A PROPOSED FRAMEWORK FOR FORECASTING THE DEMAND FOR URBAN WATER IN NEW ZEALAND

Charlotte Reed (Senior Consultant, Tonkin & Taylor) and Jonathan Reed (Principal, CH2M Beca))

ABSTRACT

The 2010 Auditor General's investigation into how we plan to meet the forecast demand for drinking water identified that Councils apply a range of approaches. Of eight Councils studied, only three were identified as effectively managing their drinking water supplies. The variation in approaches taken to demand forecasting was also an issue identified by the 2012 PwC/GHD study carried out on behalf of WaterNZ.

The 67 Local Authorities across New Zealand that operate urban water supplies face a range of challenges. Some have rapidly growing populations and others populations that are diminishing. In some locations irrigation and industrial demands are large compared to urban needs. Many face challenges of aging infrastructure or peak demand pressures.

The use of a common approach across New Zealand to forecasting the future demand for water would serve Councils well. It would provide a consistent framework to develop a forecast and should clearly identify the potential advantages and disadvantages of decisions. Councils and ratepayers could then have more confidence that investment is appropriate and made at the right time.

This paper explores demand forecast approaches that are relevant to New Zealand. It draws on established frameworks from overseas and the authors' experience of current practice here.

KEYWORDS

Demand forecasting, urban water, best practice, framework

1 INTRODUCTION AND CONTEXT

The 2010 Auditor General's investigation into how New Zealand plans to meet the forecast demand for drinking water identified that Councils apply a range of approaches. Of the eight Councils studied, only three were identified as effectively managing their drinking water supplies. In 2012 the Auditor General reported that all Councils considered they were making good progress in implementing the recommendations of the earlier report.

The 2010 report provides some clarity on the fundamental elements of demand forecasting, such as using up to date and accurate data. Overall it is a high level document and therefore does not give clear guidance on practical approaches that Councils can implement to improve their forecasts.

The variation in the approaches taken to demand forecasting was an issue identified by the 2012 PwC/GHD study carried out on behalf of WaterNZ. This study also recognised that many Councils have limited data from which to develop their forecasts.

This paper was developed to respond to these earlier reports and provide a preliminary framework for the development of demand forecasts in New Zealand.

2 EXISTING FRAMEWORKS AND PRACTICES

This section reviews three available frameworks that could be applied in New Zealand and reviews some of the existing practices associated with the development of demand forecasts here.

2.1 THE INTERNATIONAL INFRASTRUCTURE MANAGEMENT MANUAL – 2011

The International Infrastructure Management Manual (IIMM) covers a variety of asset management subject areas, including how to forecast future demand for a range of asset types. It provides some useful direction about different approaches to demand forecasting although is relatively broad. The approaches set out in the IIMM are summarised below.

The IIMM suggests a 'demand forecasting maturity index' which categorises demand forecasts between 'minimum' through 'core' and 'intermediate' to 'advanced'. When developing demand forecasts, it is useful to understand the 'level' of the information available and hence the risks and uncertainties inherent in the resulting forecast. These levels are summarised below as:

- Minimum, where the forecast is based on experienced staff predictions;
- Core, which is based on the robust projection of a primary demand factor (e.g. population growth) and analysis of historic trends;
- Intermediate, where the level of analysis improves and a range of demand scenarios are developed; and
- Advanced, where risk assessments and mitigation are integrated with the demand forecast.

The IIMM suggests that high level demand drivers include population growth, demographic and other social changes, land-use changes, economic development or decline, and environmental changes. The IIMM notes that the important drivers should be identified, following which the demand forecast can be developed based on a number of components.

Quantitative or qualitative forecasts can be developed. Quantitative forecasts are mathematically based and require more sophisticated tools and good records of historic data. Qualitative forecasts are less data intensive and rely on expert knowledge or market research.

The actual forecast can be 'top down' or 'bottom up'. A 'top down' forecast simply uses the major driver, such as population, whereas a 'bottom up' forecast will develop a forecast based on a number of different components, which may be driven by different factors. Lastly, it is also important to consider uncertainty inherent in the forecast. Where possible, the margin of error should be quantified, particularly where the forecast has a high degree of risk.

2.2 GUIDE TO DEMAND MANAGEMENT – THE URBAN WATER PLANNING FRAMEWORK

The Water Services Association of Australia (WSAA) published the Guide to Demand Management – The Urban Water Planning Framework in 2008. It covers a wider range of issues than its name suggests, actually setting out a complete framework for planning the supply-demand balance. It suggests that this is developed over a series of 5 steps, being:

- Step 1: Plan the overall process;
- Step 2: Analyse the situation;
- Step 3: Develop the response;
- Step 4: Implement the response; and

- Step 5: Monitor, evaluate and review.

Approaches to demand forecasting are included within step 2B, to develop the supply-demand balance. WSAA suggests that there are three key methods for demand forecasting, being:

- Demand forecasting using per capita consumption (PCC);
- Disaggregation of demand into sectors; and
- Disaggregation of demand into sectors and end uses.

A description of the different approaches is included as Table 2.1.

