

SOUTH DUNEDIN

In order to respond to changes in our environment, we want solutions that support all aspects of our wellbeing and are fair for everyone.



MY WELLBEING IS WALKING IN MY OWN CULTURE AND PRACTICES

A PLACE WHERE WE ALL BELONG

LOTS OF TRANSPORT OPTIONS MAKE IT EASY TO GET WHERE WE NEED TO GO

THRIVING LOCAL BUSINESSES MAKE OUR COMMUNITIES VIBRANT AND PROSPEROUS

EAT WELL AND CHEAP

A PLACE WITH A STRONG COMMUNITY CAN LIFT PEOPLE UP WHEN THEY ARE LOW

CULTURAL Wellbeing
Our traditions and cultures are an important source of collective strength

ECONOMIC Wellbeing
A strong local economy and the ability to afford what we need allows us to thrive

SOCIAL Wellbeing
Social connection supports our wellbeing and sense of belonging

SPIRITUAL Wellbeing
Our beliefs and values guide us and give us a sense of connection, meaning and strength

PHYSICAL Wellbeing
We value spaces that allow us to be active and homes that help us to be healthy

MENTAL Wellbeing
Feeling safe and having hope for the future supports our wellbeing

BELIEVING in a HIGHER POWER HELPS ME IN TIMES of CHANGE

SAFE, AFFORDABLE, HEALTHY, HOMES

GREEN SPACE

PROTECT OUR DUNES

RESTORE OUR WETLANDS

TUNA USED TO BE PLENTIFUL HERE

OUR COMMUNITY OUR FUTURE
COMMUNITY at the HEART of DECISION-MAKING

IF A COMMUNITY feels IT IS BEING LISTENED TO AND ENGAGED with IN REAL TERMS, THEN the ABILITY TO BE RESILIENT to CHANGE WILL RISE

Healthy climate change adaptation in South Dunedin

LITERATURE REVIEW AND RAPID HEALTH ASSESSMENT OF THE THREE SHORTLISTED FUTURES

Healthy climate change adaptation in South Dunedin

Literature review and rapid health assessment of the three shortlisted Futures

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Glossary

He kuputaka reo Māori

This report uses Kāi Tahu dialect, except for te reo names of national organisations. For place names, we use both Kāi Tahu and colonial place names on first use, thereafter Kāi Tahu names, except when reporting on demographic and health data for Dunedin City, a statistically defined district. For the country as a whole, we use the national, informally accepted “Aotearoa” to stand in for the longer “Aotearoa and Te Wai Pounamu”, which is more commonly used by Kāi Tahu¹. This glossary is sourced from *Te Taki Haruru: Dunedin City Council Māori Strategic Framework*, public Kāi Tahu documents, and Te Aka Online Māori Dictionary.

	Explanation
Hauora	Holistic conceptualisation of good health, vigour and good spirits
Iwi	Nation, tribe, people, bone, strength
Kaupapa	Purpose, matter for discussion
Mana	Prestige, authority, control, power, influence, status, spiritual power, charisma. Mana is a state of being for a person, place or object
Mana whenua	Māori who have a genealogical connection to the land, and hold authority or jurisdiction over land or territory. A tribe’s history and narratives are based in the lands they have occupied over generations; the land provides sustenance for the people and hospitality for guests
Tākata Whaikaha	People who are determined to do well, used specifically to describe Māori with disabilities
Taoka	Prized possession, treasure
Whakapapa	Genealogy, genealogical table, lineage, descent

Technical terms

Adaptation	Responses to the effects of climate change happening now, and that we know are coming in the future, by changing where and how we live
Co-benefits	Positive outcomes that happen in addition to the main outcome desired by a policy or action (for example positive health outcomes from well-designed climate responses)
Health equity/inequity	Health inequities are differences in health that are avoidable, unfair and unjust, because they stem from decisions outside individual control, including in environmental, economic and social foundations of health. Different people with varying levels of advantage require different approaches and resources to achieve good health, including addressing unjust foundations (health equity)
Mitigation	Measures that respond to climate change by reducing human-sourced climate pollution to return us to safe levels of greenhouse gases in the atmosphere
Residual risk	Remaining risk of flooding and/or coastal inundation after any measures that are part of the chosen Future have been taken

¹ See for example Ōtākou marae kaumatua Edward Ellison discussing the proposal to change the official name of New Zealand to Aotearoa <https://www.rnz.co.nz/news/te-manu-korihī/452781/ngai-tahu-leader-let-s-not-rush-name-change>

About this report

The work behind this report was funded by Dunedin City Council and Te Pūnaha Matatini Centre of Research Excellence for complex systems. It was led by Ōtākou Whakaihu Waka University of Otago, in partnership with Te Whatu Ora Health NZ, Urban Intelligence, Yasmine El Orfi Creative Strategy, Design & Illustration, and Te Pūnaha Matatini.

It provides the background literature review and analysis that underpins the accompanying synthesis and comparative analysis report.

To complete this rapid assessments of the health and health equity effects of the shortlisted futures, we took a holistic view of health. We drew together our previous research with communities in South Dunedin with the *South Dunedin Future Workstream 3: Risk Assessment*, the *South Dunedin Future Workstream 3: Mana Whenua Risk Assessment Report*, the draft *South Dunedin Future: Pathway Summaries*, the December 2025 draft *South Dunedin Future: Shortlist Economic Evaluation*, an updated literature review on climate change and health, and more recent literature about climate change adaptation actions and health. We use **Futures** to mean the three shortlisted Futures (three, four and five) in the *Pathway Summaries* document.

The structure of the report aligns with the wellbeing framework identified by South Dunedin communities in our previous research, and we use quotes from our previous research to foreground South Dunedin community voices throughout.

A full Kāi Tahu led health assessment of the Futures is critical to underpin decision-making.

Key messages

1. All three shortlisted Futures are better for health and health equity than a status quo/no further action approach, which would bring substantial harms to health equity. These harms would arise particularly via mental health impacts, and via multiple pathways through degraded housing and fair access to the building blocks of health and wellbeing (jobs, schools, healthcare, healthy goods and services, social connection, and places that support social, spiritual and cultural wellbeing). For all scenarios, increases in accessible public mental health support and services (including grief counselling), and strengthened social services will be crucial.
2. All Future options will bring a mix of threats to health, as well as potential for win-wins for adaptation and health (co-benefits). Minimising the threats and maximising the benefits will require putting health equity at the heart of intervention design. This includes targeted engagement with groups likely to be disproportionately affected, such as the disabled community. Choosing between pathways will involve balancing wellbeing co-benefits, anticipating trade-offs, and putting in place measures to address negative consequences ahead of time.
3. Residual flood risk remains in all three Futures, due to the possibility of an overdesign event exceeding the capacity of an adaptation measure(s), infrastructure failure, or an underestimate of the accelerating effects of climate change under scenarios where global climate change mitigation is inadequate. Under these circumstances, many if not

all of the health and equity risks described in the ‘Status quo’ section of this health assessment will apply.

4. Tiriti rights, cultural wellbeing, and hauora ki Kāi Tahu will need to be intentionally designed in to ensure decision-making responds to Kāi Tahu values, and is health promoting for mana whenua. Further work is needed to incorporate a Kāi Tahu led health assessment into decision-making.
5. All the relevant health impacts considered are characterised by existing health inequities by income, ethnicity and disability status, many of which are mediated by built-in inequities in the existing housing system.
6. Measures to intervene in the housing system through stronger housing system governance are critical to protect health from the unintended negative consequences of all options. In addition, the housing for those who remain living with residual risk will require ongoing improvements in quality and resilience, accompanied by improvements in the right to healthy housing for tenants, especially tākata whaikaha and disabled tenants. Such measures (in order of effectiveness for protecting public health) include: full ongoing government-iwi-public ownership and control of residentially zoned land in South Dunedin accompanied by the creation of a resilient, affordable healthy housing area; strengthened city-wide land use governance, planning, and investment (including in partnership with iwi and community housing providers) in high quality, accessible public housing in preparation for property acquisition; tighter controls over zoning and development; ensuring infrastructure and public investment are sequenced and align well with strategic outcomes (rather than responding to market-led development)
7. New elevated land and development on higher ground have the potential to create new injustices. In the event of choosing pathways involving new land elevation, and for all new property development on raised land, it will be critical to ensure land value uplift and increases in development value are accrued publicly rather than privately, and used to reduce housing inequities, especially for those remaining on the flat. Otherwise, new housing-related social, economic and health inequities will be introduced.
8. Pathways to health outcomes often involving multiple social and environmental risks unfolding at the same time as a result of flooding and adaptation scenarios (e.g. damp housing AND rent increases AND loss of access to healthcare), that make responses that address the “root causes” of multiple risks most cost efficient and protective.
9. Climate changes will continue to have severe and wide-ranging health impacts, especially for future generations. Reducing regional, national and global greenhouse gas emissions will provide the greatest health protection. All Futures will have opportunities to mitigate, and, potential risks for exacerbating greenhouse gas emissions.

Introduction

Climate change is arguably the most important global and national public health threat now unfolding, with worsening impacts the longer that action is delayed. Worsening flooding caused by extreme rainfall and sea-level rise are costly and harmful consequences of climate change. At the same time, preventable illnesses and injury are the largest sector cost on society: in the 2025 government budget, the health sector dwarfed other sector operational spending, as well as being the highest equal capital cost. The most cost-effective prevention actions are under local government control, including choices about climate change adaptation, land use and housing.

This rapid review and qualitative analysis provides an overview of the possible health and health equity impacts of proposed shortlisted options for climate change adaptation in South Dunedin. The project had three goals: 1. summarise the up to date literature about sea-level rise, flooding and public health relevant to Ōtepoti Dunedin; 2. Apply the literature to a “status quo scenario” for Ōtepoti, and specifically South Dunedin; 3. Analyse possible effects on public health of the three shortlisted adaptation pathways for South Dunedin, including whether there are differential effects between the proposed pathways.

