WELLINGTON WATERFRONT JUMP PLATFORM – IMPROVED WATER QUALITY

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ABSTRACT

The Jump Platform on Wellington Waterfront is a public facility which is installed above an open section of Taranaki Wharf. It consists of an elevated platform some 8 m above the water level, with stairs for access. The area is popular with swimmers and spectators and has created a focal point at the waterfront. However, monitoring showed that the water quality in the area exceeded the marine guidelines for recreational use, with results indicating a median enterococci concentration of 460 CFU/100 mL. The contamination was a result of two major stormwater catchments (Taranaki and Te Aro), which discharge close to the area. Both catchments have a significant year round baseflow, and infiltration from groundwater and sewer overflows contribute to the contamination of the stormwater discharge. Following the installation of an enclosure around the Jump Platform area, the surface water quality results show that the enterococci concentration fell from a median value of 865 CFU/100mL prior to the baffle installation, to 26 CFU/100mL.

KEYWORDS

Recreational water quality, stormwater quality, baffles, marine construction, wave forces.

1 INTRODUCTION

The Jump Platform is located adjacent to the Wellington Free Ambulance building situated at the northern end of Taranaki Street.

Photograph 1: Location of Wellington Water Jump Platform

The Jump Platform was a popular recreational area when it opened in 2012. Soon after it was opened, monitoring of the water quality showed that it was unsuitable for swimming, and due to the potential health risk to the users, it was closed in February 2013. The Jump Platform is owned by Wellington Waterfront Ltd (WWF) which is a Council Controlled Trading Organisation set up to develop and manage the waterfront land of Wellington City Council (WCC). Wellington Water Limited Ltd (WWL) manages water, wastewater and stormwater service delivery in the Wellington region on behalf of five Councils (including WCC).

Monitoring of the stormwater discharges adjacent to the Jump Platform showed that the quality is poor and has a continuous baseflow which contributes to the poor harbour water quality.

WWF and WCC's brief was to investigate options for enhancing the water quality in the location of the existing Jump Platform in order to meet the marine recreational bathing guidelines.

This paper outlines the cause of the poor water quality adjacent to the Jump Platform, the investigation process and options that were explored in order to improve the water quality, the development of the design, construction of the solution, and the resulting improvement in the water quality.

2 THE PROBLEM

2.1 STORMWATER DISCHARGES

The Taranaki and Te Aro stormwater catchments discharge under the Taranaki wharf adjacent to the Jump Platform area.

The Taranaki catchment covers approximately 69 hectares of which an estimated 60 percent is impervious. The catchment is approximately 40% central city area, parts of which carry very high traffic volumes. It has approximately 660 residential properties and an estimated residential population of 2,000. The catchment includes parts of Brooklyn, Mt Cook, Central Park and all of Taranaki Street. A small stream runs through Central Park and provides a year round baseflow. The Taranaki Street stormwater system discharges to the harbour via a culvert located at the end of Taranaki Street which is 30 m from the edge of the wharf cut out. Baseflows (flows during dry weather) from this discharge were calculated to be in the range of 10 to 25 L/s.

The Te Aro catchment covers a total area of 235 hectares of which an estimated 40 ha is impervious. It comprises approximately 36% reserve land, 49% inner and outer residential and 15% central city. The catchment includes approximately 2,200 residential properties and an estimated population of 6,500. The catchment includes Mitchelltown, parts of Kelburn, Lambton and Te Aro and a reserve area upstream. The stormwater drainage system was constructed from 1860 onwards. The Te Aro stormwater culvert discharges 14 m from the edge of the Jump Platform. Baseflows from this discharge were calculated to be in the range of 50 to 70 L/s.

Both catchments include substantial areas of the 'Town belt' which are rural in character and runoff from these areas may also contribute to the degraded stormwater quality.

The baseflow is made up of groundwater which infiltrates into the network and also may include exfiltration from the sewerage network. There are four engineered sewage overflows within the catchment including an overflow from the Te Papa sewage pump station. The frequency of sewage overflows can vary between 6 months to 2 years.

3 WATER QUALITY

3.1 GUIDELINES

The recreational bathing guidelines published by the Ministry for the Environment, (MfE, 2003) state that enterococci are the preferred indicator species in the marine environment. The New Zealand Marine Bathing

Study showed that enterococci are the indicator most closely correlated with health effects in New Zealand marine waters, confirming a pattern seen in a number of overseas studies.

