The Consequences of Demographic Change for New Zealand Water Supplies

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The Consequences of Demographic Change for New Zealand Water Supplies

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SUMMARY

Introduction

A fundamental requirement for maintaining public health within a community is access to an adequate supply of safe drinking- water. To ensure an adequate supply of water, the design of water supply infrastructure must take account of a community's demand for water.

Several factors, demographic and non-demographic, may influence a community's demand for water. Population and household size are probably the most important demographic factors.

This report follows a 2011 horizon-scanning article on water supplies and demographic change, prepared for the Ministry of Health by ESR (Report FW11081). The earlier report noted that trends of increasing and declining water demand could present risks to water quality.

This report examines in more detail how demographic changes in New Zealand may affect water supplies and what consequences for public health these changes may have. While the report does not provide policy advice, it suggests generic approaches for managing potential risks to public health that could accompany demographic change.

Expected demographic changes in New Zealand

Overall, New Zealand's population is increasing, although the growth rate is decreasing. Population increase is not occurring in all locations, and populations in some territorial authority areas are projected to remain static or decline. Populations in all areas are projected to age, with an increasing percentage of the population being aged over 65 years. The average household size in New Zealand is decreasing. This change is driven primarily by the growing number of older people. The corollary of this is that the number of households in the country will increase.

The effects of climate change are expected to occur concurrently with demographic changes, and exacerbate some of the effects of demographic changes on water supply and public health. Increased temperature will increase water demand, and meeting water demand will be become a challenge during more severe and frequent droughts. The production of safe drinking-water will be made more difficult by drought and the increased frequency and severity of heavy rain events.

Approach

The information for the study was gathered from Statistics New Zealand population projections, the long-term plans produced by territorial authorities, planning documents published by Watercare (Auckland's water provider) and interviews with managers responsible for water supplies.

Implications for public health

The study found that the population trends expected by some territorial authorities (urban and rural) are different from those evident from Statistics New Zealand's projections. There is agreement that most territorial authority areas will experience increases in population and therefore an increase in water demand. Although some territorial authorities anticipate static or declining populations, they are not expecting a substantial

drop in water demand, and therefore they will not experience the problems associated with water supply underutilisation that has occurred in some overseas jurisdictions.

The report identifies the consequences for public health of demographic changes and the associated changes in water demand. Although decreasing demand does not appear to be a concern in New Zealand, it is possible that estimates of growth are overly optimistic.

Increasing population

New Zealand's population is highly urbanised. At the 2006 Census, 86 percent of the population was living in an urban area. This included 72 percent living in main urban areas (population of 30,000 or more), 6 percent living in secondary urban areas (10,000–29,999) and 8 percent living in minor urban areas (1,000–9,999). As a result it is envisaged that increasing populations will generally be accommodated in either greenfield developments or in high-rise apartment blocks. The potential adverse public health consequences associated with supplying water to these accommodation types are listed next.

Potential public health consequences of greenfield developments and intensified housing

Adverse

- Damage to the network (including sabotage) allowing contaminant ingress.
- Pressure losses or pressure transients, which in combination with leaks and the presence of contaminants external to the pipes, increase the likelihood of contaminant ingress.
- Backflow drawing contaminants into the reticulation.
- Loss, or reduction, in the disinfection residual which increases the:
  - survival time of microbial pathogens that may gain entry into the network
  - likely extent of biofilm formation on internal pipe surfaces and consequently colonisation by opportunistic pathogens, such as *Legionella*.
- Warming of water during extended reticulation creating conditions that encourage colonisation by opportunistic pathogens, such as *Legionella,* in residential building plumbing networks.

Territorial authority long-term plans show that authorities are considering, or are undertaking, a variety of approaches to meet anticipated increases in water demand. These include leak detection and repair programmes, pressure management and water pricing strategies. The potential public health consequences of each of these approaches are summarised next.

Potential public health consequences of leak detection and repair programmes

Adverse

- Ingress of contaminants into the network during leak repairs.

Beneficial

- Reduction in pathways allowing contaminant ingress into the network (this also impacts on other steps such as pressure management).

Potential public health consequences of pressure management

Adverse

- Pressure transients and lower operating pressures increase the likelihood of contaminants being drawn into the network from water and soil external to the pipes through leaks.
- Backflow of non-potable sources from connections to the network as the result of pressure transients.

Beneficial

- Reductions in the frequency of mains bursts and the possibility of contaminant ingress.

Potential public health consequences of water pricing

Adverse

- Reduced water use by lower socioeconomic groups to reduce living costs results in inadequate personal hygiene (eg, ineffective hand washing), for example.

Water conservation measures allow the deferral of more expensive options for meeting water demand through the development of new water sources. These may include greywater recycling, rainwater harvesting, advocating the use of water efficient appliances (including low-flow fixtures) and linking water-short supplies to supplies with adequate water sources. The potential adverse public health consequences of greywater recycling and rainwater harvesting are summarised next.

Potential adverse public health consequences of greywater recycling and rainwater harvesting

Adverse

- Exposure to contaminants in the greywater through its inadvertent use for potable purposes (eg, children drinking from garden hoses connected to grey-water outlets), or cross-connection with the potable reticulation.
- Exposure to contaminants in rainwater collected for non-potable use through its intentional or inadvertent consumption.
- Contracting vector-borne diseases resulting from insect vectors breeding in water tanks.
- Poorer personal hygiene during drought because of measures to save water (eg, reduced volumes of water used for hand washing).

Territorial authorities considering allowing greywater recuse and rainwater harvesting need to be aware of these risks presented to public health. The Kapiti Coast District Council is an example of an authority that has taken major steps to reducing water demand through these conservation measures. It has adopted a change to its district plan that requires new and relocated houses to have facilities to allow rainwater harvesting and storage, or a combination of rainwater collection and greywater reuse. The plan change sets out requirements that accompany these water measures that aim to address the potential public health risks associated with greywater reuse and rainwater use for non-potable purposes.

The potential adverse public health consequences of the use of water-saving appliances and low-flow fixtures are summarised next.

Potential public health consequences of the use of water-saving appliances and low-flow fixtures

Adverse

- Scalding through the use of low-flow devices with non-automatic compensating valves.

Beneficial

- Reduced water use diminishes wastewater flows and consequently the burden on wastewater treatment plants. This reduces the likelihood of poorly treated, or untreated, wastewater being discharged into receiving waters and infecting recreational users. Reduced wastewater flow will be of particular benefit to combined sewer systems (sewers receiving sewage and stormwater).

Declining population or demand

A declining population may create difficulties for water supply infrastructure that differ from those arising from an increasing population. Generally, a declining population, particularly if the size reduction is substantial, will lower water demand. A large fall in demand could lead to serious underutilisation of a supply.

A declining population, as well as affecting water demand, reduces the rating base from which a territorial authority's services are funded. The potential public health consequences of reduced water supply funding are summarised next.

Potential public health consequences of reduced water supply funding

Adverse

- Inadequate treatment barriers, either because of the processes or their operation being unsatisfactory, resulting in contaminants reaching the supplied community.
- Insufficient monitoring of treated and reticulated water quality, with the result that the need for corrective and remedial actions is not identified.

Although water demand may fall, the reticulation network will remain unchanged. Consequently, the flow through the system will decrease and the time between the treatment of the water and it reaching consumers will increase. The potential public health consequences of reduced water flow are summarised next.

Potential public health consequences of reduced water flow

Adverse

- Particles settle out of the water and accumulate in the reticulation providing an environment for microbial growth, with the growth of opportunistic pathogens such as *Legionella* being the primary concern.
- Increased time for the residual disinfectant to react with biofilms and water contaminants causing a loss, or reduction, in the disinfectant residual and the protection it affords consumers against the ingress of contaminants.

Beneficial

- Sedimentation of pathogens with the particles to which they are attached increases the opportunity for die-off.

At the extreme, the gradual reduction in the viability of a water supply providing water for a decreasing number of people and households will end in supply closure. The potential public health consequences of water supply closure are summarised next.

Potential public health consequences of water supply closure
<u>Adverse</u>

- A community group taking over responsibility for the water supply, but the inherent uneconomic nature of the operation results in cost cutting which compromises water supply safety.
- Individual households take over responsibility for their own water supplies (eg, they sink their own bores or collect rainwater), but their operation of the supplies compromises the water quality and the risk to health is greater than when the supply was reticulated.

One of the immediate consequences of a lower demand for water is the reduced requirement for water from the treatment plant. The potential public health consequences of this are summarised next.

Potential public health consequences of reducing treatment plant output
<u>Adverse</u>

- Operating a water treatment plant below its design capacity can make maintenance of process efficacy difficult, particularly the effectiveness of the coagulation/flocculation and associated processes, resulting in poor contaminant removal and treated water quality being compromised.

Aging population and the effects of climate change

The elderly are a vulnerable sector of the population, partly because of their greater susceptibility to infection. Heavy rain events and drought arising from climate change will make it more difficult at times for water suppliers to provide an adequate, safe supply of potable water. The potential public health consequences of this are summarised next.

Potential public health consequences of an aging population
<u>Adverse</u>

- Increased numbers of elderly people become ill in the event of a community water supply becoming microbiologically contaminated, through either poor treatment plant operation, or a major decline in source water quality arising from severe flooding or drought
- Increased numbers of elderly people become ill through poor personal hygiene arising from a lack of water for sanitation purposes because drought has made it difficult for a water supplier to meet a community's water requirements.

<u>Mitigation of public health risks</u>

Consideration of the types of public health risks identified shows that it may be helpful to divide them into four classes, each to be addressed by a different mitigation approach, as follows:

- risks that can be addressed through public health risk management plans (PHRMPs)

- risks that can be addressed through regulation
- risks that can be addressed through subsidisation
- risks that can be addressed through education and the provision of information.

<u>Conclusions</u>

- Most of the territorial authorities expect to have to cope with an increased demand for water.
- There is currently no indication that any territorial authority considers that they will have to deal with supply underutilisation. This finding should be viewed with caution in case expectations of population growth are overly optimistic.
- Demographic factors other than population size, such as aging populations and changes in ethnic mix, do not appear to have been introduced into water demand projections.
- Some of the strategies being considered to meet increased water demand could have public health consequences.
- A high percentage of the water supplied to some communities is used by industrial, commercial or agricultural operations. A sudden change in water demand by one or more of these consumers could substantially affect the demand from the water supply and possibly lead to underutilisation.
- The risks to public health arising from demographic changes, the associated changes in water demand, and the strategies that might be employed to meet these challenges, can be addressed by:
    - PHRMPs
    - regulation
    - subsidisation for low-flow fixtures
    - provision of education and information.

1. INTRODUCTION

A fundamental requirement for maintaining public health within a community is access to an adequate supply of safe drinking-water. Difficulties in providing sufficient water to a community may lead to water shortages, insanitary conditions and, in some circumstances, the water supply becoming unsafe. Consequently, when designing water supply infrastructure, the community's demand for water must be taken into account.

Several factors may influence the extent to which a community uses water. However, the most important are frequently demographic factors, which include the size of the population, and its composition (eg, age and ethnicity). Non-demographic factors, such as the presence of industrial, agricultural or commercial operations, may also substantially impact on a community's demand for water.

Global demographic change, particularly global population growth, is expected to challenge all countries in the coming decades (World Economic Forum 2012). The challenges will take several forms, but certainly the provision of adequate amounts of safe water for communities will be one of these. For many developing countries, meeting their inhabitants' demands for water is already a challenge, and increasing population sizes will make providing adequate water supplies more difficult. Some developed countries will also face possible water shortages, but where population size has stabilised and is expected to decline, planning for underutilisation may be needed.

At the national level, New Zealand's population is expected to grow in the foreseeable future (StatsNZ 2012b). This demographic change will lead to many territorial authorities having to plan for increases in water demand. However, in some parts of the country, Statistics New Zealand projections show that populations will decline, and so might the demand for water.

