MUNICIPAL WATER STORAGE – HOW MUCH IS ENOUGH

Brent Manning, Manager Water and Wastes, New Plymouth District Council

ABSTRACT

Extreme events and their aftermath such as the Christchurch earthquake as witnessed by New Zealand since 22 February 2011 have served to highlight the importance of reliable water supply to serviced communities, and in particular the need to have sufficient water in storage to cope.

Christchurch was fortunate in some senses in that most of their water supply reservoirs survived the earthquake and retained water due to the response of seismic isolating valves, while other reservoirs were manually isolated in the wake of the earthquake. Ultimately these actions contributed to the relatively quick recharge of water supply networks in restoring up to 95% service to Christchurch two weeks after the quake.

Elsewhere various approaches have been taken to the problem of bulk water storage requirements in an emergency. In New Plymouth District Council's case several components have been incorporated into their standard reservoir design to allow retention of a minimum bulk volume of water for subsequent rationing and distribution through a small bore outlet on the site.

A review of New Plymouth's overall water storage requirements and allowing for both operational and extreme demands has highlighted where storage provisions are adequate, and where they are not. New Plymouth District Council has in the past ten years built eight new reservoirs to augment their network storage, and to provide redundancy and emergency storage in the case of extreme events.

A comprehensive hydraulic model of the network including bulk storage also allows a number of scenarios to be tested and validated.

The combination of the above engineering design and operational management tools gives the network manager a higher level of confidence in determining the present and future water supply needs for their respective communities. This paper will examine some of the tools and techniques used in reservoir tank design around New Zealand, and present some options for incorporation into bulk water storage design for water supply managers.

KEYWORDS

Water storage, reservoirs, seismicity, hydraulic network model

1 INTRODUCTION

Water infrastructure for towns and cities in New Zealand tend to have developed along similar lines, that is to say that a rudimentary supply for drinking and household use was first established, with further demand as urban areas built waterborne gravity sewers networks, and leading to a drive for a higher potable quality. Often water supplies were provided contiguous with a major wet industry in the town e.g. a freezing works or factory supply. As towns and cities expanded the fire risk heightened and the water network was a ready source of fire fighting water. This in itself required that the mains remain adequately charged (pressurized) and relied on a suitable storage buffer. Naturally that storage buffer was diminished as the serviced population grew requiring continual expansion and upgrade to the water network and storage tanks or reservoirs. In the past decade there has been much focus (in New Zealand) on improving treated water quality and mitigating the risk of biological hazards (namely bacteria and protozoa) through the various iterations of the Drinking Water Standards for New Zealand (DWSNZ) 2000, 2005 and 2008 respectively.

The damaging earthquakes in the Canterbury and Christchurch area over the past 14 months have served to put the spotlight back on the basic need for continual water supply, through reliability on water networks for drinking, washing, and fire-fighting, as well as other utility inter-dependencies (e.g. water used as a coolant in industrial applications).

In light of such events is it timely now for all water authorities in New Zealand to review their supply system, and to reevaluate the risk to interruption and service delivery by assessing infrastructural resilience to recognized hazards?

2 BACKGROUND

2.1 GENERAL

Resilience integrates the concepts of Risk, Crisis Management, Business Continuity Planning and Organisational Leadership to provide a platform for developing more robust and agile organisations.1

It is important for water managers to design resilient water systems including water storage, for up to the maximum credible event, and to incorporate practical features that promote a resilient recovery when the event occurs.

Technology has played its part in enabling greater operational and emergency resilience in water storage; an example is the use of automatic seismic shut-off valves.

However resilience begins at the water infrastructural planning stage taking into account risks from source to customer. Many relatively straight-forward design principles or features can be built into water systems to promote greater water security and particularly to build more than adequate systems in the first place, or to retrofit existing systems. Customers also can play their part through on-site storage supplies as is the case in Kapiti and areas where rainwater harvesting is encouraged.

So what form should the risk assessment take? To begin with you need to understand your water supply system.

2.1.1 NEW PLYMOUTH DISTRICT COUNCIL

New Plymouth's water supply system is shown diagrammatically in Appendix 1. The majority of demand is east of the city, while the significant industrial complexes including petrochemical installations posing the greatest fire risk are to the west.

All existing water reservoirs are concrete, with a prescribed service life of 80-100 years for each. The eight reservoirs constructed since 2000 are constructed to the latest seismic design standards, and are designed to remain watertight in the case of earthquake. Some older reservoirs have been also upgraded to provide an improved level of seismic resistance, through the retro-fitting of seismic restraint cables around the circumference at the wall/roof joint. All reservoir outlet pipes are now positioned such that in the event of outlet pipe rupture the reservoirs will retain 15 per cent of their contents. Oakura Reservoir number one remains to be upgraded for seismic restraint and 15 per cent volume retention. It is intended that this work will be carried out during 2011/12.

