THE IMPORTANCE OF MAINTAINING 'LIVE' STRATEGIC WASTEWATER PLANNING MODELS – A 3RD GENERATION MODEL

Richard Pullar, Wastewater Network Planner, Watercare Services Limited

Scott Wilkinson, Senior Network Engineer, SNW Consulting Limited

ABSTRACT

In 1998 North Shore City Council (NSCC) initiated 'Project CARE', their Council Action in Respect of the Environment Study to plan improvements to the city's wastewater system to protect streams and beaches. In 2002 this included the creation of their first trunk wastewater computer model, which has been progressively updated and was used as the basis for two asset planning review cycles under NSCC. Since the Council merger in 2010 Watercare has taken on the responsibility and maintenance of the Project CARE model. It is now known as the 'Rosedale Strategic Management Area (SMA) Model' - a third generation computer model which has the trunk network and key detailed models of the local network sewer areas included.

The Rosedale SMA is a highly pumped network conveying wastewater flows up to the Rosedale Wastewater Treatment Plant located at elevation RL 45 metres. The model has become a very powerful planning and operations decision making tool. Working closely with Watercare Operations, Energy and Controls Systems Teams, the Planning Team has been able to develop and fine tune pump station interstation control routines in the model and optimize the best possible use of available storage and opportunities for preferential wet weather spill locations.

Over the past 15 years a rolling programme of flow gauging, model updates and recalibration has taken place. Currently, the Rosedale SMA Model is being used to assist Watercare in the development of its Wastewater Network Strategy (a requirement of Watercare's Network Discharge Permit). As this model has been kept up-to-date i.e. 'live', it provides high confidence model outputs and history to assess completed improvement works, which will be further enhanced with proposed future flow gauging and recalibration phases. Quality of information and confidence in performance data is one of the key criteria required in Watercare's Network Discharge Permit for prioritizing improvement works.

Keywords

Strategic Planning Model, Inter Station Control, Network Performance, Project Development

1 INTRODUCTION

The Rosedale Strategic Management Area covers all of the North Shore area where wastewater flows are conveyed to the Rosedale Wastewater Treatment Plant (WWTP) located at Rosedale Road in the centre of the city. The Rosedale WWTP and transmission network were constructed in the early 1960's by the North Shore Drainage Board (NSDB), the plant is situated at an elevation of 45 metres which mean most of the contributing branch network are pumped up to the plant. It services a current residential population of 233,000 with a non-resident population equivalent of around 42,000. The resident population is forecast to grow to 330,000 by 2065, in addition flows from North West growth areas in Hobsonville, Whenuapai, Kumeu, Huapia areas to be diverted to Rosedale WWTP in 2021 and further flows to be diverted there from West Auckland in 2035.

The wastewater flows are pumped up from five large pump stations located in Wairau, Birkdale, East Coast Bays, Albany and Greenhithe. The North Shore wastewater network consists of 81 pump stations and 1,370 km piped network. In the strategic model we have included 23 pump stations, 9 storage tanks or tunnels and 135 km of branch network. The network also includes real time control or inter-station control (ISC) which manages key pump stations during wet weather to ensure fully utilisation of storage and spilling occurs at preferred locations.