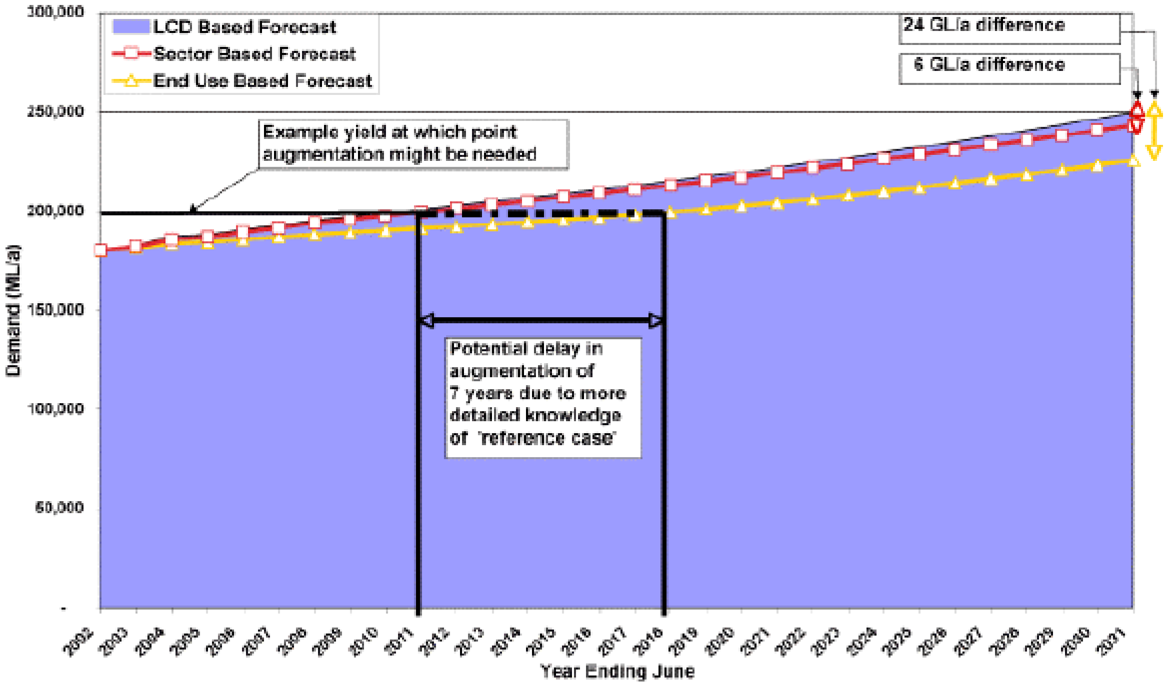
Table 2.1: Approaches to development of a demand forecast

Demand forecast method	**Description**
Per capita consumption	This approach uses a combination of historical per capita demand and the projected growth in population to forecast future demand.
Disaggregation into sectors	The forecast is disaggregated into different sectors such as residential, commercial, industrial, institutional and non-revenue water. Where possible, regression analysis is used to assess how variables affect the analysis of the demand. The forecast is then developed for each sub-sector of demand.
Disaggregation of demand into sectors and end uses	This takes the same approach as the 'disaggregation into sectors' approach but also uses a bottom-up approach to assess end use for the residential demand component. This is then calibrated against historical records of customer demand. The stock of end uses and changes in technology can then be used to forecast how residential demand may change in the future.

The WSAA guide recommends using the sector based forecast where possible, and particularly where increased demand would result in a requirement for investment in a new supply. The more refined the forecast the better informed the decision will be about requirements for investment. Disaggregation into sectors also provides information about the benefits of different demand management strategies. A comparison of demand forecast methods, taken from WSAA (2008) is reproduced as Figure 2.1. This shows how future demand tends to be over-estimated using simple approaches to demand forecasting, leading to early implementation of new water resources, where these are required.

The paper also comments on the benefits of regression analysis to establish an empirical relationship between, for example, the bulk demand for water and key variables. Once this relationship is established, it can be used to forecast demand in the future, although it relies upon the fact that the demand for water in the future will respond to these variables in the same way.

Figure 2.1: Comparison of demand forecast methods from WSAA (2008)



2.3 ENGLAND AND WALES' WATER RESOURCE PLANNING GUIDELINE

The Water Resources Planning Guideline for England and Wales was published in 2012 by the Environment Agency, OFWAT, defra and the Welsh Assembly. Water companies in England and Wales must produce a water resources plan approximately every five years. They are expected to follow this guideline, developed based on industry practice over approximately 20 years, unless they have good reason not to. The scrutiny that the water resources plans receive is a function of the forecast deficit between supply and demand.

Several different demand forecasts are required as part of the water resources plan. These are:

- Normal year, annual average;
- Dry year, annual average;
- Weighted, annual average; and
- Dry year, critical period.

These different forecasts are required for a number of reasons. Normal year average demand is the demand that is expected with little or no climatic influence. Demand increases during a dry year, which is calculated at the company's level of service. The other dry year forecast is the critical period, which is usually the summer peak but in certain cases is the expected demand when resources are at a minimum. This sometimes occurs during the autumn for water companies heavily reliant on groundwater sources. These dry year forecasts are produced for infrastructure planning purposes, i.e. to determine when additional infrastructure will be required.

The last forecast is a weighted, annual average, based on a range of climatic factors. This forecast is required by OFWAT for revenue planning purposes. Consumption, and therefore revenue, varies due to climate among other factors. Forecasting revenue based on a dry year forecast of demand leads to revenue being over-estimated in most years.

The other guidance from this document that is useful for the New Zealand context is in relation to forecasting metered and unmetered residential consumption. The guidance recommends that consumption monitors should be used to estimate PCC across the unmeasured customer base. Where possible, this should also consider variations in PCC across the area. The consumption from measured properties should be based on billing information.

The guidance also highlights the importance of understanding the customer base. This includes understanding, for example, occupancy rates and the types of properties that are currently connected and using water. It also suggests using micro-component or end use analysis, coupled with this understanding of the customer base, to justify the assessment of PCC. With this detailed understanding it is possible to consider how these important variables may vary in the future.

