Christchurch City Council

DIAMOND HARBOUR WHARF FLOATING JETTY
SITE ASSESSMENT REPORT

November 2019
Rev 1

OFFSHORE & COASTAL ENGINEERING LIMITED

New Plymouth
Telephone 0274313966
Email: ocel@clear.net.nz

OCEL House
14 Richardson Tce
PO Box 877
Christchurch 8140
Telephone 03 3790444
Email: mail@ocel.co.nz

1.0 INTRODUCTION

The Christchurch City Council (CCC) engaged Offshore and Coastal Engineering Limited (OCEL) to undertake a study to assess suitable locations for a floating jetty alongside the Diamond Harbour wharf, Lyttelton Harbour, Christchurch.

The floating jetty is to be used primarily as a passenger loading facility for the Diamond Harbour ferry service, and secondarily as short term berths for recreational vessels.

The Diamond Harbour ferry currently loads passengers via the fixed steps at the seaward end of the wharf. The steps, which can be slippery at heights below high tide level, offer little room for passengers to manoeuvre and have proven difficult to access during adverse weather conditions.

The Diamond Harbour wharf was originally constructed in 1880, with additions made in 1915 and 1969. A WSP Opus report, published September 2018, lists recommended maintenance repairs and lifecycles for the wharf. It is assumed for the purpose of this report that the wharf will continue to be maintained to an operational standard.

2.0 EXECUTIVE SUMMARY

While the location of the Diamond Harbour wharf is sited in a relatively sheltered area it is still subject to both short period locally generated waves approaching from a west–northwest direction, and long period easterly open sea swells which diffract around Stoddart Point.

Various locations adjacent to the wharf were considered during this assessment however the single location shown on OCEL drawing DR-190802-004 has been favoured as the most sheltered, and has the potential for further protection to be added by means of a wave protection wall constructed under the wharf using the existing wharf piles as supporting elements. The opportunity to add a wave protection wall would allow the ferry to have more protection than it currently has at the existing wharf if desired, and to safeguard against the predicted future increase in storm frequency and intensity associated with climate change.

The orientation of the pontoon is aligned to be head on to northwesterly waves and waves which diffract around Stoddart Point, and is similar to the alignment of the pile moorings within the bay. Should the pontoon become dynamic during short lived adverse weather events, the handrail placed alongside the gangway will assist passengers to the gangway.

The location chosen requires the gangway to be placed where the existing derrick/crane is situated. It is known that the derrick is frequently used as a swing for users jumping off the wharf and has high value to the community in regard to both its historic and recreational importance. We suggest relocating the derrick to the northwest side of the wharf so users are kept away from the vessel movement area, this location also allows the use of the steps on the north side of the triangular head for users to gain access back onto the wharf.

3.0 SITE INVESTIGATIONS

An engineering dive team were on site 16 November 2019 to undertake a survey of possible sites for the floating jetty to assess acceptable water depth, pile driveability, and the suitability of the existing wharf to provide support and access to the floating jetty.

Results of these observations are shown on OCEL drawings DR-190802-001 + 002.

Bathymetry of the area around the wharf was obtained during calm conditions with no appreciable swell at the site. Depth readings were made using a single beam echo sounder, with corrections for transducer and sound velocity made by means of a bar check (a flat plate is lowered below the transducer to several known depths below the surface and the actual depth versus measured depth is compared). Depth readings were then corrected for tidal variations and reduced to chart datum by subtracting the measured depths from water level readings obtained from the Lyttelton Port of Christchurch tide gauge. Locations of the depth readings were collected using a differentially corrected GPS.

A 3 m long water jet lance was used to probe the seabed in order to detect any rock obstructions, and to help identify subsoil strata. The depth to which the lance can penetrate is generally limited to the length of the lance, however at several sites additional penetration was achieved by pushing the water hose attached to the lance below the seabed. No obstructions were found. The probing identified a soft layer, consistent with marine silts, up to 2m depth, underlain by a firmer strata which felt like medium dense sand. Shear vane readings were taken within the marine silts strata at 1 m depth, with readings ranging between 41 – 73 kPa, and 10 – 29 kPa remoulded.

Diver observations of the seabed found it to be reasonably featureless other than some isolated rocks to the north west of the wharf near Stoddart Point, and further isolated rocks along the shoreline. The locations of these are apparent on the aerial photographs of the site due to seaweed growth on the rocks. The seabed surface consisted of soft marine silt with shells.

A brief inspection of the wharf found it to be in the same condition as the recent 2018 WSP Opus report, and suitable for supporting the proposed gangway loads.

4.0 WAVE ENERGY ENVIRONMENT

The wave climate both within and outside the Lyttelton Heads is relatively benign – compared to elsewhere on the New Zealand coastline – both in terms of the height of the wave experienced offshore and the frequency of occurrence of big sea conditions. It has no exposure to the waves generated by the prevailing westerly winds over essentially unlimited fetch lengths to the south west of New Zealand. While there is not the same long period swell background on the east coast as on the west coast depressions off the east coast can create severe weather and seastate events. Such events however are infrequent.

