AN ALTERNATIVE APPROACH TO MANAGING WASTEWATER FLOWS DURING RAIN EVENTS
"GARDENS GULLY SEWER RENEWAL"

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Abstract

As part of Timaru District Councils Strategic renewal plan, the Gardens Gully Sewer main was identified for renewal. During the process of designing the upgrade it was found that a conventional pipe size upgrade was not an economically feasible option due to a range of conditions. This was the driver for designing an alternative system incorporating in line retention tanks and utilizing hydrobrakes to regulate the flow through these tanks.

This paper works through the details of how the storage chambers were incorporated into the network, how the chambers operate and why using storage chambers in this case achieved a significantly lower capital cost and provided greater benefits to the over all wastewater network than a conventional upgrade approach.

INTRODUCTION

The Timaru District is located on the east coast in the centre of the South Island. The urban area of Timaru has a population of 30,000 with an average daily flow to the Sewage treatment plant of 25,000m^3 with approximately 50% of the flow being residential and the remainder being industrial flow.

As part of Timaru District Councils network renewal programme, the trunk gully sewer main of the Gardens Gully Catchment (Map 1) has been identified as being in need of replacement, based on age, condition and performance.

Traditionally this would have been achieved by simply analyzing the flow through the sub catchments and upgrading the network as required, but with today's technology and engineering practices, significantly better asset life and flow management are achievable. The entire catchment has been modelled, with several scenarios trialed to ensure the most cost effective option is achieved.

The selected option incorporates inline retention tanks, and has been designed to mitigate the effects of additional inflow during a range of design storm events, also to mitigate the risk of wastewater overflows to a 5year level of service (20% AEP), thus reducing the impact of uncontrolled flows into the downstream pumping station (Queen Street). With the use of in line retention it has been possible to store peak flows of the wastewater and to release these in a controlled manner ensuring downstream capacity is available.

Map 1 - Gardens Gully Catchment Overview

BACKGROUND

The Gardens Gully Catchment is predominantly a residential catchment with a large reserve area in the lower portion of the catchment. The catchment itself covers 191ha with a population of 3500 people. It consists of 3.7km of Main trunk line and with associated ancillary mains totals over 15km of Network assets, with the majority of the network installed in the early 1900's.

Historically the Gardens Gully Catchment is the Timaru Districts worst performing catchment, based on the frequency and number of wastewater overflows throughout the catchment. Predominantly these overflows will begin to occur in rain events around a 1 in 2 year event (50% AEP). (For Timaru this is approximately 35mm in a 24hour period or 10mm of rain in a 30 minute period.) There are several overflow points in the network that result in approximately 800m^3 of wastewater overflow onto private property, and over 100m^3 of overflow at the downstream pump station (Queen Street). The worst overflow is at a private property Buchan, where during rain events the Buchan is well below the hydraulic gradient resulting in a geyser 0.5m to 1.5m high for the duration of a portion of the rain event.

Based on recent flow analysis of the catchment, the peak average daily flow at the lower pump station (Queen Street) for the catchment is 55 l/s. This includes the inflow from an adjacent catchment. Peak dry weather flow for the catchment alone is 37 l/s. The additional inflow is controlled by another pump station and has a maximum discharge rate. During wet weather the peak wet weather (20%AEP) inflow to the Queen Street pump station from the gardens gully catchment rises significantly to 137 l/s which doesn't account for the wastewater overflow within the network.

There are several factors influencing the frequency and amount of overflow of wastewater within the catchment, these include:

- Significant property infill within catchment increasing the average daily flow. Illegal stormwater connections to the network resulting in inflow of stormwater, significantly increasing peak wet weather flows.

- The location of the current wastewater network being in the bottom of the gully with, large diameter concrete stormwater pipes following the same alignment directly above the sewer is adding to the infiltration to the wastewater network.

- The sewer main itself has been predominantly assessed as condition grade 5 (Worst possible) based on the New Zealand pipe condition manual from CCTV records, which further compounds the infiltration problem.

LINKAGES TO COUNCIL PLANS AND STRATAGIES

Several dependencies were identified, which included, the WWSSA (Water and Waste Sanitary Services Assessment) for Timaru Urban Area, the LTCCP (Long Term Council Community Plan), and The Councils Capital works budget.