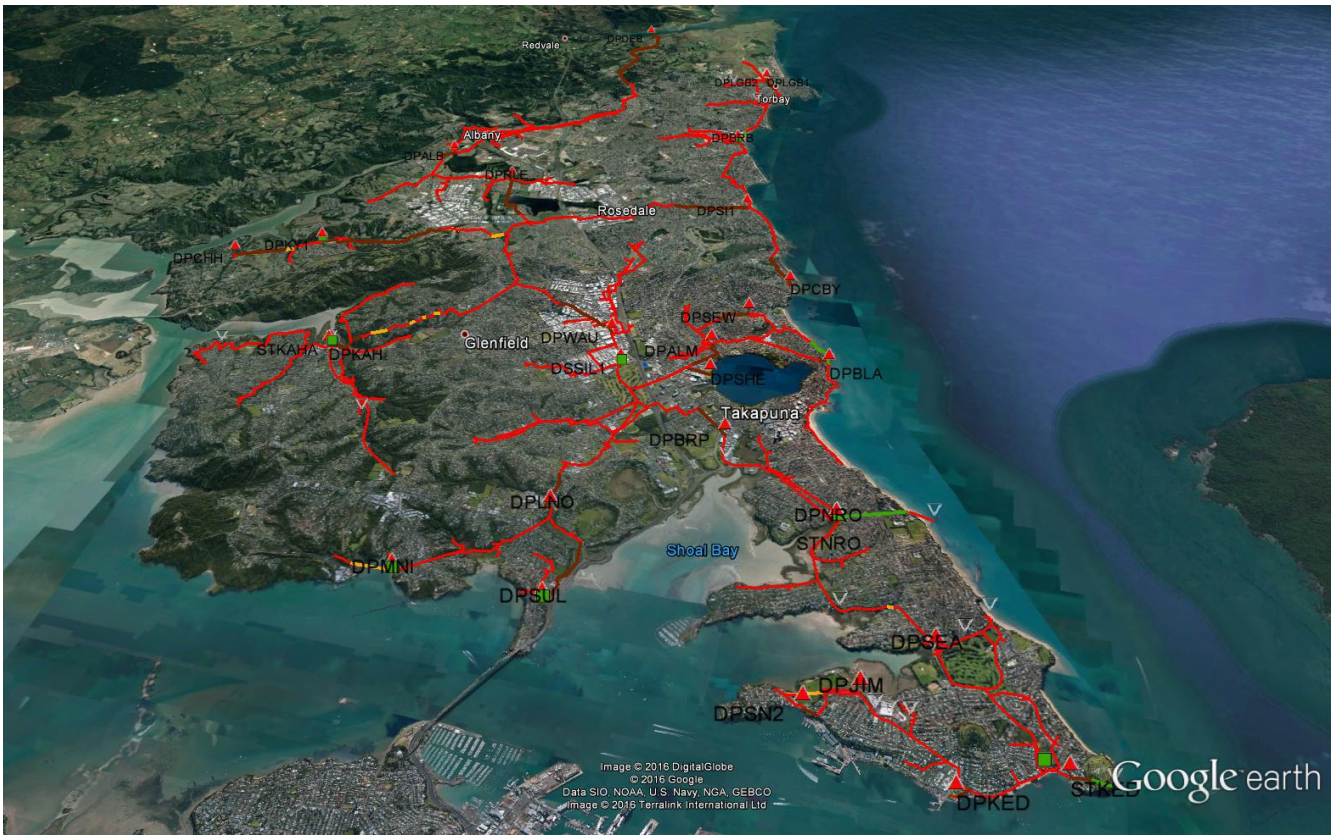

Figure 1: Rosedale SMA Wastewater Model Extents

Since 2002 Inflow and Infiltration (I/I) reduction projects have been completed in many of the older leakier catchments. Significant storage tanks and tunnels have been added to the network in Brown's Bay (4.5ML), Silverfield (6.5ML), Northboro (3.0ML), North Head (1.0ML), Kahika (4.5ML) and Long Bay (2.5ML). A branch sewer was also constructed through the Wairau Valley to allow excess wet weather flows to be stored at the Silverfield storage tank located under the North Shore Recreation Centre carpark.

NSCC were generally limited in the type of network upgrades that could be undertaken because of the peak flow limitations of Rosedale WWTP; options generally were flow reduction (I/I) or storage. However, with the completion of the new outfall to the Hauraki Gulf from the Rosedale WWTP in 2010 and plant capacity upgrades underway, options which include increased pass forward of flows to the WWTP are now being undertaken more regularly.