This report follows an horizon scanning article by Nokes et al (2011) on water supplies and demographic change prepared for the Ministry of Health (FW11081). The purpose of this report is to examine in more detail how demographic changes in New Zealand may affect water supplies and what consequences these changes might have for public health. The challenges for territorial authorities expecting population increases are examined, as are the potential challenges for authorities expecting population declines. The report also contains a section specific to Watercare's (Auckland's water service provider) planning for demographic change. Planning for the water supply of New Zealand's only 'super city' is examined for the insight it may hold for other local authorities, for example those in the Wellington area, considering the 'super city' governance model.

The report does not provide policy advice. However, it suggests generic approaches for managing potential risks to public health that could accompany demographic changes.

Report structure

> Section 2 provides a background of the demographic changes expected in New Zealand over the next 10 years, approximately.
>
> Section 3 describes the approach taken in preparing the report.
>
> Section 4 presents the findings from an examination of the long-term plans published by territorial authorities, and from interviews with territorial authority managers with responsibilities for water supplies. The section also contains

commentaries on the findings to explain their implications for the operation of water supplies.

Section 5 takes the findings of Section 4 and identifies their possible implications for public health.

Section 6, from a consideration of the nature of the public health risks identified in Section 5, suggests four approaches to mitigate these risks.

Section 7 sets out the study's conclusions.

1.1. The Office of the Auditor-General's report

In 2010, the Office of the Auditor-General released an audit of eight territorial authorities (a mix or urban and rural authorities), which assessed forecasting of future water demands by the authorities and their abilities to meet these demands (OAG 2010). The report's aim was to understand how well the country is prepared to meet the future demand for water.

Some of the report's observations are of interest in understanding the factors influencing 'demand forecasting'. The sophistication of the forecasting was determined by factors other than the size (and resources) of the authority. At the time of the audit, authorities that were operating their water supplies well within their existing capacity or that had low rates of population growth were less likely to have used detailed forecasting. The authorities that had undertaken more detailed forecasting had used data available from water metering to better model demand from different sectors within their areas. As far as can be determined from the report, the more detailed forecasting did not establish how changes in specific demographic factors, such as the distributions of age and ethnic groups within populations, may influence demand.

However, the purpose of the Office of the Auditor-General's report is fundamentally different from the public health focus of this report, and consequently has been of limited use in preparing this report.

2. BACKGROUND – EXPECTED DEMOGRAPHIC CHANGES IN NEW ZEALAND

2.1. Introduction

This section provides an overview of the key demographic changes New Zealand can expect over the next 10 years approximately. The statistics presented are obtained from the medium-term population projections in tables and documents available from the Statistics New Zealand website. The Statistics New Zealand projections take account of the effect of migration (internal and external), as well as natural increase[1].

These projections do not necessarily match the projections published by territorial authorities in their long-term plans. The territorial authority projections and the reasons for them differing from those of Statistics New Zealand are discussed in Section 4.1.

Overseas studies show that water consumption increases with household income in a community (eg, Park and Wilby 2013; Schleich and Hillenbrand 2009). However, this study found no evidence of affluence being a factor explicitly taken into account in demand projections, neither was it mentioned in the report from the Office of the Auditor-General as a factor territorial authorities considered in assessing demand. Moreover, Statistics New Zealand appears not to provide projections for household income. Consequently, although increased affluence may increase water demand in some areas of New Zealand, this report does not consider it as a separate factor.

This section also includes a note on the effects of climate change. These effects, while not demographic change, will happen as demographic changes occur, and when superimposed on some demographic changes will have implications for public health, as discussed in Section 5.4

2.2. Changes in population size

New Zealand's population is expected to increase to 5 million by the mid-2020s (StatsNZ 2012a). The increase will be particularly marked in the Auckland region. The rate of population increase is slowing. During the 2010s it was approximately 0.9 percent per annum. Population increase is projected to fall to approximately 0.8 percent per annum during the 2020s, and by the 2050s it is projected to be approximately 0.4 percent per annum (StatsNZ 2012b).

The Statistics New Zealand medium-term projections for 2011 and 2021 (StatsNZ 2012a) estimates (taking the medium-term projections at face value) that of the 67 territorial authority areas, approximately 48 can expect increases in their populations, approximately 16 can expect declines in their populations, and the populations of approximately three will remain stable. A table listing the territorial authority areas, their 2011 populations (projected from the 2006 census data), and their population trends is presented in Appendix 1 (Table A 1).

2.3. Changes in population structure

2.3.1. Age distribution within the population

Projections show that the New Zealand population is aging. All territorial authority areas will experience population aging. The fraction of their populations aged 65 years and over

[1] The difference between the birth rate and the death rate over a period of time.

will increase from approximately 13 percent of the total population in 2011 to 17 percent of the total population in 2021 (StatsNZ 2012a). Moreover, this age bracket itself will age as the number of people over 85 years of age increases. By 2061, one in four people over the age of 65 years will be over 85 years of age, compared with one in eight people in 2012 (StatsNZ 2012b).

The extent of this increase depends on the city or district. The increase in the fraction of the population that is over 65 years of age in a territorial authority area ranges from approximately 2.6 percentage points to 7.9 percentage points (StatsNZ 2012a). These changes are not a consequence of the 'baby boomer' group moving through the population structure, but are caused by the transition to lower birth rates and lower death rates (StatsNZ 2012b).

2.3.2. Ethnicity changes within the population

The ethnic mix within the New Zealand population is changing with time. At the national level, between 2011 and 2021, the proportion of Asian people within the population will increase by 3 percentage points, the proportion of Pacific Island people will increase by 1 percentage point, and the proportion of Māori people will remain virtually constant (StatsNZ 2010b). The proportion of European (and other) in the population will fall by approximately 4 percentage points. The extent to which the ethnic mix will change depends on the territorial authority area.

2.3.3. Household size

Household size (persons per household), the number of households and the population size are interrelated. Trends in population size and the number of people in a household will determine the number of households in the country or territorial authority.

The average household size in New Zealand is projected (medium-term projection) to fall from 2.6 persons in 2011 to 2.5 persons by 2021 (StatsNZ 2010b). Looking at the individual territorial authority areas shows that in 2011 (projected from the 2006 census data) household sizes ranged from 2.2 to 3.3 persons, and in 2021 the projected household sizes will range from 2.0 to 3.2 persons.

The number of single-person households is projected to increase by an average of 2 percent per year between 2006 and 2031 due to the increasing number of older people (StatsNZ 2011). Three quarters of the growth in this type of household is due to the increases in the number of people of 60 years of age and older. In 2006, 49 percent of people in single-person households were aged 60 years and older. By 2031, this percentage will have increased to 61 percent.

2.4. The effects of climate change

By 2050, temperatures in New Zealand are expected to be more than 1°C higher than those in 1990, and by 2100 the rise is likely to be more than 2°C above 1990 temperatures[2]. Accompanying these temperature changes, rainfall in the west is expected to increase, but less rain is expected in the north and east. Floods and droughts are also likely to occur more frequently and with greater intensity, and an increase in the average sea-level is projected. All of these changes have the potential to impact on water supplies. Heavy rain and drought may make providing water of an acceptable quality difficult, and increased temperature and droughts are expected to add to water demand (Nokes 2012).

[2] http://www.climatechange.govt.nz/physical-impacts-and-adaptation/ (accessed 28 June 2013)

3. APPROACH

A 10-year time frame was selected in consultation with the Ministry as appropriate for understanding how demographic changes might influence the provision of drinking-water throughout the country (by territorial authorities) and the potential accompanying public health impacts. Increased projection uncertainties beyond this horizon would have made drawing conclusions even more speculative than at the 10-year boundary.

Under the Local Government Act 2002 all local authorities are required to produce long-term council plans for their areas of jurisdiction. These documents provide a readily accessible source of information on how territorial authorities expect to see the demand for water in the district or city changing and how they intend to address these trends.

The long-term plans for all territorial authorities (city and district councils) in New Zealand as well as Greater Wellington Regional Council (because of its role as the bulk water supplier to Wellington City) and Auckland Council, were scanned, for information that would assist in understanding:

1. the nature of the information used by the council in planning for demographic changes
2. the nature of the demographic changes expected by the council
3. the council's plans for meeting these challenges
4. any other factors identified that are likely to influence the demand for water.

This entailed the examination of 67 plans, which was too many for each to be read in detail. Instead, the documents were searched for key text strings ('population', 'demograph*', 'water supply', 'assumption') to locate the sections of the document that might provide the required information.

After this initial scan of the plans, authorities expecting stable or declining populations over the next 10 years were identified. To account for the difficulties these territorial authorities might face (because of the problems associated with underutilisation of water systems reported in overseas jurisdictions (Hummel and Lux 2007)), more detailed information from these authorities was sought via interviews. Asset managers with water supply responsibilities were interviewed from three of these authorities in the North Island and two in the South Island.

The primary interest in interviewing managers from these five authorities was to determine whether they anticipated substantial underutilisation of any of their water supplies, and if so, what public health effects they foresee. There were some differences in the levels of water demand expected by the different authorities, but the first five interviews showed that the scale of underutilisation reported overseas (Hummel and Lux 2007) was not being anticipated by these authorities. Consequently, we considered more interviews to be of limited value and did not carry out any further interviews.

The managers of the selected territorial authorities were interviewed by telephone. A primary set of six questions (Table A 2) was used to initiate the interview, and unstructured questions were then asked depending on the responses to the primary questions. Interviews took approximately 20–25 minutes, and were recorded to assist with note taking. An undertaking was given before the interviews that the territorial authorities would not be identified in the report.

To collect information about the special case of the Auckland ‘super city’, documents prepared by Watercare (the Auckland city water services provider) were examined. These were the:

- *Asset Management Plan For the period: 1 July 2012 to 30 June 2022* (Watercare 2011a)
- *Auckland Regional Water Demand Management Plan* (Watercare 2011b)
- *Three Waters Final 2008 Strategic Plan* (Watercare 2008).

The water supply planning manager was also interviewed to augment the information available from the public documents.

4. FINDINGS AND COMMENTARIES

4.1. Information from long-term plans

This section presents the information obtained from the long-term plans. The information of interest from the plans was the expected demographic changes, how water demand is expected to change as a result of these changes, and the strategies that are being followed to address the challenges presented by changes in demand.

With each section of the information obtained from the plans is a commentary discussing the importance of that information with respect to water supplies.

4.1.1. Limitations of the long-term plan review

Scanning the long-term plans for pertinent text strings made extracting information from these documents manageable. However, a possible consequence of the approach was that some relevant tracts of text were missed. Consequently, the findings from the scans presented here may not be an exhaustive compilation of the relevant information the plans contained. For this reason, the details from each plan are not recorded. However, we believe that we have extracted a sufficiently high proportion of the relevant information to allow useful generalisations to be made that meet the needs of the study.

4.1.2. Projections of population size[3]

The demographic change likely to have the greatest impact on the ability of a territorial authority to supply a community with an adequate supply (in terms of quantity and quality) of drinking-water is a change in the size of its population. The nature of the population trend has a major effect on the types of challenge a water supplier will face. An increasing population is likely to create the need for meeting a demand for more water, while a declining population may create difficulties associated with funding an underutilised infrastructure. As will be seen in Section 5, both population trends may create public health risks.

Statistics New Zealand's projections, based on data from the most recent census (2006), underlie the territorial authorities' projections. In some cases, the territorial authorities have used the Statistics New Zealand projections without adjustment. In others, while the Statistics New Zealand projections have been used as the basis for a territorial authority's expected change in population, the authority has taken account of local factors it believes should be considered to provide a more accurate projection. Some of these independent projections are at variance with Statistics New Zealand's projections, in terms of both trend magnitudes and directions.

