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R1503 Rev 0

April 2021

Swan Yacht Club

Jetty 5 Sediment Investigation

marinas
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canals
breakwaters
jetties
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K1814, Report R1503 Rev 0
Record of Document Revisions

Rev	Purpose of Document	Prepared	Reviewed	Approved	Date
A	Draft for MRA review	K Worth	T Hunt	T Hunt	06.04.21
0	Issued for Client use	K Worth	T Hunt	T Hunt	20.04.21

Form 035 18/06/2013

Limitations of this Document

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1. Introduction

M P Rogers & Associates Pty Ltd (MRA) have been commissioned by the Swan Yacht Club (SYC) to investigate the siltation and boat wake issues surrounding Jetty 5. The SYC and area of siltation build up are shown in the figure below.

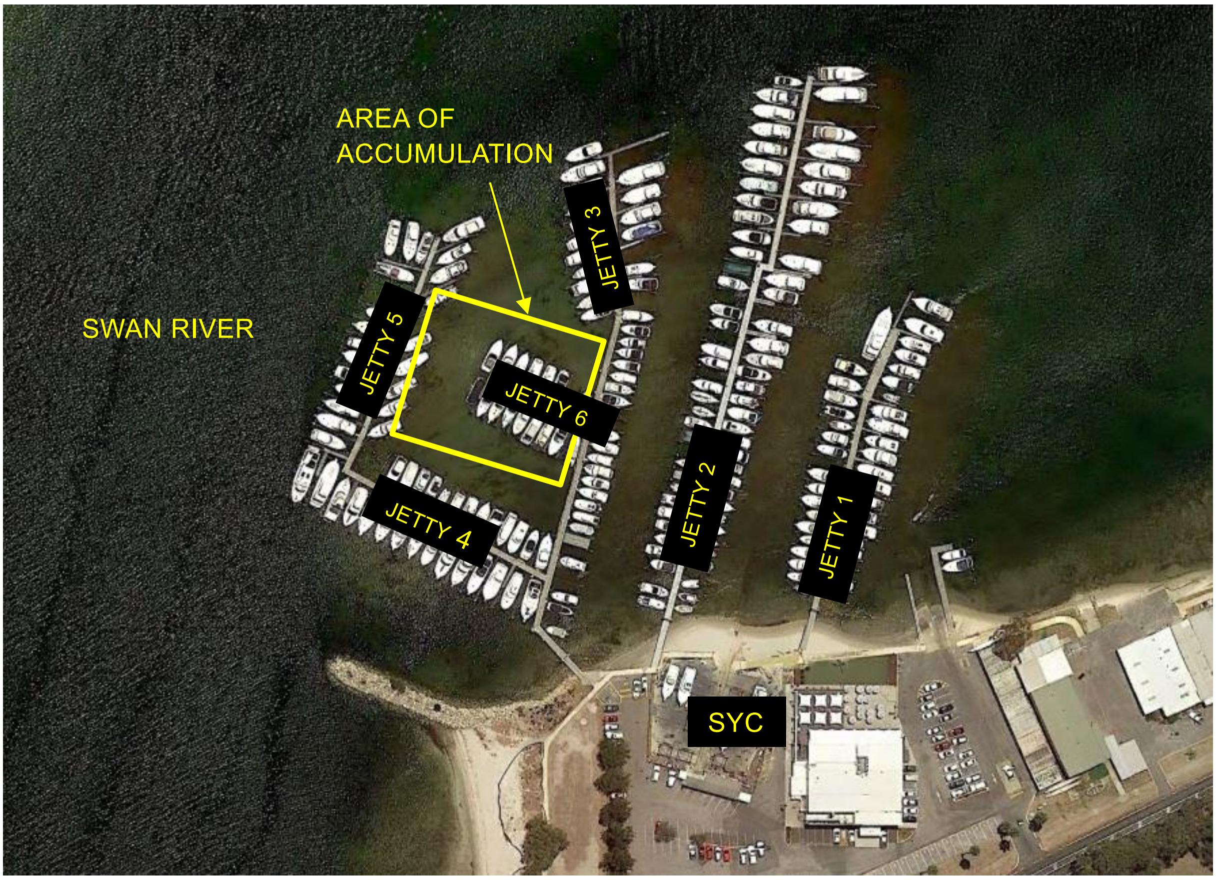

Figure 1.1 Swan Yacht Club

To investigate the source of sediment build-up, and ways to improve tranquillity in the Club, MRA have been engaged to:

- Review historical dredging campaigns completed at the Club.
- Complete hydrodynamic modelling to confirm the general patterns of sediment transport.
- Recommend options to improve siltation issues and tranquillity.

This report summarises the investigation into the source of sediment build up surrounding Jetty 5.

2. Background

The SYC was founded in 1903, and was initially located below where the Stirling Traffic Bridge is today. As a result of the construction of Stirling Traffic Bridge, the Club was relocated to reclaimed land at Preston Point in 1964 (Swan Yacht Club, 2020). Since then, the Club has undergone various configuration changes and dredging campaigns. The initial layout and existing layout of the Club is presented in the figure below.

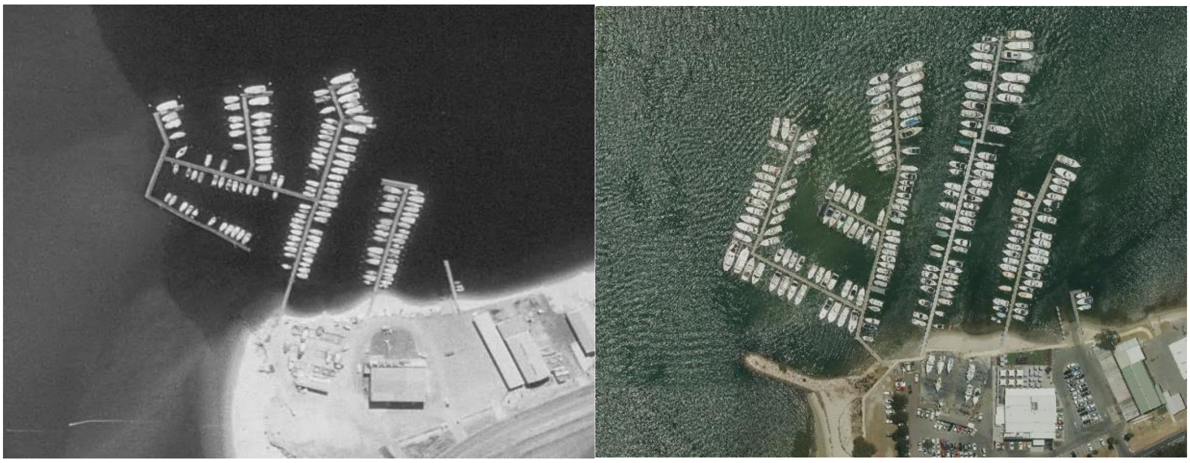

Figure 2.1 SYC (L) Initial Layout - 1970 (R) Current Layout – 2018

The Club is positioned in close proximity to the Swan River navigation channel, and is therefore susceptible to boat wake from passing vessels. In particular, Jetty 5 has historically experienced heavy boat wash and wake which has resulted in boat mooring issues.

