# Waitangi Wharf and Port Upgrade – Providing a critical lifeline at the edge of New Zealand

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# Waitangi Wharf and Port Upgrade – Providing a critical lifeline at the edge of New Zealand

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**Abstract**
One of our most remote communities, the Chatham Islands, sits 800km off New Zealand's east coast and is home to 600 people. The islands are serviced by a port which provides a lifeline for the community through the provision of every-day goods and export earnings. The port is at the end of its structural life and significant upgrades are necessary. The Waitangi Wharf Upgrade, a project of some $58 million, involves reclamation, dredging and the construction of a large breakwater. The NZ Dept. of Internal Affairs requested that the Memorial Park Alliance comprising NZTA, HEB, Downer, Tonkin + Taylor and AECOM deliver upgrade works.

The project progressed from concept design, through consenting and detailed design within 12 months; an extremely tight timeframe for a project of this scale and complexity. Extensive community engagement was undertaken throughout the process including requirements at the port and surrounding areas, existing coastal processes and likely effects of the development and options for social and environmental improvements. This built trust and established relationships, very important factors for a project this size impacting on a very small community (i.e. the construction team increased the total island population by 6%).

This paper presents an overview of the project, and the unique challenges and lessons learned by working in such a remote environment, including:

- The relative importance of the project to its community reframed port activities by highlighting the critical importance of port infrastructure  We consider that there is a huge, albeit complex, opportunity for the industry to more strongly connect communities to their ports for the benefit of the industry;
- How we must be sensitive to the communities in which we work, and strive to build strong relationships for everyone's benefit – particularly so with remote projects; and
- That physical model testing can add significant value in fine tuning a design, and providing confidence in the end solution.

*Keywords: remote construction, port, breakwater, xbloc, collaboration.*

## 1. Introduction

The Waitangi Wharf and Port Upgrade, a project of some NZ$58 million, involves reclamation, dredging and the construction of a large breakwater in one of New Zealand's, most remote communities. The extreme remoteness of the project, and its relative impact to the small community, highlighted some of the typical challenges and opportunities coastal practitioners face.  This paper presents some of the key lessons learned and opportunities highlighted by the project.

## 2. The Chatham Islands and Waitangi Wharf

The Chatham Islands, located 800km east of Wellington, are an archipelago of 11 islands rich with seafood) aquatic animals and birdlife –.

The islands are New Zealand's easternmost community, with some 600 residents inhabiting Chatham and Pitt Islands. The remainder of the Chathams form one of New Zealand's most remote and valued conservation reserves.

The Chatham Islands are located within the Chatham Rise, a relatively shallow geological plateau, surrounded by much deeper trenches. The Chatham Rise is New Zealand's most productive fishing ground.

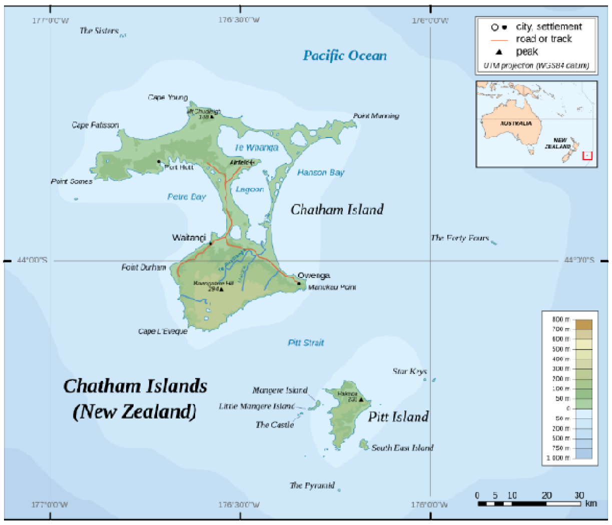


Figure 1 – Location of the Chatham Islands.

