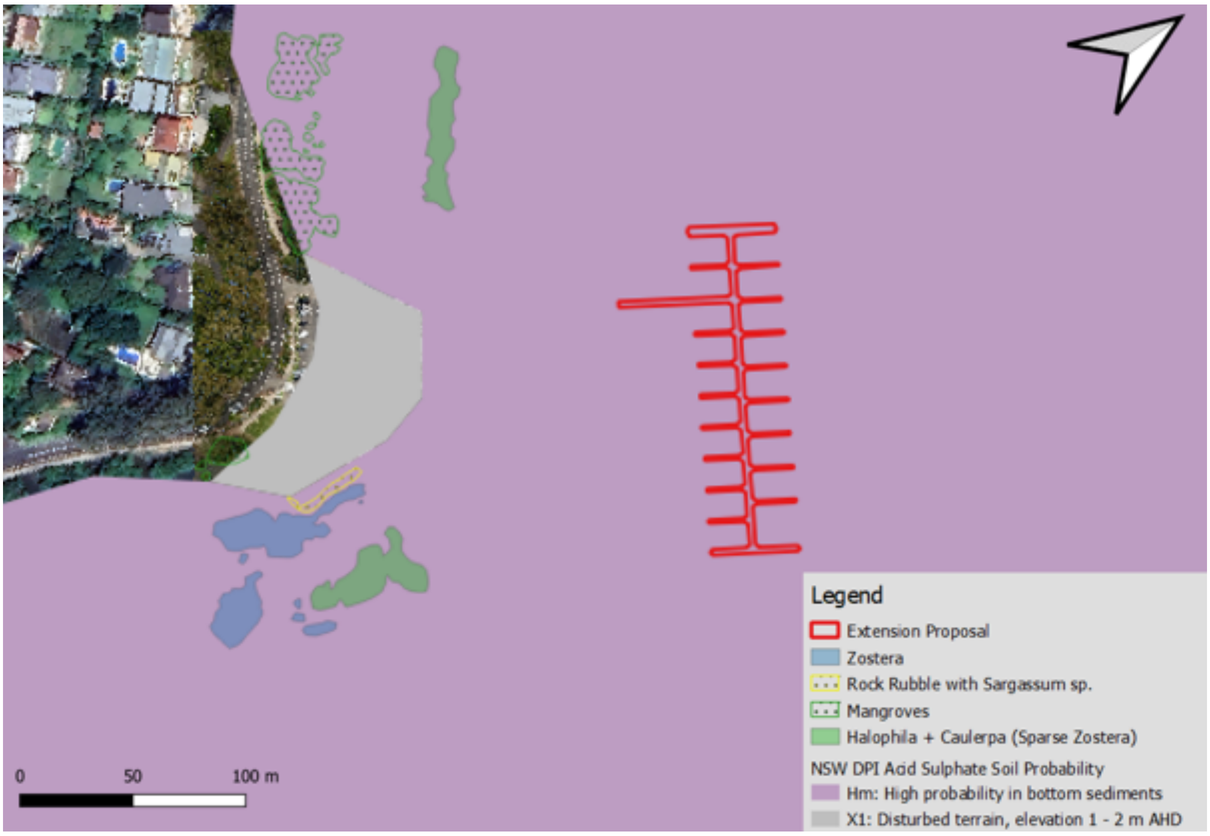

Figure 17 ASS potential map for southern Pittwater shown in relation to the Arm C placement.

For sub-tidal ASS sediments, the potential for these sediments to become active in relation to producing acid requires that sediments be **both** excavated **and** brought out of the estuarine waters to be exposed to air, and, as discussed in **Section 4** Introduction**,** the only sediment disturbance activities associated with the project are the removal of 40 swing mooring blocks and associated apparatus plus the placement of at least 38 piles for the new marine arm. There is no dredging required or anticipated and with minimum water depths of 6.5m at LAT there is no risk of seabed disturbance from vessels manoeuvring into and out of the proposed mooring pens:

- Removal of swing mooring blocks plus associated apparatus will entail the same removal operations that are undertaken at least annually for the commercial moorings as per the statutory requirements for upkeep of commercial moorings, accordingly the removal of the 40 moorings will not result in any additional surface sediment disturbance.
- Further, the sediments that are disturbed by mooring maintenance works are shallow surface sediments that are part of the benthic infaunal burrowing habitat zone (see **Figure 14**) that extends to at least 200mm below the seabed surface, and this zone is well aerated thus would not be PASS.

As noted in **Section 4.1,** all the new piles are to be driven into sub-tidal sediments from a barge-mounted pile driving rig and therefore there will be minimal sediments mobilised, as the pile driving action pushes and compresses soils aside with some entrained downwards via friction effects. As a result, the sediments remain intact and under water, and as they are not exposed to air, there is no risk of acid generation arising from piling activities.

Pile driving is associated with pulse turbidity, and this is caused partly by rig and pile driving head lateral vibration, and also via compression of sediments, whereby the laterally compressed sediments compress waters in adjacent benthic fauna burrows jetting turbid water up out from burrows. As the local waters are generally full marine salinity, these sediments rapidly fall back to re-settle on the seabed.