New Plymouth District Council is thus well served in respect of total storage capacity and security of supply.

However some reservoirs are more heavily loaded than others, with the majority of reservoirs are fed from New Plymouth Water Treatment Plant (NPWTP) Reservoir #1 with only Veale Rd and Barrett Rd reservoirs being fed from Plant Reservoir #2. The introduction of supply areas and pressure management has been able to reduce

[1] Resilient Organisations Research Report 2011/03; Post-Disaster Organisational Recovery in a Central Business District Context: The 2010 & 2011 Canterbury Earthquakes

demand on Plant # 1 and increase demand on Plant #2 by controlling pressure within the wider reticulation. Further work within the supply areas and additional pressure reduction has the potential to reduce demand and water losses, thereby increasing the effective storage.

The table below gives summaries of all reservoir capacities.

Table 1 Treated Water Storage Summary

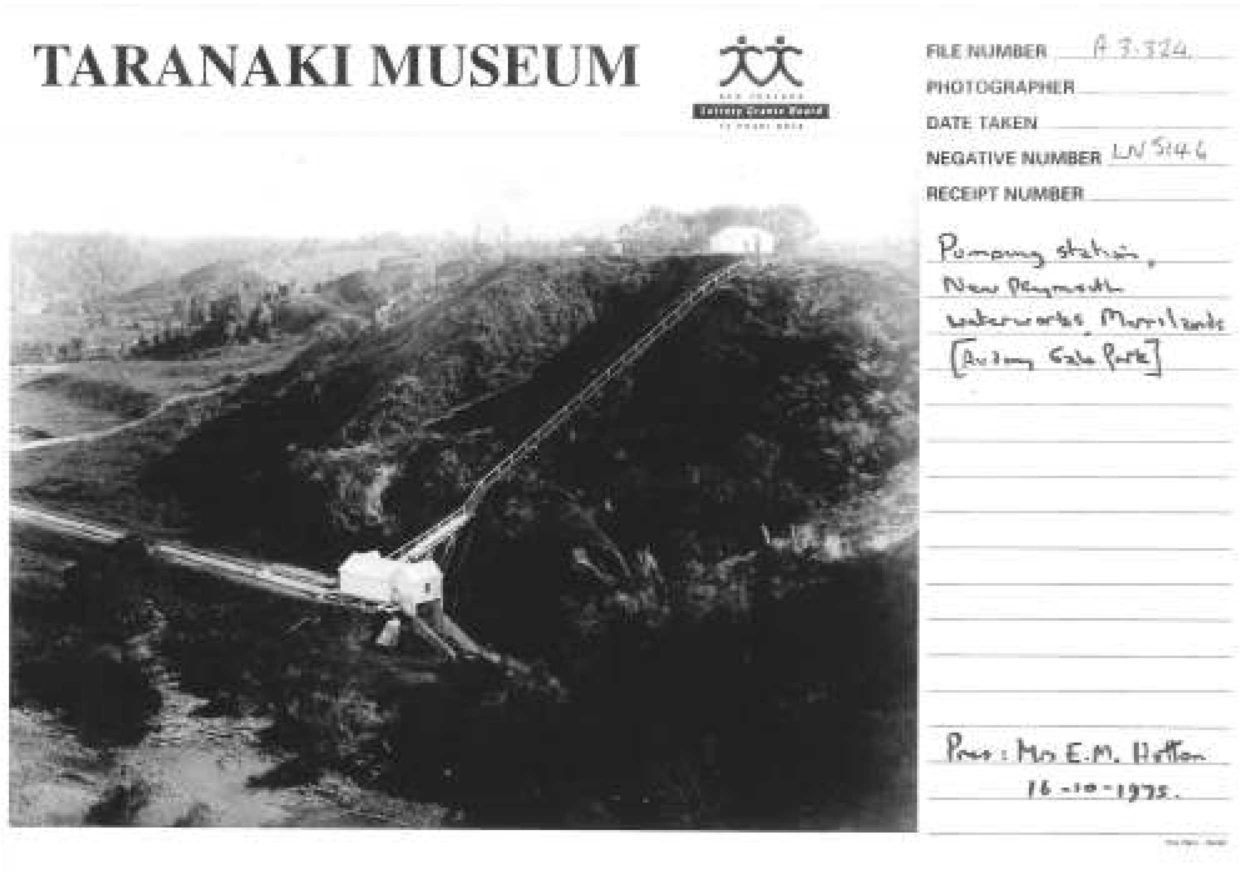
Reservoir	Total Capacity (m3)	Constructed
NP WTP #1	4,500	1972
Mangorei #1	4,500	1966
Mangorei #2	4,500	1972
Mangorei #3	4,500	2003
Henwood Road	4,500	1985
Mountain Road	4,500	1989
Faull Road	4,500	2001
Urenui	1,250	2002
Urenui Domain	300	1990
Sub-total NP East	**33,050**	
NP WTP #2	4,500	2002
Veale Road	10,000	1981
Barrett Road	4,500	2010
Sub-total NP West	**19,000**	
Oakura #1	1,250	1980
Oakura #2	1,250	2002
Sub-total Oakura	**2,500**	
Sub-total Okato	**1,250**	2002
Inglewood #1	3,650	1999
Inglewood #2	3,650	2002
Sub-total Inglewood	**7,300**	
GRAND TOTAL	**63,100**	

