JANUARY 2019

Watercare's Climate Change Strategy

Mitigation and adaptation

Contents

1.0 Introduction

Watercare is a lifeline utility, providing safe and reliable water and wastewater services to Auckland. We are New Zealand's largest water and wastewater services provider: each day, we supply around 365 million litres of water to Auckland and collect, treat and dispose of around 460 million litres of wastewater, including trade waste from industry. We draw water from 27 sources, and treat and supply it to homes and businesses via a vast network of pipes. We own and manage assets worth $10.1 billion and are continually upgrading and expanding our infrastructure to cater to the growing needs of our city.

Sustainability is intrinsic to everything we do. We have a strong relationship with the natural environment and our investment and accountability extends beyond Watercare's fixed assets to include our catchments and waterways. We are owned by Auckland Council and have a responsibility to contribute to Aucklanders' quality of life by providing safe, reliable and sustainable services, even in a changing climate.

Watercare
An Auckland Council Organisation

1.1 Climate change and its implications

Climate change is a global issue that requires significant and immediate action. The global climate has already changed at unprecedented levels and the main driver for this is a dramatic increase in greenhouse gas emissions from human activities. The term 'climate change' refers to the change of weather patterns over an extended period of time (decades to hundreds of years). Human activities are estimated to have caused an approximate increase of 1.0 degree Celsius above pre-industrial times, and this warming is likely to reach around 3 degrees Celsius by 2100 if it continues to increase at the current rate, even with existing international commitments (Intergovernmental Panel on Climate Change, IPCC – Summary for Policymakers, 2018). The global impacts of this changing climate will bring significant direct and indirect changes and challenges. These include the growing frequency of extreme weather events, more prolonged dry periods, rising sea levels and increased coastal flooding. The extremity of these impacts increases dramatically as global warming of 1.5 degrees or more is reached.

The international community has recognised climate change as one of the most pressing collective challenges the world currently faces. At the 21st Conference of Parties to the United Nations Framework Convention on Climate Change (COP21), New Zealand – along with 194 other countries – agreed to limit global warming to within 2.0 degrees Celsius above the long-term worldwide average. This has become known as the 'Paris Accord' or the 'Paris Agreement'. In relation to New Zealand's response, one of the most significant policy initiatives will be the development of the 'Zero Carbon Act' throughout 2019, which will cover New Zealand's approach to both climate change mitigation and adaptation. Businesses are coming to terms with the uncertainty of the future too, and the responsibility that we all have in reducing carbon emissions. In New Zealand, the latest climate projections predict higher temperatures, particularly in the North Island, more drought and flood events, changing rainfall patterns and rising sea levels.

Climate change undisputedly poses considerable challenges to the water and wastewater industry. It is one of the largest challenges that New Zealand and Watercare faces.

Watercare is working closely with Auckland Council and other Council-Controlled Organisations (CCO) to share learnings and align approaches to greenhouse gas reporting and action. The climate response will impact and include all Aucklanders, and Watercare has supported the development of the Auckland Climate Action Plan (ACAP).

The climate projections for Auckland, indicating how the climate will change, were commissioned for the first time in 2017. Though not exhaustive, it is likely that:

- *Spring rainfall will decline and autumn rainfall will increase.*
- *Extreme rainfall events will increase in severity with the magnitude of the 99th percentile daily rainfall (wettest one to two days) increasing by more than 25 per cent in some areas.*
- *Droughts will become more common and more severe, with the number of dry days (<1mm of rain) increasing, leading to fire risk and soil moisture deficit.*
- *Sea-level projections range from 0.2 to 1.2 metres of rise between 2040 and 2110. Many communities and infrastructure assets are near the coast and storm events combined with coastal inundation increase vulnerabilities.*

The dramatic changes in the climate have the potential to significantly impact water supply and wastewater services, disrupting service continuity and incurring substantial costs. There are key concerns for Watercare across both water and wastewater services, which include:

Water - Catchment land instability, water scarcity, diminishing raw water quality, on-site flooding, power/access road failures to plants, increasing pipe breakages, impacts on assets due to sea-level rise, dramatic changes in demand for water services with increasing peak demands, potential 'stranded assets' following land-use changes and sea-level rise.

Wastewater - Decreased effectiveness of oxidation ponds, increasing probability of wastewater bypasses, on-site flooding, impacts on critical third-party services, changes to assimilative capacities, increased instances of consent non-compliances, submerged outfalls, migratory bird impacts, greater corrosion/odour issues, a greater number of overflows, increased pumping costs, increased saltwater intrusion and flotation of assets.

Extreme climate occurrences

A number of these direct climate change impacts were highlighted during March 2017 when the Tasman Tempest storm event hit Auckland. The equivalent of two months' rain fell in 24 hours within the Hūnua Ranges, causing numerous land slips and depositing significant amounts of silt into our water storage lakes. The unprecedented levels of solids severely affected treatment processes at the Ardmore Water Treatment Plant (WTP), to the extent that we decided to cease producing water on two occasions – for around 12 hours each time. This action was taken to ensure that our customers continued to receive safe, 'Aa'-grade drinking water.

The learnings from this event are driving a number of initiatives to increase our resilience. These include the stabilisation of slopes in the Hūnua Ranges catchment areas by ending the current commercial forestry operations and reverting significant catchment areas back to native forest and enhancing the treatment barriers at the Ardmore WTP through the installation of ultraviolet light disinfection, increasing the solids processing capabilities. By adapting our operations in this way we are more resilient to these types of large storm events as they become more common in the future.

1.2 Climate change action at Watercare

We have been on the journey of climate understanding, integration, response, mitigation and adaptation for two decades now. Project Manukau, a very significant upgrade at the Māngere Wastewater Treatment Plant (WWTP) in 2003, improved processing capability and also reduced greenhouse gas emissions by 80 per cent. In 2009, a master's degree thesis on climate change impact at Watercare was completed, greenhouse gas emissions have been publicly reported for years and, more recently, specific events such as the Tasman Tempest and global conventions like the Paris Agreement have galvanised our response. We are engaging our people and have assessed the vulnerabilities of our assets and services in a changing climate. We have planted more than 120,000 native trees and shrubs in the Hūnua Ranges as the first stage of a major re-vegetation project to grow around eight million trees over the next 30 years.

This is not a challenge we can face on our own and we have therefore joined the Climate Leaders Coalition, a proactive group of corporate organisations committed to climate action, robust reporting and engagement with suppliers.

Watercare is committed to being fully sustainable, to deliver on a mission of being better tomorrow than we are today and to ensure minimum cost delivery of water and wastewater services to Aucklanders. As a lifeline utility, we have a responsibility to ensure secure supply of water and wastewater services 24/7.

1.2.1 Establishing a climate change strategy and policy

This strategy sets out the future direction for Watercare as we embark on our journey to operate a low carbon organisation that is resilient to climate impacts. The strategy covers specific actions that we will take immediately and establishes a pathway of monitoring and understanding between now and 2025 so that we can adapt to the changing climate based on evolving data and projections. The strategy also enacts Watercare's Climate Change Policy which communicates to staff and suppliers what is expected of them to contribute to our climate objectives each year.

Our intention is to operationalise the considerations of climate change from 2019 onwards so that it becomes 'business as usual' across the organisation. The climate change strategy fits under Watercare's Fully Sustainable Strategic Focus area as part of our enterprise business plan. It provides input and support to other work areas such as the energy programme and the Water Efficiency Strategy.

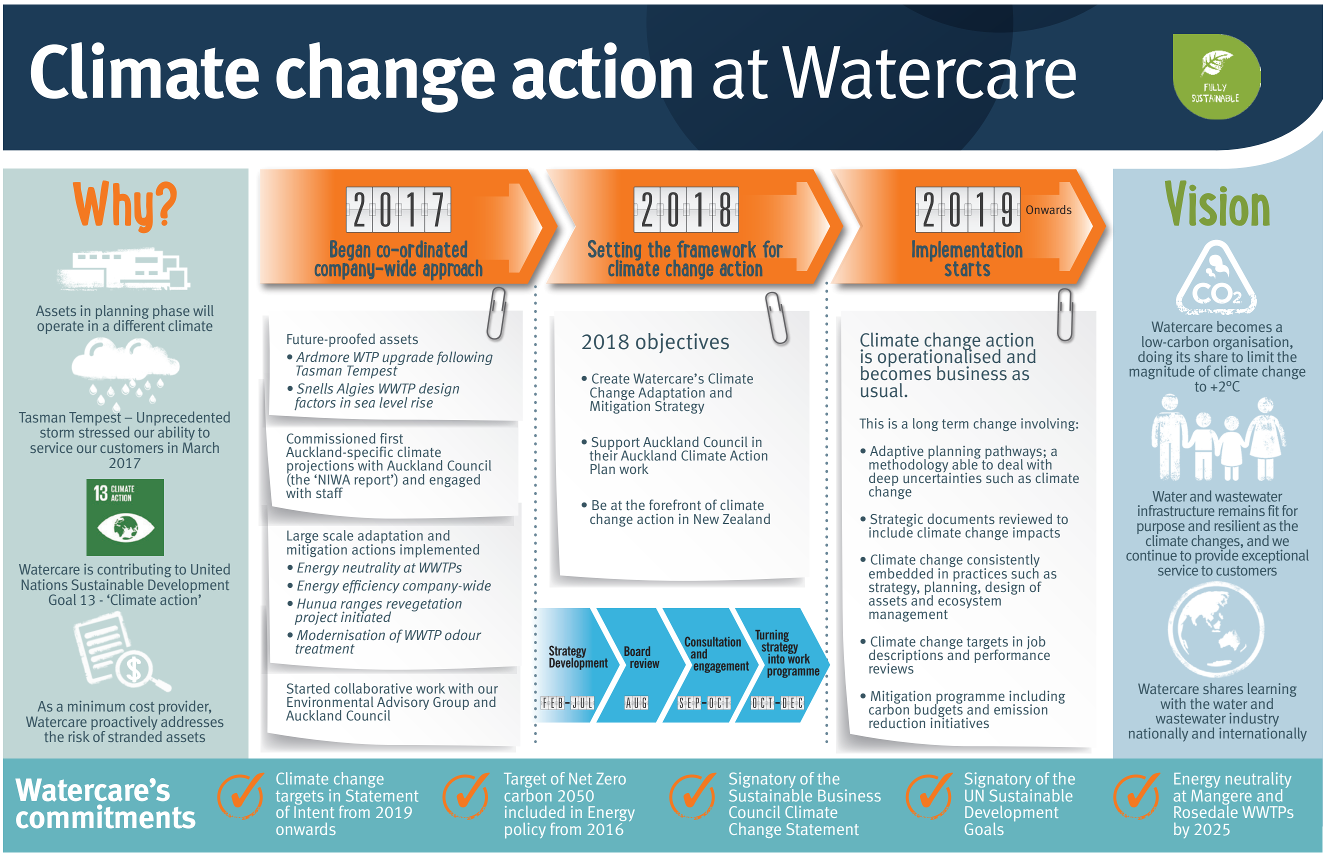


Figure 1: Climate change action at Watercare 2017-2019

2.0 Strategic principles

The following principles guide the development of our climate change strategy and its implementation:

- **Factor climate change into decision-making and operationalise it** – Make the consideration of medium- and long-term climate change in relevant investment and planning decisions business as usual.
- **Mitigation/adaptation balance** – Consider climate change mitigation as we develop adaptation solutions, to reduce our greenhouse gas emissions on an ongoing basis.
- **Start to act, even with uncertainty** – Take action now on measures that can be implemented without being certain about all dimensions of future climate change.
- **Implement adaptive planning pathways** – An adaptive plan specifies actions to be taken immediately and those required for keeping our options open to adapt in the future if needed. Tipping points and triggers are determined. This methodology is suitable to planning for deep uncertainties.
- **Identify areas of control and acknowledge dependencies with external factors**, for example with third-party providers, and find mechanisms for addressing these dependencies.
- **Build regular reviews as a core part of the strategy** – As more certainty is gained over the years in regard to the future climate and effectiveness of actions to adapt and mitigate, the strategy will need to evolve so that opportunities can be seized as they arise.
- **Deliver an agile programme of work** – An agile method of project management, to drive innovation, is suited for climate change, requiring early value generation and flexibility in an evolving context.
- **Consider all those who are impacted by climate change** – Recognise the importance of all parties, including the natural environment, Tangata Whenua and all communities in our decision making.

3.0 Where we will focus

In early 2018 climate change vulnerabilities were raised during a series of workshops and these were assessed against key criteria by Watercare teams and our Environmental Advisory Group. The actions identified in these workshops have been evaluated for their level of impact and organised into portfolios that address our response to climate change adaptation and mitigation. The collection of portfolios forms the backbone of this strategy, with immediate actions prioritised in 2019 and the delivery of all actions by 2025.

3.1 Climate change adaptation: To adapt our organisation to be resilient in a changing climate

We aim to adapt to climate change, to ensure that our assets remain fit for purpose in a changing climate, so that we can continue to provide exceptional services to customers while minimising exposure to unprecedented costs.