In summary, the proposed construction works do not require the disturbance of potential ASS via excavation, and the only disturbance of potential ASS is via pile driving works that also do not result in the excavation and exposure of ASS to air which is required to activate acid production from ASS. From the statutory point of view and in terms of the Pittwater LEP 2014 Clause 7.1(6), *development consent is not required as the works involve the disturbance of less than one tonne of soil and as the works are located more than 150 to 200m off the natural shoreline the piling works are not likely to lower the water-table.*

4.3 Potential for Disturbance of Contaminated Sediments

As described in **Section 3.2,** the survey of metal contamination of the sediments at and around the Quays Marina indicated that metal concentrations were all below the ANZG 2018 guideline *low risk of impact* concentrations. Inspection of the results in relation to silt content and sub-sample depth indicated that one main source of metal accumulation in the vicinity of the existing marina is urban stormwater runoff which resulted in accumulations of silty sediments at site EI (**Figure 15**), with accumulations of copper and zinc (albeit at below low risk levels) most likely associated with marina operations noted in surface and sub-surface samples at both EI and WI.

For the present proposal the potential for mobilisation of these sediments to the extent that there would be increased dissolved metal concentrations in the overlaying waters that could have an impact on aquatic organisms would require either bulk excavation as would be done for dredging works, or frequent mobilisation of seabed sediments by vessel-related propeller wash. As there are no excavation works associated with this project and as the Arm C pens and fairway are located in water depths greater than -6.5m AHD (i.e, > -5.6m chart datum, meaning that at the lowest astronomical tide (LAT) there would be 5.6m navigable water depth, increasing to 7.6m navigable water depth at Highest Astronomical Tide HAT), this risk is considered negligible.

As noted in the discussion of ASS mobilisation with regard to piling works (**Section 4.2** above). whilst piling works are associated with pulse turbidity, this turbidity is mainly associated with the surface sediments in the benthic zone and for the location of the piling works (sampling sites EO and WO) surface sediments have both lower metal concentrations than the corresponding sub-surface sediments and importantly have very low silt content (6 and 10%)[1] meaning that pulse turbidity arising from piling works will rapidly dissipate in the water column and the majority of mobilised sediments will fall back to the seabed rapidly as well. Accordingly, there is a negligible risk of mobilisation of sediment contaminants into the water column arising from either the construction or operation of the reconfigured marina.

[1] Note that Stantec (2024) modelled piling plume behaviour and extent based on an assumed silt content of 54%. On this assumption piling plumes would be confined to bottom waters and if unrestrained by silt curtains could extend some 200m north or 80m south dependent on tide. These plumes would not be visible from the surface and would not exceed 12mg/L turbidity for a period of about 1.5hours.

4.4 Management of Construction Activities

In-water piling and marina Arm C walkway and pen finger placement activities will require a barge plus crane and pile driving equipment. Work barges will most likely need to be manoeuvred into position using towing and/or pushing vessels and may need to be kept *in-situ* over multiple tide cycles.

Holding a barge in place for construction works is generally done using one or more barge- mounted stub piles pushed into the seabed to hold the barge in place or by using barge- mounted winches and wires connected to pre-placed mooring blocks.

As all the piling is into marine silty-sands and the piling is unlikely to cause any or significant turbidity plumes, as mobilised marine sediments fall back rapidly to the seabed in saline waters. Whilst this temporary pulse turbidity is not considered a risk for the marine benthic habitats and biota at the site this risk can be further minimised by ensuring that piling activities include the use of silt curtains to contain mobilised sediments to the piling area.

Whilst the construction works are located well offshore from any seagrass beds (see **Figure 4**), the potential impacts from the use of floating plant and manoeuvring of work vessels and barges over the inshore seagrass associated with possible site access and mooring of vessels over-night or during weekends needs to be considered. There is thus potential to directly damage or disturb aquatic habitats *via* vessel or propeller strike or by excessive propeller wash if construction vessels are brought into the shallows or are moored in the shallows. Damage to vegetated habitats can also occur from mooring or anchoring apparatus deployed in, on or over, these habitats with direct crushing from anchors or mooring blocks, or scalping of seabed habitats from wires laid across the seabed or from placing mooring piles (spuds) into the seabed.

Over and above the potential disturbance for high value seagrass beds, manoeuvring and placing construction vessels over shallow inshore seabeds also includes a risk of disturbing the pest algae *Caulerpa taxifolia*. In this regard a previous survey in 2008 towards the end of the millennium drought - when overall Pittwater water clarity had been consistently high, had mapped a greater extent of the pest algae *Caulerpa taxifolia* at the marina east side bounded offshore by the -2m chart datum depth limit, and that historic limit has been included on **Figure 4** for the purposes of indicating *possible future Caulerpa* extent.

Piling works are also associated with potential noise impacts for aquatic animals both from machinery (start up and under load) and from piling (pulse impact). As the background noise for marine animals at the southern end of Pittwater is likely to be moderate from motorised transiting vessels, noise from machinery is unlikely to affect marine animals further provided best practice machinery and pile driving start up and use methods are employed. These will include slow and sequenced starts for machinery plus pile driving and limiting work hours to avoid dawn and dusk transiting times.

These combined potential impacts can be mitigated by the inclusion of specific construction management conditions in the project Construction Environment Management Plan (CEMP) as detailed in **Section 4.4.1** below.