The Chatham Islands are economically and strategically important to New Zealand. They contribute around $46 million per annum to GDP, primarily through fishing, agriculture and tourism (Chatham Islands Council, 2015), as well as contributing to size of New Zealand's Exclusive Economic Zone (EEZ).

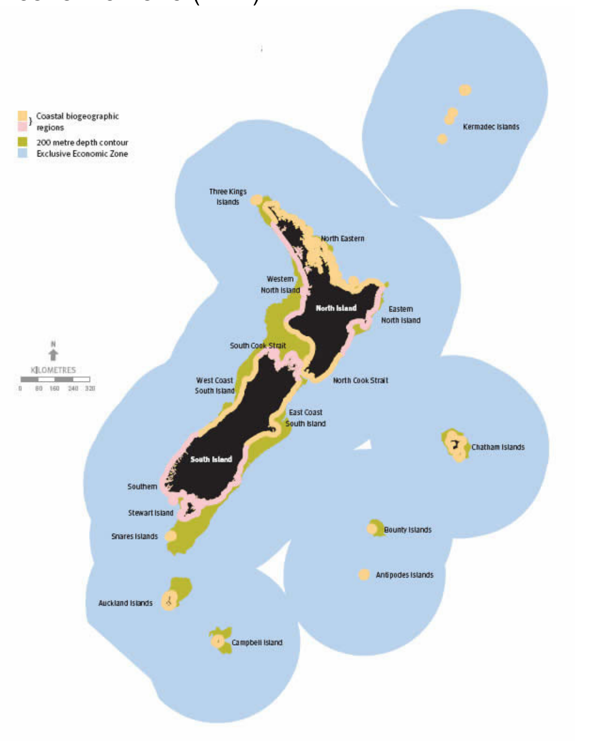


Figure 2 – New Zealand's Exclusive Economic Zone, illustrating the strategic importance of the Chatham Islands to NZ

The mainstay of the island's economy has always been centred on the natural resources of the sea, from historic practises such as whaling and sealing through to its present fishing activities that support the ongoing sustainability and economic viability of the island. The area within a 200 nautical mile radius of the Chatham Islands constitutes 10% of New Zealand's EEZ, with 6.3% of New Zealand's total fish catch being caught in this area.

The islands are serviced by one main port, located in Waitangi Bay. Waitangi Wharf is a critical lifeline – the only cargo-handling facility for exports and essential supplies, such as diesel for the electricity grid and fuel for air services. The existing wharf, and associated port is inefficient, and at times, unsafe.

The existing wharf and port layout consist of a T-shaped wharf leading from a restricted cargo handling area. Cargo handling operations are inefficient.

Of greater influence however, is the fact that the wharf is exposed to the large south-westerly swells from the South Pacific. Analysis undertaken as part of the project has shown that the wave motion at the existing wharf exceeds PIANC guidelines for safe operation approximately 50% of the time.

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Figure 3 – The existing wharf at Waitangi showing the T-shaped wharf and small operational area.

## 2.1 Environmental conditions

The Chatham Islands are located at 44°S and exposed to consistent westerly winds and waves produced by the 'roaring 40s' weather systems. Waitangi Wharf is located in the southern corner of Petre Bay and in the lee of a rocky headland; Tikitiki Hill. This provides substantial protection from the predominant westerly swells as well as waves arising from strong northwest to northeast winds which are fetch-limited within the bay. Extreme wave height (100 year ARI; swell or local sea) were hindcast (Metocean, 2015) at less than 2.2 m, however period is long (>14s) and persistent background swell occurs year round. Tidal range is small (<1m) and, below the rock shelf that lines the coastline, the sandy seabed is relatively flat.

## 3. The Waitangi Wharf Upgrade Project

With repairs required, safety concerns and inefficient operations for the existing wharf, The NZ Department of Internal Affairs (DIA) commissioned an upgrade of the wharf, on behalf of the Chatham Island Council and Chatham Islands Enterprise Trust.

