Hamilton City – Water Distribution System Strategic Planning

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ABSTRACT

Hamilton's present water supply base system was planned and installed in the early 1970s. Since then the City water consumption has almost doubled. The peak demand is now straining the capacity of some key components. It is time for strategic planning for system improvements to cope with further City growth, as the last major review was in 1989.

The established City water distribution system model using MIKE NET provided a sound base for this study. The comprehensive modelling evaluated the existing system and identified those elements that are in the most need for upgrade, thereby the best system improvements from the minimum investment were obtained. The year 2020 was adopted as a target.

The major proposed works over the 20-year period include 2 new reservoirs, 20 km of new separated bulk mains and new pumping units. The total costs of the works are estimated at about NZ$15 million.

The resulting water supply system is expected to satisfy the projected demand for year 2020 and beyond.

INTRODUCTION

Hamilton is an inland city in New Zealand with a population of about 120,000. The Waikato River (catchment area about 12,000 km^2) flows through the city and provides sufficient water source for the city.

The current water supply system has one treatment station, seven storage reservoirs, three pressure zones and a ring bulkmain system.

The water supply system for Hamilton City was last reviewed in 1989[1]. That study took a broad look at the distribution system and focused mainly on the

Treatment Station capacity, the need for a new reservoir in the Dinsdale/Newcastle Road area and interrelationships between these facilities.

In the period since 1989 the population of the City has grown by about 20% and has expanded into new areas to the west (Rotokauri area) and north east (Rototuna area). The demands on the water supply system have grown by about 18% mainly due to city growth.

As a result of the various changes and increasing demand, and recognising the triennial review of Hamilton's Strategic Plan, which is scheduled for later 2001, it was timely to carry out a full strategic review of the water supply system.

In 1997 a comprehensive review [2] of the capacity of the Water Treatment Station had been carried out. Therefore, the main purpose of this report is to review the capabilities of the present water supply system, to shape the structure of the future system strategically, and to define the parameters of the major components to meet the requirements of the planning period.

The system is operating on a daily cycle. To meet the demand of a dry summer day was considered as the design condition.

A strategy horizon of 20 years was selected for the study, although it is recognised that the life of most components of the infrastructure is more like 100 years. It is also recognised that the City will continue to grow and the demand on the water supply network will continue to increase.

Extensive modelling works using MIKENET modelling software were carried out to analyse system performance and evaluate options.

The City water network model was established and calibrated at the beginning of 2000.

EXISTING SITUATION

WATER SUPPLY SYSTEM

Raw water is abstracted from the Waikato River, treated at the treatment station in the south and supplied to the City through 7 reservoirs and bulk mains directly. The bulk mains link these reservoirs to the treatment station.
Fig 1 is the schematised city water distribution system.

