KAPITI WATER SUPPLY – QUANTIFYING LOSSES TO SUPPORT WATER MANAGEMENT

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ABSTRACT

Kapiti Coast District Council is planning to manage and meet future water demand in a potentially high growth District. The Council is currently working towards a 50-year supplementary water supply solution for the communities of Waikanae, Paraparaumu and Raumati. This project is running in parallel with Council's water conservation programme that involves a number of initiatives to reduce demand across the District. Two of the water conservation action areas are water loss reduction and data gathering.

Understanding the trends in demand and different components of demand is important for both the water conservation programme and the water supply project. To lay the foundations for this understanding, historic water consumption data was analysed from reservoir flow meters, network zone meters and commercial meters. Because the Kapiti Coast does not have universal metering, the breakdown of the total volume supplied into residential consumption and losses was not known. Using available consumption data together with a number of other data sources and tools such as BenchlossNZ, a variety of estimates were made of losses and residential use. These estimates were in reasonable agreement giving Council a realistic estimate of the true extent of losses, which were about twice what had been assumed. This work led to recommendations for improving water loss estimates and reducing water losses within the network which are now being used to inform Council's water conservation programme leading to better management of losses. This work has also contributed to Council's recent decision to reconsider universal metering for the District.

KEYWORDS

Water losses, water conservation, demands, night flows, BenchlossNZ

1 INTRODUCTION

Kapiti Coast District Council (KCDC) provides drinking water to the communities of Paekakariki, Raumati, Parapararumu, Waikanae, Hautere/Te Horo and Otaki. The largest of the Council's water supplies is the Waikanae, Paraparaumu and Raumati (WPR) network which currently services a population of approximately 37,500 people. The Waikanae River is the primary raw water source for the WPR water supply but during times of low flow in the river, when minimum flow requirements apply, the raw water source is changed to groundwater from six supplementary groundwater bores located in the Waikanae urban area. The community is dissatisfied with the taste and hardness of the supplementary groundwater supply and so an alternative source is desired. In addition, peak daily demand is nearing the consent limit for abstraction from either the Waikanae River or the Waikanae Borefield so further capacity is needed. The multi-stage Kapiti Water Supply Project (KWSP) is well advanced in seeking to identify and implement the most suitable supplementary water supply solution for WPR that will see the three communities through the next 50 years.

The KWSP is running in parallel with Council's water conservation programme. This programme involves a number of initiatives to reduce water demand across the district down to Council's adopted target peak daily demand figure of 400 L/person/day. This figure was set by Council's 2003 Sustainable Water Strategy: Water Matters. The seven action areas detailed in the Council's Water Conservation Plan are:

- Improved Data
- Water Loss Reduction

- Regulation
- Community Education
- Fostering Innovation
- Financial Incentives
- Council Leadership

Some of the specific water conservation measures are: district plan requirements for all new houses to include on-site non-potable systems, the advisory Green Plumber and Green Gardener, the annual Sustainable Home and Garden Show, interest free loans for houses built before 2008 for the purchase and installation of on-site systems, schools water essay competition and residential water use monitoring.

The target peak day demand of 400 L/person/day, with an additional allowance of 90 L/person/day for water losses, has formed a fundamental design assumption for the water supply project. In order to improve the robustness of demand forecasting for the KWSP it was important to understand the trends in demand and the different components of demand within the WPR water supply network. This coincided with Council's desire to estimate water losses in the District, starting with the larger WPR network.

2 WPR WATER SUPPLY

The Waikanae Water Treatment Plant (WTP) pumps treated water to the Kakariki Reservoir in Waikanae and the Otaihanga and Riwai Reservoirs in Paraparaumu. The Waikanae and Paraparaumu-Raumati communities are served separately from their respective reservoirs and the two networks are not interlinked. The majority of residential and commercial properties are gravity fed with on-demand supplies, although there are a few areas with restricted supplies.

The Kakariki reservoir serves the entire Waikanae urban area (Waikanae, Waikanae Beach and Peka Peka). Water from the Kakariki reservoir is also conveyed back to the water treatment plant via the reticulation for process water (chemical makeup and chlorine carry water) and domestic use. The Waikanae scheme has been split into five District Metered Areas (zones) which are locked down to enable zone meters in the scheme to measure the flow into each zone. For pressure management the Council has recently installed pressure monitoring devices for each zone and there is a pressure reducing valve at Waikanae Beach that limits the maximum pressure in this area to 80 m.

For the Paraparaumu-Raumati scheme, the reticulation layout is not so straightforward. Water pumped from the Waikanae WTP feeds into both the Otaihanga and Riwai reservoirs. The Otaihanga reservoir is connected by a rising-falling main to the trunk main that delivers water to the Riwai reservoir. Water entering/leaving the Otaihanga reservoir is not yet metered but the water level in the reservoir is continuously monitored. There are approximately 230 properties that are supplied water from the trunk main that feeds the Riwai reservoir, and the Riwai reservoir serves the remainder of the Paraparaumu-Raumati community. The Paraparaumu-Raumati scheme has more recently been split into seven zones for flow monitoring.

Figure 1 is a plan of the WPR water supply network showing the zone boundaries, the locations of the major reservoirs and the key flow meters.

There are some 337 km of Council water mains in the WPR supply area and the average age of the water mains is approximately 30 years. The most prevalent pipe materials are asbestos cement and PVC.

