



NOTICE OF MEETING

**Notice is hereby given of the Meeting of
the Risk and Assurance Committee to be held in
the Council Chamber, First Floor, Civic Theatre,
88 Tay Street, Invercargill on Tuesday 15 September
2026 at 2.00 pm**

Mr R Jackson (Chair)
Mayor T Campbell
Cr A J Arnold
Cr R I D Bond
Cr S J Broad
Cr M Lush
Cr I R Pottinger
Cr B R Stewart
Cr L Tou-McNaughton
Ms L Soper

MICHAEL DAY
CHIEF EXECUTIVE

Risk and Assurance Committee - Public

15 September 2026 02:00 PM

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1. Apologies	
2. Declaration of Interest	
a. Members are reminded of the need to stand aside from decision-making when a conflict arises between their role as an elected representative and any private or other external interest they might have.	
b. Elected members are reminded to update their register of interests as soon as practicable, including amending the register at this meeting if necessary.	
3. Public Forum	
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11.	Public Excluded Session	

Public Excluded Session

Moved , seconded that the public be excluded from the following parts of the proceedings of this meeting, namely:

- a) Minutes of the Public Excluded Session of the Risk and Assurance Committee Meeting Held on 8 June 2026
- b) Internal Audit and Continuous Improvement Update - September 2026
- c) Council Litigation Update
- d) Verbal CE Risk Update

The general subject of each matter to be considered while the public is excluded, the reason for passing this resolution in relation to each matter, and the specific grounds under section 48(1) of the Local Government Official Information and Meetings Act 1987 for the passing of this resolution are as follows:

General subject of each matter to be considered	Reason for passing this resolution in relation to each matter	Ground(s) under Section 48(1) for the passing of this resolution
a) Minutes of the Public Excluded Session of the Risk and Assurance Committee Meeting Held on 8 June 2026	Section 7(2)(a) Protect the privacy of natural persons, including that of deceased natural persons Section 7(2)(d) Avoid prejudice to measures protecting the health or safety of members of the public Section 7(2)(g) Maintain legal professional privilege Section 7(2)(h) Enable any local authority holding the information to carry out, without prejudice or disadvantage, commercial activities Section 7(2)(i) Enable any local authority holding the information to carry on, without prejudice or disadvantage, negotiations (including commercial and industrial negotiations)	Section 48(1)(a) That the public conduct of this item would be likely to result in the disclosure of information for which good reason for withholding would exist under Section 7
b) Internal Audit and Continuous Improvement Update - September 2026	Section 7(2)(j) Prevent the disclosure or use of official information	Section 48(1)(a) That the public conduct of this item would be likely to result in the disclosure

	for improper gain or improper advantage	of information for which good reason for withholding would exist under Section 7
c) Council Litigation Update	Section 7(2)(g) Maintain legal professional privilege	Section 48(1)(a) That the public conduct of this item would be likely to result in the disclosure of information for which good reason for withholding would exist under Section 7
d) Verbal CE Risk Update	Section 7(2)(a) Protect the privacy of natural persons, including that of deceased natural persons Section 7(2)(h) Enable any local authority holding the information to carry out, without prejudice or disadvantage, commercial activities	Section 48(1)(a) That the public conduct of this item would be likely to result in the disclosure of information for which good reason for withholding would exist under Section 7

**MINUTES OF THE RISK AND ASSURANCE COMMITTEE, HELD IN THE COUNCIL CHAMBERS,
FIRST FLOOR, CIVIC THEATRE, 88 TAY STREET, INVERCARGILL ON MONDAY 8 JUNE 2026
AT 9.00 AM**

Present: Mr R Jackson (Chair)
Mayor T Campbell
Cr A J Arnold
Cr R I D Bond
Cr M Lush
Cr I R Pottinger
Cr B R Stewart
Cr L Tou-McNaughton

In Attendance: Cr G M Dermody
Mr M Day – Chief Executive
Mrs P Christie – Group Manager – Finance and Assurance
Mrs T Hurst – Group Manager – Community Engagement and Corporate Services
Mr M Morris – Manager – Governance and Legal
Mr B Staunton – Chief Financial Officer
Ms R Suter – Manager – Strategy and Policy
Mr P Patton – Manager – Risk and Continuous Improvement
Ms L Knight – Manager – Communications and Marketing
Mrs C Sullivan – Senior Governance Advisor
Ms M Sievwright – Senior Executive Support

1. Apologies

Cr Broad and Ms Soper

Moved Mr Jackson, seconded Cr Bond and **RESOLVED** that the apologies be accepted.

2. Declaration of Interest

Nil.

3. Public Forum

Nil.

4. Minutes of Risk and Assurance Committee Meeting held on Tuesday 17 March 2026

A6372593

Moved Mayor Campbell, seconded Cr Tou-McNaughton and **RESOLVED** that the Minutes of the Risk and Assurance Committee meeting held on Tuesday 17 March 2026 be confirmed.

5. Fraud Policy

A6449198

Mr Peter Patton spoke to the report.

The key driver for this change was from the Audit Office who noted that the fraud policy should stand alone.

In response to a question regarding what the current risks for Council were, it was noted major risks were contract management. A number of Council policies mitigate the risk an example being the procurement policy, where conflict of interest forms were required to be submitted.

It was noted that staff awareness was key. Training was being developed for all staff to attend for their awareness.

Reporting back to the Committee would be given every 12 months.

Moved Cr Stewart, seconded Mayor Campbell and **RESOLVED** that the Risk and Assurance Committee:

1. Receives the report "Fraud Policy".
2. Notes that the draft Fraud Policy would replace the existing section 5 of the Financial Risk Management Policy which deals with fraud.
3. Approves the Fraud Policy as presented.

Recommends to Council:

4. To adopt the Fraud Policy.
5. To note the consequent amendment to the Financial Risk Management Policy being the removal of the existing section 5 which deals with fraud.

6. Financial Risks Update

A6462928

Mr Bryan Staunton spoke to the report.

It was noted that Council were compliant with all policies and this was being monitored. The average cost of debt at 31 March 2026 was 3.44% and the need for further interest rate swaps would continue to be monitored.

In response to a question regarding nett debt and why this had not been reported, it was noted that this was approximately \$150 million and this was usually presented to the Finance and Policy Committee.

In response to a question regarding liquidity ratio and what was used to calculate the ratio of 110%, it was noted this was what Council had set, ensuring appropriate term deposits to match the term deposits. This was set out in the Financial Management Policy which would be reviewed in the Long-term Plan process.

In response to clarification on the Audit New Zealand requirement for an independent assessment of the fair value assessment, it was noted that there was a difference between a full revaluation as opposed to the fair value assessment which was more of a desk top review. At this stage Audit New Zealand had suggested that Council may like to procure an independent expert to provide input to a fair value assessment which staff had declined.

In response to a question regarding the methodology of other councils as a cross reference, it was noted this information was available through councils annual reports.

In response to a question regarding the cost of an independent study, it was noted as this had not been asked for before, there was no indication of costs.

Moved Mr Jackson, seconded Mayor Campbell and **RESOLVED** that the Risk and Assurance Committee:

1. Receives the report 'Financial Risks Update'.

7. Internal Audit and Continuous Improvement Update June 2026

A6455217

Mr Peter Patton spoke to the report.

In response to a question regarding the outstanding items from the building consent audit, and how to get this lower, it was noted the team had had a turnover of staff and were working on processes for this.

In response to a question regarding if there were any areas with reoccurring control weaknesses, it was noted this was an education process of documenting continuous improvement and processes and capturing corporate knowledge.

Moved Cr Bond, seconded Mayor Campbell and **RESOLVED** that the Risk and Assurance Committee:

1. Receives the "Internal Audit and Continuous Improvement Update June 2026" report.
2. Notes the continuous improvement status outlined in table1.

3. Notes that management processes are in place to monitor and address outstanding audit recommendations.

8. Long-term Plan 2027 – 2037 Update – Audit Guidance and Assumptions Development

A6458308

Ms Rhiannon Suter spoke to the report.

In response to a question regarding where a quote in the report had come from, it was noted this was taken from the Cabinet paper regarding the Local Government Systems Improvement Bill.

In response to a question on guidance on rate capping from Central Government, it was noted that Council had been advised to take rates capping into account in years 3 to 10 of the Long-term Plan. If rates capping was not taken into consideration, Council would not pass audit.

In response to a question regarding assumptions, it was noted there were key assumptions made regarding the full ten years of the Plan.

In response to a question regarding what activities were funded by Council that could be affected, it was noted there were a range of activities and it would become clearer through the process.

In response to a question regarding the uncertainty of stormwater, and why this phrase was being used, it was noted this report was not about the details of the activity itself and reflected that stormwater was not a regulated water activity in the new regime.

Moved Mayor Campbell, seconded Cr Tou-McNaughton and **RESOLVED** that the Risk and Assurance Committee:

1. Receives the report “Long-term Plan 2027–2037 Update – Audit Guidance and Assumptions Development”.

9. Public Excluded Session

Moved Mr Jackson, seconded Cr Stewart and **RESOLVED** that the public be excluded from the following parts of the proceedings of this meeting, namely:

- a. Minutes of the Public Excluded Session of the Risk and Assurance Committee Meeting Held on 17 March 2026
- b. Risk Management Policy and Risk Management Framework
- c. Risk Appetite Workshop Summary and Development of the Risk Appetite Table
- d. Contract Risks
- e. Council Litigation Update

f. Verbal CE Risk Update

The general subject of each matter to be considered while the public is excluded, the reason for passing this resolution in relation to each matter, and the specific grounds under Section 48(1) of the Local Government Official Information and Meetings Act 1987 for the passing of this resolution are as follows:

General subject of each matter to be considered	Reason for passing this resolution in relation to each matter	Ground(s) under Section 48(1) for the passing of this resolution
a. Minutes of the Public Excluded Session of the Risk and Assurance Committee Meeting Held on 17 March 2026	Section 7(2)(g) Maintain legal professional privilege Section 7(2)(h) Enable any local authority holding the information to carry out, without prejudice or disadvantage, commercial activities Section 7(2)(i) Enable any local authority holding the information to carry on, without prejudice or disadvantage, negotiations (including commercial and industrial negotiations)	Section 48(1)(a) That the public conduct of this item would be likely to result in the disclosure of information for which good reason for withholding would exist under Section 7
b. Risk Management Policy and Risk Management Framework	Section 7(2)(h) Enable any local authority holding the information to carry out, without prejudice or disadvantage, commercial activities	Section 48(1)(a) That the public conduct of this item would be likely to result in the disclosure of information for which good reason for withholding would exist under Section 7
c. Risk Appetite Workshop Summary and Development of the Risk Appetite Table	Section 7(2)(h) Enable any local authority holding the information to carry out, without prejudice or disadvantage, commercial activities	Section 48(1)(a) That the public conduct of this item would be likely to result in the disclosure of information for which good reason for withholding would exist under Section 7
d. Contract Risks	Section 7(2)(d) Avoid prejudice to measures protecting the	Section 48(1)(a) That the public conduct of this item would be likely to result in the disclosure of

			health or safety of members of the public	information for which good reason for withholding would exist under Section 7
e. Council Update	Litigation		Section 7(2)(g) Maintain legal professional privilege	Section 48(1)(a) That the public conduct of this item would be likely to result in the disclosure of information for which good reason for withholding would exist under Section 7
f. Verbal Update	CE	Risk	Section 7(2)(a) Protect the privacy of natural persons, including that of deceased natural persons Section 7(2)(h) Enable any local authority holding the information to carry out, without prejudice or disadvantage, commercial activities	Section 48(1)(a) That the public conduct of this item would be likely to result in the disclosure of information for which good reason for withholding would exist under Section 7

There being no further business, the meeting finished at 10.48 am.

2027 – 2037 LONG-TERM PLAN DRAFT ASSUMPTIONS

To:	Risk and Assurance Committee
Meeting Date:	Tuesday 15 September 2026
From:	Rhiannon Suter - Manager – Strategy, Policy and Engagement
Approved:	Patricia Christie - Group Manager - Finance and Assurance
Approved Date:	Thursday 10 September 2026
Open Agenda:	Yes

Purpose and Summary

This report provides the Committee with an update on progress in developing assumptions for the forthcoming Long-term plan, along with a draft of the assumptions.

Recommendations

That the Risk and Assurance Committee:

1. Receives the report “2027 – 2037 Long-term plan Draft Assumptions”.
2. Notes the timing of the further updates of key inputs to the assumptions prior to audit.

Recommends to Council

3. Approves the utilisation of the draft assumptions in preparation of the Long-term plan, noting that these are still to be further refined.

Background

Council is required to develop assumptions which will underpin the 2027 – 2037 Long-term plan. These cover a range of factors, including population and growth forecasts, assumptions relating to the external environment, both financial and regulatory and around how Council will approach asset management and capital delivery, as well as other significant issues such as climate change. For this Long-term plan it is also required to make assumptions about the outcome of amalgamation and other reform processes.

Audit advice where it is relevant and has been received is noted.

Issues

Growth and Other Economic Forecasts

For each Long-term plan Council develops population, household growth and wider economic indicator forecasts to inform the Long-term plan. Infometrics have developed a probable scenario which is based on known information about new industry development from regional scenarios being developed by Great South. This is underpinned by NZ Stats and other national datasets about known trends in factors such as aging and migration. The forecasts have also been informed by data on international students provided by Southern Institute of Technology and by data from the last five years on rating units. It is important to be aware that the household's data is not an exact match for rating units, as this includes a range of different living situations such as residential retirement homes, as well as commercial and industrial rating units. The final figure used for rating unit growth will be based on a number of factors including household growth and historic rating unit growth.

Inflation

The Berl Local Government Cost-adjusters report has been released, with the final update report expected in October 2026. These underpin the Inflation assumptions used in the budget and will be further updated then.

Reserve Bank of New Zealand consumer price inflation forecasts will also be used in the assumptions in relation to cost of living and rates affordability.

Amalgamation

There are currently two separate Local Government reform processes – the Local Government Commission Southland reorganisation investigation process and Headstart. For both of these two similar options are being considered – One Unitary Council and Two unitary councils, one for the urban and one for the rural areas. There are two decision points for these processes: one in September when the Government will announce those Head Start proposals for initial consideration and one in March/ April where the second stage of Head Start, and the outcome of the Local Government phase two (option selection).

Advice on whether a going concern accounting assumption will be required is expected from the Audit Office at some point.

Reform

In addition to potential amalgamation, there are a large number of intersecting reform programmes which will all impact on the Long-term plan. This includes the Resource Management Act (RMA) and Building Act reform, waters reform, emergency management reform, earthquake strengthening building regulations and others. The reform assumptions guidance from Taitūara has been used in forming assumptions on these matters.

Rates Capping

Rates capping for non-water rates is expected to be applied from 1 July 2027 and the Audit Office requires this to be reflected in the Long-term plan from Year 3. For Years 1 and 2 councils must consider the rates cap. It is expected that Ministries for Cities, Environment, Regions and Transport (MCERT) will forecast the cap in Long-term plan Years 3 onwards, but this is not yet available. The Government has announced a 2% minimum and a 4% maximum so these will be used in preparation for modelling the plan.

It is worth noting that as a result of reform the cost to administer emergency management is estimated by National Emergency Management Agency (NEMA) to cost the Local Government sector \$83 million and that a portion of this funding increase is expected to be required to fund Emergency Management Southland. How this intersects with rates capping is not yet fully understood. The Chair of Emergency Management Southland has written to the Minister on this matter.

Development Levies

The exact time at which councils may apply the new proposed development levies structure is not yet clear. It is expected to be either 2028 or 2029. The Audit Office requires assumptions around development levies to be reflected in the plan – it is proposed to forecast these from 2028/2029 at the ratios laid out in draft assumptions (based on analysis by Morrison Low, noting assumptions for Clifton Wastewater Treatment Plant have not yet been finalised).

Climate Change and Natural Hazards

Council is required to forecast assumptions for climate change. A separate report on this matter has been provided on the detail of this to the Committee for this meeting. The draft assumptions are based on the draft scenarios and planning assumptions developed by the Regional Climate Change Working Group.

Natural hazard assumptions are being developed at a regional level by Environment Southland, and these may be updated further to reflect these as they become available.

Scenarios

For this Long-term plan it is proposed to use scenarios to stress test the forecasts. These scenarios are proposed to be developed along the following lines against the baseline forecasts:

Higher growth/ higher inflation/ stronger contractor market	Lower growth/ Lower inflation/ Weaker contractor market
+0.5 – 1% rating unit growth All growth capital projects delivered within first ten years of the plan +0.5 - 1% inflation on BERL cost adjusters +5 - 10% on capital delivery assumption	-0.1% - -0.3% rating unit growth Growth capital projects delayed beyond first ten years of the plan -0.5 - 1% inflation on BERL cost adjusters - 5 - 10% on capital delivery assumption

Next Steps

The draft assumptions will be utilised to develop the draft budget and will be updated as new information becomes available. The Risk and Assurance Committee will receive a further

update ahead of audit in December. Council will receive the draft assumptions along with all aspects of the Long-term plan in November.

Attachments

1. DRAFT 2027 – 2037 LTP Assumptions (10928725).
2. Infometrics, Long-term plan forecast assumptions for Invercargill City Council (11281314).
3. Morrison Low, ICC Viability of Development Contributions and Levies (10790239).

ASSUMPTIONS FOR INVERCARGILL CITY COUNCIL LONG-TERM PLAN 2027 - 2037

POPULATION	Likelihood	Certainty	Consequence	Council Response
Population growth In 2025 the estimated population of Invercargill was approximately 58,000. In 2027 the population is forecast to be 58,300. ¹ By 2037 59,900 people will live in Invercargill District, with up to 60,900 possible with further industry growth. ²	Likely	Medium	Moderate	Although population growth in excess of the assumptions will have a moderate to significant impact on Council finances this will have significant lead time. Council will be able to monitor the applications for consents and use this as guidance for population growth into the future. A population decline would be a more significant impact but is not expected.
Diversity The population will continue to become more diverse. The Māori population will grow from 20% in 2022 to 24% in 2037. The Asian population will grow from 8% to 17%. ³	Likely	High	Minor	Council will increase engagement opportunities for different parts of the community to help support all voices being heard. Changes to Council services are expected to be able to be accommodated within existing operational budgets through adjustment of focus.

¹ Infometrics, "Long Term Plan forecast assumptions for Invercargill City Council", September 2026, p12 (Doc Set ID 11281314)

² Infometrics, "Long Term Plan forecast assumptions for Invercargill City Council", September 2026, p12 (Doc Set ID 11281314) and Great South Sector Forecasts (data table), August 2026 (Doc Set ID 11266642)

³ Infometrics, "Long Term Plan forecast assumptions for Invercargill City Council", September 2026, p14 (Doc Set ID 11281314)

POPULATION	Likelihood	Certainty	Consequence	Council Response
Ageing Population Those aged 65 and older will form 21% of the population in 2037. The under-15 population will become smaller, forming 17% of the population in 2037. ⁴	Likely/ Almost Certain	High	Moderate	Demographic changes are clear and while future migration patterns may offset ageing to some extent, this is not expected to be of a high enough level to counter the known level of ageing. Council is considering how to respond to changing housing needs for older people through provision of elderly housing, adjustment to the District Plan and potential partnership projects. Impacts on other services including public transport, libraries and pools (e.g. hydrotherapy pool) are being planned for.
Households The number of households will grow 0.3% per annum to 2037. ⁵ Household numbers will increase from 23,600 in 2025 to 24,400 in 2037. ⁶ Households will grow slightly in size from 2.41 people per household in 2025 to 2.42 in 2037. ⁷	Moderate/ Likely	Medium	Moderate/ Major	The number of households underpins the rating base and Council revenue for activities. A decline or slower growth in households would require Council to review services and/or financial strategy.

⁴ Infometrics, "Long Term Plan forecast assumptions for Invercargill City Council", September 2026, p13 (Doc Set ID 11281314)

⁵ Infometrics, "Long Term Plan forecast assumptions for Invercargill City Council", September 2026, p15 (Doc Set ID 11281314)

⁶ Infometrics, "Long Term Plan forecast assumptions for Invercargill City Council", September 2026, p16 (Doc Set ID 11281314)

⁷ Infometrics, "Long Term Plan forecast assumptions for Invercargill City Council", September 2026, p14 (Doc Set ID 11281314)

SOCIAL	Likelihood	Certainty	Consequence	Council response
Affordability Affordability of housing, mortgage and rents will remain higher in Invercargill than the national average, although this position will tighten. ⁸ Inflation will continue to squeeze household budgets and impact abilities to pay rates. Inflation (CPI) is expected to fall to 2.6% by June 2027 and then further to 2% by 2028 ⁹	Moderate/ Likely	Medium	Major	Economic volatility remains high with economists urging caution on reliability of forecasting. Significant increases in inflation will impact not only Council's planned expenditure but the community's ability to pay. Higher than expected inflation may require review of services, capital investment and/or financial strategy. Lower inflation will improve Council's position and ability to deliver.
Community resilience Tiwai Point Aluminium Smelter is expected to continue operating for the time of the Long-term Plan.	Likely	High	Moderate	The Just Transitions Programme put in place plans in case of closure which can be reactivated. Additional investment may be required on any future announcement of closure.
Housing Stock Urban Invercargill's housing supply rate will increase slightly from 0.5% a year to 0.7% a year based on Council's intended District Plan changes, known future developments and proposed partnership projects. ¹⁰	Possible/Moderate	Medium	Moderate	Housing has been identified as a potential constraint to growth. Failure of responses to increase the supply could limit future population growth. Council would need to consider alternative responses.

⁸ Infometrics, "Long Term Plan forecast assumptions for Invercargill City Council", September 2026, p22, 23 and 24 (Doc Set ID 11281314)

⁹ Reserve Bank of New Zealand, Monetary Policy Statement, September 2026, p50 [Monetary Policy Statement September 2026 - Reserve Bank of New Zealand - Te Pūtea Matua](#)

¹⁰ Rationale report "Murihiku Southland Housing Needs Assessment", May 2023, p26 [Murihiku Southland Housing Needs Assessment](#)

SOCIAL	Likelihood	Certainty	Consequence	Council response
Community funding Core funders will have some constraints on their funding as a result of economic conditions. However, this will be partially offset by the increased diversity of local funders. Demand for Council funding is expected to remain on the current trend of small increases each year.	Likely	High	Minor	Council will continue to liaise with other funding partners, including to monitor forecast security of investment, to assist control of this risk.

ECONOMIC	Likelihood	Certainty	Consequence	Council Response
Economy Employment is forecast to grow 0.7% per annum until 2037, with initial higher growth in the early years of the plan as construction is completed on major industry projects. ¹¹	Moderate/Likely	Medium	Moderate	If employment forecasts are significantly lower this could have flow on impacts on population and affordability for the community. Council may need to refine its financial strategy.

¹¹ Infometrics, "Long Term Plan forecast assumptions for Invercargill City Council", September 2026, p5 (Doc Set ID 11281314)

ECONOMIC	Likelihood	Certainty	Consequence	Council Response
Economic diversification The investment in recent industry developments (data, aquaculture, wind farms, minerals) will improve economic diversification, which will continue and will support the resilience of the Southland economy. Volatility in the global economy may affect one or more of Invercargill's key export industries. This will further drive diversification but will slow growth. Employment growth in new industries is to offset any declines in agriculture.¹² There may be a delayed effect through the risk of impacted industries abandoning properties.	Possible	Low	Moderate	Council will continue to work closely with Great South, the Chamber of Commerce and other stakeholders to support economic diversification for the region. In the case of significant industry decline a targeted response may need to be developed. The financial impact of this assumption is on the city's rating base, infrastructure network needs and the community's rates affordability. Changes in this assumption are not expected to be sharp shocks and as a result Council will be able to flex annual plans and future LTPs to take account of these changes. At this point in time we do not expect this to have a significant effect on financial modelling for Years 1-3 of this Long-term Plan.

¹² Beyond 2025 Southland Regional Long-term Plan, p20-21 [Beyond 2025 Southland | Great South](#). Note that this plan will be updated during 2026/2027 and this assumption may be further updated.

ECONOMIC	Likelihood	Certainty	Consequence	Council Response
Central Business District The City Block development has been successfully completed and has attracted new development, including two new hotels in the city centre. Council will continue to support initiatives to drive the success of a thriving CBD. GDP will increase by \$14 million annually as a result of the investment until 2030. ¹³	Likely	High	Moderate	Council remains strongly committed to its vision “Our City with Heart – Hē Ngākau Aroha.” Any divergence from this vision could impact the financial viability of ICL but is not expected. Further investment may be required either in the City Block or associated city streets improvements.
Tourism Tourism in the Visit Southland area is expected to increase to between 160% - 165% of pre-Covid levels by 2029. ¹⁴ Invercargill is expected to proportionally benefit from this increase and demand for accommodation to increase and to be met from within existing stock.	Moderate/Likely	Medium	Minor	Tourism, while important, is not currently a major driver of the Invercargill economy, although it has great potential to grow. Council may need to invest in further infrastructure if tourism grows faster than expected and manage any flow on impact on housing availability given housing constraints.

¹³ NZIER report “Invercargill CBD regeneration”, May 2023, p17 (Doc Set ID 591936)

¹⁴ Beyond 2025 Southland Regional Long Term Plan, p56 [Beyond 2025 Southland | Great South](#). Note that this plan will be updated during 2026/2027 and this assumption may be further updated.

ECONOMIC	Likelihood	Certainty	Consequence	Council Response
International Education The number of international students in Southland is forecast to grow to 782 in 2027, and further on to 1,464 in 2037, which amounts to 16% below 2019 levels. International student numbers are forecast to grow 7.0% per annum between 2025 and 2037. Polytechnic students are forecast to grow slightly faster, at 7.1%pa, and school students slightly slower, at 6.7%pa. SIT is planning for stronger growth, of 12.4%pa between 2025 and 2027, which would lead to a total of 2,312 international students in 2037 (including SIT and schools). ¹⁵	Moderate/Likely	Medium	Minor	International students and their families create significant demand for certain categories of housing, including city centre housing. Lower numbers of international students will likely be a factor in the trend of an increasingly aged population. Lower or higher than expected numbers of international students may require an adjustment in Council response to City Centre strategy and/or other provisions/ partnerships impacting housing availability.

¹⁵ Infometrics, "Long Term Plan forecast assumptions for Invercargill City Council", September 2026, p18-19 (Doc Set ID 11281314)

ENVIRONMENTAL	Likelihood	Certainty	Consequence	Council response
Mean annual and extreme temperature (days where temp. exceeds 25°C) are expected to increase with time: By 2050: mean annual temperature increase of 1.1°C with 4 more hot days and 20 fewer cold days per annum. By 2100: mean annual temperature increase of 2.0°C, with 8 - 11 more hot days and 35 to 45 fewer cold days per annum. Annual and seasonal temperatures are projected to increase across Southland under all emissions pathways. Warming occurs across mean, maximum, and minimum temperatures and is accompanied by more hot days, more annual time spent in heatwave, and substantial declines in cold nights (minimum temperature <0°C), especially inland.¹⁶	Moderate	Low	Minor	Temperature increase while important has an indirect impact on Council operations, which are expected to be accommodated within Council plans. It will be possible to forecast the impact of climate change in more detail on the capital programme as more accurate data and modelling becomes available in future years.

¹⁶ RCCWG, Draft Climate Change Regional Projections (SSP 2 – 4.5) and Planning Assumptions, July 2026 (Doc Set ID 11234428), based on Murihiku Southland Climate Change Impact Assessment Report 2026, [Murihiku Southland Climate Change Impact Assessment Report - Environment Southland](#)

ENVIRONMENTAL	Likelihood	Certainty	Consequence	Council response
Annual rainfall is expected to increase By 2050: +5% By 2100: +8 to +9% Increased frequency of high rainfall days, i.e. increase in intensity of rainfall. Total rainfall across Southland is projected to increase modestly overall, with strong seasonal variation, while heavy rainfall indicators (including very wet days and maximum 1-day / 5-day rainfall totals) increase. Rainfall intensity for design events also increases with warming.¹⁷	Moderate	Low	Moderate/ Major	Increased intensity of rainfall is expected to result in increased flooding which is considered in Council's infrastructure planning. It will be possible to forecast the impact of climate change in more detail on the capital programme as more accurate data and modelling becomes available in future years.

¹⁷ RCCWG, Draft Climate Change Regional Projections (SSP 2 – 4.5) and Planning Assumptions, July 2026 (Doc Set ID 11234428), based on Murihiku Southland Climate Change Impact Assessment Report 2026, [Murihiku Southland Climate Change Impact Assessment Report - Environment Southland](#)

ENVIRONMENTAL	Likelihood	Certainty	Consequence	Council response
Mean sea level is expected to rise Sea level is projected to continue rising under all emissions pathways. Relative sea-level rise varies by location because local vertical land motion (VLM) can delay or accelerate when sea-level thresholds are reached. Rising mean sea level also raises the baseline for high-tide exceedance, storm-tide flooding, and coastal inundation exposure.¹⁸	Uncertain	Low	Major	There remains significant modelling which is in the process of being completed at a regional level to attain an understanding of what sea level rise is likely and its potential impact in specific areas. There are known risk areas including the Airport and Bluff which need further investigation. Council has invested in major infrastructure upgrades at Stead Street to increase protection for the city. Further work will be required on associated flood banks to maximise this investment. Environment Southland has responsibility for managing and maintaining the remainder of the city's floodbank network. It will be possible to forecast the impact of climate change on the capital programme in more detail as more accurate data and modelling becomes available in future years.

¹⁸ RCCWG, Draft Climate Change Regional Projections (SSP 2 – 4.5) and Planning Assumptions, July 2026 (Doc Set ID 11234428), based on Murihiku Southland Climate Change Impact Assessment Report 2026, [Murihiku Southland Climate Change Impact Assessment Report - Environment Southland](#)

ENVIRONMENTAL	Likelihood	Certainty	Consequence	Council response
Natural disaster Council assumes that natural hazard events, including flooding, severe rainfall, coastal inundation, storm surge, erosion, landslips, drought, wildfire, earthquake and tsunami events) will continue to occur during the 2027-2037 LTP period. The frequency and severity of weather-related events are expected to remain elevated compared with historical experience.¹⁹ There is a 75% probability of the Alpine Fault rupturing within the next 50 years.²⁰	Possible	Medium	Major/ Catastrophic	A major disaster which impacted Council's ability to operate at the same time that the community's need for disaster relief was required to be supported would require a major shift in strategy and operations. Council supports Emergency Management Southland to coordinate the response in such a situation.
Environmental renewal Council will invest to understand more about the levels of environmental damage at Ocean Beach and New River Estuary. It is possible that further investment in renewal will be required within the life of the Infrastructure Strategy.	Likely	High	Moderate	Additional investment has been made in plan. There remains uncertainty as the full scale and costs of remediation required.

¹⁹ Environment Southland, Draft Long-term Plan Assumptions - Changing Climate and Natural Hazards, August 2026 (Doc Set ID 9442121)

²⁰ <https://af8.org.nz>

CULTURAL	Likelihood	Certainty	Consequence	Council response
Māori culture Māori culture has become more visible in the city since the time of the last Long-term Plan and will continue to become more visible.	Likely/ Almost certain	High	Low	Council is working closely in partnership with Mana whenua and would seek to manage impacts through this relationship.
Civic pride Resident pride in the city following the redevelopment has increased (in 2023 80% of people said they would speak more positively about the city/ in 2026 71% people said they were proud to live in Invercargill) ^{21/22} and will continue to be positively impacted as Te Unua – Museum of Southland is completed.	Likely/ Almost certain	High	Minor	Council sees both City Block and Project 1225 as major cornerstone projects to achieving its vision – Our City with Heart – He Ngākau Aroha. The social and economic benefits are already being realised. Continued commitment to the strategy will be required for full delivery.

²¹ Southland CBD Rejuvenation Community and Business Survey Report, March 2023, p9 [CBD-Analysis-April-2023.pdf](#)

²² Invercargill City Council Residents Satisfaction Survey, 2025/2026 (Doc Set ID 9547286)

COUNCIL OPERATIONS	Likelihood	Certainty	Consequence	Council response
Amalgamation There will be some form of amalgamation within the Local Government Sector in Southland which will impact Council operations. This may take the form of one unitary authority, two unitary authorities or some other structure.²³ The services will continue to be delivered, but these will be provided by another party. For the purposes of this plan Council is assumed to be a going concern for the length of the plan.²⁴	Likely/ Possible	Medium	Major	Council is likely to not exist at the time of the 2030 Long-term plan. Some form of amalgamation which replaces Council is expected around 2028. The exact form this will take will depend on Central Government direction and/ or outcome of the current Local Government Commission process.

²³ This assumption will be updated following announcements re Head Start processes

²⁴ Awaiting advice of The Audit Office

COUNCIL OPERATIONS	Likelihood	Certainty	Consequence	Council response
Water Service Delivery At present it is assumed that Council will retain three waters for at least the first three years of the plan but that in the medium term a new structure such as a CCO remains possible, for example established during amalgamation. This will result in a structural change for Council in relation to the ownership of assets and associated debt capacity. The services will continue to be delivered, but these will be provided by another party. This will include increased regulatory requirements as required by the new regulatory authority. For the purposes of the plan, water services are assumed to be delivered in house for the length of the plan.	Likely	Medium	Major	Depending on the future structure the impact to Council operations is major but moderate for the city, as services will be maintained in any scenario. Waters Services are reflected within the parallel planning documents and sit outside the Long-term Plan.

COUNCIL OPERATIONS	Likelihood	Certainty	Consequence	Council response
Legislative changes There will be changes to legislation that have an impact on how Council will provide services. These changes may affect Council organisational structure but not change the level of service received by the customer/ratepayer in the first three years of the plan.²⁵ Enactment of the Building Amendment Bill is expected in 2027. No significant impacts are expected on Council due to the structure of our Building Control Authority function – a reduction in the volume of work is expected. Local Government (Rates Capping) Amendment Bill - Rates capping is expected to be implemented from 1 July 2029. Emergency management budget requirements are expected to rise in line with NEMA forecasts of sector wide increases of approximately \$84 million as a result of the Emergency Management Bill.²⁶	Likely	Medium	Minor/ Moderate	Management will continue to engage with Central Government to plan for changes in services in response to policy and regulation changes as they arise.

²⁵ Any specific exceptions to these identified will be noted

²⁶ To be updated when further information is available

COUNCIL OPERATIONS	Likelihood	Certainty	Consequence	Council response
Resource management reform - (Southland will complete its Regional Spatial Strategy on schedule by 2029 and Council will be required to meet 25% of the cost). Climate Change Response Bill - Council will deliver a climate adaptation plan for communities identified by the Regional Spatial Strategy from within existing policy planning resource. Building (Earthquake-prone Buildings) Amendment Bill – Reductions in work required are expected, however resourcing will be redeployed to other required areas.				
Consents Council will continue to carry out legislation-directed ordinary functions while factoring in an increase to required quality for consent conditions.	Likely	High	Moderate	Consent processes at Bluff and Clifton Water Treatment Plants have commenced, although under an increased level of uncertainty as a result of the reform programme. Any impact on the consent process as a result of this uncertainty would be significant.

COUNCIL OPERATIONS	Likelihood	Certainty	Consequence	Council response
The Funding Assistance Rate NZTA has confirmed 51% funding assistance until 2029/2030 ²⁷ . It is assumed that it will then remain at 51% for the life of the Plan.	Likely	Low	Moderate	Significant changes would have an impact on Council's ability to maintain levels of service and may require changes to budgets. Council continues to work closely in partnership with Waka Kotahi to manage this risk. If the FAR (Funding Assistance Rate) rate decreased by 1%, there would be reduction of subsidy revenue of \$x million per annum. If the funding was replaced with rates revenue, an additional x% rates increase would be required each year. If the funding was replaced with borrowings, an additional x% rates increase would be required each year to pay for interest and repayments and borrowings would increase by \$x - \$xmillion per annum. Capital and operational programmes would need to be reviewed if funding was not available.

²⁷ NZTA, FAR confirmation, 31 August 2026 (Doc Set ID 11243374)

COUNCIL OPERATIONS	Likelihood	Certainty	Consequence	Council response
Asset life Assets will remain useful until the end of their average useful life, noting this requires underlying assumptions regarding asset condition to be correct. Infrastructure installed in the 1920s is nearing end of life and requires renewal within the term of the Infrastructure Strategy.	Moderate/Likely	High	Moderate	Assets may need to be renewed earlier if this underlying assumption is incorrect. This may also change the renewal profile or may allow delayed renewal in other cases. Council will review the remaining asset life at each of the triennial asset revaluations and undertake regular asset condition assessments.
Funding for Growth Council will introduce development levies at the following rates for the following projects, noting these are within the Water Service Strategy and not the Long-term Plan: Supply development – Awarua Treatment (33%) Pipe network – Trunkmain to/ from Awarua (33%) Skye Street Reservoir and pump station (33%) Water Supply Line - Capacity to Bluff (54%) Capacity Waikiwi to Doon (100%) ²⁸ Clifton Wastewater Treatment Plant (TBC%)	Moderate/ Likely	Medium	Moderate	Development levies are a proposed funding mechanism for which the regulatory framework is not yet finalised. The timing for the identified growth projects is uncertain based on both demand and technical factors. Mitigations include regular engagement with industry and developers and updates to timing of projects as new engineering information becomes available.

²⁸ Morrison Low, ICC Viability of Development Contributions, August 2026 (Doc Set ID 10790239)

COUNCIL OPERATIONS	Likelihood	Certainty	Consequence	Council response
Capital programme delivery 100% of strategic projects are expected to be delivered. 90% of the core capital programme will be delivered in Year 1 and 2, and 100% thereafter. 100% of water, sewerage and stormwater projects (inc. pipe renewals) are expected to be delivered.	Possible	Low	Moderate	Council continues to invest in enhanced project management capacity and supporting construction sector capacity through new ways of working. The financials will be reforecast to reflect the delivery expectations each year. The financial impact of this assumption not being met is the deferral of capital expenditure until later years, higher risk of asset failure meaning assets will be sweated longer and repairs and maintenance will increase, and emergency rather than planned replacement may become more frequent.

FINANCIAL	Likelihood	Certainty	Consequence	Council Response
Rates capping Forecast rates increases for Years 3 – 10 of the plan will be between 2 – 4% as required by rates capping legislation and Council will complete exemption requests as required.	Likely	Medium	Major	Budgets will be assessed within the rates capping framework and exemption applications made as and when required. Areas of potential challenge will be identified and communicated as soon as possible.

FINANCIAL	Likelihood	Certainty	Consequence	Council Response
Inflation Operational forecasts and capital work programmes will increase by the accumulated Local Government Cost Index inflation forecast by BERL, being Local Government Administration, 2.2% declining to 1.7% by 2037 Arts and Recreation services, 1.9% climbing to 2.1% before declining again to 1.6% by 2037 Water, sewer, drainage and waste services, 2.9% climbing to 3.0% before declining again to 2.1% by 2037 Heavy and civil engineering construction, 2.2% climbing to 2.6% before declining again to 1.9% by 2037	Likely	Medium	Moderate	Cost change factors are based on information developed for councils by BERL. Significant variations to inflation would have an impact on Council's financial management. The significant changes in recent years in relation to inflation mean that level of uncertainty has increased as to whether increased fluctuations in the BERL cost estimates can be expected. Council will continue on the planned pathway for the Capital Works programme and review operational revenue and expenditure each year. If inflation was 0.5% higher than forecast this would increase Council operational costs by \$x - \$x million per annum for the first 3 years of the plan. Increases in operational costs would impact the expected rates increase in those future years.

FINANCIAL	Likelihood	Certainty	Consequence	Council Response
Asset revaluation Asset values will increase by the accumulated Local Government Cost Index inflation forecast by BERL on the last valuation value.	Likely	Medium	Moderate/ Major	Changes in valuation (cost price) or life of Council assets have a significant impact on Council's financial management and capital programme. Council will continue on the planned pathway for the Capital Works programme and monitor after each revaluation cycle. If revaluation values were 0.5% higher than forecast this would increase Council property, plant and equipment revaluation gain / (loss) by \$x million in 2024/2025.
Investment Property and Biological Assets Investment Property and biological assets are valued on a yearly basis. They are expected to increase in value in line with inflation. This is reflected in our Financial Strategy, and Accounting policies.	Likely	High	Low	Variations in valuations have no cash flow implications for Council. Council will continue to value Investment Property and forestry assets on an annual basis.
Depreciation funding on existing assets Water, Sewerage, Stormwater 100% Property 90% in Year 1, increasing by 5% per annum until 100% is reached Roading 75%	Likely	Medium	Moderate	Council will closely monitor asset condition data, critical and non-critical failure rates and capital delivery expenditure in order to ensure appropriate depreciation rates are funded at.

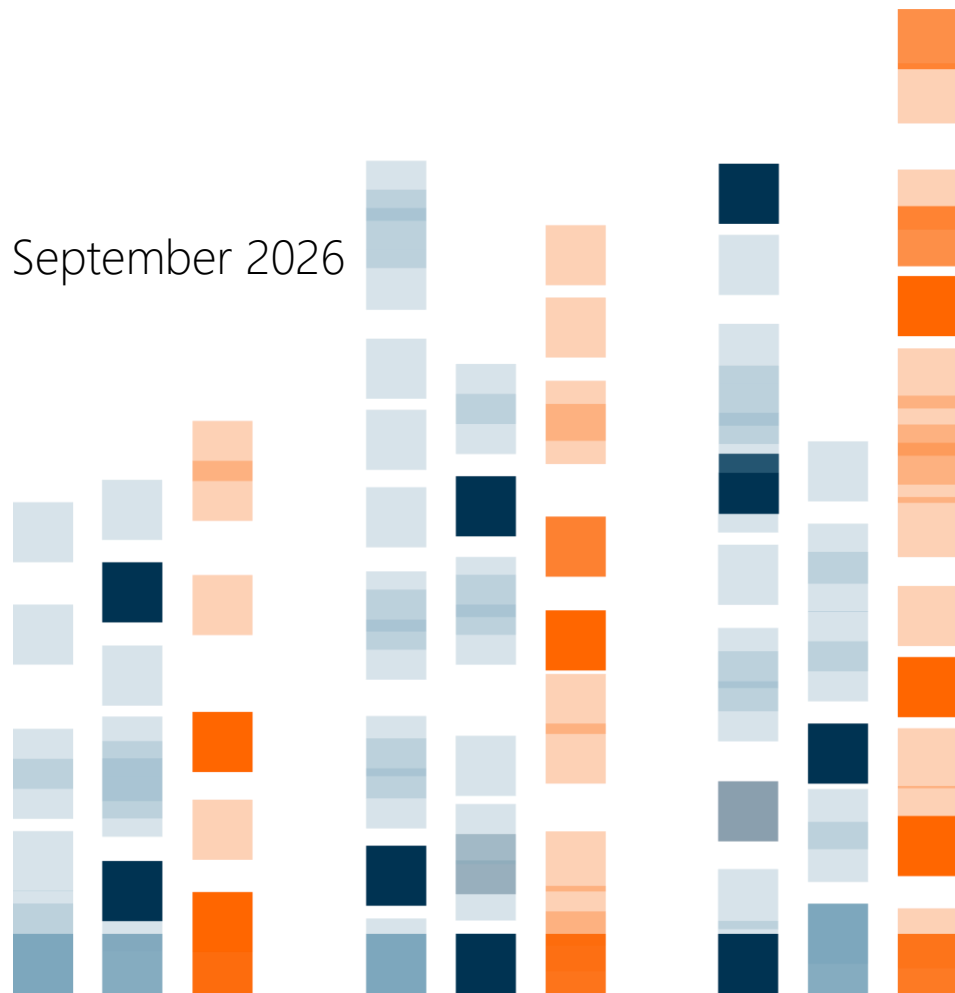
FINANCIAL	Likelihood	Certainty	Consequence	Council Response
Depreciation rates on planned asset acquisitions Buildings 2.4% Hard surfaces and appurtenance 6% Intangible assets 32.8% Investment property buildings 0% Library collections 16% Monuments and statues 0% Motor vehicles 29.3% Plants and equipment 23.5% Restricted buildings 0% Roads, bridges and footpaths 3.5% Stormwater systems 1.5% Wastewater Other Assets 1.4% Wastewater treatment plants 6.4% Water other assets 2.1% Water treatment plants 2%	Likely	High	Low	Regular reviews of appropriate rates incorporating asset life and value data are undertaken as part of the asset revaluation process.

FINANCIAL	Likelihood	Certainty	Consequence	Council Response																				
Interest rates - Borrowing Expected interest rates on borrowing will be <table><tr><td>2028</td><td>4.50%</td></tr><tr><td>2029</td><td>4.75%</td></tr><tr><td>2030</td><td>4.75%</td></tr><tr><td>2031</td><td>5.00%</td></tr><tr><td>2032</td><td>5.00%</td></tr><tr><td>2033</td><td>5.25%</td></tr><tr><td>2034</td><td>5.50%</td></tr><tr><td>2035</td><td>5.50%</td></tr><tr><td>2036</td><td>5.50%</td></tr><tr><td>2037</td><td>5.50%</td></tr></table>	2028	4.50%	2029	4.75%	2030	4.75%	2031	5.00%	2032	5.00%	2033	5.25%	2034	5.50%	2035	5.50%	2036	5.50%	2037	5.50%	Moderate/Likely	Medium	Moderate	A significant change in interest rates and the cost of borrowing would have a significant impact on Council budgets. Changes to services or the Financial Strategy would need to be considered. If interest rates were 0.5% higher than forecast this would increase Council finance expenses by \$x – \$x million per annum for the first 3 years of the Plan.
2028	4.50%																							
2029	4.75%																							
2030	4.75%																							
2031	5.00%																							
2032	5.00%																							
2033	5.25%																							
2034	5.50%																							
2035	5.50%																							
2036	5.50%																							
2037	5.50%																							

FINANCIAL		Likelihood	Certainty	Consequence	Council Response
Interest rates – Cash and Deposits Return on cash and term deposits are expected to be:		Likely/ Almost Certain	Medium	Minor	Term deposit rates currently vary between providers but most providers have a discount on rates from their prime lending rates. If interest rates were 0.5% higher than forecast this would increase Council finance revenue by \$x million per annum for each of the first 3 years of the Plan.
2028	3.50%				
2029	3.75%				
2030	3.75%				
2031	4.00%				
2032	4.00%				
2033	4.25%				
2034	4.50%				
2035	4.50%				
2036	4.50%				
2037	4.50%				

FINANCIAL	Likelihood	Certainty	Consequence	Council Response
Dividends from ICHL Dividends will be minimum \$5.5 million each year of the ten years of the plan, plus an additional \$4 million dividend per annum until 2033/2034.	Likely	Medium	Minor/ Moderate	There would be a negative impact on Council's overall revenue and cash position if the dividend level was not maintained, which would increase the burden on ratepayers. Council will consider strategic reliance on dividend noting increased levels of economic uncertainty and the impact of Council future direction to ICHL regarding holding of non-financial strategic assets.
External Funding It is assumed Council will achieve the level of external funding as estimated.	Possible/ Moderate	Medium	Minor/Moderate	Council is expecting external funding from Central Government, community and private investment, into a number of strategic projects. While not all funding may be achieved, the estimates are based on expert analysis and are expected to be at least partially fulfilled. Council expects to be in a position to meet any shortfall.
Land Sale Revenue Revenue from the sale of land is forecast to amount to \$x in 2027/2028, \$x in 2028/2029, and \$x in 2029/2030.	Possible/Moderate	Medium	Minor/Moderate	Some or all land may not be sold or may be sold for a lower value. Council expects to be in a position to meet any shortfall.

Long Term Plan forecast assumptions for Invercargill City Council



Authorship

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Executive summary

Introduction

Invercargill City Council commissioned Infometrics to prepare forecasts and analysis to inform its 2027 to 2037 Long Term Plan. The report brings together employment forecasts, population and household projections, international student forecasts, and housing affordability analysis for Invercargill City.

Key projects underpin modest, steady growth

Overall, Invercargill is expected to experience modest but steady growth over the Long Term Plan period. Major Southland projects, including aquaculture expansion, Datagrid, Aspiring Metals, and wind farm developments, are expected to lift employment and support migration, particularly in the late 2020s.

Employment to grow 0.7%pa to 2037

Employment in Invercargill is forecast to grow by an average of 0.7% per annum between 2027 and 2037, reaching 33,900 filled jobs by 2037. Growth is expected to be strongest in the late 2020s as construction activity associated with Datagrid and wind farm peaks, before easing in the early 2030s. Longer term, employment is forecast to reach 41,100 by 2057.

Population, households grow 0.3%pa to 2037

Invercargill's population is projected to grow by 0.3%pa between 2027 and 2037, reaching 59,900 people by 2037 and 65,600 by 2057. Households are also projected to grow 0.3%pa to 2037, from 23,600 in 2025 to 24,400 in 2037. The city's population is expected to continue ageing, with the share of residents aged 65 and over rising to 21% by 2037, while the under-15 population share declines.

Further slow recovery for international students

International student enrolments in Southland remain well below pre-pandemic levels and are expected to recover slowly. Student numbers are forecast to reach 1,464 by 2037, still 16% below 2019 levels.

Affordable housing, rent affordability decline

Housing remains more affordable in Invercargill than nationally, despite lower household incomes. In 2026, Invercargill's house-value to income ratio was 3.9 compared with 5.9 nationally, and mortgage repayments accounted for 23% of mean household incomes compared with 35% nationally. However, rental affordability has deteriorated, with rents rising from 14% of mean household incomes in 2005 to 18% in 2026, narrowing Invercargill's rental affordability advantage.

Introduction

Invercargill City Council commissioned Infometrics to produce forecasts and analysis to inform the development of their 2027 to 2037 Long Term Plan. In this report, we outline employment and international student forecasts, as well as population and household projections, for Invercargill City. We also analyse the city's household incomes and what this means for housing affordability.

Our approach

Baseline forecast

The baseline or foundation of our forecasts reflects a continuation of current economic and policy settings, globally, nationally and locally. Infometrics forecasts regional employment through a combination of three models. Our macro-economic model provides forecasts of national employment on an annual basis up to 2031. Our general equilibrium model forecasts national employment by industry over the long-term. Finally, our regional forecasting model breaks these forecasts down to industries in each region.

These forecasts were updated in February 2026, using regional employment and GDP estimates as of March 2025.

Modelling major projects

Southland is facing the prospect of several major projects, and we have prepared work for Great South to understand the impact of each project. However, for the purpose of informing Invercargill City's Long Term Plan, we have focused on consented projects, which are more certain and have more specific information available. In addition to the baseline forecast described above, our forecasts include aquaculture, Datagrid, Aspiring Metals and wind farm developments.

Aquaculture

We have allowed for growth in Southland Region's salmon production from 5,000 tonnes per annum in 2025 to 40,000 in 2057. Growth to 2037 aligns with the consented Hananui project, producing 16,000 tonnes at peak. The employment impact of aquaculture growth is modelled on Hananui's economic impact assessment, including a spread across aquaculture and seafood processing. Growth beyond 2037 would require additional projects to be consented, consistent with the Murihiku Aquaculture pathway.

There are additional opportunities in aquaculture (onshore, and besides Salmon) but have not been modelled in this report.

Datagrid

Datagrid proposes to build a large data centre near Makarewa, located in Southland District but near Invercargill City. Datagrid has a significant employment demand during construction, followed by a modest ongoing level of employment for operation. Analysis by Analysys Mason for Datagrid estimates that construction of Datagrid will support 460 to 750 jobs (midpoint of 605 jobs) across the South Island over a five-year construction period. Additional jobs are expected to be supported for the submarine cable construction, but we have not included these at all, as a large proportion of this work is likely to be delivered offshore and by specialist overseas cable laying companies.

We have been advised that Datagrid's construction period has since been shortened to two years, which based on the midpoint estimate of 605 jobs for five years, amounts to 1,500 jobs over two years. This is a substantial number, given that the entire Southland

Invercargill City Council - Long Term Plan forecast assumptions – September 2026

Region construction industry totalled 4,550 filled jobs in 2025. Since 2000, the largest increase in construction employment in Southland Region was 9.3% in 2002, associated with construction of Southland Hospital. We have taken the 9.3% increase in 2002 as an upper limit, which implies Southland Region construction jobs will grow by a maximum of 420 for Datagrid. The remaining jobs can be met through:

- Displacement of other construction activity in Southland Region, with a portion of the existing construction industry focusing on Datagrid, and other non-urgent construction work in the region delayed.
- Workers from other regions coming into Southland to work on Datagrid while residing elsewhere, which could involve driving from nearby regions, or flying from further afield, on a regular basis.
- Prefabrication of construction elements in other regions, to be transported into Southland, will mean some of the construction jobs can effectively be performed outside Southland Region.

For the Southland construction jobs supported by Datagrid, we have assumed these are spread across the existing construction industry. Across Southland Region, 63% of construction jobs are with firms located in Invercargill City, followed by 26% in Southland District and 11% in Gore. This reflects the location of the business or depot, from where these businesses may serve the wider region.

Ongoing operation of Datagrid is estimated to support 72-80 jobs (midpoint 76 jobs) per year, based on estimates from Datagrid.

Wind farms

Great South has identified a total of six wind farms totalling 290 turbines, either under construction or proposed for Southland Region. None of these farms are located in Invercargill City, but their significant construction works will have an impact on construction employment in Invercargill. We have estimated that these 290 turbines will generate a net 977 filled jobs in construction, in addition to the baseline employment, based on economic impact analysis of Contact's Southland wind farm. These projects are expected to support employment to 2031, with jobs spread across the region using the same approach outlined for Datagrid.

Aspiring Metals

Aspiring Metals propose to build a manufacturing facility in Invercargill City that extracts high-value minerals and green hydrogen from local rock waste. Aspiring Metals expects to employ up to 82 FTE jobs by 2037. Recent media releases have described the plant as supporting up to 200 FTE jobs, however, this larger figure includes indirect jobs, such as those with suppliers to their facility.

Population

Our population projection approach follows a traditional cohort component projection method, in which the starting population is broken up into age and gender cohorts. Each cohort is analysed and projected separately – considering the probabilities of different life events for each cohort in each five-year period. The life events include fertility, mortality, migration, household formation, and labour force participation. We

Invercargill City Council - Long Term Plan forecast assumptions – September 2026

also consider how these probabilities have changed over time and how they may change in future – for example, how labour force participation has risen among older age groups as life expectancy has extended over time.

The key point of difference for our population projections is that our employment forecasts inform projected net migration. We consider employment growth and labour force participation to assess labour force shortfalls in each region, which indicates how net migration will be distributed within the country.

Our projections start with a baseline population projection, based on the baseline employment forecast noted previously. We then bring in the estimated employment impacts of aquaculture, Datagrid, Aspiring Metals, and wind farms, comparing to the projected labour force, to estimate any labour force shortfalls. Where labour force shortfalls persist, our model allows for additional net migration to meet this demand – reflecting workers migrating into the region for jobs, and permanently adding to the region's population. We consider labour force shortfalls for Southland Region as a whole first, reflecting that there are extensive patterns of commuting established across Southland's three territorial authorities. Then, we apportion migration to each of the three territorial authorities reflecting historical growth patterns and the location of employment.

Employment

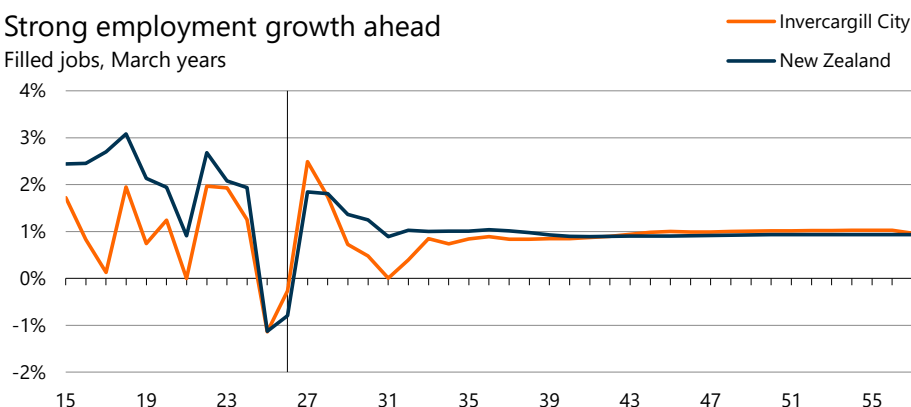
Invercargill employment grows 0.7%pa to 2037

Employment growth in Invercargill lagged New Zealand over the past decade, with Invercargill filled jobs growing 0.9%pa between 2016 and 2025, as jobs rose 1.9%pa nationally. Chart 1 shows that strong job growth in 2027 is set to push Invercargill's growth ahead of New Zealand, followed by more modest growth as Datagrid and wind construction work scales down by the early 2030s. Employment in Invercargill is forecast to grow 0.7%pa on average between 2027 and 2037, behind national growth of 1.1%.

Chart 1

Strong employment growth ahead

Filled jobs, March years



Source: Infometrics, Stats NZ

Between 2037 and 2057, Invercargill employment is forecast to grow 1.0%, just ahead of national growth of 0.9%.

Invercargill employment totals 33,900 in 2037

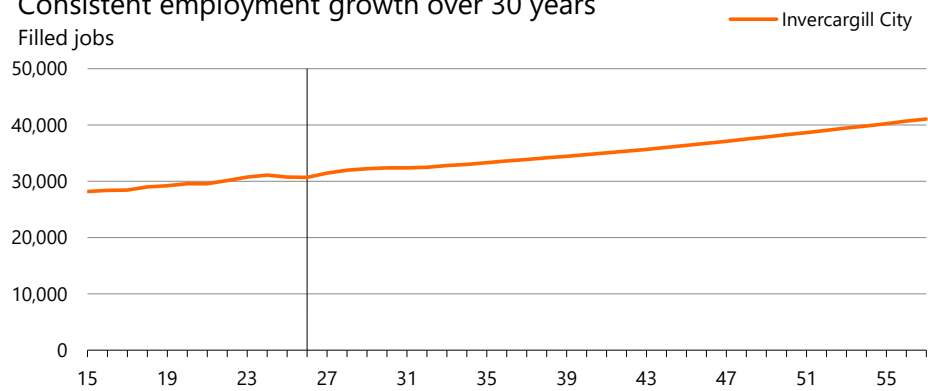
Employment in Invercargill rose from 28,400 in 2016 to 30,800 in 2026. Chart 2 shows that Invercargill employment is forecast to rise to 31,500 in 2027, then 33,900 in 2037, and on to 41,100 in 2057.

Invercargill City Council - Long Term Plan forecast assumptions – September 2026

Chart 2

Consistent employment growth over 30 years

Filled jobs



Source: Infometrics, Stats NZ

Population and households

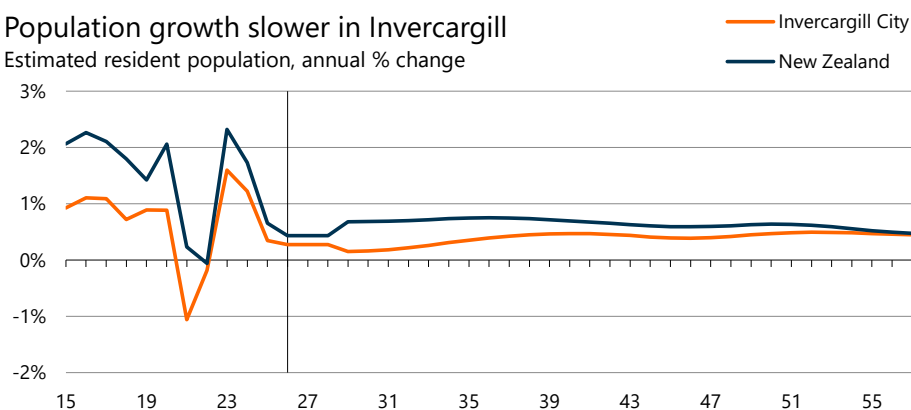
Invercargill's population grows 0.3%pa to 2037

Invercargill's population grew 0.7%pa on average between 2015 and 2025, less than half the national average of 1.5%pa (see Chart 3). Between 2027 and 2037, this gap is expected to narrow, with Invercargill's population projected to grow 0.3%pa, compared to 0.7%pa nationally. National and local population growth is slowing as the population ages, however, key projects in Southland are expected to generate employment, drive migration and in turn elevate population growth higher than it would have otherwise been, particularly in the late 2020s. For New Zealand, international net migration is currently low relative to historical levels, contributing to a relatively low rate of population growth. However, migration is expected to recover into the 2030s, as an ageing population drives a higher need for replacement workers, driving a slight pickup in New Zealand's rate of growth.

Chart 3

Population growth slower in Invercargill

Estimated resident population, annual % change



Source: Infometrics, Stats NZ

Between 2037 and 2057, Invercargill's population is projected to grow 0.5%pa, compared to 0.8%pa nationally.

Invercargill's population to total 59,900 in 2037

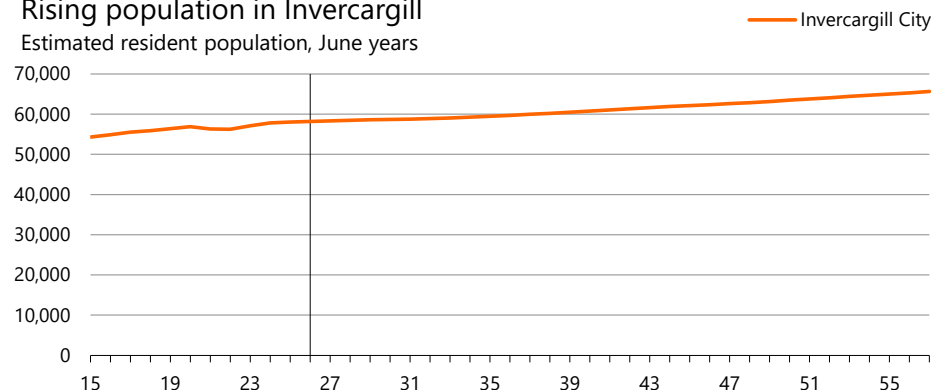
Invercargill's population has been through a long period of recovery over the past 55 years. Invercargill's population totalled 59,600 in 1981, but loss of major employers saw the population ease to 50,200 in 2000. From this low point, the population has recovered steadily, to 54,900 in 2016 and on to 58,000 in 2025. Chart 4 shows that Invercargill's population is projected to rise to 58,300 in 2027, then 59,900 in 2037, and on to 65,600 in 2057.

Invercargill City Council - Long Term Plan forecast assumptions – September 2026

Chart 4

Rising population in Invercargill

Estimated resident population, June years



Source: Infometrics, Stats NZ

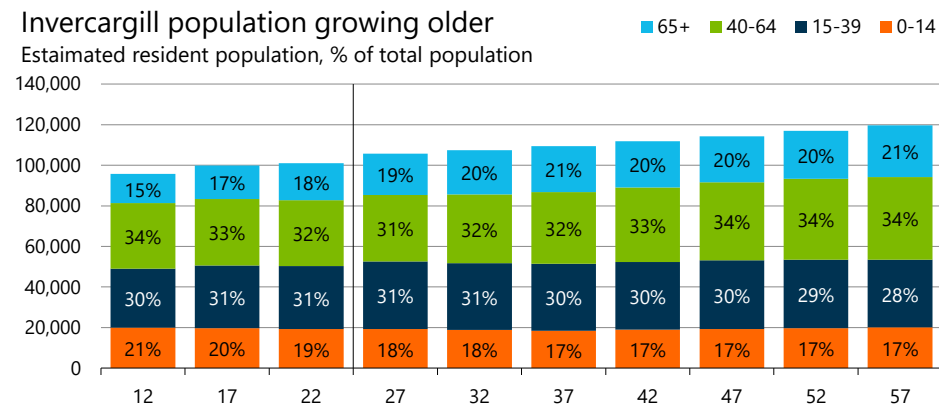
Invercargill's population getting older

Invercargill's population is projected to continue getting older. The 65-years-and-older (65+) age group grew from 15% of the population in 2012 to 18% in 2022. Chart 5 shows that by 2037, the 65+ age group will make up 21% of the city's population. The 40-64-year-old age group is projected to hold at around 32% of the city's population up to 2037.