This report forms the basis for the accompanying synthesis for decision-makers. It is based on a rapid updated review of evidence about sea-level rise, flooding, and elements of adaptation linked to public health outcomes, a previous systematised literature review; previous health and climate adaptation research with South Dunedin communities, climate scientists and policy-makers; and evidence-informed expert judgement under substantial uncertainty and incomplete information. Further sense-checking was also undertaken with the South Dunedin Community Network.

Health and wellbeing encompass many highly interconnected, aspects. Public health understandings of health and wellbeing recognise these interconnections, as well as that health is influenced by environmental, social, economic and political contexts and policies, including housing, climate, social connection and the cost of living ^[1,2], and that unequal exposure to both positive and negative contexts and policies drive inequitable health outcomes ^[3]. Our previous qualitative work with South Dunedin communities included bringing together their own understandings of health as it related to flooding and sea-level rise, resulting in a set of important wellbeing outcomes, summarised in the illustration on the front cover of this report. This set of outcomes aligns closely with the climate health evidence, and has formed the basis for structuring this report, and the accompanying summary and analysis report.

While we have categorised impacts into different groups, it should be emphasised that they can happen together and are deeply interconnected. When individuals, whānau or communities are not well in one aspect of their health, this can have detrimental impacts on their wider wellbeing. Previous research in South Dunedin demonstrates these interconnections dynamically as feedback maps, to demonstrate how over time, adaptation choices can flow through into a range of positive and negative outcomes. A fuller description of these interconnections can be found [here](#), with an overview in Figure 1.

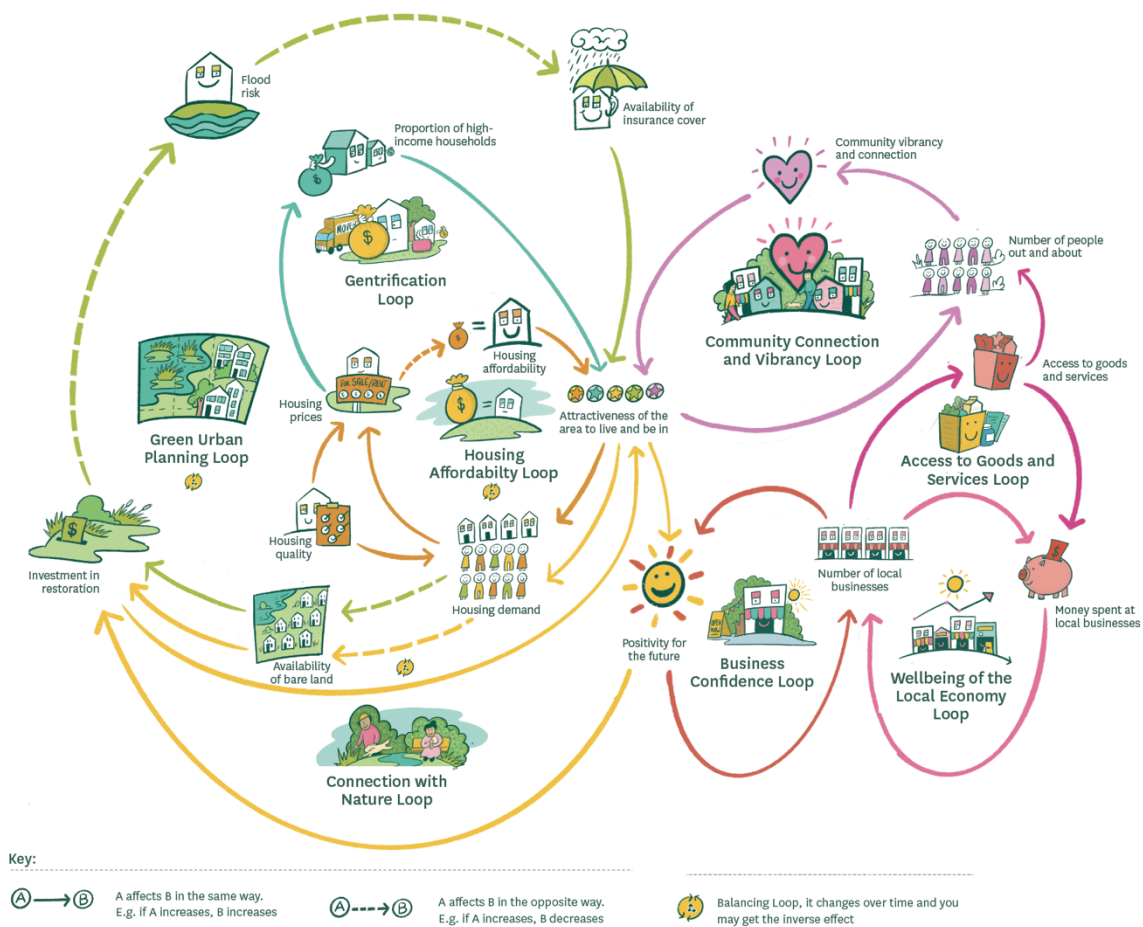


Figure 1 Dynamic interconnections between flooding, sea level rise and wellbeing^[4]

Fairness and justice are essential for everyone’s health and wellbeing, and consideration is given to how the three adaptation options may exacerbate or provide the opportunity to reduce existing health and wellbeing injustices, as well as consequences of the status quo approach. A justice approach to health also recognises that obligations exist to ensure mana whenua and Māori rights under te Tiriti o Waitangi and international instruments, including the right to health and tino rangatiratanga^[5,6], as well as wider human rights, including rights to health^[7], and the right to a decent home^[8]. We use the term ‘equity’, informed by evidence about the structural drivers of unjust climate-related outcomes (norms, institutions, social relations, and social stratification that affect health and equity in a given population), and Aotearoa-specific definitions and criteria for climate justice, especially Indigenous climate justice^[9–11]. Structural inequities in health are already prominent in Aotearoa NZ by income and ethnicity, particularly for Māori, across all of the health outcomes of relevance to this assessment. Intergenerational inequities are also important when considering climate change adaptation interventions – since existing children and young people, and future generations, will already face the harmful effects of our current collective inadequate mitigation actions, unequal harms to children and young people of adaptation choices represent a double burden of climate injustice. This also highlights the importance of giving weight to children’s and young people’s views on their own wellbeing in the adaptation options.

The health impacts described in this review primarily draw on sources relating to urban areas in high-income countries, though some insights draw from low- and middle-income countries where impacts are considered generalisable to an Aotearoa NZ context. Specific insights from research in South Dunedin are also provided throughout, with reference to two pieces of health research in South Dunedin: a healthy adaptation project by Harrison, et al. [12–14] which sought to understand the factors influencing the community’s wellbeing and aspirations for the future in the context of flooding and sea-level rise, and a project by Baillie, et al. conducting an analysis of post-flood hospitalisations following the 2015 flood [15]. While the focus is on the urban setting, many of the health impacts described are also applicable to rural communities. There will, however, be some unique climate-health connections relevant for rural communities, for example, implications of flooding for drinking water quality for those reliant on groundwater bores, and increased risks of becoming cut off from critical services (including health and emergency services) and social networks.

Reference to flooding throughout this review includes flooding related to sea-level rise, as well as to heavy rainfall.

South Dunedin – demographics, health and healthcare

South Dunedin is home for approximately 15,000 people, which constitutes 11.6% of Dunedin City’s total population^[16]. The population of South Dunedin is diverse, with a demographic profile that has some notable differences, relevant to South Dunedin Futures, from that of Dunedin City^[17].

This is demonstrated by the most recent census in 2023. At the time of the census, South Dunedin and Dunedin City populations had similar median age (39.7 years and 40.7 years respectively), however review of age distribution found that South Dunedin had a lower percentage of those aged under 29 years and a higher percentage aged 65 years or more. This was particularly noticeable in South Dunedin, St Kilda North and Caversham, the areas which contain several rest homes. In terms of ethnicity, compared to Dunedin City, the South Dunedin population had a slightly greater percentage of people who identify as Māori (12.8% compared to 10.8%) and Pacific Peoples (6.1% vs. 3.9%). Gender distributions were similar between South Dunedin and Dunedin City populations.

In the NZDep2023^[18], multiple areas of South Dunedin received scores of higher socioeconomic deprivation. Caversham, South Dunedin and Hillside-Portsmouth drive were scored as areas of the most socioeconomic deprivation (NZDep2023 9- 10), St Kilda and Forbury were areas of moderate socioeconomic deprivation (NZDep 7-8), and Musselburgh and Tainui areas had lower deprivation scores (NZDep 3-4). The only other areas of the city that had similar scores were Brockville, and the areas that comprised North Dunedin^[19].

Housing and mobility are other characteristics of the South Dunedin population that are relevant to the South Dunedin Futures proposal. In the 2023 census, a lower percentage of the South Dunedin population were homeowners compared to Dunedin City (42.5% vs. 51.1%), therefore rental tenure was relatively common. South Dunedin was also an area of high residential turn over, as the population had been occupying their homes for less time than Dunedin City (median years at usual residence 8.5 vs. 10.1). Mobility was another point of

difference as a greater percentage of the South Dunedin population reported difficulty walking than the Dunedin City population (13.7% compared to 10.8%). This difference was consistent throughout measures of increasing difficulty walking (i.e. some, a lot and unable)^[19]. These demographic data suggest that the South Dunedin population experiences health inequities.

In Aotearoa there are unfair, unjust and avoidable differences in health, which are distributed by ethnicity, socioeconomic status, disability and other social determinants of health including housing^[3]. The inequitable distribution of health is measured by many health metrics; self-rated health is one such measure. In the 2024/25 NZ Health Survey, most adults in Aotearoa rated their health as good, very good or excellent health. However, compared to other sub-population groups, Māori, Pacific peoples, disabled adults and tākata whaikaha, and those who live in the most socioeconomically deprived areas were significantly less likely to report good health^[16].