DIA requested that the Memorial Park Alliance – an existing partnership comprising The New Zealand Transport Agency, construction firms HEB and Downer, and consultants, Tonkin + Taylor and AECOM – deliver the $58 million worth of urgent upgrade works.

The resulting Waitangi Wharf Upgrade Project seeks to improve the safety, reliability and efficiency of wharf operations. And to future-proof the wharf for the community's expanding export and production requirements, while improving animal welfare for exported livestock.

The key elements of the project include:

- Reclamation of 9,500m$^2$ of land for a new por;t
- Construction of new commercial and fishing wharves, 90m and 40m respectively;
- A 180m long breakwater;
- Dredging of the approach and berthing area;
- Establishment of two quarries to provide aggregate for reclamation fill and breakwater armour; and
- Establishment of a concrete batching plant and construction yard to produce the three thousand concrete armour units required to withstand the local wave climate.


Figure 4 – Layout of the proposed Waitangi Wharf. Showing the key features relative to the existing situation. Note to reviewer – better quality image with readable text will be sourced.

## 4. The projects important context

Some of the lessons learned came about as a result of the unique Chatham Islands context which is important to understand. That particular context was;

### 4.1 A small and tight knit community

The island population is just 600 people. And they are very parochial, with most resident's generational islanders.

The project was going to result in a temporary workforce meaning a 6% increase in the islands population. We had to be very conscious of the potential impact this would have on the small, tight knit community.

### 4.2 A community where everyone has a direct relationship with the port

Individual's reliance on the port, and relationship with it, is so much more direct on the Chathams than in mainland New Zealand.

Almost every family on the island is involved in farming or fishing, often both. Their livelihood relies on the individual farmer or fishermen arranging their own shipping off the island direct with the shipping companies.

As consumers, the relationship with the port is so much more direct. If a Chatham Islander needs to purchase a new fridge – they cannot go to the shops. They must buy one from 'New Zealand' (as locals refer to the mainland) and arrange for it to be shipped to the island, where they will pick it up from the port themselves.

Such is their reliance on the port (and the unreliability of shipping) that locals talk about the shipping schedule like most farming communities talk about the weather.

### 4.3 A remote location with limited infrastructure

Constructing such a large project, on an island with limited infrastructure presents many challenges. Such as;

- No suitable quarry for the 100,000 cu.m of aggregates required;
- No rock large enough for breakwater armour;
- No concrete plant to construct armour units;
- No water supply to make concrete (the town supply was already under capacity);
- Very limited, and only small, construction plant on the island;
- A diesel supply chain set up to support the local community, and not the large amount of heavy machinery that would be needed to construct the works;
- Limited accommodation for the 40 strong workforce;

We were required to effectively engineer the project from first principals. This necessitated close collaboration between the client, design and construction teams, the local community and local businesses.

## 5. Breakwater design

As part of the Waitangi Wharf upgrade, a breakwater was deemed necessary to:

- Provide protection to the reclamation against wave erosion;
- Provide protection to the reclamation against wave overtopping and inundation;
- Reduce the wave climate in the lee of the breakwater to decrease the number of days where berthing is not possible at the wharf.

### 5.1 Breakwater planform

Ship operators suggest that with the typical 12-14s period swells, they are currently able to berth in swell wave conditions less than 0.5 m, berthing becomes marginal in waves of 0.5 - 0.75m and they are not able to berth in wave heights larger than 0.75m. However, mooring lines are reported frequently broken indicating berthing safe conditions are being frequently exceeded.

The new breakwater and wharf configuration will, however, induce waves to approach the moored vessels from the quarter (45°) to beam (90°) rather than head on (0°) as presently occurs. Vessels are less stable with waves approaching from this angle [5] and so require a lower wave climate to achieve the same level of service. Additionally, the proposed berth is a vertical quay wall which will reflect incident waves further reducing the tolerable wave condition under which berthing and working is safe compared to the existing open piled structure. These changes must be taken into account along with the reduced wave height in determining any change in berthing under a new wharf configuration.