4.4.1 Aquatic CEMP Inclusions for Construction Activities

All contractors undertaking construction work associated with the project shall ensure that their activities do not cause any harm to the marine vegetation habitats (i.e., seagrass beds) inshore of the project footprint, as identified on **Figure 4**. They must also be made aware that there could be areas with the declared pest algae species *Caulerpa taxifolia* (see historical occurrence outer limit indicated as a red line on **Figure 4** - south of the construction works and generally south of the -2m chart datum contour plus east of the marina, and that their activities should be undertaken to minimise the risk of disturbance or spread of this alga. In order to achieve these aims, contractors shall implement the following precautions:

- There will be no stockpiling of demolition or construction materials on the seabed.
- By virtue of the shallow depths over the marine vegetation habitats either side of the project footprint area, no vessel is to be taken over or left over the indicated marine vegetation (seagrass bed) habitats unless there is adequate vessel clearance depth (including allowance for tidal movement plus wind, vessel and swell wave heights) over the habitats. The estimations of clearance depths will also need to account for vessel propulsion gear clearance depths to ensure no propeller or wash scouring damage.
- No vessel is to be moored with anchor or other bottom tackle located in the known **or potential** *Caulerpa taxifolia* pest algae habitats located in in-shore waters from off from the intertidal beaches and offshore from the marina seawall out beyond the mapped marine vegetation habitats to about the -2m chart datum (**Figure 4**)

- Where possible, the construction contractor should utilise existing marina or adjacent marina infrastructure for mooring rather than setting temporary mooring blocks. If inshore mooring blocks are required, they will still need to be set to ensure no crushing or scouring damage to the seagrass beds as indicated in **Figure 3**.
- No mooring lines or cables are to be laid across the marine vegetation habitats if there is any risk of these cables reaching the bottom due to wave action or low tides. If deployed, they must be suitably buoyed prior to laying, and kept buoyed once laid, to prevent cable drag and cable swing damage (scalping) to marine vegetation areas and to prevent disturbance and fragmentation of the pest algae species *Caulerpa*. Where this is impractical, contractors should use floating rope.
- In order to minimise wash and prevent bottom scouring of the marine vegetation habitats and to prevent mobilisation of the pest algae *Caulerpa*, towing or pushing vessels must not use excessive power to manoeuvre barges into place near the designated marine vegetation habitats. Scouring damage can also be minimised by 'working the wind and tides', i.e., only moving floating plant into place on high tides and under favourable or no winds.
- Potential startling noise impacts on marine animals will be minimised by including slow and sequenced starts for machinery plus pile driving operations and limiting work hours to avoid dawn and dusk transiting times.
- All the wetted surface areas of mooring or construction related materials taken from the waters must be inspected for fragments of the declared pest algae species *Caulerpa taxifolia* (**Figure 18**) and these fragments must be collected and disposed of into plastic bags then placed into garbage bins on shore (i.e., in the manner recommended in the NSW Fisheries' *Caulerpa* Management Plan).
- All construction related equipment that comes in contact with the seabed (including mooring tackle, cables, ropes and anchors), must also be inspected for attached fragments of *Caulerpa taxifolia* with fragments collected and disposed of as above.

Figure 18 The pest algae *Caulerpa taxifolia* attached to a segment of chain.

4.5 Operational Impacts

The proposal is for a reconfiguration of the existing marine to accommodate more vessels in fixed pens and less on swing moorings and accordingly potential operational impacts around preventing vessel collisions and damage, preventing water pollution and management of spills will be included into the present Quays Marina Operational Environmental Management Plan (OEMP) which would then be reviewed and updated as required.

The proposed marina reconfiguration has the new inner marina berths fairway situated in depths greater than 5.6 m at the lowest astronomical tide, and the proposed berths are to accommodate vessels up to 65 feet, where these size vessels generally have a maximum draft up to 2m. This would leave more than 3.6m water depth between the lower side of the vessel propulsion at LAT increasing to 5.6m separation at HAT. These depths are sufficient to prevent sediment scouring or sediment mobilisation from vessel movements.

The proposal includes the removal of 40 swing moorings, where the average size boat on these moorings is approximately 40 feet. The new marina arm is proposed to berth 40 boats, with an average size of 60-65 feet. This will result in a larger surface area of vessel antifoul wetted surfaces and therefore an increased amount of copper leaching from berthed vessels in the locality. The overall dispersion of this increased copper loading will also be dependent on the predicted overall changes to coastal processes arising from the reconfigured marina and in this respect Sytante3c (2024) concluded that:

> *The proposed works will not change the coastal processes significantly at this site. The present marina facilities will attenuate waves that propagate to the site – differently for different directions and hence reduce wave overtopping. The extension of the marina facilities will increase this attenuation to some extent. Wave attenuation is less for longer period waves.*

On this basis, it can be conservatively assumed that the overall accumulation of copper from copper-based antifouling of vessels in the new outer arm would over time become similar to that found under the present Arm B. In this respect and as presented in **Section 3.1** the sediment copper background concentrations for the seabed under the proposed Arm C is 8.9±1.1 mg/kg compared to 20±2mg/kg for the Arm B surface sediments. As these existing marina concentrations are still well below the ANZG(2018) lower risk concentration value of 65mg/kg, it is concluded that the overall risk for benthic ecosystems under the new Arm C derived from copper based antifouling leachate from berthed vessels can be considered low. This outcome can be managed by including an annual water quality and sediment quality monitoring program similar to the sampling program undertaken for this proposal (**Sections 3.1 & 3.2**) which can be included as a Condition of Consent with the program details to be approved as part of the pre-commencement approvals process.

