URBAN STORMWATER CATCHMENT UPGRADE UNDER PRESSURE: TACY STREET STORMWATER PUMP STATION

1. ABSTRACT

In 2008 Wellington City Council was designing the Indoor Community Sports Center (ICSC). This massive structure would create a significant change in land use in the Kilbirnie catchment and put more pressure on an undersized network with sea level rise on the horizon. Capacity saw this as a major challenge and an opportunity. Instead of developing a dedicated network for the ICSC, Capacity chose instead to enhance the existing network by adding a pump station.

The location of the pump station created issues for local businesses due to the proximity to parking and shop frontages. The site was on reclaimed land, with a high water table, a live 1800mm diameter stormwater pipe and a number of other utilities. To meet these challenges Capacity specifically asked for innovation in the RFP. SKM developed a solution that addressed these issues and catered for future flows of 5.5m³/s while allowing the network to operate as a gravity pipeline in smaller rain events

Innovation continued into construction, Brian Perry Civil, developed a methodology that constructed the pump station as a caisson, avoiding sheet pilling and extensive dewatering, which was a major risk.

Overall the project delivers an excellent outcome for the community. The key to converting this challenge into success was that opportunities for innovation were maximized, by giving each party scope to innovate at the earliest opportunity.

KEYWORDS: Stormwater, Pump Station, Catchment Management, Climate Change, Flooding

2. INTRODUCTION

The Kilbirnie catchment in Wellington bridges the gap between the Miramar peninsular and the rest of Wellington City. The catchment is flat with the majority of the catchment less than 5m above mean sea level. As a result, the existing stormwater network is heavily constrained by the tide.

In 2008 Wellington City Council was proceeding with the Indoor Community Sports Center (ICSC), with detailed design in progress. This massive structure would create a significant change in land use in the Kilbirnie catchment (with an increase of impervious areas) and put more pressure on an undersized network in the short term. In addition, sea level rise is expected to decrease the effectiveness of the existing stormwater network.

Capacity saw this as a major challenge and an opportunity. Instead of developing a dedicated stormwater network for the ICSC, Capacity chose instead to enhance the existing network by adding a pump station. This would address the ICSC's impact and go some way to mitigating the effects of climate change on the stormwater network for part of the catchment. Economically this option was also assessed. Time was of the essence however as the commencement of the construction of the sports Centre was imminent.

The location of the pump station was largely governed by the location of the ICSC, however locating the pump station along the only access road to a new business park created significant issues. Figure 1 below shows a plan of the site, note the existing outfall in the centre north of the plan and the ICSC in the south east corner.

Figure 1: Site Location

The size of the site was only the beginning of the constraints. Subsequent investigation would reveal that the proposed site was on reclaimed land with a high water table, a number of high voltage cables along with other utilities and a live 1800mm diameter stormwater pipe running through it. To say innovation was required in all stages of the project was an understatement.

3. DISCUSSION

CATCHMENT MANAGEMENT AND PROJECT PLANNING

Localised rain storms had affected a number of Wellington city's suburbs in 1994 and 1995 leading to a city-wide flood hazard study. This study identified and prioritised areas for further investigation. In 2002 the Kilbirnie stormwater catchment management plan, highlighted areas in the Kilbirnie catchment that were subject to flooding in a 50 year return rain event. In 2008 when an Indoor Community Sports Centre was planned on a site adjacent to an area of Kilbirnie already prone to flooding, options to manage the runoff from this site and mitigate the risk of flooding in the adjacent catchment were investigated. Existing pipes were identified as being undersized for the current situation even before the addition of the ICSC runoff.

After assessing the options, Capacity identified the cost of upgrading trunk pipes was prohibitively expensive within existing budgets, requiring a rethink of ideas. A modelling study \ identified that a stormwater pump station could increase the capacity of the existing trunk network enabling it to cater for the current shortfall, climate change and the ICSC.