Table A 1 in the Appendix 1 lists, for each territorial authority, the population trend for the approximate period of the long-term plans based on the Statistics New Zealand projections, and the trend stated in the long-term plan by the authority.

Table 1 summarises the population trend information from Table A1. It shows that the majority of territorial authorities expect their populations to grow, as does Statistics New Zealand. Apparent differences between the two projections arise in relation to those authorities for which static or declining populations are projected.

[3] The discussion relates to population projections for territorial authority areas, not populations served by water supplies.

Table 1 **Summary of population trends from territorial authority long-term plans and Statistics New Zealand projections.**

Anticipated Change in Population	Long-term Plan (2012-2022)	Statistics NZ Projection (2011-2021)
Increase	46	48
Static	11	3
Decline	10	16

Territorial authorities with small populations are more likely to have projections indicating static or declining populations than larger authorities (Table 2).

Table 2 **Information showing how the likelihood of a territorial authority expecting a population increase is associated with the population band.**

Population Band	Number of TAs in the Population Band	Percentage of TAs Expected to Show a Population Increase[1]	Percentage of TAs Expecting a Population Increase[2]
<20,000	24	50	58
20,000–100,000	35	83	74
>100,000	7	100	71

[1]Based on Statistics New Zealand's medium-term projections
[2]Based on long-term plans
TA: territorial authority

Based on the long-term plans, 46 councils expect their districts' populations to increase over the period 2012–2022. Statistics New Zealand's projections show that between 2011 and 2021, increases in population are expected to range from slight (0.5%) to significant (19%) (StatsNZ 2012a). Eleven councils anticipate population declines and almost the same number expect their populations to remain approximately stable. A few councils note that over the 10-year period covered by their plans, initial population growths may turn to declines. These have been counted as declining populations.

The incorporation of local factors not taken into account by Statistics New Zealand is important for achieving more accurate projections. However, an overly optimistic view of growth by an authority could result in an unexpected decline in water demand. Articles in the media show that some people in small rural communities do not share the optimistic views of growing populations in their areas[4].

Many territorial authorities, mainly those with rural and urban communities, record that while populations are expected to increase in some areas within their district, population declines are expected in others. Most often, rural areas are expected to suffer population losses, although the occasional city council also notes the loss of population from one or more suburbs, possibly accompanied by growth in other city areas. These observations are consistent with the likelihood of population decline being related to the size of the community as presented in Table 2.

[4] For example, 'Rural exodus: goodbye country … small town NZ in decline as rush to cities grows.' *New Zealand Herald* 6 December 2012. URL: http://www.nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid=10852242 (accessed 22 May 2013).

While expected trends in populations were identified in all long-term plans, the implications for water supplies were not always explicitly stated.

Commentary

A territorial authority with an increasing population, and a correspondingly increasing rating base, is financially better placed to maintain an adequate, safe supply of water than an authority with a declining population. However, planning to ensure that the increased water demand can be met is required, and this is discussed in Section 4.1.5.

For territorial authorities planning for declining populations, the problem turns from one of water resources to financial resources. The per capita cost of maintaining a water supply increases as the size of the population served declines (Hummel and Lux 2007). Some component costs of operating a water supply are proportional to the population supplied, such as treatment chemical costs and power. Other costs, such as the depreciation of assets, do not scale with the size of the population served. Thus a territorial authority with a declining population has less income and the cost of producing the water increases per resident.

In the absence of cross-subsidisation, charges for water in a community with a declining population will need to be increased, unless operational savings can be made. Cost cutting in operation and maintenance, unless done carefully, could put the safety of the water at risk. Furthermore, the available funding may be insufficient to ensure the viability of the supply indefinitely.

Although not documented, a vicious cycle may also develop as a result of rate increases to compensate for a declining rating base. It provides an increased incentive for the remaining members of a community to migrate.

Germany's experience of the consequences of declining populations shows what can happen when there are marked reductions in water demand from large water supplies (Hummel and Lux 2007). In Germany, the impacts of migration depend on the scale being considered. At the national level, immigration has increased population size, but at state and county levels, the inter-regional migration that has occurred since reunification has had different effects. While there are areas of population stability in eastern Germany, some areas are losing population rapidly to the west, and within the eastern regions, there is a population drain from rural to urban areas. Some of these areas are expected to have lost half of their present population by 2050. Areas of population increases and population declines can be geographically close.

In parts of Germany, total water demand is declining as consumer numbers decrease. This is being accompanied by a decline in per capita consumption, due to changes in water saving household technology and low-flow fixtures (eg, washing machines and dishwashers, low-flow shower heads), greater environmental awareness by consumers and increasing water prices. The subsequent underutilisation of water has had major impacts on the functional capacity and financial viability of water (and wastewater) systems. With falls in demand and reductions in water flows comes the need for more frequent flushing of the network to address potential problems of sediment accumulation, decay of disinfectant residual and microbial regrowth.

In some residential areas of eastern Germany, utilisation of water and wastewater systems can be less than half that for which they were designed. These systems cannot be closed down because they have to be maintained to supply the remaining population. Paradoxically, extension of underutilised systems is sometimes needed to provide water to new residential or industrial areas.

Although population size is a key factor in determining a community's water demand, it is not the only factor, as discussed in the following sections.

4.1.3. Projections for other demographic factors

Although change in population size is usually the primary driver of changes in water demand, other factors can influence water demand and the way in which water is best provided to a community. Two of these factors, population age distribution and occupancy/number of dwellings, are discussed in this section.

The Office of the Auditor-General's report (OAG 2010) found that selected territorial authorities accounted for growth in populations and growth in the numbers of dwellings, but did not account for changes in distributions of age or ethnicity. This is not necessarily a shortcoming in the projections. The contributions these factors make to demand may be minor compared with the overall uncertainty in the projections.

Changes in ethnicity distribution may have implications for water demand, perhaps through different cultural practices, but we are unaware of any studies being undertaken, either in New Zealand or overseas, to quantify differences in water use by different ethnic groups. Consequently, ethnicity is not considered in this report.

4.1.3.1. Population age

All long-term plans that comment on the age distribution within their populations concur with the Statistics New Zealand projections of an aging population discussed in Section 2.3.1.

None of the plans discuss how the changing age distribution might affect water consumption, and it is reasonable to conclude that it is not a factor that has been taken into account when estimating water demand. There are two reasons for this. First, the effect of age on demand is minor compared with that of population size, and second, there is no New Zealand information on which to base any modelling.

Commentary

While there does not appear to be any New Zealand studies that have determined how age influences water consumption, other studies in other jurisdictions have been undertaken. Hummel and Lux (2007) record a Dutch study that reported declining use of water by those aged 65 years and older (119 L/person/day) compared with the consumption of water by 18–24-year-old people (150 L/person/day). The Dutch figures indicate that an aging population will reduce a community's water demand, all other things being equal. In contrast, analysis of German data by Schleich and Hillenbrand (2009) found that water consumption increases with age. A United States study in 1992, referred to by Hummel and Lux (2007), reported that adults use less water than children, but more water than teenagers.

It seems likely that context will have a marked influence on how water consumption depends on age. For example, in communities in which high-density housing is the primary form of accommodation, older people are likely to use less water than in communities in which space allows older people to maintain gardens with their associated need for water (Birrell et al 2005). While these differences may be apparent at the national level, separate surveys of communities within the same country may be necessary for a territorial authority to establish how their aging population may affect water demand.

An aging population, especially in a district also expecting a declining population, potentially creates the problem of a territorial authority having insufficient resources to provide the amenities and services expected of it by its rate payers.

4.1.3.2. Household size and numbers

Slightly more than one-quarter of the long-term plans note a trend of decreasing household size. Household size is linked to the increase in the number of dwellings a territorial authority is expecting in their area. An increase in the number of people living alone (Section 2.3.3), because of either family dissolution or an aging population with older couples losing partners, increases the number of dwellings needed to accommodate a given population.

Commentary

Decreasing household size increases water demand (Birrell et al 2005; Park and Wilby 2013). Some components of a household's water consumption depend on the number of occupants, but there are other components that are independent of the number of people in the dwelling (eg, garden watering). Consequently, if the population of a district remains static, but household size falls so that the number of dwellings accommodating the population increases, there will be a net increase in water consumption.

The Consumer Council for Water[5] in the United Kingdom has estimates of annual water consumption by households of different size, ranging from a single person to a six-person household[6]. The average usage by a single-person household is 66 m^3, while that for a six-person household is 200 m^3 (compare with six times the single household usage of 396 m^3). The greater per capita use of water by smaller households, together with the increasing number of this type of household, will increase the water demand beyond that arising from population increase alone.

As the growing number of older people is the primary driver of the increase in single-person household (StatsNZ 2013), this is another means by which aging population .will affect water demand.

The way in which a larger population is housed also has an impact on the supply of water (Birrell et al 2005). Increasing the density of housing does not require expansion of the reticulation network. However, greenfield development[7] requires a greater investment in underground infrastructure. Expansion of the reticulation network brings with it the difficulty of maintaining a satisfactory disinfectant residual and the associated water quality problems if a residual cannot be maintained.

4.1.4. Projections for non-demographic factors

Despite the primary interest in the effects of demographic change on water demand and quality, non-demographic factors in some communities may also strongly influence water demand. Non-demographic factors that were recorded in long-term plans, included:

- land-use changes
- mining development

[5] A non-departmental public body independent of the water regulator and water suppliers that represents water and sewage consumers

[6] http://www.ccwater.org.uk/server.php?show=ConWebDoc.913 (accessed 25 June 2013)

[7] The expansion of new development into rural areas

- the effects of climate change
- industrial (general)
- changes in agricultural, industrial and commercial operations
- tourism
- absentee populations
- large transient populations in small communities
- seasonal demand
- aging infrastructure.

Commentary

Where a substantial percentage of the water produced by a small water supply is consumed by a single non-residential customer, the viability of the water supply can depend on the continued demand from the non-residential customer.

Changes to demand that result from demographic changes occur on a relatively long time scale. This gives the water supplier time to plan for operating with a different water demand. The same is not true when a non-residential consumer's demand changes. For example, the closure of an industrial operation can come with little warning, giving the supplier virtually no time for planning.

Small water supplies are also vulnerable to **variable** demands. In the list provided previously, tourism, absentee populations, transient populations and seasonal demand, can all exert a variable demand on a supply. In these circumstances, the water supply must have the capacity (treatment plant output and an adequate sizing of pipes in the reticulation network) to meet peak demand. However, there will be periods when this capacity is underutilised. In the case of tourism, consumers will not necessarily pay directly (through rates) for the operation and maintenance of a supply, and increased tourist income in the community will be required to support supply viability.

Section 7 of the Resource Management Act requires all councils, in exercising their functions, to have particular regard to the effects of climate change. Several long-term plans record that the effects of climate change will be a factor influencing their ability to meet water demand. This may be affected by reduced availability of source water and increased demand. The effects of climate change are anticipated to have geographic dependence as noted in Section 2.4, consequently, the influence of climate change on water availability will be a greater concern to some territorial authorities than others. Climate change will become more important in the longer term than in the period covered by the long-term plans.

4.1.5. Strategies identified for coping with demographic changes

Many of the long-term plans provide some understanding of the ways in which territorial authorities intend to meet the challenges of increasing water demands. These are primarily authorities expecting increases in their populations, but there are a few instances of authorities expecting static or declining populations that report how they intend to conserve water, because of increased demand arising from non-demographic factors. No strategies for managing reductions in water demand were found in the long-term plans, although the ramifications for water supply operation in the face of a declining rating base are noted.

To meet an increased demand for water, there are two broad approaches open to a territorial authority, either reduce consumption or increase supply. A combination of both may also be used.

Actions for reducing water consumption recorded in the long-term plans included:

- water demand management – this generic statement was often made without further elaboration
- leak detection, or water-loss reduction programmes
- community education programmes
- metering and charging strategies
- water restrictions
- promotion of the use of water-saving plumbing fixtures
- xeriscaping (planning gardens to reduce the need for water).

