Proposed Georges Cove Marina
Sydney Western City Planning Panel
2018SSW027 – Liverpool – DA-611/2018
Questions Related to Flooding and Coastal Management SEPP in response to the Panel's *REASONS FOR DEFERRAL* received on 19Mar2021

The Sydney Western City Planning Panel (the 'Planning Panel') Record of Deferral for the Georges Cove Marina application (8 March 2021) lists "Outstanding Issues" that include requests for additional engineering details for the marina.

This letter provides detailed responses to issues 1 to 27 and is supported by the following information regarding marina design, rock revetment design and flood levels and velocities:

- Pacific Pontoon and Pier Details of Piling System and Marina Experience – provided as Appendix A of this letter;
- Additional flood modelling undertaken by Cardo in 2021 as part of preparing this response – provided as Appendix B of this letter;
- Flood evacuation details for the marina;
- Figures showing:
    - peak water flow velocities for 100 year ARI and PMF
    - pile and pontoon arrangements
    - photographic examples of riverine pontoons;
    - a typical cross-section of river foreshore rock protection;
    - revetment cross-sections at 10 locations along the marina foreshore; and
    - location plans in relation to river foreshore rock protection.

These comments relate to flooding of the proposed marina and associated potential hazards. The Planning Panel has provided a number of questions requiring further information. These questions are listed below and each dealt with individually in the same numerology as the Record of Deferral .

"Outstanding Issues"

1. **Noted.**
2. **Noted**
3. **Noted**

(a) Flood risks

1. **Noted**
2. **Location of the facility in a flood channel**

Cardno has undertaken flood modelling of the 100 yr ARI flood and the Probable Maximum Flood (PMF) using Council's TUFLOW model for the Georges River. The distribution of peak flood velocities across the marina basin are presented in Figures 1 and 2.

m 0409 912 631 e mark.tooker@tookerandassociates.com.au a 30 Walworth Avenue, Newport abn 39 619 046 070

In the 100 yr ARI flood, the peak velocities in the marina basin range from 0.3m/s up to 1m/s. The main flood channel with peak velocities of 1m/s to 2 m/s is located out of the marina basin.

In the PMF, the peak velocities in the marina basin show the south western half of marina basin in the main flood flow path with peak velocities up to 1.2m/s.

Therefore, it can be said that the marina basin is not in the main flood channel in the 100 yr ARI flood, and in the PMF the south western half of the marina basin is in the main flood channel. **The flood velocities are readily manageable in terms of designing a pile anchoring and floating pontoon system for the marina facility.**

3. Probability of Flood Occurrence for 100 yr ARI Flood

Noted.

4. Floating Marinas are Rare in Flood Affected Rivers

In the Georges River, the BoM provides a flood warning of 12 hours for floods that are predicted to exceed RL 4m AHD. This flood warning is provided by various means including digital text, BoM web site, radio and TV. For severe floods up to the PMF, there is around 13 hours warning time to evacuate the marina site (this includes the BoM warning time plus the time for flood to rise from RL 4m AHD up to higher flood levels). The BoM flood warning can be sent by text to many marina staff and boat owners with craft in the marina.

However, there is no need to evacuate craft from the marina because the marina will be designed to withstand the 90,000 yr ARI flood which is predicted to rise to RL 9m AHD.

There are numerous examples of floating marinas and boating facilities in floodprone rivers in Brisbane and Sydney. In the Brisbane River, there are the Rivergate Marina, Dockside Marina, Bulimba Marina, Brisbane Power House pontoon berths, many residential development marinas and many River Cat ferry pontoon wharfs. In the Georges River, there are the Lugarno Marina and many boat ramp pontoon facilities. In the Parramatta River, there are many public river ferry pontoon wharfs.

Worldwide, there are many floating marinas in flood affected rivers. **As such, floating pontoon boating facilities in rivers are not unusual or rare.**

5. Piling and Pontoon System for the Marina

A double-telescopic pile configuration is proposed with no pile extending above the pontoon walkway level. This is shown in Figure 3 and 4 and Pacific Pontoon and Pier Design letter attached at Appendix A.

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The primary pile (outside casing) will be embedded approximately 8 m with the remaining 2m extending to approximately the lowest tidal level. The inner-casing would be approximately 9m long and rise to allow a primary top level of RL 6.1m to accommodate the 100 yr ARI flood planning level but with an additional innermost telescopic 9m casing design (inside casing) which allows the pontoon to rise with the flood levels to RL 9.1 m AHD (and in actuality, past its design height to over RL 12m AHD which is above the PMF level of RL 10.2m AHD).

The flood at a level of RL 9m AHD has been estimated by Cardno Engineers to have an average **recurrence interval of between 102,000 years and 135,000 years** (see Appendix B). We have selected the recurrence interval for a RL 9m AHD flood as 100,000 years for the marina site. When allowances are made for climate change effects, the flood recurrence would **reduce to approximately 1 in 90,000yr flood** (see Section 18 below). **The adoption of this piling and pontoon system far exceeds design criteria of a 100yr ARI flood adopted by government authorities for public and private boating facilities.**

The marina berthing/pontoon system will be designed to resist the flow/velocity/debris/boat loads of up to a 90,000yr ARI flood so that berthed craft would not be released and washed downstream in a severe flood.

The engineers at Cardno have undertaken flood modelling and estimated peak velocities in the marina basin during the 100 yr ARI flood will range from 0.3 m/sec to 1 m/sec (see Figure 1). This corresponds with the 100 yr ARI modelling presented in the from Georges Cove Marina EIS (EMM 2019) Appendix C2).

The engineers at Cardno have undertaken flood modelling of the PMF flood using the Council's TUFLOW model and have calculated estimated peak velocities in the marina basin when flood levels reach RL 9m AHD (1 in 90,000yr ARI flood). These peak flood velocities at RL 9m AHD are estimated to range from 0.2 to 1.2 m/sec (see Figure 2). **The lateral loads imposed by the 1.2m/s flood flows could be readily accommodated in the proposed pile and pontoon marina facility.**

The company Pacific Pontoon and Pier are experienced in design of these piling and pontoon systems for floating marinas and has provided the attached letter indicating their experience in these designs (see Appendix A). The detailed design at the CC stage will provide a suitable spacing of the piles on the marina and pontoon structure to withstand the expected hydraulic, debris and moored craft forces. Preliminary design by Pacific Pontoon and Pier suggest that a 610mm diameter steel outer pile with overlapping 2 stage inner steel telescopic sections would be adequate for flood loads up to the 1 in 90,000 year ARI flood.

The top of the pile will be structurally connected to the pontoons as shown at Figure 3. The rising water levels will provide the hydraulic lift under the pontoons to raise the inner telescopic piles to the design level of RL 9.1m AHD (and 3m above, which is higher than the RL 10.2m AHD PMF level, if necessary, although this is beyond the design range).

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The pontoons will form a structural unit readily able to withstand the lateral loads between the piles. **There will be no requirement for additional anchoring of the pontoons via cables/chains from the bed or side of the marina.**

The tie point cleats on the pontoons will also be **structurally mounted** (not merely surface mounted) onto the frame of the pontoons. There will be four tie down points (spring lines) on the pontoons for each craft. For the craft on the downstream side of each of the main walkway pontoons, there will be an additional tie down point, structurally fixed, to allow an additional bow line for those vessels, allowing for 5 secure lines for those vessels.

This design will far exceed the 100yr ARI flood limit design criteria/standard used by government authorities for approval of boating facilities on major rivers in Sydney and Brisbane.

6. Design Detail for the Marina Piling and Pontoon System

Design of the proposed pile and pontoon system for the Georges Cove Marina will deal with the water level rise and resist the lateral loads imposed by the flood velocities, debris and craft loads for floods up to the 90,000 year ARI event.

Design detail is provided in Section 5 above. This design far exceeds the 100yr ARI flood limit design criteria used by government authorities for boating facilities on major rivers in Sydney and Brisbane.

The Liverpool Council's Engineers have adopted the 100 year ARI flood level as the appropriate level to design its own recent public boating piling and pontoon facilities. The landing pontoons at the Davy Robinson boat ramp have 6m high piles to allow for the 100 year ARI flood events. Furthermore, the RMS in designing the public wharf facilities in the Parramatta River (even upstream at Parramatta) also adopted the 100 year ARI flood as the appropriate design criteria for piling public ferry landing facilities (see photographs attached at Figures 5 and 6). Similarly, in the Brisbane River, which has 100 yr flood levels similar to the Georges River at the subject site, designers adopted the 100 yr flood levels to design the 6m high piles at floating marinas and public boating facilities (see photographs at Figures 7 and 8).

Georges Cove Marina are using the 90,000 year ARI design criteria which is unheard of with respect to design criteria.

In terms of flood damage to houses, the State and Local government guidelines **do not** adopt the criteria of the Probable Maximum Flood level (PMF) for protection against property damage but rather a lower flood level which is the Flood Planning Level (FPL), being the 100yr ARI flood plus 0.5m freeboard (which equates to RL 6.1m AHD for proposed Marina site). In floods with severity between the between the Flood Planning Level and the PMF, there will be substantial damage to residences across Greater Sydney and particularly along the major rivers in Sydney such as the Georges, Nepean, Cooks, and Parramatta Rivers. Also, many cars parked along roads will be swept along by the PMF flows.

m 0409 912 631 e mark.tooker@tookerandassociates.com.au a 30 Walworth Avenue, Newport abn 39 619 046 070

We have learnt from previous marina failures and adopted a far higher flood design criteria for the design of the Georges Cove Marina. For the marina, the flood design criteria adopted is the 90,000 year ARI flood. This requires the piles to retain the pontoons in place up to RL 9.1m AHD. The piles will be a double telescopic pile arrangement with a first stage design level of RL 6.1m to accommodate the 100 yr ARI flood planning level but with a further 3m rise provided for in a travelling telescopic 9m section which permits the pontoon to further rise in a controlled manner should the flood levels rise to RL 9.1 m AHD.

The adoption of this piling system by Georges Cove Marina far exceeds design criteria of a 100yr ARI flood adopted by Council and government authorities for public boating facilities.

A detailed Flood Emergency Response Plan will be prepared at CC stage dealing with the flood evacuation of boats or securing them in place. **In summary**, **there is no need to evacuate craft from the marina because the marina will be designed to withstand the 90,000 yr ARI flood which is predicted to rise to RL 9m AHD.** The evacuation process for the marina berths would be:

i. Issue evacuation order to all people in the marina on receipt of the BoM flood warning;
ii. Some boat owners who are on site at the time of the warning might decide to move their boats to bays nearer to Botany Bay;
iii. No boats will be allowed to be moved from the marina 4 hours after the BoM warning;
iv. All boats would be properly flood-secured to the pontoons;
v. All unsecured equipment on the floating berths would be relocated to the marina building at floors above the PMF flood.

7. Likelihood and Consequences of Marina Failure

As stated in Section 3 of the Record of Deferral by the Sydney Western City Planning Panel, there is an estimated cumulative risk of 45% for the 100 yr ARI flood level occurring or been exceeded over the 60 year life of the marina. The Georges Cove Marina has been designed for the 90,000 year ARI flood which the Cardno Engineers have estimated (see Appendix B) has a cumulative risk of occurring or being exceeded of only 0.067 of 1% (or 0.067%).

The pile design ensures the pontoons and craft stay in place in floods up to the 90,000 year ARI event. The pontoons will be designed as structural beams between the pile supports with an ability to withstand the velocity, debris and craft lateral loads.

The proposed marina design ensures that the risk to boats and to boats floating down river from the marina is miniscule, far exceeds community expectations, and far exceeds government current-day practice for public boating facilities and approval of private boating facilities. The proposed marina design also far exceeds the current Council Standards of design required to minimise flood damages to

m 0409 912 631 e mark.tooker@tookerandassociates.com.au a 30 Walworth Avenue, Newport abn 39 619 046 070

homes and cars parked in streets which is set at the flood planning level (100 yr ARI flood plus 500mm – this is RL 6.1m AHD at the proposed marina site).

8. Consideration of Risk in Marina Design

The marina design has given full and considered attention to the potential hazard to downstream people and homes resulting from the marina failure in a flood. This has resulted in the selection of a design criteria for the marina which is the 90,000 year ARI flood and its associated lateral loads from flow velocity, debris and craft. The telescopic piling system and pontoon system which could resist and stay in place for this 90,000 year ARI flood. There is negligible risk of this severe flood being exceeded over the 60 year life of the marina (0.067% chance). This **design far exceeds the guidelines adopted by public authorities in their own structures** and have approved for private boating facilities which would typically have a 45% chance of being exceeded leading to marina failure in a severe flood.

9. Severity of Consequences required by Coastal Act and SEPP

The proposed marina has adopted design criteria which far exceeds the design criteria of other marinas or public boating facilities. It would be designed to be able to withstand the 90,000 year ARI flood which has an estimated risk of 0.067% of occurring or being exceeded during the 60 year life of the marina. Most public and private boating facilities are designed for the 100 year ARI flood which has a 45% estimated risk of being exceeded over a 60 year life.

The proposed marina, therefore, will not cause increased risk of coastal hazards on the subject land or other land as required by the Coastal Act and SEPP.

10. Engineering Design Challenges

There are no unusual design challenges for the marina. The design needs to ensure all elements are designed for the estimated flood, velocity and debris loads with an appropriate safety factor.

Telescopic piles have been installed in marinas and do not require any special construction requirements.

The preliminary design by Pacific Pontoon and Pier (see Figures 3 and 4) shows the 10m long (approx.) outer steel pile (610mm diameter) whose flanged cap top is about 400m above the -0.732m AHD low tide level, with the first stage normally extending a metre or so to RL 0.988m AHD (normal tidal range) and with the capability of the two the inner telescopic piles lifting ultimately to RL 9.1m AHD while still structurally confined within each pile section. The preliminary design indicates that the outer pile would be embedded approximately 8m below the bed of the marina basin and the two telescopic inner piles would each be approximately 9m long.

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The rising water levels will provide the hydraulic lift under the pontoons to raise the inner telescopic piles to the design level of RL 9.1m AHD (and 3m above, which is higher than the PMF, if necessary, although this is beyond the design range).

The tie point cleats on the pontoons will also be **structurally mounted** (not merely surface mounted) onto the frame of the pontoons. There will be four tie down points (spring lines) on the pontoons for each craft. For the craft on the downstream side of each of the main walkway pontoons, there will be an additional tie down point, structurally fixed, to allow an additional bow line to the bow of those vessels, allowing for 5 secure lines for those vessels.

11. Appearance and Construction Impacts of the Marina

The wet berth facility will be designed to be safe and unaffected up to the 90,000 yr ARI flood which is more than appropriate from a safety viewpoint. The flood safety for this marina will far exceed the design criteria adopted and approved for private boating facilities which is limited to the 100 yr ARI flood.

In essence, the telescopic design makes the piles hidden in all circumstances below the pontoons. As such, the piles do not pose any visual conflicts from the pontoons or the marina buildings.

The minimum habitable floor level in the marina buildings is RL 6.1m AHD. The marina pontoons will float over the normal tidal range up to about 1m AHD. Views from the main public areas at and above RL 6.1m AHD in the Maritime Building and Private Marina Club will not be affected or obstructed by the marina wet berth structure including the pontoons and piles.

The construction techniques for the marina will be the same as for any marina. The steel piles will be driven into the bed at suitable spacings to provide structural support for the marina system in a severe flood (90,000 yr ARI flood). Preliminary design by Pacific Pontoons and Pier indicates that the pile embedment depth will be approximately 8m. Pile layouts would be typically designed to have one at the end of each finger walkway in a double berth arrangement and spaced along the main pontoon walkways but flood modelling will be used to assist the Engineers' detailed design calculations.

12. More Engineering Information for the Marina

More engineering information is provided in this response to the Planning Panel in terms of engineering structural design, flood modelling to ascertain peak velocities in the marina basin, flood risk assessments, assessment of climate change impacts on flood levels and assessment of appropriate design flood conditions.

13. Aesthetic Appearance of the Piles

The top of the proposed piles for the subject marina is just above the pontoon deck (see Figures 3 and 4).

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The aesthetic of the marina is enhanced by the telescoping, unobtrusive pile design as no piles will be visible above the marina pontoon walkways.

14. Coastal Management SEPP

See below.

15. Clause 15 Coastal Management SEPP

This response provides additional details regarding engineering structural elements and their design as well as the estimation of flood risks in a severe flood.

The proposed marina has been designed to withstand a 90,000 year ARI flood which is a significantly higher design criteria than the 100 year ARI flood criteria applied to public and private boating facilities by government authorities in Sydney and Brisbane. It is also significantly higher than the NSW government flood policy criteria for protection of flood damage to homes and cars which is the 100 year ARI flood level plus 500mm freeboard or RL 6.1m AHD at the subject marina site.

The adoption of this 90,000year ARI flood design criteria means that the risk of this flood occurring or being exceeded is negligible over the 60 year life of the marina (0.067% chance of this occurring). Given this negligible risk of a flood exceeding the adopted design flood (90,000 year flood) and the engineering design elements which will adequately deal with this design flood, it can be said that **the proposed marina would not cause increased risk of coastal hazards on the subject land or other land.**

16. No Coastal Vulnerability Area Mapping for Coastal Management SEPP

As discussed in Section 15 above, **the proposed Marina development would not cause increased risk of coastal hazards on the subject land or other land** and as such, it will comply with Clause 15 even without mapping of the Coastal Vulnerability Area.

17. Coastal Management Act – Climate Change Influences on Flooding

Noted.

18. Climate Change Impacts on Flooding

The adoption of a telescopic pile berthing system for operational design accommodating up to a RL 9.1m AHD flood (1 in 90,000 yr) means that climate change influences on flood levels have been readily accommodated.

The Engineers at Cardno have predicted that a sea level rise by 2100 of up to 0.9m would add about 0.1m to severe flood levels at the marina site. This was based on an assessment of the influence of a 0.6m rise in tidal levels in Botany Bay as undertaken in the 1991 Georges River Flood Study (see Appendix B).

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The BoM/CSIRO research paper by Dowdy et al October 2015 predicted climate induced increases in severe rainfall (20yr maximum 1 day rainfall) for the north eastern NSW coast (including Sydney) of 15% for the IPCC intermediate Greenhouse scenario (RCP4.5) and 25% for the worst case IPCC Greenhouse scenario (RCP8.5).

Engineers at Cardno have estimated that the climate change induced increases in rainfall intensity on the Georges River catchment would increase the 100 yr ARI flood level to the 200 yr ARI flood level at the subject site in year 2100 which would mean an increase in flood level for the 100 yr ARI flood by between 0.1m to 0.15m for the IPCC intermediate Greenhouse scenario. For the worst-case IPCC Greenhouse scenario, the 100 yr ARI flood level at the marina site would therefore be increased to the 500 yr ARI flood level which would mean an increase by between 0.3m to 0.4m (see Appendix B).

The overall influence of climate change including sea level rise (0.1m) and increased rainfall intensities at year 2100 would range from 0.25m to 0.5m in the 100 yr flood (see Appendix B). **Thus, the 100 yr ARI flood level at the marina site in year 2100 assuming the worst case 2100 IPCC climate change influences would be approximately 6.1m AHD.** This is the **same level as the existing Flood Planning Level** which is the 100 yr ARI flood level (RL 5.6m AHD) plus 500mm freeboard. This 500mm Council-mandated freeboard therefore provides an allowance to cover the worst-case climate changes increases in flood levels.

Furthermore, the marina pile/pontoon system proposed will be readily able to extend past RL 6.1m AHD up to 9.1m AHD and as such, can readily accommodate climate change impacts at the marina site well beyond the above assessment by Cardno.

Due to the conservative marina piling design and factors as discussed above, it is clear that climate change would not cause any increased risk of coastal hazards at the subject site or result in increased risk of coastal hazards on other lands.