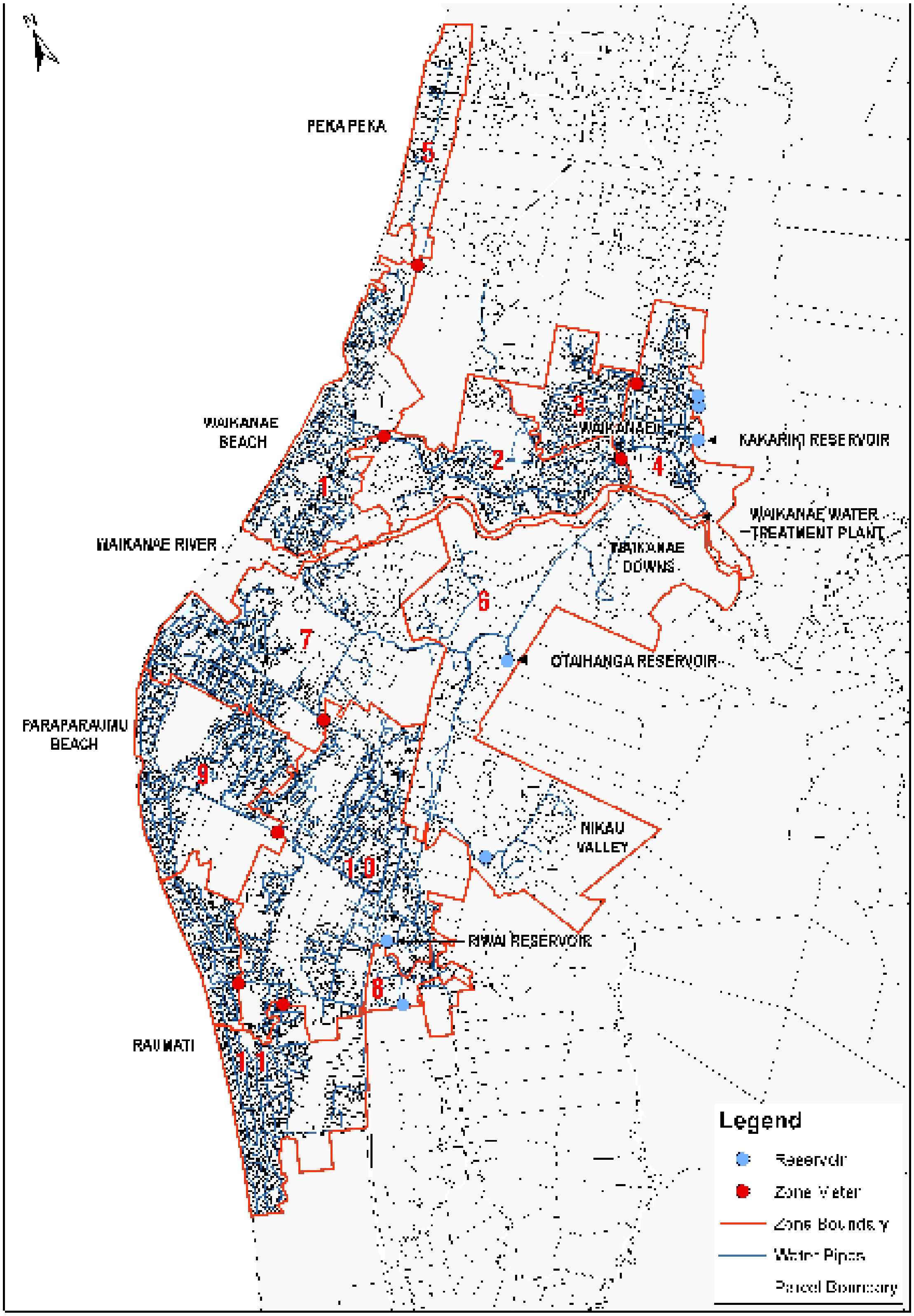
The Kapiti Coast District does not have universal water metering but Council does meter water supplied to many commercial properties and Council facilities. The Council's new Water Supply Bylaw 2010 enables Council to meter and charge for water supply at all premises with extraordinary activities (e.g. commercial, industrial, agricultural, lifestyle blocks, educational institutions, rest homes). The Water Supply Bylaw came into force on 1 July 2010, therefore the number of meters and quality of data for quantifying extraordinary water use is expected to improve going forward. Not all metered water use is for commercial purposes; residential users who have lifestyle blocks, a spa or swimming pool in excess of 10 m^3 capacity or use more than 350 m^3/year are now also classified as extraordinary users and so will be metered and charged for their excess water use under the bylaw. Additionally there are some residential users that have volunteered to have water meters.

The new Water Supply Bylaw also provides a means to enforce Council's commitment to managing water use. Under the bylaw private property owners are required to fix any leaks identified on the private side of the water supply network. Currently, Council has staff and contractors working on routine leak detection and repairs. The programme involves comprehensive acoustic leak detection surveys by water supply zone. When a leak is identified, its location is recorded and if it is on a Council main or service connection it is scheduled for repair by the Council's in-house maintenance team. If a leak is identified on private property, the homeowner is notified, either in person at the time of testing or by letter. If the leak is significant, the Council may install a meter to monitor the night-flows (and therefore level of private leakage) for that property. Under the new bylaw, Council has the power to fine homeowners who do not fix private leaks within 21 days.

Based on past leak detection records, Council believe leaks within the WPR network are more prevalent on private property and Council service pipes rather than main supply pipelines. Following leak detection ground surveys in 2010 in areas of Waikanae covering around 2,100 properties, Council estimated that losses identified from private connections totalled 360 m^3/day, while the repaired leaks on the Council side of the system saved 150 m^3/day. The leaks detected on the Council side of the service connections were predominantly faulty tobies or pinhole leaks of copper service pipes. Some of these leaks were associated with pitting corrosion of copper pipework which was a significant problem in the Kapiti Coast in the 1970s and 1980s. Private leaks varied from dripping taps and leaky toilet cisterns to large losses (i.e. up to 100 m^3/connection/day) through split underground supply pipes. Most of the large private leaks involved alkathene pipe, a low density polyethylene pipe intended for low pressure agricultural use, commonly used for plumbing in houses built in the 1980s and 1990s.

While Council endeavours to quickly respond to and repair leaks reported by the community, many leaks on underground pipes are not readily visible at the surface because of the high porosity of the sandy soils in the WPR network area.

Figure 1: WPR Water Supply Network



3 WPR WATER DEMAND REVIEW

3.1 OVERALL DEMAND TRENDS

Council measures and reports daily gross water consumption for the Waikanae and Paraparaumu-Raumati schemes using flow meters at the outlets of the Kakariki and Riwai reservoirs. The daily water consumption in m^3/day is posted on Council's "Water Watch" website.

The daily volume of water leaving the Kakariki and Riwai reservoirs is used for reporting consumption rather than the daily volume of water leaving the Waikanae WTP because the reservoir outflows are more reflective of actual demand patterns and account for the buffering effects of the reservoirs. There are some properties (approximately 230) between the Waikanae WTP and Riwai reservoir that are served from the bulk supply main upstream of the Riwai reservoir. To date these properties have been included in the per person consumption figures for Paraparaumu-Raumati even though their demand is not included in the total water consumption data.

The annual trends in consumption for the WPR water supply over the past 11 years are illustrated in Figure 2. The demand per person is calculated by dividing consumption by the estimated population, and therefore the per person demand includes losses and non-residential (commercial) use. It can be seen from this graph that peak demand has reduced since the early 2000s, which is most likely attributable to Council's initial conservation work associated with the 2003 Sustainable Water Management Strategy. However, the ratio of annual average demand to annual minimum demand is reducing, which may be indicative of greater losses within the supply.

The peak day demand for WPR across the last five years averages at 590 L/person/day (including commercial use and losses). Therefore to meet the KWSP design requirement of 490 L/person/day, the peak day demand needs to be further reduced by about 100 L/person/day.