2.1 Historical Dredging

The SYC basin has an extensive dredging history, with campaigns completed by the Public Works Department and the Club consistently since 1967 (DPLH, 2005). The table below shows information collated from the SYC regarding these campaigns.

Table 2.1 Historical Dredging Campaigns

Date	Description of Works
1967	Construction of boating basin at Preston Point for SYC.
December 1971	Dredging in SYC boating basin.
1980	Dredging of Preston Point Channel.
1983-84	SYC removed old jetties and dredged whole area.
1985	Dredging from Western boundary of SYC (approx. 6,000 m^3). Rapid siltation necessitated further removal of 2,000 m^3 by October 1985.
1993-94	Dredging of SYC area Jetty 4, 5 & 6 (4,000 m^3).
1997-98	Dredging of SYC area Jetty 4, 5 & 6 (3,000 m^3).
2002-03	Dredging of SYC area Jetty 4, 5 & 6 (3,000 m^3).
December 2008	Dredging of SYC area Jetty 4, 5 & 6 (3,000 m^3).
September 2012	Dredging of SYC area Jetty 4, 5 & 6 (3,000 m^3).
November 2019	Dredging of SYC area Jetty 4, 5 & 6 (3,000 m^3).

The Club has consistently been dredged every 3 - 7 years since the 1993-94 campaign. These campaigns are considered 'reactive', meaning that they are proposed when the Club is experiencing navigational issues as a result of the build up of sediment. This indicates that once the dredging has occurred, it takes on average 3 – 7 years for the siltation to affect navigation.

2.2 Assessment of Dredged Volumes

In November 2020 hydrographic survey was completed around the SYC so that the rate of infill from the previous dredging campaign in November 2019 could be determined. No post-works survey was completed after the November 2019 dredging, therefore it was assumed that the dredging was completed to the design requirements (-1.7 mCD). It is noted that this is a critical assumption. The assumed post dredge depth, and November 2020 survey were then used to determine the elevation difference around the SYC. This difference plot is presented in Appendix A.

The difference plot was analysed to work out the net volume of infill around the build-up area. This was determined to equal approximately 1,500 m^3 and assuming the dredging was completed to design, indicates that the sediment infills at an approximate rate of 1,500 m^3/year.

3. Model Setup, Calibration & Validation

To determine the general patterns of sediment transport and the sources of sediment infill at SYC a hydrodynamic model was developed using Delft3D.

3.1 Model Setup

The Delft suite of models is a fully integrated computer software suite that enables a multi-disciplinary approach to 3D computations for coastal, river and estuarine areas. It can carry out simulations of flows, sediment transport, water quality, morphological developments and ecology (Deltares 2011). The Delft3D models are widely used around the world.

The Delft3D Flow module is a multi-dimensional (2D or 3D) hydrodynamic and transport simulation program which calculates non-steady flow and transport phenomena that result from tidal and meteorological forcing (Deltares 2011). Modelling for this study was completed using a 2D Delft3D Flow Model.

3.1.1 Model Grids

To adequately resolve tidal and wind driven currents requires simulation over a large modelling domain. However, to provide adequate resolution to properly resolve currents in the area of interest around the SYC requires a high model resolution. As a result, to improve computational efficiency it was necessary to use a domain decomposition model setup whereby model resolution is increased surrounding the areas of interest.

The Delft3D Flow module was therefore set up using two model domains. The locations and extent of the model domains are shown in Figure 3.1.