19. Past Damage to Marinas in Mooloolaba 1980 and Brisbane River 2011

It is difficult to comment accurately about past events causing damage to marinas without a detailed knowledge of the flood characteristics and marina design criteria. The 2011 Brisbane River flood was estimated by flood consultants WMA (2011) to have a return interval of 1:120 years ARI. Yet, given that the design standard for private and public marinas and boating facilities did not exceed the 100 year ARI flood in the Brisbane River, it is not surprising that many marinas in the Brisbane River were damaged in the 2011 in a 1:120yr ARI flood.

What we have learnt from the past damages to river marinas is that adoption of a higher design criteria flood would result in negligible increased coastal hazards for the subject land and other land. The proposed marina is being designed for a 90,000 year ARI flood which greatly exceeds the return interval of the 2011 Brisbane River flood and as such, the proposed marina will have an adequate

m 0409 912 631 e mark.tooker@tookerandassociates.com.au a 30 Walworth Avenue, Newport abn 39 619 046 070

design to resist the forces imposed by floods much greater than the 2011 Brisbane River flood.

20. Marinas in Similar Locations

As noted in Section 4 above, there are a number of marinas in the Brisbane River mentioned however, their behaviour in a flood depends upon the design criteria adopted for their site-specific flood characteristics.

Obviously, if the design criteria adopted for a marina is the 100 year ARI flood, then in more severe floods the marina might sustain damage. Past experience with less conservative marina designs has prompted the selection of a higher flood design criteria for the subject marina.

The flood design criteria adopted for the subject marina is a 90,000 year ARI flood event and its chance of occurring in the life of the marina is 0.067% (and not 45% if the adopted design criteria were to be the standard 100 year ARI flood used by Liverpool Council and TfNSW).

The chance that the Georges Cove Marina system design criteria would be exceeded in a flood over its life is negligible. Therefore, the proposed marina would not increase coastal hazards on the subject land or other land.

The BoM provides a 12 hour warning for floods at the proposed marina site which are predicted to be higher than RL 4m at the subject site. There is approximately 13 hours in total warning time for people in the marina to evacuate the site in a severe flood. **There will be no need to evacuate berthed craft because the piling/pontoon system has been designed to withstand the forces of a 90,000 yr ARI flood including the theoretical increased effects of climate change.**

As described in Section 6, a detailed Flood Emergency Response Plan will be prepared at CC stage dealing with the wet berths and securing boats in place.

21. Marina Buildings

Noted.

22. Flood Emergency Response Plan (FERP)

A detailed Flood Emergency Response Plan (FERP) will be prepared at the CC stage for the wet berths and the marina buildings.

One of the main elements of the FERP is the provision of flood signage in the carpark and along the flood evacuation route. There are many other elements included to ensure flood evacuation in vehicles and on foot is safe.

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(b) Bank Protection Measures

23. Rock Revetment Typical Cross Section

The typical rock revetment cross section along the marina riverfront is presented in Figure 9. See response below for details.

24. Plan Layout of Rock Revetment and Site Boundary Along Foreshore

The surveyed site boundary, the location of the bottom of the rock protection works (ie the rock revetment toe) and the top of the rock protection works are presented in Figure 10. The revetment toe will be located fully within the surveyed boundary of the privately-owned site (Lot 70 DP1254895).

The cross sections through the rock revetment, site boundary and revetment toe levels are presented on the surveyed bank and river levels in Figures 11 to 14.

The typical details of the marina rock revetment wall include a 1H:1.5V slope with a double primary (outer) layer of nominally 300-1000mm diameter rocks over a smaller secondary (inner) layer of nominally 100-200mm diameter aggregate protection over a bidum geotextile fabric covering a smoothly battered profile with an anchored rock toe. The secondary (inner) protection armour material should be no less in size than 10% of the diameter of the primary (outer) rock size. The crest level of the wall at RL 1.9m AHD has been stipulated by the Council to replicate the typical riparian conditions along this section of the river.

The rock revetment toe level will vary along the wall between RL -2m and -5.2m AHD (top of toe) subject to detailed design. The proposed toe levels of the wall are shown on Figures 11 to 14. The horizontal width of the wall will vary from approximately 5.8m to 7.1m wide on the river foreshore side as measured from the edge of toe to the landward extent of the wall.

In the marina basin there will be a consistent bed level of approximately RL -2.9m AHD and hence the armour rock revetment will be approximately 6.7m wide in the marina basin.

There is approximately a 40m wide vegetated riparian corridor proposed between the proposed marina basin and river foreshore with public access and amenities. On the inner side (marina side) there will be a shallow area along the inner rock armouring so as the provide a reeded habitat for macrophytes and aquatic fauna. The river side part of the corridor would be planted with terrestrial riparian vegetation.

At the basin entrance, the size of the primary armour has been increased and the benching of rock at the top of the wall has been widen to resist any flood flows which may flow down the face of the revetment at the entrance.

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At upstream and downstream ends of the foreshore revetment, the wall will be returned inland 20m (subject to detailed design) within the site northern and southern boundaries to stabilise the end of the revetement wall.

The toe of the proposed rock revetment along the river foreshore has been located on private land such that none of the structure of the revetment is located on TfNSW land (see Figure 10). The position of the top of the revetment will vary slightly in response to the various toe levels proposed for the wall. **As such, there is no requirement for TfNSW to provide landowner's consent for the marina development application to be determined.**

25. Flood Overtopping of Revetment at the Basin Entrance

The flooding levels in the marina basin and the river will rise together and gradually submerge the top of the foreshore revetment. The area between the marina basin and the river foreshore will form a riparian corridor which Council has required to be stabilised with riparian vegetation.

Engineers at Cardno have provided the time series of velocity from the flood models at three locations (1 and 2 on either side of the basin entrance and 3 in the middle of the southern part of the revetment) at the top of the foreshore revetment (RL 1.9m AHD) for the 20 year ARI, 100 year ARI and PMF floods (see Appendix B and Figure 15). The peak velocities are as follows:

Flood	Locations		
	1	2	3
20yr	0.52m/s	0.80	0.41
100yr	0.69	0.98	0.57
PMF	0.93	1.21	0.81

A relationship between flow velocity and rock size (diameter) to protect channels and steep shutes was formulated by Isbash (1936) for turbulent flow rivers:

$$d_{50} = \frac{V^2}{2.g.K^2(Sr - 1)}$$

where d_{50}=median rock diameter
V=velocity
K= 0.89 for high turbulent rivers
K= 1.2 for low turbulent rivers
Sr=specific gravity of rock=2.2

At the marina entrance (locations 1 and 2), the rock size required (d_{50}), using the high turbulent river K factor, would range from 15mm to 80mm for the 20yr ARI to the PMF flood. A typical factor of safety of 2 would be adopted for the

m 0409 912 631 e mark.tooker@tookerandassociates.com.au a 30 Walworth Avenue, Newport abn 39 619 046 070

recommended rock size which for the marina basin entrance would be a d_{50} of 160mm.

The size of primary rock protection proposed along the foreshore revetment is a d_{50} of 650mm (range 300mm-1000mm) **providing an increased factor of safety of approximately 6.5.**

The size of primary rock protection proposed on the ends of the revetment at the marina basin entrance is a d_{50} of 900mm (range 800mm-1000mm) **providing an increased factor of safety of approximately 11.**

The estimated peak velocity for the proposed riparian area on top of the revetment would experience peak flood velocities in the 20yr, 100yr and PMF of 0.4m/s to 0.8m/s. The riparian vegetation would be capable of resisting scour under these conditions

Therefore, the risk of a flood overtopping of the revetment and then causing instability in the primary armour is negligible.

26. Rock Revetment Cross Sections Overlaid on River Cross Sections

These cross sections are provided in Figures 11 to 14 and indicate that the toe levels of the proposed revetment are suitable to support the rock revetment.

27. Upstream and Downstream End Effects of the Revetment

Rock armouring of the site's foreshore was required by Liverpool City Council as a condition of the rezoning of the site in 2006, and thus is proposed along the entire river foreshore as part of the marina application to comply with this requirement. The proposed rock armoured revetment along the foreshore will be returned landward by approximately 20m (subject to detailed design) at the upstream and downstream ends of the site to ensure the revetment is not outflanked (see Figure 10). **This will ensure that there is no increase in the risk of coastal hazards on the subject development and adjacent properties.**

The properties upstream of the marina site are the Flower Power site and then Council's public boat ramp known as Davy Robinson Reserve (see Figure 16). The upstream properties are located on the outside of a river bend and would be exposed to "erosive" forces. The marina site frontage is in a transitional zone which is relatively stable and the adjoining downstream (EQ) site is located on the inside of a river bend and therefore subject to "depositional" forces.

The existing river foreshore on the proposed marina site currently has mainly concrete/brick rubble protection. The vertical bank (ie where erosion of the base of the bank has occurred) along other nearby unprotected sites opposite is mainly caused by boat wake.

m 0409 912 631 e mark.tooker@tookerandassociates.com.au a 30 Walworth Avenue, Newport abn 39 619 046 070

The existing river foreshore on Davy Robinson Reserve has a rock revetment protection. The current foreshore of the upstream Flower Power site consists of a combination of vegetation coverage and concrete/brick rubble protection of it's foreshore. As part of the 2006 rezoning of the Flower Power site, it too is required to rock armour it's foreshore as part of any future development.

There is a current Planning Proposal with Council for the redevelopment of the Flower Power site for a large mixed-use residential development which, as required, shows a rock armoured revetment along the river foreshore as part of it's development obligations. In this instance, the rock revetment for the marina would occur in the near term (1-2 years). In the medium term (2-4 years), the Flower Power site will be rock armoured as per their proposal giving an overall improvement to the existing site's standard of armouring. The marina rock revetment would connect directly to the revetment for the Flower Power site creating continuous foreshore protection between the southern end of the marina and Davy Robinson Park where there is currently no engineered protection. **This will reduce coastal hazards in the long term compared to the existing situation.**

In the short term, the marina rock revetment would be returned from the marina lands foreshore in a westward direction (inland) at the northern end (at the boundary) on the marina land to secure this end of the marina revetment. The existing foreshore vegetation and rubble protection on the Flower Power site will continue to maintain the existing shoreline (until it is armoured) and **the proposed marina rock revetment will not increase the coastal hazard risk or erosion for the Flower Power site.**

The adjoining downstream property (the EQ site) has extensive riparian vegetation along its foreshore in what is an "accreting" area on the inside of a bend.

There is a Planning Proposal with Council for the redevelopment of the EQ site for a large mixed use residential development which has indicated foreshore improvements and various means of foreshore protection.

In this instance, the foreshore of the EQ site would continue to be protected in the medium term (2-4 years) before redevelopment, and sediment would continue to accrete along its foreshore and there would be no increase in coastal hazards.

In the short term, the rock revetment for the marina river foreshore would continue south and wrap westwards (inland) at the marina southern boundary to secure the marina revetment near the boundary with the EQ site. **There would be no increase in coastal hazards for the EQ site created by the Council-required armouring for the proposed marina.**

(c) SEPP 55

Points 28 to 34

To be addressed by Dr. Ian Swane/Dr. Phil Towler

m 0409 912 631 e mark.tooker@tookerandassociates.com.au a 30 Walworth Avenue, Newport abn 39 619 046 070

(d) Additional Observations

Points 35 to 42
Noted.

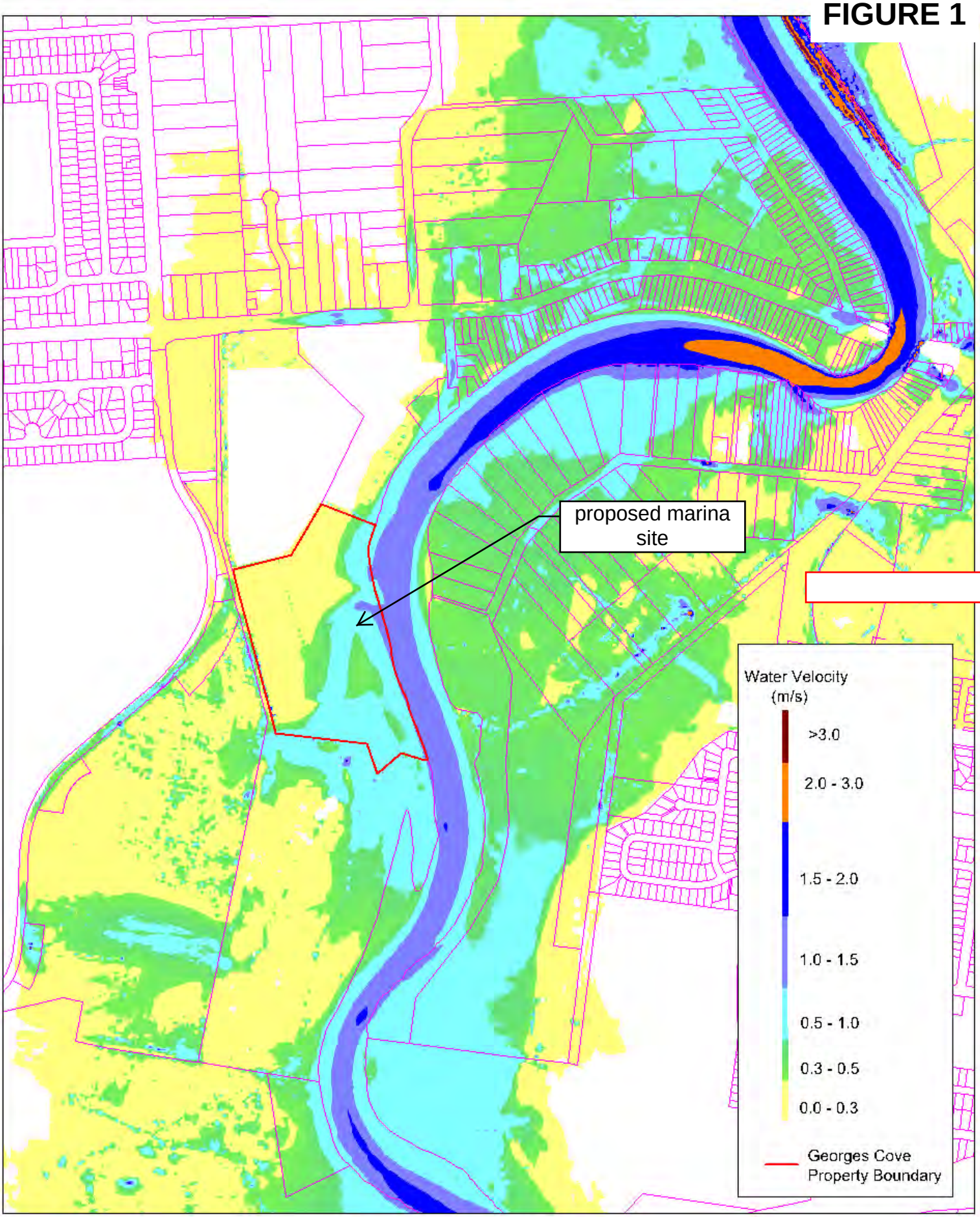
Mark Tooker
Director
Tooker and Associates

m 0409 912 631 e mark.tooker@tookerandassociates.com.au a 30 Walworth Avenue, Newport abn 39 619 046 070

FIGURES

m 0409 912 631 e mark.tooker@tookerandassociates.com.au a 30 Walworth Avenue, Newport abn 39 619 046 070

FIGURE 1



Cardno

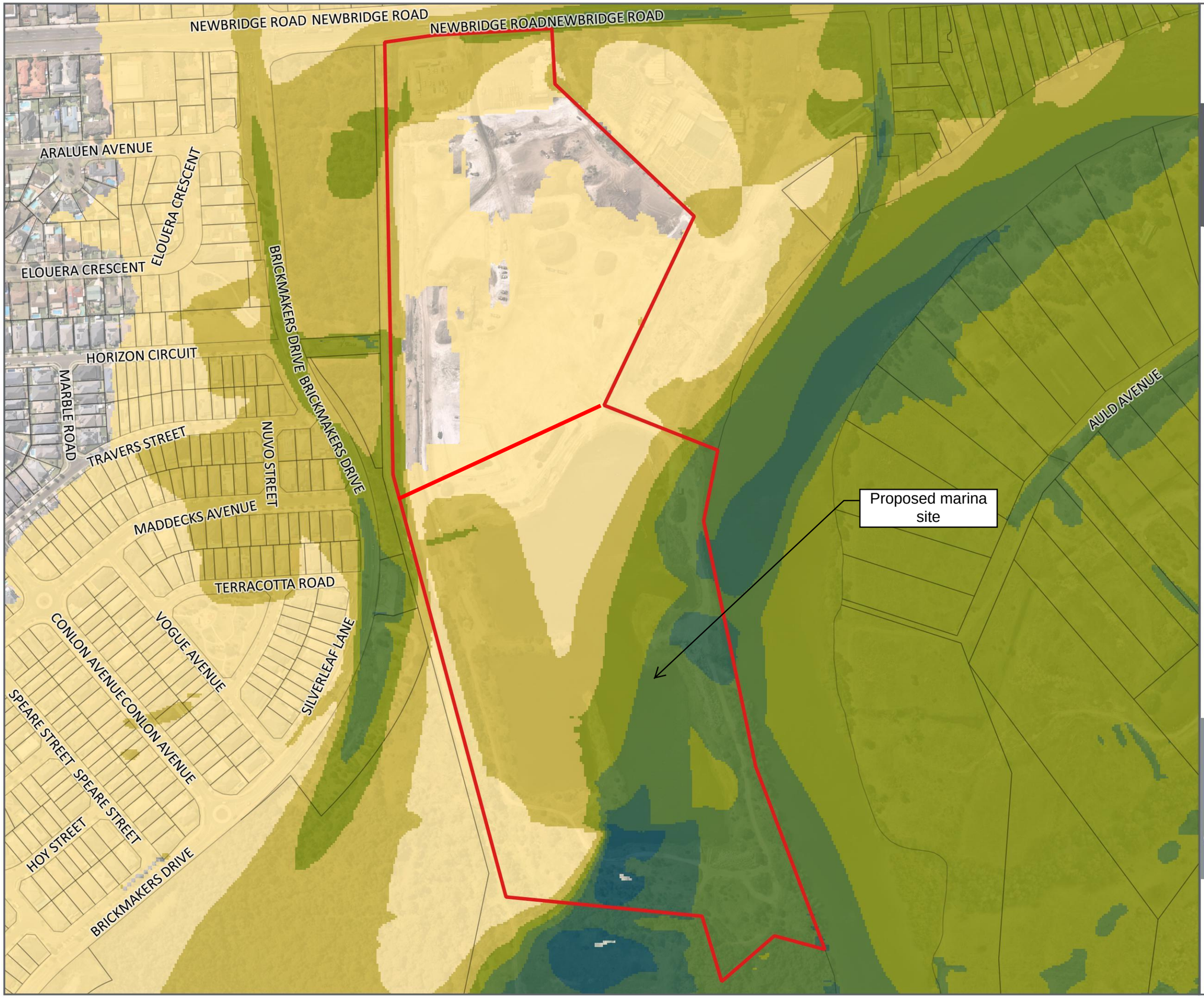
NA49913037
January 2018

Georges Cove
Flood Impact Assessment

Figure 7
100 year ARI
Peak Velocity
Design (Jan18)

Source:
Cardno letter report
13 April 2018

FIGURE 2



Flood Velocity

Flood Level in Marina at 9mAHD

Legend

Figures

- Site Area

Flood Velocity(m/s)