In relation to peak demand, the guidance refers to the United Kingdom Water Industry Research (UKWIR) group publication "Peak Water Demand Forecasting Methodology" (2006). This document introduces two useful concepts:

- The need to 'normalise' the annual average demand used to calculate the peak factor, removing any significant effects due to climate, customer or other changes; and
- A 'peak volume' approach, which focuses on events with an understood volume (a summer tourist influx, for example) which may not change in relation to increase or decreases in population.

UKWIR notes that a test of repeatability should be applied to peak demand analyses, as meaningful analysis cannot be carried out on 'one off' peak events. For example, peak demands linked to high temperatures can be meaningfully analysed, whereas irregular events that are unrelated to average demand, such as mains bursts, cannot be.

Consideration of the 'peak volume' approach is useful, particularly in smaller communities. This can help to minimise the risk of over-estimating peak demand by applying a peak factor calculated from a single event to a seasonal increase in demand. Peak day demand should be considered in the context of a peak demand period (week, month and season) to clearly understand how this should be incorporated in the demand forecast.

It may not be feasible for Local Authorities in New Zealand to adopt the recommendations in this guidance document wholesale, but they do provide a useful and detailed framework to guide the development of a demand forecast.

2.4 CURRENT NEW ZEALAND PRACTICES

There are a number of forecasting approaches in use in New Zealand at present. These vary in complexity and are briefly summarised below.

The simplest approach to forecasting is to assess the trend in total historic production and to forecast this forward into the future. The key underlying assumption of this approach is that the future will be the same as the past for all factors that influence water supply, or that changes in one component, such as the rate of population change, will be offset by changes in other components, for example the per capita use of water. Creating reliable and defensible forecasts is not possible using this method. However, it has the advantage of being simple to prepare.

A number of communities use an approach of 'gross' PCC to forecast demand. This is achieved by dividing the total water into supply by the estimated connected population for any given year, then multiplying this by the forecast future population. The consumption per person in this instance incorporates all domestic and non-domestic demand as well as all unaccounted for water. This approach again relies upon each component of demand remaining similar, or any changes offsetting each other. If a single figure of gross PCC is used for forecasting, then the reliability of the estimate of connected population is critical to the accuracy of the future forecast.

Some Councils use the rules of thumb set out in the New Zealand Standard for Land development and subdivision infrastructure (NZS4404) for forecasting future demands from new communities connecting to the water supply. Like all standards this may provide a reasonable starting point for a forecasting approach, but does not consider significant demand drivers such as lifestyle, land use, climate and levels of service. It is also focused on infrastructure capacity to meet sub-daily peak demand and can therefore over-estimate demand for water resource planning purposes.

Nelson City Council and Tasman District Council are two local authorities that have access to metered customer data, and who are therefore able to use more detailed analyses of demand and its driving factors. They are also able to consider the potential effect of any strategies on future demand (Office of the Auditor General, 2010).

For those Councils where existing or new industrial customers represent a significant component of current or forecast future demand, discussions with these customers in relation to their expected future use are an important aspect of demand forecasting.

Peak demand is usually the main driver for the balance between supply and demand. Most New Zealand Councils use a peak demand factor that is calculated using the maximum production volume for the year, divided by the average daily production for the year. In practice, peak demand is often managed, particularly in small communities, by the implementation of restrictions.

3 DATA

3.1 DATA ANALYSIS AND INTERPRETATION

All methods of demand forecasting are an assessment of whether, and how, the future will be different to the past. Capturing relevant historical data, validating it and interpreting it are therefore critical to understanding past demand trends and what has caused them, which in turn enables an assessment of future changes and what these may mean.

Careful inspection of available datasets is critical to understanding demand. Any analysis undertaken without careful and detailed consideration of the available data risks drawing false conclusions. As a minimum, data should be reviewed to identify:

- Annual demand trends;
- Possible leakage events;
- Possible data anomalies;
- The timing and duration of peak periods; and
- Sources of uncertainty.

One study undertaken by the authors considered peak demand for a small urban community. Inspection of the historical data identified that the highest peaking factors were driven by peak day demands occurring outside of the summer months. The data were interrogated further and discussions were held with operations staff. An initial hypothesis, that the recorded data points were in error, was disproven by more detailed investigation. Operations staff reviewed records of changing water levels in the storage reservoirs, which showed that the system demand was real. Activity records showed that the volumes were typically due to large leaks in the supply system. This demonstrates the value in making the effort to interrogate and understand the available data, which can then be used to inform the demand forecast.

Where possible more than one source of data should be used to verify previous demand volumes. The example above refers to telemetered data for the service reservoir. Other data sources may include abstraction records, metered volumes or other operational activity records relating to water treatment or distribution activities. In addition to ‘normal’ demands, sources of high or atypical demand include:

- Plant operating requirements, for example filter backwashing;
- Distribution network operating requirements, for example mains flushing;
- Seasonal peak demands, for example public holidays;
- Special events, such as rural fires or other tankered water uses;
- Errors arising from data recording systems; and
- High demands from large individual users.

Data anomalies can be identified in a number of ways. Simple examples include:

- Reported production volumes higher than the rated capacity of the treatment works or other constraining infrastructure, such as treated water pumps;
- Data points that are significantly higher or lower than the rest of the demand record, particularly outside the summer peak period; or
- Very different and inexplicable results when compared with similar New Zealand or international communities.

3.2 DATA TO FORM THE BASIS OF THE FORECAST

As discussed above, a robust review of the available data is important to guide the demand forecast. In the authors' experience, the following are essential to understand.

- **Connected population**

  The connected population effects both the analysis of existing demand and the future forecast. An accurate estimate of the connected population is necessary to understand consumption per person. Small errors in the estimate of connected population can lead to significant errors, even in very large communities. It is recommended that a combination of data from Statistics New Zealand, customer records, network records and aerial photography is used to carefully assess the connected population. Consideration should also be given to the likely margin of error and the subsequent effect on PCC.

