Estuarine Risk Management Report for “Yamba”, 23 & 25-33 Robertson Road, Scotland Island, NSW 2105

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1 Introduction

1.1 Northern Beaches Council's Requirements for an Estuarine Risk Management Report

Salients Pty Limited was approached by Benjamin Chan of Sam Crawford Architects to prepare an estuarine risk management report (this report) for the proposed raising of two boat sheds fronting properties along Robertson Road, Scotland Island at No. 23 (Lot 140 of DP12749) and 25-33 (Lot 10 of DP 1106130). Collectively, the properties are known as "Yamba". The properties are located on the north-western foreshore of Scotland Island, which is in southern Pittwater, north of Sydney.

This report addresses the requirements of Northern Beaches Council (Council), through preparation of an Estuarine Risk Management Report (ERMR). Council have requested that an ERMR be prepared as the raised boat sheds will be affected by wave action and tides. A previous report was prepared for the site by Salients on behalf of a different client, in 2018 and the current report incorporates many of the findings of that previous report. The site was reinspected during preparation of the present report and the requirements of Northern Beaches Council reconfirmed.

Appendix 7 to the Pittwater 21 Development Control Plan (DCP) [1] contains the "*Estuarine Risk Management Policy for Development in Pittwater*". That policy requires that risks from wave action and tidal inundation are properly considered by the development. Consideration of those risks is the main aim of this report.

1.2 Proposed Development

The proposed development includes raising two pre-existing boat sheds at the foreshore fronting the two properties. The approximate layout of the proposed works is shown in Figure 1. Importantly, Section B3.7 of Council's DCP indicates that the Estuarine Planning Level does not apply to Jetties, Bridging Ramps or Pontoons (seaward of the foreshore). The analysis is therefore limited to the boat sheds, adjacent timber boardwalks and skids, and the seawall and beach. With reference to Figure 1 and Figure 2, these features, and proposed modifications, are described below:

- **Boat Shed and Walkway fronting No. 23**: The existing timber boat shed is around 5.3m long (shore perpendicular) and 4.2m wide (shore parallel). Timber boardwalks provide access from the shore to the boat shed along its eastern (1.65m wide) and northern (1.45m wide) sides. The jetty at the property projects northwards into Pittwater from the eastern side of these boardwalks. The entire structure, including the jetty, is supported on piers.

[1] Version incorporating Amendments 1 through 25 has been used throughout this report. The DCP for Pittwater is still in effect as of February 2020.

Figure 1: Waterfront Development Elements

0 5 10 15 20 25 m

APPROX SCALE

Estuarine Risk Management Report 23-33 Robertson Road, Scotland Island Beach	REV A	DRAWN EN	CHECK DJW

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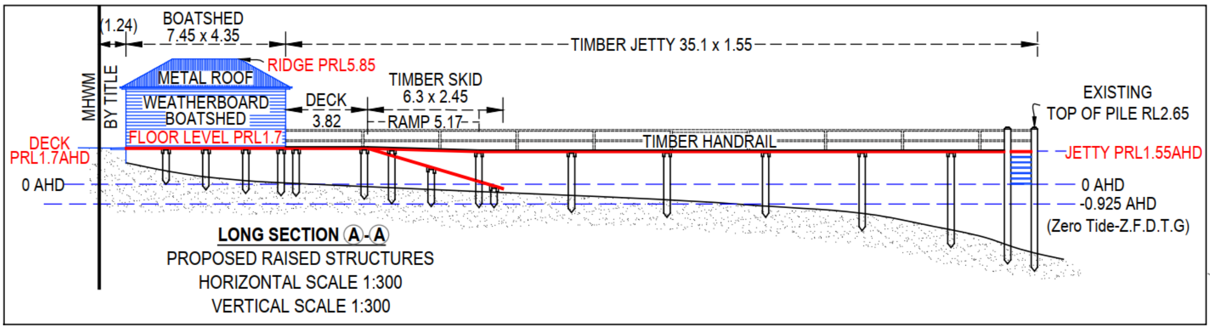

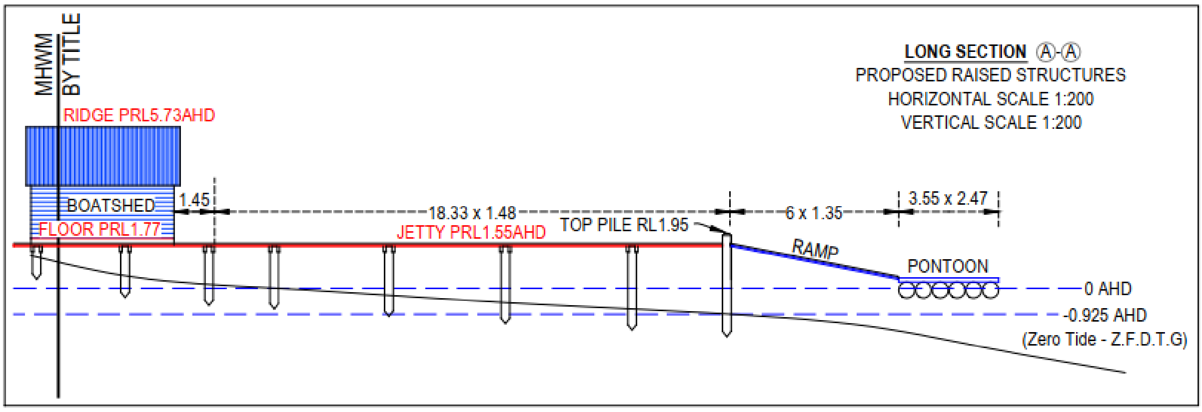

Figure 2 Long Sections Showing Proposed Boatshed, Jetty and Pontoon Arrangements. The eastern structure, fronting No. 25-33, is shown at top and the western, fronting No. 23, at the bottom (extracted from plans by SDG Land Development Solutions (2018, provided in Appendix B)).

The trafficable surface of the boardwalk (and jetty) is at around 1.23 to 1.25m AHD. The existing internal floor level of the boatshed is 1.45m AHD. The proposal includes raising the boat shed to an internal floor level of 1.77m AHD, and the timber decking to 1.55m AHD.

- **Boat Shed and Walkway fronting 25-33**: The existing timber boat shed is around 7.45m long (shore perpendicular) and 4.35m wide (shore parallel). Timber boardwalks provide access from the shore to the boat shed along its north-eastern (2.9m wide) and north-western (offshore, 3.8m wide) sides. The jetty at the property projects into Pittwater from the boardwalk. A dilapidated timber boat skid (6.25m long by 2.5m wide) also projects from the front of the timber boardwalk to the beach, at a slope of around 1V:4H. The entire structure, including the jetty, is supported on piers.

  The trafficable surface of the boardwalk (and jetty) is at around 1.30m AHD. The existing internal floor level of the boatshed is 1.35m AHD. The proposal includes raising both the timber decking and the internal floor level of the boat shed to an elevation of 1.70m AHD.

- **Seawall and Stone Stairs:** A small flight of stone steps, leading from the foreshore to the beach, is adjacent to the southern corner of the boat shed servicing No. 25-33. A low stone seawall extends westwards from this location, marking the rear of the beach for some 25 metres before disappearing below the back-beach sand level. When inspected, this seawall had a typical height of 400 to 500mm above the sand, although this would vary depending on how much sand is present at any given time.

1.3 Outline of Report

The requirements for this report have been determined through a review of Appendix 7 to the DCP, initial contact with Council's Principal Coast and Estuary Officer, and Section B3.7 *"Estuarine Hazard – Low Density Residential"* of the DCP. The identified requirements are presented in the remainder of this report as follows:

- Section 2 contains a description of the site locality and environment, insofar as it relates to waves and water levels that could interact with the raised structures. The design life of the development is also discussed, as this affects the allowance for sea level rise that needs to be made and the magnitude of design waves.
- Section 3 considers the nature of the existing foreshore, seawall and the structural loadings that could be applied in design. Issues surrounding durability and functionality are also discussed.
- Section 4 includes a risk assessment. Risks are identified and assessed. Where appropriate, mitigation strategies are outlined.

1.4 Confirmation

Salients Pty Ltd has 20M public liability insurance and 10M professional indemnity insurance. Furthermore, the author of this report, Dr David Wainwright is a chartered engineer with the Environmental and Civil Colleges of Engineers Australia and has been a practicing coastal engineer for close to 25 years. David's PhD is in Coastal Engineering. A signed copy of "Form 1" which pertains to this Estuarine Risk Management Report is provided as Appendix A.

2 Details of the Environment at the Site

2.1 Site Locality

Appropriate design wave and tide conditions are governed by the location of the Site within Pittwater, Pittwater's connection to the ocean, and the Site's exposure to fetches over which winds can blow to generate local waves. Due to its sheltered location, oceanic swell is not a significant issue at the Site. The location of the Site within Pittwater is shown in Figure 3.

Of interest is the fetch for local wind waves, which could approach from directions spanning clockwise from west to north east.

2.2 Proposed Design Life for Facility

Council's policy specifies a design project life of 100 years, unless it can be *otherwise justified by the applicant* (and accepted by Council). The design life proposed has an impact on design conditions in terms of the amount of sea level rise allowance used.

The Australian Standard for the design of maritime structures (Standards Australia, 2005) recommends that a design life of 25 years be adopted for a small craft facility[2]. The boat sheds fit squarely into this category. A 25-year design life is appropriate and has been assumed and adopted henceforth in this report.