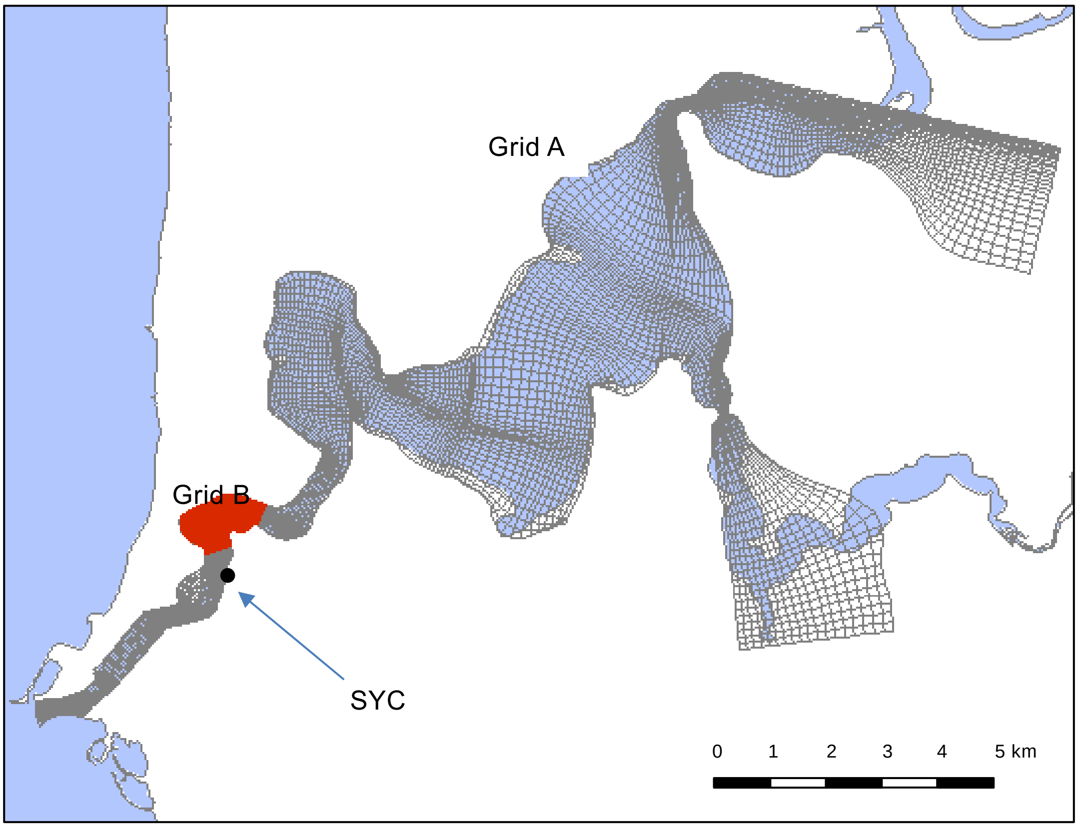

Figure 3.1 Spatial Extent of Delf3D Flow Model Domains

Boundaries to the model included an ocean boundary at the mouth of the Inner Harbour and upstream boundaries within Perth Water and the Canning River. Virtual basins were included as boundary conditions on the upstream boundaries to account for the effect of the rivers further upstream which were not included in the model domain.

The model bathymetry was obtained from various surveys completed by the Department of Transport (DoT) and JBA Surveys. Where available, higher accuracy surveys and more recent surveys were used in preference to older less accurate surveys.

3.1.2 Input Data

The following inputs were used in the model.

- Ocean Water Level
  The recorded water level within the Fremantle Fishing Boat Harbour was used to set the water level at the ocean boundary of the model.

- Wind
  Wind was included in the model using wind data recorded by the Bureau of Metereology at the Inner Dolphin Pylon, situated in Melville.

3.2 Model Calibration & Validation

The model was calibrated and validated against the available measurements taken in 2015 and 2020 which included the following.

- Water level measurements at Barrack Street Jetty.

- Drogue current measurements taken around the SYC in November 2020.

A period from 14 to 30 June 2015 was used to calibrate the model. The parameters that were used in MRA's previously calibrated Swan River model (MRA 2016), were again used in the setup of this model.

The comparison between the modelled and measured water levels at the Barrack Street Jetty is presented in the following plot.

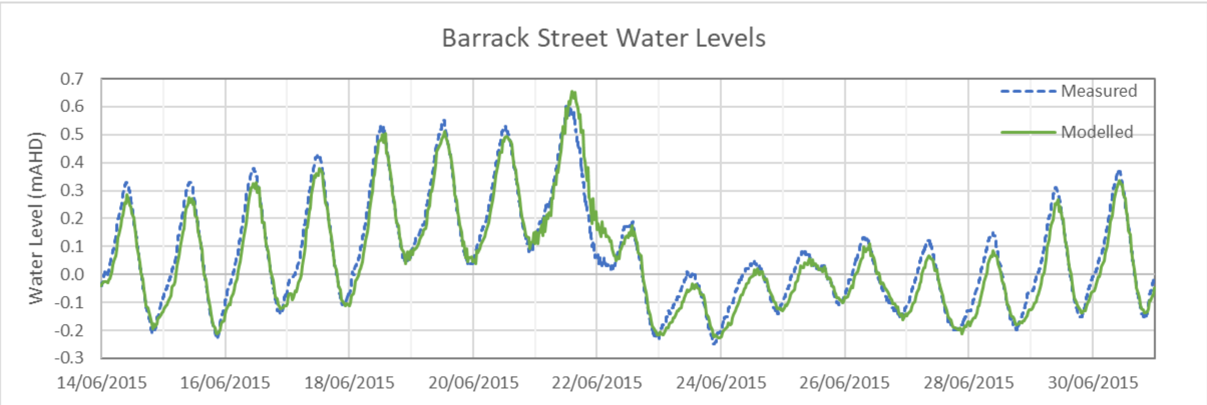

Figure 3.2 Barrack Street Water Levels

This shows that the modelled water level matches very well with the measurements and therefore the flow of water between the ocean and Barrack Street is being accurately replicated in the model.

A period from 4 to 18 November 2020 was used to validate the model. This utilized updated bathymetry, and compared the measured and modelled drogue data around SYC. The purpose of comparing modelled drogue data paths to measured drogue paths, is to ensure that the model is accurately representing current speed, direction and patterns.

The drogue measurements were collected on 11 November 2020 between 9:00AM and 4:30PM around the SYC. The measurements were taken by placing a weighted PVC pipe with a handheld GPS into the river, and tracking its movements during the flood and ebb tidal phases.

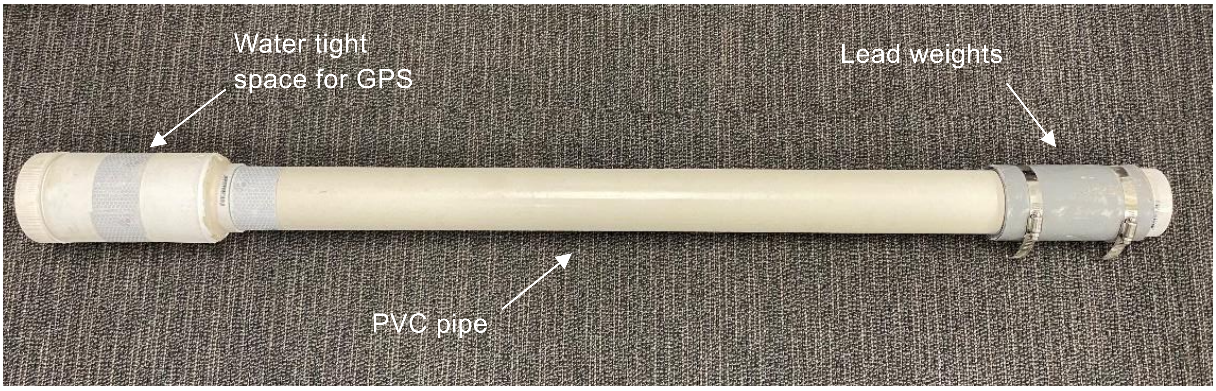

Figure 3.3 MRA Drogue

Figure 3.4 Drogue Deployment

The comparison between the modelled and measured drogue tracks during an ebb tidal phase around SYC is presented in the following plot.