- **Residential and non-residential consumption**

  It is important to understand the difference between residential and non-residential consumption. In one study that the authors' have been closely involved with residential consumption forms only one third of the overall demand. Using a gross PCC approach to this demand forecast would result in considerable error, as the non-residential consumption is not expected to increase at a rate proportional to population.

- **The effects of climate and other significant demand drivers**

  Failure to consider the effects of climate, along with other significant demand drivers, can be one of the key failings of demand forecasts. It is essential to understand the key drivers behind the available historic data when using these data as the basis of a forecast. The demand for water usually responds to climate, but as discussed above high demand could be due to events such as large leaks. Understanding how these factors affect the base data enable a more accurate forecast of future demand to be developed.

3.3 PEAK DEMAND

3.3.1 OVERVIEW

Peak demand is often the main driver for investment in new water resources. It is therefore important that peak demand drivers and the response of consumers to climatic factors is well understood. The peak demand for water is driven by, for example, increased domestic use of water (garden watering, etc.), higher industrial and other non-domestic demands and seasonal changes in population.

Water supplies in large urban centres usually aim to comply with a stated level of service; i.e. restrictions are only applied under a certain return period drought event. In other, usually smaller New Zealand communities, peak demand is usually managed by applying restrictions on an annual basis. In this case the restrictions usually change through a number of ‘levels’ in response to increasing demand. Understanding the level of service and how this affects the peak demand forecast is important.

3.3.2 NON DOMESTIC PEAK EVENTS

The link between increased domestic demand and temperature is widely acknowledged. Changes in non-domestic consumption during peak periods are often less well document.

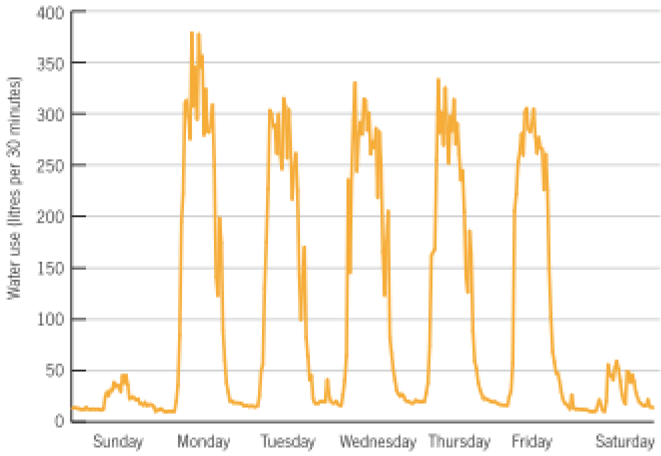
Research undertaken by the Victoria University of Wellington (Bint et al, undated) studied water use in commercial office buildings in the Wellington Central Business District (CBD). This study found that there was a relationship between the type of cooling used in the building, and its average annual water consumption, compared on a Net Lettable Area basis. Buildings with natural cooling had a lower average water use than those with mechanical cooling. The study stated that 67% of the mechanically cooled buildings used water cooled chillers and water cooled heat rejection units, accounting for the higher water use by this sub-group. Hence, higher demand from commercial office buildings can be expected in the summer months due to air-conditioning demands.

Work by Bint (2011) also showed that the water demand for commercial office buildings was highest on weekdays and lower on the weekends (Figure 3.1). This is intuitive, as office buildings have higher occupancy during the week. This could lead to different peak demand patterns when compared to domestic demands that often peak over the weekend, which is normally attributed to garden watering, car and boat washing and other outdoor uses.

Much detailed research was required to reach this detailed level of understanding in relation to a particular customer type. These data can be used to inform predictions carried out by other water suppliers in relation to commercial office buildings.

Whilst is may not be practical to carry out detailed research into all customers, the principle of understanding the drivers for and timing of peak demand for a customer or customer group can be important if this is driving significant future infrastructure investment.

Figure 3.1: Average time-of-use data from a monitored office building in Wellington



Source: Bint (2011)

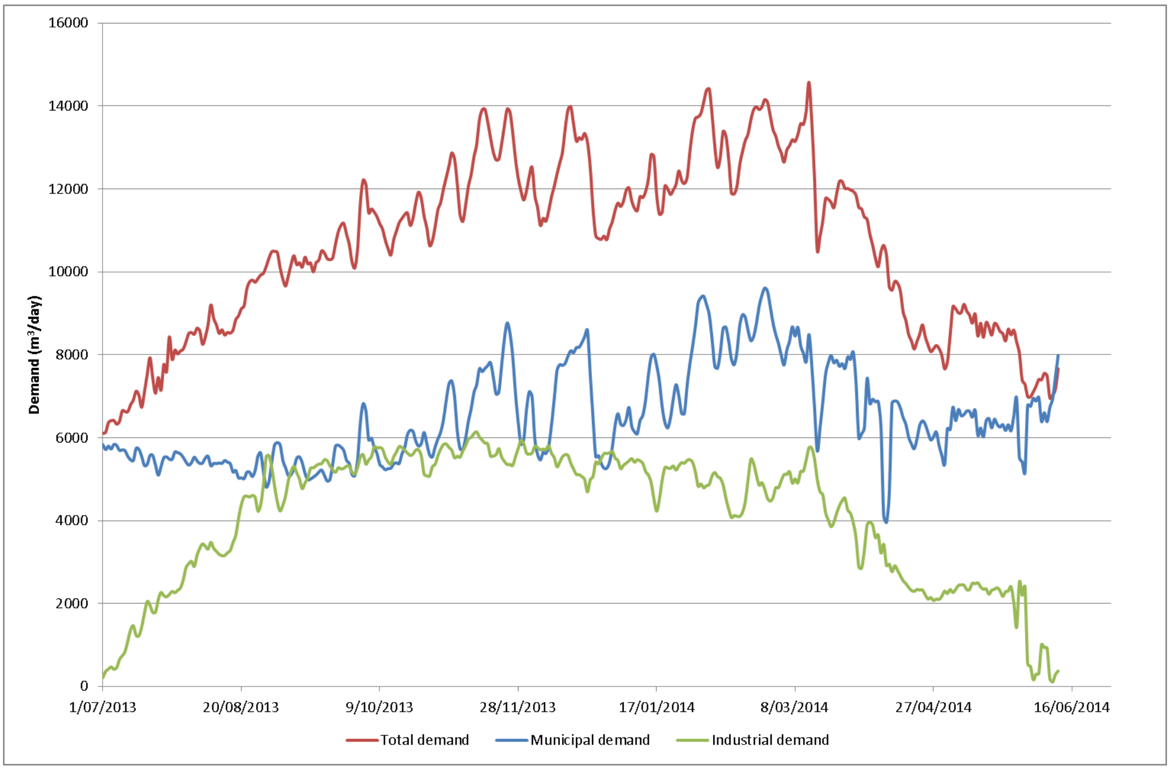
3.3.3 INDUSTRIAL AND DOMESTIC PEAK DEMANDS