When the two parts of the supply are compared (refer Figure 3) it is apparent that Waikanae has much higher peak and average demand on a per person basis than Paraparaumu-Raumati. However, the peak day demand for Paraparaumu-Raumati also exceeds 490 L/person/day.

3.2 COMPONENTS OF DEMAND

Simplistically the three main components of demand are residential consumption, commercial/industrial consumption and water losses. Commercial/industrial consumption can be determined from metering records, although this is only an average demand because meters are read only quarterly or annually, and also not all commercial users in Kapiti are currently metered. On the whole there is very little industrial activity in the WPR area and the largest water user is the Waikanae Water Treatment Plant (although most of this water is used within the treatment process so the majority of the water is put back into supply). Commercial/industrial consumption (including the WTP) is estimated to be approximately 10% of the total average day demand.

This leaves residential consumption and water losses, but without residential water metering the breakdown of the total volume supplied between residential consumption and losses is not known. However, with some assumptions and the use of other data sources, losses can be estimated, leaving the remainder to be taken as residential consumption.

Figure 2: WPR Water Demands 2000/01-2010/11

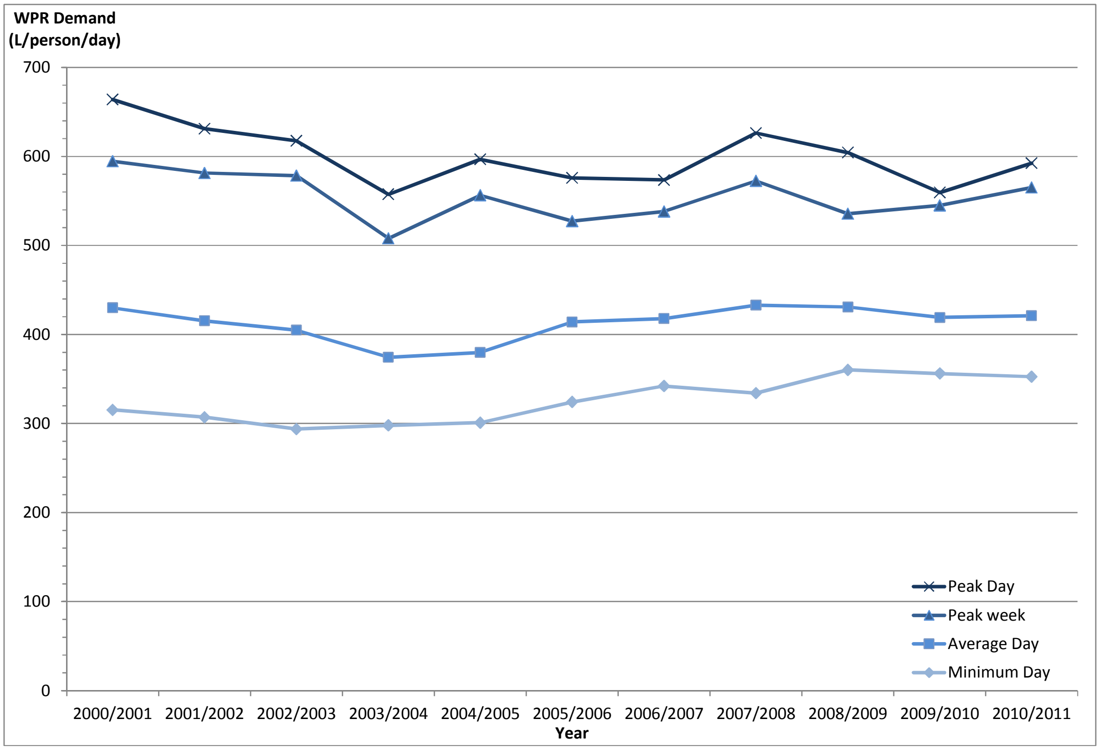
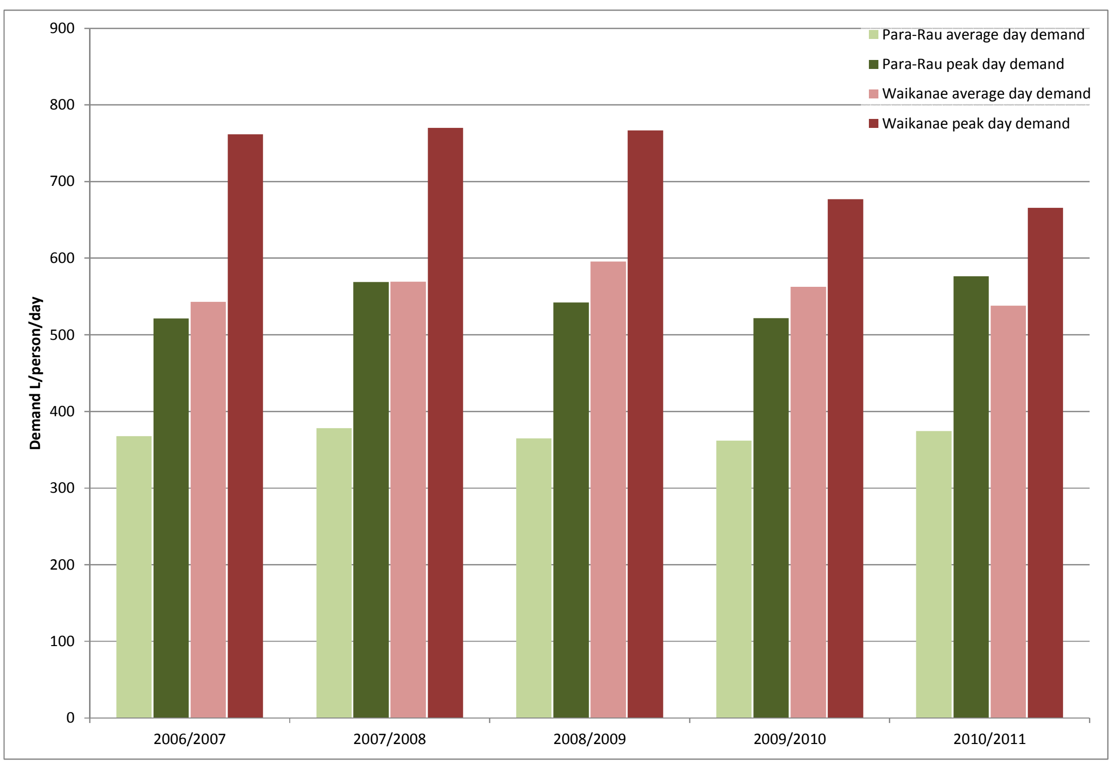


Figure 3: Waikanae and Paraparaumu-Raumati Water Demands 2006/07-2010/11



4 COUNCIL'S WATER LOSS REDUCTION STRATEGY

In early 2010, Council prepared a Water Loss Reduction Strategy that has been incorporated into the Water Activity Asset Management Plan. The strategy covers the whole District and has the following objectives:

- Understand the varying water usage and losses within the District's supply networks
- Confirm terminology and methodology for monitoring and reporting on water losses
- Reduce water losses to economically and environmentally sustainable levels within 3 years
- Report on performance.