- <= 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1
- 1 - 1.2

Source:
Cardno PMF modelling
email dated 16 March 2021

FIGURE 2

1:3,500 Scale at A3

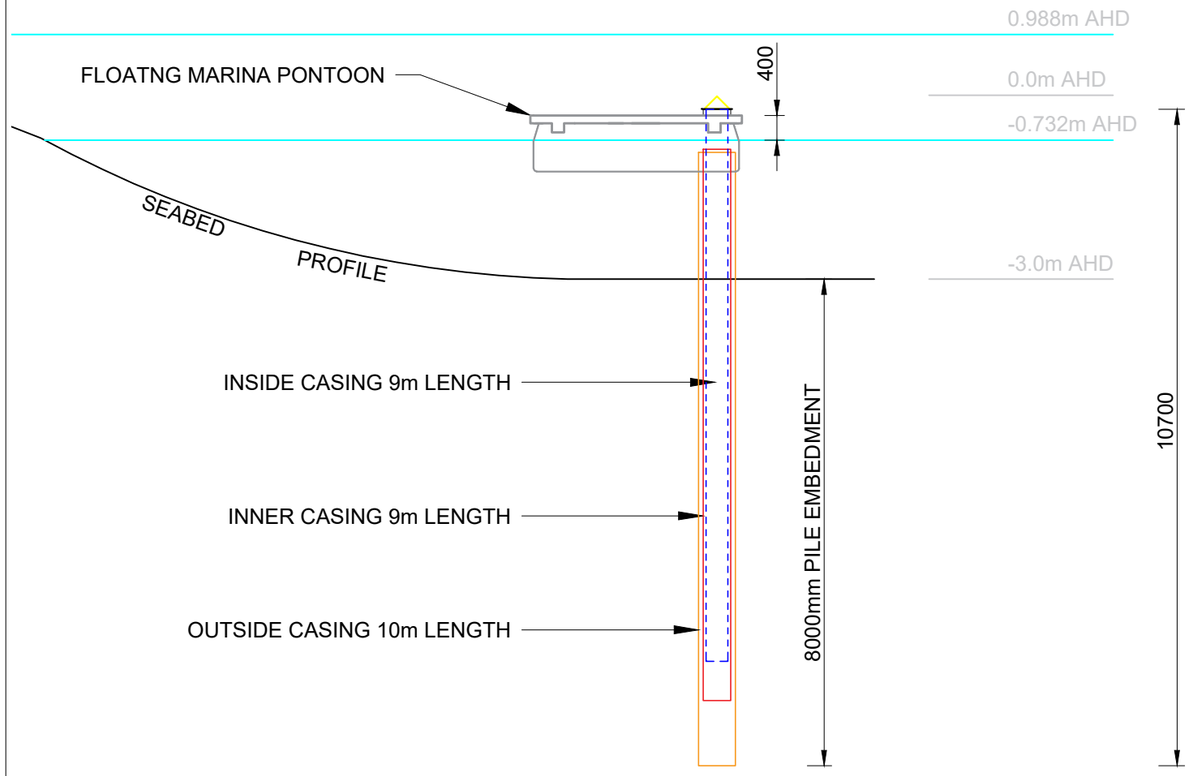
0 40 80 120 160 200 m

N

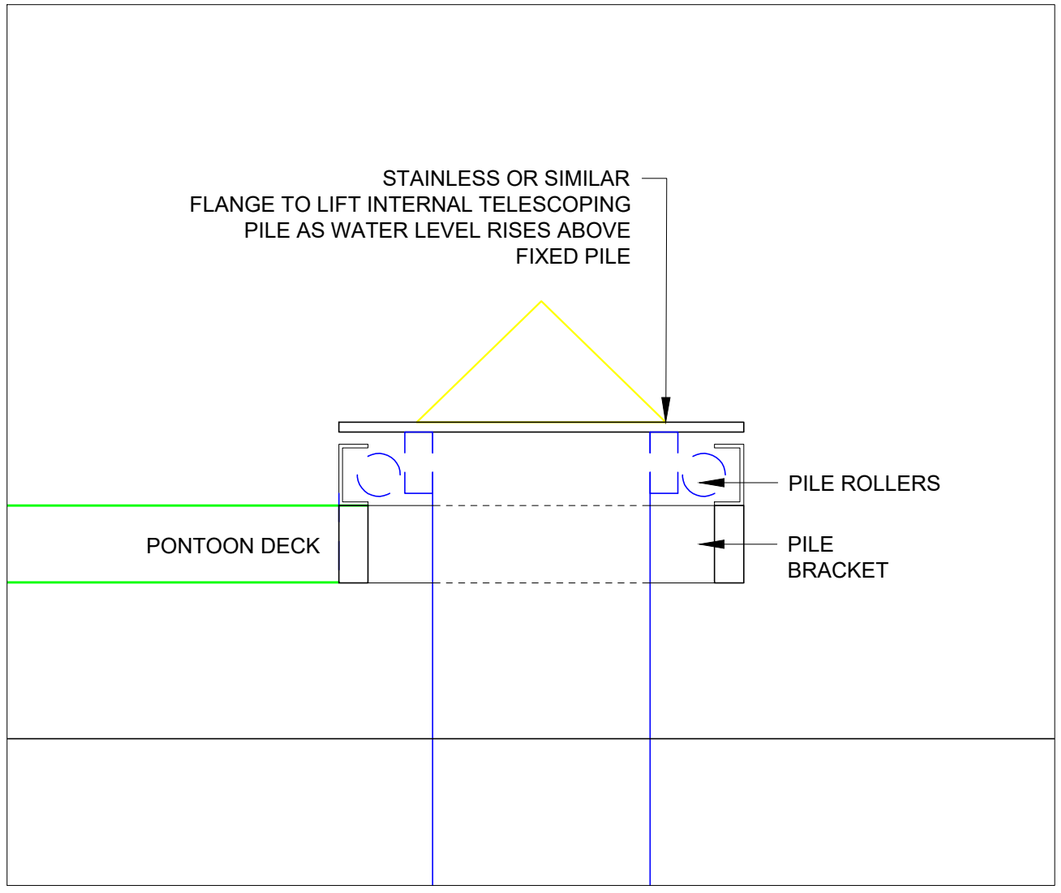
Cardno

Map Produced by St Leonards Water (AWE)
Date: 2021-3-16| Project: XXXXXXXX
Coordinate System: MGA Zone 56
Map: Georges Cove FA_Figures.qgz

FIGURE 3



TELESCOPIC PILE UNDER GENERAL CONDITIONS



FLANGE CONNECTION
1:10 @ A3

GEORGES COVE MARINA PILE AND PONTOON ARRANGEMENT SHEET 1

REV	DATE	DR	CH	AMENDMENT
A	25.03.21	SD	--	ISSUE FOR INFORMATION

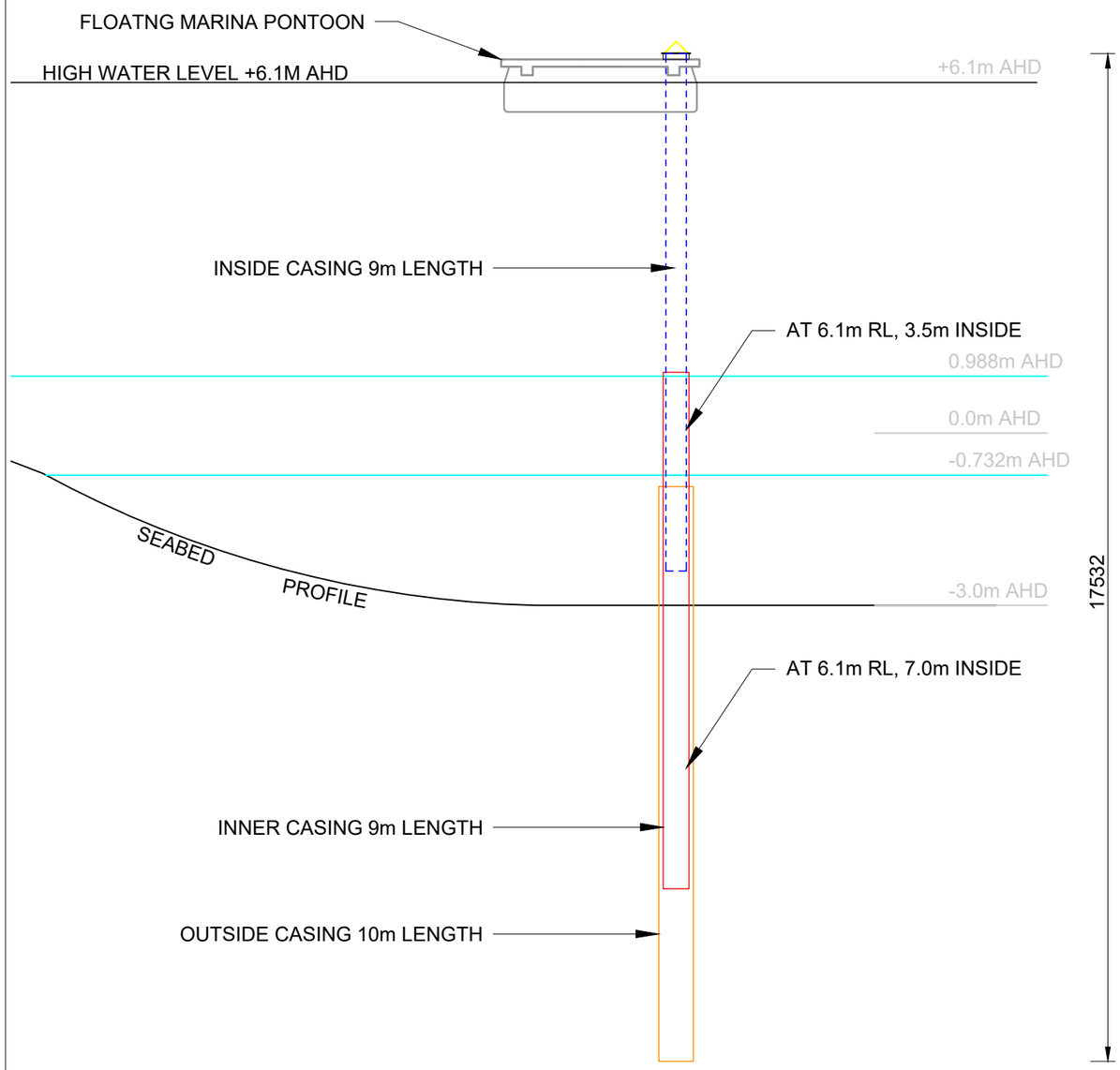
PACIFIC PONTOON & PIER (OPERATIONS) PTY LTD
PHONE: (07) 5593 6988
FAX: (07) 5593 6449
E-MAIL: admin@pacificpontoon.com
ABN: 17 604 284 531
ADDRESS: 83-87 Dover Drive
Burleigh Heads, QLD 4220

PACIFIC PONTOON

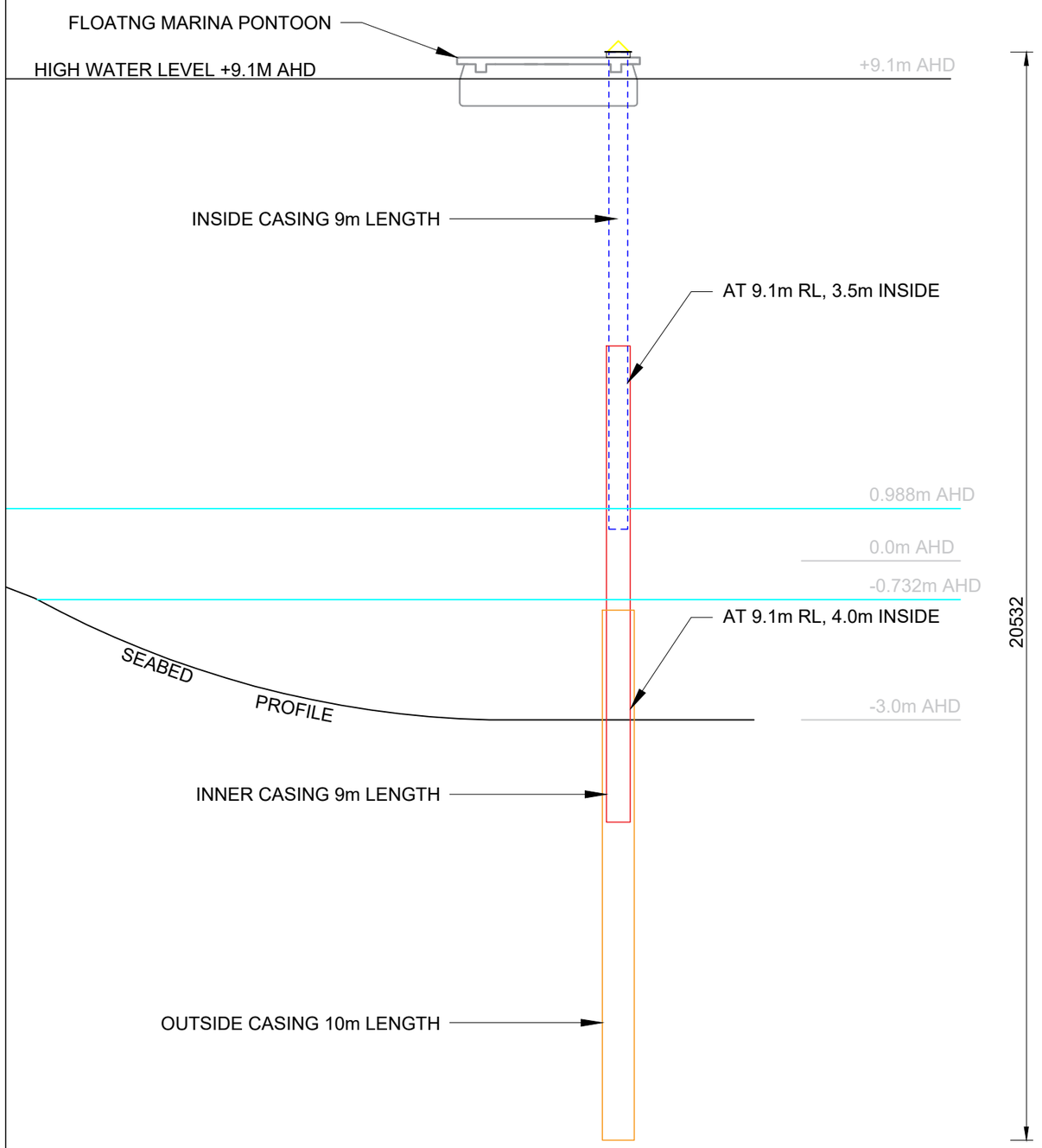
CLIENT: BENEDICT
PROJECT: 11 NARABANG WAY. BELROSE
Scale: 1:100 @ A3
Start Date: 00.00.0000
Height Datum: AHD
TITLE: TELESCOPING PILE CONCEPT
Dwg No.: CON - P101
Rev: A

GEORGES COVE MARINA PILE AND PONTOON ARRANGEMENT SHEET 2

FIGURE 4



TELESCOPIC PILE UNDER INDICATIVE 1:100 YR EVENT



TELESCOPIC PILE UNDER INDICATIVE 1:90,000 YR EVENT

REV	DATE	DR	CH	AMENDMENT
B	25.03.21	SD	--	ISSUE FOR INFORMATION
A	11.03.21	SD	--	ISSUE FOR INFORMATION

PACIFIC PONTOON & PIER (OPERATIONS) PTY LTD
PHONE: (07) 5593 6988
FAX: (07) 5593 6449
E-MAIL: admin@pacificpontoon.com
ABN: 17 604 284 531
ADDRESS: 83-87 Dover Drive
Burleigh Heads, QLD 4220

PACIFIC PONTOON

CLIENT: BENEDICT

PROJECT: 11 NARABANG WAY. BELROSE

Scale: 1:100 @ A3 | Start Date: 00.00.0000 | Height Datum: AHD

TITLE: TELESCOPING PILE CONCEPT

Dwg No.: CON - P100 | Rev: B

FIGURE 5

DAVY ROBINSON PARK BOATRAMP
GEORGES RIVER

Source: Roads and Maritime

Figure 3-3: Artist's impression

PROPOSED PARRAMATTA FERRY WHARF UPGRADE

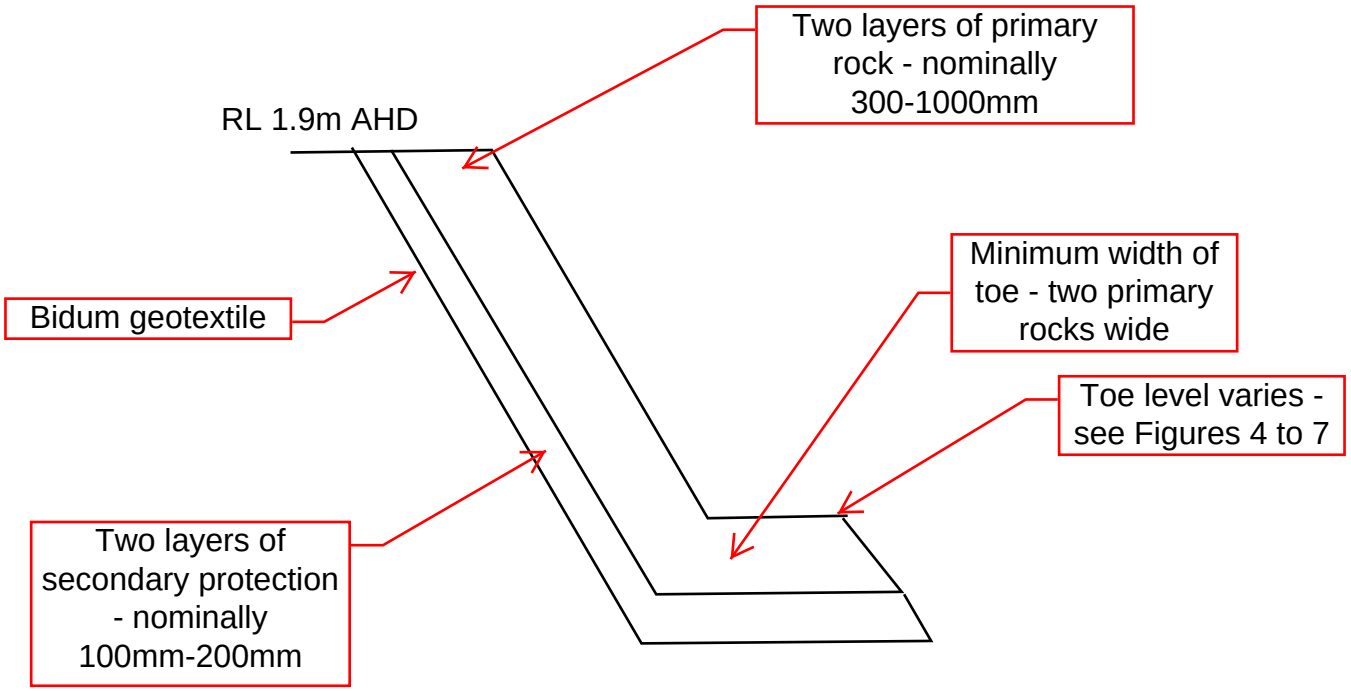
FIGURE 7

BULIMBA MARINA
BRISBANE RIVER

FIGURE 8


Stella
Dockside Marina & The Story Bridge
Dockside Marina & The Story Bridge
3/6

FIGURE 9



TYPICAL ROCK REVETMENT FORESHORE WALL CROSS SECTION

River Foreshore Rock Protection
Typical Cross Section

FIGURE 10

R3 ZONE
RESIDENTIAL DEVELOPMENT BY OTHERS

RE2 ZONE
MARINA DEVELOPMENT PROPOSED UNDER THIS APPLICATION

PT 200 DP1117280

201 DP1117280

PT 200 DP1117280

6 DP1065574

PT 310 DP1118048

6 DP1065574

ROCK REVETMENT WALL RETURN (20m)

CONTROL LINE

TOP OF ROCK PROTECTION WORKS

BOTTOM OF ROCK PROTECTION WORKS

EXTENDED AREA OF ROCK REVETMENT WITH 0.8m-1m PRIMARY ARMOUR

TOP OF ROCK PROTECTION WORKS

CONTROL LINE

BOTTOM OF ROCK PROTECTION WORKS

ROCK REVETMENT WALL RETURN (20m)