A combination of phase-resolving wave modelling (CGwave and Mike21 BW) and Optimoor was used to determine ship motion under the existing configuration and for incrementally increasing breakwater lengths. PIANC (1995) provides *recommended motion criteria for safe working conditions* and gives the effective thresholds for the ship motions of Surge, Sway, Heave, Yaw, Pitch and Roll for various vessel classes. Analysis found that under the existing configuration, ship motion was exceeding safe working conditions 66% of the time or an average of 246 days/year (c.f 11% of the year based on the operator's Hs=0.75m threshold). Increased breakwater length resulted in reduced wave height at the berth, a length of 65 m beyond the wharf was eventually adopted based on cost and operability criteria. This length reduced ship motion exceedances to 26% of the time based on PIANC (1995).

### 5.2 Breakwater armour

Breakwater armour protects the breakwater structure from wave attack and was a critical component of the project. Due to the very remote location, a 'zero maintenance' (or as close to as possible) was sought.

Early inspection and testing of local rock by engineering geologists indicated that the potential rock quarry sources on the island were good quality basalt with densities in excess of 2.8 t/m3, but size was limited by shear planes to typically less than 400kg. Design was therefore undertaken with this constraint in mind.

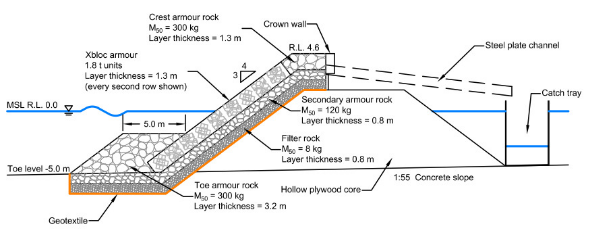
A range of options were considered including conventional rock breakwater, reshaping breakwater, concrete caisson structure or concrete armour units. A lack of suitable size rock on island and very high transport costs to island resulted in concrete armour units being preferred for breakwater construction. After reviewing a range of potential armour units as described within PIANC (2005), Xbloc® units have been selected as most cost-effective and well-proven unit.

Due to the requirement for 'low maintenance', a 0.1% AEP wave height was selected incorporating the upper 95% confidence interval [2]. This resulted in a design wave height of Hs=2.7 m (the site is in the lee of a large headland). The resulting Xbloc® (DMC, 2014) was 0.75m$^3$ or 1.8T and small enough that the available rock on island was suitable to be used as underlayer material (a critical cost factor), something not possible with larger randomly placed units.

Figure 5 - Xbloc placed on a test slope

### 5.3 Physical model testing

Physical model testing of armour stability was undertaken at the Water Research Laboratory in Sydney on a 2D breakwater cross section and around the breakwater head using a quasi-3D test. The testing also allowed wave forces on the crown wall and wave overtopping rates to be assessed. Results [6] were used to optimise design and identify value engineering opportunities such as replacing crest armour for local rock and also to identify potential design issues.



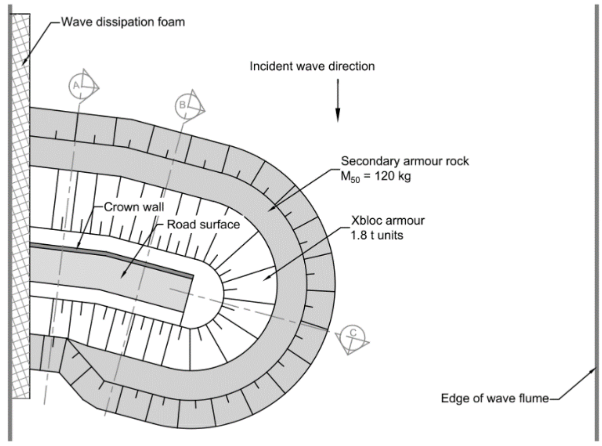




Figure 6 - Example of physical model 2D (top) and quasi-3D (lower) test configurations

