Engineers & Consultants

Kaitaia Wastewater Overflow Reduction Study

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Abstract

The Far North District Council (FNDC) has experienced a very high frequency of wet weather wastewater overflows resulting in community concerns and an abatement notice from the Northland Regional Council. Initial estimates to improve the situation also raised community concerns around the ability to fund improvements. FNDC commissioned a study to find the best value solutions to improve the network and reduce wet weather overflow frequencies to one spill per year or better.

The investigations adopted two significant changes to a traditional approach when seeking solutions to network performance issues. Firstly the point of diminishing returns was established using a cost benefit approach. This included consideration of a wide range of options to identify the best value solutions. Secondly a long term rainfall series was used, rather than the use of design storms, which do not reliably reflect the performance of the system. A previously built and calibrated model was made available for this study. A verification process was undertaken to assess the reliability of the model and its limitations.

This paper discusses the background to why these alternative approaches are preferred, as well as the outcomes. The paper also discusses the results of the different improvement types that are possible, given the interesting hydraulic attributes of the network.

Significant cost efficiencies have been identified and put to FNDC for consideration.

Keywords

Wastewater network, wastewater network performance, overflows, containment standard, cost benefit analyses, cost optimisation

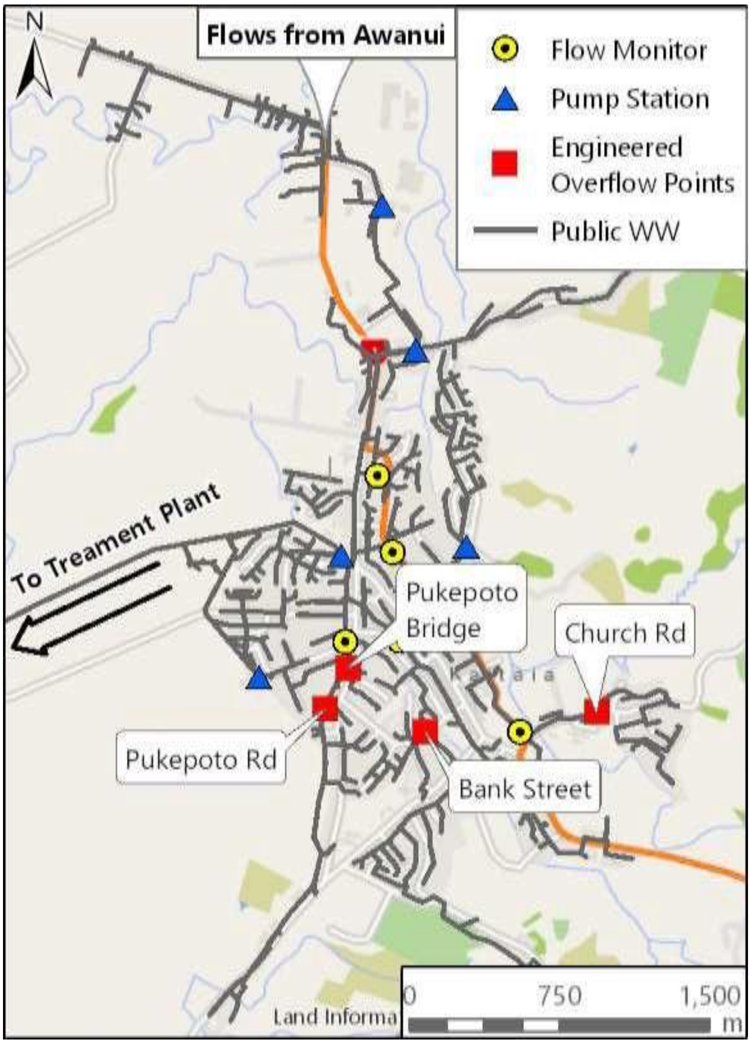

Figure 1: The Kaitaia Wastewater Network

Presenter profile

Jan Heijs has more than 35 years' experience in water management in New Zealand and The Netherlands, offering strategic advice in stormwater and wastewater management, water sensitive design, green infrastructure and asset management. Jan has championed many initiatives related to water management including community participation.

1.0 Introduction

1.1 Study Background

Far North District Council (FNDC) owns and operates the wastewater network and wastewater treatment plant servicing Kaitaia and Awanui. This network is approximately 44 km long with a total of 18 pumping stations. The majority of the system was installed in the late 1950's to early 1960's and is starting to show its age with increasing inflow and infiltration (I/I) evident in wet weather overflows, another is dry weather capacity in some locations. There are around 15 overflow events observed during a typical year.

Figure 1 shows a map of the Kaitaia wastewater network, including the key overflow locations. In most of the maps used in this paper only the central area including the key overflow locations will be displayed.

Investigations related to wet weather overflows and solutions go back many years. These included flow gauge studies, I/I analyses, the development of a hydraulic model and subsequent upgrades. The latest version of the model was completed in May 2016. At this time it was recalibrated based on more recent flow gauge information from 2015-2016, as well as telemetry data from pumping stations and overflows.

An initial study in 2010 estimated the costs to contain the wastewater volumes predicted in a 1-year, 2-year and 5-year storm event being respectively, $13.7 million, $16.6 million and $25.95 million dollars. Based on this study, consultation was undertaken and Council opted to aim to contain the wastewater volumes predicted in a 1-year storm event and included $13.7 million dollars in their Long Term Plan, showing a commitment to address this issue. The 2010 study was based on a previous version of the hydraulic model, not on the re-calibrated model.

In April 2016, the Northland Regional Council issued FNDC with an abatement notice to cease discharging untreated wastewater. The media had picked up on this issue several times over the last decade calling for action and expressing concerns around costs to fix the problem (Figure 2).

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Sewerage system repair cost soars

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With no money set aside for the upgrade, it would have to be included in the council's 2015-25 Long Term Plan, Mr Somers said.

Infrastructure committee chairman John Vujcich said the new councillors only learned of the problem a few weeks ago

Figure 2: Newspaper article

The overflow reduction study was both to address concerns raised by FNDC and the Kaitaia community and in response to the abatement notice.

1.2 Wastewater Network Performance and Regulation

In an ideal world a separate sewer network would collect and convey all wastewater inputs to a treatment facility for processing; before discharging an effluent of suitable quality, to the environment. In practice many networks do not operate in this manner, with intermittent discharge of raw untreated wastewater to private properties and waterways occurring. These discharges or overflows occur through two differing mechanisms:

- Controlled, through an engineered overflow point (EOP), and
- Uncontrolled, through a manhole lid, gully trap or catchpit.