With regards to considering the South Dunedin Futures proposal, it is necessary to consider that the South Dunedin population is likely already experiencing inequitable health outcomes and will be more susceptible to the negative health impacts of flooding and adaptation measures.

The healthcare system of Aotearoa is already under considerable pressure due to increased demand for services. This is demonstrated by the wait times reported in primary care and hospital-based services. In the 2024/25 NZ Health Survey, wait time was the most reported barrier to primary care access, followed by cost. This experience was not equal, as these barriers to accessing primary care were more commonly reported by Māori, Pacific peoples, tākata whaikaha and disabled adults, and those living in areas of the most socioeconomic deprivation^[20,21]. Emergency Departments report increasing visit volumes, as a result only 72% of ED patients in 2024 met the target of being admitted, discharged or transferred within 6 hours of arrival^[22]. Hospital-based services have also been reporting long wait times, as approximately 40% of patients in 2024 were waiting more than four months for specialist appointments and elective treatments^[22]. Mental health services have been particularly in demand and there has been an increasing percentage of adults and children reporting unmet need for professional help for emotions, stress, mental health or substance use^[21]. This health system strain leaves many people with health care needs that are not being met, particularly Māori, Pacific Peoples and those living in areas of high socioeconomic deprivation^[23].

Local hospitalisation and ED visit data gives some limited insight into the unmet health need of the South Dunedin population. In 2025, 18.3% of Dunedin City Hospital admissions and 17.0% of ED visits in the Dunedin City population were South Dunedin residents^[24]. Both percentages were disproportionately higher than the percentage of the Dunedin City population that resides in South Dunedin – 11.6%. This use of hospital services by those living in South Dunedin suggests there is more unmet health need in this population compared to Dunedin City, likely due to the inequitable distribution of determinants of health, including access to preventative and primary health care services.

These health system pressures are relevant to the shortlisted Futures, as the health impacts of flooding and adaptation measures will increase demand for healthcare, a demand which services may have limited capacity to respond to.

Note: For this section, South Dunedin has been identified as comprising of eight Statistical Area 2s (SA2s); Caversham, Forbury, South Dunedin, Hillside Portsmouth Drive, Saint Kilda North, Saint Kilda South, Musselburgh and Tainui. Some of these statistical areas contain geographical locations that fall outside the area discussed in the South Dunedin Futures proposal (particularly Tainui).

SDF shortlisted options

These are summarised briefly below. There are some elements common to all scenarios:

- Early investment in improved stormwater pipes and water pumps
- Redevelopment of Forbury racecourse into a blue and green space
- Development of variable amounts of new medium or high-density housing behind the coastal dunes
- Rezoning of some houses and business to avoid (re)development or intensification, or to require raised floors/floodable ground levels
- Early acquisition of properties in roughly 8 lowest-lying residential blocks of Musselburgh (including potentially Tainui School), and a similar sized area of Forbury Corner
- Equally low amounts of residual risk of regular flooding for those remaining on the flat, with uncertain lower-probability, higher-severity risks from coastal flooding and infrastructure failure
- An economic assumption that redevelopment results in land value and property developer value uplift – though it's currently unclear who will accrue these benefits (Economic Evaluation Report)
- All open waterways are canal-like: soft sided with pumped flows
- All have effects on a mixture of key community services
- **Important further information is needed for all scenarios to improve understanding of health and health equity implications:**
 - **A summary of the mix of housing lost and gained by tenure type, including residential aged care**
 - **A full stocktake of community services and facilities to assess their comparative loss and gain over time (including early childhood education, schools, health and social services, community facilities, places for community connection, sports centres and fields, places for recreation, healthy and unhealthy food and beverage retail).**
 - **Expected changes in the ability to get around in South Dunedin on foot, and by wheelchair, bike and bus**
 - **The process and governance of housing (re)development**
 - **Greater clarity about the net numbers and area of greenspaces gained**

The health-relevant summary of differentiating features below is drawn from the shortlisted pathways maps and narrative descriptions, as well as further detailed information provided by SDF team, consultants, and the economic evaluation report.

Future 3

- Median amount of property acquisition, with slightly less net gain of property from redevelopment in the long-term compared to Future 5
- Redevelopment is medium-density in nature
 - Substantial amount of short-term property acquisition (1190 properties - more than Future 4, less than Future 5)
 - Addition of new properties in the medium-long term (2,130 total - more than Future 4, similar but slightly less than Future 5). New medium-density housing developed along Victoria Road and Forbury Road as land raising is completed
 - Area of retreated land greater than that of Future 3, less than Future 4 (80.7 hectares)
- Just under a third of a partial list of existing community identified services and facilities affected, including three community-identified health centres
- The greatest reliance on “engineered infrastructure”
 - A focus on pumps and pipes to achieve low residual flood risk
 - In the medium term, the harbourside seawall will be extended to Bayfield Park with the raising of road levels (this is the same as Future 4, but more extensive than the seawall suggested in Future 5)
 - Land elevation, particularly in the area around Forbury Corner, in the medium term, with development of new medium-density housing in the long-term
- Nature-oriented solutions are utilised the least
 - Some development of green spaces in the medium term, in low-lying areas such as Musselburgh, Forbury Corner, Bayfield Park, recreational sports grounds
 - Use of existing parks for stormwater storage in the short-term, and minor storage increases in the long-term

Future 4

- The least property acquisition in the short-term (1160 properties), however includes less addition of properties in the medium and long-term (910 total), thus net loss of housing. This is different from Futures 3 and 5.
- Greatest number of households remaining on the flat in low continuous risk
- New coastal high-density housing development on Victoria Road
- The smallest area of retreated land of all three futures (69 hectares)
- No land elevation, unlike in both Future 3 and 5
- Just under a third of a partial list of existing community identified services and facilities affected, affected, including one community-identified health centre
- Closest alignment with a “nature-based, making way for water” approach, with wetland restoration, and open water channels emphasised
 - Substantial use of “making way for water” through environmental restoration (wetlands, parks and reserves), as well as open channels and canals (16 hectare of wetlands and 3.5km of open water channels expected). This is the same as Future 5.
 - Use of recreational parks for water storage in the short term

- Construction of waterway network in the medium term, some alignment with natural systems and greenspaces.
 - Addition of greenspaces
 - Construction of green spaces in areas of persistent groundwater emergence
 - Greenspaces to include mix of natural reserves, sports fields and parks
 - Greatest emphasis on biodiversity restoration
- Greatest narrative attention paid to integrated land use planning for active travel

Future 5

- The highest degree of property acquisition and need for relocation in the short term (1740), followed by the greatest long-term net gain in housing (650 + 1660)
- Redevelopment of housing is medium density (Victoria Rd, Forbury Corner)
- Land elevation in the Forbury Corner area in the medium term
- Over a third of a partial list of existing community identified services and facilities affected, more than Futures 3 and 4, including one community-identified health centre
- Shorter seawall than Futures 3 and 4:
 - Requires property-level zoning and restrictions to manage inundation
 - Additional coastal protection such as inland coastal bund near Otaki Road in the medium term
 - Expectation over the long term that the commercial area along Portsmouth Drive will periodically flood with seawater during coastal storms
- Includes new open water solutions:
 - Water storage, canals as described in Future 4
 - Stormwater storage in recreational sports fields in the short term, connected to the waterway network and a pumped system
 - Construction of a network of canals, as described in Future 4, in the medium term
 - Greenspace similar to Future 4, with the exception of the area near Bayview Highschool which is likely to be converted to open space in the long term
- A greater intensity of intervention and construction in the medium-term period

When assessing the effects of the shortlisted options in the later parts of this report, we compare them with no further adaptive action (“status quo”), as well as each other. We undertook rapid reviews of the literature for the major components of each option, including some components that were common to more than one option (e.g. managed retreat, large-scale land elevation, land use change to increase blue- and green-spaces), as well as considering the effects of these options through the cause and effect maps generated in the South Dunedin healthy adaptation project ^[14].

Status quo

The status quo (doing no more than “business-as-usual”) option poses a significant threat to health and wellbeing from flooding and sea-level rise.

Community feedback suggests communities of South Dunedin recognise the risks associated with adopting a status quo approach, with those taking part in community engagement in 2025 overwhelmingly rejecting the approach ^[25,26]. The *Mana Whenua Risk Assessment Report* also highlights substantial risks to Kāi Tahu cultural values, and wider environmental, social and economic outcomes of continuing with the current pathway.

The health, wellbeing and equity impacts of flooding vary by flood severity (including velocity, duration, depth), emergency preparedness, and timely access to healthcare. As the climate changes, flood events will continue becoming more frequent and severe. The potential implications of a status quo response are also relevant for a failure of any of the other adaptation options (for example a major infrastructure failure, or an underestimate of the accelerating effects of climate change if global climate change mitigation is inadequate).

The overall effects of flooding and sea-level rise described below are not unique to South Dunedin, and are equally applicable to other parts of the city. However, further risks relating to access arise for more rural and remote parts of the city. It’s worth noting also, that climate change will have other effects on health across the city (e.g. through temperature extremes, ocean acidification, food supply and affordability, freshwater, mental health and climate-related migration).

Health equity

In public health, we define health equity as addressing the avoidable and unjust distribution of the social, economic, environmental, institutional and policy building blocks of health that underpin unequal health outcomes for population groups, for instance by ethnicity, socio-economic status, gender and age group. These are mostly outside individual control, and require collective actions by society to address, including by system leadership, local and central government and policy makers.

Worsening existing inequities

There is concern amongst those living in, and working with, the South Dunedin community that flooding or sea-level rise would exacerbate existing inequities by disproportionately affecting those already more susceptible to harm ^[12]. This includes those on low incomes or government income support, disabled people and tākata whaikaha, older adults, renters, those with existing health conditions, Māori and Pacific Peoples residing in South Dunedin, as well as those with no or limited English. As one participant from a study looking at the health and wellbeing impacts of flooding and sea-level rise in South Dunedin described: *“It’s kind of in the same way that COVID-19 hasn’t created inequities in society, all it does is blow apart existing issues”* ^[12].