5 ASSESSMENT AGAINST RELEVANT LEGISLATION AND SEARS

Table 2 provides a SEARs requirements checklist for matters relating to water quality and aquatic ecology impact assessment with cross-references to the Sections in this report that address each item. The remainder of this Section provides assessments against relevant legislation or specific SEARs requirements not consider in previous Sections.

5.1 SEPP (BC) 21, SEPP(RH) 21 and CMA

Figure 19 shows the relevant SEPP (Resilience and Hazard) 2021 coastal zone mapping as defined under the *Coastal Management Act* 2016. The proposal area falls under the *Coastal Environmental Area* Zone:

- The site is included in the coastal environmental by virtue of it being in a tidal estuary.
- The site is not a coastal wetland nor is it located within 100m of a coastal wetland, with the closest defined wetlands comprising mangroves located inshore to the west of the proposal site some 170m away (**Figure 4**).

Under the Coastal Management Act 2016 (CMA) the relevant management objective (Clause 8(2)a) is *to protect and enhance the coastal environmental values and natural processes of coastal waters, estuaries, coastal lakes and coastal lagoons, and enhance natural character, scenic value, biological diversity and ecosystem integrity.* This management objective is then encapsulated in SEPP(RH) Clause 2.10(1a-1d), and Clause 2.10(2) sets out the requirements for avoidance (2a), and where impacts cannot be avoided that suitable minimisation and mitigation of impacts is included (2b & 2c):

- Provided suitable and approved impact minimisation measures are incorporated into the project CEMP and into the project Operational Management Plan as set out in **Section 4.4** above, it is concluded that the SEPP(R&H)2021 Section 2.10 management objectives can be satisfied.

Table 2 SEARS & DPI Fisheries Checklist		This Report Section	Other Reports
SEARS Key *Issues* & related DPI Fisheries Issues (Red)			
	Construction methodology & construction impacts	4.4	
	Impacts on Shorline and Seabed (if dredging)	4.1	Stantec (2024)
Statutory Context			
	Assess against CMA, SEPP (BC) Chap 2, BCA, LEP & DCP	5.1	
	Assess WMA and FMA triggers	5.2, 5.3	
Biodiversity			
	Aq & Riparian Foreshore Environments & coastal wetlands	1.1	
	1 Marine Ecology Assessment for Fisheries P&G 2013	This Report	
	Construction impacts plus AMMMO for no net loss	4 & 5.3	
	4 Coastal process impacts	4.4	Stantec (2024)
	3 Need for Syngnathid relocation Plan for Mooring Removals	2.1 & 4.1	
	Piling Methodology	4.1	
	Construction and Operational EMSs	4.4 & 4.5	
	Impacts on threatened spps, popularions, commumnities	2.1	
	Impact of ongoing maintenance	4.5	
	AMMO details	5.2	
	DPI Fisheries & Council Additional requirements	As listed	
Soil & Water			
	Description of riparin lands and drainage	1.1	
	Impacts wrt DCCEEW Water Controlled Activity Approvals	5.x	
	2 Hydrological Assessment to confirm no dredging required	4(intro)	ACS (2024)
	9 ASS assessment	4.2	
	Sediment & Erosion Control Measures	4.4	
	6,7 Construction & Operational Impact on estuary	4.4 & 4.5	
	8 Management of Contaminated Sediments	3.1 & 4.3	
	Flood Risk & mitigation	NA	SEE
	Ulitlities Assessment & Estuary Water Quality Monitoring	4.5	SEE
	Integrated Water Cycle Management Plan		SEE
SEPP Hazards & Risk (Chap 2 & 4)			
	Contaminated sediments & proposed management.	3.1 & 4.3	
	Operational Environmental Protection Equipment	4.5	OEMP
	Spill and vessel sewage mitigation & management	4.5	OEMP
Construction Impacts			
	Noise & Vibration Impacts	4.4 & 4.4.1	
Waste Management			
	Demolition & Construction Waste management	4.4.1	

Figure 19 SEPP (Resilience and Hazard) 2021 Coastal Zone Mapping.

5.2 Water Management Act CAA

Section 91E of the Water Management Act 2000 outlines the requirements for a Controlled Activity Approval (CAA). Controlled activity included construction of infrastructure within a watercourse, waterfront land, or riparian zone where *waterfront land* includes the bed of any river, lake or estuary. The DCCEEW Waters Guidelines for Instream works on Waterfront Land for this proposed marina reconfiguration list the following relevant considerations to be made:

> *The design and construction of works or activities within a watercourse or adjoining waterfront land should protect and enhance water flow, water quality, stream ecology and existing riparian vegetation. Impacts on the hydrologic, hydraulic and geomorphic functions of a watercourse should also be minimised:*

- For the listed hydrological requirements, the Stantec 2024 report (as summarised in this report at **Section 4.5**), states that *the proposed reconfiguration will not change the coastal processes significantly at this site. The present marina facilities will attenuate waves that propagate to the site – differently for different directions and hence reduce wave overtopping. The extension of the marina facilities will increase this attenuation to some extent. Wave attenuation is less for longer period waves*.
- This present report provides the assessment of the proposal on the water quality, stream ecology and existing riparian vegetation of the site and concluded that the construction and operation of the refurbished facility can be undertaken to protect stream ecology and existing riparian vegetation provided that these activities are undertaken as per the provisions of approved CEMP and OEMP that include the recommendations for construction and operational management requirements of this present report.