At some point, under a certain rain event, all wastewater networks hydraulic capacity will be exceeded and a spill to the environment will occur. The occurrence of these spills is legislated through the Resource Management Act (RMA), where generally a containment standard is developed including the consideration of community expectations and affordability. Once a Local Authority has developed its desired containment standard, this is usually encapsulated in a Network Discharge Consent (NDC) which regulates the performance of the wastewater network with the regulator responsible for overseeing its application by the network operator. A NDC often also defines:

- The capacity of an existing network and its ability to accommodate growth, and
- The improvement works to meet the NDC performance target.

1.3 Wastewater Network Performance Theory

Water entering in a separate sewer network can be classified into three sources:

- Dry Weather Flow (DWF): a combination of domestic, commercial and industrial loads,
- Rainfall Derived Inflow and Infiltration (RDII), rainfall which enters the wastewater network from a variety of sources,
- Groundwater Infiltration (GWI), water entering the network from the groundwater table.

The above three water sources combined can overwhelm the wastewater network capacity, causing a spill to the environment.

Most gravity wastewater networks leak and receive some amount of RDII and GWI; these wet weather inflows generally dominate sewer capacity and for a significant enough storm (and antecedent condition combination) a sewer can be overwhelmed by this water, causing a spill to the environment, with excessive RDII being the mostly likely reasons for sewer failure. Hence understanding the RDII response is critical to assessing how the sewer network could be overwhelmed and how frequent this occurrence of failure is expected to be; and this defines the sewer network capacity.

RDII is a complex phenomenon that is difficult and expensive to measure, represent and source, as amongst many other factors it can be both a point and diffuse source, enter both private and public assets and is highly dependent on antecedent conditions. Further the RDII characteristics are often unique to a given catchment and are not fixed in time i.e. deterioration of the network over time results in increasing leakiness. To quantify and reliably estimate RDII requires extensive data collection and planning resources, which allows the capacity of the sewer to be assessed. Understanding and representing RDII is crucial to assessing sewer capacity and its exceedance.

2.0 Purpose of the Study

In the initial tender process FNDC was asking to find solutions to improve the network to reduce wet weather overflow frequencies to 1 spill per year or better. The intent was to explore optimal solutions to eliminate overflows for 1-year, 2-year and 5-year storm events using design storms to carry out performance analyses. The investigation and analysis was to consider a range of possible solutions to enable FNDC to determine the most appropriate solution and strategy to resolve the issues.

FNDC wanted I/I reduction to be considered but was aware of the limitation of what reductions could be realistically achieved. It was important to provide for a transparent and comprehensive process so that all potential options were adequately investigated.

During the scoping process Morphum suggested a fresh approach and to modify the process for two main reasons:

1. Using design storms does not reflect actual performance and
2. The choice of adopting a 1:1 year performance standard was not based on a comprehensive cost-benefit analysis.

This resulted in the use of long-term time series rainfall data for performance analysis, and a cost benefit approach to options development.

2.1 Use of Design Storms vs. Use of Long Term Time Series

Using design storms to assess network performance has limitations. Every individual storm has its own characteristics. Also antecedent soil conditions play a very important role in the system performance of a separated sewer network, equally as important as the rainfall characteristics. Return periods for wet weather overflow occurrences are not the same as for rainfall events. A rainfall event in a dry season might not cause an overflow while the same event in a wet season will. Using a long term time series (LTS), a model that does reliably represent soil moisture effects (which affects I/I rates), and statistical analyses of the model outcomes (overflow events) provides a more robust understanding of system performance including overflow frequencies, volumes and duration.

Using an LTS approach could potentially also save capital investment because it is expected to be cheaper to achieve a 1 yr ARI overflow performance frequency vs achieving full containment during a 1 yr ARI rainfall event. Section 7.1 provide further detail on this specifically for Kaitaia.

For the purpose of this paper we will use the term ARI (Average Recurrence Interval) for overflow performance, unless otherwise stated. For example a 6 month ARI is one overflow per six months or two overflows per year, a 3 month ARI is one overflow per three months or four overflows per year and a 2 year ARI is one overflow per two years, etc. Overflow performance outcomes are expressed as an annual average based on the use of the long term time series. Any one year will be different.

2.2 Setting a Performance Standard Based on a Cost Benefit Analysis

The justification behind the need for a performance standard based on a cost benefit analyses is based on:

a. The need to have a fit-for-purpose standard
b. The need to set this standard based on a full assessment of costs and benefits

Why do we need a fit-for-purpose network performance standard?

A network performance standard can be expressed as a spill frequency or have a (pipe) capacity as a target. Some network operators use a theoretical peaking factor as a performance standard, such as four times the Average Dry Weather Flow (ADWF). Others have no clear performance standards and as such may be operating in a reactive mode and consequently responding to perceived system failures, but without a benchmark to determine whether this is true or not.

A peaking factor is still used when designing greenfield wastewater networks, however a modelled peaking factor provides limited information about the actual performance of an existing network, whether it cause overflows or whether it can cater for future growth. For example, some parts of the network might experience peaking factors of well over four times the ADWF and don't have overflows or other capacity issues while other parts of the network have overflows with peaking factors well below four times the ADWF. It is not uncommon that parts of the network, that were designed many decades ago, have loadings well above their design assumption but don't experience any issues.

If a network performance standard is available, this will enable the network operator:

- To benchmark performance. When is the performance too bad?
- To use actual performance (using a calibrated model) rather than a theoretical peaking factor to target any money spent on resolving or preventing real issues.
- To justify capital works and help prioritise these works.
- To assess development applications and the ability of the network to service growth.
- To provide a transparent framework for reporting performance in severe events. This is required in order to avoid reactive and expensive network upgrades to address a problem that occurred during an event that the network was not designed to provide for.
- To use as the basis for a network discharge consent application. Regional Councils in New Zealand increasingly include a network performance standard in their consent conditions. The recommended cost-benefit approach is in keeping with the Best Practicable Options (BPO) approach in the RMA and has been proven to be very useful in consent processes elsewhere.

Why use a cost benefit method to support a network performance standard Thorough analysis of the costs and benefits of achieving a range of performance standards is important to ensure an informed decision is made when setting a performance standard. Figure 3 shows a typical illustration of diminishing returns. As in many cost benefit assessments, the law of diminishing returns has been shown to be applicable to wastewater network projects we have been involved with.