This concern is backed by national and international evidence, which highlights that those already experiencing inequitable and unjust health or social outcomes will be disproportionately

affected by flooding and climate change^[6,27–33], with climate change adding to existing geographic injustices. For example, those on low incomes are less likely to be able to afford insurance or to pay for repairs from flood damage, meaning they are more likely to live in homes that are damp and become mouldy following an event. In Cyclone Gabrielle (2023), disabled people and tākata whaikaha, those with chronic conditions and older adults faced acute challenges in evacuating during flooding, with some becoming isolated for longer periods of time, heightening their risk and experiences of stress and anxiety^[34].

It has been observed also that a number of demographic groups who already experience inequities live in South Dunedin because it is flat and affordable, meaning they are also more geographically at risk in the first place^[35,36](see also^[29,37,38]):

“If you continue to have real [housing supply] pressure so that the only affordable housing is crappy private rentals in South Dunedin that have issues, you sort of force people into living in areas which do have increased flood-proneness and do impact their health”.

Those renting their homes in a market-based private rental sector are also likely to be disproportionately affected by flooding due to:

- lower likelihood of insurance cover compared to owner-occupiers^[39,40]
- Potentially facing eviction or rent increases following a flood^[41,42]
- Having little or no control over the repair of their flood-damaged homes^[39,43]
- Potentially having lower financial resources to be able to afford insurance cover or pay for lost or damaged items^[39,44]
- Existing higher rates of damp and mould in housing that would be worsened by flooding, as shown in the 2023 census data in Figure 2

Housing quality

● 2018 ● 2023



Dwellings that have mould

more than an A4 size page sometimes or always:

Owned

11.6%

9.9%

Not owned

28.0%

22.9%



Dwellings that are damp

at least some of the time:

Owned

14.8%

13.1%

Not owned

35.8%

29.2%

Figure 2 Rates of mould and damp in owned and rented dwellings, 2018 and 2023 census^[45]

Social and cultural wellbeing

Connection to place

Kāi Tahu have an unbroken, dynamic whakapapa relationship to what is now South Dunedin, a profoundly altered environment as a result of colonisation. The risks to Kāi Tahu values of a status quo scenario have been described in the *Mana Whenua Risk Assessment Report*, with implications for a holistic understanding of health and wellbeing that are not covered in this report.

For current residents of South Dunedin, flooding and sea-level rise alters people's sense of belonging and relationship to place and community, which form important aspects of wellbeing^[15,46-49]. When these connections and components of identity are altered, this can negatively affect wellbeing, including experiences solastalgia or distress, grief and loss from environmental change while still living in place^[50].

Disruptions to 'place' include the 'hollowing out' of communities that further undermines social networks important for wellbeing and resilience, and feelings of loneliness and being 'left behind' for those who remain^[48,51].

There are concerns within the South Dunedin community that increasing flood risk will, over time, lead to people, businesses and services to move from the area if they are able^[12]. This

includes a worst-case scenario, in which nothing is done to ‘save’ the area, leaving it to be potentially exposed to a catastrophic events, with fear and uncertainty leading to the area being considered a ‘lost’ cause. This could lead to a reactive and market-driven mass exodus of those who are able to leave, leaving those behind in increasingly deteriorating and high-risk conditions: *“The people who can afford to leave will leave, and the people who can't will remain there, dealing with the impacts”* ^[12].

Declining insurance cover would be an important driver of market-driven retreat, as participants in a study on the health and wellbeing impacts of flooding in South Dunedin noted ^[12] (see also ^[52]):

“The way insurers are looking at places like South Dunedin and whether they would continue to insure... When you said what's one of the worst-case scenarios, that would be a worst-case scenario for many people. You'd see potentially people walking away from homes or people just stop buying and so worst-case scenario, you could probably create small ghost suburbs or streets if people walked away. I don't think we're there yet, but it's a risk to be aware of.”

“The banks will say; we're not going to lend for people in there. And then what happens is that you start doing all this weird stuff to the market where some people will go in there and if they don't need insurance and they self-insure, and they don't need a mortgage, they'll end up buying up properties to rent and then you end up putting a whole new social structure in there... And that might be 20, 30, 40 years where you could completely collapse the market well before permanent inundation”.

For those who could not afford to move or sell their homes at a depreciated value, they may become ‘stuck’ in an increasingly at-risk area ^[12]:

“The people who can't afford to get out or who are renting are stuck there. And that's where you get that situation of a kind of slum happening where your property price is dropping, but someone's gonna live there because you've got a population who doesn't have anywhere else to go”.

In turn, this could lead to an increasing concentration of low-income and rental households, further reducing the appeal of the area for those who can afford to live elsewhere.

Potential flow-on effects of a large movement of people from the area for wider community wellbeing include:

- Loss of social connections, particularly important for those living alone and older adults
- Reduced sense of safety or security if social networks move out of the area, particularly for older adults whose main point of social contact may be their neighbours checking in on them, for example
- Declining school rolls
- Declining income for local businesses
- Declining investment in the community, affecting community pride and vibrancy
- Additional demand pressure on the availability of affordable housing or temporary accommodation elsewhere in the city

- Longer vehicle commute times to work or education from other areas of the city, which can negatively affect physical wellbeing.
- Loss of place-specific community and intergenerational knowledges about food growing

Economic and financial wellbeing impacts

Flooding impacts the financial and broader economic wellbeing of households and communities, resulting from property damage, the loss of assets, and disrupted access to goods and services ^[53–58]. The financial and economic flow-on effects include:

- Reduced business operations
- Lost wages from time taken off to recover
- Reduced productivity or increased absenteeism due to people’s ongoing experience of negative psychological and physical effects

Where negative economic and financial impacts reduce people’s disposable income, this can increase stress levels and undermine their ability to afford quality housing, nutritious food, and healthcare that support good health and wellbeing ^[59–62]. Those already on low incomes or with high employment precarity are likely to be disproportionately affected, and there are concerns that residents in South Dunedin could turn increasingly to predatory lenders in times of flood-related financial stress ^[12].

Concerns have been raised that if recurrent flooding or increase flood risk lead to the temporary or permanent closure of businesses and service providers in South Dunedin, it could negatively affect the wider city’s economy by making it harder to attract high-skilled workers, and would also negatively affect the sense of energy and vibrancy in the area ^[12]:

“It’s also the perception of how well the area is doing. People want to feel that they’re living in an area where there’s a bit of life and something’s growing. It’s a bit of vibrancy, because if you’re in decline, it affects your mood”.

Housing, services and infrastructure

Housing and health

Housing is a key mechanism through which flooding can indirectly affect a wide range of physical, mental, socioeconomic, and cultural health outcomes. This occurs via various means, including ^[41,54,63–67]:

- Reduced ability to heat one’s home, due to persistent dampness. Those experiencing fuel poverty are disproportionately affected
- Overcrowding as a result of mismatched design, unaffordability, displacement, or damage to housing, for example an entire family sleeping in the same room
- Growth of mould and fungi due to damp housing conditions
- Leading to displacement and homelessness, including increased wait periods for public housing

Associated health impacts include ^[68–71]:

- Worsening or increased risk of respiratory and cardiovascular illnesses (e.g. asthma, mould allergies, chronic smoking-related lung disease, high blood pressure, heart attacks and strokes)
- Negative mental and emotional wellbeing implications of living in damaged, damp, cold, mouldy or insecure housing
- Reduced social wellbeing, due to not wanting to have people over to poor-quality housing, or because of reduced overall wellbeing from living in poor-quality housing
- More broadly, negative social, mental and financial wellbeing impacts associated with absenteeism from school and work

Flooding and sea-level rise (raising the groundwater table) would exacerbate widespread issues of poor-quality housing in South Dunedin related to a number of factors, including ^[12]:

- Age and condition of the housing stock
- Use of poor-quality construction materials
- Inadequate housing and rental standards
- Poor ventilation and heating

As has been described ^[12]:

“In South Dunedin a lot of older homes are still not double glazed, so dampness even without flooding is gonna be an issue. Damp and mould, and then if you have got water with flooding issues it's just going to make it even worse trying to dry them out, but also for people's health”.

For those subject to recurring flooding, they may be hesitant or unable to claim on their insurance because of high excess payments, or fears over coverage and no claims bonus losses or increased premiums, meaning they continue living in flood-damaged homes ^[72].

Over time, as flood risk increases, the area is likely to become less attractive to live in and property values may decline. Homeowners (including landlords) may be less likely to pay to upgrade or maintain their property, leading to deteriorating conditions ^[12].

In addition to housing, prolonged periods spent in other flood-damaged indoor environments can negatively affect health and wellbeing e.g. schools, workplaces.

Disrupted power supply and health

Loss of power due to flooding can negatively affect health in numerous ways, including ^[64,73–76]:

- Compromising electronic medical equipment, as well as to equipment and medications used in health and residential care
- Lead to food spoilage and prevent some from boiling contaminated water
- Increase the risk of falls, due to a lack of lighting
- Increase fire risk where alternative means of heating and lighting (e.g. candles) are used
- Compromising emergency relief operations (including loss of communications), with implications for provision of emergency healthcare and access to flood-affected people.

Health system impacts

Increased direct and indirect negative health impacts from severe and/or recurring flooding can create additional demand on health system services, with potential implications for system capacity and provision of timely treatment. This is particularly likely during a sudden, severe event ^[27]. Additionally, flood damage to healthcare services (including primary care, mental health, and oral health services) can compromise their ability to provide care, as a result of ^[63,77-80].