The WWSSA for Timaru urban area showed the statement of Timaru's District Councils intended role in meeting the current demand for the existing wastewater reticulation to be a secure service up to and including a 1 in 5 year event.

The LTCCP provides current target levels of no more than 8 overflows per 1 in 5 year event for the entire district. Currently The Gardens Catchment alone has at least 6 overflows per 1 in 5 year event. The implication of this legislation means any major upgrade within this catchment will require a significant upgrade of the existing level of service to meet the criteria.

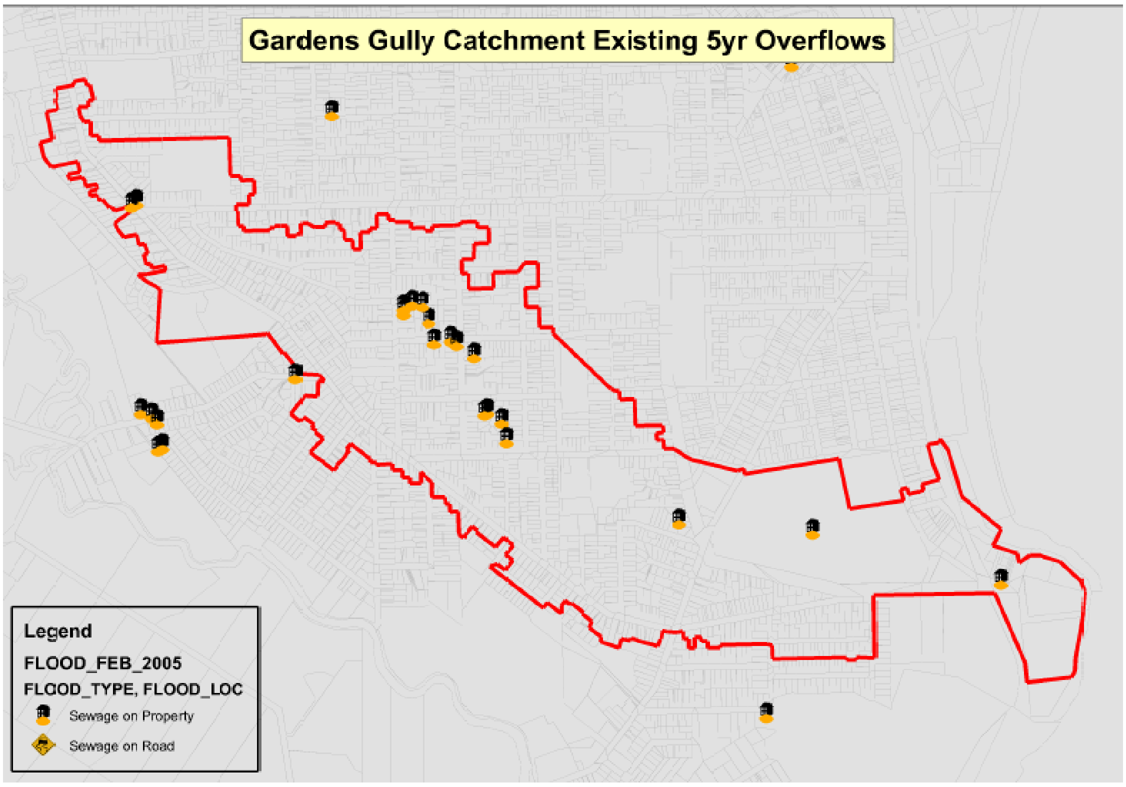
Council budgets allocated $1.9 million dollars funding for this project, and with over 3km of main trunk sewer potentially to be upgraded and difficult construction areas through private property, keeping within this budget was going to be a challenge in itself.

THE GARDENS GULLY MODEL

An essential tool for any major renewal process in today's increasingly technology driven environment, involves, building and calibrating a hydraulic model. Once completed several scenarios can be modeled quickly and efficiently to ensure the most economically and engineering practicable option can be selected and implemented that minimize the risk of the project failing to meet the performance criteria.