Some such issues included a lack of crown wall return at the end of the breakwater allowing Xbloc® to be displaced across the breakwater and displacement of toe armour on the leeward side of the breakwater head (a known weak area). Toe armour rock were displaced beyond expectation based on empirical guidance resulting in Xbloc® being exposed and displaced from the toe and beginning to unravel (a 'catastrophic failure'). These problems were solved by modifying the design; the crown wall was continued around the end of the crest and the Xbloc® toe was continued to underlying rock rather than rafted on sand. This testing provided confidence that the design was both robust and as cost-efficient as possible.

### 5.4 Construction aspects

As previously discussed, the typical wave climate was low but persistent year round (refer Figure 7). This meant that construction would need to occur during wave events. This was challenging given the small core and filter materials and precise placement required.

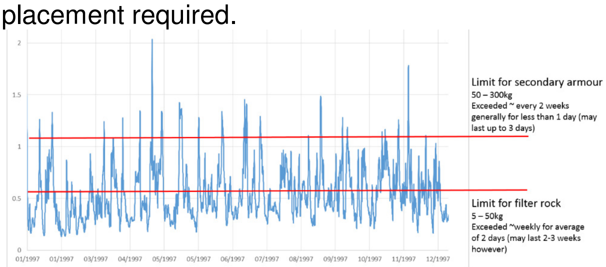



Figure 7 – Time-series of hindcast wave height [5] for 2012 with indicative thresholds for initiation of damage to core/filter layer and secondary armour.

To improve certainly around the design, physical model testing was undertaken on 'in construction' sections to simulate typical conditions and moderate storm events. It was found that the core and filter material were moved under waves as low as 0.5 m, which occurred weekly for 2-3 days but at times for as long as 2-3 weeks. The secondary armour was moved when waves exceeded 1.2m which occurred every 2 weeks on average, though generally for less than one day. In both these cases, the damage was typically a slumping of material (Figure 8) from above the waterline to below the zone of wave energy. This provided useful information on the construction thresholds and on repair methodologies.

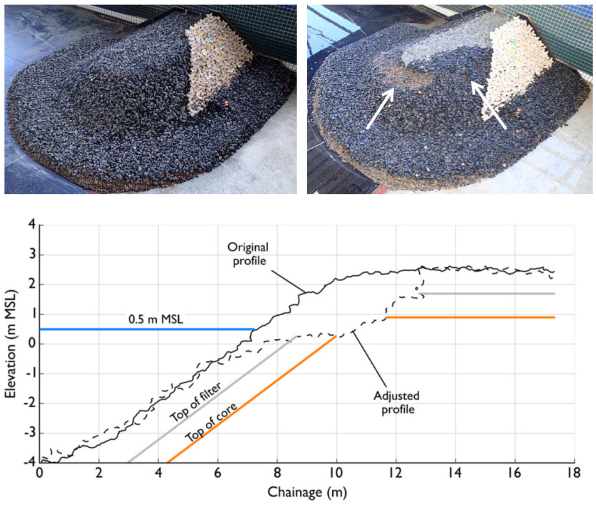



Figure 8 - Effect of increasing wave height from 0.55 to 1.2 m on secondary armour rock before the xbloc are placed

## 6. Key lessons and opportunities

### 6.1 Connect communities to their ports

Waitangi Wharf and port is essential to the sustainability of the Chatham Islands as a community. And the community are intrinsically aware of this.

The short-term impact of the project on the community was significant.

Yet much more than any other project we have been involved in before, there was an understanding that those impacts, and potential impacts, were part of the trade off. The community were right to have concerns, and we worked closely with them to minimise any adverse effects. But they knew the project was for the good – because without the port, there is no Chatham Islands community.