Chart 5

Invercargill population growing older

Estimated resident population, % of total population



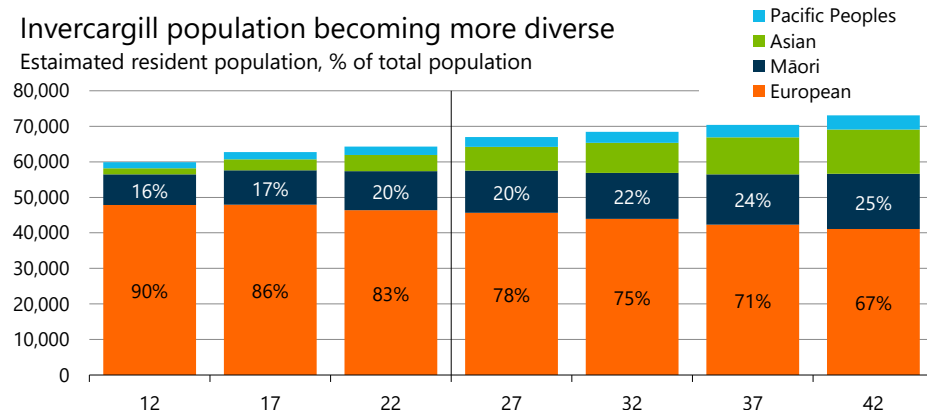
Source: Infometrics, Stats NZ

Invercargill's younger population is projected to continue declining. The under-15-year-old population eased from 21% in 2012 to 19% in 2022, and is projected to ease to 17% in 2037. Invercargill faces similar drivers of population change as the rest of the country, with an ageing population and decreasing fertility rates.

Invercargill becoming more diverse

Invercargill's population has already become more diverse, and this diversity is set to increase further. These changes are driven by faster ageing in the European ethnic group than other ethnic groups, and migration bringing in greater diversity. Chart 6 shows that people identifying with European ethnicity have eased from 90% of the population in 2012 to 83% in 2022, and is projected to ease to 78% in 2027 and 71% in 2037. At the same time, Māori ethnicity is growing quickly, from 16% in 2012 to 20% in 2022, on to 20% in 2027 and 24% in 2037.

Chart 6



Note: People can identify with more than one ethnicity, so percentages add to greater than 100%. Source: Infometrics, Stats NZ

Asian is the fastest growing ethnic group in Invercargill, with the city's population identifying with Asian ethnicity set to grow from 4,500 in 2022 to 10,400 in 2037, more than doubling. The proportion of the population identifying with Asian ethnicity is set to rise from 8% in 2022 to 17% in 2037. The population identifying with Pacific ethnicity is set to grow from 4% in 2022 to 6% in 2037.

Smaller households, but becoming larger

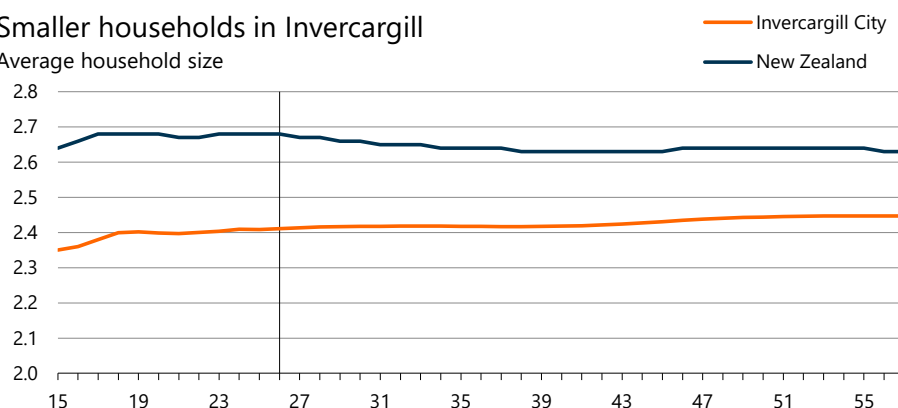
The average size of Invercargill households is appreciably lower than the national average. Chart 7 shows that in 2025, the average Invercargill household had 2.41 residents, compared to 2.68 nationally. The difference largely reflects Invercargill's older population, with older age groups more likely to form smaller households, such as couples without children, or single persons, as opposed to larger households with children. Invercargill's average household size is projected to rise slightly, starting at 2.41 in 2027, then up to 2.42 in 2037, and on to 2.45 in 2057. New Zealand's average household size is projected to remain much larger than Invercargill's, though it will ease to 2.64 in 2037 and 2.63 in 2057.

Invercargill City Council - Long Term Plan forecast assumptions – September 2026

Chart 7

Smaller households in Invercargill

Average household size



Source: Infometrics, Stats NZ

The slight increase in average household size in Invercargill means that the number of households will grow slightly slower than the population.

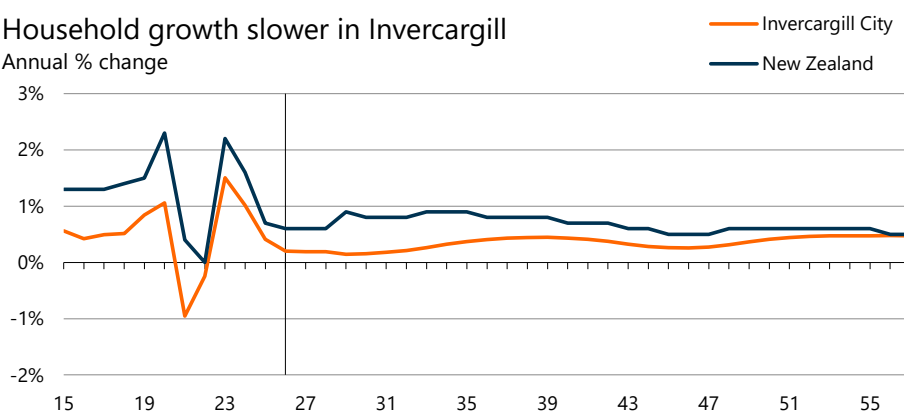
Households grow 0.3%pa to 2037

Household growth largely mirrors population growth, though changes in average household size can modify that trend. Chart 8 shows that the number of households in Invercargill rose 0.5%pa on average between 2016 and 2025, and is projected to grow 0.3%pa between 2027 and 2037, followed by 0.4%pa between 2037 and 2057.

Chart 8

Household growth slower in Invercargill

Annual % change



Source: Infometrics, Stats NZ

Household growth is faster nationally, growing 1.3%pa between 2016 and 2025, and projected to grow 0.8%pa between 2027 and 2037, and 0.6%pa between 2037 and 2057.

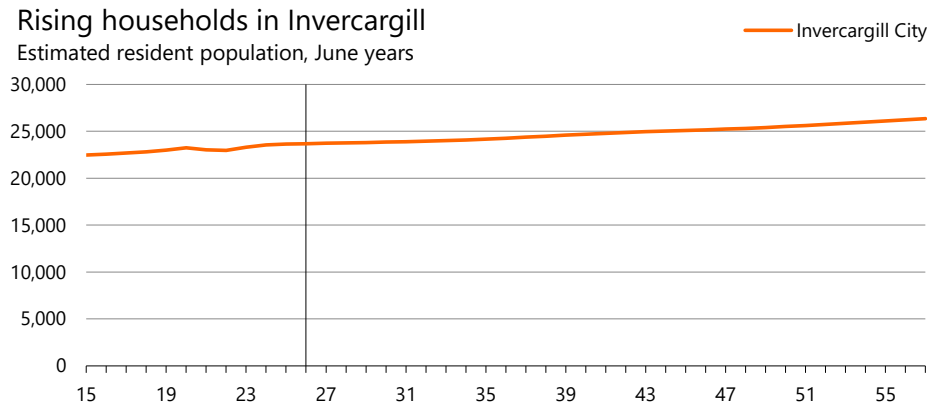
Invercargill households total 24,300 in 2037

The number of households in Invercargill has grown from 22,600 in 2016 to 23,600 in 2025. Chart 9 shows that the number of households is projected to grow to 23,700 in 2027, then 24,400 in 2037, and 26,300 in 2057.

Chart 9

Rising households in Invercargill

Estimated resident population, June years



Source: Infometrics, Stats NZ

International students

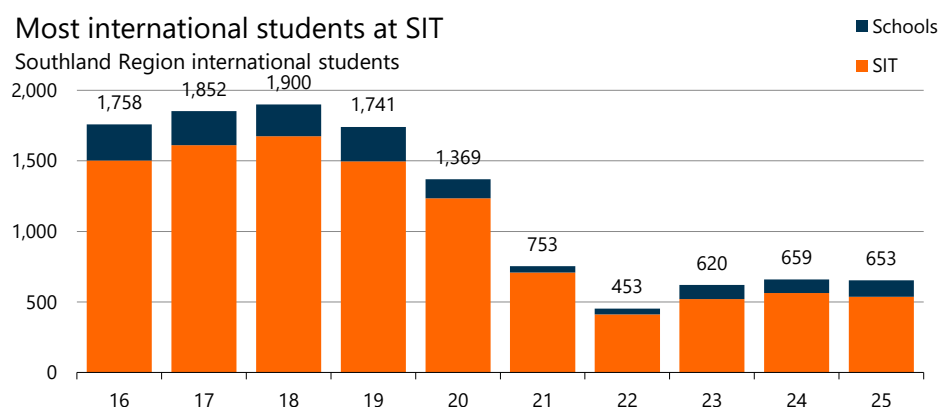
Long road to recovery ahead

International student enrolments have fallen since the COVID-19 pandemic in 2020 and merging of Southern Institute of Technology (SIT) into Te Pukenga. In 2019, there were a total of 1,521 international students in Southland Region (see Chart 10), including 1,496 total international students at SIT and 245 full international fee-paying students at Southland schools. As of 2025, there were a total of 653 international students in Southland, a slight improvement from the low point of 2022, but still well below pre-pandemic levels.

Chart 10

Most international students at SIT

Southland Region international students



Source: Infometrics, Education Counts, SIT

Southland Region lags in recovery

The number of international students at polytechnics nationally in 2025 was 47% below 2019 levels, but 64% below for SIT. This shows that SIT is lagging the polytechnic sector nationally in its international recovery.

Southland's international school students are further behind. The number of international students at schools nationally in 2025 was 13% below 2019 levels, but 53% below for Southland schools.

National visa approvals continue to recover

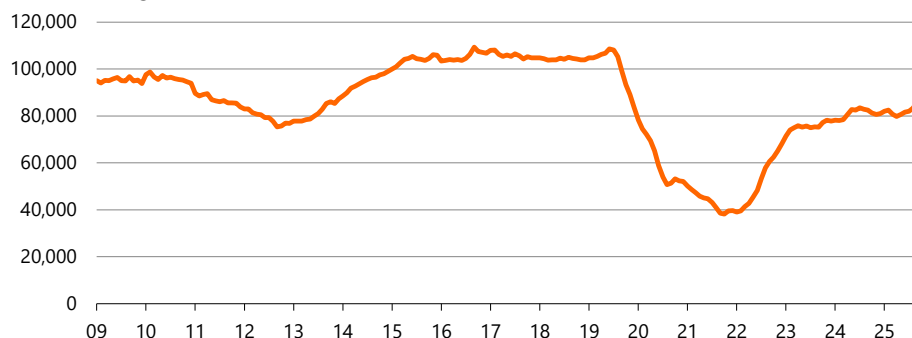
Nationally, student visa approval numbers are recovering, but still have some way to go. Student visa approvals totalled 67,500 in the year to May 2026, 17% below 2019 levels (see Chart 11).

Invercargill City Council - Long Term Plan forecast assumptions – September 2026

Chart 11

Student visa approvals New Zealand

Annual rolling total



Source: Infometrics, Immigration NZ

Forecasting international students

We forecast growth in international students in Southland through several steps

- 1) Start with our existing forecasts of international visitor arrivals, as general tourism and international education have been closely correlated in the past and are affected by similar factors such as the cost of international air travel. These forecasts show international visitor arrivals recovering to 2019 levels in 2028, with moderate growth thereafter, though recovery varies by market.
- 2) Apply forecast international visitor arrival growth to international student numbers in Southland, with weightings accounting for the significance of different world regions for different international education sectors. For example, Asia makes up 90% of international students in polytechnics in 2025, so growth of Asian visitor arrivals drives 90% of polytechnic student numbers.
- 3) Add adjustment to allow for recovery of market share. Southland's share of New Zealand's international student market is below its pre-pandemic level. With the newly independent SIT focusing on international students, we have assumed it will return to pre-pandemic market share over the next decade, which means faster growth than broader international visitor arrivals. International school student numbers were also allowed a degree of 'catch up' in their market share, but constrained by growth in SIT international students, reflecting the connected nature of regional international education market development.

Slow recovery for international students

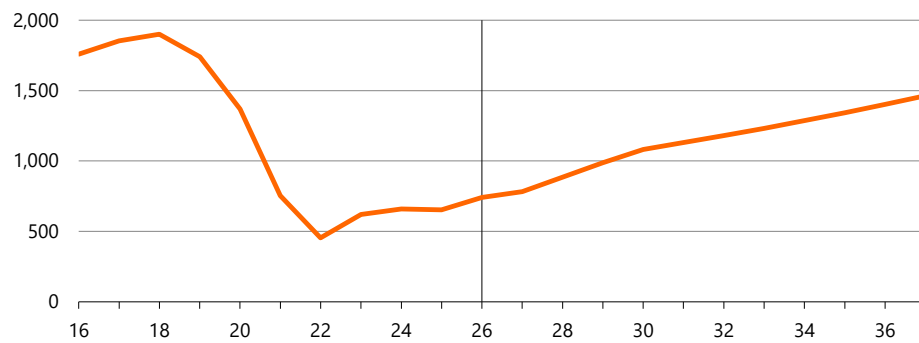
The number of international students in Southland is forecast to grow to 782 in 2027, and further on to 1,464 in 2037, which amounts to 16% below 2019 levels (see Chart 12). Slower growth is expected in 2026 and 2027, reflecting disruption and higher travel costs associated with the Iran War.

Invercargill City Council - Long Term Plan forecast assumptions – September 2026

Chart 12

Slow recovery for international students in Southland

Southland Region, international students at school and SIT



Source: Infometrics, Education Counts, SIT

International student numbers are forecast to grow 7.0%pa between 2025 and 2037. Polytechnic students are forecast to grow slightly faster, at 7.1%pa, and school students slightly slower, at 6.7%pa. SIT is planning for stronger growth, of 12.4%pa between 2025 and 2027, which would lead to a total of 2,312 international students in 2037 (including SIT and schools). The level of growth planned for by SIT is especially ambitious, and represents an upside risk to our forecast.

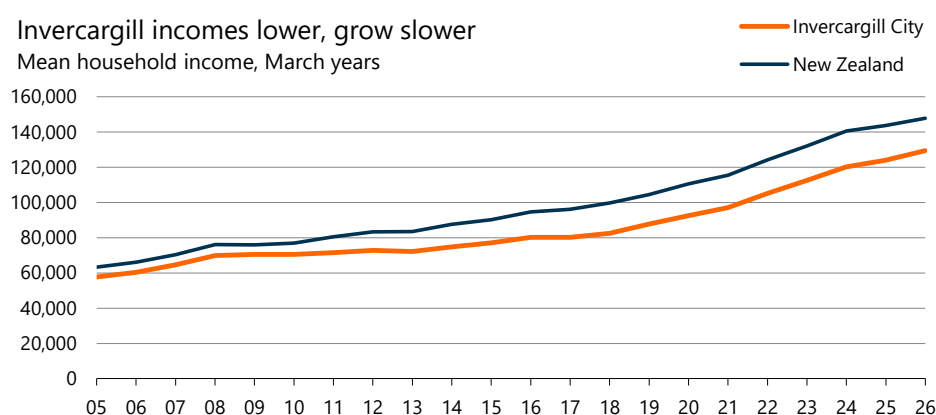
Housing affordability

Lower household incomes in Invercargill

Household incomes in Invercargill City are consistently below the national average, with Chart 13 showing that the gap has widened over the past 20 years as Invercargill's incomes have grown more slowly. In 2005, Invercargill's average household income was 9% below the national average, but by 2026 were 12% below. In 2026, Invercargill's average household income was \$129,500, behind \$147,900 nationally.

Chart 13

Invercargill incomes lower, grow slower
Mean household income, March years



Source: Infometrics, Stats NZ

Wide range of household incomes

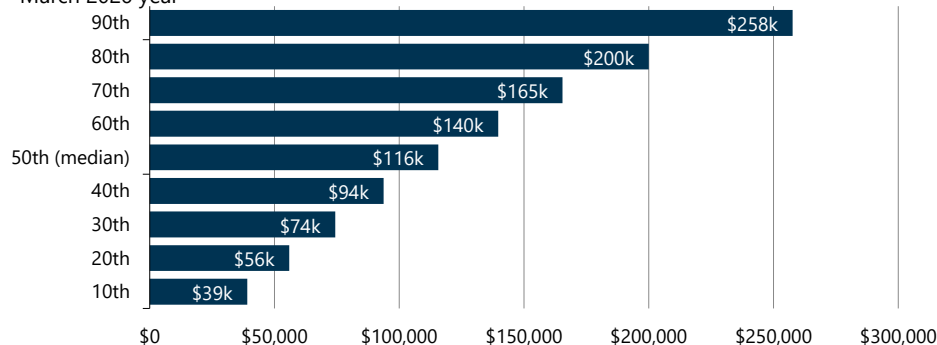
There is a wide range of household incomes in Invercargill City. Chart 14 shows incomes by percentile – for example, the 10th percentile represents the level of income that 10% of households earn less than, and 90% of households earn more than. Invercargill City's 10th percentile household income was \$39,000 in 2025, a third of the median or 50th percentile income. The 90th percentile household income, which is the income that 90% of households earn less than, was \$258,000, more than double the 50th percentile or median income.

Invercargill City Council - Long Term Plan forecast assumptions – September 2026

Chart 14

Household income by percentile in Invercargill City

March 2026 year



Source: Infometrics, Stats NZ

Common household incomes

To put the dollar values of the income percentiles into perspective, we have compared these to common household income sources. A key consideration is that housing affordability is based on household income, which is the total income of all usual residents in a household – which could be one person, a couple, or more. We have not considered tax, Working for Families tax credits, Accommodation Supplement or rates rebates due to data limitations.

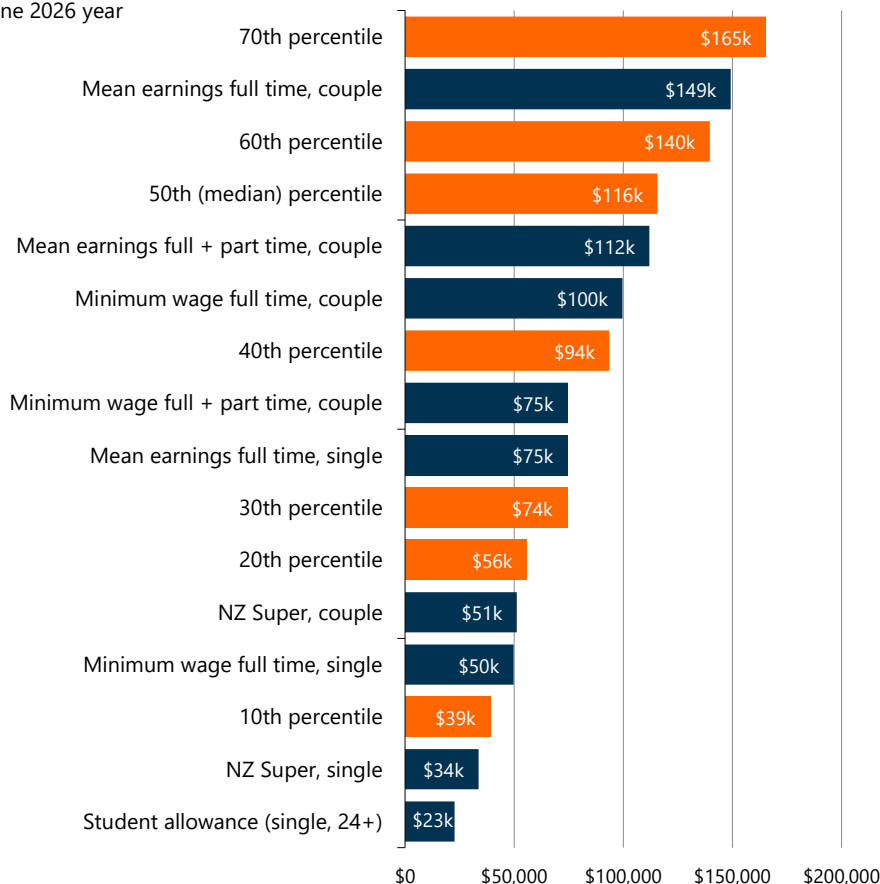
Chart 15 shows that a couple earning NZ Super with no other sources of income has a household income of \$51,000 per year, which places them in between the 10th percentile (\$39,000) and 20th percentile (\$56,000) for Invercargill.

Invercargill City Council - Long Term Plan forecast assumptions – September 2026

Chart 15

Common household incomes in Invercargill City

June 2026 year



Source: Infometrics, Stats NZ, MSD

Households made up of a single person with a lower income source invariably have a low household income, at or below the 20th percentile of \$56,000. A single person earning NZ Super earns \$34,000 per year, or \$50,000 earning minimum wage full time. A household made up of a single person working full time at the minimum wage would have a lower income than a retired couple on NZ Super.

However, for households with two earners, incomes are appreciably higher. A single person earning Invercargill's mean earnings of \$75,000 would place just about the 30th percentile as a single person household. A couple both working full time for Invercargill's mean earnings would have a household income of \$149,000, between the 60th and 70th percentiles. Households can achieve relatively high household incomes from two people working full time in average earning jobs.

More affordable housing in Invercargill

Invercargill has a much lower house-value to income ratio than the national average, meaning that houses are more affordable to buy in Invercargill. Chart 16 shows that

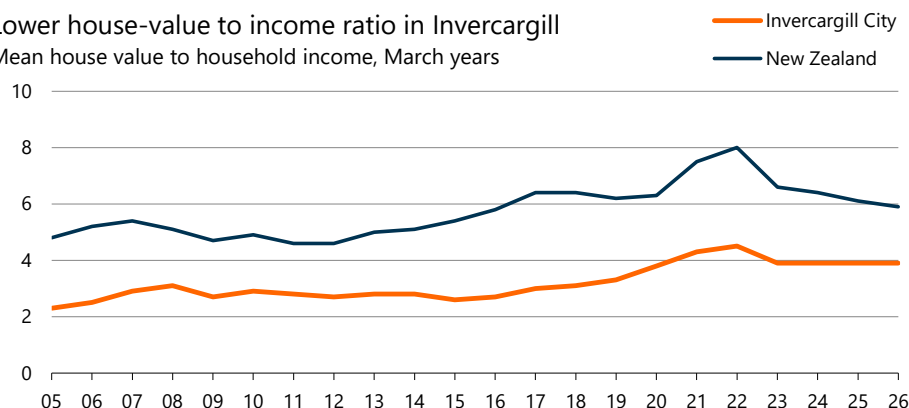
Invercargill City Council - Long Term Plan forecast assumptions – September 2026

Invercargill's house-value to income ratio has held steady at 3.9 over 2023 to 2026, compared to the national ratio of 5.9 in 2026.

Chart 16

Lower house-value to income ratio in Invercargill

Mean house value to household income, March years



Source: Infometrics, Stats NZ, Cotality

A significant gap between the Invercargill and New Zealand ratio has persisted over the past 20 years. Even after accounting for Invercargill's lower incomes, houses are still much more affordable in Invercargill than the national average.

In the year to March 2026, Invercargill's mean house value was \$504,100, over half the national average of \$871,800.

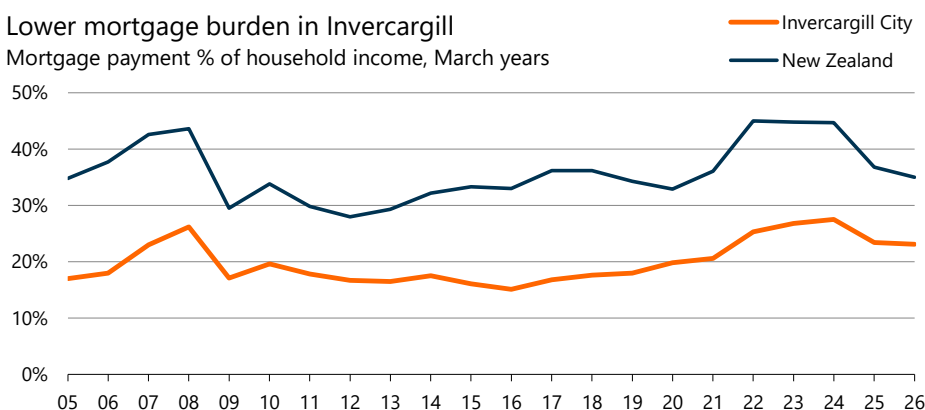
Lower mortgage burden

The house-value to income ratio is a useful diagnostic, but the mortgage payment share of income measure better reflects what households actually experience. Mortgage repayments are influenced by interest rates, in addition to house values, so this measure can be more volatile. Chart 17 shows that in 2026, mortgage repayments amounted to 23% of mean household incomes in Invercargill, well below the national average of 35%.

Chart 17

Lower mortgage burden in Invercargill

Mortgage payment % of household income, March years



Invercargill City Council - Long Term Plan forecast assumptions – September 2026

Source: Infometrics, Stats NZ, MBIE

Invercargill has maintained its mortgage affordability edge relative to New Zealand throughout the past 20 years.

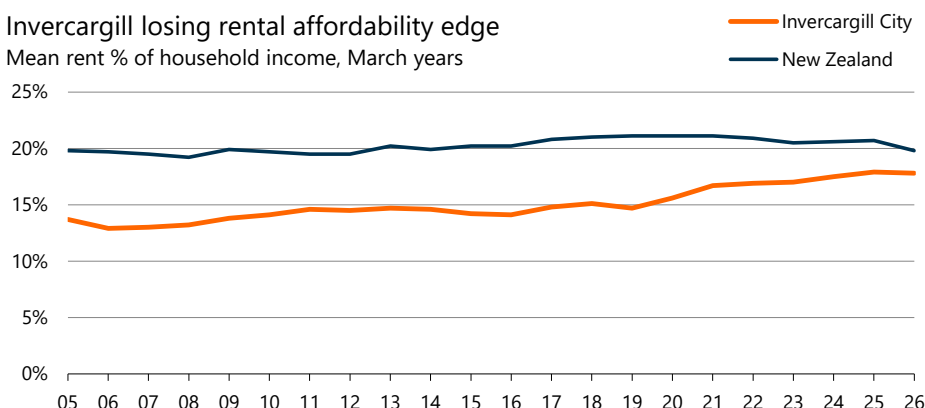
To calculate the mortgage repayment share, we have taken the mean house value, mean household income, and assumed a 25-year mortgage with 20% deposit and average 2-year fixed mortgage rates.

Invercargill rent becoming less affordable

Invercargill rents are more affordable than the national average, with mean rents amounting to 18% of mean household incomes, compared to 20% nationally. In the year to March 2026, Invercargill's mean rent was \$444 per week, below \$564 nationally. However, Chart 18 shows that the gap between Invercargill and the national average has narrowed over the past 20 years.

Chart 18

Invercargill losing rental affordability edge
Mean rent % of household income, March years



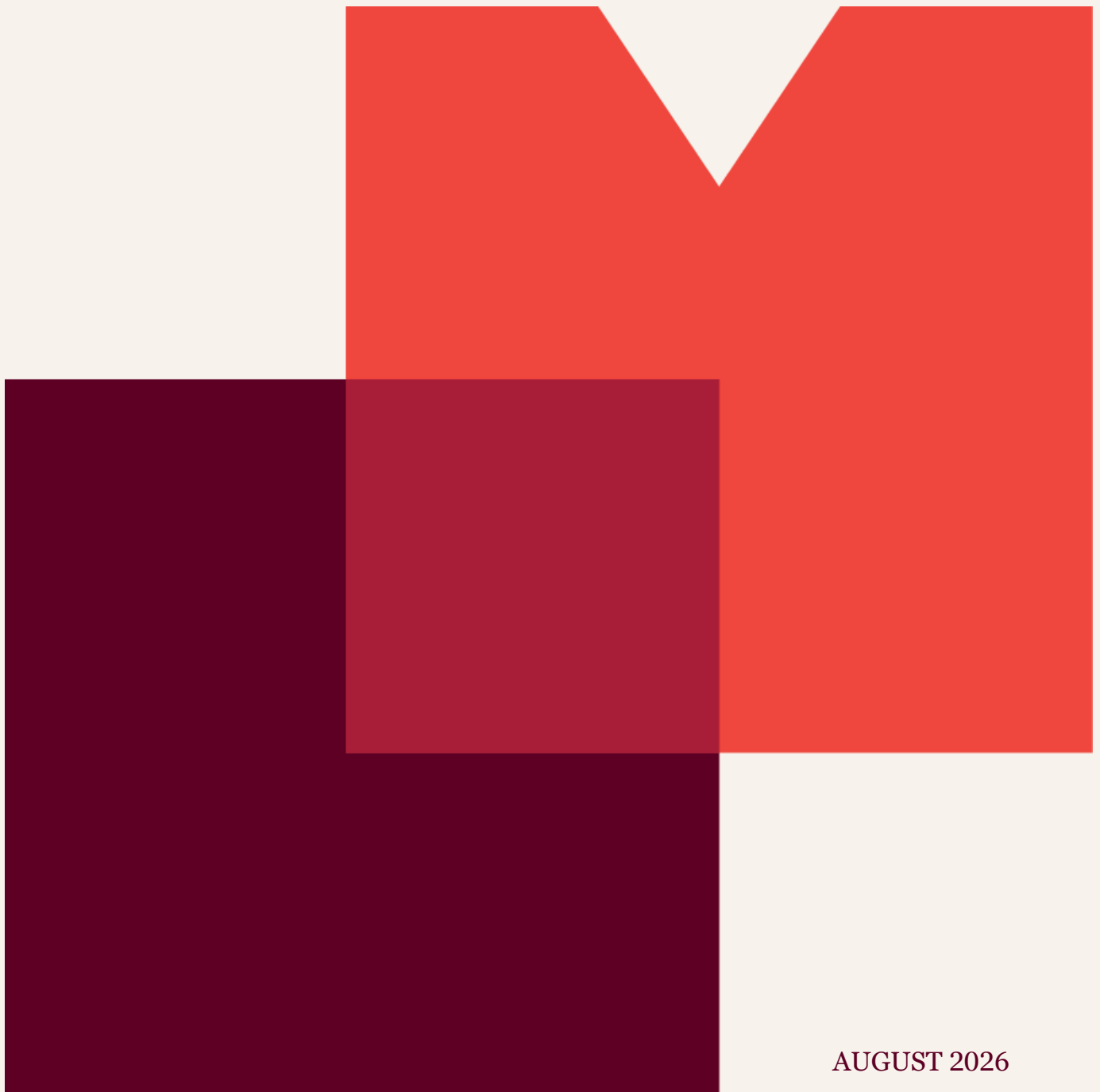
Source: Infometrics, MBIE, Stats NZ

Invercargill's rental affordability has deteriorated from 14% in 2005 to 18% in 2026, as New Zealand's rental affordability was largely unchanged from 20% in 2005. This deterioration means Invercargill is losing its rental affordability edge. This deterioration has been driven by a combination of slower household income growth and faster rent growth in Invercargill, compared to the national average.



Viability of Development Contributions

Invercargill City Council



AUGUST 2026



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Executive summary

Invercargill City Council (ICC) does not currently have a development contributions or financial contributions policy.

While ICC does not have current formal arrangements to collect a contribution for growth infrastructure from developers, it will enter into bespoke agreements with developers on occasion. These agreements are typically agreements between ICC and a single developer or landowner.

These arrangements do not provide the consistency or comprehensive cost recovery available under a formal growth funding regime, but they have provided a mechanism for addressing individual growth related infrastructure requirements.

As part of the work to develop its Long Term Plan, ICC has engaged Morrison Low Advisory to undertake analysis of the relative merits of adopting a Development Contributions policy. A key consideration for whether such a policy should be adopted is the potential introduction of a new growth funding tool, Development Levies.

The report considers the current growth environment and infrastructure requirements in Invercargill, and the potential financial implications associated with adopting a Development Contributions policy now. It concludes that, on balance, there is likely to be limited merit in adopting a Development Contributions policy with the 2027 Long Term Plan. Specifically, it finds that:

- The financial benefits of adopting a Development Contributions policy with the 2027 Long Term Plan appear to be modest, with a cumulative benefit to 2030, compared to waiting until Development Levies are available, of only around \$50,000 to \$120,000.
- Growth in Invercargill is already modest, with an existing housing surplus, and growth is not specifically constrained to the development areas which will benefit from infrastructure investment.
- There is a reasonable amount of uncertainty regarding the scope and nature of the growth projects relating to the alternative water supply project. If these projects are included in a Development Contributions policy there is a risk that Development Contributions would need to be returned if the projects do not proceed, and if the projects are not included, the potential income from Development Contributions could be as much as 70% lower.
- There is a risk that a Development Contributions policy would require significant revision within a relatively short period. Proposed Development Levies legislation is expected to substantially replace the current Development Contributions framework. In ICC's circumstances, there is a risk that the effort involved in developing, consulting on and administering a Development Contributions policy would outweigh the incremental benefits achieved before a replacement regime is available.
- ICC is not without interim options should significant growth occur before Development Levies are introduced. The Council currently uses bespoke funding agreements where developments require additional infrastructure investment, and proposed legislative reforms also indicate that future targeted rating mechanisms may provide additional options for recovering growth related infrastructure costs that have already been incurred.

On that basis, we recommend that ICC defers adopting a Development Contributions policy until there is greater certainty about the scope and timing of the alternative water supply projects, or until the Development Levies legislation has been enacted.



Background and context

Invercargill City Council (ICC) does not currently have a development contributions or financial contributions policy. While it does not have current formal arrangements to collect a contribution for growth infrastructure from developers, it will enter into bespoke agreements with developers on occasion.

These agreements are typically agreements between ICC and a single developer or landowner. They typically arise where a developer requests connection to an ICC water or wastewater network and additional infrastructure (such as a pump station) is required to support that connection.

At a national level and local level there is an increasing expectation that “growth pays for growth”. This has been particularly prominent in the three waters space, with the Commerce Commission requiring that water providers provide a “growth funding policy” and make specific disclosures regarding growth and connection charges within their districts.

Locally, there have been concerns raised by some members of the public that ICC’s lack of a development contributions policy may be slowing down growth. Some developers have also indicated that the current ad hoc arrangements sometimes benefit future developers who have not made a financial contribution toward the infrastructure.

The current Coalition Government has also introduced draft legislation to replace the current development contributions regime with a new funding tool “Development Levies”, new targeted rates, and improvements to the Infrastructure Funding and Financing Act as part of its broader “Going for Housing Growth” policy.

An exposure draft of the Local Government (Infrastructure Funding) Amendment Bill (the Bill) was released in early 2026. The Bill introduces Development Levies as a new funding tool and has an indicative implementation date of 1 July 2028. The Bill proposes a three-year period over which development contributions would be entirely phased out.

Growth

Invercargill is not currently experiencing significant levels of housing growth or development activity. A housing needs assessment undertaken in 2023 by Rationale identified that Invercargill had broadly the right number of houses to support the current and expected future needs of its residents, however its housing stock was not necessarily of the right type or condition.

Statistics New Zealand’s latest population growth estimates¹ place Invercargill in the bottom half of projected growth rates, with a predicted 0.4% annual population growth through to 2053 (based on 2023 Census data). Over a 20-year period, this means roughly 2,000 properties would be needed to accommodate the increased population.

According to the 2023 census, Invercargill City had 1,626 unoccupied dwellings. Building consent data held by Statistics New Zealand also shows that Invercargill City averages 180 building consents for new dwellings per year over the last three years, with 231 being issued in 2026.

Through discussions with ICC’s asset managers, it was suggested that the existing three waters and roading networks for Invercargill had sufficient capacity to manage current and expected future residential demand. However, some investment may be needed to expand networks into new areas or support industrial and commercial growth.

¹ Statistics New Zealand *Subnational population projections: 2023(base)–2053* published 25 September 2025



There have been increasing market signals of future industrial growth to the south of the city, particularly around the port and Bluff. The water supply to Bluff is currently at, or close to, capacity and a new water supply will need to be secured to support development in this area.

There is further commercial development occurring in the broader Southland region, particularly in relation to the new data centre. The data centre will be located within the Southland District. There has been some discussion about it seeking a connection to Invercargill's water supply, however discussions on this are ongoing and the extent to which this may be needed is still to be confirmed.

Legislative context

Development Contributions

Development Contributions are charges levied under the Local Government Act 2002 for the express purpose of enabling “territorial authorities to recover from those persons undertaking development a fair, equitable and proportionate portion of the total cost of capital expenditure necessary to service growth over the long term”.

Development Contributions can only be charged:

- If the effects or cumulative effects of development will create, or have created, the need for ICC to provide new assets or assets of additional capacity.
- When development activity occurs. Development is defined as any subdivision, building, land use, or work that generates a demand for infrastructure.
- In relation to capital expenditure, and only capital expenditure that is owned by ICC.
- For reserves, community facilities or network infrastructure.
- If ICC has a Development Contributions policy.
- For projects listed in a schedule of assets that is included as part of the Development Contributions policy, and for which planned projects are included in ICC's Long Term Plan.

The Local Government Act 2002 also includes specific assessment triggers for Development Contributions. Development Contributions cannot be assessed, or required, outside of these events:

- A resource consent being granted.
- A building consent being granted.
- A project information memorandum being issued for non-consented small standalone dwellings.
- An authorisation for service connection is granted.

In practice, this means that ICC cannot collect Development Contributions for developments or building work that have already been completed. Additionally, Development Contributions can only be charged where the net impact of the development results in an increased demand on infrastructure. Where development relates to the replacement of an existing home with a newer building, it is likely that no Development Contribution will be payable.

While the Local Government Act does allow developments and infrastructure projects to be grouped by geographic area, councils must do so in a manner that balances administrative efficiency with the principles of fairness and equity and generally avoids grouping across the entire district wherever practical. For example, where capital expenditure is intended to service Bluff, Development Contributions should not be collected from development elsewhere in the city.



Development Levies

Development Levies are a new funding tool that has been proposed as part of the current Coalition Government's Going for Housing Growth Policy. An exposure draft of the legislation which would enable Development Levies was proactively released for comment in November 2025. While submissions have closed on the exposure draft, no formal legislation has been introduced at this stage.

A key reason cited by the Government for the design of Development Levies is that the Development Contributions regime is no longer fit for purpose and was designed for a planning system in which councils exert a greater level of control over the location and timing of growth. As a consequence, while intended to recover the full cost of growth, Development Contributions typically result in under-recovery of growth costs.

A lot of the details regarding the Development Levies regime are still being developed, however, it is intended that:

- Costs will be recovered across the entire “levy area” with the default assumption being that a levy area is the entire district. Councils will require a “good reason” to adopt more than one levy area.
- While levies will be calculated by reference to eligible projects, there will be no requirement to deliver those specific projects.
- Levies will have independent regulatory oversight; this will indicatively be provided by the Commerce Commission.
- There will be a prescribed methodology for calculating Development Levies.
- Councils will be required to charge interest on unpaid Development Levies quarterly and will be entitled to reassess Development Levies if a period of 3 years has passed since the levy was last assessed.
- A Development Levies policy comes into effect when it is made publicly available for consultation, rather than when adopted.

Consultation on the exposure draft closed in early 2026, and a Bill was expected to be introduced in May 2026. At the time of writing, July 2026, no such Bill has been introduced. It is intended that the legislation would be passed in early 2027, with councils able to begin charging Development Levies from July 2028.

Councils will have the discretion to phase increased charges in over time.

A table setting out some of the key differences between Development Levies and Development Contributions is provided below.



	Development Contributions	Development Levies
Collection area	Subdivision or catchment level with express legislative requirement to avoid collection at district level where practical.	Entire district or levy area.
Use of money	Only on projects listed in a schedule of assets with limited exceptions.	Must be spent on the service and within the area for which it was collected but no requirement to spend on specific projects.
Variability in charges	Can differ between subdivisions/areas.	Can be levied across an entire district or levy area. Can apply high cost overlays if justified.
Reassessments	Charge assessed on application date, no opportunity to reassess even if a number of years have passed.	Can be reassessed every 3 years.
Interest costs	Can recover expected financing costs for infrastructure funding but no interest charges added to assessed development contribution charges.	Can recover financing costs within the set levy amount. Must also charge interest on unpaid levies every quarter.
Implementation date	From date policy is adopted. Anytime following consultation.	From date policy is made publicly available. Not before 1 July 2028.
Triggers for assessment	Resource consent, Building consent, PIM, service connection.	Resource consent, Building consent, PIM, service connection.
Regulatory oversight	None	Some form of oversight. Likely Commerce Commission.
Calculation	Consistent with “capacity life” of infrastructure but not specific methodology.	Prescribed methodology/approach.



Financial analysis

Approach

The key reason for a council to adopt a Development Contributions policy is to shift the burden of funding growth infrastructure away from Council and onto developers, landowners or future property owners within the district.

To determine the financial effectiveness of a potential Development Contributions policy for ICC, we have:

- Reviewed the capital projects that are proposed to be included in ICC's 2027 long term plan.
- Estimated the proportion of the project costs that relates to, and is recoverable from, growth.
- Estimated future housing demand and growth over 20 years.
- Calculated a per unit charge for Development Contributions.

This has produced high level forecasts which serve as a reasonable estimate of potential Development Contributions revenue for ICC. Further, detailed cost estimates and growth projection work would be required to determine actual Development Contribution charges.

The detailed assumptions and approach are outlined in Appendix A.

Growth projects

We identified five capital projects that may include a growth component. These are all water-related projects. Most (about 70%) of the potential recoverable cost is linked to the alternative water supply programme, which is still subject to further technical investigation.

If the alternative water supply projects were excluded, the potential Development Contributions revenue would reduce materially, by up to around 70% based on the current project list.

Those projects are identified in the table below:

Project name	Activity	Value	Growth %	Timing
Supply development – Awarua treatment	Water	\$11.4 million	33%	2028-2030
Pipe network – Trunkmain to/from Awarua	Water	\$17 million	33%	2028-2030
Skye Street Reservoir and pump station	Water	\$6.7 million	33%	2028-2030
Capacity to Bluff	Water	\$26.7 million	54%	2034-2037
Capacity Waikiwi to Doon	Water	\$10.7 million	100%	2030-2032



Potential revenue and financial impacts

Based on high-level modelling, a Development Contributions policy could generate around \$2.3 million per year once fully operating. This is based on an indicative charge of around \$23,000 per new property. These figures should be treated as estimates only, because they depend on actual growth, final project costs, and the final growth share of each project.

Development Contributions do not reduce rates dollar for dollar. They are capital receipts, meaning they are used to fund infrastructure or repay debt. The benefit to ratepayers is mainly through lower borrowing and lower interest costs over time.

When we compared the option of adopting a Development Contributions policy with the 2027 Long Term Plan against the option of waiting until the Development Levies legislation is in effect, we found that the net financial difference is in the range of \$50,000 to \$120,000 through to 2030. The full extent of the differences will be largely dependent on the final costs of developing and administering a Development Contributions policy.

A summary of the key financial differences between the option of adopting a Development Contributions policy with the 2027 Long Term Plan versus waiting until Development Levies legislation is passed is set out in the table below.

	Adopt Development Contributions Policy	Wait for Development Levies	Comments
Total Development Levies or Development Contributions received through to 2029/30	\$5,700,000	\$3,920,000	
Total interest saved through 2029/30	\$415,000	\$195,000	
Total policy development and adoption costs through 2029/2030	\$100,000 - \$200,000	\$50,000-\$100,000	Development Contributions option includes two sets of costs.
Total administration costs through 2029/30	\$150,000- \$210,000	\$100,000 – \$140,000	Development Contributions option includes administrative costs one year earlier.
Net saving/(cost) for ratepayers through 2030	\$5,000 – \$165,000	(\$45,000) - \$45,000	

The modelling indicates that adopting a Development Contributions policy with the 2027 Long Term Plan would allow ICC to collect growth-related revenue earlier. However, the short-term rates benefit is modest once policy development, consultation and administration costs are taken into account. On the current assumptions, the financial case for adopting a policy in 2027 is not strong on its own.



Alternative funding arrangements

The underlying objective for adopting a development contributions policy, or development levies when the new legislation is passed, is to ensure that “growth pays for growth”. In the absence of a development contributions policy, there are some alternative funding arrangements which could be considered. These are covered in the table below.

Some of these arrangements may be able to be used in conjunction with others.

Tool	Strengths	Weaknesses
Establishment of a levy under the Infrastructure Funding and Financing Act 2020 (an IFFA levy)	- Debt is not held on council balance sheet - Levy is clearly ringfenced towards specific purpose and designed for large scale projects - Can be used for projects completed up to 2 years earlier than a levy proposal² - Is not tied to development triggers (so allows recovery from growth that has already occurred)	- Borrowing rate is typically higher than LGFA lending - The combined impact of a levy plus rates is likely similar (or potentially higher) than rates directly - Have typically been difficult and costly to set up though recent legislative changes will improve this³ - Not typically targeted towards “new” properties
Development agreements or bespoke arrangements (status quo)	- Do not require changes to current processes - Provide flexibility to agree bespoke arrangements that suit the specific development and infrastructure needs - Is part of a negotiated commitment, meaning council isn’t exposed to risk of building infrastructure in anticipation of development	- Typically only suitable for large scale development - Usually require both parties to be motivated to enter into an agreement (for example an existing absence of enabling infrastructure or development contributions that the developer wants to negotiate “out” of) - May penalise first movers who carry most of the cost without a mechanism to reimburse those developers at a later date (and recover from subsequent developers) - Difficult to implement for infrastructure that is already in place/constructed
Developer funding / Public Private Partnership Developer funds and builds infrastructure, and council makes payments over time (with potential asset transfer at future date)	- Council does not have to be an infrastructure banker – shifts risk to developer - May result in debt being “off-balance sheet” depending on specific arrangements - May result in lower design and build costs	- Financing costs likely higher than Council costs - Requires strong relationship and contract management - Perception of privatisation of public services - Requires clear contract specification and design input

² Following enactment of the ² Infrastructure Funding and Financing Amendment Bill which recently passed its third reading

³ Infrastructure Funding and Financing Amendment Bill which recently passed its third reading has streamlined this process



Tool	Strengths	Weaknesses
		• May create anti-competitive behaviour • Repayments are likely to still come from rates (though these could be highly targeted) • Cannot also use development contributions or levies unless infrastructure is owned by Council
Private sector owned and delivered No council involved beyond consenting, no connection to council networks	• Council does not fund or collect rates	• May not deliver broader network outcomes for Council • Council may need to take over in the future, creating additional costs • No public good outcomes, or these may come at cost • May create anti-competitive behaviour • Could result in multiple, ad-hoc, sub-optimal solutions • Not suitable for all infrastructure
Targeted rates (current legislative framework) Setting a targeted rate (with or without differentials) in a specific geographic location to recover costs of supporting growth	• Can be implemented within existing systems • Can be expressly linked to specific infrastructure investment and separated on rates bill if needed • Can apply to capital or operating expenditure • Borrowing costs reflect ICC's borrowing cost	• Are still rates, and may create affordability pressure for some property owners • Generally recovered from a defined class of properties rather than solely new development • Would need to be substantiated and supported in ICC's revenue and financing policy • May have a long recovery period
Lump sum contribution under Part 4A of the Local Government (Rating) Act 2002	• Does not have to be specifically for "development" • Capital cost can be revised once following final costs becoming known • Can support recovery over time through lump sums and targeted rates	• Defers payment until property is connected (and infrastructure built) • Cannot compel upfront lump sum • Capital expenditure only • Needs to be documented in a capital project funding plan • No explicit legislative mechanism for distinguishing between existing properties and future development in the same way as development contributions • Properties would need to be defined in the capital project funding plan, which may make changes arising from growth, rezoning, subdivision, or expansion of serviced areas more administratively complex than a development contributions regime



Tool	Strengths	Weaknesses
Targeted rates (future) The Going for Housing Growth proposals suggest introduction of a new targeted rate that can be applied to new subdivisions/development after a certain date	- Highly targeted at properties that have benefited from investment - Can be applied toward the recovery of costs from past projects - Relatively simple to administer	- Debt remains on Council's balance sheet - No current legislation to enable this – implementation is at risk of legislation being enacted - Likely to lead to a slower recovery of costs than development contributions - May impact affordability of new homes - Could be discontinued by any future council leading to under-recovery of costs

While a range of alternative funding mechanisms are available, most would either require significant implementation effort, are not specifically targeted at growth, or are better suited to large scale infrastructure programmes. Given ICC's current growth profile, borrowing capacity, and the anticipated introduction of Development Levies and associated targeted rate mechanisms, we do not consider there to be a compelling case for pursuing an interim replacement for Development Contributions at this time.

We note however that the Government has indicated that future targeted rate mechanisms may allow councils to recover capital costs from development occurring after a specified date. Subject to the final form of the legislation, this may provide a mechanism for recovering some growth related infrastructure costs incurred before Development Levies are implemented.



Summary

The question for ICC is not whether Development Contributions are capable of recovering growth costs, but whether it is proportionate to establish a Development Contributions policy when the estimated net benefit before the likely introduction of Development Levies is relatively modest. To answer this, we must consider the broader context of development contributions, the problems that they were introduced to address and the reasons that they are now being replaced.

Development Contributions legislation was introduced in a regulatory environment which typically included more restrictions on where, and when, growth can occur. Since then, the National Policy Statement on Urban Development, the introduction of the Fast Track Approvals process, and increasingly permissive district plans mean that the location and timing of growth is often unpredictable.

This introduces risk for councils, that either growth occurs in an area where Development Contributions do not apply, or that growth and the related investment in infrastructure that supports that growth fall out of sequence. When this occurs, Development Contributions become a less effective tool for recovering the costs of that growth.

In Invercargill, we understand that growth has typically been unpredictable and ad hoc in nature. There have been a number of discussions held between council staff and potential developers or landowners, but there is very little certainty about if, when, or where growth may actually occur.

Where growth has occurred, ICC has generally been able to address infrastructure funding requirements through bespoke agreements with developers and landowners. While those arrangements do not provide the consistency and transparency of a formal Development Contributions regime, they reduce the urgency associated with implementing a policy over what may be a relatively short transition period.

At the same time, there are only a limited number of programmed growth related capital projects, with the majority of those projects relating to the alternative water supply. Importantly, the alternative water supply project, and the associated growth elements of that project, are dependent on the technical outcomes of investigatory work that has yet to be concluded. The decision about whether to proceed with those projects is not being driven purely by financial constraints.

In our view this means that, for ICC, there is limited merit in proceeding with the introduction of a Development Contributions policy through the 2027 Long Term Plan. While there are some financial benefits associated with earlier adoption, in our view these are not significant enough to justify the earlier investment and administrative costs of around \$100,000 - \$200,000.

This is particularly the case given the estimated lifespan of such a policy and that the majority of eligible growth costs relate to projects associated with the alternative water supply projects which is subject to technical investigation.



Appendix A Approach and assumptions

The financial analysis contained in this report relies on the following methodology and key assumptions.

- The growth allocation for those projects has been determined using the cost allocation methodology that we typically apply for Development Contributions policies elsewhere, noting that these are high level estimates only at this stage and detailed work would be required to determine this allocation accurately should a policy be adopted.
- A 20 year collection period for the growth costs has been assumed.
- The cost of borrowing on growth related debt has been assumed at 5.5%.
- We have assumed all capital projects would be recovered across the entire Invercargill district and that growth occurs in line with the Statistics New Zealand medium growth projections.
- We have assumed a housing density of 2.4 people per house.
- Assumed that all new residents must be accommodated in a new dwelling which attracts a full Development Contributions charge. We note that existing housing surpluses may mean that not all new buildings or population will require a new dwelling in reality.
- There is a time delay between the adoption of a Development Contributions policy and the receipt of Development Contributions. Based on analysis undertaken elsewhere this means that ICC could expect less than 55% of this amount in the first year of its policy.
- There may be a “flurry” of resource consent applications ahead of a Development Contributions policy being adopted meaning that the number of consents on which a Development Contribution is assessed will be lower in the first year. For the purposes of our analysis, we’ve reduced the number of applications in the first year by 20%.
- The amount received must be applied towards the capital costs of constructing infrastructure or the repayment of the debt. This means that Development Contributions receipts do not give rise to a dollar for dollar offset on rates.
- The total revenue requirements are based on Statistics New Zealand growth projections. If growth does not occur at the pace projected by Statistics New Zealand or occurs outside of the development areas for which a Development Contribution is being charged, revenue projections will not be met.
- A Development Contributions policy will have a number of costs including initial drafting costs, legal review, consultation costs, and ongoing administrative costs.

For the comparison of adopting a Development Contributions policy with the 2027 Long Term Plan versus deferring work until Development Levies legislation is passed, we have also made the following assumptions in the deferral scenario:

- While the alternative water supply is still included in these calculations at full cost, the Development Levies legislation indicates that this money would not have to be applied to the alternative water supply project, so the specific project risks are greatly mitigated.
- Because Development Levies are applicable from the date that the policy was first made public for consultation, we have assumed that the full number of consents that would be received in the first year will be charged a Development Levy.
- We have not included interest charged on unpaid Development Levies. The amount received would be the same in either scenario and in the realm of \$10,000 to \$15,000 per annum.



Appendix B Detailed scenario comparison

Rates savings if implemented with 2027 Long Term Plan

We have set out a high level estimate of financial implications in the table below. This includes an assumption that the alternative water supply project continues and will include a growth component.

	2026/27	2027/28	2028/29	2029/30	Total to 2030
Potential Development Contributions revenue received	\$0	\$1,200,000	\$2,250,000	\$2,250,000	\$5,700,000
Cumulative Development Contributions received	\$0	\$1,200,000	\$3,450,000	\$5,700,000	\$5,700,000
Annual interest saving ⁴	\$0	\$35,000	\$130,000	\$250,000	\$413,000
Policy development, review and consultation ⁵	\$50,000 – \$100,000	\$50,000 – \$100,000			\$100,000 – \$200,000
Ongoing policy maintenance	\$0	\$50,000 – \$70,000	\$50,000 – \$70,000	\$50,000 – \$70,000	\$150,000 – \$210,000
Net saving (cost) p.a.	(\$50,000 – \$100,000)	(\$65,000 – \$135,000)	\$60,000 – \$80,000	\$180,000 – \$200,000	\$5,000 – \$165,000

Rates savings if ICC waits until Development Levies are in place

The alternative scenario, that ICC does not introduce a Development Contributions policy with its 2027 Long Term Plan, is set out below.

This assumes that the same growth allocation approach and projects are included in a Development Levies policy, and that the approach to calculating Development Levies is broadly consistent with Development Contributions. Note the following differences are also assumed in the below table.

⁴ 5.5% calculated on the average of the opening and closing balances.

⁵ Repeated in 2027/28 to account for the development costs of a development levies policy.



	2026/27	2027/28	2028/29	2029/30	Total to 2030
Potential Development Levies revenue received	\$0	\$0	\$1,670,000	\$2,250,000	\$3,920,000
Cumulative Development Levies received	\$0	\$0	\$1,670,000	\$3,920,000	\$5,590,000
Annual interest saving ⁶	\$0	\$0	\$45,000	\$150,000	\$195,000
Policy development, review and consultation ⁷	\$0	\$50,000 – \$100,000			\$50,000- \$100,000
Ongoing policy maintenance	\$0	\$0	\$50,000 - \$70,000	\$50,000 - \$70,000	\$100,000 – \$140,000
Net saving	\$0	(\$50,000 - \$100,000)	(\$5,000 - \$25,000)	\$80,000 - \$100,000	(\$45,000) - \$45,000

⁶ 5.5% calculated on the average of the opening and closing balances.

⁷ Repeated in 2027/28 to account for the development costs of a development levies policy.



Document Status

Job #	Version	Written	Reviewed	Approved	Report Date
3110	1.0 Final	S.Cross	M.Johnson	S.Cross	22 July 2026
3110	2.0 Updated	S.Cross	M.Johnson	S.Cross	4 August 2026



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2026 DRAFT ANNUAL REPORT UPDATE

To:	Risk and Assurance Committee
Meeting Date:	Tuesday 15 September 2026
From:	Bryan Staunton – Chief Financial Officer
Approved:	Patricia Christie – Group Manager – Finance and Assurance
Approved Date:	Wednesday 9 September 2026
Open Agenda:	Yes
Public Excluded Agenda:	No

Purpose and Summary

The purpose of this report is to provide the Risk and Assurance Committee, and Council with an update on the preparation of the Annual Report including key milestone dates, key issues and progress to date.

The Audit Office is expected to complete the audit prior to 30 October, and the Annual Report is planned for adoption on 30 October 2026.

Invercargill City Holdings Limited's audit is currently underway, and the Council group consolidation is starting to be prepared. As such, the focus of this paper is on the key issues identified to date.

Recommendations

That the Risk and Assurance Committee:

1. Receives the report "2026 Draft Annual Report Update".
2. Notes:
 - a. The key milestone dates for completion for the 2026 Annual Report and the progress to date against these milestones.
 - b. The key issues for the preparation and audit of the 2026 Annual Report.
3. Requests that the Chair is provided with updates from officers on progress against milestones, key issues and audit progress, as the next scheduled meeting of this Committee will be to recommend the Annual Report to Council for adoption.

Background

Annual Report 2026 Key Milestones

As previously reported to the Risk and Assurance Committee, the Annual Report timetable is as follows:

• Interim audit begins	28 April 2026 - completed
• Pre-final review	15 June 2026 - completed
• Draft annual report available for audit	11 September 2026
• Final audit begins	14 September 2026
• Final financial statements available	27 October 2026
• Audit opinion issued	By Monday 02 November 2026
• Draft report to the Council issued	By Monday 02 November 2026

The interim audit and pre-final review have both been successfully completed.

The Audit Office will be commencing their final year-end audit on 14 September 2026, with the draft annual report at the time of writing on track to be delivered to the Audit Office on 11 September 2026. No major risks have been identified which would prevent the above key milestones from being completed on schedule.

Issues

Key Issues for the Annual Report

The key issue identified to date, for this Annual Report is the movement in the fair value of Three Waters and roading assets. Council completed revaluations of land and buildings and roading asset classes as at 30 June 2025 in line with its three yearly revaluation cycle. The other major asset class - Three Waters were valued at 30 June 2024.

There has been a significant increase in the Capital Goods Price Index (CGPI) for the past quarter following the unrest in the Middle East and the impact on global oil prices. Three Waters assets have a projected inflation increase of \$57.310 million or 9.23% since the last valuation two years ago. Roothing assets have a projected inflation increase of \$22.503 million or 5.08% since the last valuation one year ago. Operational land and buildings have a projected inflationary increase of \$4.60 million or 2.82% since the previous valuation a year ago.

Initial discussions with The Audit Office have indicated that the projected movement will be within the permissible audit materiality, and no adjustments will be required. However, the increase in asset values is likely to remain one of the key issues for the audit.

The annual investment property revaluation resulted in an increase in value of \$0.03 million.

Reduction of Parking Refund Provision

In 2024 following the identification that parking fines had been incorrectly levied and would need to be refunded a fund was created (balance sheet provision) from which to refund the incorrect parking fines.

Since the provision was created in April 2024 \$82,599 has been refunded to users incorrectly fined. This represents 15% of the total population of incorrectly collected fines. Only \$264 has been refunded in the 2025-26 year. While Council still has an obligation to refund, the likelihood of having to refund the full amount is unlikely. It is for this reason that the provision has been reduced by \$100,000. The closing balance of the provision at 30 June 2026 is \$88,361.

Next Steps

Tasks supporting the preparation of the annual reports will continue by the Finance team and other key supporting areas.

Regular meetings are and will continue to be held with the Audit Office around key issues and issues arising from the Council and subsidiary company audits.

Attachments

None

2027 – 2037 LTP AUDIT ENGAGEMENT LETTER

To: Risk and Assurance Committee

Meeting Date: Tuesday 15 September 2026

From: Rhiannon Suter – Manager – Strategy, Policy and Engagement

Approved: Patricia Christie - Group Manager - Finance and Assurance

Approved Date: Thursday 10 September 2026

Open Agenda: Yes

Purpose and Summary

The Audit Office has provided the draft letter of engagement for the 2027 – 2037 Long-term plan (LTP). The proposed fees are not yet available. There are a number of risks to the timeline of the process which are outlined in this report.

Recommendations

That the Risk and Assurance Committee:

1. Receives the report "2027 – 2037 LTP Audit Engagement Letter".

Recommend to Council:

2. That the Mayor signs the 2027 – 2037 LTP Audit Engagement Letter.

Background

By statute an audit is a required part of the LTP, and the Audit Office has been appointed by the Auditor General as the Council's auditor. Initial discussions have been held with the audit team to discuss timelines and areas of focus. These are included within the draft audit letter of engagement and the risks related to the process are noted below.

Issues

The primary risk to the timeline is the complexity and transitional state of the regulatory environment, which is impacting on a wide range of planning of aspects of Councils operations, as well as on the final detail of the approach which auditors will take.

This uncertainty may impact either Council's ability to provide completed components on schedule to the auditors or the audit team's ability to complete various stages of the audit on time.

Three particular points of note in the timeline are:

- **Delivery of all components in draft including the draft consultation document by 11 January 2027.** This relies on Council making key decisions in October, November and December which are likely to be made more challenging by the budgetary pressures created by inflation, enhanced requirements driven by regulation and constrained funding environment.
- **Audit Office sign off of the consultation document on 8 March.** Ministry for Cities, Environment, Regions and Transport (MCERT) note that the rates capping regulation is expected to pass in March and this may cause issues which auditors will need to assist with during the LTP process.
- **Availability of the full LTP document to audit on 28 May.** Dependent on the decisions made by Council in agreeing a draft LTP for consultation there may be challenging consultation discussions to be had with the community and this, together with any adjustments required by technical detail of new regulations becoming available later in the process, may cause challenges in delivering the final document to audit on their original preferred date of 21 May. This may then flow on to challenges in responding to audit feedback to complete the sign off the document by 30 June 2027. It is noted that the statutory deadline for adoption of the LTP is 30 June and rates are planned to be set on 30 June also.

Council officers are working closely with auditors to ensure that information is shared as early as possible in the process.

Next Steps

The Risk and Assurance Committee will receive a further update on the audit process in December 2026.

Attachments

Draft Audit Engagement Letter (11267132).



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website: www.ao.parliament.nz

3 September 2026

Tom Campbell
Mayor
Invercargill City Council
Private Bag 90104
Invercargill 9840

Dear Tom

Audit engagement letter: Audit of the consultation document and long-term plan for the period commencing 1 July 2027

This audit engagement letter is sent to you on behalf of the Auditor-General, who is the auditor of all “public entities”, including Invercargill City Council (the Council), under section 14 of the Public Audit Act 2001. The Auditor-General has appointed me, Rudie Tomlinson, using the staff and resources of The Audit Office (the Office), under section 32 and 33 of the Public Audit Act 2001, to carry out the audit of the Council’s consultation document and long-term plan (LTP).

This letter outlines the terms of the audit engagement, including:

- the Council’s responsibilities;
- our responsibilities;
- our approach to the audit;
- areas of audit focus;
- audit logistics;
- professional fees; and
- personnel.

The letter seeks your agreement to the terms of the engagement.

Our audit is carried out in accordance with International Standard on Assurance Engagements (New Zealand) 3000 (Revised): *Assurance Engagements Other Than Audits or Reviews of Historical*

Financial Information. We also consider the requirements of the Auditor-General's Auditing Standards where applicable and refer to the International Standard on Assurance Engagements 3400: *The Examination of Prospective Financial Information.*

1 Council's responsibilities

Our audit will be carried out on the basis that the Council acknowledges that it has responsibility for preparing the consultation document and LTP, by applying the Council's own assumptions, in accordance with the Local Government Act 2002 (the Act) (in particular, the requirements of Part 6 and Schedule 10) and in accordance with generally accepted accounting practice in New Zealand.

1.1 General responsibilities

The general responsibilities of the Council are consistent with those for the annual report, as set out in the audit engagement letter dated 19 February 2026. The general responsibilities set out in detail in Appendix 1 of that audit engagement letter are:

- responsibilities for compliance with laws and regulations; and
- responsibilities to establish and maintain appropriate standards of conduct and personal integrity.

1.2 Specific responsibilities

In addition to those general responsibilities, the Council is responsible for preparing the consultation document and the LTP including:

- maintaining accounting and other records that:
 - correctly record and explain the forecast transactions of the Council;
 - enable the Council to monitor the resources, activities, and entities under its control;
 - enable the Council's forecast financial position to be determined with reasonable accuracy at any time; and
 - enable the Council to prepare forecast financial statements and performance information that comply with legislation; and
- providing us with:
 - access to all information and assumptions relevant to preparing the consultation document and LTP, such as records, documentation, and other matters;
 - additional information that we may request from the Council for the purpose of the audit;

- unrestricted access to Council members and employees that we consider necessary; and
- written confirmation of representations made to us in connection with the audit.