The adaptation portfolios of work are focused on monitoring and modelling, as well as on understanding the impacts and implications of a changing climate so that we can make informed long-term decisions. The nine adaptation portfolios are:

1. Update climate change modelling and information
2. Understand the impact of changing demand patterns
3. Understand water source resilience to a changing climate
4. Understand treatment plant resilience to a changing climate
5. Understand network resilience to a changing climate
6. Understand the effects on and our responsibilities to the environment
7. Integrate climate changes in our emergency preparedness
8. Collaborate on the impacts of climate changes to development and land use
9. Partner with utilities for long-term planning.

Within each portfolio we have identified a range of actions that will be taken to achieve positive impact in each area. These portfolios will be delivered by cross-functional teams. The details of each are provided in Appendix F.

Long-term climate adaptation

From the year 2025, and out to the 22nd century, a series of 'long-term pathways' has been proposed. These pathways provide various adaptation-related options mapped out to an 'adaptive pathways approach'. The deep uncertainties associated with climate change make the adaptive pathways approach highly applicable.

If, for example, the rate of sea-level rise is faster than anticipated, any associated management/design actions within the long-term pathways can be initiated earlier than originally planned, and be continuously reviewed at various 'trigger' times. This approach provides flexibility and eliminates any surprises that can occur if planning processes and outcomes are locked in using more traditional planning methods.

For areas that are projected to be adversely impacted by sea level rise/coastal inundation and flooding, Watercare will work with Auckland Council. Discussions will cover the options available to ensure the continuation of services (via the protection of assets) and those which would lead to the discontinuation of services (through the abandonment of assets), together with planning for the growth of Auckland. This will enable Auckland Council and Watercare to make timely, long-term and effective land-use planning decisions.

The planning responses to areas that are susceptible to the impacts of climate change are typically as follows:

- Retreat – *This involves no effort to protect land. In extreme cases, entire areas may be abandoned or not developed.*
- Accommodation – *This implies that people continue to use the land at their own risk, but do not prevent the land from being inundated or eroded. This option involves elevating buildings and implementing emergency evacuation procedures.*
- Protection – *This involves erecting hard structures, as well as soft solutions, such as dunes and vegetation.*

Watercare is aware that discussion of these options with affected communities will be complex, and often contentious, and that a multi-agency approach will need to be taken.

3.2 Climate change mitigation: To operate a low-carbon organisation, aiming for Net Zero emissions by 2050

By being a low-carbon-generating organisation, we aim to do our share to help keep global warming well within 2.0 degrees Celsius. We will reduce our operating costs and aim to avoid catastrophic changes to our environment and lifestyles.

Watercare's carbon footprint in 2017/18 was 37,250 tonnes CO_2e and is made up of energy, wastewater emissions, vehicle fuel and purchased goods such as lime. This is the equivalent to driving nearly 4,500 times around the world in a medium-sized car or the electricity needed to power over 42,500 Kiwi homes.

These emissions vary from year to year, but have generally been decreasing over the past five years, even as Auckland's population has increased. For more details on our carbon footprint, see Appendix D.

The five mitigation portfolios focus on key opportunities within our organisation.

10. Planting and carbon removals
11. Energy efficiency of our operations and generation of renewable energy
12. Energy neutrality at our two largest wastewater treatment plants
13. Reduction in process and treatment emissions
14. Low carbon infrastructure delivery.

There are a number of flagship actions that already support these portfolios:

- Partnership with the Energy Efficiency and Conservation Authority (EECA) has led to improved energy optimisation. Upgrades to our primary sedimentation tank sprayer at the Māngere WWTP resulted in 3.5GWh of electricity savings.
- The nitrate shunt process has been initiated at the Māngere WWTP and has significantly reduced the aeration requirements in the reactor clarifiers, leading to 2.75GWh of electricity savings.
- The installation of thermal hydrolysis at the Rosedale WWTP is on track. When completed, this will be a first of a kind in New Zealand and will substantially increase the amount of biogas produced, which will lead to the generation of electricity required to run the plant.
- In 2019 we will commission three solar pilot plants which are expected to generate around 450,000kWh of electricity.
- So far, we have grown over 120,000 native plants as part of the Hūnua Ranges re-vegetation project, which will extend to around eight million over the next 30 years.

Watercare's emission reduction pathways and targets are being established through the analysis of past, present and future greenhouse gas emissions in the context of the Science Based Targets initiative. This worldwide protocol ensures carbon reduction by businesses matches the latest climate science.

Operational carbon targets have been set, as below, and align with keeping the global temperature increase within 1.5 degrees Celsius:

- Net Zero emissions by 2050
- Reduce operational greenhouse gas emissions by 45 per cent by the year 2030.

Infrastructure carbon

Watercare has a large infrastructure influence as a result of our robust programme of renewals and new capital projects. We have established an ambitious target to drive innovation and new thinking in infrastructure delivery that addresses our carbon impacts. To ensure we are a positive influence in this area, we are reviewing and rethinking design standards, facility plans, servicing strategies and business cases to include a lens that consistently considers climate change in future. Watercare has a target to:

- Reduce infrastructure emissions by 40 per cent by the year 2025

The first step in this work will be establishing a baseline and integrating the capital and operating cost of carbon into our business cases.

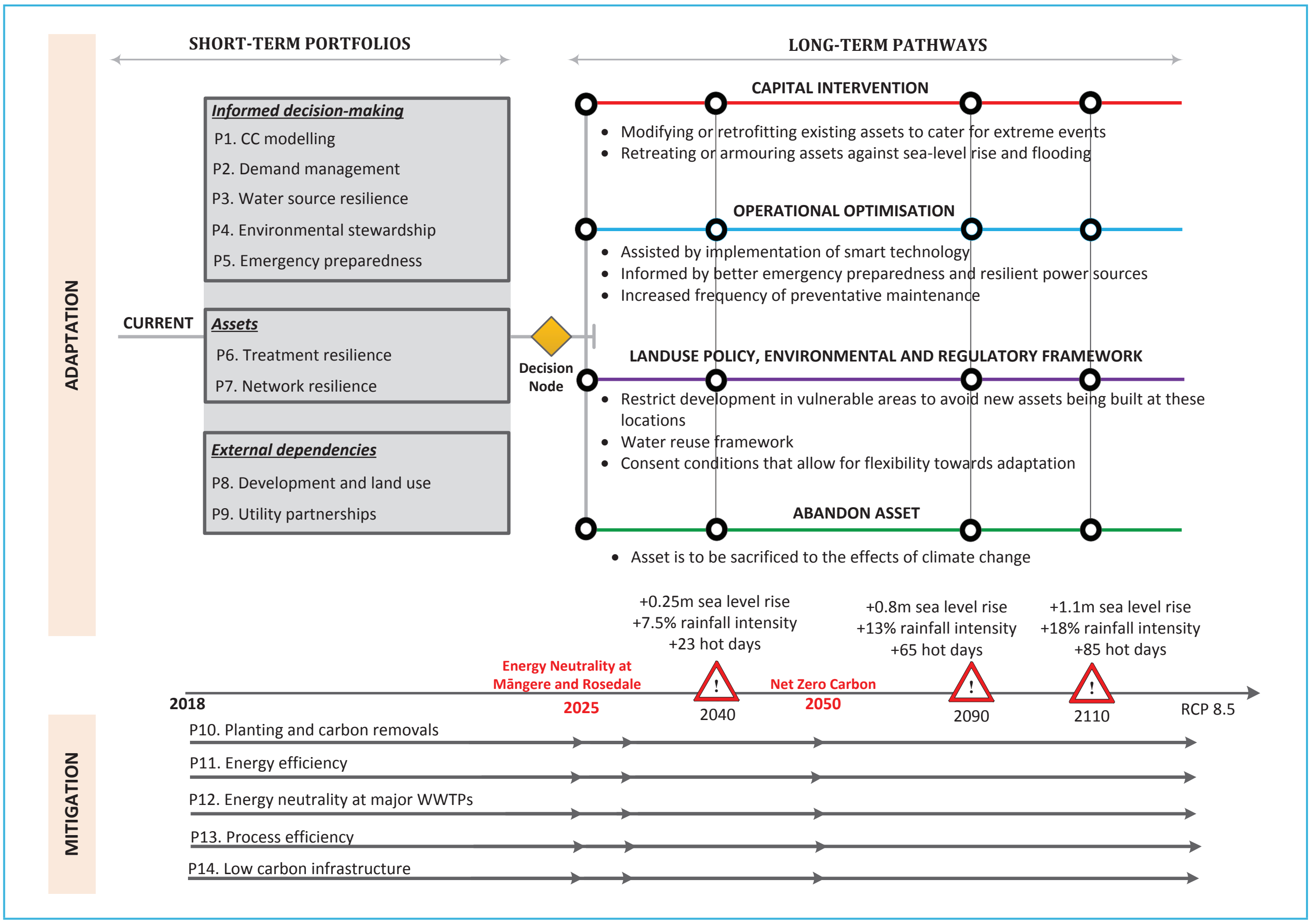


Figure 2: Short-term portfolios, long-term adaptation pathways and ongoing mitigation

4.0 Our work plan – how we are going to do this

To achieve these goals and actions, we will need to work together. The portfolios all require cross-functional working internally and this challenge requires external collaboration across many sectors and stakeholders. We know we don't have all the answers and we will work proactively with our suppliers, customers and stakeholders to achieve our climate goals.

A work programme established in 2019 comprises the following three stages:

- Stage 1: Establish framework and identify teams
- Stage 2: Initiate priority activities that are required as building blocks
- Stage 3: Integration of climate change considerations, tools and processes to adopt a 'business as usual' (BAU) approach.

Mitigation

We will examine our greenhouse gas footprint, building capability within the organisation to understand our emission sources and incentivise emissions reductions through performance indicators and innovation.

To achieve our 45 per cent reduction in operational emissions by 2030 and Net Zero 2050 target, we will develop roadmaps for each major emission source. Employees across our organisation will workshop the current activities that support our emissions reductions, understand the gap to meet our target and establish work plans to deliver the next steps.

Innovative approach to reducing emissions

Over the next five years, we will invest in and run an Energy Efficiency Revolving Fund (EERF) to implement and support non-BAU energy and carbon-reduction opportunities and innovations throughout our organisation.

We will report on our emissions annually to demonstrate our progress against our targets, which will be established as part of our commitment to Science Based Targets.

Details of the mitigation strategy and key focus areas can be found in Appendix E.

Adaptation

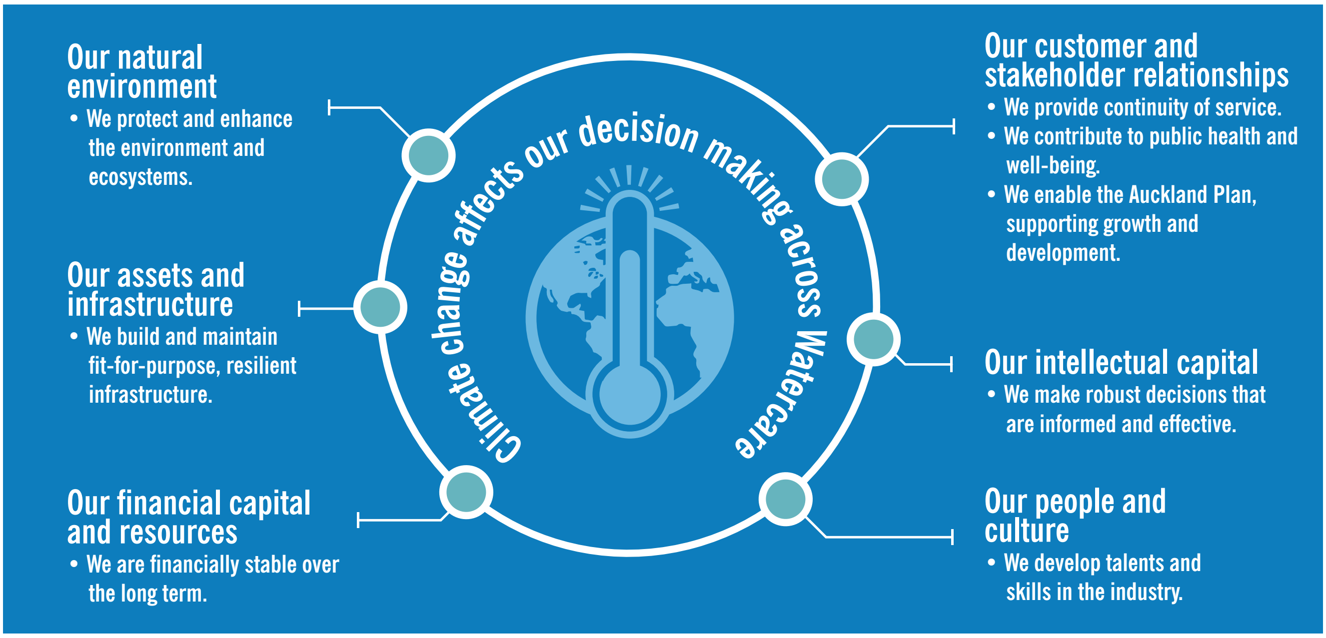
A major challenge that Watercare faces is the longevity of our assets and long-term impacts of decisions that we make today. For example, a large transmission pipeline we plan in 2019 is expected to still be operational in 2119.