Overall, the scale and relatively infrequent use of the structure (compared to use of residential buildings) lead to our assessment that the structure represents a *"low degree of hazard to life or property"*. A related table from the maritime structures Standard indicates that the 2% Annual Exceedance Probability (AEP) wave[3] would be an appropriate wave height for the 25-year design life. Such wave heights would have an approximate 40% chance of occurring at least once over a 25-year design life.

[2] Refer to Table 6.1 of AS4997, 2005

[3] Refer to Table 5.4 of AS4997, 2005

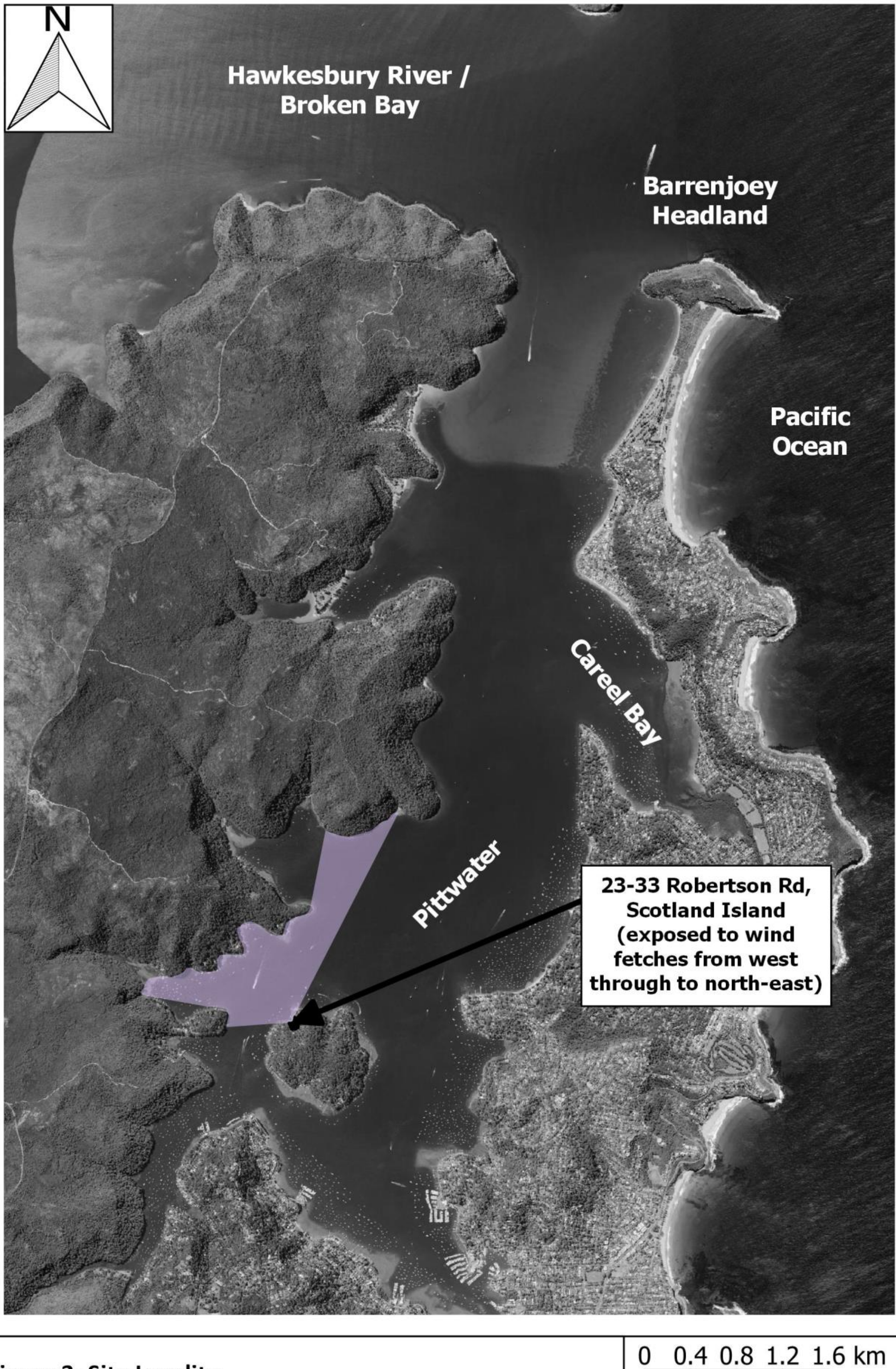

Figure 3: Site Locality

Estuarine Risk Management Report 23-33 Robertson Road, Scotland Island Beach	REV A	DRAWN EN	CHECK DJW	Salients

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2.3 Consideration of Wave Environment

Previous work by Lawson and Treloar (2004, 2003) and Cardno (2015) examined the wind wave climate around Pittwater. Those studies applied extreme wind speed analysis to a wind record from Sydney Airport, which can be reasonably applied to Pittwater, resulting in estimated extreme wind speeds from directions between west and north-east as shown in Table 1.

Table 1 Estimated Extreme Wind Speeds for Pittwater (m/s) (from Lawson & Treloar (2003), Table 3.5)

	West	North West	North	North East
1% AEP Gust Speed	38.3	33.9	28.4	23.8
5% AEP Gust Speed	35.0	31.3	26.1	22.9
1% AEP 10 min Average	26.6	21.3	19.3	18.3
5% AEP 10 min Average	24.3	21.3	17.8	17.6
1% AEP 3 hr Average	25.5	22.1	18.5	17.6
5% AEP 3 hr Average	23.3	20.4	17.0	16.9

To estimate extreme nearshore wave conditions around Scotland Island, the response of a computational wave model to a range of wind speeds from 16 compass directions was assessed. Those responses were used, by Lawson and Treloar, to transfer the time series of wind speeds from Sydney Airport to a corresponding time series of waves near Scotland Island. Statistical analysis then determined the occurrence of extreme wave conditions near the north-western shoreline of Scotland Island. The resulting local wind-generated waves that are indicated as being applicable to 23-33 Robertson Road are replicated in Table 2.

Table 2 Estimated Extreme Wind Wave Heights near 23-33 Robertson Road ('NW Scotland Island' from Lawson & Treloar (2003), Table 3.7)

Recurrence	Wind Wave Height ($H_{s,w}$, m)
5% AEP	0.89
2% AEP	0.93
1% AEP	1.00
0.5% AEP[4]	1.04

A check of design wave heights, considering the length of wave generation fetch from directions ranging clockwise from west to north east, was made using the simplified methods presented in the US Army Corps of Engineers Coastal Engineering Manual[5]. The values for significant wind wave height presented in Table 2 were found to be reasonable and have been adopted for design.

For this report, the 2% AEP significant wave height (H_s of 0.93m) was adopted. AS4997 recommends a factor of 1.5 be applied to the H_s wave height to obtain the H_1 wave height, which represents the highest 1% of waves occurring during a design storm and should be used in determining structural loads. Accordingly, a wave with height 1.40m (1.50 × 0.93) can be used in deriving forces for structural design.

It is possible that a wave of this height may not make it to the Site without breaking. This is governed by the following relationship:

$$H_b = \gamma \times h_b$$

Where H_b is the size of the wave that would break in water depth h_b and γ is the breaker index, which is commonly given a value of 0.78. A nearshore depth of around 1.8m is required for a 1.4m wave to pass without breaking before it reaches the foreshore. Examination of recent survey data indicates that bed elevations close to around 0.0m AHD are present at the front of both boat sheds. Combining a high tide and some wind set-up, a water level of around 1.3 to 1.4m AHD could be experienced, albeit rarely, at the Site. Furthermore, the wave breaking process begins some distance offshore of the

[4] Values not reported in Lawson & Treloar (2003). Estimated via logarithmic extrapolation.
[5] http://www.publications.usace.army.mil/USACE-Publications/Engineer-Manuals/u43544q/436F617374616C/

Site, in deeper water. Adopting a conservative stance, it is reasonable to assume that the full wave height (1.4m) can reach and break on the structure.

Design water levels at the site are discussed in more detail in the following section.

2.4 Consideration of Water Level Environment

Council's designated Estuarine Planning Level (EPL) for the site is 2.73m AHD. Under this condition, the design wave of 1.40m AHD could easily propagate all the way to the foreshore and the full wave height would govern design. It is important to understand how the EPL has been derived. It contains the following components:

- Storm Tide.
- Wind Setup.
- Wave Related Increment.
- Freeboard.
- Sea Level Rise.

Each of these are discussed in turn.

Storm tide includes the astronomical tide and other large-scale processes that act to raise the ocean water level over large distances (i.e. 100s of km). For the most recent analyses (Cardno, 2015), a storm tide of 1.44m AHD was applied across Pittwater, which differed from that originally determined by the Pittwater Estuary Processes Study (Lawson & Treloar, 2003).

By applying the 1% AEP 3 hourly average wind speeds from Table 1 to a hydrodynamic model, the following wind setup values were determined along the north-western Scotland Island foreshore (Lawson & Treloar, 2003):

- North Westerly Wind: +0.03m
- Northerly Wind: +0.08
- North Easterly Wind: +0.09m
- Easterly Wind: +0.06m

For all other directions, winds across Pittwater indicated a set down of water levels along north-western Scotland Island. The value adopted for the Site in the most recent analysis of water levels was +0.09m (Cardno, 2015). This is likely to occur concurrently with wind waves approaching from the north east.