We assume that elected members are familiar with those responsibilities and, where necessary, have obtained advice about them.

For clarity, we note the following statutory responsibilities as set out in the Act:

- Section 93 of the Act requires the Council to have an LTP at all times, and Part 1 of Schedule 10 prescribes the information that must be included in the LTP.
- Section 111 requires that information required to be included in the LTP is prepared in accordance with applicable generally accepted accounting practice standards, where relevant standards exist.
- Section 83 (with reference to section 93A) sets out the special consultative procedure that the Council is required to follow to adopt the consultation document and LTP.
- Section 93C(4) requires an auditor's report on the consultation document, and section 94 requires a separate opinion on the LTP.

Please note that the audit does not relieve the Council of any of its responsibilities.

1.3 Publication of the consultation document and adopted long-term plan on the Council's website

The Council is responsible for the electronic presentation of the consultation document and LTP on its website. This includes ensuring that there are enough security and controls over information on the website to maintain the integrity of the presented data.

2 Our responsibilities

2.1 Carrying out the audit

The Act requires us to provide separate reports on the consultation document (under section 93C(4) of the Act) and on the LTP (under section 94(1) of the Act).

For each document, our audit addresses the following overarching objectives:

- Whether the document gives effect to its relevant statutory purpose.
- The quality of the information and assumptions underlying the information included.

Our report on the LTP also addresses:

- the completeness and accuracy of the disclosures required by Part 2 of the Local Government (Financial Reporting and Prudence) Regulations 2014.

Our work to assess the quality of underlying information and assumptions is expected to be aligned, as far as practicable, with the Council's programme of work throughout the LTP preparation period.

2.2 Statutory purpose

We assess whether the consultation document and the LTP meet their respective statutory purposes. Given the different purposes of each document, this involves considering different matters for each report.

2.3 Our independence

It is essential that the audit team remain both economically and attitudinally independent of the Council (including management personnel and the elected members). This involves being, and appearing to be, free of any interest that might be regarded, whatever its actual effect, as being incompatible with integrity, objectivity, and independence.

2.4 Quality of information and assumptions

We obtain evidence about the quality of the information and assumptions underlying the information in the consultation document and LTP. This involves applying professional judgement, including assessing the risks of material misstatement whether due to fraud or error.

Our audit involves performing procedures that examine, on a test basis, evidence supporting assumptions, amounts, and disclosures in the consultation document and LTP, and evaluating the overall adequacy of the presentation of information.

We also review other information associated with the consultation document and LTP to identify whether there are material inconsistencies with the audited consultation document and LTP.

2.5 Materiality

Consistent with the annual audit, the audit of the consultation document and LTP is performed in accordance with the principle of materiality, as applied through the exercise of professional judgement. Materiality is considered across the 10-year period of the LTP (and, where relevant, beyond), recognising that the nature and level of materiality, and the auditor's assessment thereof, may differ between the initial and outer years of the forecast period. This reflects that the initial years are typically informed by more detailed and proximate assumptions, and the outer years subject to a wider range of potential variation due to the longer time horizon.

Materiality is a key factor influencing our judgement about the areas to be tested and the nature and extent of audit procedures performed. In planning and performing the audit, we aim to obtain assurance that the consultation document and LTP, and the information and

assumptions underlying them, are free from material misstatements, whether caused by fraud or error.

Material misstatements are differences or omissions of amounts and disclosures that, in our judgement, are likely to influence a reader's overall understanding of the consultation document and LTP.

If material misstatements are identified and not corrected, we will refer to them in our audit report. Our preference is for any material misstatement to be corrected, thereby avoiding the need for such reference.

2.6 What our audit reports *do not* provide

Our reports on the consultation document and LTP:

- do not provide a guarantee of the absolute accuracy of the information in the relevant document;
- do not provide a guarantee that the Council has complied with all relevant legal obligations;
- do not express an opinion on the merits of policy choices;
- in the case of councils that are water organisations, do not express an opinion on any water services strategy adopted under section 230 of the Local Government (Water Services) Act 2025¹; and
- do not include an opinion on whether the forecasts will be achieved.

3 Our approach to the audit

3.1 The content of the consultation document

The Act emphasises the discretion of the Council to decide what is appropriate to include in the consultation document and the associated consultation process. In deciding what to include in the consultation document, the Council must have regard to its significance and engagement policy, and the importance of other matters to the city and its communities.

We will need to understand how the Council has approached the task of applying its significance and engagement policy, and how it has weighed the importance of other matters in deciding what to include in the consultation document. This will help inform our assessment of whether the consultation document achieves its statutory purpose.

¹ An opinion on a water services strategy adopted under section 230 of the Local Government (Water Services) Act 2025 may be provided under a separate engagement, if requested under section 239 of that Act.

3.2 Adopting and auditing the underlying information

Before adopting the consultation document, section 93G of the Act requires the Council to prepare and adopt the information that:

- is relied on by the content of the consultation document;
- is necessary to enable the Auditor-General to issue an audit report under section 93C(4); and
- provides the basis for the preparation of the LTP.

The information to be prepared and adopted needs to be sufficient to enable the Council to prepare the consultation document.

Consistent with the guidance of Taituarā, Local Government Professionals Aotearoa, our view is that the core building blocks of an LTP will be needed to support an effective consultation document. This will include, but not be limited to, draft financial and infrastructure strategies and the information that underlies them, including asset management information, assumptions, defined levels of service, funding and financial policies, and a complete set of financial forecasts at an activity level.

We will work with management to understand the information proposed to be adopted and assess whether it will enable us to issue an audit report under section 93C(4).

From a practical perspective, it will be important that the Council is well advanced with the preparation of the full LTP when it issues the consultation document. Otherwise, you may find it difficult to complete the work and adopt the full LTP before your deadline. The same is true for our audit work. The more audit work that can be completed at the first stage of the process, the less pressure there will be on you and our audit team at the end of the process.

3.3 Controls relevant to the preparation of the consultation document and LTP

The Council is responsible for establishing and maintaining accounting and internal control systems (appropriate to the size of the Council). This includes policies and procedures used to prepare the consultation document and LTP, and to provide reasonable quality information and assumptions underlying these documents. We will obtain an understanding of internal control over the preparation of the consultation document and LTP. In addition to talking to Council staff, we will evaluate the design of relevant controls and whether they have been implemented.

Our review of your LTP self-assessment response (see 3.5) and key controls relating to the underlying information and development of the LTP is useful to our initial assessment of audit risk and in designing the nature and extent of our overall audit work.

3.4 Project management, reporting deadlines, and audit progress

The development of the consultation document and LTP is a significant and complex project, requiring a comprehensive project plan to ensure they integrate the Council's plans, policy decisions, and assumptions. Successful delivery of an integrated plan on time requires a project commitment throughout the organisation including from the elected representatives.

We will discuss with you the Council's approach to preparing and completing the LTP, including when key information will be available for auditing, and work with the Council to agree the timing of our work.

3.5 Self-assessment

We intend to use a self-assessment to assist our audit planning. The self-assessment asks you to reflect on your most significant issues and risks, governance of the LTP project, the systems and processes you have in place (particularly to meet the purposes in the Act for the consultation document and the LTP), asset management, performance management and reporting, and financial management.

It can also be a useful tool for Council to identify key changes and judgements planned for the LTP, including those that significantly affect levels of service, asset investment, and the Council's long-term financial outlook. The self-assessment will be provided separately, and we ask that you please complete and return this assessment by 6 November 2026.

4 Areas of audit focus

The quality of the Council's financial forecasts is significantly affected by whether the assumptions they are based on are reasonable. The Act requires councils to clearly outline the significant forecasting assumptions and risks that underlie the forecast financial statements in the LTP (Schedule 10, clause 17). Prospective Financial Statements (PBE FRS 42) also require the disclosure of significant assumptions.

We will assess whether the Council's significant assumptions are reasonable, clearly identified, complete, and consistently applied across the LTP, consultation document, and supporting information.

We will also assess whether the level of uncertainty associated with key assumptions is appropriately reflected and disclosed in the LTP.

Based on our planning to date, we have identified several focus areas where the related assumptions involve greater judgement and uncertainty and therefore present a higher risk of material misstatement. We outline these below.

4.1 Sector reforms

The Council will be preparing its LTP during a period of significant legislative and structural change. The Council will need to adopt the most appropriate assumptions based on the best available information about policy direction and legislative intent, with clear disclosure of those assumptions and the associated level of uncertainty.

A summary of the reforms already in place, or expected to affect the LTP, is set out below.

Our audit work will assess whether the Council's assumptions and disclosures reasonably reflect these changes and the associated uncertainty.

- **Structural reform:** Initial Cabinet decisions on reorganisation proposals are expected in 2027 for councils participating in early-stage reform processes. Councils not participating are expected to progress on a longer timeframe after the 2028 elections. While direct impacts on current LTP forecasts are likely to be limited, disclosures about the potential implications, significance, and associated uncertainty will be important.
- **Rates capping:** Legislation is expected in 2027 with a cap proposed to take effect from 1 July 2029. While the detailed design remains uncertain, there is a clear expectation that rates increases will be constrained. Rates increases are expected to be monitored by central government in the period leading up to implementation. Disclosure about the impact on forecasts and the uncertainty will be important.
- **Water services reform:** LTP assumptions should be based on the adopted and approved water services delivery plan and associated investment programme. This includes consideration of transition issues arising from changes to service delivery arrangements, such as overhead allocation, debt and guarantee arrangements, targeted rates collection, and accounting and service level arrangements. For in-house delivery models, the Council should ensure that there is clear documentation supporting the allocation of overheads and shared costs, and that the LTP appropriately includes required information and excludes non-permitted information in accordance with legislative requirements.
- **Resource Management Act reform:** Fast-tracked consents and other Phase 2 changes may impact councils' infrastructure demand and related financial forecasts. Looking ahead, Phase 3 reforms are expected to introduce a new planning system during the LTP period. Councils should consider the implications of implementing these reforms, including capability and transition requirements, and reflect them in their LTP planning and budgeting where relevant. (See [Resource management reforms | Ministry for the Environment](#)).
- **Development Levies and Infrastructure Financing Act changes:** Legislation is likely to be enacted by the time the consultation document is issued. The Council will need to consider whether assumptions appropriately reflect the potential impact of these changes including the introduction of new Levies from July 2028, where development levies are in place.

- **Local Government (Systems Improvement) Amendment Bill:**
 - The Bill is expected to pass before the draft LTP is prepared. The Bill amends the purpose of local government through removing the four well-beings and increasing focus on infrastructure, public services, regulatory functions, and economic growth. The Council will need to ensure the LTP is aligned to the new purpose.
 - The Bill also enables groups of activities and benchmarks on council performance to be set through regulations. It will also give the Secretary for Local Government wider powers to make rules related to performance reporting. The Council may need to reflect new or changing reporting requirements in the LTP because of any new regulations or rules.

4.2 Financial sustainability and prudence

An important function of a council's LTP audit is concluding whether the forecast financial information is financially prudent and based on reasonable assumptions.

There are several factors that the Council needs to consider when preparing the consultation document and LTP to ensure the LTP is financially prudent. These include:

- the impact of rates caps on revenue over the forecast period;
- the impact on revenue, expenditure, and debt of structural changes (such as the removal of water assets); and
- changes to the Council's debt covenant and financial strategy limits.

Our audit work will focus on how the Council's forecasts have factored in these changes and funding constraints. At a minimum, we will focus on:

- whether the constraints have been appropriately reflected in the Council's levels of service;
- the adequacy of disclosures about the risk to critical assets if the Council defers asset maintenance;
- the consequential impact on financial prudence and balanced budget metrics and forecast cashflows trends; and
- the reasonableness of key assumptions, such as:
 - revenue increases;
 - cost reductions, including savings assumptions;
 - asset sales or recycling;
 - revenue assumed from third parties; and
 - development levy/contributions.

4.3 Asset planning

Quality asset information is critical to supporting renewals and capital forecasts in the LTP. Sector observations indicate that renewals forecasts continue to be below depreciation on average, while the quality and reliability of condition and performance information for critical assets remains variable. Together, these factors increase the risk of suboptimal investment decisions and highlight the importance of evidence-based renewals and maintenance programmes.

Given the significance of infrastructure investment and management to the Council's activities, we will consider the reasonableness of the Council's asset forecasts in the context of the quality and reliability of asset condition and performance information.

Our work will include considering how Council has:

- explained any necessary trade-off between affordability and asset investment requirements, and the risks and implications of those trade-offs;
- factored in changes in levels of service to the financial forecasts;
- factored in the reliability of underlying asset data about condition and performance; and
- factored industry capacity constraints into assumptions about project delivery timing.

4.4 Performance framework

The Council's performance framework should be meaningful and appropriate in the context of its significant activities, investment decisions, and funding constraints. It is a key mechanism for accountability to ratepayers and other stakeholders over time. The Council will also need to consider how changes in activities affect the performance framework included in the LTP.

Our work will include:

- obtaining a high-level understanding of how the Council has applied its judgement in relation to the selection, aggregation, measurement, and presentation of the performance framework (noting that PBE FRS 48 requires disclosure of these judgements in the annual report); and
- considering whether the performance framework is clear, gives reasonable coverage of the local authority's activities, and covers the important dimensions of performance for each activity.

4.5 Climate change assumptions and responses

The Climate Change Commission recently released its [2026 national climate change risk assessment](#). Some of the most significant risks identified directly impact local authorities.

The Council may need to develop strategies to adapt to climate change risks and ensure its strategies and plans are consistent with decisions in other key documents, such as infrastructure strategies (regarding managed retreat, infrastructure capacity, and the location of assets), financial strategies, and financial forecasts (regarding useful lives, insurability, and weather event recovery).

Our work will include:

- assessing whether key climate-related assumptions are reasonable, supportable, and adequately disclosed;
- understanding how the Council's adaptation strategies have been integrated into the LTP, including the financial forecasts, forecast levels of service, and performance information; and
- ensuring the LTP clearly explains significant trade-offs between risk and cost, including why the Council has adopted certain assumptions in establishing financial forecasts and, where relevant, how performance frameworks reflect investments in greenhouse gas emission reductions.

4.6 Financial strategy and infrastructure strategy

The infrastructure and financial strategies are central to the LTP framework, setting priorities for infrastructure investment and the Council's funding approach. High-quality strategies are essential to effective long-term planning and resource prioritisation.

Our work will include considering how the Council has:

- aligned the infrastructure and financial strategies;
- balanced the budget and been financially prudent;
- integrated the effect of key assumptions about demographic and population changes, and significant changes to levels of service; and
- ensured the plausibility of key relationships in the forecasts, such as:
 - renewals and depreciation forecasts;
 - debt, interest, and capital expenditure relationships; and
 - renewals, capital expenditure, and levels of service; and
- developed and applied cost and inflation assumptions.

4.7 Financial model

The Council's financial modelling is a significant component of the underlying information that supports the financial strategy and infrastructure strategy. We will place particular emphasis on the integrity and logic of the Council's financial modelling.

5 Audit logistics

5.1 Audit timing

The key dates in the audit timetable are as follows:

Self-assessment provided to the Council	28 September 2026
Self-assessment returned to audit team for consideration	6 November 2026
Audit planning commences	9 November 2026
Infrastructure and financial strategies available for audit	TBC
Proposed consultation document available for audit, with all supporting documentation	11 January 2027
Consultation document audit (fieldwork)	18 January- 19 February 2027
Consultation document audit (hot review and final changes)	22-26 February 2027
Audit report on consultation document required	8 March 2027
Finalised report to governors on consultation document engagement	8 March 2027
Proposed LTP for adoption available for audit	25 May 2027
LTP audit (fieldwork)	26 May-16 June 2027
LTP audit (hot review and final changes)	17-22 June 2027
Audit report on adopted LTP required	30 June 2027
Finalised report to governors on LTP engagement	30 June 2027

Should we encounter any significant problems or delays during the audit, we will inform you immediately.

To ensure that we meet agreed deadlines, it is essential that the dates agreed are adhered to.

5.2 Workspace and information

The following should be made available to our staff during our audit:

- A suitable workspace for computer use (in keeping with the health and safety requirements discussed in Appendix 1).
- Electronic copies of key documents.

5.3 Provision of a report to Council

In addition to the audit report, at the end of the engagement we will provide a report to the Council communicating relevant matters that came to our attention. This may include significant weaknesses in the Council's systems and any uncorrected misstatements, as well as any identified and relevant breaches of laws and regulations during the audit.

Please note that the Auditor-General may refer to matters that are identified in the audit of consultation documents and LTPs in a report to Parliament if it is in the public interest, in keeping with section 20 of the Public Audit Act 2001.

6 Professional fees

Our professional fees will be based on a fee structure that takes account of changes to the key cost drivers since the last LTP. In developing the fee structure, we are mindful that the sector continues to experience significant reform since the last LTP and that this will impact the preparation and audit of the LTP to varying degrees.

Once the fee structure has been developed, we will share that with you.

As stated in the Public Audit Act 2001, fees must be reasonable to both parties, having regard to:

- the nature and extent of the services provided;
- the requirements of auditing standards published under section 23;
- the qualifications and experience of the persons necessarily engaged in providing the services; and
- any other matters the Auditor-General thinks fit.

We will discuss the proposed fee with you.

Once we have agreed a fee between us, we reserve the right to recover any costs incurred in good faith should a legislative change alter the audit requirements.

The proposed fee is based on the following assumptions:

- All documents and information required to complete the audit is complete and provided within the agreed timelines. This includes:
 - the draft consultation document;
 - the full draft financial strategy;
 - the draft infrastructure strategy; and
 - the key underlying assumptions and information that supports the draft consultation document.
- All documents provided will be subject to appropriate levels of quality review by the Council before they are submitted for audit.
- The consultation document and LTP will include all relevant disclosures.
- There will be an appropriate level of assistance from your staff.
- We will review, at most, two drafts of each of the consultation document and LTP during our audit.
- We will also review one printer's proof copy of the consultation document and LTP, and one copy of the electronic version of the consultation document and LTP (for publication on your website).
- Other than changes/potential changes known at the time the audit fee was agreed, there are no other significant changes in the structure or level of operations of the Council impacting on the audit – such as the establishment of a council-controlled organisation to deliver core functions, or a major restructuring of groups of activities.
- The local authority is preparing forecast financial statements for the "Council parent" only, rather than including consolidated forecast financial statements for the Council and any controlled entities in the adopted LTP.

If the scope and/or amount of work changes significantly (such as a change in direction while developing the consultation document, or between the development of the consultation document and the LTP), we will discuss the issues with you at the time.

If information is not available for the visits as agreed, or the systems and controls the Council uses to prepare the underlying information and assumptions cannot be relied on, we will seek to recover additional costs incurred as a result. We will endeavour to inform you as soon as possible should such a situation arise.

This fee is exclusive of any subsequent amendments the Council might make to the adopted LTP under section 93D.

7 Personnel

Our personnel involved in the management of the audit are:

Rudie Tomlinson	Director
Monique Kruger	Manager
Luke Devereaux	Audit Supervisor

We have endeavoured to maintain staff continuity as far as possible.

8 Agreement

Please sign and return the attached copy of this letter to indicate that:

- it is in accordance with your understanding of the arrangements for this audit of the consultation document and LTP for the period commencing 1 July 2027; and
- you accept the terms of the engagement set out in this letter that apply specifically to the audit of the consultation document and LTP and supplement the existing audit engagement letter dated 19 February 2026.

If there are any matters requiring further clarification, please do not hesitate to contact me.

Yours sincerely



Rudie Tomlinson
Director

cc Michael Day, Chief Executive
Patricia Christie, Group Manager – Finance and Assurance
Rhiannon Suter, Manager - Strategy and Policy

I acknowledge that this letter is in accordance with my understanding of the arrangements of the audit engagement. I also acknowledge the terms of the engagement that apply specifically to the audit of the consultation document and LTP, and that supplement the existing audit engagement letter dated 19 February 2026.

Signed: _____ Date: _____
Tom Campbell
Mayor

Appendix 1: Other general terms and conditions

Health and safety of audit staff

The Auditor-General and the Audit Office take seriously their responsibility to provide a safe working environment for audit staff. Under the Health and Safety at Work Act 2015, we need to make arrangements with you to keep our audit staff safe while they are working at your premises.

We expect you to provide our audit staff with a safe work environment that is without risks to their health and safety. This includes providing adequate lighting and ventilation, suitable desks and chairs, and safety equipment where required. We also expect you to provide them with all information or training necessary to protect them from any risks they may be exposed to at your premises. This includes advising them of emergency evacuation procedures and how to report any health and safety issues.

Confidentiality and data storage

We will keep confidential the information we acquire in the course of the audit engagement. We are entitled to use or disclose confidential information where we have a legal or professional right or duty to do so.

You authorise The Audit Office to use any information we acquire in the course of the audit engagement as necessary to support the Auditor-General in the exercise of their functions, powers, and duties under the Public Audit Act 2001. This may include using information for in-house training, precedents for technical audit issues, benchmarking, and for quality improvement and efficiency initiatives.

The Office adheres to the Government Chief Digital Officer (GCDO) requirements for storing up to and including RESTRICTED material in cloud services, using only the approved five-eyes nations. The GCDO has also provided endorsement for a further four countries, which the Office uses for secondary storage, back-ups or BCP environments. The Office can, based on detailed risk assessment, approve other countries to be used, however this is done on a case-by-case basis.

Appendix 2: Respective responsibilities when using the Office's client portal tool

The Office has engaged Audit Dashboard Incorporated to provide a client portal, AuditDashboard.

AuditDashboard is a secure online tool that will make it easier for files to be shared between the Office and the Council and for your people to work with us. We will request and receive files from your organisation through AuditDashboard.

For more information, please refer to: [Working with your auditor — The Audit Office](#)

Your organisation's obligations when using AuditDashboard

AuditDashboard implements industry standard encryption and security controls to keep your organisation's data safe. However, each user of AuditDashboard is responsible for ensuring these controls can operate. Your organisation is responsible for your users' use of AuditDashboard.

Upon registering, each user will be required to read and accept individual Terms of Use. These are aligned with your organisation's obligations in this letter. The Terms of Use can be viewed at auditdashboard.com/Account/Terms.

We expect you to ensure that AuditDashboard users in your organisation know that they must only access AuditDashboard using devices that have been approved for work purposes by your organisation. By using approved devices in conjunction with complying with your organisation's own policy on computer use, users are more likely to comply with the Terms of Use that each user must agree to.

We expect your organisation to provide an environment that supports AuditDashboard users in your organisation to:

- use a secure network with firewall protection;
- use a modern, up-to-date browser, and an operating system that features integrated anti-virus and anti-malware software;
- use their own unique user account each time they access AuditDashboard, and comply with the password security measures in the Terms of Use;
- take the same precautions when using AuditDashboard as they would with other secure online transactions, such as ecommerce and banking;
- logout of AuditDashboard, lock their system and secure their computer when left unattended; and
- not misuse AuditDashboard.

Your organisation must inform the Office if a user leaves, or if a change in circumstances (for example, a change in role) means that a user should no longer have access to AuditDashboard. Once we have been informed, we will remove access for that user.

Your organisation must inform the Office of any information that should be restricted so it can only be viewed by specified users, such as payroll data.

Your organisation must notify the Office immediately of any unauthorised use of an AuditDashboard account or in the event that a user's account details are compromised.

We expect your organisation to maintain the confidentiality and integrity of the content and technology of AuditDashboard to at least the same level of care required by your organisation in respect of its own confidential information, but in no event using less than a reasonable standard of care.

Your obligations when your agent uses AuditDashboard

Your organisation might engage an agent ("your agent") to perform some financial functions, for example, an external accountant to prepare your organisation's financial statements. In such circumstances, your agent might hold files, on behalf of your organisation, which are relevant to your organisation's audit.

If your organisation requests the Office to add your agent as an AuditDashboard user, your organisation is wholly responsible for your agent's use of AuditDashboard. Accordingly, your organisation must ensure that your agent:

- is aware of your organisation's obligations to the Office;
- is aware that they must agree to and abide by the Terms of Use that apply to AuditDashboard users;
- is required to be subject to a computer use policy, and work in a secure environment, which enables them to comply with the Terms of Use; and
- agrees to notify your organisation immediately of any unauthorised use of an AuditDashboard account.

Our responsibilities

We are responsible for the security of the data provided by you to us for the purpose of an audit engagement.

We are responsible for obtaining assurance that AuditDashboard is secure for the classification and sensitivity of data that is involved. When we engaged AuditDashboard, we considered risk, security, privacy, functionality, and business requirements. These are all fundamental requirements for information governance and assurance².

² NZ Information Security Manual v3 – section 4.1.11 & 4.1.12

The Office does not guarantee the availability of AuditDashboard. We reserve the right to withdraw AuditDashboard at our discretion. Where possible, we will notify your organisation in advance.

If our contract with AuditDashboard is terminated, AuditDashboard will delete your organisation's data, except if you request its return, or such data is required by the Office to perform the audit engagement.

CLIMATE CHANGE UPDATE

To:	Risk and Assurance Committee
Meeting Date:	Tuesday 15 September 2026
From:	Rhiannon Suter – Manager – Strategy, Policy and Engagement
Approved:	Jonathan Shaw – Group Manager – Consenting and Environment
Approved Date:	Wednesday 9 September 2026
Open Agenda:	Yes

Purpose and Summary

Council is part of the Regional Climate Change Working Group which has provided an update on development of climate planning assumptions. In addition, Council has completed greenhouse gas emissions assessment for Council activities for the 2024/2025 period in preparation for the Long-term Plan.

Recommendations

That the Risk and Assurance Committee:

1. Receives the report "Climate Change Update".
2. Notes the letter and report sent to Mayor Tom Campbell outlining the progress of the Regional Climate Change Working Group in selecting scenarios for climate planning and development of assumptions for Long-term Planning.
3. Notes the primary report of the Murihiku Southland Region Climate Change Impact Assessment 2026.

Recommend to Council:

4. Approves to use the medium emissions scenario (SSP 2 – 4.5) as the base for the Long-term Plan, with the higher emissions scenario (SSP 3 – 7.0) considered for planning for larger projects as relevant.
5. Approves to not proceed with further greenhouse gas emissions assessments for Council operations until such a time as the sector is required to undertake reporting, noting the limited usefulness due to frequent methodology changes and complexity of analysis.

Background

This report provides updates from the Regional Climate Change Working Group which has been in place since 2022, as well as for the greenhouse gas inventory which the current Long-term Plan provides for taking place once a triennium to inform Long-term Planning.

Council adopted the Murihiku Southland regional Climate Change Strategy in 2024. It has two pillars, mitigation and adaptation.

Issues

Regional Climate Change Working Group

The Regional Climate Change Working Group has completed and is seeking feedback on the proposed climate change scenarios and draft assumptions.

The communication from the working group is attached, along with a letter from Minister Watts with advice for councils regarding setting of assumptions on climate change.

The proposed scenario for Long-term Planning recommended by the Regional Climate Change Working Group aligns with the advice of Minister Watts.

It is worth noting that some of the inputs which are required in order to make use of the climate change scenarios, particularly river flood modelling, are not yet ready, which will limit its immediate usefulness for this long-term Plan.

Draft assumptions utilising the proposed regional baselines are provided in the separate draft assumptions report to this meeting.

Greenhouse Gas Emissions Assessment

Council undertakes a greenhouse gas inventory once every triennium under the mitigation pillar of the climate change strategy, to inform its Long-term Planning.

The initial baseline inventory for carbon emissions was completed for the 2020/2021 year which showed that Council emitted 15,590 tCO₂e for the period. The carbon emissions for the 2022/2023 period increased to 19,253 tCO₂e, which was recalculated to 18,991 tCO₂e in this latest review. This was impacted by a methodology change, as well as an increase in Category 4 (Purchased Goods and Service and Capital Goods) emissions and Category 1 emissions (inc. wastewater, diesel etc.). The emissions for 2024/2025 increased again to 38,978 tCO₂e. Some of this was due to "real world" changes such as increased emissions related to construction of the museum and other parts of the capital programme, and reduction in the amount of air travel. Other changes were linked to scope change and methodology change, for example emissions from wood chips have increased considerably but there has been no significant change in consumption at Splash Palace.

The methodology for completing a greenhouse gas inventory is complex and the work required to complete the process is resource intensive. The number of variables and the changing nature of the methodology and international guidance make comparison between years difficult.

It is challenging to determine where a change is real or related to modelling changes, and it is further difficult to assess what the source of the change was. As a result, identifying and supporting positive change is challenging. Instead, it may be more productive to identify actions which in most circumstances will reduce impact and support those. As a result, it is recommended not to undertake further assessment for the next planning cycle until requirements for the sector are clearly established.

Climate Change Response Amendment Bill

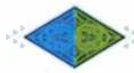
This Bill was introduced in July and if adopted, Councils will be required to prepare and adopt Climate Change adaptation plans for those areas identified as priority areas under the Regional Spatial Plan. Resource will be required to be dedicated to this activity.

Next Steps

Draft assumptions based on the regional perimeters will be finalised as part of the Long-term Plan and are presented in a separate report to this meeting.

Attachments

- Appendix 1 - Letter to Mayor Campbell Update on Joint Climate Action Planning (Phase Three) (ID 10791912)
- Appendix 2 - Earth Sciences New Zealand Climate Change Impact Across the Southland Region Assessment Report 2026 (ID 11234330)
- Appendix 3 - Letter from Minister Watts Climate Change Assumptions in Council Planning (ID 10792684)
- Appendix 4 - Invercargill City Council Greenhouse Gas Emissions Inventory Report 2024/2025 (ID 2576862)



TE AO
MĀRAMA INC.



Our reference: A1510640

14 July 2026

Mayor T Campbell
Invercargill City Council
Via email: tom.campbell@icc.govt.nz

Kia ora Mayor Campbell

Update on joint Climate Action Planning (Phase Three)

On behalf of the Regional Climate Change Working Group (RCCWG)², we are pleased to provide an update on progress towards developing Murihiku Southland's first regional Climate Action Plan.

The Regional Climate Change Strategy (2024) established shared regional aspirations for responding to our changing climate, while the Regional Framework for Action on Climate (2025) identified a programme of collaborative work to support these aspirations.

The current phase of work focuses on developing a regional **Climate Action Plan** that can support participating organisations as they prepare their respective 2027–2037 Long-term Plans, while also refining the foundations for longer-term regional collaboration on climate adaptation and resilience. At its workshop on **2 July 2026**, the Regional Climate Change Working Group reached an important milestone. Members considered and provided direction on several of the foundational components that will underpin the Climate Action Plan, including:

- the purpose of the Climate Action Plan;
- recommended climate planning scenarios;
- draft climate planning assumptions; and
- the relationship between regional coordination and local decision-making.

These components continue to be refined and will ultimately inform development of the first draft Climate Action Plan.

Why we are writing now?

The RCCWG has deliberately chosen to share these emerging components with partner councils and Te Ao Mārama Inc at this early stage.

Rather than presenting councils with a largely completed Climate Action Plan immediately before Long-term Plan consultation and audit processes commence, the Working Group considers it

² Each agency is represented on the governance RCCWG for the current triennium by the following people:

- Environment Southland – Cr Phil Morrison (co-chair), Cr Maurice Rodway
- Te Ao Mārama – Dean Whaanga (co-chair)
- Gore District Council – Cr Paul McPhail, Cr Neville Phillips
- Invercargill City Council – Cr Alex Crackett, Cr Andrea DeVries
- Southland District Council – Cr Michael Weusten, Cr Matt Wilson

preferable to progressively share the thinking that is informing the Plan's development. This approach allows elected members to become familiar with the proposed planning foundations, raise questions, identify matters requiring further consideration, and provide feedback while there remains genuine opportunity to refine the work.

It is intended that this progressive approach reduces the likelihood of unexpected issues emerging later in the Long-term Plan process and supports greater transparency throughout development of the Climate Action Plan.

What is attached?

Three supporting documents are enclosed. The first explains the proposed climate planning scenarios recommended by the Working Group and how they fit within a broader climate planning and decision-making hierarchy. It also explains why climate scenarios are used; not to predict the future, but to improve decision-making under uncertainty.

The second summarises the latest regional climate projections prepared by Earth Sciences New Zealand and presents a draft set of climate planning assumptions. These assumptions are intended to provide a common regional planning baseline that participating organisations may choose to use when developing their own plans. They have been deliberately selected because they are supported by robust scientific evidence, are broadly relevant across partner organisations, and benefit from regional consistency, while recognising that each organisation must continue to exercise its own judgement in fulfilling its statutory responsibilities.

The third document is the inter-agency workshop report from the Governance Regional Climate Change Working Group, summarising the discussion and progress made at the 2 July 2026 workshop.

Collectively, these documents begin illustrating the planning architecture that is emerging through the draft Climate Action Plan. They distinguish between the regional coordination of climate science, scenarios and planning assumptions, and the independent planning, investment and policy decisions that appropriately remain the responsibility of each partner organisation.

Feedback

At this stage, councils are **not** being asked to endorse the attached material or adopt any new policy positions.

Rather, the Working Group would welcome any comments on whether the proposed approach provides an appropriate balance between regional consistency and local decision-making, and whether the proposed climate scenarios and draft planning assumptions provide a useful foundation for future planning.

Should your Council or organisation wish to discuss any aspect of this work in greater detail, members of the RCCWG would be pleased to attend a workshop or briefing during July or August.

Feedback received during this period will assist the Working Group in refining these components before further development of the draft Climate Action Plan.

Looking ahead

The next Regional Climate Change Working Group workshop is scheduled for **27 August 2026**, where attention will focus on developing and prioritising the actions that will form the core of the draft Climate Action Plan.

The Working Group intends to continue progressively developing the Plan in the months ahead with the objective of preparing a draft Climate Action Plan ahead of councils' Long-term Plan consultation processes, while recognising that each participating organisation will ultimately determine how the information is considered and applied within its own planning and decision-making frameworks.

Thank you for your continued support of this collaborative regional initiative. We look forward to continuing to work alongside all partner agencies as this important programme progresses.

Ngā mihi nui

Two handwritten signatures in black ink. The signature on the left is 'P. Morrison' and the signature on the right is 'Dean Whaanga'.

Cr Phil Morrison (ES) Dean Whaanga (Te Ao Mārama)

Co-chairs of the Regional Climate Change Working Group

On behalf of members: Cr Paul McPhail (GDC), Cr Alex Crackett (ICC), Cr Michael Weusten (SDC), Cr Maurice Rodway (ES), Cr Neville Phillips (GDC), Cr Andrea DeVries (ICC), Cr Matt Wilson (SDC).

Attachments

1. Proposed climate planning scenarios (A1517457)
2. Draft climate projections and planning assumptions (A1517427)
3. G-RCCWG inter-agency workshop report – 2 July 2026 (A1505574)

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Proposed Climate Scenarios in Regional Climate Action Planning

1. Climate Planning and Decision-Making Hierarchy

This hierarchy illustrates how climate science, scenarios, projections, planning assumptions, risk assessments and investment decisions are connected. It also identifies the primary organisations responsible for each layer of the climate planning system, helping distinguish regional coordination responsibilities from local decision-making responsibilities.

Hierarchy Layer	Primary Steward / Source
Climate Science	International scientific community (synthesised by IPCC)
Climate Scenarios	IPCC / international climate modelling community
National Climate Change Risk Assessment (NCCRA)	Climate Change Commission
Regional Projections	Earth Sciences New Zealand
Regional Planning Assumptions	Regional Climate Change Working Group
Regional Climate Action Plan (CAP)	Regional Climate Change Working Group
Regional Risk Assessment	Regional Climate Change Working Group (likely priority CAP action)
Local Risk Assessment	Individual councils and agencies
Consequence Ratings	Individual councils and agencies
Asset Impacts	Asset owners
Financial Implications	Individual councils and agencies
Investment Responses	Elected members and governing bodies

2. Climate Scenarios in Regional Climate Action Planning

“Climate scenarios are not used to predict the future; they are used to test whether today's decisions remain sensible across a range of plausible futures.”

The purpose of climate scenarios in support of regional climate action planning is to increase confidence in decisions. This approach also supports adaptive pathway planning, enabling investment decisions to be staged and adjusted as conditions change and new information becomes available.

It is intended that climate action planning is an ongoing process of planning, implementation, monitoring, learning, and adaptation. Climate scenarios support this process by helping decision-makers consider uncertainty explicitly, make prudent decisions using the best information currently available, and avoid creating unnecessary risks or costs for future generations.

In this way, climate scenarios are not a source of certainty. They are a tool for making better decisions in the face of uncertainty. As climate science evolves and observed emissions pathways change, the appropriateness of planning scenarios should be periodically reviewed and updated.

3. Aligned Planning Scenarios for Murihiku Southland

For the purpose of the Climate Action Plan and development of council Long Term Plans for the period 2027-2036, it is considered sensible for RCCWG partner agencies to align on the use of a common set of climate planning scenarios.

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SOUTHLAND
REGIONAL COUNCIL
Te Taiao TongaGO RURAL
CITY LIVINGInvercargill
CITY COUNCILSOUTHLAND
DISTRICT COUNCIL

The RCCWG recommends using SSP2-4.5 as a primary planning scenario and SSP3-7.0 as a secondary, resilience-testing scenario.

Primary Planning Scenario	Secondary Scenario
SSP2-4.5	SSP3-7.0
Maps to LG Sector Scenario 2 – <i>Leaving it to the next generation</i>	Maps to LG Sector Scenario 3 – <i>Inheriting a broken world</i>
A future that provides a practical and credible basis for regional planning and decision-making.	A more challenging future used to test the resilience of decisions, infrastructure, and communities under heightened climate risk.
Used primarily for baseline strategic planning.	Used primarily for stress-testing long-lived infrastructure and adaptation resilience, and enabling consideration of high-risk adaptation needs.
Supports analysis based on the question: <i>If the future unfolds broadly along this pathway, what should we be doing now?</i>	Supports analysis based on the question: <i>If conditions prove significantly more challenging than expected, where are our vulnerabilities?</i>
Most useful in planning for: • long-term plans • infrastructure maintenance • land-use planning • climate action priorities • adaptation planning • community engagement	Most useful in planning for: • regional spatial plans • critical infrastructure resilience • emergency management • coastal adaptation • flood protection and resilience • lifeline utilities • long-lived assets • contingency planning

Together, these two scenarios provide a planning range that supports both day-to-day strategic planning and consideration of more severe but plausible, future risks.

This approach is intended to support the evolution of **scenario-informed adaptive governance**. Scenario-informed planning does not seek to identify the "correct" future. Rather, it seeks to make today's decisions more robust across a range of plausible futures while retaining flexibility to adapt as knowledge evolves.

Note: This approach is consistent with recent Government guidance encouraging councils to use a range of credible climate scenarios, clearly identify their primary planning scenario, and use higher-emissions scenarios primarily for stress testing and contingency planning.

DRAFT Climate Planning Assumptions

The climate projections and planning assumptions are intended to provide a common regional baseline for planning. They simplify a much larger body of scientific evidence into a manageable set of assumptions that are broadly relevant across partner organisations. They should not replace more detailed analysis where required, particularly where multiple climate hazards interact. Planning based primarily on individual hazards may underestimate future risk where cascading or compound impacts are likely.

Selection principles

These planning assumptions have not been selected because they represent every projected climate change. Rather, they have been selected because they:

- are supported by robust regional scientific evidence
- are relevant across multiple partner organisations
- influence long-term planning and investment decisions
- benefit from regional consistency
- avoid replacing the detailed judgement that individual councils must continue to exercise for their own statutory responsibilities

Regional projections: How the climate *might* change under different scenarios based on scientific understanding/evidence.

Scenario: Shared Socioeconomic Pathway (SSP)	Projection period	Mean temperature change	Annual rainfall change	Heavy rainfall / extreme rainfall change	Annual hot day changes	Annual cold nights changes	Annual time spent in heatwave	PED ¹ accumulation change	Absolute sea level rise
SSP 2-4.5	2050	+1.0°C	+4.2%	+6.3 mm/day;	+3.5 days/yr	-25.3 days/yr	+6.5 days/yr	+5 mm	+0.213
SSP 2-4.5	2090	+1.8°C	+8.0%	+13.2 mm/day;	+6.5 days/yr	-26.9 days/yr	+12.4 days/yr	+7 mm	+0.470
SSP 3-7.0	2050	+1.2°C	+4.3%	+8.4 mm/day;	+4.8 days/yr	-18.6 days/yr	+9.1 days/yr	+11 mm	+0.231
SSP 3-7.0	2090	+2.8°C	+8.1%	+15.7 mm/day;	+14.4 days/yr	-36.6 days/yr	+27.8 days/yr	+21 mm	+0.585
Evidence/source: ESNZ 2026 Murihiku Southland Climate Impact Assessment Report		°C, relative to 1995-2014 Vol 2 Table 1-1	%, relative to 1995-2014 Vol 2 Table 1-14	maximum annual 1-day rainfall total changes + (mm/day, relative to 1995-2014) Vol 2 Table 1-23 + 24	days, relative to 1995-2014 Vol 2 Table 1-7	days, relative to 1995-2014 Vol 2 table 1-9	days, relative to 1995-2014 Vol 2 Table 1-11	mm, relative to 1995-2014 Vol 2 Table 1-37	mm, relative to 1995-2014 midpoint 2005 Interpolated from Vol 4 Table 1-3

DRAFT Climate planning assumptions: A simplified, agreed set of statements based on the regional projections, about how the future climate is expected to behave at a regional level.

Theme	Assumption	Expected impact (why it matters)	Relevance across Murihiku Southland local government partners	Evidence
Temperature and heat	Regional temperatures are projected to increase across Southland under all emissions pathways. Warming occurs across mean, maximum, and minimum temperatures and is accompanied by more hot days, more annual time spent in heatwave, and substantial declines in cold nights (minimum temperature <0°C), especially inland.	Increased thermal stress on infrastructure and assets; higher evapotranspiration and pressure on freshwater systems; increased heat-related health and safety risk for staff and communities; changes to ecosystem function and water quality; and increasing need to account for heat exposure, asset performance and climate adaptation in long-term planning.	Relevant to all RCCWG partners. Particularly important for inland communities, water resources, transport networks, community facilities, environmental management, emergency response, public health planning and vulnerable populations.	ESNZ Vol 1 + 2

¹ PED = Potential Evapotranspiration Deficit

Risk and Assurance Committee - Public - Climate Change Update

Theme	Assumption	Expected impact (why it matters)	Relevance across Murihiku Southland local government partners	Evidence
Rainfall total and intensity	Total rainfall across Southland is projected to increase modestly overall, with strong seasonal variation, while heavy rainfall indicators (including very wet days and maximum 1-day / 5-day rainfall totals) increase. Rainfall intensity for design events also increases with warming.	Increased pressure on stormwater, wastewater and drainage systems; increasing flood, erosion and sediment risks; affects infrastructure design standards and asset resilience; and influences long-term planning for transport, land use and community infrastructure.	Relevant to all RCCWG partners. Environment Southland has flood-risk and river-management responsibilities, while territorial authorities manage roads, stormwater, wastewater, land-use planning, critical infrastructure and community resilience.	ESNZ Vol 1 + 2
Flood system	Heavy rainfall is projected to become more intense and river flood behaviour is projected to strengthen across most Southland catchments. This includes increases in heavy-rainfall indicators, maximum annual 1-day and 5-day rainfall totals and increases in river flood metrics such as Mean Annual Flood and higher-flow indicators across most river reaches.	Increased pressure on flood protection schemes, drainage networks, bridges, culverts and transport links; increased flood recovery and maintenance costs; greater emergency management demands; and increased need for investment in flood resilience, hazard mitigation and adaptation planning.	Particularly relevant to Environment Southland, but also important for Southland District Council, Gore District Council and Invercargill City Council where communities, roads, infrastructure and services are exposed to river flood hazards.	ESNZ Vol 1 + 2 + 3
Water availability and seasonal scarcity	Evaporative demand increases with warming, creating greater seasonal water stress even where annual rainfall increases. Southland's future water balance is increasingly characterised by wetter winter/spring conditions but greater summer scarcity risk in some areas because higher temperatures increase atmospheric demand for water and summer recharge/low-flow conditions worsen in parts of the region.	Increased pressure on water allocation, environmental flows and groundwater resources; greater risk of seasonal water shortages and ecological stress; increased demand for monitoring and freshwater management; and implications for irrigation, industry, community water supplies and climate adaptation planning.	Relevant to all RCCWG partners. Relevant across the region, with implications for urban water supply, rural communities, agriculture, industry, freshwater ecosystems and mana whenua values associated with wai.	ESNZ Vol 1 + 2
Relative sea-level rise and coastal change	Sea level is projected to continue rising under all emissions pathways. Relative sea-level rise varies by location because local vertical land motion (VLM) can delay or accelerate when sea-level thresholds are reached. Rising mean sea level also raises the baseline for high-tide exceedance, storm-tide flooding, and coastal inundation exposure.	Increased exposure of coastal communities, infrastructure and low-lying land to inundation and erosion; reduced drainage performance in some locations; increased adaptation planning requirements; and greater pressure on asset management, land-use planning and long-term service provision in coastal environments.	Particularly relevant to Invercargill City Council, Southland District Council, Environment Southland and Te Ao Mārama. Less directly relevant to Gore District Council but still relevant through regional transport, emergency management, funding and shared adaptation planning.	ESNZ Vol 1 + 4
Extreme weather and compound events	Climate hazards in Southland are projected to interact across systems rather than occur in isolation. Heavy rainfall and river flooding are projected to increase, sea level will continue to rise, and higher sea levels will increase the frequency and extent of high-tide exceedance and storm-tide flooding. Increasing temperatures, heatwaves, seasonal drying and water scarcity will also place additional pressure on natural and built systems. Compound impacts are expected to become increasingly important where multiple hazards occur simultaneously or in close succession.	Multiple hazards can increase the likelihood, scale and duration of disruptions to infrastructure, communities and services. Planning based primarily on individual hazards is therefore likely to underestimate future risk where climate hazards interact across systems or occur in close succession. Compound events may affect flood protection, stormwater, transport, water resources and coastal systems simultaneously, increasing emergency response requirements, recovery costs, asset stress, service interruptions and adaptation investment needs.	Relevant to all RCCWG partners. Also relevant to Emergency Management Southland functions, lifeline utilities, local roads, community facilities, water services, flood protection schemes, rural communities, coastal settlements and regional coordination activities.	ESNZ Vol 1 + 4
Ecosystem resilience	Ecosystems across Murihiku Southland, including freshwater, terrestrial, coastal and marine systems, are expected to experience increasing pressure from warming temperatures, altered rainfall and flow regimes, sea-level rise, marine heatwaves, seasonal water stress and climate-related disturbance events. Maintaining ecosystem resilience will become increasingly important as ecological conditions, species distributions and ecosystem processes continue to change. Climate change is also expected to influence the distribution and behaviour of pests, weeds and diseases, reinforcing the need for adaptive ecosystem and biosecurity management.	Reduced ecosystem resilience may affect freshwater quality, indigenous biodiversity, coastal environments, mahinga kai, biosecurity risk, erosion control, flood attenuation, recreation, cultural values and the natural systems that support community and economic wellbeing. Climate change may also reduce the effectiveness of restoration, pest management and environmental protection programmes unless they are designed to adapt as conditions change.	Relevant to all RCCWG partners. Particularly important for Environment Southland's freshwater, biodiversity, biosecurity, coastal and catchment responsibilities; Te Ao Mārama's role as kaitiaki; and territorial authorities' responsibilities for reserves, coastal settlements, land-use planning, water services, community wellbeing, infrastructure resilience and adaptation planning.	ESNZ Vol 1 + 2 + 4



Regional Climate Change Working Group Report

To: Environment Southland
Te Ao Mārama Board
Gore District Council
Invercargill City Council
Southland District Council

Workshop Date: Thursday 2 July 2026

From: Staff Regional Climate Change Working Group

Purpose

This report provides all Councils and the Te Ao Mārama Board with an update on the third governance Regional Climate Change Working Group (G-RCCWG) workshop of the new triennium, held 2 July 2026.

Executive Summary

The focus of the governance workshop was:

1. Confirming the purpose and some foundational components of Phase Three: development of the Climate Action Plan (CAP) – climate scenarios, projections, and climate planning assumptions
2. Considering Southland-specific risk in the context of the 2026 National Climate Change Risk Assessment
3. Introducing the Action 1.2 – Review of RCCWG governance arrangements report

The G-RCCWG is monitoring the progress of resourced actions in the Regional Framework for Action on Climate alongside developing the first Regional Climate Action Plan to inform councils' long-term plans for 2027-2037.

Recommendation

That councils and the Te Ao Mārama Board receive the report "Regional Climate Change Working Group Report".

Background

Establishment of inaugural working group

Following a regional climate change hui in July 2022, Environment Southland and Te Ao Mārama established the Regional Climate Change Working Group (RCCWG) to coordinate a regional response to climate change, comprising both governance and staff representatives from each of the territorial authorities, the regional council, and Te Ao Mārama.

2023-2025 Triennium

The RCCWG has since progressed two key phases: the adoption of the [Regional Climate Change Strategy](#) (RCCS) 2024, which sets shared principles and aspirations, and the [Regional](#)



[Framework for Action on Climate](#) (RFfA) 2025, which establishes a coordinated programme of work, including continuation of the RCCWG.

New 2026-2028 Triennium

Following the 2025 local government elections, the governance group was re-established for the new triennium. The first two RCCWG workshops introduced the group to the Local Government Climate Scenarios, and the latest climate science. The current focus is on developing the first Murihiku Southland Climate Action Plan, aligned with councils' Long-Term Plans (2027-2037).

RCCWG workshop – 2 July 2026

Climate Action Plan Content, Purpose and Process

Murihiku Southland's first regional Climate Action Plan (Phase Three) will establish a coordinated approach to support long-term decision-making. The Climate Action Plan is intended to be refreshed three-yearly alongside with councils' Long-Term Plans (LTP).

A draft Climate Action Plan will be prepared pre-LTP consultation, with the goal of formal adoption post-LTP. The overall draft structure of the Climate Action Plan was supported by the RCCWG.

Climate Action Plan Purpose

Members support an iterative approach to defining the Climate Action Plan's purpose, incorporating wider stakeholder input, and reflecting an intergenerational and transitional approach. There was general agreement on the proposed direction, with minor refinements. The group will prioritise identifying and resourcing actions.

Concerns were raised regarding the RCCWG's lack of formal decision-making authority and the need for the Climate Action Plan to provide a clearer mandate for coordinated advocacy. The Climate Action Plan could align advocacy across councils and establish a transparent approach to legitimising advocacy efforts. Regional identification of priorities was noted as useful to support this.

Climate Scenarios

Members reached consensus on the use of two climate scenarios – a medium emissions scenario SSP2-4.5 and a high emissions scenario SSP3-7.0 as credible and practical planning tools, noting they provide a balanced and realistic basis for decision-making. The scenarios align with previous regional work and national guidance, including the 2026 Murihiku Southland Climate Change Impacts Report, Local Government Scenarios, and the 2026 National Climate Change Risk Assessment.

The group noted a recent letter from the Minister for Local Government, which cautions against using SSP5-8.5 as the base planning scenario. It was noted that the consensus reached during the workshop aligns with the direction of this letter.

Discussion highlighted the need to regularly revisit scenarios in light of evolving science and lived experience. It was acknowledged that councils may still apply additional scenarios to meet specific agency modelling needs.



Climate Projections and Planning Assumptions

The group reviewed and approved in principle a set of climate projections and planning assumptions developed by staff to underpin preparation of the Climate Action Plan, subject to agreed amendments. Agencies will retain the ability to interpret and respond to the assumptions in the context of their role and legislative requirements.

Suggestions were made to further strengthen the projections, including incorporating additional factors such as sea level rise, heatwaves, wind events, dry periods, and biosecurity impacts. There was also support for improving spatial relevance through a more catchment-based approach.

Murihiku Southland Climate Risk

SDC staff facilitated a workshop to explore key regional climate risks using the 2026 National Climate Change Risk Assessment, noting that future adaptation planning will need to be grounded in robust climate risk assessment.

Members reinforced that climate risks in Murihiku Southland are increasing in scale, complexity, and interconnection. Key pressure points were identified in emergency management, water infrastructure, ecosystems, and transport networks, with compounding events placing increasing strain on system capacity and resilience. Risks to community wellbeing, Māori values and whenua, and key economic sectors were also recognised, with impacts unevenly distributed across the region.

While existing responses and initiatives were acknowledged, these are often fragmented, under-resourced or reactive, reflecting broader misalignment between policy, funding, and delivery systems. Overall, the workshop highlighted the need for stronger coordination, clearer roles and responsibilities, and more integrated planning approaches to support effective and equitable long-term adaptation.

Developing Climate Action Plan Actions

Climate Action Plan actions will be the focus of the next RCCWG workshop on 27 August. In the interim, it was agreed that staff will draw on previous conversations to progress the shortlisting of actions to prepare for the next workshop discussions.

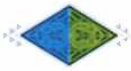
RCCWG update on other key projects

RfFA Quarter 4 progress update: A high-level update was provided on the actions identified in the RfFA, for the last quarter April-June 2026 (refer to **appendix 1**).

Action 1.2: A final report reviewing RCCWG governance arrangements was prepared by Te Whakahaere in January 2026, supported by a summary and next steps document. Discussion of the report has not yet progressed at the governance level; it was shared at this workshop and was agreed to be discussed at a future meeting.

Next steps

- Staff to continue refining regional climate projections and planning assumptions to support CAP development.
- Staff to assemble a Climate Action Plan prototype for consideration at the next G-RCCWG workshop (27 August 2026).



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Key Messages

1. The RCCWG remains committed to a collaborative regional approach, moving beyond individual council perspectives to collective action.
2. A shared commitment to manaakitanga underpins this work, with a focus on collective use of people, knowledge, and resources.
3. There is strong alignment across agencies on climate projections and planning assumptions, providing a consistent foundation for action.
4. Open, robust discussions continue to strengthen shared understanding and decision-making.
5. The focus of this work remains on progressing practical, implementable actions.
6. Regional collaboration must be matched by resourcing and delivery capacity to maintain pace and momentum.
7. The role of the RCCWG continues to evolve in response to changes in the local government context
8. There is increasing alignment in thinking across the group, supporting coordinated regional responses.

Appendices

Appendix 1:

Regional Framework for Action on Climate for Murihiku Southland – High-level progress monitoring: Fourth Quarter April-June 2026



APPENDIX 1

Regional Framework for Action on Climate for Murihiku Southland

High-level Progress Monitoring Document FY-Q4 Apr-Jun 2026

Progress Monitor (traffic light system)

Progressing well	At risk	Progress limited
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Climate action	Q4	Update
1 Strengthening local government capability and organisational resilience		
1.1 Continue to participate in the Regional Climate Change Working Group as an inter-agency group collaborating across local government and Te Ao Mārama.		The RCCWG ToR was agreed (subject to minor amendments) at the 8 May G-RCCWG workshop and presented to ES S&P 3 June. The ToR will remain a living document and can be reviewed i.e. for example if there is further progress with respect to Action 1.2 below.
1.2 Review regional governance arrangements to consider how Murihiku Southland local government agencies can best coordinate, collaborate and advocate on local climate change responses.		A summary paper and supporting documents have been developed and are now progressing to 2TEG and the G-RCCWG for governance consideration.
1.3 Collaborate to develop regional positions on climate related issues to advocate to central government on behalf of our region.		The staff RCCWG received a presentation on the Ratepayers Assistance Scheme (20 April 2026), with further consideration of a G-RCCWG letter of support, subject to progression alongside central government reform. A broader mechanism to progress this action has not yet been considered.
1.4 Integrate climate change considerations across operations, including decisions, policies, projects, procurement and infrastructure.		Each RCCWG agency is on their own individual journey to progress this action. The latest stocktake was presented to the G-RCCWG at their first workshop 12 March 2026.
1.5 Measure organisational greenhouse gas emissions regularly (in accordance with Ministry for the Environment guidance and relevant ISO standards).		Each RCCWG agency is on their own individual journey to progress this action. The latest stocktake was presented to the G-RCCWG at their first workshop 12 March 2026.
2 Partnering with Papatipu Rūnanga to uphold mana whenua leadership and decision-making in climate initiatives		
2.1 Involve ngā Papatipu Rūnanga representatives in the design and implementation of collective climate change responses.		Te Ao Mārama, on behalf of Ngā Papatipu Rūnanga, has continued to contribute across council partner workstreams to support the integration of climate-related responses and considerations into decision-making. Key areas of involvement include spatial planning, resource consent processes, broader climate resilience work, and emergency management kaupapa. The nature of this action is ongoing and contribution spans across various work programs with Council partners.
3 Enabling inclusive participation in regional climate leadership		
3.1 Host a regular Climate Collaboration Hui and use insights to inform Climate Action Plan updates.		No progress. This is intended to be factored into the RCCWG work planning for 2026? However, it may now be too late to initiate a hui to support phase three: climate action planning, unless it is directly incorporated as part of LTP engagement opportunities.
4 Developing a comprehensive understanding of key risks and opportunities		
4.1 Regularly review regional climate science needs, involving councils, mana whenua, research partners, and key stakeholders to inform annual planning and long-term planning processes.		Stocktaking of regional climate science needs has commenced and will be discussed at the G-RCCWG workshop (2 July 2026), alongside alignment with AP and LTP milestones.
4.2 Publish a revised Southland climate change impact assessment.		The Climate Impact Assessment was released (15 April 2026) and presented across councils and staff forums (April–May 2026), with supporting communications tools such a broad set of 'FAQs' being developed to assist.
4.3 Undertake a 'Regional Natural Hazards Knowledge Assessment' to fully understand regional-scale hazards, including those relating to our changing climate.		Regional natural hazards knowledge assessment stocktake is underway (Stage 1 due 30 June 2026), with further stages continuing into 2026–27.
5 Collaborating to obtain up-to-date science and modelling of climate hazards		
5.1 Develop flood modelling projects in collaboration with key agencies to meet shared planning and community resilience needs.		Flood modelling updates have been provided to G-RCCWG (8 May) and ICC (23 April 2026). Coastal inundation modelling underway (completion due end of June 2026).



5.2	Work with research partners and councils to define additional modelling needs (e.g., coastal inundation, drought, fire risk).		For consideration as part of phase three: climate action planning via the RCCWG.
6 Investigating how nature-based solutions can support climate resilience			
6.1	Publish the findings of the 'Murihiku Slow the Flow' pilot project.		This action is complete.
6.2	Consider the findings of the 'Murihiku Slow the Flow' pilot project when developing a regional floodplain management approach.		"Murihiku Slow the Flow" findings were considered G-RCCWG (8 May). These may also be considered as part of phase three: climate action planning via the RCCWG.
7 Improving accessibility of information and our collective understanding of local climate change impacts, risks and opportunities			
7.1	Maintain and regularly update council websites with localised climate information and guidance.		Initial website improvements and investigation into climate change and natural hazards information are underway, with further review to inform future enhancements and potential regional portal development.
8 Engaging communities in shaping adaptation priorities			
8.1	Develop a best practice regional approach to climate engagement that embeds community values into the risk assessment and adaptation planning process.		Community spatial planning processes are underway across SDC and ICC, supported by a regional spatial planning inter-agency workshop (27 May), with ongoing work to align related streams.
9 Collaborating with partners to strengthen community climate resilience			
9.1	Partner with Emergency Management Southland to align adaptation planning with the 4Rs framework (Reduction, Readiness, Response, and Recovery).		New EMS Group Manager/Group Controller commenced (May 2026), with a briefing planned on the climate change and natural hazards portfolio.
9.2	Improve inter-agency role clarity and systems to better support the Reduction, Readiness, Response and Recovery framework operating effectively in Southland.		New EMS Group Manager/Group Controller commenced (May 2026), with a briefing planned on the climate change and natural hazards portfolio.
9.3	Develop a catchment approach to floodplain management, reflecting ki uta ki tai principles and working across territorial boundaries.		"Murihiku Slow the Flow" findings were considered G-RCCWG (8 May). These may also be considered as part of phase three: climate action planning via the RCCWG.
10 Building community understanding of why net zero matters and how it can be achieved			
10.1	Support Great South to continue regular measurement and reporting of Murihiku Southland's regional greenhouse gas emissions inventory.		No update.
10.2	Support Great South to create a web-based regional emissions information tool.		No further progress this quarter. Next steps may be considered as part of phase three: climate action planning via the RCCWG (for example, the potential development of a climate change web portal).
10.3	Continue to support Great South's existing Net Zero Southland decarbonisation programmes for businesses and community organisations.		Great South delivered decarbonization workshops in May 2026: the Future Proof Business Academy.
11 Supporting regional net zero initiatives and clarify local government's role in them			
11.1	Obtain up-to-date regional transition risk and opportunities assessment, expanding to consider social, cultural and environmental impacts, to inform an equitable and inclusive transition to a low emissions region.		Great South revised Net Zero technical papers approved by the Great South Boars, with public outputs due end of June 2026 and potential consideration at G-RCCWG (2 July 2026), noting timing constraints for CAP and LTP alignment.
12 Monitoring, evaluating and reporting on progress towards our climate change outcomes			
12.1	Review the Regional Climate Change Strategy every three years.		Drafting of the phase three: Climate Action Plan has commenced and will be discussed as part of the climate action planning process at the 2 July RCCWG workshop.
12.2	Track and maintain a record of the progress of resourced actions within the Regional Framework for Action on Climate.		A high-level RFA action summary was provided (8 May) and will be updated monthly and reported quarterly to G-RCCWG, with the next update scheduled (2 July).
12.3	Integrate monitoring and evaluation against climate change outcomes into climate change projects and work programmes.		Each RCCWG agency is on their own individual journey to progress this action. The latest stocktake was presented to the G-RCCWG at their first workshop 12 March 2026.
13 Seeking community feedback on our regional response to our changing climate			
13.1	Regularly repeat Environment Southland's regional climate change perceptions survey to track shifts in awareness, concern, and community expectations over time.		Latest climate perceptions survey findings released (3 June 2026), with insights and materials to inform phase three: climate action planning and related workstreams.



Climate change impact across the Southland region

**IPCC 6th Assessment Report update - Volume 1:
Main report**

Prepared for Environment Southland

February 2026

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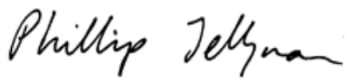
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Executive summary

Purpose

The global climate system is changing and will continue to change for decades to come. These changes will have implications not only for New Zealand's climate and weather systems but also for freshwater availability for downstream users and for hazard exposure (inland and coastal). Due to the nature of climate change, trends will vary across the country, throughout the century, and among different climate change scenarios. This report addresses potential impacts of climate change on climate, hydrology, marine and coastal processes across the Southland region using downscaled Global Climate Model (GCM) outputs from 1971–2099 under different global warming scenarios. The combination of six GCMs and three emissions scenarios allows consideration of a plausible range of future trajectories of greenhouse gas emissions and climatic responses.

Methods

The climate projections used in this report are derived from the 6th Coupled Model Intercomparison Project (CMIP6), which incorporates several significant scientific and modelling advances. The projections are based on six GCMs which are different from those previously used for New Zealand studies that were derived from the 5th Coupled Model Intercomparison Project (CMIP5). Climate change projections are generated for three emissions scenarios: SSP2-4.5, SSP3-7.0 and SSP5-8.5. Dynamical downscaling was used to produce the CMIP6 NZ climate projections using CSIRO's Conformal Cubic Atmospheric Model (CCAM) to at hourly climate simulations, for all climate variables of interest, available at 12 km spatial resolution across New Zealand.

The hydrological modelling builds on the Deep South National Science Challenge project 'Climate change impact on national hydrology' that coupled New Zealand's CMIP5 climate projections with the TopNet hydrological model, Earth Sciences New Zealand's uncalibrated, nationally parameterised surface water hydrological model. The modelling methodology follows recommendations provided as part of the Ministry for the Environment project 'Pilot CMIP5-CMIP6 hydrological projections intercomparison study'. The TopNet model has been implemented as part of the New Zealand Water Modelling (NZWaM) framework and is routinely used for surface water hydrological modelling applications in New Zealand.

Future projections of New Zealand's Earth System Model were used to quantify sea surface temperatures, marine heatwaves and ocean acidification. This fully-coupled Earth System Model has a finer spatial resolution around New Zealand compared to other ocean models in the CMIP5/6 archives, enabling better representation of coastal circulation and coastal processes.