The water quality bacteriological ‘trigger’ values defined in the bathing guidelines are given below. These values are classified into three categories as shown in Table 1. The management response incorporates follow up sampling and sanitary surveys triggered by Alert/Amber and Action/Red modes as outlined in the Table 1 below. Health warnings are issued when water samples taken from a recreational site exceed the Action/Red level of the guidelines.

Table 1: Ministry for the Environment bacteriological trigger values for coastal waters

Mode	**Guideline Enterococci (cfu/100mL)**	**Management Response**
Surveillance/Green	Single sample ≤140	Routine monitoring
Alert/Amber	Single sample >140	Increased monitoring, investigation of source and risk assessment – sanitary survey
Action/Red	Two consecutive samples within 24 hours >280	Increased monitoring and investigation of source - sanitary survey

Following determination of a potential public health risk from swimming in the Jump Platform area, WCC and WWL implemented a targeted water quality sampling programme in and around the Taranaki wharf area. Initially five sites were sampled for enterococci on a daily basis.

In addition, WWL and WCC developed a 30-week water quality sampling plan in collaboration with Greater Wellington Regional Council, Regional Public Health and WWF. The purpose is to gain a better understanding of water quality at several waterfront locations and also to assess the suitability for recreational purposes.

The Ministry for the Environment and Regional Council websites provide a Suitability for Recreation Grade (SFRG) which is an overall water quality grade based on long-term information. A SFRG describes the likely health risk from direct contact with the water at any one time. It only relates to health risk from faecal contamination of water from disease causing organisms (i.e., it does not include health risk from toxic algae).

Since April 2013, after the platform was closed, a further expanded programme of sampling has been carried out. The program included sampling from both the stormwater network and the harbour sites.

Photograph 2: Water quality monitoring locations

3.2 MARINE WATER QUALITY

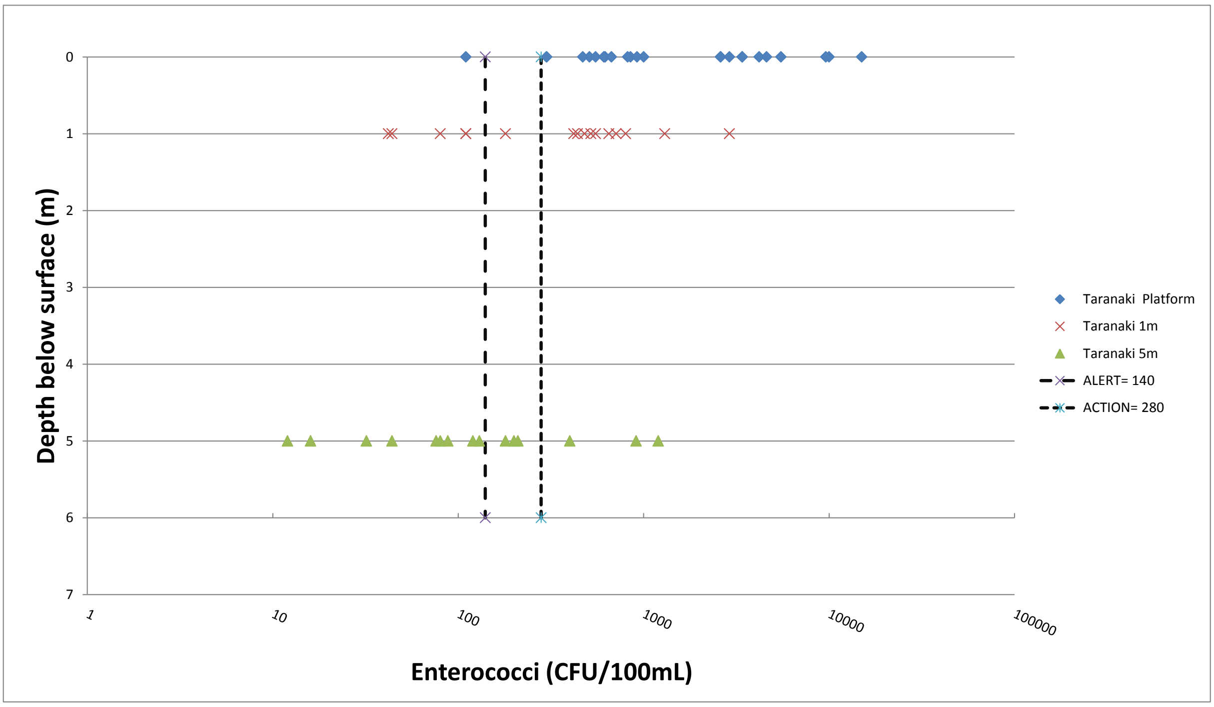
Water samples are taken weekly from the marine environment. The sampling results for the Taranaki and Te Papa locations are given in Table 2 below. They show that the enterococci concentration at the Jump Platform location was in excess of the recreational bathing standards (median 460 CFU/100mL at 1m depth), and that the concentration at both locations reduces with increasing depth.