These long-term decisions require additional information, updated climate models and proactive planning to accommodate potential climate change scenarios. Watercare teams will be required to understand climate risks in more detail and to integrate the impacts on the strategic direction of our servicing strategies as well as how we plan and design new infrastructure.

Details of the adaptation and mitigation portfolios are included in Appendix F and will be managed through an evolving climate change work programme.

5.0 Our integrated approach and review

Climate action fits within the framework of integrated thinking at Watercare – connecting performance with purpose and creating value in the long term by identifying, executing and monitoring our business decisions and strategies.



It is acknowledged that there is a large amount of uncertainty in the development of planning pathways, incomplete data sets on which to base decisions and a significantly changing regulatory landscape. To ensure that Watercare's response to climate change is flexible, effective and responsive to the unpredictable environment, regular reviews will take place. These reviews will include considerations of:

- The natural capitals considered in integrated reporting
- Central government's legislation and strategy updates
- Local government's plans and strategies
- Changing Watercare priorities and strategies.

A six-monthly scan of changing factors, such as regulation, will provide direction and insight.

Staying updated

In late 2018 the Intergovernmental Panel on Climate Change (IPCC) released a special report on the impacts of global warming of 1.5 degrees Celsius above pre-industrial levels. The guidance has been used to guide target setting and mitigation considerations. This updated information creates a new level of urgency in the response to climate change and impacts the targets and strategies in our mitigation portfolios. The severity of the report was summarised as:

Pathways limiting global warming to 1.5°C with no or limited overshoot would require rapid and far-reaching transitions in energy, land, urban and infrastructure, and industrial systems. These systems transitions are unprecedented in terms of scale, but not necessarily in terms of speed, and imply deep emissions reductions in all sectors, a wide portfolio of mitigation options and a significant upscaling of investments in those options.

An annual holistic review of the strategy's performance, organisational integration and policy efficacy in a changing climate will be made and updates and amendments made as required.

Appendix A – Watercare climate change policy

Climate Change Policy

The Challenge of Climate Change

A changing climate brings challenges to water and wastewater service providers including increasing dry periods, increasing number of 'hot' days, increasing magnitude and frequency of rainfall events and rising sea levels.

Governments, industry and civil society are transitioning to a low greenhouse gas future, requiring rapid, far reaching and unprecedented changes to all aspects of society.

Therefore, Watercare is committed to play our part in the mitigation of greenhouse gas emissions and to take proactive action on the adaptation to the impacts of climate change.

Our Objectives

- To become a low carbon organisation - aiming for net zero emissions by 2050.
- To become climate resilient - reducing our vulnerabilities to the impacts of a changing climate. This will mean continuously adapting Watercare's activities to the effects of long-term climate change and be prepared for the shocks from specific weather events.

Our Actions

To deliver on our commitment, we will:

- Achieve energy neutrality at the Māngere and Rosedale wastewater treatment plants by the end of 2025.
- Plant 1,900 hectares of native trees in the Hūnua Ranges in the next 30 years that are suited to a changing climate and will optimise carbon sequestration.
- Introduce carbon budgets and targets as a performance measure for our infrastructure projects and procurement
- Update our business processes such as design standards, facility plans, servicing strategies and business cases to consistently include climate change and carbon reduction
- Understand the impacts when deciding whether to build/not build infrastructure in areas prone to sea level rise
- Improve the resilience of our current sources, treatment and conveyance assets so that they are fit for purpose for a changing climate
- Address climate change impacts not only on our physical assets but also on community, cultural and natural ecosystems
- Be aware of our critical dependences on third party suppliers and will work to clearly identify, understand, and manage their potential impacts on our services.
- Actively consider alternative sources of water supply and work to drive down per capita water demand.

Our short term targets - 2019

- We will initiate a company-wide climate change mitigation and adaptation strategy including a work programme built on adaptive planning and integrated thinking principles
- We will develop emission reduction pathways for our operations through the Science Based Targets initiative, aiming for 45% reduction by 2030.
- We will develop an infrastructure carbon reduction pathway, aiming for 40% reduction in infrastructure emissions between 2020 and 2025

Raveen Jaduram
Chief Executive

Relevant UN SDGs

Appendix B – The future climate - climate change projections for Auckland

B.1 Introduction

Auckland's climate is changing. In mid-2017, Auckland Council and various Council Controlled Organisations commissioned the National Institute of Water and Atmospheric Research (NIWA) to model projected climate changes for Auckland and assess the potential impacts of climate change on Auckland's environments and various sectors. This strategy is based on these projections, which go out to the year 2120.

As an overview, the seasonal distribution of rainfall is projected to change markedly in Auckland. It is likely that spring rainfall will decline and autumn rainfall will increase, but annual total rainfall may not change significantly. Extreme rainfall events, both in number and intensity are is likely to increase in Auckland because a warmer atmosphere can hold more moisture. In addition, droughts are projected to become more common and more severe in Auckland due to changing rainfall patterns and temperature increases. Winds are projected to decrease. There is some uncertainty about the effects of climate change on the number and characteristics of tropical and ex-tropical cyclones which may affect Auckland. Global sea level is also projected to rise, and this will be a significant issue for Auckland as much of the communities and infrastructure are near the coast.

The climate change projections, cover the coming century – and into early 22nd century. More specifically, the projections are divided into three time periods:

- Year 2040 (the period between years 2031 – 2050)
- Year 2090 (the period between years 2051 – 2100)
- Year 2110 (the period between years 2101 – 2120)

These time periods can be discussed as the medium term, long term, and the very long-term respectively. Of major interest, will be the projections out to year 2110, since planned 'long lived' infrastructure has a life in excess of 100 years, therefore, projections to the year 2110 will cover the approaching 'end of life' for those assets.

Assessing possible changes for future climate change due to anthropogenic activity is difficult because climate projections depend strongly on estimates for future greenhouse gas (GHG) concentrations. These concentrations can be influenced by global economic activity, population changes, technology advances, and various countries' policy settings. In addition, different climate model simulations can produce somewhat different results for future climate change projections.

This range of uncertainty has been dealt with by the Intergovernmental Panel on Climate Change (IPCC) through the consideration of a range of global greenhouse gas 'emissions scenarios' that are associated with possible economic and social/political developments during the 21st century. The NIWA report, and this strategy, uses two emission scenarios (technically known as Representative Concentration Pathways (RCPs)), namely:

- RCP4.5 – This emulates the global greenhouse gas emission scenario known as the 'stabilisation' scenario – meaning that emissions world-wide would be fully stabilised by the year 2100, and would never increase beyond this level. This emission scenario, in effect, closely mimics the outcomes of the 'Paris Agreement 2015', whose objective is to achieve net-carbon neutrality by the second half of this century.
- RCP8.5 – This emission scenario emulates 'business as usual (BAU)', meaning global GHG emissions continue to climb, unabated, at their current projected rate. This would lead to 'high' global greenhouse gas concentration levels.

B.2 Descriptions of the Significant Climate Change Projections for Auckland

B.2.1 Temperature

Key messages

- Auckland is projected to warm considerably into the future. Projections for the RCP4.5 emission scenario indicate a mean annual temperature increase of 1.6 °C by the year 2110, and for the RCP8.5 emission scenario, a mean annual temperature increase of 3.4 °C.
- Most of Auckland is projected to experience over 40-50 additional hot days per year (defined as days › 25 °C) by 2110 under the RCP4.5 (20 at present), and 70 more hot days per year under RCP8.5.
- The number of cold nights/frosts (‹0 °C) declines everywhere in Auckland.

B.2.1.1 Temperature extremes

Temperature extremes are presented as 'hot days', where the daily maximum temperature exceeds 25°C and 'cold nights', where the daily minimum temperature is less than 0°C. Most of the Auckland Isthmus currently experiences 15 to 24 hot days per year.

- RCP4.5 Stabilisation scenario – The projected increase in hot days for year 2040 is for an extra 10 days (over the Waitakere and Hūnua Ranges) and an extra 20 days for all other parts of Auckland. This increases in the year 2110 to an extra 20 days (over the Waitakere and Hūnua Ranges) and an extra 50 days for the all other parts of Auckland.
- RCP8.5 Business as usual scenario – This is the more significant change – for the year 2040, the projected increase in hot days is an extra 15 days (over the Waitakere and Hūnua Ranges) and an extra 30 days for the rest of the area. For the year 2110, an extra 70 to 100+ hot days are projected.

B.2.2 Rainfall

Key messages

- Overall, total rainfall for Auckland is projected to increase only marginally by between 5 and 10% over the next one hundred years for both emission scenarios. However, rainfall seasonality is expected to increase – spring rainfall is projected to decline, while autumn rainfall is projected to increase.
- Extreme, rare rainfall events are likely to increase in intensity in Auckland because a warmer atmosphere can hold more water.
- The magnitude (size) of 99th percentile of daily rainfall (the 1-2 wettest rain days of the year) is projected to increase across most of Auckland, by more than 25% for the southeast locations by the year 2110.
- The number of dry days (‹ 1 mm of rain) per year is projected to increase.
- Auckland is projected to become increasingly drought-prone. The number of days of soil moisture deficit (SMD) is projected to increase with time. Currently the number of SMD averages around 40 for southern areas, and over 70 days of SMD in the northeast and the Isthmus. By year 2110, for RCP8.5 emission scenario, most of the area is projected to see an increase of 16-24 days of SMD per, with more than 28 extra SMD days projected for northern parts of Auckland.

B.2.2.1 99th Percentile of Daily Rainfall (1-2 wettest rain days of the year)

At present, the Auckland Airport receives around 130 days of rain per year (1981 – 2010 average). Therefore, the 99th percentile equates to approximately the 1 to 2 wettest rains days per year on average. The average annual 99th percentile of daily rain from 1981-2010 at the Auckland Airport was 48.2mm.

- RCP4.5 Stabilisation scenario – There is no increase in the 99th percentile of daily rainfall projected for year 2040 over the majority of Auckland, while an increase in magnitude of 10% is projected over the Waitakere and Hūnua Ranges. For the year 2110, the increase in the 99th percentile daily rainfall is projected to be 5% over the majority of the area, with an increase of 15% over the Waitakere and Hūnua Ranges.
- RCP8.5 Business as usual scenario – For the year 2040, the projected increase in magnitude of the 99th percentile daily rainfall is an extra 5%, for the majority of Auckland, while an increase in magnitude of 10% is projected over the Waitakere and Hūnua Ranges. For the year 2110, a more significant increase in the projected magnitude of the 99th percentile is projected to be 10% for the majority of Auckland, with an increase of 25%+ over the Waitakere and Hūnua Ranges.

B.2.2.2 Soil Moisture Deficit Days

The present number of soil moisture deficit (SMD) days are highest in the northeast of the region, and the Auckland Isthmus, with over 70 days of SMD per year on average. The southern parts of Auckland experiences the lowest number of days that experience SMD, with less than 40 days per year. The largest number of days of SMD occurs in summer when most of Auckland experiences 40-50 days of SMD. In winter, the whole area experiences no days of SMD on average.

- RCP4.5 Stabilisation scenario – There is no increase in the number of days of SMD projected for year 2040 over the Waitakere and Hūnua Ranges, but an increase of 8 days over the majority of Auckland. For the year 2110, the increase in the number of days of SMD is projected to be 8 days over Waitakere and Hūnua Ranges with an increase of 20 days over the majority of the area.
- RCP8.5 Business as usual scenario – For the year 2040, the projected increase in the number of days of SMD over the Waitakere and Hūnua Ranges is 4 days and a 12 day increase for the majority of Auckland. For the year 2110, the projected increase is 16 days for the Waitakere and Hūnua Ranges, and an increase of 32+ days for the majority of Auckland.

Similar projected changes relate to the number of 'dry days' (defined as days with ‹ 1 mm of rainfall). Currently, the average number of dry days at the Auckland Airport is 237 days per year. An increase in the number of annual dry days is projected for most of Auckland in the future. Spring is generally the season where the largest increase in dry days is projected. By the year 2110 under the RCP4.5 scenario, most of Auckland is projected to experience six to nine more dry days per year. By 2110 under the RCP8.5 scenario, most of Auckland is projected to experience 12-21 more dry days per year.

B.2.3 Climate Change and Sea-Level Rise

Key messages

- Future sea-level rise (SLR) is a significant issue for Auckland as much of the region's communities and infrastructure are near the coast.
- Actual measured sea-level rise to date at the Port of Auckland has risen by 1.60 ± 0.08 mm per year since the early 20th century, with an acceleration of SLR in recent years. This is an approximate total rise of 19 cm since the year 1899, which has been mostly attributable to the thermal expansion of the ocean.
- By 2100, global SLR will likely be in the range of 0.28-0.98 m (IPCC). Collapse of marine based components of Antarctic Ice sheets could cause global SLR to rise substantially higher.
- 0.5 m of SLR is projected for New Zealand between years 2080 and 2110, and 1.0 m of SLR is projected for New Zealand between 2100 and after 2200, depending on the climate change scenario. A RCP8.5 scenario in the Ministry for the Environments publication Coastal Hazards and Climate Change: Guidance for Local Government, 2017, is for a 1.9 m rise by year 2150.
- Low-lying coastal areas in Auckland are the most vulnerable to inundation from SLR, including parts of the Central Business District, eastern bays (e.g. Mission Bay), Onehunga, Māngere Bridge, Devonport, and Helensville.
- The east coast of Auckland is more sensitive to sea level rise related erosion and storm surge inundation than the open west coast, due to different exposure, geology, landforms, tidal range, and variation in wave height.