Steps for increasing the supply of available water included:

- promotion of rainwater harvesting (for non-potable use) and greywater reuse
- construction of new reservoirs or treatment plants, or the development of new sources to allow more water to be supplied
- extension or merging of reticulations to enable communities that may struggle to meet water demand to be supplied from another well-supplied network.

Commentary

Where the increase in water demand does not exceed a system's capacity, water conservation may be sufficient to avoid having to commission a new source or sources of water in the 10-year time frame. Water conservation alone will be inadequate when anticipated increases in demand result in the system's capacity being exceeded, but it can defer the need for expenditure on the development of new sources.

Of the actions to reduce water consumption listed previously, the two most frequently recorded are leak detection/water loss reduction programmes and metering/charging strategies. Greywater reuse was explicitly noted only once, and rainwater harvesting only three times[8]. Some Australian authorities are turning to recycling of non-potable water or wastewater to meet their demands for water[9], but this is not being widely considered in New Zealand. It is beyond the scope of this study to examine the reasons for this, but wariness of the potential public health risks, the generally greater availability of water in New Zealand compared with Australia, and cost-effectiveness may be contributors.

The apparent absence of strategies for addressing falling water demand, where declining populations are expected, is understandable.

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[8] It is possible both greywater reuse and rainwater storage are included in some long-term plans under a more generic heading.

[9] URL: http://www.recycledwater.com.au/index.php?id=28 (accessed 20 May 2013)

a. The expected population declines are relatively small, and, as a consequence, so will be the corresponding reductions in water consumption. For this reason, territorial authorities do not anticipate difficulties resulting from small reductions in water demand, and certainly not problems of the magnitude of those forecast in Europe (Hummel and Lux 2007).

b. The extent to which the effects of climate change could increase water demand is being considered by some territorial authority water managers as a factor that may counteract any fall in demand arising from declining populations (see Section 4.2).

c. Small communities (population less than approximately 1000) in which population declines are most likely to occur, are sometimes those that have to maintain water supplies capable of meeting increased seasonal demand.

One of the purposes of the interviews discussed in Section 4.2 was to discuss possible problems associated with declining populations with water suppliers.

4.1.6. Christchurch's three-year plan

Christchurch City Council (CCC) and the Government have agreed to delay the preparation of the council's next long-term plan until 2015. At this stage, the city council and the Government (eg, Canterbury Earthquake Recovery Authority) consider that the council needs to focus on more immediate goals than those expected in a 10-year long-term plan. As a result, a three-year plan (submissions closed on 19 April 2013) has been prepared (CCC 2013).

The city has suffered a 3.6 percent net decrease in population since the first of the two significant earthquakes, and 7822 homes are in areas zoned 'red' by the Government, and these are in areas in which rebuilding is unlikely (CCC 2013). Modelling suggests that increases in population and household numbers will lag behind pre-earthquake expectations by about seven years.

While the city population is expected to increase overall, the number of dwellings in 'red' zones implies that the possibility of underutilisation of parts of the water supply exists. A section within the three-year plan (available as separate document), *Christchurch Recovery and Rebuild Issues and Challenges*, acknowledges that in the short-to-medium term there may be a surplus of community infrastructure, but greater detail is not provided. 'Negative effects and risks' are identified in the three-year plan, but they do not include the consequences of underutilisation of parts of the water supply network.

With the increasing number of households in new greenfield developments, peak demand for water is expected to increase, and demand management strategies are being put in place. The CCC expects that new water supply infrastructure, required for greenfield developments, will be funded by the developers[10]. Infill housing is not expected to increase demand.

To help the council meet its legal obligations of supplying water that meets the drinking-water standards, the council plans, where necessary, to abandon small water supplies and connect these communities to the reticulated Christchurch supply.

[10] "It is expected that any new infrastructure for growth will be funded by developers. The Council may consider assistance with funding of the service where there are significant public health issues. This would be assessed on a case–by–case basis." (CCC 2013, Part 2. Water Supply p.24).

In summary, the possibility of underutilisation of parts of the water supply exists. The possibility of generic infrastructure underutilisation is acknowledged and the need to manage this noted, but there is no further discussion about possible impacts on the water supply.

4.2. Interviews with water supply managers from territorial authorities expecting static or declining populations

This section summarises the information gathered through the interviews with water supply asset managers from five territorial authorities expecting near static or declining populations. The key points from the individual interviews are provided in Appendix 3.

The interviews started by confirming the population trend on which the authority's plan is based, and then moved on to determine how this, along with other demographic changes (such as aging population and household size), was expected to influence water demand. Questions were also asked about the possible effects of non-demographic changes on water demand, with one question specifically including the effects of climate change.

None of the interviewees considered changes in water demand to be significant. Nevertheless, the possible difficulties that might be faced in association with declining demand were discussed, albeit hypothetically.

Although all of the interviewees faced similar population trends, their circumstances were slightly different, which was reflected in the information they provided. The most important observations from the interviews are summarised next.

a. Although factors other than population size, such as age, were acknowledged as influencing water demand, these were not used as primary predictors of water demand. In the opinion of two asset managers interviewed, older people use more water than younger people because of their interest in keeping their gardens green. These opinions were based on personal observations rather than objective measurement undertaken of water consumption.

b. Three of the authorities are expecting static water demands, one a slightly increased demand, while one noted an increased demand associated with an increase in the number of dwellings, despite the authority expecting the district's population to remain static.

c. Water consumption by industrial or agricultural operations contributes to the water demands that have to be met by supplies in some of the districts.

d. Sudden changes in consumption by industrial or agricultural activities supplied by territorial authority-owned supplies due to closures, for example, were not a concern for any of the managers interviewed, because they considered such eventualities unlikely. This was particularly true if their supplies are providing water to more than one major non-residential customer. When asked whether they would expect problems with operating supplies if there were significant falls in demand, the managers believed that unless there were drastic falls in demand, practical difficulties associated with operating the supplies were unlikely. In some instances this was because their treatment plants could be operated at reduced flows if necessary. In other cases, where the sources were groundwater and the treatments involved disinfection only, both abstraction rates from the ground and the chemical or ultraviolet doses were readily adjustable.

e. Some managers acknowledged that major drops in demand would have implications for the economics of the operation of the supplies, and they noted the probable need for increased water charges. One authority connects supplies, where it is physically easy to do so, to allow a supply with excess capacity to provide water to a supply that struggles to meet demand at times. Another authority requires farmers requesting supplies to sign agreements for the minimum number of connections before work starts, to reduce the risk to its capital investment when establishing new rural supplies.

f. Opinions differed about the effects climate change might have on an authority's water supplies, at least in the near future. Some of the thoughts regarding climate change included:

   - uncertainty in climate projections making planning difficult
   - groundwater sources already beginning to run dry during droughts, and communities being 'naïve' in thinking that climate change will not worsen the situation
   - that while supplies were able to cope with the recent drought in early 2013, territorial authorities are working to increase storage to cope with the increased likelihood of more severe droughts
   - unsecure sources being upgraded to reduce their vulnerability because of the area already being dry and climate change projections indicating it will become drier
   - the effects of climate change will not create problems in the foreseeable future as there is ample capacity in the existing source and a supplementary source is available, if necessary.

g. Nationally, there is a net migration from rural to urban areas, but one authority has found a slight increase in demand from their rural supplies because of an increasing number of lifestyle blocks.

h. Not all authorities considered leak detection and repair a cost-effective approach to water conservation. One authority, which has a good supply of water, is prepared to operate its old supplies with their existing water losses rather than meet the expenses associated with leak detection and repair, at least until increased demand makes it economic to carry out repairs.

4.3. Auckland's case

4.3.1. Introduction

On 1 July 2012, the amalgamation of Auckland City with six neighbouring territorial authorities and the Auckland Regional Council created the Auckland Council. On the same date, Watercare became a council- controlled organisation, owned by Auckland Council, with responsibility for supplying water to approximately 1.3 million consumers throughout the region.

Auckland is the first and only 'super city' in New Zealand, but there are suggestions that this model could be followed in other areas, such as the Wellington region with its local authorities[11] although special legislation would have to be drafted for this to eventuate.

[11] URL: http://wellington.scoop.co.nz/?p=54974 (accessed 20 May 2013)

Watercare's planning for demographic changes in Auckland may be helpful in understanding the challenges other 'super cities' might face. This section examines more closely how demographic changes in Auckland are expected to affect Auckland's metropolitan water supply and Watercare's plans for meeting the challenges these changes present.

This section was prepared on the basis of information contained in three Watercare documents (Watercare 2008; 2011a; 2011b) and an interview with Watercare's water supply planning manager.

4.3.2. Auckland's demographic changes

Auckland Council's medium-term population projection for the period from 2012 to 2022 is for a population increase in the region of 270,000 people, and for the population to have increased by 470,000 people (Watercare 2011a) by 2031. Watercare anticipates that most of the urban expansion resulting from the population increase will occur in the Rodney and Franklin wards through greenfield development. Other urban expansion is likely in Flatbush and Massey North/Westgate. The remaining urban population increase will be accommodated by intensification of existing urban areas.

Statistics New Zealand's projections show an aging population in the Auckland region, and Asian and Pacific Island peoples are expected to make up larger percentages of the regional population. The projections also show reducing occupancy rates (persons per dwelling) in the region, and the *Asset Management Plan For the period: 1 July 2012 to 30 June 2022* (Watercare 2011a) notes that this will increase the per capita water consumption.

4.3.3. Water demand projections

Watercare's water demand projections are based on Auckland Council's growth projections. Three levels of water demand projection (low, medium and high) are produced to account for projection uncertainty. These tiered projections allow for growth in the metropolitan and non-metropolitan water supplies that Watercare operates.

Watercare identifies several drivers it expects to influence demand. These include actions taken as part of its water demand strategy discussed in Section 4.3.4.

Drivers likely to increase demand

a. Population growth is expected to increase demand through a population increase and a decrease in occupancy (decreased occupancy increases the number of dwellings required to house a given population, which increases the population's water consumption).

b. Spatial planning. Greenfield development with larger property sizes will increase water use.

c. Economic factors. An economic upturn will increase industrial, commercial and agricultural activity, and with it water use.

d. Effects of climate change. During dry periods, increased irrigation (including domestic gardens), pipe bursts, and roof catchments requiring supplementary water (as their tanks run dry) will increase water demand.

e. Changes in water-use patterns. 'Wet' industries in the centre of Auckland may relocate to other areas thereby shifting the location of the demand.

f. Introduction of water meters to non-metered areas. Lower tariffs may increase water use.

g. Water losses due to undetected leaks, illegal connections and under-reading of meters (due to consumers believing they are using less water than is actually the case).

h. Water tankers providing roof catchments with supplementary water during dry periods.

i. Network extensions to areas formerly on private supply leading to an overall increase in demand despite there being no population growth.

Population growth is the main driver determining overall demand for water. However, peak demand must also be taken into account. It drives investment in infrastructure, as treatment plants and pipelines must have the capacity to meet the demand for water during the periods of highest usage.

Drivers likely to decrease demand

a. Spatial planning. Intensification of development within existing areas reduces per capita water consumption because of less opportunity for outdoor water use (smaller gardens).

b. Economic factors. An economic downturn will decrease industrial, commercial and agricultural activity, and with it water use.

c. Water losses. Leakage control and pressure management will reduce losses.

d. Technology change. Smart metering will make usage more obvious to consumers.

The spatial planning factor is unknown, but will affect Watercare's plans for meeting demographic change. The Auckland Plan[12] currently aims for 90 percent of the population growth to be accommodated within existing urban areas, and 10 percent of the population to be accommodated in greenfield developments. However, Section 2.2.3 of the draft Auckland Unitary Plan[13], which at time of writing this report is being commented on, has a proposed growth split of 60–70 percent in urban areas and 30–40 percent in greenfield developments.