The capacity of the pipe network is able to be confirmed through improved hydraulic modeling. New Plymouth District Council purchased hydraulic modeling software in 2005 and built and calibrated a comprehensive model piloting the process with the smaller Inglewood water supply first to provide verification of the results.

2.1.2 HISTORY

New Plymouth city's first public water supply was a local river source in the early 1900s relying on diesel driven pumps to deliver the water to an elevated small open tank, from which the city was gravity fed through a limited network of typically spiral riveted steel pipe.

Figure 1: New Plymouth's first public water supply



The first attempts at a hydro-powered electricity supply for New Plymouth occurred on the same river from about 1908 onwards, leading ultimately to the construction of the Mangamahoe Dam and impounded lake of 800,000 cubic meters from 1930. Although it was a hydro-electric scheme the opportunity was seized to augment an improved water supply to New Plymouth city off the main penstocks to the power station (locally referred to as the "high head" scheme. This water supply was gravity driven all the way to the original open reservoir and thence to the town.

Initially the town was served by the open reservoir until the construction of two circular concrete pre-cast paneled reservoirs (enclosed tanks) on the same Mangorei Road site in 1966 and 1972. This coincided with the construction of a new water treatment plant adjacent to Lake Mangamahoe and both contact tank storage (900 m3) within the plant and a contact reservoir of 4,500m3 of similar design to the Mangorei reservoirs.

This reservoir design was interesting in that it incorporated a pitched precast roof panel all coming together at the centre and self-supported and secured by way of a centre ring; i.e. no centre supporting column required. The perimeter end of the roof panel is simply supported on a corbel cast into the vertical wall panel (see Figure 3 below).

By 1973 total water storage available to New Plymouth city was 14,200 m3 to service a population of 52,000.

That equates to an average of 273 litres (l) storage/person per day not allowing for industrial and fire demand.

In the 1970s major development of the Taranaki oil and gas fields occurred with corresponding expansion at the New Plymouth Port and construction of the New Plymouth (then) gas-fired power station and chimney adjacent, and the nearby Omata tank farm for liquid storage of bulk volumes of petrochemicals for shipping.

In the 1980s the so-called Think Big projects began in earnest in Taranaki including the Motunui Synfuels plant and Waitara Valley Petralgas plant.

A further 10,000 m3 reinforced concrete panel reservoir was constructed on the outskirts of the growing city in 1981 at Veale Road, succeeded by another decade of relatively rapid infrastructural improvements as a result of impending local body amalgamation (1989) from which New Plymouths water supply was extended firstly to Bell Block, and then Waitara. This extension necessitated the building of two more circular reservoirs of 4,500m3 capacity at Henwood' Road and Mountain Road separately.

By 1990 total storage available was 33,200 m3 for a serviced population of 56,000 (estimated).

Not until a decade later (post 2000) did the New Plymouth District Council embark on building more reservoirs, as part of a wider strategy to expand the water network to interlink the major North Taranaki coastal towns and villages and in so doing to provide more treated water storage for redundancy and resilience.

A further 8 reservoirs were constructed in the period 2000 – 2004, with 3 of these being circular 4,500 m3 concrete tanks for the New Plymouth supply, now incorporating a central column for improved seismic performance, and in light of code changes since the 1980s.

Figure2: Barrett Road reservoir under construction

A further 4,500m3 reservoir to the circular, central column design was built 2008-09 and commissioned 2010 at Barrett Road.

The total storage now available to the New Plymouth water supply area being 52,050 m3 for a population of 59,072,[2] having an average daily demand of 26,438[3].

In simple terms this represents 1.9 days storage at current average daily demand and 1.3 x peak daily demand.