Industrial demands can be a large component of a small water supply in New Zealand and it is therefore important to understand how peak demand can vary with a large industrial component.. An example is shown by

Figure 3.2, where the industrial demand is a large component of the overall supply. This shows a distint seasonal trend, with demand increasing over the spring to a long peak of several months, before reducing to close to zero over the autumn.

By comparison, the municipal demand is much more stable, although shows a definite seasonal peak over the summer months. The combination of the two demands leads to a wide variety of demand that needs to be considered by the demand forecast. The difference between minimum, average and peak demands are great and careful analysis is required to avoid overestimating future peak demands. In this case, the development of a component based forecast is essential.

Figure 3.2: Profile showing municipal and domestic demand



4 OUTLINE FRAMEWORK FOR NEW ZEALAND

4.1 GAP ANALYSIS OF EXISTING FRAMEWORKS FOR THE NEW ZEALAND CONTEXT

The IIMM is a framework that can be applied to forecast the future demand for water in New Zealand. Although it guides a practitioner through this process, it is generic across many different Council planning requirements. It is therefore a useful high level guidance document but does not provide specific guidance or references to enable a potable water demand forecast to be developed as this is not its purpose. It makes some very worthwhile points with regard to how a demand forecast can address different levels of complexity and how uncertainty should be considered in the final outputs.

This paper has identified two other frameworks, from Australia and the UK, that are specific to water resource planning. These are therefore useful guidance documents as they provide practical advice about the development of a demand forecast. However, they are both specific to the UK and Australian water industries and therefore some parts of these documents are not necessarily relevant to the NZ context. Both are reasonably complex and/or promote the development of a complex approach to demand forecasting.

The WSAA framework is probably most relevant to New Zealand Councils as it is reasonably flexible. However, it is directed at forecasting the future demand for water within medium to large urban centres. In New Zealand there are over 60 Councils which supply water to approximately 4 million people, leading to some very small water supplies. In these cases, the available frameworks are not necessarily useful from a practical viewpoint as the Councils will not have the resources available to develop a demand forecast to the required level of detail.

This section draws on the methods set out in the three referenced guidance documents, along with practical experience of demand forecasting in New Zealand, to recommend a proposed approach for the New Zealand context.

4.2 RECOMMENDED APPROACH TO THE DEMAND FORECAST AND A SUGGESTED FRAMEWORK

This section summarises a recommended approach to the development of demand forecasts in New Zealand. This is in two parts, first a process which is based on the IIMM methodology, followed by a description of a framework recommending the level of detail for forecasting.

4.2.1 THE DEMAND FORECAST PROCESS

The suggested approach to the development of a demand forecast in the New Zealand context is shown as Figure 4.1. This shows a number of steps, each of which are described below.

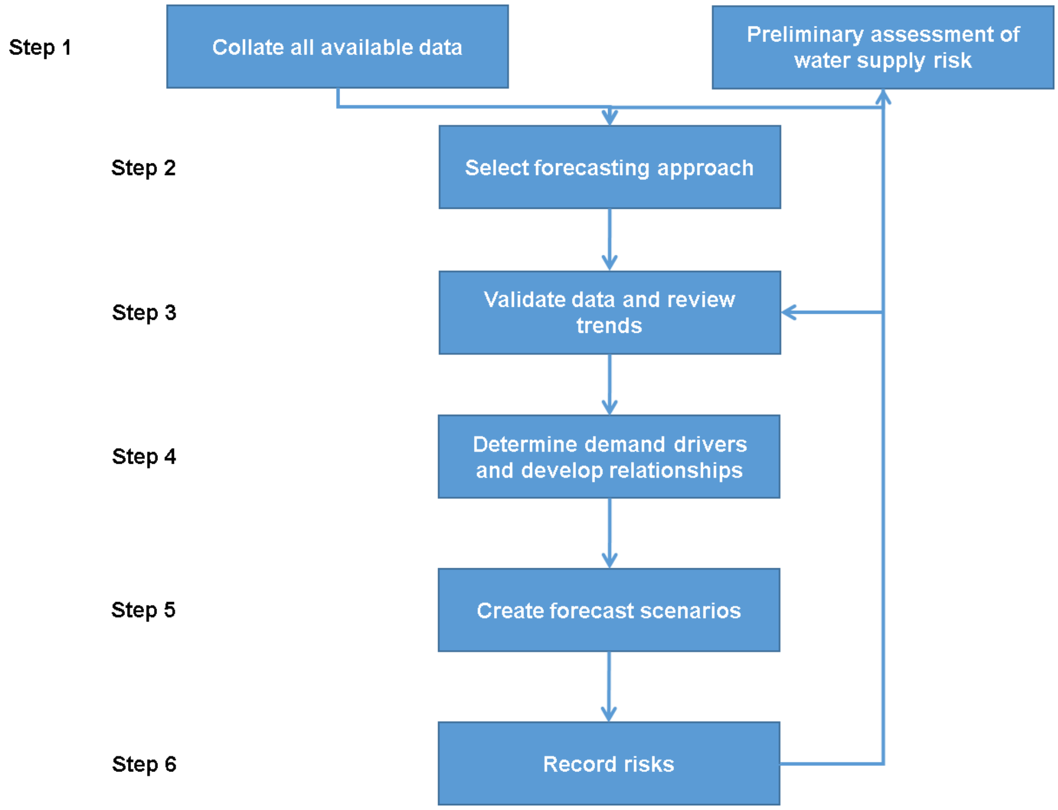
Step 1 – Collate all available data and carry out a preliminary assessment of water supply risk