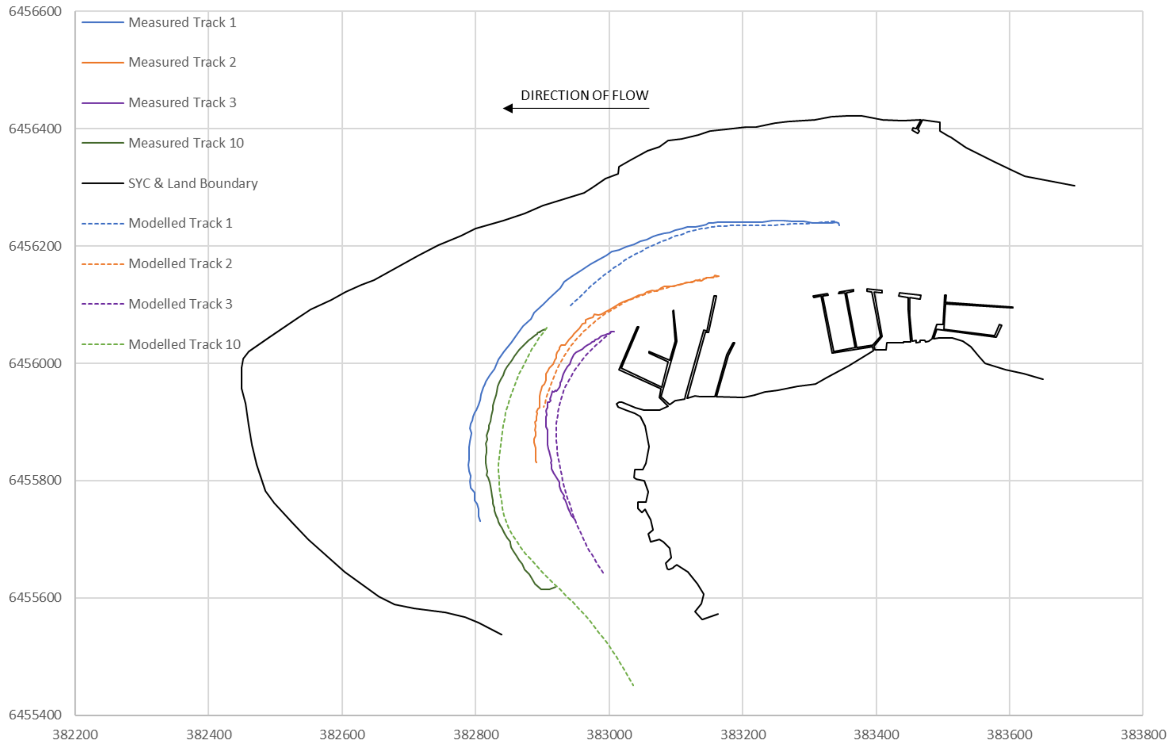

Figure 3.5 Ebb Current Tracks

This shows that the model is accurately representing the movement of the current during ebb tidal flows. The comparison between the modelled and measured drogue tracks during the flood tidal phase is presented in the figure below.

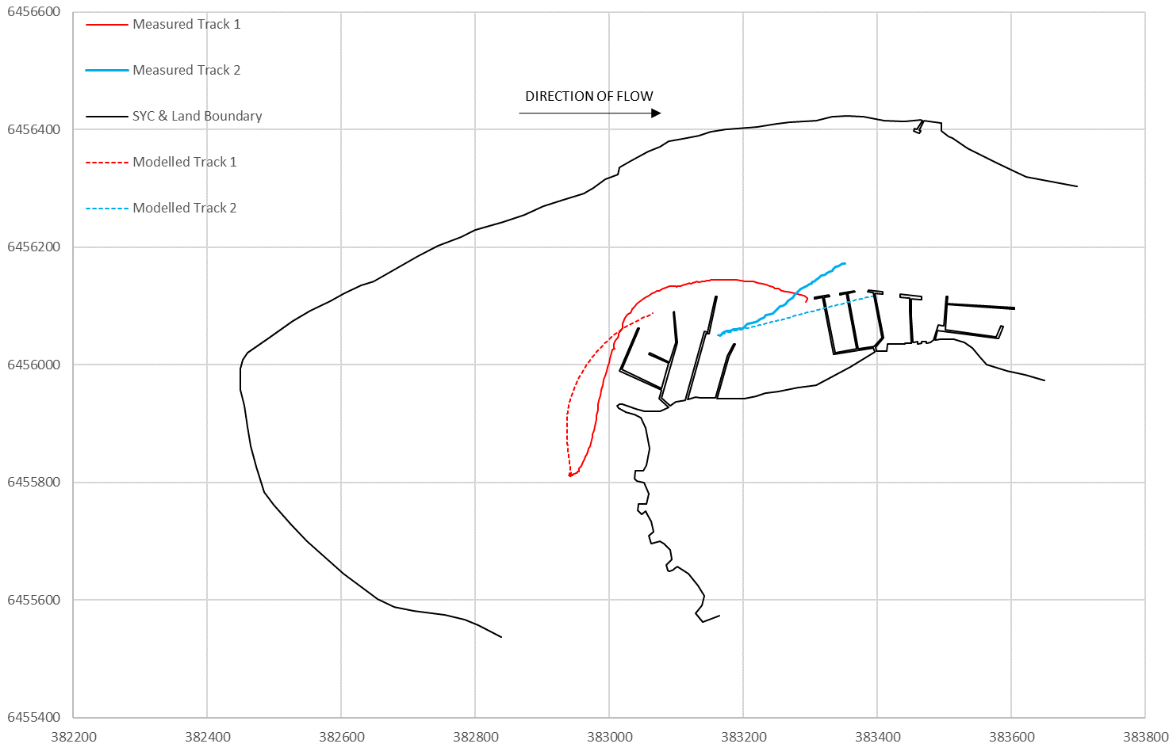

Figure 3.6 Flood Current Tracks

The flood current movements are not as accurately represented as the ebb movements. This is a result of the model not perfectly capturing the switch of tidal phase. Due to timing restrictions, drogue measurements could only be taken for two flood tracks, and these tracks were measured immediately after slack tide. The slow nature of the current speeds at this time make it difficult to validate an approximate hydrodynamic model to these movements.

4. Sediment Transport Model

To determine an approximate sediment transport model, outputs from the calibrated and validated hydrodynamic model were used.