It could be argued that any city in New Zealand is equally reliant on their port. Certainly the country as a whole is equally reliant on its ports in totality. We must be able to import and export. Yet, on mainland New Zealand, the vast majority of the public do not appreciate this importance. And as such, ports most often face resistance to development and growth.

If we can connect our mainland communities to the importance of our ports, we could see a shift in sentiment towards port development and port operation. The authors believe there is a huge, albeit complex, opportunity for the industry in this regard.

### 6.2 Procurement matters

Too often remote projects, particularly in the Pacific, are procured using a linear procurement model – of design, tender and construct.

The New Zealand Transport Agency (NZTA), as advisors to DIA, are a mature infrastructure delivery agency. They recognised that with the tight timeframes, limited scope definition, and the challenges of delivering a project in a location with limited infrastructure, that an Alliance procurement model was the best approach.

Alliancing brings all parties required to deliver a project, including the client, into a single collective agreement. With a pain share / gain share agreement. The model encourages all parties to work together for best for project outcomes.

From the outset the environmental, design and construction teams were working side by side. Even the earliest decisions were made with all delivery partners present. For a project where all of the plant, machinery and person power required to undertake the works needed to be shipped more than 800km – such collaboration was priceless. Design decisions were influenced by the plant that was going to be present on the island.

Its known that good collaboration often leads to better outcomes. In the case of remote projects, this is even more acute. Funders should consider procurement methods carefully for remote projects – as there is significant advantage in choosing the right method, and one that allows collaboration, as DIA and NZTA did in this instance.

### 6.3 Good relationships help to achieve a win-win

The Waitangi Wharf Upgrade really put the value of relationships under the spot light.

With such a small community, who were going to be significantly impacted by the works, and whom we needed considerable assistance from, we recognised early that relationships would be paramount.

The Alliance dedicated considerable effort to integrating with the community and building strong relationships.

One of our drivers was that the project relied heavily on the services of the islands businesses. Be it, accommodation, fuel, shipping, flights, and labour force – we needed them to deliver the project. We needed them more than then needed us.

But with a small community, and given the economic impact the project was likely to have, we had to be sensitive around how we engaged with the business community.

Ultimately, our philosophy was to strive for win-win outcomes, with as many local businesses as possible.

Another driver was our will to have a positive influence on the island community. With such a small and tight knit community, the Alliance workforce had the ability to have a significant impact on the island. We needed to make sure it was a positive, and respectful impact. Considerable effort was put into inducting all staff into the culture of the island – with our induction packs put together with the help of the local community. And we recognised that the everyday counted. It was important for the workforce to be part of the community, from entering a touch team in the local competition, to attending community events, and even frequenting the local pub – the was a very conscious effort to be a 'good island citizen'. It was one of the non-financial key result areas for the project.

To date, our efforts in building relationships have been extremely worthwhile. The Alliance has achieved better financial outcomes through agreements with the business community. The community feel they have a project team they can trust. The workforce are enjoying their time on the island. And the island are happy to have their temporary residents contributing to the island community in a positive way.

This would not be possible with investing the time to really get to know the local community and build those strong relationships.

Figure 9 - Waitangi Wharf upgrade during construction in Jan 2017

## 7. Summary

The unique challenges and context of constructing the $58M Waitangi Wharf Upgrade on the Chatham Islands, has served to highlight opportunities that coastal practitioners and port developers may be able to seize with other developments. Most importantly;

- The relative importance of the project to its community reframed port activities by highlighting the critical importance of port infrastructure We consider that there is a huge, albeit complex, opportunity for the industry to more strongly connect communities to their ports for the benefit of the industry.
- The challenges of remote working are best overcome with a highly collaborative approach. And procurement plays a key role in fostering collaboration.;
- How we must be sensitive to the communities in which we work, and strive to build strong relationships for everyone's benefit – particularly so with remote projects; and
- That physical model testing can add significant value in fine tuning a design, and providing confidence in the end solution.

## 8. References

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