All available data pertaining to the demand forecast should be collated. This should include bulk abstraction records, consumption data (where available), service reservoir level data where relevant and records of consumption from large consumers. The data should be validated by comparing the different data sets, particularly to determine the validity of periods of peak demand and/or other critical periods. Other required data include historical climate data, the historical, current and forecast population and other information about the customer base such as the split between domestic and non-domestic users.

The current risk to the water supply and the required level of service should then be considered. This should include comparison of the recorded demands with the expected capacity of water treatment plants (WTPs) and by comparison with the resource consents. A preliminary assessment of the risk to the water supply should then be developed, by considering these key questions:

- Is there sufficient WTP capacity to meet the required level of service?
- Is there enough resilience in the water supply system?
- Is growth expected that will limit the Council's ability to supply water?
- Could future demand exceed the terms of the Resource Consent in the near to medium future?

Figure 4.1: Suggested demand forecast framework



Step 2 – Select the forecasting approach

The proposed demand forecast framework is described in section 4.2.2 and guides the level of detail that should be applied to the development of a demand forecast, depending on the risks to the water supply.

Step 3 –Validate data and review trends

Following the selection of the demand forecast methodology, the data validation work from step 1 should be extended where necessary. As part of this step in the process, the data should be interrogated, understood and a decision made about whether it can be relied upon.

Once the available data are clearly understood, any trends can be reviewed to improve the understanding of demand drivers. This may include, for example:

- Assessing how population has changed over time;
- Reviewing how demand, and if available the different components of demand, has changed over time;
- Investigating demand patterns from large consumers; and
- Examining the seasonal variation in demand and the reasons for this.

For more complex level of forecasting and where sufficient data exists, it is feasible to carry out this analysis for each component of demand. This will provide more insight as to how the different sectors of demand have changed over time and if there are different drivers which affect these components.

Step 4 – Determine demand drivers and develop relationships

Once the trends in demand are more fully understood, analyses should be carried out to assess the key drivers which will affect demand in the future and develop relationships for use in the forecast. Importantly, this should focus on developing trends and relationships with demand drivers that can be forecast into the future. This may include population, properties, industrial growth rates or land use changes / zoning.

At a simple level this would perhaps be limited to the assessment of how gross PCC has changed over a number of recent years and how this is affected by demand drivers such as climate. At a more complex level, demand drivers and relationships would be developed for each component of demand, often using techniques such as regression analysis to develop inputs to the demand forecast.

It is also important to consider the uncertainty associated with each of these components of demand, to enable overall uncertainties to be assessed once the forecast is complete. This is considered further under Step 6 of this process.

Step 5 – Develop forecast scenarios

Once the relationships and demand drivers have been established, the forecast can be developed. Once the background data and relationships are clearly understood this step is a reasonably mechanistic process to combine the different components of the forecast.

Section 2.3 of this paper identified a number of different demand forecast types that can be developed to inform infrastructure and revenue planning. Consideration of the reasons for the preparation of the forecast is important. For example, using a peak day forecast for revenue planning would lead to expected revenue being significantly over-estimated.

Scenarios can also be developed at this stage. This may include, for example, consideration of the effects of demand management, universal metering or an alternative growth scenario. In some New Zealand communities, the population may be forecast to reduce over time and this scenario would be important to test.

It is also important to check that the demand forecast in the first year of the forecast closely matches recorded or expected demands. If, for example, the peak day forecast shows demand far higher than has recently been recorded it is likely that there are errors in the peaking factor that is applied and this should be reviewed.

Step 6 – Record risks

The final step in the process is to record the risks and uncertainties that are inherent in the demand forecast. As a minimum this should consider the level of risk that the Council is willing to accept and assess when there is expected to be a deficit in the supply-demand balance.

Understanding the uncertainties in the base data which underlie the demand forecast is very important. Where possible this should be quantified and scenario analysis used to test any changes in these assumptions. This should enable the Council to improve its understanding of the risks to the supply-demand balance. As a minimum a qualitative or descriptive summary of risks should be prepared so that the context of the demand forecast is clearly communicated to decision makers and other interested parties.