In late 2009, Capacity released an RFP for design services for the project. The project brief called for a pump station to deliver a design flow of 5.5m3/s (future catchment flow) at a 2.5m head (to overcome sea level rise). Capacity initially had a budget of $1M and specifically asked for innovation in the RFP to try to meet this target and to overcome the challenges that the site possessed.

The project was subsequently won by SKM and investigation begun shortly after that.

SITE INVESTIGATION

Before the geotechnical investigation began at Tacy Street it was noted that there was a possibility that contaminated material may be present. Extensive investigations at the nearby ICSC identified no significant contamination was present. Given the proximity of the two sites (approx. 150m) there was some risk that contaminated material would however be found on the pump station site. Ultimately no contaminated material was identified during the investigation or the subsequent construction.

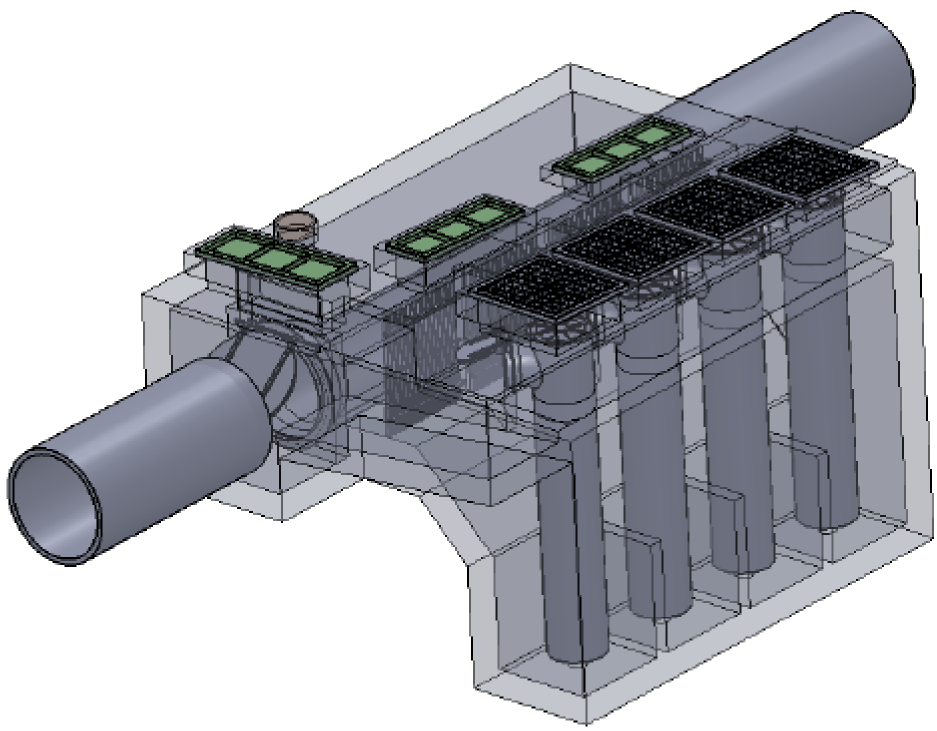
Site geotechnical investigation identified that the water table was relatively static at approximately 2m below ground level. The ground, based on two bore holes 10m apart, was a mixture of reclaimed land and marine sands to a depth of 25m.

Analysis of the observed geologic conditions identified that the cone of influence from dewatering (depending on which of the two boreholes was used in the calculations) was between 30 and 200m. Any dewatering scheme would require careful consideration and management to avoid damage to surround structures and infrastructure.

DESIGN SOLUTION

The budget constraints and the anticipated infrequent use of the pump station meant a dedicated rising main for the pump station was not a feasible solution. The design basis that was eventually selected was based on a combination of design guides for stormwater pump stations from the US. The concept design developed of the pump station can be seen in the figure below.

Figure 2: Concept Design



The hydraulics of the pump station are very simple. The head requirement to drive the design flow through the downstream pipeline was identified to be in the area of 300mm. The design featured a flap gate and 4 pumps in draft tubes, lifting the flow over the flap gate in large storm events. The flap gate was orientated in such a way that smaller events could pass the flap without the need for pumps, but also to keep the tide and debris out of the upstream network.