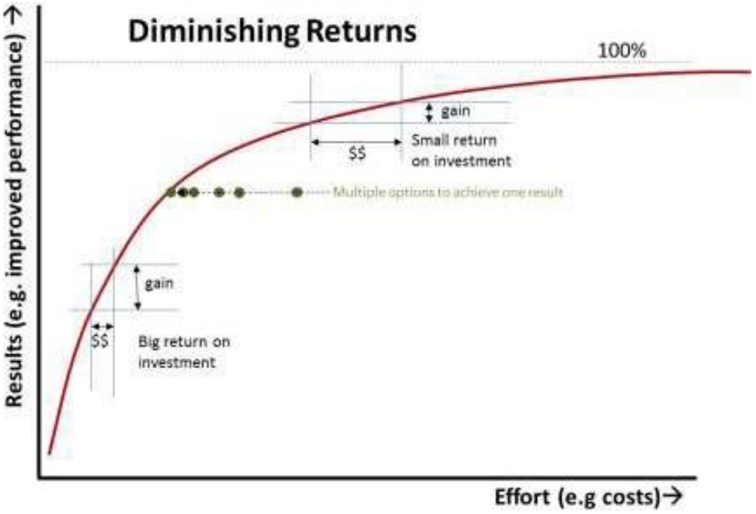

Figure 3: Typical diminishing returns graph

In addition to looking at the monetary costs, other non-cost criteria should be considered, for example by using a Multi Criteria Analyses (MCA).

3.0 Project Process

A flexible project direction framework was adopted that included a number of holding points mainly after key milestones, so that the scope of further investigations could be altered based on learnings of the work undertaken in the previous stage.

The project was broken up into five key phases, being:

- Phase 1: Information Gathering
- Phase 2: Existing and Future System Performance
- Phase 3: Option Analyses and Cost Benefit Assessment
- Phase 4: Decision on Future Performance Target
- Phase 5: Implementation Strategy

This paper is focused on phases 2, 3 and 4.

4.0 Model Reliability

It is important to ensure that solutions aren't being developed to solve fictitious model issues which don't actually occur in the network. The wastewater model of Kaitaia, while calibrated, is only a representation of the actual network and dependent of the quality of asset data, the gauge data and the locations of the flow gauges used. The calibrated model may over or under state network performance.

To achieve this the model needs to be "ground truthed" as much as possible. However once confidence is gained the model becomes an invaluable tool in developing an optimal solution set, the scoping of solutions and as an operative model going forward.

At the start of this study a model verification process was undertaken, comparing model results to telemetry data, observations by operational staff and a comparison of modelled and gauged results during a few rainfall events.

Overall the model was determined to be of moderate reliability. The model was found to be more reliable looking at the EOP performance on the trunk lines, and less reliable in the small sub-catchments at the top of the network extents. This can be explained by the fact that the model was not calibrated at that level. No gauging was undertaken in these smaller sub-catchments. Hence the modelled frequency and volumes from the uncontrolled overflows are considered less reliable and more monitoring is required to confirm the actual performance and possible future investments in these areas.

Another round of gauging and calibration would delay this project by 1–2 years, improve the reliability but unlikely have a material effect on these investigations. Because of this the model was deemed fit for purpose to undertaken the cost benefit analyses and cost optimisation. However, some of the recommended solutions may need further investigation and gauging to confirm scope. These additional investigations will be planned as part of the design process.

5.0 Existing and Future System Performance

5.1 Future Demand

Assumptions had to be made to define the future network and the future loads to reflect changes in the wastewater dry and wet weather flows over 50 years to assess future system performance under a 'do nothing/business as usual' scenario.

To establish this future hydrology, assumptions were made related to future growth, changes in land use, network extensions, changes in rainfall and changes in I/I. All assumptions will have some uncertainty. There was also uncertainty related to flow gauge results (as discussed in the previous chapter) that needed to be accounted for in future demand analysis.

The key uncertainties for future flows for the Kaitaia catchment are:

- Continuing deterioration of the network and associated changes in leakiness (I/I).
- The impact of climate change on rainfall and subsequently on wet weather overflows.
- Network extensions to accommodate new properties and possible growth in population (although this is not predicted) and changes in industrial/commercial discharges.
- Effectiveness of programmed I/I improvements
- Changes in expectations, legal framework (consents), costs, funding, priorities, etc.
- Changes in modelled performance as a result of more gauging in part to resolve model reliability issues

The effects of these uncertainties on the existing and future system performance and the future improvement programme is difficult to quantify. Some of the uncertainties will be able to be managed (in some way) at future stages of this project. The following approach was agreed:

1. Assumption of a 25% increase in wet weather flows over 50 years
2. Size of improvement works is based in this 25% increase. In cases where the incremental costs are shown to be significant and/or prohibitive, or when work can be staged lower flows could be used.

5.2 Assessment Framework for Overflow Performance

Using the LTS method, the performance of the network is presented spatially as annual average wet weather overflow frequencies related to two types of overflow locations (see also section 1.2):

- Engineered Overflow points (EOPs).
- Uncontrolled overflow locations.

5.3 Performance Assessment Outcomes

Figure 4 shows the existing system performance as an average annual wet weather overflow frequency using 6 years of rainfall data in the LTS. Table 1 shows the average annual frequency, volumes and durations for the existing and future performance at the four EOPs.

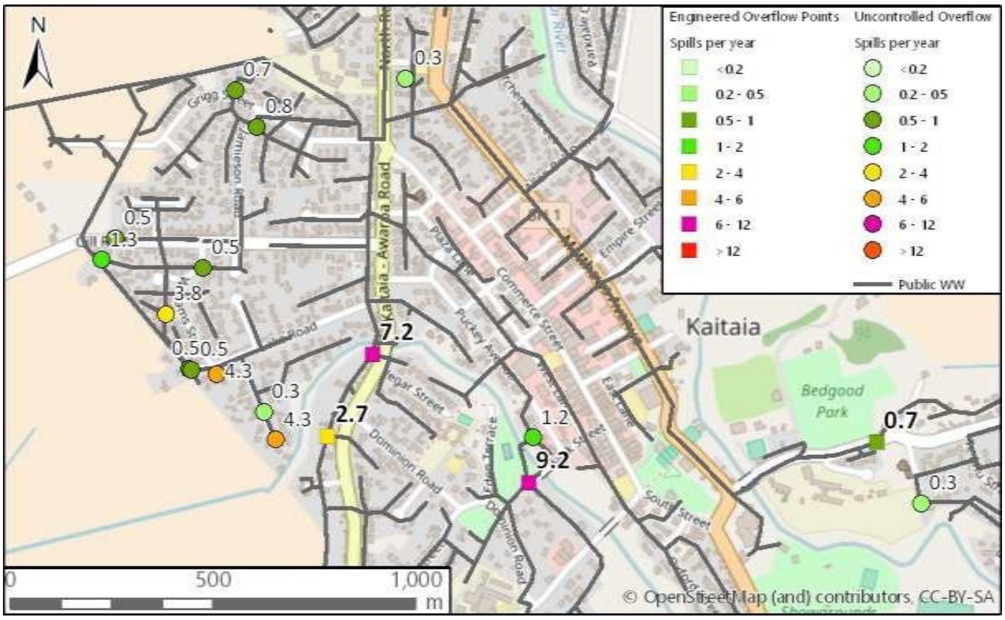

Figure 4: Existing system performance

Table 1: Average annual frequencies and volumes at key EOP locations under existing and future loads

	Frequencies [spills/year]			Volumes* [m^3/year]		
	Existing	Future	Increase	Existing	Future	Increase
Bank Street	9.2	15.9	73%	1,819	3,850	112%
Pukepoto Bridge	7.2	10.2	42%	3,911	6,766	73%
Pukepoto Road	2.7	4.0	48%	24	20	-11%
Church Road	0.7	1.8	157%	12	60	400%
Total EOPs				**5,766**	**10,696**	**86%**

**Volumes include volumes lost through uncontrolled overflows*

Observations

It was observed from the existing and future performance model runs that doing nothing will lead to a significant increase in already unacceptable high wet weather overflow frequencies and volumes. For example at the Bank Street overflow, a 25% increase in loads results in a 73% increase in frequency (from 9.2 to 15.9) and 112% increase in volumes.