Two tide-gauge records were analysed: the Port of Bluff gauge operated by South Port and archived by LINZ, and the Stead Street Bridge gauge operated by Environment Southland. Both records span more than 30 years, providing a robust basis for assessing mean sea-level trends, tidal characteristics, and extreme storm-tide levels. All datasets were quality-assured to identify gaps, check datum consistency, and remove any artefacts or offset changes prior to analysis.

Future sea-level rise projections are based on five Shared Socioeconomic Pathway (SSP) scenarios aligned with Ministry for the Environment guidance and the NZSeaRise programme. These projections indicate a wide range of possible outcomes, with higher-emissions scenarios leading to substantially greater sea-level rise by 2150. The timing of when key sea-level thresholds are reached varies across scenarios, reinforcing the need for adaptive, staged planning approaches.

Intercomparison of the CMIP5-CMIP6 atmospheric changes

ESNZ has previously conducted an intercomparison across New Zealand comparing projected changes across a range of climate variables for two scenarios producing similar levels of CO₂ by the end of the century. The scenarios considered were RCP4.5 (CMIP5) versus SSP2-4.5 (CMIP6) and RCP8.5 (CMIP5) versus SSP3-7.0 (CMIP6)¹. The key messages relevant to the Southland region are as follows:

- **Air temperature:** CMIP6 projects generally larger increases than those under CMIP5. However, the number of hot days (>25°C) predicted is lower under CMIP6.
- **Precipitation:** CMIP6 projects generally smaller overall changes than CMIP5 but with large seasonal differences in autumn and winter.
- **Dry days:** The number of days for which precipitation is less than 1 mm is projected to increase under CMIP6 compared to CMIP5. Heavy rainfall extremes (i.e., 99th percentile calculated on the wet days) are projected to be larger under SSP2-4.5 (CMIP6) than RCP 4.5 (CMIP5), and smaller under SSP3-7.0 (CMIP6) than RCP8.5 (CMIP5) by the end of the century.
- **Wind speed:** Average and strong wind speeds are projected to change less under CMIP6 than CMIP5. Work on wind speed projections is ongoing, and it is currently advised to use caution when using wind projections.

Results

It is not possible to attribute the modelled differences between two time periods (in this report, mid-century and end of century) solely to climate change, as natural climate variability may add to, or subtract from, the climate change effect. The potential impacts of climate change are presented as averages across the six model projections, which reduces the underlying natural variability to some extent. With these caveats in mind, the potential effects of changing climate over this century across the Southland region and Freshwater Management Units (FMUs) are summarised below across the different domains for each metric considered.

Climate domain

The projected mean temperature changes across the Southland region increase with time and emissions scenario. Future annual average warming spans a wide range: 0.9–1.4°C by 2050, and 1.8–3.6°C by 2090, largely dependent on scenario. Seasonally, most warming occurs in summer by mid-century and during autumn-winter and summer by the end of century. Changes in maximum and minimum temperature follow similar patterns, with the largest change in the

¹ The mismatch in RCP-SSP scenario for high emission scenario (unlike low-emission scenarios RCP4.5 and SSP2-4.5) is explained by the comparison of global annual mean CO₂ concentration by 2100 between the different scenarios. Global annual mean CO₂ concentration is projected to reach 840 ppm by 2100 under RCP8.5, 870 ppm under SSP3-7.0 and 1130 ppm under SSP5-8.5

maximum temperature projected during summer (up to 3.9 °C for SSP5-8.5 by the end of century), while the largest change in the minimum temperature is projected during winter (up to 3.6°C for SSP5-8.5 by the end of century). Diurnal range (i.e., difference between daily minimum and maximum temperature) is expected to increase with time and emission scenario, with the largest increase projected for summer and autumn.

Changes in extreme temperatures mirror the average annual signal. The average number of hot days is expected to rise from 3–5 days by 2050 to 6–19 days by 2090. Heatwave days (consecutive days >25°C) are projected to increase — particularly at higher elevations — across all scenarios by up to 8 days by 2050 and up to 36 days by 2090. Conversely, frost days are expected to decline by up to 20 days by mid-century, and by 25–45 days by the end of the century. Growing degree days will increase with time and emissions scenario, with the largest seasonal rise during summer.

Projected changes in rainfall show a marked seasonality and variability across the Southland region. Annual rainfall is expected to increase slightly by mid-century (5%), rising to 8–13% by the end of the century, with larger increases in western and eastern areas. One exception is the Garvie Mountains region (headwaters of the Waikaia River) where annual rainfall is projected to decrease by up to 10% across all scenarios. Seasonally the largest increases are projected during winter and spring (up to 40%), while summer and autumn precipitation is more variable with increase/decrease (between -20% and + 20%) depending on elevation, location, time and emission scenarios.

By mid-century, the number of wet days may increase slightly (up to 1 day) but decrease by up to 2.5 days by the end of the century. Spatially, increases in wet days occur mainly in the headwaters of the three Waiau hydro-electric generation lakes and coastal Southland. Decreases are concentrated in the eastern Waiau and north of the Hokonui syncline.

The number days where the total precipitation exceeds 10 mm is projected to increase across Southland at all time slices and emission scenarios, except for some areas in the lower Fiordland (Cameron/Princess Mountain ranges) and upper Maitara (Waikaia catchment) where small decreases (up to eight days) are expected for both mid-century and end of century.

The number of very wet days (i.e., days where the total precipitation exceeds 25 mm) is projected to increase across Southland at all time slices and emission scenarios, except for a small area in the eastern Waiau catchment (northern part of the Livingstone/Thomson Mountain range) and lower Fiordland (Cameron/Princess Mountain ranges) where a small decrease is expected by mid-century.

The number of heavy wet days (i.e., days where the total precipitation exceeds 50 mm) is also projected to increase across Southland under all scenarios, with the largest increase in northern Fiordland (north of the Cameron-Princess-Kaherekoau Mountain ranges). This increase is smaller than that for very wet days.

Projected changes in maximum annual 1-day rainfall (Rx1d) rise with time and emissions scenario, reflecting changes in very wet and heavy wet days. Rx1d is expected to increase by an average of 11 mm by mid-century and 23 mm by the end of the century, with local increases of up to 80 mm in the Waiau headwaters.

By mid-century, decreases in annual maximum 5-day rainfall (Rx5d) are projected for the Thomson and Ailsa Mountain ranges (up to 25 mm) while other areas, particularly Fiordland, may see increases of up to 50 mm. At the end of the century, Rx5d is projected to increase across the region, with Fiordland experiencing rises of up to 75–100 mm.

By mid-century the number of dry days may decrease slightly (up to 1 day), mainly in low-elevation areas, except in the three Waiau hydro-electric generation lakes. The number of dry days is expected to increase by up to 2 days by century's end, particularly north of the Hokonui syncline, while Waiau headwaters may see decreases.

Relative humidity is projected to slightly decrease with time and emission scenarios by up to 1%.

Solar radiation is projected to rise slightly (up to 1 W.m^{-2}) except under SSP 2-4.5 where a decrease is expected. Seasonally, solar radiation is expected to increase in summer and autumn (by up to 7 W.m^{-2} in summer by end of century) and decrease in winter and spring (by up to 4 W.m^{-2} in winter by end of century). Spatially, the largest decrease occurs in Fiordland's Darran Range, while the largest increase is across Maitava and Oreti Freshwater Management Units (FMUs).

Cloud cover is expected to decrease slightly (by up to 2%), mainly from October to April, with some minor increases expected for July/August. Fiordland headwaters may see increases mid-century, while Maitava–Oreti and eastern Waiau experience the largest decreases by the end of the century.

We note that work is ongoing on the wind speed projections, therefore caution is required in using the following results:

Annual average wind speed may rise slightly (up to 4%) across Southland under all scenarios. Seasonally, wind speed is expected to increase in winter and spring (up to 12% in winter under SSP5-8.5) and decrease for summer and autumn (up to 5 % under SSP3-7.0) by the end of the century. Spatially, annual average wind speed may decrease in Fiordland (north of the Franklin Range) and north-east Maitava (Old Man Range), while the largest increases occur north of the Hokonui syncline for the Maitava and Oreti, for most of the Aparima and most of the Waiau River downstream of Manapouri and south of Takitimu mountain ranges.

The number of calm days (i.e., mean wind speed $<1.5 \text{ m.s}^{-1}$) is expected to remain relatively unchanged, with minor seasonal shifts: slight decreases in June–September across scenarios and slight increases by the end of the century for February–March.

Windy days (i.e., mean wind speed $>10 \text{ m s}^{-1}$) are expected to increase (up to 10 days annually) especially during June–October (up to 3 days per month by the end of the century). Changes in windy days are spatially variable; northern Fiordland may experience reductions (up to 20 days/yr), while most of the Maitava-Oreti-Aparima and Waituna may experience increases (up to 20 days/yr). Strong wind changes (99th percentile) are likely to follow similar patterns.

Southland's prevailing wind direction - typically spanning the westerly quarter (from northwest through to southwest) - is projected to remain unchanged through time and warming.

Changes in meteorological drought (assessed using Potential Evaporation Deficit or PED) indicate Southland will experience increased drought: limited under SSP2-4.5 (up to 7 mm) and

greater under higher emission scenarios (up to 23 mm). Spatially, the headwaters of the Waikaia River may see the largest increase (up to 150 mm under SSP5-8.5), with smaller changes elsewhere. Conversely, the probability of annual PED accumulation >200 mm reflects similar trends: the Waikaia and upper Maitai may exceed 200 mm by at least 50%, while coastal Oreti and Waituna catchments may see decreases (up to 20%).

Changes in rainfall intensity correlate with temperature changes: mid-century rainfall intensity increases range from 4.8% (2-year ARI, 1-hour event) to 18% (100-year ARI, 1-hour event); by century's end the range is 16% to 46% for the same events.

Probable Maximum Precipitation (PMP) is projected to change linearly with mean annual air temperature at a rate of 8.34% per °C, regardless of scenario or storm duration.

Cryosphere domain

Changes in snow volume reflect changes in precipitation and temperature. Decreases in snow volume are expected to reach at least 50% across Southland mountain ranges by mid-century for SSP3-7.0 and SSP5-8.5, with smaller reductions in the lower-elevation range of the Waiau and the Garvie mountain range under SSP2-4.5. By the end of the century and regardless of the level of warming, snow volume is projected to decrease by at least 50% across Southland.

Changes in the number of snow days are projected to remain largely unchanged by the 2050s across emission scenarios, although the northern headwater mountain ranges are projected to experience a reduction of up to 30 snow days. Similar spatial patterns are projected for the end of the century with greater reductions in snow days under higher-emission scenarios. The Garvie Mountains (Maitai) are projected to experience snow day reductions of at least 90 days.

Snow line is expected to rise across Southland mountain ranges over time and under all emission scenarios. By mid-century, the snow line is expected to increase by up to 300 m across Southland regardless of scenario. By the end of the century, snow line is expected to increase by approximately 400–670 m depending on the level of warming. While snow may persist on the highest mountain ranges, it is projected that lower mountain ranges will have fewer than 90 days of snow cover by the end of the century.

Hydrology domain

The bias-corrected hydrological modelling chain is judged appropriate for use in this project. The hydrological bias correction was undertaken using a simple method that aims to match the long-term average riverine and cryospheric metrics across Southland rivers. This method allowed the bias-corrected model to adequately reproduce the mean flow metrics for all natural flow catchments. The bias corrected models also matched the mid- to lower-end values of the high flow metrics (95th percentile of non-exceedance) and the mid- to high-end values of the low flow metrics (25th percentile of the annual flow time series) for the natural flow catchments. However, the bias corrected models were less able to reproduce the more extreme flows, i.e., the lowest values for the low flow metrics, or the highest values for the high flow metrics. This indicates that further work is required to ensure the adequacy of the bias correction methods for these more extreme flow conditions.

Mean annual flood is projected to increase across nearly all Southland River reaches (at least 95%), with the greatest increases by the end of the century under SSP5-8.5 (up to 42%). While the magnitude of mean annual flood is projected to decrease for a small pocket within each

FMU, flood magnitude is projected to decrease for the headwaters of the Waikaia catchment (Mataura FMU).

Changes in the magnitude of the Q5 (i.e., river flow magnitude exceeded five percent of the time) and of the Q25 (i.e., river flow magnitude exceeded twenty-five percent of the time) reflect changes in mean annual flood albeit with a reduced range of magnitude (up to 20% for changes in Q5 and up to 9% for changes in Q25), suggesting a possible shift in the distribution of high flows under warming conditions.

Changes in the average annual number of Fre3 events are projected to vary across Southland rivers depending on location, time and emission scenario. By the end of the century under SSP5-8.5, the number of annual Fre3 events is projected to increase by between one and two events across all FMUs, except the Waiau FMU for which the increase is limited to one additional event. Spatially, decreases are projected for up to 11% of river reaches across Southland with decreases of up to five events in some areas of the Aparima and Mataura FMUs.

Changes in the magnitude of mean discharge reflect changes in average annual precipitation. The magnitude of the mean flow is projected to increase across nearly all Southland river reaches (at least 90%), with the greatest increases by the end of the century under SSP5-8.5 greenhouse gas concentration scenarios (average increase of 15% across Southland rivers). However, the magnitude of mean flow is projected to decrease for several reaches within each FMUs (up to 16% in the Waiau FMU and 23% in the Mataura FMU).

Changes in annual flows were considered in terms of changes in mean annual flows (more sensitive to extremes) and median annual flows. Across most Southland rivers, mean annual flow is projected to increase, with the greatest increases by the end of the century under SSP5-8.5 (average increase of 15% across Southland rivers). A notable difference occurs in the lower Mataura River, whereby the end of the century under very high greenhouse gas concentration scenarios, median annual flows are projected to increase by 10%, while mean annual flows are projected to increase only by up to five percent. The magnitude of mean annual flow is projected to decrease in some areas within each FMU (e.g., up to 17% of the reaches in the Mataura and Waiau FMUs).

The magnitude of seasonal average flows is projected to increase across nearly all Southland rivers in every season except summer, with the greatest increases by the end of the century under SSP5-8.5 (average increase of at least 30% across Southland rivers). In contrast, the direction of change in summer flows is projected to vary with time and scenario, while the magnitude of change is limited to a range of -5 to 5%. Regardless of time and scenario, summer average flows are predicted to decrease in the Waiau and Fiordland FMUs, and across the Mataura FMU by the end of century under SSP3-7.0 and mid-century under SSP5-8.5. Summer flows across the Aparima and Oreti FMUs are projected to increase regardless of time and scenarios. Overall, changes in seasonal average flows suggest a possible larger shift in Southland rivers' hydrological regimes under warming conditions, with spatial differences identified across FMUs.

Changes in the magnitude of the Q75 (i.e., river flow magnitude exceeded seventy-five percent of the time) and Q95 (i.e., river flow magnitude exceeded ninety-five percent of the time), shows a different spatial pattern to the mean flow. Both metrics are projected to decrease by the end of the century under high (SSP3-7.0) and very high (SSP5-8.5) greenhouse gas scenarios, with

average decrease up to 6% across Southland rivers. However, while Q75 is projected to increase across the Fiordland FMU, and to a lesser extent the Aparima and Waituna FMUs, Q95 is projected to increase only for the Fiordland FMU. Overall, changes in low flow metrics associated to changes in seasonal average flows suggest a possible larger shift in Southland rivers' hydrological regimes under warming conditions, with spatial differences identified across FMUs.

Changes in the magnitude of mean annual 7-day low flow vary across Southland rivers in both direction and magnitude. At FMU scale, the largest decrease in mean annual 7-day low flow is predicted across the Waiau FMU by mid-century under SSP3-7.0 (-11.1%), while the largest increase is predicted across the Aparima FMU by the end of the century under SSP2-4.5 (+ 50%). Spatially, mean annual 7-day low flow is expected to decrease by at least 23% for most reaches located in the Oreti and Maituna main stems by mid-century under SSP3-7.0. Mean annual 7-day low flow is projected to decrease in parts of every FMU (up to more than 60% across all FMUs, except for the Waituna FMU). These changes point to significant shifts in low flow hydrological regimes across Southland rivers under emission scenarios.

Changes in the magnitude of flow reliability vary across Southland rivers in both direction and magnitude. At FMU scale, the largest decrease in flow reliability is predicted across the Aparima, Waituna and Maituna FMUs by end of century under SSP2-4.5 (up to at least -0.05), while the largest increase is predicted across the Waiau FMU by the end of the century under all emission scenarios (+ 0.02). Spatially, flow reliability is projected to decrease across at least 69% of the reaches in every FMU, with the largest decrease projected in the Aparima-Oreti and Maituna main stems (up to -0.08) by the end of century under SSP5-8.5. Changes in flow reliability point to river water being less consistently available to meet environmental or water-use needs under future warming, reflecting a shift towards greater variability and uncertainty in water regimes.

Changes in the magnitude of water supply reliability vary across Southland rivers in both direction and magnitude. At FMU scale, the largest decrease in water supply reliability is predicted across the Aparima, Waituna and Maituna FMUs by end of century under SSP2-4.5 (up to at least -0.05), while the largest increase is predicted across the Waiau FMU by the end of the century under SSP2-4.5 and SSP5-8.5 (+ 0.01). Spatially, water supply reliability is projected to decrease for most FMU river main stems (up to -0.1) by end of century under SSP5-8.5. Changes in water supply reliability extend changes in flow reliability and indicate river water will be less consistently available to meet water demand during the irrigation season, likely increasing the frequency of water-use shortages under future warming.

Changes in the magnitude of land surface recharge vary across Southland shallow aquifers in both direction and magnitude. At annual and FMU scale, land surface recharge is projected to decrease across the Oreti FMU with warming (up to -6%), with the largest increase in land surface recharge predicted across all other FMUs under all emission scenarios (up to 12.6% for the Aparima by end of century under SSP5-8.5). At seasonal scale, land surface recharge is projected to increase during autumn and winter across all FMUs through time and emission scenarios, except for small pockets within the Oreti and Waiau FMUs. In summer, however, land surface recharge is projected to decrease with warming across most shallow aquifers in the Oreti (except the Five Rivers aquifer), Waituna and lower Maituna FMUs (by up to 50% for some aquifers under SSP5-8.5). In spring, decreases in land surface recharge are limited to parts of the lower Oreti and Waiau aquifers, specifically under SSP5-8.5. Overall, decreases in spring

and summer land surface recharge points to intensifying risks of hydrological and agricultural drought, water scarcity (e.g., access to groundwater resource for drinking water supply in the lower Mataura), and ecosystem stress across the Oreti-Waituna and lower Mataura FMUs under future warming.

Magnitude of the maximum daily and hourly annual peak discharge is generally projected to increase with time, warming and return period across Southland rivers, noting that for some locations the largest rises occur under SSP3-7.0 rather than the SSP5-8.5 scenario. These results mirror the changes in precipitation extremes.

Magnitude in peak daily discharge associated with 12hr and 24 hr duration PMP (referred as 12hr PMF and 24 hr PMF) is projected to increase with warming. Under a 1°C warming scenario, most FMUs, except the Mataura FMU, are projected to experience an increase between 10 and 20% in the magnitude of the PMFs (independently of the event duration). Spatial differences in changes to the 12hr and 24 hr PMF magnitude are more pronounced for warming greater than 2°C, with the largest changes predicted for the Mataura FMU because of the timing of the PMP event (winter PMP). While changes in PMF across different storm durations generally follow the same pattern as rainfall depth changes predicted by the HIRDS tool, changes in PMF are predicted to not increase with storm duration at some locations. This may be due to the methodology used to predict climate-change adjustments to PMP rainfall depths across duration. Further investigations are needed to understand these changes and better characterise the impacts of rarer rainfall events.

Stream temperature is projected to increase uniformly across Southland rivers with time and warming, at both annual and seasonal time scale. Spatially, the largest increases are projected under SSP5-8.5 at the outlets of the main river stems (up 4°C), while the lowest increases are projected in the upper reaches of FMUs (up to 1°C). These changes directly reflect changes in air temperature at both annual and seasonal time scale and signal greater stress on freshwater ecosystems.

Intercomparison of the CMIP5-CMIP6 changes in hydrological metric projection

Intercomparison of the magnitude of the projected change in three hydrological metrics (mean annual flood, annual and seasonal average discharge and water supply reliability) was carried out between the CMIP5 derived assessment and this assessment. As per the atmospheric analysis, the intercomparison was completed for two scenarios producing similar levels of CO₂ by the end of the century. The scenarios considered were RCP4.5 (CMIP5) versus SSP2-4.5 (CMIP6) and RCP8.5 (CMIP5) versus SSP3-7.0 (CMIP6). While the CMIP5 assessment was developed using a non-bias-corrected modelling chain, the CMIP6 assessment uses a bias-corrected modelling chain. The bias correction methodology does not affect the intercomparison of changes in river flow metrics. The key messages relevant to the Southland region are:

- Change in the magnitude of mean annual flood under CMIP6 are generally smaller than those projected under CMIP5. However, the spatial distribution of these changes differs, especially under the lower-emission scenario, mean annual flood projected to decrease up to 50% under RCP4.5 (CMIP5) for the upper Oreti FMU by the end of the century, while increases of up to 20% are projected under SSP2-4.5 (CMIP6).

- Changes in annual average discharge remain similar under the lower-emission scenario for the Maitava FMU. However, while little change is projected for the remaining Southland main rivers under RCP 4.5 (CMIP5), increases of up to 20% are projected under SSP2-4.5 (CMIP6). Under higher emission scenarios, similar magnitudes of change are projected under RCP8.5 (CMIP5) and SSP5-8.5 (CMIP6), except for the Maitava FMU, where little change or a decrease is projected under CMIP6.
- While differences in the magnitude of change are noted for seasonal average flow, with smaller changes projected under CMIP6, differences in spatial distribution and direction of change are identified depending on the emission scenario, as follows:
 - Winter flows are projected to decrease for the Waikawa catchment under CMIP6, while winter flows are projected to increase under CMIP5. Winter flows are projected to increase in lower Maitava and Oreti FMU under SSP2-4.5 (CMIP6), with little change projected under RCP4.5 (CMIP5) for those locations.
 - Changes in summer discharge are consistent between the two assessments for the Maitava FMU. However, differences in the direction of the change are projected for the Aparima, Oreti and Waiau FMUs particularly under higher-emission scenarios.
 - Changes in spring discharge are consistent between the two assessments with differences only in the magnitude of change.
 - Changes in autumn discharge are not spatially consistent between the two assessments, particularly for the Aparima, Oreti and Maitava FMUs, with increases in autumn discharge projected under RCP4.5 (CMIP5), while decreases are projected under SSP2-4.5 (CMIP6).
- The magnitude of absolute change in water supply reliability is consistent across both assessments. However, differences in the direction of the change are identified for both emissions scenarios, with water supply reliability projected to decrease across most rivers under RCP8.5 (CMIP5) while increasing under SSP5-8.5 (except for the lower Oreti FMU).

Sea-level domain

Tidal analysis showed differences in the tidal characteristics at Bluff and Stead Street, with Bluff experiencing a larger tidal range. High-tide exceedance curves were used to identify how often high tides might reach critical elevations, and these were then adjusted to reflect projected sea-level rise. Additionally, storm-tide levels—caused by the combined effects of tide, storm surge, and wave setup—were statistically modelled for both locations. Bluff was found to be more exposed to extreme sea levels under storm-tide conditions, which are expected to become more frequent as sea levels rise.

Historical observations from Bluff and Stead Street show a clear and ongoing rise in mean seas level, consistent with trends observed elsewhere in New Zealand. While year to year variability

remains high, recent decades show higher average sea levels than earlier periods, increasing the frequency of coastal flooding during high tides and storm events.

Future projections, based on IPCC AR6 scenarios and data from the NZSeaRise programme, indicate that sea levels will continue to rise under all emission pathways. These projections include estimates of when critical sea-level thresholds (e.g., 0.2 m, 0.6 m, and 1.0 m above 2020 levels) are likely to be reached, both with and without adjustments for local vertical land movement—information that is essential for future risk and infrastructure planning.

This sea-level analysis highlights the increasing exposure of coastal communities and infrastructure to flooding and erosion hazards. It provides important information to inform planning, infrastructure investment, and risk management decisions across Southland. The modelling shows that Southland property exposure to coastal flooding (with a 100-year ARI) will increase anywhere from 20% to 76% over time, under different emission scenarios and if land subsidence over the next 100 years. The results underline the need for proactive adaptation measures that consider not only global sea-level rise but also local land movement and extreme events.

Marine domain

Sea surface temperatures (SSTs) are projected to increase over time and under all emission scenarios due to anthropogenic greenhouse gas emissions. By the end of the century, SSTs are projected to increase by up to 1°C under the low-emission stabilisation scenario (SSP1-2.6) and by more than 3°C under SSP3-7.0.

Linked to SST change, marine heatwaves are expected to increase over time and under all emission scenarios. By the end of the century, marine heatwave intensity is projected to increase by up to 0.5°C under SSP1-2.6 and exceed 2 °C under SSP3-7.0. Conversely, the frequency of marine heatwaves is expected to increase from 15–30 days per year (under current climate conditions) to 120–200 days per year under SSP1-2.6 and up to 365 days per year under SSP3-7.0.

The below table is provided in this Executive Summary to assist readers interested in the key findings for each Freshwater Management Unit (FMU).

FMU	Summary of change
Mataura	<u>Climate domain</u> By the end of century, the average temperatures are expected to increase by 1.8 to 3.6°C depending on the emission scenario. Projected changes in seasonal temperature are elevation-dependent during summer and autumn in higher emission scenario, and more uniform during winter and spring season. Similar changes are projected for the minimum temperature. Hot days are expected to increase by approximately 11 to 30 days, with the largest increase for the upper Mataura between an area delineated by Gore-Waikaka and Lumsden townships, including the Waikaia River valley (up to 60 days).

FMU	Summary of change
	The number of cold nights (taken as the number of cold days) is projected to decrease by between 26 to 42 days (depending on the scenario). Coastal Maitara (south of Gore township) may experience up to 50 fewer cold days, while high elevations (Garvie and Umbrella mountain ranges) may have up to 100 fewer cold days. Heatwave frequency is expected to increase with emission scenario and elevation with increase ranging from 20 to 60 days in coastal Maitara up to 80 days in Maitara's mountain ranges. By the end of century, the annual precipitation is projected to increase with emission scenario between 7.5 to 10 percent. Spatial decrease in precipitation (up to 10%) is expected independently of emission scenario in the Garvie Mountains. The area of largest increase in precipitation develops from an area between Gore - Waikaia and Cattle Flats townships under SSP3-7.0, to south of a line Cattle Flats-Waikaia townships under SSP 5-8.5. From a seasonal point of view, winter then spring and summer seasons are projected to experience the largest increases (ranging from 5 to 20%), while autumn precipitation increases moderately (up to 2%) under emission scenarios SSP3-7.0 and SSP5-8.5. Number of wet days are projected to decrease up to 9 days with emission scenario and elevation, except under SSP 2-4.5 under which it is projected to increase up to 3 days across lower elevation terrain. However, number of wet and very wet days and rain days above 10 mm are projected to increase independently of emission scenario and elevation by up to 3 to 6 days. Conversely, the number of dry days is projected to increase by up to 3 days independent of emission scenario and elevation, except for north of Gore where the number of dry days is expected up to 6 days, with larger changes projected for the Old Man range (up to 9 days). Rx1d magnitude is projected to increase up to 20 mm independently of elevation and emission scenario. Conversely, Rx5d is projected to follow similar spatial pattern with increase up to 50 mm. Relative humidity is projected to slightly decrease with emission scenario across the FMU by up to 3%, while solar radiation is expected to increase by up to 5% (except for the Garvie Mountains where solar radiation is expected to decrease by up to 10%). Wind speed is projected to increase with emission scenario and elevation by up to 10%, except for the Garvie Mountains where wind speed is projected to decrease by up to 10% independently of the emission scenario. Meteorological drought frequency is projected to decrease independent of emission scenario by up to 40 days south of a line from Lumsden-Gore township, with decrease up to 20 days for the remainder of the FMU except for the Garvie and Umbrella mountains which are projected to experience an increase by up to 40 days of meteorological drought frequency. Change in rainfall depth follows change in annual average temperature. Rainfall depth is projected to increase from 8% (for 2-year ARI of 120 hrs storm duration) up to 49% (for a 100-year ARI of 1hr storm duration). Similar patterns are projected for the change in PMP depth independently of storm duration. PMP depth is projected to increase with warming from 15% up to 30%.

FMU	Summary of change
	<u>Hydrology domain</u> By the end of the century high flow metrics (mean annual flood, Q5 and Q25) are expected to increase by 4% to 40% by the end of century depending on emission scenario level and high flow metric for most of the river reaches in the Maitara FMU. However, some decreases are projected in isolated pockets and to a larger extent in the headwaters of the Waikato River. Annual average number of Fre3 events are projected to slightly increase with emission scenario up to an additional 1.2 event per year for most of the river reaches in the Maitara FMU. From a season point of view, winter and summer are projected to experience the moderate increase up to 0.3 event, with smaller increase projected for the remaining seasons. Average flow metrics (mean flow and mean annual flows) are expected to increase by 8% to 14% by the end of century, for most of the river reaches in the Maitara FMU, with the largest increase projected under low emission scenario (SSP2-4.5). Some decreases are projected in isolated pockets and to a larger extent in the headwaters of the Waikato River, associated with the change in precipitation. Seasonal flow is projected to increase with emission scenario, for most of the river reaches in the Maitara FMU, during winter-spring and autumn ranging from 0.4% to 21.4%, with smallest increase projected under SSP3-7.0. Summer flows are projected to be more variable, with largest increase (up to 2.6%) under SSP2-4.5 and largest decrease (up to 12.2%) under SSP3-7.0. Annual Q25 is projected to increase with emission scenario, for most river reaches in the Maitara FMU, up to 14% under SSP2-4.5 and SSP5-8.5, with smallest increase projected under SSP3-7.0 (up to 7.5%) and SSP5-8.5 (up to 11.4%). Q75 and Q95 are projected to moderately increase up to 4.3% under SSP2-4.5, while decreasing (between 10 and 12% for Q75 and 17% for Q95) with increased emission scenarios. 7-day mean annual low flow magnitude is projected to increase, for most river reaches in the Maitara FMU, under SSP2-4.5 (up to 39.2%) and SSP5-8.5 (up to 9.8%). 7-day mean annual low flow magnitude is projected to moderately decrease (up to 2.2%) under SSP3-7.0. Flow reliability and water supply reliability are projected to decrease independent of emission scenario with the largest decrease (up to 0.04) projected under SSP2-4.5. Annual average groundwater recharge is projected to increase across emission scenario, except for isolated pockets of the Maitara shallow aquifers, with largest increase projected under SSP2-4.5 (up to 8.5%) and lowest increase under SSP3-7.0 (up to 1.9%). Seasonally, winter recharge is projected to increase with emission scenario (up to 23.9%), while summer recharge is more variable. Summer recharge is projected to slightly increase under SSP2-4.5 and SSP5-8.5 (up to 2.7%) and to decrease up to 20.4% under SSP3-7.0. Magnitude of the maximum daily and hourly annual peak discharge is projected to increase with time-emission scenario and return period across the FMU. However, the magnitude of changes varies by location and emission scenario. Change in PMF magnitude associated with 12hr and 24 hr PMP duration event is increasing with warming and is impacted by the timing of the PMP event (summer/winter event) and onset cryospheric contribution. Summer PMF is projected to increase from 10% up to 60%, while change in winter PMF magnitude is amplified (compared to summer PMF) due to change in precipitation phase with warming and added contribution of snow melt to flood generation mechanism.

FMU	Summary of change
	<u>Coastal domain</u> By the end of century SLR increase with emission scenario and position along the coastline, with larger SLR (including LVM) projected with increased emission scenario. A 50 cm SLR increment could be reached between 2050 under SSP5-8.5 and 2081 under SSP2-4.5.
Oreti	<u>Climate domain</u> By the end of century, average temperatures are expected to increase by between 1.8 to 3.5 °C depending on the emission scenario. Changes in seasonal temperature are elevation dependant during summer and autumn season, and more uniform during winter and spring season. Similar changes are projected for the minimum temperature. Hot days are expected to increase by between 11 to 32 days, with the largest increase for the mid Oreti in an area located between Winton-Lumsden and Mossburn townships (up to 60 days). Number of cold nights (taken as the number of cold days) is expected to decrease with emission scenario and elevation by between 26 to 42 days across the Oreti. Coastal Oreti is projected to experience a reduction of the number of cold days by up to 50 days independently of emission scenario, increasing with elevation (Eyre Mountain range) up to 100 days. Heatwave frequency is expected to increase with emission scenario and elevation, with increases ranging from 20 to 60 days in coastal Oreti, and up to 80 days in the Oreti River's mountain ranges. Annual average precipitation is expected to increase with emission scenario, with increases ranging from 10 to 14 percent across the Oreti. The largest increases (up to 20%) are located south of Lumsden township. Precipitation in the Oreti mountain ranges is expected to increase by up to 10% independently of emission scenario. From a seasonal point of view, winter then spring and summer seasons are projected to experience the largest increase 11 to 25% with increased emission scenarios, while autumn precipitation increases moderately (up to 5%) under emission scenarios SSP3-7.0 and SSP5-8.5. Number of wet days is projected to decrease up to 6 days with emission scenario and elevation, except under SSP 2-4.5 under which it is projected to increase up to 3 days across lower elevation terrain. However, number of wet and very wet days are projected to increase independently of emission scenario and elevation by up to 5 to 6 days. Conversely, the number of dry days is projected to increase by up to 3 days independent of emission scenario and elevation, except for north of the Hokonui syncline where number of dry days are expected up to 6 days. Rx1d magnitude is projected to increase up to 20 mm independently of elevation and emission scenario. Conversely, Rx5d is projected to follow similar spatial pattern with increases up to 50 mm. By the end of century relative humidity is projected to decrease slightly with emission scenario across the FMU by up to 3%, while solar radiation is expected to increase by up to 5%. Wind speed is projected to increase with emission scenario and elevation by up to 10% north of Dipton township.

FMU	Summary of change
	Meteorological drought frequency is projected to decrease independent of emission scenario by up to 40 days, except for south of the Eyre mountains for which a decrease is projected by up to 20 days. Change in rainfall depth follows changes in annual average temperature. Rainfall depth is projected to increase from 8% (for 2-year ARI of 120 hrs storm duration) up to 48% (for a 100-year ARI of 1hr storm duration). Similar patterns are projected for the change in PMP depth independently of storm duration. PMP depth is projected to increase with warming from 15% up to 29%. <u>Hydrology domain</u> By the end of century, high flow metrics (mean annual flood, Q5 and Q25) are expected to increase by 4.1% to 50% depending on emission scenario level and high flow metric for most of the river reaches in the Oreti FMU. Little change in the annual average number of Fre3 events are projected with emission scenario (up by 1.3 event per year) for most of the river reaches in the Oreti FMU. From a season point of view, winter and summer are projected to experience the moderate increase up to 0.5 event, with similar decrease projected for the remaining seasons. Average flow metrics (mean flow and mean annual flows) are expected to increase with emission scenario by 14% to 21% by the end of century, for most of the river reaches in the Oreti FMU, with the smallest increase projected under high emission scenario (SSP3-7.0). Seasonal flow is projected to increase with emission scenario, for most of the river reaches in the Oreti FMU, ranging from 7.8% to 24%, with the largest increases (larger than 16%) projected during winter and spring and the smallest increase projected in summer under SSP3-7.0 (7.8%). Annual Q25 is projected to increase with emission scenario, for most river reaches in the Oreti FMU, up to 21% under SSP5-8.5, with the smallest increase (up to 14.7%) projected under SSP3-7.0. Changes in Q75 vary with time and emission scenarios. Q75 is projected to slightly increase (1.0%) under SSP2-4.5, and to decrease up to 20% with higher emission scenarios. Q95 is projected to decrease with emission scenario by 3.1% to 20.8% by the end of the century, for most reaches in the Oreti FMU. Changes in 7-day mean annual low flow magnitude are more variable to those in Q75. 7-day mean annual low flow is projected to increase, for most river reaches in the Oreti FMU, under SSP2-4.5 (up to 37.4%) and SSP3-7.0 (up to 6%), but to decrease up to 4% under SSP5-8.5. Flow reliability and water supply reliability are projected to decrease independent of emission scenario with the largest decrease (up to 0.03) projected under SSP2-4.5. Annual average groundwater recharge is generally projected to decrease with emission scenario, except for isolated pockets of the Oreti shallow aquifers, with largest decrease projected under SSP3-7.0 (up to 6.2%) and increase under SSP2-4.5 (up to 1.0%). Seasonally, winter recharge is projected to increase across emission scenario (largest increase up to 23.3% under SSP2-4.5), while summer recharge is projected to decrease with emission scenario (up to 22.6% under SSP3-7.0 and SSP5-8.5).

FMU	Summary of change
	Magnitude of the maximum daily and hourly annual peak discharge is projected to increase with time-emission scenario and return period across the FMU. However, the magnitude of changes varies by location and emission scenario. Change in PMF magnitude associated with 12hr and 24 hr PMP duration event is increasing with warming. PMF is projected to increase from 9% (under +1.0°C warming) up to 34% (under +3.0°C warming) ranging from 9% to 49% depending on GCM and timing of the PMP event. <u>Coastal domain</u> By the end of century SLR increase with emission scenario and position along the coastline, with larger SLR (including LVM) projected with increased emission scenario. A 50 cm SLR increment could be reached between 2056 under SSP5-8.5 and 2104 under SSP2-4.5.
Aparima	<u>Climate domain</u> By the end of century, average temperatures are expected to increase between 1.8 to 3.5°C depending on the emission scenario. Changes in seasonal temperature are elevation dependant during summer and autumn, and more uniform during winter and spring season. Similar changes are projected for the minimum temperature. Hot days are expected to increase between 11 to 32 days, with the largest increase (up to 60 days) for the mid-Aparima for an area south of the Hokonui syncline to Otautau township. Number of cold nights (taken as the number of cold days) is expected to decrease with emission scenario and elevation, with decreases ranging from 28 to 46 days across the Aparima, except for the Takitimu range for which the number of cold days is projected to increase up to 10 days. Heatwave frequency is expected to increase with emission scenario and elevation with increases ranging from 20 to 60 days for most of the Aparima, and up to 80 days in the Takitimu mountain range. By the end of century, annual average precipitation increases with emission scenario from 10 to 14 percent across the Aparima. Spatially, the largest increases are located south of Wreys Bush township. From a seasonal point of view, winter then spring and summer seasons are projected to experience the largest increases (11-24%), while autumn precipitation increases up to 10% but decrease with increased emission scenarios. Number of wet days is projected to decrease by up to 6 days with emission scenario and elevation, except under SSP2-4.5 under which it is projected to increase up to 3 days across lower elevation terrain. However, the number of wet and very wet days is projected to increase independently of emission scenario and elevation by up to 5 to 6 days. Conversely, the number of dry days is projected to increase by up to 3 days independent of emission scenario and elevation, except for the Takitimu and Eyre mountain ranges where number of dry days are expected to increase up to 6 days. Rx1d magnitude is projected to increase by up to 20 mm, independent of elevation and emission scenario. Rx5d is projected to follow similar spatial pattern with increase up to 50 mm. By the end of century relative humidity is projected to decrease slightly with emission scenario across the FMU by up to 3%, while solar radiation is expected to increase by up to 5%. Wind speed is projected to increase with emission scenario and elevation by up to 10% for most of the FMU.

FMU	Summary of change
	Meteorological drought frequency is projected to decrease independent of emission scenario by up to 40 days, except for the Takitimu Mountains for which a decrease up to 20 days is projected. Change in rainfall depth is following change follows change in annual average temperature. Rainfall depth is projected to increase from 8% (for 2-year ARI of 120 hrs storm duration) up to 48% (for a 100-year ARI of 1hr storm duration). Similar patterns are projected for the change in PMP depth independently of storm duration. PMP depth is projected to increase with warming from 15% up to 29%. <u>Hydrology domain</u> By the end of century high flow metrics (mean annual flood, Q5 and Q25) are expected to increase, for most of the river reaches in the Aparima FMU, by 6% to 68% depending on emission scenario and high flow metric. Annual average number of Fre3 events are projected to slightly increase with emission scenario up to an additional 1.6 event per year for most of the river reaches in the Aparima FMU. From a season point of view, winter and summer are projected to experience moderate increase up to 0.5event, while smaller changes are projected for the remaining seasons. Average flow metrics (mean flow and mean annual flows) are expected to increase with emission scenario by 12% to 21% by the end of century, for most of the river reaches in the Aparima FMU, with the lowest increase projected under high emission scenario (SSP3-7.0). Seasonal flow is projected to increase with emission scenario, for most of the river reaches in the Aparima FMU, up to 28%, with the smallest increase projected under SSP3-7.0. Annual Q25 is projected to increase with emission scenario, for most river reaches in the Aparima FMU, up to 17% under SSP2-4.5 and SSP5-8.5, with the smallest increase (up to 10%) projected under SSP3-7.0. Q75 is projected to increase under SSP2-4.5 (up to 14.6%) and SSP5-8.5 (up to 4.7%) but decrease (by 2.7%) under SSP3-7.0. Changes in 7-day mean annual low flow magnitude are more variables than those in Q75. 7-day mean annual low flow is projected to increase, for most river reaches in the Aparima FMU, under SSP2-4.5 and SSP5-8.5 (up to 51.9%), but to decrease up to 7.8% under SSP3-7.0. Q95 is projected to increase under SSP2-4.5 (up to 12.6%) and decrease with increased warming (by 6.1% under SSP3-7.0). Flow reliability and water supply reliability are projected to decrease independent of emission scenario with the largest decrease (up to 0.05) projected under SSP2-4.5. Annual average groundwater recharge is projected to increase across emission scenario, except for isolated pockets of the Aparima shallow aquifers, with largest increase projected under SSP5-8.5 (up to 12.7%) and lowest increase under SSP3-7.0 (up to 4.6%). Seasonally, winter recharge is projected to increase with emission scenario (up to 25%), while summer recharge is more variable. Summer recharge is projected to increase under SSP2-4.5 and SSP5-8.5 (up to 25.5% under SSP5-8.5) and to decrease for lower emission scenario (up to 2.2 % under SSP3-7.0). Magnitude of the maximum daily and hourly annual peak discharge is projected to increase with time-warming and return period across the FMU. However, the magnitude of changes varies by location and emission scenario. Change in PMF magnitude associated with 12hr and 24 hr PMP duration event is increasing with warming. PMF is projected to increase from 16% (under +1.0°C warming) up to 60% (under +3.0°C warming and ranging from 11% to more than 100% depending on location, GCM and timing of the PMP event.

FMU	Summary of change
	<u>Coastal domain</u> By the end of century SLR increase with emission scenario and position along the coastline, with larger SLR (including LVM) projected with increased emission scenario. A 50 cm SLR increment could be reached between 2059 under SSP5-8.5 and 2094 under SSP2-4.5.
Waituna	<u>Climate domain</u> By the end of century, average and seasonal temperatures are expected to increase between 1.7 to 3.4°C depending on the emission scenario. Similar changes are projected for the minimum temperature. Hot days are expected to increase between 10 to 32 days. Cold nights (taken as the number of cold days) is expected to decrease by between 12 to 16 days depending on emission scenario. Heatwave frequency is expected to increase with emission scenario between 20 days up to 60 days under largest emission scenario. Annual average precipitation is projected to increase with emission scenario, with increases from 11 to 18 %. From a seasonal point of view, winter then spring and summer seasons are projected to experience the largest increase (6 to 30%) with increased emission scenarios, while autumn precipitation increases are moderate (up to 10%) but decrease with increased emission scenarios. Number of wet days is projected to decrease up to 3 days with emission scenario and elevation, except under SSP2-4.5 under which it is projected to increase up to 3 days. However, number of wet and very wet days are projected to increase independently of emission scenario by up to 5 to 6 days. Conversely, the number of dry days is projected to increase by up to 3 days independent across the Waituna. Rx1d magnitude is projected to increase up to 20 mm. Conversely, Rx5d is projected to follow similar spatial pattern with increase up to 50 mm. By the end of century relative humidity is projected to slightly decrease with emission scenario across the FMU by up to 3%, while solar radiation is expected to increase by up to 5%. Wind speed is projected to increase with emission scenario and elevation by up to 5%. Meteorological drought frequency is projected to decrease independent of emission scenario by up to 40 days. Change in rainfall depth is following change in annual average temperature with warming. Rainfall depth is projected to increase from 8% (for 2-year ARI of 120 hrs storm duration) up to 46% (for a 100-year ARI of 1hr storm duration). Similar patterns are projected for the change in PMP depth independently of storm duration. PMP depth is projected to increase with warming from 14% up to 28%.

FMU	Summary of change
	<u>Hydrology domain</u> By the end of century high flow metrics (mean annual flood, Q5 and Q25) are expected to increase by 17% to 60% by the end of century depending on emission scenario level and high flow metric for most of the river reaches in the Waituna FMU. Annual average number of Fre3 events are projected to slightly increase with emission scenario up to an additional 1.4 event per year for most of the river reaches in the Waituna FMU. From a season point of view, summer is projected to experience the moderate increase up to 0.4 event, with smaller increase projected for the remaining seasons, except for winter (up to 0.2 event independently of emission scenario). Average flow metrics (mean flow and mean annual flows) are expected to between 20% and 25% by the end of century, for most of the river reaches in the Waituna FMU, with the largest increase projected under very high emission scenario (SSP5-8.5). Seasonal flow is projected to increase with emission scenario, for most of the river reaches in the Waituna FMU, up to 18% under SSP2-4.5 and SSP3-7.0, to 30% projected under SSP5-8.5. Q75 is projected to increase under SSP2-4.5 (up to 12.7%) and SSP5-8.5 (up to 4.6%), but decrease (by 8.4%) under SSP3-7.0. Annual Q25 is projected to increase with emission scenario, for most river reaches in the Waituna FMU, up to 25% under SSP2-4.5 and SSP5-8.5, with the smallest increase (up to 17%) projected under SSP3-7.0. 7-day mean annual low flow magnitude is projected to increase with emission scenario, for most river reaches in the Waituna FMU. The largest increase in 7-day mean annual low flow magnitude is projected under SSP2-4.5 and SSP5-8.5 (up to 24.5 %) and the lowest increase projected under SSP3-7.0 (up to 16.7 %). Q95 is projected to increase under SSP2-4.5 (up to 10.1%) and decrease with increased warming (by 13.3% under SSP3-7.0). Flow reliability and water supply reliability are projected to decrease independent of emission scenario with the largest decrease (up to 0.08) projected under SSP2-4.5 reducing to a decrease up to 0.02 under SSP5-8.5. Annual average groundwater recharge is projected to increase across emission scenario, except for isolated pockets of the Waituna shallow aquifers, with largest increase projected under SSP2-4.5 and SSP5-8.5 (up to 17%) and lowest increase under SSP3-7.0 (up to 10.6%). Seasonally, winter recharge is projected to increase with emission scenario (up to 31.7%), while summer recharge is more variable. Summer recharge is projected to increase under SSP2-4.5 and SSP5-8.5 (up to around 12%) and to decrease (up to 17.9%) under SSP3-7.0. <u>Coastal domain</u> By the end of century SLR increase with emission scenario and position along the coastline, with larger SLR (including LVM) projected with increased emission scenario. A 50 cm SLR increment could be reached between 2055 under SSP 5-8.5 and 2083 under SSP 2-4.5.

FMU	Summary of change
Waiau	<u>Climate domain</u> By the end of century average temperatures are expected to increase between 1.8 to 3.5°C depending on the emission scenario. Changes in seasonal temperature are elevation dependant during summer and autumn season, and more uniform during winter and spring season. Similar changes are projected for the minimum temperature. Hot days are expected to increase relatively uniformly between 5 to 16 days depending on emission scenario level, except for the Thomson Mountain range projected to experience lesser increase. Number of cold nights (taken as the number of cold days) is expected to decrease with emission scenario and elevation by between 35 to 60 days. Coastal Waiau and the Waiau River valley are projected to experience reduction on cold days by up to 50 days independently of emission scenario, while higher elevation (especially headwaters of the three hydro-electric generation lakes) are projected to experience larger change up to 125 days. Heatwave frequency is expected to increase with emission scenario and elevation with increase ranging from 20 to 40 days for most of the Waiau, and up to 80 days in all Waiau mountain ranges. Annual average precipitation is projected to increase with emission scenario, with increases ranging from 7 up to 12% across the Waiau. Spatially, the largest increases are localised in the headwaters of the Upukerora and Whitestone Rivers, headwater of Lake Te Anau and Manapouri and coastal Waiau (up to 20%) under the largest emission scenario. From a seasonal point of view, winter and spring seasons are projected to experience similarly the largest increase ranging from 11 to 26%, while autumn precipitations increase is minimal under increased emission scenario. Number of wet days is projected to decrease up to 9 days with emission scenario and elevation, except under SSP2-4.5 under which it is projected to increase up to 3 days including the western headwaters of the three hydro-electricity generation lakes. However, number of and very wet days are projected to increase by up to 5 to 6 days across the Waiau, except in the headwaters of the three hydro-generation lakes for which increase in number of wet days is projected to be up to 9 to 10 days. Conversely, the number of dry days are projected to increase by up to 3 days independent of emission scenario and elevation, except for the Livingstone – Thompson and Takitimu mountain ranges where number of dry days are expected up to 6 days. Rx1d magnitude is projected to increase with elevation from 20 mm at the coast to up to 80 mm in the headwaters of the three hydro-generation lakes. Conversely, Rx5d is projected to follow similar spatial pattern with increase up to 75 mm in the headwaters of the three hydro-generation lakes. By the end of century relative humidity is projected to slightly decrease with emission scenario across the FMU by up to 3%, and up to 3% south of the Takitimu Mountains. Solar radiation is expected to increase by up to 5% east of the three hydro-generation lakes. Wind speed is projected to increase with emission scenario independently of elevation by up to 5%, with an area delimited by Kepler to Takitimu mountains to Monowai township for which wind speed is projected to decrease by up to 10% under SSP 5-8.5.

FMU	Summary of change
	Meteorological drought frequency is projected to decrease independent of emission scenario by up to 40 days east of the Waiau River and the lower reaches of the Whitestone and Upukerora rivers. Similar patterns are projected for the headwaters of the three hydro-generation lakes. Change in rainfall depth is following change in annual average temperature with warming. Rainfall depth is projected to increase from 8% (for 2-year ARI of 120 hrs storm duration) up to 49% (for a 100-year ARI of 1hr storm duration). Similar patterns are projected for the change in PMP depth independently of storm duration. PMP depth is projected to increase with warming from 15% up to 29%. <u>Hydrology domain</u> By the end of century high flow metrics (mean annual flood, Q5 and Q25) are expected to increase by 5% to 45% by the end of century depending on emission scenario level and high flow metric for most of the river reaches in the Waiau FMU. Annual average number of Fre3 events are projected to slightly increase with emission scenario up to an additional 0.9 event per year for most of the river reaches in the Waiau FMU. From a season point of view, most of the changes are projected to occur in winter, while little change is projected for the remaining seasons. Average flow metrics (mean flow and mean annual flows) are expected to increase with emission scenario by 9% to 15.4% by the end of century, for most of the river reaches in the Waiau FMU, with the smallest increase projected under high emission scenario (SSP3-7.0). Seasonal flow is projected to increase with emission scenario, for most of the river reaches in the Waiau FMU, during winter-spring and autumn. Change in winter flows is ranging from 27% to 40% during winter, with the largest increase projected under SSP5-8.5, while lower increases are projected for autumn and spring (largest increase up to 12% under SSP2-4.5). Summer flows are projected to have little change to large decrease across emission scenarios, with the largest decrease (up to 11%) projected under SSP3-7.0. Annual Q25 is projected to increase with emission scenario, for most river reaches in the Waiau FMU, up to 13.8% under SSP5-8.5, with the smallest increase (up to 8.8%) projected under SSP3-7.0. Changes in Q75 and Q95 are variable with emission scenario. Q75 and Q95 are projected to increase under SSP2-4.5 (up to 5% for both Q75 and Q95), and to decrease with higher emission scenarios, with the largest decrease up to 5.5%, projected for Q75 under SSP3-7.0 and for Q95 under SSP5-8.5. Changes in 7-day mean annual low flow magnitude are similar to those in Q75 and Q95. 7-day mean annual low flow is projected to increase, for most river reaches in the Waiau FMU, under SSP2-4.5 (up to 12.7%), but to decrease up to 11% under SSP3-7.0 and SSP5-8.5. Projected changes in flow reliability and water supply reliability are variables. Flow reliability is projected to increase with emission scenario (up to 0.02 under SSP5-8.5), while water supply reliability is projected to decrease (up to 0.01) under SSP2-4.5 and remain unchanged with increased emission scenario. Annual average groundwater recharge is projected to increase across emission scenario, except for isolated pockets of Waiau shallow aquifers, with the largest increase projected under SSP5-8.5 (up to 6.1) and the lowest increase under SSP3-7.0 (up to 1.7%). Seasonally, winter recharge is projected to increase with emission scenario (up to 32%), while summer recharge is more variable. Summer recharge is projected to increase under SSP5-8.5 (up to 1.5%) and to decrease for lower emission scenario (up to 12.9% under SSP3-7.0).

FMU	Summary of change
	Magnitude of the maximum daily and hourly annual peak discharge is projected to increase with time-emission scenario and return period across the FMU. However, the magnitude of changes varies by location and emission scenario. Change in PMF magnitude associated with 12hr and 24 hr PMP duration event is increasing with warming and is impacted by timing of the PMP event (summer/winter event) and onset cryospheric contribution. Summer PMF is projected to increase from 10% up to 40%, while change in winter PMF magnitude is amplified (compared to summer PMF) due to change in precipitation phase with warming and added contribution of snow melt to flood generation mechanism.
Fiordland	<u>Climate domain</u> By the end of century, average temperatures are expected to increase between 1.7 to 3.3 °C depending on the emission scenario. Changes in seasonal temperature are elevation dependant for summer and autumn season, and more uniform during winter and spring season. Similar changes are projected for the minimum temperature. Hot days are expected to increase relatively uniformly by between 1 to 5 days depending on emission scenario level and elevation, with coastal Fiordland experiencing less change. Number of cold nights (taken as the number of cold days) are expected to decrease with emission scenario and elevation, with increases ranging from 22 to 35 days across Fiordland. Coastal Fiordland is projected to experience reduction of cold days by up to 50 days independently of emission scenario, while higher elevations are projected to experience larger changes up to 100 days. Heatwave frequency is expected to increase with warming independent of elevation with increases ranging from 20 to 60 days. Annual average precipitation is projected to increase with emission scenario and elevation, with increases ranging from 7% up to 13%. From a seasonal point of view, winter then spring seasons are projected to experience the largest increase ranging from 11 to 26 %, while summer and autumn precipitation increases are moderate (up to 5%) and the lowest under SSP3-7.0. Number of wet days are projected to decrease up to 6 days with emission scenario and elevation, except under SSP 2-4.5 under which southern Fiordland is projected to increase up to 3 days. However, number of wet and very wet days are projected to increase by up to 12 to 15 days closer to the Fiordland coast, depending on emission scenario, and north of the Franklin Mountains. Conversely, the number of dry days is projected to increase by up to 3 days independent of emission scenario and elevation. Rx1d magnitude is projected to increase with elevation and distance to coast from 20 mm in coastal Fiordland to up to 80 mm in Fiordland headwater catchments. Rx5d is projected to follow similar trend with increase up to 100 mm north of the Franklin Mountains. By the end of the century, relative humidity is projected to slightly decrease with emission scenario across the FMU by up to 2%. Solar radiation is expected to increase by up to 5% south of the Cameron and Kaherekoau mountain ranges while decreasing by up to 10% north of the Franklin Mountain range.

FMU	Summary of change
	Meteorological drought frequency is projected to decrease independent of emission scenario by up to 40 days west and north of the Cameron and Kaherekoau Mountains with decrease in meteorological drought frequency projected for low elevation coastal Fiordland. Change in rainfall depth is following change in annual average temperature with warming. Rainfall depth is projected to increase from 8% (for 2-year ARI of 120 hrs storm duration) up to 45% (for a 100-year ARI 1hr storm duration). Similar patterns are projected for the change in PMP depth independently of storm duration. PMP depth is projected to increase with warming from 14% up to 27%. <u>Hydrology domain</u> By the end of century high flow metrics (mean annual flood, Q5 and Q25) are expected to increase by 6% to 29% by the end of century depending on emission scenario level and high flow metric for most of the river reaches in the Fiordland FMU. Annual average number of Fre3 events are projected to slightly increase with emission scenario up to an additional 1.4 event per year for most of the river reaches in the Fiordland FMU. From a season point of view, winter is projected to experience a moderate increase up to 0.8 event, while little change is projected during summer (-0.1 event). Average flow metrics (mean flow and mean annual flows) are expected to increase with emission scenario by 8% to 12% by the end of century, for most of the river reaches in the Fiordland FMU. Seasonal flow is projected to increase with emission scenario, for most of the river reaches in the Fiordland FMU, during winter and spring ranging from 13% to 35%. Changes in autumn flow are depending on emission scenario, with increase by up to 8% under SSP2-4.5 and decrease by 2% under SSP3-7.0. Summer flows are projected to decrease across emission scenarios, with largest decrease (by up to 8%) projected under SSP3-7.0. Annual Q25 is projected to increase with emission scenario, for most river reaches in the Fiordland FMU, up to 14.8% under SSP5-8.5. Changes in Q75 and Q95 are projected to increase with emission scenario. Changes in Q75 and Q95 are projected up to 12%, under SSP2-4.5, with the smallest increase, up to 6%, projected under SSP3-7.0. Changes in 7-day mean annual low flow magnitude are more variables than those in Q75 and Q95. 7-day mean annual low flow is projected to increase, for most river reaches in the Fiordland FMU, under SSP2-4.5 and SSP3-7.0 (up to 14.1%), but to decrease up to 2.2 % under SSP5-8.5. Projected changes in flow reliability and water supply reliability are variables. Those are projected to decrease under SSP2-4.5 and SSP3-7.0 (up to 0.02) and increase (up to 0.01) projected under SSP5-8.5. <u>Coastal domain</u> By the end of century SLR increase with emission scenario and position along the coastline, with larger SLR (including LVM) projected with increased emission scenario. A 50 cm SLR increment could be reached between 2058 under SSP5-8.5 and 2092 under SSP2-4.5

1 Introduction

The climate is changing and it is accepted internationally that further changes will result from increasing amounts of greenhouse gases in the atmosphere. In addition, climate will also vary from year to year and decade to decade due to natural processes such as El Niño. Climate change effects over the next decades are predictable with some level of certainty, and will vary from place to place throughout New Zealand (Ministry for the Environment, MfE 2018).

Environment Southland, in collaboration with Invercargill City Council, Southland District Council and Gore District Council (the Councils), commissioned Earth Sciences New Zealand (ESNZ) to produce an update of the 2018 regional assessment of the impacts of climate change for Southland (Zammit et al. 2018) that was completed using downscaled climate projections derived from the 5th Coupled Model Intercomparison Project (CMIP5), (IPCC 2014). The updated assessment combines recently released national climate model projections with regionally specific information and modelling to produce regionally specific projections across climate, hydrological, coastal and ocean domains. The potential impacts of changing climate over this century are generated and summarised across Southland region, for riverine and coastal areas, and for specific requested locations (depending on the domain considered). Analyses across the domains are provided through summary maps describing the differences between the historical period 1995–2014 and two future periods: mid-century (2031–2050) and late-century (2081–2099).

Climate domain

The national climate projections are based on a six Global Circulation Model (GCM) ensemble included within the 6th Coupled Model Intercomparison Project (CMIP6) (IPCC 2023), which incorporates several significant science and modelling advances. Those GCMs were validated, downscaled for New Zealand, and evaluated over the period 1980–2015 (with the period 1995–2014 being referred as the historical period) compared to global observational reanalysis data, and based on a large number of climate variables and indicators (Gibson et al. 2024a). The updated assessment aims to provide regional information about numerous variables for multiple spatial and temporal criteria within the Southland region to assess impacts of climate change which can be used to support strategic planning and adaptation by councils and the community. The work will also summarise the expected impacts of climate change on specific issues, sectors, or environments.

The potential impacts of a changing climate over this century are generated and summarised across Southland region, for riverine and coastal areas and for specific requested locations (depending on the domain considered). Climate projections associated with three emission scenarios were assessed: SSP2-4.5, SSP3-7.0 and SSP5-8.5. Dynamical downscaling was used to produce the CMIP6 NZ climate projections, which was undertaken using CSIRO's Conformal Cubic Atmospheric Model (CCAM) (Gibson et al. 2024a) to produce hourly climate simulations, for all climate variables of interest, available at 12 km spatial resolution across New Zealand.

For operational reasons, analysis of associated high intensity rainfall information continues to use CMIP5 data. Analysis results, performed predominantly at daily timesteps, are presented as absolute (usually for the historical period) and relative change in the parameters and variables of interest and are available in GIS format. Supporting datasets are also provided. Analysis will be performed predominantly at daily timesteps with the analysis results presented

as monthly, seasonal, annual, or probability summaries. Analysis will be performed for the Southland region and its component Freshwater Management Units, catchments, or town/port (as specified in the RFP).

Changes across the climate domain are provided as netcdf gridded information to Environment Southland for current warming level (historical period as absolute value) and change across SSP2-4.5, SSP3-7.0 and SSP5-8.5 scenarios by mid-century (2031–2050) and late-century (2081–2099).

Hydrological domain

The hydrological projections are generated by coupling the CMIP6 climate projections with the TopNet hydrological model (Clark et al. 2008). The TopNet model has been implemented as part of the New Zealand Modelling (NZWaM) framework and is routinely used for surface water hydrological modelling applications in New Zealand. The coupling methodology (referred as the modelling chain) is adapted from the Deep South National Science Challenge project ‘Climate change impact on national hydrology’ (Collins 2020). It follows recommendations provided as part of the Ministry for the Environment project ‘Pilot CMIP5-CMIP6 hydrological projections intercomparison study’ (Zammit et al. 2024).

Changes across the hydrological domain are provided as csv dataset as well as ArcGIS-Pro layouts to Environment Southland for current warming level (historical period as absolute value) and change across SSP2-4.5, SSP3-7.0 and SSP5-8.5 scenarios by mid-century (2031–2050) and late-century (2081–2099).

Sea-level

Understanding how sea level is changing is critical for managing the risks to Southland’s coastal communities, infrastructure, and ecosystems. This component of the climate change impact assessment focuses on evaluating past and future changes in sea level and how these interact with tides and storm events to influence flood and erosion risk.

The analysis combines measured tide gauge records with the latest national projections from the NZSeaRise programme. These projections consider global climate scenarios alongside local factors such as vertical land movement, which is occurring in parts of Southland and contributes to increased relative sea-level rise. Two long-term sea-level monitoring sites—Bluff and Stead Street—provided the basis for trend analysis and extreme sea-level modelling.

The study assessed not only gradual sea-level rise but also how future higher sea levels will amplify the impact of high tides and storm-tide events. By modelling storm-tide extremes and considering projected sea-level increments, the report helps identify when key risk thresholds might be exceeded and what this means for coastal exposure across the region.

This work supports strategic planning by providing a robust, locally relevant understanding of sea-level rise and its potential impacts under a changing climate.

Ocean domain

ESNZ assessed future projections of New Zealand’s Earth System model to quantify sea surface temperatures, marine heatwaves and ocean acidification (Behrens et al. 2022). This fully coupled Earth System model has a finer spatial resolution around New Zealand compared to other ocean models used as part of the CMIP5/6 archives and therefore captures coastal

circulation and coastal processes better. ESNZ assessed the relevant local variations to apply to the three New Zealand-wide sea-level rise (SLR) scenarios to 2120 that ESNZ (formerly NIWA) developed for the MfE Coastal Hazards and Climate Change Guidance (Ministry for the Environment 2017).

The report associated with the “Climate change impact across the Southland region-IPCC 6th Assessment Report update” report is composed of the following four volumes:

- Volume 1 (this report) introduces the climate change projections (Section 2), the methodology used to estimate climate change impact across the different domains (Section 3), a brief description of Southland’s present climate (Section 4) and presents a summary of the potential impact of climate change across different industry sectors in Southland (Section 5).
- Volume 2 presents the results of the expected changes across the atmospheric domain.
- Volume 3 presents the modelling chain bias correction, the expected changes across the Cryosphere and Hydrology domains.
- Volume 4 presents the results of the expected changes across the Coastal and Ocean domains.