B.2.3.1 Impacts of sea-level rise (SLR)

Rising sea level in past decades is already affecting human activities and infrastructure in coastal areas, with a higher base mean sea level contributing to increased vulnerability to storms and tsunami events.

Key impacts of rising sea level are:

- Gradual inundation of low-lying marsh and the adjoining dry land on spring-high tides;
- Escalation in the frequency of nuisance and damaging coastal flooding events (which has been evident in several low-lying coastal margins of Auckland, such as Tamaki Drive);
- Exacerbated erosion of sand/gravel shoreline and unconsolidated cliffs (unless sediment supply increases);
- Increased incursion of saltwater in lowland rivers and nearby groundwater aquifers, rising water tables in tidally-influenced systems.

B.2.3.2 Projections for sea-level rise

By the year 2100, global-average SLR will likely (i.e. 66% chance) be in the range of 0.36-0.71 m for the RCP4.5 scenario, and the range of 0.52-0.98 m for the RCP8.5 scenario. A one metre sea-level rise is referred to at the policy level and mapped with a 1-100 year return coastal inundation level, in the Auckland Unitary Plan. It should also be understood that it is virtually certain that global SLR will continue for many centuries beyond 2100, with the amount of rise being dependant on future emissions.

B.2.4 Coastal sensitivity in Auckland

In 2012, NIWA completed a study on the sensitivity of New Zealand's coasts to the effects of coastal climate change. For this work, Coastal Sensitivity Indices (CSI) were developed for New Zealand's soft shore coastline.

The east coast of the Auckland is more sensitive to climate change-related erosion than the west coast, with the most sensitive areas being between Whangaparaoa Peninsula and North Head on the North Shore, and around the Maraetai-Kawakawa Bay coast in the southeast of the region. The least sensitive areas to climate-change related coastal erosion are from the Kaipara South Head to the Manukau Heads on the west coast of Auckland.

In relation to future coastal inundation, the east coast shows a similar pattern in that it is more sensitive than the west coast. The most sensitive areas of Auckland are Omaha Beach and Wenderholm in the northeast of the region, and in the areas near Clevedon in the southeast of the region. The least sensitive area to future coastal inundation is from Kaipara South Head to the Manukau Heads on the west coast.

B.3 Other Significant Impacts of Climate Change on Auckland

B.3.1 Wildfire and climate change

New Zealand's native species evolved under conditions of highly infrequent natural fire, and are generally poorly adapted to survive fire and recover in its wake. Some large native tree species, which are found in the Auckland Region, are sensitive to fire (e.g. kauri, tawa, taraire, kahikatea, rimu, totara, matai), however other species are fire-adapted (e.g. kanuka, manuka, cabbage trees, bracken).

Key messages

- Fire risk is projected to increase in Auckland in the future due to increasing temperatures, lower rainfall, and more droughts.
- A 10-30% increase in Seasonal Severity Rating is projected for Auckland in the mid and late 21st century, compared to the historical period.
- An increase in the number of Very High and Extreme forest fire danger days is projected, with a 50-100% increase projected north of the Auckland Isthmus and a 40-50% increase projected south of the isthmus by the end of the 21st century. Some individual models project an even higher increase in Very High and Extreme forest fire danger days.

B.3.2 Indigenous biodiversity impacts from climate change

Key messages:

- Auckland's vulnerable forest and wetland ecosystems may be under pressure due to changes in rainfall patterns and an increasing frequency and intensity of drought.
- Increased intensity of extreme rainfall events is likely to encourage more slips and soil erosion, leading to sedimentation in waterways and receiving environments as well as habitat loss.
- Indigenous biodiversity is at risk from an increase in pest species due to climate change.

Most New Zealand plants and animals are adapted to cooler average conditions than those prevailing at present, due to much of the past 2.5 million years being mostly colder than now. Therefore, climate change is projected to be a powerful stressor on terrestrial and freshwater ecosystems in the second half of the 21st century, especially under high-warming scenarios.

Many New Zealand freshwater systems currently have water quality issues, and warmer water temperatures could exacerbate water quality problems in areas with already high loadings of nutrients, causing algal or cyanobacterial blooms to become more frequent or have earlier onset times in the warmer seasons.

B.3.3 Biosecurity impacts from climate change

Key messages

- The most important driver of pest invasion is likely to be temperature, modified by rainfall, humidity and carbon dioxide.
- Some pests and weeds may currently be dormant in Auckland, awaiting some perturbation such as climate change to allow them to spread and flourish, e.g. locusts and army worms. New mosquito species may also become established, with the potential for tropical diseases such as dengue and Ross River virus.
- Kauri dieback may also be exacerbated by climate change, as well as fungal diseases such as myrtle rust.

B.3.4 The development of future climate change projection models

Further developments are expected in relation to global climate change modelling systems. Currently, the New Zealand Earth System Model (NZESM) is being developed, as part of the Deep South National Science Challenge, and in partnership with the UK Meteorological Office, and will contain improved formulations of Southern Ocean and Antarctic processes.

NIWA is also setting up an upgraded regional climate model, with improved physics and dynamics, and higher resolution than the model used to generate the projections in the NIWA report, 2017. The next generation of New Zealand climate change projections will make use of this regional model to downscale the NZESM, and potentially allow downscaling of the global projections of the IPCC Sixth Assessment Report (due to be produced in 2021).

Appendix C – Identified consequences of climate change on Watercare

The more significant projected climate changes for Auckland over the mid to late 21st century, and into the early 22nd century, have been assessed (via a series of workshops) for their potential impacts on Watercare's ability to deliver water supply and wastewater services. This covered conveyance networks, treatment, customer demand, water sources and wastewater discharge environments.

Specifically, the significant climate related changes that were assessed were:

- Increasing number of hot days (temperatures ›25°C)
- Increasing number of days of soil moisture deficit
- Increasing wild fire risk
- Increasing magnitude of the 99th percentile of daily rainfall (1-2 wettest rain days of the year)
- Sea-level rise

The climate change related impacts to biodiversity and biosecurity were also considered. All these projected changes in climate were taken from NIWA's December 2017 report, Climate Variability and Change – Auckland Region.

C.1 Climate change adaptation – identified consequences of climate change on Watercare's water supply

C1.1 Water sources

The most significant climate change related impacts on water supply catchments include decreasing land stability due to prolonged periods of heavy rainfall or extended dry periods being immediately followed by larger magnitude, extreme rainfall events. Losses of current native vegetation could also occur due to enhanced wild fire risk. All of the above projected changes could impact on dam stability and safety. Increasingly elevated water tables due to sea-level rise could also adversely impact dam safety due to increasing buoyancy forces on the base of a dam.

We are likely to see increasing fluctuations in water availability from our sources. Decreases in summer and autumn precipitation and higher losses of water from vegetation absorption and evaporation due to higher temperatures could lead to reduced yields of surface and ground water sources, especially in relation to the non-metropolitan water sources, such as Helensville and Warkworth. A loss of storage capacity due to sediment build up in dams could add to the reduced yield of surface sources. A potential social vulnerability is an increase in flooding complaints downstream of Watercare's dams if spilling occurs more often in wet weather. Impacts of sea-level rise on water sources include the increasing likelihood of saline intrusion – especially for the Onehunga and Waiuku bores, and the potential upstream movement of the saline wedge of the Waikato River. Reducing ice melt could also affect the volume of water available for use in the Waikato River. Regarding groundwater sources, an impact on yield is likely to happen as a long term cumulative after at least five years of reduced recharge, as experienced in Canterbury recently.

This reduced yield, along with higher temperatures and low-flow conditions would also have detrimental impacts on raw water quality from all water sources due to increased microbiological activity, changes in organics and increased sediments.

C.1.2 Water treatment

Projected changes in climate would have a number of consequences on Watercare's water supply treatment plants. Large inputs of sediment into the surface water sources due to landslides or increased run off, would cause issues with water treatment plants.

Increasing micro-biological activity due to higher temperatures and lower flows may increase the likelihood of periods of diminished raw water quality. Increased fire risk has the potential to change the chemical characteristics of raw water through ashes being washed to the lakes. A change in land-use toward horticulture instead of dairy farming country-wide (assuming emissions reduction measures in NZ include reducing dairy farming) could result in more pesticides in waterways. These changes to water quality in turn would require water treatment plants to increase their treatment capabilities, therefore having to enlarge their operating envelopes. Projected higher magnitude rainfall events would bring a heightened vulnerability to treatment plants from on-site flooding and damages to critical third party infrastructure, such as roading, communications, and power supply, during storm events. This may affect supply chains (e.g. chemicals), and the ability to provide 24/7 staffing during extreme events. There may also be a scarcity of chemicals required for treatment and emitting large amounts of greenhouse gas in their production such as lime. Through increased climate change mitigation actions, there may be pressure to reduce lime usage.

C.1.3 Water conveyance

The projected increases of prolonged dry periods would induce a greater number of pipe breakages resulting in increased flushing. Projected temperature increases would lead to some degree of chlorine decay in the network, requiring more chlorine boosters. Large magnitude rainfall events would also impact water supply conveyance networks from increased land instability, flood induced erosion, and power failures. Repairs would become more difficult under higher groundwater table conditions, as dewatering of the area would be required before proceeding. The winter window for planned repairs of pipes could be reduced because of higher temperatures and demand in spring and autumn. Increased rainfall could also damage/block roads which would restrict our access to repair or deliver generators.

Sea level rise could lead to reductions in asset life, mainly due to increased corrosion from salt water on the outside of pipes. Increasing coastal inundation, accompanied with elevated water tables, could also contribute to decreased stability through the floatation of assets. There is the potential for loss of gravity supply if infrastructure needs to be retreated inland which would result in increased energy costs for pumping.

C.1.4 Water demand

There is a likelihood that due to increasingly prolonged hot and dry periods, there will be corresponding increases in peak water demand, for metropolitan and non- metropolitan water supplies. Further water demands could come from the greater need to flush pipes due to increasing pipe breakages, and greater firefighting demands. There could also be increasing demand from the non-connected population who cannot self-sustain during long dry periods. It may become more difficult to gain consent with reduced resources and increasing demand for water from the Waikato River.

Increased variability in demand caused by extreme rainfall events immediately following dry periods, would necessitate rapid plant turndowns, potentially causing operational challenges. There may be changes in behaviour in response to local and global changes to water supply. Peak demand could change. In a more extreme scenario, theft of water may occur if the price of water increases to fund climate change adaptation. Could there be riots over water? Alternatively, people could understand the need to change their behaviour and water use, leading to less social disruption than described above. An increase in climate change refugees increasing the population would increase demand for water.

C.1.5 Other

Projected sea level rise would have significant impacts, such as the increasing probability for the occurrence of "stranded assets". Regulated land use changes – such as urban intensification, the development of greenfield areas, or decisions to retreat (or defend) an area would impact on the demand for water supply services. Such changes in demand could subsequently result in the occurrence of infrastructure that was either under, or over-sized, or even becoming totally redundant (therefore "stranded") as the communities it serviced have retreated to areas less affected by climate change impacts. This would impact on any existing levels of service.

C.2 Climate change adaptation – identified consequences of climate change on Watercare's wastewater services

Wastewater treatment, conveyance, demand and discharge environments were assessed.

C.2.1 Consequences on wastewater treatment plants

A number of potentially significant consequences may result from the projected impacts of climate change in relation to WWTPs. Plants with oxidation ponds may be impacted by increased algal blooms during warmer and dryer periods, which may reduce treatment effectiveness. Higher temperatures around standing water bodies would increase mosquito growth which could cause public health impacts such as the spread of mosquito borne diseases, such as malaria. It could lead to standing water bodies being banned. However, oxidation ponds may be taken out of service by 2052 following new discharge consent requirements, therefore avoiding this issue.

The treatment performance of biological processes increases with temperature, which may be an opportunity for our plants. Prolonged dry periods followed by extreme rainfall events would lead to increased loads of first flush events, and increased I&I may lead to more dilute flows in wet weather. This would cause highly variable wastewater load concentrations, potentially causing operational issues at treatment plants. Larger magnitude extreme rainfall events would likely increase the probability of wastewater treatment plant partial bypasses, and non-compliances with resource consent conditions in relation to both quality and quantity parameters. Lime is specifically required in the biosolids process. The production of lime emits large amounts of greenhouse gas. Its use could be restricted due to mitigation initiatives on suppliers.