Two other factors that Watercare's demand projections take into account are (from the interview):

a. that not every person being added to the population will necessarily contribute to water demand, as they may be on an unreticulated supply

b. Watercare's target of reducing the 2004 water consumption by 15 percent by 2025 (Watercare 2008).

[12] URL: http://theplan.theaucklandplan.govt.nz/ (accessed 30 May 2013)

[13] URL: http://unitaryplan.aucklandcouncil.govt.nz/pages/plan/Book.aspx (accessed 20 May 2013)

4.3.4. Asset management and water demand management strategy

4.3.4.1. Asset management plan

Watercare's *Asset Management Plan For the period: 1 July 2012 to 30 June 2022* (Watercare 2011a) identifies three components and their present contributions to water demand. Watercare's water demand is presently:

- 61 percent residential
- 26 percent commercial, industrial and agricultural
- the remainder (13%) is accounted for by leaks, illegal connections and fire-fighting.

Watercare's focus has been on understanding and planning for residential demand, because this is the largest contributor to demand. However, work is now underway to understand demand trends arising from non-residential customers. This information will eventually feed into the demand-planning process.

As discussed in Section 4.3.4.2, Watercare's short-term approach to meeting demand is to reduce water demand, but planning for increased takes from existing sources and treatment plant upgrades have been projected out 50 years.

4.3.4.2. Water demand management

Watercare's aim is to have sufficient 'headroom' (excess capacity) in its supply to be able to operate with an unrestricted water supply during droughts having a return period of up to one in 100 years. Two approaches will achieve this, namely, reducing water demand and increasing the available supply of water.

Watercare's immediate focus is on demand reduction, with the target of reducing the consumption in 2004 by 15 percent by 2025. The demand reduction strategy will not overcome, but will defer the need for further investment in infrastructure. Moreover, Watercare's calculations published in the *Three Waters Final 2008 Strategic Plan* (Watercare 2008) show that effective leak management (demand reduction) has a much lower marginal cost per cubic metre of water than bringing new sources on-stream.

Watercare has identified 17 approaches for reducing water demand (see Appendix 4 Table A 3). Four of these approaches include the use of non-potable water. Watercare has considered the reuse of water as part the *Three Waters Final 2008 Strategic Plan*, although a **workshop** to prioritise demand reduction approaches ranked non-potable water use as having the lowest priority.

The *Three Waters Final 2008 Strategic Plan* covers stormwater (rainwater collection), greywater and reclaimed water from wastewater treatment. It proposes that 10 percent of supply could be met from these sources by 2025, subject to a cost-benefit analysis. However, before it commits to using any of these water sources, Watercare plans to work with the Auckland Council to ensure that social, cultural, environmental and economic factors are fully understood. Initial cost-benefit considerations indicate that non-potable uses do not become viable at a regional level until other water source options have been exhausted.

Charging for water based on consumption is a key and effective tool for managing water demand. This is regarded globally as being best practice for water demand management and is already carried out in Auckland (Watercare 2011b). Interestingly, Watercare notes that Auckland is one of only a few large cities in the world to have implemented universal metering.

Manipulation of the price charged per unit volume of water is also an effective way of ensuring efficient water use. However, this instrument has to be used judiciously, as Watercare is under a statutory obligation to minimise costs and ensure that prices remain affordable (Watercare 2011b).

4.3.5. The impact of development on water supplies

Rather than establish small, separate water supplies to provide water to greenfield developments, Watercare presently supplies them by extending its metropolitan reticulation network. This approach will continue for supplying future greenfield developments. While Watercare does not anticipate any engineering limits associated with doing this, it acknowledges that extending the network presents possible problems in maintaining water quality. The primary concern is maintaining a satisfactory disinfectant residual.

Disinfectant residuals are presently maintained in the northern extremities of the network by booster stations providing secondary chlorination. Watercare's preferred approach to ensuring a satisfactory disinfectant residual is to improve the removal of organics (which present a chlorine demand) at their central treatment facility. As well as improving the longevity of the disinfectant residual, this approach has other water quality benefits, particularly with regard to taste.

A further consideration in opting for retention of centralised water treatment is that Watercare's calculations show it is more economical than operating a series of small peripheral plants.

4.3.6. Summary of messages for future 'super cities'

The details of other territorial authority amalgamations will be different from those of Auckland. However, this brief examination of Auckland's situation identifies some points that many need to be considered for other amalgamations.

a. The way in which new growth will be accommodated (greenfield, brownfield[14] or intensification of existing urban areas) will influence how the water supply system will develop.

b. In the event that greenfield development is planned as the primary means of accommodating the growing population, the relative merits of extending the existing reticulation network, or developing smaller satellite supplies, should be evaluated.

c. Extension of the reticulation network to supply greenfield or brownfield developments may degrade water quality because of the difficulty in maintaining a disinfectant residual. While disinfectant boosting in the reticulation network is one way of ensuring an adequate disinfectant residual, a strategy of improving the removal of organics (to minimise the disinfectant demand) during treatment will facilitate the maintenance of a residual, reduce disinfectant consumption and improve the aesthetic properties of the reticulated water.

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[14] This is development on land previously used for industrial purposes. Although some reticulated network will exist in these areas, it may need to be extended.

d. Residential demand is likely to be the largest component of water consumption. Consequently, understanding this component of demand, including how it arises and what might be done to reduce it, should be an early step in managing demand, followed by studying non-residential demand.

5. IMPLICATIONS OF THIS STUDY'S FINDINGS FOR PUBLIC HEALTH

5.1. Introduction

Future demographic changes and non-demographic factors will influence the water demands that territorial authorities have to manage. Authorities have identified a range of strategies that they have either already implemented, or are considering, to meet anticipated changes in demand. This section examines the possible implications of the changes in demand for public health and the strategies being considered to address them. Section 5.2 considers the implications for public health of an increasing population and Section 5.3 looks at the possible consequences of a declining population and declining demand. There are also public health implications of an aging population, not necessarily related to changes in demand for water. These are considered in Section 5.4

For many territorial authorities, it is almost certain that water demand will increase, as will the need to implement strategies to meet the demand. Consequently, it is reasonable to expect that some of the public health implications identified in Section 5.2 may be encountered.

The situation for static or declining populations is different. Neither the long-term plans for territorial authorities nor the interviews showed expectations of significant decreases in water demand. Territorial authorities are aware that declining populations could adversely affect the economics of their water supplies, but we have not identified concerns about degraded water quality or difficulties with supply operation. It seems very unlikely that the more extreme situations arising from underutilisation of water supplies experienced in places such as Germany will be encountered in New Zealand in the near future. As a result, the discussion presented in Section 5.3 is more speculative than that in Section 5.2. Although Section 5.3 appears to address concerns that have no basis presently, territorial authorities may be faced with the challenges associated with reduced demand should optimism about growth in some of the smaller rural communities prove unfounded.

5.2. Increasing population

5.2.1. Introduction

The public health implications associated with increasing population fall into two categories, those arising from the:

a. need to accommodate a larger population

b. strategies for dealing with the increased demand for water.

This section examines each category separately.

5.2.2. Accommodating more people

A growing population increases the number of households to be supplied. Larger households use water more efficiently than smaller households (on a per capita basis) (Birrell et al 2005). Car washing, dishwashing, laundering, house cleaning and lawn watering (where applicable) consume similar amounts of water whether a household is large or small. Consequently, the decrease in household size, which is expected across the country, will add to water consumption beyond that anticipated on the basis of population alone. In addition to this, the way in which an increasing population is accommodated influences how much water it needs and the extent to which the reticulation network needs to grow.

New Zealand's population is highly urbanised. At the 2006 Census, 86 percent of the population was living in an urban area (Ministry of Social Development 2010). This included 72 percent living in main urban areas (population of 30,000 or more), 6 percent living in secondary urban areas (10,000–29,999) and 8 percent living in minor urban areas (1,000–9,999). Based on this information, increases in population can be generally expected to be accommodated in urban areas.

5.2.2.1. Greenfield development

Where additional inhabitants are accommodated by greenfield developments in New Zealand, existing reticulation networks are extended to supply these new areas. (In some instances network extension may be required for Brownfield development). The development of modular systems mooted in the overseas literature (eg, Hummel and Lux 2007) has not been identified in plans or in conversations with water suppliers.

Public health risks associated with network extensions could arise because of failure in the integrity of pipes or reservoirs, or difficulties in maintaining a satisfactory disinfectant residual.

Potential public health consequences of greenfield developments
<u>Adverse</u>

- Damage to the network (including sabotage) allowing contaminant ingress.
- Pressure losses or pressure transients, which in combination with leaks and the presence of contaminants external to the pipes, increase the likelihood of contaminant ingress.
- Backflow drawing contaminants into the reticulation.
- Loss, or reduction, in the disinfectant residual which increases the
  - survival time of microbial pathogens that may gain entry into the network
  - likely extent of biofilm formation on internal pipe surfaces and consequently colonisation by opportunistic pathogens such as *Legionella*.
- Warming of water during extended reticulation creating conditions that encourage colonisation by opportunistic pathogens, such as *Legionella*, in residential building plumbing networks.

These events could occur at present, but a larger network increases the likelihood of their occurrence. Public health risk management plans (PHRMPs) offer a tool for managing these risks.

5.2.2.2. Intensified housing in existing urban areas

Steps to increase population density in existing urban areas will decrease the available space for gardens and reduce water demand through reduced garden irrigation.

The development of large high-rise apartment blocks to increase the amounts of accommodation available could create hazards to public health that, while strictly not a responsibility of the water supplier, are water-supply related. For example, centralised hot water- and air-conditioning systems in large building complexes could give rise to the incubation of *Legionella* and its release into the air through plumbing outlets (most commonly showers), and air conditioning.

The risk of Legionnaire's disease could be increased by heavy rain events, which are expected to increase in frequency as climate change progresses. *Legionella* bacteria are relatively resistant to standard water disinfection processes (USEPA 2000). Inadequate removal of organic sediment and *Legionella* bacteria from water supply source water during rain events could result in dispersal of the bacteria through the reticulated network, and subsequently into the plumbing of buildings (Stout and Yu 1997). Improved maintenance of potable water distribution systems within buildings, and treatment processes designed to eradicate the *Legionella* and prevent its re-colonisation of the system are steps that should lessen the risk of disease.

Potential public health consequences of intensified housing
Adverse
- Growth of *Legionella* in large apartment block reticulation systems.

Other risks to public health may arise from denser accommodation, such as an increase in person-to-person infections, but these are unrelated to water supply and fall outside the scope of this report.

5.2.3. Water demand management strategies

Territorial authority long-term plans show that authorities are considering, or are already undertaking, a variety of approaches to meet anticipated increases in water demand resulting from factors that include population growth, non-residential water consumption and the effects of climate change. Many of the approaches appear to be neutral with respect to public health, that is, they are unlikely to increase or decrease risks to public health. This section comments only on those strategies that could have positive or negative impacts on public health.

5.2.3.1. Leak detection and repair programmes

A large percentage of the water produced by a water treatment plant can be lost through leaks (LeChevallier et al undated). The **reduction** of leakage, rather than its **elimination**, is the intention of leak detection and repair programmes. Although many suppliers consider these programmes an important first step in conserving water, the interviews showed that not all territorial authorities believe it to be cost-effective at present.

Potential public health consequences of leak detection and repair programmes
Adverse
- Ingress of contaminants into the network during leak repairs.

Beneficial
- Reduction in pathways allowing contaminant ingress into the network (this also impacts on other steps such as pressure management).

5.2.3.2. Pressure management

Pressure management controls system pressures to reduce water loss through leaks while maintaining a pressure consistent with user satisfaction and supply safety. It also reduces pipe failure. Sophisticated systems, combining hardware with software, are available to help water suppliers implement pressure management[15].