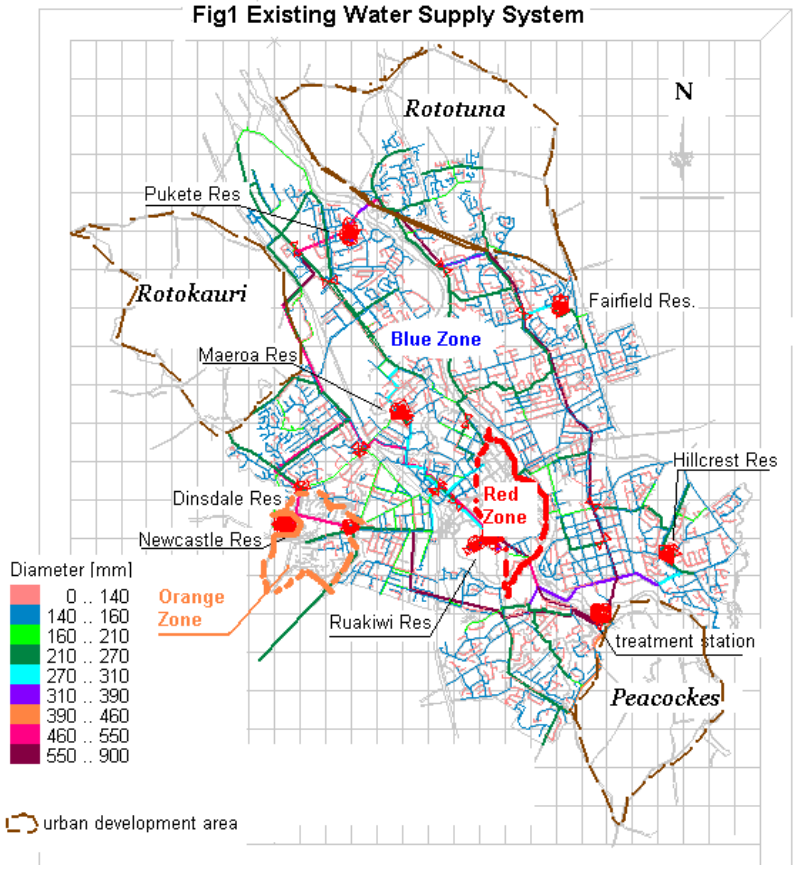


Fig.1. Existing Water Supply System

The main components of the system are:

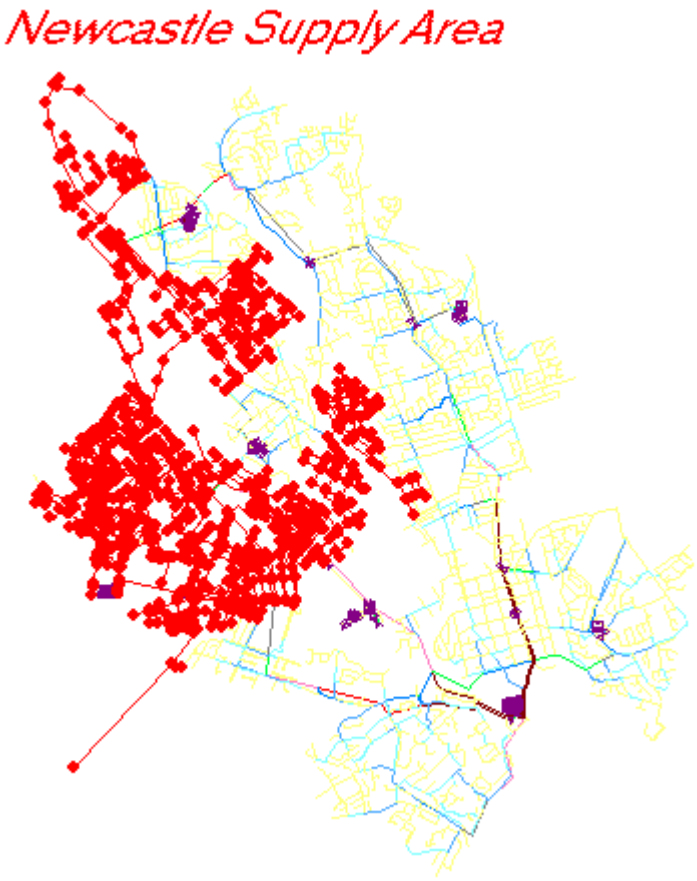
- 8 high lift pumps at the treatment station.
- 3 pressure zones, named Red(grade RL92m), Orange(RL82m) and Blue(RL75m) independently. 90% of the city is in Blue zone with a minimum target grade of RL75m.
- 7 reservoirs around the city, 3 of them supply water with booster pumps.
- 560 km of pipeline, diameter ranging from 100mm to 750mm, and 340km of ridermains(<100mm).

Table 2 shows the parameters of these reservoirs.