Waves within Pegasus Bay generally fall into two categories, locally derived wind generated waves (typically 3 to 5 seconds period) and swell waves (typically 8 to 20 seconds period) from more distant storms in the southern ocean which refract around Banks Peninsula. The wave directions exhibit seasonal variations with north-east waves prevailing in summer and south-east waves predominating in winter. Longer calm weather windows are generally available in the summer period when extreme weather events are less likely, however, periods of complete calm occur in early to mid winter.

Lyttelton Harbour being relatively long and narrow effectively acts as a wave direction filter and only waves aligned with the harbour axis can pass up the harbour. In reality this is not much of a restriction on wave energy as long period swell waves from the south/southeast can refract around Banks Peninsula to run straight up the harbour. Only waves from the north/north northeast are filtered out by the harbour axis alignment and break on the southern shore of the harbour.

Wave probability, height exceedance and directional data are given in Table No 1 below for a site outside the Heads in 16 m water depth. For the highest 1% of waves, significant wave heights exceeding 2.16 m > 95% come from the north east and east north east.

	Wave Height Exceeding m			
Direction	**>0.76**	**>1.65**	**>2.16**	**>2.86**
N	4.6	0.1	0.0	0.0
NNE	10.3	5.2	1.2	0.0
NE	19.5	32.6	46.9	60.0
ENE	38.6	51.0	48.6	34.4
E	10.8	9.2	3.2	5.6
ESE	1.6	0.6	0.0	0.0
SE	0.9	0.3	0.0	0.0
SSE	0.6	0.2	0.0	0.0
S	0.8	0.2	0.0	0.0
SSW	1.4	0.3	0.0	0.0
SW	2.2	0.1	0.0	0.0
WSW	2.2	0.1	0.0	0.0
W	1.0	0.0	0.0	0.0
WNW	0.9	0.0	0.0	0.0
NW	1.5	0.0	0.0	0.0
NNW	3.0	0.0	0.0	0.0
% of time	50.0	5.0	1.0	0.1

Table No 1

The wave data was generated by using the National (USA) Oceanic and Atmospheric Administration (NOAA) NWW3 (NOAA Wave Watch 3) global wave model to derive, hindcast, wave parameters – significant wave height H_s, peak period T_p and direction for a deep water site offshore Banks Peninsula. A wave refraction analysis using the Simulating Waves Nearshore (SWAN) wave model was run to transfer the wave data inshore to the site at the start of the proposed navigation channel.

Although monochromatic – uniform wave period – swell wave conditions can be experienced in the harbour the typical sea comprises a spectrum of waves of different heights, wave periods and directions. The seastate can be characterised by the significant wave height H_s, and the zero upcrossing period T_z where $T_z \approx 0.71.T_p$,. the peak wave energy period.

The distribution by period (%) of waves that exceed various significant wave height for the site in 16 m water depth outside the Heads are given in Table No 2 below. For the NE/ENE waves higher than 2.16 m approximately 30% have periods greater than 10 seconds.

	Wave Height Exceeding m			
Peak Period s	**>0.76**	**>1.65**	**>2.16**	**>2.86**
<=7.4	64.2	30.2	36.0	14.40
8.3	7.4	12.4	22.9	38.9
9.4	9.7	8.1	10.6	24.4
10.6	10.2	15.3	7.9	10.0
12.0	6.0	23.6	10.8	12.2
13.6	1.9	10.0	11.8	0.0
15.3	0.5	0.4	0.0	0.0
>=17.3	0.1	0.0	0.0	0.0
% of time	50.0	5.0	1.0	0.1

Table No 2

Distribution by period (%)of waves that exceed various heights,
for node ltc1 at the entrance to the harbour

The height of swell waves passing up the harbour decreases primarily as a result of bottom friction and diffraction effects. Figure Nos 1 and 2 show the decrease in swell wave height with distance from the harbour entrance. At Stoddart Point the eastern headland at the entrance to Diamond Harbour, 6 km from the harbour entrance, the maximum swell wave height has decreased by 73%. The wavelength for a 12 second period swell wave off Stoddart Point is close to 100 m, the wave steepness expressed in terms of wave height over wave length is low and the principal effect is a surging action, forward under the wave crest back under the wave trough. The long period wave diffracts efficiently into the wave shadow behind Stoddart Point and as long as the ferry berth is orientated to face into the diffracted wave the effect on the ferry berthed alongside the floating berth is tolerable provided the mooring lines are tight. Diffraction is the process whereby wave energy radiates into the wave shadow behind a headland or breakwater. Figure no.3 shows a comparison of wave diffraction diagrams for long period (12 sec) and short (3.5 sec) period waves centred on Stoddart Point. The wave height decreases much faster - as indicated by coefficient K' the ratio of the wave height at the location considered to the incident wave height - with radial distance from the Point for the short period waves – 19 m wave length - than for the swell waves. Hence the interest in locating the ferry pontoon further away from the Point than the existing wharf. Steep short period waves generated by the predominant NE wind are far more common than swell waves. Stoddart Point provides good protection from short period waves passing up the harbour. For locations in excess of 4 wavelengths (76 m) from the Point the wave height is 11% of the short period wave height at the Point.