Potential public health consequences of pressure management

Adverse

- Pressure transients and lower operating pressures increase the likelihood of contaminants being drawn into the network from water and soil external to the pipes through leaks.
- Backflow of non-potable water sources from connections to the network as a result of pressure transients.

Beneficial

- Reductions in the frequency of mains bursts and the possibility of contaminant ingress.

A review undertaken by the Water Research Centre in the United Kingdom found that although low and negative pressures have been observed, the likelihood of very low pressures resulting from either sudden demand or exceptionally high demands was very low. However, very rapid increases in demand did increase the likelihood of very low pressures, as did low customer density (Creasey and Hunter 2008).

5.2.3.3. Water pricing and metering

The implementation of pricing policies is linked to the installation of meters as water consumption needs to be measured. Metering alone may reduce water demand through the consumer becoming more aware of their water use. Adjusting the price of the water to further reduce demand is an additional tool that is available once metering is in place, but it needs to be used with discretion.

Potential public health consequences of water pricing

Adverse

- Reduced water use by lower socioeconomic groups to lower living costs results in inadequate personal hygiene (eg, ineffective hand washing), for example.

5.2.3.4. The use of water-saving appliances and low-flow fixtures

Encouraging the use of water-saving appliances and low-flow fixtures has been identified in some long-term plans for managing water demand. There are several unrelated ways in which the use of these devices may affect public health.

Potential public health consequences of the use of water-saving appliances and low-flow fixtures

Adverse

- Scalding through the use of low-flow devices with non-automatic compensating valves (.ASSE 2012).

Beneficial

- Reduced water use diminishes wastewater flows and consequently the burden on wastewater treatment plants. This reduces the likelihood of poorly treated, or untreated, wastewater being discharged into receiving waters and infecting recreational users. Reduced wastewater flow will be of particular benefit to combined sewer systems (sewers receiving sewage and stormwater).

[15] For example, URL: http://www.i2owater.com/water-pressure-management/ (accessed 30 May 2013)

Reduced water usage also has less direct health benefits. Water and wastewater treatment and reticulation together are energy intensive. For example water and wastewater treatment constituted 57 percent (carbon dioxide equivalent) of the Kapiti Coast District's greenhouse gas emissions in 2001 (Heinrich 2007). Reducing energy requirements reduces emissions to the atmosphere and coincidentally leads to a reduction in other air pollutants such as fine particles, sulphur dioxide or nitrogen oxides, which have the potential to adversely affect health.

5.2.4. New sources of water

Water conservation measures allow the deferral of more expensive options for meeting water demand through the development of new water sources. Greywater reuse and rainwater harvesting are explicitly mentioned in only a few long-term plans. Watercare considers that the implementation of these strategies is not presently economic from a regional water supply perspective. Despite this, some territorial authorities have taken steps to encourage the use of these strategies, and others may find it necessary if they experience increasing difficulty in meeting their communities' demand for water.

This section discusses greywater reuse and rainwater harvesting in some detail because of the extent to which these strategies may be used and their potential risk to public health. The Kapiti Coast District Council (KCDC) is one of the territorial authorities that have taken major steps towards the use of both strategies. To provide some insight into the matters needing to be considered when implementing these strategies, this section examines the reasons for the KCDC turning to these strategies, the actions taken in implementing the strategies and the steps taken to try to address possible health risks.

Reasons KCDC is encouraging greywater reuse and rainwater harvesting

The KCDC has three catchments that provide its supply of water. The bulk of the district's water is taken from the Waikanae catchment. The district has a high overall per capita water consumption. Usage does vary with the community, with the average consumption ranging from 400–760 L/person/day, and the peak consumption ranging from 660–1480 L/person/day (OAG 2010). Twice in 2008, peak demand came close to exceeding the permitted take from the Waikanae catchment (KCDC 2011). The KCDC's projected water demand for 2020 is approximately 35 percent greater than the district's 2010 consumption (OAG 2010).

In the Kapiti Coast district, summer water consumption is 40 percent greater than the winter usage and outdoor garden irrigation accounts for most of this increase (KCDC 2011). The KDCD notes that treating water to a potable quality is expensive and that much of this high quality water is used for flushing toilets or garden irrigation (KCDC 2011). High peak demand for water is a concern for the council.

Actions taken by KCDC

The Council did make non-regulatory attempts to reduce peak demand but with limited success (KCDC 2009). In 2002, the Council required water saving devices in areas rezoned to residential. For many new developments, this amounted to the use of rainwater tanks and a restricted water supply.

In 2003, the KCDC adopted its Water Matters Sustainable Water Use Strategy (KCDC 2002). The strategy set out the Council's vision for the management of its water resource for the following 50 years, and recognised the importance of water conservation in achieving the vision.

As a result of adopting the Water Matters Sustainable Water Use Strategy, a proposed change to the district plan was notified in 2008. Submissions on the proposed plan change raised four key issues:

a. implementation costs for homeowners and building companies
b. the use alternative water demand management options
c. the use of water meters
d. health risks associated with greywater reuse.

(There were also requests to withdraw the plan change.)

In 2009, the council publicly notified its decision to make Plan Change 75 to the district plan (KCDC 2011). The KCDC's 2011 document provides the details of the changes (KCDC 2011), but the key provisions for permitted activities include the requirement that all new or relocated homes within the district have either:

a. a storage tank of minimum 10,000 L capacity for rainwater collection to provide a supply of non-potable water for outdoor use or for flushing toilets, or
b. a storage tank of minimum 4,000 L capacity for rainwater collection to provide a supply of non-potable water for outdoor use or for flushing toilets, and a greywater reuse system for outside irrigation.

No outdoor taps are to be connected to public water supply.

The potential public health consequences of greywater reuse and rainwater harvesting are noted in this report in Sections 5.2.4.1 and 5.2.4.2, respectively. These sections also discuss the safeguards included in Plan Change 75 to mitigate these risks.

The KCDC has supported the plan change through the preparation of:

a. an information pamphlet discussing the potential health risks associated with greywater reuse and how these can minimised (KCDC undated)
b. a code of practice for rainwater harvesting and greywater reuse (KCDC 2012).

5.2.4.1. Greywater reuse

Greywater reuse and its associated health risks have been the subjects of many studies, and an update this work is provided in an ESR literature review prepared for the Ministry of Health (ESR 2013). This section identifies the potential public health consequences of greywater reuse and the requirements contained within Plan Change 75 to protect against public health risks.

Potential public health consequences of greywater reuse
<u>Adverse</u>

- Exposure to contaminants present in the greywater through its ponding on the soil surface, inadvertent use for potable purposes (eg, people in particular children drinking from garden hoses connected to greywater outlets), or cross-connection with the potable reticulation.

Plan change 75 contains two approaches to reducing the likelihood of exposure to contaminants in greywater: minimising contaminant concentrations in the greywater and reducing public exposure to the greywater.

The plan change states that the greywater can only be collected from the bathroom (excluding the toilet) and laundry washing machines (not sinks) to reduce contaminant levels in the collected water. Kitchens are a greywater source, but the microbial contaminants in kitchen greywater are relatively high (World Health Organization 2006). The plan change also includes other requirements to reduce contaminant concentrations in the reused water.

a. Storage of the greywater is not permitted, as nutrient levels will encourage microbial growth. The only treatment permitted is primary screening or filtration.

b. It must be possible to switch the greywater back to the sewer should the quality of the greywater make this necessary.

c. The system must have a coarse filter to remove solids, and oils and greases.

d. The greywater system must shut off in the event of sewage backflow.

Several requirements in the plan change aim to protect against exposure to the greywater.

e. Greywater must be automatically diverted to the sewer in the event of heavy rainfall, to avoid ponding.

f. There must be adequate setback from sites where the greywater is irrigated and neighbouring properties and private bores.

g. A greywater reuse system may collect greywater from only one dwelling to avoid system overload.

h. Sub-surface irrigation must be used for disposal of the greywater, and the irrigation site must have a suitable slope and soil type.

i. The system must contain a device (other than storage) for attenuating surge flows.

j. The system must be configures sot that there is no possibility of greywater cross contaminating the potable water supply.

There are also the general requirements that the system must be installed by an approved installer, and that the set-up of the greywater reuse system, and maintenance instructions, must be attached to the land information memorandum.***Rainwater harvesting***

Watercare's economic analysis of rainwater harvesting at a water-supply scale shows it is an economically unviable option as a new water source. However, they do encourage rainwater harvesting at the individual-dwelling scale.

Rainwater harvesting may provide water for potable and non-potable purposes. The KCDC, through Plan Change 75, allows the use of rainwater for non-potable purposes to reduce the demand for treated water. However, where population increase leads to greater settlement in rural areas where there is no reticulated water supply, rainwater may be the only water source available for potable as well as non-potable purposes. Where access to an alternative source, such as groundwater, is possible, rainwater may be used for non-potable purposes. This section considers the risks to health that may arise from potable and non-potable use.

Rainwater may be of satisfactory quality before it reaches a collection surface, but from that point on its quality may be degraded microbiologically and chemically. People collecting rainwater as their potable water source should maintain their collection system to preserve the quality of the rainwater. However, urban dwellers collecting rainwater for non-potable use are unlikely to take these steps, and the consumption of rainwater under these circumstances will carry increased risk.

Apart from ingesting pathogens in rainwater used for potable purposes, exposure to pathogens through inhalation is also possible. In February 2006, an outbreak of Legionnarie's disease was identified in Beachlands, a small, isolated east Auckland suburb. The *Legionella* bacteria were isolated from the roof-collected rainwater systems of five households (three associated with cases, Simmons et al 2008).

Potential public health consequences of rainwater harvesting
<u>Adverse</u>

- Exposure to contaminants (microbiological and chemical) present in rainwater collected for non-potable use through its intentional or inadvertent consumption.
- Contracting vector-borne diseases resulting from insect vectors breeding in water tanks.
- Poorer personal hygiene during drought because of measures to save water (eg, reduced volumes of water used for hand washing).

Managing the risk associated with using rainwater for potable purposes is discussed in detail in the Ministry of Health's Public Health Risk Management Plan Guide S1.2, Roof Water Sources[16].

The safeguards required for rainwater being harvested for non-potable purposes to supplement a reticulated water supply are different from those ideally used for potable water harvesting. The KCDC's Plan Change 75 requirements include safeguards to reduce the risk to public health.

a. The harvested water can only be used for outside irrigation or toilet flushing.

b. Separate plumbing is required where toilets are supplied with harvested rainwater, and backflow prevention devices must also be fitted to prevent cross-contamination of drinking-water.

c. Pipes carrying non-potable water must be labelled and coloured to distinguish them from the potable system.

d. Permanent "no drinking" signage must be displayed over outdoor taps where they are connected to a rainwater tank.

e. Roof guttering and tank vents must have insect-proof screens.

To ensure that dwellings using rainwater have sufficient water for reasonable use, Plan Change 75 allows a restricted top-up of rainwater tanks with potable water.

Whether the water is required for potable or non-potable use, the potential contaminants are the same as are the reasons for their presence in the water.

5.2.4.3. Connection of supplies

Some territorial authorities noted they have linked water-short supplies to supplies with adequate water sources. This strategy is essentially an expansion of the distribution

[16] http://www.health.govt.nz/publication/public-health-risk-management-plan-guides-drinking-water-supplies (accessed 25 June 2013).

network and, consequently, the possibility exists for the public health effects noted in Section 5.2.2.1 to arise.

5.3. Declining population

5.3.1. Introduction

A declining population may create difficulties for water supply infrastructure that differ from those arising from an increasing population. Generally, a declining population, particularly if the size reduction is substantial, will lower water demand. A large fall in demand could lead to serious underutilisation of a supply.