A "Wave Related Increment" component was also determined for north-west Scotland Island. This component accounts for run-up and overtopping of the foreshore and is therefore related to the type of foreshore (e.g. sloping natural, vertical seawall etc.). For the foreshore fronting No. 23 and 25-33 Robertson Rd, the character is most closely represented by a sandy beach. The present day 1% AEP still water level, including wind set up allowance, is 1.53m AHD, meaning that the still water level is very close to the back-beach elevation. The crest of the low seawall at the back of the beach is between 1.6 and 1.7m AHD. For this condition, Lawson and Treloar determined a wave related increment of 0.5m. Ultimately, a 'present day' estuarine planning level of 2.33m AHD, which also included a freeboard of 0.3m, was determined for the Site. Cardno (2015) describes the freeboard as a "factor of safety" which provides a level of mitigation against risk exposure arising from uncertainties, particularly with relation to wave run-up.

For climate change related sea level rise, Council has adopted a rise of 0.4m by 2050 and 0.9m by 2100. Within Cardno (2015), these were considered to be relative to a "present day level" of 0.0m. With sea level rise of 0.4m (by 2050), a total estuarine planning level of 2.73m AHD was determined.

In considering the degree of periodic foreshore infrastructure inundation that could be expected from tides of different frequencies within Pittwater, Cardno (2015) also presented more statistics as shown in Table 3. These do not include the wave related increment or freeboard.

Table 3 Comparison of Still Water Levels from Astronomical Tides (m AHD, to nearest 0.1m)

	"Present Day"	2050 (including 0.4m Sea-level rise)
Fortnightly High Tide	0.6	1.0
Monthly High Tide	1.0	1.3
Bi Annual (King) Tide	1.2	1.6
100yr Storm Tide	1.4[6]	1.8

With 0.4m of sea level rise, biannual astronomical tides in Pittwater would be at 1.6m AHD, very close to the crest of the back-beach seawall. Furthermore, the internal floors of the existing boat sheds (presently at 1.45m AHD) would be inundated at least a couple of times a year. The proposed floor level for both boat sheds would be above all normal astronomical tides (including king tides), with the proposal aiming to raise

[6] Note that a level of 1.44 (1.84 at 2050) was used in derivation of the Estuarine Planning Level

the floor to 1.77m AHD (No. 23) and 1.70m AHD (No. 25-33). Any raising of the existing boat sheds will mitigate against inundation.

2.5 Potential Justification for Modifying the Estuarine Planning Level

Considering the components of the EPL, the storm tide adopted is reasonably typical for estimates based on the record available from Fort Denison. Varying the storm tide level to represent a 2% AEP event (applicable for a 50yr design life), instead of a 1% event, would typically result in lowering the level by a few centimetres.

The sea level rise allowance applied in Cardno (2015) appears to be 0.4m between 2015 and 2050 and a further 0.5m between 2050 and 2100. Most widely accepted projections now indicate that the rate of sea level rise will accelerate over time. A comparatively conservative approach is to consider a linear increase between 2015 and 2050. This approach projects around 0.34m of sea level rise by 2045, at the end of a 25-year design life for the raised boat sheds. Allowing for this adjustment represents a potential reduction in the EPL by 0.06m.

Finally, adoption of the 2% AEP wave height discussed in Section 2.3 (0.93m), instead of the wave height adopted by Cardno (2015), would reduce the EPL by some 14-15cm. In total, considering a design life extending to 2045, an appropriate planning level for the foreshore of around 2.52m AHD could be applied. The design still water level, without freeboard, for this modified condition (~1.87m AHD) would still exceed the proposed floor elevation of both boat sheds. The potential for inundation should be considered as part of structural design for the raised structure, with the frequency of inundation increasing with time as sea levels rise.

3 Interaction of Water Levels and Waves with the Proposal

3.1 Existing Foreshore and Structural Conditions

3.1.1 Introduction

Salients' staff inspected the site on 31st October 2017, for a previous client, between midday and around 1:30 in the afternoon, to coincide with low tide. A thorough photographic record was collected, and small pits were hand excavated in front of the back-beach seawall. The site was again inspected and photographed on 16th February 2020 at around 10:30am (also at low tide). The entire foreshore, as seen on that day from the jetty fronting No. 25-33 is shown in Figure 4.

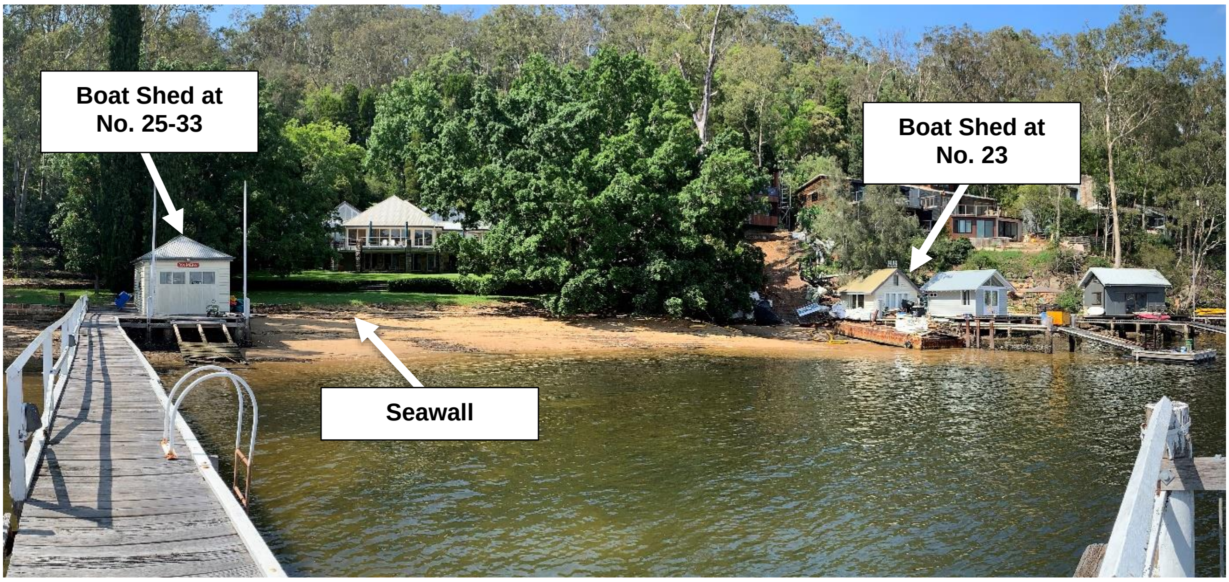


Figure 4 Foreshore at "Yamba", 10:30am, 16 February 2020

3.1.2 Boat Shed at No. 23

The boat shed at No. 23 (Figure 5 and Figure 6) is of weatherboard construction with a corrugated steel roof. Twin bifold doors are present at the front of the structure and sliding glass doors along its eastern side. The superstructure appears to be in reasonable condition, however, close inspection of the structure on 16th February 2020 was impeded by ongoing construction at the site. The substructure is of typical timber construction, comprising piers, headstocks, girders and planks. The timbers, particularly the decking planks, are weathered but appear serviceable. Most of the jetty and boat shed's piers have been encased in concrete and are heavily encrusted with oysters within the intertidal zone. The concrete encasement is likely provided to protect against deterioration caused by marine borers. Chainwire mesh has been attached to the eastern edges of the boat shed substructure, and along the eastern edge of the jetty, between the deck and the bed. The purpose of the chainwire is unclear, although it is encrusted with oyster shells in the intertidal zone and would reduce wave energy and debris being carried across into the beach between the two boat sheds.

Figure 5 View from Jetty, Onshore to Boat Shed, No. 23 Robertson Rd, Scotland Island, 31 October 2017

Figure 6 View Offshore along eastern edge of Jetty, No. 23 Robertson Rd, Scotland Island, 31 October 2017

3.1.3 Boat Shed at No 25-33

The boat shed fronting No. 25-33 (Figure 7 and Figure 8) is of weatherboard construction with a corrugated steel roof. Twin bifold doors are present at the front of the structure, along with a small window and shade sail along its eastern side. It appears that rainwater is collected from the roof of the structure and power is available through external weatherproof power points on the eastern wall. The interior of the structure was not inspected and, therefore, we are not able to provide comment on the existing provision of services and their appropriateness. The superstructure appears to be in reasonable condition. The substructure is of typical timber construction, comprising piers, headstocks, girders and planks. The timbers, particularly the decking planks, are weathered, and several planks are broken and/or loose. Most of the jetty and boat shed's piers have been encased in concrete within the intertidal zone and are heavily encrusted with oysters. The concrete encasement is likely provided to protect against deterioration caused by marine borers. A dilapidated timber boat skid is provided at the front of the walkway on the seaward edge of the boat shed. Most of the planks are missing from the skid and the piers holding the seaward end seem to have settled noticeably. Chainwire mesh has been attached to the western and northern edges of the boat shed substructure and along the western edge of the jetty, however, the mesh has become detached from the northern half of the jetty. The purpose of the chainwire is unclear, although it is encrusted with oyster shells in the intertidal zone and would reduce wave energy and debris being carried across into the beach between the two boat sheds.