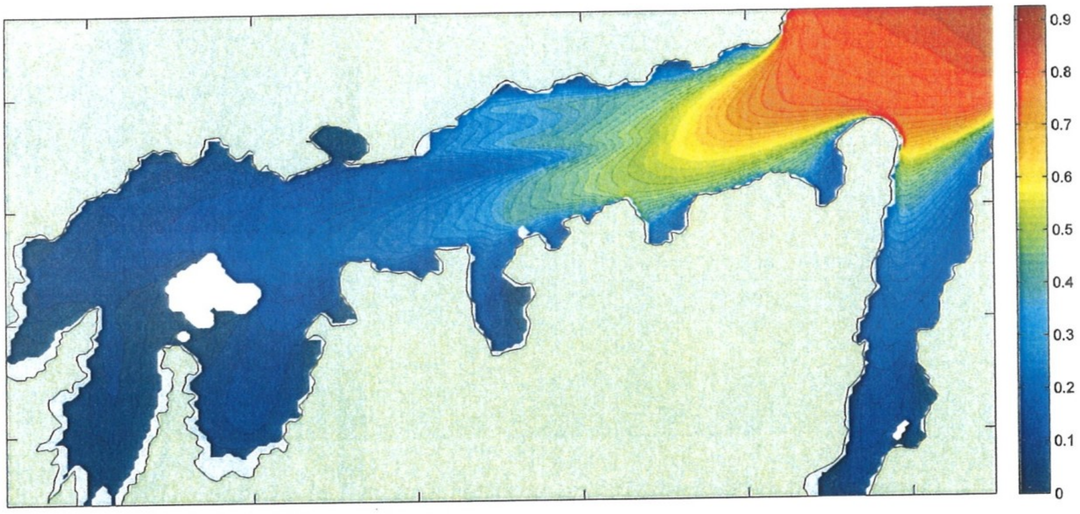


Figure No 1

Short period waves generated on the cross harbour fetch to the North/NorthWest of the existing jetty run straight into the Bay, there is no protection however the ferry can be moored pointing into the sea and wind which helps mitigate the vessel movement alongside. If the ferry pontoon is located in the lee of the existing wharf and a wave fence is installed under the wharf the ferry will have more protection than it currently has at the existing wharf.