While Council has historically undertaken work to review water losses and actively locate leaks, there was no plan to guide or prioritise ongoing work. The strategy was a good tool for re-focusing efforts and aligning water loss reduction work with Council's other policies, including the Water Conservation Plan. Incorporating the strategy within the Water Asset Management Plan will ensure an ongoing commitment and allocation of adequate funding and resources to work towards a successful water loss reduction programme.

Real loss management performance, based on the Infrastructure Leakage Index (ILI), has been divided into four categories by the World Bank Institute. These bands apply to developed countries and are outlined in Table 1 (as per Water NZ Water Loss Guidelines (Lambert & Taylor, 2010)). In the Water Loss Reduction Strategy Council estimated that it was in Band C for losses. The strategy aims to reduce losses to achieve Band B within 3 years, with a review at this time to reset targets, and the long term aim is to further reduce losses to achieve Band A to support the ongoing sustainable water usage for the District.

Because Council did not know the extent of losses within the District, the starting point for the water loss reduction programme was to estimate the current level of losses. Once Council had a better handle on where it stood with regard to losses, an implementation plan or programme of works with key performance indicators could be formulated.

Table 1: World Bank Institute Real Loss Management Performance Bands

ILI range	WBI Band	Description of performance category
Less than 2	A	Further loss reduction may be uneconomic unless there are shortages; careful analysis needed to identify cost-effective improvement
2 to 4	B	Potential for marked improvements; consider pressure management, better active leakage control practices, and better network maintenance
4 to 8	C	Poor leakage record; tolerable only if water is plentiful and cheap; even then, analyse level and nature of leakage and intensify leakage reduction efforts
More than 8	D	Very inefficient use of resources; leakage reduction programs imperative and high priority

5 QUANTIFYING LOSSES

5.1 OBJECTIVES

The objectives of the work to quantify losses for the WPR water supply network were:

- to estimate water losses and provide Council with data that can be used going forward to assess the effectiveness of its water loss reduction programme (i.e., benchmarking)
- to inform Council's Water Loss Reduction and Water Conservation programmes
- to identify information gaps in monitoring water use and losses
- to assess whether the allowance of 90 L/person/day for losses used for the Kapiti Water Supply Project is appropriate.

5.2 INPUTS

In order to quantify losses in the time available, the data already held by Council had to be used in the best way possible. Council collects and stores an extensive collection of data related to the WPR water supply. Instantaneous flow records are available for the reservoir outlet flow meters and the zone flow meters. Council's SCADA system also records water levels in the reservoirs and pressure measurements from permanent pressure monitoring sites within the reticulation. In addition Council's GIS system holds information about pipe lengths, water connections and rateable properties, and a database of water meter readings is maintained for billing extraordinary users.

There is also data available on wastewater flows which could be used as a check on the water used indoors.

5.3 DATA CONFIDENCE

5.3.1 FLOWMETER ACCURACY

The key details for all of the water treatment plant, reservoir and reticulation flow meters were collated, including the specified accuracy and calibration details. The water treatment plant output is measured by two electromagnetic flow meters (one for Paraparaumu-Raumati and one for Waikanae). The Kakariki and Riwai reservoirs have electromagnetic flow meters at their outlets, while turbine meters are used for zone metering within the reticulation.

The electromagnetic flow meters are verified annually, and the latest calibration verification certificates show that all of the meters are functioning within normal working limits and are within ±2% of original calibration certification. While this does not confirm that the meters are reading the correct flows, regular calibration of the electronics is valuable for checking the flow meter set up. This was recently demonstrated at the Kakariki reservoir where it was found that a replacement panel had the wrong flow factors for the installed sensor. Consequently this meter was over-reading by 1.8%. On-site flow readings have also been compared with SCADA data to check the signal from the flow transmitters to the telemetry is correct.

Collating the flow meter data highlighted that most of the zone meters had not been calibrated for a very long time and Council is currently working through a programme of replacing the metering mechanisms of the turbine meters with re-calibrated meter mechanisms.

5.3.2 RESERVOIR BALANCES

Water balances on the WPR supply's reservoirs were carried out to check the accuracy of the flow meters used to measure water consumption. The water balances were based on daily volumetric flows entering and leaving each reservoir and changes in the volume of water stored in the reservoir each day (based on continuous ultrasonic level readings).

For each reservoir the daily net flow through the reservoir (i.e. the flow in minus the flow out) was compared to the change in storage volume for that day. If these readings were not close, it indicated that there was a problem with one of the flow meters and further investigation was needed. The water balance for Riwai Reservoir was complicated by the lack of information for flows entering/leaving Otaihanga Reservoir and the water consumed by the properties between the WTP and Riwai reservoir, which are either not metered or not continuously metered. As the majority of these properties are on restricted supplies some assumptions could be made about their consumption and an annual water balance on the system between the WTP and Riwai reservoir confirmed these assumptions were appropriate.

From the reservoir balance it was found that the net flow and change in storage followed the same trends from day to day and over the four weeks of data analysed the discrepancy between net flow and the change in storage volume was low overall (<2% of reservoir outflow). The reservoir balance does not necessarily confirm the accuracy of the flow meters as the difference between the net flow and change in reservoir volume represents:

- any leakage from the reservoirs or trunk mains between the WTP and reservoirs
- other losses between the WTP and reservoirs, including authorised consumption
- inaccuracies arising from the flow meters, level sensors or data manipulation.

Drop tests are planned for the Kakariki and Riwai reservoirs to further validate the outlet flow meters which are critical for Council's reporting of water consumption and estimating water losses.

5.3.3 NETWORK DATA

While Council's GIS system is continually updated to reflect new or renewed assets, it is difficult to gauge the accuracy of the GIS data with respect to length of mains, number of connections and number of properties. The number of water supply connections in some areas has been verified by an on-site survey. The number of properties with vacant land is assumed to be small and so all properties are assumed to be using water. The effect of this assumption on the overall loss estimates should be small, but if an allowance for vacant properties was made the loss estimates would be higher.

The populations for WPR are based on the 2006 Census usually resident populations and medium growth projections as per Council's Long Term Plan. Populations for the individual zones were pro-rated from the overall supply population based on the number of connections within the zones.