Large rainfall events and sea level rise could lead to the greater occurrences of on-site flooding, possible overtopping of wastewater treatment ponds, and damages to critical third party services, such as such as roading, communications, and power supply. This may affect various supply chains (chemicals, fuels), and the ability to provide 24/7 staffing during extreme events. Projected sea level rise on low-lying WWTPs (especially Māngere including Puketutu, Pukekohe wetlands, and Helensville) will cause particular issues. Increasing occurrences of coastal inundation and coastal erosion could cause damage to or trigger floatation of assets. Rising sea levels would result in saturation of wastewater dam toes and erosion if suitable erosion protection is not put in place. Many of the wastewater dams appear to be formed on soft alluvial material, and as seawater level rises, the risk of reduced stability issues will arise. There will be stability and erosion hazards with rising sea levels at wastewater treatment dams located amongst the mangrove swamps (Helensville, Wellsford, Snells-Algies and Waiwera). Pukekohe WWTP also faces risk due to flooding by the Waikato River.

Flood levels for pumps and assets may need to be reviewed. Saltwater intrusion in the network would increase both the volume and salinity of influent. The hydraulic capacity of existing wastewater treatment plant outfalls would be reduced because of a higher sea level.

Puketutu's leachate modelling is based on current levels of groundwater contamination. Sea level rise and other factors could change those levels, hence affecting the consent. This may happen after Puketutu has been filled, avoiding the issue.

C.2.2 Consequences on the natural environment of wastewater treatment plants

Reductions in dilution and increasing temperatures would potentially increase microbiological activity and algal growth in treated wastewater receiving environments. Environmental impacts including climate-related ones described above may trigger discharge consents reviews. The ability of harbours to assimilate nitrogen and phosphorous is affected by temperature and it is not certain yet whether increased temperature will increase or decrease this assimilation due to the complexity of these environmental systems. Ammonia is more likely to become toxic at elevated temperatures. Benefits from longer dry periods, and elevated temperatures, include improved performance from land disposal plants, and more opportunities to discharge treated wastewater into aquifers. These impacts could also result in opportunities for resource recovery and product creation from wastewater treatment. Odour complaints could increase.

Increasing high intensity rainfall events would have the implications of causing resource consent non-compliances due to the exceedance of maximum discharge volumes and having to discharge outside of the effluent quality consent window. In relation to wastewater discharges to land the ability to discharge to land in wet weather would be reduced. The volume of partial plant bypasses could increase and result in detrimental impacts on the respective receiving environments.

Rising sea levels would impact the circulation and dilution of receiving environments (both positive and negative), as well as having backwater and seawater infiltration effects, and the possible submergence of effluent outfalls. Another consequence of sea level rise would be the impacts on bird life – especially migratory birds about the Māngere WWTP foreshore.

C.2.3 Consequences on wastewater conveyance

The projected increases in dry periods, combined with higher temperatures, would induce greater hydrogen sulphide production and increased solids settling (both due to reduced flow velocities). This will increase corrosion and odour issues, as well as safety risks associated with increased hydrogen sulphide production. At higher temperature, toxicity of ammonia increases, causing health and safety risks for workers.

Increased pipe failures due to differential ground settlements and root intrusion would likely occur in both public and private networks. This in turn would cause greater losses of untreated effluent to the environment and additional requirements for pipe clearing.

Larger extreme rainfall events would increase the frequency and magnitude of wet weather overflow events (due to increased inflow and infiltration and increased base flows) including an increase in the number of manholes popping. The Safeswim programme would also be impacted by increased overflows, while people may be swimming more because of increased temperatures. Odour treatment bio-filters could become flooded during wet weather events.

Large rainfall events and sea level rise could inundate engineered overflow points and would require alternative solutions located above flood level. Increased pumping would occur and storage tanks would fill faster, and stay full, longer. During wet weather events, private gully traps could become flooded, which would introduce significant quantities of water into the wastewater system. An increase in the level of river flow flood levels could lead to the floatation of pipe bridges. Heavy rainfall would cause increasing land instability which could bury pipe networks and related assets. Increases in surface water flow velocities could cause additional scouring and stressors of pipes, thereby reducing their life span. Sea level rise impacts on wastewater conveyance networks would include coastal inundation of low-lying pump stations, additional asset corrosion from saline water, increased infiltration due to elevated water tables in coastal areas, and the floatation of various pump stations, storage tanks, and pipes. Inundation could also damage sea walls and sewer protection devices which protect network assets against storm surges.

C.2.4 Impacts of climate change on the demand for wastewater services

The projected impacts of climate change are very likely to influence changes in people's water and wastewater use behaviour. Increased impacts on wastewater networks during prolonged dry periods could occur due to some people reducing their water use, and this in turn would have the effect of increasing the concentration and the amount of solids in the wastewater stream. Some people may increase their usage of wet wipes in an effort to "save water".

Projected increases in extreme rainfall events may induce more people to illegally connect their stormwater downpipes into their gully traps in an effort to reduce on-site flooding of domestic properties.

Demand could increase as a result of increased climate change refugees moving to Auckland, either from the Pacific or New Zealanders currently living overseas. Wastewater reuse could become more attractive and lead to industries getting established close to our plants to create a reuse scheme, creating opportunities in that space. Industries could also investigate sewer mining. Could we develop a New Zealand advantage – opportunities in reuse and recovery from wastewater that other countries won't have?

Greater future demands for a more decentralised approach to wastewater management may also occur, both in terms of local wastewater treatment plants and on-site systems such as sceptic tanks, composting toilets, greywater recycling and rainwater tanks. These changing perspectives could have an unpredictable impact on demand and therefore on wastewater volumes.

C.2.5 Other

As previously described for water supply, projected sea level rise would have significant impacts on wastewater networks such as the increasing probability for the occurrence of "stranded assets". Regulated land use changes – such as urban intensification, the development of greenfield areas, or decisions to retreat (or defend) an area – would impact on the demand for wastewater services. Such changes in demand could subsequently result in the occurrence of infrastructure that was either under, or over-sized, or even becoming totally redundant (therefore "stranded").

Impacts such as these would have direct effects on any established levels of service, as well as the operating costs of the affected infrastructure. This could have implications on existing and future planning. This and other factors could lead to public pressure to reduce the cost of wastewater services. There could be an increased need for communicating the need for upgrading infrastructure to cater for larger loads even though flows are reducing due to changing behaviours and water saving initiatives.

Appendix D – Watercare's greenhouse gas emissions

D.1 Mitigation context worldwide

Climate change action is twofold. While climate change adaptation aims at adapting our infrastructure and operations to a changing climate, climate change mitigation addresses the root cause by limiting the magnitude of change. This is done through reducing the release of greenhouse gas emissions in the atmosphere (e.g. energy efficiency projects) and increasing their removal (e.g. planting trees). The removal of greenhouse gas (GHG) emissions is called sequestration and the natural or artificial reservoir storing them (e.g. forest) is called a carbon sink.

The United Nations Framework Convention on Climate Change (UNFCCC) states in Article 2:

The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties (COP) may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a timeframe sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.

The 21st Conference of the Parties of the UNFCCC in (COP 21) took place in Paris in December 2015 and led to the "Paris climate agreement", ratified by 170 countries as of November 2017. The Paris Agreement's central aim is to address the threat of climate change by keeping global temperature rise this century to well below 2 ∞ Celsius above pre-industrial levels, and to pursue efforts to limit temperature increase to 1.5 ∞ Celsius. This threshold of 2 ∞ has been established by the UNFCCC as 'the limit to prevent dangerous anthropogenic interference with the climate system', which is commonly seen as the limit before catastrophic impacts occur.

The International Panel on Climate Change (IPCC) states that mitigation scenarios that are likely to keep temperature change caused by anthropogenic greenhouse gas emissions to less than 2 ∞ Celsius are characterised by atmospheric concentrations of about 450 parts per million (ppm) of CO_2 equivalent in 2100. The 2017 atmospheric concentration peaked at 412 ppm.

Scenarios that aim to stay below 450 ppm by 2100 include substantial cuts in anthropogenic GHG emissions by mid-century. This has led to the concept of "Net Zero Carbon 2050" now widely adopted worldwide. This means that humanity should strive to decrease its greenhouse gas emissions and increase its carbon sinks to reduce its net carbon contribution into the atmosphere to zero by 2050 in order to avoid changing the climate catastrophically.

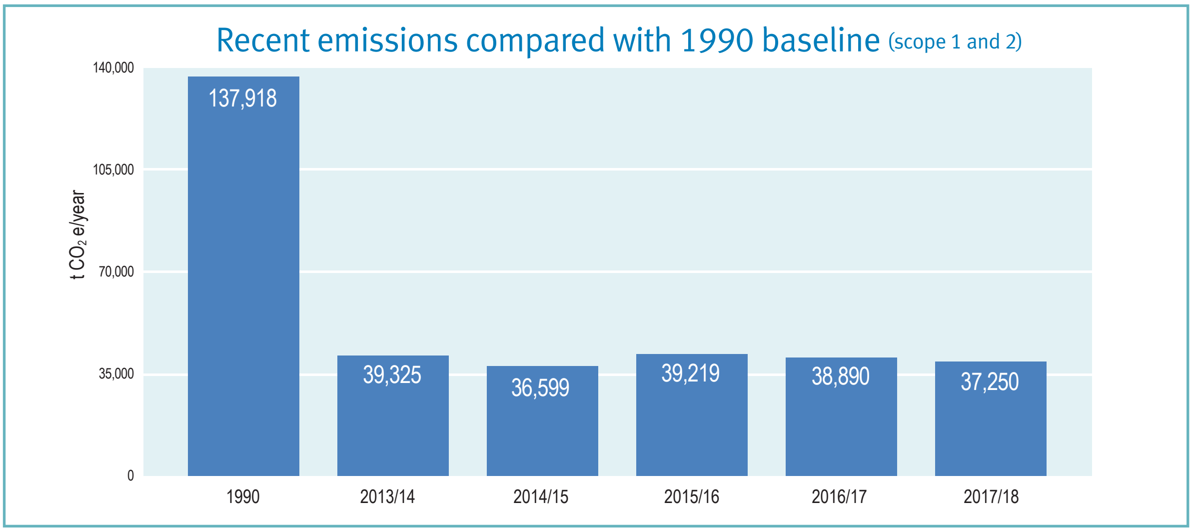
As indicated above, the Paris Climate Agreement commits ratified countries to take action on climate change mitigation. New Zealand ratified the Paris Climate Agreement on October 2016 and the Agreement itself entered force on November 2016. New Zealand's commitment (called a 'National Determined Contribution', NDC) made as part of the Paris agreement is a reduction of greenhouse gas emissions by 30% by 2030 compared with 2005 levels. However, since then a clear intention has been set by the government to reduce emissions further and have a bill developed with the objective of a Net Zero Carbon Act being in force by mid-2019. This act will have the central aim to reduce New Zealand's emissions to net zero by the year 2050.

D.2 Watercare's greenhouse gas emissions

Watercare started accounting for its carbon emissions in 2004. Since that time, and until 2014, the accounting included scopes 1 and 2 only[1]. When the carbon accounting was first established, the 1990 baseline was also calculated.

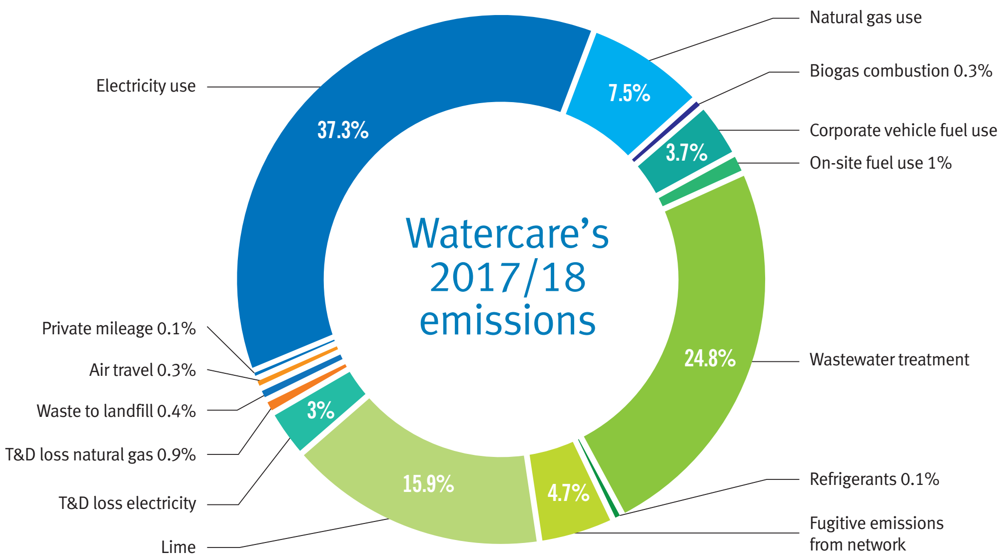
In 2003, Watercare completed "Project Manukau", a major upgrade of the Māngere WWTP. The project consisted of replacing the open-air oxidation ponds and sludge lagoons by land-based treatment with capture of methane and nitrous oxide emissions. An assessment done by the network of cities called C40 as part of their Measurement and Planning initiative in 2017 assessed that the upgrade has led to a 88% reduction in emissions as compared to the 1990 baseline.