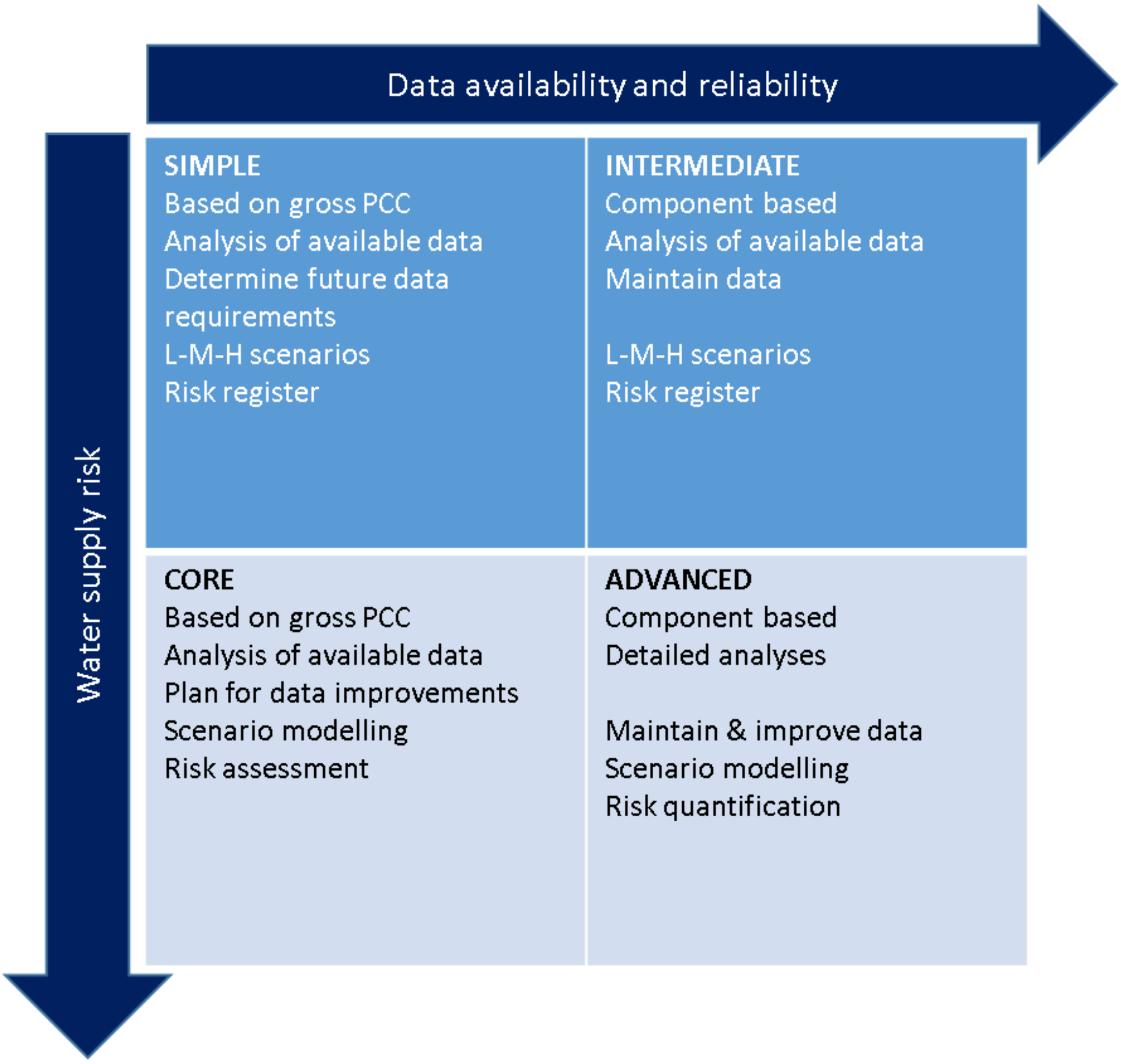
Summary

These steps should identify any ongoing actions that should be carried out to either improve the forecast or monitor important aspects of it. This may include improved monitoring of abstraction records or improving the current understanding of the connected population. Clearly setting out the reasons for these actions, together with a timeframe for their implementation, is important to enable the demand forecast to be improved in the future. This creates a feedback loop to steps 1 and 3 of this process.

4.2.2 DEMAND FORECAST FRAMEWORK

The proposed framework for the development of a demand forecast is shown as Figure 4.2. This suggests the level of analysis that should be applied to the development of the demand forecast, depending on the water supply risk and the data availability and reliability. The intention is to take a practical approach that can be applied across many New Zealand Councils. Where there is a risk to the water supply more detailed analysis of data should be undertaken and a more complex forecasting approach applied. This may require a staged process to improve data collection over several years, where these are not currently available.

Figure 4.2: The proposed demand forecast framework



Simple approach

Where the water supply risk is low and few data are available, there is limited benefit to be gained from highly complex analyses of demand. Nevertheless, a minimum degree of rigour should be applied. A gross PCC forecast is considered reasonable, rather than perhaps a forecast of historic production trends.

The quality of the data underpinning the forecast should be interrogated and understood – if the data are poor, then in reality the forecast is so uncertain that no firm conclusion on future water supply needs can be reached. In such cases plans should be put in place to reach a minimum level of reliable data, for example validated daily water production volumes.

Scenario analyses are important, to confirm if and when the level of water supply risk could be expected to change. If a high growth scenario results in a possible water supply shortfall within the planning period for a new scheme (around 10 years) then a higher level of risk may exist than initially assumed.

The risk register should record in a qualitative or descriptive manner the data uncertainties or gaps, knowledge of the water supply scheme and any underlying opportunities, risks or concerns. This can help inform future analyses or discussions with decision makers.

Core

Where water supply risk is a concern, but data remain limited, a more detailed analysis should be undertaken. A forecast of gross PCC may be the only option available, but the analysis of data should seek to understand:

- Current and forecast connected population, in detail;
- The impact of climate on total demand volumes;
- Recent demand trends;
- Peak demands, including the operation of the system and the related peak demand requirements. For example there may be three days of service reservoir storage available in the distribution system and this should be considered in the peak demand forecast; and
- Changes to the water demands of large users, through conversations with these organisations.