Although underutilisation appears unlikely in New Zealand, this section discusses how water supplies could be affected by declining demand, for completeness. Awareness of these possibilities may assist in understanding the potential risks to public health that could arise in New Zealand's small rural communities (the most vulnerable to population declines), should unexpected reductions in water demand occur.

5.3.2. Factors affecting demand other than population decline

In addition to declining populations, two other factors may contribute to a falling demand for water.

a. Change in non-residential water demand

   Non-residential water demand includes the demand from industrial, commercial and agricultural activities drawing from a community supply. A change in the demand from one of these activities will only have a significant effect on the water supply if the activity uses a large percentage of the water produced by the supply.

   The change in demand that results from a decline in the population can be predicted and planned for in advance. However, a water supplier may get little warning of a fall in demand from one or more major non-residential customers curtailing their water consumption, or closing down their operations. Further, because the reasons for a change in non-residential demand may not be evident in advance, for example, the sudden collapse of an overseas market, taking them into account when preparing water demand projections is impossible.

   The closure of an activity could also indirectly affect water demand. Loss of employment in a community may result in a fall in population as people move away.

b. Water conservation measures

   The water demand management strategies required for dealing with increasing demand are unlikely to be needed by authorities facing major declines in demand. A possible exception is the situation in which there is a seasonal increase in demand that, without some water conservation, could lead to water shortages.

   Individuals in a community may also take steps to conserve water without the territorial authority's encouragement. Hummel and Lux (2007) note new technologies and greater environmental awareness are resulting in more efficient water use.

5.3.2.1. Water supply funding

A declining population, as well as affecting water demand, reduces the rating base from which a territorial authority's services are funded. This makes cuts in expenditure on the water supply more likely. Such cuts may adversely affect water supply infrastructure, maintenance and operation. Their effects on supplies could include:

a. a limited ability to respond to a proposed introduction of hazards into the catchment or recharge zone

b. delays in any treatment upgrades necessary for achieving compliance with the *Drinking-water Standards for New Zealand*

c. delays in replacing unreliable equipment

d. delays in purchasing equipment that will allow automated monitoring and process control

e. loss of experienced staff, or inability to hire adequately qualified staff

f. reduced levels of monitoring for possible contaminants.

Potential public health consequences of reduced water supply funding

<u>Adverse</u>

- Inadequate treatment barriers, either because of the processes or their operation being unsatisfactory, resulting in contaminants reaching the supplied community.
- Insufficient monitoring of treated and reticulated water quality, with the result that the need for corrective and remedial actions is not identified.

Compliance with the Health Act 1956 requires 'all practicable steps' to be taken to comply with the *Drinking-Water Standards for New Zealand*. As 'financial position' needs to be taken into account when assessing compliance with this requirement of the Act, risks to public health from a water supply that is struggling for funding may not be managed by regulation.

Increasing water charges to compensate for a shrinking rating base, may be counterproductive as it will encourage water conservation, thereby further reducing the water demand.

5.3.2.2. Water flow

Although water demand may fall, the reticulation network will remain unchanged (pipe diameters and lengths will be the same). Consequently, the flow through the system will decrease and the time between the treatment of the water and it reaching consumers will increase.

Potential public health consequences of reduced water flow
<u>Adverse</u>

- Particles settle out of the water and accumulate in the reticulation, providing an environment for microbial growth, with the growth of opportunistic pathogens being the primary concern.
- Increased time for the residual disinfectant to react with biofilms and water contaminants causing a loss, or reduction, in the disinfectant residual and the protection it affords consumers against the ingress of contaminants.

<u>Beneficial</u>

- Sedimentation of pathogens with the particles to which they are attached increases the opportunity for die-off.

5.3.2.3. *Supply closure*

At the extreme, the gradual reduction in the viability of a supply providing water for a decreasing number of people and households will end in supply closure.

Potential public health consequences of water supply closure
<u>Adverse</u>

- A community group taking over responsibility for the water supply, but the inherent uneconomic nature of the operation results in cost cutting which compromises water supply safety.
- Individual households take over responsibility for their own water supplies (eg, they sink their own bores or collect rainwater), but their operation of the supplies compromises the water quality and the risk to health is greater than when the supply was reticulated.

5.3.2.4. *Water treatment plant*

One of the immediate consequences of a lower demand for water is the reduced requirement for water from the treatment plant.

The difficulty in reducing the treatment plant output depends on the nature of the treatment plant. For example, the output from a plant treating groundwater with ultraviolet radiation can be modified readily to suit demand. The situation may be more difficult for full conventional treatment (even a small plant) that has been designed to provide an output well in excess of what is needed.

Potential public health consequences of reducing treatment plant output
<u>Adverse</u>

- Operating a water treatment plant below its design capacity can make maintenance of process efficacy difficult, particularly the effectiveness of the coagulation/flocculation and associated processes, resulting in poor contaminant removal and treated water quality being compromised.

The predicament faced by communities with declining populations is worsened if they also have to deal with substantial seasonal changes in water demand. Such changes can also create difficulties for small supplies with growing populations. To meet peak demand, a community's water supply may need to retain a capacity to provide water for a population greater than the residential (rate-paying) population. In the absence of subsidisation, the community may have difficulty meeting the costs of supply maintenance and operation.

5.4. Aging population and the effects of climate change

The elderly are a vulnerable sector of the population. One of the contributors to this vulnerability is their increased susceptibility to infection – a result of the decline in their immune function (Opal et al 2005). As a consequence of the increased infection susceptibility, the elderly are more likely to become ill than most of the rest of the population after ingesting microbiologically-contaminated drinking-water. The effects of climate change, primarily flooding and drought, occurring concurrently with population aging, will increase the likelihood of this vulnerable sector of the population being exposed, at times, to microbiologically-contaminated water.

Potential public health consequences of an aging population
Adverse

- Increased numbers of elderly people become ill in the event of a community water supply becoming microbiologically contaminated, through either poor treatment plant operation, or a major decline in source water quality arising from severe flooding or drought.
- Increased numbers of elderly people become ill through poor personal hygiene arising from a lack of water for sanitation purposes because drought has made it difficult for a water supplier to meet a community's water requirements.

hould the effects of climate change adversely affect drinking water quality, other vulnerable sectors of the population, such as the very young and the immunocompromised, will also be at greater risk of infection.

6. MITIGATING PUBLIC HEALTH CONSEQUENCES

Section 5 has set out the consequences for public health that **could** arise because of demographic changes and more generally because of changes in water demand. This section discusses the generic approaches that could be taken to mitigate the risks to public health identified in Section 5.

Mitigations fall into four broad categories determined by the nature of the strategy used to deal with water demand changes.

a. Risks that can be addressed through PHRMPs

   The majority of risks arise from changes to the operation of a water supply or modifications to the supply. Consider, for example, the risks associated with increased difficulty in maintaining an adequate disinfectant residual. This difficulty may arise through an increased size of the reticulation network (supply modification), or reduced flows in a network because of reduced demand (changed operation). PHRMPs are designed to manage these types of risk.

   The territorial authority and the drinking-water assessor need to be aware of the changes taking place in a supply as it adapts to demographic changes. Risks identified and preventive measures to guard against them can then be incorporated into the next revision of the water supply's PHRMP.

b. Risks that can be addressed through regulation

   Under some circumstances public health risks that follow demographic change, particularly increased water demand, may be more reliably addressed though regulation (perhaps in combination with PHRMPs). The public health risks that may result from the reuse of greywater water, or the collection of rainwater for non-potable use, are examples of this type of risk. (The mitigation steps that have been used by the KCDC in its district plan to address the risks associated with these two particular examples are discussed in Sections 5.2.4.1 and 5.2.4.2.)

   A common characteristic of these strategies is that our understanding of the risks they present is still developing. This may lead to an under-estimation of the risk by territorial authorities when using the strategy. As a result, the Ministry may consider that regulation is the most effective means of addressing the risks they entail.

c. Risks that can be addressed through subsidies

   Water conservation measures do provide an approach to the management of public health risks arising from water shortage. The provision of subsidies to support conservation measures, such as the use of water-efficient appliances and low-flow fixtures, offers a means to augment the roles of PHRMPs and regulation in minimising public health risks in both community and individual water supplies.

d. Risks that can be addressed through education and the provision of information

   In situations in which individuals become responsible for their own water supplies because of demographic change, control of risk through PHRMPs or regulation will be inappropriate or impracticable. Under these circumstances, education and the provision of information to guide householders in managing the risk themselves may be the best approach to mitigate public health risks.

7. CONCLUSIONS

The review of the information gathered for this report leads to several conclusions.

a. Most territorial authorities are expecting to have to cope with increased demands for water, either because of demographic changes alone, or because of these changes in response to increased industrial, commercial or agricultural consumption.

b. There is currently no indication that where declines in water demand may occur, the extent of the decline will be sufficient to lead to the levels of underutilisation reported in some other developed countries.

   This finding should be viewed with caution. It relies, in part, on optimistic expectations of growth in rural areas being realised. These expectations are contrary to the observations of local residents in some rural areas, reported by the popular media.

c. Demographic factors other than population size, such as aging populations and changes in ethnic mix do not appear to have been introduced into water demand projections. While water suppliers may have opinions about the increased use of water by older people, for example, there was no evidence of studies that scientifically support these opinions.

d. Some of the strategies being considered to meet increased water demand could have public health consequences, but many of these should be manageable through the implementation of satisfactory PHRMPs.

e. A high percentage of the water supplied to some communities is used by industrial, commercial or agricultural operations. While none of the authorities interviewed for this project consider that a sudden fall in demand in the event of the closure of one or more of these non-residential consumers is very likely, if it were to happen, there would be implications for financial viability of the supplies.

f. The risks to public health arising from demographic changes, the associated changes in water demand, and the strategies that might be employed to meet these challenges, can be addressed by four approaches.

   - Ensuring that PHRMPs identify the new risks resulting from demographic changes as they become apparent.
   - Putting regulations in place when the public health risks associated with demand management strategies are not clearly understood (eg, non-potable water recycling).
   - Provision of subsidies to support the use of water-efficient appliances and low-flow fixtures.
   - Educating and informing householders when they become responsible for their water supplies (eg, more people moving onto lifestyle blocks, or reticulated systems being closed down).

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APPENDIX 1 POPULATION TRENDS

Table A 1 Population trends for territorial authority areas from Statistics New Zealand projections and territorial authority long-term plans.