5.3 Fisheries Management Act Permit Requirements

In terms of overall aquatic ecology impact assessment:

- The project *avoids* impact on key fish habitat by location of the Arm C floating moorings well offshore over deeper waters.
- The project *mitigates* seabed benthic habitat disturbance the currently arises from mooring chain drag plus from annual mooring cleaning activities by removing 40 swing moorings including inshore moorings that may currently include some pest algae cober from time to time.
- The project will *minimise* potential construction related impacts by incorporating aquatic CEMP measures into the overall project CEMP. Operational impacts from use of Arm C pen mooring will be *minimised* by updating the current Marina OEMP.
- The loss of seabed benthic habitat to placement of piles will be *offset* by the provision of wetted surface habitat on the piles and floating pens plus walkways that will be colonised by diverse assemblages of attached and encrusting biota.

Part 7 of the Fisheries Management Act 1994 (FMA) sets out the conditions under which permits are required for various construction activities, and the conditions under which a permit may be granted are specified in the Fisheries NSW Policy and Guidelines (NSW Fisheries 2013). With respect to estuarine activities, permits are required *inter alia* for the "*taking or harming of marine vegetation*" or for "*reclamation or dredging works*".

- The present proposal does not include activities that fall under the definition of dredging or reclamation.
- The risk of construction-related damage to the inshore seagrass beds associated with the use of construction vessels can be suitably mitigated by the incorporation of appropriate construction vessel use limitations as described in **Section 4.4.1** above.

Accordingly, it is concluded that the project is not likely to require an FMA Part 7 Permit for either *dredging /reclamation* or *harming marine vegetation*.

5.4 Conclusions

As the project Arm C mooring reconfiguration works are located over deep waters that are open to wind and wave mixing with unvegetated sandy seabed sediments below, the identified marine vegetation habitats inshore plus the seabed benthic habitats under the proposed Arm C would not be directly impacted by the proposed construction works. Sediment and water quality impacts are considered sufficiently low so that the aquatic organisms in the water column and in the sediments would not be adversely impacted provided that suggested Construction and Operational Environmental management procedures in the project CEMP and updated OEMP are applied and adhered to. This will need to be demonstrated by the inclusion of an outlined annual estuarine water quality and sediment quality monitoring program to be approved by Council as part of the Conditions of Consent.

As the proposal does not include dredging or reclamation, and, provided that construction related mitigation measure to prevent physical damage impacts to adjacent marine vegetation as outlined in this report are adopted, the *low* risk of loss of seagrass to water-based construction works can be further reduced to *negligible*. The project will not require a *permit to harm marine vegetation* or for *dredging or reclamation* under the FMA and would meet the aquatic ecology protection requirements of the Water Management Act in regards to a Controlled Activity Application.

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ANNEXURE A

THE QUAYS MARINA RECONFIGURATION

- SEDIMENT SAMPLING NOTES
- SEDIMENT AND WATER QUALITY LAB ANALYSIS
- SEDIMENT AND WATER QUALITY SITE MAP
- CORE PHOTOGRAPHS
- SEDIMENT SAMPLING RESULTS
- WATER QUALITY SAMPLING RESULTS
- METERED WATER QUALITY DATA
- ALS LAB REPORT

	Table 1 – Sediment core sampling notes The Quays Marina				
Site	Surface/ Bottom sample	Core Depth	Easting	Northing	Sampling notes
	S/B	cm			
EO	S/B	50	341518	6275322	Sample was generally made up of clean marine sands with minimal shell fragments. Bottom 200mm of sample was darker in colour (grey). No odour or organic plant material.
EI	S/B	50	341503	6275238	Sample was sticky thick silt throughout entire core. Also contained shell fragments and some organics. Slight sulphur smell.
WO	S/B	50	341417	6275366	Similar to EO with coarser clean marine sands sand and minimal shell fragments. Bottom 300mm was grey in colour. No odour or organic plant material.
WI	S/B	50	338642	6251196	Sample was silt sands throughout entire core. Also contained shell fragments and some organics.

	Table 2 – The Quays ALS Lab Analysis								
				Lab Analysis					
Sample Id	**Sample Date**	Matrix	Total Bottles	Particle Sizing	TOC EP003	*HCl Extractable metals suite SD-4	DOC	TSS (low level)	Dissolved Copper - Ultra Trace
EI-Surf	24.4.24	SW	4				X	X	X
EI-Bott	24.4.24	SW	4				X	X	X
EO-Surf	24.4.24	SW	4				X	X	X
EO-Bott	24.4.24	SW	4				X	X	X
WI-Surf	24.4.24	SW	4				X	X	X
WI-Bott	24.4.24	SW	4				X	X	X
WO-Surf	24.4.24	SW	4				X	X	X
WO-Bott	24.4.24	SW	4				X	X	X
EI	24.4.24	SED	2	X	X	X			
EI-B	24.4.24	SED	2	X	X	X			
EO	24.4.24	SED	2	X	X	X			
EO-B	24.4.24	SED	2	X	X	X			
WI	24.4.24	SED	2	X	X	X			
WI-B	24.4.24	SED	2	X	X	X			
WO	24.4.24	SED	2	X	X	X			
WO-B	24.4.24	SED	2	X	X	X			
	Note: ***metals** (Sb, As, Cd, Cr, Cu, Pb, Ni, Ag, Zn, & Hg), All Diss Cu and DOC samples have been field filtered. Analysis should be done to Analysis to be done to meet ANZG 2018 DGVs. **SW** = Saline waters, **SED** = Marine Sediments.								