Table 2: Weekly enterococci sampling results for Taranaki and Te Papa locations

	Taranaki Jump Platform			**Te Papa**		
Depth	**Surface**	**1m**	**5m**	**0.5m**	**2m**	**15m**
Count	23	16	15	13	13	12
Min	110	42	12	20	4	12
Median	1,000	460	120	130	100	70
95%ile	9,960	1,700	1,000	1,460	600	160
Max	15,000	2,900	1,200	2,600	700	220

The above results of the weekly sampling are graphed below. The results at the Taranaki Platform location show that at the 1m sampling depth the median results are approximately half, and the 95 percentile and maximum results are approximately five times lower than the surface water results. At the 5m sampling depth the results are approximately ten times lower than the surface water results. Freshwater floats above the more dense seawater, and this is the likely reason the high concentration of enterococci at the surface.

Figure 1: Weekly enterococci samples from Taranaki Street Jump Platform versus depth



3.3 STORMWATER QUALITY

Stormwater quality is sampled fortnightly from the discharges into the harbour. In addition, WWL samples stormwater in the network as part of their pollution monitoring programme. The network data is displayed in the figures below in terms of the distance upstream of the discharge point for the two catchments. While the data is highly variable, as can be expected for faecal monitoring, it typically varies by three orders of magnitude, from 100 to 100,000 CFU/100mL, through the whole of the urban area.

Stormwater discharges are considered to be the largest contributor to poor microbiological water quality in the harbour.