The area where the pump station was to be constructed was heavily congested with other utilities especially power – approximately 12 11KV cables had to be relayed to facilitate construction. The size of the pump station was relatively small at 10m wide by 12m long and 7m deep. The existing road had to be completely closed during construction. A temporary road on the berm and footpath was allocated as a corridor for vehicles.

Mechanically, outside of the flap gate major components were limited to four Grundfos axial flow pump each delivering 1,375l/s at their design duty point. Each pump sat in its own draft tube which was designed by the pump supplier.

The structure was designed to be constructed of cast in situ reinforced concrete. The design had to be compliant with HN-HO72 – Tacy Street has been designated as carrying heavy vehicles that service the sports centre. The structure was also designed to meet importance level 4 as defined in the building code.

The control regime was designed on the fact that the existing network could be left to surcharge until the critical up stream catchment was at risk of flooding before pumps needed to be stated. The control scheme had one pump starting at 300mm below any flooding beginning further up in the catchment. Subsequently adding additional pumps as needed if this level is exceeded. Then as the level in the pump station decreased pumps are removed from duty.

As the pumps would be discharging not far above this critical level the pumps needed to reduce the level in the pump station during their start up cycle to a point where the pumps could operate on their curves, otherwise risk triggering the under current protection system for the motors.

PROCUREMENT

As discussed above during the design and investigation phase of the project it was identified that proximity of the homes and commercial building paired with the high cone of influence form dewatering was a major risk. The anticipated construction solution to manage this risk was sheet pile the construction area dewater and re-inject ground water to manage the settlement risk. The team was conscious not to limit the number of contractors to those who had the capability to manage groundwater in such a way, so the dewatering and shoring methodology was given to the contractors as an option for innovation in the tender. The full geotechnical study developed in the design phase was released as part of the tender package.

The market responded. The successful contractor Brian Perry Civil proposing to construct the main body of the pump station as a caisson. Thereby avoiding the need for sheet pilling and minimizing the dewatering during construction.

CONSTRUCTION

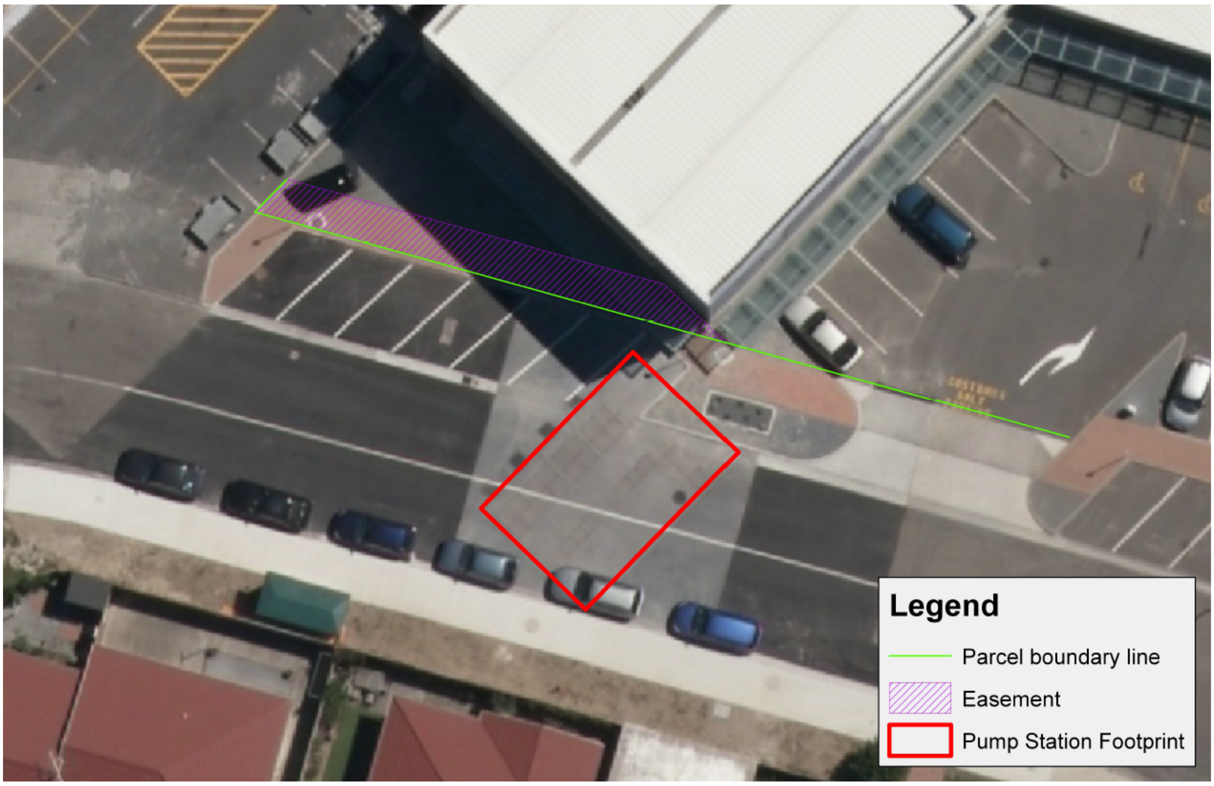
Construction of a major piece of infrastructure such as this pump station was always going to be a challenge on a heavily constrained site.