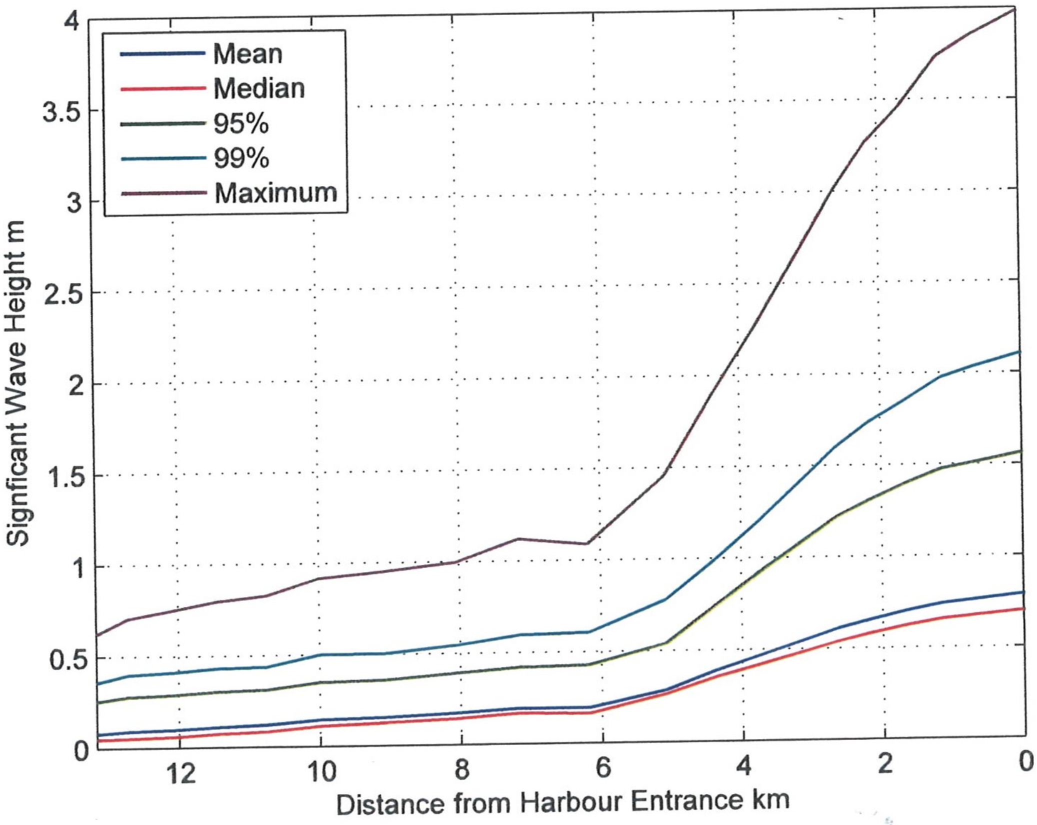
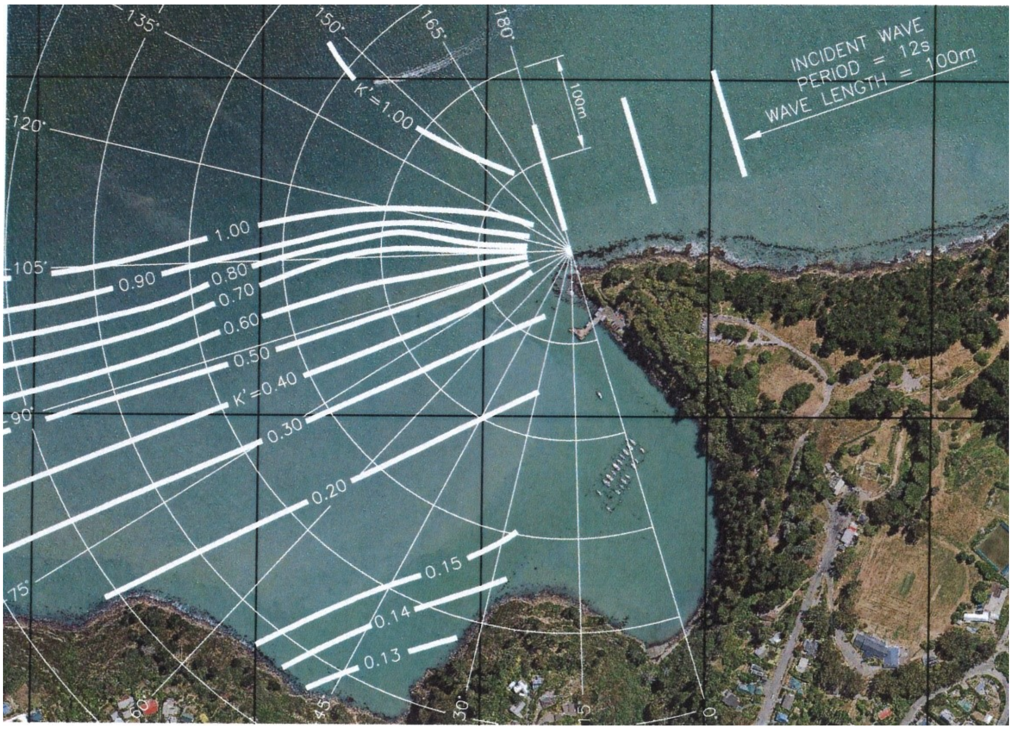
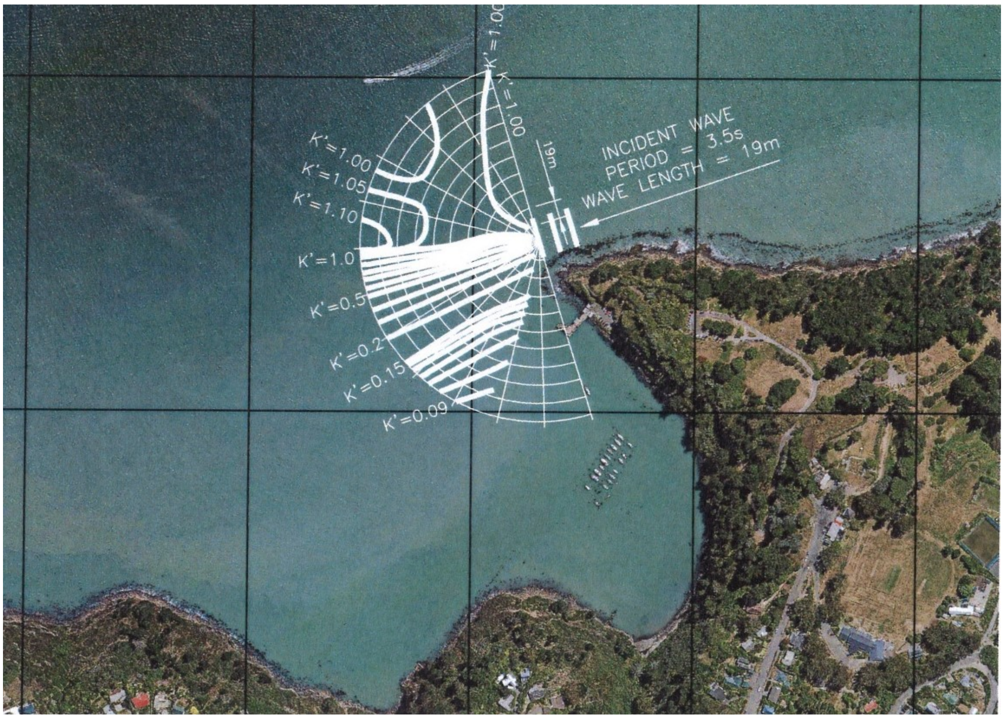


Figure No 2



Period = 12 seconds, wave length = 100 m



Period = 3.5 seconds, wave length = 19 m

Figure No 3

Aerial photograph showing the diffraction of short period easterly waves around Stoddart Point

5.0 PONTOON LOCATION AND SIZE

The pontoon has been located on the site shown to maximise the natural protection offered by Stoddart Point. The existing wharf structure is reasonably transparent to waves i.e. it does not offer much wave protection, however if desired a wave protection wall can be installed under the wharf using the wharf piles for support. Having the possibility to construct a wave protection wall would allow the ferry to have more protection than it currently has at the existing wharf, and safeguard against the predicted future increase in storm frequency and intensity associated with climate change. The location of the pontoon will still allow the use of the existing dinghy ramp on the south side of the wharf, having sufficient room for the dinghies to pass on the landward side of the pontoon. At mid through to low tide there will be sufficient height clearance for dinghies to pass under the gangway.