The hydraulic model for the Gardens Gully project was built using Infoworks CS. Existing survey and engineering plans provided the majority of the data required to complete the base model. Additional survey and inspections were undertaken where required to ensure the model accurately represented the wastewater network. During this period an eight week flow survey was undertaken, which included, very fortunately, three significant rain events to enable accurate calibration.

The calibrated hydraulic model, produced excellent results in comparison to actual flow data, and also reproduced known overflow issues from historical observed data. (Map 2)



Map 2 – Historical Overflows

DESIGN SCENARIOS – Conventional approach

As part of the conventional approach several design scenarios where applied to the base model. These scenarios included upgrading the main gully pipe diameter sufficiently to meet the required level of service. Currently the main trunk ranges in pipe size from 225mm diameter to 300mm diameter, with critical response duration of 30mins in a 1 in 5 year storm event. Upgrading the majority of network to 300mm diameter on the existing grade and alignment did not produce any significant reduction in the amount of overflow due to the predominant hydraulic gradient, in common overflow areas. The second option trialed was to upgrade the trunk main pipe to 450mm diameter, the larger pipe allowed some room for storage during times of peak flow. This option only slightly reduced the overall amount of overflow in the problem areas, although it did mitigate one problem area, but effectively only shifted the problem downstream. A pipe upgrade of 450mm to 600mm diameter was also trialed. Modelling results showed this option mitigated sewage overflow to the required level of service, with one exception, the downstream pump station (Queen Street) becomes inundated with wastewater resulting in an extremely large overflow at the station. It was thought with this pump station due for an upgrade or replacement with a gravity system within 5 years this option could still be feasible and was used for comparison purposes.

To mitigate the overflow and provide the required level of service it was now becoming clear a regular upgrade option was not going to be feasible with the cost of a 600mm Dia upgrade throughout the catchment being very costly and significantly disruptive to residents, a new approach had to be taken.

AN ALTERNATIVE WAY OF THINKING

Conclusions were reached that storage of peak wastewater flows were required to meet the required levels of service effectively and efficiently.

Stemming from the idea of utilizing larger pipe diameters to provide some retention of additional inflow, scenarios were trialed in the model of large diameter in line retention tanks, with flow regulating devices known as hydrobrakes, while slightly increasing the size of trunk main to 300mm diameter.

The Retention Tanks

The retention tanks (Fig 1) designed for the Gardens Gully upgrade are made up of 1200mm Dia PKS (Profile Kanel System) pipe in 6m lengths to be electofusion welded together on site, totaling over 100m in length for each retention tank. The upstream end of the tanks, have had a 50mm thick polyethylene sheet extrusion welded to end to seal the end. A 300mm diameter PE pipe was cut in half horizontally, and extrusion welded to the bottom of the 1200mm diameter retention tank, sheets of polyethylene were also extrusion welded at a grade of 1in8 from the top of the half pipe to the wall of the retention tank to help keep the tank clean after an event when the tank has been operated. This effectively created a modern day egg shape sewer. The downstream end of the retention tank is attached to a manhole which houses the hydrobrake, and allows for internal access to the retention tank.

The retention tanks have been designed to maintain required self cleaning and minimum velocities of 0.7m/s. This velocity is also required to efficiently operate the hydrobrake. By the inclusion of a DWF channel incorporated into the bottom of the retention tank, the required velocities were achieved.

Odor control has been addressed for the retention tanks via a connection between a network pole vent to the manhole at the end of the retention tank. The vent inlet is above the maximum surcharge level to ensue the tank is vented at all times and especially during times when wastewater is being stored.

The Hydrobrake

The hydrobrake (Fig 2) is a flow regulating device and was chosen for its ability to self control the flow to the required level of service whilst reducing the risk of blockage by providing an increased discharge diameter over a conventional orifice or pinch valve. The hydrobrake has been designed by Hydro international and operates by, allowing normal flow to continue downstream uninterrupted, but as flow increases through the hydrobrake to a point where, as the head of the flow increases the hydrobrake self vortexes thus allowing some of the flow to continue but at a limited capacity, thus beginning the process of filling the retention tank. With the ability to self regulate the flow it also removed the cost of any telemetry set up to control it, and also removed the need to manually operate it during times of wet weather. The hydrobrake, although with a high capital cost, has a lower overall lifecycle cost due to reduced operational and maintenance costs as compared to mechanical or telemetry operated valves.