Figure 1
Proposed marina reconfiguration
Drawing**: 4336-02**

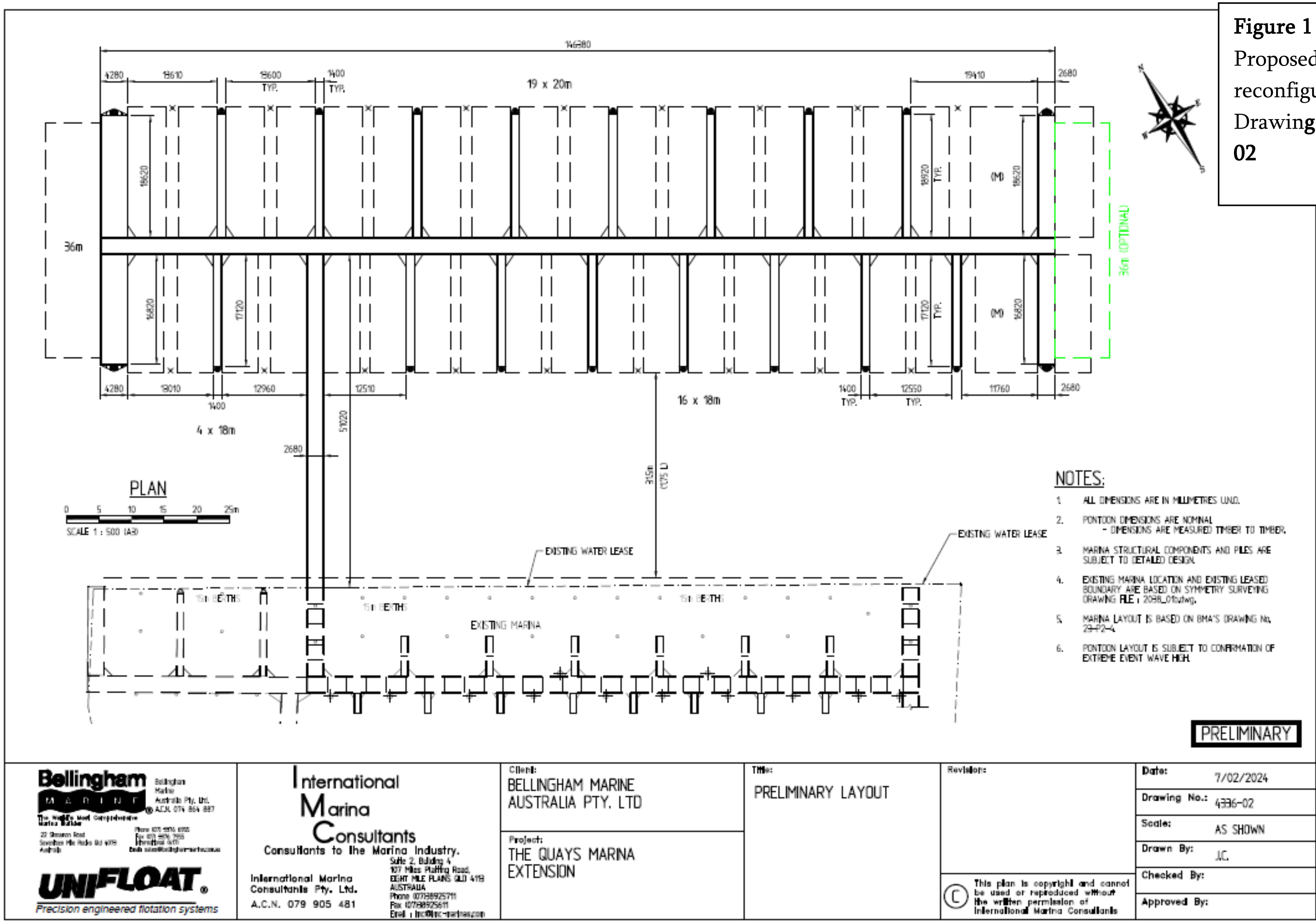

Figure 2 Sediment core samples from EI and EO.

Figure 3 Sediment core samples from WI and WO.