The pontoon is orientated in a north west to south east direction (approximately parallel to shore) so that it is aligned head on to northwesterly waves and waves that have diffracted around Stoddard Point. This matches the orientation of the existing pile moorings located within the bay.

The 15 m x 4 m pontoon shown on the attached drawings is suited to the current vessels in the Diamond Harbour ferry fleet, being the Black Diamond, a 12 m long x 4 m beam catamaran which was launched in 2001, and the Fiordlander 1, a 15.85 m long x 4.1 m beam Fiordland class vessel launched in 1963. We are aware that at the time of writing the ferry operator, Black Cat Cruises, are proposing to replace these vessels with a new electric ferry. The 15 m pontoon also allows for the berthing of up to two recreational boats on the landward side of the pontoon.

6.0 MATERIAL OPTIONS

The pontoon can be constructed from either coated steel or reinforced concrete. From our involvement in recent floating jetty projects, involving pontoons constructed from both materials, we have found concrete pontoons offer cheaper construction costs and less maintenance.

Reinforced concrete pontoons require a specialist supplier. There are none situated locally, and only one situated within the South Island, with several others based in the North Island. For larger projects of multiple units concrete forms are typically shipped to site to enable local fabrication, however the pontoon size shown can be constructed as a single concrete pontoon unit and is transportable, allowing for off-site production. The pontoons are typically an exterior shell of reinforced concrete with a polystyrene or closed cell polyurethane filled core, and typically have a freeboard (the height of the deck above water) range of 0.5 – 0.65 m. Concrete pontoons offer a durability in excess of 50 years, and require little maintenance other than the cleaning of marine fouling. Anti-fouling paint coatings can be applied prior to installation to defer the time to first cleaning. A concrete pontoon will be considerably heavier than its steel counterpart, and hence less dynamic than a steel version under adverse weather conditions.

Steel pontoons can be constructed by most engineering fabricators. They offer greater versatility for the inclusion of custom features ie timber or FRP decking, and allow specific freeboard heights to be achieved. Protection from corrosion is achieved through a combination of paint coatings and anodes. There are a variety of coatings available, ranging from high build epoxies to hot metal sprayed aluminium, all offering various degrees of cost, durability in terms of times to first maintenance and impact resistance, and ease of repair. The minimum coating design life should be 20 years. Recoating of the pontoon paint system requires it to be removed from the water, which would be most likely be achieved by towing it to the Lyttelton dry dock.

Similar to the pontoons, the piles can be either precast concrete or coated steel. The piles require a braced connection to the top between pairs at each end, which is easiest achieved using steel. Corrosion protection for the steel piles is as mentioned above for the pontoons, with the exception that coatings cannot be applied to the interior surface of the pile, and any recoating to the exterior surface must be done insitu. Protection to the interior of the pile is typically achieved by filling the pile with concrete. Alternatively the top of the pile can be capped (sealed) to limit the amount of oxygen available within the pile, galvanic corrosion will initially begin then cease once the oxygen content has been depleted. Note that anodes will only provide protection to areas below the water line. The weight of a concrete pile is significantly heavier than its steel counterpart and hence requires larger installation plant (crane and barge), increasing the installation cost. The cost advantage of concrete piles is typically only realised when large numbers are installed. It is becoming common practice to sleeve piles with surfaces that allow easy cleaning and inhibit marine growth, as a deterrence to the establishment of invasive marine species. This is easiest achieved by installing PE pipes over the piles and filling the annulus between the pile and PE pipe sleeve with sand or grout. The placing of an outer sleeve has the added advantage of protecting the pile coating system from impact damage.

The heavy duty pile guides will be required to be fabricated from coated steel.

The gangway is required to have a minimum length of 15m, this results in a slope of 1V:4.5H at mean low water springs (MLWS) tide. The maximum slope, which would occur should the water level drop to 0.0m chart datum, is 1V:3.7H, which is within the maximum slope of 1V:3.5H required by AS 3962 – Guidelines for Design of Marinas. These slopes are similar to those at the Lyttelton ferry terminal floating jetty and the Akaroa wharf floating jetties. While the minimum width requirement for the gangway is 0.9m, we recommend a width of 1.2m for this situation due to the high passenger numbers. This matches the width of the gangways at the Akaroa wharf floating jetties. The gangway can be constructed from either coated steel or aluminium. While aluminium has a higher fabrication cost, its longer durability, negligible maintenance costs, and cheaper installation cost make it the favoured material for gangways.