- Loss of medical records
- Compromised medications,
- Compromised sterile storage for surgical equipment
- Disruptions to power and clean water supply
- Disruptions to staffing such as occupational safety risks and reduced availability of staff (due to personal flooding health and wellbeing impacts)

Access issues

Where flooding compromises transportation infrastructure or access more generally, this can have a range of negative impacts, with implications for health and wellbeing, including ^[64,78,80-82]:

- Negative mental wellbeing due to stress or social isolation
- Disrupted access to emergency services and routine healthcare

Insights from a blind South Dunedin resident give an example of the difficulties that arose when flooding caused changes in the layout of their healthcare provider's premises ^[12]:

“It was an inconvenience for everyone, but for me, the places I go, me and my dog have to sort of learn the routes to where we're going. It's like going somewhere new and so then you don't know your way around. And for some people, just going to new places is stressful anyway”.

Additionally, disabled people and tākata whaikaha experience disproportionate challenges during a flood in evacuating, accessing emergency information, and getting to evacuations centres that are accessible and meet their needs ^[83].

Over time, increasing flood risk and reduced insurability of properties could mean businesses and services leave the area, potentially reducing access to the goods and services that support wellbeing, especially for those with mobility challenges such as older residents and members of the disabled and tākata whaikaha communities ^[12].

Mental wellbeing

In high income countries, the mental health impacts of flooding are the most widely experienced, more so than physical health impacts ^[53,54,84-89]. It is likely that the majority of those who experience floods will be negatively affected, whether that be immediate symptoms following the flood or long-term conditions that are persistent for years afterwards ^[39,87,90-92]. Studies show that compared to prior to the flood, or to non-flooded populations, those who

experience floods are much more likely to experience negative health impacts^[86,93]. This likelihood is thought to be increased for those who had persistent damage to or had flood water in their home, experienced disruption to services, had to relocate for over six months and experienced displacement^[88,89,93,94].

Negative mental health impacts include: stress, depression, general mental distress, anxiety, sleep disruption, grief, sense of helplessness, and post-traumatic stress disorder^[34,54,55,95–104].

These can arise from:

- Lived experience of flooding
- Anticipated experience of flooding or fear of future flooding, including when it rains^[27,34,39,46,105]
- Repeated flood exposure^[106], or anticipation of recurring flooding^[107],^[108],^[109]
- Loss or damage to homes and property, which can form an important part of one's identity^[27,84,110], and associated loss of sense of belonging to place, even for those able to return home^[27,46,84,111]
- Disruption to daily life^[27,46,111]
- Evacuation and displacement^[39,53,55,112,113] (or, anticipation of having to leave) can cause persistent negative mental and emotional health outcomes, particularly for older adults^[47,114] and those who are disabled. As one disability advocate described as part of previous research undertaken in South Dunedin:

“Some of the people in the floods... all of a sudden they needed to move and they had nowhere to go. They had no control over their lives at all. There was no accessible accommodation, so people had to go in motels or were uplifted and relocated without choice or any consideration, and actually nowhere to go.”

- Disrupted access to social networks and loneliness^[47]
- Financial stresses related to losses or damage sustained during a flood, loss of insurance cover or increase premiums, and concerns about declines in the value of one's property^[27,39,84,93,93,111,115]
- Disputes with insurance companies^[116]
- Awareness that climate change is a man-made problem, which may lead to feelings of anger, despair and a more complex grief process^[117,118]
- High stress levels associated with an event can lead to an increase in violence, particularly towards children, women, disabled people and tākata whaikaha^[119,120].

The many interactions between flooding and mental health can create a downward spiral for mental health (for example disrupted social networks, plus loss of insurance cover, followed by having to move as a result, leading to further worsening of social isolation, anxiety and depression). Ongoing and repeated evacuation and displacement can compound negative impacts.

In South Dunedin, the mental health impacts of flooding under a status quo scenario are likely to be widespread and long-term, with a range of severities from mild/moderate requiring

primary care treatment and medication use, to a smaller proportion requiring inpatient treatment.

Residents who experienced flooding in 2015 describe some of the emotional toll they and others in the community experienced and continue to experience ^[12] (see also ^[35]):

“Every rainfall, you're scared that every time you [will] get flooded. This goes through my mind all the time.” (p.141)

“One of the impacts of flooding is fear and the sense of helplessness, which leads to depression and/or anger... I think fear and helplessness and anger sits like a miasma over this stuff.” (p.141)

Those who are directly exposed to flooding are more likely to experience negative mental health impacts, although those affected by flooding (but not exposed) can also experience negative effects ^[94,121].

Psychological distress can also affect first responders, healthcare workers, and others involved in the emergency response ^[77,122–125].

Older adults ^[39,54,114,126], those with existing health conditions, former refugees, and women may be more likely to experience anxiety, depression and symptoms of post-traumatic stress disorder (PTSD). Women may have slower recovery status due to typically bearing the main responsibility for looking after dependents ^[39,46,127]. More generally, not having sufficient social support appears to increase the risk of worse mental health outcomes ^[114].

Social connections are essential for supporting mental wellbeing before, during and after an event. For some, access to religious or spiritual community is important for supporting one's spiritual and social wellbeing ^[128], though flooding may undermine ability to access one's place of worship and community of faith.

Negative mental wellbeing (e.g. stress) is also linked to negative physical health outcomes, such as an increased risk of cardiovascular disease ^[129,130].

Community vibrancy and wellbeing

Closely connected, but not exclusive to, the negative impacts of flooding on the local economy and the desirability of the area to live in is the importance of community vibrancy for supporting residents' wellbeing. Research in South Dunedin reports concerns about economic decline and loss of community, both actual and perceived, negatively affect community wellbeing ^[12]:

“It's depressing... it's just a loss of community. Loss of a sense of community and loss of actual community. Community is a collection of people. And if you don't have that, it's gone. And it's a cyclical type thing, so if a café shuts down, and a group of shops, then the people who go to the cafe and then go shopping don't go. And it's a cycle, it's a downward spiral”.

Declining investment in a geographical community or changing demographics can be incremental, but may also reach a tipping point where change occurs rapidly, making management of change especially difficult ^[113].

Recurring flooding can also negatively impact vibrancy and the appeal of the area to live and be in by compromising assets such as green spaces, recreational facilities, and the other public spaces.

Physical health

Flood-related deaths

Deaths can occur during, or immediately subsequent, to flooding events. A review of international flooding events found the median number of deaths per event was 9 ^[131]. Nationally, recent examples of flood-related mortality include three drownings during the Auckland Anniversary floods (2023) ^[132] and 11 fatalities during Cyclone Gabrielle (2023) from drowning, landslides, hypothermia and the loss of medical oxygen supply ^[133].

The most common form of flood-related death in high-income countries are drowning and physical trauma from contact with debris ^[104,131,134,135]. Other causes of flood-related death include those arising from ^[54,81,134–136]:

- Exposure to cold
- Fires
- Electrocutation from downed power lines or other damaged electrical wiring ^[137]

Deaths occur more often in major urban areas, when people become trapped in motor vehicles or engage in unnecessary risk-taking ^[54,56,134,138].

- Men are at a higher risk of dying as a result of flooding than women ^[28,131,138]
- Children are also at higher risk of death both during and post-flood ^[139]
- There is some evidence that those who drown in their homes are more likely to be elderly ^[134]

Non-fatal injuries

Non-fatal injuries are commonly reported following flood exposure ^[134]. More severe floods (e.g. flash floods, those with fast-moving waters) pose a higher risk of injury ^[29,34,54,126,134].

- Cuts, puncture wounds, subsequent loss of limbs, sprains, strains, fractures, burns, electric shock, and inhalation injury can occur from being hit by debris during a flood or in post-flood clean-up, and by rapid attempts to evacuate and secure possessions and property (including prior to the flood)

A descriptive analysis of acute hospitalisation events before and after the 2015 South Dunedin flood found that hospitalisations with injury diagnoses increased in the flooded population compared to the non-flooded population ^[15]. The flooded population was 3.2 times as likely to be admitted to hospital with an injury compared to the non-flooded population (note; flooded population injury hospitalisation rate was 1.6 times as high in the flooded group compared to the non-flooded group in the six weeks prior the flood) ^[15].

Respiratory health impacts

Upper respiratory infections are one of the most common diseases caused by flooding [46,140–142]. Those directly exposed to flooding are the most likely to develop respiratory illness following an event, compared to those not exposed [101,140,143]. The risk increases due to exposure to contaminated water, overcrowding in evacuation centres, and damaged or damp housing [54,63–65,69,137,144]. Risk is also linked to duration of flooding, as one study has estimated a 1% increase in influenza diagnoses per day of flooding [145].

Following a flood, there is evidence of increased non-infectious respiratory disease, including asthma, hay fever and mould allergies [65,68,69,86,140,145]. This is attributed to worsened air quality [146,147] and damp and mouldy housing [65]. Fungi and moulds that produce airborne toxins are known to worsen asthma [148–152]. Hospital admissions from respiratory infections and asthma rose in areas of South Dunedin flooded in 2015 and remained high after 3 months, suggesting that longer-term housing dampness is already an important issue [15].

Damp housing and asthma are already very important health burdens in Aotearoa [153], where the prevalence of both is higher than most OECD² countries. They have lifelong and intergenerational consequences through time off school and poor educational outcomes, leading to lower income in adulthood, and an increased likelihood of intergenerational poor housing for the children of these adults, reinforcing health injustices.

Other infectious disease

Flooding is a known risk factor for infectious diseases, including those transmitted through contact with contaminated flood water, swimming in contaminated coastal waters and food, or by increasing migration and habitation of ticks, rodents and mosquitos (however this is observed mainly in tropical climates) [137,144,154,155].

In South Dunedin, the most relevant infectious disease exposures are contact with contaminated flood [54,156–158] or sea waters [159] (during and following an event, including as part of clean-up activities), or consumption of contaminated food (especially contaminated seafood). These are important risk factors for a range of infectious diseases, including:

- Gastrointestinal infections [46,86,88,140,160,161]
 - A descriptive analysis of acute hospitalisation events over a 10-year study period (01 January 2010 and 31 December 2019), before and after the 2015 South Dunedin flood, found that gastrointestinal and skin disease diagnoses peaked in the flooded group within six weeks of the flood [15]
 - More broadly, drawing on a prospective cohort of children born in Aotearoa between 2009 and 2010, study authors found that the overall risk of hospitalisation with waterborne diseases (enteric bacterial and viral infections) almost doubled in the two days following heavy rainfall [162]
- Skin infections and irritations (e.g. inflammatory skin diseases such as dermatitis, skin infections such as cellulitis and impetigo) [34,46,86,160,163,164]

² The Organisation for Economic Co-operation and Development (OECD) includes 38 member countries and the European Union, many of them high income countries, to inform policy, develop global standards and best practice, and provide benchmarking or comparative data between members.