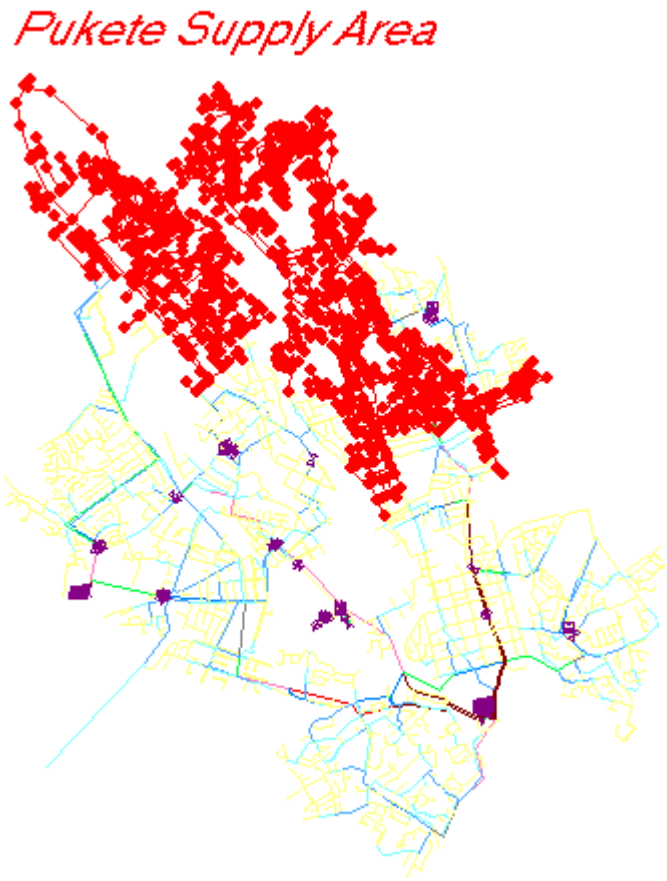
Pressure Zone	Reservoir Name	**Top Water Level RL (in metres)**	**Volume Megalitres**	
			Total	**Used at Present**
Blue				
	Newcastle	76.0	21.0	7
	Pukete	54.5	22.5	9.7
	Maeroa	62.5	3.3	2.0
	Fairfield	55.5	4.5	3.0
	Hillcrest	74	0.9	0
Total – Blue Zone			52.2	25.7
Orange	Dinsdale	81.3	4.5	1.1
Red	Ruakiwi	91.5	11.5	4.0
Total			68	

Table 2 Reservoir Parameters

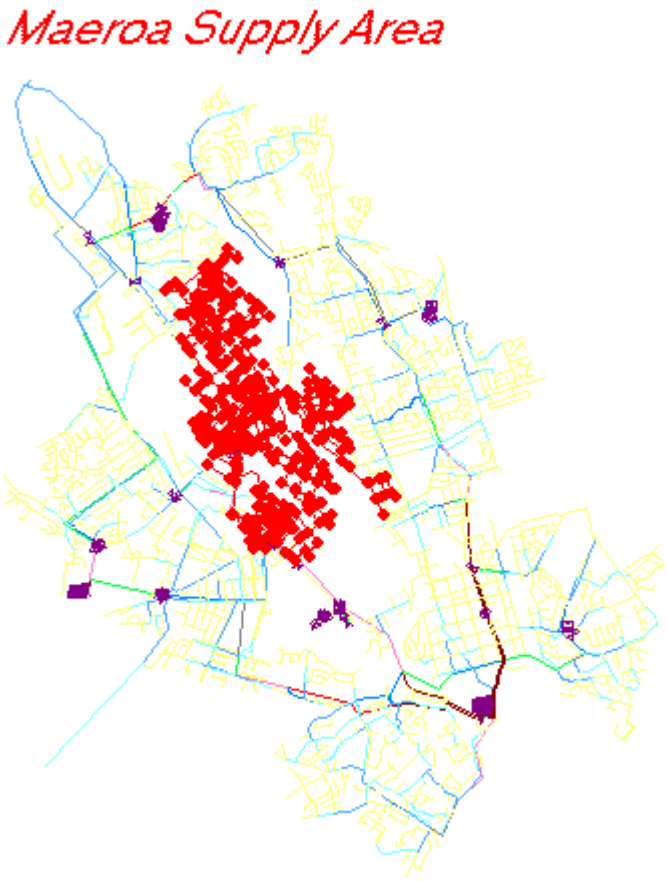
The total reservoir storage volume of the existing system is about 68ML, about 1.5 times of current annual average daily demand (AADD). This is at the bottom of the acceptable range of the ratio of reservoir storage to AADD in New Zealand (1.5-3.0)