The network's performance has improved markedly in the past 15 years when previously the NSCC received regular adverse media coverage relating to wet weather overflows; especially to their many bathing beaches. For example, in 2002 Mairangi Bay had an average annual spill frequency of 12 and with the completion of the Browns Bay Storage Tunnel in 2006 it reduced to 6.5 spills per year. This will decrease to less than 1 spill per year with the upgrades to the Sidmouth Pump Station and East Coast Bay Branch Sewer which are currently being undertaken by Watercare. The upgrades proposed in East Coast Bays will also cater for growth through intensification in the catchment as well as Greenfield growth of 14,000 additional people in Long Bay at the top of the network.

The Proposed Auckland Unitary Plan will allow significantly more brownfield intensification, with revised population models likely to show more growth in many of the North Shore areas especially Takapuna, Northcote, Browns Bay, Albany, Long Bay and Greenhithe. The Rosedale SMA model has and will continue to be a valuable tool in allowing an improved understanding of the impacts of this growth and the development of optimal infrastructure solutions to manage those impacts.

The SMA model is needed to develop the Wastewater Network Strategy which is required to be undertaken on a 6 yearly cycle in Watercare's Network Discharge Permit. The strategy reports on improvement works completed and current network performance achieved. It details the future work programme proposed to cater for growth and areas where wet weather spill frequency exceeds consent guidelines. The SMA model is often

used in conjunction with the network catchment models as the SMA model does not include enough detail to assess I/I or local network issues.

2 2015 MODEL UPDATE

The Rosedale model was initially developed in 2002 as part of the former NSCC's Project CARE. It was subsequently reviewed in 2006, during which the model was rebuilt and recalibrated, recently constructed capital work upgrades were included and model extents increased to incorporate further known network issues.

In 2015 a third review of the SMA model was undertaken, which included the following model changes:

- Conversion from DHI Mouse to DHI Mike Urban software platform.
- A review of the model extents in line with the following criteria:
  - Significant hydraulic restrictions (i.e. Engineered Overflow Points (EOP), uncontrolled manhole lid overflows, for which trunk network upgrades are expected to be required to resolve
  - Transmission network features
  - Sub catchments ≤ 5,000 Residents
  - Pump stations with peak pump rate capacities ≥ 30 l/s
  - Pipes with Diameter ≥300mm.
- Updated using Watercare's latest GIS asset information, which included new assets, as well as the adoption of new Watercare asset ID's,
- Incorporation of new EOP and bifurcation asset inspection data.
- Update of pump station setups with new pump station information.
- Incorporation of the latest capital work upgrades including the:
  - Birkdale Branch Sewer upgrade works (completed 2011)
  - Hillcrest A Branch Sewer upgrade and diversion works (completed 2012)
  - North Branch Sewer works in Albany (completed 2014)
  - Glenfield Relief Branch Sewer upgrade works (completed 2015)
  - Awaruku to Browns Bay East Coast Bays Branch Sewer upgrade works (completed 2012)
  - Long Bay Pump Station and Rising Main / Branch pipeline works associated with the Long Bay Development. (completed 2012)
- Updating of the model catchment data to incorporate higher confidence hydrological parameters from recently completed detailed catchment studies in Devonport, Milford / Takapuna / Forrest Hill, Northcote / Chatswood, Campbells Bay, Castor Bay and Torbay.
- Modification of the dry weather flow parameters for the Greenhithe catchment area to better reflect a rebalancing of values across sub-catchments.
- The adoption of simplified ISC routines to better reflect the connectivity between pump station setups.

It should be noted the no catchment re-gauging / recalibration was undertaken as part of 2015 model review. However, the adoption of hydrological parameters from recently completed detailed catchment studies allows the latest hydrology to be adopted for the older areas of the Rosedale SMA for which Inflow and Infiltration (I/I) issues are known to be of concern. A verification of these adopted hydrological parameters was undertaken as part of the 2015 model review to ensure consistency in model performance between the Rosedale SMA strategic model and detailed models.