Figure 7 View from Jetty, Onshore to Boat Shed, No. 25-33 Robertson Rd, Scotland Island, 16 February 2020

Figure 8 Western side of Boat Shed, No 25-33 Robertson Rd, Scotland Island, 16 February 2020

3.1.4 Sandy Beach and Seawall

An apparently stable sandy beach was present along the foreshore at the property during the site inspection. Overall, sand was plentiful at the middle of this stretch, but somewhat diminished towards both boat sheds, more so to the west. The inspection carried out in February 2020 followed a significant storm event during the preceding fortnight. Minor, wave driven foreshore erosion was present closer towards the western boat shed (No. 23). The erosion is not active and is of limited concern.

Historical aerial and satellite photography were also inspected via the Google Earth™ software package. This indicated that an exposed sandy beach has been consistently present at this location over recent years (digital aerial photography was available from around 2004). These photographs indicate that the eastern end of the beach is typically stable and there is no evidence of significant erosion events on the aerial photographs. Considering the erosion witnessed during the site inspection in February 2020, it seems likely that the beach recovers quickly following erosion events. The western end is often obscured in aerial and satellite imagery by the presence of a large fig tree (see Figure 10). Overall, the sandy beach is well protected from erosion due to the limited fetch lengths and alignment of the beach.

Immediately west of the eastern boat shed, a short flight of three stairs provides access from the foreshore down on to the beach. The lower step was covered by sand at the time of the earlier inspection in 2017. Excavation of the beach in front of the stairs revealed that the bottom of the stairs was supported on a foundation formed from sandstone boulders. Considering survey data provided in Appendix B, the base of the cemented dimensioned sandstone stairs is cast at a level of around 0.75m AHD.

To the west of the stairs, a low, near vertical sandstone seawall demarcates the back of the beach for around 25m. When inspected on 16th February 2020, the eastern end of this seawall was around 500mm high above the sand level. Further to the west, the wall disappears below the sand, and the extent of the wall in this direction is uncertain. The beach surface at the eastern end of the beach comprises a flat berm of 5-10m extending seaward from the seawall, and a beach face slope of around 1 in 20. At the time of inspection in 2017, the width of the berm was noted to narrow and the beach to steepen slightly, with distance west. The variation in beach shape reflects slightly more exposure to wind waves from the north east with distance west along the beach.

The seawall is of non-cemented dry-stone construction comprising prismatic sandstones of, typically, 400 to 600mm alongshore by 100mm high by 200mm shore normal. By excavating pits in front of the seawall, the condition of the toe was determined. The wall contains a vertical section around 400-500mm high (4-5 stones) and a sloped "self-launching" toe of around 1m width at a slope of 1V:2H. The entire structure appears to be founded on a gravel base. Accordingly, the seawall is around 1m high. Considering surveyed elevations of the top of the wall, this places the toe at around 0.6 to 0.7m AHD.

Figure 9 Back Beach Seawall, 25-33 Robertson Rd, Scotland Island

Figure 10 Back Beach Seawall, 25-33 Robertson Rd, Scotland Island (view towards west)

The seawall is in reasonable repair and is suitable for its present purpose. However it is likely that the seawall provides more of a landscaping function (demarcation of beach from lawn) than any protective function at present. Over time, with sea level rise, some lowering of the beach may occur, and overtopping of the back of the beach may begin to occur more frequently. These actions will likely begin to test the structural integrity of this wall; however, a reasonable degree of thought has gone into the engineering of this structure and it may prove robust for some time into the future. Regardless, there is plenty of space for the optional landward relocation of the seawall (to maintain sandy beach width), and other options, including re-armouring with larger stone and/or raising the seawall, remain possible. Given the small scale of the seawall, ongoing monitoring following any significant storms and repair as necessary is an appropriate management strategy for the seawall. Future adaptation of the structure can be considered if it becomes necessary in future.

3.2 Determination of Structural Design Conditions

As described in Section 2.5, Council's estuarine planning level for the site is 2.73m AHD, although it could be argued that an alternative, lower level of 2.52m AHD is justified. Clearly, the proposed floor levels of both structures (1.7m AHD and 1.77m AHD) are significantly lower than either of the original or alternative estuarine planning levels.

Raising the floor of the boat sheds, even to a small degree, will reduce the design wave forces experienced and the frequency with which the boat sheds are adversely inundated. In this regard, any raising of the boat sheds is positive from a risk management perspective. Even so, it is worthwhile to consider the serviceability of the raised structures through their design life and to consider the forces that would be applied in designing a new boat shed for structural integrity. The remainder of this chapter considers these issues.

To provide a safe, habitable floor level for a 25-year design life, the floor of the boat sheds would need to be raised to 2.52m AHD. However, a boat shed, when used primarily for boat storage, does not need a habitable floor and a lower floor is acceptable.

Clause B3.7 of Council's DCP notes that:

> *"Consideration may be given on a merit basis to a floor level of a boat shed at a level lower than the Estuarine Planning Level where it can be demonstrated through an Estuarine Risk Management Report that the boat shed is structurally designed to withstand periodic wave action and tidal inundation up the Estuarine Planning Level"*

It is our opinion that raising the boat sheds to 1.77m (No. 23) and 1.7m AHD (No. 25-33) represents a reasonable compromise, considering adjacent ground and jetty levels. It appears impractical to raise the boat shed floors significantly higher. At these levels, the floors would not be inundated, except during rare events at the end of the design life, including a projected sea level rise of 0.34m. Even so, the flooring and lower wall timbers can (and should) be designed to handle temporary, but infrequent, inundation to meet the requirements of Council at the end of the structure's design life.

Waves will load the foreshore structures in several ways, which are dealt with in turn:

- Waves slamming against the vertical sides of structures.
- Waves breaking onto the face of the boat skid and across the horizontal surfaces, causing shear and uplift force.
- Waves passing beneath the underside of the structure which causes positive and negative pressures on the underside as the wave passes.
- Wave forces on vertical piles.

Due to the short-period waves and nature of the resulting forces, it is appropriate to consider that all the above wave forces could load the structure at the same time. A design wave height of 1.4m at the foreshore has been assumed. Waves that reach the foreshore will break and potentially slam against vertical surfaces of the structures during an extreme wave condition at the end of the structure's design life.

3.2.1 Waves Acting against Vertical Planar Surfaces

The wave forces discussed below should be applied to all vertical planar surfaces such as boat shed walls and the sides of structural members.

The method presented by Goda (2010) for calculating the wave forces on a vertical breakwater can be conservatively adopted. Goda's model produces a (roughly) triangular pressure distribution which varies with height. It is necessary to consider those components of the EPL that should be included in this force calculation. It is appropriate to include the storm tide, wind setup and sea level rise components in determining a still water level across which the wave will propagate. The wave related increment can be ignored in this instance as Goda's method calculates the amount which the wave will run up a vertical planar surface. An argument could be mounted for ignoring the freeboard as well, but in this instance, it is considered appropriately conservative to retain that component. Considering the information in Sections 2.3 through 2.5, and adopting Council's original EPL, but with a 2% AEP design wave, the design condition comprises a 1.4m high wave propagating across a still water level of 2.23m AHD.

Using Goda's method, a peak wave pressure of 4.7 kPa is calculated at the adopted "still water level" of 2.23m AHD. We recommend that this horizontal pressure be considered to act evenly on all parts of vertical surfaces below 2.23m AHD. Goda's method calculates that the waves could run up the face of a vertical surface to a height of 4.83m AHD, although this behaviour would be intermittent and only occur at the peak of the storm surge. The wave pressure distribution should be considered to reduce linearly between 2.23m and 4.83m AHD, from 4.7 kPa to zero.

This vertical pressure distribution represents the conditions at the peak of a temporally varying distribution that changes with a period equal to the incident wave period (around 1.9 seconds, derived from linear wave theory). There is also potential for a very high impulsive breaking wave force to impact on the structure. Goda notes that this can occur when there is:

1 A broad rubble berm at a high elevation; or

2 The sea bottom is steep, and the incident wave is not.

Neither of these conditions are met, so impulsive breaking wave forces are not a concern in this instance.

3.2.2 Waves Acting Across Upper Face of Horizontal Planar Surfaces (e.g. Pathways)

When a wave breaks and rushes across a horizontal surface, a tangential shear stress acts across that surface. An appropriate value for this force has been determined considering that the maximum velocity flowing across the timber walkway decking surfaces would occur when the full design wave height (1.40m) breaks across the pathway. An estimate of the velocity was determined by adding:

- the approach wave speed, and
- a velocity equal to the height of the wave, converted to an equivalent velocity via Bernoulli's equation.

By rounding up, a conservative estimate of the shear stress is 0.5kPa. This force can be considered to work as both a tangential drag force and a lift force (also 0.5kPa), with both the drag and lift acting at the same time.

3.2.3 Waves Acting on Piles

The forces acting on a pile can be calculated using the Morison equation as outlined in the USACE Coastal Engineering Manual. Importantly, the force will depend on the diameter and surface roughness of the pile, which will not be determined until detailed structural design is undertaken. While this should be assessed by the structural engineer examining the structure, it appears likely that the pressure force of a wave slamming into the boat shed walls is likely to be the major contributor of bending moments induced in the piles. The support of boat sheds on piers is common and structural design to accommodate the required forces is unlikely to be problematic.