Table 3 The Quays Marina Sediment Sampling Results												
Analyte	LOR	Units	ANZECC 18		MPR							
	MPR		DGV	GV Hi	WO-S	WO-B	WI-S	WI-B	EO-S	EO-B	EI-S	EI-B
Antimony	1	mg/kg	2	25	<1	<1	<1	<1	<1	<1	<1	<1
Arsenic	1	mg/kg	20	70	1.2	1.4	1.4	1.3	1.1	1.4	3	2.3
Cadmium	0.1	mg/kg	1.5	10	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.2
Chromium	1	mg/kg	80	370	1.5	1.9	2.8	1.8	<1	1.3	4	4.7
Copper	1	mg/kg	65	270	9	10.1	18.2	12.9	7.4	9.2	21.3	2.4
Lead	1	mg/kg	50	220	3.5	4.3	7.5	8.6	3.1	4.1	7.4	3.4
Nickel	1	mg/kg	21	52	<1	<1	<1	<1	<1	<1	1.4	1.6
Silver	1	mg/kg	1	3.7	<1	<1	<1	<1	<1	<1	<1	<1
Zinc	1	mg/kg	200	410	12.2	15.4	33.9	22.7	9.6	13.8	35.7	15.8
Mercury	0.1	mg/kg	0.15	1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
TOC	0.02	%			0.22	0.27	0.54	0.35	0.16	0.19	1.93	2.19
Moisture conent	1	%			26.6	26.6	29.7	27.6	23.2	25	45.3	49.6
75µm	1	%			90	88	86	88	94	93	58	56
150µm	1	%			71	73	64	68	76	80	45	45
300µm	1	%			28	34	28	32	31	38	29	30
425µm	1	%			13	16	16	20	13	18	23	24
600µm	1	%			5	9	10	14	5	8	20	21
1180µm	1	%			1	3	3	5	<1	2	16	17
2.36mm	1	%			<1	<1	<1	<1	<1	<1	10	12
4.75mm	1	%			<1	<1	<1	<1	<1	<1	5	7
9.5mm	1	%			<1	<1	<1	<1	<1	<1	<1	<1
19mm	1	%			<1	<1	<1	<1	<1	<1	<1	<1
37.5mm	1	%			<1	<1	<1	<1	<1	<1	<1	<1
75mm	1	%			<1	<1	<1	<1	<1	<1	<1	<1
Fines (<75µm)	1	%			10	12	14	12	6	7	42	44
Sand (>75µm)	1	%			90	87	85	86	94	92	46	43
Gravel (>2mm)	1	%			<1	1	1	2	<1	1	12	13
Cobbles (>6cm)	1	%			<1	<1	<1	<1	<1	<1	<1	<1
Colour Key		Below DGV		Between DGV & GVHigh						Above GVhigh		
Total organic carbon, S = Surface sediments, B = bottom sediments												

Table 4 The Quays Marina Water Quality Sampling Results

	LOR	Units	ANZG 2018	WO-S	WO-B	WI-S	WI-B	EO-S	EO-B	EI-S	EI-B
Dissolved Copper (Cu)	1	µg/L	1.3	2	2	2	2	2	2	3	3
Dissolved Organic Carbon	1	mg/L		2	2	1	1	2	1	1	1
Dissolved Cu DOC Modified DGV at 95% Species protection				2.27	2.27	1.03	1.03	2.27	1.03	1.03	1.03
Colour Coding		Dissolved copper values are above the DOC ANZG 2018 modified guideline value at 95% species protection									

Table 5 - SDL Physical Water Quality Results Depth Profiles.										
ID	Tag	Date/Time	Temp (C)	Turb (ntu)	pH (pH)	ORP (mv)	Sal (ppt)	D.O. (%sat)	Depth (M)	D.O. (mg/l)
55	EO	24/04/2024 18:01	21.36	0.3	7.99	328	31.75	113.1	0.09	8.32
56	EO	24/04/2024 18:01	21.35	0.0	7.99	328	33.52	113.2	0.32	8.24
57	EO	24/04/2024 18:02	21.33	0.0	8.00	328	33.53	113.1	0.61	8.23
58	EO	24/04/2024 18:02	21.32	0.1	8.00	329	33.52	113.1	0.87	8.24
59	EO	24/04/2024 18:02	21.30	0.0	8.00	329	33.52	113.1	1.44	8.24
60	EO	24/04/2024 18:02	21.29	0.0	8.01	329	33.53	112.8	1.81	8.22
61	EO	24/04/2024 18:02	21.27	0.0	8.01	329	33.53	112.7	2.22	8.21
62	EO	24/04/2024 18:02	21.26	0.1	8.01	329	33.53	112.4	2.68	8.19
63	EO	24/04/2024 18:03	21.26	0.0	8.01	330	33.53	112.3	3.07	8.19
64	EO	24/04/2024 18:03	21.25	0.0	8.02	330	33.54	112.0	3.39	8.17
65	EO	24/04/2024 18:03	21.25	0.0	8.02	330	33.54	111.9	3.74	8.16
66	EO	24/04/2024 18:03	21.24	0.0	8.02	330	33.54	111.7	3.90	8.15
67	EO	24/04/2024 18:03	21.24	0.1	8.02	331	33.54	111.4	4.37	8.12
68	EO	24/04/2024 18:04	21.24	0.1	8.02	331	33.54	110.7	4.75	8.07
69	EO	24/04/2024 18:04	21.24	0.1	8.02	325	33.54	108.3	4.64	7.90
70	EO	24/04/2024 18:04	21.24	0.1	8.02	325	33.54	108.4	5.44	7.91
71	EO	24/04/2024 18:04	21.24	0.1	8.02	326	33.54	108.6	5.90	7.92
72	EO	24/04/2024 18:05	21.24	0.1	8.02	327	33.54	108.5	6.31	7.91
73	WO	24/04/2024 18:44	21.32	0.1	7.98	324	33.53	113.2	0.23	8.24
74	WO	24/04/2024 18:44	21.33	0.0	7.98	324	33.53	113.2	0.40	8.24
75	WO	24/04/2024 18:44	21.33	0.0	7.99	324	33.53	113.3	0.60	8.25
76	WO	24/04/2024 18:44	21.32	0.0	7.99	324	33.54	113.2	0.81	8.24
77	WO	24/04/2024 18:44	21.32	0.0	8.00	324	33.53	113.1	1.14	8.23
78	WO	24/04/2024 18:45	21.30	0.0	8.00	324	33.54	112.7	1.30	8.21
79	WO	24/04/2024 18:45	21.32	0.0	8.01	324	33.54	112.3	1.51	8.18
80	WO	24/04/2024 18:45	21.31	0.0	8.01	324	33.54	112.5	1.76	8.20
81	WO	24/04/2024 18:45	21.29	0.1	8.02	324	33.54	112.2	2.22	8.17
82	WO	24/04/2024 18:45	21.27	0.0	8.02	324	33.53	111.9	2.92	8.16
83	WO	24/04/2024 18:46	21.25	0.1	8.02	324	33.54	111.8	3.64	8.15
84	WO	24/04/2024 18:46	21.25	0.1	8.02	324	33.55	111.3	4.29	8.11
85	WO	24/04/2024 18:46	21.25	0.4	8.02	324	33.54	110.6	4.74	8.06
86	WO	24/04/2024 18:46	21.24	0.0	8.02	324	33.54	109.5	5.42	7.98
87	WO	24/04/2024 18:46	21.24	0.6	8.02	325	33.55	109.0	6.05	7.95
88	WO	24/04/2024 18:46	21.24	0.1	8.03	325	33.55	108.7	6.77	7.92
89	WO	24/04/2024 18:47	21.23	0.1	8.03	325	33.55	108.5	7.24	7.91
90	WO	24/04/2024 18:47	21.22	0.1	8.03	325	33.55	108.4	7.74	7.91
91	WI	24/04/2024 19:18	21.37	0.1	8.02	322	33.53	112.2	0.14	8.16
92	WI	24/04/2024 19:18	21.38	0.1	8.03	322	33.53	112.2	0.32	8.16
93	WI	24/04/2024 19:18	21.37	0.1	8.03	322	33.53	112.2	0.63	8.16
94	WI	24/04/2024 19:18	21.37	0.0	8.04	322	33.54	112.1	0.89	8.16
95	WI	24/04/2024 19:18	21.38	0.0	8.04	322	33.53	112.1	1.25	8.15
96	WI	24/04/2024 19:19	21.38	0.0	8.04	322	33.53	112.1	1.54	8.15