Model validation checks for both dry and wet weather flow with the Rosedale SMA were limited to the following:

- peak flow, volume and pump start checks at all pump stations
- peak flow and volume checks at key points along the trunk pipe network.

Overall a good validation match (within a ± 10% tolerance range) against historical study values was generally achieved for almost all pump / trunk volumes, with any outliers easily explained by model changes undertaken as part of the 2015 model review.

The 2015 SMA model update took 12 months to complete with an overall cost of $150,000, which covered modeling and asset data capture. If a full update of the SMA model had been undertaken, which would involve regauging, recalibration, system performance assessment and option development, it would cost an estimated $1M to $1.5M and taken 2.5 years to complete.

3 SYSTEM PERFORMANCE

The following system performance issues were assessed as part of the 2015 model review:

- Sewer Dry Weather Flow Capacity
- Pipe Siltation Potential
- Pump Station Dry Weather Flow Capacity
- 22.5 Year LTS Rainfall Dependent Inflow and Infiltration
- 22.5 Year LTS Network Overflows (both volume and frequencies)
- 6 Month ARI Pipe Surcharging and Network Overflows (volume only)
- 6 Month ARI Pump Station Capacity.

These system performance issues were assessed for each of the following five development scenarios:

1. Existing Network with 2015 Population without inter-station control
2. Existing Network with 2015 Population and inter-station control
3. Committed Network with 2015 Population and inter-station control
4. Committed Network with 2030 Population and inter-station control
5. Committed Network with 2065 Population and inter-station control.

The undertaking of a system performance assessment for the five different development scenarios allowed the following identification and understandings:

- Current deficiencies within the existing wastewater network, with the confirmation of key trunk overflow locations
- Key areas for which detailed catchment modelling has yet to be undertaken, such as the Beach Haven and Greenhithe catchments
- The effectiveness of the existing ISC routine in both reducing total overflow volumes and redirecting the bulk of the remaining spills to high energy environments
- The effectiveness of the proposed committed capital works programme in addressing both existing and future network deficiencies
- The highlighting of remaining network deficiencies and the likely staging of any future capital works required to address them.

A comparison of these system SMA model performance results against those results derived in the detailed catchment studies identified the following issues:

- The over-estimation of some trunk network spill volumes and frequencies due to upstream network overflow locations and local pump station storage facilities not being included in the strategic Rosedale SMA model extents
- The loss of detailed I/I result information due to the model hydrology for the detailed catchment model having to be averaged across the larger sub-catchment areas applied in the strategic Rosedale SMA model.

Therefore, whilst a strategic model approach is effective in assessing both the key trunk network deficiencies and the effectiveness of the proposed capital works programme, such modeling does not negate the need for more detailed catchment modeling to also be undertaken. In particular, detailed catchment models can identify the following issues not addressed by the strategic trunk network model:

- Local network deficiencies outside the strategic trunk network model extents that can only be addressed with a local network capital works programme

- A check of local pump station performance outside the strategic trunk network model extents
- A more precise pinpointing of local I/I issues allowing a better concentration of potential I/I remediation works.

A total of 20 SCADA overflow points are monitored within the Rosedale SMA model extents, with data provided as part of this model review for an eight year period (2006 to 2012). A comparison of the overflow frequencies between the SCADA and 22.5 year LTS model results determined that a good verification match was generally achieved for eight of the 20 monitored sites, including the key spill locations for Northboro Storage Tunnel and the Silverfield Storage Tank. Four additional sites show variances in spill frequencies, which is probably associated with differences between the actual and modeled ISC settings. The poor verification match at the remaining eight sites is generally associated with uncertainties regarding the SCADA overflow setting, remoteness of the overflow site from the SCADA monitored site and limited confidence in the SMA gauging data, such as that used for the Greenhithe catchment area.