4.1 Sediment Conditions

Several samples were collected in between Jetty 3 and 4 and analysed to give a representative sediment size (d_{50}) of 0.30 mm (Western Environmental 2019).

4.2 Calculation of Movements

The movement of sediment is complex. There is no simple or straightforward method that is applicable to the wide range of sediment and hydraulic conditions experienced in nature.

In the late 1980s, Delft completed an extensive research program into the movement of seabed sediment under the influence of waves and currents. These are the primary mechanisms of sediment movement. This initial work has since been expanded and further developed and is reported in van Rijn (2012). Simple general formulae for sand transport in rivers, estuaries and coastal waters are presented, and these formulae have been used to approximate minimum value current velocities for initiation of sediment transport.

Sediment transport can take place as a bedload, suspended load or both. The type of sediment transport depends on the size and the bed materials and the flow conditions. Bed load particle movement will occur when the instantaneous fluid force on a particle is just larger than the instantaneous resisting force related to the submerged particle weight and the friction coefficient. This limit is referred to as the initiation of motion.

The recommended methods and calculations of van Rijn have been used to estimate the potential sediment movement from the measured currents.

4.3 Limits of Movement – Currents

The critical depth averaged current velocities for initiation of motion were calculated based on a value for d_{50} of 0.30 mm. To determine a conceptual model of sediment transport, the Delft3D model was run for the month of November 2020. Water depth, depth averaged current velocity, and current direction were output from the model at nine locations around the SYC. These locations analysed together can provide a conceptual model of sediment transport. The figure below shows the location of these positions.

Figure 4.1 Sediment Transport Analysis Points

Each point was analysed to determine whether the depth averaged current speeds reach the critical speeds needed for initiation of motion. The analysis then involved determining whether the current was moving towards the area of build up or away. The table and figure below present the results of the analysis.

Table 4.1 Sediment Transport Analysis

Point	Sediment Moving Towards Area of Build Up (%)	Sediment Moving Away from Area of Build Up (%)	Net Sediment Movement[1] (%)
1	0	0	0
2	1	3	-2
3	9	13	-4
4	16	23	-7
5	26	21	5
6	18	6	12
7	18	3	15
8	11	0	11
9	2	0	2

Notes 1. Positive values represent movement towards the area of build-up.

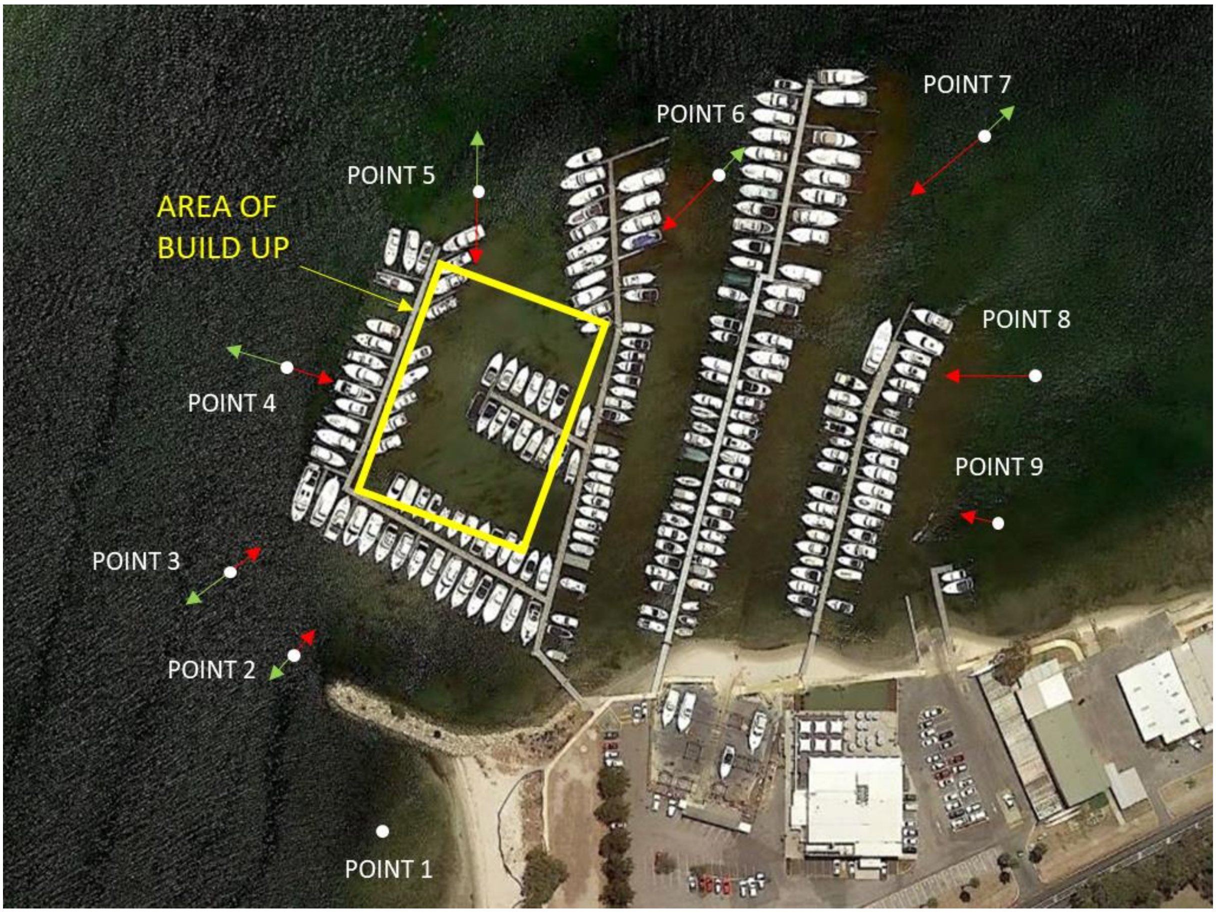

Figure 4.2 Visual Representation of Sediment Movement

The table and plot show that the greatest amount of movement of sediment towards the build-up area originates from the north east side of the club. This indicates that the only way to significantly improve siltation issues around Jetty 5 is through the construction of a hard structure around SYC that interrupts the natural sediment movement.