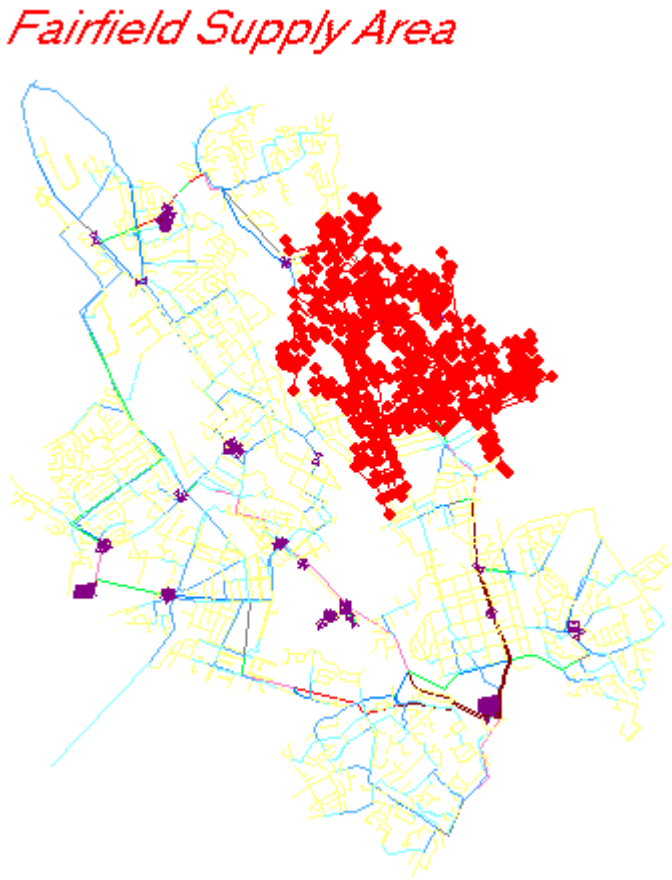
Newcastle Supply Area



Pukete Supply Area



Maeroa Supply Area



Fairfield Supply Area

CONSUMPTION AND PATTERNS

The current AADD is 47 ML/day.
The short term system capacity, which is the integration of the capacity of the pumps, pipe reticulation and reservoirs, was assessed to be about 90ML/day, slightly more than the maximum daily demand of 84.5ML recorded in 1999.

About 70% of the water consumption is for domestic uses, and 30% for industrial and commercial uses.
Reservoir telemetry data was used to achieve demand patterns. The domestic and non-domestic patterns in summer time are as fig 2.

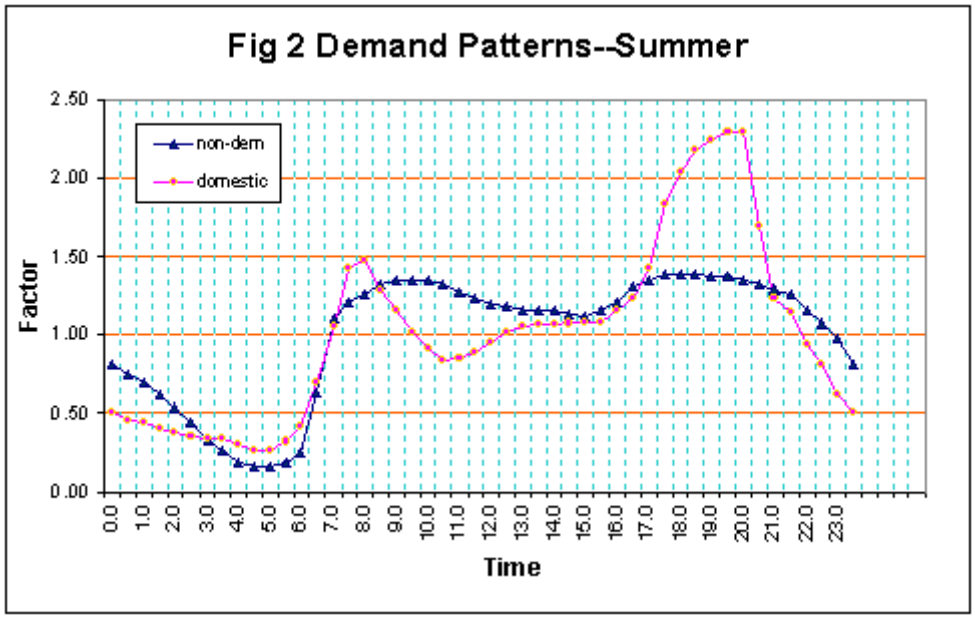


Fig.2. Demand Patterns - Summer

RISKS

Hamilton uses less than 1% of the flow from the Waikato River, therefore there is little risk of supply from the drought.