These differences highlight the limitations of a strategic trunk network modeling approach, with some under or over prediction of spill volumes / frequencies to be expected. The results also highlight the importance of both maintaining and understanding the pump station SCADA settings to allow the effective comparison of real and modeled network results.

4 COMMITTED NETWORK UPGRADES AND SYSTEM PERFORMANCE IMPROVEMENTS

The next five years of committed works for the Rosedale SMA are shown below in table 1.

Committed Project	Estimated Value $M	2017	2018	2019	2020	2021
Fred Thomas Drive PS and Storage Tank	23.5					
Wairau PS and Rising Main	35					
Northcote Branch Sewer	9.5					
East Coast Bays Branch Sewer	29					
Sidmouth PS upgrade	17					
Inter-station control Improvements	0.2					

Table 1: Rosedale SMA Committed Works

The resulting system performance achieves a marked improvement in the East Coast Bays, Wairau Valley, Takapuna Hauraki and Northcote areas. Average annual spill frequency is much improved in many locations and the overall annual wet weather overflow volume being reduced by 45%.

The committed works will also enable upstream conveyance improvements; this is especially the case with the increase in capacity at the new Wairau Pump Station, Northcote branch sewer and the new Fred Thomas Drive pump station / storage tank. The common driver for all these projects is that they are conveyance increase type projects. The projects undertaken in the previous 15 years tended to be storage and I/I reduction focused. The committed projects all unlock the potential of conveyance upgrades when developing future network solutions in the upstream catchments. The solutions have been developed by using the local network model and SMA model in tandem, Watercare has adopted this practice successfully in the Devonport Peninsular, Northcote/Chatswood, Milford / East Takapuna, East Coast Bays, and the Glenfield catchments.

In previous SMA model reviews (2002 & 2006) the mix of solutions developed in nearly all cases I/I reduction was undertaken in mini-catchments identified in the detailed network model as having excessively leakiness indicators. Many of the catchments had significant amounts of storage constructed; this was also complimented by bringing back into service many of the pre NSDB holding tanks. These holding tanks serviced older areas such as Birkenhead, Northcote Point, Takapuna, Hauraki, and Devonport, they all had outfalls into higher energy receiving environment and were emptied on each high tide. They were typically 0.3 to 0.5ML in capacity, with Northboro being the largest at 3ML. Bringing them back into service was a clever low cost solution that created a total of 6.2ML of storage and the outfalls from these historic holding tanks form the bulk of the preferred spill points within the current wastewater network.

5 FUTURE NETWORK UPGRADES

The Rosedale SMA model results demonstrate that the committed capital works programme will not fully address all network deficiencies, with nine distinct problem areas remaining that will require additional remedial solutions to be investigated and developed.