5. Potential Improvement Options

The Club have looked into a number of options that could potentially improve the siltation and tranquillity issues surrounding Jetty 5. These have included the redesign of Jetty 5 and the extension of the Preston Point groyne. These options, as well as the construction of additional hard structures, are assessed below against their ability to improve tranquillity, reduce siltation build up and the likelihood of gaining approval from the Department of Biodiversity, Conservations and Attractions (DBCA), and the Department of Planning, Lands and Heritage (DPLH).

5.1 Redesign of Jetty 5

Multiple conceptual redesigns of Jetty 5 have been proposed by Searle Consulting Pty Ltd and Bellingham Marine and were provided to MRA by SYC. These are discussed further below.

5.1.1 Reconfigured Fixed Jetties

The options presented by Searle Consulting involve the reconfiguration of Jetty 5 to ensure no pens are on the exposed side of the jetty, and the northern extension to Jetty 6. The layout of the proposed fixed structures with various pen sizes are presented in the figures below.

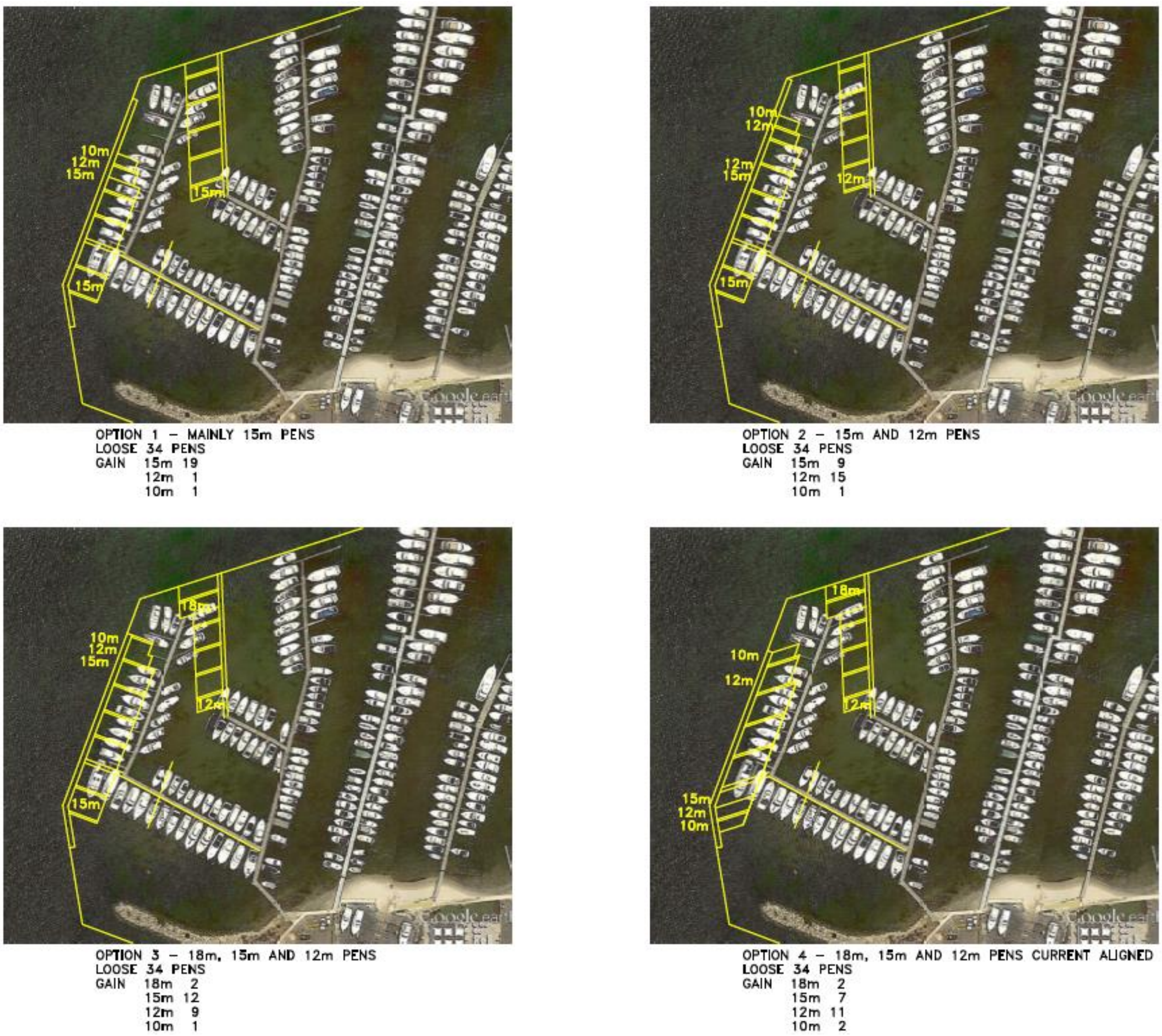

Figure 5.1 Redesign of Jetty 5 (Searle Consulting)

The re-allocation of pens to the protected side of Jetty 5 will improve tranquillity for the effected boats moored at Jetty 5. The redesigns would also likely be approved by DBCA and DPLH, as the works involve upgrades of existing jetty structures.

The options presented above are unlikely to improve the siltation issue, however a reduction in Jetty 5 pen sizes from the current configuration will require less navigable depth. The current pen sizes at Jetty 5 are presented in the figure below.