7.0 ESTIMATED COSTS

The costs below are based on recent projects constructed within the South Island.

15 m x 4 m Concrete Pontoon –	$135k
15 m x 4 m steel pontoon (epoxy coatings) –	$190k
4 x 600 NB x 15m steel piles including installation –	$96k
4 x DN 710 SDR 21 PN8 PE100 x 10 m pile sleeves -	$20k
1 x 15 m aluminium gangway + installation –	$58k
Engineering design –	$18.6k
Building consent (note consent exemption may be possible) -	$6 k
Contingency 10%	
Total cost concrete pontoon –	$367k
Total cost steel pontoon –	$427k

Note all costs exclude GST and do not include any costings for the wave protection wall.

8.0 CONSULTATION FOR DETAILED DESIGN

The ferry service and wharf provide important transportation links and access to the sea for the local community. It is our expectation that the CCC will conduct involved consultation with the local community with comments made available for consideration into the detailed design. The ferry operator, Black Cat Cruises, have not been approached during this site assessment. It will be necessary to consult with the ferry operator during the detailed design phase to ensure the design meets their operational needs and will continue to do so in the future, with particular regard to their requirements and preferences for fendering, mooring attachments and freeboard. There are various options available for the form of the floating jetty all with varied capital expenditure, maintenance costs and performance characteristics. Close consultation with the CCC is required to ensure that the end solution meets their expectations.

NOTE:

1. AERIAL PHOTOGRAPHY SOURCED FROM LINZ DATA SERVICE AND LICENSED FOR RE-USE UNDER THE CREATIVE COMMONS ATTRIBUTION 4.0 INTERNATIONAL LICENCE.
2. BATHYMETRY OBTAINED FROM BOAT ECHO SOUNDER RUNS REDUCED TO CHART DATUM USING LPC TIDE GAUGE READINGS
3. ALL DEPTHS SHOWN ARE METRES BELOW CHART DATUM
   MAJOR CONTOUR INTERVAL 1.0m
   MINOR CONTOUR INTERVAL 0.25m
   MHWS = +2.60m CD
   MLWS = +0.26m CD

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OCEL
OFFSHORE AND COASTAL ENGINEERING LIMITED

14 Richardson Terrace
PO Box 877
Christchurch
Tel (03) 3790444
Fax (03) 3790333

49 Crown Hill Street
PO Box 151
New Plymouth
Tel (067) 512310
Fax (067) 512310

CHRISTCHURCH CITY COUNCIL

DIAMOND HARBOUR WHARF FLOATING JETTY

SITE BATHYMETRY

Scale (A3)	ACAD Filename
1:500	190802/DR-190802-001R1
Drawing No.	Rev.
DR-190802-001	1

SITE INVESTIGATION RESULTS

LOCATION	NZTM NZGD2000 COORDS mE	NZTM NZGD2000 COORDS mN	REMARKS
1	1578724.4	5169924.7	WATER JET PROBE TO 3.5m DEPTH UNOBSTRUCTED. 0–2m SOFT MARINE SEDIMENTS (FELT LIKE SILTS) 2–3.5m FIRMER (FELT LIKE MEDIUM DENSE SAND) SHEAR VANE AT 1m DEPTH: 41 kPa 10 kPa REMOULDED
2	1578739.9	5169912.7	WATER JET PROBE TO 4.5m DEPTH UNOBSTRUCTED. 0–2m SOFT MARINE SEDIMENTS (FELT LIKE SILTS) 2–4.5m FIRMER (FELT LIKE MEDIUM DENSE SAND) SHEAR VANE AT 1m DEPTH: 53 kPa 26 kPa REMOULDED
3	1578753.6	5169915.4	WATER JET PROBE TO 4.0m DEPTH UNOBSTRUCTED. 0–2m SOFT MARINE SEDIMENTS (FELT LIKE SILTS) 2–4m FIRMER (FELT LIKE MEDIUM DENSE SAND) SHEAR VANE AT 1m DEPTH: 50 kPa 29 kPa REMOULDED
4	1578760.5	5169923.2	WATER JET PROBE TO 3.0m DEPTH UNOBSTRUCTED. 0–2m SOFT MARINE SEDIMENTS (FELT LIKE SILTS) 2–3.0m FIRMER (FELT LIKE MEDIUM DENSE SAND) SHEAR VANE AT 1m DEPTH: 73 kPa 23 kPa REMOULDED