The major unforeseen risk that materialised was that the sinking the caisson took significantly longer than what the contractor had anticipated. This under estimation of productivity lead to a substantial increase in construction duration and which subsequently impacted on nearby businesses. This required extensive consultation with the businesses, whose access, parking and visibility were impacted by the construction activities. Capacity worked with these businesses to increase signage in other areas to minimize the impact during the construction period and the site was rearranged to increase visibility of the stores.

Given the proximity of the large commercial building the fact that there was no damage during the lengthy and complicated construction was a credit to Brian Perry Civil.

Figure 3 below is an aerial photo of the pump station site soon after construction was completed. The red box is the outline of the actual pump station, the remaining concrete that can be seen is the transition slabs for traffic. The newly sealed area either side of the concrete slabs was approximately the extent of the construction site, to say the business owners were relieved when construction was complete was an understatement.

Figure 3: Construction Complete



COMMISSIONING

A challenge for any large stormwater pump station is to find enough water to test it with anywhere near its designed operating point. It was decided to commission the pump station by wedging the non-return flap open and allowing the tide to fill the network, then at high tide to pump it dry.

This initial commissioning was successful, minor corrections were identified and made to the electrical systems. Up to two pumps could be run for approximately two minutes at the peak of the tide (at a combined flow of approximately 2,750 l/s) before the network was drained too low for commissioning to continue.

It took three months for the water levels in the network to reach to a level where the pump station had reached its designed start point – commissioning at last! This first run led to the discovery that the control regime needed to be refined. It was identified that initial duty pump was going into fault as it was operating off its curve. By increasing the number of pumps in the startup cycle to two, this problem was addressed.

4. CONCLUSION

This project is a testament to seeing challenges as opportunities and seeking out alternative solutions. Instead of being prescriptive, the opportunity to innovate was encouraged from the outset. This enabled designers to consider a number of possible solutions and contractors to consider alternative construction methodologies. When it came to dealing with some unanticipated challenges there remained a willingness to overcome the challenges and work towards a solution.

For others considering stormwater upgrades, investigating the use of pump station should be considered as they may offer cost effective solutions. Given the (relatively) small foot print this is especially attractive in urban environments, but careful management of stakeholders in close proximity to construction is critical.

Technically, the challenges of commissioning stormwater pump stations needs to considered, in that that full commissioning may not be possible due to a lack of water. Careful monitoring of the first rain events are important to fully commission such a facility.