5.4 METHODS AND FINDINGS

Water losses were calculated by both 'bottom up' (minimum night flow) and 'top down' (annual water balance) methods. Losses were calculated for WPR as a whole, as well as the Waikanae network, the Paraparaumu-Raumati network, and four of the Waikanae zones. Losses were not calculated for Peka Peka (the fifth Waikanae zone) because all of the properties in this zone are on restricted supply meaning that flows should be fairly constant throughout the day and so night flows are not indicative of losses. The best way to determine losses in the Peka Peka zone would be to close the inlet to each connection and check the flow through the zone meter. Losses were not calculated for the individual Paraparaumu zones because these had not yet been locked down.

For the minimum night flow method, flow from the Riwai Reservoir only was considered for Paraparaumu. It was not practical to examine night flows from the WTP clearwell as it is pumped. This means that the water loss figures calculated for Paraparaumu by this method do not include the Nikau Valley, Otaihanga and Waikanae Downs areas, which are supplied upstream of the Riwai Reservoir. These small zones are mainly on restricted supplies and the losses in these areas are expected to be relatively low.

For the annual water balance method, the network as a whole was considered, and the water supplied is that from the pumped from the clearwell at the WTP from 1 July 2009 to 30 June 2010. Thus for the Paraparaumu water balance loss estimate, the Nikau Valley, Otaihanga and Waikanae Downs areas are included within the Paraparaumu water losses estimate.

Losses were reported using four units:

- m^3/day
- L/connection/day
- L/person/day
- Infrastructure Leakage Index (ILI)

These units are consistent with Council's Water Loss Reduction Strategy. The consistent use of these units in future reporting of water losses is important for assessing improvements in water loss reduction.

5.4.1 MINIMUM NIGHT FLOWS

Council provided instantaneous flow data for a two week period in June 2010 and a two week period in July 2010 for the reservoir outlet flow meters and the Waikanae zone meters. It was decided to look at flows during this time of year because in winter the assumption can be made that there is little or no night time outdoor demand for water (eg, night watering of gardens), which makes estimating losses easier. The minimum flows in July were consistently lower than those in June so the July data was used for the loss estimates.

For each flow meter the minimum flow for each day was identified and then checked to confirm that it occurred between 1:00 am and 5:00 am. Data was also reviewed to check that the night flows were not affected by filling of smaller service reservoirs within the network. The minimum night flow (MNF) for calculating losses was then taken to be the average of the daily minima over the two-week period.

The losses for each area were then estimated from the MNFs by allowing for genuine night time use and multiplying by an hour-to-day factor. The hour-to-day factor is also called a night-day factor and accounts for the effect of pressure within the reticulation on leakage rates throughout the day and hence the increased rate of leakage at night due to higher pressures in the system at this time. At first an hour-to-day factor of 22 was used, in line with the recommendations of Farley and Trow (2003). Genuine night time use of 2.5 L/connection/hour was allowed for in accordance with the WaterNZ Water Loss Guidelines (Lambert & Taylor, 2010), which recommend a customer night consumption of 2-2.5 L/connection/hour for unmetered residential properties. For this analysis, it was assumed that genuine night time use did not include private leakage.

For the Waikanae area, the WTP is a fairly big night user of water so this was subtracted from the Kakariki MNF, as was the flow through the Peka Peka zone meter (restricted supply zone). Table 2 gives the average MNFs and loss estimates for the WPR water supply based on flow data between 5-18 July 2010.

The WaterNZ Water Loss Guidelines provide a methodology for calculating a 'Snapshot' Infrastructure Leakage Index, which is the ratio of night time losses to the calculated unavoidable annual real losses (UARL). Unlike the ILI calculated using BenchlossNZ (Section 5.4.2 below), the snapshot ILIs include consumer-side losses.

Table 3 shows the breakdown of the Waikanae loss estimate between the four metered zones. The MNFs for each zone are calculated by subtracting the average MNFs exiting the zone from the average MNF entering the zone. The high rates of losses for Waikanae zones 2 and 3 compared to zones 1 and 2 suggest that there could be errors in the flow measurements by the zone meters, which reinforces the need to have the zone meters calibrated or replaced.

Table 2: WPR Losses Estimates Based on Minimum Night Flows (July 2010)

	Paraparaumu-Raumati (excl. areas upstream of Riwai reservoir)	Waikanae (excl. zone 5)	Total
Estimated night losses (m^3/hour)	122	104	226
Estimated losses (m^3/day)	2,680	2,290	4,970
Estimated losses (L/connection/day)	270	470	340
Estimated losses (L/person/day)	110	190	130
Unavoidable Annual Real Losses (m^3/hour)	35	13	48
'Snapshot' Infrastructure Leakage Index	3.5	8.0	4.7

Table 3: Waikanae Losses Estimates Based on Minimum Night Flows (July 2010)

	Zone 1	Zone 2	Zone 3	Zone 4
Estimated night losses (m^3/hour)	10	48	40	6
Estimated losses (m^3/day)	220	1,060	880	130
Estimated losses (L/connection/day)	110	950	980	150
Estimated losses (L/person/day)	50	370	370	60
Unavoidable Annual Real Losses (m^3/hour)	5	3	2	3
'Snapshot' Infrastructure Leakage Index	2	16	20	2

The observed variation in reticulation pressure can be used to scale the MNFs instead of a nominal hour-to-day factor of 22. Examination of pressure monitoring data for the Waikanae and Paraparaumu-Raumati networks showed that there was only a relatively small pressure fluctuation throughout the day, which means that the rate of leakage throughout the day and night should be fairly constant. While the locations of the permanent pressure monitoring sites are not necessarily at the Average Zone Point (AZP), the daily variation in pressures at the Council monitoring sites should be representative of the variation across the network. The ratio of observed average pressure to maximum pressure ranged between 0.95 and 0.99. These are higher than the hour-to-day scaling factor of 0.92 (22 hours out of 24), which would indicate that the minimum night flow method with an hour-to-day factor of 22 is likely to be under estimating losses.

When the loss estimate calculations were re-run with the observed hour-to-day factors, the losses increased to the figures given in Table 4.

Table 4: Losses Estimates based on night flows and observed pressure variations (July 2010)

	Paraparaumu -Raumati (excl. zones 5, 6 & 7)	Waikanae					WPR Total
		Zone 1	Zone 2	Zone 3	Zone 4	Total (excl. zone 5)	
Estimated losses (m^3/day)	2,820	230	1,150	940	160	2,480	5,300
Estimated losses (L/connection/day)	290	120	1,020	1,050	180	510	360
Estimated losses (L/person/day)	110	60	400	400	70	210	140

5.4.2 WATER BALANCE

The BenchlossNZ software (NZWWA, 2008) was used to undertake an annual water balance for the WPR water supply in order to estimate water losses using a 'top-down' approach.