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Fax (067) 512310

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SITE INVESTIGATION RESULTS

Scale (A3)	ACAD Filename
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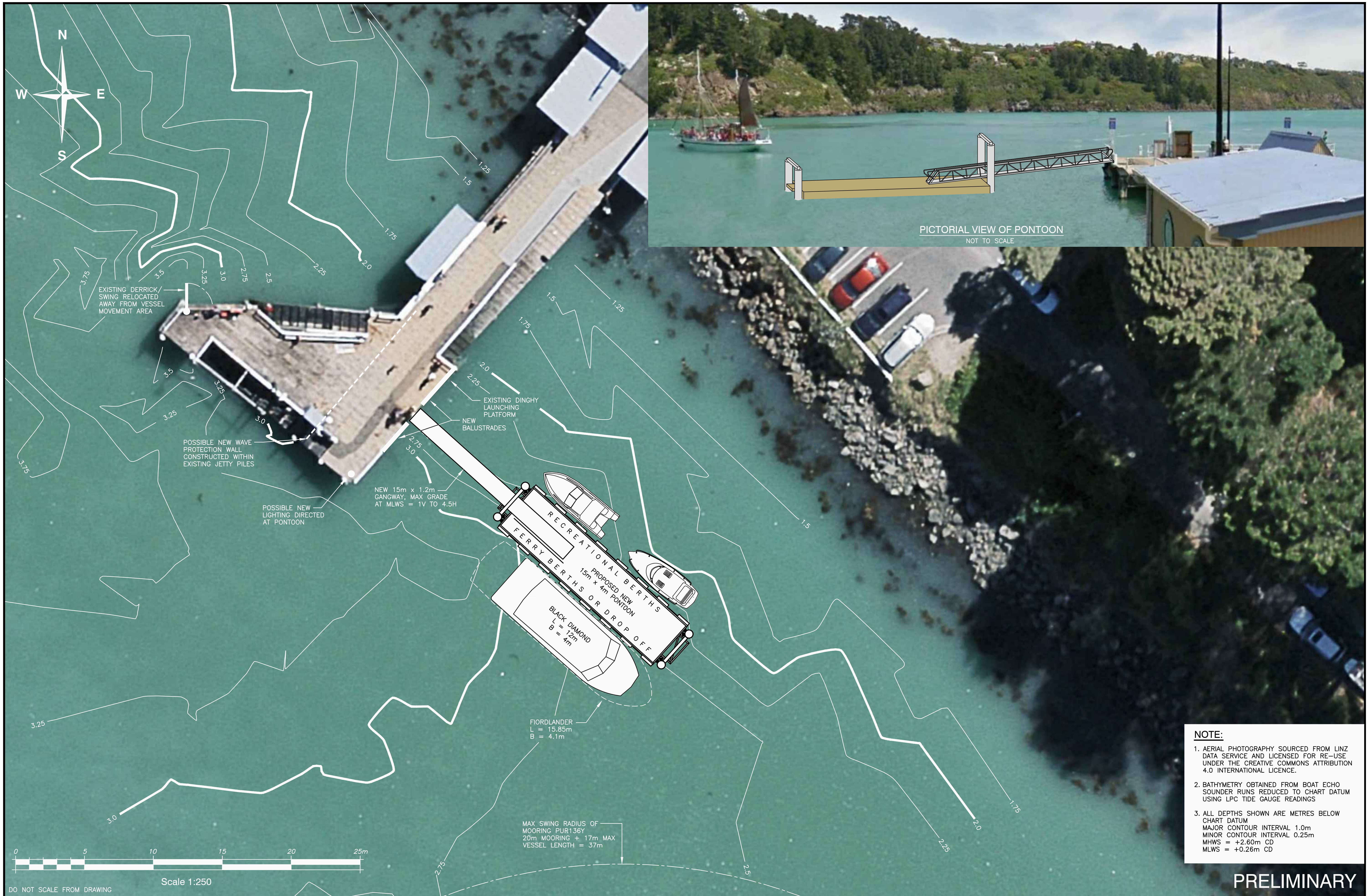
Drawing No.	Rev.
DR-190802-002	1



PICTORIAL VIEW OF PONTOON

NOT TO SCALE

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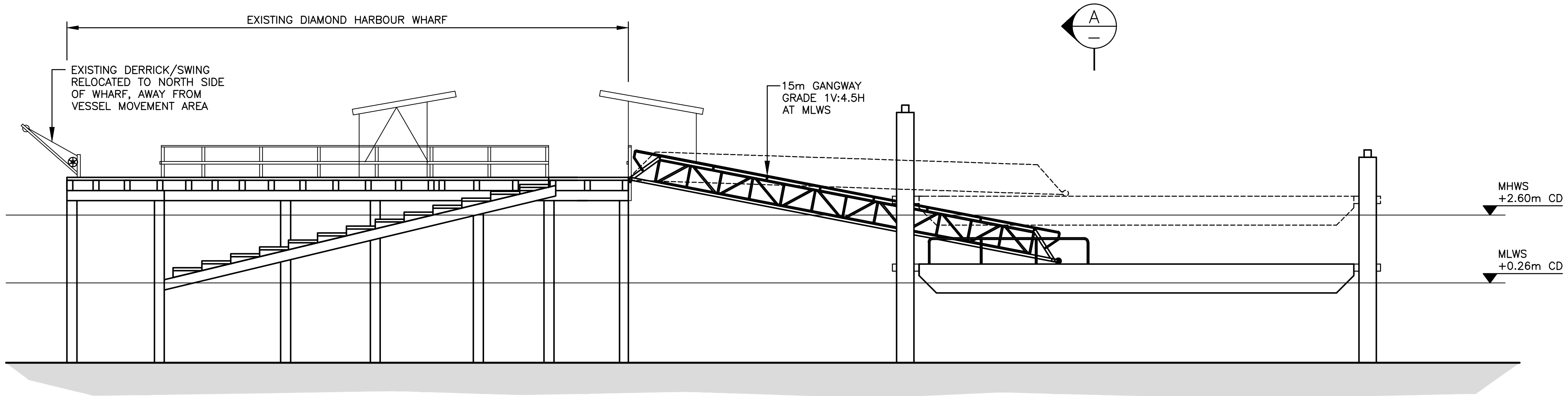
PLAN OF PROPOSED PONTOON