3.2.4 Waves Acting on the Underside of Horizontal Surfaces

As a wave passes below the suspended floor of the boat shed, a pressure force would alternate between pushing and pulling on that surface. AS4997 recommends that this can be estimated by the height of the wave crest above the structure, as if the structure wasn't there, increased by a factor of 2 (Section 5.9.4 of AS4997). Assuming a deck level of 1.5m AHD (the lowest, and most conservative in this case) A wave height of 1.40m, multiplied by 2 and then converted to an equivalent hydrostatic pressure results in a pressure of 28.1kPa acting on the underside of the boat shed floor, with that pressure able to act either upwards or downwards on the floor.

This alternating pressure should be applied as a load to the boat skid, walkway and boat shed floor.

3.2.5 Summary of Structural Design Actions

Raising the floor of the boat sheds, even to a small degree, will reduce the design wave forces experienced, and the frequency with which the boat sheds are adversely inundated. Therefore, any raising of the boat sheds is positive from a risk management perspective in this regard.

In summary, the following load conditions should be considered during a review of the structural adequacy of the raised structures:

- An even pressure of 4.7 kPa up to 2.23m AHD, with a linearly decreasing pressure above 2.23m, reducing from 4.7 kPa to 0kPa at 4.83m AHD. This pressure varies with time and the values presented above represent conditions as the peak of a wave slamming into the structure.
- A shear stress and lift force of 0.5kPa, in accordance with Section 3.2.2 acting on horizontal surfaces (such as pathway surfaces and timber decks).
- Both negative and positive pressures (two separate cases) on the underside of the floor, boat skid and walkway as outlined in Section 3.2.4. These pressures should be considered to cover the entire floor.
- Drag and inertial forces acting on piles, which could be calculated using Morison's equation, once decisions are made regarding the diameter and materials to be used in raising the structure.

All forces should have factors applied in accordance with standard structural engineering practice. Some guidance on appropriate factors is also provided in AS4997 *Design of Maritime Structures.*

3.3 Other Design Considerations

Other structural loads, in accordance with normal structural design practice (winds, dead loads and pedestrian loads etc.) also need to be considered. Buoyancy forces should also be assessed with the structure considered empty and inundated to 2.57m AHD. The height of 2.57m is calculated from the design still water level of 1.87m AHD plus half the design wave height of 1.40m in accordance with AS4997.

The potential for fatigue to occur due to repeated but less severe loading, or deterioration of structural members, for example, through the actions of marine borers needs to be considered. As part of structural design, an appropriate program for structural inspection and expected maintenance requirements is to be provided. This is discussed further under Section 4.7. Consideration of the durability of members comprising the floor and lower walls of the boat sheds and associated walkways is required. These members should be designed to handle regular inundation (say more than a couple of times a year) at the end of the boat shed's design life. If electrical fixtures are to be provided at the boat sheds, these should be kept above Council's Estuarine Planning Level of 2.73m AHD. Similarly, the floor of the shed should enable draining, and a gap of 6mm between decking planks, or similar, is recommended to enable rapid draining, drying and ventilation after an inundation event. Structural member and connection design below the design inundation elevation should also consider the need for drying and ventilation. The grade of all surfaces should encourage water to drain back into Pittwater to avoid ponding of onshore area.

Gaps between planks on the boat skid's upper surface should be maximised as much as is practically achievable to reduce the run up of waves and minimise the impact of waves on the front wall and doors of the boat shed.

4 Risk Assessment and Management Strategy

4.1 Background

A risk assessment and management strategy for the works has been prepared using the guidance provided by the international risk management standard, ISO 31000. That standard suggests the following steps for risk assessment:

- Establish the risk management context.
- Identify the Risks.
- Assess the Likelihood and Consequences of those Risks.
- Evaluate the Risks.

Management strategies can then be suggested for those risks which are unacceptable.

4.2 Establish the Context

The risks assessed by this strategy relate to elevated water levels and waves, insofar as they may impact on the following foreshore elements:

- Boat Sheds;
- Associated Timber decking; and
- Boat Skid.

The different risks that are of relevance in the context of Council deciding about a development application fall into the following three categories:

1. Structural.
2. Safety.
3. Environmental.

4.3 Identification of Risks

The three risk categories listed above were considered in turn. Risks that could possibly be of some concern (even minor) have been listed and numbered for further consideration.

4.3.1 Structural Risks

Risk 1: *There is a risk that the foreshore structures will fail under elevated water level and/or wave conditions.*

Risk 2: *There is a risk that the foreshore structures will deteriorate over time, making them more susceptible to failure under even moderate loads.*

4.3.2 Safety Risks

There are two types of safety risks broadly considered, those that arise during construction, and those that arise during use of the facilities. The proposed works are typical for foreshore structures of this type and abnormal construction risks are not expected. It is expected that the contractor completing the work will comply with standard safe building practice and Work Health and Safety legislation, giving due consideration to the hazards present in a marine environment. Construction safety risks are not considered further here.

Regarding safety risks during use of the facilities, the assessment requires consideration of the existing situation, and how modification of the facilities might impact on the exposure of individuals to dangerous wave and water level conditions.

Individuals may approach the facility from the water side or the land side. In terms of approaches from the water side, the modified facilities will improve safety, with more elevated fixed surfaces to which a vessel could be moored and/or safer exit from the water during periods of elevated water levels and waves. Therefore, risks associated with approaches from the water side are made less severe by the proposal and not considered further here.

With approaches from the land side, however, the following risk has been identified:

Risk 3: *There is a risk that construction of the facilities will create a perception that the foreshore is safer during periods of elevated water levels and waves, increasing the exposure of people to being knocked down by waves and potentially drowned.*

4.3.3 Environmental Risks

Facilities such as this can potentially interact with waves to have undesirable impacts on environmental processes. The proposed foreshore structures will not impact on water levels in Pittwater. One risk has been identified:

Risk 4: *There is a risk that raising the boat sheds will allow greater wave energy to affect the beach, potentially changing the character (width, steepness of the beach).*

4.4 Method for Likelihood Assessment

The likelihoods of the identified risks have been assessed qualitatively using the descriptors provided in Table 4 (adapted from AS5334 (Australian Standards, 2013)).

Table 4 Likelihood Assessment Table.

Likelihood Rating	Descriptor
Almost Certain	Could occur several times per year
Likely	May arise about once per year
Possible	Maybe a couple of times in a generation
Unlikely	Maybe once in a generation
Very Unlikely	Maybe once in a lifetime

The assessment of likelihood for each of the identified risks is presented in Section 4.7.

4.5 Method for Consequences Assessment

The consequences of the identified risks have been assessed qualitatively using the descriptors provided in Table 5 (adapted from AS5334 (Australian Standards, 2013)).

Table 5 Consequences Assessment Table.

Consequence Rating	Structural Factors	Safety/Health Factors	Environmental Factors
Insignificant	No damage	No adverse effects	No adverse effects on natural environment
Minor	No permanent damage, minor restoration required	Slight adverse human health effects	Minimal effects on the natural environment
Moderate	Limited damage, recoverable by maintenance and minor repair	Adverse human health impacts	Some damage to the environment including local ecosystems

Consequence Rating	Structural Factors	Safety/Health Factors	Environmental Factors
Major	Extensive damage requiring major repair	Permanent physical injuries and fatalities to a single individual	Significant effect on the environment and local ecosystems. Remedial action required.
Catastrophic	Significant permanent damage or loss of structure	Injuries and/or fatalities involving multiple individuals	Very significant environmental loss with extensive remedial action required.

The assessment of consequences for the identified risks is presented in Section 4.7

4.6 Method for Risk Evaluation

Using the likelihoods and consequences descriptors presented above, evaluation of the risks has been completed using Table 6 (adapted from AS5334 (Australian Standards, 2013)).

AS5334 regards that the following treatments are applicable:

- *Low* risks would typically be addressed through routine maintenance and day to day operations.
- *Moderate* risks would require a change to the design or maintenance regime of assets.
- *High* risks require detailed research and appropriate planning (or design).
- *Extreme* risks would require immediate action to mitigate.

The evaluation of each of the identified risks is presented in Section 4.7

Table 6 Risk Rating Matrix

Likelihood	Consequences				
	Insignificant	Minor	Moderate	Major	Catastrophic
Almost Certain	Low	Moderate	High	Extreme	Extreme
Likely	Low	Moderate	Moderate	High	Extreme
Possible	Low	Low	Moderate	High	Extreme
Unlikely	Low	Low	Moderate	Moderate	High
Very Unlikely	Low	Low	Low	Moderate	Moderate

4.7 Risk Management Discussion and Treatment

The following discusses risk assessment, evaluation and proposed management strategies for each of the five risks in turn.

Risk 1: *There is a risk that the foreshore structures will fail under elevated water level and/or wave conditions.*

Overall, the force of waves during the design event and less severe events is destructive. These design events could be expected to occur once or twice in a generation (Possible) and, if the structure is under designed, extensive damage could be expected (Major). A "high" risk would be indicated for an under designed structure.

Risk Management Action 1

> The recommended action here is to ensure that the raised structure is assessed by a qualified structural engineer, considering the loadings outlined in Section 3 of this report, and that other loads and suitable factors are applied in accordance with standard structural engineering practice. Allowance must be made for suitable drainage of this water back towards Pittwater.

This action would reduce the consequences to "Minor" in nature, resulting in a "Low" risk rating.