[2] Per Register of Community Drinking-Water Supplies in New Zealand, 2011 Edition

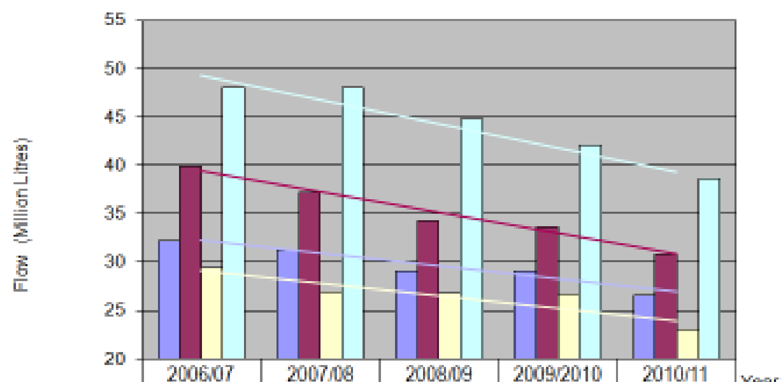
[3] From 2010-11 NP WTP production figures

The risk of interruption to supply on each key trunk main to each reservoir site has been assessed through use of a simple spreadsheet table and from which the relative storage adequacy can be evaluated. Leading in turn to designing solutions through redundancy (additional or alternative supply pipelines), greater surety (more storage) or flexibility (through bypasses which can be manually or remotely opened or even off line pump stations or commissioning of alternative emergency supplies).

In developing towns' main reticulation systems, a water supply authority needs to cater for fire demand in addition to the domestic/industrial water usage.

In the figure below the average and peak daily demand is shown for the past five years.

Figure 3: New Plymouth water demand 2006-11



	2006/07	2007/08	2008/09	2009/2010	2010/11
Average Daily Demand (Million Litres)	32	31	29	29	27
Peak Month Average Daily Demand (Million Litres)	40	37	34	34	31
Lowest Month Average Daily Demand (Million Litres)	29	27	27	27	23
Peak Day Flow Rate (Million Litres)	48	48	45	42	39

The peak annual average daily demand was 40,000 m3 in 2006/07. The declining values in the years since can be partially attributed to demand management measures impelemnted since 2007.

2.2 FIRE FIGHTING REGULATIONS

Under the Local Government Act 1974 territorial authorities are required to install fire hydrants and to keep them charged within the urban fire districts (as gazetted under the 1975 Fire Act).

The New Zealand fire fighting water supplies code of practice 2008 provides direction on what constitutes a sufficient minimum supply of water pressure and volume for fire fighting in structures in urban fire districts. The code of practice is non-mandatory but could be incorporated into relevant bylaws under the Local Government Act 2002 or district plans prepared under the Resource Management Act.

Table 2 gives a summary of the fire fighting flow requirements per these guidelines. The table lists the minimum requirements for fire fighting water supplies.

Table 2: Fire-fighting flows and storage per SNZ 4509:2008

Fire Water Classification	Reticulated Water Supply			Minimum Water Storage (non-reticulated supply)	
	Required water flow within a distance of 135m	Additional water flow within a distance of 270m	Maximum number of fire hydrants to provide flow	Time fire fighting (minutes)	Volume required (m3)
FW1 (Single family homes with a sprinkler system installed to an approved standard)	450 l/min (7.5 l/s)	-	1	15	7
FW2 (All other structures (apart from single family homes) with a sprinkler system installed to an approved standard, and non-sprinklered houses and multi-unit dwellings, but excluding multi-storey apartment blocks	750 l/min (12.5 l/s)	750 L/min	2	30	45
FW3	1500 L/min (25 l/s)	1500 L/min	3	60	180
FW4	3000 l/min (50l/s)	3000 L/min	4	90	540
FW5	4500 l/min (75 l/s)	4500 L/min	6	120	1080
FW6	6000 l/min	6000 L/min	8	180	2160
FW7	As calculated				

(Table reproduced from SNZ PAS 4509: 2008)

The code recommends that water supply systems be designed to provide 60% of annual peak demand in addition to the fire flow. Fire flows may be calculated from application of table 2 above or by way of separate calculation methods on a case by cases basis (e.g. for FW 7 classifications) as outlined in Appendices H and J to SNZ PAS 4509: 2008.

The code does stress the need for New Zealand Fire Service collaboration with the Water Supply Authority and under Appendix B relating to alternative fire fighting water supplies the code states;

"The water supply must be reasonably protected from vandalism and tampering…."

Interestingly the code is silent on the use of automatic closing seismic isolating valves on reservoir outlets.

2.3 DESIGN REQUIREMENTS

The applicable code for design of concrete structures for the storage of liquids is NZS 3106 revised in 2009.

The structural design codes of joint standard AS/NZS 1170 and amendments supplement NZS 3106.

The changes in the New Zealand Standard NZS 1170 Part 5 introduced 2004 are particularly relevant to water authorities in that it includes new means of specifying performance criteria (e.g. water-tightness class).

Ongoing seismic events since 4 September 2010 in Christchurch and Selwyn districts however have brought to light the seismic potential and highlighted some common failure modes of past reservoir design.