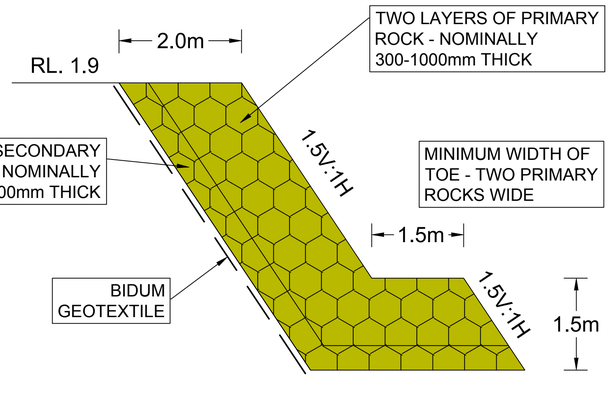
LOT 70 in DP1254895 BOUNDARY

GEORGES RIVER

GEORGES RIVER

N

SECTION No.100
SECTION No.101
SECTION No.102
SECTION No.103
SECTION No.104
SECTION No.105
SECTION No.106
SECTION No.107
SECTION No.108
SECTION No.109



ROCK REVETMENT TYPICAL DETAIL
RATIO:- 1:50

Issue	App	Date	Description
B	S.G.	30-03-2021	UPDATED PER CLIENTS DIRECTION
A	S.G.	23-03-2021	ISSUED FOR CC

Client: BENEDICT INDUSTRIES
Designed by : S.G.
Date of Drawing : 23-03-2021
Ratio (A1) : 1:1000

Datum : AHD
Origin of Levels : SSM 49623 RL 3.310 VIDE SCIMS
Date of Survey : 20-10-2014

JMD Development Consultants

John M. Daly & Associates PTY LTD
A.B.N. 88051977989
Surveying
Engineering
Project Management
Licensed Water Service Co ordinators
32 Iolanthe Street
P.O. BOX 25
CAMPBELLTOWN N.S.W. 2560
PH. (02) 4625 5055
FAX (02) 4628 2013
email: admin@jmd.com.au

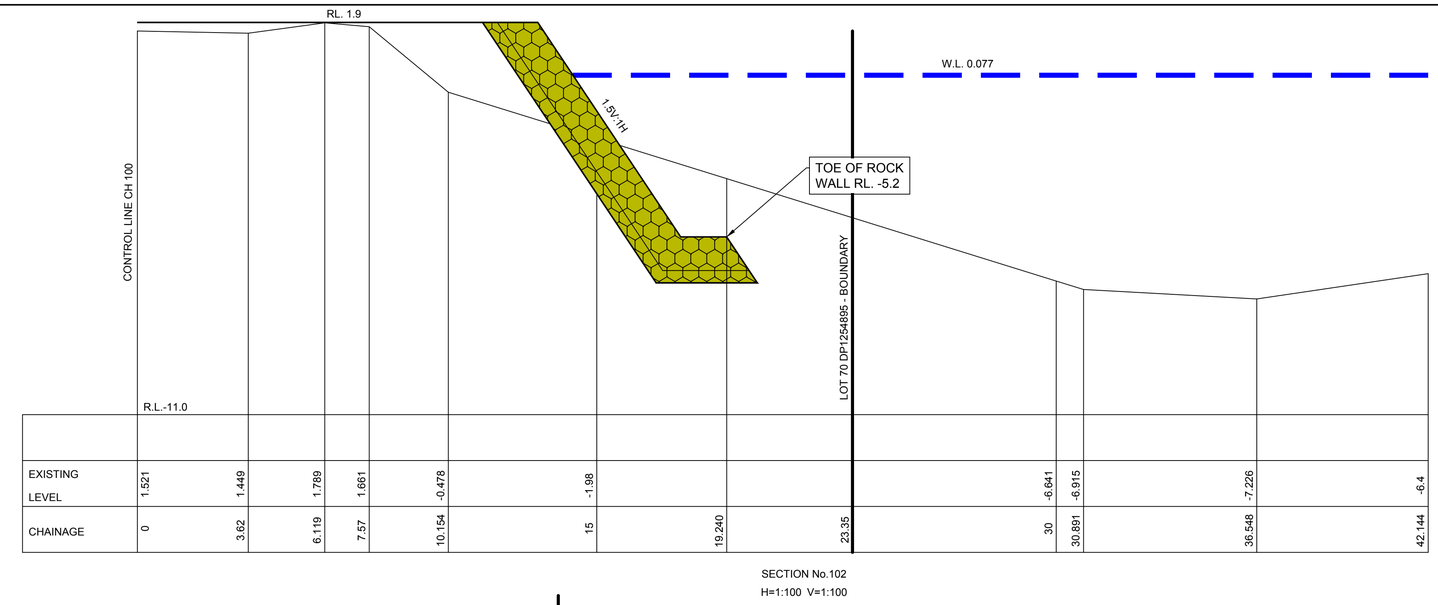
Project : LOT 70 IN DP 1254895 146 NEWBRIDGE ROAD, MOOREBANK

PLAN SHOWING PROPOSED GEORGES RIVER BANK REVETMENT WORKS AND FUTURE MARINA DEVELOPMENT

Locality : MOOREBANK
L.G.A. : LIVERPOOL

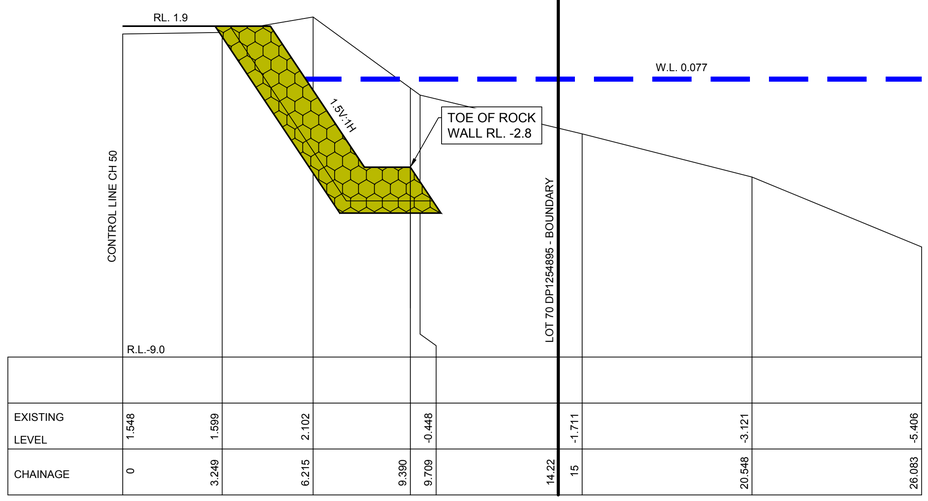
Sheet 2 of 6 sheets
Ref: 14005B-E4
CAD Ref: S:\JOBS\14\14005\14005B - BENEDICTS\ENG\CAD\E4 - GEORGES RIVER EMBANKMENT\DWG\14005B-E4_BASE1

FIGURE 11



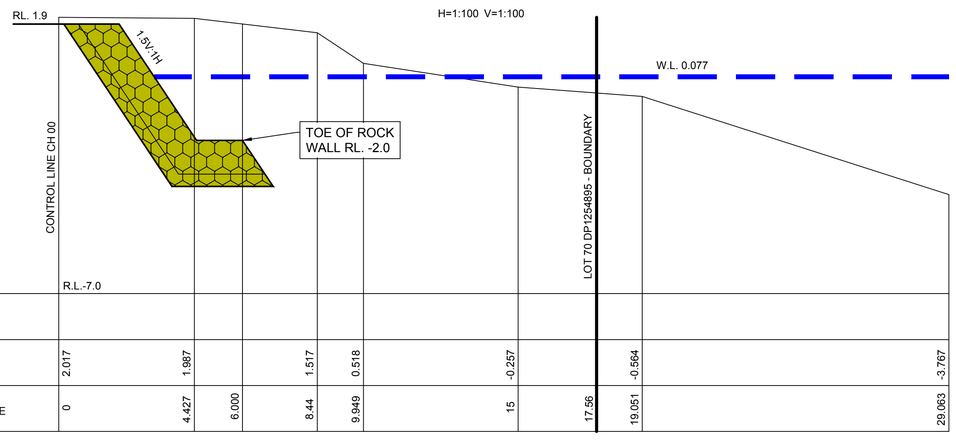
EXISTING LEVEL	1.521	1.449	1.789	1.661	-0.478	-1.98		-6.641	-6.915	-7.226	-6.4
CHAINAGE	0	3.62	6.119	7.57	10.154	15	19.240	23.35	30	30.891	36.548	42.144

SECTION No.102
H=1:100 V=1:100



EXISTING LEVEL	1.548	1.599	2.102		-0.448		-1.711	-3.121	-5.406
CHAINAGE	0	3.249	6.215	9.390	9.709	14.22	15	20.548	26.083

SECTION No.101
H=1:100 V=1:100



EXISTING LEVEL	2.017	1.987		1.517	0.518	-0.257		-0.564	-3.767
CHAINAGE	0	4.427	6.000	8.44	9.949	15	17.56	19.051	29.063

SECTION No.100
H=1:100 V=1:100

Note: see Figure 10 for cross section locations

REVETMENT CROSS SECTIONS SHEET 1

Issue	App	Date	Description
B	S.G.	30-03-2021	UPDATED PER CLIENTS DIRECTION
A	S.G.	23-03-2021	ISSUED FOR CC

Client: BENEDICT INDUSTRIES
Designed by : S.G.
Date of Drawing : 23-03-2021
Ratio (A1) : 1:100

Datum : AHD
Origin of Levels : SSM 49623 RL 3.310 VIDE SCIMS
Date of Survey : 20-10-2014

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John M. Daly & Associates PTY LTD
Surveying Engineering Project Management
Licensed Water Service Co ordinators
A.B.N. 88051977989
32 Iolanthe Street
P.O. BOX 25
CAMPBELLTOWN N.S.W. 2560
PH. (02) 4625 5055
FAX (02) 4628 2013
email: admin@jmd.com.au

Project : LOT 70 IN DP 1254895 146 NEWBRIDGE ROAD, MOOREBANK

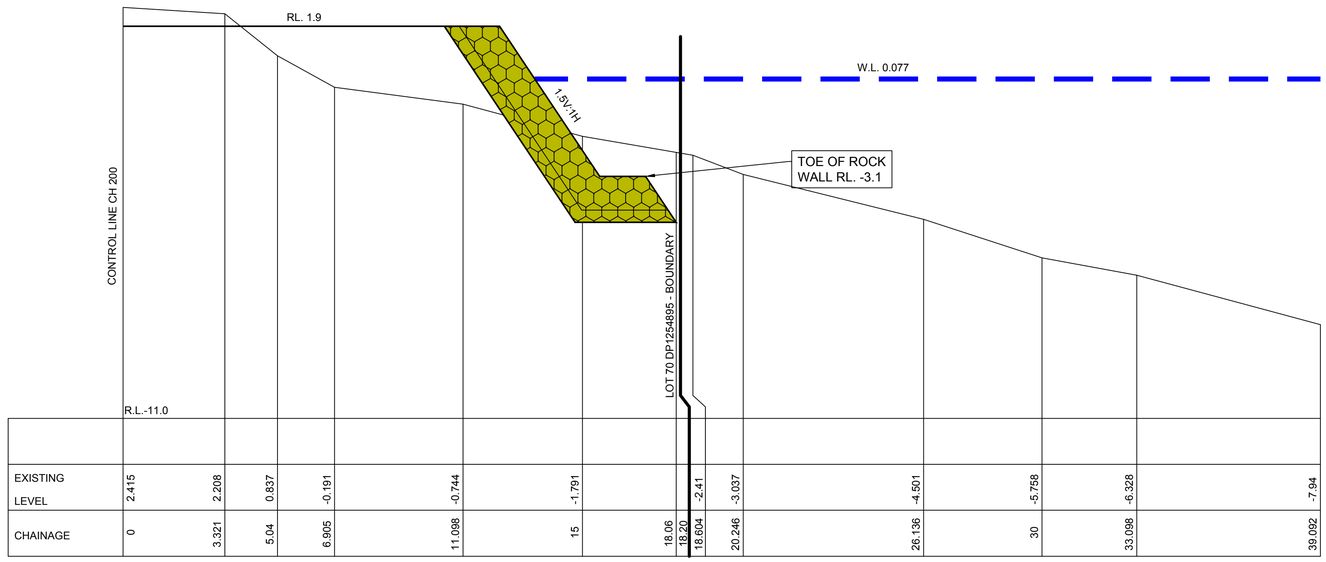
CROSS SECTIONS No.100 - No.102

Locality : MOOREBANK
L.G.A. : LIVERPOOL

Sheet 3 of 6 sheets
Ref: 14005B-E4

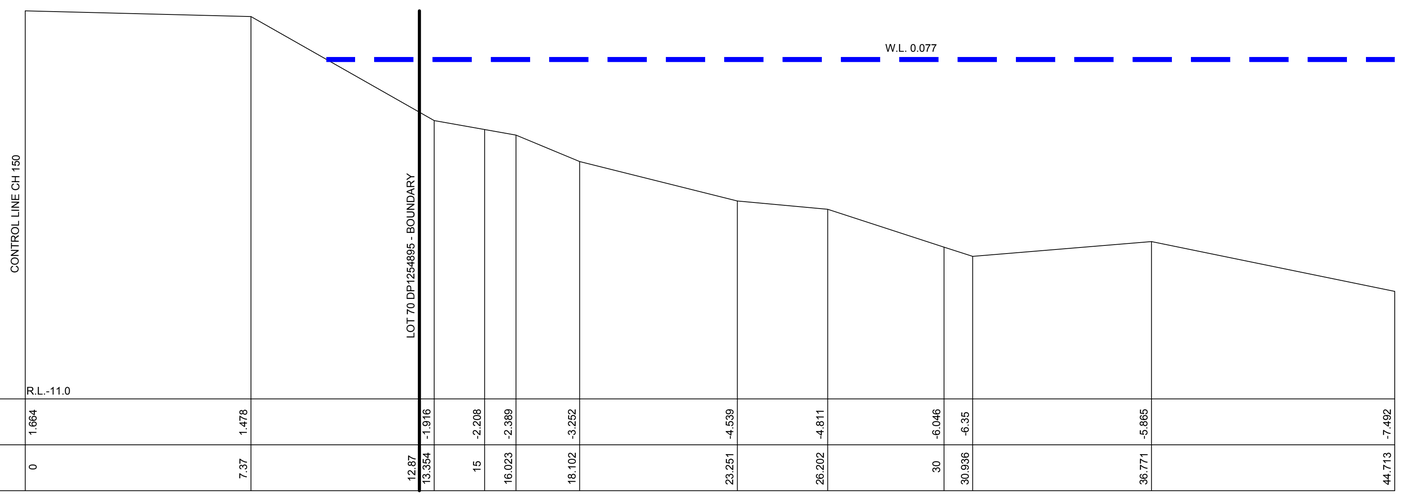
CAD Ref: S:\JOBS\14\14005\14005B - BENEDICTS\ENG\CAD\E4 - GEORGES RIVER EMBANKMENT\DWG\14005B-E4_BASE1

FIGURE 12



EXISTING LEVEL	2.415	2.208	0.837	-0.191	-0.744	-1.791		-2.41	-3.037	-4.501	-5.758	-6.328	-7.94
CHAINAGE	0	3.321	5.04	6.905	11.098	15	18.06	18.20	18.604	20.246	26.136	30	33.098	39.092

SECTION No.104
H=1:100 V=1:100



EXISTING LEVEL	1.664	1.478		-1.916	-2.208	-2.389	-3.252	-4.539	-4.811	-6.046	-6.35	-5.865	-7.492
CHAINAGE	0	7.37	12.87	13.354	15	16.023	18.102	23.251	26.202	30	30.936	36.771	44.713

SECTION No.103
H=1:100 V=1:100

Note: see Figure 10 for the cross section locations

REVETMENT CROSS SECTION SHEET 2

Issue	App	Date	Description
B	S.G.	30-03-2021	UPDATED PER CLIENTS DIRECTION
A	S.G.	23-03-2021	ISSUED FOR CC

Client: BENEDICT INDUSTRIES
Designed by : S.G.
Date of Drawing : 23-03-2021
Ratio (A1) : 1:100

Datum : AHD
Origin of Levels : SSM 49623 RL 3.310 VIDE SCIMS
Date of Survey : 20-10-2014

JMD Development Consultants

John M. Daly & Associates PTY LTD
A.B.N. 88051977989
Surveying
Engineering
Project Management
Licensed Water Service Co ordinators
32 Iolanthe Street
P.O. BOX 25
CAMPBELLTOWN N.S.W. 2560
PH. (02) 4625 5055
FAX (02) 4628 2013
email: admin@jmd.com.au

Project : LOT 70 IN DP 1245895, 146 NEWBRIDGE ROAD, MOOREBANK

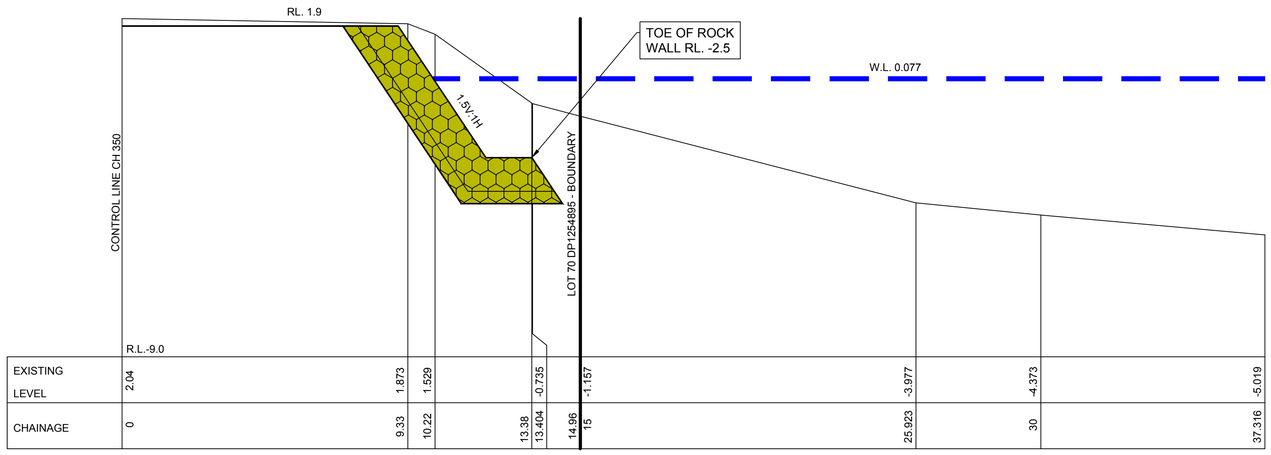
Sheet 4 of 6 sheets

CROSS SECTIONS No.103 - No.104

Ref: 14005B-E4

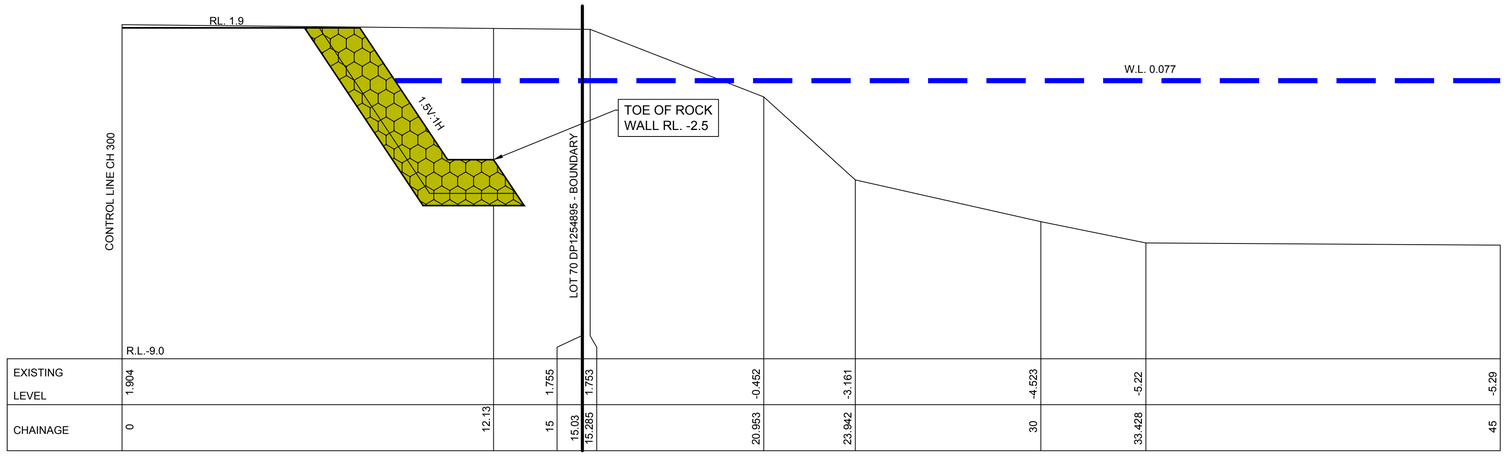
Locality : MOOREBANK
L.G.A. : LIVERPOOL
CAD Ref: S:\JOBS\14\14005\14005B - BENEDICTS\ENG\CAD\E4 - GEORGES RIVER EMBANKMENT\DWG\14005B-E4_BASE1