Table 4 shows the annual water balance for the WPR supply for the 2009/10 financial year. The following assumptions were made in this water balance:

- Billed unmetered consumption (i.e. residential) is based on 230 L/person/day, plus private underground supply pipe losses (i.e. leakage within private property). The WaterNZ Water Loss Guidelines give the residential water consumption in Tauranga as 210 L/person/day. Tauranga is considered to be fairly similar to Kapiti in terms of climate and lifestyle and so the demand for water should be similar. However, residential use is metered in Tauranga and so to account for the effects of metering this value has been revised upwards for Kapiti to 230 L/person/day and underground supply pipe losses (as calculated by BenchlossNZ) have also been added. This results in residential use equivalent to approximately 260 L/person/day.

- All commercial property (i.e. non-residential property) is metered. Commercial properties that are not metered are incorporated within the unmetered residential demand and so are assumed to have residential-type consumption. The Water Treatment Plant demand was entered as unbilled metered demand to identify it separately from other non-residential demands.

- The majority of water is billed, either through metering, or as part of the rates paid to KCDC. Water that may be unbilled, such as hydrant testing, system flushing, etc. is assumed to be less than 0.5% of the total water supplied (as given in the BenchlossNZ User Manual (McKenzie & Lambert, 2008)).

- Unauthorised consumption through illegal connections, etc. is assumed to be 0.1% of the water supplied (as given in the BenchlossNZ User Manual).

- The effect of seasonal population increase is negligible on water demands.

Table 5: WPR Supply Annual Water Balance 2009/10

<table>
<tr><td rowspan="5">Own Sources
5,686,700 m^3</td><td rowspan="8">System Input Volume
5,686,700 m^3</td><td rowspan="5">Authorised Consumption
4,210,700 m^3</td><td rowspan="3">Billed Authorised Consumption
4,055,100 m^3</td><td>Billed Water Exported
0 m^3</td><td rowspan="3">Revenue Water
4,055,100 m^3</td></tr>
<tr><td>Billed Metered Consumption
606,600 m^3</td></tr>
<tr><td>Billed Unmetered Consumption
3,448,600 m^3</td></tr>
<tr><td rowspan="2">Unbilled Authorised Consumption
155,500 m^3</td><td>Unbilled Metered Consumption
127,800 m^3</td><td rowspan="5">Non-Revenue Water (excl. leakage within private properties)
1,631,600 m^3</td></tr>
<tr><td>Unbilled Unmetered Consumption
27,800 m^3</td></tr>
<tr><td rowspan="3">Water Imported
0 m^3</td><td rowspan="3">Water Losses
1,476,100 m^3</td><td rowspan="2">Apparent Losses
5,700 m^3</td><td>Unauthorised Consumption
5,700 m^3</td></tr>
<tr><td>Customer Metering Under-registration
0 m^3</td></tr>
<tr><td>Real Losses
1,470,400 m^3</td><td>Real Losses
1,470,400 m^3</td></tr>
</table>

Consumer-side (private) leakage is considered part of the authorised unmetered residential consumption within a network in BenchlossNZ. Thus in the water balance above it is included within "Billed Unmetered Consumption" as opposed to "Real Losses" or "Non-Revenue Water".

Table 6 breaks the water balance down by area and separates out some of the loss information calculated by the BenchlossNZ software. The BenchlossNZ analysis shows that for the overall WPR area the level of losses (based on ILI) is in WBI band B. Looking more closely at the Paraparaumu and Waikanae areas, the analysis shows that the losses in the Waikanae network are significant and fall in WBI band C, whereas the level of losses within the Paraparaumu-Raumati network falls within WBI band B (and is close to being in WBI band A). Note that the ILI calculated by BenchlossNZ does not include consumer-side leakage, which is estimated by BenchlossNZ at 67 L/property/day for the WPR area (based on average length of consumer-side pipework and factors for the characteristics of the network, e.g. fully metered networks will have lower consumer-side leakage than unmetered networks). In order to achieve an ILI in Waikanae that matches the ILI for the Paraparaumu-Raumati part of the network, current annual real losses within the Waikanae area need to be reduced by some 1,500 m^3/day.

Table 6: BenchlossNZ Losses Summary 2009/10

	Unit	Paraparaumu -Raumati	Waikanae	WPR
Consumer-Side Leakage (CSL)	m^3/year	298,000	127,200	425,400
Current Annual Real Losses (CARL)	m^3/year	672,100	798,200	1,470,400
Total Losses (CSL + CARL)	m^3/day L/conn/day L/person/day	2,700 270 100	2,500 520 210	5,200 350 140
Unavoidable Annual Real Losses	L/conn/day	87	67	81
ILI (CARL/UARL)		2.1	6.6	3.4

Without domestic metering, the losses estimated by the BenchlossNZ software are very dependent on the assumed residential demand and estimated residential side leakage. If residential consumption is greater than 230 L/person/day, then 5,200 m^3/day may be an overestimate of the level of losses. For example, with an average residential water consumption of 250 L/person/day then the losses are estimated to be 4,500 m^3/day (including consumer-side leakage).