In general these failure modes would seem to be the roof/wall and wall/floor joints, which in many cases have not proved robust enough to retain the stored water. Having said that it is worth remembering that most, if not all, of the Christchurch reservoirs were designed to an earlier code and that the vertical ground accelerations far exceeded even the current seismicity criteria. In addition water sloshing as a result of the ground waves can have a major impact on water-tightness and integrity of particularly wall and roof connections.

Nonetheless it is reasonable to expect that the events in Christchurch will provide a useful reference for the concrete and water industries to review performance of water retaining structures and some current design practices.

Figure 4: Seismic retrofitting of reservoir

At New Plymouth District Council reservoirs designed under pre-2000 codes were progressively retro-fitted to give greater seismic strengthening for infrastructural resilience.

2.4 PLANNING TOOLS

In the past water networks have traditionally been expanded with primarily residential population growth, with trunk mains being extended as the demand gets close to, or exceeds the ability to supply. Often service is extended in leaps and bounds sometimes initiated by a major water demand in an area (e.g. a new industrial complex or wet industry reliant on large volumes of water for business). New Plymouth is no different in this respect.

In my observations it is probably only in recent decades that integrated planning with neighbouring authorities along catchment boundary lines (rather than superficial local government boundaries) has begun to occur more regularly. The 1994 Auckland water drought was a portent for inter-catchment transfer of water and an authority integrated solution for water management for example.

The availability, functionality and relative affordability of hydraulic network models incorporating complex network analysis now allow a more thorough analysis of demand patterns and effects, through scenario modeling.

In New Plymouth District Council's case a network model purchased in 2007 and calibrated 2008 has allowed us to input actual demand, assess that against future demand and risk events and determine the 'weak' points in our water network. Despite our relatively high level of storage (in per capita per day terms) we have found that additional water storage is required on or near the Henwood Road reservoir site to satisfactorily meet future demand through growth , and/or a major fire event in Bell Block.

Separately a major fire demand at or near Port Taranaki could see elevated local residential areas lose supply completely, as shown by the negative pressure contours on the map below. This in itself is concerning as it represents a significant backflow hazard. The fire demand modeled was that indicated by consultants undertaking planning and feasibility work as required to meet code requirements for a potential LNG terminal sited at the Port.

On 16 August 2007 a major fire at a largely redundant warehouse (it was the old Dairy Factory) in Inglewood Taranaki, was fought for several hours overnight, resulting in the use of approximately 3,300 m3 of water on the fire, and the reduction of reservoir levels to nearly 40%[4].

Staff were able to calibrate the model to represent the fire demand after the event and assess the validity of the model under exceptional demand and therefore gain confidence in the modeled effects of pressure reduction initiatives that were about to be introduced. In any case the reservoir storage was sufficient for this incident but just what size of fire and demand should municipalities be planning for?

NZS 4509:2008 provides methods for determining the fire fighting water supply required in various fire water supply classification areas. (FW1 – FW8). Not only does the code provide guidance for low and pressure requirements and indication of the number of hydrants to be used to obtain this water, it also indicates the minimum amount of storage required in the case of non reticulated supply for fire fighting purposes. Not withstanding that the storage provision relates to non-reticulated supply, it is not unreasonable to suggest that the nominated volume of storage must also be present in the reticulated supply in order to maintain the required flow and pressure from hydrants. Given that the volume of storage must be retained for fire fighting purposes and should not be used for operational purposes then this has a significant impact on the available storage in a water network. FW6 is not an unreasonable level of fire classification and is the classification given to working / business / storage activities such as manufacturing processing or bulk storage with a largest firecell of 800 – 1,000m2. In the case of New Plymouth with a typical reservoir capacity of 4,500m3 of which 15% is reserved for emergency supply and is inaccessible and with a FW6 storage requirement of 2,160m3 then the normal operating range of the reservoir is limited to between 63% and 100% capacity. Therefore only 37% (1665m3) of the total stored volume is available for normal operational requirements.

This led New Plymouth District Council to reconsider operation of its reservoirs supplying the distribution network in conjunction with a demand management program it began planning from 2005.

2.5 ESTABLISHMENT OF NEW PLYMOUTH SUPPLY ZONES

Following the successful implementation of supply zoning and pressure management in Inglewood which resulted in an 8% reduction in consumption and 30% reduction in estimated leakage, NPDC planned and implemented 16 supply zones on the New Plymouth water supply. The hydraulic model was again used to establish confidence in the impact that the reticulation changes would have. The primary objectives of the supply zones was to establish discrete areas of the reticulation which were supplied from specific reservoirs, to provide opportunity to control pressure in areas of high pressure, to manage risks of loss of supply and or stored water due to natural hazards, and to improve the balance of demand on the New Plymouth Treatment plant reservoirs which was itself a limiting factor in the availability of stored water.

The supply zones were established using stream and river crossings as primary boundaries. This reduces the risk of infrastructure damage in storm events as well as being practical due to the limited number of reticulation crossing points.