- Ear, eye infections ^[144,163]

Bacterial skin infections have already been increasing over time in Aotearoa, with Australasia having the third highest rates of any region (after Sub-Saharan Africa and South Asia). They are unjustly distributed by income and ethnicity. Streptococcal skin infections (e.g. impetigo or school sores) are important because these bacteria can lead to rheumatic fever and severe kidney inflammation ^[165]. These risks are increasing as climate change progresses because of temperature and rainfall changes ^[166].

Those at heightened risk include:

- Immunocompromised individuals, at risk of severe illness ^[144]
- Children may be at higher risk of waterborne infectious diseases due to poorer hygiene practices and immature immune systems ^[139,167]

Infectious disease spread following a flood disaster may also result from disruption to healthcare services, overcrowding, and unhygienic living conditions ^[29,54,56,134,163,168,169].

Chronic, non-infectious illnesses

While there appears to be little evidence regarding the impact of flooding on chronic illness, this is highly likely due to methodological challenges of conducting such research, rather than a lack of risk.

There is some evidence that heart diseases and stroke may also be linked to flooding ^[46,170–173]. This includes in South Dunedin, where heart disease and stroke increased for a short period after the 2015 flood ^[15].

There is an increased risk of chronic diseases like diabetes, cancer, and chronic cardiovascular disease due to interruption of treatment and care ^[46,64,171,174–176]. Interruptions include ^[47,174,177]:

- Damage to healthcare system infrastructure
- Disrupted access to healthcare services and medication
- Displacement and evacuation,
- Unhygienic living conditions
- Loss of electricity powering medical equipment, such as oxygen

Those with a chronic illness which means they rely on electrical medical equipment are particularly at risk when flooding results in power loss ^[137].

Residents of aged care facilities in the area are susceptible to harm, particularly those in nursing homes who have existing health conditions and are reliant on others to evacuate ^[178].

Exposure to hazardous materials

Flooding can cause the release of dangerous chemicals such as pesticides and other toxic materials such as asbestos and trace metals into contaminated water, mud or materials. These contaminants affect ecosystems, including humans, and tend to accumulate with very long-term effects because they do not break down. Human exposure to contaminants is associated with ^[157,179] ^[29,64,88,180–184].

- Cancer, cardiovascular, gastrointestinal, and neurological diseases
- Nausea, sore throats, skin irritation, stomach pain
- Negative impacts on children’s growth and development, with some toxic chemicals acting as endocrine disruptors
- Carbon monoxide poisoning from using gasoline powered devices, for example to heat or dry out buildings

In South Dunedin, a number of Hazardous Activities and Industries List (HAIL) contaminated land sites are at risk from flooding and coastal erosion, which could lead to the spread of hazardous materials ^[185], and chemical and trace water pollution is an identified issue for fresh and marine waters close to urban areas in Aotearoa^[186].

Pregnancy and birth outcomes

Flooding may be linked to negative pregnancy and birth outcomes, arising from ^[139]:

- Direct physical health impacts of flooding
- Stress and other negative mental health conditions
- Disrupted access to healthcare services

Potential outcomes include lower birthweight and shorter length of gestation, associated with higher risk of ^[139,187]:

- Higher risk of infant deaths and illnesses
- Developmental problems
- Immune system impacts
- Poor nutrition in early childhood

Health implications across the three shortlisted futures

In the following sections, we apply the same wellbeing framework identified by South Dunedin community participants in previous research, to consider the potential negative and positive health, wellbeing and equity implications of the three draft shortlisted futures, noting again the incomplete information currently available, and the ability to shape these outcomes through attention to more detailed design, as well as choices about governance and implementation. Many of these consequences are possible with all three pathways, while some would only be seen in one or two of the pathways. Alongside risks to health and wellbeing, each of the adaptation futures offers potential opportunities to promote health and equity^[188,189]. Despite all the options having some opportunities for health co-benefits, these won't happen as a matter of course – rather, these win-win opportunities will need to be designed in.

Many of the possible consequences are also relevant to similar possible pathways for climate change adaptation to flooding and sea-level rise across the city.

Health equity

We note that in all scenarios, property acquisition and relocation precedes the development of higher density housing on elevated land. Unless there is targeted affordable housing investment in South Dunedin or the wider city in preparation for property acquisition, this will increase pressure on housing affordability locally and city-wide, adding to the housing crisis already underway in Ōtepoti (homelessness, housing unaffordability, private rental supply pressures), increasing health and social inequities.

There is a high risk that adaptation, if undertaken with narrow scope that focuses on infrastructure and land use change without considering the wider flow-on effects and the building blocks of wellbeing, will worsen existing health and social inequities. This can take many forms, for example, those already experiencing inequitable outcomes will be further disproportionately affected in the following situations:

- If adaptation measures increase the appeal of the area to live in, driving up house and rent prices, reducing affordability for existing residents
- Where residents are required to relocate within the existing constrained housing market, are not given sufficient support to do so, are moved to areas that are further away from the places and services they need to access (including without adequate public transport options), or are relocated to housing that does not meet their needs (e.g. affordability, quality, size, accessibility)
- When accessibility is not incorporated into the design of adaptation measures (e.g. relocation of communities to raised land)
- If relocated households are supported into higher quality housing in lower flood-risk areas, while remaining households carry residual risk and continue to bear the health consequences of poor-quality housing, this creates new “postcode lottery” inequities.

Reduction in health inequities related to housing

Managed relocation under all three Futures offers the opportunity to improve the quality of housing in the area, with significant potential to improve health equity by reducing the disproportionate burden of poor health outcomes on those living in sub-standard housing. This can be achieved by:

- Using design that exceeds the healthy home standards, ensuring healthy indoor environments
- Increased energy efficiency to heat and cool homes providing financial resilience against energy price increases
- Adhering to universal design principles that ensure building design that suits people of all ages and ability, to support accessibility for all

The significant health gains possible via improvements to housing quality would improve quality of life, reduce school and work absenteeism, and provide associated financial benefits from cost savings and increased productivity. While those currently experiencing housing and health inequities would benefit the most, though such measures would positively support health and wellbeing across all affected households.

Reduction in transport health inequities through improved active travel

All three Futures have opportunities to incorporate urban design that supports active forms of transport (walking, cycling), which would have benefits for health equity by enhancing access to work and education, reducing costs associated with travel, increasing physical activity, and reducing air pollution which disproportionately affects those with existing health respiratory and cardiovascular health conditions (including Māori and Pacific Peoples), children, and older adults.

Residual risk

All three adaptation futures still have residual risk, which remains moderate in the short-term, before lowering over the longer-term. Residual risk could include a major infrastructure failure during an extreme weather event within the 100-year period accounted for in the risk assessment and adaptation design (2025-2125) ^[12]:

“You can on the surface appear to be creating a safe city because you invested in some pipes or whatever and you're like ‘cool we fixed the problem’... It decreases the risk in the present... but you increase the risk down the track of a failure, and you increase the risk because you potentially increase the density of people living there”.

There is also residual risk from coastal flooding over the long-term for all Futures, as sea-levels rise. Where adaptation measures fail or become overwhelmed, many if not all of the health risks described in under the ‘Status quo’ section of this health assessment will apply. Where present-day adaptation actions create perceptions of safety, encouraging existing residents to remain in place or new residents to move into the area, this may maintain or even increase the total population at risk from hazardous and catastrophic flooding. This risk may be heightened if measures undertaken as part of (or alongside) adaptation increase the appeal of the area to live in (e.g. investing in community facilities and restoring natural spaces, improving housing quality

etc). The inclusion of areas for medium- or high-density development under all Futures could mean more people potentially living in the area, with residual risk.

In addition to residents, businesses and service providers are also subject to this residual risk.

Beyond 2100, sea-level rise and the severity of extreme weather events are likely to continue to worsen, meaning that long-term future risk may see younger and future generations faced with similar risk and decisions about adaptation responses that reflect similar threats to health, wellbeing and equity as those outlined in this health assessment.

Emissions associated with adaptation

It has been recognised that there is likely to be significant emissions associated with the implementation of all three futures ^[26], which contributes to the very same sea-level rise and extreme weather events that negatively affect health, wellbeing and equity outcomes both in Aotearoa and globally.

Taking actions to reduce the level of emissions generated by adaptation activities, planning to ensure relocated communities have ample options for active and public transport to reduce travel-related emissions, and making the most of opportunities to enhance natural spaces that can absorb emissions can go towards mitigating some of these consequences of adaptation.

Social and cultural wellbeing

Disruption and loss from change

The three proposed adaptation futures all represent change to the South Dunedin community and area. Change, including transformative change to reduce flood risk, may affect people's sense of place attachment and be perceived as posing a threat to one's existing quality of life ^[113]. Transformation of landscapes are expected to be greatest for Futures 3 and 5, as they include land elevation measures. Future 5 in particular is expected to have the highest number of buildings demolished and land retreated from.

While the 'status quo' option also results in change and loss, it may feel more abstract or like something of which the full effects will only be felt 'later' and possibly not within the lifetimes of many current residents (whether this is true or not). In comparison, the more proactive approach of undertaking adaptation before worse scenarios eventuate may, ironically, engender feelings that actions were undertaken 'too early' or were an 'overreaction' to a problem that is perceived to be 'solvable' with via less intrusive or conspicuous measures.