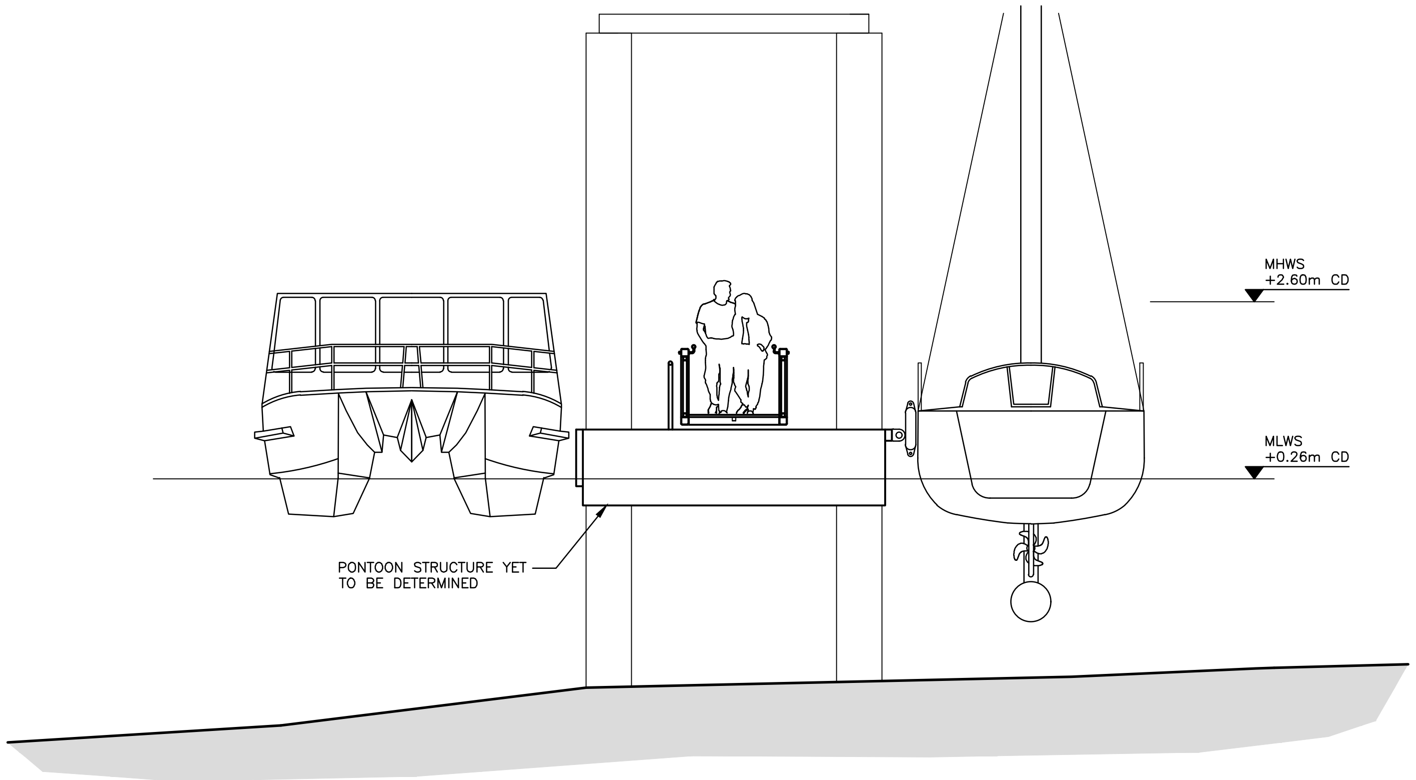
Scale (A3)	ACAD Filename
1:250	190802/DR-190802-004R1
Drawing No.	Rev.
DR-190802-004	1



A

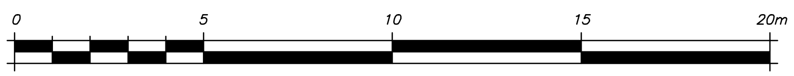
SIDE ELEVATION OF PONTOON

Scale 1:200



SECTION A

Scale 1:100



Scale 1:200

Scale 1:100

DO NOT SCALE FROM DRAWING

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CHRISTCHURCH CITY COUNCIL

DIAMOND HARBOUR WHARF FLOATING JETTY

ELEVATIONS OF PROPOSED PONTOON

Scale (A3)	ACAD Filename
1:100, 200	190802/DR-190802-005R1
Drawing No.	Rev.
DR-190802-005	1