Risk 2: *There is a risk that the foreshore structures will deteriorate over time, making them more susceptible to failure under even moderate loads.*

It is likely that the structures will deteriorate with time. However, the nature of the failure that could be expected is only partial failure of a structure, which could be remediated through minor repairs and maintenance (replacement of failing members etc.). This results in a moderate risk rating, however, if the following two actions are adopted, the risk rating would be reduced to "Low".

Risk Management Action 2

> Again, ongoing degradation of the structure can be addressed by design. Construction materials and connections should be suitable for exposure to harsh conditions, including occasional inundation and regular wave action. A storm generating waves of 0.5m could be expected at least once a year and waves of 0.2m height would occur frequently. If appropriate, the design should allow for a loss of structural integrity (serviceability and strength) over time.

Risk Management Action 3

> A maintenance and inspection regime, appropriate for the construction materials adopted should be defined by the structural designer, so that any abnormal deterioration of the structure is identified before it becomes problematic. Furthermore, the structural design should consider the accessibility of structural members if it is expected that they would need to be replaced. For example, planks on the timber skid would be inundated daily from the beginning of that structure's life, making them potentially susceptible to marine borers, however, the design could ensure that those members are easily replaceable.

Risk 3: *There is a risk that construction of the facilities will create a perception that the foreshore is safe during periods of elevated water levels and waves, increasing the exposure of people to being knocked over by waves and potentially drowned.*

The design event is a rare occurrence. Furthermore, it would take the occurrence of abnormal circumstances, or a lapse of judgement, for individuals to approach the foreshore during the height of a storm. This may happen, but the number of individuals that could approach the foreshore from the landward side during a storm would be limited to the residents of No. 23 and 23-33 Robertson Rd, and their visitors. Even if these people did approach the foreshore, the elevated and/or clear nature of landward approaches to both boat sheds would normally mean that visibility is reasonable, except at night. Overall, it is considered that there is an extremely remote chance that problems would occur, but that the consequences could be “Major”. A “Moderate” risk rating is implied.

Risk Management Action 4

> The probability of occurrence is remote, but the consequences could be major. For the eastern boat shed, the wide, open and elevated grassed area means that the risk is Low for that boat shed. For the boat shed fronting No. 23, it is recommended that signs be provided along the landward approaches to the boat shed, landward of the foreshore, warning of the potential dangers during high water levels and waves during storms. To ensure that the signs can be seen during low light conditions, it is also recommended that a light which illuminates those signs and is triggered by motion be installed. Such lights could also have the practical function of illuminating the foreshore, making the facility more useable, for example, at night. While this will not eliminate the potentially major consequences, it is considered that these actions are reasonably practicable and cost effective.

Risk 4: *There is a risk that raising the boat sheds will allow greater wave energy to affect the beach, potentially changing the character (width, steepness of the beach).*

Overall, the wave and current climate is benign, however, the presence of a stable sandy beach is a unique feature for Scotland Island that is desirable to retain.

Risk Management Action 5

> Raising the boat shed will allow more wave energy to approach the beach in between the two boat sheds during large storms. Changes to this wave climate may upset the equilibrium of that beach. Minor changes in wave climate can have a seemingly disproportionate effect on a small beach. As this is one of the few (if not the only) substantial sandy beaches along the foreshore of Scotland Island, steps to mitigate against any changes in the beach wave climate are worthwhile.
>
> We recommend that the raised structure include outer lateral girders with soffits that are at least as low as those which presently exist. Alternatively, wave baffles (timber boards attached to the outer edge of the girders with small gaps between them) could be installed from the outer girders down to the same level. Baffles would need to be designed using the forces outlined in Section 3.2. The purpose of these two actions is to block waves such that the wave energy environment at the beach face remains the same as it would have been if the present structure levels were retained. The practicality of which option is ultimately adopted (deeper beams or baffle boards) will depend on the associated cost. With these modifications, the assessed risk rating is low.

5 Summary and Endorsement

Overall, any raising of the two boat sheds at 23 and 25-33 Robertson Road is going to reduce risks associated with safety and property damage.

In planning for the raising operation, a check of the structural performance of the proposed structure should be made. The authors are unsure whether the existing piers are going to be replaced or re-used. Regardless, the integrity of the structures, once raised, should be checked against the design forces outlined in this report.

The raised structures can be modified to withstand appropriate water and wave loadings without failure. Appropriate environmental loadings are presented in Section 3 of this report and summarised in Section 3.2.5. Other considerations which a structural designer should regard are presented in Section 3.3.

A risk assessment was undertaken and the outcomes of that assessment, including the actions that should be taken to mitigate against those risks, are summarised in Section 4.7. The risks arising from the development are minor, and can be easily addressed during design and construction.

The proposed boat shed raising can be achieved without undue impacts or negative consequences to public safety or the environment. A formal endorsement of the findings of this report is provided in Appendix A.

As part of this assessment, we have also considered the condition of the existing foreshore seawall. The wall appears to be in reasonable condition, although it is prone to attack during elevated water levels. Future conditions may test its integrity as sea levels rise. There exist potential adaptation options that could be applied to this seawall in future, if the need for repairs becomes too frequent. The need for such adaptation actions will not be affected by the proposed boat shed modifications.

6 References

Australian Standards, 2013. AS 5334 Climate Change Adaptation for Settlements and Infrastructure.

Cardno, 2015. Pittwater Estuary Mapping of Sea Level Rise Impacts (Revised Draft Report No. LJ2882/R2658v7).

Goda, Y., 2010. Random Seas and Design of Maritime Structures, 3rd ed, Advanced Series on Ocean Engineering. World Scientific, Singapore.

Lawson & Treloar, 2004. Estuarine Planning Level Mapping Pittwater Estuary (No. J2230/R2075).

Lawson & Treloar, 2003. Pittwater Estuary Processes Study (No. J1942/R1945).

SDG Land Development Solutions, 2018. Plans (2 of) showing proposed refurbishment to existing waterfront improvements at No. 23 and No 25-33 Robertson Rd, Scotland Island.

Standards Australia, 2005. AS4997-2005 Australian Standard Guidelines for the design of maritime structures.

Appendix A “Form 1” for Estuarine Risk Management Report Certification

FORM NO. 1

To be submitted with Estuarine Risk Management Report

Development Application for Sam Crawford Architects

Address of site 23 and 25-33 Robertsons Road, Scotland Island

Declaration made by a Coastal Engineer as part of an Estuarine Risk Management Report

I, David Wainwright, on behalf of Salients Pty Ltd

on this the 26th February, 2020

certify that I am a Coastal Engineer as defined by the Estuarine Risk Management Policy for Development in Pittwater and I am authorised by the above organisation/company to issue this document and to certify that the organisation/company has a current professional indemnity policy of at least $2 million.

Please mark appropriate box

X I have prepared the detailed Estuarine Risk Management Report referenced below in accordance with the Estuarine Risk Management Policy for Development in Pittwater

☐ I am willing to technically verify that the detailed Estuarine Risk Management Report referenced below has been prepared in accordance with the Estuarine Risk Management Policy for Development in Pittwater

☐ I have examined the site and the proposed development/alteration in detail and, as detailed in my report, am of the opinion that the Development Application only involves Minor Development/Alterations or is sited such that a detailed Estuarine Risk Management Report is not required.

Estuarine Risk Management Report Details:

Report Title: Estuarine Risk Management Report for “Yamba” 23 & 25-33 Robertson Road Scotland Island, NSW 2105

Report Date:26th February, 2020

Author: Dr David Wainwright

Documentation which relate to or are relied upon in report preparation:

Australian Standards, 2013. AS 5334 Climate Change Adaptation for Settlements and Infrastructure.
Cardno, 2015. Pittwater Estuary Mapping of Sea Level Rise Impacts (Revised Draft Report No. LJ2882/R2658v7).
Goda, Y., 2010. Random Seas and Design of Maritime Structures, 3rd ed, Advanced Series on Ocean Engineering. World Scientific, Singapore.
Lawson & Treloar, 2004. Estuarine Planning Level Mapping Pittwater Estuary (No. J2230/R2075).
Lawson & Treloar, 2003. Pittwater Estuary Processes Study (No. J1942/R1945).
SDG Land Development Solutions, 2018. Plans (2 of) showing proposed refurbishment to existing waterfront improvements at No. 23 and No 25-33 Robertson Rd, Scotland Island. Prepared for Estuary Construction.
Standards Australia, 2005. AS4997-2005 Australian Standard Guidelines for the design of maritime structures.

I am aware that the above Estuarine Risk Management Report, prepared for the above mentioned site is to be submitted in support of a Development Application for this site and will be relied on by Northern Beaches Council as the basis for ensuring that the estuarine risk management aspects of the proposed development have been adequately addressed to achieve an acceptable risk management level for the life of the structure, taken as at least 100 years unless otherwise stated and justified in the Report and that all reasonable and practical measures have been identified to remove foreseeable risk.