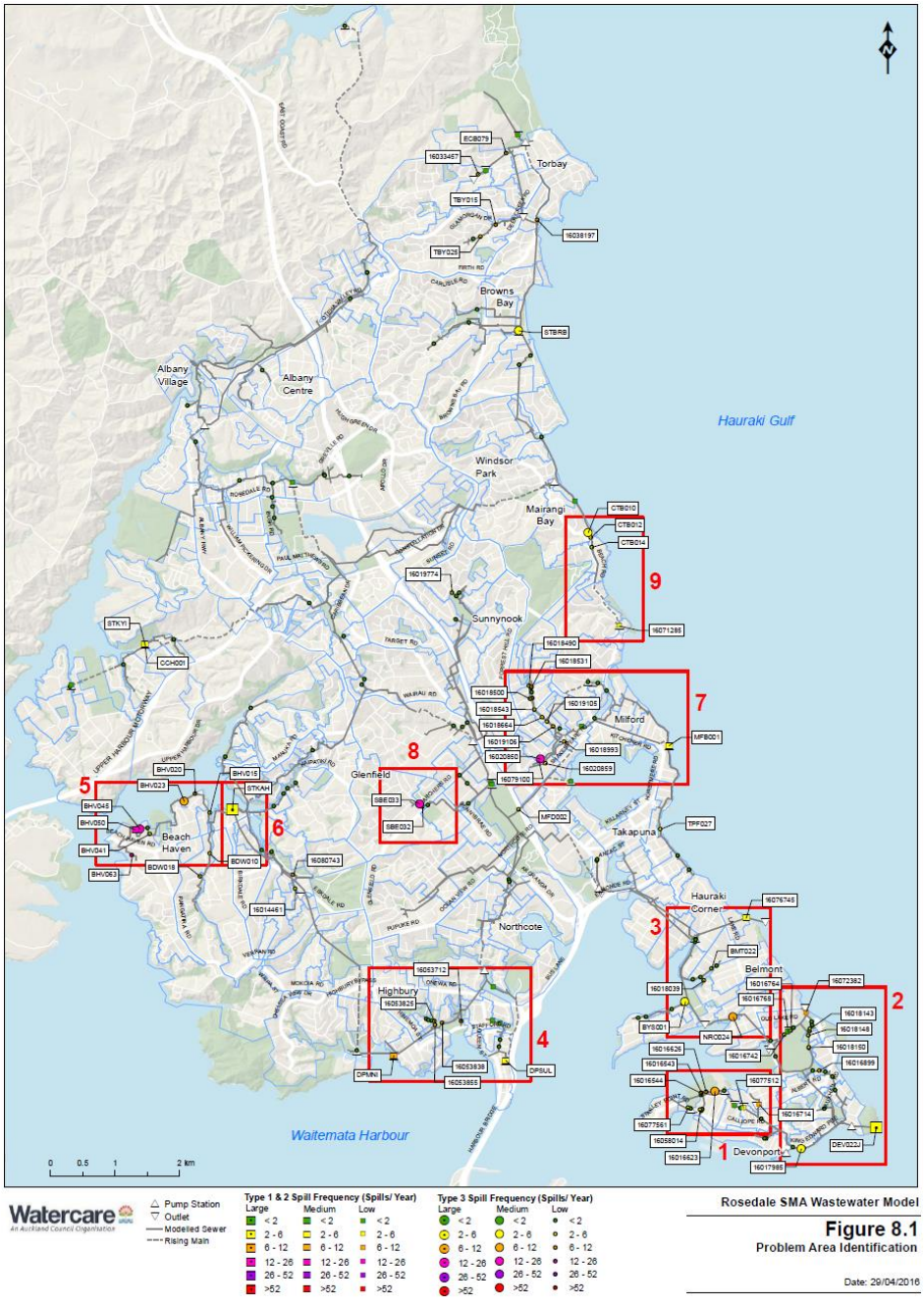

Figure 2: Rosedale SMA Model Spill Frequency & Problem Areas

The future remedial solutions will need to be considered to address both growth and excessive wet weather overflow issues, with a combination of two or more typically recommended as a solution mix.

- Capital Works
    - Conveyance increase – upgrading of pump stations and pipes.
    - Storage – tanks and online pipes, the utilization of storage facilities can be optimized with ISC.
    - Diversion – diverting flows into adjacent catchment or pipes with under-utilised capacity.
    - Flow reduction – Inflow and Infiltration remediation, Watercare have developed an I/I effectiveness tool based on actual I/I remediation work which have been assessed for pre and post remediation leakiness. This means resulting flow improvement from the treated mini-catchment can be accurately predicted.
- Operational Improvements
    - Preferential spill points – mainly achieved through ISC, not a solution but a measure which can avoid spilling in low energy or sensitive environments such as streams and bathing beaches.
    - Improved pipe cleaning – focus silt prone areas with low velocities where build up can reduce pipe conveyance.

There are limitations in developing solutions using only the SMA type model as it does not have the definition to assess I/I or future network solutions, these should be developed using both the detailed network and Rosedale SMA strategic trunk network models in tandem. Watercare have already adopted this practice successfully in the Devonport Peninsula, Northcote/Chatswood, Milford / East Takapuna, East Coast Bays, and Glenfield catchments.