Information provided by operational staff confirmed the high frequency of overflows of the EOP's but did not align with model results showing overflows from uncontrolled overflow points.

The volume calculated as spilling from the uncontrolled overflows has been assigned to the EOP's to ensure the total volumes are accounted for. This might lead to oversizing of the improvement works but the risk is too high not to account for these. Further investigations (flow gauging) might be required if resolving this issue can lead to significant cost savings. Remedial actions should focus on reducing overflows from these EOPs. Future investigations need to confirm or deny whether local uncontrolled overflows need addressing.

Closer hydraulic analyses confirmed that the overflows at Pukepoto Bridge and Pukepoto Road are largely caused by wastewater backing up showing inadequate capacity in the network to the treatment plant while the overflows at Bank Street are mainly caused by local loadings.

6.0 Option Identification, Cost Optimisation and Cost Benefit Analyses

Based on the outcomes of the existing and future performance assessment (see section 5.3) a range of solution categories were identified to test their effectiveness in reducing overflow frequencies. This part is discussed in section 6.1.

Subsequently more than 70 options were identified and hydraulically tested. These options were identified using an iterative process refining the scope of individual components to improve either the performance and/or reduce the costs. This part is discussed in section 6.2. A cost-unit database was used for the calculation of costs.

6.1 Option Identification and Initial Shortlisting

A number of generic solution categories were explored and tested as the initial stage of the option optimisation process. These tests were undertaken to verify (1) whether these types would be able to reduce the overflow frequencies and (2) to test whether order of magnitude of costs would already eliminate these option types from further consideration.

The solution categories were (some are diagrammatically shown in Figure 5):

1. Storage: In-pipe and (stand-alone) tanks.
2. Pass Forward: Increase pipe capacity through existing gravity mains through to WWTP.
3. Bisect and pump with a new rising main: Taking the South & West catchments to WWTP.
4. Increase Hydraulic Grade Line: between Pukepoto Bridge and WWTP.
5. Topping (re-routing North and East catchments): Upgrade existing pump stations or a new pump station at the bottom of those catchments.
6. I/I Programme (in combination with and separately from above options).
7. Real Time Control (RTC), including storage at PS's.
8. Do-nothing: This is the future system performance as discussed in section 5.3).

For most solution categories a number of iterations were undertaken to see whether changing diameters, storage size, pump capacities and network configuration would improve the outcomes.

Observations

It was observed that the overflows at Pukepoto Rd were of high/similar frequency to Pukepoto Bridge but that the volumes were very small. This would not warrant an isolated solution, in part because the two locations are relatively close to each other. The modelled flows might also be conservative due to the observations made in section 4. Hence it was recommended to have a common capacity upgrade to get the flows to Pukepoto Bridge and allow for that in all the scenarios but only progress with implementing this solution when the need is verified through additional investigations.

Storage options worked well for Bank Street but were not effective for Pukepoto Bridge because of backflow as mentioned earlier. The preference on tanks vs inline storage would be determined in a preliminary design phase mainly based on costs and constructability.

Passing forward flows by increasing capacity between all overflows and the treatment plant adequately reduced overflow frequencies in Bank Street but did not reduce the frequency enough at Pukepoto Bridge.

The bisect and pump solution with a pump station at Bonnetts Rd and new rising main to the treatment plant worked well for reducing overflow frequency at Pukepoto Bridge but not for Bank Street. Additional storage of improved capacity would be required to resolve this.

Also observed was:

- RTC and the topping options didn't show significant benefits and were not progressed.
- Church road has a relatively low overflow frequency and could be addressed in isolation.
- Inflow and infiltration in priority catchments (RDII>10%) in isolation did not adequately reduce overflow frequencies.