Figure 2: Faecal coliform data in the Taranaki stormwater catchment

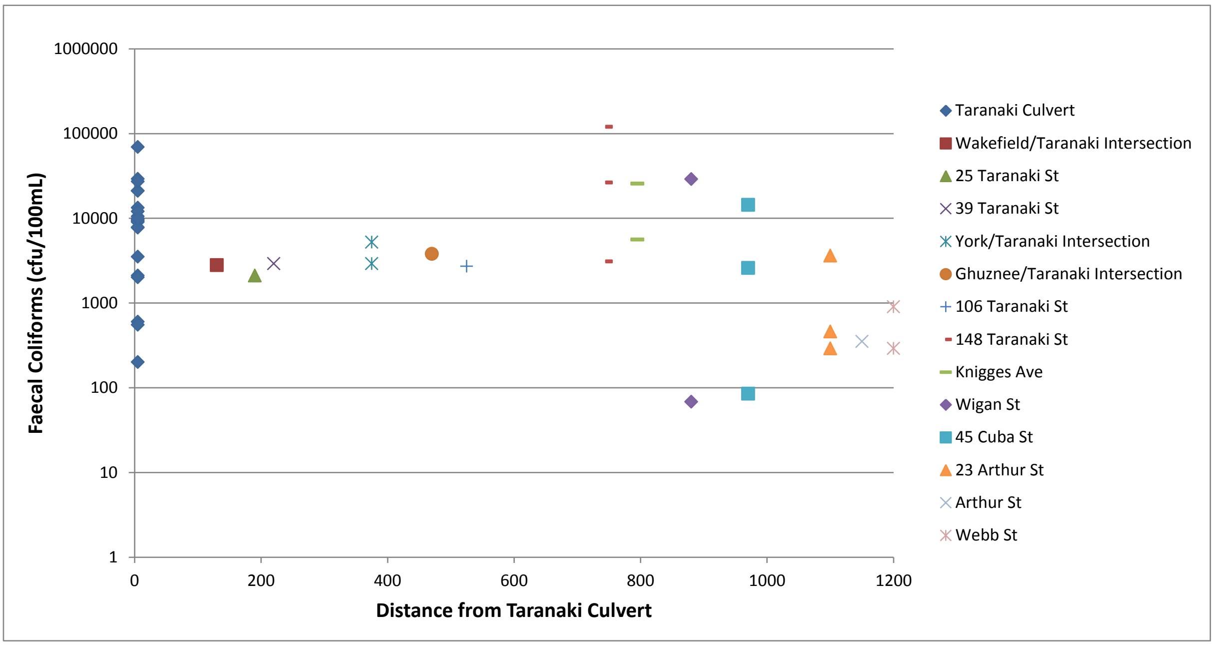
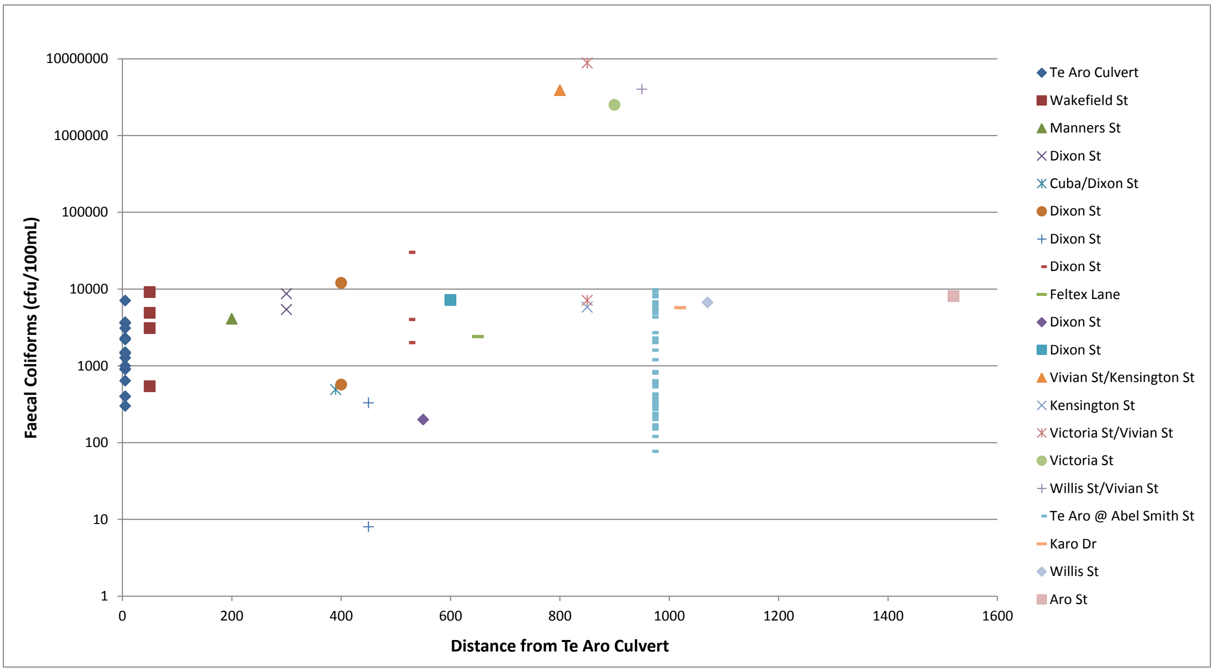


Figure 3: Faecal coliform data in the Te Aro stormwater catchment



4 EXPLORING THE OPTIONS

4.1 DROGUE TESTING

In the initial options work, Beca undertook a simplified drogue test to determine the current movements in and around the Jump Platform area. The test was started at high tide and concluded at low tide. Oranges were dropped into the water at varying times and locations and their movements tracked. Although GPS trackers would provide a more precise measurement of location and current, they were not suitable for this application as the GPS signal would not work underneath the wharf.

The conditions on the day of the test were still and clear resulting in minimal potential for wind to affect the drift. In general it was observed that oranges that were released in the southern half of the Jump Platform tended to stay in the area. Oranges that were released to the north of the area eventually moved back out into the harbour. The mid tide currents were calculated to be moving at approximately 0.04m/s. This was higher than expected for the area and it was considered that this may be impacted by the stormwater baseflow.

4.2 WORKSHOP

Due to the complexity of the problem and the multiple stakeholders, we proposed a high level workshop to initially filter out what options were likely to be technically feasible, within budget, able to be consented, and acceptable to the varying stakeholders who had an interest in this area.