The SMA modeling indicated that the Devonport Peninsula catchment area (Problem Areas 1, 2 and 3) will still contribute around 42% of the total remaining wet weather spills even with the implementation of the downstream committed work upgrades. However, the bulk of this wet weather spill occurs at the St Leonards Beach outfall from the Northboro Pump Station storage tank. Developing solutions in this catchment is an example of using both the Rosedale SMA strategic trunk model and the Devonport Peninsula detailed network model. The recommended solutions for the peninsular involve increasing the capacity of the Northboro Pump Station from 270 l/s to 410l/s, some local network augmentations and diversions and significant I/I remediation works in the Devonport and Narrow Neck catchments.

Figure 3: Problem Areas 1, 2 & 3 Devonport Peninsular: showing average annual spill frequency

Solutions have also been developed for other problem areas located in Chatswood / Northcote (Problem Area 4), Forrest Hill, Wairau Valley Mairangi Bay and Castor Bay (Problem Areas 7, 8, and 9), using a mix of the Rosedale SMA strategic trunk model and detailed network models.

The Rosedale SMA model also identifies post committed work overflow issues to remain both within the Beach Haven catchment and immediately upstream of the Kahika Pump Station / Storage Ttank (Problem Areas 5 and 6). As the Rosedale SMA strategic model does not have the ability to understand the problem in enough clarity to develop optimal mix of remedial solutions, a detailed network model will need to be developed for this catchment area.

6 FUTURE MODEL UPDATES

The next major update to the Rosedale SMA model is likely to be in 2021, when ideally much of the committed works programmed will have been completed and the actual network performance can be gauged and modeled. Also by 2021 the Rosedale WWTP will be receiving flows from the North West Growth Area via the new Northern Interceptor, this growth area covers Hobsonville, Red Hills, Massey North, Whenuapai and Kumeu / Huapia, this network will need to be included into the model. Ultimately the North West Growth Area will have a population of 150,000 and additional flows from large areas of business zoned land. Later model updates will need to include northern areas of Waitakere with a population of 90,000 which are to be diverted to the Rosedale SMA from the Mangere SMA on 2035.