2 Introduction to climate change and natural variability

2.1 Global climate modelling

Assessing possible changes for our future climate due to anthropogenic activity is difficult because climate projections depend strongly on estimates for future greenhouse gas concentrations. Those concentrations depend on global greenhouse gas emissions that are driven by factors such as economic activity, population changes, technological advances and policies for sustainable resource use. In addition, for a specific future trajectory of global greenhouse gas emissions, different climate model simulations produced somewhat different results for future climate change.

Coupled global atmosphere-ocean general circulation models are used to generate climate change projections for prescribed scenarios of future greenhouse gas concentrations. The CMIP6 project (Eyring et al. 2016) comprises model results from approximately 100 climate models across 49 different modelling groups (Hausfather 2019, WCRP 2021). Some of the notable improvements to CMIP6 models, compared with CMIP5 models, include higher atmosphere and ocean resolution, and the inclusion of new and more complex processes such as interactive chemistry, active land processes, ice sheets and permafrost (Simpkins 2017).

2.2 Downscaling of global climate model data

In regions characterised by complex and coastal terrain, such as New Zealand, the raw output from GCMs can contain large biases. This generally means that GCMs should not be used directly in downstream climate impact studies, especially for local and regional applications. Well-known issues include that GCMs struggle to capture orographic precipitation and extremes over New Zealand, the intensity of extreme events such as tropical cyclones, as well as the impact of elevation and coastal processes on temperature variability (Gibson et al. 2024a).

Due to these issues, downscaling² is a valuable tool for better capturing smaller scale processes that impact climate while enhancing the spatial resolution of projections. The Conformal Cubic Atmospheric Model (CCAM) is used as the primary model for dynamical downscaling of selected CMIP6 GCMs over New Zealand. CCAM has been extensively used for downscaling over Australia in CMIP3 (Perkins et al. 2014), CMIP5 (Evans et al. 2021), and CMIP6 (Chapman et al. 2023, Grose et al. 2023) climate projections.

When compared to NIWA's previous CMIP5 downscaling (MfE 2018), the current CMIP6 downscaling has been driven by updated CMIP6 GCMs and scenarios, different regional models run at higher resolution, and a modified bias correction methodology has been applied. Gibson et al. (2023, 2024a) extensively documents the CCAM model, grid configuration, physics settings, and experiment design utilised for the CMIP6 downscaling effort. Considering the improvements outlined above, CMIP6 data are more suitable for use than corresponding CMIP5 data.

² Deriving local climate information from larger-scale model or observation dataset. See glossary for further details.

2.3 Climate change scenarios

Assessing possible changes for our future climate due to human activity is challenging because climate projections strongly depend on estimates for future greenhouse gas concentrations. In turn, those concentrations depend on global greenhouse gas emissions that are driven by factors such as economic activity, population changes, technological advances and policies for mitigation and sustainable resource use. This range of uncertainty has been dealt with by the Intergovernmental Panel on Climate Change (IPCC) through consideration of ‘scenarios’ that describe concentrations of greenhouse gases in the atmosphere. The range of scenarios are associated with possible economic, political, and social developments during the twenty-first century.

In the IPCC Sixth Assessment Report, which is based on CMIP6 models, the scenarios are called Shared Socio-economic Pathways (SSPs). This is a new range of pathways compared to the IPCC Fifth Assessment Report, which used Representative Concentration Pathways (RCPs). In contrast to RCPs — which focus only on changes in atmospheric composition — SSP emission scenarios originate from a wide array of socioeconomic drivers (Bodeker et al. 2022). These include economic, political, and technological developments, as well as population growth.

The updated projections for New Zealand use SSP scenarios. These SSP scenarios start in 2015, and are abbreviated as SSP1-1.9, SSP1-2.6, SSP2-4.5, SSP3-7.0 and SSP5-8.5, in order of increasing greenhouse gas emissions. These SSPs represent narratives characterised as ‘sustainability’ (SSP1), ‘middle of the road’ (SSP2), ‘regional rivalry’ (SSP3) and ‘fossil-fuel intensive development’ (SSP5). SSPs also specify the end-of-21st-century radiative forcing reached e.g., the ‘4.5’ in SSP2-4.5 assumes a radiative forcing of 4.5 W m² in 2100. The following definition of each SSP is adapted from IPCC (2021):

- SSP1-1.9 and SSP1-2.6 are scenarios with very low and low greenhouse gas emissions, with CO₂ emissions declining to net zero around or after 2050, followed by varying levels of net negative CO₂ emissions.
- SSP2-4.5 is an intermediate greenhouse gas emissions scenario, with CO₂ emissions remaining around current levels until the middle of the century.
- SSP3-7.0 and SSP5-8.5 are high and very high greenhouse gas emissions scenarios, with CO₂ emissions that roughly double from current levels by 2100 and 2050, respectively.

Bodeker et al. (2022) note that while some of the RCP and SSP scenarios reach the same radiative forcing by 2100 (e.g., RCP4.5 and SSP2-4.5), the greenhouse gas emissions and concentration pathways taken to reach that radiative forcing are not necessarily the same (Figure 2-1, Figure 2-2). However, the premise of both RCPs and SSPs is the same; they present scenarios that cover the range of possible future development of anthropogenic drivers of climate change (IPCC 2021). Note, neither the IPCC nor scenario developers have placed likelihoods on any scenario.

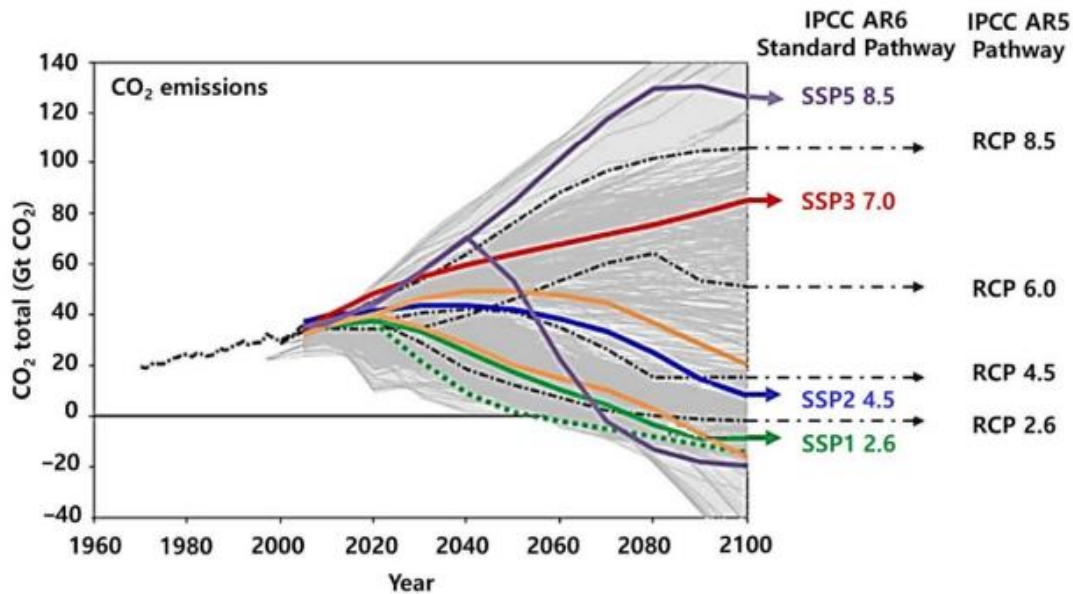


Figure 2-1: Global CO₂ emissions for the 21st century scenarios. Sourced from An et al. (2022).

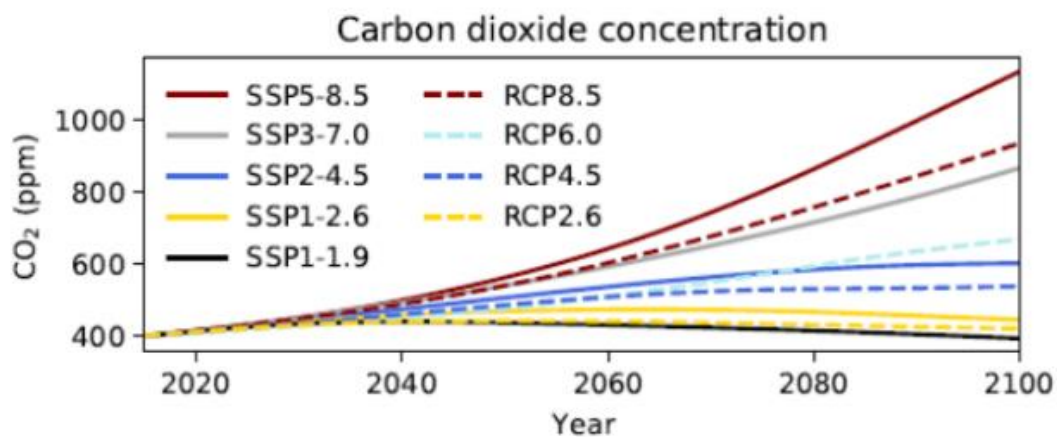


Figure 2-2: Global annual mean CO₂ concentrations for the 21st century scenarios. Sourced from Bodeker et al. (2022).

2.4 New Zealand climate change

Published information about the expected impacts of climate change on New Zealand is summarised and assessed in the Australasia chapter of the IPCC Working Group II Risk Assessment report (Lawrence et al. 2023) as well as a report published by the Ministry for the Environment (Bodeker et al. 2022), and recent publications on NIWA's CMIP6 projections (Broadbent et al. 2025, Gibson et al. 2025). Key findings from these publications include:

- The regional climate is changing. The Australasia region continues to demonstrate long-term trends toward higher surface air and sea surface temperatures, more hot extremes and fewer cold extremes, and changed rainfall patterns.

- The region has exhibited warming to the present and is virtually certain to continue to do so. New Zealand mean annual temperature has increased, on average, by 0.11°C per decade over the period 1909–2024 (Figure 2-3). Annual temperature changes have emerged above natural variability.

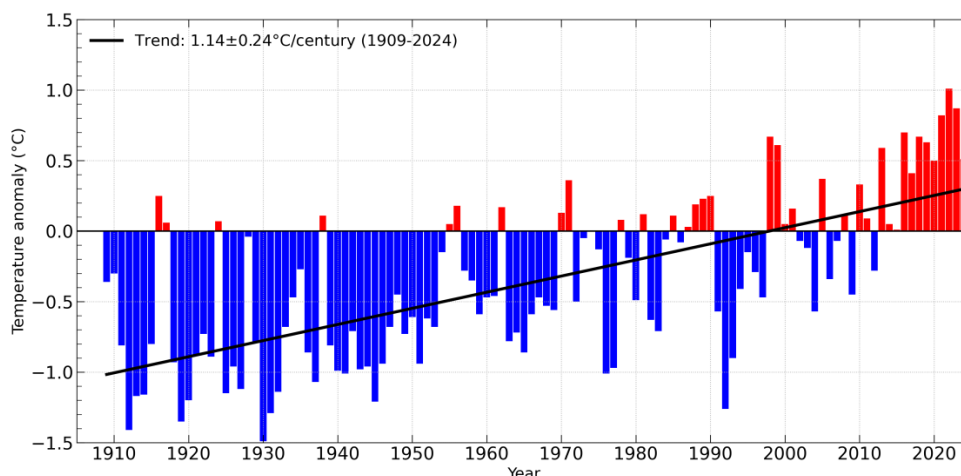


Figure 2-3: Air temperature anomalies (in C) over land, relative to a 1995–2014 baseline. Air temperature anomalies calculated from the New Zealand seven-station.

- Warming is projected to continue through the 21st century along with other changes in climate. Warming is expected to be associated with rising snow lines, decrease in snow depth, more frequent hot extremes, less frequent cold extremes, and increasing heavy rainfall related to flood risk for most areas across New Zealand. In particular:
 - Enhanced warming in the East Australian Current region of the Tasman Sea is projected.
 - An increase in marine heatwaves and ocean acidity is projected.
 - Fire weather is projected to increase in many parts of New Zealand. Regional sea-level rise will very likely exceed the historical rate, consistent with global mean trends.
 - Different spatial pattern of projected changes to annual maximum compared to minimum temperatures.
 - Precipitation is projected to increase in southern New Zealand. Precipitation changes are seasonally and orientation dependant (projected increase in winter and spring rainfall in the west and south, with less rainfall in the east and north, and more summer rainfall in the east of both islands, with less rainfall in the west and central North Island).
 - A general increase in annual maximum precipitation even in some areas of decreased annual precipitation.

- Future effects of the El Niño Southern Oscillation (ENSO) cycle upon New Zealand climate are not expected to change significantly this century. The future of trends in the Southern Annular Mode (SAM) and the location of the mid-latitude jet stream depends on greenhouse gas mitigation action and how quickly the ozone hole recovers.
- Without adaptation, further climate-related changes are projected to have substantial impacts on water resources, coastal ecosystems, infrastructure, health, agriculture, and biodiversity.

Additional information about recent New Zealand climate change can be found in Gibson et al. (2024b).

2.5 Natural factors causing fluctuation in climate patterns over New Zealand

Much of the material in this report focuses on the projected impact on the climate of, and oceans surrounding Southland over the coming century of increases in global anthropogenic greenhouse gas concentrations. However, natural variations will also continue to occur. Much of the variation in New Zealand's climate is random and lasts for only a short period, but longer term, quasi-cyclic variations in climate can be attributed to different factors. Three large-scale oscillations that influence climate in New Zealand are the El Niño-Southern Oscillation, the Interdecadal Pacific Oscillation, and the Southern Annular Mode (Ministry for the Environment, 2008). Those involved in (or planning for) climate-sensitive activities in Southland will need to cope with the sum of both anthropogenic climate change and natural climate variability.

2.5.1 The effect of El Nino and La Nina

El Niño-Southern Oscillation (ENSO) is a natural mode of climate variability that has wide-ranging impacts around the Pacific basin (Murphy and Timbal 2014). ENSO involves a movement of warm ocean water from one side of the equatorial Pacific to the other, changing atmospheric circulation patterns in the tropics and subtropics, with corresponding shifts for rainfall and mean sea level across the Pacific.

During El Niño, easterly trade winds weaken and warm water 'spills' eastward across the equatorial Pacific, accompanied by higher rainfall than normal in the central-east Pacific. La Niña produces opposite effects and is typified by an intensification of easterly trade winds, and retention of warm ocean waters over the western Pacific. ENSO events occur on average 3 to 7 years apart, typically becoming established in April or May and persisting for about a year thereafter (Figure 2-4).

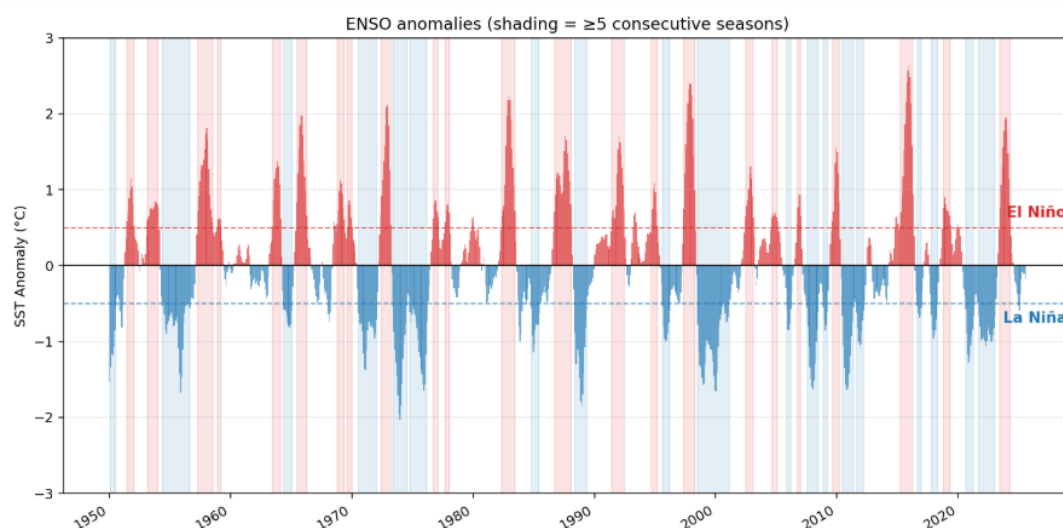


Figure 2-4: Time series of NINO3.4 sea surface temperature anomalies from 1950-2025 with reference period being 1991–2020. Values >0.5 correspond with El Niño, values <-0.5 correspond with La Niña and values between $[-0.5, 0.5]$ are considered as weak SSTs anomalies. Data sourced from <https://www.ncei.noaa.gov/access/monitoring/enso/sst>.

During El Niño events, the weakened trade winds cause New Zealand to experience on average a stronger than normal south-westerly airflow. This generally brings lower seasonal temperatures to the country and drier than normal conditions to the north and east of New Zealand, and wetter than usual conditions for parts of Southland (Hennessy et al. 2007) (Figure 2-4). Mean sea level around New Zealand can be several centimetres (up to 12 cm) lower than “normal” during peak El Niño events (Ministry for the Environment 2017). During La Niña conditions, the strengthened trade winds usually cause New Zealand to experience more north-easterly airflow than normal, higher-than-normal temperatures (especially during summer), and drier conditions for much of the South Island, including Southland (Figure 2-5). Mean sea level is generally higher than normal.

According to IPCC (2023), ENSO is highly likely to remain the dominant mode of natural climate variability in the 21st century (Bodeker et al. 2022), and rainfall variability relating to ENSO is likely to increase. While there is uncertainty in whether there will be meaningful change in ENSO variability over the next 50 to 100 years, there is evidence that the intensity of events may increase.

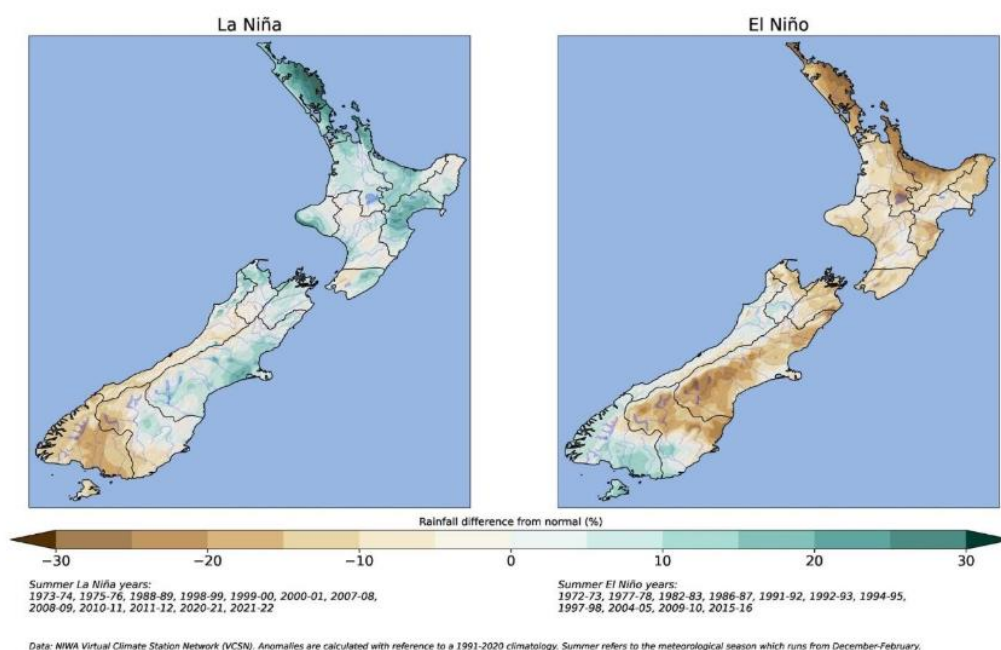
Summer rainfall during La Niña & El Niño

Figure 2-5: Average summer percentage of normal rainfall during El Niño (left) and La Niña (right) in New Zealand. Sourced from ESNZ.

2.5.2 The effects of the Interdecadal Pacific Oscillation

The Interdecadal Pacific Oscillation (IPO) is a large-scale, long-period oscillation that influences climate variability over the Pacific Basin including New Zealand (Salinger et al. 2001). The IPO operates at a multi-decadal scale, with phases lasting around 20 to 30 years. During the positive phase of the IPO, sea surface temperatures around New Zealand tend to be lower, and westerly winds stronger, resulting in wetter conditions for Southland (Figure 2-6). Mean sea level around New Zealand tends to be lower than "normal" or trends in sea-level rise reduced. The opposite occurs in the negative IPO phase (e.g. the Pacific has been in this phase since ~ 1989³). The IPO can modify New Zealand's connection to ENSO, and it also positively reinforces (dampens) the impacts of El Niño during IPO positive and negative phases, and of La Niña during the opposite IPO phases.

³ IPO time series sourced from psl.noaa.gov/data/timeseries/IPOTPI/tpi.timeseries.ersstv5.data

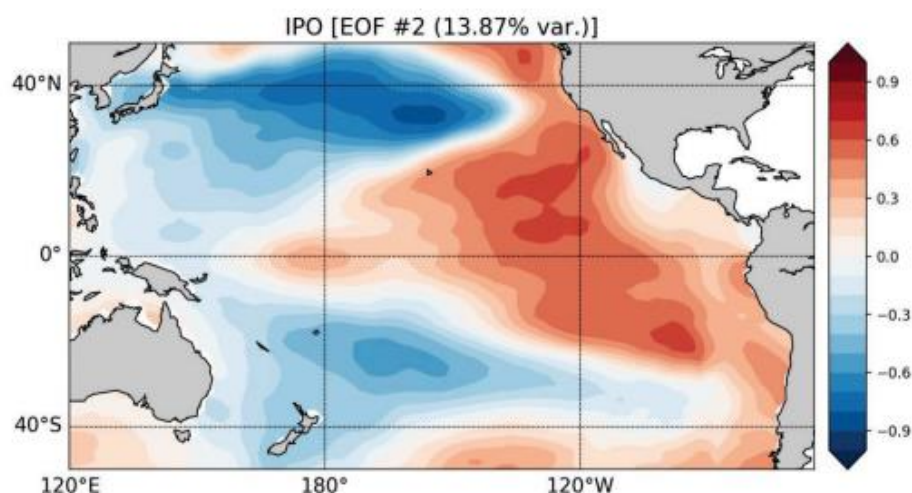


Figure 2-6: SST anomaly spatial pattern (Empirical Orthogonal Function, or EOF) associated with the positive phase of the Interdecadal Pacific Oscillation. The pattern shown, with positive SST anomalies in the eastern tropical Pacific, is IPO+. The IPO- phase has anomalies of opposite sign everywhere. Data source: ERSST version 5 dataset.

2.5.3 The effects of the Southern Annular mode

The Southern Annular Mode (SAM) represents the variability of circumpolar atmospheric jets that encircle the Southern Hemisphere and extend out to the latitudes of New Zealand. It is the leading mode of variability in the Southern hemisphere atmospheric circulation on month-to-month and interannual time scales. The SAM is often modulated by ENSO, and both phenomena affect New Zealand's climate in terms of westerly wind strength and storm occurrence (Renwick and Thompson 2006). In its positive phase, the SAM is associated with relatively light winds and more settled weather over New Zealand, with stronger westerly winds further south towards Antarctica. In contrast, the negative phase of the SAM is associated with unsettled weather and stronger westerly winds over New Zealand, whereas wind and storms decrease towards Antarctica. (Figure 2-6, Figure 2-7). Kidston et al. (2009) describe the impacts of the SAM on the climate of southern New Zealand (including Southland):

- When the SAM is positive:
 - More easterly winds than normal during summer.
 - More northwesterly winds than normal during winter.
 - Reduced summer rainfall throughout Southland.
 - Increased winter rainfall for Fiordland, reduced winter rainfall for eastern and southern parts of Southland.
 - Higher than average monthly mean maximum temperatures in summer and winter.
- When the SAM is negative:
 - More southwesterly winds than normal.

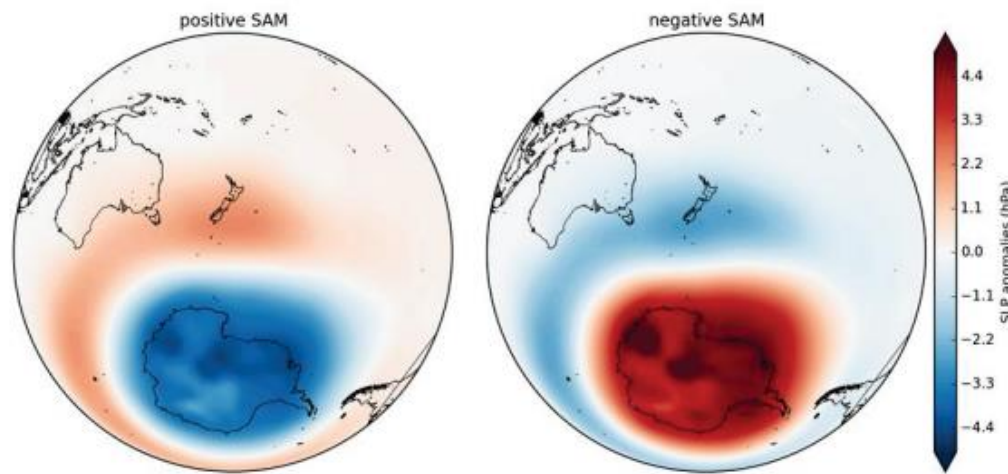


Figure 2-7: Pattern of the pressure variations associated with the positive (left) and negative (right) phases of the SAM. Blue shading indicates below-average pressures and red shading indicates above average pressures. Monthly composites were made using the PC associated with the first EOF of Southern Hemisphere monthly geopotential anomalies at 850 hPa from the NCEP / NCAR reanalysis (Section 2.3.3) using a threshold of ± 1 std. Data source: <http://www.esrl.noaa.gov/psd/data/gridded/data.ncep.reanalysis.html>.

2.5.4 Interactions between natural climate cycles and climate changes

El Niño-Southern Oscillation

ENSO is highly likely to remain the dominant mode of natural climate variability in the 21st century, and that rainfall variability relating to ENSO is likely to increase (IPCC 2013a, Huang and Xie 2015). However, there is uncertainty about future changes to the amplitude and spatial pattern of ENSO. According to Cai et al. (2014), there may be an increase in ‘extreme’ El Niño events (like the 1982/83, 1997/98 and 2016/17 El Niño events) with increasing concentrations of greenhouse gases in the atmosphere, due to faster warming over the eastern equatorial Pacific Ocean. Bodeker et al. (2022) note there is no systematic signal in changes in Southern Hemisphere teleconnections associated with ENSO. Therefore, those authors suggest that the typical average effects of ENSO upon New Zealand seen in recent decades will continue into the future.

Interdecadal Pacific Oscillation

The IPO influences global mean temperatures through its influence on Pacific sea surface temperatures (Meehl et al. 2013). When the IPO is in its negative phase, Pacific SSTs are cooler than usual, which has led to observed hiatuses in global warming (for example, the shift from the positive to negative IPO in the early 2000s). In contrast, a positive IPO exhibits above normal SSTs in the Pacific, leading to an acceleration in global mean temperatures (e.g., the shift from the negative to positive IPO in the 1970s). The future behaviour of the IPO is uncertain but Meehl et al. (2013) suggests that hiatus periods (associated with negative IPO periods) may become slightly longer.

Southern Annular Mode

Two drivers are expected to have competing influences on the future trends in the SAM:

1. The ongoing reduction of ozone-depleting substances and associated recovery of the ozone hole is expected to drive more occurrences of the negative SAM, particularly in summer (Bodeker et al. 2022).
2. Increasing concentrations of greenhouse gases will encourage more occurrences of the positive SAM throughout the year (Bodeker et al. 2022).

By 2100, the net result for future trend in the SAM is therefore likely to be relatively little change from present (Banerjee et al. 2020, Simpson et al. 2025). However, uncertainty in how future greenhouse gas emissions will trade off against the recovery of the ozone hole leads to uncertainty in how the SAM will influence New Zealand's future climate. According to Bodeker et al. (2022), if higher emissions scenarios eventuate we would expect a SAM influence on New Zealand of more frequent warmer and drier conditions in many regions (but wetter conditions in the eastern North Island, and the northeast South Island in summer). Conversely, if low emissions scenarios eventuate then the expected SAM effect on New Zealand in summertime is for more frequent unsettled periods with more precipitation in many regions (but drier in the eastern North Island and northeast South Island), and cooler conditions.

Much of the material presented hereafter focuses on the projected impact on the climate and oceans of, and surrounding, the Southland region over the coming century of increases in global anthropogenic greenhouse gas concentrations. But natural variations, associated with El Niño, La Niña, the Interdecadal Pacific Oscillation, the Southern Annular Mode, and "climate noise", will also continue to occur.

An example of this for temperature (from an overall New Zealand perspective) is shown in Figure 2-8. This figure shows annual temperature anomalies relative to the 1986–2005 base period used throughout this report. The solid black line on the left-hand side represents NIWA's 7-station temperature anomalies (i.e., the average over Auckland, Masterton, Wellington, Nelson, Hokitika, Lincoln, and Dunedin), and the dashed black line represents the 1909–2014 trend of 0.92 °C/century extrapolated to 2100. All the other line plots and shading refer to the air temperature averaged over the region 33–48 °S, 160–190 °W, and thus encompasses air temperature over the surrounding seas as well as land air temperatures over New Zealand.

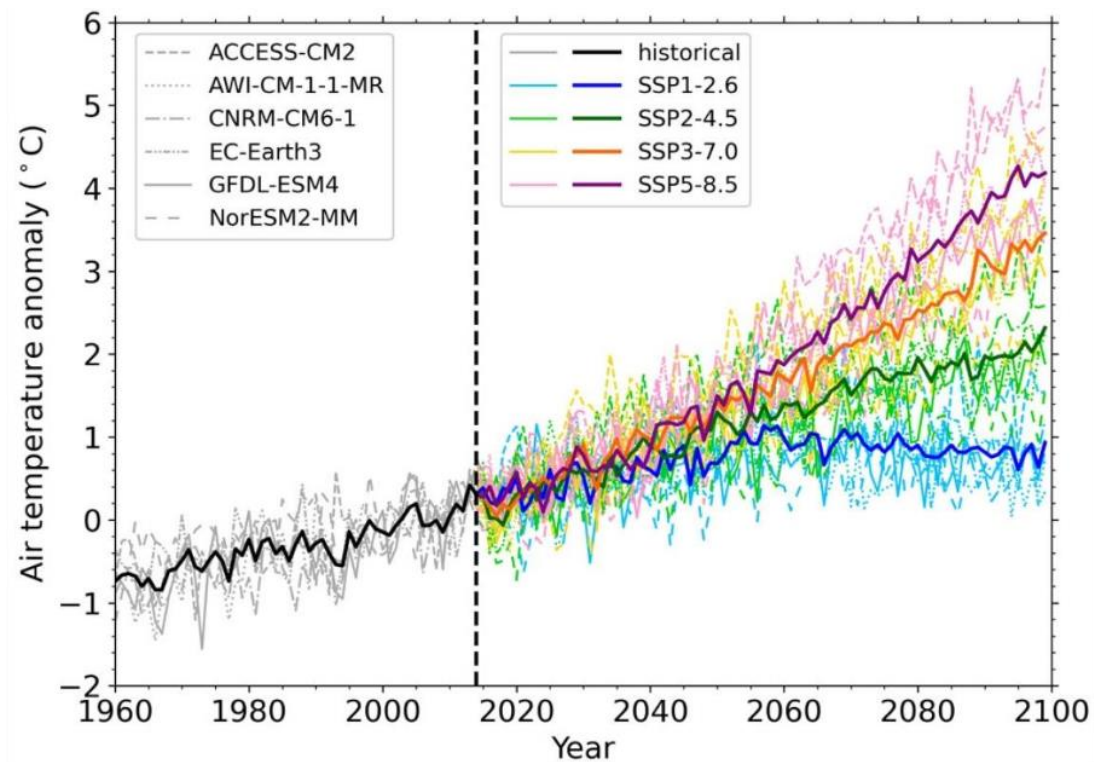


Figure 2-8: Evolution of national (land-based) annual air temperature anomalies projected by the downscaled models out to year 2100 under various SSPs. Anomalies are computed relative to the 1995–2014 base period. Source (NIWA): Updated national climate projections for New Zealand | Earth Sciences New Zealand | NIWA.

As discussed in Section 2.5, the IPO and the El Niño/La Niña cycle influence New Zealand sea level. So, the sea levels we experience over the coming century will also result from the sum of anthropogenic trend and natural variability.

In essence, natural variability will add to the human-induced trends at times, while at others it may offset part of the anthropogenic effect. Those involved in (or planning for) climate-sensitive activities in the Southland region will need to cope with the sum of both anthropogenic change and natural variability.

3 Methodology

3.1 Climate change impact assessment

3.1.1 Measuring climate change effect

To measure the effect of climate change on the chosen metrics, downscaled CMIP6 climate projections from the baseline period [1990s (1995–2014)] are compared to the mid-century [2050s (2041–2060)] and end of century [2090s (2081–2099)] using the IPCC recommended estimation method (IPCC 2023). The magnitude of the effect is determined by the difference between the metrics or thresholds calculated over the baseline and future periods as follows:

- For climate, ocean, coastal climate change impact assessment, analysis is reported using year defined as the period between 1 January and 31 December of each calendar year.
- Change in magnitude associated with extreme value analysis is reported using year defined as the period between 1 January and 31 December of each calendar year.
- Change in hydrological variable magnitude, is reported using hydrological year definition (period between 1 June and 31 May) with the numbered year indicating the calendar year of the hydrological year. As a result, the change in hydrological variable magnitude by the end of century covers the period 2081–2098, instead of 2081–2099.
- Change in cryospheric variable magnitude, is reported using snow year definition (period between 1 April and 31 March) with the number year indicating the calendar year of the snow year. As a result, the change in cryospheric variable magnitude by the end of century covers the period 2081–2098, instead of 2081–2099.
- Change in stream water temperature, is reported using water year definition (period between 1 October and 30 September) with the number year indicating the calendar year of the water year. For modelling purpose, seasons were defined as half years with Summer being the period October to March of the water year, and Winter being the period April to September of the water year.

3.1.2 Climate change impact assessment

A brief description of each variable to be reported is provided hereafter, as well as current limitations associated with the analysis. With the exception of SLR, all “changes” refer to differences between the historical period 1995–2014 and two future periods (2041–2060 and 2081–2099), noting the exceptions to the end year of the 2090s period listed above. Table 3-1 presents a description of the analysis carried out and reported across regional (Southland), Freshwater Management Unit (FMU) and catchment scales.

The change in these variables between the baseline and projection periods is represented in either percentage or absolute terms depending on the variable in question. The results for the six GCMs are combined into either a multi-model average (for climate variables) or a multi-model median (for hydrological variables), and the results of climate change scenarios are kept

separate. This approach provides annual and seasonal maps for each statistic, representing average/median changes in that statistic between baseline and mid-century and baseline and late century. Changes in hydrological statistics are reported for the lower end of river reaches (for riverine characteristics) or as watershed average characteristic (for watershed scale hydrological and cryospheric characteristics) while changes in climate statistics are reported on at the scale (12 km) of the atmospheric model across the Southland region.

Table 3-1: Variable and methods used to report climate change impact across Southland, Freshwater Management Unit and catchment scales.

Variable	Description
Precipitation	Average precipitation: change in the annual-average and seasonal-average precipitation for each time slice. Maximum annual daily: change in the annual-average maximum daily precipitation for each time slice. Maximum annual 5 days: change in the annual-average maximum 5 days precipitation for each time slice. Days with rain above threshold: change in the annual average number of day above threshold for each time slice. Intensity: change of intensity is provided as per specific weather event analysis. Dry day projection is characterised by the change in annual average number of days where total daily precipitation is less than 1 mm/day. Wet day projection is characterised by the change in annual average number of days where total daily precipitation is equal to or larger than 1 mm/day. Heavy rain day projection is characterised by the change in annual average number of days where total precipitation is equal to or larger than 50 mm/day.
Temperature	Average temperature: change in the annual-average and seasonal-average daily temperature for each time slice. Average minimum temperature: change in the annual-average and seasonal-average mean minimum for each time slice. Number of hot days: Change in the annual number of days where temperature is 25°C or above. Number of cold days: Change in the annual number of days where minimum temperature is 0°C or below. Heatwave days: For this analysis a heatwave is defined as at least three consecutive days when the temperature is 25°C or above. The estimation of the distribution of heatwave (annual distribution) is carried out over the year July to June in order not to break up any heatwaves that cross the December-January period. Growing degree-days: change in the mean annual accumulative number of degrees Celsius exceeding a threshold over the period 1 July to 30 June, with a temperature threshold representing a threshold temperature for plant growth taken as 10°C.

Variable	Description
Other climate variables	Relative Humidity: change in the annual-average, seasonal-average and monthly average relative humidity for each time slice. Solar Radiation: change in the annual-average and monthly average shortwave and longwave solar radiation for each time slice. Cloud cover: change in the annual-average and monthly average cloud cover for each time slice. Wind speed and wind direction: change in the seasonal-average wind speed and wind direction for each time slice. Calm and windy days: change in the annual-average and monthly average number of calm and windy days for each time slice. Strong wind: change in the annual-average, and monthly average ninety-ninth percentile of wind speed for each time slice. Potential Evapotranspiration Deficit (PED): change in the amount of water (in mm) needed to be added as irrigation, or replenished by rainfall, to keep pastures growing at levels that are not constrained by a shortage of water. Change in PED are reported at annual time scale for each time slice. Probability of PED over 200 mm: change in the probability of PED exceeding 200mm per year (as annual average) across each time slice.
Ocean	Annual mean sea level: change in average annual sea level around Southland based on national scale assessment (Coastal Hazards and Climate Change Guidance, MfE 2017) and NZ Sea Rise MBIE endeavour programme (NZ SeaRise Programme). Sea temperature: change in average annual change in sea temperature around Southland based on New Zealand Earth system model and findings from Deep south National Science Challenge project Marine heatwaves and the link with climate extremes (Deep South Challenge). Probabilistic assessment being carried out using sea temperature threshold. Change in acidification.
Projected sea-level rise	Sea Level Rise: projected change in average annual sea level around Southland based on national scale assessment (Coastal Hazards and Climate Change Guidance, MfE 2017) and NZ Sea Rise MBIE Endeavour programme as sea-level. Change at decade scales is quite similar across New Zealand, so no large variations are expected. Years when specific increments are reached. Building and replacement costs with SLR and 1% AEP storm. Local variation of sea-level rise: Due to existing data limitation, those changes are limited to an appraisal of vertical land movement (based on available continuous GPS data and publications) and an updated check on the sea-level trend from the Bluff tide-gauge record.

Variable	Description
Hydrology	High flows metrics: change for each time slice in the Mean Annual Flood (representing the change in the mean largest peak flow for each year), Q5 and Q25, which represents river flow exceeded five and twenty-five percent of the time (resp.). Mean Annual Flood typically represents flows that are exceeded less than one percent of the time and have a return period between two and three years. Flushing flows: Annual and seasonal change, per season and time slice, of the average number of events per year exceeding three times the median flow with a gap of 3 days or 5 days between events. Average flows metrics: change for each time slice in the average seasonal river flow metric for each time slice, calculated as annual or seasonal average and annual median as river flows tends to not be normally distributed (as opposed as climate variables). Low flows: change in low flow for each time slice. Low flow metrics are represented by Q75 and Q95, which represents river flow exceeded seventy-five and ninety-five percent of the time, and the 7-day mean annual low flow metrics, calculated as average yearly 7-day rolling minimum discharge over the summer season defined as the period between 1st September and 30th April of each hydrological year. Flow reliability/Water supply reliability: change for each time slice of the average fraction of time during each irrigation season (spanning from 1 September to 30 April) that the river flow is too low and thus irrigation is restricted. To define the river conditions at which abstraction for irrigation becomes restricted, a local minimum flow condition is set based on the proposed National Environmental Standard (NES) for Environmental Flows and Water Levels (Ministry for the Environment 2008) or environmental flow thresholds established by Environment Southland. Water supply reliability varies between 0 and 100 percent and is often between 0.9 and 1.0 for New Zealand rivers. Recharge rates: change for each time slice in annual, seasonal and monthly average net land surface recharge calculated over Southland non-confined aquifers as defined using the Hydrogeological Stack Unit layer (White et al. 2019).
Oceanographic	Projected sea surface temperatures, ocean acidification and marine heat waves including anomalies to historic values will be assessed around Southland. Marine heatwaves are characterised by marine heatwave intensity and annual marine heatwave days.
Water temperature	Water temperature: change in the seasonal and monthly water temperature using linear correlation between air temperature and water temperature where available for each time slice.
Cryospheric	Cryospheric metrics: change for each time slice in annual and seasonal average snow volume, taken as snow water equivalent, snowfall and snow melt calculated using the cryospheric process model embedded within the TopNet model (Clark et al. 2008). Snow line: change for each time slice of the annual and seasonal average elevation of the interface between snow free and snow-covered area. Number of snow days: change for each time slice of the annual and seasonal average number of snow days, characterised as number of days of precipitation concurrent with temperature below the temperature accumulation threshold of 2°C as represented within the degree day model used in TopNet (Clark et al. 2008). Changes reported for 14 catchments.

Variable	Description
Weather events	Drought changes in frequency: change in drought frequency are reported as drought change in frequency above 200 mm threshold of PED. However, large uncertainties exist in the derivation of the downscaled driven climate variables (solar radiation, relative humidity, wind) so results are likely to have a large uncertainty. Change in precipitation events in tabular format for the following locations: Gore, Mataura and Riversdale townships (Mataura catchment); Winton and Lumsden (Oreti catchment); Waihopai Dam (Waihopai River); and New River Estuary.
Spatial extent	Analysis of change for variable of interest will be reported graphically on each Freshwater Management Units (FMU) from ES (i.e., Mataura, Waituna, Aparima, Oreti, Waiau and Fiordland).

3.2 Atmospheric modelling

The CMIP6 model archive was developed to support the IPCC's 6th assessment report (IPCC 2023). Gibson et al. (2024a) evaluated the CMIP6 GCMs for performance over the New Zealand region using model outputs for the period 1980–2015 (referred to as the hindcast period) compared to global observational reanalysis data and based on a large number of climate variables and indicators. Six of the CMIP6 GCMs were selected as best at representing climatic dynamics around New Zealand. These six GCMs span a range of climate model sensitivities and are relatively independent from one another. The six CMIP6 models selected are:

- ACCESS-CM2 (Bi et al. 2020);
- AWI-CM-1.1-MR (Semmler et al. 2020);
- CNRM-CM6-1 (Voldoire et al. 2019);
- EC-Earth3 (Döscher et al. 2022);
- GFDL-ESM4 (Dunne et al. 2020); and
- NorESM2-MM (Seland et al. 2020).

These six CMIP6 GCMs were used to generate climate change projections for the recent historic period plus four emission scenarios: SSP1-2.6 (not used for this report), SSP2-4.5, SSP3-7.0 and SSP5-8.5. Dynamical downscaling to produce the CMIP6 New Zealand climate projections was undertaken using CSIRO's Conformal Cubic Atmospheric Model (CCAM) (Gibson et al. 2024a) to produce hourly climate simulations, for all climate variables of interest, available at 12 km spatial resolution across New Zealand.

While a bias corrected high resolution (5 km spatial resolution) dataset was generated for a limited set of climate variables (precipitation, minimum and maximum temperature and potential evapotranspiration; Campbell et al. 2024), we are proposing to use the lower 12 km resolution products which were created as part of the project (Gibson et al 2024b). This choice of the low spatial resolution dataset is driven by the following:

- Only a limited number of climate variables are available at high resolution which will generate additional uncertainties within the hydrological projections (due to the analytical estimation of climate variables that is required for the hydrological

model). For consistency across the requested climate variables, it is recommended to use the low-resolution climate dataset;

- The bias correction of the high-resolution climate dataset was completed using the Virtual Climate Station Network (Tait et al. 2006, Campbell et al. 2024) for daily precipitation and daily maximum/minimum temperature. The use of the CMIP6 bias corrected dataset may require additional bias correction across Southland for each climate variable of interest such as relative humidity, incoming short-wave radiation, atmospheric pressure and wind);
- The bias correction of the high-resolution climate dataset was carried out for each variable independently of other climate variables. Gibson et al. (2024b) recommend using the low-resolution climate projections (12 km) for hydrological assessment;
- The high-resolution bias corrected dataset is available only at daily time step, which will limit its use for assessment of hydro-climate extremes, especially for representation of high flow simulations in the majority of catchments in New Zealand (over 75 percent), which are characterised by a time of concentration of less than 24 hours (Griffiths and McKerchar 2012).

The impact of climate change on climate variables will be based on yearly characterisation over the period 1 January–31 December.

In addition to the provision of spatial change in climate variable, Table 3-2 presents a description of the climate analysis completed at required locations (Table 3-3).

Table 3-2: Variable and methods used to report climate change impact at specific locations.

Variable	Description
Precipitation	Change in number of days with rain above or below threshold: change characterised across time slice in the change in annual average number of days where total precipitation is equal or larger than, or equal or smaller than a defined rainfall threshold.
Temperature	Heatwave: Change in 'heatwave days'. For this analysis a heatwave is defined as at least three consecutive days when the temperature is 25°C or above. The estimation of the distribution of heatwave will be carried out over the year July to June in order not to break up any heatwaves that cross the December-January period. Frost days: change in annual number of days where average daily temperature is 0°C or below. Overnight minimum: represented by change in minimum daily temperature.
Wind	Calm days: change in the annual-average and monthly average number of calm days for each time slice reported at location of interest.

Variable	Description
Weather events	Drought change in frequency: change in drought frequency will be reported as drought change in frequency above specific threshold of PED (to be agreed with ES at the start of the project). However, large uncertainties exist in the derivation of the downscaled driven climate variables (solar radiation, relative humidity, wind) so results are likely to have a large uncertainty. Change in precipitation events in tabular format for the following locations: Gore, Mataura and Riversdale townships (Mataura catchment); Winton and Lumsden (Oreti catchment); Waihopai Dam (Waihopai River); and New River Estuary.

Table 3-3: Location where climate information is required.

Town location	Town location	Town location	Town location
Invercargill	Winton	Tuatapere	Milford Sound
Riverton	Lumsden	Oban	Garston
Mataura	Te Anau	Riversdale	Mossburn
Gore	Otautau	Waikaka	Bluff

3.2.1 Design rainfall

To determine design rainfall totals, we are using the High Intensity Rainfall Design System tool (HIRDS) version 4 developed by NIWA (Carey-Smith et al. 2018). HIRDS provides a map-based interface to enable rainfall estimates to be provided at any location in New Zealand under current and future climate conditions.

As HIRDS has not yet been updated using the New Zealand CMIP6 climate projections, HIRDS projections of rainfall depth are based on the New Zealand CMIP5 climate projections (Ministry for the Environment 2018):

- Change in rainfall depth under future scenario is provided, for each event duration and return period, by HIRDS' CMIP5 derived change in rainfall depth per degree change (Carey-Smith et al. 2018).
- Mid-century and end of century change in temperature is calculated based on the 20-year average change in temperature for each SSP scenario for mid and end-century time period.

Change in rainfall designed precipitation will be provided for the 16 township locations (see Table 3-4).

Table 3-4: Location where design rainfall information is required.

Town location	Town location	Town location
Invercargill	Te Anau	Milford Sound
Riverton	Otautau	Garston
Mataura	Tuatapere	Mossburn
Gore	Oban	Bluff
Winton	Riversdale	
Lumsden	Waikaka	

3.2.2 Possible Maximum Precipitation

Possible Maximum Precipitation (PMP) is generated using a tool recently developed and funded by the New Zealand Dam Safety Hydrology Group (DSHG) chaired by David Payne (Mercury). The Dam Safety Hydrology Group (DSHG), formed from 6 major dam owners in New Zealand (Meridian Energy, Mercury Energy, Contact Energy, Genesis Energy, Manawa Energy and Watercare Services. The tool (Bodeker et al. 2023) provides the ability to calculate PMP estimations calculated over upstream surface water draining catchment, using an automated implementation of the New Zealand's PMP methodology developed by Tomlinson and Thompson (Tomlinson and Thompson 1992, commonly referred as the 'Blue-Book') using two approaches:

- PMP estimations using the original Tomlinson and Thompson (1992) storm catalogue and ancillary data sets;
- PMP estimations using updated storm catalogue, including events over the period 1988–2023, along with updated data sets (such as 100-year dewpoint temperature and rainfall).

The authors indicate that PMP estimations using the updated storm catalogue can be different from those generated using the 'Blue-Book' data (Figure 3-1). In some regions (e.g., Northland, Gisborne, Bay of Plenty, Central North Island, Canterbury) this newer estimate is higher than would be derived using only the Blue Book, and in other regions (e.g., south-west of the North Island and the Southern Alps), lower.

As part of the project, PMP is estimated for upstream catchments associated with 18 locations presented in Table 3-5 for 12-24-48-72 hrs storm durations. To ensure that Probable Maximum Flood (PMF) can be provided for those locations (see Section 3.3.5), those locations are mapped to the closest DN3 Strahler 3 river reach.

Table 3-5: Location where PMP estimation is required. The location represents the outlet of the surface water catchment draining at that location.

PMP location	PMP location	PMP location
Fairlight at Cainard Station	Mokoreta at Mt Alexander	Pourakino Valley at Cascade Road
Five Rivers at Five Rivers Station	Ohai at Wether Hill Station	Garston at Nevis Road
Glenlapa at Round Hill	Waiau River at Clifden	Whitestone Aquifer at Lynwood
Hamilton Burn at Mt Hamilton Road	Waikaia River at Piano Flat	Oban
Hokonui Hills at Lora Station	Wendon Valley at Waikaka	Bluff
McKellars Flat at Gorge Burn	Woodlands at Garvie Road	Invercargill (Waihopai dam)

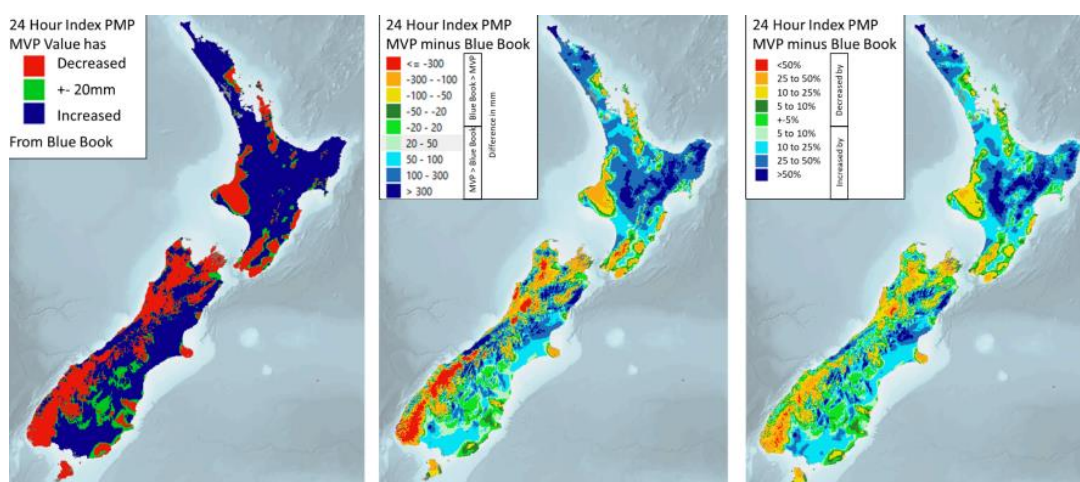


Figure 3-1: Differences in 24-hour indexed PMP. Left panel shows where PMP estimates are within 20 mm (green), where PMP estimates decrease in the MVP (red), and where PMP estimates increase in the MVP (blue). Centre panel shows the absolute change in mm while right panel shows the percentage change. Sourced from Bodeker et al. (2023).

Climate change projections of PMP (magnitude) for different durations are generated using the methodology devised by the DSHG group. Change in rainfall depth is calculated at each location for each emission scenario based on the average change in air temperature in increments of 1 degree ranging from 1°C (current climate warming condition) to 4°C (corresponding to a warming of 3°C by 2100).

3.3 Hydrological modelling

3.3.1 Hydrological model description

The hydrological modelling methods used in this study are adapted from the Deep South National Science Challenge project ‘Climate change impact on national hydrology’ (DSC 2019, Collins 2020), hereafter referred to as the DSC project. In addition, the modelling methodology follows recommendations provided as part of the Ministry for the Environment project ‘Pilot CMIP5-CMIP6 hydrological projections intercomparison study’ (Zammit et al. 2024).

In the DSC project the CMIP5 New Zealand climate projections were coupled with TopNet (Clark et al. 2008), NIWA’s uncalibrated, nationally parameterised surface water hydrological model. The TopNet model is implemented as part of the New Zealand Modelling (NZWaM) framework (Zammit et al. 2025) and is routinely used for surface water hydrological modelling applications in New Zealand.

As part of the DSC project, the version of TopNet used did not consider water transfers between catchments or other water storages and did not model aquifer water balances, nor did it simulate the impacts of water use activities on hydrological regimes. The Topnet model has been thoroughly validated at the national scale against hydrological records (McMillan et al. 2016) and is similar to the hydrological model used by NIWA for short-term flood forecasting risk across New Zealand (McMillan et al. 2013, Cattoën et al. 2022). It has been generally found to perform better for large, wet catchments, while significantly underestimating high flow responses. The model has been shown to perform well in both low and high flow situations if calibrated, but transferring calibration parameters to ungauged catchments has proven challenging (Singh et al. 2017). As such the uncalibrated model has been considered as useful in undertaking previous national scale climate change impact assessment (Collins 2020).

As part of the project, we implement an updated version of the TopNet model. The updated version of TopNet is suitable for surface water-dominated catchments but does not address the impact of regional groundwater movement on hydrological regimes, or conceptualise water use activities under current and future climate projections (which is outside of the scope of the project). Nevertheless, this version of TopNet is different from the version implemented as part of Collins (2020) and ES’s ‘CMIP5 Climate change assessment’ project (Zammit et al. 2018). A brief description of the differences in TopNet conceptualisation is provided below:

- The current conceptualisation of hydrological processes was improved following enhancements by Griffiths et al. (2021):
 - improved conceptualisation of evapotranspiration processes after Feddes et al. (1978); and
 - improved representation of cryospheric processes achieved by updating TopNet’s simple temperature index model parameterisation to represent Mediterranean climate (Conway et al. 2023).
- Parametrisation of watershed scale infiltration excess runoff processes to improve high flow response, implemented as part of the [Mā te haumarū ō te wai](#) project.

Spatial information and datasets used to develop TopNet as part of the DSC project included:

- Catchment topography based on a nationally available 8 m Digital Elevation Model (DEM);
- Physiographical data based on the Land Cover Database - version 5 (LCDB5) and Land Resource Inventory (Newsome et al. 2000);
- Soil data based on the Fundamental Soil Layer information (FSL) (Newsome et al. 2000); and
- Hydrological properties based on the River Environment Classification version 2.3 (REC2.3), with land cover characteristics derived from the LCDB5 (Snelder and Biggs 2002) and mapped onto digital river network version 3.1 (DN3v1 - high resolution digital river network generated in collaboration with ES as part of the NZWaM project).

Because of TopNet assumptions, soil and land use characteristics within each computational sub-catchment are homogenised. Essentially this means that the soil characteristics and physical properties of different land uses, such as pasture and forest, will be spatially averaged, and the hydrological model outputs will be an approximation of conditions across agricultural land use over the period 1980–2099. Despite the ability of the uncalibrated TopNet model (i.e., a priori parametrised TopNet model across Southland) to reproduce observed hydrological characteristics across New Zealand as a whole (see Booker and Woods 2014, McMillan et al. 2016, Cattoën et al. 2022), model bias correction or calibration is recommended to match catchment-specific hydrological behaviour (Zammit 2019).

3.3.2 Hydrological model parametrisation

TopNet model parameterisation uses the concept of parameter multipliers, because one of the main assumptions of the model implementation is that the spatial distribution of the parameters is determined *a priori* from catchment physiographic information (see Clark et al. 2008).

TopNet requires the determination of seven hydrological parameter multipliers and ten snow-related parameters for each sub-catchment (see Table 3-6). The initial values of the parameter multipliers are set to a value of 1, while snow-related parameters are initialised based on previous study results for the area. The values of the parameter multipliers are adjusted through calibration or bias correction as described below.

Table 3-6: Range of TopNet parameter multipliers used during calibration process. Default values of the TopNet parameters are spatially distributed and provided by national datasets (see Clark et al. 2008 for further information).

Parameter name (internal name)	Parameter description	Calibrated range
Hydrological parameters		
Saturated store sensitivity (topmodf)	Describes exponential decrease of soil hydraulic conductivity with depth	[0.01–2] * default
Drainable soil water (swater1)	Range between saturation and field capacity	[0.05–10] * default
Plant available soil water (swater2)	Range between field capacity and wilting point	[0.05–10] * default

Parameter name (internal name)	Parameter description	Calibrated range
Hydraulic Conductivity at saturation (hydcond0)	Catchment average hydraulic conductivity at saturation at the surface	[0.1–10000]*default
Ch_exp	Clapp-Hornberger c exponent	[0.05–10] * default
Ga-psif	Green-Ampt wetting front suction	[0.05–10] * default
canscap	canopy storage capacity	[0.05–10] * default
canenh	canopy evaporation enhancement factor	[0.05–10] * default
Overland flow velocity (overvel)	Catchment average surface rugosity	[0.1–10]*default
Manning n	Characterises the roughness of each reach	[0.1–10] *default
Atmospheric lapse rate (atmlaps)	Change in temperature with elevation, used to adjust temperatures from climate data sites to basin centroid	[0.7–1.5] * default
Gauge Undercatch (gucatch)	Adjustment for non-representative precipitation	[0.5–1.5] * default
Top-soil Hydraulic Conductivity associated with infiltration excess runoff	catchment-scale infiltration excess runoff factor	[0.1–10] * default
Snow parameters		
threshold for snow accumulation (th_accm)	Temperature threshold for snow accumulation	270.15–275.15 [K]
Threshold for snow melt (th_melt)	Temperature threshold for snow melt	269.15–274.15 [K]
snowddf	Degree-day factor for snow melt	1–10 [mm K ⁻¹ day ⁻¹]
Minddf	Calendar day of the minimum degree-day-factor day	1–366 [days]
Maxddf	Calendar day of the maximum degree-day-factor day	1–366 [days]
snowamp	Seasonal amplitude of degree-day factor for snow melt	0–5 mm K ⁻¹ day ⁻¹]
snowros	Addition in melt factor caused by rain-on-snow events	0–5 mm K ⁻¹ day ⁻¹]
dec melt	Decrease in melt due to higher albedo after fresh snow	0–5 mm K ⁻¹ day ⁻¹]
albdecy	Time decay of snow albedo	1–5 days
cv_snow	Sub-grid variability representing the distribution of the snowpack across the catchment	0–2 [-]

3.3.3 Hydrological variables

As part of the project, impact of climate change is carried out for the following hydrological metrics:

- Mean annual flood (MAF) – The mean of the largest peak flows for each year. For New Zealand rivers, this flow is typically exceeded less than one per cent of the time and has a return period of between two and three years.
- Q5 – The river flow exceeded five per cent of the time. This is typically a high flow metric lower than MAF.
- Average number of Fre3 days – Average number of events per year for which river discharge exceeds three times the median river discharge (Biggs 2000) considering a 3 day and 5 day filter period (Booker 2013).
- Mean river flow – River flow averaged over the period of analysis.
- Mean and median annual flows- Mean and median annual river discharge.
- Seasonal average flows – mean river discharge calculated across hydrological year (i.e., after August 1, until July 31 the following year) during Winter (June-July-August), Spring (September-October-November), Summer (December-January-February) and Autumn (March-April-May) period.
- Mean annual low flow (7dMALF) – The mean of the lowest 7-day average flows in each year of a period of interest.
- Annual Q25 - The annual average river flow that is exceeded twenty-five per cent of the time. This is typically a flow metric providing insights into the average flow during the second quartile of the year.
- Q75 – The river flow exceeded seventy-five per cent of the time. This is typically a low flow metric higher than the 7-day MALF but lower than mean river flow.
- Q95 – The river flow exceeded ninety-five per cent of the time. This is typically a low flow metric used by Environment Southland for riverine water consenting purpose.
- Flow reliability – The fraction of time that the flow is equal to or below the National Environmental Standard (NES) for Environmental Flows and Water Levels (Ministry for the Environment 2008) minimum flow threshold as defined previously, and in this case without accounting for any water takes. Using a simple and nationally consistent method permits national comparisons of the results transparently, even though local circumstances will differ. The minimum flow below which abstraction must cease is thus:

$$Q_{min} = \begin{cases} 90\% \text{ of MALF when } Q_{mean} \leq 5m^3/s \\ 80\% \text{ of MALF when } Q_{mean} > 5m^3/s \end{cases} \quad (1)$$

where *MALF* is the mean annual 7-day low flow calculated from the baseline hydrological data.

- Water Supply Reliability - The average fraction of time during each irrigation season (spanning September 1 to April 30 of each hydrological year) that the river flow is too low and thus irrigation is restricted.

Unless specified, the hydrological metric is calculated as an annual average quantity estimated using calendar year aggregation. The 7dMALF and flow reliability hydrological metrics are estimated using hydrological year spanning June 1 to May 31 the following calendar year. Water Supply reliability hydrological metric is estimated over the irrigation season spanning September 1 to April 30 of each hydrological year.

In addition to riverine flow hydrological metrics, recharge rates across non-confined aquifers (see Figure 3-2) are provided as the average annual and seasonal vertical drainage between TopNet's watershed root zone and groundwater zone. As TopNet is a watershed based hydrological model, it is assumed that any watersheds overlying Environment Southland's non confined-aquifer layers (Environment Southland, pers. comm.) is fully contributing to the recharge of the aquifer.

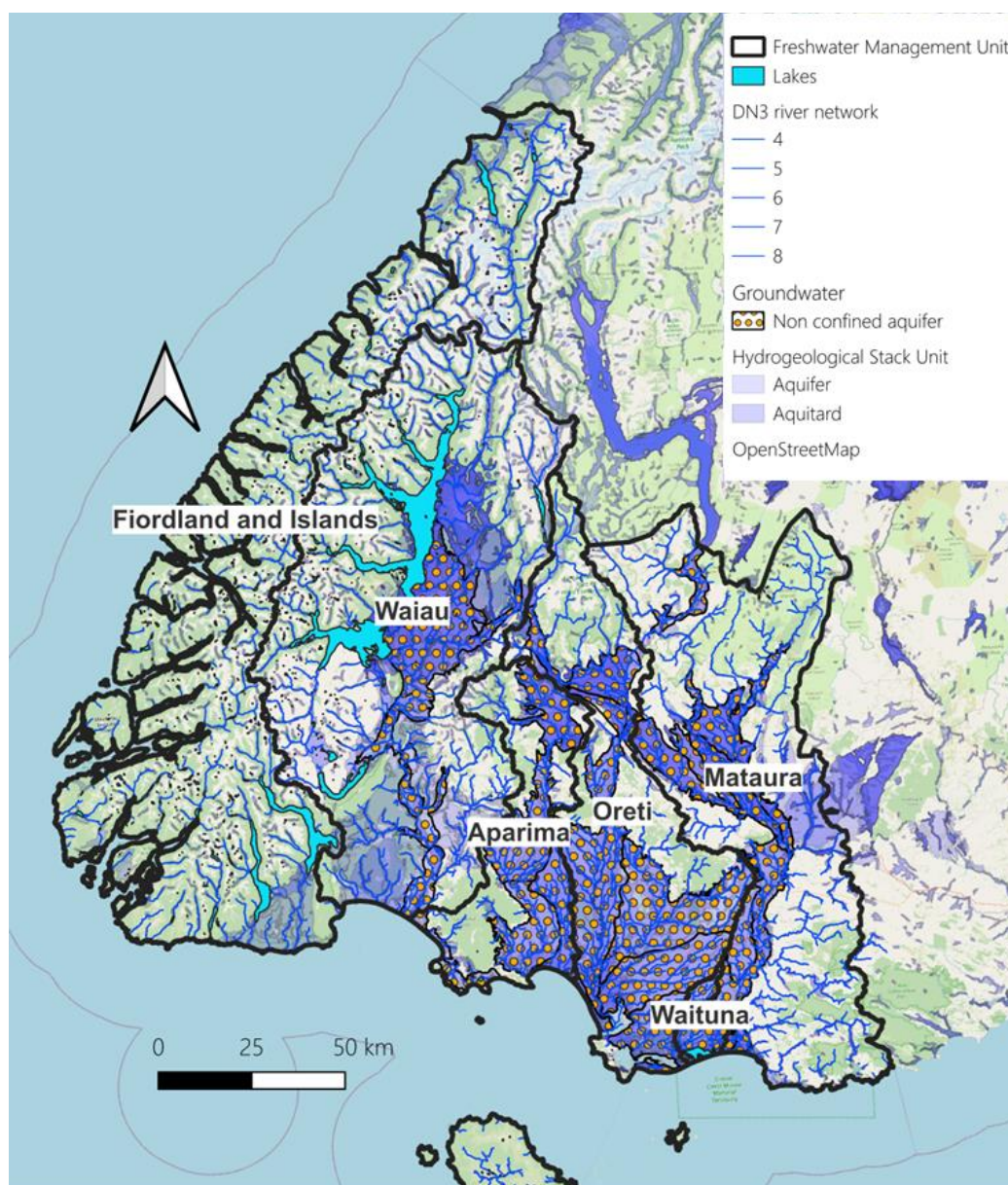


Figure 3-2: Hydrogeological Stack Units and shallow aquifers across the Southland region.