The graph below displays the evolution of Watercare's direct greenhouse gas emissions since 2013, compared with the 1990 baseline (scope 1 and 2)



The carbon accounting methodology was reviewed in 2013/2014. Watercare's carbon footprint is now calculated in conformance with the Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard (World Resource Institute, 2004) and informed by the Greenhouse Protocol Scope 3 (World Resource Institute, 2011) methodology. Watercare undertook a materiality assessment of key emission sources, aiming at assessing which emission source should be included in the company's carbon accounting. Following this review, the operational reporting boundary has been extended to increase the number of emissions sources included in scopes 1 and 2 and to include scope 3 emissions. These boundaries are used to set our targets.

Watercare's emissions in 2017/18 stand at 29,580 tonnes of CO2e (equivalent CO2) for scope 1 and 2 and at 37,250 tCO2e when including the current scope 3 defined in 2014[2]. The breakdown per emission source is following:



1 *The GHG Protocol Corporate Standard classifies a company's GHG emissions into three 'scopes'. Scope 1 emissions are direct emissions from owned or controlled sources. Scope 2 emissions are indirect emissions from the generation of purchased energy. Scope 3 emissions are all indirect emissions (not included in scope 2) that occur in the value chain of the reporting company, including both upstream and downstream emissions.*

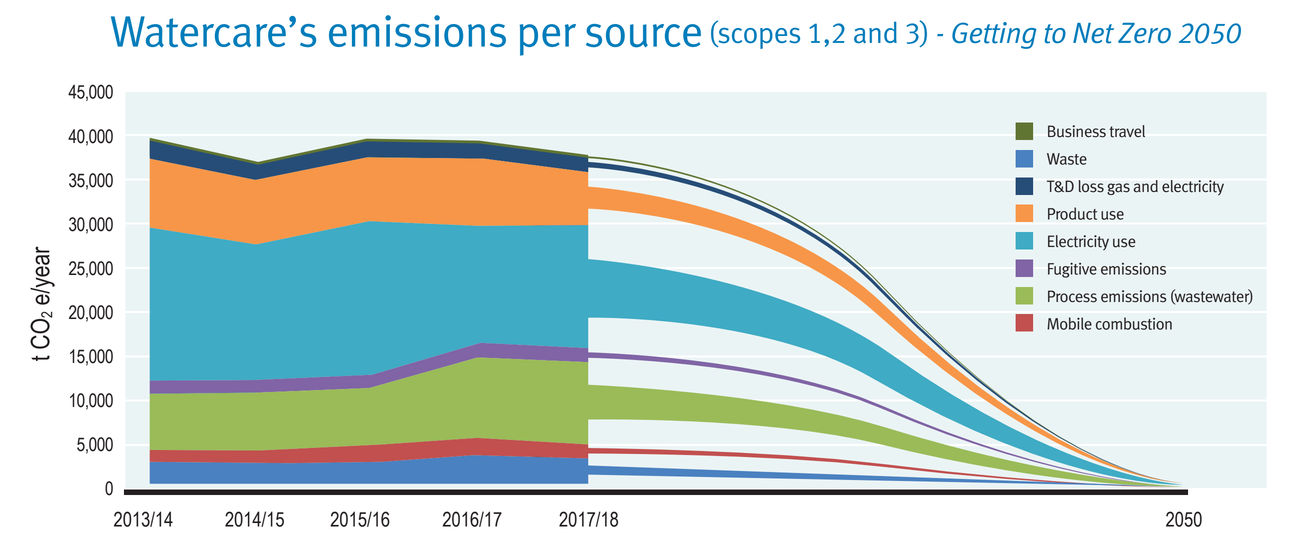
2 *A review of emissions reported in the 2017/18 annual report highlighted a small reporting error in scope 3 emissions. The total greenhouse gas for 2017/18 should read 37,250 not 36,400 as reported.*

D.3 Net Zero Emissions by 2050

Net Zero emissions by 2050 is what Watercare is aiming for in order to contribute to keeping global temperature increase well within two degrees Celsius. This objective is captured in the Energy policy and is being integrated across all aspects of the business.

The diagram below is a simplified view of Watercare's journey towards Net Zero 2050. The aim of the climate change mitigation strategy will be to determine the shape and timing of the emission reduction pathways represented with dotted lines. Initiatives already underway such as energy efficiency and energy neutrality (assuming no new additional emissions are generated by the move to energy neutrality) will contribute to Net Zero emissions 2050 by reducing the amount of carbon emitted by Watercare. Other initiatives such as the transition from commercial to native forestry through the re-vegetation project in the Hūnua ranges could act as a carbon sink by capturing carbon. A considerable amount of focus and investment will be required to achieve these goals.

Adaptation measures can also contribute towards Net Zero emissions 2050 if they include design and process options that release lower greenhouse gas emissions compared to existing traditional options.



Appendix E – Mitigation strategy - emission pathway

E.1 Introduction

Watercare is committed to become a low carbon organisation, doing its share to limit the magnitude of climate change by establishing pathways to achieve net zero emissions by 2050.

To achieve this the understanding of carbon impacts and integration of efficiency actions will be embedded into business as usual for teams across the business. The review of strategic documents, integration of climate considerations into practices such as planning, design and eco system management as well as targets in the performance review framework will support this challenge.

These are particularly relevant in the following areas.

E.2 Science based targets initiative (SBTI).

Science-based targets provide organisations with a clearly defined emissions pathway by specifying how much and how quickly to reduce greenhouse gas emissions. It is a collaboration between CDP, the United Nations Global Compact (UNGC), World Resources Institute (WRI), and the World Wide Fund for Nature (WWF). Watercare is committed to establish greenhouse gas reduction targets and pathways that are based on science.

Through this process the following target has been established, which aligns with keeping global temperature increases within 1.5 degrees Celsius:

- Reduce operational greenhouse gas emissions by 45% by the year 2030

This target is based on the 2017/18 financial year and covers scope 1 and 2 emissions. This baseline year and boundary has been used as it is the most recent in terms of setting the strategy and aligns with the principles of the science based target initiative.

Scope 3 targets (covering supply chain and purchased goods) will be established to support engagement and delivery of the Low carbon infrastructure target.

E.3 Emissions pathway

Working through the SBTI requires a robust understanding of current emissions and an indication of potential emission reduction opportunities into the future. It is clear that there is Global and National uncertainty in emission reduction pathways and this is true for Watercare also. This is due to the nature of evolving technology as well as the influences of regulatory changes and organizational innovation and ability to embrace change.

Watercare will focus on reducing emissions in the following areas to create an emissions reduction pathway in line with the established SBTI targets.

E3.1 Energy efficiency

Watercare has established a commitment to minimise the need for energy (electricity and fuel) and greenhouse gas emissions by integrating world-class energy management practices in operations and planning. The Energy Policy provides an overview of the ways of work to achieve this which is managed by the Energy Team.

E3.1.1 Energy generation

An extension of energy efficiency is electricity generation. Opportunities exist in hydro, solar and most significantly, biogas generation at major wastewater treatment plants. Strategies for the increased generation of electricity from hydro and solar sits within the energy and energy neutrality teams and new opportunities are being maximised in line with appropriate return on investment.

In 2018 44.2 GWh of electricity (26% of total consumption) was generated from hydro and biogas production with three pilot solar projects being approved for installation.

E3.1.2 Energy neutrality

Wastewater is rich in organic carbon, which when captured as sludge and treated via anaerobic digestion produces biogas. Watercare's two major WWTPs currently recover energy from biogas which is generated through anaerobic digestion of sludge. The Energy Neutrality programme aims to both reduce energy demand at WWTPs through process and technology changes and also increase biogas yields from anaerobic digestion. The result being a major facility whose power runs entirely on the wastewater of Auckland by 2025. This is a multi-stage, complex and considerably interrelated process which includes specific work streams on process optimisation, biochemistry optimisation, carbon harvesting, bio solids and gas production and proactive wet weather treatment planning.

The results of energy neutrality would be a 37 GWh reduction in electricity consumption.

E3.2.1 Treatment process emission reductions

Wastewater treatment (23%), fugitive emissions from the network (4.8%) and lime use (16.2%) make up a significant portion of Watercare's greenhouse gas emissions. The methodology to measure these emissions is being improved however it is recognised that there are opportunities to optimise consumption of materials, investigate process changes and seek reductions in this area.

E.4 Planting and carbon removals

Watercare's target of net zero emissions by 2050 will require a significant change in the way the business operates. The efficiencies and improvements will drive down emissions however there will be a limit to how far this can go. Removing carbon from the atmosphere in some form will be required to achieve the final target.

Watercare will look into opportunities that could act as a carbon sink. This may include planting trees, the investigation of other natural carbon removals (eg algae, kelp or chemical processes) and keeping an eye on technology that achieves these goals.

The Hūnua Ranges re-vegetation project is an example of a potential carbon sink. Over the next 30 years approximately eight million trees will be grown over 1900 hectares to support land stability and resilience of a major water catchment area.

E.5 Infrastructure carbon

Watercare owns and operates $10.1 billion of water and wastewater infrastructure assets. Existing water and wastewater assets are operated, maintained and renewed and new assets are planned and built to meet demand as Auckland grows. These construction projects, considered as scope 3 in greenhouse gas accounting, are required to ensure the ongoing delivery of services to the people of Auckland.

A process of reviewing and rethinking design standards, facility plans, servicing strategies and business cases to include a lens that consistently considers climate change will ensure a positive influence. By working with partners, rethinking traditional approaches and embracing innovation large infrastructure carbon savings can be achieved. Product based design, digital design, carbon baselining and modelling tools will be explored to support this journey. Furthermore, rethinking projects with a carbon lens also has the ability to reduce cost and improve safety outcomes.

Watercare has a target to:

- Reduce infrastructure emissions by 40% by the year 2025

E.6 Innovative approach required to reimagine Watercare's work

Watercare's emissions have been generally steady in recent years whilst the population has grown and energy intensive water standards have increased. To become a low emission organisation and achieve future emission reduction targets the entire business will need to be involved. This is a long term change and the operationalisation of emission reduction will include the review of strategic documents, consistently embedding climate change consideration in practices such as planning, design and operation of assets and establishing individual and business unit targets.

Furthermore, achieving these goals will require a new way of thinking and an innovative approach to old and new problems. Watercare staff are excellent problem solvers and critical thinkers and this will be focused on the climate challenge.

E.7 Sustainable Development Goals (SDGs)

Watercare has committed to supporting the SDGs through a partnership with the Water Services Association of Australia. The SDGs provide a valuable lens for climate change activities and emission pathways. The following goals and their specific targets have been identified as having most relevance and will be considered within Watercare's work plan. They have been adapted to be relevant at an organisation level and will be used as a guide for our progress.

SDG 6 Clean Water and Sanitation

- Achieve equitable access to safe and affordable drinking water for all
- Improve water quality by reducing pollution, providing wastewater treatment and increasing water recycling and safe reuse
- Substantially increase water-use efficiency
- Protect and restore water related ecosystems

SDG 7 Clean and Affordable Energy

- Substantially increase the share of renewable energy
- Double the rate of improvement in energy efficiency

SDG 9 Industry, Innovation and Infrastructure

- Develop quality, reliable, sustainable and resilient infrastructure
- Upgrade infrastructure and retrofit industries to make them sustainable

SDG 12 Responsible Consumption and Production

- Reduce waste generation through prevention, reduction, recycling and reuse
- Adopt sustainable practices and integrate sustainability information into reporting cycles
- Promote procurement practices that are sustainable
- Ensure people have the relevant information and awareness of sustainable development and lifestyles in harmony with nature

SDG 13 Climate Action

- Strengthen resilience and adaptive capacity to climate related hazards
- Integrate climate change measures into policies, strategies and planning
- Improve education, awareness raising and human and institutional capacity on climate change

Appendix F – Adaptive planning pathways for climate action

Development of strategic pathways

Watercare's climate change action plan comprises adaptation and mitigation actions. Adaptation actions were raised by the teams during a series of workshops and organised into short-term areas of work, called portfolios, and high-level long-term pathways (Figure E-1). Each portfolio provides potential solutions to a climate change issue given our current knowledge. Each long-term pathway comprises a high-level category of future adaptation actions that can be taken given the outcomes of the short-term portfolios.

For example, short-term modelling and monitoring of an asset vulnerable to flooding will inform whether it can be (i) protected via capital intervention (e.g. raise the asset), or, (ii) if deemed not critical, can be allowed to fail during flood events and operationally resumed and maintained at increased frequencies, or, (iii) maintained at current service levels by restricting development removing the need for expensive capacity upgrades and renewals or (iv) sacrificed to the effects of future climate change if other options are deemed unsuitable.

Modelled changes (triggers) in sea-level rise, rainfall intensity and number of hot days are placed on the timeline to serve as signposts. Implementation of short-term portfolios of actions will further clarify these signposts and their trigger values.

Portfolios of mitigation actions are shown separately as on-going actions with targets in the short-term (energy-neutrality at Māngere and Rosedale WWTPs by 2025) and long term (company-wide net-zero carbon target in 2050) highlighted on the timeline.