FIGURE 13



EXISTING LEVEL	2.04	1.873	1.529	-0.735	-1.157	-3.977	-4.373	-5.019		
CHAINAGE	0	9.33	10.22	13.38	13.404	14.96	15	25.923	30	37.316

SECTION No.107
H=1:100 V=1:100



EXISTING LEVEL	1.904	1.755	1.753	-0.452	-3.161	-4.523	-5.22	-5.29		
CHAINAGE	0	12.13	15	15.03	15.285	20.953	23.942	30	33.428	45

SECTION No.106
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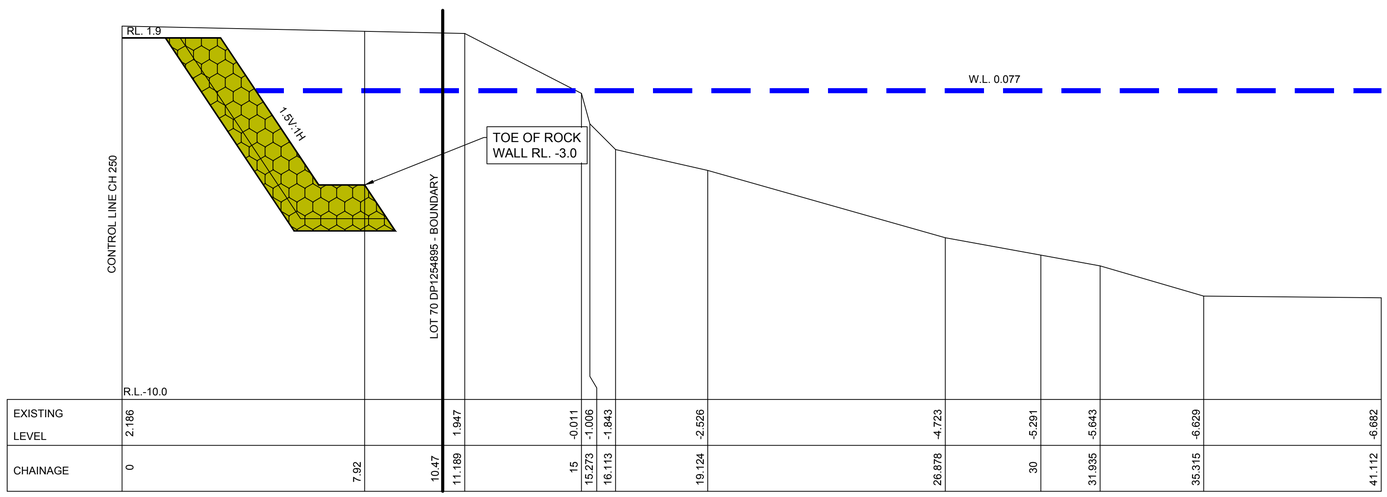


EXISTING LEVEL	2.186	1.947	-0.011	-1.006	-1.843	-2.526	-4.723	-5.291	-5.643	-6.629	-6.682
CHAINAGE	0	7.92	10.47	11.189	15	15.273	16.113	19.124	26.878	30	31.935	35.315	41.112

SECTION No.105
H=1:100 V=1:100

Note: see Figure 10 for cross section locations

REVETMENT CROSS SECTIONS SHEET 3

Issue	App	Date	Description
B	S.G.	30-03-2021	UPDATED PER CLIENTS DIRECTION
A	S.G.	23-03-2021	ISSUED FOR CC

Client: BENEDICT INDUSTRIES
Designed by : S.G.
Date of Drawing : 23-03-2021
Ratio (A1) : 1:100

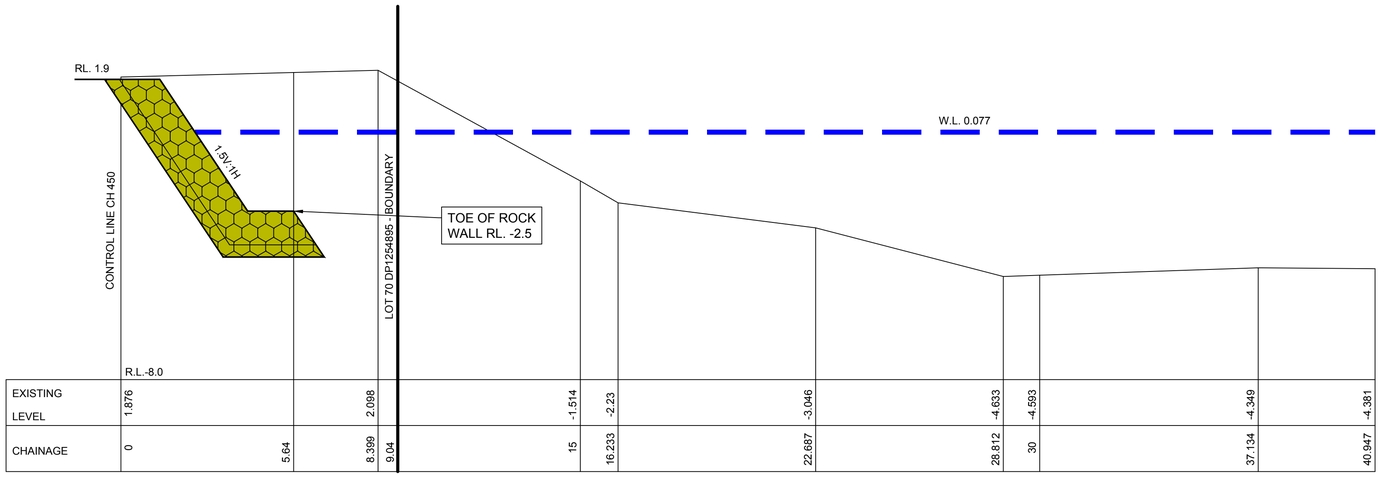
Datum : AHD
Origin of Levels : SSM 49623 RL 3.310 VIDE SCIMS
Date of Survey : 20-10-2014

JMD Development Consultants

John M. Daly & Associates PTY LTD
A.B.N. 88051977989
Surveying
Engineering
Project Management
Licensed Water Service Co ordinators
32 Iolanthe Street
P.O. BOX 25
CAMPBELLTOWN N.S.W. 2560
PH. (02) 4625 5055
FAX (02) 4628 2013
email: admin@jmd.com.au

Project : LOT 70 IN DP 1245895, 146 NEWBRIDGE ROAD, MOOREBANK
Sheet 5 of 6 sheets
CROSS SECTIONS No.105 - No.107
Ref: 14005B-E4
Locality : MOOREBANK
L.G.A. : LIVERPOOL
CAD Ref: S:\JOBS\14\14005\14005B - BENEDICTS\ENG\CAD\E4 - GEORGES RIVER EMBANKMENT\DWG\14005B-E4_BASE1

FIGURE 14



EXISTING LEVEL	1.876		2.098		-1.514	-2.23	-3.046	-4.633	-4.593	-4.349	-4.381	
CHAINAGE	0	5.64	8.399	9.04	15	16.233	22.687	28.812	30	37.134	40.947	

SECTION No.109
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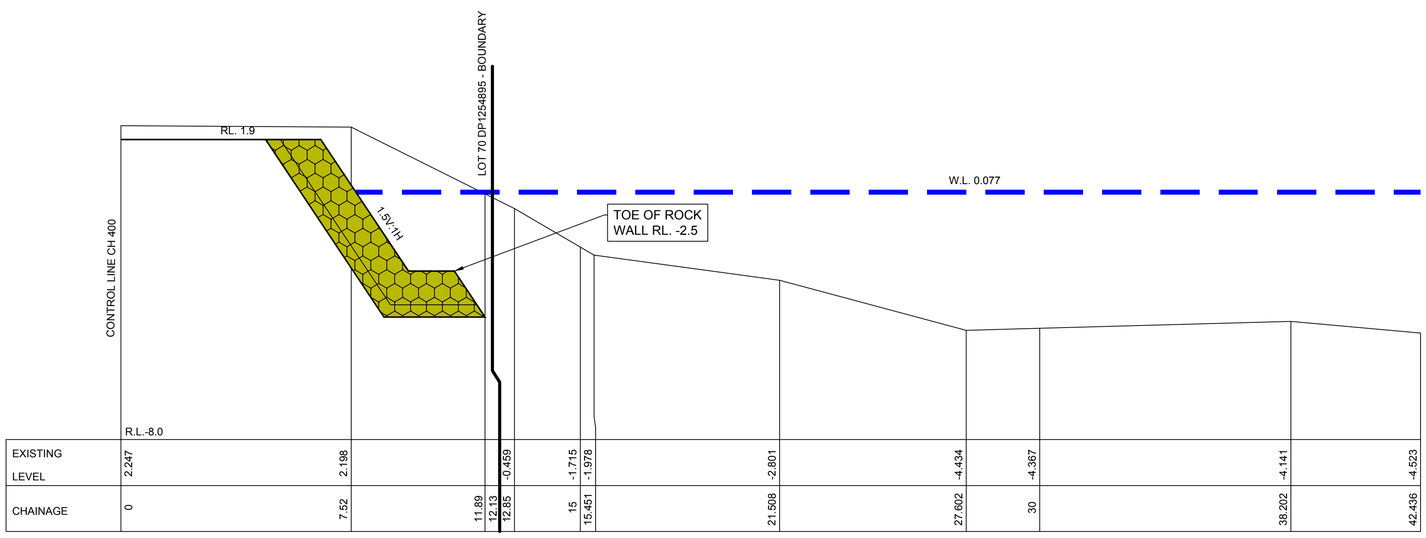


EXISTING LEVEL	2.247		2.198		-0.459	-1.715	-1.978	-2.801	-4.434	-4.367	-4.141	-4.523
CHAINAGE	0	7.52	11.89	12.13	12.85	15	15.451	21.508	27.602	30	38.202	42.436

SECTION No.108
H=1:100 V=1:100

Note: see Figure 10 for cross section locations

REVETMENT CROSS SECTIONS SHEET 4

Issue	App	Date	Description
B	S.G.	30-03-2021	UPDATED PER CLIENTS DIRECTION
A	S.G.	23-03-2021	ISSUED FOR CC

Client: BENEDICT INDUSTRIES
Designed by : S.G.
Date of Drawing : 23-03-2021
Ratio (A1) : 1:100

Datum : AHD
Origin of Levels : SSM 49623 RL 3.310 VIDE SCIMS
Date of Survey : 20-10-2014

JMD Development Consultants

John M. Daly & Associates PTY LTD
Surveying Engineering Project Management
Licensed Water Service Co ordinators
A.B.N. 88051977989
32 Iolanthe Street
P.O. BOX 25
CAMPBELLTOWN N.S.W. 2560
PH. (02) 4625 5055
FAX (02) 4628 2013
email: admin@jmd.com.au

Project : LOT 70 IN DP 1245895, 146 NEWBRIDGE ROAD, MOOREBANK

Sheet 6 of 6 sheets

CROSS SECTIONS No.108 - No.109

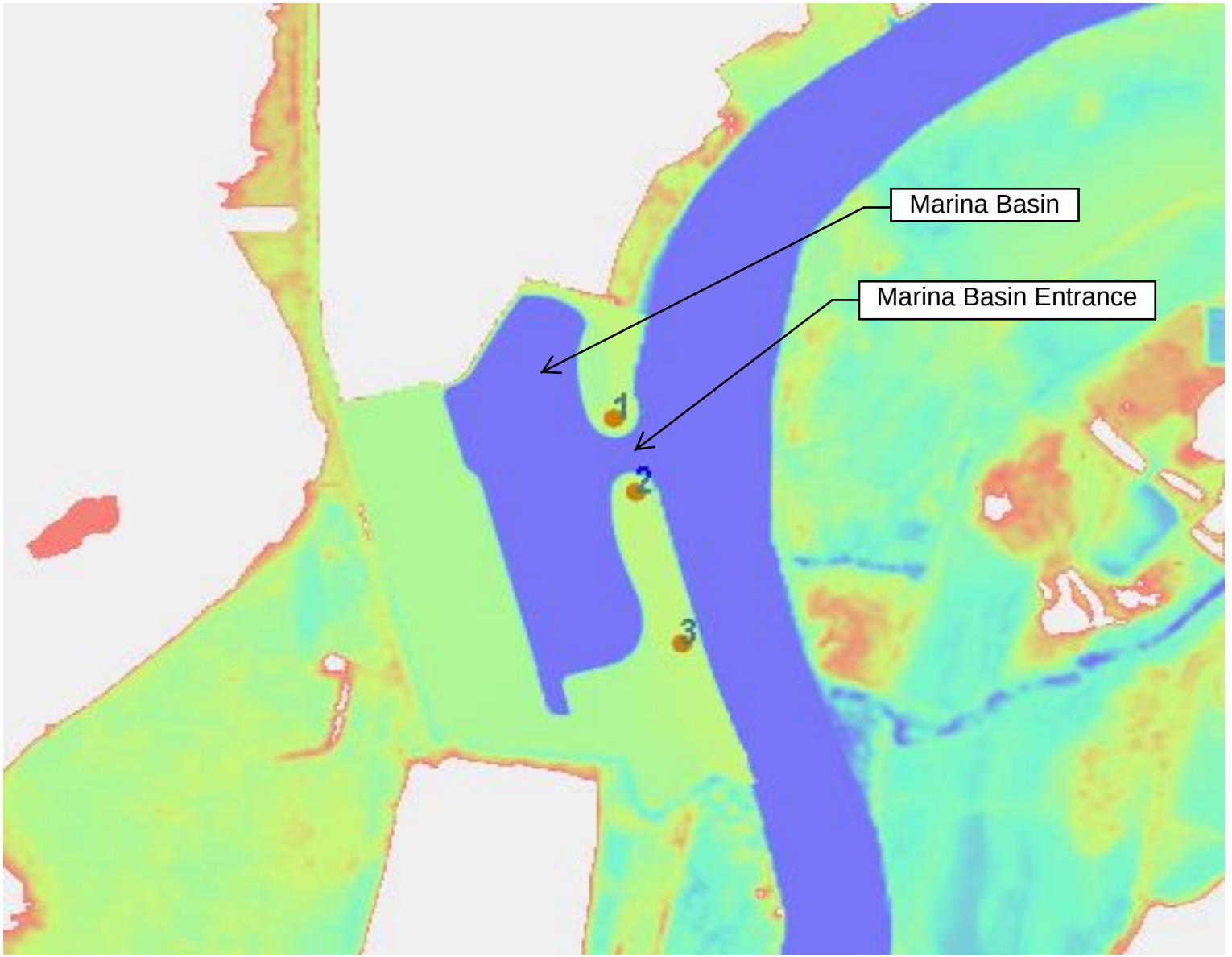
Ref: 14005B-E4

Locality : MOOREBANK

L.G.A. : LIVERPOOL

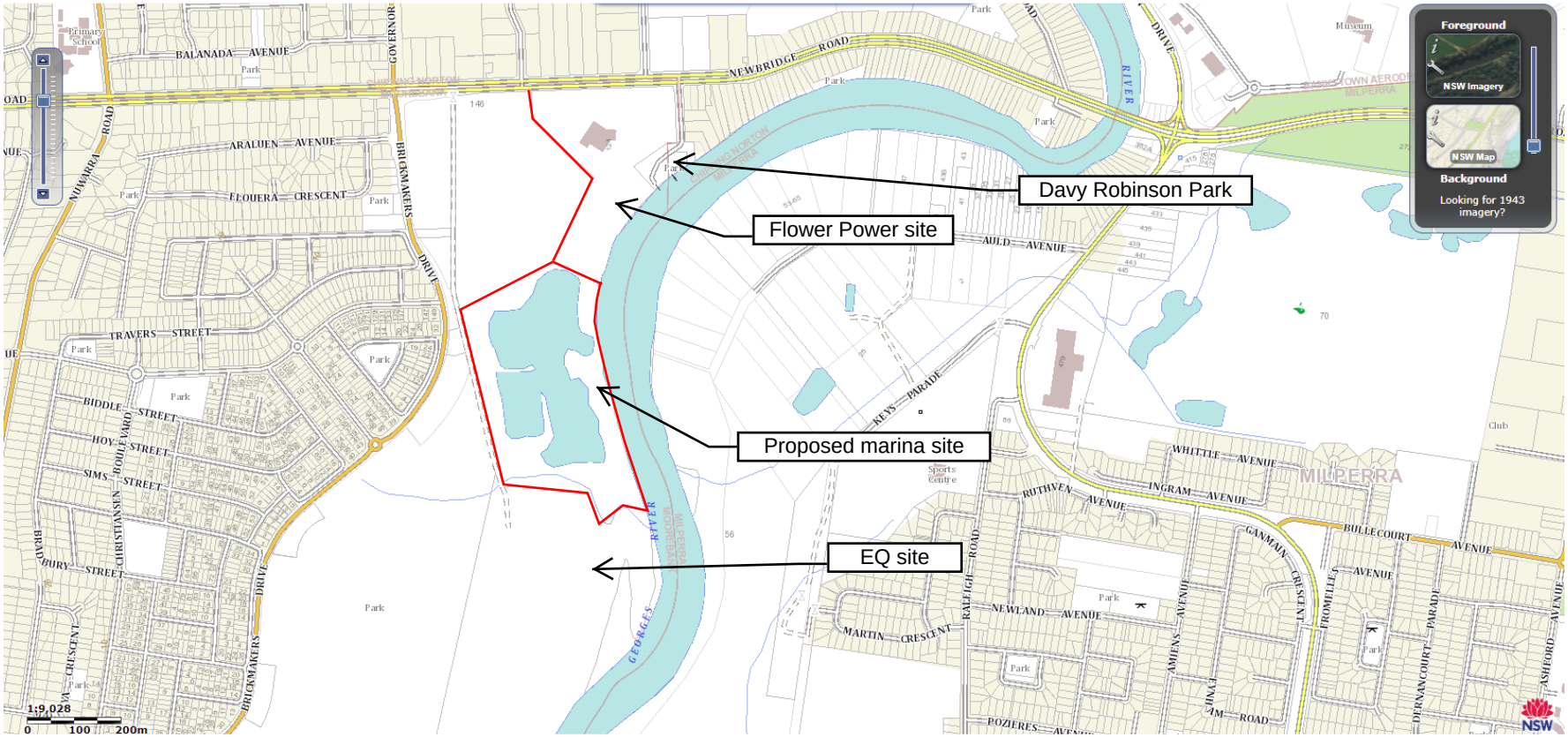
CAD Ref: S:\JOBS\14\14005\14005B - BENEDICTS\ENG\CAD\E4 - GEORGES RIVER EMBANKMENT\DWG\14005B-E4_BASE1

FIGURE 15



FLOOD PEAK VELOCITY TIME SERIES LOCATIONS

FIGURE 16



LOCALITY PLAN

APPENDIX A
Pacific Pontoon and Pier
Details of Piling System and Marina Experience

m 0409 912 631 e mark.tooker@tookerandassociates.com.au a 30 Walworth Avenue, Newport abn 39 619 046 070

PACIFIC PONTOON

Celebrating Over 30 Years of Innovation

18/03/2021

Ernest Dupere - Director

Benedict
11a Narabang Way
Belrose NSW 2085

Reference: Telescopic Piles Design Intent

Dear Ernest,

Pacific Pontoon & Pier appreciates your enquiry and request for preliminary advice regarding design and construction of a telescopic piling system as a method of marina pontoon restraint.