Environment Southland's non -confined aquifers presented as orange dot polygon, with national aquifer dataset (blue) and aquitard (blue-green) derived from Hydrogeological Stack Units (White et al. 2019).

3.3.4 Hydrological extremes

Extreme events, such as floods, are often defined to be the maximum value of a quantity over a given period of time. Flood size at a given location is usually characterised by its intensity (peak flow rate or peak flow), its duration (length of the event) and its frequency (annual, seasonal, etc.) (Langbein 1949). The statistical limiting model describing how large a flood will get is referred to as the Extreme Value distribution (EVD). EVDs have similar statistical basis as the Central Limit Theorem (CLT), which specifies that the mean of a large sample has a normal distribution regardless of the underlying distribution. The main difference between EV theory

and CLT is that the CLT concerns the behaviour of the mean of random variables, while EV theory concerns the behaviour of the tails of those distributions.

EVDs are of the following three types (Haan 1977), as long as the distribution is well behaved (Gumbel 1958). Extreme value theory, in particular the extremal types theorem (Leadbetter et al. 1983), suggests that the distribution of these maxima should be close to one of the extreme value types:

- EVD Type I (EVD1): Gumbel distribution, that is the most common EVD characterised with no upper or lower limits (usually referred to as unbounded).
- EVD Type II (EVD2): Fréchet distribution, bounded at the lower end, is usually used to model maximum values.
- EVD Type III (EVD3): Weibull distribution, bounded at the upper end, is usually used to assess product reliability to model failure and life data analysis.

The Generalised Extreme Value distribution (GEV, Von Mises 1936, Jenkinson 1955, Coles 2001) is a three-parameter distribution that combines all three extreme value types into a single form. The GEV distribution has been widely used for modelling the distribution of annual maximum flood peaks in at-site and regional settings (Hosking et al. 1985, Smith 1987, Martins and Stedinger 2000). In addition to flood modelling, the GEV distribution is commonly used to model many other natural extreme events (Bauer 1996, Coles 2001). One of the primary advantages of the GEV distribution is its ability to characterise flood magnitude regardless of the underlying flood generating distribution.

The Cumulative Distribution Function (CDF) for the GEV is:

$$F(x; \mu, \sigma, \zeta) = \exp \left\{ - \left[1 + \zeta \left(\frac{x - \mu}{\sigma} \right)^{-1/\zeta} \right] \right\} \quad (2)$$

Where σ and $1 + \zeta(x - \mu)/\sigma$ must be greater than zero. μ is referred as the location parameter and indicates where the distribution is located, σ is referred as the scale parameter and determines the width of the distribution, and ζ is referred as the shape parameter that affects the tail of the distribution. The shape parameter defines which distribution the Generalised Extreme Value distribution takes on:

- When the shape parameter ζ is equal to 0, the GEV is EVD Type I (EV1).
- When ζ is greater than 0, the GEV is EVD Type II (EV2).
- When ζ is less than 0, the GEV is EVD Type III (EV3).

Flood frequency analysis (FFA) is used as the basis to devise and implement strategies associated with mitigation and limitation of flood impacts. A key concept is the design flood peak value, typically set in national regulations by specifying an average recurrence interval, or return period, T , associated with an annual exceedance probability (AEP) of being exceeded in each year equal to $P = 1/T$. The T -year flood, in turn, is estimated based on the analysis of past floods, with the selection of a probability distribution to perform this inference using a sample with size $S \ll T$ (Benson 1962) (i.e., S is very much less than T). In practice, due to the short period of observation record, large T -year flood (e.g., flood magnitude associated with 1000-

year return period) is estimated using a limited sample of historical floods, with S taken between 50 and 70 years.

Flood magnitudes are characterised by their Annual Recurrence Interval (ARI) or Return Period, which represents the average time, in years, between floods of a specific magnitude. Flood magnitudes can also be expressed as, and is defined by, an Annual Exceedance Probability (AEP) which is the probability a flood that size occurs in a given year (e.g., a 100-year ARI flood has a 1% AEP), with the AEP being associated with the GEV CDF.

Hydrological extremes, including estimation of the flood magnitude associated with PMP, are generated at 27 locations presented in Table 3-7 for the following ARI:

- Streamblank flood 1:2.33 year ARI- usually referred as the Mean Annual Flood (MAF);
- Common flood: 1:5 year ARI, 1:10 year ARI, 1:20 year ARI;
- Large floods: 1:50 years ARI, 1:100 year ARI and 1:200 year ARI;
- Extreme floods: PMF associated with PMP.

To ensure that the hydrological extremes are located on the digital river network used, those locations are mapped to the closest DN3 Strahler 3 river reach. It is important to note that the modelling chain bias correction aims to represent mid-range to low flow hydrological regimes. Bakker (2025) identified that the analysis of flood frequency requires bias correcting the CMIP6 modelling chain to match observed flood frequency using the TopNet hydrological model. This additional bias correction (i.e. in addition to the water resource bias correction carried out as part of this project) can be carried out by correcting the volume of precipitation and/or the infiltration excess runoff catchment scale parameters. As a result, the analysis presented in this section is illustrative of the impact of climate change on flood magnitude across the Southland region.

Table 3-7: Hydrological extreme locations.

Hydrological extreme location	Hydrological extreme location	Hydrological extreme location
Mataura Catchment to Cattle Flat Township	Waiau at Tutapere Township	Waikaia Catchment
Mataura Catchment to Gore Township	Oreti Catchment to Wallacetown Township	Whitestone Catchment
Mataura Catchment to Wyndham Catchment Township	Winton Stream to Winton Township	Mokoreta Catchment
Waikaia Catchment to Waikaia Township	Aparima River to Otautau Township	Makarewa Catchment
Waikaka Stream to Gore Township	Otautau Stream to Otautau Township	Mararoa Catchment
Oreti Catchment to Lumsden Township	Waihopai River to Invercargill City	Orauea Catchment
Oreti Catchment to Winton Township	Otepuni Stream to Invercargill City	Waimea Catchment
Oreti Catchment to Wallacetown Township	Kingswell Creek to Invercargill City	Waikawa Catchment
Winton Stream to Winton Township	Upukerora Catchment	Waituna Catchment
Aparima at Thornbury Bridge	Irthing Catchment	

Due to the relative short length of the annual time series, large uncertainties are expected for the estimation of the magnitude of the peak flow discharge associated with low frequency event (larger than 1:50 year or 1:100-year ARI) and its comparison with FF magnitude derived from observations. This is due mainly to two main reasons. Firstly, large statistical uncertainty is inherent with the characterisation of low frequency event. Secondly, the CMIP6 climate projections, while representing a step change in the reproduction of historical climate extreme indices (Gibson et al. 2024a), have a weak temporal correlation with observed climate that may translate to timing mismatch with observed historical events. As a result, caution has to be taken regarding the calculation of the magnitude of peak flow discharge, their interpretation and their use to inform planning decision process. As some locations of interest are not locations for which streamflow observation is available it is proposed to provide a comparison of the magnitude of the peak flow discharge with the national flood frequency tool (Henderson et al. 2018) for selected ARI. As the flood frequency tool does not provide estimation of change in the magnitude of flood peak discharge under climate change, the intercomparison will be provided only for the hindcast time slice.

Climate change impact on Flood Frequency magnitude (FF) is carried out by fitting GEV distribution, at each location of interest, of the annual maximum discharge time series under

future climate projections. The analysis is completed using R (R Core Team 2021) using the ‘extRemes’ package (Gilleland and Katz 2016).

- Due to the relatively short length of each time slice considered (20 years), the analysis will be carried out for each time slice assuming stationarity of hydro-climate processes over the duration of the time slice.
- The annual FF is to be completed for each GCM (20 years annual time series) and as pooled GCM (120 years annual time series assuming equiprobability between the six GCMS) to reduce uncertainty of estimations of flood magnitude associated with different annual exceedance probabilities. While results are available for each GCM driven historical simulations, only pooled GCM analysis is presented to reduce uncertainty.
- Analysis of the change in FF will be reported for each location and for each SSP:
 - Magnitude of flood peak discharge for 1 hr and 24 hr duration for each ARI and its associated 95th percentile confidence interval for each GCM and pooled GCM, associated with the estimation of the magnitude of flood peak discharge.
 - Magnitude of flood peak discharge for 24 hr duration for each selected ARI and its associated 95th percentile confidence interval as provided by the national flood frequency tool.

3.3.5 Probable Maximum Flood

As part of the project, at each location of interest PMF is defined as the PMF peak discharge associated with PMP event for each storm duration (Clavert-Gaumont et al. 2017, Rastogi et al. 2017, Sammen et al. 2022).

Estimation of the climate change impacts on Probable Maximum Flood (PMF) requires the combination of estimation of climate change impacts on PMP coupled with hydrological models (Clavert-Gaumont et al. 2017, Rastogi et al. 2017, Sammen et al. 2022). As part of the project, we are following a similar methodology by coupling PMPs (represented using rainfall design event approach for each duration of interest) calculated under current and future climate change scenarios with the hydrological model to calculate PMFs under current and future climate projections. The use of the hydrological model to calculate PMF enables us to simulate the impacts of increased warming on runoff generation processes, combined with a variety of initial conditions (including timing through the year).

The temporal hourly signature of the PMP for 24 hrs storm durations is identified for each GCM as the historical rainfall event generating the largest daily volume of precipitation. As part of the analysis, the following two assumptions are made:

- As PMP events are spatially very large rainfall events, it is assumed that all locations within the same surface water catchment will experience the PMP event over the same time (i.e., the data of the largest event does not change spatially across location within the same surface water catchment).
- Only the rainfall depth is affected by increase warming (i.e., the timing of the PMP storm does not change with warming).

3.3.6 Cryosphere locations

Snow fall volume, snow volume (simulated as snow storage in the TopNet model) and snow melt are generated using the cryospheric module associated with the TopNet hydrological model for 12 mountain ranges located across the Southland region (see Table 3-8). Due to difference in orientation, cryospheric analysis is presented based on the surface water catchment. As a result, a mountain range split between two Freshwater Management Units (FMU) may have different estimations based on their orientation.

Table 3-8: Mountain range information request.

Mountain range	Freshwater Management Unit
Eyre Mountains	Oreti and Mataura
Thomson Mountains	Mararoa and Oreti
Livingston Mountains	Mararoa and Waiau
Takitimu Mountains	Aparima and Waiau
Garvie Mountains	Mataura and Waikaia
Umbrella Mountains	Waikaia
Hunter Mountains	Waiau
Kepler Mountains	Waiau
Murchison Mountains	Waiau
Stuart Mountains	Waiau
Franklin Mountains	Waiau
Earl Mountains	Waiau

The estimation of two additional cryospheric variables is required by Environment Southland for those mountain ranges: number of snow days and snow line defined as follow:

- Snow days are identified as days when snow fall occurs and are identified as rainy days associated with air temperature lower than 1°C.
- Seasonal Snow line is defined as the elevation with an average annual snow cover duration of 90 days. For each catchment, the snow line elevation is determined by finding the annual average snow cover duration within each 100-metre elevation band, then interpolating between the mid-point elevations of the bands with the two closest snow cover durations (i.e. moving upwards, the last band with <90 days and the first band with >90 days). Snow cover duration is determined as the number of days with average fractional snow cover area >50% within each elevation band. The snow line elevation is found separately for each catchment, year and GCM simulation, then averaged for each time period (historical, mid-century, end-of-century).

- Snow volume is calculated as snow storage within the TopNet model and is represented as snow storage in kg/m² or meter snow water equivalent.

3.3.7 Modelling chain bias correction methodology

As the GCM simulations are ‘free-running’ (i.e., based only on initial conditions, and not updated with climate observations) comparisons between present and future hydrological conditions can be made directly (as each GCM is characterised by specific physical assumptions and parameterisation), but this also means that the variability simulated in hydrological hindcasts do not track observational records over the period 1995–2014. Furthermore, biases in the rainfall simulated by the models can combine with biases in the hydrological model to create flow-duration-curves that differ significantly from the observed.

Bias correction and calibration are procedures that involve adjusting a model’s parameter values and inputs such that the model’s outputs (i.e., simulations) more closely match historical measurements (i.e., observations). For TopNet in particular, despite the ability of the uncalibrated model to reproduce some observed hydrological characteristics across New Zealand as a whole (see Booker and Woods 2012, McMillan et al. 2016, Cattoën et al. 2022), model bias correction or calibration is recommended to match catchment-specific hydrological behaviour (Zammit 2019).

Calibration aims to achieve model simulations that provide the best overall fit to each individual observation, averaged across all observations. Goodness of calibration is often expressed through metrics such as root mean square error or R². Calibration is known to be very challenging for GCM-driven hydro-climate modelling, of the type undertaken in this study. As a result, the model outputs exhibit weak temporal correlation with weather observations and as such with hydrological observations. When applied to the hydro-climate modelling chain, Malek et al. (2022) found that common strategies for reducing errors in hydrologic projections can themselves strongly distort projected climate vulnerabilities associated with water resource management. As a result, calibration of GCM-driven hydro-climate simulations is location dependent, difficult to transpose to ungauged locations, computationally intensive and requires observation time series, and hence is overall generally difficult to achieve.

Bias correction aims for the model output to reproduce the long-term statistical characteristics of the observations (e.g., expressed as mean, variance, etc.), rather than their true individual values. Different bias correction techniques are available for both climate and hydrological modelling, including linear scaling, variance scaling, quantile mapping, and trend-preserving quantile mapping, with each method having its own strengths and weaknesses. Regardless of method used, bias correction is generally less computationally intensive than calibration. Among those methods, quantile mapping has been found to be among the best bias correction techniques for catchment-specific hydro-climate modelling (Willkofer et al. 2018). However, when applying quantile mapping bias correction to climate simulations, Lafon et al. (2012) found it to be sensitive not only to the method used but also the baseline period. In addition, as a catchment-specific method, the application of quantile mapping bias correction is limited at larger scale and cannot be applied for catchments without any hydrological observations.

As part of the project, a bias correction of the rainfall for each GCM driven simulation was carried out, without undertaking a GCM specific calibration for each relevant streamflow observation. Due to its simplicity, the bias correction can be developed for locations at which

streamflow time series observations are available, or for locations at which hydrological metrics are available.

Due to its conceptualisation, the bias correction targets long-term average hydrological characteristics, rather than event based hydrological characteristics that would be possible with calibration. It focusses on the following steps and is associated with surface water catchment conceptualisation of hydrological processes:

- *Correction of upstream precipitation volume*, ignoring internal variation in soil moisture and snow storages. For each site we calculate, over the period 1995–2014, the mean annual precipitation (referred as target precipitation hereafter) using mean annual runoff as calculated from the streamflow observation time series and the mean annual actual evapotranspiration. The bias correction of the precipitation is given by the ratio of the GCM-specific mean annual precipitation compared to the target precipitation. The accuracy of the bias correction is depending on the following: i) applicability of surface water conceptualisation to each subbasin, and ii) applicability of the long-term average actual evapotranspiration dataset (Tait et al. 2006, Woods et al. 2006) generated over the period 1966–2006 to the hindcast period (1995–2014).
- *Correction of the annual average upstream snow cover area*, as a proxy for the upstream snow volume. The correction is characterised by the annual average snow cover duration metric and analysis of catchment scale daily average fractional snow cover area derived from NASA’s Moderate Resolution Imaging Spectroradiometer Snow Cover Area dataset (MODIS-SCA) (contact: Dr Pascal Sirguey, University of Otago) over the period 2000–2015. The bias correction assumed that the catchment average snow cover duration is primarily controlled by the precipitation volume and snow accumulation temperature threshold within the TopNet model. The cryospheric component of the bias correction aims to improve the representation of snow melt contribution to summer low flow.
- *Correction of the evapotranspiration parameterisation* to better represent low flow hydrological metrics and mean annual runoff across Southland. It is assumed that catchment-scale soil moisture and associated flow generation processes during summer months are mainly controlled by catchment-scale evapotranspiration processes which are characterised by the catchment-scale plant available water parameter within the TopNet model.
- *Correction of infiltration excess runoff parameterisation* to better represent low flow hydrological metrics across Southland. It is assumed that catchment-scale soil moisture and associated flow generation processes during summer months are partially impacted by infiltration excess runoff parameterisation that is characterised by the catchment-scale infiltration excess runoff parameter within the TopNet model. As part of the modelling chain bias correction, this parameter is set to be GCM dependant as it depends on GCM specific sub-daily rainfall intensity distribution that is independent of the hydrological model considered.

The bias correction is carried out at a spatial scale relevant to the climate projections using the following order:

- Bias correction of relevant hydrological characteristics at natural flow sites (i.e., streamflow stations for which impact of human activities is considered negligible) across the full flow range.
- Bias correction of relevant winter hydrological characteristics for flow sites whose flow regime is impacted by human activities, under the assumption that human impacts are minimal during the winter period and that little bias is present in the seasonal cycle of the precipitation (Cambell et al. 2024).
- Bias correction of relevant cryospheric characteristics for large mountainous regions within Southland using MODIS-SCA annual average Snow Cover Duration (SCD) and annual average daily fractional Snow Cover Area (fSCA) for mountain range.
- Bias correction of relevant hydrological metrics for ungauged locations where possible. Those metrics can be based on NZ River Maps hydrological metrics (Booker and Woods 2014, Whitehead et al. 2019). Booker and Woods (2014) dataset is used primarily to generate the upstream precipitation bias correction and (if possible) to provide an estimation of low flow metrics at locations without adequate observations (e.g., locations without streamflow observation, locations where streamflow observation is impacted by human activities, locations where streamflow observations are not long enough to be used as part of the bias correction process).

Figure 3-3 and Table 3-9 present the locations where flow characteristics, selected in collaboration with Environment Southland’s Hydrology team, are bias corrected across the full hydrological regimes (annual hydrological regime for natural flow sites) and/or winter flow regime for winter flow sites. Site classed as “winter” site encompasses: i) streamflow observation site that is affected by upstream human activities (e.g., sites located downstream of hydro-electricity generation lakes, or by large surface water and/or groundwater takes activities), ii) streamflow gauging station at site classed as “Natural” impacted by regional groundwater movements, and iii) streamflow gauging stations classed as “Natural” missing at least 50% of daily average streamflow observations over the period 1995–2014.

Table 3-9: Physiographic information for bias corrected streamflow sites.

Freshwater Management Unit	Tideda ID	Site name	Hydrological regime Bias correction
Aparima	78906	Aparima Dunrobin	Natural
	78901	Aparima at Thornburry	Winter
Oreti	78606	Oreti at three Kings	Natural
Mataura	77563	Waikaia at Piano Flat	Natural
	77505	Mataura at Parawa	Winter
	77506	Mataura at Tuturau	Winter
	77519	Mataura at Seaward Downs	Winter
	77527	Mokoreta at McKays Rd	Winter
	77528	Waikaka Stm at Willowbank	Winter
	77561	Waikaia at Mahers Beach Rd	Winter
Waiau	80201	Rowallan Burn at Old Mill	Natural
	79740	Spey at West Arm	Natural
	79708*	Waiau at Queens Reach	Winter
	79737	Mararoa at Cliffs	Winter
Fiordland	83201	Lyvia Ck at Deep Cove	Natural

* Bias correction not carried out for Waiau at Queens Reach as not meeting the threshold of 50% of observations present over the period 1994–2014.

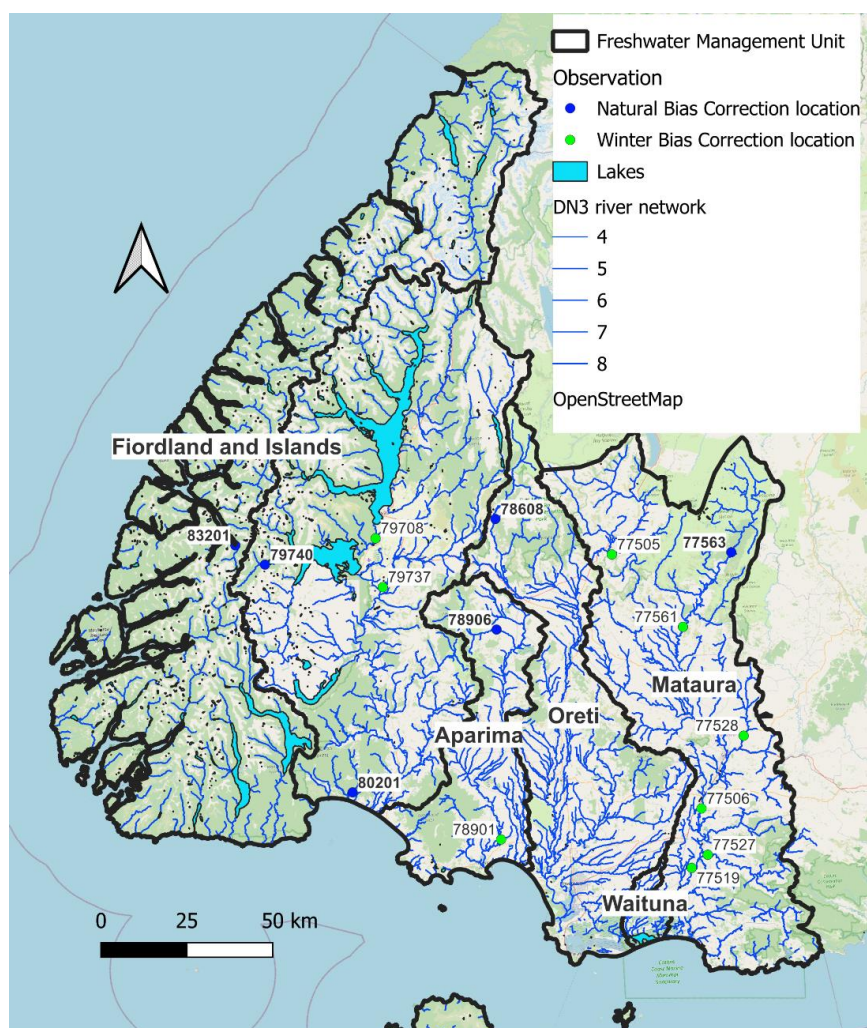


Figure 3-3: Location of the flow sites (represented by their Tideda ID) used as part of the modelling chain bias correction. Blue dots represent locations for which bias correction is carried out across the full hydrological regime (“natural flow sites”), while green dots represent locations for which winter hydrological regimes are bias corrected.

Following discussions with Environment Southland, the Southland region was disaggregated in 100 subbasins on which the bias correction is performed (Figure 3-4) with 32 subbasins located within the Maitura/Waituna FMUs, 8 subbasins located within the Aparima FMU, 22 subbasins located within the Oreti FMU, 25 subbasins within the Waiau FMU and 13 subbasins within the Fiordland FMU.

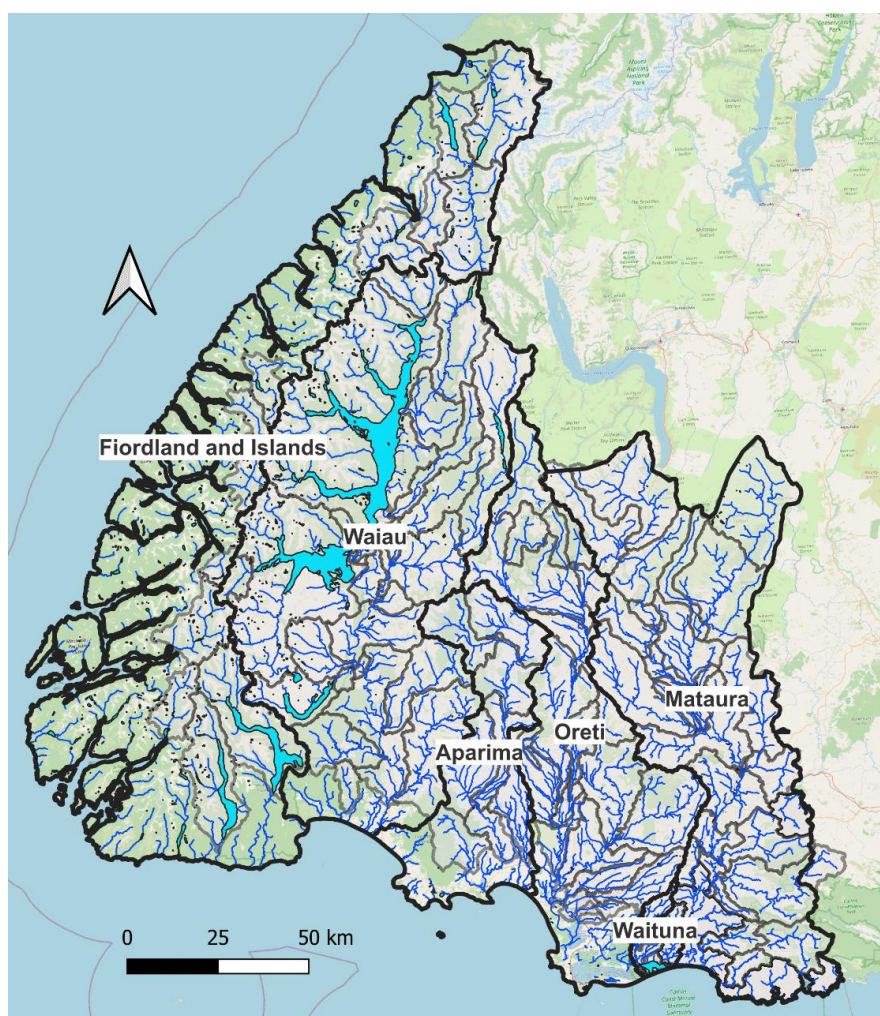


Figure 3-4: Bias corrected watersheds (dark grey outline) within each of Southland's FMU (black outline). Coastal watersheds (not shown on the map) are not bias corrected.

Validation of the bias correction is carried out as follows:

- At the outlet of each subbasin, the accuracy of the bias correction is carried out using Mean flow (QMean) and 7day Mean annual low flow (Q7DMALF). This is the primary objective of the bias correction, as estimation of QMean and Q7DMALF are available either from observation or from NZRiverMaps.
- At streamflow gauged locations, the accuracy of the bias correction is out as per Zammit et al. (2024), using the following nine statistical scores:
 - The accuracy of the calibration process is estimated in terms of the Nash-Sutcliffe efficiency coefficient calculated on the discharge (NS) and on the logarithm of the discharge (NS Log). The NS score represents a measure of the residual variance versus the data variance. A NS score of 1 indicates that the simulation perfectly mimics the observations in time and volume. A negative NS score indicates that the average of the observation is a better

predictor than the modelled flow. The NS score represents the ability of the model to mimic the observations during high flow periods, while the NS Log score represents the ability of the model to mimic the observations during low flow periods.

- KGE (Kling-Gupta Efficiency), KGE_{lf} (Kling-Gupta Efficiency for low values) and KGE_{km} (Kling-Gupta Efficiency with knowable-moment). KGE was developed to provide additional information that the Nash-Sutcliffe efficiency and to facilitate the analysis of the relative importance, in the context of hydrological modelling, of its different components (correlation, bias and variability). KGE_{lf} represents a standardised measure of the ability of a model to reproduce low flows (Garcia et al. 2017) and was developed to circumvent some issues associated with the use of NS Log to support water management decisions. KGE_{lf} is taken as the average of the Kling-Gupta Efficiency (Gupta et al. 2009) for the discharge and its inverse. KGE_{km} was developed by Pizarro and Jorquera (2024) to provide a reliable estimation and effective description of high-order statistics from typical hydrological samples and, therefore, reducing uncertainty in their estimation and computation of the KGE. A KGE/KGE_{lf}/KGE_{km} score value of 1 indicates that the simulation perfectly mimics the observations in time and volume. A KGE/KGE_{lf}/KGE_{km} score lower than -0.41 indicates that the average discharge is a better predictor of the observations than the simulation (Kling et al. 2012, Knoben et al. 2019).
- Percentage bias (PBIAS) measures the average tendency of the simulated values to be larger or smaller than their observed ones. The optimal value of PBIAS is 0.0, with low-magnitude values indicating accurate model simulation. Positive values indicate overestimation bias, whereas negative values indicate model underestimation bias.
- Pbias_{fdc} (PBIAS_{fdc}) measures the percent bias in the slope of the mid-segment of the flow duration curve (Yilmaz et al. 2008). The mid-segment is characterised by a percentage of exceedance between 20% and 70%. The optimal value of PBIAS_{fdc} is 0.0, with low-magnitude values indicating accurate model distribution of mid-flow range. Positive values indicate overestimation bias, whereas negative values indicate model underestimation bias.
- The Index of Agreement (D) (Willmot 1981) represents a standardized measure of the degree of model prediction error. A value of 1 indicates a perfect match, while a value of 0 indicates no agreement at all between observed and predicted data. Despite D being able to detect additive and proportional differences in the observed and simulated means and variances, it is extremely sensitive to extreme values due to its formulation (Legates and McCabe 1999).
- Volumetric Efficiency (VE) (Criss and Winston 2008) is used to circumvent some problems associated with NS. It varies between 0 and 1 and represents the fraction of water delivered at the proper time.

- At natural and winter flow sites, comparison of the average daily observed and predicted discharge (to identify potential issues in the reproduction of seasonality of the hydrological regime), daily observed and predicted flow duration curve (to identify potential mismatches in the statistical distribution of the flows) and cumulative flow (to identify potential issues related to systematic bias in the bias correction process).

Table 3-10 provides a qualitative description of the quality of the bias correction result based on the value of the statistical scores used.

Table 3-10: Classification of Nash-Sutcliffe, KGE, Pbias, D and VE scores.

Score	Classification
NS/NSLog/KG scores	
NS < 0.4	Poor
0.4 < NS < 0.6	Adequate
0.6 < NS < 0.8	Good
NS > 0.8	Excellent
PBIAS/ PBIASfdc scores	
PBIAS ⁴ < 10%	Very good
10% < PBIAS < 15%	Good
15% < PBIAS < 25%	Satisfactory
PBIAS > 25%	Poor
D score	
D < 0.5	Poor
0.5 < D < 0.8	Acceptable
D > 0.8	Good to Excellent
VE score	
VE < 0.4	Poor
0.4 < V < 0.7	Acceptable
VE > 0.7	Good to Excellent

⁴ |PBIAS| represents the absolute value of the PBIAS score.

It is important to note that the validation of the bias correction using statistical scores is dependent on the timing and seasonal behaviour of the GCM driven precipitation. While there is consistency across the GCMs regarding simulation of historical air temperature, this may not be the case regarding precipitation (Campbell et al. 2024). As a result, the use of conventional hydrological statistics to assess the accuracy of the bias corrected modelling chain may be limited at locations with large bias in seasonal cycle of precipitation (further details see Campbell et al. 2024, Figure 3-4).

As part of the bias correction process the following constraints have been imposed to each of the bias corrected parameters

- The value of the correction factor for upstream precipitation volume is limited to a range [0.25-2.5]. The range was determined based on previously completed TopNet calibration for the Aparima-Oreti and Mataura FMUs (Zammit et al. 2019, Zammit et al. 2020, Zammit et al. 2021) that indicated that the correction factor for upstream precipitation volume associated with the use of the observed derived daily gridded Virtual Climate station Network (VCSN) precipitation (Tait et al. 2006) varies between 0.6 and 1.8 across those three FMUs. As part of the investigations, the correction factor for the upstream precipitation is GCM specific.

Correction factor value larger than 1.2 tends to indicate either a large underestimation in the GCM derived mean annual precipitation to generate long-term average discharge under a surface water conceptualisation (underestimation of the orographic effect on precipitation in catchment with large elevation change due to the spatial resolution of the CCAM model), or that the location where the bias correction is carried out is subject to regional groundwater influence (e.g. spring discharge within the subbasin, reaches within the subbasin can be classed as gaining reaches).

Correction factor value smaller than 0.8 tends to indicate that either a large overestimation in the GCM derived mean annual precipitation to generate long-term average discharge under a surface water conceptualisation, or that the location where the bias correction is carried out is subject to regional groundwater influence (e.g., reaches within the subbasin can be classed as losing reaches), or could be associated with small basin that were generated due to river network junctions or location of gauging stations.

- The correction of the temperature of accumulation correction is limited to a range of [-5°C, 5°C]. The range of the temperature correction is based on analysis carried out as part of the Deep South National Challenge project “Snow, ice and glaciers in our changing climate” ([Snow, ice and glaciers in our changing climate | Deep South Challenge](#)) and is GCM specific. This project estimated that the annual average error in air temperature at high elevation could reach up to 5°C to reproduce 250 m resolution gridded derived MODIS-SCA annual average SCD in the Clutha catchment.

The correction of the temperature aims to: i) minimise the error on the estimation of the annual average SCD by a maximum of 7 days, ii) reproduce the seasonal pattern of MODIS derived annual average SCA, iii) reproduce the timing of

seasonal average start of the snow accumulation period as well as the timing of the seasonal average melt of the snowpack, iv) summer month seasonal average SCA as a proxy of percentage of the area covered by permanent snow.

- The correction of the evapotranspiration parametrisation is limited to a range [0.25–2.5]. The range was determined based on previously completed TopNet calibration for the Aparima-Oreti and Mataura FMUs (Zammit et al. 2019, Zammit et al. 2020, Zammit et al. 2021). Currently, the evapotranspiration parameter within the TopNet model is determined based on class 1 land cover classification (Newsome 2000). As such, the correction aims to represent the adaptation of the vegetation to Southland climate and weather patterns, which is GCM specific.

The correction of the evapotranspiration aims to better represent low flow hydrological metrics while minimising its impact on mean annual runoff across Southland. It is important to note that, under a surface water conceptualisation, low flow estimation is largely controlled by GCM specific seasonal rainfall patterns. As such, the current simple bias correction process may have limited impact on the reproduction of low flow metrics.

- The correction of infiltration excess runoff parameterisation is limited to a range [0.5–9]. This range was determined through experiment as part of the project.

The correction of the infiltration excess runoff parameterisation is carried out at the FMU scale and is GCM specific (as associated with the sub-daily rainfall distribution that is specific to each GCM). Its optimisation is a trade-off between the ability of the simulations to reflect high flow metrics and hydrological statistics, and the ability of the model to represent low flow metrics based on analysis of Flow Duration Curve (FDC).

As part of the project, TopNet has been run continuously from 1980 to 2099, with a spin-up period 1980–1994 excluded from the final analysis. However, as the hydrological model used is uncalibrated, it is recommended that only the change analysis be used to inform discussions (Collins and Zammit 2016, Collins et al. 2019).

As riverine water stress period occurs over the summer period, climate change impact assessment on annual and seasonal hydrological metrics will be carried out using hydrological year defined as the period between 1 June and 31 May. Climate change impact assessment on annual and seasonal cryospheric metrics are carried out using snow year defined as the period between 1 April and 31 March.

3.4 Stream temperature

3.4.1 Stream temperature observations

Water temperature data, and concomitant river flow data where it was available, were obtained from Canterbury (40 locations), Taranaki (19 locations), and Southland (20 locations) regional councils and from NIWA. Environment Southland water temperature observation meta data is presented in Table 3-11 and mapped on DN3 river network (Figure 3-5).

Table 3-11: Water temperature and flow observation across the Southland region.

Site ID	name	Start Observation	End Observation	Concurrent Flow
77502	Mataura at Wyndham	22-Aug-06	16-Jul-18	No
77504	Mataura at Gore	26-Oct-99	1-Jan-25	Yes
77505	Mataura at Parawa	26-Aug-98	1-May-03	Yes
77506	Mataura at Tuturau	8-Dec-96	29-Apr-09	Yes
77519	Mataura at Seaward Downs	20-Feb-98	22-Mar-17	Yes
77525	Waimea Stream at Mandeville	30-Sep-99	1-Jan-25	Yes
77528	Waikaka Stream at Willowbank	27-Jun-00	10-Jun-19	Yes
77563	Waikaia at Piano Flat	3-Nov-95	14-Feb-25	Yes
77583	Oteramika Stream at Seaward Downs	9-Jan-96	28-Apr-03	Yes
78601	Oreti at Wallacetown	1-Oct-97	1-Nov-13	Yes
78608	Oreti at Three Kings	4-Sep-98	1-Jan-25	Yes
78625	Otapiri Stream at Otapiri Gorge	1-Jul-98	26-Nov-24	Yes
78634	Makarewa at Counsell Road	20-May-99	1-Jan-25	Yes
78636	Oreti at Lumsden Cableway	25-Aug-98	6-Jan-25	Yes
78637	Irthing Stream at Ellis Road	26-Aug-98	1-Jan-25	Yes
78901	Aparima at Thornbury	26-Jul-05	1-Jan-25	Yes
78906	Aparima at Dunrobin	30-Aug-00	1-Jan-25	Yes
78912	Hamilton Burn at Waterloo Road	9-Jul-98	1-Jan-25	Yes
79701	Waiau at Tuatapere	19-May-16	1-Apr-25	Yes
79735	Waiau at Sunnyside	28-Sep-00	1-Jan-25	Yes
789052	Pourakino at Pourakino Valley	2-Jul-04	3-Feb-25	Yes

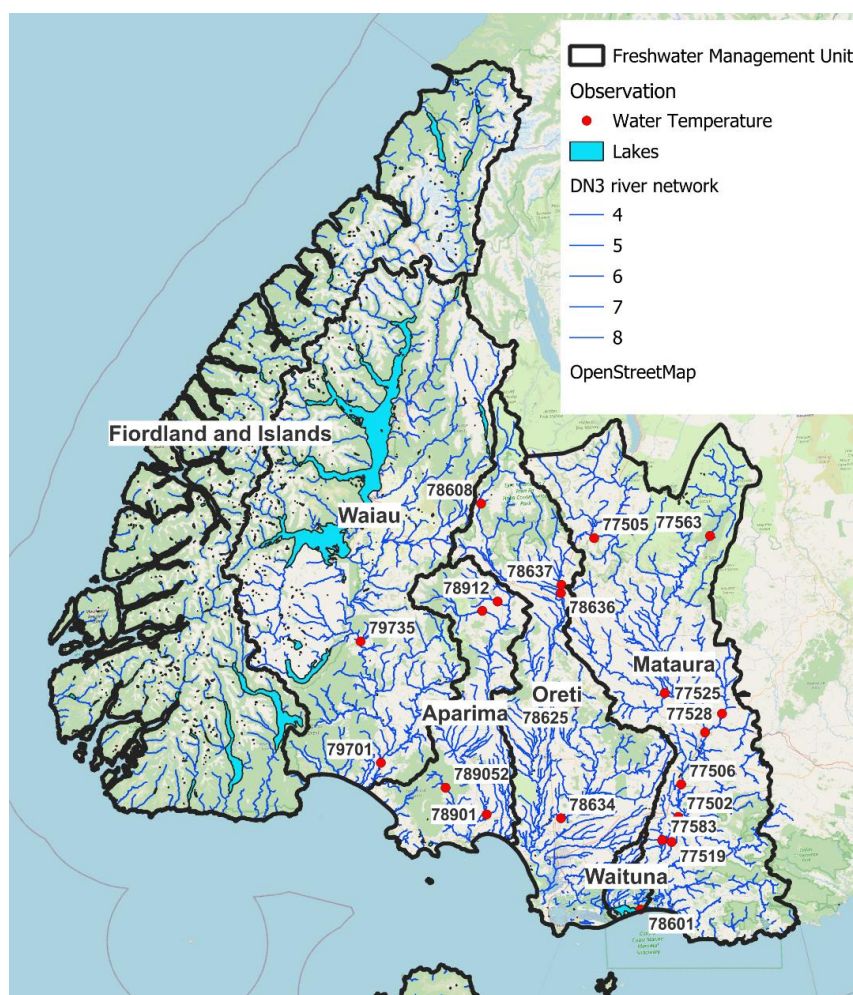


Figure 3-5: Stream water temperature observation location. Water temperature gauges identified using their Tideda ID.

Mean daily water temperature was calculated for each day at each site by averaging all observed water temperature values (e.g., hourly, 15-minutely, irregular) at each site on each calendar day. For each site, mean daily river flow was calculated by averaging all observed river flow values within each calendar day.

Local and average upstream mean daily air temperature time-series were obtained from the Virtual Climate Station Network (Tait et al. 2006) on each day at each site, by averaging maximum daily air temperature and minimum daily air temperature. For each site, the local mean daily air temperature was interpolated by applying a weighted average over the four nearest VCSN grid points. The same interpolation method was applied to obtain the air temperature at the mid-points of all upstream segments. Air temperature over the entire upstream catchment was then calculated by applying an area-weighted average to all upstream air temperatures (but these upstream air temperature data were not used in this analysis).

It is important to note that water temperature is modelled on the DN2.4 river network that is at a coarser resolution than DN3.1 used for hydrological modelling purpose. This is due to the fact that at the time of the project, extrapolation REC classes (Snelder and Biggs 2002) have been generated for DN2.4 digital river network and associated Rec watersheds.

3.4.2 Stream temperature model

The following four stream temperature models have been developed to estimate stream temperature at location of stream temperature and/or flow sites:

- Daily stream temperature as local daily air temperature (control model).
- Daily Stream temperature predicted from local daily air temperature on the same day.
- Daily stream temperature predicted from local daily air temperature on the same day and the difference in air temperature and the average of the preceding three days temperature.
- Daily stream temperature from local daily air temperature and daily river flow.

For validation purpose, air temperature was estimated for the daily minimum and maximum gridded air temperature generated as part of the Virtual Climate Station Network (VCSN, Tait et al. 2006) dataset. The VCSN is a five kilometres resolution daily gridded climate product generated based on daily climate observation directly ingested in NIWA climate database (CliDB).

Validation across all sites (regardless of region) shows that at the daily resolution the addition of flow improved predictive performance but also introduced a bias. The addition of antecedent air temperature improved predictive performance more than the addition of flow. Regional analysis indicated that for Southland, the model that incorporated some antecedent information about air temperature performed best across the 20 sites.

The parameters of the stream temperature model for Southland were modelled as a function of landscape-scale watershed characteristics in order to produce a landscape-scale model that could predict water temperature at ungauged locations. The landscape-scale predictor variables chosen, described hereafter, have some physical basis for influencing the relationship between river water temperature and air temperature (and flow where relevant):

- LocHab: an ordinal estimate of habitat type (influence water depth and therefore water volume).
- segSolarRadSum: an estimate of summer solar radiation (influence energy input to the river water from the sun directly).
- segAveElev: local elevation (influences slope and therefore hydraulics, but also the range of air temperatures, possible link to influence of snow).
- TURB_Median: an estimate of water clarity defined as turbidity (influences albedo of water and therefore transfer of solar radiation to heat, may also have a link to hydraulic conditions).

As part of the climate change impact assessment on stream temperature, we assume that landscape predictors are independent of future warming conditions.

3.5 Ocean modelling

Oceanic data for this report is based on hydrodynamic modelling using New Zealand Earth System Model (NZESM). This Coupled Model Inter Comparison Project -class model uses the Unified Model to simulate the atmosphere, NEMO for the ocean, Medus for the ocean-biogeochemistry and CICE for sea-ice. NZESM has been tuned for New Zealand applications by refining the oceanic model mesh from 1° to 0.2° around New Zealand, allowing for a better representation of fine scale oceanic processes (e.g., coastal currents as per Behrens et al. 2020).

A set of 3 historical simulations have been conducted covering the period from 1940 to 2014, which were initialized from simulations of United Kingdom Earth System Model. Three future scenarios branched off from the historical simulation in 2015, following the SSP 2.6, SSP 4.5 and SSP 7.0, Greenhouse gas emissions specifications. These future climate change scenarios cover the period 2015 to 2100. For this report sea surface temperatures and pH have been extracted and analyzed. Marine heatwave metrics (MHW intensities and MHW days) have been computed using 5-daily SST temperature fields using the widely used definition as per Hobday et al. (2016).

3.6 Sea-level analysis

3.6.1 Gauge Data

Two tide-gauge records from Port of Bluff and Stead Street Bridge (Invercargill) were used in this report to summarise mean sea-level trends and extreme storm-tide levels (Figure 3-6).

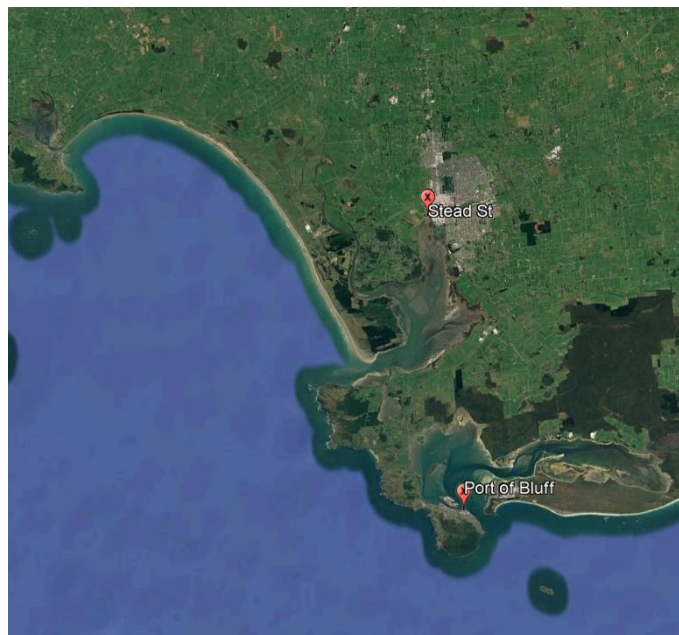


Figure 3-6: Locations of the two tide gauges used in this report. Stead Street is operated by Environment Southland, Port of Bluff by South Port.

The >30-year tide-gauge data from the Port of Bluff (Southport) was obtained from Land Information NZ (LINZ) sea-level archive and quality-controlled for any major glitches and gaps focusing on extreme storm-tide events. The Bluff sea-level recorder runs from 12 December 1982 and has a recording duration of 32-years until the end of 2024. Initially, the sampling interval was 1-hourly until 2010, then it changed to 5 minutes until 2011, and since then it has been sampling at 1-minute intervals. The complete sea level record includes 81 gaps larger than 24 hours, with the longest gap spanning 1661 days from 1 July 1989. The full QA'd Port of Bluff sea-level record in Figure 3-7 shows no apparent issues with datum or offset.

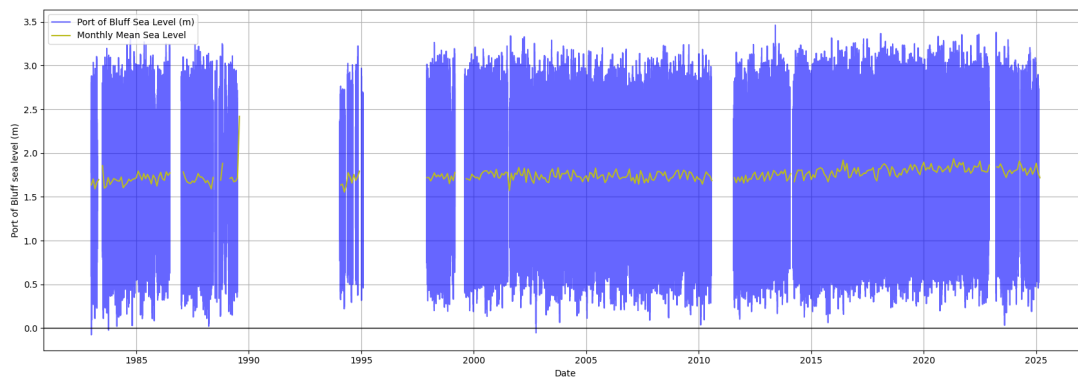


Figure 3-7: Quality assured Bluff sea-level data. Blue line sea level (m) relative to BVD-55 where gauge zero is 1.611 m. Black line represents gauge zero relative to local vertical datum. Yellow line monthly mean sea-level.

The Stead Street sea-level record, obtained from Environment Southland, spans approximately 32 years, beginning with the installation of the gauge on 24 March 1992 and continuing to the present. Over this period, several changes in sampling frequency have occurred. Initially, sea-level measurements were recorded at 15-minute intervals until March 1999, when the sampling frequency increased to 10-minute intervals. In February 2000, the recording interval reverted to 15 minutes before being further refined to 5-minute intervals in September 2000. From August 2010, the gauge initially recorded data at 1-minute intervals; however, this was later reduced to 10-minute intervals from 20 June 2013. On 9 October 2019, the sampling frequency was increased again to 5-minute intervals, which remains the current recording resolution.

Despite these changes in sampling frequency, the record is generally continuous. The most significant gap in the record lasts 37 days, beginning on 5 October 1993. Figure 3-8 presents the complete quality-assured (QA'd) Stead Street sea-level record. There are no apparent offset changes evident in the record, nor are there any documented changes to the gauge setup that would indicate systematic shifts in the measured sea level.

The Stead Street tidal record is strongly influenced by river flow, leading to a tidal signal that is noticeably skewed. This freshwater input reduces the overall tidal range at Stead Street compared to the more marine-dominated conditions observed at the Port of Bluff. As a result, the difference between high and low tide is less pronounced. Additionally, the tidal residual at Stead Street exhibits distinct peaks, which are primarily driven by freshwater flood events. These peaks reflect the impact of river discharge on local water levels, further complicating the tidal dynamics in this area.

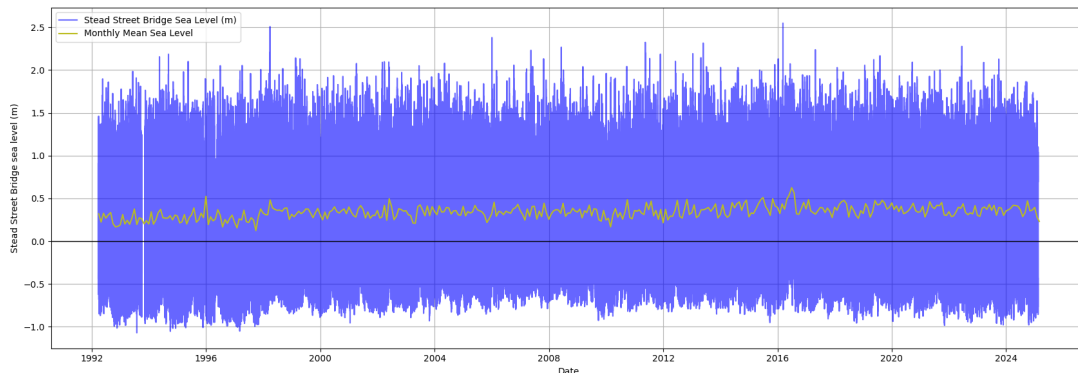


Figure 3-8: Quality assured Stead Street sea-level data. Blue line sea level (m) relative to BVD-55. Black line represents gauge zero relative to local vertical datum. Yellow line monthly mean sea-level.

3.6.2 Tides, sea level rise, change in extreme storm tide

Tidal elevations were predicted using tidal harmonic analysis, which was applied to each sea-level record.

Tidal harmonic analysis was undertaken using Versatile Harmonic Tidal Analysis (Foreman et al. 2009), applying a signal-to-noise ratio (the ratio of the tidal variance to the non-tidal variance) of 10.

Timeseries of tidal predictions were created by fitting the tidal harmonics and predicting the tides on an annual basis. The tidal predictions are more accurate when resolved on an annual basis, since the tidal harmonic constituents change subtly from year to year. Long-term average tidal harmonic constituents (e.g., M_2 , N_2 and S_2 in Table 7-1) were calculated by applying the harmonic analysis to the whole record (epoch-averaged constituents).

High-tide exceedance curves for the present day were generated for both the Bluff and Stead Street records. These curves quantify the distribution of all high tides based on tide predictions spanning several decades (excluding weather and climate influences). They were then be used to assess how the frequency of high tides exceeding specific thresholds changes under three example sea-level rise (SLR) scenarios: 0.2 m, 0.4 m, and 0.8 m.

All sea-level records exhibit a rising trend in MSL. Tides and surges all ride on top of the MSL. To analyse changes in storm tides and surge through time, the underlying sea-level rise trend must first be removed. There are two main causes of rising MSL through time:

1. Absolute (or eustatic) rise in ocean levels around New Zealand.
2. Relative (or local) sea-level rise, which is the net rise from absolute, regional-sea offsets and local vertical land movement, measured relative to the local landmass.

The sea level gauges sit on the land surface, so they are recording relative sea-level rise (RSLR). It is RSLR that is observable through time in Figure 3-7 and Figure 3-8.

To detrend the datasets, linear fits to the relative annual MSL were calculated using a least-squares analysis (Table 3-12). These linear fits were subtracted from the non-tidal residuals before undertaking further analyses.

We note that the trend for Stead Street, calculated in Table 3-13, as not used in the analysis. This is because Stead Street is influenced by freshwater inflows, and the observed trend is as likely to reflect increased storminess and freshwater inflows as it is mean sea-level changes.

Table 3-12: Linear fits for sea level detrend.

Sea Level record	Linear detrend (mm/year)	Zero axis crossing date for linear fit detrending (MVD)
Bluff	1.78	7 December 1921
Stead Street	2.18	28 June 1848

Earth Science New Zealand assessed the local variations in sea-level to apply New Zealand-wide sea-level rise (SLR) scenarios to 2200. These scenarios are based on the most recent global SLR projections issued by the IPCC in 2021 (Fox-Kemper et al. 2021). These projections use updated shared socio-economic pathways (SSPs), which incorporate socioeconomic assumptions and emissions trajectories. The updated SSPs are outlined in the **MfE Coastal Hazards and Climate Change Guidance** (Ministry for the Environment 2024). The scenarios cover a wide range of plausible societal and climatic futures, from a 1.5°C ‘best-case’ low-emissions scenario (SSP1-2.6) to a high-emissions scenario (SSP5-8.5) with over 4°C of warming by 2100 (Chen et al. 2021). Even under the low-emissions scenario (SSP1-2.6), average SLR around Aotearoa could exceed 1 m shortly after 2200 (Table 6).

Table 3-13: Estimated years when absolute sea-level rise (SLR) thresholds may be reached based on recommended projections for a central location in Aotearoa New. Adapted from the MfE Coastal Hazards and Climate Change Guidance.

SLR (metres)	Year achieved for SSP5-8.5 H+ (83rd percentile)	Year achieved for SSP5-8.5 (median)	Year achieved for SSP3-7.0 (median)	Year achieved for SSP2-4.5 (median)	Year achieved for SSP1-2.6 (median)
0.2	2035	2040	2045	2045	2050
0.3	2050	2055	2060	2060	2070
0.4	2055	2065	2070	2080	2090
0.5	2065	2075	2080	2090	2110
0.6	2070	2080	2090	2100	2130
0.7	2080	2090	2100	2115	2150
0.8	2085	2100	2110	2130	2180
0.9	2090	2105	2115	2140	2200
1.0	2095	2115	2125	2155	>2200
1.2	2105	2130	2140	2185	>2200
1.4	2115	2145	2160	>2200	>2200
1.6	2130	2160	2175	>2200	>2200
1.8	2140	2180	2200	>2200	>2200
2.0	2150	2195	>2200	>2200	>2200

The records were analysed for annual exceedance probabilities (AEP) of storm-tide levels (relative to Bluff Vertical Datum-1955) up to potentially 1% AEP. In parallel, extreme storm-tide level results were also available from a project completed by NIWA for Invercargill City Council on a storm-tide analysis of the Stead Street gauge in Invercargill. These updated AEP storm-tide levels are then available to the councils for improving design levels for coastal stopbanks, roads, stormwater and drainage systems and assessing coastal flood risks.

High-tide exceedance curves for present day were produced from the Bluff record and Stead Street (Invercargill), which can be used to quantify the distribution of all high tides from tide predictions over many decades (excluding weather and climate effects) and then assess the change in these high-tide markers being exceeded by high tides with three example values of SLR (0.2, 0.4 and 0.8 m).

3.6.3 Storm tide extreme value analysis

Storm-tide is defined as the sea-level peak reached during a storm event, from a combination of **tide + storm surge** (Figure 3-9). It is the storm-tide that is primarily measured by sea-level gauges such as the Port of Bluff and Stead Street gauges analysed here.

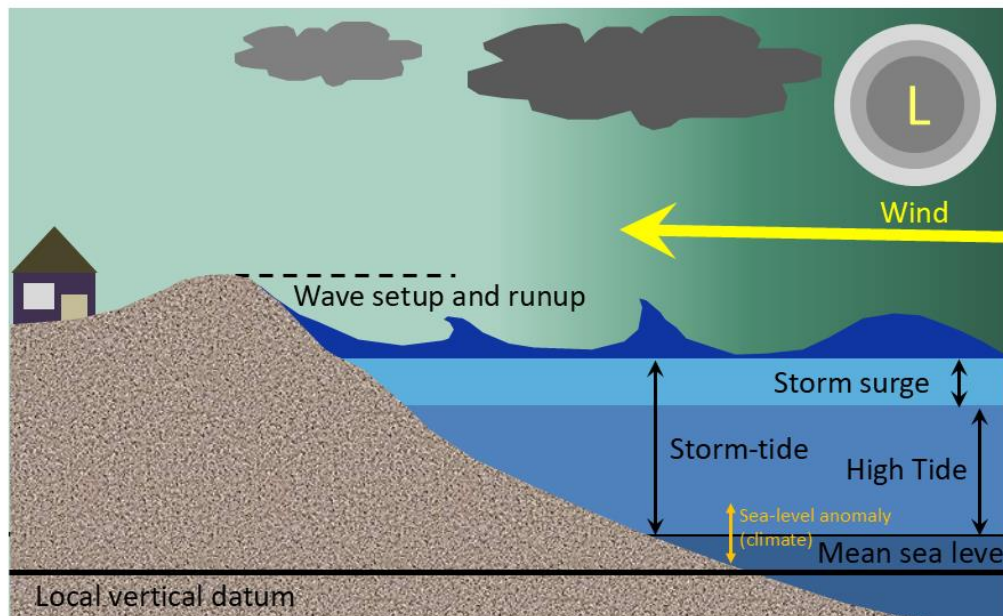


Figure 3-9: Components that contribute to storm-tide and wave overtopping. L= low-pressure weather system.

We subsampled all sea-level data to 1 h intervals after first applying a 15 min running average to minimise the effect of far infragravity and tsunami waves. The data were linearly detrended to a zero-mean relative to local vertical datum for each gauge, to remove the effects of historical SLR from the sea-level distribution and create a quasi-stationary time series required for extreme value analysis (Coles 2001). Therefore, here we define the term “**storm tide**” as the total water level above BVD-55 from the sum of tide plus storm surge.

The extreme value analysis was applied to high water levels, with mean sea-level adjustments incorporated where appropriate. The time series was declustered to isolate statistically independent peak events—defined as local maxima separated by at least three days and with a storm-tide level. These peaks were then analysed using a univariate approach, primarily fitting a Generalised Pareto Distribution (GPD) to values exceeding the 95th percentile threshold. This approach enables the estimation of return levels (with 95% confidence intervals) for the storm-tide itself, without requiring assumptions about the dependence structure between separate processes like surge and tide. By focusing on the storm-tide as an integrated variable, the analysis provides a direct assessment of the water levels most relevant to coastal inundation and stop bank performance under extreme conditions.

For the Bluff site, the GPD fit resulted in a location parameter of 1.44, scale of 0.145, and shape of -0.316 .

In parallel with the GPD method, a Generalised Extreme Value (GEV) distribution was fitted to the annual maxima series at each site. The GEV approach uses block maxima (in this case, one annual maximum per year) and provides an independent validation of the return level estimates derived from the GPD method. Both methods are commonly used for extreme value modelling, and they generally yield similar results. For short records, the GPD makes use of more of the data so can provide better confidence in the fits and reliably extrapolate up to 10 times the record length, at the expense of requiring subjective choice of sampling thresholds. The GEV fitted to annual maxima overcomes the need to choose a threshold but is wasteful of data because it only uses the largest event within the calendar year so is best used on long records—it can reliably extrapolate to return periods of 3–5 times the record length.

At the Stead Street site, the GPD fit did not perform well, likely due to the limited number or quality of peak events above the threshold. As a result, a GEV analysis was applied instead, using annual maximum storm-tide levels. This alternative provided a more stable and representative fit for estimating extreme return levels at this location. The Stead Street GEV fit had a location parameter of 1.98, scale of -0.028 , and shape of 0.098. By employing both GPD and GEV models, the analysis ensures robustness and flexibility in accounting for site-specific data limitations and behaviours.

Once fitted, the extreme-value models can be checked by plotting them against the measured maxima, assuming that the maxima follow a double-exponential (Gumbel) distribution (Gringorten 1963). The maxima should lie within the confidence intervals of the fitted model.

There are two commonly used ways to express the likelihood of occurrence of an extreme sea level:

- Annual exceedance probability (AEP) – The probability of a given (usually high) sea level being equalled or exceeded in elevation, in any calendar year. AEP can be specified as a fraction of 1 (e.g., 0.01) or a percentage (e.g., 1%).
- Average recurrence interval (ARI) – The average time interval (ideally averaged over a long time period and many “events”) that is expected to elapse between recurrences of an infrequent event of a given large magnitude (or larger). A large infrequent event would be expected to be equalled or exceeded in elevation, once, on average, every “ARI” years. The term return period is often substituted for ARI.

3.7 Coastal risk exposure

Coastal flood risk in this study is the frequency and magnitude of property exposure to flood waters. We analyse flood risk using the RiskScape multi-hazard model framework (Paulik et al. 2023a), which is a modular and configurable system designed to evaluate coastal flooding exposure and impacts from extreme sea levels (ESLs) and sea level rise (SLR) under current and projected climate conditions.

3.7.1 Hazard maps

Spatiotemporal maps of episodic flooding from extreme sea-levels (ESLs) for present-day and higher sea levels were obtained from Paulik et al. (2023b). ESL flooding maps represent a 100-year annual recurrence interval (ARI) event i.e., 1% annual exceedance probability (AEP). The mapping process involved extracting digital elevation model (DEM) raster cells situated below ESL and elevations using a static inundation mapping technique (Stephens et al. 2021). A comprehensive national DEM for coastal regions (Paulik et al. 2020, 2021), up to an elevation of 20 m above present-day mean sea levels, was established by amalgamating LIDAR DEMs resampled to a 10-meter resolution and employing a fully convolutional neural network (FCN) model to rectify vertical biases in the Shuttle Radar Topography Mission (SRTM) data (Meadows and Wilson 2021). Flood depth calculations were performed by computing the disparity between ESL water surface heights and land elevations for DEM grid cells. To ensure accuracy, only grid cells with a hydrologic connection to coastlines were considered, thereby minimizing the risk of overestimating inundation extents. Additionally, topographic protection structures like levees were identified from aerial imagery and incorporated into the analysis, albeit without detailed design-level information. Consequently, land protection was assumed up to ESLs corresponding to a 100-year recurrence interval at present-day mean sea level (MSL). This was consistent with statutory flood hazard risk management directed by the New Zealand Coastal Policy Statement (Department of Conservation 2010), which requires regional and local authorities to avoid increasing the risk of social, environmental and economic harm from coastal hazards, over at least a future 100-year timeframe. Future ESL flooding maps were generated incrementally for MSL increments ranging from 0.1 to 2 m, regardless of future projections of RSL rise.

New Zealand RSL projections for Shared Socioeconomic Pathways (SSPs) were obtained from probabilistic RSL projections estimated using the Framework for Assessing Changes to Sea-level (FACTS) from the IPCC Assessment Report 6 (Levy et al. 2023; Naish et al. 2024). These projections, incorporating VLM effects, were based on interferometric synthetic aperture radar (InSAR) data calibrated with campaign and continuous Global Navigation Satellite System (GNSS) measurements. In this study, we investigate land movement effects on flood risk timing and magnitude by selecting RSL projections with and without local VLM for SSP 1 to 5 over 100 years (2020–2120) relative to a 1995–2014 baseline period (0 m at year ~ 2005). RSL projections from Naish et al. (2024) were obtained for 7435 coastal sites from <https://searise.takiwa.co/>. Medium confidence climatic processes for each SSP scenario were represented by RSL curves, which were spatially joined to flood-exposed properties to evaluate the future timing of expected exposure to flood waters.