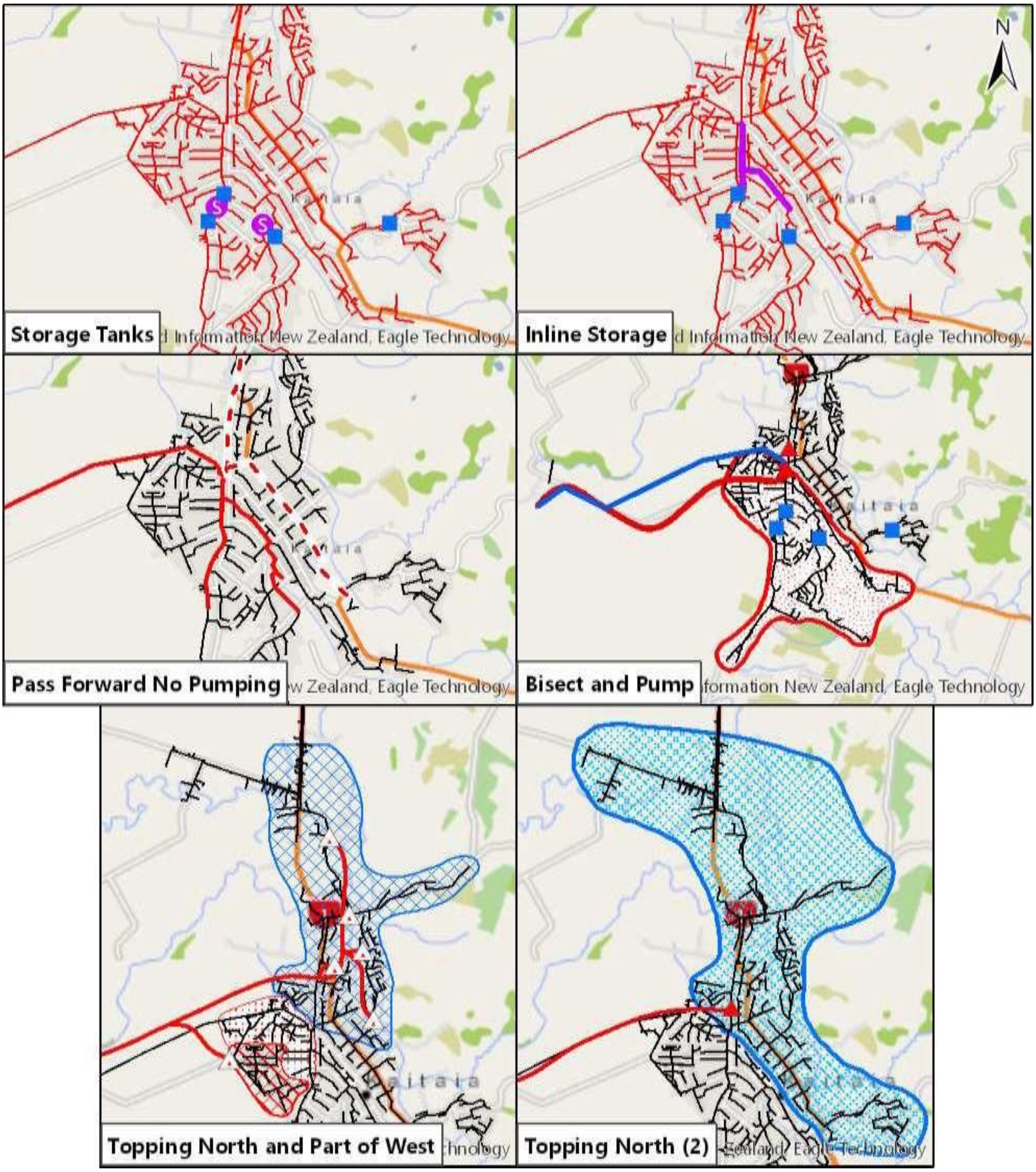

Figure 5: Main solution categories

6.2 Refinement, Cost Optimisation and Cost Benefit Analyses

The options developed, when testing the solution categories as discussed in the previous section and the learnings from this, where used to further develop more detailed and cost effective solutions.

The focus was to find options to meet the 1 year ARI containment standard, being the standard FNDC had adopted provisionally in the last LTP (conditional on further investigations). With every option the modelled performance was often different which generated cost and performance outputs across a wider range of overflow frequencies.

Many of the 70 options modelled have been discarded for a range of reasons, mostly because there was another similar option that provide a better outcome looking at costs and/or overflow frequency.

Figure 6 shows the best performing options showing their capital cost in millions, against their performance (containment standard achieved). Also shown is the budget available in the LTP to achieve a 1 year ARI containment standard. The options in three boxes represent the options that achieve a minimum containment standard of 3 month ARI (4 overflow per year), 6 month ARI (2 overflows per year) and 1 year ARI (1 overflow per year).

Observations

- There is a significant cost difference between having to meet a 3 month ARI compared to a 6 month ARI, but the cost to achieve a 6 month ARI or a 1 year ARI are very similar. This is mainly because the concept solution to achieve the 3 month ARI cannot be up-scaled to achieve the 6 month ARI standard, this is discussed further in section 6.3.
- The cost to achieve a 1 year ARI containment standards ($10.4M) is significantly lower compared to the LTP budget of $13.7M; a saving of 25%.
- This graph doesn't show the diminishing return shape (as explained in section 2.2) because the scale used on the y-axis uses a linear scale of return periods suggesting that there is no limit in what can be achieved. This graph however better allowed interpretation and comparing of individual options.