Pacific Pontoon & Pier have manufactured and installed over 10,000 berths in Australia and overseas, including previously a telescopic piles marina system in Double Bay, Sydney.

I have attached our capability statement for further information on our system and examples of presently installed marinas.

The following indicative design criteria for the proposed marina development is a 1:100-year flood with corresponding flow velocity of 1.0m/sec. Top of pile height is typically +6.1m AHD to cope with the 1:100 yr water levels, with the capacity to extend to +9.1m AHD telescopically, providing capacity for a 1:90,000yr flood level. The corresponding flow velocity is expected to be 1.2m/sec. Typical water depths approx. 3m.

Our initial high-level assessment assumes that approx. 610mm diameter steel piles would provide the outer casing, and 560mm diameter steel piles to provide the inner casing. Sizing of the piles can be increased or decreased to suit design inputs and loads. Attached drawing (CON-P100 A) indicates the typical setup of a telescoping piles system.

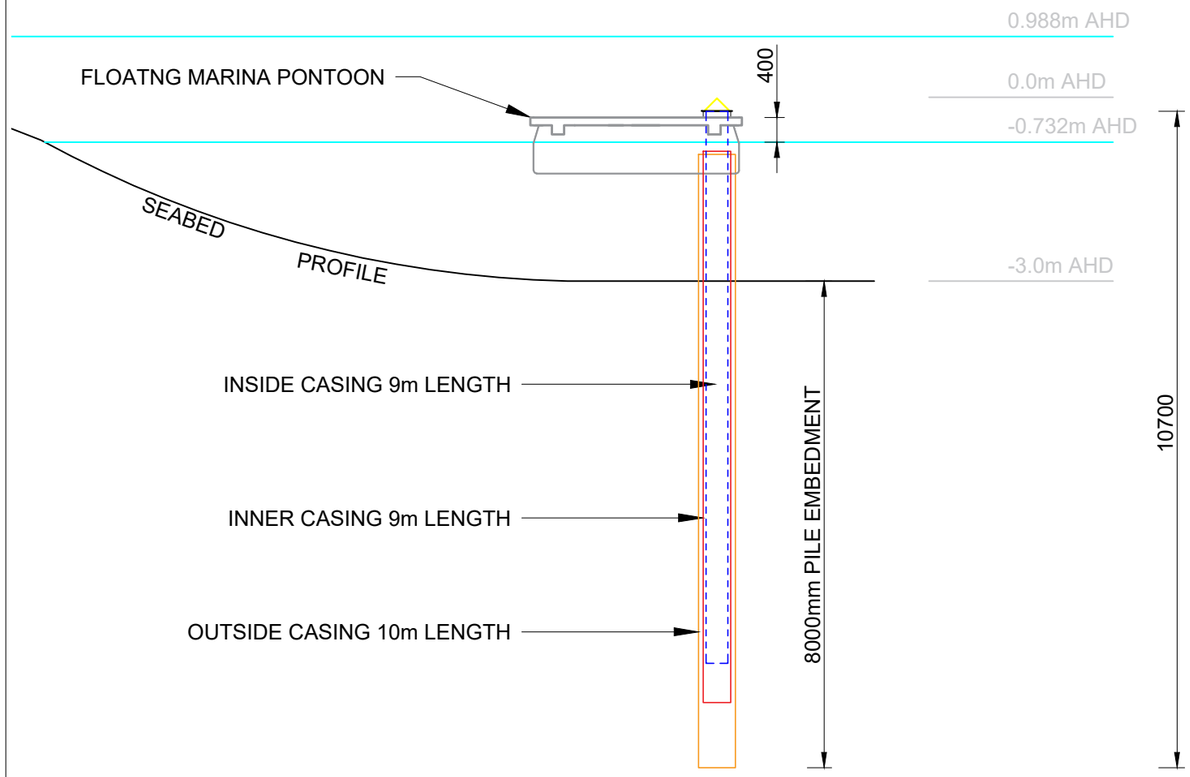
Given previous experience installing telescoping piled systems, and marinas subject to severe design constraints, we recommend that a marina system capable of withstanding the proposed water level design inputs could readily be achieved via the application of a telescopic system for marina restraint.

We look forward to being of any further assistance to support your consideration of a proposed marina system.

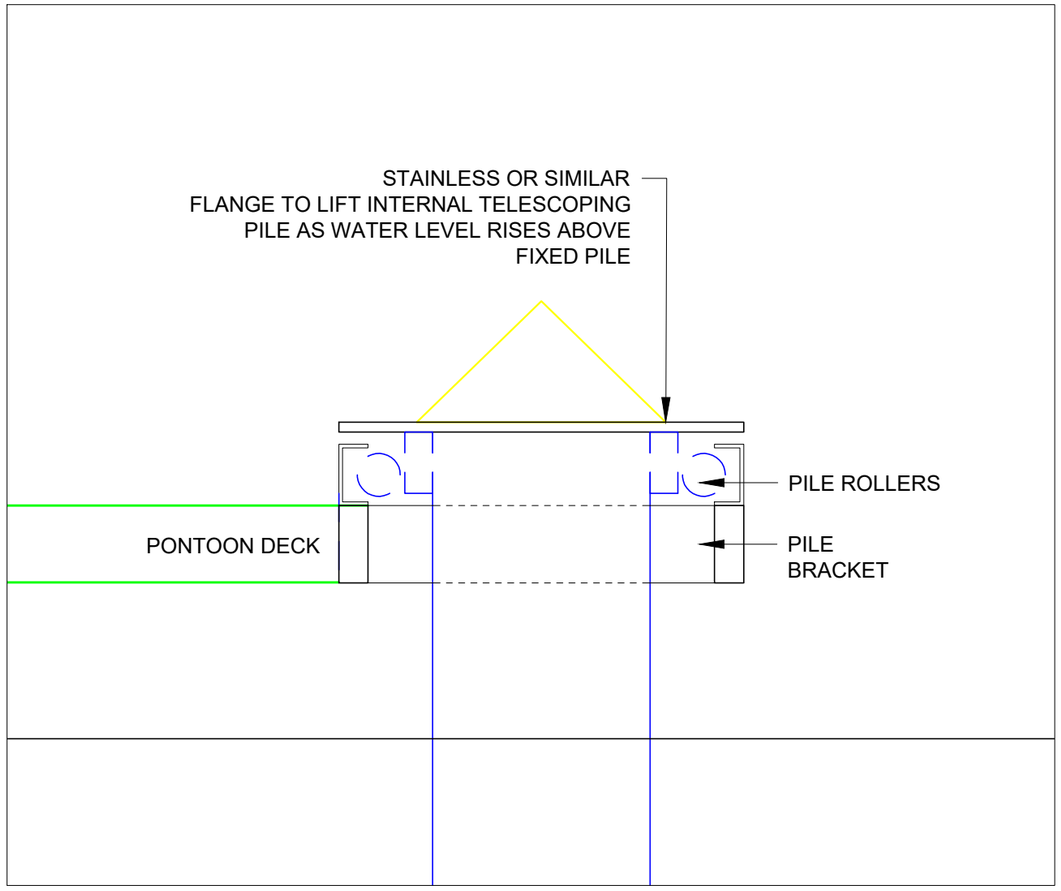
Kind regards,

Simon Doyle
Engineering Manager

PACIFIC PONTOON & PIER OPERATIONS PTY LTD ABN 17 604 284 531
83-87 Dover Drive Burleigh Heads QLD 4220
Phone: + 617 5593 6988 Fax: +617 5593 6449
Email: admin@pacificpontoon.com Web: www.pacificpontoon.com



TELESCOPIC PILE UNDER GENERAL CONDITIONS



FLANGE CONNECTION
1:10 @ A3

REV	DATE	DR	CH	AMENDMENT
A	25.03.21	SD	--	ISSUE FOR INFORMATION

PACIFIC PONTOON & PIER (OPERATIONS) PTY LTD
PHONE: (07) 5593 6988
FAX: (07) 5593 6449
E-MAIL: admin@pacificpontoon.com
ABN: 17 604 284 531
ADDRESS: 83-87 Dover Drive
Burleigh Heads, QLD 4220

PACIFIC PONTOON

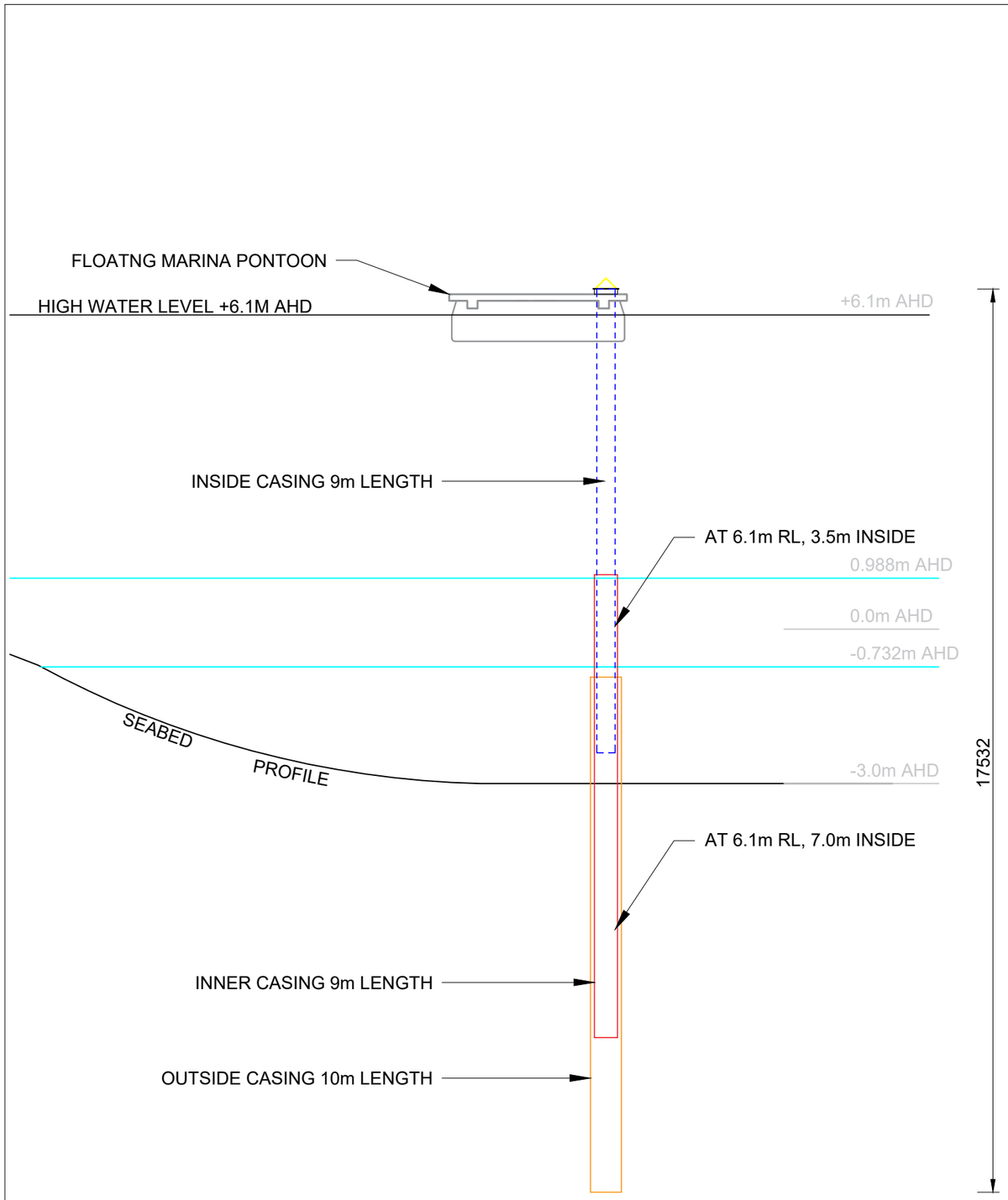
CLIENT: BENEDICT

PROJECT: 11 NARABANG WAY. BELROSE

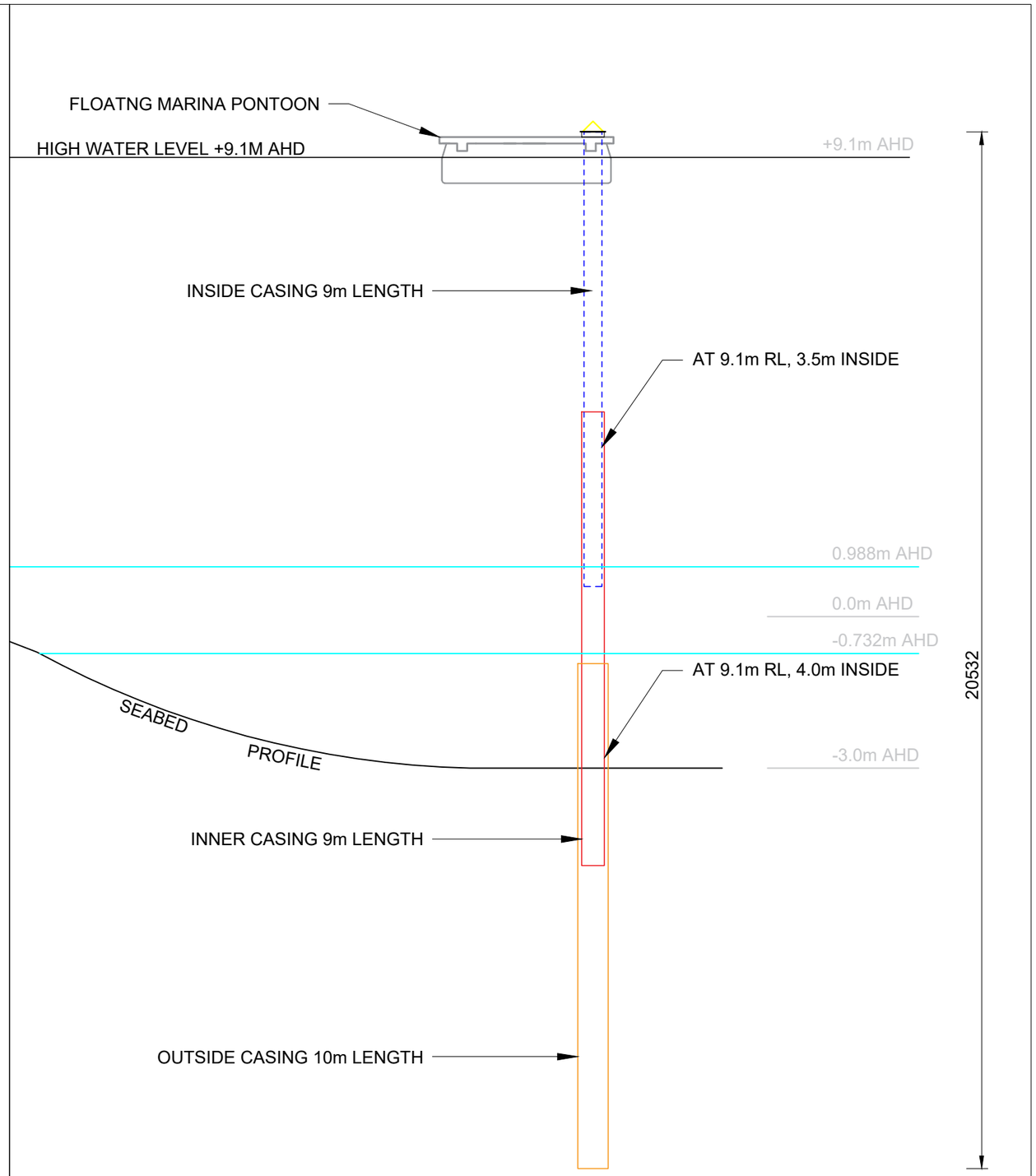
Scale: 1:100 @ A3 | Start Date: 00.00.0000 | Height Datum: AHD

TITLE: TELESCOPING PILE CONCEPT

Dwg No.: CON - P101 | Rev: A



TELESCOPIC PILE UNDER INDICATIVE 1:100 YR EVENT



TELESCOPIC PILE UNDER INDICATIVE 1:90,000 YR EVENT

REV	DATE	DR	CH	AMENDMENT
B	25.03.21	SD	--	ISSUE FOR INFORMATION
A	11.03.21	SD	--	ISSUE FOR INFORMATION

PACIFIC PONTOON & PIER (OPERATIONS) PTY LTD
PHONE: (07) 5593 6988
FAX: (07) 5593 6449
E-MAIL: admin@pacificpontoon.com
ABN: 17 604 284 531
ADDRESS: 83-87 Dover Drive
Burleigh Heads, QLD 4220

PACIFIC PONTOON

CLIENT: BENEDICT

PROJECT: 11 NARABANG WAY. BELROSE

Scale: 1:100 @ A3 | Start Date: 00.00.0000 | Height Datum: AHD

TITLE: TELESCOPING PILE CONCEPT

Dwg No.: CON - P100 | Rev: B

PACIFIC PONTOON

Capabilities Statement

“32 years, 67 Marinas, and over 10,000 marina pens later, Pacific Pontoon & Pier has grown through innovation, research and development to be arguably the largest marina builder in Australia. Marinas that are economical and built to last”.

COMPANY PROFILE

Pacific Pontoon & Pier is a wholly Australian-owned company whose head office is based on the Gold Coast, Queensland.

The Gold Coast has historically been the centre of the booming Australian boating industry, presenting a water-based lifestyle in a perfect location. Waterfront living has continued to be highly sought after and has driven the growth of the marine industry world-wide.

Pacific Pontoon & Pier has grown through innovation, research and development, to be arguably the largest marina builder in Australia in recent years, developing a product range that has revolutionised marina construction, supplying a low maintenance, high density and aesthetically pleasing marina product.

30 years ago Pacific Pontoon & Pier (PPP) could see the need to move away from the waler-thru-rod design that then dominated the marina construction industry in Australia.
PPP set out to design a system that used low-maintenance and high-durability construction materials and methodologies. The ambition was to develop a system that would deliver a design life of 30 years with- out major and expensive overhauls or regular thru-rod tightening.

This system has been further developed over the past 30 years, with improvements and details that can only come with experience.

The Gold Coast office includes a well-equipped design department and all design work and layout detail and is managed by the Hattingh father and son engineers and owners of the business. Both have a hands-on approach to the design and construction of the marina system. *"Our system is improved on an ongoing basis, ensuring every client obtains the full benefit of the company's 30 years of experience."*

The company has acquired its own fleet of piling rigs and an impressive list of plant and equipment.

32 years, 67 marinas, and over 10,000 marina pens later, Pacific Pontoon & Pier are the quiet achievers of the Australian marina industry

PACIFIC PONTOON

THE MARINA SYSTEM

Pacific Pontoon & Pier's floatation system generally comprises HDPE encased polystyrene floats, broom finished concrete decks. Patented aluminium extruded frames, all fixed into position by piles.

Pontoons are not formed by moulds therefore, length, width, height can be changed easily. The ability to angle pontoons creates design features significant indeed. Pontoons can be manufactured in 13 metre single lengths to maximize transport options.

The strong, and precise nature of the system allows for it's use in a multiple range of applications. The concrete finish provides a long life, low maintenance platform that is impervious to the harsh marine environment.