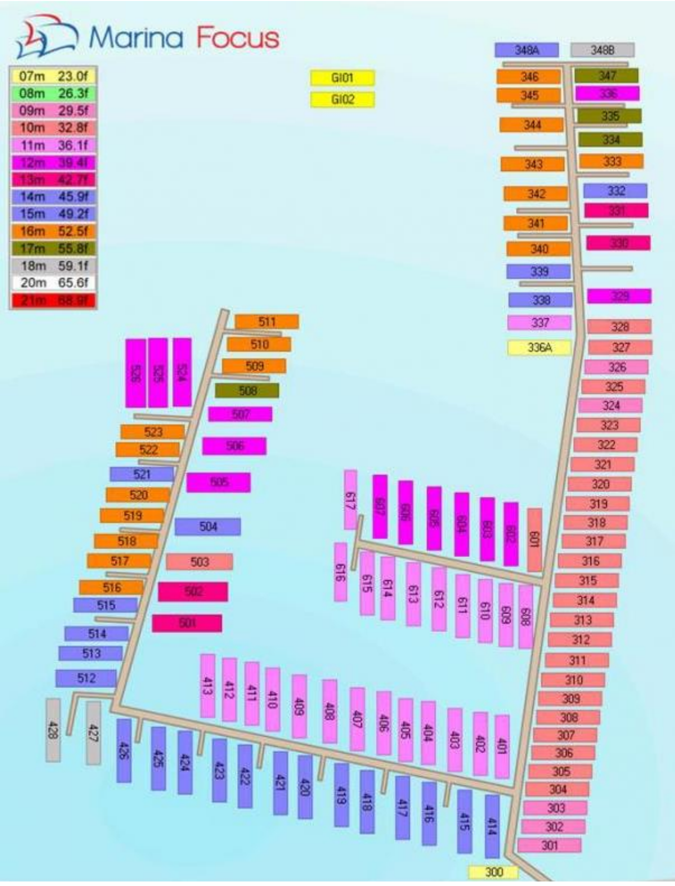

Figure 5.2 SYC Pen Sizes

The existing pens on the protected side of Jetty 5 are comprised of a range of pen sizes from 17 m to 12 m. The four options presented by Searle remove all pen sizes greater than 15 m from Jetty 5, reducing the navigable depth needed around Jetty 5. The smaller vessels require less depth and therefore less maintenance dredging would be required.

5.1.2 Floating Attenuators & Pens

Bellingham Marine provided two options to the Club for the replacement of Jetty 5 with a floating attenuator. The layout of the proposed floating attenuator structure with 15 m and 12 m pen sizes are presented in the figure below.

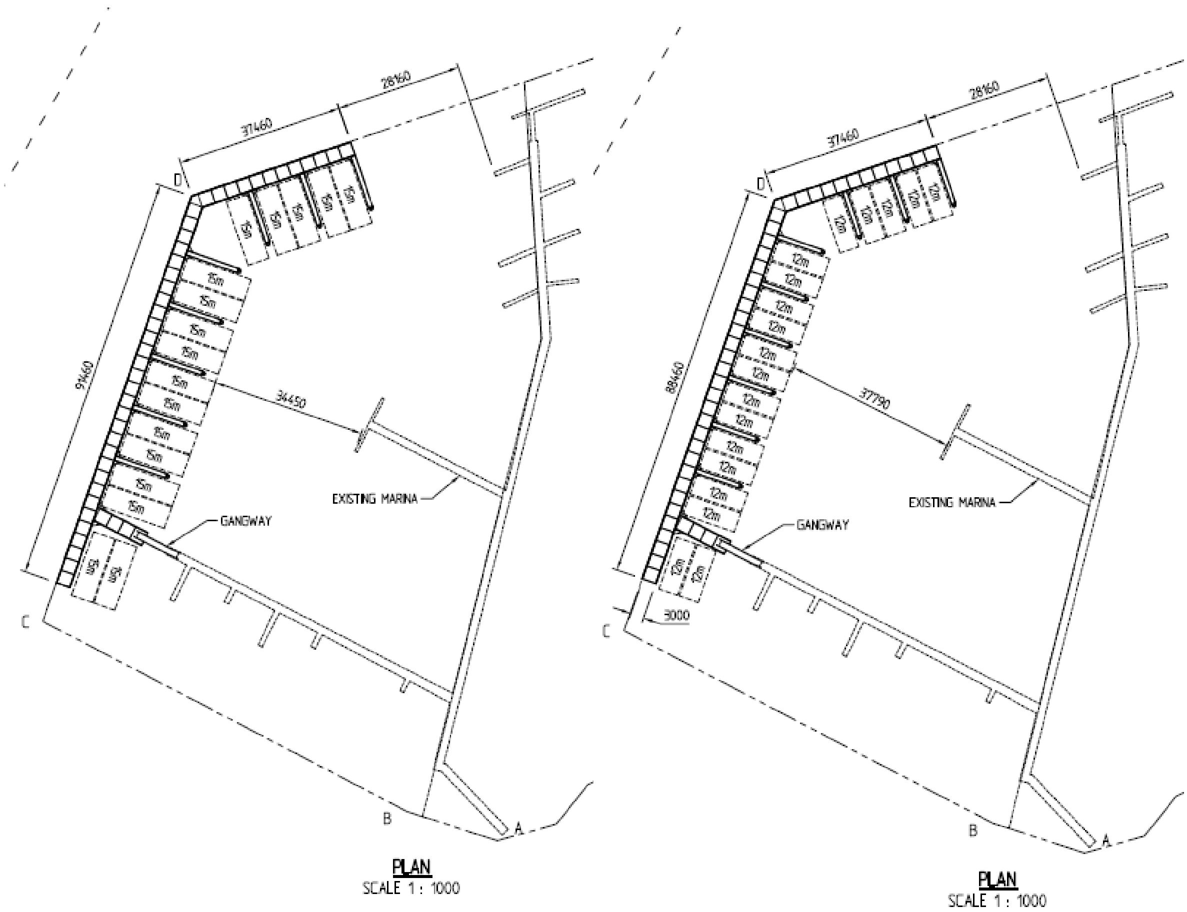

Figure 5.3 Floating Attenuator Options for Jetty 5 (Bellingham Marine)

The floating attenuator structure would dampen boat wake from passing vessels and improve tranquillity within the Club, and around Jetty 5. These works would likely gain DPLH and DBCA approval as the works involve the upgrade of an existing structure.

Similar to the options provided by Searle Consultants, the installation of the floating attenuator is unlikely to directly improve siltation issues. However, both options presented above reduce the current pen sizes. The navigable depth required for the smaller pens will be less than the navigable depth currently needed, therefore potentially reducing the volume and frequency of maintenance dredging needed.

This option, through increased protection from the attenuator, is likely to provide improved wave conditions within the pens compared to the fixed option. This is on the basis that the attenuator is designed appropriately for the wave climate. No further details of the profile or design of the attenuator have been provided and therefore no assessment of the appropriateness of the attenuator itself has been completed.

5.2 Extension of Preston Point Groyne

The option of extending the Preston Point groyne has been discussed in the past to prevent sediment build up. However, the modelling and assessment indicates that there is minimal sediment movement around the groyne compared to other locations, and extending it would not improve the siltation issue around Jetty 5. Extension of the groyne would also be unlikely to improve the tranquillity issues from passing vessels. It is not recommended this is explored further as a solution to the options being considered.