The possible risks to supply are more likely from power failure, treatment station fault, earthquake, or pollution in the river.

Earthquake is an unknown quantity. But an earthquake of sufficient magnitude to make the plant inoperative would probably also cause severe damage to the bulk mains and reservoirs.

Newcastle, Disndale, Hillcrest and Ruakiwi reservoirs could supply the city by gravity in case of power failure. Modelling indicates that downtown could be supplied by Ruakiwi Reservoir, Dinsdale Area by Dinsdale Reservoir, and the rest of the city (90%) by Newcastle Reservoir for about 8 hours at AADD in this case. The treatment plant, classified as an "essential" service site, has 3 independent power supplies and power outages unlikely to be greater than 6 hours.

If case that the treatment station failed for whatever reason, the system could use all the reservoirs to supply the city (presuming power is available). If all reservoirs are full, Dinsdale Reservoir could supply Orange zone for about 3 days (AADD). Ruakiwi could supply downtown for 3 days (AADD). The reservoirs in Blue zone could supply the rest of the city for about 1.5 day.

CITY DEVELOPMENT, POPULATION, AND DEMAND PREDICTIONS

The population of Hamilton City at the start of 2001 is estimated to be approximately 120,000 people. It is predicted that by 2020 the population will have grown to about 147,000 people – an increase of 22% [3].

Demand prediction was based on the comparison and analysis of the predicted population growth rate and the past City consumption trends. On that basis the annual average daily demand for the year 2020 is estimated at 58 ML/day and the peak daily consumption is estimated at 106 ML/day. About 70% of the water consumption will be for domestic uses.

CITY GROWTH AREAS

There are 3 areas (see fig1) within the present city boundary that are designated for city growth:-

- Rototuna in the North East, 1200 ha, ground level RL35~62m [4].
- Rotokauri in the North West, 955 ha, ground level RL32~55m [5].
- Peacockes in the South West, 900 ha, ground level RL40~80m [6].

It is predicted that during the 20-year planning period about half of the population growth will occur on the east side of the river with weighting towards the north. Most of the commercial and industrial growth will be on the western side of the river.

The route for the proposed expressway has now been decided and the designation process will commence in 2001. The expressway skirts along the eastern side of the City just to the east of Fairview Downs, the Ruakura research centre and the Nevada Road area.

There has been some political expression that the new expressway will form a natural eastern city boundary. If that happens then it is possible that residential development may proceed into this eastern area in preference to Rotokauri and

particularly Peacockes. All of that growth is likely to be beyond the 20-year planning period for this study but it is important to be mindful of future growth directions.

THE EFFECT OF GROWTH

These major urban development areas are all located near the city boundary. Rototuna in north east and Rotokauri in north west will be the main developing areas in the next 20 years. These two areas are currently out of the water supply capability. Therefore major facilities for water supply services will be required and the performance of the existing components will change correspondingly. The existing users might be affected and consequent problems might occur.

SYSTEM DEFICIENCIES

Finding deficiencies of the existing system is a good basis to seek strategies for the future system development.

System deficiencies were identified by extensive modelling analysis, such as:

- Dry summer situation.
- Response to emergency (e.g. fire, power failure, station fault).
- 2010 City development against the current supply system.
- 2020 City development against the current supply system.

These modelling exercises tested various scenarios, examined the current system, and identified the following deficiencies:

- The maximum daily demand is close to the system supply capacity.
- Some high lift pumps at the treatment station are not running efficiently due to changed duties.
- Pukete Reservoir (23ML) is easy to supply water but difficult to fill.
- There are water pressure problems in some areas around the city Fig.3.
- The eastern bulkmain from the treatment station to Ruakura is under capacity. There is only 1 bulk main on the eastern side of the city, but 2 on the western side.
- There needs to be extra reservoirs to bring total reservoir capacity above the industry standard 1.5 times AADD in the near future.
- Reservoir storage volume on the eastern side of the city is under 10% of the total, but the consumption is over 40% of the total.