Even for those in the community who fully support the need for adaptation, and even when changes are well-signalled and developed with as broad a range of community support as possible, change remains a difficult process for many that requires sensitivity to support wellbeing. This may be particularly relevant for those who may be formally relocated ^[12]:

“Even if [the community] may accept the necessity of it on some level, [managed retreat] will have traumatic effects on a lot of people... Even if there were many positive things that are associated with it in terms of better quality housing and things like that,

people are going to miss things and feel that impact of having to move out...because of reasons that are out of their control. There'll be others that will probably embrace the change... But I think without question, there will be significant negative effects in general across the community associated with any kind of managed retreat”.

In addition to relocation, adaptation is likely to result in changes in the ‘feel’ of the community, its make-up, how it looks, and its landscape. Impacts of these changes on health can include feelings of distress, trauma, grief, sense of loss, diminished sense of belonging. This may happen even if the area is ‘improved’ as a result of the adaptation measures, simply because they represent a change or disruption to what has been. These feelings may also be held concurrently with positive emotions (e.g. hope, relief action is being taken, optimism about how the community may look in the future). Awareness and acknowledgement of this complexity may help people to process their range of their emotional responses.

Alterations to the land and built infrastructure in the community to accommodate waterways, wetlands, and land grading may also be viewed as a loss of local history and what ‘makes South Dunedin the place it is’ that can undermine cultural wellbeing. For example, if historical buildings or sites need to be removed or converted to natural spaces. This loss is also likely to occur under a ‘status quo’ approach, however the act of witnessing these changes being actively, and in some instances perhaps very suddenly, undertaken as part of a planned process, rather than a more gradual deterioration from flood exposure, may engender more acute negative feelings for some people. The loss people may experience as part of these processes should be acknowledged, and inclusion in design of new spaces made where possible.

Approaches which engage in genuine partnership with community may help to reduce these negative experiences and support peoples’ sense of agency, self-determination and ownership of the process that is essential for wellbeing and acceptance of change ^[12,190,191].

Meaningful Te Tiriti partnership with mana whenua specifically aligns with upholding the value of ‘mana’ that forms part of *Te Taki Haruru: DCC Māori Strategic Framework* principles and values ^[192].

Displacement

One of the most significant, acute forms of disruption arising from the three adaptation futures is that of the displacement of people where relocation will occur. This is likely to negatively affect the wellbeing of those who are displaced by various means ^[113,193–196]:

- Undermining access to social networks
- Undermining access to local services including healthcare, facilities, schools, and workplaces
- Disrupting connection to place and sense of belonging
- Reduced sense of self-determination, or control over one’s life
- Negatively affecting financial wellbeing
- Relocation to poor quality, insecure housing
- Social conflict or tensions relating to limited resources, including land or housing

The negative effects of displacement are likely to be experienced inequitably. For example, the disabled community within South Dunedin will be disproportionately affected by disrupted access to formal and informal support systems. Many disabled Ōtepoti residents live in South Dunedin specifically because of its flat topography, and because of this, this is where many have their social networks and where many service providers operate from.

Some people in South Dunedin have already experienced various forms of displacement from home countries (e.g. through war, political unrest, and climate change). Further threat of displacement is likely to trigger past displacement trauma.

When people are displaced, the ability to remain close to their existing community may help to lessen some of these negative impacts, by continuing to provide access to social supports and usual services^[197], and minimising changes to commute times. However, negative impacts can still arise from relocation even when many residents relocate to nearby areas and therefore are able to maintain many of these links. For example, following the Christchurch earthquake, there was an increase in the likelihood and frequency of those mandated to relocate (generally within the city) receiving treatment for moderate mental health problems^[198]. This effect continued for over two year and persisted over the longest period for older adults^[198].

Consideration should also be given to the wellbeing of residents in receiving communities (i.e. the areas which people who have been displaced move to), including the impacts of disruption, change, and increased demand for local housing^[199]. There is increasing guidance from international experience about processes that build in positive benefits while avoiding harms.

Future 5 is expected to have the largest proportion of buildings demolished and land retreated from, followed by Future 3, and therefore the highest degree of adaptation-driven displacement. However, if a larger number of properties remain situated in areas on the Flat with greater relative risk during an extreme weather or coastal flooding event under Future 4, there would be higher likelihood of post-event displacement compared to the other Futures.

Opportunities for improving cultural wellbeing

Harrison's work showed that cultural wellbeing can be supported by processes that create opportunities for people to process and positively reimagine their connection to place, and are undertaken in ways that are culturally appropriate for the many diverse communities within South Dunedin.

Increasing connection to nature

All three adaptation futures allow for an increase in the amount of natural space in the area, including varying degrees of biodiversity and ecological restoration. In addition to being an important ecological wellbeing outcome itself, enhanced and biodiverse natural spaces help to mitigate flood risk, and provide a wide range of other co-benefits for health. For example, exposure to urban natural spaces (green, blue spaces) has been associated with^[189,200–211]:

- Increased physical activity, including where there are opportunities for active transport (walking, cycling), associated with reductions in the prevalence of obesity, cardiovascular disease and cancer

- Increased opportunities for recreation, socialising and community-building in natural spaces
- Deepened relationships with, and ethics of care towards, te taiao, the natural world
- Improved mental health, particularly lower levels of anxiety and depression and psychological benefits
- Higher self-reported health
- Social interactions and community bonding
- Higher self-reported sense of community belonging and attachment to place ^[203]
- Reductions in crime, violence and aggression
- Lower rates of morbidity in a range of diseases including cardiovascular, musculoskeletal, respiratory, neurological, and digestive diseases
- Potential reductions in noise pollution
- Specifically, health benefits for older adults' health, including lower mortality, slower decline in walking speed, lower risk of cardiovascular disease, slower cognitive decline, stress reduction, decreased inflammation, improved social connectedness, and quality of life improvements for those with dementia and Alzheimer's ^[201]
- Reduction in mortality: one Scottish study demonstrated that over a 17 year period, those living closest to a regenerating canal had more than double the mortality rate decline of those who live furthest away ^(^[212]).

Increased natural spaces have an urban cooling effect, which reduces heat stress that can result in heat exhaustion, heart cramps, heat strokes and mortality ^[208,213–216]. Combining all the evidence together suggested an average cooling effect of 2.5°C during warmest months attributable to urban blue sites (compared to other urban sites) ^[213].

Urban green spaces are also linked to reduced exposure to air pollutants, with benefits for health including respiratory and cardiovascular health ^[204,208,217].

While there are many positive health benefits that can arise from an increase in natural spaces in urban areas, careful planning of natural spaces, using a systems approach, is needed to minimise potential unintended adverse effects, such as increased pollen, creation of habitats suitable for rodents, ticks and mosquitoes, and the growth of toxic algae in water bodies ^[215,218]. However, even with careful planning, there remains an increased risk of negative health impacts associated with increased natural spaces in the area, particularly if the presence of new vector-borne diseases emerge locally as a warming climate extends their spatial distribution. Further, open water sources may pose a risk of contact with contaminated water or drowning ^[219].

Housing, services and infrastructure

Unintended flood risk consequences of increased demand for housing

Measures to reduce flood risk and increase the amount of natural spaces and freshwater ecosystems in the area, is likely to increase demand for housing in the area because of the reduced risk, enhanced aesthetics and ability to connect to nature.

Over the longer-term, housing and commercial/industrial demand could put pressure for development of available land, particularly as collective memories about flood risk can decline over time. Without appropriate controls on land use, this could see land sub-divided and developed, increasing the amount of impervious surface in the area, making it harder for water to drain away and increasing surface runoff. This is likely to increase local flood risk and associated health and wellbeing impacts described under the 'status quo' scenario. An increase in the amount of impervious surfaces (e.g. concrete) may also increase the urban heat island effect, trapping heat and increasing temperatures, with implications for heat-related mortality and morbidity ^[220].

Even where alternative solutions are found (for example, building 'up' rather than 'out', considerations need to be given to the accessibility of multi-storey properties, quality of construction and design, and how potentially increasing the total number of people living in the area adds additional pressure on water infrastructure (potentially increasing flood risk once more) and puts more people at risk in the event of catastrophic failure of adaptation measures (e.g. structures themselves fail, or are overwhelmed in an event larger than they were designed to withstand).

Risk of gentrification

Under the current market-driven system, when demand for housing increases and outstrips supply, prices will also increase. House price increases can negatively impact those on lower incomes by:

- Reducing affordability, particularly for renters
- Potentially leading to rental properties being sold, and tenants evicted as a result

As described above, housing demand may increase house prices in South Dunedin. Without interventions in the market, this could lead to a reinforcing cycle of gentrification (where increasingly privileged and wealthy households displace original residents), particularly in areas with the greatest reductions in flood risk. Gentrification would mean some current residents are no longer able to afford to live in the area (especially renters, and those in social housing), leading to their displacement ^[12,221-223].

Market-driven changes in the neighbourhood make-up would almost certainly lead to inequitable outcomes for those priced out of the local market who would find it difficult to find housing elsewhere within the price range ^[113,224,225], and who would also potentially experience the negative wellbeing impacts of becoming removed from their existing community, networks, and local services like doctors and schools.

Increased housing values and gentrification may also result from adaptations that increase the aesthetic and appeal of the area to live in ^[226], including through enhanced greenspaces, and urban realm.

Interventions in the housing market to protect housing affordability and tenure security, and improved governance of the housing system for wellbeing and fairness goals would be needed to counteract these effects.

Ongoing housing risks for existing housing remaining on the flat

Under all the pathways, a substantial amount of South Dunedin's housing will remain, carrying through existing housing quality and affordability issues, as well as the long-term effects of floods that are already occurring (e.g. damp and mould). If this is coupled with market-led development of new housing on elevated land in the area, there is a high risk of creating new health and social inequities, where long-term residents in older housing stock are unjustly bearing both continuous (if much reduced) residual risk, at the same time as experiencing poorer quality housing, than those who are relocated (depending on the approach taken) and those later moving into the new housing in the area.