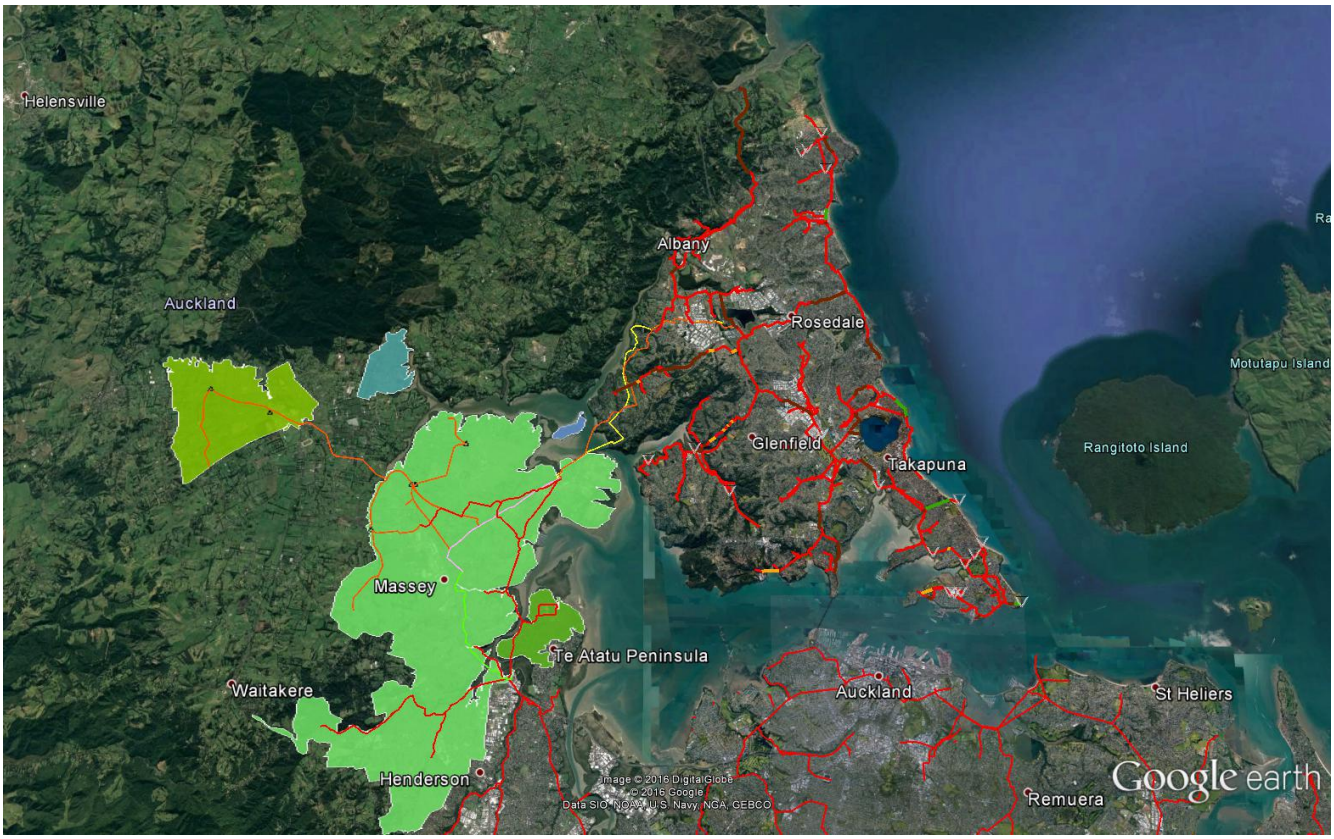

Figure 4: Future Urban Areas and Network to be included progressively into the Rosedale SMA

In the period between now and the next major upgrade of the Rosedale SMA model, themodel will need to be kept live with versions of the model that contain the following:

- Committed projects as they are completed
- Future upgrades as those are developed and approved for inclusion in the capital works programme
- Changes in ISC

As discussed previously catchments that are likely to require detailed network models include Beach Haven and Greenhithe, it is likely Beach Haven will be a priority for detailed modeling as operational issues are being reported, whereas Greenhithe has no such current reported operational issues.

7 CONCLUSION

The Rosedale SMA model is an example of a strategic model that has been maintained and enhanced over 15 years, it has been the planning tool that has been the basis for all the major capital works undertaken to date. The value of the capital works developed using versions of the SMA model to date has been $194M with a further $114M of committed works programmed for the next five years.

It has also allowed Watercare to:

- Understand network performance with confidence, this information is required for network compliance
- Direct where detailed network models may be required
- Understanding the impacts of population growth
- Develop a ISC regime that optimizes the use of storage facilities and associated preferred overflow points to higher energy receiving environments

When strategic models are first developed it is an expensive and time consuming process, so it is desirable that these models are maintained and not left to lose their relevance. Maintaining this type of model does mean periodically regauging and calibrating of the model. The latest update of the Rosedale SMA model was achieved by adopting the information coming from the detailed catchment network models. This approach, along with keeping versions with programmed capital works, gives Watercare a tool which is fit for purpose. The update has been undertaken in a shorter time frame and at a lower cost than a full regauge and recalibration of the model.

ACKNOWLEDGEMENTS

Tim Lockie, Nicola Haszard, Jo Costello and Nathan Shaw.

REFERENCES (Arial, 11)

Project CARE Review Model System Performance Report; NSCC, 2010

Rosedale SMA – Network Analysis, Report 02 System Performance Assessment; Watercare Services Ltd, 2016