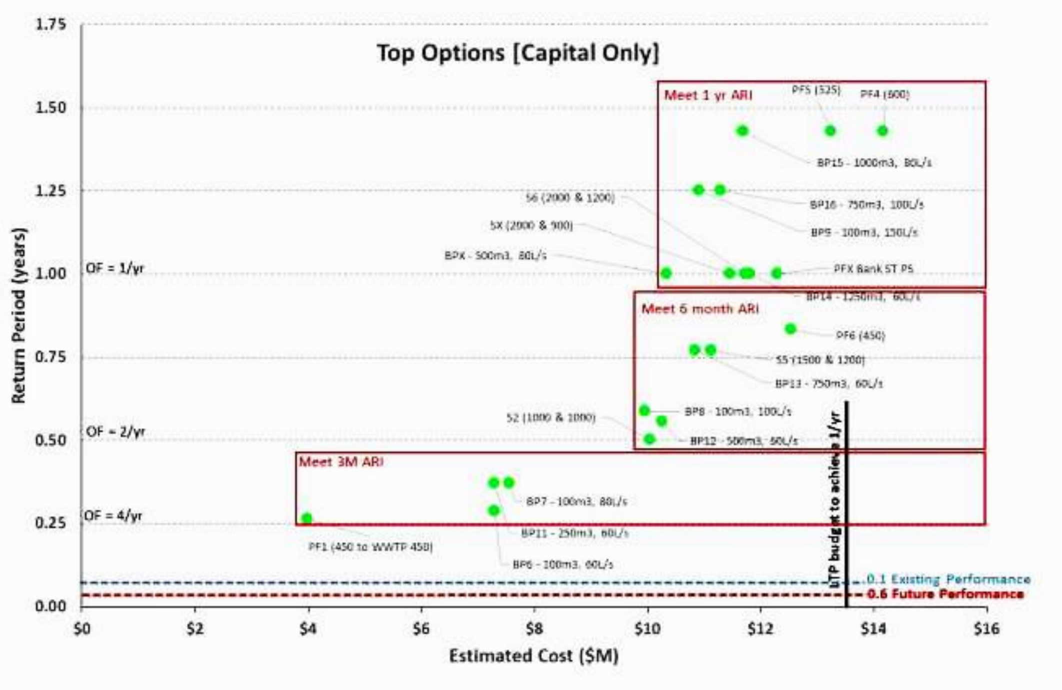

Figure 6: Top options – costs and resulting overflow performance

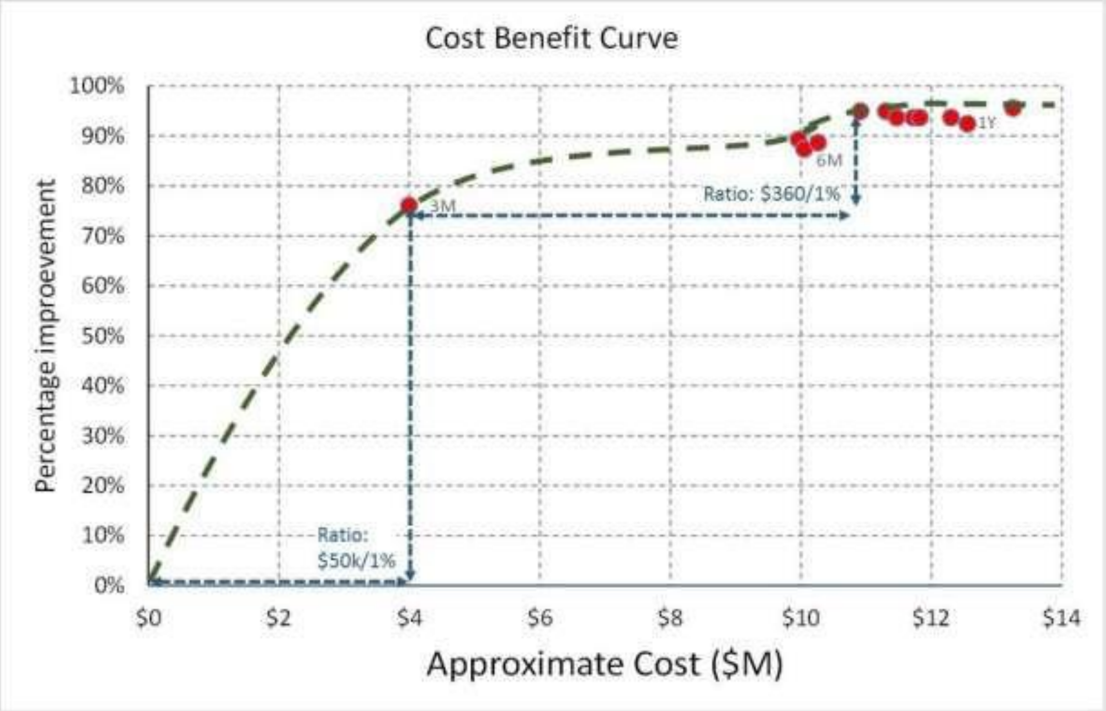

Figure 7: Cost Benefit Curve

Figure 7 shows the top options again but using the percentage improvement in overflow performance along to Y-axis as needed to demonstrate the diminishing returns. This graph clearly shows that a 76% improvement compared to 'Business as Usual' can be achieved for $4.0 million while it would take $10.0 million to achieve an 89% and $10.9 million to achieve a 95% improvement.

Expressed as a cost benefit ratio, the ratio (using cost in millions of dollars per percentage improvement) meeting the 3 month ARI option would have a ratio of 0.05 (or $50,000 for every percentage improvement) while meeting the 1 year ARI would have a ratio of 0.11 (or $110,000 for every percentage improvement). The incremental improvement would equate to a ratio of 0.36 (or $360,000 for every percentage improvement).

6.3 About Some Key Options in More Detail

Pass forward options

Figure 8 shows the pass forward options to meet a 3 month ARI standard (PF1) and to meet a 1 year ARI standard (PF5). These options rely on increasing the capacity of the trunk network.

PF1 only increases capacity by the construction of a 450mm line starting at the Bank Street overflow, past Bonnetts Road to a location just West of Kaitaia, where the flows are connected the existing line to the treatment plant. Because of the limited capacity of this existing asset and the consequential backflow, the performance cannot be further improved.

This frequency can only be further reduced by extending this new sewer all the way to the treatment plant (PF5) that clearly comes at a cost. The estimated costs for this option is $13.2M and achieves a 1 yr ARI.

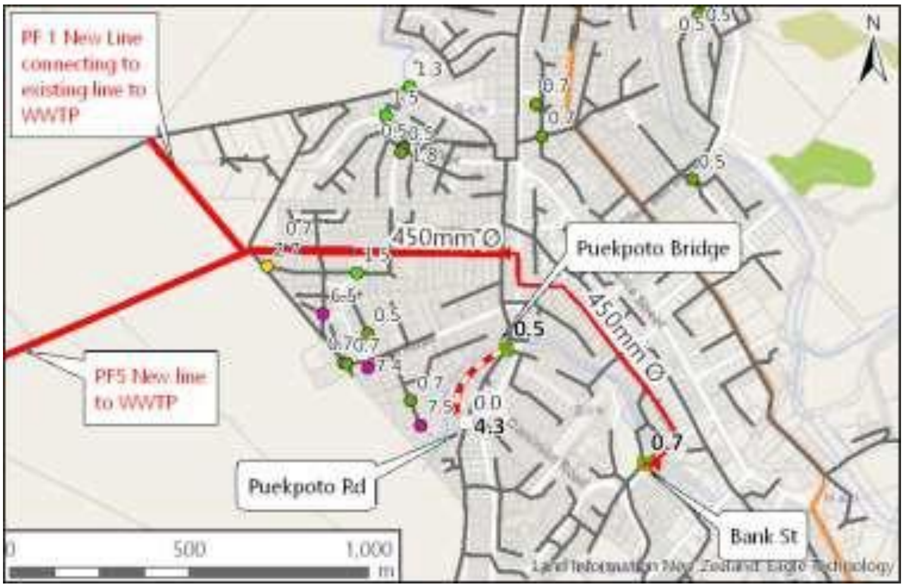

Figure 8: Top pass forward options

Storage options

Figure 9 shows the storage option to achieve a 1 yr ARI. It requires a storage tank of approximately 2000 m^3 at Pukepoto Bridge, 900 m^3 at Bank Street plus a small storage tank of 100 m^3 at Church Rd at a cost of \$11.7 M. The size to meet a 6 month ARI at these three locations are respectively 1000 m^3, 100 m^3 and 0 m^3 at a cost of \$10.1 M.

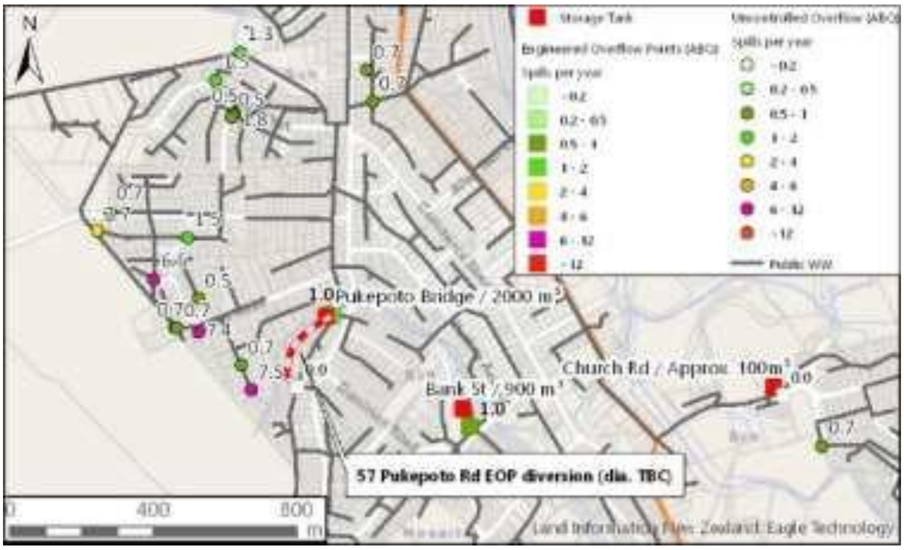

Figure 9: Top storage options

Bisect and pump options

The Bisect and pump options, as shown in Figure 10, has a pump station located at Bonnetts Road with a rising main connecting directly to the treatment plant. This option is more flexible because the capacity of the pumping station and the wet well storage can be varied. The option can also be staged with stage 1 achieving a reduction in overflow frequencies from a less than 1 month ARI (15 overflows per year) to a 4 month ARI and the full option is able to achieve a 6 month or 1 year ARI. Further investigations and clarification of some of the reliability issues could be used to refine the scope of the second stage. In other words the advantage of this option is that it is more future proof. The disadvantage of this option is that although the capital costs are similar to the other options to achieve a 1 yr ARI, the NPV costs are higher because of the pumping required.