Signature:

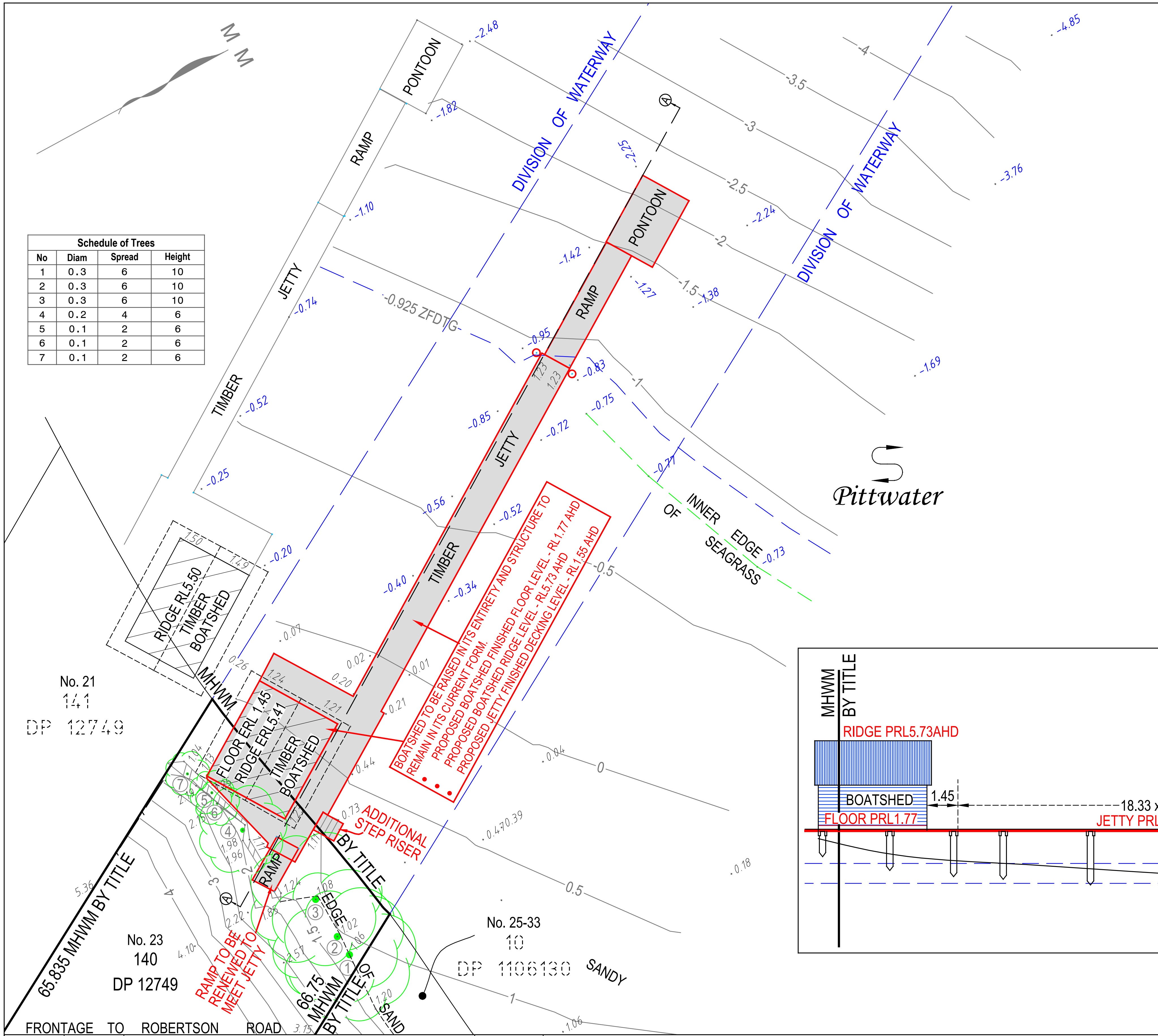
Name: Dr David Wainwright

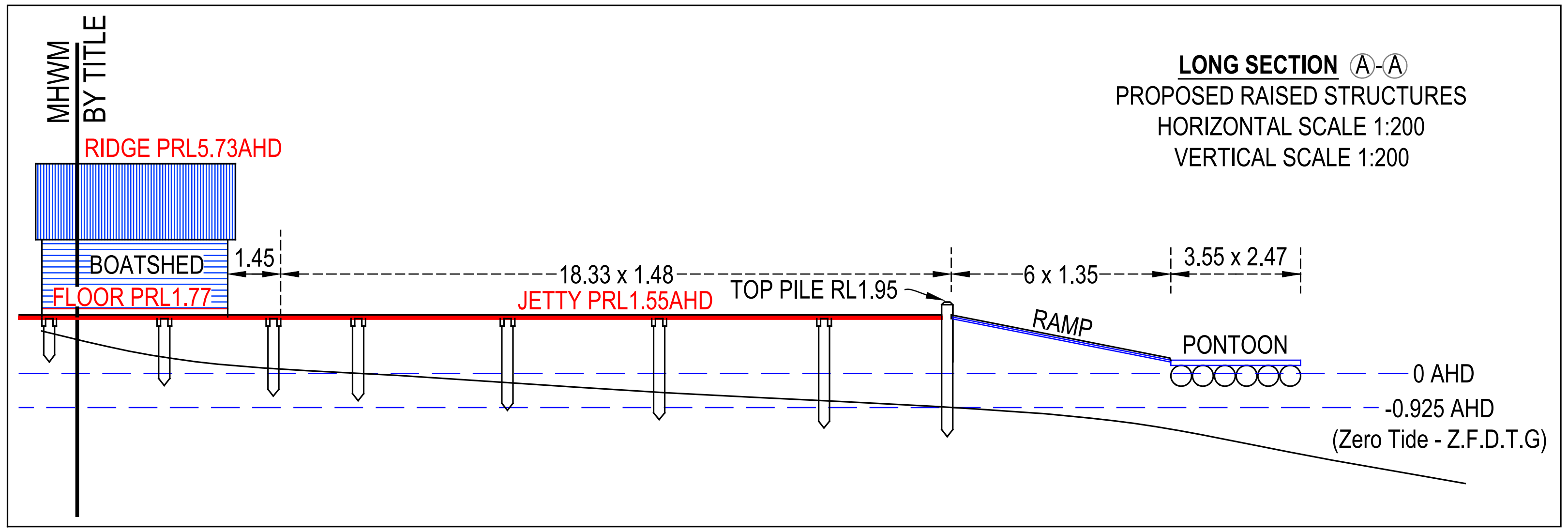
Chartered Professional Status: MIEAust, CPEng, NER (Civil and Environmental Colleges), APEC Engineer, IntPE(Aus)

Membership No. 884280

Appendix B Survey Plans and Design Plans SDG Land Development Solutions, Revision C: January 17, 2018

Schedule of Trees			
No	Diam	Spread	Height
1	0.3	6	10
2	0.3	6	10
3	0.3	6	10
4	0.2	4	6
5	0.1	2	6
6	0.1	2	6
7	0.1	2	6





DRAFT

MICHAEL TRIFIRO
Land Surveyor Registered under
The Surveying and Spatial Information Act 2002

EXISTING AREAS BELOW MHWM	m²
PART BOATSHED	13.7
TIMBER JETTY	42.8
RAMP	8.0
PONTOON	8.8
PART STEPS	0.9
TOTAL	74.2

LEGEND:-

EG	denotes EAVE & GUTTER
MP	denotes MOORING PILE
SP	denotes STABILISING PILE
WT	denotes WATER TANK
ZFDTG	denotes ZERO FORT DENISON TIDE GAUGE (RL -0.925 AHD)
	denotes PROPOSED WORKS
ERL	denotes EXISTING REDUCED LEVEL
PRL	denotes PROPOSED REDUCED LEVEL

GENERAL NOTES:-

1. THIS SURVEY IS NOT A 'LAND SURVEY' AS DEFINED BY THE SURVEYING AND SPATIAL INFORMATION ACT, 2002.
2. THE BOUNDARIES OF THE LAND HAVE BEEN SURVEYED. UNLESS SHOWN BY OFFSETS, THE POSITION OF THE FEATURES SHOWN IS DIAGRAMMATIC ONLY.
3. BOUNDARIES NOT MARKED
4. LEVELS ARE ON AUSTRALIAN HEIGHT DATUM (AHD.)
5. ONLY TREES GREATER THAN 3.5 METRES IN HEIGHT ARE SHOWN ON THIS PLAN AND THEIR POSITIONS AREA DIAGRAMMATIC ONLY AND MAY REQUIRE ADDITIONAL SURVEY WHERE CRITICAL TO DESIGN.
6. CONTOURS ARE INDICATIVE AT GROUND FORM ONLY. SPOT LEVELS ONLY SHOULD BE USED FOR CALCULATIONS OF QUANTITIES WITH CAUTION.
7. THE ORIGIN OF LEVELS COMES FROM SSM14633 RL0.765 CLASS LB ORDER L2 ADOPTED FROM SCIMS ON 13/10/2017 AND CONFIRMED BY TIDAL OBSERVATION DATA FROM NSW OFFICE OF ENVIRONMENT AND HERITAGE.
8. CONTOUR INTERVAL 0.5 m.
9. ALL SETOUT LEVELS MUST BE REFERRED TO THE BENCH MARK.
10. THIS PLAN IS FOR DEVELOPMENT APPLICATION PURPOSES ONLY. FURTHER DETAILED ENGINEERING PLANS MAY BE REQUIRED FOR THE PURPOSE OF OBTAINING A CONSTRUCTION CERTIFICATE.