Following agreement of the key design objectives and constraints, a workshop and brainstorming session was held. A high level assessment of the technical challenges, likely public perception, likelihood of success, health and safety considerations, consenting requirements, and cost to implement were undertaken at this stage, and the options ranked.

The four options that were discussed at workshop were:

a) Pumping higher quality seawater from further out in the harbour into the Jump Platform area to provide flushing and regular turnover of the water.

b) Installing a submarine baffle or curtain to direct stormwater flows away from the Jump Platform.

c) Creating a “swimming pool” enclosure within the bounds of the wharf cutaway.

d) Installing of a low flow stormwater pipe out of the main stormwater culvert to direct the baseflow away from the area.

The workshop culminated in all parties agreeing on a single option of diverting the stormwater using a baffle, with the option being carried forward to the feasibility study and conceptual costing. It was acknowledged at the workshop that each of the options considered carried varying degrees of technical risk, cost and certainty of success. This option whilst having some technical challenges was considered worthy of further investigation.

4.3 CONCEPT OPTIONS

During the course of the concept work on the baffle option, WCC and WWF agreed that the additional option of piping the stormwater baseflow away from the area, and other options from the workshop be included in the concepts.

The following options were explored as concept designs for the purpose of improving water quality at the Jump Platform area.

4.3.1 FLOATING DIVERSION BAFFLE

This option has a floating baffle in order to divert the stormwater away from the Jump Platform area. The bottom of the baffle would be fixed between rows of piles with a horizontal suspended chain and vertical chains to a ground chain to keep the baffle in position. As the tide rises the baffle floats on the water surface and the slack in the vertical chains is taken up. The buoyancy of the floating pipe balances the weight of the suspended baffle and vertical chains.

The length of the baffle would need to be such that it diverts the stormwater away from the Jump Platform area. This would require a sufficient distance so that the incoming tidal movement or wind does not move the displaced stormwater back into the area.

4.3.2 ENCLOSURE WITH FLOATING OR FIXED BAFFLES

The “swimming pool” enclosure option involves a baffle which would shield the area from the stormwater baseflow. The floating baffle would be installed around the perimeter of the jump area between rows of piles under the wharf. Weights on the seabed were an option to hold the baffle in position. The baffle would need to be restrained with tethering ropes between rows of piles in order prevent it being damaged against the piles, although these were considered to be a hazard for swimmers.

A variation on this option was to fix the top and bottom of the baffle to wires and attach these to the piles. With the baffle being restrained, it would need to resist wave forces, which can be significant at 21 kN/m width for a 5 year storm event.

Introducing potable water into the enclosure was considered in order to maintain an area of higher water quality. Theoretically the water level difference between the sea and the fresh water inside the baffle should be 50 mm (due to the differing densities) thereby creating a flow of water out of the bottom of the enclosure.

As an alternative to the using potable water, sea water could be introduced from another location where the water quality is better. The median water quality at the Te Papa location at a depth of 15m is typically below the Alert/Amber monitoring level for enterococci of 140 CFU/100mL. This would require a small submersible pump with a pipeline to the Jump Platform area about 40m away. However, with the mixing of pumped sea water, the water quality inside the enclosure would be uncertain.

4.3.3 BASEFLOW PIPE

Diverting stormwater baseflows away from the jump area would remove significant levels of pollutants. This option involves redirecting the baseflows by connecting a small diameter pipe to the two culvert outlets and discharging them to another location.

In order to direct the flow through the diversion pipeline, a build-up in the water level in the culvert is required. Options that were considered for this included an overflow chamber on the end of the culverts and check valves. Check valves would only open during flood conditions and while closed would divert the baseflow to the pipeline. Two check valve options were investigated; duck-billed and the proprietary WaStop. WWL advised that flooding is experienced in the Taranaki and Te Aro culvert catchments during storms, so only an additional 150 mm headloss could be tolerated to avoid a reduction in the stormwater capacity. A chamber presents a significant additional head. Duckbills check valves would have introduced approximately 0.2m of head and 0.45 m for the WaStop. The piped diversion option was therefore discounted on the basis of raising the risk of flooding upstream.