3.7.2 Exposure maps

Southland property information represented in the national district valuation roll (DVR) was obtained from Environment Southland via South Territorial Authorities. The DVR contains a representation of the boundaries of all known properties in Southland. Property features (i.e., vector polygons) are represented as land parcels and contain identifier information about the property unit and other property perspectives. Information on property ‘zoning’, ‘actual use’, ‘capital value’, ‘improvement value’ and ‘land value’ is reported in this study along with property location based on the corresponding territorial authority.

3.7.3 Exposure calculation

Southland property risk to coastal flooding was evaluated using RiskScape software (Paulik et al. 2023a). RiskScape supports a flexible modelling engine for multi-hazard risk analysis that is centred on a well-established conceptual framework for risk quantification:

$$R = f(H_i, E) \quad (3)$$

where, risk (R) is a function (f) of the consequences from hazard (H) event i exposing a property (E) to flood waters. Property exposure to flood waters (F_E) is determined when:

$$F_E = \begin{cases} 1, & WD < 0.05 \text{ m} \\ 0, & WD \geq 0.05 \text{ m} \end{cases} \quad (4)$$

where, water depth above ground (WD) exceeds a limiting depth of 0.05 m. The limiting depth value accounts for the potential uncertainty of water presence at the flood map grid cell, with water depths >0.05 m indicating a high likelihood of flooding. Southland properties corresponding to $F_E = 1$ are then enumerated at regional and territorial authority levels for each ESL and RSL scenario.

4 Present-day and future climate of Southland

Southland is both the most southern and western part of New Zealand and generally the first to be influenced by weather systems moving onto the country from the west or south. It is well exposed to these systems, although western parts of Fiordland are sheltered from the south and the area east of the western ranges is partially sheltered from the north and northwest. The Southland region is in the latitudes of prevailing westerly winds, and areas around Foveaux Strait frequently experience strong winds, but the winds are lighter inland. Winter is typically the least windy time of year, as well as the driest time of year for many areas.

The western ranges, with annual rainfall exceeding 6,000 mm in some parts, are among the rainiest places on Earth. In contrast, the drier eastern lowlands and hills receive annual rainfall totals predominantly between 500–1,000 mm. Dry spells of more than two weeks occur occasionally. Temperatures are on average lower than over the rest of the country, with frosts and snowfalls occurring comparatively frequently each year. On average, Southland receives less sunshine than the remainder of the country. For more information about Southland's present-day climate other than the information presented in this report, see Macara (2013).

The future climate of Southland will be influenced by a combination of the effects of anthropogenic climate change, plus the natural interannual and interdecadal variability resulting from phenomena such as the El Niño-Southern Oscillation (ENSO), the Interdecadal Pacific Oscillation (IPO), and the Southern Annular Mode (SAM).

5 Climate change impact by industry sectors

5.1 Council Infrastructure

5.1.1 Roads and highway infrastructure

One of the main considerations for roading is a significant decline in frost days, with a potential decline of up to 40 fewer frost days per year by 2090. While this may reduce some winter maintenance costs, higher temperatures and more frequent heatwaves could cause problems for road surfaces, including softening and damage to bitumen.

Southland's transport network is also vulnerable to flooding and storm damage. Projected increases in heavy rainfall, including more very wet days and higher extreme daily and five-day totals, and flood magnitude will raise the risk of bridge and road washouts, particularly where infrastructure is close to rivers such as the Mataura, Oreti, and Aparima.

In addition, coastal roads will face increasing challenges from sea-level rise combined with storm surge, particularly in low-lying urban areas such as Bluff and Riverton, and local flooding. Maintenance and adaptation planning will be needed to manage the growing risks to both inland and coastal transport corridors.

5.1.2 Potable water supply

Much of Southland's potable surface water is sourced from the region's four main rainfall fed rivers: the Waiau, Aparima, Oreti, and Mataura. Increases in the mean annual rainfall and streamflow may make riverine supply more reliable. However, flows into **meltwater-fed lakes** such as **Manapōuri and Te Anau**, which may become less reliable as climate change drives higher temperatures and snowpack losses.

Due to projected reduction in annual average land surface recharge (mainly in the lower Oreti and Mataura FMUs), potential drinking groundwater source in those areas may be increased stress under future warming. While land surface recharge is projected to increase across all shallow aquifers during winter, large decreases are projected during summer months (and a lesser extent spring) potentially exacerbating recently on-going water scarcity in those regions.

At the same time **higher temperatures, more frequent heatwaves, and urban growth** could increase demand for drinking water. And more intense rainfall could raise the risk of contamination of potable water stores. The potential quality and quantity of potable water is impacted by Southland's future climate.

5.1.3 Stormwater and wastewater

Stormwater and wastewater systems in Southland are particularly vulnerable to climate change because their discharge points are typically located at the **lowest elevations of populated areas**. Projected increases in **extreme rainfall intensity and multi-day rainfall totals** could readily exceed current design capacities, leading to system overflows and localised flooding. This risk is especially relevant for towns like **Invercargill, Gore, and Riverton**, where infrastructure is close to rivers and estuaries.

In **low-lying coastal areas**, where groundwater levels are closely linked to the sea, **sea-level rise** could further reduce the performance of both stormwater and wastewater systems. Rising

seas combined with storm surges could increase the likelihood of backflow and reduced drainage capacity.

In urban areas climate change could impact the handling of sewage sludge with increased maximum temperatures combined with increase in green-waste volume (due to increase in favourable growing conditions).

Southland's wastewater systems are more likely to face **persistent increases in inflows and infiltration**, compounding the challenge of managing higher peak loads during extreme rainfall events.

Table 5-1: Infrastructure summary table.

Climate Change Driver	Risks	Opportunities
Decline in frost days (up to -40 by 2090)	Reduced frost heave but potential shift in road maintenance priorities	Lower winter maintenance costs; safer winter travel conditions
Higher temperatures & more heatwaves	Softening and rutting of roading materials; heat damage to roads	Adoption of more heat-resilient road materials and design standards
Heavier rainfall & extreme events	Bridge and road washouts (Mataura, Oreti, Aparima valleys); rural access disrupted	Strengthens case for upgrading culverts, bridges, and flood-resilient designs
Sea-level rise & storm surge (coastal areas e.g. Bluff, Riverton)	Overtopping, erosion, and permanent inundation of coastal roads	Coastal adaptation planning, potential realignment or retreat of vulnerable routes
Increased annual rainfall & streamflow	Possible flooding impacts on water supply infrastructure	Improved reliability of supply from rainfall-fed rivers (Waiau, Aparima, Oreti, Mataura)
Snowpack loss (meltwater-fed lakes Manapouri, Te Anau)	Less reliable inflows affecting drinking water security	Incentive for diversified water storage and supply sources
Hotter summers & urban growth	Rising potable water demand and pressure on supply networks	Promotes water conservation, smart metering, and demand management
More intense rainfall	Contamination of potable water and storage facilities	Investment in upgraded treatment and protection of source water
Extreme rainfall intensity & multi-day totals	Stormwater/wastewater system overflows; localised flooding in towns (e.g. Invercargill, Gore, Riverton)	Incentivises green infrastructure (wetlands, permeable surfaces) to reduce runoff

Climate Change Driver	Risks	Opportunities
Sea-level rise & groundwater interaction	Reduced stormwater/wastewater capacity; saline intrusion and backflow	Opportunity to redesign outfalls, install backflow prevention, and integrate coastal resilience
Persistent inflows & infiltration to wastewater	Greater treatment volumes and costs; bypass risks in wet weather	Sewer renewal programmes and stormwater–wastewater separation
Higher maximum temperatures & more vegetation growth	Increased sewage sludge and green waste volumes to manage	Potential to capture biogas/compost from increased organic waste streams

5.2 Agriculture

Agriculture is central to Southland’s economy, particularly dairy, sheep and beef farming. While many of the climate impacts listed above can indirectly affect these industries, it is worth describing how climate change could directly impact this sector given its importance in the region.

5.2.1 Impacts of warming temperatures on pasture and crops

Southland is projected to experience increases in annual rainfall; nevertheless, projections of **potential evapotranspiration deficit (PED)** suggest the region could face greater water stress in the future. Drier soils may create challenges for farming systems that depend on reliable pasture growth. Even under scenarios where annual rainfall increases, higher temperatures and evapotranspiration rates mean that water demand for irrigation could rise, placing pressure on available water resources.

A plant’s demand for water, and its sensitivity to water stress, varies across its growth cycle. The **timing of drier conditions** is therefore critical: a late-summer drying, after most growth is complete, is far less damaging than a late winter or early spring drought that prevents crops and pastures from reaching their full productive potential.

At the same time, not all impacts of warming are necessarily negative. Higher temperatures will bring an increase in **growing degree days (GDD)**, supporting faster pasture growth and potentially enabling new crop opportunities. The projected **decrease in frost days** may also be beneficial to agriculture by reducing frost damage to sensitive plants and extending the growing season. These positive shifts need to be weighed against the risks of higher PED and increased water stress.

Elevated atmospheric CO₂ may partially mitigate increased PED under limited water supply. The **CO₂ fertilisation effect** reduces water loss through transpiration and improves crop water-use efficiency. Faster growth stimulated by higher CO₂ can also allow some plants to mature earlier, helping them avoid exposure to late-season drying.

Ultimately, the balance of these trade-offs will depend on the crop or pasture system in question. **Bespoke crop and pasture modelling** will be needed to fully assess how increased

GDD, reduced frost days, and higher PED interact to shape productivity and resilience in Southland's farming systems.

5.2.2 Impacts of flooding on pasture and crops

Heavy rainfall events are projected to become more intense in Southland, increasing the risk of land erosion, landslides, and slips. These processes are particularly significant in areas used for agriculture, horticulture, and forestry, where exposed soils and steep terrain make landscapes more vulnerable. Erosion not only reduces the productive capacity of the land but also has downstream effects through sedimentation of rivers and streams. Sediment loading reduces water quality, alters aquatic habitats, and contributes to greater flood risk by raising riverbeds and reducing channel capacity.

For farmers and land managers, these processes translate into **significant economic stress**. Major erosion events can strip away fertile topsoil, reduce pasture productivity, and damage crops, fences, and farm infrastructure. The long-term recovery from such events can be costly, requiring re-grassing, soil stabilisation, and sometimes changes in land use. Horticultural enterprises are particularly vulnerable, as even short-term waterlogging of soils can damage crops, while sediment deposition reduces soil fertility and structure.

In addition to erosion, **pluvial flooding** (caused by extreme rainfall overwhelming drainage capacity) will increasingly affect low-lying farmland. Crops and pastures may be inundated for longer periods, leading to plant stress, reduced yields, and, in severe cases, total loss of production. Livestock systems may also be disrupted, with grazing land unavailable and animal health compromised by wet conditions.

Coastal flooding, driven by a combination of extreme rainfall, storm surge, and sea-level rise, presents another growing risk for Southland's agricultural sector. Coastal farmland is at risk of periodic inundation and saltwater intrusion, which can reduce soil productivity and, over time, make some areas unsuitable for traditional farming practices.

Together, these impacts highlight the dual challenge of managing both the **direct physical damage** caused by heavy rainfall events and the **longer-term productivity losses** that follow. Adaptation will likely require investment in improved drainage systems, soil conservation measures such as riparian planting and erosion control, and, in some areas, shifts to more flood- and salt-tolerant crops or alternative land uses. Catchment-scale approaches to land and water management will become increasingly important in minimising the cascading effects of erosion and sedimentation on both farms and downstream communities.

Table 5-2: Agriculture summary table.

Climate Change Driver	Risks	Opportunities
Warming temperatures & higher PED	Drier soils, greater irrigation demand, pressure on water resources	Improved water-use efficiency; investment in on-farm water storage
Timing of dryness (late winter/early spring)	Reduced pasture growth and crop yields	Adjusted planting/grazing schedules; better drought forecasting
Increased growing degree days (GDD)	Faster pasture turnover may stress farm systems if unmanaged	Longer growing season; potential for new crop opportunities

Climate Change Driver	Risks	Opportunities
Decline in frost days	Fewer natural pest controls, adverse impacts to plants/animals adjusted to frost	Reduced frost damage to crops; extended growing season
Elevated CO₂ (fertilisation effect)	Uneven benefits across species; does not eliminate evaporative drought risk	Improved water-use efficiency and faster plant growth
More intense rainfall & flooding	Soil erosion, landslides, slips, and sedimentation reducing land productivity	Justifies soil conservation practices and riparian planting
Erosion & sedimentation	Reduced water quality, altered aquatic habitats, raised riverbeds increasing flood risk	Catchment-scale land management to protect both farms and downstream communities
Pluvial flooding (overland runoff)	Waterlogging of soils, crop loss, livestock health impacts	Improved farm drainage and flood-adapted land-use planning
Coastal flooding & saltwater intrusion	Loss of productive coastal farmland	Transition to salt-tolerant crops; strategic land-use change or retreat

5.3 Forestry

The Otago–Southland wood supply region is dominated by ***Pinus radiata*** (63%), ***Douglas-fir*** (***Pseudotsuga menziesii***; 26%), and ***eucalypts*** (7%).

5.3.1 Growth and disease

Warming temperatures and a longer growing season are expected to improve ***Pinus radiata*** **growth** in cooler parts of Southland. However, these gains may be offset by increased disease pressure. ***Dothistroma needle blight***, which thrives in moderate temperatures, is projected to become more severe in Southland under climate change, reducing potential productivity gains.

For ***Douglas-fir***, the outlook is less positive. The severity of ***Swiss needle cast*** (***Phaeocryptopus gaeumannii***), the most widespread disease affecting this species, is strongly correlated with warmer winter temperatures. As winters become milder, outbreaks are expected to intensify, reducing Douglas-fir productivity across the region.

5.3.2 Wildfire risk

Climate change is likely to **increase wildfire risk** in Southland's forests. Key contributing factors include:

- Warmer weather, drier soils, and windier conditions that make fuels easier to ignite.
- A longer fire season, starting earlier in spring and extending later into autumn.
- More thunderstorms and lightning, increasing ignition events as possible.

Afforestation with exotic species such as ***Pinus radiata***, a key climate change mitigation strategy, may further heighten fire risk. Exotic conifer and eucalypt plantations burn more

intensely than pasture, shrubland, or most native forests. Among plantation species, ***Pinus radiata*** is particularly fire-sensitive, while **Douglas-fir and eucalypts** are more fire-adapted. In contrast, many indigenous New Zealand plants are relatively non-flammable, offering potential value in fire-resilient landscape planning.

Table 5-3: Forestry summary table.

Climate Change Driver	Risks	Opportunities
Warming temperatures & longer growing season	Productivity gains may be offset by disease outbreaks	Enhanced growth potential for <i>Pinus radiata</i> in cooler parts of Southland
Dothistroma needle blight (<i>Pinus radiata</i>)	More severe infections in Southland under warmer, wetter conditions	Investment in resistant genotypes, improved silviculture, and targeted spraying
Swiss needle cast (Douglas-fir)	Increased severity as winters warm, reducing Douglas-fir productivity	Potential to shift planting zones, trial alternative species better suited to warmer climates
Warmer, drier soils, and windier conditions	Fuels dry faster, making forests more flammable	Stronger fire management planning, fuel reduction, and landscape-scale firebreaks
Longer fire season	Greater firefighting demand and costs; higher risk of large-scale burns	Justifies investment in year-round fire readiness and rapid-response capacity
More thunderstorms and lightning	Increased ignition events	Advanced monitoring, early-warning systems, and fire suppression technology
Afforestation with exotic species (e.g. <i>Pinus radiata</i>, eucalypts)	Exotic plantations more flammable than native shrubland/forest; higher fire hazard	Strategic land-use planning: mix of exotics with less-flammable native plantings for resilience
Species flammability differences	<i>Pinus radiata</i> highly fire-sensitive, Douglas-fir and eucalypts more fire-adapted	Potential to select species mixes that balance growth, economic value, and fire resilience

5.4 Terrestrial biosecurity and infectious diseases

Climate change is widely regarded as one of the greatest challenges facing indigenous ecosystems in the coming century. For Southland, where the economy relies heavily on efficient primary production systems, the risk of exotic pests and diseases affecting agriculture and horticulture must be carefully managed.

5.4.1 Terrestrial biosecurity

A warmer climate could bring new biosecurity challenges by enabling the establishment of pest animals, weeds, and diseases that are currently limited by Southland's cooler conditions. The greatest concern lies with species that already arrive seasonally but fail to establish, along with those already recognised as high-risk invaders.

Although climate change will affect organisms and ecosystems in many ways, temperature is expected to be the most important driver of pest invasions, influenced by rainfall, humidity, and carbon dioxide levels. Regional winds and currents may also play a role by increasing the likelihood of new pests reaching New Zealand and establishing locally.

Some of the world's most damaging invasive ant species, such as the big-headed ant (*Pheidole megacephala*) and the Argentine ant (*Linepithema humile*), are already present in New Zealand. Continued warming could encourage their spread into Southland. Similarly, fruit flies remain a major threat to horticulture, with central and eastern Southland projected to become increasingly suitable for their establishment later this century, though the region will still be less suitable than much of the North Island.

The arrival of new pest plants and the greater invasiveness of existing weeds is also a concern. As frosts become less frequent and more insect pollinators are able to survive warmer winters, a wider range of weed species will be able to establish and compete with native plants. Farmers and growers in Southland may increasingly adopt plant species currently grown further north, while ornamental plants that escape cultivation may naturalise and become invasive under warmer conditions.

It is important to note that while many biosecurity threats may arrive from outside New Zealand, others are already present within the country. These "sleepers" remain at low levels under current conditions but may spread and flourish under a warmer climate. Examples include invasive weeds as well as invertebrates such as the migratory locust (*Locusta migratoria*) and the tropical armyworm (*Spodoptera litura*).

5.4.2 Infectious diseases

The Southland region may face increasing pressure from novel diseases and their vectors as the climate warms. Twelve mosquito species were present before human settlement, and since then four exotic species capable of spreading disease have become established. More than 30 additional exotic mosquito species have been intercepted at national entry points, highlighting the ongoing risk of new arrivals.

Some pathogens carried by ticks and mosquitoes are currently limited in New Zealand by cooler temperatures — for example, *Theileria orientalis* (tick-borne), West Nile virus, and bovine ephemeral fever virus. However, under warmer conditions these diseases can spread rapidly, with the potential for explosive outbreaks once suitable climate thresholds are crossed.

Table 5-4: Summary of terrestrial biosecurity and infectious diseases.

Climate Change Driver	Risks	Opportunities
Warmer climate & fewer frosts	Greater survival and spread of exotic pests, weeds, and diseases	Strengthened biosecurity; investment in monitoring and eradication programmes
Spread of existing pests	Damage to crops, pastures, and horticulture systems	Justifies targeted pest management and development of resistant crop varieties
New invasive weeds & ornamental escapees	Competition with native plants and productive species; increased management costs	Adoption of alternative crops/land uses; expansion of weed biocontrol programmes
Sleeper pests already in NZ (e.g. locusts, armyworms)	Potential outbreaks triggered by warmer conditions	Proactive risk assessments and adaptive farm biosecurity planning
Expansion of insect pollinators under warmer winters	Facilitation of invasive weed spread and establishment	Improved ecosystem monitoring and adaptive management of landscapes
Novel disease vectors (mosquitoes, ticks)	Establishment of new species capable of transmitting disease	Stronger surveillance and vector control measures
Pathogens (e.g. <i>Theileria orientalis</i>, West Nile virus, bovine ephemeral fever)	Risk of outbreaks affecting livestock and human health	Vaccines, treatments, and farmer preparedness programmes

5.5 Fishing and aquaculture

5.5.1 Aquatic Biosecurity

The primary entry pathway for aquatic biosecurity risks into New Zealand remains **international shipping**, through organisms carried in ballast water or attached to ship hulls. Climate change is expected to increase these risks: warmer ocean temperatures and shifting currents may allow marine species — including pests and pathogens not previously seen in New Zealand waters — to arrive, survive, and establish. Around New Zealand, sea temperatures are projected to rise (especially to the west), while seawater pH will continue to decrease. Both factors will influence which organisms can thrive in local ecosystems.

Long-term changes in marine conditions, particularly warmer water, may create new ecological compatibilities and alter host–pathogen relationships. Warmer seas and freshwater systems are known to increase host susceptibility to disease, raising the likelihood of new aquatic diseases emerging in regions such as Southland. This could affect both wild species and aquaculture operations.

5.5.2 Freshwater biosecurity

In freshwater systems, higher water temperatures could favour the expansion of **warm-water pest fish** such as koi carp, goldfish, tench, rudd, and catfish. These species degrade water quality and reduce indigenous biodiversity. Warmer conditions may also facilitate the establishment of tropical aquarium fish that are accidentally or deliberately released into the wild.

Similarly, invasive **warm-climate aquatic plants** such as water hyacinth (*Eichhornia crassipes*) and water fern (*Salvinia molesta*) could expand under rising temperatures, further threatening freshwater habitats.

5.5.3 Emerging risks

As with terrestrial biosecurity, many organisms already present in New Zealand but not currently considered pests could become problematic under a changing climate. Warmer waters and altered ecological balances may provide the trigger for these “sleepers species” to spread and cause new impacts on ecosystems, water quality, and aquaculture.

Table 5-5: Summary Fishing and aquaculture.

Climate Change Driver	Risks	Opportunities
International shipping (ballast water & hull fouling)	Introduction of new marine pests and pathogens	Strengthened port biosecurity, ballast water treatment, and hull management
Warmer sea temperatures	Expansion of invasive marine species; higher disease susceptibility in wild species and aquaculture	Diversification into species that thrive in warmer waters; selective breeding for resilience
Shifting ocean currents	New pathways for exotic species to reach Southland	Enhanced forecasting and regional monitoring of marine biosecurity risks
Ocean acidification (lower seawater pH)	Stress on shellfish and calcifying organisms; altered species competitiveness	Adaptation in aquaculture practices, investment in resilient species and farming systems
Altered host–pathogen interactions	Increased likelihood of aquatic disease outbreaks affecting fisheries and aquaculture	Proactive surveillance, early-warning systems, and improved veterinary responses
Higher freshwater temperatures	Spread of warm-water pest fish (koi carp, catfish, rudd, etc.); degraded water quality and biodiversity loss	Stronger freshwater biosecurity controls; targeted eradication and management programmes
Invasive aquatic plants (e.g., water hyacinth, water fern)	Habitat loss, reduced water quality, competition with native species	Early detection, containment strategies, and use of biocontrol agents where feasible

5.6 Tourism

Changes in **snow cover** are expected to significantly impact the ski industry in Southland and Central Otago. Shorter and less reliable ski seasons will create challenges for operators. However, tourism numbers from Australia may increase as snow cover in Australia declines rapidly, making New Zealand a more attractive option for winter holidays. Beyond skiing, New Zealand's alpine and glacier landscapes may become more appealing as their relative rarity increases globally.

In general, **warmer and drier conditions** are likely to benefit Southland's tourism sector by lengthening the summer season and supporting activities such as hiking, cycling, and nature-based tourism. On the other hand, **wetter conditions, flooding, and extreme weather events** could disrupt visitor access, damage infrastructure, and reduce the attractiveness of outdoor destinations.

A significant portion of Southland's tourism relies on **rivers and lakes**, including activities such as fishing, jet boating, rafting, kayaking, and scenic cruising. Projected changes in river flow – with more water in winter and spring but drier conditions in summer – will directly affect these operations year-round, altering both safety and the reliability of experiences.

Table 5-6: Summary snow cover.

Climate Change Driver	Risks	Opportunities
Declining snow cover	Shorter, less reliable ski seasons; reduced viability for winter sports	Increased Australian visitor numbers as snow declines there; NZ alpine/glacier landscapes gain global appeal
Warmer, drier conditions	Risk of heat stress during peak summer; potential pressure on water resources	Longer summer season; boost to hiking, cycling, camping, and nature-based tourism
Wetter conditions & extreme weather events	Flooding, slips, and storms may damage infrastructure and disrupt visitor access	Incentive to strengthen infrastructure resilience and diversify tourism products
Changes in river flow (wetter winters/springs, drier summers)	Unreliable conditions for fishing, rafting, jet boating, kayaking, and scenic cruising	Potential to extend river-based tourism in winter/spring when flows are higher
Alpine & glacier retreat	Loss of iconic features over time, reducing attraction for some visitors	Increased global rarity may enhance scenic value in the medium term

5.7 Renewable Energy Sector

Climate change is expected to alter hydro-electricity generation in Southland through changes in river inflows, lake storage, and drought risk. Large hydro-generation schemes located in Southland western catchments (Fiordland, western Waiaua) may see more stable or increased inflows (mainly through increase in precipitation), while smaller and local hydro schemes located in eastern and inland FMUs (Waikaia, Mataura, Oreti) may face increased variability through higher drought risk and reduced reliability. Two main risks are identified for the large hydro-generation lakes: i) increased inflow variability due to projected decline of snowpack with warming (reduced spring/summer snowmelt), ii) and increased flood and spill risk due to increased heavy rainfall events forcing spill from hydro-generation lakes.

Climate change is expected to have mixed impact on wind electricity generation across Southland. While little change is expected in term of wind patterns, strong seasonal changes are projected through time and warming for wind speed (decrease in summer and autumn, increase in winter and spring), frequency of windy days and strong wind magnitude (decrease in summer, increase for remaining season). As a result, wind generation could potentially increase under future warming, but changes in wind intensity, and increased seasonal variability could impact electricity supply balance when paired with hydro-lakes inflows.

6 Summary

The global climate system is changing and will continue to change for decades to come. These changes will have implications not only for New Zealand's climate and weather systems but also for freshwater availability for downstream users and for hazard exposure (inland and coastal). Due to the nature of climate change, trends will vary across the country, over the course of the century, and among scenarios of climate change. This report addresses potential impacts of climate change on a range of components of climate, hydrology, marine and coastal processes across Southland using downscaled Global Climate Model (GCM) outputs from 1971–2099 under different global warming scenarios. The combination of six GCMs and three emission scenarios allows us to consider a plausible range of future trajectories of greenhouse gas emissions and climatic responses.

It is not possible to attribute the modelled differences between two time periods (in this report, mid-century and end of century) solely to climate change, as natural climate variability is also present and may add to, or subtract from, the climate change effect. The resulting potential impacts of climate change are presented through averaging of the six model projections, which does reduce the underlying natural variability to some extent. With these caveats in mind, the potential effects of changing climate over this century across the Southland region and Freshwater Management Units (FMUs) are summarised as follows across the different domains for each metric considered:

Climate domain

The projected mean temperature changes across the Southland region increase with time and emissions scenario. Future annual average warming spans a wide range: 0.9–1.4°C by 2050, and 1.8–3.6°C by 2090, largely dependent on scenario. Seasonally, most warming occurs in summer by mid-century and during autumn-winter and summer by the end of century. Changes in maximum and minimum temperature follow similar patterns, with the largest change in the maximum temperature projected during summer (up to 3.9 °C for SSP5-8.5 by the end of century), while the largest change in the minimum temperature is projected during winter (up to 3.6°C for SSP5-8.5 by the end of century). Diurnal range (i.e., difference between daily minimum and maximum temperature) is expected to increase with time and emission scenario, with the largest increase projected for summer and autumn.

Changes in extreme temperatures mirror the average annual signal. The average number of hot days is expected to rise from 3–5 days by 2050 to 6–19 days by 2090. Heatwave days (consecutive days >25°C) are projected to increase — particularly at higher elevations — across all scenarios by up to 8 days by 2050 and up to 36 days by 2090. Conversely, frost days are expected to decline by up to 20 days by mid-century, and by 25–45 days by the end of the century. Growing degree days will increase with time and emissions scenario, with the largest seasonal rise during summer.

Projected changes in rainfall show a marked seasonality and variability across the Southland region. Annual rainfall is expected to increase slightly by mid-century (5%), rising to 8–13% by the end of the century, with larger increases in western and eastern areas. One exception is the Garvie Mountains region (headwaters of the Waikaia River) where annual rainfall is projected to decrease by up to 10% across all scenarios. Seasonally the largest increases are projected during winter and spring (up to 40%), while summer and autumn precipitation is more variable

with increase/decrease (between -20% and + 20%) depending on elevation, location, time and emission scenarios.

By mid-century, the number of wet days may increase slightly (up to 1 day) but decrease by up to 2.5 days by the end of the century. Spatially, increases in wet days occur mainly in the headwaters of the three Waiau hydro-electric generation lakes and coastal Southland. Decreases are concentrated in the eastern Waiau and north of the Hokonui syncline.

The number days where the total precipitation exceeds 10 mm is projected to increase across Southland at all time slices and emission scenarios, except for some areas in the lower Fiordland (Cameron/Princess Mountain ranges) and upper Maitava (Waikaia catchment) where small decreases (up to eight days) are expected for both mid-century and end of century.

The number of very wet days (i.e., days where the total precipitation exceeds 25 mm) is projected to increase across Southland at all time slices and emission scenarios, except for a small area in the eastern Waiau catchment (northern part of the Livingstone/Thomson Mountain range) and lower Fiordland (Cameron/Princess Mountain ranges) where a small decrease is expected by mid-century.

The number of heavy wet days (i.e., days where the total precipitation exceeds 50 mm) is also projected to increase across Southland under all scenarios, with the largest increase in northern Fiordland (north of the Cameron-Princess-Kaherekoau Mountain ranges). This increase is smaller than that for very wet days.

Projected changes in maximum annual 1-day rainfall (Rx1d) rise with time and emissions scenario, reflecting changes in very wet and heavy wet days. Rx1d is expected to increase by an average of 11 mm by mid-century and 23 mm by the end of the century, with local increases of up to 80 mm in the Waiau headwaters.

By mid-century, decreases in annual maximum 5-day rainfall (Rx5d) are projected for the Thomson and Ailsa Mountain ranges (up to 25 mm) while other areas, particularly Fiordland, may see increases of up to 50 mm. At the end of the century, Rx5d is projected to increase across the region, with Fiordland experiencing rises of up to 75–100 mm.

By mid-century the number of dry days may decrease slightly (up to 1 day), mainly in low-elevation areas, except in the three Waiau hydro-electric generation lakes. The number of dry days is expected to increase by up to 2 days by century's end, particularly north of the Hokonui syncline, while Waiau headwaters may see decreases.

Relative humidity is projected to slightly decrease with time and emission scenarios by up to 1%.

Solar radiation is projected to rise slightly (up to 1 W.m⁻²) except under SSP 2-4.5 where a decrease is expected. Seasonally, solar radiation is expected to increase in summer and autumn (by up to 7 W.m⁻² in summer by end of century) and decrease in winter and spring (by up to 4 W.m⁻² in winter by end of century). Spatially, the largest decrease occurs in Fiordland's Darran Range, while the largest increase is across Maitava and Oreti Freshwater Management Units (FMUs).

Cloud cover is expected to decrease slightly (by up to 2%), mainly from October to April, with some minor increases expected for July/August. Fiordland headwaters may see increases mid-

century, while Mataura–Oreti and eastern Waiau experience the largest decreases by the end of the century.

We note that work is ongoing on the wind speed projections, therefore caution is required in using the following results:

Annual average wind speed may rise slightly (up to 4%) across Southland under all scenarios. Seasonally, wind speed is expected to increase in winter and spring (up to 12% in winter under SSP5-8.5) and decrease for summer and autumn (up to 5 % under SSP3-7.0) by the end of the century. Spatially, annual average wind speed may decrease in Fiordland (north of the Franklin Range) and north-east Mataura (Old Man Range), while the largest increases occur north of the Hokonui syncline for the Mataura and Oreti, for most of the Aparima and most of the Waiau River downstream of Manapouri and south of Takitimu mountain ranges.

The number of calm days (i.e., mean wind speed $<1.5 \text{ m.s}^{-1}$) is expected to remain relatively unchanged, with minor seasonal shifts: slight decreases in June–September across scenarios and slight increases by the end of the century for February–March.

Windy days (i.e., mean wind speed $>10 \text{ m.s}^{-1}$) are expected to increase (up to 10 days annually) especially during June–October (up to 3 days per month by the end of the century). Changes in windy days are spatially variable; northern Fiordland may experience reductions (up to 20 days/yr), while most of the Mataura-Oreti-Aparima and Waituna may experience increases (up to 20 days/yr). Strong wind changes (99th percentile) are likely to follow similar patterns.

Southland’s prevailing wind direction - typically spanning the westerly quarter (from northwest through to southwest) - is projected to remain unchanged through time and warming.

Changes in meteorological drought (assessed using Potential Evaporation Deficit or PED) indicate Southland will experience increased drought: limited under SSP2-4.5 (up to 7 mm) and greater under higher emission scenarios (up to 23 mm). Spatially, the headwaters of the Waikaia River may see the largest increase (up to 150 mm under SSP5-8.5), with smaller changes elsewhere. Conversely, the probability of annual PED accumulation $>200 \text{ mm}$ reflects similar trends: the Waikaia and upper Mataura may exceed 200 mm by at least 50%, while coastal Oreti and Waituna catchments may see decreases (up to 20%).

Changes in rainfall intensity correlate with temperature changes: mid-century rainfall intensity increases range from 4.8% (2-year ARI, 1-hour event) to 18% (100-year ARI, 1-hour event); by century’s end the range is 16% to 46% for the same events.

Probable Maximum Precipitation (PMP) is projected to change linearly with mean annual air temperature at a rate of 8.34% per °C, regardless of scenario or storm duration.

Cryosphere domain

Changes in snow volume reflect changes in precipitation and temperature. Decreases in snow volume are expected to reach at least 50% across Southland mountain ranges by mid-century for SSP3-7.0 and SSP5-8.5, with smaller reductions in the lower-elevation range of the Waiau and the Garvie mountain range under SSP2-4.5. By the end of the century and regardless of the level of warming, snow volume is projected to decrease by at least 50% across Southland.

Changes in the number of snow days are projected to remain largely unchanged by the 2050s across emission scenarios, although the northern headwater mountain ranges are projected to

experience a reduction of up to 30 snow days. Similar spatial patterns are projected for the end of the century with greater reductions in snow days under higher-emission scenarios. The Garvie Mountains (Mataura) are projected to experience snow day reductions of at least 90 days.

Snow line is expected to rise across Southland mountain ranges over time and under all emission scenarios. By mid-century, the snow line is expected to increase by up to 300 m across Southland regardless of scenario. By the end of the century, snow line is expected to increase by approximately 400–670 m depending on the level of warming. While snow may persist on the highest mountain ranges, it is projected that lower mountain ranges will have fewer than 90 days of snow cover by the end of the century.

Hydrology domain

The bias-corrected hydrological modelling chain is judged appropriate for use in this project. The hydrological bias correction was undertaken using a simple method that aims to match the long-term average riverine and cryospheric metrics across Southland rivers. This method allowed the bias-corrected model to adequately reproduce the mean flow metrics for all natural flow catchments. The bias corrected models also matched the mid- to lower-end values of the high flow metrics (95th percentile of non-exceedance) and the mid- to high-end values of the low flow metrics (25th percentile of the annual flow time series) for the natural flow catchments. However, the bias corrected models were less able to reproduce the more extreme flows, i.e., the lowest values for the low flow metrics, or the highest values for the high flow metrics. This indicates that further work is required to ensure the adequacy of the bias correction methods for these more extreme flow conditions.

Mean annual flood is projected to increase across nearly all Southland River reaches (at least 95%), with the greatest increases by the end of the century under SSP5-8.5 (up to 42%). While the magnitude of mean annual flood is projected to decrease for a small pocket within each FMU, flood magnitude is projected to decrease for the headwaters of the Waikaia catchment (Mataura FMU).

Changes in the magnitude of the Q5 (i.e., river flow magnitude exceeded five percent of the time) and of the Q25 (i.e., river flow magnitude exceeded twenty-five percent of the time) reflect changes in mean annual flood albeit with a reduced range of magnitude (up to 20% for changes in Q5 and up to 9% for changes in Q25), suggesting a possible shift in the distribution of high flows under warming conditions.

Changes in the average annual number of Fre3 events are projected to vary across Southland rivers depending on location, time and emission scenario. By the end of the century under SSP5-8.5, the number of annual Fre3 events is projected to increase by between one and two events across all FMUs, except the Waiau FMU for which the increase is limited to one additional event. Spatially, decreases are projected for up to 11% of river reaches across Southland with decreases of up to five events in some areas of the Aparima and Mataura FMUs.

Changes in the magnitude of mean discharge reflect changes in average annual precipitation. The magnitude of the mean flow is projected to increase across nearly all Southland river reaches (at least 90%), with the greatest increases by the end of the century under SSP5-8.5 greenhouse gas concentration scenarios (average increase of 15% across Southland rivers).

However, the magnitude of mean flow is projected to decrease for several reaches within each FMUs (up to 16% in the Waiau FMU and 23% in the Mataura FMU).

Changes in annual flows were considered in terms of changes in mean annual flows (more sensitive to extremes) and median annual flows. Across most Southland rivers, mean annual flow is projected to increase, with the greatest increases by the end of the century under SSP5-8.5 (average increase of 15% across Southland rivers). A notable difference occurs in the lower Mataura River, whereby the end of the century under very high greenhouse gas concentration scenarios, median annual flows are projected to increase by 10%, while mean annual flows are projected to increase only by up to five percent. The magnitude of mean annual flow is projected to decrease in some areas within each FMU (e.g., up to 17% of the reaches in the Mataura and Waiau FMUs).

The magnitude of seasonal average flows is projected to increase across nearly all Southland rivers in every season except summer, with the greatest increases by the end of the century under SSP5-8.5 (average increase of at least 30% across Southland rivers). In contrast, the direction of change in summer flows is projected to vary with time and scenario, while the magnitude of change is limited to a range of -5 to 5%. Regardless of time and scenario, summer average flows are predicted to decrease in the Waiau and Fiordland FMUs, and across the Mataura FMU by the end of century under SSP3-7.0 and mid-century under SSP5-8.5. Summer flows across the Aparima and Oreti FMUs are projected to increase regardless of time and scenarios. Overall, changes in seasonal average flows suggest a possible larger shift in Southland rivers' hydrological regimes under warming conditions, with spatial differences identified across FMUs.

Changes in the magnitude of the Q75 (i.e., river flow magnitude exceeded seventy-five percent of the time) and Q95 (i.e., river flow magnitude exceeded ninety-five percent of the time), shows a different spatial pattern to the mean flow. Both metrics are projected to decrease by the end of the century under high (SSP3-7.0) and very high (SSP5-8.5) greenhouse gas scenarios, with average decrease up to 6% across Southland rivers. However, while Q75 is projected to increase across the Fiordland FMU, and to a lesser extent the Aparima and Waituna FMUs, Q95 is projected to increase only for the Fiordland FMU. Overall, changes in low flow metrics associated to changes in seasonal average flows suggest a possible larger shift in Southland rivers' hydrological regimes under warming conditions, with spatial differences identified across FMUs.

Changes in the magnitude of mean annual 7-day low flow vary across Southland rivers in both direction and magnitude. At FMU scale, the largest decrease in mean annual 7-day low flow is predicted across the Waiau FMU by mid-century under SSP3-7.0 (-11.1%), while the largest increase is predicted across the Aparima FMU by the end of the century under SSP2-4.5 (+50%). Spatially, mean annual 7-day low flow is expected to decrease by at least 23% for most reaches located in the Oreti and Mataura main stems by mid-century under SSP3-7.0. Mean annual 7-day low flow is projected to decrease in parts of every FMU (up to more than 60% across all FMUs, except for the Waituna FMU). These changes point to significant shifts in low flow hydrological regimes across Southland rivers under emission scenarios.

Changes in the magnitude of flow reliability vary across Southland rivers in both direction and magnitude. At FMU scale, the largest decrease in flow reliability is predicted across the Aparima, Waituna and Mataura FMUs by end of century under SSP2-4.5 (up to at least -0.05),

while the largest increase is predicted across the Waiau FMU by the end of the century under all emission scenarios (+ 0.02). Spatially, flow reliability is projected to decrease across at least 69% of the reaches in every FMU, with the largest decrease projected in the Aparima-Oreti and Mataura main stems (up to -0.08) by the end of century under SSP5-8.5. Changes in flow reliability point to river water being less consistently available to meet environmental or water-use needs under future warming, reflecting a shift towards greater variability and uncertainty in water regimes.

Changes in the magnitude of water supply reliability vary across Southland rivers in both direction and magnitude. At FMU scale, the largest decrease in water supply reliability is predicted across the Aparima, Waituna and Mataura FMUs by end of century under SSP2-4.5 (up to at least -0.05), while the largest increase is predicted across the Waiau FMU by the end of the century under SSP2-4.5 and SSP5-8.5 (+ 0.01). Spatially, water supply reliability is projected to decrease for most FMU river main stems (up to -0.1) by end of century under SSP5-8.5. Changes in water supply reliability extend changes in flow reliability and indicate river water will be less consistently available to meet water demand during the irrigation season, likely increasing the frequency of water-use shortages under future warming.

Changes in the magnitude of land surface recharge vary across Southland shallow aquifers in both direction and magnitude. At annual and FMU scale, land surface recharge is projected to decrease across the Oreti FMU with warming (up to -6%), with the largest increase in land surface recharge predicted across all other FMUs under all emission scenarios (up to 12.6% for the Aparima by end of century under SSP5-8.5). At seasonal scale, land surface recharge is projected to increase during autumn and winter across all FMUs through time and emission scenarios, except for small pockets within the Oreti and Waiau FMUs. In summer, however, land surface recharge is projected to decrease with warming across most shallow aquifers in the Oreti (except the Five Rivers aquifer), Waituna and lower Mataura FMUs (by up to 50% for some aquifers under SSP5-8.5). In spring, decreases in land surface recharge are limited to parts of the lower Oreti and Waiau aquifers, specifically under SSP5-8.5. Overall, decreases in spring and summer land surface recharge points to intensifying risks of hydrological and agricultural drought, water scarcity (e.g., access to groundwater resource for drinking water supply in the lower Mataura), and ecosystem stress across the Oreti-Waituna and lower Mataura FMUs under future warming.

Magnitude of the maximum daily and hourly annual peak discharge is generally projected to increase with time, warming and return period across Southland rivers, noting that for some locations the largest rises occur under SSP3-7.0 rather than the SSP5-8.5 scenario. These results mirror the changes in precipitation extremes.

Magnitude in peak daily discharge associated with 12hr and 24 hr duration PMP (referred as 12hr PMF and 24 hr PMF) is projected to increase with warming. Under a 1°C warming scenario, most FMUs, except the Mataura FMU, are projected to experience an increase between 10 and 20% in the magnitude of the PMFs (independently of the event duration). Spatial differences in changes to the 12hr and 24 hr PMF magnitude are more pronounced for warming greater than 2°C, with the largest changes predicted for the Mataura FMU because of the timing of the PMP event (winter PMP). While changes in PMF across different storm durations generally follow the same pattern as rainfall depth changes predicted by the HIRDS tool, changes in PMF are predicted to not increase with storm duration at some locations. This may be due to the methodology used to predict climate-change adjustments to PMP rainfall depths across

duration. Further investigations are needed to understand these changes and better characterise the impacts of rarer rainfall events.

Stream temperature is projected to increase uniformly across Southland rivers with time and warming, at both annual and seasonal time scale. Spatially, the largest increases are projected under SSP5-8.5 at the outlets of the main river stems (up 4°C), while the lowest increases are projected in the upper reaches of FMUs (up to 1°C). These changes directly reflect changes in air temperature at both annual and seasonal time scale and signal greater stress on freshwater ecosystems.

Intercomparison of the CMIP5-CMIP6 changes in hydrological metric projection

Intercomparison of the magnitude of the projected change in three hydrological metrics (mean annual flood, annual and seasonal average discharge and water supply reliability) was carried out between the CMIP5 derived assessment and this assessment. As per the atmospheric analysis, the intercomparison was completed for two scenarios producing similar levels of CO₂ by the end of the century. The scenarios considered were RCP4.5 (CMIP5) versus SSP2-4.5 (CMIP6) and RCP8.5 (CMIP5) versus SSP3-7.0 (CMIP6). While the CMIP5 assessment was developed using a non-bias-corrected modelling chain, the CMIP6 assessment uses a bias-corrected modelling chain. The bias correction methodology does not affect the intercomparison of changes in river flow metrics. The key messages relevant to the Southland region are:

- Change in the magnitude of mean annual flood under CMIP6 are generally smaller than those projected under CMIP5. However, the spatial distribution of these changes differs, especially under the lower-emission scenario, mean annual flood projected to decrease up to 50% under RCP4.5 (CMIP5) for the upper Oreti FMU by the end of the century, while increases of up to 20% are projected under SSP2-4.5 (CMIP6).
- Changes in annual average discharge remain similar under the lower-emission scenario for the Mataura FMU. However, while little change is projected for the remaining Southland main rivers under RCP 4.5 (CMIP5), increases of up to 20% are projected under SSP2-4.5 (CMIP6). Under higher emission scenarios, similar magnitudes of change are projected under RCP8.5 (CMIP5) and SSP5-8.5 (CMIP6), except for the Mataura FMU, where little change or a decrease is projected under CMIP6.
- While differences in the magnitude of change are noted for seasonal average flow, with smaller changes projected under CMIP6, differences in spatial distribution and direction of change are identified depending on the emission scenario, as follows:
 - Winter flows are projected to decrease for the Waikawa catchment under CMIP6, while winter flows are projected to increase under CMIP5. Winter flows are projected to increase in lower Mataura and Oreti FMU under SSP2-4.5 (CMIP6), with little change projected under RCP4.5 (CMIP5) for those locations.

- Changes in summer discharge are consistent between the two assessments for the Maitava FMU. However, differences in the direction of the change are projected for the Aparima, Oreti and Waiau FMUs particularly under higher-emission scenarios.
- Changes in spring discharge are consistent between the two assessments with differences only in the magnitude of change.
- Changes in autumn discharge are not spatially consistent between the two assessments, particularly for the Aparima, Oreti and Maitava FMUs, with increases in autumn discharge projected under RCP4.5 (CMIP5), while decreases are projected under SSP2-4.5 (CMIP6).
- The magnitude of absolute change in water supply reliability is consistent across both assessments. However, differences in the direction of the change are identified for both emissions scenarios, with water supply reliability projected to decrease across most rivers under RCP8.5 (CMIP5) while increasing under SSP5-8.5 (except for the lower Oreti FMU).

Sea-level domain

Tidal analysis showed differences in the tidal characteristics at Bluff and Stead Street, with Bluff experiencing a larger tidal range. High-tide exceedance curves were used to identify how often high tides might reach critical elevations, and these were then adjusted to reflect projected sea-level rise. Additionally, storm-tide levels—caused by the combined effects of tide, storm surge, and wave setup—were statistically modelled for both locations. Bluff was found to be more exposed to extreme sea levels under storm-tide conditions, which are expected to become more frequent as sea levels rise.

Historical observations from Bluff and Stead Street show a clear and ongoing rise in mean seas level, consistent with trends observed elsewhere in New Zealand. While year to year variability remains high, recent decades show higher average sea levels than earlier periods, increasing the frequency of coastal flooding during high tides and storm events.

Future projections, based on IPCC AR6 scenarios and data from the NZSeaRise programme, indicate that sea levels will continue to rise under all emission pathways. These projections include estimates of when critical sea-level thresholds (e.g., 0.2 m, 0.6 m, and 1.0 m above 2020 levels) are likely to be reached, both with and without adjustments for local vertical land movement—information that is essential for future risk and infrastructure planning.

This sea-level analysis highlights the increasing exposure of coastal communities and infrastructure to flooding and erosion hazards. It provides important information to inform planning, infrastructure investment, and risk management decisions across Southland. The modelling shows that Southland property exposure to coastal flooding (with a 100-year ARI) will increase anywhere from 20% to 76% over time, under different emission scenarios and if land subsidence over the next 100 years. The results underline the need for proactive adaptation measures that consider not only global sea-level rise but also local land movement and extreme events.

Marine domain

Sea surface temperatures (SSTs) are projected to increase over time and under all emission scenarios due to anthropogenic greenhouse gas emissions. By the end of the century, SSTs are projected to increase by up to 1°C under the low-emission stabilisation scenario (SSP1-2.6) and by more than 3°C under SSP3-7.0.

Linked to SST change, marine heatwaves are expected to increase over time and under all emission scenarios. By the end of the century, marine heatwave intensity is projected to increase by up to 0.5°C under SSP1-2.6 and exceed 2 °C under SSP3-7.0. Conversely, the frequency of marine heatwaves is expected to increase from 15–30 days per year (under current climate conditions) to 120–200 days per year under SSP1-2.6 and up to 365 days per year under SSP3-7.0.

The below table is provided in this Executive Summary to assist readers interested in the key findings for each Freshwater Management Unit (FMU).

7 Glossary of abbreviations and terms

Anthropogenic	Originating in human activity
ARI	Average recurrence interval. The average time interval (averaged over a very long time period and many "events") that is expected to elapse between recurrences of an infrequent event
Bias-corrected	The process of using observations (e.g. data from existing climate stations, or streamflow stations) to calibrate climate model or climate-hydro modelling chain simulations. This ensures climate model or hydrological output resemble a given location's climate and weather/ hydrological characteristics appropriately
CCAM	Conformal Cubic Atmospheric Model, which uses dynamical downscaling to simulate climate and weather at finer resolutions than GCMs. Developed by CSIRO in Australia
Climate variable	An element of the climate that is liable to vary or change, e.g. temperature, rainfall
CMIP5	Fifth Coupled Model Intercomparison Project. This project involved a number of experiments with coupled atmosphere-ocean global climate models, most of which were reported on in the IPCC Fifth Assessment Report, Working Group I
CMIP6	Sixth Coupled Model Intercomparison Project. This project involved a number of experiments with coupled atmosphere-ocean global climate models, most of which were reported on in the IPCC Sixth Assessment Report, Working Group I
Downscaling	Deriving local climate information from larger-scale model or observational data. Two main methods exist – statistical and dynamical. Statistical methods develop statistical relationships between large-scale atmospheric variables (e.g., circulation and moisture variations) and local climate variables (e.g., rainfall variations). Dynamical methods use the output of a regional climate/weather model driven by a larger-scale global model
Ensemble	Referring here to the collection of six GCMs that were selected for downscaling and bias-correction in New Zealand
GCMs	Global Climate Models
IPCC	Intergovernmental Panel on Climate Change. This body was established in 1988 by the World Meteorological Organisation (WMO) and the United Nations Environment Programme (UNEP) to objectively assess scientific, technical and socioeconomic information relevant to understanding the scientific basis of risk of human-induced climate change, its potential impacts and options for adaptation and mitigation. One of its major outputs is regular assessments of the climate system and our knowledge of climate change, known as Assessment Reports

Radiative forcing	The difference between the energy entering our atmosphere and the energy leaving it. If the number is greater than zero, our atmospheric temperature can increase
RCPs	Representative Concentration Pathways. These comprise scenarios used in CMIP5 modelling. They describe four possible climate futures represented by the concentration of greenhouse gases in the atmosphere, all of which are considered possible depending on how much greenhouse gases are emitted in the years to come. The four RCPs, RCP2.6, RCP4.5, RCP6, and RCP8.5, are named after a possible range of radiative forcing values in the year 2100 relative to pre-industrial values (+2.6, +4.5, +6.0, and +8.5 W m ² , respectively)
Seven-station series	This refers to seven long-term temperature records used to assess New Zealand's warming on the century time-scale. The sites are located in Auckland, Wellington, Masterton, Nelson, Hokitika, Lincoln, and Dunedin
SSPs	Shared Socioeconomic Pathways. These comprise scenarios of projected socioeconomic global changes up to 2100, used in CMIP6 modelling
SST	Sea-surface temperature. The temperature of the uppermost layer of the ocean

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Hon Simon Watts

Minister of Climate Change
Minister of Local Government
Minister of Revenue
Minister for Auckland



Dear Mayors, Chairs and Chief Executives,

I am writing regarding the use of climate change assumptions in council planning, infrastructure investment, asset management, and regulatory decision-making.

The Government expects councils to continue planning for climate risks and ensuring communities are resilient to future climate impacts. Climate adaptation remains an important responsibility of local government.

However, the Government is increasingly concerned that some climate-related planning and investment decisions may be relying on high-end emissions scenarios in a way that results in unnecessary costs being imposed on ratepayers, businesses, and communities.

Recent international assessments indicate that SSP5-8.5 and its predecessor RCP8.5 are best regarded as less likely, high-impact emissions scenarios that are useful for stress testing and contingency planning. They should not automatically be treated as the central or most likely future when making decisions that affect infrastructure investment, land use, property rights, or rates.

New Zealand faces significant infrastructure challenges. Every dollar spent on resilience measures is a dollar that cannot be spent on fixing roads, upgrading water infrastructure, improving community facilities, or reducing pressure on rates. Councils must therefore ensure climate-related decisions are proportionate, evidence-based, and represent value for money.

Accordingly, the Government expects councils to:

- Use a range of credible climate scenarios when assessing infrastructure and planning decisions, including medium and high-end scenarios.
- Clearly identify which scenario has been adopted as the primary planning assumption and explain why.
- Demonstrate the additional costs associated with higher-end climate assumptions and disclose the impact on rates, debt, and long-term affordability.
- Prioritise adaptive pathways and staged investment approaches wherever practical, rather than defaulting to immediate construction of infrastructure designed solely around worst-case assumptions.

- Ensure that regulatory decisions affecting landowners, businesses, and communities are supported by robust evidence and are proportionate to the risks being managed.
- Subject major climate-driven capital expenditure proposals to rigorous cost-benefit analysis and independent challenge.

The Government's expectation is clear: councils should plan for climate risks, but they must also plan for affordability.

High-end scenarios such as SSP5-8.5 remain useful for testing resilience and understanding extreme risks. However, the Government does not consider it appropriate for worst-case assumptions to become the default basis for investment decisions that impose significant costs on current and future ratepayers.

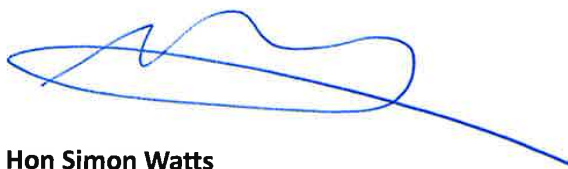
Councils should be able to demonstrate that climate-related investments are necessary, proportionate, and represent the best use of scarce public resources.

The Government will work with the sector to improve consistency and transparency in climate-related planning and infrastructure decisions. I have directed officials to undertake a stocktake of current council practices and provide advice on whether additional national direction, reporting requirements, or legislative changes are required to ensure climate-related decisions appropriately balance resilience, affordability, and value for money for ratepayers.

New Zealanders rightly expect councils to prepare for future risks. They also expect councils to avoid unnecessary gold-plating, focus on practical solutions, and exercise discipline when spending ratepayer money.

I encourage elected members and council executives to review their current planning assumptions and decision-making frameworks considering these expectations.

Yours sincerely,



Hon Simon Watts
Minister of Climate Change

Cc: Hon Chris Bishop
Minister Responsible for RMA Reform



Invercargill City Council

GREENHOUSE GAS

INVENTORY REPORT

Prepared in accordance with ISO 14064-1:2018

1 July 2024 – 30 June 2025

VERSION 1.4

AUDIT STATUS Unaudited

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Invercargill City Council

GREENHOUSE GAS

INVENTORY REPORT

Prepared in accordance with ISO 14064-1:2018

PREPARED BY Jamie Harknett BA MCCSP, Carbon and Energy Consultant, CarbonEES

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APPROVED BY Rhiannon Suter, Manager – Strategy, Policy and Engagement, Invercargill City Council

Disclaimer: This greenhouse gas inventory report has been prepared by Energy and Technical Services Ltd (CarbonEES) for informational purposes. Every effort has been made to ensure that the report is accurate and has been prepared in accordance with ISO 14064-1:2018. However, CarbonEES assumes no liability for any reliance placed on this report, nor for any error or omission from this report.

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Greenhouse Gas Emissions Inventory Summary

Purpose of this report and limitations

Invercargill City Council (ICC) commissioned CarbonEES to calculate its organisational greenhouse gas inventory for the government financial year 2025 (1 July 2024 to 30 June 2025).

The purpose of this report is to transparently disclose ICC's GHG emissions and how they are quantified.

This report was prepared in accordance with the requirements of international standard ISO 14064-1:2018.

In Invercargill City Council's (ICC) financial year 2025 (FY24/25, 1 July 2024 to 30 June 2025), ICC's total greenhouse gas (GHG) emissions were 38,978 tonnes of CO₂e (tCO₂e), across ISO 14064-1:2018 Categories 1, 2, 3, and 4.

This is a 150 percent increase from 15,590 tCO₂e in FY20/21, ICC's base year, and a 105% increase from 18,991 in FY22/23. However, this degree of increase in reported emissions is due to a multitude of factors and is not necessarily reflective of business as usual operations, nor always of genuine emission increases. Changes in methodology, updates to emission factors, greater quality of data, and an increase in the scope of activities measured have all contributed to this increase in emissions. It is key to note that an increase in the scope of activities measured is a good thing in greenhouse gas reporting, even though it results in an apparent increase in emissions. It is also important to note that as data is only measured every two financial years, there can be limited confidence in any apparent trends. To gain more insight, inventories should be developed every financial year.

The emissions profile can be seen in Figure 1, which shows a breakdown of ICC's organisational emissions by each Category, comparing FY24/25 against previous reporting periods. Table 1 summarises the same emissions in written form, including indication of the percentage change between FY24/25 and the previous reporting periods. Table 3 breaks each Category into its activities. To clearly display the impact purchased goods and services and capital goods have on the emissions profile, Figure 2 and Table 2 separate these out from the rest of Category 4. Like other changes in the report, these are influenced by changes in spend and consumption, but in this case are also strongly influenced by change in methodology as higher quality emission factors are developed. A high degree of uncertainty also accompanies the emissions factors as they are spend-based.

A consistent colour scheme regarding the emission Categories has been applied to the figures and tables throughout this report. Blue indicates Category 1 – Direct Emissions, green indicates Category 2 – Imported Energy Indirect Emissions, yellow indicates Category 3 – Indirect Emissions from Transportation, and orange indicates Category 4 – Indirect emissions from products used by an organisation. Figures have been rounded to the nearest integer.

Figure 1: Organisational gross emissions FY20/21 - FY24/25 in tCO₂e.

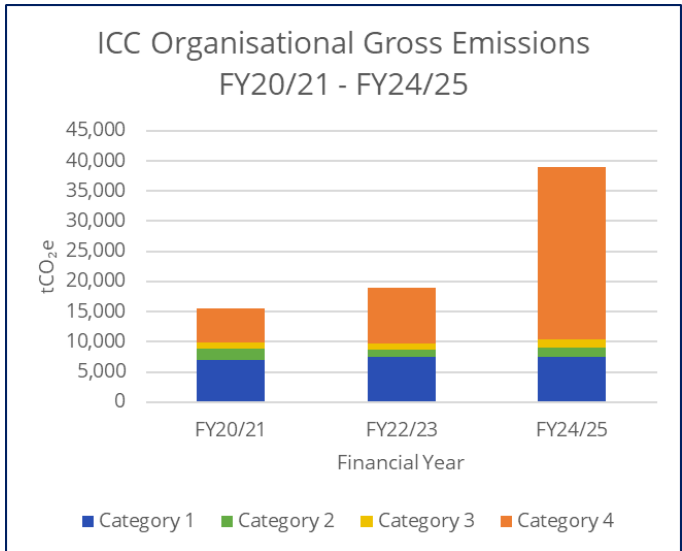


Table 1: Emissions by Category in tCO₂e, FY20/21 – FY24/25.

Emissions Category	FY20/21	FY22/23	FY24/25	% Change between FY20/21 and FY24/25	% Change between FY22/23 and FY24/25
Category 1	6,919	7,462	7,463	8%	<1%
Category 2	1,943	1,213	1,622	-17%	34%
Category 3	1,104	965	1,298	18%	35%
Category 4	5,624	9,352	28,595	408%	206%
Total	15,590	18,991	38,978	150%	105%

Greenhouse Gas Emissions Inventory Summary

Figure 2: Organisational gross emissions excluding PGaS and CAPEX FY20/21 - FY24/25 in tCO₂e.

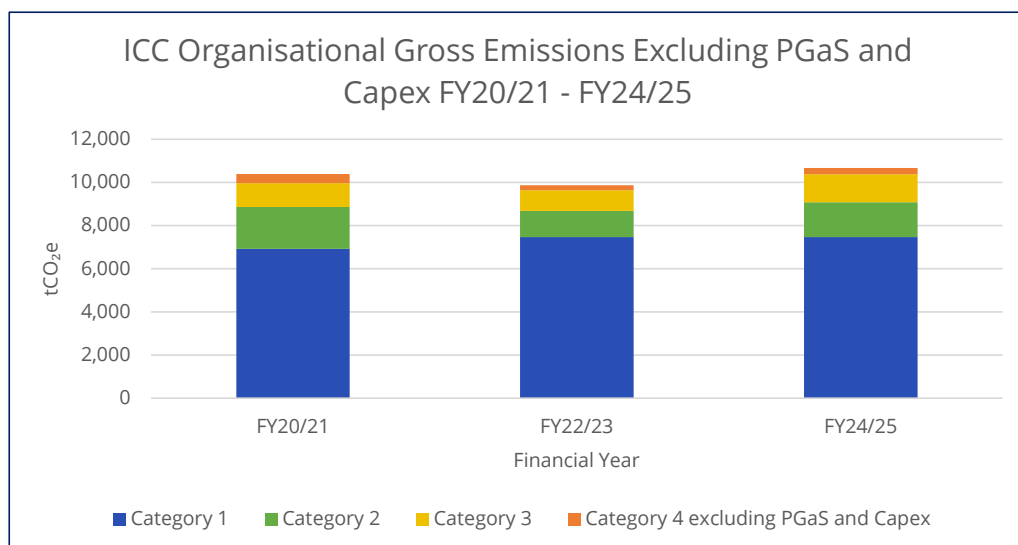


Table 2: Emissions by Category in tCO₂e with Purchased Goods and Services (PGaS) and Capital Expenditure (CAPEX) separated, FY20/21 - FY24/25.

Emissions Category	FY20/21	FY22/23	FY24/25	% Change between FY20/21 and FY24/25	% Change between FY22/23 and FY24/25
Category 1	6,919	7,462	7,463	8%	<1%
Category 2	1,943	1,213	1,622	-17%	34%
Category 3	1,104	965	1,298	18%	35%
Category 4	419	230	291	-30%	27%
PGaS	4,800	5,915	10,170	112%	72%
CAPEX	405	3,207	18,134	4,375%	465%
Total	15,590	18,991	38,978	150%	105%

Greenhouse Gas Emissions Inventory Summary

Table 3: GHG Inventory by Category and activity in tCO₂e, FY24/25 compared to base year FY20/21. NM = not measured.

Emissions Category	FY20/21 tCO ₂ e	FY22/23 tCO ₂ e	FY24/25 tCO ₂ e
Category 1 - Direct Emissions			
Wastewater Treatment Plants	5,999	6,825	6,653
Mobile Fuel Combustion (Fleet)	231	183	166
Fuel (Stationary)	398	200	265
LPG	114	125	120
Woodchips	59	60	154
Agricultural Emissions	117	65	101
CO ₂	NM	NM	4
Refrigerants (404A)	NM	4	NM
Total	6,919	7,462	7,463

Category 2 - Imported Energy Indirect Emissions			
Purchased Electricity	1,943	1,213	1,622
Total	1,943	1,213	1,622

Category 3 - Indirect Emissions from Transportation			
Downstream Transportation and Distribution	803	525	888
Air Travel	43	123	71
Other Business Travel	6	6	6
Employee Commuting and Working from Home	253	311	334
Total	1,104	965	1,298

Category 4 - Indirect emissions from products used by an organisation			
Purchased Goods & Services	4,800	5,915	10,170
Capital Goods	405	3,207	18,134
Upstream Fuel and Energy-Related Activities	327	184	213
General Waste and Recycling	7	≤1	39
Wastewater Treatment Plants (Sludge Disposal)	84	45	39
Total	5,624	9,352	28,595

1.0 Introduction

This report is a greenhouse gas (GHG) inventory report for Invercargill City Council (ICC) for the period 01 July 2024 to 30 June 2025. ICC commissioned CarbonEES in June 2025 to calculate its organisational GHG inventory for its financial year 2025 (FY24/25).

A GHG inventory is a list of emission sources and their associated emissions, quantified using standardised methods. The emissions included in this GHG inventory are emitted due to activities under the operational control of ICC during the reporting period.

The purpose of this report is to transparently disclose these GHG emissions and how they are quantified.