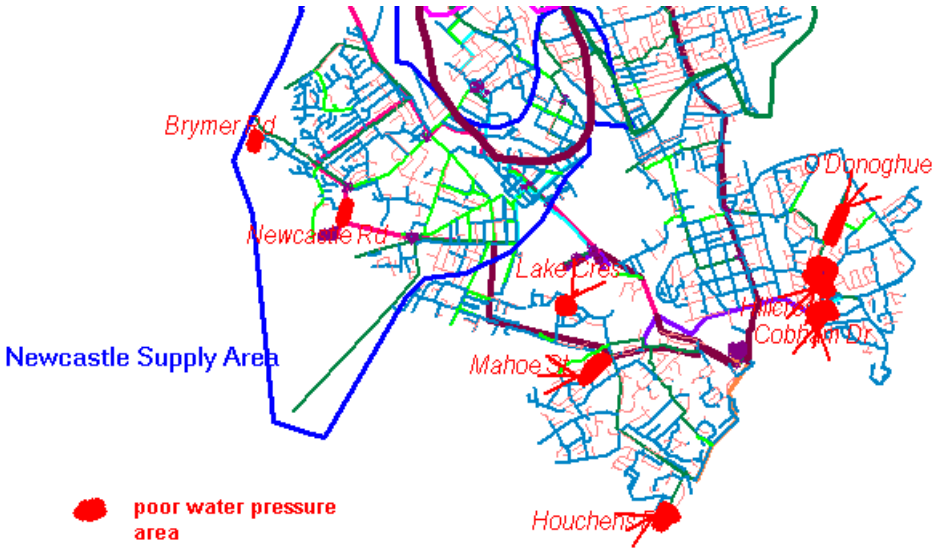


Fig.3. Water Pressure Problems

SYSTEM DEVELOPMENT PHILOSOPHY

The drive of the city development and the supply system deficiencies require the following to be considered to seek system development:

- Ensure that the agreed level of service be met for all consumers and increase supply security.
- Use existing infrastructure efficiently.
- Locate new reservoirs where the future water supply deficient areas are (to reduce costs for laying pipes).
- Because the reservoir and bulk main lifetime are over 100 years, the system should be planned reasonably flexible to adapt to city development variations and further longer term development after the designed system is commissioned.
- The designed system should be operating efficiently.
- Proposed reservoir should have no adverse effects to the existing reservoirs.
- System operation and optimisation must be considered to ensure costs are acceptable to the community.

SYSTEM DEVELOPMENT

The cost benefit of upgrading different component in the network is different. Therefore various situations needed to be modelled to assess their sensitivities. To meet the requirement in the next 20 years, system development options were then obtained by a few combinations of some effective and economical components.
Structuring the future system strategically and operating efficiently, along with cost benefits, are the main focus to evaluate different options and possibilities. An option mainly with the following works was evaluated as the best:

- Upgrade 2 high lift pumps at the Treatment Station.

- Install 10 km 600mm bulk mains on the eastern side of the city. This will not have major lateral connection on the way and act as an express way to deliver water from the treatment station side in the south to the northern end of the city, where the demanding area is.

- 17ML Hamilton South Reservoir and associated filling pump and 450~600mm bulk mains. This reservoir will supply water by gravity targeting the eastern side of the city and act as the backup for the treatment station. The supply security level will be increased. The operational level will probably be between RL80~85, 5~10m higher than the system normal operational grade. The excess of the grade is designed to deliver higher pressure through the proposed 10km bulk mains, and to change the dynamic supply zone of Fairfield reservoir northwards and Pukete Reservoir westwards.

- 12 ML Rototuna Reservoir and associated booster pump and 450mm bulk mains. It will be located in the high demanding area and supply water at peak time by a booster pump and by gravity in case of power failure.

- 450mm bulk mains to extend Pukete and Newcastle reservoirs supply areas to Rotokauri future urban area. These two major reservoirs will be better utilised.