4.3.4 DIVERSION OF THE BASEFLOW TO THE SEWER

This option involved diverting the baseflow of stormwater to the sewer. The benefit of this option is that it removes the contaminated baseflow from the discharge and goes some way to improving the water quality in the harbour. The baseflow would need to be diverted in the stormwater system upstream of the influence of the high tide level so that seawater is not discharged to the sewer. Diversion of the flows would need to cease during wet weather in order to avoid overloading the sewer. This option was discussed with WWL however the initial feedback was that this is contrary to the objective of removing Inflow and Infiltration (I/I) from the sewer system. The consent conditions for the Moa Point wastewater treatment plant include a condition related to I/I control and this option was unlikely to be viewed favourably during consent reviews.

4.3.5 FULL FLOW DIVERSION

This option considered diverting the full stormwater flows approximately 50 m to the north of the Jump Platform. A full flow diversion would require the stormwater culverts to be extended with 1800 mm and 2000 mm diameter pipes traversing 60m and 120m from the Te Aro culvert and Taranaki culverts respectively. The pipes would head north along the seabed and be fastened to concrete blocks.

The initial headloss calculations for this option indicated that the Te Aro pipeline would have approximately 150 mm headloss, with the Taranaki pipeline being approximately 250 mm. This option, in addition to being expensive and difficult to install, was not compliant with the 150 mm headloss limitations for the stormwater system.

4.3.6 MOVING THE PLATFORM

Moving the platform to another location, whilst outside the scope of the study, would have been the most straightforward option to implement. This would only have been a beneficial option if the water quality at the new location was significantly better than the existing platform area. Water quality monitoring data shows that at the Te Papa and Harris Street locations, the median and 95 percentile enterococci concentrations are significantly lower than the Taranaki Platform location. The 95 percentiles still exceed the Alert/Amber Level so there would be times when the platform would need to be closed due to poor water quality. Moving the platform would have required new piles and associated resource consents.

4.3.7 ELIMINATING CONTAMINATION

Eliminating the contamination from the stormwater discharges, whilst also outside the scope of this study, would not have been viable even within the medium term. Eliminating contamination of the stormwater system is a long term goal for WCC and WWL. This would have involved spending tens or possibly hundreds of million dollars to upgrade the network to eliminate sewer cross connections to stormwater, and reduce inflow and infiltration to the sewer network.

4.3.8 THE COSTS

The costs, based on the concept designs, were estimated as follows:

a) Enclosure with fixed baffle $150,000

b) Enclosure with floating baffle $155,000

c) Floating diversion baffle $300,000

d) Fixed diversion baffle $450,000

e) Piped diversion & check valve $450,000

f) Diversion of baseflow to the sewer $900,000

g) Full flow diversion >$700,000

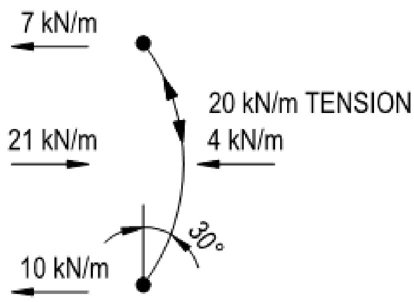
On the basis of the costs, and likely success and simplicity, the option of the enclosure with a fixed baffle was selected by WWF.

5 DETAILED DESIGN

5.1 WAVE FORCES

We calculated wave forces on the baffle enclosure on the basis of wind speed and longest wind fetch across Wellington Harbour of 8km, using the wave hindcasting method given in U.S. Army Corps of Engineers (2006). For a 5 year return period the forces on the baffle were calculated to be 21 kN/m width. It was recognised that designing a flexible baffle for a greater return period may not be practical and some damage could be expected at higher forces. The net force on the baffle was determined by the difference in the wave force and the force of the water displaced behind the baffle as it deflects out. The strain properties of the material determine its degree of deflection. Figure 4 illustrates the forces.

Figure 4: Wave Forces on the Baffle



5.2 MATERIAL SELECTION

Various options were considered for the baffle materials including HDPE, reinforced polypropylene and PVC. One of the main considerations was the tensile strength of the materials as it needs to resist wave forces and the ability to fix the material to the steel cables. PVC was selected as the most suitable material as it has a tensile strength of 76 kN/m width and provides the ability to be welded into pockets around a supporting cable. The baffle materials needed to be robust and suitable for use in the marine environment. Barnacle growth is prolific and could impact on durability, and wave forces in extreme events could cause damage. WWL also noted that the stormwater discharges can sometimes contain illegally dumped corrosive chemicals.

Grade 316 stainless steel was selected for the supporting cables for the top and bottom of the baffle.