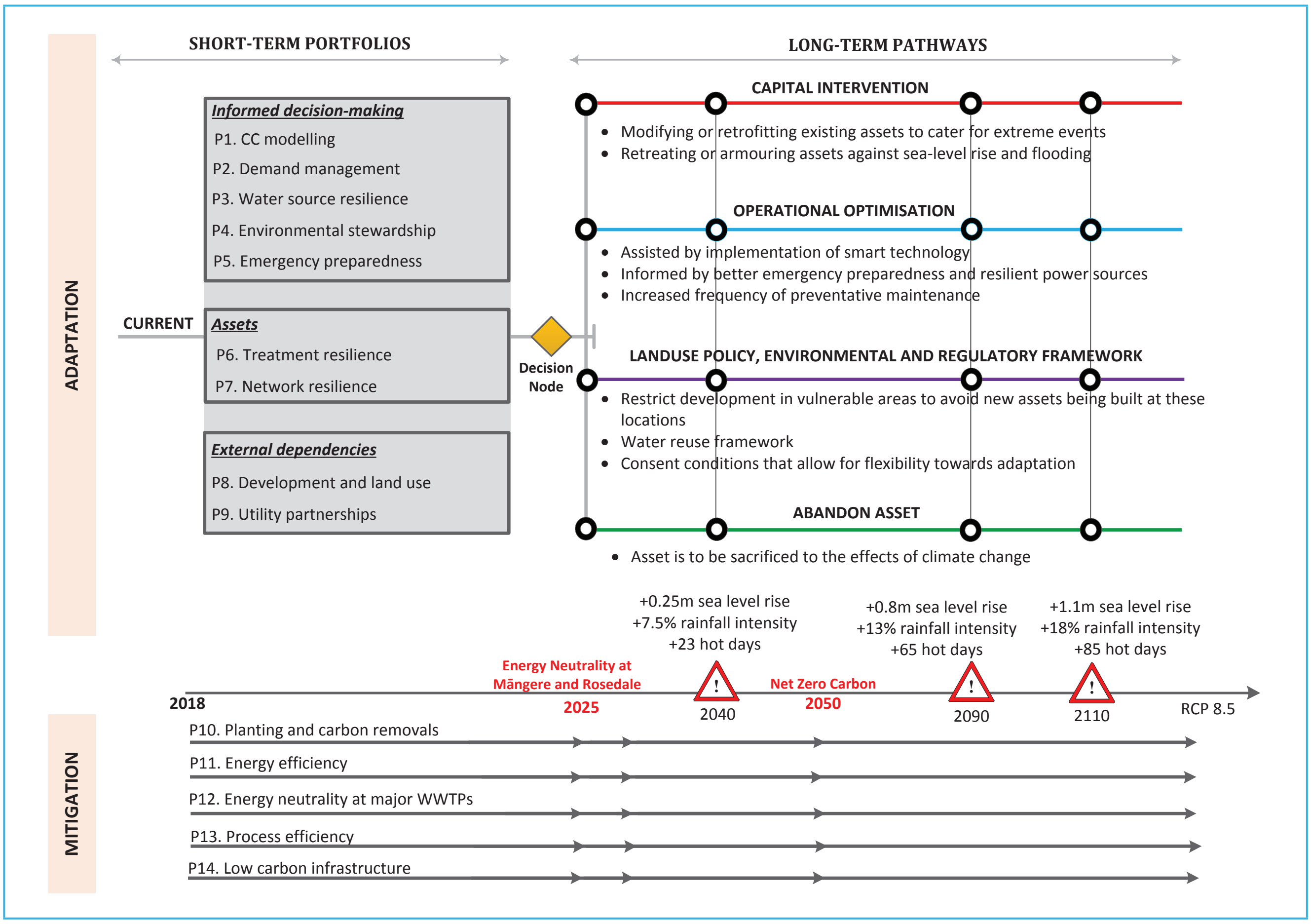


Figure F-1: Watercare's climate change action plan

Description of portfolios

Watercare's adaptation work plan will focus on the delivery of nine short term portfolios by 2025 with the overarching aim of improving monitoring protocols and establishing a greater understanding of existing asset resilience to future threats. These are characterised into three value streams – Informed decision making, Assets and External dependencies. Desired future states within these portfolios provide a direction of travel and numerous individual actions are required to achieve the goal.

Watercare's mitigation work plan will focus on delivery of five on-going portfolios that may evolve over time in order to meet the Net Zero emission target by 2050.

P:1. Climate change modelling

Climate impacts are modelled so that we are informed in our planning

This portfolio will update climate change modelling to include wider Watercare servicing areas not currently included in the NIWA models and ensure that the existing models are constantly updated as new information comes to light. For example, an understanding of the vulnerability of the Waikato water treatment plant (WTP) and the Pukekohe wastewater treatment plant (WWTP) to climate change effects is required prior to planned upgrades beginning in 2024. There are localised examples of where this information is already being utilised to ensure climate resilience such as the Snells-Algies waste water treatment plant.

Existing climate change models are required to be further localised and updated so that modelled outputs can be used to:

(i) Identify vulnerable assets and locations.

(ii) Inform further detailed monitoring and modelling requirements for identified vulnerabilities, for example, of sea-levels, soil-saturation and slope stability at a critical asset.

(iii) Modelled outputs are to be of sufficient quality and resolution such that the information they provide is able to be used for future planning and design decisions; including whether existing vulnerable assets are to be protected, relocated or decommissioned. No new assets are to be designed in unsustainable locations.

P:2. Understanding impact of climate change on demand patterns

Demand is managed through understanding and influencing consumption in a changing climate so that we can continue to serve our customers and keep costs under control

a. Understanding current demand patterns

Increased measurement of water consumption will be required to improve understanding of current demand patterns, including spatial and temporal variations in water demand. A Water Consumption Dashboard is currently in development as part of Watercare's Strategic Transformation Programme (STP) to help improve insights into the drivers for demand. This dashboard will demonstrate consumption spatially across Auckland. An understanding is required of the future impact of wet industries on demand for water and wastewater services. Identification of large users extracting water from bores and discharging into the reticulated wastewater system is required. Monitoring of current trends will enable the understanding of changes in future demand patterns due to climate change.

The establishment of smart-metering is under way and will enable a review of tanker filling and tracking of theft from hydrants/stand pipes. This will allow greater enforcement of an existing bylaw on theft and tampering with the network.

b. Updating the water efficiency strategy to include climate change impact

The impact of climate change on demand will be alleviated by progressing key initiatives highlighted in the Water Efficiency Strategy. These initiatives include community education programmes and smart meter installations. Further collaboration with electricity providers to promote education on water and energy use is proposed. STP insights into water consumption will inform the success of water efficiency improvement measures detailed in the Water Efficiency Strategy. The Water Efficiency Strategy will also require updating to take into consideration STP insights into drivers for demand and impacts of climate change on future demand.

c. Finalise design standards around changing water demand

Design standards will be updated to reflect changing water demand patterns. The draft code of practice recognises the reduction in residential per capita consumption from 225 L/p/d to 185 L/p/d.

d. Demand model support system

Data collected by the above monitoring and investigative endeavours will be centralised in a model based decision support tool that will enable further understanding of demand patters in various climate scenarios.

P:3. Understanding water source resilience

There is enough water of an acceptable quality so that we can meet Auckland's growing demand in a changing climate

P:3.1. Monitoring and modelling of source volume and quality

An understanding is required of the quality and volume of water currently available in Watercare catchments. This includes updating baseline storage in dams whose volumes have been affected by sedimentation build-up following recent storm events. Existing groundwater yields are to also be substantiated in terms of quality, quantity and sea level rise impacts.

Modelling platforms that utilise past rain data are to be updated to include changes in current and future rain patterns. This includes the Integrated Water Source Management Model (ISMM) which is currently used to manage raw water supply. The rainfall-runoff model of the ISMM will require regular calibration as the climate changes.

The outcomes of the above monitoring and modelling investigations are to be centralised in a decision support tool that can be used to optimise storage against variability in weather patterns.

P:3.2. Feasibility of winter harvest and reuse

Investigations into alternative climate resilient water source options are also required, including the feasibility of winter harvesting to identify where dams can be expanded to harness larger rainfall events and the viability of using treated wastewater to recharge water sources.

P:4. Understanding treatment resilience

Treatment plants are fit for purpose in a changing climate so that we can continue to service customers whilst keeping costs down and restoring the natural environment

P:4.1. Water treatment technology solutions

Technology upgrades and innovations are currently being incorporated into existing water treatment sources to manage raw water quality risk. These include ultrasonic units for algae reduction, powdered activated dosing (Huia WTP) and ultraviolet disinfection retrofit at Ardmore WTP. Continual investigation into technology improvements and innovation will be required to address source water quality deterioration as the climate changes.

P:4.2. Impact on the treatment process of WW flow and load variation

Monitoring of wastewater flows and loads being conveyed into the WWTPs will be required to understand the impact of flow and load variability on the treatment process. Flow and load variability introduced by pump station operation, chemical odour control and extreme weather events can significantly impact WWTP behaviour and bypasses. Monitoring of the seasonal and long term climate change influences on algal blooms in wastewater oxidation ponds is also required. The use of monitoring data can then be used in the development of treatment capacity envelopes for typical flow and load variations expected and therefore enhance operational resiliency.

P:5. Understanding network resilience

Pipes are fit for purpose in a changing climate so that we can continue to service our customers whilst keeping costs under control and minimising our environmental impacts.

P:5.1. Network monitoring and modelling

The impact of temperature on chlorine decay in water networks are to be monitored and long term trends understood. Monitoring of the impact of root intrusion into pipes from trees planted in new developments is required. Historical flotation risks of transmission assets due to improper geotechnical considerations are also to be investigated and avoided in new installations.

Flow gauging and modelling of the wastewater networks to understand the impact of increased wet weather events on wastewater overflows will be required. An understanding of the impact of increasing dry and warm periods on sulphide production will also be required and may be incorporated into a wider gauging and modelling strategy. A study of wastewater networks in warmer cities will assist in informing future system behaviour. The development of an integrated odour and corrosion decision support system, similar to the tool developed by Sydney Water, will assist in understanding the health and safety impacts of sulphide production and costs of sustainable sulphide management.

The use of smart sensor networks in real time monitoring of water and wastewater assets are to also be investigated. This will require collaboration with cellular network operators and other utility providers also using this technology.

P:5.2. Resilient design and construction of networks

To minimise the impact of dry and warm weather, design and construction of assets with flexible and corrosion resistant pipe materials are recommended. Continual understanding and documentation of how design standards are affected by climate change is required. Mechanisms of enforcement of these evolving design standards are to also be established. Improved interconnection of networks to create resilience will allow repair work to be carried out and managed in a smaller winter window.

P:6. Understanding effects and responsibilities on the environment in a changing climate

The natural environment is understood so that we can inform our long term decision making, restore the natural environment where possible and maintain/improve our social licence to operate

P:6.1. Environmental monitoring

Environmental monitoring of long term trends is required to inform future decision making. An analysis of the assimilative capacities of receiving environments to understand the impact of long term temperature changes on nutrients is required and can be included in the deliverables of the Manukau and Waikato water quality models. Environmental monitoring should be aligned with Auckland Council's approach to maintain the desired consistency across the region and improve baseline understanding. A database centralising all environmental monitoring at Watercare will be developed and trends visible and accessible to all staff. This is currently being undertaken as part of the STP.

P:6.2. Puketutu groundwater modelling

Groundwater modelling at Puketutu will also need updating as climate models evolve to understand the effect of leachate contamination on rising water tables during extreme events.

P:7. Emergency preparedness

Extreme weather events due to a changing climate are prepared for so that we can continue to service our customers and keep costs down

P:7.1. Site vulnerability assessment to power, road access and communications

Assessments of individual asset and site vulnerability to power and communications outages and the effect of road closures on critical chemical supplies to the WWTPs are required. A review of existing back-up communications systems is required and the upgrade of communications systems as informed by the review. Site emergency preparedness measures are to be updated and will inform the annual review of utility contingency plans.

P:7.2. Review and update of headworks operational plan

Current headworks operational plans are due for a review and update and should include emergency preparedness measures that may be required as a result of climate change effects on extreme events.

P:7.3. Community emergency measures during extreme events, including communications strategy

Communication and education measures are required for households and communities who may be affected by flooding downstream of dams. Increased preparedness for water restriction events through improved communication tools, e.g. videos, social media etc. are required. A better understanding is required of water savings that can be achieved during water restriction scenarios.

P:8. Development and landuse

The impacts of a changing climate have been considered in our land use and development activities so that we can continue to service our customers and keep costs under control

P:8.1. Interfacing with Auckland Council

An internal interface with Auckland council and developers is to be established to collaboratively understand region-wide strategy for protection and abandonment of communities. Population growth projections should consider the impact of climate change immigrants and returning citizens. The impact of abandoned communities on shifting populations should also be considered. A cross-functional mechanism is required across council and CCOs to support good infrastructure development such that no new assets are being built in unsustainable locations.

P:8.2. Geotechnical database

A better connection is required with Watercare's as-built records and the Auckland geotechnical database

P:8.3. Real estate master plan

An understanding is required of the land required to implement adaptation and mitigation actions and strategic land acquisition measures implemented.

P:8.4. Network strategy documentation for NDC

Climate change effects and adaptation measures are to be included in the next network strategy document for NDC

P:9. Partnerships with utilities

Partnerships with utilities, including those providing lifeline services, are maintained and enhanced so that we can continue to operate during emergencies and take a multi-agency approach to planning for the long-term.