97	WI	24/04/2024 19:19	21.38	0.0	8.05	322	33.54	112.0	2.08	8.15
98	WI	24/04/2024 19:19	21.36	0.1	8.05	322	33.53	112.0	2.57	8.15
99	WI	24/04/2024 19:19	21.35	0.1	8.05	322	33.54	111.9	3.00	8.15
100	WI	24/04/2024 19:19	21.36	0.1	8.05	322	33.54	111.9	3.51	8.14
101	WI	24/04/2024 19:19	21.36	0.0	8.06	322	33.54	111.9	3.79	8.14
102	WI	24/04/2024 19:19	21.35	0.0	8.06	322	33.52	111.7	4.19	8.13
103	WI	24/04/2024 19:20	21.33	0.1	8.06	322	33.54	111.4	4.69	8.11
104	WI	24/04/2024 19:20	21.32	0.0	8.06	323	33.53	111.0	5.10	8.09
105	WI	24/04/2024 19:20	21.30	0.0	8.06	323	33.54	109.9	5.54	8.01
106	WI	24/04/2024 19:20	21.31	0.0	8.06	323	33.54	109.7	5.93	7.99
107	WI	24/04/2024 19:20	21.31	0.1	8.07	323	33.54	109.6	6.31	7.98
108	WI	24/04/2024 19:21	21.28	0.1	8.07	323	33.53	109.4	6.69	7.97
109	WI	24/04/2024 19:21	21.28	0.2	8.07	323	33.54	108.9	6.66	7.94
110	WI	24/04/2024 19:21	21.26	0.1	8.07	323	33.54	108.4	7.01	7.90
111	WI	24/04/2024 19:21	21.26	4.2	8.07	323	33.54	108.1	7.11	7.88
112	EI	24/04/2024 20:04	21.40	0.1	8.00	322	33.53	113.4	0.24	8.25
113	EI	24/04/2024 20:04	21.40	0.1	8.01	322	33.53	113.5	0.37	8.25
114	EI	24/04/2024 20:05	21.39	0.1	8.01	322	33.54	113.4	0.65	8.25
115	EI	24/04/2024 20:05	21.38	0.1	8.02	322	33.54	113.2	0.89	8.23
116	EI	24/04/2024 20:05	21.39	0.1	8.03	322	33.53	113.1	1.22	8.22
117	EI	24/04/2024 20:05	21.39	0.1	8.03	322	33.54	113.0	1.73	8.22
118	EI	24/04/2024 20:05	21.39	0.1	8.04	323	33.54	113.1	2.17	8.22
119	EI	24/04/2024 20:06	21.39	0.1	8.04	322	33.54	113.1	2.56	8.23
120	EI	24/04/2024 20:06	21.39	0.0	8.05	323	33.55	113.2	2.92	8.23
121	EI	24/04/2024 20:06	21.39	0.1	8.05	323	33.55	113.3	3.29	8.24
122	EI	24/04/2024 20:06	21.39	0.2	8.06	323	33.54	113.3	3.74	8.24
123	EI	24/04/2024 20:07	21.38	0.1	8.07	323	33.54	113.4	4.09	8.25
124	EI	24/04/2024 20:07	21.38	0.1	8.07	323	33.55	113.4	4.47	8.25


Legend
Rock Rubble with Sargassum sp.
Mangroves
Halophila + Caulerpa (Sparse Zostera)
Zostera
Extension Proposal
Map Datum/Projection:
WGS / UTM Zone 56
0
25
50 m