We discussed durability issues with WWF and noted that the baffle solution was novel and unproven with the aim of achieving an improvement in water quality with a limited budget. It was recognised that an improvement in water quality would be a staged approach and that further water quality monitoring and other upgrades would be required.

5.3 POTABLE WATER

Our design included the connection of three piped droppers into the jump area, connected to an adjacent water main for the purpose of delivering potable water into the enclosure. The purpose of this is to displace the contaminated stormwater and maintain an area of higher water quality.

5.4 SAFETY IN DESIGN

A Safety in Design review was carried out with representatives from WWF and the baffle supplier. This considered the risks during construction, during use, and maintenance. Construction risks were to be mitigated with appropriate construction plans. Recommendations for reducing risk to swimmers included installing suitable warning signage, regular inspections to remove debris in the jump area, and the installation of a pontoon within the area to provide an area to swim up to, or for potential rescue purposes.

5.5 RESOURCE CONSENT

The installation of the baffle required a resource consent for the diversion of water under Rule 76 of the Wellington Regional Coastal Plan (WRCP). In addition the wharf has historic merit status in the WRCP and Greater Wellington Regional Council was consulted in regards to this proposal and the effects on historic merit.

6 CONSTRUCTION

6.1 TENDERING

The project was carried out in two separate contracts;

a) Detailed design and supply of the baffles and fixings.

b) Installation of the baffle.

For the design and supply of the baffle a single supplier, Viking Containment Ltd, was invited to submit a price for the work. Viking Containment had been involved from the outset of the project, providing specific advice on the material selection and the design of the baffle and fixings.

Two underwater construction companies were invited to tender for the installation of the baffle. The installation contract was awarded to New Zealand Diving and Salvage Ltd.

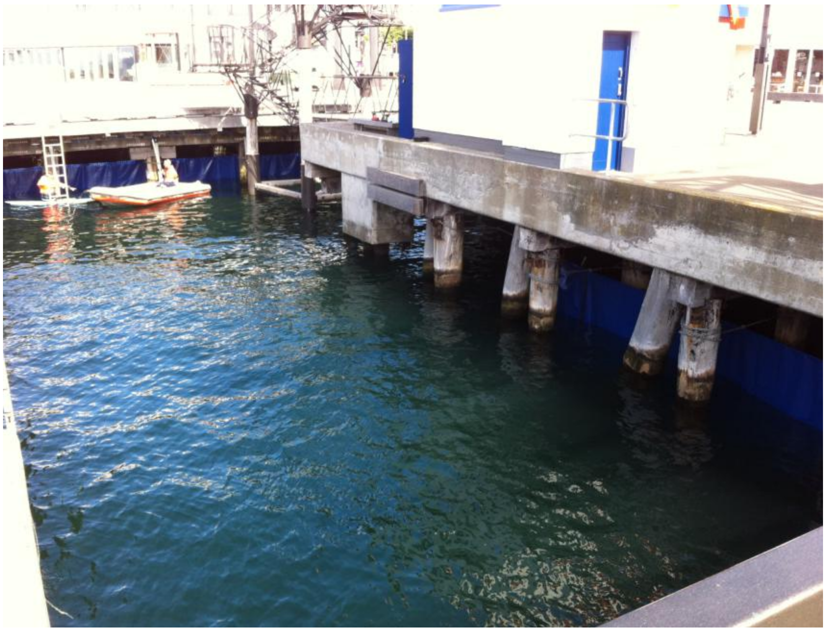
6.2 CONSTRUCTION

Some challenges were encountered during the supply and installation of the baffle. Construction under water is time consuming and the baffle materials were difficult to handle in water. Both supplier and installer made significant efforts to come up with novel solutions. The project was completed at the end of May 2014.

The total cost for the supply and installation of the baffle was $150,000 including design and construction supervision fees, and resource consent preparation.