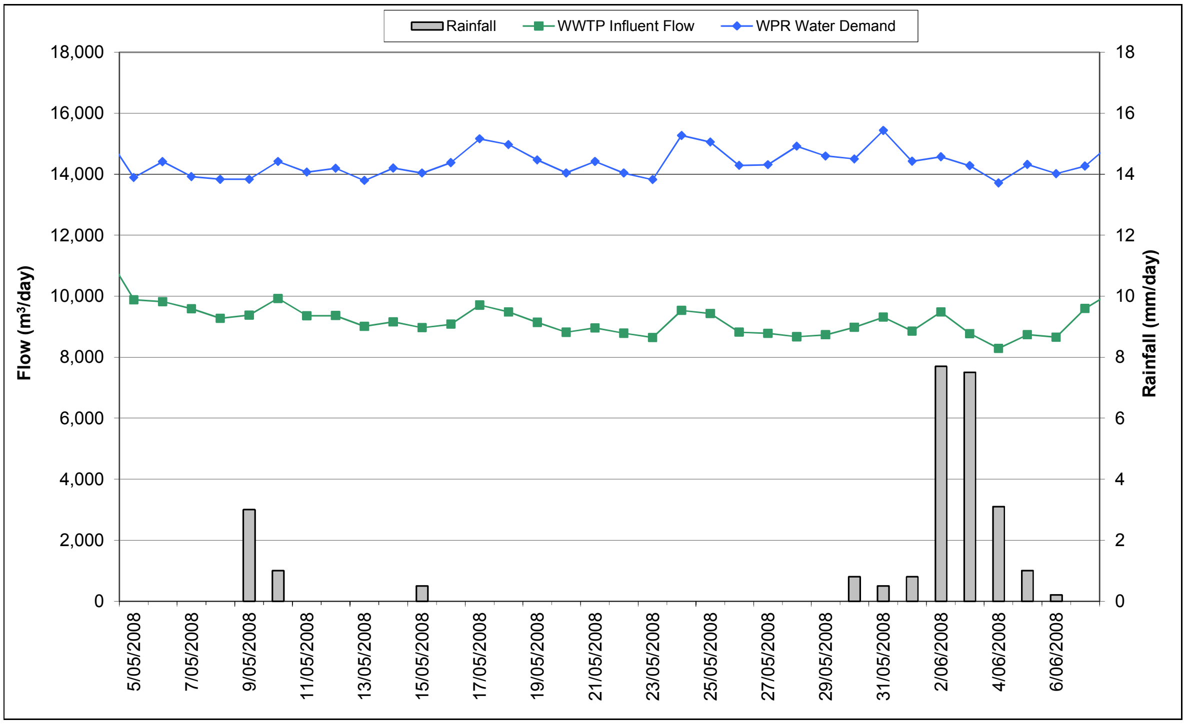
5.4.3 WASTEWATER FLOWS

Wastewater from the WPR water supply area is transferred to the Paraparaumu Wastewater Treatment Plant (WWTP). Daily wastewater flows received at the inlet works of the Paraparaumu WWTP were used to validate the losses estimates made above. The wastewater flows into the treatment plant were analysed over days during dry periods in winter (April to October), when water use would be mostly indoor and sewer inflow and infiltration effects would be low. It is therefore reasonable to assume that on these days all water used would be transferred to the wastewater system and so the difference between the water demand and the wastewater flow must be losses (ie, it assumes the losses are not transferred to the WWTP as wastewater).

The data shows an average difference between the water demand and wastewater inflows over the selected dry winter days is around 5,400 m^3/day. Figure 4 below shows the difference between the water demand and wastewater influent flows for a relatively dry period in May 2008.

If there is infiltration occurring in the winter, then the difference between the water demand and wastewater flow would be the minimum level of losses in the system (because wastewater flows without infiltration would be lower), and the true level of losses would be somewhat higher. Conversely if there is outdoor water use occurring in the winter then the true level of losses would be lower.

Figure 4: Comparison with Daily Water Demand and Wastewater Flows (May 2008)



5.5 SUMMARY OF LOSSES

The losses estimates from the three methods outlined above are summarised in Table 7 and the results show good agreement. The final WPR system water loss estimate was taken to be 5,200 m^3/day, which is equivalent to approximately 350 L/connection/day or 140 L/person/day. This is more than 1.5 times the 90 L/person/day assumed to date for the Kapiti Water Supply Project.

The loss analyses show that losses are more significant in Waikanae than Paraparaumu-Raumati. Initial indications are that zones 2 and 3 in Waikanae are most problematic but this needs to be reviewed once the zone meters have been calibrated.

It is noted that the loss values are only estimates because all of the methods for evaluating losses require assumptions. The minimum night flow method uses an assumption of 2.5 L/connection/hour for genuine night time use, while the water balance method (BenchlossNZ) requires an assumed average daily demand for all unmetered properties.

Table 7: Summary of Losses Estimates for WPR water supply

Method	Losses Estimate
Minimum Night Flow (with observed pressure variation)	5,300 m^3/day
BenchlossNZ	5,200 m^3/day
Comparison with Wastewater Flows	5,400 m^3/day
Final Estimate	**5,200 m^3/day**

6 RESIDENTIAL WATER DEMAND

6.1 TOTAL RESIDENTIAL DEMAND

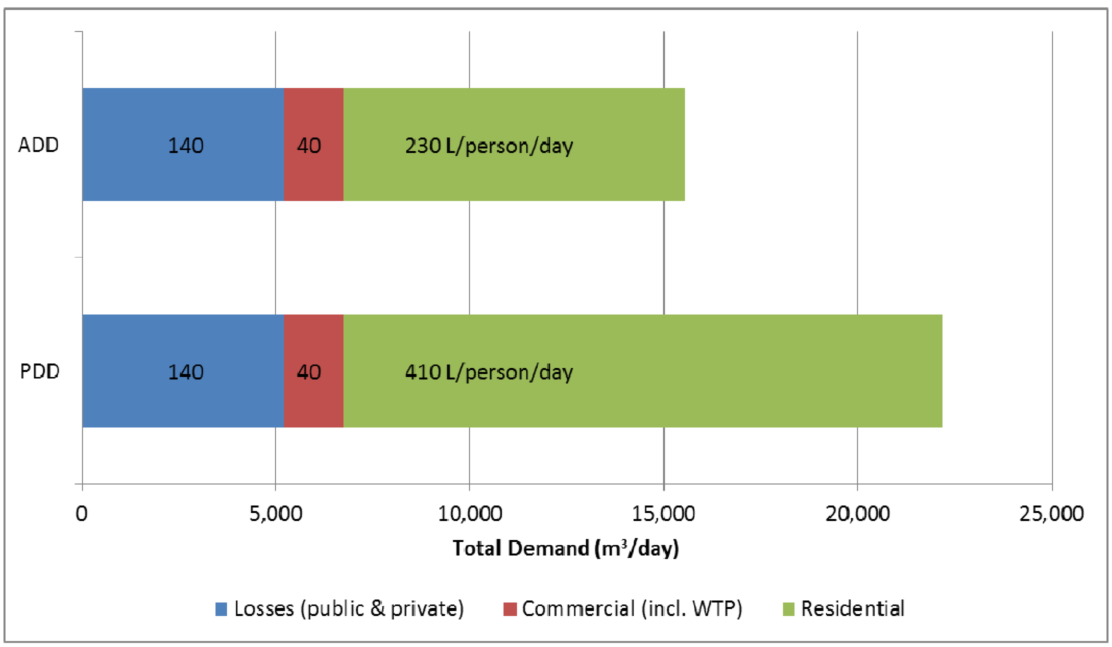
With a current total average day demand of 15,550 m^3/day, average losses of 5,200 m^3/day and average commercial use of 1,540 m^3/day, the average day residential demand (indoor and outdoor) is estimated to be 8,810 m^3/day or 230 L/person/day. This residential demand is more than that determined by a BRANZ study (Henrich, 2007) of water use in 12 homes on the Kapiti Coast over 8 months. From this study the average residential demand was 184 L/person/day. However, this small sample cannot be assumed to be representative of the whole District.

From analysis of the wastewater flow data, the dry weather wastewater flow is around 9,000 m^3/day. Assuming that dry weather wastewater flows directly correspond to indoor water usage, and subtracting the metered commercial water consumption, gives an average indoor residential demand of approximately 210 L/person/day. This is comparable to the average day demand of 230 L/person/day above especially when considering the BRANZ study found that average outdoor residential demand was approximately 30 L/person/day.