Territorial Authority Area	2011 Population Projection	Population Trend	
		Statistics NZ Projections	Long-term Plan
Far North district	58,500	Increase	Static
Whangarei district	80,600	Increase	Increase
Kaipara district	19,150	Increase	Static
Auckland	1,485,300	Increase	Increase
Thames-Coromandel district	27,000	Increase	Increase
Hauraki district	18,750	Increase	Increase
Waikato district	64,300	Increase	Increase
Matamata-Piako district	31,900	Increase	Increase
Hamilton city	145,700	Increase	Increase
Waipa district	46,000	Increase	Increase
Otorohanga district	9330	Decrease	Decrease
South Waikato district	22,900	Decrease	Static
Waitomo district	9630	Decrease	Decrease
Taupo district	34,100	Increase	Increase
Western Bay of Plenty district	45,800	Increase	Increase
Tauranga city	115,800	Increase	Increase
Rotorua district	68,900	Increase	Increase
Whakatane district	34,500	Decrease	Static
Kawerau district	6950	Decrease	Increase
Opotiki district	8960	Decrease	Increase
Gisborne district	46,600	Increase	Decrease
Wairoa district	8380	Decrease	Decrease
Hastings district	75,500	Increase	Static
Napier city	57,700	Increase	Increase
Central Hawke's Bay district	13,500	Static	Decrease
New Plymouth district	73,800	Increase	Increase
Stratford district	9180	Static	Static
South Taranaki district	26,900	Decrease	Static
Ruapehu district	13,400	Decrease	Decrease
Wanganui district	43,600	Decrease	Static
Rangitikei district	14,850	Decrease	Decrease
Manawatu district	27,600	Increase	Increase
Palmerston North city	84,600	Increase	Increase
Tararua district	17,700	Decrease	Increase
Horowhenua district	30,700	Decrease	Increase
Kapiti Coast district	49,800	Increase	Static
Porirua city	52,700	Increase	Increase

Territorial Authority Area	2011 Population Projection	Population Trend	
		Statistics NZ Projections	Long-term Plan
Upper Hutt city	41,500	Increase	Increase
Lower Hutt city	103,000	Increase	Decrease
Wellington city	200,200	Increase	Increase
Masterton district	23,500	Static	Increase
Carterton district	7640	Increase	Increase
South Wairarapa district	9420	Increase	Static
Tasman district	48,000	Increase	Increase
Nelson city	46,300	Increase	Increase
Marlborough district	45,700	Increase	Increase
Kaikoura district	3860	Increase	Increase
Buller district	10,100	Increase	Increase
Grey district	13,850	Increase	Increase
Westland district	8980	Increase	Static
Hurunui district	11,350	Increase	Increase
Waimakariri district	48,600	Increase	Increase
Christchurch city	367,900	Increase	Decrease
Selwyn district	41,100	Increase	Increase
Ashburton district	30,100	Increase	Increase
Timaru district	44,700	Increase	Increase
Mackenzie district	4040	Increase	Increase
Waimate district	7620	Increase	Increase
Chatham Islands territory	640	Decrease	Increase
Waitaki district	20,900	Increase	Decrease
Central Otago district	18,400	Increase	Increase
Queenstown-Lakes district	28,700	Increase	Increase
Dunedin city	125,900	Increase	Increase
Clutha district	17,550	Decrease	Increase
Southland district	29,600	Increase	Increase
Gore district	12,300	Decrease	Increase
Invercargill city	53,000	Increase	Increase

APPENDIX 2 INTERVIEW QUESTIONS

Table A 2 Primary questions for telephone interviews with water supply managers from territorial authorities expecting static or declining populations.

1. Do you expect the projected changes in your district's population to affect the demand for water in the district, and how?
2. In addition to changes in population size, are there are other demographic factors (eg, aging population, changes in ethnic mix, changes in occupancy), you expect to affect the demand for water in your district and/or your ability to supply water?
3. Apart from demographic factors, what else in your district could create a risk to your ability to supply water to your communities (eg, the closure of large industrial or agricultural operations to which you presently supply water)?
4. What challenges to your water supply(ies) do you see changes in these demographic and non-demographic factors causing in the next 10 or even 20 years?
5. What actions are you taking, or planning to take, to address these challenges?
6. Do you think changes in climate will add to the difficulties of meeting the challenges created by demographic changes?

APPENDIX 3 INTERVIEW SUMMARIES

This appendix summarises the interviews with managers having water system responsibilities from territorial authorities expecting static or declining populations.

Territorial Authority A

- The area overall is expected to have a stable population, although the population of the one of the larger communities in the district is expected to be static or decline slightly. The largest community in this territorial authority's area has a population of about 2900 people, all others have population of fewer than 500 people.

- Over the remainder of the district, no increase in water demand is expected.

- Contributions to the major centre in the district come from young families returning to the district and people retiring from rural areas.

- Any increase in demand that might arise from the effects of climate change can be met through water conservation measures (such as leak minimisation), consequently they see little need for upgrading the supply to meet water quantity needs. Treatment plant improvements are being made to achieve compliance with water quality standards.

- The most important measure for keeping up with demand is considered to be leak minimisation, although steps to increase reservoir capacity would also be considered, if water conservation was unable to meet demand.

- This district does not have any major wet industrial operations, the closure of which might lead to underutilisation of a community supply.

- Dairy farms are the major non-demographic factor creating a water demand. These are supplied from rural supplies which are not supported by any other rate payers; and farmers are charged on the volume of water used. As these supplies are mainly stock-water providers, if farmers were to walk off the land (because of the market) the supplies would close without affecting others.

- The water supply manager's belief was that the greatest problem for water supplies with respect to the effects of climate change is naivety among consumers. Some groundwater sources are already beginning to run dry during droughts.

Territorial Authority B

- This authority operates two large urban centres, two small urban settlements and 15 rural water schemes, the largest serving a few thousand people, and the smallest a few hundred people.

- Water demand is expected to be approximately static in all of them, and meeting it is not considered to be a problem. In addition to the human population, farming operations and freezing works contribute to the water demand.

- Young people are coming into the district (although the net change is still for an aging population). The change in the age distribution within the district is not considered to have had a marked increase on water demand.

- To reduce the risk to the authority of capital investment in rural water supplies that may close because of a collapse in the market, farmers wanting a new supply established are required to sign an agreement for a minimum number of connections to the supply, before any pipes are laid.

- The freezing works in the district is supplied by a community supply. The closure of the works is considered very unlikely, hence the possible impact this would have on the community's supply is not under consideration over the next decade. Moreover, if the works were to close, the treatment plant can run at lower flows.

- In relation to the effects of climate change:
    - uncertainty in projections makes any planning difficult
    - the authority has been monitoring storage levels through the recent drought to determine their ability to meet increased demand
    - the authority is working to increase storage
    - the authority has been able to cope with the recent drought.

Territorial Authority C

- This authority has one major urban water supply and several rural water supplies.

- Based on the Statistics New Zealand projections, a slow decline in the population within the district is anticipated, hence no significant increase in water demand is expected. There is a slight increase in demand for the rural supplies because of movement into lifestyle blocks.

- Five major wet industries are supplied from the authority's urban supply, consuming approximately 20 percent of the water produced. The authority considers it very unlikely that all of these industries would close and create underutilisation. However, should such an event occur, water charges would need to increase. There would be no physical difficulties in reducing output, as the abstraction from the groundwater source and chlorine dosing can be scaled to meet the drop in demand.

- In the long term, the development of a new bore field is planned, not to cope with an increased demand, but because the existing bores are over 50 years old and need to be replaced.

- The urban supply has a capacity to supply 38,000 m^3 per day. In summer, the average daily demand is 30–32,000 m^3, while the daily winter demand is 22–

23,000 m^3, with garden watering accounting for the bulk of this difference. Although the supply has plenty of capacity outside of summer, the summer demand is much closer to capacity. Leak detection work is underway to reduce water losses, and although water metering is being considered, it is unlikely to be implemented within the next 10 years.

Territorial Authority D

- The population in this district is expected to remain static, but the demand for water in all supplies is increasing because of an increasing number of dwellings that need to be supplied (and a corresponding decrease in occupancy). There is one urban water supply in this territorial authority's area. The 18 other supplies provide water to fewer than 1000 people.

- Although no measurements have been made, the water supply manager believes that the influence of demographic factors other than population growth on water demand depends on the area and the wealth of the residents. In his view, older people generally use more water than the young because of the effort they put into keeping their garden green and of the older people, the wealthier tend to use the most water.

- With regard to non-demographic factors influencing demand, a meat-processing operation consumes approximately 10 percent of their largest urban centre's water. In rural supplies, irrigation by dairy farmers accounts for most of the water used.

- Although there is the possibility of reduced demand because of decreased industrial or agricultural water consumption, this is not considered a concern for small supplies. The greatest concern would be the need to increase the charge for water to meet the cost of production, although demand could decline by 20 percent without a major price increase needing to be considered. The treatment plant was designed with spare capacity so that it can operate at 50 percent of capacity without operational difficulties.

- To meet the increasing demand, the authority is using a combined strategy of developing new sources and water conservation. Many of their systems are quite old, but leak detection and repair is uneconomic; it is more economic to allow the water to be lost. Detection and repair are expected to become more attractive options as demand increases and more expensive alternatives for meeting demand need to be considered. They are considering joining reticulation systems so that a supply with excess capacity can provide water to one struggling to meet demand. This approach appears to be economic in some instances, but in others providing additional storage is a better option.

- The district is a relatively dry area already and the effects of climate change are expected to worsen this, although they do not expect this to be a problem in the foreseeable future. Some sources are unsecure and the authority has been upgrading to new sources where this is possible.

Territorial authority E

- The district's population is approximately 7000 people, and the authority has responsibility for only one (urban) water supply. Statistics New Zealand projections indicate a likely decline in the district's population, although the authority is trying to minimise this trend.

- The authority is expecting little change in the number of people, or the number of dwellings needing to be supplied, so water demand is likely to remain static. Significant shifts of the population within the district, which may affect the demand on a single supply, are not expected.

- The authority has a plentiful supply of water, which is used without requiring restrictions (even during the recent drought). There is no residential water metering.

- There are seasonal differences in demand, with summer demand being approximately three-times higher than that in the winter. The water supply manager believes that older people use more water (for garden irrigation) than other sectors of the population, although there is no documented evidence to support this.

- Twenty wet industries contribute to the demand the authority's supply has to meet. In winter this constitutes approximately 25 percent of the water produced, and in summer this figure falls to approximately 10 percent. The impact on the supply of a few of these closing down would not be significant. If there were to be a 50 percent reduction in demand, this would be a problem.

- Water demand is unlikely to change. Ten years ago there was a major drive by industrial users to reduce their demand for water. As a result, consumption dropped by 25 percent and, except for minor fluctuations, it has remained at this level.

- Underutilisation of the supply is unlikely to be a problem. At present, the water is pumped out of the ground, treated with ultraviolet radiation and pumped up to a reservoir. To match a decrease in demand, it would simply be a matter of operating the pumps feeding the reservoir less frequently. There would be no need to downgrade the plant to reduce demand.

- A marked reduction in demand would affect income streams to fund asset replacement which is a fixed cost component. The actual operation costs, predominantly power, scale with the amount of water used.

- Additional demand arising from the effects of climate change is not expected to create great difficulties. A supplementary bore is available if necessary, and restrictions on the use of water for gardening could be put in place if further reductions in use were required.

APPENDIX 4 WATERCARE'S WATER DEMAND MANAGEMENT OPTIONS

Table A 3 Water demand management options recorded in Section 5.3 of Watercare's regional water demand management plan (Watercare 2011b).

Demand Management Option	Comment
1. Large water users	Identify potential areas to reduce water use and develop large user/industrial programmes
2. Communications and provision of information	Provide customers with information about water use, ways of saving water and customer-side leakage
3. Residential customer water efficiency initiatives	Better understand customer use, behaviour and attitudes to target programmes better and encourage water-wise behaviour
4. Promotion of water-efficient devices	Work with government, Auckland Council and retailers to promote water-efficient appliances in existing homes and businesses
5. Regulation of indoor water use	Change bylaws, regulations and/or building codes to require installation of water-efficient devices in new developments.
6. Commercial water use	Develop an audit toolkit and other key tools to enable existing commercial customers to reduce water use
7. Schools' water use	Continue working with schools to advocate water-wise messages and investigate/implement initiatives to save more water
8. Metering	Investigate future opportunities, improvements, technology advances and synergies with other utilities
9. Price	Understanding price impacts of water and wastewater charging, including tariffs and volumetric charging
10. Non-revenue losses	Improve understanding and management of system to reduce non-revenue losses where practicable and economic
11. Watercare and other council-controlled organisations' water-efficiency programmes	Identify areas of high water use during operation and develop capital or operational schemes to reduce this. Advocate water-wise messages internally

Demand Management Option	Comment
12. Auckland Council's water use	Work to develop water efficiency leadership by Auckland Council, including targets for water efficiency
13. –16. These relate to the beneficial use of non-potable water (stormwater or greywater), either for new buildings or retrofitting older buildings	
17. The beneficial use of treated wastewater for industrial and other uses	

APPENDIX 5 REPORT DISTRIBUTION

Copies have been made and distributed to:

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Further copies of this report may be obtained from:

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