Known problems of ragging occurring on the hydrobrakes resulting in blockages have been addressed in the design on the chamber housing the hydrobrake. The normal flow channel in the manhole has been created to ensure a smooth transition between the wastewater and the hydrobrake leaving no sharp edges exposed, mitigating the risk of any potential blockage from ragging.

Final design

After identifying key locations where storage would be a benefit, 3 storage chambers and their hydrobrakes were inputted into the model. Modelling results showed the two upper catchment storage chambers provided excellent relief from overflows, whilst the downstream storage chamber provided little benefit. After analyzing the modeling results of the downstream catchment overflow issue (Craigie Ave Geyser) it was determined that the cause of the downstream pipe network surcharging was due to limited capacity.

The model was then re simulated with only 2 storage chambers upstream, and two pipe size upgrades. The desired result was achieved, mitigating all overflows within the catchment to the 1in5 year level of service. This option also provided an increase in peak time of concentration for the catchment, providing an extra buffer for the downstream pump station (Queen Street) in times of peak flow.

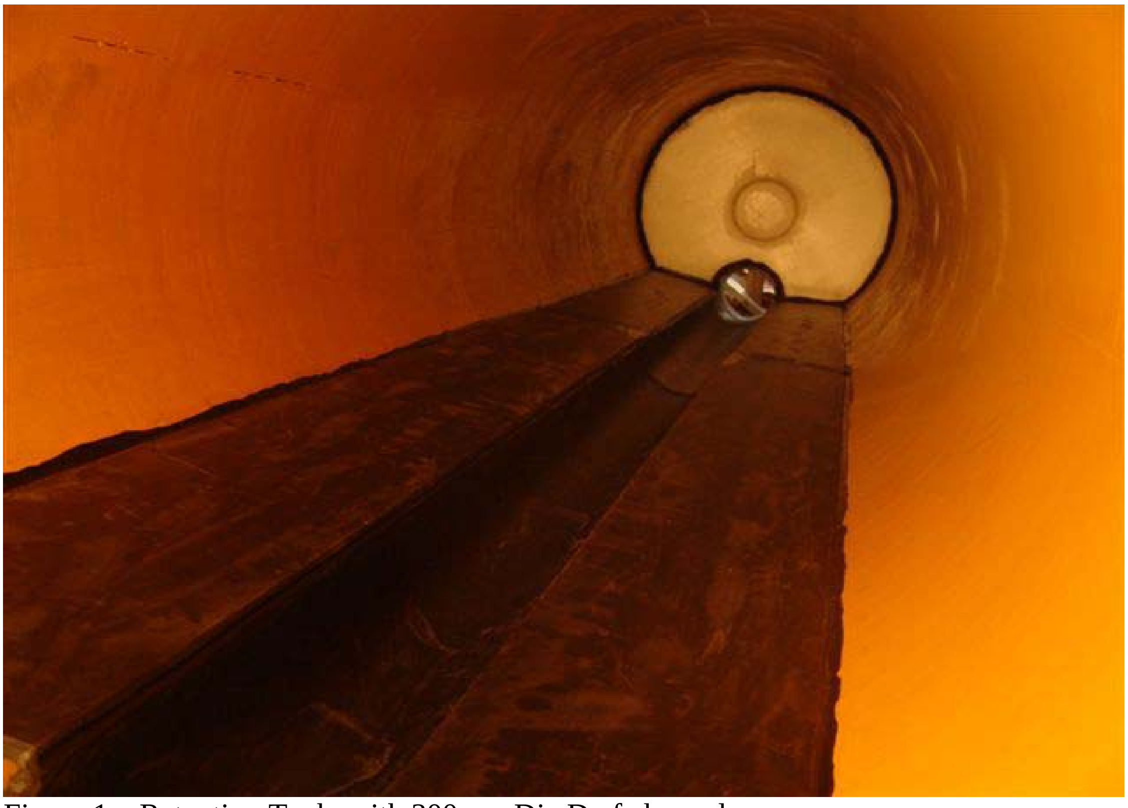


Figure 1 – Retention Tank, with 300mm Dia Dwf channel

Figure 2 – Hydrobrake & Cross section of Installed Hydrobrake

OPTION COMPARISONS

The two options that provided the required level of service were;

- The storage chamber option (Option 1)
- The large diameter trunk main option (Option 2)

These were then assessed further in terms of community impacts and benefits, overall net improvement to the wastewater reticulation, and economic viability.