Validating the data, particularly with regard to data outliers, should be rigorously pursued, using the guidance in section 3.1. Required data improvements should be identified and prioritised.

A range of scenarios should be considered to understand how the timing of future investment could vary. This should consider low, medium and high population, the impact of any proposed formal demand management, unaccounted for water or metering programme or any possible changes to the frequency or scale of restrictions to supply. Scenarios that reflect the range of possible data values (a notable example is the particular value of gross PCC selected for forecasting purposes) should also be developed.

The risk assessment should attempt to quantify the uncertainty of each aspect underpinning the demand forecast, ideally with an upper and lower bound. As for the simple example it should also assess other known and relevant water supply risks, opportunities and concerns.

Intermediate

Where good data are available, but water supply risk is low, the benefits of the data should be maximised without entering into disproportionately complex analyses.

As for all forecasts, the data should be analysed, validated and understood – the level of water supply risk cannot be reliably determined if the data are poorly understood.

A component based forecast should be developed. This is in-line with recommendations by IIMM, WSAA and the UK water resources planning framework. WSAA notes that a gross PCC forecast is more likely to overestimate future demands (as indicated in Figure 2.1), hence a component based forecast (domestic, non-domestic and non-revenue water, as a minimum) has value. Non-revenue water can be forecast linked to future estimated connections, lengths of mains, expected volumes or if necessary percentages. Non-domestic demand drivers could include individual users, or changes in zone areas or types.

Plans should be put in place to maintain the quality of data collected and as for the Simple methodology, low, medium and high scenarios developed, along with a qualitative risk register. The low, medium and high scenarios should consider each demand component, not only population.

Advanced

Where the water supply risk is high and data are available, the full utility of the available information should be employed.

A detailed analysis of each component of data should be carried out, including links to climate or other temporal influences, where possible. The uncertainties associated with the data should be identified and quantified, for later consideration.

The development of a component based forecast is required, with separate forecasts of domestic, non-domestic and non-revenue demand as a minimum as for the Intermediate approach. Where this type of Advanced forecasting method is considered appropriate, the WSAA (2008) and Environment Agency et. al (2012) guidance documents should be referred to, in order to assist practitioners with the development of the forecast. As recommended by WSAA (2008), consideration should be given to end use and how this may change over time as a result of changing technologies. Where population growth is a driver for the forecast, the type of growth (low or high density) should be reviewed and consideration given to whether consumption from new properties is expected to reflect current consumption, or be lower.

As for the Core methodology, peak demands should be investigated in detail, likely using regression techniques. Work should be carried out to link the expected level of peak demand with the required level of service. Any factors that can suppress peak demand should be considered. This may include the timing of peaks from the different components of demand (domestic vs non domestic, for example) or trends associated with large users. The effect of storage within the distribution network and how this may enable the duration of the peak period used for forecasting should also be considered, together with how the peak factor may be suppressed as population grows.

The uncertainty associated with the demand forecast should be quantified. Ideally this would be based on the quantified upper, mid and lower bounds of the input data to determine the range of uncertainty inherent in the forecast. Subsequent to this, scenario analysis could be carried out (similar to the Core approach) to understand how the timing of future investment could vary.

The risk assessment should quantify the uncertainty of each aspect underpinning the demand forecast. Ideally, statistical analyses would be used to enable these uncertainties to be combined to provide a probabilistic risk assessment. Risks should be carefully communicated to decision makers and interested parties to enable the most appropriate decisions to be made about future investments.

For each of the forecasting approaches it is important to monitor the accuracy of the forecast and to continue to adjust and update it as new information come to light.

5 CONCLUSIONS

This paper concludes that:

- The OAG (2010) referred to the use of the IIMM guidance for planning purposes and this paper concurs that it forms the only framework directly applicable to New Zealand demand forecasts, but it is very generic;

- The Auditor General (2010) did not give clear guidance on practical approaches that Councils can implement to improve demand forecasts;

- Other frameworks exist from Australia and the UK which give more detailed guidance that is relevant for incorporation in New Zealand demand forecasts;

- A key part of the demand forecast process is to transform the available data into useful information to inform the demand forecast;

- Different methodologies can be applied to the development of a demand forecast that are applicable to the water supply risk and level of data available;

- This paper has suggested a process, based on the IIMM, which can be followed to develop a demand forecast; and

- The recommended framework in this paper guides the suggested level of effort required to develop the demand forecast, based on the water supply risk, data availability and reliability.

REFERENCES

Bint , L. (2011) Benchmarking water use in office buildings, Build 125, August / September 2011

Bint, L, Isaacs, N., Vale, R. (undated) Water Performance Benchmarks for New Zealand: an approach to understanding water consumption in commercial office buildings

Environment Agency, defra, Welsh Assembly & OFWAT, (2012), Water Resources Planning Guidelines.

NAMS Group (NZ) and IPWEA (AU), (2011). 'International Infrastructure Management Manual',

Office of the Auditor General, (2010) 'Local authorities: Planning to meet the forecast demand for drinking water'

Office of the Auditor General, (2012) 'Public entities' progress in implementing the Auditor-General's recommendations 2012, Part 5: Local authorities: Planning to meet the forecast demand for drinking water'

PwC and GHD, (July 2012) 'Implementing the National Infrastructure Plan in the Water Industry – A Pilot Study'

Standards New Zealand, NZS4404 Land development and subdivision infrastructure

United Kingdom Water Industry Research (UKWIR) (2006) *"Peak Water Demand Forecasting Methodology"* demand

Water Services Association of Australia, (2008), Guide to demand management.