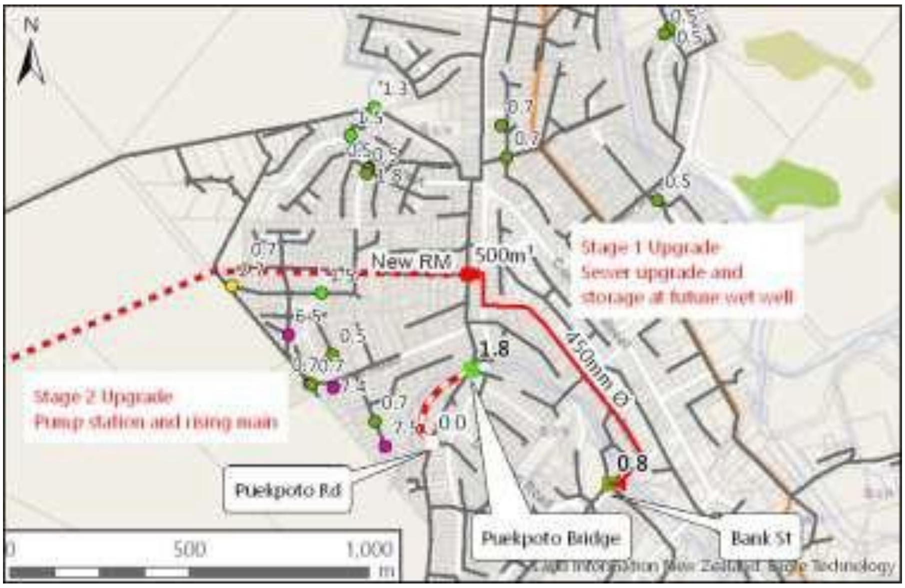

Figure 10: Top bisect and pump option

7.0 Discussion

7.1 Design Storm Versus LTS

As described in section 2.1, using design storms to assess network performance has significant limitations. This section utilizes the Kaitaia Wastewater model to demonstrate these limitations.

Figure 11 shows the relationship between soil saturation (antecedence) and spill volume for a given 1 year design storm rainfall across the range of 0% to 100% soil saturation. This figure clearly shows the sensitivity of the design storm to antecedent conditions. The red arrow in this graph shows the 1 year spill volume (annual average) based on using the LTS.

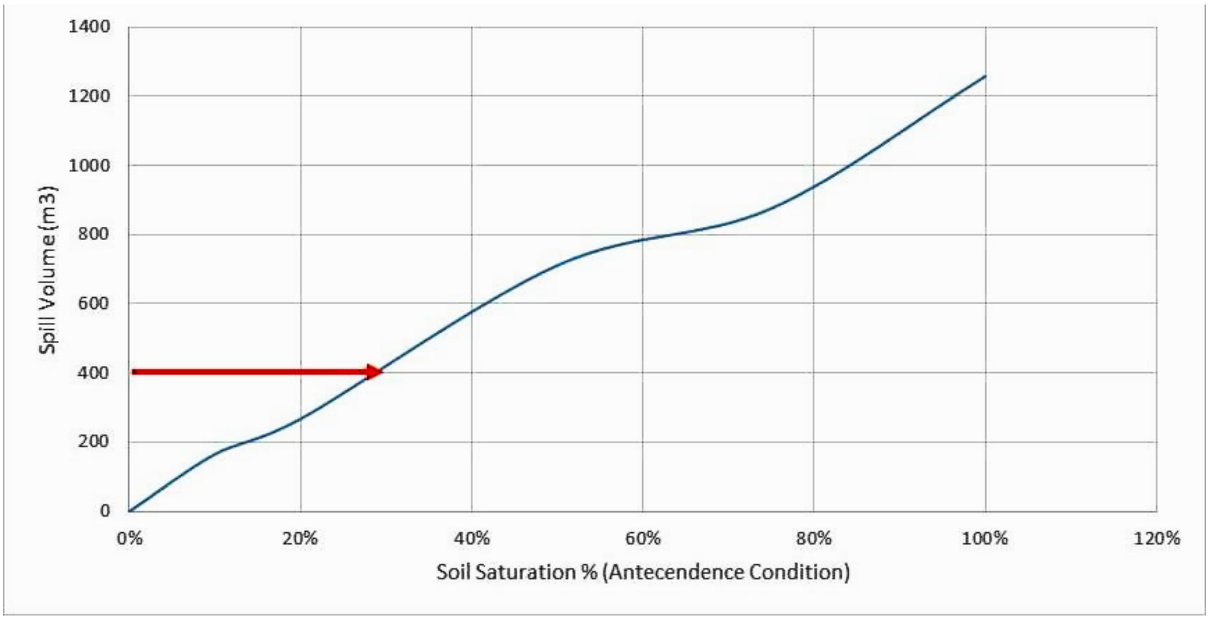

Figure 11: 1 year design storm rainfall, soil saturation vs. overflow spill volume

If a 1-year rainfall design storm is specified as the containment standard for a given catchment, this could be interpreted to mean that network should not spill for any 1-year Figure 10: top bisect and pump option design rainfall regardless of antecedent conditions, hence solutions should be sized assuming that the 1-year design storm occurs after an extended wet period with a 100% saturated soil resulting in spill volume for the below case tripling. On the other hand, if the adopted antecedent condition is a completely dry soil, then no spill is simulated to occur in Kaitaia network. This particular overflow used is known to spill several times a year. When adopting a 100% (or 0%) soil saturation in the model, the outcomes would misrepresent the actual performance of the network.

Figure 12 compares the rainfall profile for the 1-year design storm and the LTS rain event corresponding to the 1-year overflow volume. As this figure indicates this LTS rainfall event is less intense than the design storm rainfall, indicating the importance of the antecedent conditions.