Effects on existing health and community services, and community facilities

A partial list of key community services, including parks, places for sport and recreation, schools, health centres, churches and shops, was generated as part of the risk assessment. The list included 72 community services, which were then assessed for impact (not further defined) across the three shortlisted futures. We note that about a third of these listed community services would be affected in some way under all scenarios, with churches perhaps most often identified as affected. More community services overall were identified as affected under Future 5, while more health centres (3 rather than 1) would be affected under Future 3. Across all three Futures, the balance of retail loss and gain between healthy (e.g. supermarkets, fruit and vegetable shops, and other affordable healthy food outlets, like the Bowling Club) and unhealthy (dairies, unhealthy takeaways, alcohol, fast food) will influence community nutrition-related health outcomes, including heart disease, cancer and diabetes^[227].

Water safety risks from adding new bodies of water

Drowning is the second most common cause of injury deaths for children in Aotearoa ^[228], and we have one of the highest rates of drowning among OECD countries. Adding new unsecured bodies of water brings additional risks of drowning, especially for children. Greater risk is expected for water channels that are sometimes empty, but have high flows of water during storm events, as they can become unintended places for play during dry periods, making sudden rises in water level more likely to lead to injury and death.

The use of open channels means these risks are expected to be highest under Futures 4 and 5.

Well-integrated natural blue space may pose a lower risk, as streams and wetlands are more likely to be permanently wet, and therefore incorporated into water safety planning by families and communities.

Housing opportunities

Managed relocation and housing redevelopment under all three Futures may create the opportunity to improve the quality of housing for residents, with design that meets and exceeds the healthy home standards and aligns with universal design building principles to support accessibility for all, with substantial flow on affects for population health, and reduced burden across the health system. For example, each dollar invested in just housing insulation has been shown to return savings to the public health sector of nearly two dollars, while the return on investment for installing heat pumps is 7.5:1^[229].

Building or retrofitting homes to be climate resilient and increase their energy efficiency would lower heating-related emissions and increase resilience to energy prices increases, while also reducing the negative health outcomes associated with cold, damp housing such as respiratory and cardiovascular disease ^[209,218,230,231]. This would reduce the prevalence of illness and poor health outcomes associated with living in poor quality housing, which in turn would reduce pressure on the health system, including lowering hospital admissions. Improved sources of heating from coal or wood burning open fires and stoves to electric sources of heating, such as heat pumps and heat pump hot water heating would also improve area-wide air quality, reducing air pollution deaths, hospitalisations and sick days off school and work ^[232].

As discussed under the 'Health Equity' section, interventions in the housing market will be needed to ensure these potential benefits are equitable, and that healthy, affordable, accessible and climate resilient housing is achieved, including provision of housing developed with community providers ^[5]. For example, measures to increase housing energy efficiency will help to address energy poverty, creating healthier indoor environments which would improve health, quality of life, and reduce the number of hospitalisations and burden on other local health services associated with living in poor quality housing.

For those displaced as part of the adaptation process, consideration should be given to their specific needs and priorities (e.g. accessibility within their homes, distance to existing services, appropriateness of house size etc.), as well as the needs of existing residents in the area to support wellbeing, reduce inequitable housing outcomes and avoid worsening overcrowding and homelessness ^[199].

Reduced flood risk

All three options are expected to lead to a reduction in flood risk for South Dunedin by increasing stormwater infrastructure capacity, removing people from harm's way, increasing natural spaces and restoring wetlands (also referred to as 'blue-green' spaces). This offers the opportunity to reduce significant harm from future flooding that would otherwise occur under a 'status quo' scenario. All Futures include improvements to stormwater management, reducing the risk of extreme rainfall overwhelming wastewater infrastructure, with flow on reductions in risk of gastroenteritis, either from direct contact with contaminated floodwaters, or by swimming in contamination of coastal waters. However, all three adaptations continue to carry residual risk (unmitigated risk) of coastal inundation, failure of infrastructure, and severe weather causing power failures to pump systems.

Opportunities for improved Accessibility

Changes in land use offer some opportunities to enhance accessibility by incorporating universal design principles into the design of amended spaces or infrastructure, with benefits for equity, quality of life and wellbeing more generally. These opportunities should be centred in decision-making and meaningfully informed by end-user needs.

Mental health

Resistance to change, anger, and distrust

Resistance to change can lead to negative wellbeing outcomes such as anger, anxiety, social tension, and distrust towards authorities ^[66], as has been experienced previously in South Dunedin ^[12,233,234].

In particular, some degree of resistance to managed relocation is likely ^[235], even potentially from those who have experienced flooding previously, as recent examples from across the country indicate ^[236–238].

Again, meaningful partnership in the transition as well as clearly identified opportunities or co-benefits arising from the adaptation futures may help to minimise negative experiences and increase acceptance of the need for change, and particularly for proactive forms of change. The alternative, in which the community experiences actions being done *to* rather than *with* them undermines their agency and sense of self-efficacy. As one South Dunedin resident described in 2020:

This is a community that has no trust whatsoever in decision-makers, it's used to things being done to it. That passivity and passive aggressive stuff has very real impacts on mental health. Violence would be part of that. When a community feels itself about to be done to, mental health indicators will drop. Whereas, conversely, if a community feels that it is being listened to and engaged with in real terms, then the ability to be resilient to change... will rise and is going to be a major positive in terms of community welfare.

Since that time, deeper engagement and more participatory partnerships between decision-makers and community around climate change adaptation suggest wellbeing benefits. For example, improved sense of inclusion, community wellbeing, trust and having concerns heard (ref), which are all positive for social and mental wellbeing.

Benefits of being able to stay in place

Those who are able to remain in place under the three adaptation futures (with reduced flood risk) are likely to experience maintained or even enhanced mental and physical wellbeing from being able to maintain connections to their place. This includes their continued ability to access local services and social support networks. However, experiences are highly likely to vary across the community, with many still potentially experiencing negative emotions in response to, for example, the changing look of the area or others in their community moving elsewhere.

Knowing something's being done

Knowing that local government is taking timely action to reduce flood risk is likely to help with reducing negative emotions such as fear, anxiety, anger, frustration and distress, as will messaging that is honest about what is and is not known, and solutions-focussed ^[12].

All three adaptation futures represent a commitment by local government to invest in South Dunedin's future, which can have a significant influence on the degree to which residents and business owners themselves feel optimism and confidence about the area's future ^[12]:

If you're seeing investment in your community, you're not gonna think 'I need to leave tomorrow'... It makes you feel more positive about the place you're in".

Hope for the future is essential for wellbeing, and can encourage further private investment into the area, creating a positive feedback cycle of optimism and investment in place.

Physical health

The most substantial effects on physical health across the three futures are health inequities mediated by housing availability, affordability and quality, e.g. via displacement, pressures on the overall housing system in Ōtepoti, worsening homelessness, overcrowding and infectious disease; dampness, mould, and respiratory illness; and having to choose between housing costs and healthcare or healthy food. Implications for housing have been described in previous sections. This section therefore covers other, non-housing-related effects.

Negative impacts associated with implementing adaptation actions

All three futures involve construction works which will cause varying degrees of disruption for nearby residents. Future 5 is expected to have the highest degree of construction works, associated with land elevation and creation of open channels.

Residents' exposure to construction noise may negatively impact health, including potentially resulting in stress, frustration, declines in quality of life, and cardiovascular stress^[239,240]. Noise mitigation plans can reduce the potential health impact of construction noise for nearby residents, though may not mitigate the impacts entirely.

Construction-related dust and airborne materials are also associated with negative health impacts for construction workers, including chronic respiratory diseases and symptoms, respiratory infections, and some cancers^[241]. Nearby residents would also be at risk from exposure to dust, as well as air pollution from heavy vehicle movements associated with construction.

Construction effects on health, wellbeing and health equity are not limited to South Dunedin. The fill needed for land elevation is likely to come from existing or new quarries, with effects similar to the above on any communities nearby those quarries. Quarrying comes with effects on whenua and whakapapa connections for iwi and hapū whose land is quarried^[242], as well as local and downstream effects on landscapes, terrestrial ecosystems and freshwater^[243].

Vector-borne disease risk from new open water channels

In the long-term (2090 and beyond), there is mixed evidence for the possibility of health-significant mosquitoes becoming established as far south as Ōtepoti^[244] (with dengue fever carried by *Aedes albopictus* the most likely). At the same time, increasing international migration resulting from climate change will increase the number of imported cases of vector-borne disease (of which dengue and Ross River virus are probably the most important for Aotearoa), noting that South Dunedin is already home to the city's largest refugee and migrant communities. Other relevant risks also increase risk of transmission, especially access to healthcare, poverty, and household crowding.

The understanding of water body types, water quality and species-specific mosquito habitat preference is still emerging. Stagnant puddles and pools, and polluted water bodies are established targets of mosquito management, with more recent suggestions that urban engineered water bodies (e.g. open stormwater pipes) are a preferred mosquito habitat over high quality water in natural ecosystems (streams and wetlands) (see for example ^[245]). Given the likelihood of interactions between social and climate factors in South Dunedin, this suggests that care will be needed to design in the long-term design of water bodies with a greater emphasis on restoration of native biodiversity, and land use and water quality well-managed, in preference to open pipes, drains, and concrete canals. Further care may be needed with mosquito surveillance, and in the long-term greater attention to how pooled water with high rainfall is managed, especially in warmer months.

Opportunities from improvements in active transport

The adaptation futures provide the opportunity to implement urban design that encourages and supports active forms of transport (walking, cycling), which would not only reduce emissions, but also support health, wellbeing and resilience to climate, economic and oil price shocks via various means including ^[246]:

- Increased physical activity
- Reductions in air pollution, with benefits for respiratory and cardiovascular health
- Reductions in physical injury where cyclists and pedestrians are kept safely separated from motor traffic

These improvements in mental, physical and cultural wellbeing and access to services like healthcare, can in turn set off a “virtuous” cycle, since better health and health equity improves individual and community resilience to future severe weather events and sea-level rise.

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