Photograph 3: View under the wharf during installation

Photograph 5: The completed baffle

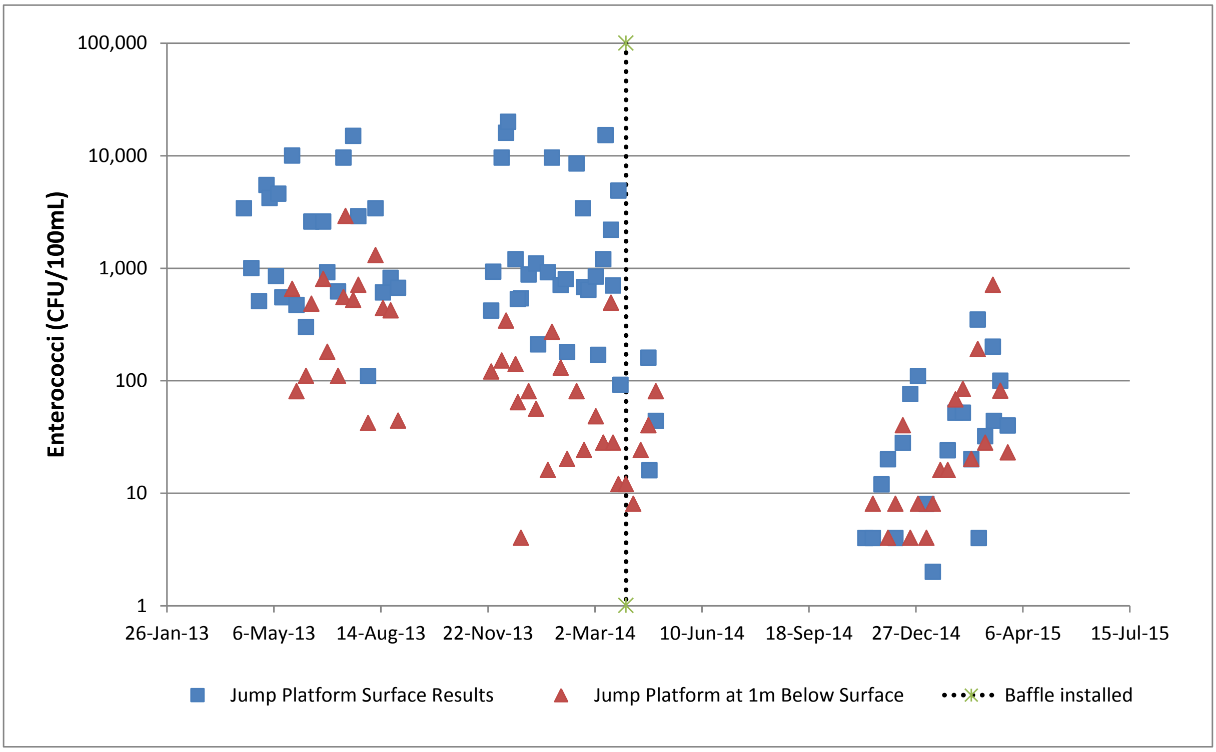


7 THE RESULTS

The installation of the baffle was completed on the 31 March 2015 and on the same day potable water was discharged into the enclosure and continued for a period of 3 days. The surface water quality results show that the enterococci concentration fell from a median value of 865 CFU/100mL before the baffle installation, to 26

CFU/100mL following its installation. Enterococci exceeded the Alert/Amber Mode during the bathing season twice only with concentrations measured at the surface of 200 and 350 CFU/100mL. The results are shown in Figure 5 below.

Figure 5: Enterococci results at the Jump Platform before and after the baffle installation



During the time that potable water was discharged into the enclosure, and for one week following that, the water quality was significantly improved with enterococci results of < 4 CFU/100mL at the water surface and 8 to 24 CFU/100mL at 1m depth. Potable water is no longer used to improve the water quality however the enclosure alone results in an improvement in the water quality by reducing the stormwater flows into the Jump Platform area.

At the time of writing, the baffle remains in reasonable condition, having proved to be durable considering the severe environment and potentially large wave forces. Some tears due to pier bolts puncturing through were a problem. It was recognised that the baffle would need inspection and maintenance from time to time.

8 CONCLUSIONS

Stormwater discharges can potentially cause degradation of water quality due to sewer cross connections and sewer leakage into the stormwater network. Improving the water quality of stormwater discharges requires a significant long term investment in sewerage rehabilitation and stormwater treatment. This Jump Platform project illustrates the impact that poor stormwater quality can have on bathing water quality and the potential risks to public health. In this case the enclosure provided a cost effective solution, resulted in an improvement to the water quality, and compliance with the marine bathing guidelines. Marine conditions are harsh and the selection of materials is important to achieve a reasonable life. In this case the durability of baffle and fixings is proving to be acceptable.

ACKNOWLEDGEMENTS

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Wellington Water Ltd for the provision of water quality data and advice during the concept options.

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