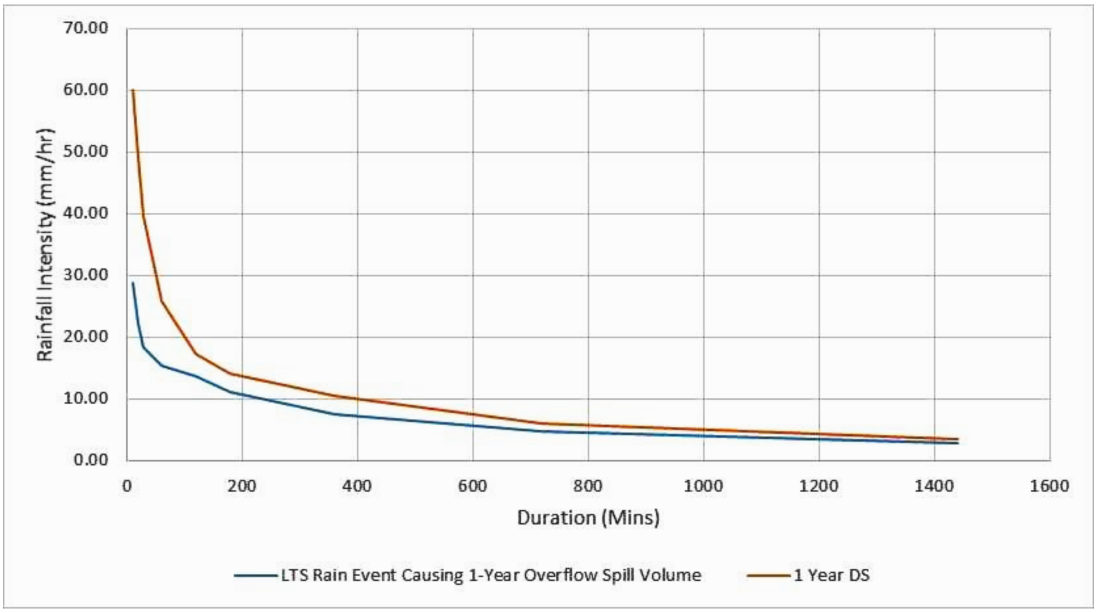

Figure 12: 1 year design storm and LTS rainfall causing 1 year overflow volume

7.2 What About Inflow and Infiltration?

The main cause of wet weather overflows is inflow and infiltration (I/I): stormwater entering the private and public parts of the separated wastewater network causing overflows. The model runs undertaken in the options assessment have demonstrated that reducing I/I only, doesn't achieve a sufficient reduction in overflow frequency. Experience elsewhere has shown that reducing I/I is expensive and has uncertain reduction levels.

Undertaking I/I reduction work in combination with condition driven renewals will reduce I/I in the long term and therefore will prolong the life (capacity) of the network and is good asset management practice. It can also reduce the scope of outstanding improvement project in the long term. FNDC has expressed the desire to at least not make the I/I problem worse. A hold-the-line objective as suggested is sound asset management practice.

Previous experience has shown that a "down-pipe and gully trap only programme" will not reduce I/I to a level where measurable improvements in network performance can be achieved. Conversely not including private properties in an I/I reduction programme would have a similar outcome. Results of private property inspections undertaken in the past show it is very likely that a significant percentage of public and private network need fixing.

To support this approach, previous experience has also shown that an industry with a certainty of an ongoing work volume is required to achieve consistent work quality. An ongoing budget for renewals (condition and performance driven) in the private and public network can support the establishment of a reliable local industry.

A common approach to address faulty private laterals is serving notice on property owners where I/I testing show defects and requiring residents to fix the issues. This is generally expensive (for home owners) and has proven very difficult to enforce. Given the socioeconomic status this may be even be more difficult in Kaitaia. During stakeholder consultation as part of the project, suggestions have been made by a number of parties (operations staff, Iwi, and Morphum staff) to use an alternative approach to address this issue such as a community based initiative with the added advantage of providing jobs, upskilling a small taskforce and creating local ownership of the problem. Such an approach might also attract alternative funding. This is currently being considered.

7.3 Final Decision on Future Overflow Standard Pending

At the time this paper was finalised, FNDC had not yet decided on the future containment standard. It is likely that this will also be depending on consultation with key stakeholders, including iwi and the Regional Council and be finally made in the context of the next LTP, where all Council expenses will be considered against affordability.

With the outcomes of this investigation, the Council is in a better position to make an informed decision. It can also be used to engage in discussions with the Regional Council as part of a network discharge consent process. The cost benefit approach is in keeping with the Best Practicable Options method as required under the RMA.

8.0 Conclusions

Using a Long term time series (LTS) was found to be more reliable compared to the use of design storms. The actual behavior of a wastewater network is significantly influence by antecedent conditions (soil saturation). Because these conditions vary widely, the outcomes of a design storm approach vary too across the range of soil saturation levels possible. Secondly a statistical based assessment of actual overflow behavior (what comes out) is a better representation of the network performance compared to the use of a return period of rain events (what goes in).

It is generally important to understand the reliability of the model and its limitations. In this study, the reliability of the hydraulic model was found adequate for this strategic planning project (cost-benefit and option analyses) but the scope of some of the improvement works should be confirmed using an updated model based on more detailed flow gauging in some of the locations.

The cost benefit analyses demonstrated that it is relatively cost effective to improve the number of wet weather overflows from 15 per year to 4 per year and much more expensive to improve it further to a 2 per year or 1 per year frequency. The diminishing returns clearly set in at about 4 overflows per year.

More than 70 options were considered to identify the most cost effective solutions to meet a range of performance standards. Some of these options have limitation as to what can be achieved looking at flexibility or whether they can be staged. The final choice of the preferred option will be depending on the containment standard adopted and the degree of flexibility desired.

When adopting the 3 month ARI, the Council could save 9.7 million dollar compared to what was allowed for in the LTP. When adopting a 1yr ARI the savings would still be $3.3 million or 25%.

Having a performance standard is important to justify expenditure and improvement works in a transparent way. This investigation has enabled the Far North District Council to make an informed decision on the future Containments Standard they want to adopt. Stakeholder and community consultation are yet to be undertaken before this decision is made.

In summary:

- Using a long term time series in network performance assessment provides more reliable and statistically more robust information on the performance of a wastewater network compared to the use of design storms.
- A detailed cost benefit approach will typically show diminishing returns relationship. This will assist in an informed decision for the adoption of a network performance standard
- A detailed cost option analyses looking at a mix of improvement solutions such as storage, conveyance and I/I reduction is required to identify the best value solutions to achieve a performance standard. In addition to cost, flexibility to adapt to future changes and the ability to phase an improvement programme are other important considerations.
- The basis for this type of study is a reliable hydraulic model. Undertaking a model verification and understanding the models limitations provides context when assessing the many model outcomes as part of the option analyses and also provides in indication about the reliability of the recommended improvement works and in which cases more (detailed) investigation are required to confirm the final scope.

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