[4] Total storage for Inglewood is 7,500 m3

The zones are typically based around reticulation being supplied from one reservoir except for the CBD area. Supplying a single zone from a single reservoir enables the water to be contained in the event of a contamination event, and also protects the balance of stored water in the event of a catastrophic reticulation failure.

The Central Business District (CBD), Fitzroy residential, and Fitzroy industrial areas utilized a contour elevation as an artificial boundary to enable pressure reduction to be introduced at a later date, once private sprinkler systems are addressed.

The CBD zone is fed from three reservoirs utilizing pressure reducing valves to marginally reduce pressure at this stage by 100kPa (approx 9%) to manage the demand on the individual reservoirs. This alone has increased the daily demand on NP WTP#2 by 7,000 m3/d and reduced demand on NP WTP#1 by a similar amount.

The incremental development of the NP water reticulation has created some areas which are difficult to manage and which would not have been recognized without the hydraulic model. The imbalance on the treatment plant reservoirs created by the incremental development had not been considered. There are areas of reticulation, in particular Glen Avon, Bell Block and Waitara, where management of the water pressure and security of the infrastructure is limited by the need to maintain very high pressure in low lying areas simply to ensure sufficient supply to high elevation areas further downstream.

Improvements are planned by means of a second trunk main to those high elevation areas to provide redundancy and to enable the subsequent introduction of pressure reduction to Waitara, Bell Block and Glen Avon in turn. Ultimately this may mean the construction of new reservoirs on the Faull Road and Henwood Road sites respectively.

Alternatively more storage could simply be provided to each locality in turn but at nearly $2M[5] cost per reservoir the better option is build the additional turn supply mains (giving greater flexibility and reliability of supply in any case) and rely upon the in-built storage at the head of the system.

In addition each new remote reservoir site poses additional security and water quality management risks.

2.6 SECURITY OF STORAGE

What are the threats to reservoir security (and in particular sufficient retention of the stored water) to allow continuity of service, emergency supply without significant deterioration of water quality?

I have defined the threats into the following categories;

(1) Natural hazards (earthquake, landslide, erosion, Tsunami)

(2) System hazards (equipment failure, chemical under or over dosing, manual error, changing codes)

(3) Deliberate attack (third party damage, sabotage, acts of terrorism, cyber attack)

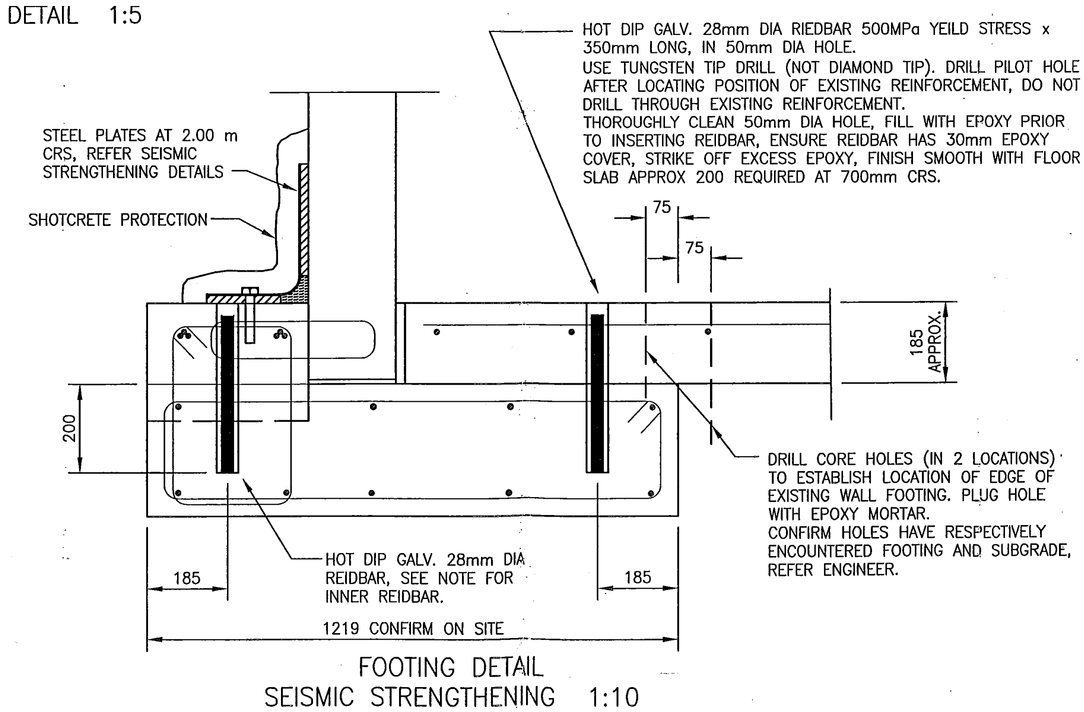
In many senses the natural hazards are those that are easiest to design for as they can normally be identified, scoped and evaluated with an appropriate design response. The difficulty arises when a new thereat is identified for existing infrastructure for which the asset was not designed or constructed to cope. New Plymouth District Council found in 2000 that all of its previously built circular reservoirs of the free standing roof design (seven in total) did not have sufficient seismic capacity particularly in the base/wall connections and precast roof panels to wall connections. The solution was to design remedial strengthening for base seismic strengthening and top level seismic strengthening. That typically consisted of:

Base Seismic Strengthening: epoxy bonding of angle shaped steel plates to the bottom of the outer face of the walls and foundations around the outer perimeters of the reservoir(s) and drilling and epoxying into place studs or dowels between the floor and ring beam foundation on the inside faces. The remedial work has substantially increased the capacity for the transfer of seismic shear forces at the base of the reservoirs.

---

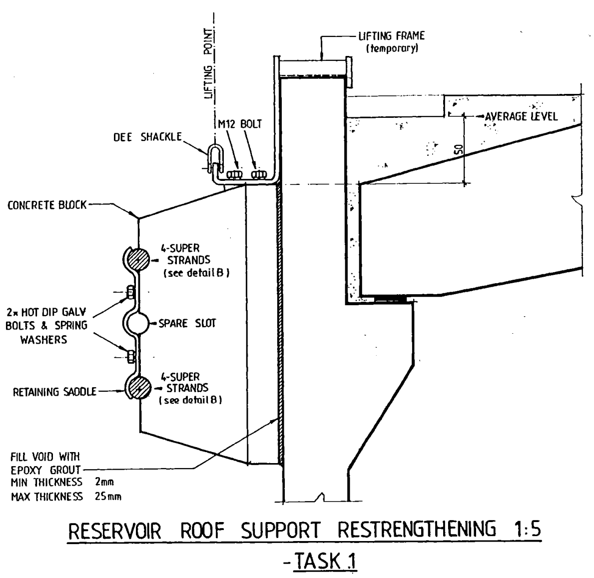
[5] Based on recent capital costs for 4,500m3 circular precast reinforced concrete post-tensioned reservoirs

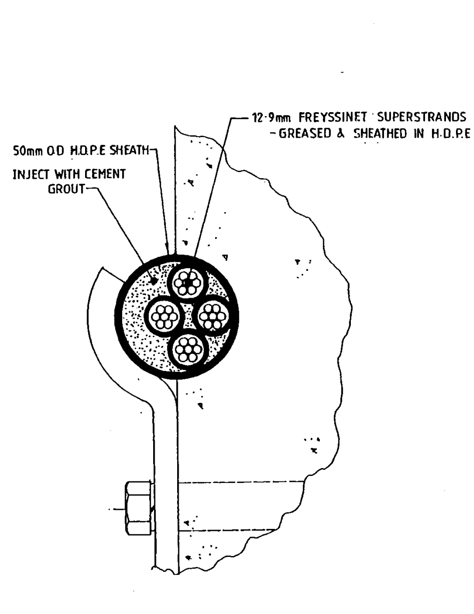
Figure 5: Base seismic strengthening of wall panel/floor connection



Top Level Seismic Strengthening: external hoop post-tensioning with greased and sheathed tendons outside concrete block packers at top wall level on the reservoirs. These improvements have substantially increased the hoop strength at the top of the wall to resist horizontal seismic loads at rook level by constraining the movement possible between the roof panel which is supported on the inside wall corbel.

Figures 6 and 7: Roof/wall panel connection seismic strengthening and exterior post tension cables





Access: Opportunity was taken at the same time as the above works to improve the security of access and egress to the reservoirs also. This consisted of replacing the previous hinged steel access hatches with locked down access hatches with separate ventilation stacks and a raised nib around the hatch to prevent the unintended ingress of rainfall runoff and vermin. A second access hatch in this style was also added to give alternative access (or egress) for staff and to improve ventilation of the airspace within the reservoir. For safety the access hatch lids are lockable in both the closed and open positions. All metalwork was done in 316 stainless steel.