5.3 Construction of Alternative Structures

The hydrodynamic modelling and sediment transport analysis indicates that sediment movement in the vicinity of the club is likely generated from various directions. The most viable way to manage this would be to interrupt this movement with a vertical wall, breakwater or similar structure. This would likely be required around the extents of the club and would need to extend to the riverbed to ensure sediment movement into the area of the pens is interrupted.

The construction of vertical walls around SYC would interrupt the natural sediment movement. This would not only help the siltation issues, but it would also block boat wake and therefore prevent boat mooring issues.

The construction of vertical walls in the Swan River requires the submission of a Development Application (DA) to DBCA and Section 18 consultation and approval from DPLH. Due to the obstructive nature of the works involved with the construction of a vertical wall encompassing the Club, it is likely that approval from DBCA would require extensive additional assessments and consultation to satisfy their requirements. It is likely this process would take in the order of 6 to 9 months.

Section 18 approval involves Aboriginal heritage consultation, assessment of impacts and can be a long and relatively costly process. This process is likely to take in the order of 12 months.

In addition, it is unclear that approval for these type of structures would be approved, due to their significant change to both the local conditions, amenity and function of this section of the Swan River.

The potential layout of a vertical wall structure around SYC is presented in the figure below. This is one example of this type of structure and other forms and configurations would be possible.

Figure 5.4 Potential Vertical Wall Layout

Similar to vertical walls, a breakwater would improve siltation and tranquillity issues, but would take up substantially more space and is even less likely to be approved by DBCA and DPLH.

A summary of the various options and their ability to achieve each criterion are presented in the Table below.

Table 5.1 Potential Improvement Options for SYC

Option	Criteria 1 Siltation	Criteria 2 Tranquillity	Likely DBCA/DPLH Support
Jetty 5 Redesign – Fixed Jetty	×	✓	✓
Jetty 5 Redesign – Floating Attenuator	×	✓	✓
Groyne Extension	×	×	×
Vertical Walls	✓	✓	×
Breakwater	✓	✓	×

The fixed and floating options will improve tranquillity to varying degrees through the reallocation of pens to the protected side of Jetty 5 and would be more likely to gain DBCA/DPLH approval. Out of the two alternatives, the floating attenuator structure will dampen wave conditions within the pens, and would hence be more effective in improving tranquillity to the protected areas behind the structure compared to the fixed option. Bellingham Marine presented two wave attenuator designs with 12 m and 15 m pens. The attenuator design utilising 12 m pens would require less navigable depth, which would be expected to result in less maintenance dredging and would therefore would be the preferred option.

This is based on the assumption that the floating attenuator structure is appropriately suitable and designed for the wave and vessel wake conditions experienced at the site.

The groyne extension option does not meet any of the required criteria and is not a viable option for the Club.

The construction of an alternative structure such as a vertical wall around the Club would be most effective in improving the siltation issues surrounding Jetty 5. This structure would also improve tranquillity within the Club by blocking passing boat wake. However, DBCA and DPLH would be less likely to approve these works given the scale, and environmental impact. MRA would be able to assist the Club in the preparation of these approvals to DBCA and DPLH if the Club want to proceed with this option, as well as the investigation and design involved with the construction of a vertical wall/breakwater.

6. Conclusion

This report has investigated the sediment build up and boat wake issues surrounding Jetty 5 at the SYC. The assessment included a review of historical dredging campaigns at the club, the setup, calibration and results of hydrodynamic modelling around the Club, and a high-level conceptual sediment transport model. Several options were presented and assessed with regards to their ability to improve siltation, tranquillity, and their likely acceptance by DBCA and DPLH. These included:

- Redesign of Jetty 5 with a fixed structure.
- Redesign of Jetty 5 with a floating attenuator.
- Extension of Preston Point Groyne.
- Construction of a vertical wall/breakwater around SYC.

The assessment indicates that the source of sediment that is causing navigational issues is originating from both the south and north-east sides of the Club. Reducing the natural build-up of sediment would need to involve the construction of a structure around the Club that blocks the natural movement of sediment. These works would result in a substantial change to the local conditions, amenity and function of the area and may be more onerous and less likely to gain approval from DBCA and DPLH.

Of the options provided, the redesign of Jetty 5 with a floating wave attenuator structure, with smaller pen sizes, appears the most appropriate. This may assist in reducing the dredging requirements through a reduced navigable depth requirement. The wave attenuator structure will also improve wave conditions within the pens on the lee side of the structure, and is likely to gain DBCA/DPLH approval.

7. References

Department of Planning Lands and Heritage (DPLH) 2005. *Swan Yacht Club – Siltation of Boat Pens*. Prepared for Swan Yacht Club

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Western Environmental, 2019. *Swan Yacht Club Dredging Project – Environmental Management Plan.* Prepared for M P Rogers & Associates Pty Ltd (MRA)

8. Appendices

Appendix A Difference Plot

Appendix A Difference Plot

AT CORRECT SCALE THIS IS 100 mm

LEGEND:

DIFFERENCE (m)

	> 1.0
	0.8 TO 1.0
	0.6 TO 0.8
	0.4 TO 0.6
	0.2 TO 0.4
	0.0 TO 0.2
	0.0 TO −0.2
	−0.2 TO −0.4
	−0.4 TO −0.6
	−0.6 TO −0.8
	−0.8 TO −1.0
	< −1.0

NOTES:

1. HYDROSURVEYS COMPLETED BY JBA SURVEYS IN OCTOBER 2019 AND NOVEMBER 2020.
2. HORIZONTAL DATUM IS MAP GRID OF AUSTRALIA 1994 (MGA94). VERTICAL DATUM IS CHART DATUM (CD).
3. NO POST DREDGE SURVEY AVAILABLE. DIFFERENCE PLOT ASSUMED DREDGING COMPLETED TO DESIGN.

AT CORRECT SCALE THIS IS 100 mm

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DRAWN	R BORJA
CHECKED	T HUNT

DIFFERENCE PLOT -ASSUMED OCT 2019 POST DREDGE TO NOV 2020

SWAN YACHT CLUB

SCALE AT A3 AS SHOWN

DECEMBER 2020

SK1814–01A

P:\MRA Paying Jobs\K1814 SYC – Jetty 5 Modelling Investigation\5 MRA Dwgs\D1814 – Difference Plot m p rogers & associates pl

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