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ISSUE	DATE	AMENDMENT	SURV/CHK
A	10/10/17	ORIGINAL ISSUE	GS/MT
B	11/01/18	GENERAL AMENDMENTS	GS/MT
C	17/01/18	GENERAL AMENDMENTS	GS/MT

PLAN SHOWING PROPOSED REFURBISHMENT TO EXISTING WATERFRONT STRUCTURES FOR LOT 140 IN DP 12749 BEING No.23 ROBERTSON ROAD, SCOTLAND ISLAND
LGA: NORTHERN BEACHES

CLIENT: **ESTUARY CONSTRUCTION**

ORIGIN OF LEVELS: **SSM 14633 RL 0.765**
DATUM: **A.H.D.**

SCALE: **1:200**
ORIGIN OF COORDINATES: **ASSUMED**
DATUM: **N/A**

REF: **7476_2**
DATE: **17/01/2018**
SURV/CHK: **GS/MT**
SHEET **1** OF **1** SHEETS

PLAN **A3**
ISSUE **C**

SDG LAND DEVELOPMENT SOLUTIONS
A.B.N. 85 213 523 621
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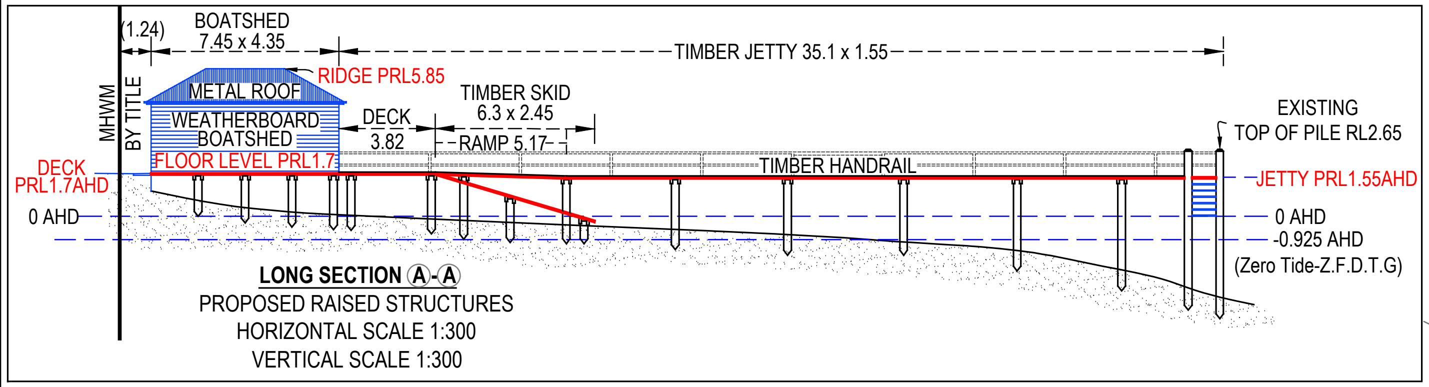
P.O.Box 2572
NORTH PARRAMATTA 1750
t: (02) 9630 7955
e: office@sdg.net.au
w: www.sdg.net.au



EXISTING AREAS BELOW MHWM	m²
RECLAMATION (IN 2 PARTS)	71.1
TIMBER BOATSHED	32.3
TIMBER JETTY (INC. TIMBER DECK)	111.1
RAMP	8.3
PONTOON (EXCL. PT. RAMP)	17.3
JETTY STEPS	3.7
TIMBER SKID	14.8
STONE STEPS (X2)	2.0
STABILISING PILES	SP x 2
MOORING PILES	MP x 1
SPRINGER PILES	x 2
TOTAL	260.6

DRAFT

MICHAEL TRIFIRO
Land Surveyor Registered under
The Surveying and Spatial Information Act 2002

LEGEND:-

- EG denotes EAVE & GUTTER
- MP denotes MOORING PILE
- SP denotes STABILISING PILE
- WT denotes WATER TANK
- ZFDTG denotes ZERO FORT DENISON TIDE GAUGE (RL -0.925 AHD)
- (red) denotes PROPOSED WORKS
- ERL denotes EXISTING REDUCED LEVEL
- PRL denotes PROPOSED REDUCED LEVEL

GENERAL NOTES:-

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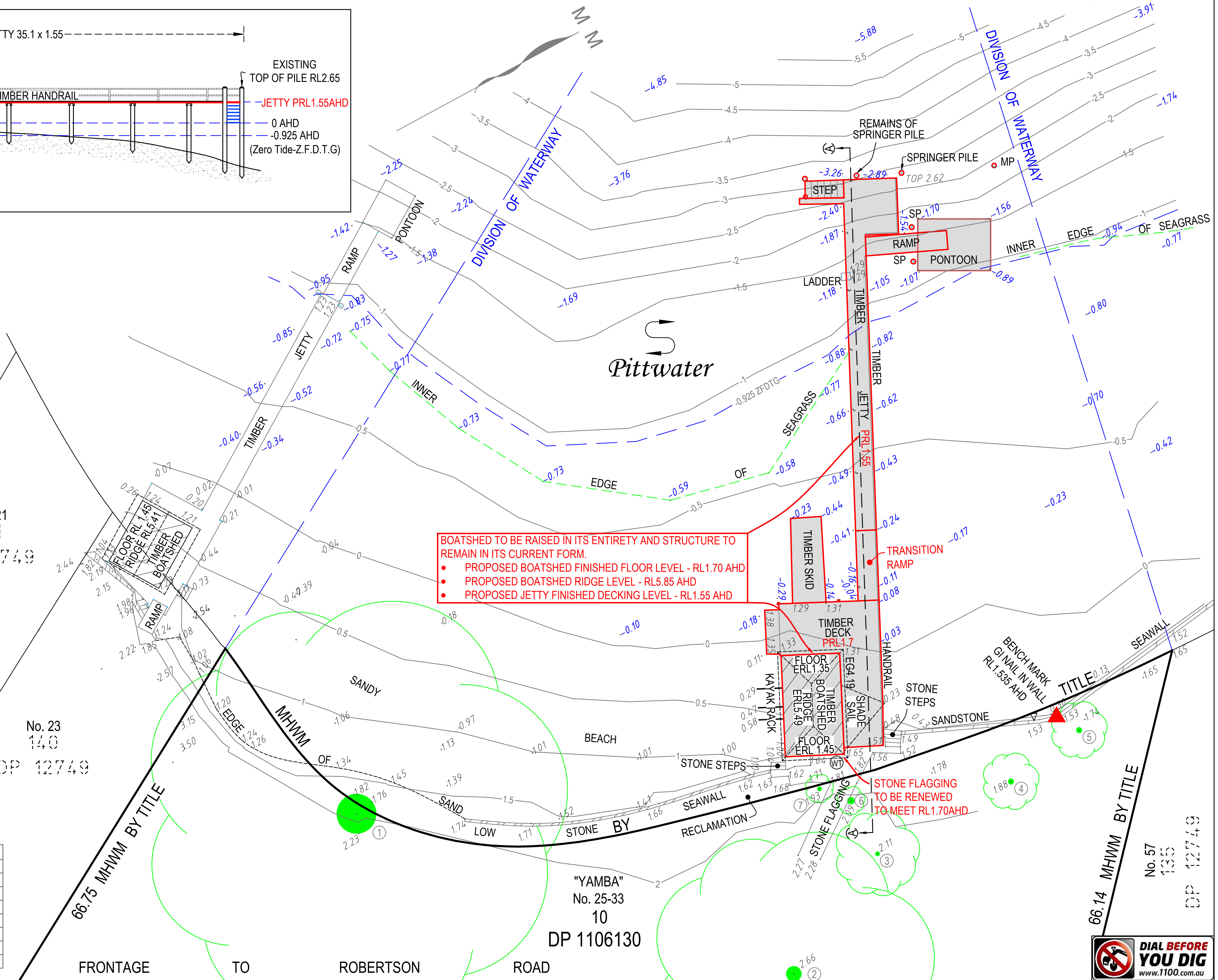
8. CONTOUR INTERVAL 0.5 m.
9. ALL SETOUT LEVELS MUST BE REFERRED TO THE BENCH MARK.
10. THIS PLAN IS FOR DEVELOPMENT APPLICATION PURPOSES ONLY. FURTHER DETAILED ENGINEERING PLANS MAY BE REQUIRED FOR THE PURPOSE OF OBTAINING A CONSTRUCTION CERTIFICATE.

Schedule of Trees

No	Diam	Spread	Height
1	2.0	30	20
2	1.1	20	20
3	0.3	6	10
4	0.4	4	10
5	0.4	4	10
6	0.5	2	16
7	0.3	2	10



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ISSUE	DATE	AMENDMENT	SURV/CHK
A	10/10/17	ORIGINAL ISSUE	GS/MT
B	11/01/18	GENERAL AMENDMENTS	GS/MT
C	17/01/18	GENERAL AMENDMENTS	GS/MT

PLAN SHOWING PROPOSED REFURBISHMENT TO EXISTING WATERFRONT IMPROVEMENTS FOR LOT 10 IN DP 1106130 BEING No.25-33 ROBERTSON ROAD, SCOTLAND ISLAND
LGA: NORTHERN BEACHES

CLIENT: **ESTUARY CONSTRUCTION**

ORIGIN OF LEVELS: **SSM 14633 RL 0.765**
DATUM: **A.H.D.**

SCALE: **1:300**
ORIGIN OF COORDINATES: **ASSUMED**
DATUM: **N/A**

REF: **7476_1**
DATE: **17/01/2018**
SURV/CHK: **GS/MT**
SHEET **1** OF **1** SHEETS

PLAN **A3**
ISSUE **C**

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w: www.sdg.net.au