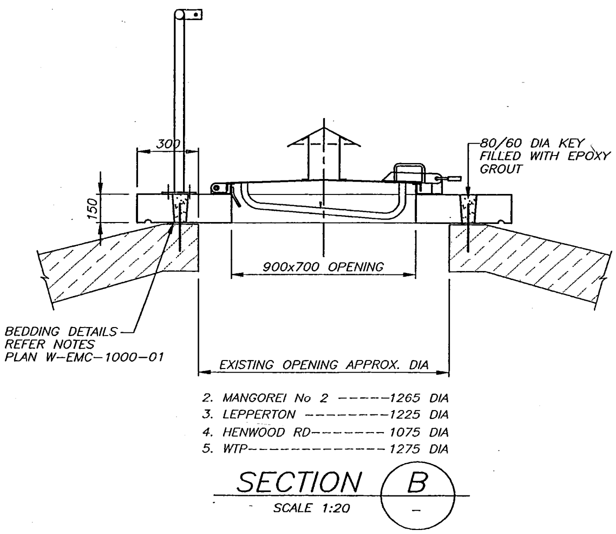


Figure 8: Central access hatch and vent

Some other features were incorporated into the reservoir retrofit to improve retention of stored water in the aftermath of a major natural event, and for efficient normal operation

They were;

- The outlet pipe complete with anti-vortex device, is installed at 15% of the internal height of the reservoir (see below)
- Installation of a vertical up stand on the floor outlet – the purpose is to ensure that even in the event of a breaching of the outlet pipe not all water will be drained from the reservoir, and the remaining 15%[6] can later be meted out
- A dedicated emergency connection (typically 50mm diameter) is provided off the scour pipe to enable the meting out of water during the emergency – this in itself implies customers coming to the reservoir, so needs to be planned for in the emergency
- A 5 m3 drainage chamber to collect and control the discharge of contaminated drainage from the reservoir (typically off the bottom) when draining down and cleaning operations are done
- All internal pipe work (up to the first flange outside the reservoir) and including the wall penetrations and all other exposed metalwork is grade 316 stainless steel.
- The top of the overflow pipe should be at Top Water Level (TWL) with a trumpet entry
- The outlet pipe is sited diametrically opposite to the inlet pipe to promote good flow circulation
- The installation of flexible rubber bellows on the outlet, protected by a stainless steel shroud[7]

[6] This is the standard design criteria for New Plymouth District Council

[7] New Plymouth District Council don't use automatic closing seismic isolating valves

The preference is to have a minimum of sites to manage but to incorporate two identical reservoirs on each site to provide redundancy and flexibility of operations, while maximizing the capital investment on the site. A typical layout is given at Appendix 2.

3 CONCLUSIONS

New Plymouth District Council has been fortunate not to have suffered any major natural disasters or crises affecting reservoirs and water supply in recent decades, nonetheless we consider it prudent to plan for such possibilities, and in so doing have come up with a suite of pragmatic and planning measures for determination of storage requirements, reservoir structural design and security.

Such measures may be used by other water supply authorities in providing water storage to their water supplies.

Particular focus should be given to consolidation of infrastructure on existing sites, using the model of two (or more) reservoirs per site.

New Plymouth District Council is planning to achieve treated water storage volumes of up to 2 days of average daily demand for its respective supplies. Further storage is to be added at the Henwood Road site in order to meet future development demand in the Bell Block and Glen Avon area. This will enhance fire fighting capacity to the same area and in particular the Airport once further trunk mains in the vicinity of the Airport. A further reservoir may also be constructed in the next decade at Faull Road to provide greater storage to the east, and redundancy to Waitara. This necessitates the building of a 9 km overland trunk main prior.

Adherence to the New Zealand Fire Service Code of Practice for firefighting water supplies SNZ PAS 4509:2008 may prove costly for some councils to meet given the specified flows, particularly for urban development's with fire-cells rated FW 4 and greater, and the related storage requirements for firefighting reserves.

Peak annual demand for the New Plymouth water supply has been measured at 40,000 m3 per day. Using the code requirements referred above; 60% of annual peak demand is therefore 24,000 m3. Fire storage is additional. If we assume one FW 6 classification per SNZ PAS 4509:2008 for the 16 zones then required additional fire storage is 16 x 2,160 m3 = 34,560. Total storage required then is 58,560 m3.

Current storage available is 52,050 with two further 4,500m3 reservoirs planned for Henwood Road and Faull Road (as above). While these improvements will give a total stored capacity slightly more than the theoretical value, it is worth noting that decreasing annual total and average demand through demand management initiatives and water loss reduction will further improve the overall situation. Interestingly had New Plymouth District Council not established the zones and continued with one single supply zone for the city then overall storage requirements would be reduced (as any reservoir linked into the single zone can provide the required storage rather than a dedicated reservoir per zone). The zones however have been necessary to enable our demand management initiatives to succeed in the first place.

ACKNOWLEDGEMENTS

Andrew Venmore, Water Supply Manager, Whangarei District Council

Ron Lambert, Senior Researcher, Puke Ariki and District Libraries, New Plymouth District Council

Graeme Pool, Operations Manager, Water and Wastes team, New Plymouth District Council

REFERENCES

SNZ PAS 4509: 2008 New Zealand Fire Service Firefighting Water Supplies Code of Practice

NPDC Water Asset Management Plant (WAMP) draft version 2011