MARINA PROJECTS—(Commercial)

Commercial Marina Facility
Ports North Cairns Marlin Marina Qld - Multi Berth Marina
RMYC Port Hacking NSW — Multi Berth Marina
Department of Transport and Main Roads: Giru Qld — Public Pontoon Facility
Department of Transport and Main Roads: Buxton Qld — Public Pontoon Facility
Port of Airlie Qld—Multi Berth Marina
Double Bay Marina Sydney Harbour—Multi Berth Marina
Machans Marina NSW—Multi Berth Marina
Marmong Point Marina NSW— Multi Berth Marina & Boardwalk
Port Stephens Council NSW—Boat Ramp Pontoon facility
Ipswich Council Qld—Public Pontoon Facility
Commercial Rowing Club Qld—Rowing Pontoon Facility
Dubbo City Council NSW—Public Pontoon Facility
Rowing Queensland —Rowing Pontoon
DERM Fort Lytton National Park Qld—Public Pontoon Facility
Loganlea High School Qld—Pontoon Facility
Lourdes Hill College Qld—Rowing Pontoon
Gold Coast Sailing Club Qld—Disabled Sailors Pontoon Facility
Logan Council Qld—Public Pontoon Facility

(continued next page)

MARINA PROJECTS—(continued)

Commercial Marina Facility
Naia Waterfront Development - New Caledonia
Beaches, Metung, Victoria — Multi berth marina
Oasis Apartments, Queensland —Multi berth marina
Sir John Chandler Park - Public facility Brisbane River QLD
Marina Quays Hope Island, Queensland—Multi berth marina
National Maritime Museum NSW - service pontoon
National Maritime Museum Darling harbor NSW—Multi berth marina
National Maritime Museum NSW - South Wharf and large vessel berthing
1770, Queensland—Public Launching Facility
NSW Maritime, Tweed Heads—Government vessel pontoons
Port Douglas Combined Services Club—Commercial pontoon facility
Sunshine Coast Regional Council—Public 74 metre gangway & pontoon facility
Hope Harbour, Queensland—Multi Berth Marina
Canning Reserve—Public Launching Facility - Victoria
RSAYS, South Australia—Multi berth marina
RSAYS - South Australia—Fuel docking pontoon
Breakwater Marina, Townsville—Private development villas,
Breakwater Marina, Townsville—Multi berth marina
Spinnaker Marina, Queensland—Fuel docking pontoon
Phillip Island, Multi Berth Marina Victoria
Newport Quays Marina, Multi Berth Marina South Australia
Gippsland Lakes Yacht Club Marina, Victoria
Pittwater Council—Public Pontoon Facility, Pittwater NSW
Royal Motor Yacht Club– Multi Berth Marina Newport Sydney
Newport Marina, QLD—Multi berth marina

(continued next page)

MARINA PROJECTS—(continued)

Commercial Marina Facility
Pioneer Sea foods Marina, Multi Berth Marina Queensland
Seoul City Council, Seoul—Government Ferry Pontoons
Martha Cove Marina – Multi Berth Marina Victoria
Queenscliff Council, VIC
Patterson Lakes, VIC—Group mooring marinas
Wallaroo Marina South Australia—Multi residential waterfront pontoons
Horizon Shores Marina, QLD—Multi berth marina
Nandi – Fiji Development
Tweed Heads Southern Boat Harbour NSW—Multi berth marina
Allisee Marina, QLD—Multi berth marina
Mooloolaba Wharf Marina, QLD—Multi berth marina
Arno Bay Marina, South Australia—Multi berth marina
Clarence Valley Marina, NSW
Newcastle Cruising Yacht Club, NSW—Multi berth marina
Glenelq – Local Council, South Australia
Port Vincent Marina, South Australia—Multi berth marina
Pinnacle Marina, QLD—Multi berth marina
Sentinell Building Berths, QLD—Multi berth marina
Bowen Sea foods Marina, QLD—Multi berth marina
Tipperary Waters Marina, NT—Multi berth marina
Tin Can Bay Fishing Boat Marina, QLD—Multi berth marina
Bayview Haven, NT—Public boardwalk and multi berth marina
Palazzo Versace Marina, QLD—Multi berth marina and boardwalk
Couran Cove Marina, QLD—Multi berth marina and boardwalk
Brisbane Water Police Marina, QLD—Multi berth marina

SAFETY STATEMENT

Pacific Pontoon & Pier is a company dedicated to the safety and welfare of all personnel operating within its sphere of influence.

Pacific Pontoon & Pier considers health & safety to be of top priority in the everyday activities of the company. It is the policy of the company to provide and maintain safe and healthy working conditions for all employees, contractors and others that may be affected directly or indirectly by its activities.

The company conducts its operations in such a manner as to:

- Provide a safe working climate
- Ensure the safety & health of all employees
- To establish safe working practices throughout it's operations
- To develop a high degree of safety awareness amongst all personnel
- To provide employees with the required skills and support, to meet the company's ongoing commitment to health and safety
- To provide competent advice to management on health and safety matters as well as a means to monitor performance

The company recognizes that safety is good business practice, and firmly believes that proper management of these issues will contribute positively to its efficiency and business success.

The Management team undertakes to review this policy on a regular basis.

Health & safety are line management responsibilities that form an integral part of the duties of all managers, site foremen, and leading hands in upholding the company's policy.

All employees have a clear duty to exercise self-discipline, maintain an attitude of safety consciousness and prevent injury to themselves an others.

Pacific Pontoon & Pier is committed to improving safety within the organization and to continue the management and planning of safety with the same dedication as with all other commercial affairs. The company is committed to producing an attainable set of Safety Objectives that is managed and controlled by the Management team.

Accompanied within this Capability Statement you will find these detailed internal arrangements within the company's Safety and Operating documents.

Willem Hattingh

Managing Director

MARGATE MARINA, TAS

Client	:	Margate Marina
Location	:	Hobart, TAS
Project description	:	124-Berth Marina and Fuel Pontoon

CAIRNS MARLIN MARINA

Client : Ports North

Location : Cairns, Qld

Project description : Multi Berth Marina Extension

PACIFIC PONTOON

DOUBLE BAY MARINA

Client	:	Double Bay Marina
Location	:	Sydney Harbour, NSW
Project description	:	Multi Berth Marina Replacement

PACIFIC PONTOON

MARMONG POINT

Client : Marmong Point Marina

Location : Lake Macquarie, NSW

Project description : Construction of Multi Berth Marina and Boardwalk

BUXTON PUBLIC PONTOON

Client : Qld Department of Transport

Location : Buxton, Qld

Project description : Public Pontoon Facility

PACIFIC PONTOON

GIRU PUBLIC PONTOON

Client : Qld Department of Transport

Location : Giru, North Qld

Project description : Public Pontoon Facility

PACIFIC PONTOON

Port Of Airlie

Client : Meridien Marinas

Location : Airlie Beach, Queensland

Project description : Multi Berth Marina

PACIFIC PONTOON

MARTHA COVE

Client	:	City Pacific
Location	:	Martha Cove, Victoria
Project description	:	Construction of a 1,000 Berth Marina (3 harbours)

PACIFIC PONTOON

Gippsland Lakes Yacht Club

Client : Gippsland Ports

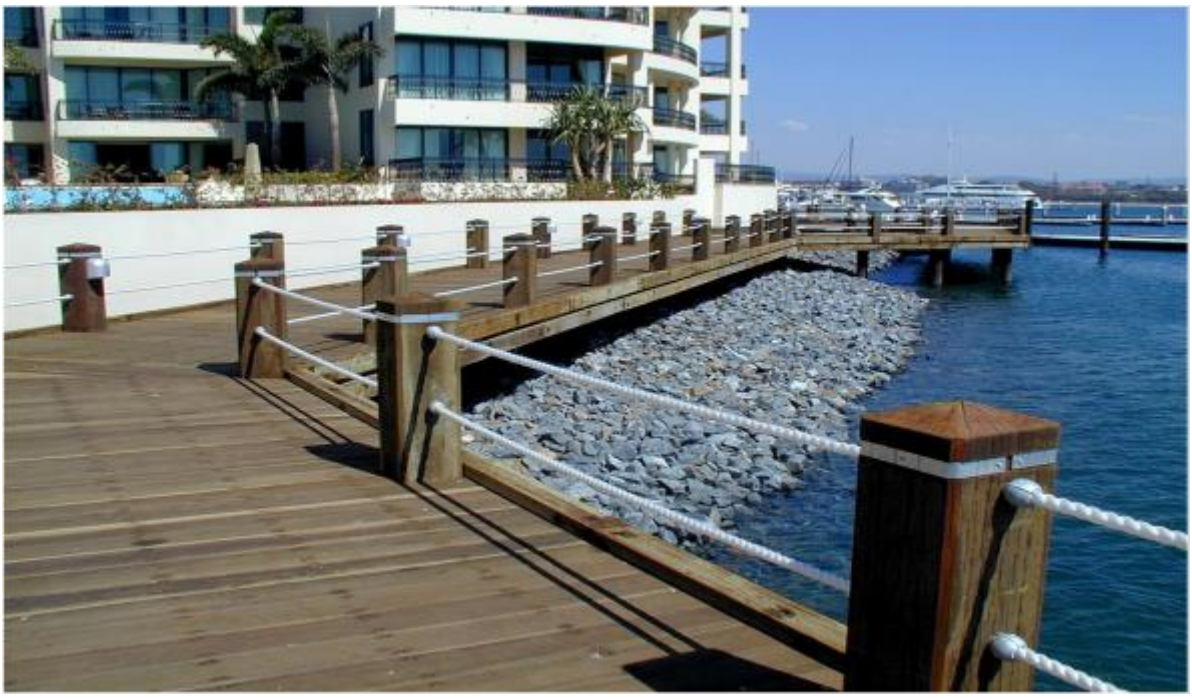
Location : The Esplanade, Paynesville Victoria

Project description : Construction of Multi Berth Marina

PACIFIC PONTOON

Palazzo Versace Marina

Client	:	Palazzo Versace Hotel
Location	:	Sea World Drive, Gold Coast Australia
Project description	:	Construction of Multi Berth Marina & Boardwalk



PACIFIC PONTOON

Port Vincent Marina

Client	:	Paradise Developments Pty Ltd
Location	:	Port Vincent, South Australia
Project description	:	Construction of Multi Berth Marina

Dunethin Lake

Client	:	Sunshine Coast Regional Council
Location	:	Sunshine Coast, Queensland
Project description	:	Public Canoe Launching Pontoon for Disabled Use

Karuah Boat Ramp

Client	:	Port Stephens Council
Location	:	Karuah, Port Stephens
Project description	:	Public Boat Ramp Pontoon Facility

PACIFIC PONTOON

1770 PUBLIC PONTOON

Client : Gladstone Regional Council

Location : 1770, Qld

Project description : Public Launching Facility

PACIFIC PONTOON

Pontoon System Specifications

General	Pacific Pontoon and Pier's proprietary system comprises generally of reinforced concrete deck, polystyrene positive floatation encased with high-density polyethylene. Pontoons are joined together by the use of proprietary elastomeric hinges (University of Queensland tested and certified). The system is fixed in position by the use of piles (generally concrete or steel). The high mass of broomed finish concrete deck with concrete beams underneath provides a safe and extremely stable platform. Hinged aluminium trussed gangways provide access from the shore to the marina. The system is designed to require only minimal maintenance. No timber walers, therefore no re-tensioning of through rods or ongoing whaler replacement. Service pedestals are fully supported and insulated within the system Patented aluminium extrusion with exclusive design fully moulded fender Solid concrete corner splays accommodating any angle or design requirement
Walkway/Finger Pontoon Sizes	Walkway and finger sizes are determined by marina design. Because moulds are not used, module sizes can be designed in large 13 metre lengths and 4 metre widths where needed. Finger can be angled and faceted in a myriad of designs to achieve maximum vessel berthing.
Deck	The system comprises of 125mm reinforced concrete deck with additional reinforced concrete structural beams beneath (exceeding Australian Standards requirements)
Buoyancy	The pontoon core is expanded SL grade polystyrene providing 100% reserve buoyancy.
Freeboard	Buoyancy of standard pontoons is arranged for a 400mm freeboard. Specific nominated freeboards can be varied, and ramped freeboards are not a problem.
Draft	Draft and weight of pontoons can be increased to accommodate various wave climates.

Pontoon System Specifications—(continued)

Services

Services may be ducted along perimeter of pontoon or more commonly trenched within the deck of the pontoon system.

Electrical wiring is armoured cable or double insulated PVC run in continuous heavy-duty conduit, except for the gangway tidal loop range, where flexible double insulated cable is used and supported under the gangway. Cables are run in one continuous length from the gangway to distribution switchboards/service pedestals.

Ducts are provided across walkways for power cords between vessel and service pedestal.

Service Modules

Service pedestals are mounted on the concreted knee bracket area. PVC conduit runs through the pontoon deck to under the service pedestals providing a splash free zone. One service module for every two berths is usually provided.

Telecom and television cable can be provided where needed.
Single and three phase units are available and can be metred if required

Fire Fighting System

The fire fighting system comprises of the following equipment fully installed in accordance with the requirements of AS 3962 and as required by the respective Local Authority Fire Regulations.

1. Fire hose reels 2. Fire extinguishers in cabinets

A common line of HDPE flexible pipe for fire and potable water is allowed unless specified to the contrary.

Cleats

Heavy-duty cast aluminium mooring cleats are fitted to each berth. Cleats are cast into deck during construction.

Pontoon Connections

If required, pontoons are connected using proprietary elastomeric hinges. These hinges incorporate steel plates encapsulated in high-density polyurethane.

Hinges are University of Queensland tested to provide strength and flexibility for the system to move with wave action but have memory without stress fatigue.

Pile Guides

Structural alloy rolled with 6 no. ultra-high molecular weight polyurethane rollers.

Gangway

Marine grade aluminium trussed gangways, attached on the shore abutment. Transition plates are incorporated within gangway to ensure smooth transition from the gangway to the pontoon at all times.

Quality Policy Statement

Pacific Pontoon & Pier (PPP) is a company whose aim is to ensure total customer satisfaction, through the design, manufacture and installation of specialised foreshore and harbour related structures.

In particular, PPP specialises in the design, manufacture and installation of floating marina systems that utilise state of the art, floatation modules.

Our primary objective is to ensure customer satisfaction and confidence in our products.

The senior management of PPP are fully committed to the successful implementation and continuation of all the elements of the Quality System outlined in the following pages.

Quality is everyone's responsibility, and all company personnel are expected to actively participate in all quality-related activities.

It is the policy of the company to establish and maintain an effective and efficient quality system, planned and developed in conjunction with all management functions, which ensures a timely and cost effective service to the client for each project undertaken.

This document outlines the system, which assures that the quality requirements of both the company and its clients are identified, and that uniform control of these requirements is adequately and consistently applied. It defines how effective control is established through the provision of written procedures and checklists, which allows the prompt detection and rectification of non-conformities and system defects.

Pacific Pontoon & Pier's quality control system is an internal system, designed to satisfy the particular needs of each client on an individual project basis.

Willem Hattingh
Managing Director

Piling Barges

Piles and pile-driving

Pacific Pontoon & Pier's piling rigs named "Kingfisher" & "Hammer" are fully transportable Australia wide.
A record of each pile and an "as driven" survey is made available on completion of work.

Key Personnel

Will Hattingh (snr)	Group CEO	Doctorate in Aerospace Masters in Electrical Engineering 20+ Years Experience in Management & Technical Design 10+ Years In Construction Management
Willem Hattingh (jnr)	Managing Director	Qualified Civil Engineer with 8+ Years in MarinaDesign & Construction
Simon Doyle	Engienering and Projects Manager	Qualified Civil/Structural Engineer with 2 Years Experience in the Marina Industry and 10 Years Engineering Experience
Brooke Wilson	Production Manager	15 Years Experience in Marina Construction Industry
Kylee Heagney	Finance Manager	12 Years Experience in the Finance
James Kroll	Project Engineer	Qualified Engineer and Accountant with 2 Years Experience in the Marina Industry

PLANT & MATERIAL:

- In house design team
- In house engineering team
- In house pile survey team
- 4,000 Square metres of manufacturing facilities
- Queensland & Victorian manufacturing plants
- 2 piling barges plus ancillary tenders
- Experienced pile driving team
- Over 10,000 marina berths designed, constructed & installed

Commercial Gangway

Fire extinguisher box & fire hose

Fully molded fender strip

Mooring cleat— 2 x sizes available

Pile guides with circular frame

Service pits with internal conduits

Pile guides on fingers

Cover strip over elastomeric hinge

certificate of registration

This is to certify that the management systems of

Pacific Pontoon & Pier Pty Ltd

have been formally assessed by International Certifications and found to comply with the requirements of

ISO 9001:2015

Quality Management Systems - Requirements

Scope of Registration:

Design, manufacture and installation of pontoons and piers

Registered Site(s):

87 Dover Drive, Burleigh Heads, QLD, 4220, Australia

10 Sep 2018
Issue Date

30 Aug 2021
Expiry Date

Oliver. L. Evans
Chief Executive Officer
International Certifications

INTERNATIONAL CERTIFICATIONS • REGISTRATION NUMBER • C43582

JAS-ANZ

MEMBER OF MULTILATERAL RECOGNITION ARRANGEMENT IAF

INTERNATIONAL CERTIFICATIONS ISO 9001 www.intlcert.com

INSPIRING CONFIDENCE Since 1994

APPENDIX B
Cardno Advice

m 0409 912 631 e mark.tooker@tookerandassociates.com.au a 30 Walworth Avenue, Newport abn 39 619 046 070

From: Brett Phillips
Sent: Thursday, 11 March 2021 5:56 PM
To: Mark Tooker <mark.tooker@tookerandassociates.com.au>
Cc: Stephen Yu <Stephen.Yu@cardno.com.au>
Subject: 59919131 Georges Cove Marina Design

Mark,

Noting that the catchment area to Picnic Point reported in the 1991 Georges River Flood Study is 661 km^2, it was estimated that the catchment area to Newbridge Road is around 640 km^2. The recommended AEP of the PMP determined from Figure 8.3.2 for a catchment area of 640 km^2 was 6.4 X 10^{-7} (around 1,560,000 yrs ARI). This AEP was assigned to the estimates of the PMF in the vicinity of the subject property.

Indicative ARI of a 9.0 m AHD Flood Level

The ARI of the flood level that just overtops the pile cap at 9.00 m AHD was estimated using a log-normal interpolation between the 100 yr ARI flood level and reported values of the PMF level. This assessment is summarised in the following table.

Flood	ARI (yrs)	Flood Level (m AHD)		
100 yr	100	5.52	5.52	Georges Cove model calibrated to MIKE-11 results in 2014
	135,000	9.0		Log-Normal Interpolation
	102,350		9.0	Log-Normal Interpolation
PMF	1,560,000	10.2	10.4	

PMF = 10.4 m AHD from 1991 Georges River Flood Study
PMF = 10.2 m AHD from 2004 Georges River Floodplain Risk Management Study (MIKE-11)

Climate Change

Typically, the 0.5% AEP and 0.2% AEP flood are adopted as surrogates for increases in rainfall intensities due to climate change as follows

- The 0.5% AEP rainfall approximates a 10% rainfall increase which is approximately the increases estimated under RCP4.5 by around the year 2100
- The 0.2% AEP rainfall approximates a 20% rainfall increase which is approximately the increases estimated under RCP8.5 by around the year 2100
- The expected indicative increase above the 1% AEP flood level in the 0.5% AEP flood levels is around 0.1m – 0.15 m;
- The expected indicative increase above the 1% AEP flood level in the 0.2% AEP flood levels is around 0.3 m – 0.4 m;

Cheers
Brett

Dr Brett C Phillips
DISCIPLINE LEADER - WATER
SENIOR PRINCIPAL - HYDROLOGY
CARDNO

Phone +61 2 9496 7700 Fax +61 2 9439 5170 Direct +61 2 9496 7777 Mobile +61 413 437 365
Address Level 9, The Forum, 203 Pacific Highway, St Leonards, New South Wales 2065 Australia

Mark

We are pleased to forward the following results for your consideration.