P:10. Planting and carbon removals

Carbon sequestration and carbon sink activities have been investigated and invested in that support our response to climate change impacts whilst also reducing our greenhouse gas footprint

The Hūnua ranges re-vegetation project is to enhance slope stability and drought resilience through planting of natives and drought resilient plants.

P:11. Energy efficiency and generation

Energy use and supply is actively managed so that we can reduce our greenhouse gas emissions as much as possible

Energy efficiency targets and an active programme is in place to drive an improvement in business practice, including the selection of energy efficient options in new projects and optimisation of current assets.

P:12. Energy neutrality at major WWTPs

Technologies and processes that enable Māngere and Rosedale WWTPs to be energy neutral and self-sufficient have been implemented so that we can reduce our greenhouse gas emissions as much as possible

An energy neutrality programme is underway for Māngere and Rosedale WWTPs with a goal of 37GW energy efficiency gains by 2025. This will be supported by enhancing the generation of energy from biogas generation and the reduction of energy required to run the plants.

P:13. Treatment process emissions

Greenhouse gas emissions from the treatment of water and wastewater are reduced.

For example, thermal hydrolysis introduced in the Energy Neutrality programme will remove the requirement of lime stabilisation for biosolids.

P:14. Low carbon infrastructure

How we plan, design, build and re-use infrastructure has been reviewed so that we can reduce our greenhouse gas emissions as much as possible

Baselining and target setting will drive updates in work processes to ensure that carbon is considered in infrastructure project design and delivery.

Delivery of the short term portfolios

The use of key aspects of the agile methodology is proposed for the delivery of the work plan for the short-term portfolios. In an agile framework, tasks are iteratively delivered over the course of the programme timeline. The portfolios have been arranged into respective groups, called value streams, which will form the structure for the work plan.

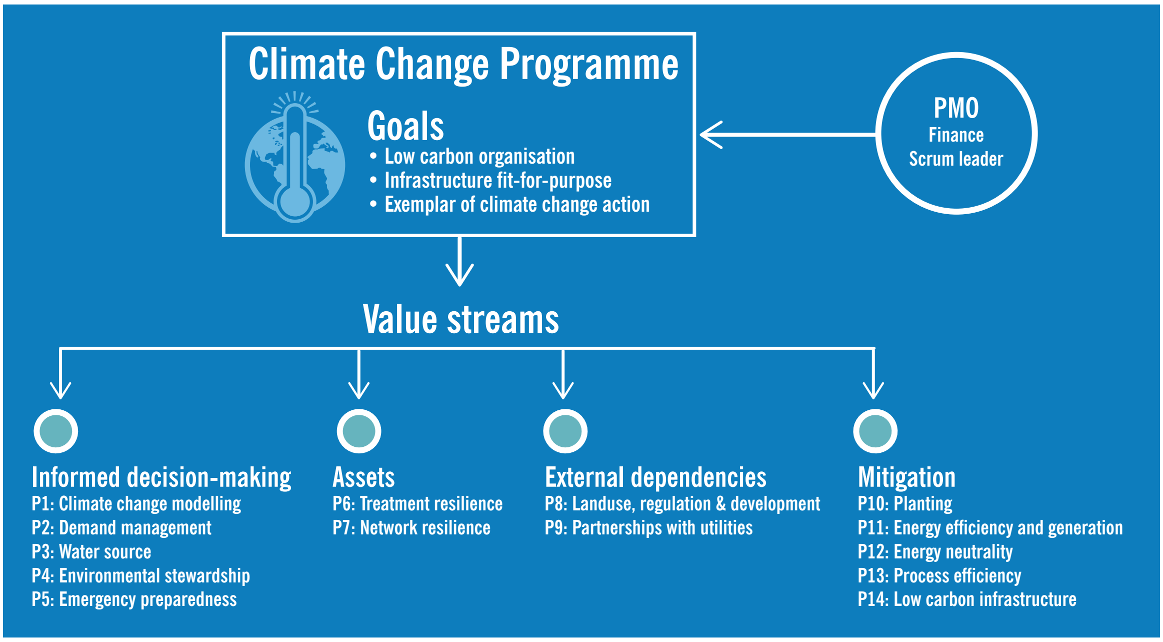


Figure F-3: Proposed structure of the climate change programme based on an Agile methodology

Based on an agile structure, the climate change programme will comprise the following personnel;

- Programme Manager, who is responsible for the delivery of the programme backlog (i.e. portfolios) and regular update of its content as the programme evolves. The programme manager will be assisted by the Project Management Office, Finance and a Scrum Leader in the delivery of the programme.

- Value stream leaders responsible for each of the four value streams.
- Portfolio owners that are responsible for the development, management and delivery of the 14 climate change portfolios. The portfolio owner will lead a cross-functional team of developers that are existing personnel in the business. Portfolios are currently organised such that actions in each portfolio can be carried out as an extension of activities already taking place within the business and further leading to the completion new actions as resources become available. Teams can either be static with a single team delivering the portfolio's objectives from start to finish or dynamic with personnel changing at each iteration of delivery; depending on the task and the individual's area of responsibility in the business.

The following methodology from the Agile framework will be adopted:

1. Initial value statements will be well defined to ensure there is a point of reference to work towards. The programme manager, scrum leader and value stream leaders will identify impacts and deliverables of each portfolio.
2. The development team in each portfolio are responsible for the creation of a 'tasks backlog' that are required to be completed for the delivery of the portfolio.
3. The Programme Manager and Development Teams together prioritise tasks into iterations. The entire Development Team will be responsible for the delivery of the iterations.

Regular meetings amongst Development Teams will be used to track progress of an iteration. At the completion of an iteration, outcomes will be showcased to the programme team. The Programme Manager will be responsible for tracking and updating the progress of the programme objectives which will be fed-back into the updating of tasks and iterations as the programme evolves.

The long term goal is to upskill employees and processes to ensure climate change mitigation and adaptation objectives are achieved. To make climate change considerations 'business as usual'. This will require high levels of collaboration within Watercare and draw on cross functional expertise.

There are three key stages set out in the work plan to achieve this:

1. Establish framework and identify Development teams
2. Initiate priority tasks within portfolios that are required as building blocks
3. Integration of climate change considerations, tools and process to BAU

Aspects of each stage will happen in parallel, however some activities have pre-requisites before they can be started. The framework and building block tasks will be initiated in the first six months of 2019 to initiate the flow of integration into business as usual.

Appendix G – Strategy development process

1. SYSTEM ANALYSIS AND ENVISIONING

A. Context analysis
- Collect and analyse data (NIWA report, Watercare's GHG emissions)
- Connection with climate change work with Auckland Council

B. Uncover the imperative for change
- Assets will be seriously impacted if we carry on business-as-usual
- Contributing to limit the magnitude of climate change impacts (<2°C)

C. Define the vision
- Mitigate GHG emissions to net zero by 2050
- Adapt to be fit for purpose for future climate change

D. Formulate guiding principles
- Formulate a suite of principles that act in synergy to fulfil the vision

E. Mandate
- Board approval for climate change strategy development

Workshop 1 (October 2017) Adaptation- Water

Workshop 2 (November 2017) Adaptation- Wastewater

Workshop 3 (November 2017) Consolidation- preliminary selection

CONTEXT

Apr 2018

Narrative and consequences

2. STRATEGY DEVELOPMENT

ADAPTATION

A. Identify vulnerabilities
- Identify underlying vulnerabilities of the current system and domains that require change if the vision is to be achieved

B. Identify existing action/capability
- Identify Watercare's current capability, including existing knowledge, tools and resources, to address adaptation challenges

C. Identify future action/capability
- Identify required future capability for Watercare to be able to address adaptation challenges

D. Generate strategic options for implementation
- Assess importance, feasibility and urgency of identified actions to address vulnerabilities and enable transformative change

E. Generate strategic pathways
- Refine and organise strategic options into pathways, to form a draft strategy ready for review

MITIGATION

F. Determine emission reduction pathway

Workshops 4 (Water) and 5 (WW) Confirming vulnerabilities and existing capabilities

Workshops 6 (Water) and 7 (WW) Identifying further actions required for climate change mitigation and adaptation

Workshops 8 (Water) and 9 (WW) Assessing the feasibility of climate change actions

Workshop 10 (Water and WW) Constructing the pathway

3. REVIEW
- Review by teams, senior management, board, Environmental Advisory Group (EAG)
- Prioritised actions

Sep 2018

DRAFT STRATEGY

4. CONSULTATION AND PROGRAMME DEVELOPMENT
- Consultation with Auckland Council and stakeholders identified through the EAG and the Strategy Development Process
- Specific actions, budgets, responsibilities and timelines assigned

Nov 2018

FINAL STRATEGY

STRATEGY

Dec 2018

5. EMBED IN PRACTICE AND EVOLVE
- Operationalise climate change strategy into business-as-usual
- Monitoring, evaluation and feeding back to higher levels so that strategic programme is able to adapt with new system conditions.

TACTICAL

Appendix H – References and influence in strategy development

Climate Change Policy and Strategy Bibliography

Auckland Council Sustainability Office 2018: ***Auckland Region Climate Change Projections and Impacts***. Revised January 2018.

This NIWA produced report was prepared for Auckland Council, Controlled Organisations, and District Health Boards. This report addresses the expected changes for 21 different climate variables out to the year 2120, and found that future climate changes are likely to be significant and will impact the entire Auckland region. These climate change projections formed the basis of the Watercare workshops during the assessment of water and wastewater-related vulnerabilities.

Ministry for the Environment 2017: ***Adapting to Climate Change in New Zealand: Stocktake Report from the Climate Change Adaptation Technical Working Group*** – December 2017.

This "Stocktake Report" discusses the likely impacts of climate change on New Zealand, and brings together what the various sectors (including local government) have been doing to adapt to climate change. Watercare was interviewed in the development of this report.

Ministry for the Environment 2017: ***Coastal Hazards and Climate Change: Guidance for Local Government.*** December 2017.

Provides good guidance when considering the impacts of climate change on coastal hazards. It also provided a good introduction to the adaptive pathways approach.

Motu – Economic and Public Policy Research 2017: ***Climate Change & Stormwater and Wastewater Systems – Motu Note #28.*** October 2017.

This paper was commissioned by the National Science Challenges – The Deep South Project. This Paper sets out the impacts that climate change will likely have on wastewater and stormwater systems, highlights a number of information constraints and recommends the use of the Dynamic Adaptive Policy Pathways (DAPP) framework when making decisions under uncertainty. Watercare was a contributor to this project.

Intergovernmental Panel on Climate Change: ***Summary for Policymakers. In: Global warming of 1.5°C.*** October 2018

For the first time this paper has brought light to the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways required to achieve this target. The findings in this paper are cited and were used as context for target setting.

Water Services Association of Australia (WSAA) 2016: ***Project Report: Climate Change Adaptation Guidelines*** – February 2016. WSA 303 - 2016-v1.2.

These WSAA Guidelines provided the high-level structure to Watercare's Climate Change adaptation and mitigation strategy. These adaptation Guidelines were selected due to their clear and logical structure, and ease of application to the organisation. Watercare is a member of WSAA.

Watercare Environmental Advisory Group (EAG) 2018: ***Watercare's Climate Strategy – EAG Recommendation Memorandum*** – July 2018.

Watercare's EAG made seven recommendations to the climate strategy, ranging from clarifying the development of the Strategy, through to monitoring and reviewing approaches, and suggesting a programme for the socialising of the strategy. These recommendations were incorporated into the drafting of the final strategy

United States Environmental Protection Agency (US EPA) 2015: ***The Climate Ready Water Utilities Adaptation Strategies Guide for Water Utilities.***

This US EPA Guide offers easy to follow and comprehensive guidance when developing an adaptation strategy for water utilities. This helped reinforce the structure followed for our adaptation workshops.

Watercare's Submissions in Relation to Climate Change

New Zealand Productivity Commission – ***The Low-Emissions Economy: Draft Report*** – April 2018

Watercare's specific interest in this Report was due to the particular question – "Should the New Zealand Emissions Trading Scheme be extended to cover wastewater treatment plants?" We submitted that no, WWTP's should not be included in the NZ ETS, primarily due to the uncertainties around accurately measuring GHG emissions. NZPC's Final Report (Sept 2018) recommended that MfE and Local Government New Zealand should begin a project to improve measurement methodologies for WWTPs, and WWTP's should be incentivised to reduce emissions.

Ministry for the Environment – ***Our Climate Your Say: Consultation on the Zero Carbon Bill*** – June 2018

Watercare supported the net zero emissions target for 2050, supported the establishment of a Climate Change Commission, and the developing of National Adaptation Plans.

Ministry for the Environment – ***Improvements to the Emissions Trading Scheme – Consultation Document*** – August 2018.

Overall support to the recommended high-level proposals, but did not get into any detail.

Forestry New Zealand – ***A Better ETS for Forestry – Proposed amendments to the Climate Change Response Act 2002 – Consultation Document*** – August 2018.

Gave overall support to many of the proposals to improve the ETS for forestry. Our substantive point was that the ETS should recognised the planting of indigenous forestry in place of exotic forestry on pre-1990 forestry land.