With a total peak day demand of 22,200 m^3/day in 2008/09 (which was much greater than the peak day demand in 2009/10) and assuming losses and commercial use are constant at their average rates, the peak day residential demand is approximately 15,460 m^3/day or 410 L/person/day.

The breakdown of water use described above is illustrated in the graphic below (Figure 5). These residential demands exclude consumer-side losses which have been accounted for within the losses estimate of 5,200 m^3/day.

Figure 5: Breakdown of Peak and Average Day Demands



7 IMPLICATIONS FOR WATER MANAGEMENT

7.1 WATER LOSS REDUCTION PROGRAMME

Having quantified losses for the WPR water supply, Council are implementing an active water loss reduction programme as a priority.

7.1.1 INFORMATION GAPS AND DATA GATHERING

With respect to better understanding and improving the accuracy of losses estimates the following recommendations were made. Most of these activities are underway or planned for the coming year.

- Calibrate or replace the metering modules in the zone meters which have not been calibrated since the meters were installed about 15 years ago.

- Undertake drop tests for the Riwai and Kakariki reservoirs to determine the accuracy of these flowmeters and increase confidence in the recorded flows.

- Install additional (possibly temporary) zone meters in Waikanae to create sub-zones and better identify problem areas within the existing zones (in particular zones 2 & 3 if they still have higher leakage rates after zone meter calibration).

- Implement a residential consumption monitoring programme. Such a programme is already planned under the Water Conservation Plan. The intention was to meter residential volunteers and multiple domestic properties (e.g. on rider main and in cul-de-sacs) which is a useful check that volunteers' usage is not being influenced by their knowledge of the presence of a meter. As well as providing data to guide the conservation programme, the results of this monitoring would be useful for ascertaining the appropriate residential consumption to use in BenchlossNZ and it could also provide more information about typical genuine night time water use.

- Actively meter all extraordinary water users and specifically identify residential metered connections so as to differentiate their consumption from commercial demand.

- Collect asset information while undertaking leak detection surveys to update Council's asset database.

- Determine and apply confidence intervals to the BenchlossNZ analysis.

- Estimate losses for Council's other water supply schemes.

With regards to collecting more data, the qualification is that data should not just be collected for data's sake - something needs to be done with it.

7.1.2 IMPLEMENTATION PLAN

The following ideas were put forward for inclusion in Council's water loss reduction implementation plan. Some of these had already been identified within Water Conservation Plan and most of the actions are already underway.

- Regularly review minimum night flows recorded by reservoir and zone flow meters for changes or inconsistencies. Council has developed a spreadsheet tool that links to the SCADA system to facilitate the monitoring of night flows.

- Establish leakage thresholds for minimum night flows for each water supply zone and use this information to target leak detection efforts.

- Improve resourcing of acoustic leak detection programme so that zones can be completed more quickly and checked more frequently.

- Hold a forum with local plumbers to learn more about consumer-side leaks and how these should be best targeted, and also raise awareness within the industry of Council's loss reduction programme.

- Continue community education about consumer-side losses.
- Investigate and implement pressure management opportunities to reduce losses, focusing on the Waikanae area in the first instance.
- Optimise pipe renewals programme to target areas of high leakage and consider blanket replacement of service pipes in any areas where the leak detection work shows this is warranted.
- Determine the most economic level of loss reduction and set Key Performance Indicators (KPIs) for loss reduction.
- Increase the focus within Council on water loss reduction to match that of water demand reduction.

7.2 REPORTING DEMANDS AND LOSSES

Council's target for peak day demand is 400 L/person/day and the target for losses is 90 L/person/day.

For clear and consistent reporting against these targets, the components of water use that are included or excluded from these targets need to be well defined. For example, does the losses target apply to the total of public and consumer-side losses or just losses on the public network? Similarly, does the peak day demand target include commercial and industrial use and/or consumer-side losses?

Without universal metering of all individual water connections the most effective tool for monitoring losses is the measurement of minimum night flows, but this does not provide any differentiation between losses on private properties and losses on the public network. Similarly, using the data currently available, residential demand can only be estimated and monitored by subtracting average metered commercial demands and losses estimates from the total volume of water delivered to a supply area or zone.

Therefore, based on the data currently being collected, it is recommended that the targets be defined as follows:

- Loss target includes water losses from both the public network and on private properties.
- Peak day demand target includes residential, commercial and industrial water use but excludes losses (both private and public).

7.3 DEMAND FORECASTING AND CAPACITY PLANNING

The previous Council had vigorously debated the concept of universal water metering, but had ultimately voted against it and water meters were specifically excluded from the scope of the water supply project when it commenced in 2009. In early 2011 the new Council was briefed on the extent of the losses and the number of private leaks being identified by the leak detection programme. With the quantity of water loss from some private leaks, Council took a different view on universal metering and voted to include it in the draft 2011 Annual Plan. This move was taken to give more certainty that water consumption and loss targets will be met.

Work on the new supplementary supply scheme (KWSP) will continue because the community still desires an alternative supplementary supply to the existing bore water supply. However, with universal metering the amount of uncertainty in the demand forecasts is reduced and so the amount of headroom included in the capacity forecasts may be able to be reduced. This will enable Council to better stage capital investment over a longer period of time. While the water loss estimate for WPR is much higher than what had been allowed for in the KWSP demand forecasting, Council are confident that with a range of measures (water conservation, water loss reduction and universal water metering) peak day demand can be reduced to 490 L/person/day.

8 CONCLUSIONS

Using the information already held by Council, an assessment of losses for the Waikanae-Paraparaumu-Raumati supply has been undertaken using three methods – minimum night flow, water balance (BenchlossNZ) and dry weather wastewater flows. The three methods gave good agreement, with a final water loss estimate figure of 5,200 m^3/day, which is equivalent to approximately 350 L/connection/day or 140 L/person/day. This is more than 1.5 times the 90 L/person/day that had been allowed for in the KWSP demand forecasting.

For the first time Council now has a realistic, albeit approximate, estimate of the extent of water losses in the WPR network. Once the extent of the losses was recognised at a political level, it was sufficient to force a major shift in Council policy to plan for the implementation of universal metering.

Although there is much work to be done in refining the water loss estimates and implementing the water loss reduction programme, the exercise undertaken for the Waikanae-Paraparaumu-Raumati water supply demonstrates the importance of making realistic estimates of losses. Most Councils collect the type of information and data used in this exercise, and could undertake similar assessments of water losses. Given that many communities have similar age and types of network assets as the Kapiti Coast, it is likely that there will be similar outcomes in terms of the true extent of losses. As for the Kapiti Coast, the knowledge gained will aid both asset management and water conservation efforts.

ACKNOWLEDGEMENTS

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