Distribution of 100 yr ARI Flows

On 9 April we emailed you a Figure which identifies the sections across which the 100 yr ARI flow which were extracted under pre-development conditions (refer NA49913037 Georges River 100 yr ARI Flow Distribution.pdf). The estimated flow distribution is as follows:

ID	Peak Flow (m3/s)	Flow Distribution
C1	333.3	16%
C2	10.9	1%
C3	455.1	22%
C4	851.3	41%
C5	442.7	21%
Total	2093.3	

This may be of general interest for any marina design.

Velocity Distribution at 9.00 m AHD

We undertook the following tasks:

(i) Reviewed the latest TUFLOW model of Georges Cove

(ii) Extracted the 36 hour Extreme Flood boundary conditions from the MIKE-11 files supplied by Council previously

(iii) Checked the floodplain model representation of proposed buildings/development and update if needed to represent proposed buildings on Georges Cove and the adjacent Mirvac site

(iv) Ran the Extreme Flood under post-development conditions;

(v) Extracted and map the results at the time which generates flooding in the marina at around 9.0 m AHD.

1_9m AHD_Flood Level Contour on Flood Depth.pdf

This is a plot of the indicative flood level contours when floodwaters reach 9.0 m AHD at Georges Cove.

2_9m AHD_Flood Velocity .pdf

This is a plot of the indicative flood velocities when floodwaters reach 9.0 m AHD at Georges Cove.

2_9m AHD_Flood Velocity Vectors.pdf

This is a plot of the indicative flood velocity vectors when floodwaters reach 9.0 m AHD at Georges Cove.

Impact of Sea Level Rise

Pages from 1991 Georges River Flood Study.pdf

Figure H4 gives an indication of the sensitivity to a 0.6 m difference in the level in Botany Bay. Noting that the 100 yr ARI flow at Georges Cove is 2,100 m^3/s it would be possible to broadly infer the indicative impact of a future Botany Bay level at 0.9 m AHD.

Cheers
Brett

Dr Brett C Phillips
DISCIPLINE LEADER - WATER
SENIOR PRINCIPAL - HYDROLOGY
CARDNO

Phone +61 2 9496 7700 Fax +61 2 9439 5170 Direct +61 2 9496 7777 Mobile +61 413 437 365
Address Level 9, The Forum, 203 Pacific Highway, St Leonards, New South Wales 2065 Australia
Postal PO Box 19, St Leonards NSW 1590
Email brett.phillips@cardno.com.au Web www.cardno.com

Mark,

My estimate is: 0.067%

Cheers
Brett

Dr Brett C Phillips
DISCIPLINE LEADER - WATER
SENIOR PRINCIPAL - HYDROLOGY
CARDNO

Phone +61 2 9496 7700 Fax +61 2 9439 5170 Direct +61 2 9496 7777 Mobile +61 413 437 365
Address Level 9, The Forum, 203 Pacific Highway, St Leonards, New South Wales 2065 Australia
Postal PO Box 19, St Leonards NSW 1590
Email brett.phillips@cardno.com.au Web www.cardno.com

CONNECT WITH CARDNO

From: Mark Tooker <mark.tooker@tookerandassociates.com.au>
Sent: Wednesday, 24 March 2021 4:54 PM
To: Brett Phillips <Brett.Phillips@cardno.com.au>
Subject: RE: Georges Cove Marina - Flood Probability

Brett,
What is the cumulative probability of a 90,000yr ARI flood occurring within the marina life over say 60 years?
Thanks
Mark

Mark Tooker
Director
Tooker and Associates

M +61 409 912 631 T +61 2 9999 5501
mark.tooker@tookerandassociates.com.au|

Time_series [Read-Only] - Excel

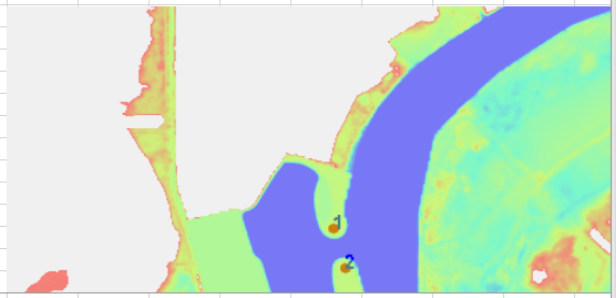
SUSAN TOOKER

File Home Insert Page Layout Formulas Data Review View Help Tell me what you want to do Share

Normal Page Break Preview Page Layout Custom Views — Workbook Views
Ruler Formula Bar Gridlines Headings — Show
Zoom 100% Zoom to Selection — Zoom
New Window Arrange All Freeze Panes Split Hide Unhide View Side by Side Synchronous Scrolling Reset Window Position — Window
Switch Windows — Macros

P22

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	20yr ARI Flood														
2															
3	Location 1					Location 2						Location 3			
4	Time	Velocity	Level	Depth		Time	Velocity	Level	Depth			Time	Velocity	Level	Depth
5	0	0	1.9	0		0	0	1.9	0			0	0	1.90	0
6	0.25	0	1.9	0		0.25	0	1.9	0			0.25	0	1.90	0
7	0.5	0	1.9	0		0.5	0	1.9	0			0.5	0	1.90	0
8	0.75	0	1.9	0		0.75	0	1.9	0			0.75	0	1.90	0
9	1	0	1.9	0		1	0	1.9	0			1	0	1.90	0
10	1.25	0	1.9	0		1.25	0	1.9	0			1.25	0	1.90	0
11	1.5	0	1.9	0		1.5	0	1.9	0			1.5	0	1.90	0
12	1.75	0	1.9	0		1.75	0	1.9	0			1.75	0	1.90	0
13	2	0	1.9	0		2	0	1.9	0			2	0	1.90	0
14	2.25	0	1.9	0		2.25	0	1.9	0			2.25	0	1.90	0
15	2.5	0	1.9	0		2.5	0	1.9	0			2.5	0	1.90	0
16	2.75	0	1.9	0		2.75	0	1.9	0			2.75	0	1.90	0
17	3	0	1.9	0		3	0	1.9	0			3	0	1.90	0
102	24.25	0.485	4.388	2.488		24.25	0.766	4.383	2.483			24.25	0.397	4.371	2.473
103	24.5	0.496	4.435	2.535		24.5	0.777	4.43	2.531			24.5	0.402	4.419	2.521
104	24.75	0.505	4.477	2.577		24.75	0.785	4.472	2.572			24.75	0.405	4.461	2.563
105	25	0.511	4.513	2.614		25	0.791	4.509	2.609			25	0.408	4.497	2.599
106	25.25	0.516	4.545	2.645		25.25	0.794	4.54	2.64			25.25	0.41	4.529	2.631
107	25.5	0.519	4.571	2.672		25.5	0.795	4.567	2.667			25.5	0.412	4.556	2.658
108	25.75	0.52	4.593	2.693		25.75	0.795	4.588	2.688			25.75	0.412	4.578	2.68
109	26	0.519	4.61	2.71		26	0.792	4.605	2.705			26	0.411	4.595	2.697
110	26.25	0.517	4.623	2.723		26.25	0.787	4.619	2.719			26.25	0.41	4.609	2.711
111	26.5	0.514	4.633	2.733		26.5	0.782	4.628	2.728			26.5	0.408	4.618	2.72
112	26.75	0.51	4.638	2.738		26.75	0.775	4.634	2.734			26.75	0.405	4.624	2.726
113	27	0.504	4.639	2.74		27	0.767	4.635	2.735			27	0.401	4.626	2.728
114	27.25	0.498	4.637	2.737		27.25	0.757	4.633	2.733			27.25	0.397	4.623	2.725
115	27.5	0.491	4.631	2.731		27.5	0.747	4.627	2.727			27.5	0.393	4.618	2.72
116	27.75	0.483	4.621	2.721		27.75	0.736	4.617	2.717			27.75	0.388	4.608	2.71
117	28	0.475	4.608	2.708		28	0.725	4.604	2.704			28	0.383	4.595	2.697
118	28.25	0.466	4.591	2.691		28.25	0.713	4.587	2.687			28.25	0.378	4.578	2.68
119	28.5	0.456	4.571	2.671		28.5	0.7	4.567	2.667			28.5	0.372	4.558	2.66



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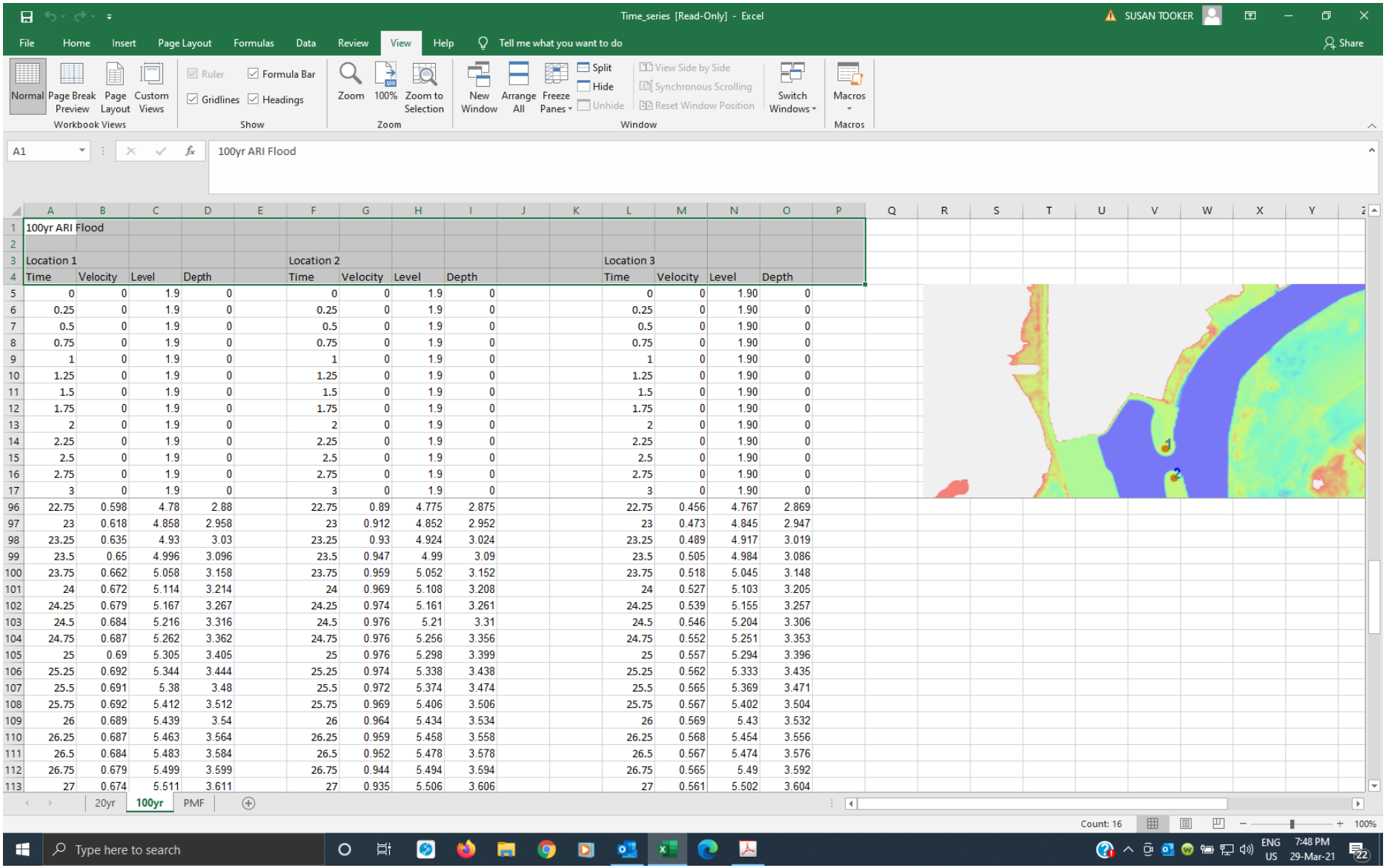
FLOOD PEAK VELOCITY TIME SERIES
20YR ARI FLOOD



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A1 100yr ARI Flood

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	100yr ARI Flood															
2																
3	Location 1					Location 2						Location 3				
4	Time	Velocity	Level	Depth		Time	Velocity	Level	Depth			Time	Velocity	Level	Depth	
5	0	0	1.9	0		0	0	1.9	0			0	0	1.90	0	
6	0.25	0	1.9	0		0.25	0	1.9	0			0.25	0	1.90	0	
7	0.5	0	1.9	0		0.5	0	1.9	0			0.5	0	1.90	0	
8	0.75	0	1.9	0		0.75	0	1.9	0			0.75	0	1.90	0	
9	1	0	1.9	0		1	0	1.9	0			1	0	1.90	0	
10	1.25	0	1.9	0		1.25	0	1.9	0			1.25	0	1.90	0	
11	1.5	0	1.9	0		1.5	0	1.9	0			1.5	0	1.90	0	
12	1.75	0	1.9	0		1.75	0	1.9	0			1.75	0	1.90	0	
13	2	0	1.9	0		2	0	1.9	0			2	0	1.90	0	
14	2.25	0	1.9	0		2.25	0	1.9	0			2.25	0	1.90	0	
15	2.5	0	1.9	0		2.5	0	1.9	0			2.5	0	1.90	0	
16	2.75	0	1.9	0		2.75	0	1.9	0			2.75	0	1.90	0	
17	3	0	1.9	0		3	0	1.9	0			3	0	1.90	0	
96	22.75	0.598	4.78	2.88		22.75	0.89	4.775	2.875			22.75	0.456	4.767	2.869	
97	23	0.618	4.858	2.958		23	0.912	4.852	2.952			23	0.473	4.845	2.947	
98	23.25	0.635	4.93	3.03		23.25	0.93	4.924	3.024			23.25	0.489	4.917	3.019	
99	23.5	0.65	4.996	3.096		23.5	0.947	4.99	3.09			23.5	0.505	4.984	3.086	
100	23.75	0.662	5.058	3.158		23.75	0.959	5.052	3.152			23.75	0.518	5.045	3.148	
101	24	0.672	5.114	3.214		24	0.969	5.108	3.208			24	0.527	5.103	3.205	
102	24.25	0.679	5.167	3.267		24.25	0.974	5.161	3.261			24.25	0.539	5.155	3.257	
103	24.5	0.684	5.216	3.316		24.5	0.976	5.21	3.31			24.5	0.546	5.204	3.306	
104	24.75	0.687	5.262	3.362		24.75	0.976	5.256	3.356			24.75	0.552	5.251	3.353	
105	25	0.69	5.305	3.405		25	0.976	5.298	3.399			25	0.557	5.294	3.396	
106	25.25	0.692	5.344	3.444		25.25	0.974	5.338	3.438			25.25	0.562	5.333	3.435	
107	25.5	0.691	5.38	3.48		25.5	0.972	5.374	3.474			25.5	0.565	5.369	3.471	
108	25.75	0.692	5.412	3.512		25.75	0.969	5.406	3.506			25.75	0.567	5.402	3.504	
109	26	0.689	5.439	3.54		26	0.964	5.434	3.534			26	0.569	5.43	3.532	
110	26.25	0.687	5.463	3.564		26.25	0.959	5.458	3.558			26.25	0.568	5.454	3.556	
111	26.5	0.684	5.483	3.584		26.5	0.952	5.478	3.578			26.5	0.567	5.474	3.576	
112	26.75	0.679	5.499	3.599		26.75	0.944	5.494	3.594			26.75	0.565	5.49	3.592	
113	27	0.674	5.511	3.611		27	0.935	5.506	3.606			27	0.561	5.502	3.604	

20yr 100yr PMF

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FLOOD PEAK VELOCITIES TIME SERIES
100YR ARI FLOOD

Time_series [Read-Only] - Excel

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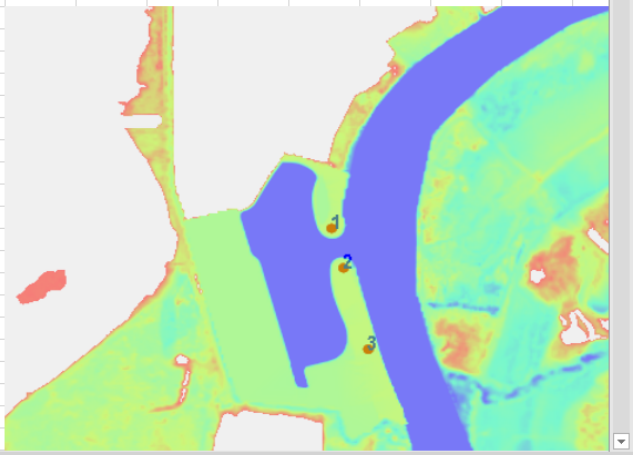
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	PMF Flood														
2															
3	Location 1					Location 2						Location 3			
4	Time	Velocity	Level	Depth		Time	Velocity	Level	Depth			Time	Velocity	Level	Depth
5	0	0	1.9	0		0	0	1.9	0			0	0	1.90	0
6	0.017	0	1.9	0		0.017	0	1.9	0			0.017	0	1.90	0
7	0.033	0	1.9	0		0.033	0	1.9	0			0.033	0	1.90	0
8	0.05	0	1.9	0		0.05	0	1.9	0			0.05	0	1.90	0
9	0.067	0	1.9	0		0.067	0	1.9	0			0.067	0	1.90	0
10	0.083	0	1.9	0		0.083	0	1.9	0			0.083	0	1.90	0
11	0.1	0	1.9	0		0.1	0	1.9	0			0.1	0	1.90	0
12	0.117	0	1.9	0		0.117	0	1.9	0			0.117	0	1.90	0
13	0.133	0	1.9	0		0.133	0	1.9	0			0.133	0	1.90	0
14	0.15	0	1.9	0		0.15	0	1.9	0			0.15	0	1.90	0
15	0.167	0	1.9	0		0.167	0	1.9	0			0.167	0	1.90	0
16	0.183	0	1.9	0		0.183	0	1.9	0			0.183	0	1.90	0
17	0.2	0	1.9	0		0.2	0	1.9	0			0.2	0	1.90	0
18	0.217	0	1.9	0		0.217	0	1.9	0			0.217	0	1.90	0
19	0.233	0	1.9	0		0.233	0	1.9	0			0.233	0	1.90	0
20	0.25	0	1.9	0		0.25	0	1.9	0			0.25	0	1.90	0
21	0.267	0	1.9	0		0.267	0	1.9	0			0.267	0	1.90	0
22	0.283	0	1.9	0		0.283	0	1.9	0			0.283	0	1.90	0
23	0.3	0	1.9	0		0.3	0	1.9	0			0.3	0	1.90	0
24	0.317	0	1.9	0		0.317	0	1.9	0			0.317	0	1.90	0
676	11.183	0.927	6.689	4.789		11.183	1.208	6.68	4.78			11.183	0.807	6.675	4.777
677	11.2	0.927	6.697	4.797		11.2	1.207	6.688	4.788			11.2	0.807	6.683	4.785
678	11.217	0.928	6.706	4.806		11.217	1.208	6.696	4.797			11.217	0.807	6.691	4.793
679	11.233	0.929	6.714	4.814		11.233	1.209	6.705	4.805			11.233	0.807	6.699	4.801
680	11.25	0.929	6.722	4.822		11.25	1.208	6.713	4.813			11.25	0.807	6.708	4.81
681	11.267	0.93	6.731	4.831		11.267	1.208	6.722	4.822			11.267	0.807	6.716	4.818
682	11.283	0.93	6.739	4.839		11.283	1.208	6.73	4.83			11.283	0.807	6.724	4.826
683	11.3	0.93	6.747	4.848		11.3	1.208	6.738	4.838			11.3	0.807	6.733	4.835
684	11.317	0.929	6.756	4.856		11.317	1.207	6.747	4.847			11.317	0.806	6.741	4.843
685	11.333	0.928	6.765	4.865		11.333	1.205	6.756	4.856			11.333	0.806	6.75	4.852
686	11.35	0.927	6.774	4.874		11.35	1.204	6.765	4.865			11.35	0.804	6.759	4.861



20yr 100yr PMF

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PMF FLOOD