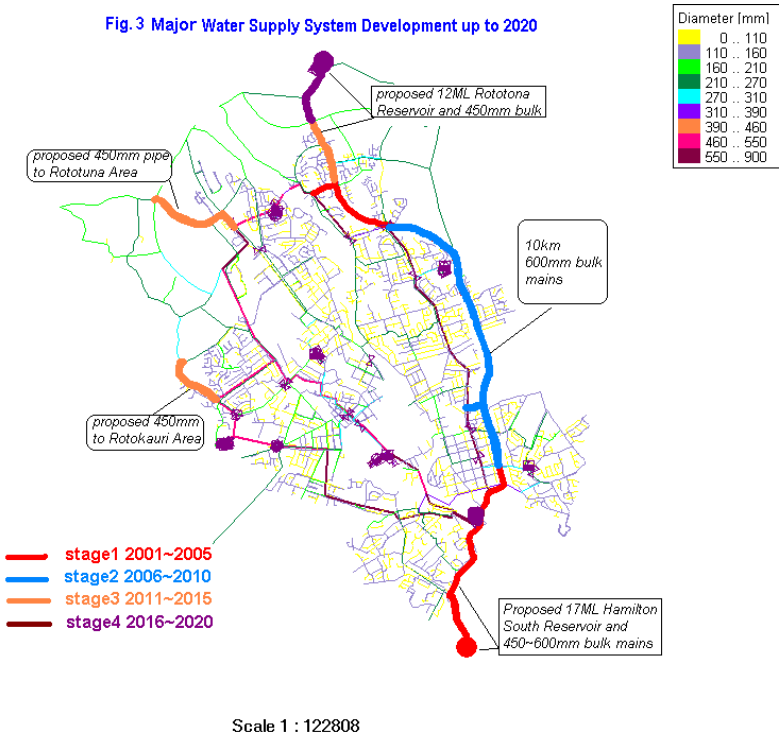


Fig.4. Major Water Supply System

The proposed 2020 water supply system has bulk mains and reservoirs distributed around the city effectively. Reservoir storage volume that could service the eastern side of the city will increase significantly. The reservoir volume (ML) in lue zone, which consumes about 90% of total water demand, would be:

Target	**Present**			2020		
	Total Volume	**Supply by gravity**	**Demand**	**Total Volume**	**Supply by gravity**	**demand**
City east	5.4	0.9	40%	34.6 ML	29.9 *	45%
City west	62.6	37	60%	62.8 ML	37	55%

**Rototuna Reservoir could supply by gravity in case of power failure.*

The total supply system capacity would probably meet the city demand of 2035, estimated by the present developing rate.

The general features of the 2020 system are:

1. That the water supply to the eastern side of the city, especially Rototuna area, would be improved significantly. Water supply problem to Rototuna would be solved radically.

2. Current low water pressure areas in Lake Crescent, Mahoe Street, Houchens Avenue, Hillcrest Road would be removed.

3. Pukete reservoir supply area would be extended to both Rototuna and Rotokauri. This reservoir will also be easy to fill and well utiliseed.

4. The Waikato District Land along eastern City boundary could become active due to a convenient water supply service.

5. The treatment station would have much less stress to operate, especially in summer time.

6. Hamilton South Reservoir would play a key role in the distribution system. It would:

- Stabilise the system water pressure in the south.
- Push Fairfield Reservoir supply zone northwards.
- Squeeze Newcastle and Pukete supply areas towards Rotokauri.
- Be able to supply both sides of the city in emergency.

Further water supply system development for longer term was considered in this task. Water services for further urban development areas could be easily fulfilled:

- Rotokauri-using Newcastle and Pukete reservoirs.
- Waikato Land along express way-Rototuna reservoir and bulk mains.
- Peacockes area-Hamilton South Reservoir and WTS.

CONCLUSION

The system was optimised to fit Hamilton's local situation by means of MIKENET water network modelling against various scenarios. By identifying the constraints of the existing system, strategies to develop the system were created. The optimised option would not only meet the projected requirements, but also be cost effective, meet the agreed level of service, and utilise the existing components in a better way. The system will also be able to handle different emergency situation more effectively.

ACKNOWLEDGEMENTS

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[4] **Rototuna Structure Plan**. BCHF, 1999.

[5] **Rotokauri Structure Plan**, Draft Consultant's Brief. Strategic Group, Hamilton City Council, 2000.

[6] **Hamilton's Growth to the Year 2000**. Peacocke's Area. Hamilton City Council, 1996.