Community Impacts

Community impact was a significant consideration with this project as over 50% of the trunk main is located in private property, and in some cases the main runs very close to existing buildings. With the storage option (Option 1), the chambers have been designed to be installed on sites located within the road reserve, and the size of the gully main upgrade for the storage option was minimal and viable to be installed using trenchless technology methods. The large diameter trunk main option (Option 2) required pipe sizes of 600mm diameter exceeded the capabilities of the current machines to directional drill. Therefore this option would have to be installed using open cut method, causing major property disruption for the duration of the project, and risk potential property damage with deep trenches close to dwellings.

Overall net improvement to the network

Option 1 achieved the required level of service, provided an increase in time of concentration of peak flow for rain events, improving the ability of the downstream pump station to cope with large rain events, and with the storage chamber managed to keep overflow locations to the same areas for larger rain events (greater than a 10% AEP). Option 2 also meet the required level of service, but had a negative impact on the downstream pump station by allowing the peak flow to increase and reducing the time of concentration, inundating the pump station during wet weather flow. The overflow locations also remained constant for option 2 in larger rain events due to a very similar hydraulic gradient as the existing trunk main.

Economic Viability

This was assessed in terms of overall project cost, available budget, and cost per metre of upgraded network to meet the level of service. The cost of option 1 was estimated on the basis that, it will require 1400m of trunk main to be upgraded to 300mm Dia installed using trenchless technology methods, i.e. directional drilling, require 19 fully sealed Manholes, 2 storage chambers with their associated hydrobrakes, and involve the replacement and alteration of 8 private service connections and the reconnection of 40 service laterals. This option's estimate was put at $1.5 million which equated out to be $1071 per metre of network upgraded. A second independant estimate was also obtained and confirmed the initial estimate. Option 2 was estimated on the basis that, it will require 1400m of 450mm Dia upgrade and 1400m of 600mm Dia upgrade. With these pipe sizes, micro-tunnelling was really the only trenchless option available, and with the high costs associated with micro tunneling it was decided to cost the project as an open cut trenching method. The project also required 28 manholes, and the re connection of 52 connections. This option was estimated to cost $4.5 million, which equated out to be $1607 per metre of network upgraded.

The table below summarizes the difference between the options, with the storage option clearly the better option in terms of community benefit, with a lower overall cost, minimal property disruption, providing a 20% AEP level of service, and future benefits with a reduction in overall network costs with less impact on the downstream network.

Table 1 - Summary of Option Comparisons

	Option 1		Option 2	
Project cost estimate	$1,500,000	☺	$4,500,000	☹
Cost per metre of Upgrade	$1071/m @1400m	☺	$1607/m @2800m	☹
Community Impact	Minimal	☺	Major	☹
Community Benefit	20% AEP, 0 Overflows	☺	20% AEP, 0 Overflows	☺
Downstream Effects	Minimal	☺	Significant	☹
Network Benefit	Positive	☺	Negative	☹
Overall	☺☺		☹☹	

CONCLUSION

An alternative way of thinking has led to an integrated approach of asset upgrade and renewal, by using the latest technologies available to achieve the project goals.

The use of hydraulic modelling has enabled this project to be designed to its peak potential and compared and evaluated against all other available options to achieve the goal of providing the level of service as set out in council policy, whilst maintaining economic viability.

By utilizing in line retention and using hydrobrakes to regulate the flow, the Timaru District Council has been able to significantly reduce the capital outlay for the project, reduce the overall depreciation on the network, increase the overall time of concentration for the catchment, improve the inflow regime into the downstream pump station, and has minimized the impact on the community by enabling the use of trenchless technology through private property.

Managing the flow through the Gardens Gully Catchment is a key component and fits with the overall wastewater network renewal strategy.