A consistent colour scheme regarding the emission Categories has been applied to the figures and tables throughout this report. Emission categories. Blue indicates Category 1, green indicates Category 2, yellow indicates Category 3, and orange indicates Category 4. Figures have been rounded to the nearest integer.

1.1 Statement of Intent

ISO 14064-1:2018, 9.3.1 (r)

CarbonEES is committed to preparing transparent and consistent carbon accounting and reporting in line with global best-practice. Therefore, ICC's GHG inventory has been prepared in accordance with the requirements of ISO 14064-1:2018.

This report specifically relates to the emissions of ICC and has been prepared as part of their carbon reduction journey. To ensure this report is fit for purpose, ICC has identified its intended uses and users. These have been listed in Table 4 and have informed how CarbonEES formulated this report.

Table 4: ICC's intended use cases and intended users for this GHG inventory report.

Intended users of this GHG Inventory Report	Intended uses of this GHG Inventory Report
- ICC officers and executive leadership.	- To understand ICC's emissions profile and track the progress of the impact of future actions to reduce ICC's organisational carbon footprint.
- ICC elected member, mana whenua representatives, and staff.	- To communicate accordingly with staff, the public, and other stakeholders.
- The general public.	- To prepare for the likely future introduction of mandatory reporting.

1.2 Description of Invercargill City Council

ISO 14064-1:2018, 9.3.1 (a) and 9.3.2 (a, b)

Invercargill City Council (ICC) leads and represents Invercargill as a democratic decision-making body. Its purpose is to promote social, economic, environmental and cultural well-being in Invercargill City.

1.0 Introduction

1.3 Persons Responsible

ISO 14064-1:2018, 9.3.1 (b)

This GHG inventory report was prepared by Jamie Harknett and Don MacKenzie at CarbonEES. It was reviewed by Lynne Lawson at CarbonEES. It was approved by Rhiannon Suter at ICC.

1.4 Reporting Period Covered

ISO 14064-1:2018, 9.3.1 (c)

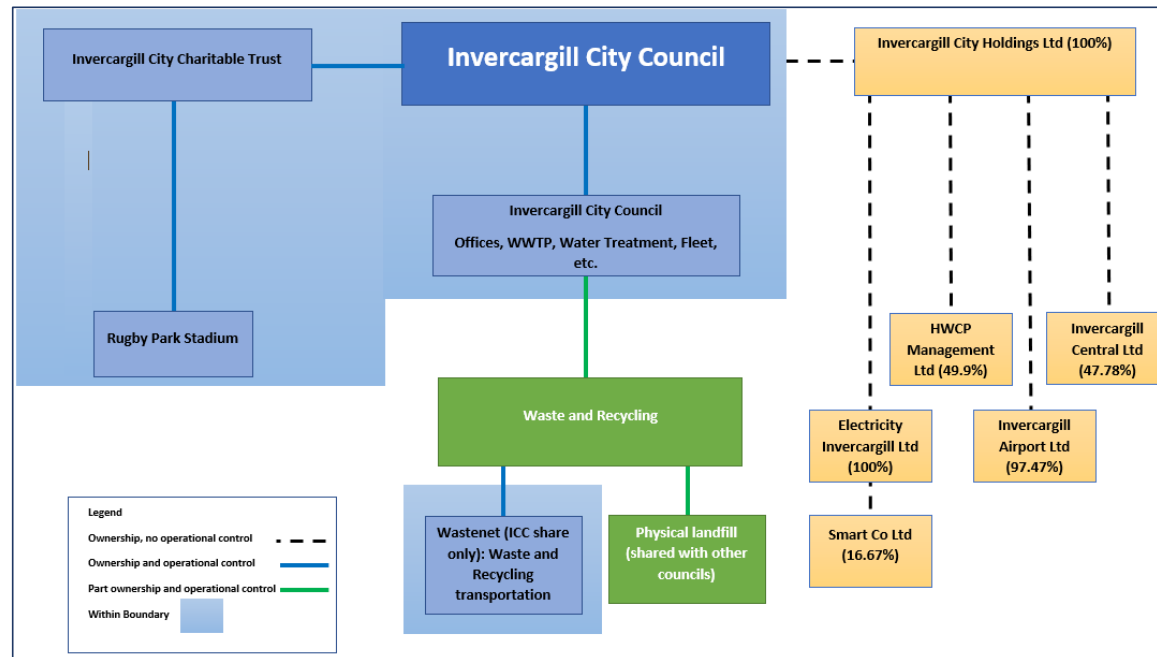
This GHG inventory report covers ICC's financial year 01 July 2024 to 30 June 2025 (FY24/25).

2.0 Organisational Boundaries

ISO 14064-1:2018, 9.3.1 (d)

For an organisation to accurately report its GHG emissions, it must first establish its organisational boundary. The organisational boundary determines the parameters for GHG reporting in the ICC inventory. This boundary refers to the legal composition of the organisation and if the organisation has any direct control over the sources of the emissions. Figure 3 illustrates the organisational boundary of ICC. The boundary has not been updated since reporting began in FY20/21.

Figure 3: ICC's organisational boundary as of 30 June 2025.



3.0 Reporting Boundaries

This section establishes and documents ICC's reporting boundary, including the identification of the relevant Category 1, 2, 3, and 4 emissions and removals associated with ICC's operations.

3.1 Operational Boundaries

ISO 14064-1:2018, 9.3.1 (e)

An operational boundary was used to determine which emission sources were included and excluded in this report, and to define the significant emission sources. GHG emission sources from ICC were identified with reference to ISO 14064-1:2018, with guidance from the GHG Protocol.

Table 5 describes the ISO 14064-1:2018 emission Categories used in this report. There are two further categories: Category 5, which covers emissions from products created by an organisation; and Category 6, which covers anything not categorised under a previous Category. Neither Category 5 nor 6 apply to ICC.

Table 5: Categories as defined by ISO 14064-1:2018.

Emission Category	Description	Example
Category 1: Direct Emissions	Direct emissions that occur from sources owned or controlled by ICC.	The combustion of fuels in ICC's vehicle fleet.
Category 2: Imported Energy Indirect Emissions	Emissions associated with the generation of electricity that is purchased by ICC.	Electricity consumed at ICC facilities.
Category 3: Indirect Emissions from Transportation	Emissions that are a consequence of ICC's activities that result in transportation being utilised.	Air travel for business and transportation of goods by freight services.
Category 4: Indirect emissions from products used by an organisation	Emissions related to ICC purchasing goods and services from third parties, for use in their operations.	Emissions from waste generated in ICC operations and emissions from purchased goods and services.

3.0 Reporting Boundaries

3.2 Information Management Procedures

ISO 14064-1:2018, 9.3.1 (s), 9.3.2 (i)

GHG emissions sources from ICC were identified by CarbonEES and confirmed by ICC for this GHG inventory. As an external company, CarbonEES requires confirmation from ICC to ensure 100 percent of emissions are covered and accurately represent ICC's activities.

CarbonEES have internal process guidelines to ensure the data is handled and stored securely. Activity data are manually prepared for the GHG inventory by business analysts, then are multiplied by the most recent and relevant emissions factors.

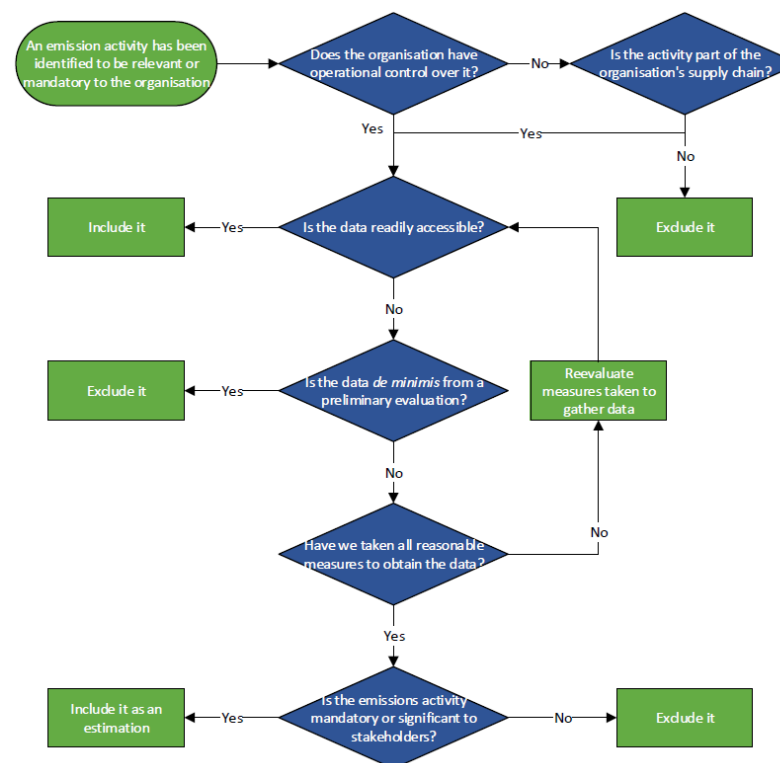
CarbonEES does not get the GHG inventory data verified externally, as it is ICC's responsibility to get its GHG inventory audited. This report is currently unverified (version 1). Council is reporting outside its Statement of Service Performance and as such audit is not required.

3.3 Significance Criteria

ISO 14064-1:2018, 9.3.1 (e)

All identified direct emission sources were deemed significant and included. Indirect emissions sources were deemed significant and included based on the principles of completeness and transparency. ICC looks to disclose all their indirect emissions that fall within its organisational boundary (i.e. all are considered significant), with exclusions only being permitted using the decision tree in Figure 4. ICC have defined 'de minimis' as $\leq$ one percent and have assumed a materiality threshold of $\leq$ five percent.

Figure 4: Significance Criteria Decision Tree.



3.0 Reporting Boundaries

3.4 Inventory Emission Sources, Emission Factors, and Activity Data

ISO14064-1:2018, 9.3.1 (g, h, o)

Tables 6 - 9 provide summaries of the emissions sources included in ICC's GHG inventory. The table also comments on the emission factors used, and who the data was provided by.

Table 6: Category 1 emissions included in the GHG inventory.

Emission Category	Emission Source	Emission Factors	Data Provided By
Category 1 - Direct Emissions	Wastewater Treatment Plants	Water NZ (2021)	ICC
	LPG	MfE (2025)	ICC Rockgas
	Stationary Fuel Combustion	MfE (2025) Thinkstep ANZ (2024)	ICC RD Petroleum
	Mobile Fuel Combustion (Fleet)	MfE (2025)	Z
	Woodchips	MfE (2025)	ICC Niagara
	Agriculture	MfE (2025)	ICC
	CO ₂	MfE (2025)	ICC

Table 7: Category 2 emissions included in the GHG inventory.

Emission Category	Emission Source	Emission Factors	Data Provided By
Category 2 - Indirect Emissions from Imported Energy	Purchased Electricity	MfE (2025)	Meridian

Table 8: Category 3 emissions included in the GHG inventory.

Emission Category	Emission Source	Emission Factors	Data Provided By
Category 3 - Indirect Emissions from Transportation	Downstream Transportation and Distribution	Thinkstep ANZ (2024)	ICC
	Business Travel and Accommodation	MfE (2025) Thinkstep ANZ (2024)	ICC Air New Zealand
	Employee Commuting and Working from Home	MfE (2025)	ICC

Table 9: Category 4 emissions included in the GHG inventory.

Emission Category	Emission Source	Emission Factors	Data Provided By
Category 4 - Indirect Emissions from Products Used by ICC	Purchased Goods & Services and Capital Goods	Thinkstep ANZ (2024) DEFRA (2025)	ICC
	Fuel and Energy-Related Activities	DCCEEW (2024) MfE (2025)	ICC Rockgas RD Petroleum Z Meridian Fullcircle
	Waste Generated in Operations	MfE (2025) Turner et al. (2015) Thinkstep ANZ (2024)	Clearaway KiwiSkips ICC

3.0 Reporting Boundaries

3.5 Exclusions

ISO 14064-1:2018, 9.3.1 (i)

The following sources of emissions have been recognised and excluded from this GHG inventory. These sources have been deemed insignificant to ICC, not relevant to the inventory, and/or not practically or economically viable to be measured currently.

Refrigerants (Category 1 – Direct Emissions) Consumption data was unavailable for this activity.

Client and Visitor Transport (Category 3 – Indirect Emissions from Transportation) Consumption data was unavailable for this activity.

3.6 Impact of Uncertainty

ISO 14064-1:2018, 9.3.1 (p, q)

The process of preparing a GHG inventory involves a certain level of uncertainty. To reduce this uncertainty, verifiable source data has been chosen. In situations where data uncertainty persists, a cautious estimation method has been used to ensure that emissions are overestimated rather than underestimated.

The impact of uncertainty has been considered when assessing data quality. This process is qualitative and is explained further in Appendix A.

3.7 Selected Base Year

ISO 14064-1:2018, 9.3.1 (k)

The base year for ICC is 01 July 2020 – 30 June 2021 (FY20/21). This provides a benchmark for ICC to compare their emissions against. The total emissions for ICC in their base year were 15,590 tCO₂e.

3.7.1 Changes to Historic Base Year

ISO 14064-1:2018, 9.3.1 (l, m)

ICC recalculate their base year if any of the following apply:

- If emission factors have changed significantly and were relevant to prior years.
- If the scope of what is measured within an inventory has changed significantly.
- If the methodology of calculating emissions from activities has changed significantly.

3.7.2 Changes to Historic Years

The FY22/23 was updated in November 2025 to correct identified inaccuracies. The following activities were updated:

- Wastewater Treatment Plants (the emissions from sludge disposal were separated out into Category 4. Figures were revised from 6,870 tCO₂e in Category 1 to 6,825 tCO₂e in Category 1 and 45 tCO₂e in Category 4).
- LPG (the emissions were originally calculated using gas expenditure and a dollar-spend emission factor. This has been updated to primary data in kg and an MfE (2023) emission factor. Figures were revised from 23 tCO₂e to 125 tCO₂e).
- Woodchips (the emission factors were updated to be the correct MfE (2023) emission factors for 'wood – residential'. Figures were revised from 712 tCO₂e to 60 tCO₂e).
- Employee commuting and working from home (the calculations were corrected. Figures were revised from 21 tCO₂e to 311 tCO₂e).
- Water supply (the emissions were removed as they are considered to be double counting. Figures were revised from 2 tCO₂e to 0 tCO₂e. Water supply emissions were not included in FY20/21).

These changes result in the total emissions for FY22/23 changing from 19,253 tCO₂e as originally reported to 18,991 tCO₂e. All figures for FY22/23 in this report are the revised figures.

4.0 GHG Emissions Calculations and Results

ISO 14064-1:2018, 9.3.1 (j, m, n, o) and 9.3.2 (f, j, k)

This section presents the results of ICC's GHG inventory for FY24/25. It offers a broad overview covering all emissions activities and categories and a detailed review of each activity or Category during this select period. Within the detailed review is an explanation of each emission source.

This section applies rounding to values to the nearest tonne of CO₂e. For more detailed figures, we encourage readers to view the accompanying GHG inventory.

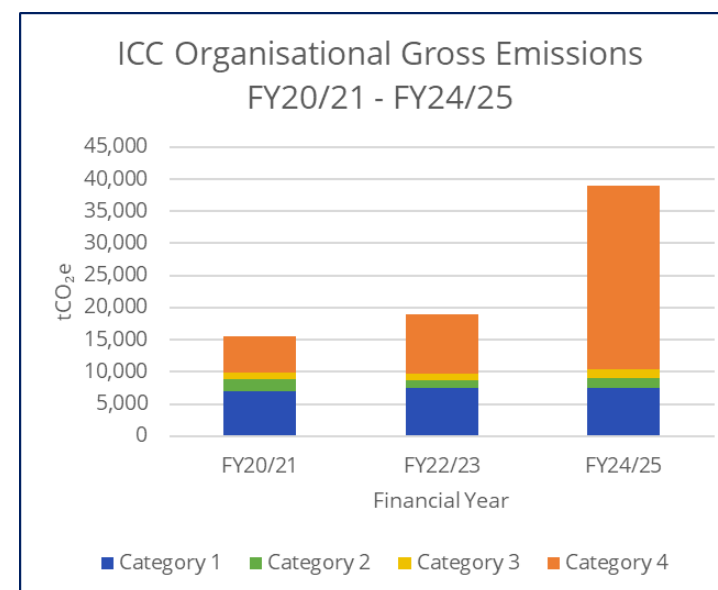
4.1 Organisational Emissions by Category

The total organisational emissions for ICC in FY24/25 were 38,978 tCO₂e. The emissions breakdown by Category is shown for FY25 and all previous reporting periods in Figure 5. Tables 10 and 11 detail ICC's organisational emissions for base year FY20/21, FY22/23, and FY24/25, with columns describing the percentage change in emissions between the financial years. Figure 6 shows the emissions from the highest emitting activities.

Table 10: Base year FY20/21, FY22/23, and FY24/25 gross emissions (tCO₂e).

Emission Category	FY20/21 Total Emissions	FY20/21 % of Total Inventory	FY22/23 Total Emissions	FY22/23 % of Total Inventory	FY24/25 Total Emissions	FY24/25 % of Total Inventory
Category 1	6,919	44%	7,462	39%	7,463	19%
Category 2	1,943	12%	1,213	6%	1,622	4%
Category 3	1,104	7%	965	5%	1,298	3%
Category 4	5,624	36%	9,352	49%	28,595	73%

Figure 5: Organisational emissions FY20/21 – FY24/25 (tCO₂e).



Category 1: Direct Emissions	Category 2 – Indirect Emissions from Imported Energy
Category 3 – Indirect Emissions from Transportation	Category 4 – Indirect Emissions from Products Used by ICC

4.0 GHG Emissions Calculations and Results

4.1 Organisational Emissions by Category

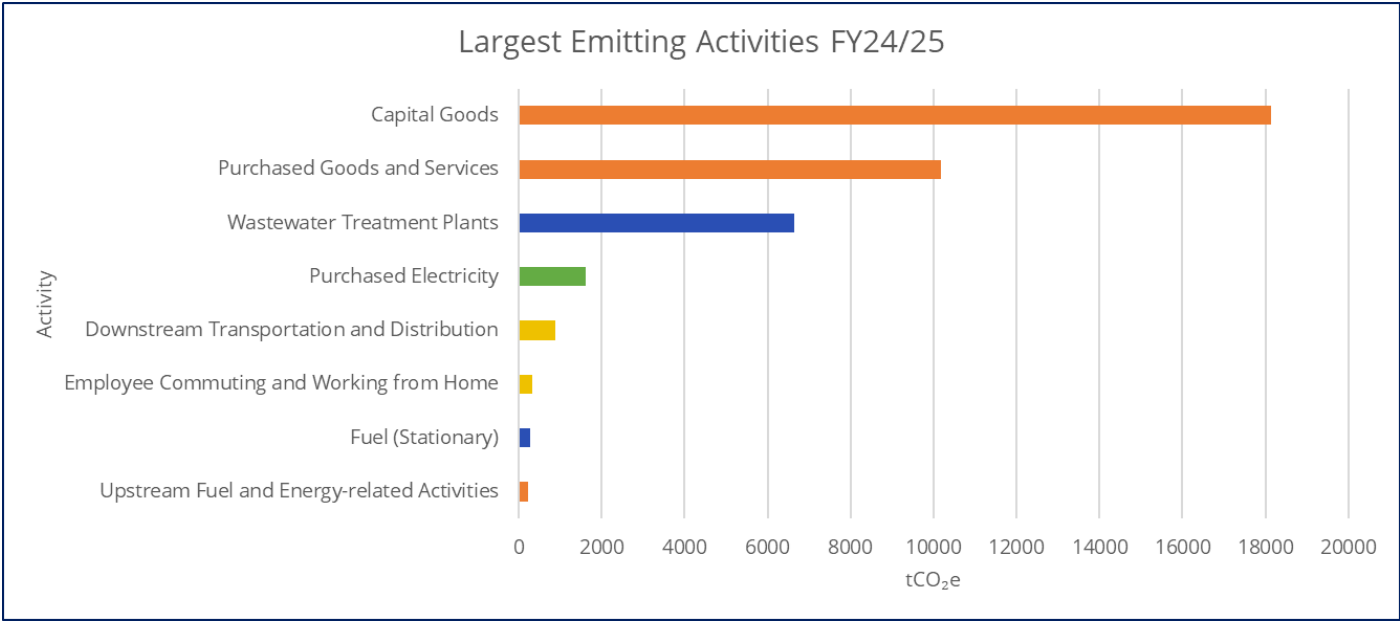
Table 11: Base year FY20/21, FY22/23, and FY24/25 emissions (tCO₂e). NM = not measured.

Emission Category	Emission Source	FY20/21	FY22/23	FY24/25	FY20/21 – FY24/25 difference	FY22/23 – FY24/25 difference
Category 1 – Direct Emissions	Wastewater Treatment Plants	5,999	6,825	6,653	11%	-3%
	Mobile Fuel Combustion (Fleet)	231	183	166	-28%	-9%
	Fuel (stationary)	398	200	265	-33%	33%
	LPG	114	125	120	5%	-4%
	Woodchips	59	60	154	159%	158%
	Agricultural Emissions	117	65	101	-14%	55%
	CO ₂	NM	NM	4	NM	NM
	Refrigerants	NM	4	NM	NM	NM
Category 2 – Indirect Emissions from Imported Energy	Purchased Electricity	1,943	1,213	1,622	-17%	34%
Category 3 – Indirect Emissions from Transportation	Downstream Transportation and Distribution	803	525	888	11%	69%
	Air Travel	43	123	71	66%	-42%
	Other Business Travel	6	6	6	-8%	2%
	Employee Commuting and Working from Home	253	311	334	32%	7%
Category 4 – Indirect Emissions from Products Used by ICC	Purchased Goods & Services	4,800	5,915	10,170	112%	72%
	Capital Goods	405	3,207	18,134	4,375%	465%
	Upstream Fuel and Energy-Related Activities	327	184	213	-35%	16%
	Waste Generated in Operations	7	≤1	39	432%	4,258%
	Wastewater Treatment Plants (Sludge Disposal)	84	45	39	-54%	-13%

4.0 GHG Emissions Calculations and Results

4.1 Organisational Emissions by Category

Figure 6: Largest emitting activities FY24/25 (tCO₂e).



4.0 GHG Emissions Calculations and Results

4.2 Category 1 - Direct Emissions

Category 1 emissions are the direct emissions that occur from sources owned or controlled by ICC. The Category 1 activities captured in this report are wastewater treatment plants, fleet fuel usage (petrol and diesel), stationary fuel usages (diesel), LPG, woodchips, agricultural emissions, and CO₂. Category 1 emissions in FY24/25 (7,463 tCO₂e) have increased eight percent when compared to ICC's base year FY20/21 (6,919 tCO₂e) and increased by less than one percent against FY22/23 (7,462 tCO₂e). Figures 7 and 8 and Table 12 show ICC's organisational Category 1 emissions.

Figure 7: FY20/21 – FY24/25 organisational Category 1 emissions by activity (tCO₂e).

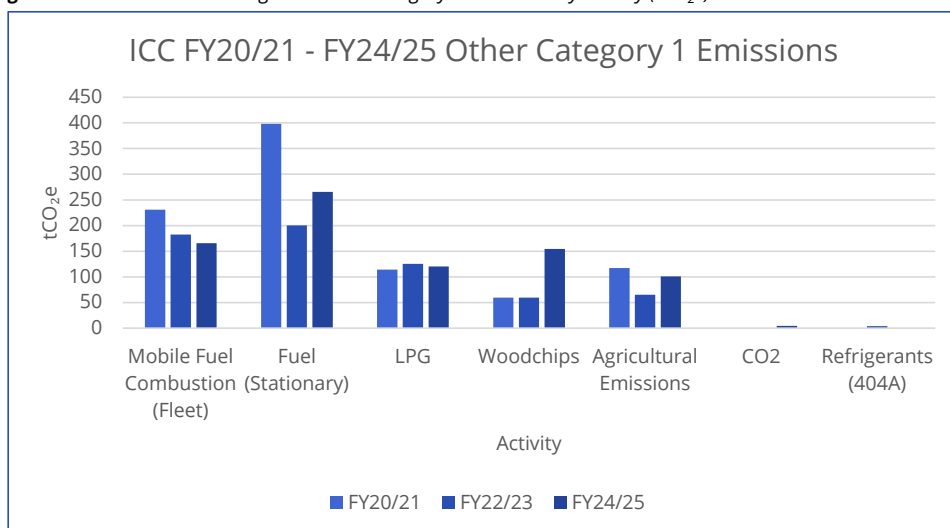


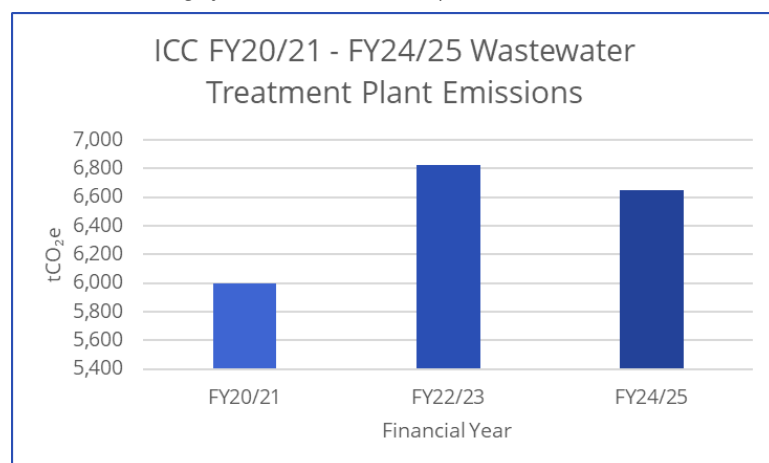
Table 12: Baseline FY20/21, FY22/23, and FY24/25 organisational Category 1 emissions with further details regarding reductions/increases. NM = not measured.

Category 1 Activity	tCO ₂ e			% of Category 1			% of Overall Emissions			% Change between FY20/21 and FY24/25	% Change between FY22/23 and FY24/25
	FY20/21	FY22/23	FY24/25	FY20/21	FY22/23	FY24/25	FY20/21	FY22/23	FY24/25		
Wastewater Treatment Plants	5,999	6,825	6,653	87%	91%	89%	38%	36%	17%	11%	-3%
Fuel (Fleet)	231	183	166	3%	2%	2%	1%	≤1%	≤1%	-28%	-9%
Fuel (stationary)	398	200	265	6%	3%	4%	3%	1%	≤1%	-33%	33%
LPG	114	125	120	2%	2%	2%	≤1%	≤1%	≤1%	5%	-4%
Woodchips	59	60	154	≤1%	≤1%	2%	≤1%	≤1%	≤1%	159%	158%
Agricultural Emissions	117	65	101	2%	≤1%	1%	≤1%	≤1%	≤1%	-14%	55%
CO ₂	NM	NM	4	NM	NM	≤1%	NM	NM	≤1%	NM	NM
Refrigerants (404A)	NM	4	NM	NM	≤1%	NM	NM	≤1%	NM	NM	NM
Total	6,919	7,462	7,463				44%	39%	19%	8%	≤1%

4.0 GHG Emissions Calculations and Results

4.2 Category 1 – Direct Emissions

Figure 8: FY20/21 – FY24/25 Category 1 wastewater treatment plant emissions (tCO₂e).



4.2.1 Wastewater Treatment Plants

ICC owns and operates Clifton, Bluff, and Omaui wastewater treatment plants (WWTP) that treat the wastewater for Invercargill City. This includes wastewater that is generated on ICC premises and residential wastewater that is treated at the plants. The emissions were calculated by ICC engineers using the Level 2 methodology from the Water NZ (2021) guidelines. The emissions from wastewater treatment in FY24/25 (6,653 tCO₂e) have increased by 11 percent against FY20/21 (5,999 tCO₂e) and decreased by 3 percent against FY22/23 (6,825 tCO₂e).

Although ICC use Level 2 methodology, which has a much higher degree of accuracy than Level 1, there is still a lot of uncertainty surrounding the calculation of wastewater treatment plant emissions. Emissions vary in wastewater processes both temporally and spatially. Some variance between years can also be expected, but in general the decrease seen between FY22/23 and FY24/25 is due to less biogas production and a general reduction in strength of influent to the plant.

4.2.2 Mobile Fuel Combustion (Fleet)

Mobile fuel combustion (fleet) captures the direct emissions from the burning of petrol and/or diesel in ICC's vehicle fleet. The emissions from mobile fuel combustion in FY24/25 (166 tCO₂e) have decreased by 28 percent against ICC's base year FY20/21 (231 tCO₂e) and by 9 percent against FY22/23 (183 tCO₂e). This decrease is directly linked to the decrease in mobile fuel combustion. With some of the fleet being changed to electric/hybrid vehicles in 2025, this trend can be expected to continue.

Fuel consumption data is provided by Z Energy in the form of fuel topped up by each vehicle per transaction during the reporting period. The data has been assessed to be of a high quality, due to the granular nature and representativeness of the emissions activity of burning fossil fuels for energy. There is some uncertainty associated with the activity data, as the data is not technologically representative of the fuel burned, but rather the amount topped up.

The emissions were calculated using the associated MfE (2025) emission factors for diesel and regular petrol. There is uncertainty associated with these emission factors, as they were calculated using data and methods from the 2023 calendar year. There is also a small uncertainty surrounding the variance in calorific values of fuels of ±1.7 percent for petrol, and ±0.9 percent for diesel.

4.0 GHG Emissions Calculations and Results

4.2 Category 1 – Direct Emissions

4.2.3 Stationary Fuel Combustion

Stationary fuel combustion captures all direct emissions from the burning of diesel fuel in stationary combustion engines. For ICC, this includes fuel used at Splash Palace, within the Parks team, with the Three Water team, by the Tisbury Storage Sprinkler Pump, and by the Civic Theatre Fire Pump. In FY22/23, only figures from the Parks team were provided. Noting the change in scope, the stationary fuel combustion emissions in FY24/25 (265 tCO₂e) have decreased by 33 percent from FY20/21 (398 tCO₂e) and increased by 33 percent from FY22/23 (200 tCO₂e). These changes are directly linked to the changes in recorded stationary fuel combustion. However, because of the change in scope of what was recorded, no conclusions can be drawn on consumption trends.

Data was retrieved from a variety of sources for this activity: RD Petroleum invoices for Splash Palace, Go Fuel invoices for Three Waters, and emails from ICC staff for the other sites.

The majority of emissions were calculated using the associated MfE (2025) emission factors for stationary diesel burned in commercial operations. There is uncertainty associated with these emission factors, as they were calculated using data and methods from the 2023 calendar year. There is an insignificant amount of uncertainty surrounding the variance in calorific values of stationary commercial diesel of ± 0.5 percent. A small number of emissions were calculated using the Thinkstep ANZ (2024) emission factor for diesel as only financial spend data was available.

4.2.4 LPG

ICC is supplied with LPG cylinders by RockGas for their operations within the Parks and Venues team. The activity data is provided in invoices addressed to ICC from RockGas, which contain the number of cylinders (largely measured in litres) switched out by RockGas during the reporting period, and also in emails from ICC staff. Litres of LPG were then converted to kilograms for emissions calculations, using a conversion factor of 0.51 kilograms per litre as according to Elgas.

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There is some uncertainty associated with the conversion factor, as it may not be relevant to the LPG data supplied by RockGas. Emissions from LPG in FY24/25 (120 tCO₂e) have increased by five percent from FY20/21 (114 tCO₂e) and decreased by four percent from FY22/23 (125 tCO₂e). These changes in emissions are directly linked to the change in consumption of LPG. The cremator at the Crematorium was refractured in 2024, which should keep its consumption of LPG efficient for ten years. Variables such as body sizes and number of cremations are variables that cannot be planned for, and have not been analysed.

The emissions were calculated using the stationary LPG emission factor from MfE (2025). There is uncertainty associated with these emission factors, as they were calculated using data and methods from the 2023 calendar year. There is also a small amount of uncertainty surrounding the variance in calorific values of natural gas of ± 2.4 percent.

4.2.5 Woodchips

ICC uses woodchips for heating at Splash Palace. For inventory reporting, only CH₄ and N₂O are reported within the boundary. The CO₂ emissions are biogenic, or equal to the CO₂ absorbed by the feedstock during its lifespan, and so are treated as carbon neutral. These emissions are reported separately in the inventory under biogenic emissions.

Data was provided in form of a summary from the supplier Niagara of cubic metres of woodchip supplied to Splash Palace in the reporting period. This was then converted to kilograms using an assumption of 250kgs per m³.

Emissions from woodchips in FY24/25 (154 tCO₂e) have increased by 159% from FY20/21 (59 tCO₂e) and by 158% from FY22/23 (60 tCO₂e). Multiple factors could be contributing to this increase, including a change in the woodchips' properties, the required conversion of cubic metres to kilograms in the absence of weight data, a change in use of woodchips at Splash Palace due to weather, and the update by MfE of the emission factor.

4.0 GHG Emissions Calculations and Results

4.2 Category 1 – Direct Emissions

4.2.5 Woodchips

In FY22/23, the MfE (2023) emission factor for 'wood – residential' was used. For FY24/25, a more appropriate emission factor, 'wood – chips, commercial use' has been created (MfE, 2025). This emission factor is 63% stronger than the one for 'wood – residential' and so has contributed significantly to the increase in reported emissions from woodchips. This emission factor is more suited to the activity, but there are still uncertainties surrounded the conversion: MfE has provided the uncertainty values of $\pm 45\%$ for CO_2 , $\pm 50\%$ for CH_4 , and $\pm 50\%$ for N_2O .

4.2.6 Agricultural Emissions

Agricultural emissions captures the enteric fermentation, manure management, and agricultural soil emissions related to livestock ownership. This reporting period, sheep, goats, alpaca, swine, and poultry were reported on, which is an expansion on just sheep in previous years. The emissions from agricultural emissions in FY24/25 (101 t CO_2e) have decreased by 14 percent since FY20/21 (117 t CO_2e) and increased by 55 percent since FY22/23 (65 t CO_2e). However, because of the change in scope of what was recorded, no conclusions can be drawn on trends.

There is uncertainty associated with the quality of the data, in that numbers of animals are likely to change throughout the year and a single number taken at one point in time is not representative of these changes. However, it is recommended by MfE to use livestock numbers as at 30 June, so this is inline with current practice.

The emissions were calculated using the associated MfE (2025) emission factors for enteric fermentation, manure management, and agricultural soil emissions of each type of livestock. There is uncertainty associated with these emission factors, as they were calculated using data and methods from the 2023 calendar year and are based on the average per-animal biological emissions and do not take account of the unique factors that impact emissions such as live-weights, productivity, and feed quality. MfE provide an uncertainty value of $\pm 15.5\%$ for enteric fermentation, $\pm 20\%$ for CH_4 from manure management, ± 100 for N_2O from manure management, and $\pm 54.1\%$ for agricultural soils.

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4.2.7 CO_2

CO_2 captures the direct emissions from CO_2 gas released into the atmosphere. ICC purchases CO_2 gas for direct use in their operations at Splash Palace. This emission source had not been captured in previous greenhouse gas inventories.

The activity data for CO_2 released was supplied by ICC staff, who summarised the invoices provided by Coregas. Because the emissions are not emitted on the purchasing of the gas but rather on the use of it, CarbonEES staff then calculated how much gas was likely consumed within the reporting period rather than pre-purchased.

Although the data is not technologically representative of the gas that is released into the atmosphere, it is assumed that top-ups of CO_2 are purchased to replace gas that has been released into the atmosphere. Therefore, the activity data is high quality. As the emission activity is kilograms of CO_2 , the MfE (2025) emission factor of 1 is used and is deemed to be a high-quality direct measure of emissions.

4.2.8 Refrigerants

Refrigerants captures all direct emissions from refrigerants in HVAC systems at ICC's sites leaking into the atmosphere. This is an infrequent emission activity, as the emissions are calculated against refrigerant top-ups, which are done on an as-required basis.

Activity data from this emission activity was not supplied for the FY25 reporting period. There is uncertainty associated with the assumption that since there were no top-ups in the FY24/25 reporting period that there were no emissions, as emissions from leaks may have occurred but not been measured.

4.0 GHG Emissions Calculations and Results

4.3 Category 2 – Indirect Emissions from Imported Energy

Category 2 emissions are indirect GHG emissions associated with the purchase of energy (electricity, steam, heat, or cooling), where the emissions occur off-site. Although Category 2 emissions physically occur at the facility where they are generated, they are accounted for in an organisation's GHG inventory because they are a result of the organisation's energy use. In this case, Category 2 emissions are from purchased electricity (at all sites) which is used for office lighting, space heating, hot water, and appliances. Category 2 emissions in FY24/25 (1,622 tCO₂e) have risen when compared to FY22/23 (1,213 tCO₂e), in large part due to the fluctuation in renewable energy mix in the national electricity supply. Figures 9 and 10 and Tables 13 and 14 show ICC's organisational Category 2 emissions.

Figure 9: FY20/21 – FY24/25 organisational Category 1 emissions by activity (tCO₂e).

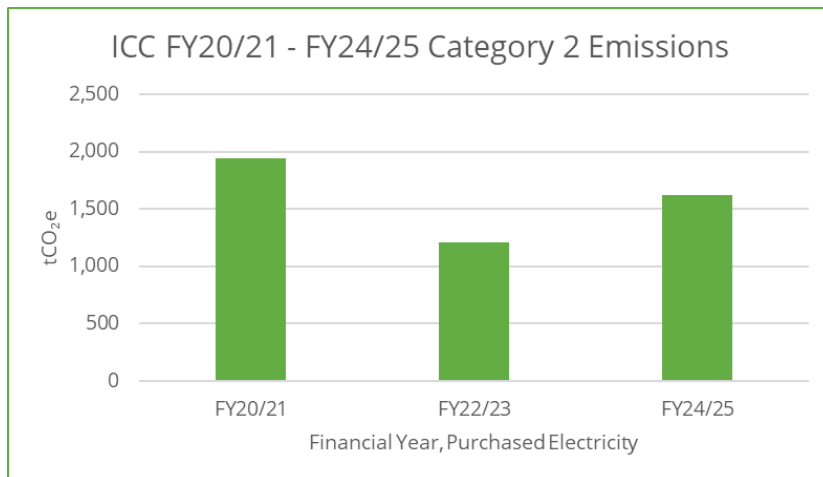
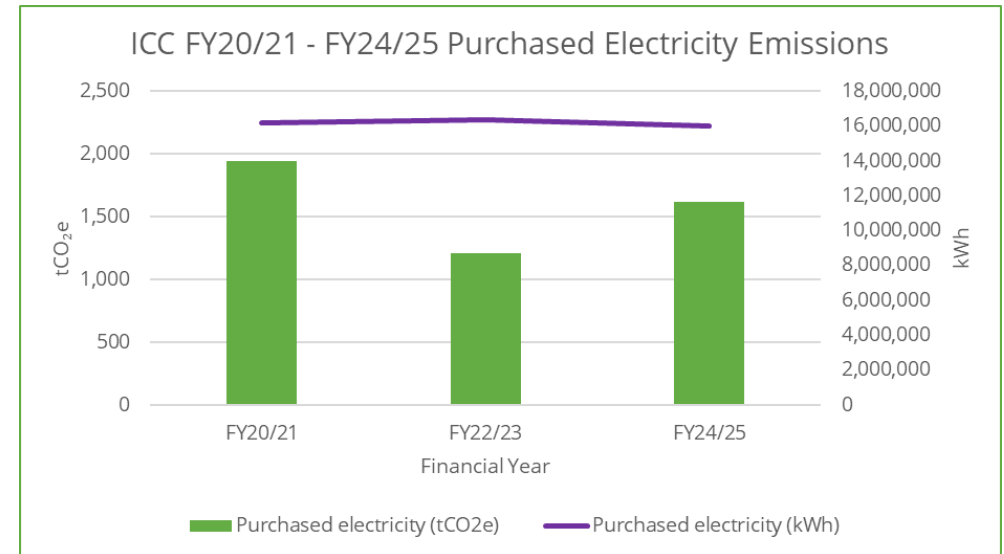


Figure 10: FY20/21 – FY24/25 organisational purchased electricity emissions (tCO₂e) contrasted with kWh purchased.



4.0 GHG Emissions Calculations and Results

4.3 Category 2 – Indirect Emissions from Imported Energy

Table 13: FY20/21, FY22/23, and FY24/25 organisational Category 2 emissions with further details regarding reductions/increases.

	tCO ₂ e			% of Category 2			% of Overall Emissions			% Change between FY20/21 and FY24/25	% Change between FY22/23 and FY24/25
	FY20/21	FY22/23	FY24/25	FY20/21	FY22/23	FY24/25	FY20/21	FY22/23	FY24/25		
Category 2 Activity											
Purchased Electricity	1,943	1,213	1,622	100%	100%	100%	12%	6%	4%	-17%	34%

Table 14: FY20/21, FY 22/23, and FY24/25 organisational Category 2 emissions compared against kWh.

	FY20/21	FY22/23	FY24/25
Purchased Electricity Emissions (tCO ₂ e)	1,943	1,213	1,622
Purchased Electricity (kWh)	16,189,336	16,354,412	15,988,345

4.3.1 Purchased Electricity

Purchased electricity captures all indirect emissions from electricity used at ICC's sites for their operations (lighting, heating etc), including stormwater and sewage pumps within Invercargill City.

The emissions from purchased electricity have decreased by 17 percent against ICC's base year FY20/21, but increased by 34 percent against FY22/23. This is despite a 2 percent decrease in electricity consumption between the FY22/23 and FY24/25 reporting periods. This is largely due to a 38.7 percent increase in the emission factor for purchased electricity in MfE (2025). There was no change in the methodology used to calculate the emission factor. However, in 2022 and 2023, emissions from electricity generation were relatively low due to favourable weather conditions and strong hydro inflows. In contrast, 2024 saw an increase in the proportion of fossil fuel-based generation.

Therefore, it is difficult to use changes in emissions to understand activity increases and reductions. Figure 10 illustrates this clearly, where purchased kWh are relatively consistent across FYs 20/21, 22/23, and 24/25, but emissions are significantly higher in FYs 20/21 and 24/25 than in 22/23.

Activity data were measured through invoice reports provided by Meridian Energy, which detail the electricity consumption at each meter during the reporting period. This data has been assessed to be of a high data quality, due to their granular nature and representativeness of the emissions activity of consuming electricity.

The emissions were calculated using the associated quarterly MfE emission factors for purchased electricity, and with the quarterly emission factor from the previous year where the most up-to-date factor is not yet available. Using an average grid emission factor for electricity will inevitably introduce a certain level of inaccuracy, as the generation mix varies depending on geographical location, time of day, and time of year. A band of uncertainty has not been provided by MfE for this emission factor.

4.0 GHG Emissions Calculations and Results

4.4 Category 3 – Indirect Emissions from Transportation

Category 3 emissions are indirect emissions from transportation. These are activities such as downstream transportation and distribution, business travel, and employee commuting and working from home. Category 3 emissions in FY24/25 (1,298 tCO₂e) have decreased by 18 percent compared to ICC's base year FY20/21 (1,104 tCO₂e) and increased by 35 percent against FY22/23 (965 tCO₂e). These changes in emissions are due in large part to a change in emission factors for spend-based data such as downstream transportation and distribution. Figure 11 and Table 15 show ICC's organisational Category 3 emissions.

Figure 11: FY20/21 – FY24/25 organisational Category 3 emissions by activity (tCO₂e).

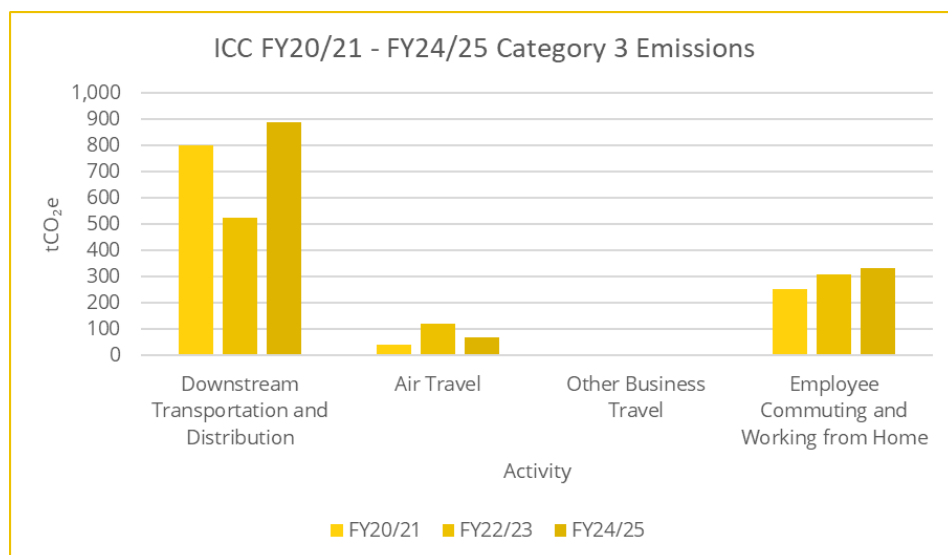


Table 15: FY20/21, FY22/23, and FY24/25 organisational Category 3 emissions with further details regarding reductions/increases.

Category 3 Activity	tCO ₂ e			% of Category 3			% of Overall Emissions			% Change between FY20/21 and FY24/25	% Change between FY22/23 and FY24/25
	FY20/21	FY22/23	FY24/25	FY20/21	FY22/23	FY24/25	FY20/21	FY22/23	FY24/25		
Downstream Transportation and Distribution	803	525	888	73%	54%	68%	5%	3%	2%	11%	69%
Air Travel	43	123	71	4%	13%	5%	≤1%	≤1%	≤1%	66%	-42%
Accommodation	3	4	4	≤1%	≤1%	≤1%	≤1%	≤1%	≤1%	27%	-5%
Business Travel in Personal Vehicles	NM	≤1	1	NM	≤1%	≤1%	NM	≤1%	≤1%	NM	46%
Rental Car	3	≤1	≤1	≤1%	≤1%	≤1%	≤1%	≤1%	≤1%	-90%	76%
Taxi Travel	≤1	≤1	≤1	≤1%	≤1%	≤1%	≤1%	≤1%	≤1%	1%	-30%
Employee Commuting and Working from Home	253	311	334	23%	32%	26%	2%	2%	≤1%	32%	7%
Total	1,104	965	1,298				7%	5%	3%	18%	35%

4.0 GHG Emissions Calculations and Results

4.4 Category 3 – Indirect Emissions from Transportation

4.4.1 Downstream Transportation and Distribution

Freight transportation and distribution captures emissions from freight services that are due to goods shipped from ICC sites. The emissions from this activity come from the fuel burned by vehicles used for the transportation of goods, such as delivery vans. For ICC, this emission activity included courier and freight and the transportation of community waste. The emissions from this activity in FY24/25 (888 tCO₂e) have increased by 11 percent from FY20/21 (803 tCO₂e) and by 69 percent from FY22/23 (525 tCO₂e).

Activity data for this emission activity have been supplied by ICC staff, stemming from financial reporting. Although tonnes transported and kilometres travelled were provided for the transportation of community waste, further detail on the number of trips taken by vehicles would be required to calculate tonne-kilometres. In future years, if this level of detail is obtainable, it will result in a higher level of accuracy in calculating these emissions. Because data has been provided in different forms between reporting periods, it is difficult to draw comparisons or conclusions between the years. However, it can be noted that ICC's freight and courier volumes have been fairly consistent over the last few years according to internal reports, but suppliers' costs have increased. The digitisation project also required a high volume of freight in 2024 and 2025.

There is little uncertainty surrounding the data collection process of the activity data, as it comes from financial reporting. However, there is some uncertainty surrounding the activity data, as the financial spend is not technologically representative of the amount of fuel combusted by the vehicles transporting the goods.

The emissions were calculated using postal and courier services and road transport services emission factors from Thinkstep ANZ (2024). As these emission factors are spend-based, there is significant uncertainty in their relevance, accuracy, and technological representativeness.

Although always a significant activity, the emissions from downstream transportation and distribution have risen and fallen over the last few reporting periods. This is due in large part to a shift in methodology as different emission factors have been developed or updated. In FY20/21, Motu emission factors were used; in FY22/23, Market Economics, and in FY24/25, Thinkstep ANZ.

4.4.2 Business Travel

Business travel captures all emissions that are associated with paid travel for ICC's operations, including air travel, hotel accommodation, rental car travel, taxi travel, and mileage reimbursements, by modes not owned or operated by ICC. The emissions from this activity come from the fuel burned by vehicles used for business travel, and the energy emissions from a hotel room during a staff member's stay.

Emissions from business travel in FY24/25 (77 tCO₂e) have increased by 56 percent against ICC's base year FY20/21 (49 tCO₂e), and decreased by 40 percent against FY22/23 (129 tCO₂e). Some of the increase against FY20/21 is likely due to Covid restrictions. The decrease against FY22/23 could be due to ICC's Financial Risk Management Policy requiring virtual attendance at meetings and conferences to be considered where appropriate.

The activity data for ICC's business travel is varied and detailed further in the sections below.

Air Travel

The majority of activity data for domestic air travel was derived from air travel booked through Air New Zealand, and distances and class were taken from the Air New Zealand report. There is uncertainty associated with the activity data, as the flight paths travelled can vary depending on the time of year and weather. Emissions in FY24/25 (71 tCO₂e) have increased by 66 percent from FY20/21 (43 tCO₂e) and decreased by 42 percent from FY22/23 (123 tCO₂e). These changes are linked directly to the change in kilometres flown.

The emissions were calculated using the MfE (2025) domestic and short haul emission factors with radiative forcing. As specific aircrafts were not provided by Air New Zealand, only the generic emission factors could be used.

4.0 GHG Emissions Calculations and Results

4.4 Category 3 – Indirect Emissions from Transportation

4.4.2 Business Travel

These emission factors have been calculated using the average total fuel used by an aircraft between fuel top ups, the average number of flights a plane travels, and the average number of seats occupied on a plane (assuming an 80 percent occupancy). Due to the number of assumptions when deriving these emission factors, a certain degree of inaccuracy can be expected. A band of uncertainty has not been provided by MfE for this emission factor.

A small amount of spend-based data was found in the mileage reimbursement documentation. There is much less certainty around both this data and the Thinkstep ANZ (2024) emission factor.

Hotel Accommodation

The activity data for both domestic and international hotel accommodation were the number of hotel room-nights booked for the reporting period, as tracked by ICC staff. As the activity data is the number of room-nights rather than the amount of energy used in the hotel room, there is a degree of uncertainty associated with the technological representativeness of the activity data. Accommodation emissions in FY24/25 (four tCO₂e) have increased 27 percent from FY20/21 (three tCO₂e) and decreased five percent from FY22/23 (four tCO₂e), linked to changes in the number of accommodation nights.

Emissions were calculated using emission factors from MfE (2025), which were sourced from the 2024 edition of the Cornell Hotel Sustainability Benchmarking Index, which uses data from the 2022 calendar year. The calculations are skewed towards upmarket and chain hotels, and do not distinguish a property's facilities. This means it is difficult to compare two separate hotels because some may contain distinct energy intensive attributes (such as restaurants, laundry service, and swimming pools). There is also geographical uncertainty associated with using a national average emission factor. Therefore, inaccuracy surrounding the emission factors can be expected.

Taxi Travel

The activity data for taxi travel was spend-based from ICC's financial records. Emissions from this activity in FY24/25 have increased by one percent against FY20/21 and decreased by 30 percent against FY22/23, largely linked to changes in kilometres travelled (but all less than 1 tCO₂e). This data has a high degree of uncertainty associated with the spend data being technologically unrepresentative of the emissions activity of fuel burned by the taxis. The activity data also does not distinguish between fuel-types. However, as there is a distance component to taxi charges, the degree of technological uncertainty is less than other spend-based emission activities.

As such, the emissions were calculated using a spend-based emission factor provided by MfE. The taxi travel emission factors were derived from an average of the factors for a petrol, diesel, petrol plug-in hybrid and electric vehicle, for a 2010–2015 fleet and 2000–3000 cc vehicle class, due to unavailability of more up-to-date data on New Zealand's taxi fleet. The emission factors were also derived using an average cost per km rate of \$3.52 per kilometre. A large degree of uncertainty can be expected from this methodology, due to the number of assumptions made surrounding the technology and geography of the emission factor.

Rental Car

The activity data for rental car hire was spend-based data supplied by ICC staff. Emissions from this activity in FY24/25 (less than one tCO₂e) have decreased by 90 percent from FY20/21 (three tCO₂e) and increased by 76% from FY22/23 (less than one tCO₂e). These changes are linked to changes in the frequency of rental car usage, resulting in more kilometres travelled. This data has a high degree of uncertainty associated with the spend data being technologically unrepresentative of the kilometres travelled, and therefore far removed from the emissions activity of fuel burned by the vehicles. The emissions were calculated using the road passenger transport emission factor from Thinkstep ANZ (2024) which carries with it the uncertainty of a spend-based emission factor. If ICC is able to track the kilometres travelled or the fuel used by rental cars in future reporting periods, this will result in a higher quality estimation of emissions.

4.0 GHG Emissions Calculations and Results

4.4 Category 3 – Indirect Emissions from Transportation

4.4.2 Business Travel

Business Travel in Personal Vehicles

The activity data for business travel in personal vehicles was derived from ICC's financial records. Where kilometres were included in the line description, these were used instead of the financial data. Where kilometres were not included, the IRD FY23/24 reimbursement rate of 104c/km was used to calculate the kilometres driven as that is what ICC currently use. Emissions from this activity in FY24/25 (one tCO₂e) have increased by 46 percent from FY22/23 (less than one tCO₂e), with these changes linked to an increase in the number of kilometres travelled in personal vehicles.

There is uncertainty associated with this data, as the data is not technologically representative of the specific fuel being burned. There is also uncertainty as the search used to find the mileage reimbursement data also returned a line for flights reimbursement, so it is possible there has also been omission of some relevant entries. Mileage reimbursements also do not capture the quantity of fuel consumed by the vehicle, as the rate that fuel is used across the distance would vary due to vehicle efficiency and driving conditions.

The emissions were calculated using the MfE (2025) default emission factor for private petrol vehicles. The emission factor was derived using average fuel consumption rates for vehicles, which may result in inaccuracies in the emissions data. There may also be uncertainty associated with the relevance and technological representativeness of the emission factor, as the fuel type of the activity data is unknown.

4.4.3 Employee Commuting and Working from Home

The employee commuting and working from home data was taken from the employee commuting survey conducted in September and October 2025. The nature of a survey means that there is uncertainty surrounding the completeness of the data and whether it is representative of the ICC workforce as a whole. With only a 32% response rate, there is a high chance in the calculations made from the data being inaccurate as they are based on assumptions. However, the survey conducted in 2025 was much more granular than the ones conducted in previous reporting periods and is has therefore resulted in higher quality data, giving more certainty to the FY24/25 calculations. The emissions from this activity in FY24/25 (334 tCO₂e) have increased 32 percent from FY20/21 (253 tCO₂e) and seven percent from FY22/23 (311 tCO₂e).

The data on staff commuting habits included the kilometre distance of a respondent's travel to and from the office and the mode of transport taken. Vehicle details such as engine size, number of passengers present if carpooling, and fuel type were sometimes provided, whereas vehicle age was absent. Emissions were calculated using the travel emission factors from MfE (2025) most relevant to the primary mode of transport listed. Where engine size is unavailable, default emission factors were used for the corresponding fuel-type. Where fuel-type is unavailable, the vehicle is assumed to be petrol. The age of the vehicle is always assumed to be manufactured between 2010 – 2015, to be consistent with the default emission factors provided by MfE. Electric bikes are assumed to have a similar emissions profile to small electric motorbikes, in absence of emission factors for this mode of transport. The degree of uncertainty due to technological representativeness widens depending on the amount of vehicle details unavailable.

4.0 GHG Emissions Calculations and Results

4.4 Category 3 – Indirect Emissions from Transportation

4.4.3 Employee Commuting and Working from Home

For public transport, default passenger-kilometre emission factors were used in absence of fuel-type information, with uncertainty due to assumptions on the average fuel used and the technological representativeness of calculating emissions against passenger-kilometres versus fuel burned.

The number of work-from-home days were also taken from the employee commuting survey. There is a level of uncertainty surrounding the technological representativeness of the activity data, as the number of days working from home is not representative of the amount of energy consumed during a work-from-home day, and misses information such as whether heating is used.

The emissions were calculated using the MfE (2025) default emission factor for working from home. The emission factor was calculated by estimating the amount of energy consumed by an employee while working from home, which includes assumptions surrounding the equipment used, number of hours worked, and that the employee uses heating for five months of the year. As there is a lack of data in New Zealand surrounding the average work from home set up, or the amount of energy used by New Zealanders when working from home, a high level of uncertainty can be expected. A band of uncertainty has not been provided by MfE for this emission factor.

4.0 GHG Emissions Calculations and Results

4.5 Category 4 – Indirect Emissions from Products Used

Category 4 emissions are indirect emissions from products used by an organisation. These include services an organisation pays for, through the course of undertaking its own activities. This Category also includes waste generated by the organisation and upstream transmission and distribution losses from purchased electricity/natural gas.

Category 4 emissions in FY24/25 (28,595 tCO₂e) have increased by 408 percent compared to ICC's base year FY20/21 (5,624 tCO₂e) and by 206 percent compared to FY22/23 (9,352 tCO₂e). This is largely due to the increased measurement of purchased goods & services and capital goods, alongside a change in emission factors. Figures 12 and 13 and Table 16 show ICC's organisational Category 4 emissions.

Figure 12: FY24 - FY25 organisational Category 4 emissions by activity (tCO₂e).

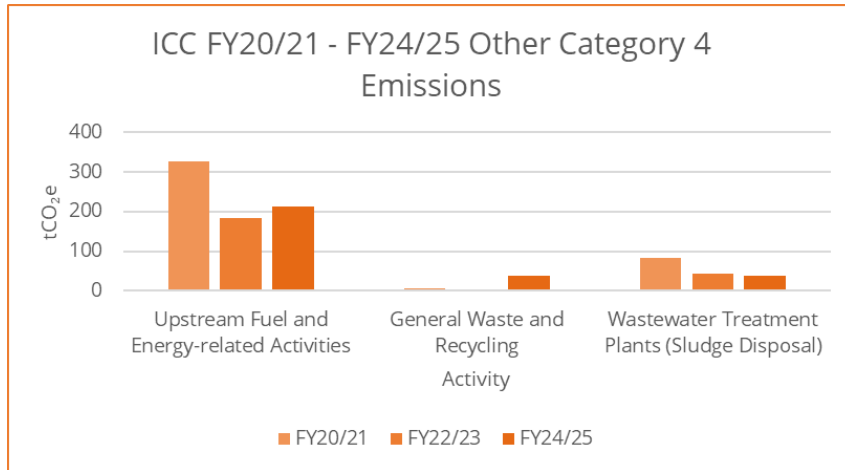
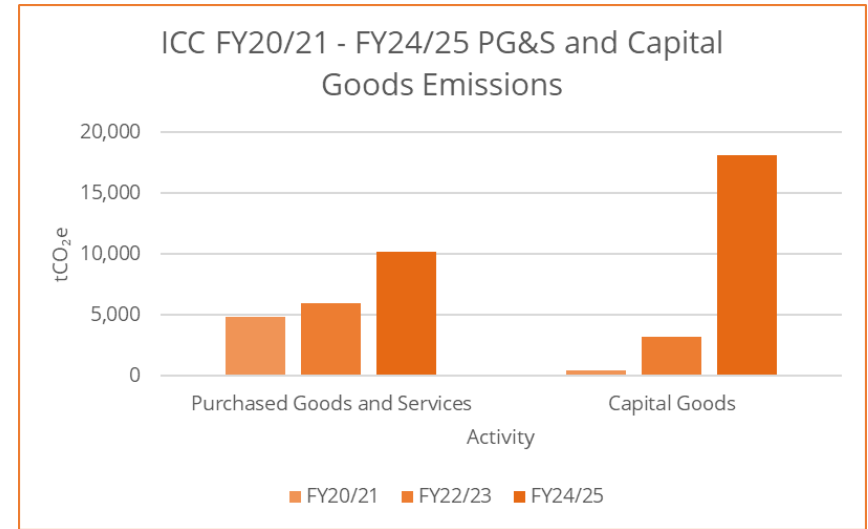


Figure 13: FY24 - FY25 purchased goods & services and capital goods emissions (tCO₂e).



4.0 GHG Emissions Calculations and Results

4.5 Category 4 – Indirect Emissions from Products Used

Table 16: FY20/21, FY22/23, and FY24/25 organisational Category 4 emissions with further details regarding reductions/increases.

	tCO ₂ e			% of Category 4			% of Overall Emissions			% Change between FY20/21 and FY24/25	% Change between FY22/23 and FY24/25
Category 4 Activity	FY20/21	FY22/23	FY24/25	FY20/21	FY22/23	FY24/25	FY20/21	FY22/23	FY24/25		
Purchased Goods & Services	4,800	5,915	10,170	85%	63%	36%	31%	31%	26%	112%	72%
Capital Goods	405	3,207	18,134	7%	34%	63%	3%	17%	47%	4,375%	465%
Upstream Fuel and Energy-Related Activities	327	184	213	6%	2%	≤1%	2%	≤1%	≤1%	-35%	16%
General Waste and Recycling	7	≤1	39	≤1%	≤1%	≤1%	≤1%	≤1%	≤1%	432%	4,258%
Wastewater Treatment Plants (Sludge Disposal)	84	45	39	1%	≤1%	≤1%	≤1%	≤1%	≤1%	-54%	-13%
Total	5,624	9,352	28,595				36%	49%	73%	408%	206%

4.0 GHG Emissions Calculations and Results

4.5 Category 4 – Indirect Emissions from Products Used

4.5.1 Purchased Goods & Services and Capital Goods

Operational and Capital Expenditure

The data for purchased goods & services and capital goods, excluding paper and water supply, was calculated using ICC's trial balance which contains operational and capital expenditure from the reporting period.

Prior to emissions calculations, the data was prepared to remove any costs associated with activities covered elsewhere in the GHG inventory and any accounting entries that do not carry corresponding carbon emissions. This is to remove any double counting of emissions. Due to the trial balance being a summary rather than a line-by-line ledger, there is the possibility that some activities have not been identified in the trial balance and have been included twice.

The activity data has a high degree of uncertainty associated with the spend data being technologically unrepresentative of the emissions activity. The spend data within each category is likely to include multiple types of goods and services, but has been summarised as just one, leading to uncertainty in the accuracy of the data.

The emissions were calculated using the Thinkstep ANZ (2024) spend-based emission factors, adjusted for inflation. Thinkstep ANZ spend-based emission factors were selected based on the relevancy to the category name. As with the activity data, there is a high degree of uncertainty associated with spend-based emission factors, as they are technologically unrepresentative of the emission activity. There is also some uncertainty surrounding whether the inflation-based adjustments are representative of how the emissions from this activity per dollar have changed with time. A band of uncertainty has not been provided by Thinkstep ANZ for this emission factor.

The emissions from this activity in FY24/25 (18,134 tCO₂e) increased by 444 percent from FY20/21 (5,205 tCO₂e) and by 210 percent from FY22/23 (3,207 tCO₂e). In part, this is due to an increased spend on these activities, alongside an increase in scope of what is captured in reporting. Alongside this, a change in methodology has occurred due to different emission factors being developed or updated. In FY20/21, Motu emission factors were used; in FY22/23, Market Economics, and in FY24/25, Thinkstep ANZ.

Water supply

Historically, emissions from water supply have been captured in the ICC GHG inventories and reports. However, CarbonEES now considers that to be double-counting. The MfE emission factor for water supply is calculated based on energy used in the operation of water supply pumps. However, ICC already captures these emissions under their purchased electricity. Other emissions from the water supply's facilities and processes are not captured by the MfE emission factor, but are likely captured under purchased goods & services and capital goods (eg UV filters, chemicals). As the historical inclusion of water supply emissions was de minimis, they did not have a material impact on previous inventories and reports. However, as other activities within the FY22/23 inventory were recalculated in 2025, water supply was removed from this inventory.

Paper

Paper captures the indirect emissions associated with the energy consumed when producing the paper supplied to ICC. The activity data was supplied by OfficeMax, where the kilograms of paper was provided by transaction. There is some uncertainty associated with the activity data, as the weight of paper isn't technologically representative of the emission activity of energy consumed in paper production.

4.0 GHG Emissions Calculations and Results

4.5 Category 4 – Indirect Emissions from Products Used

4.5.1 Purchased Goods & Services and Capital Goods

A New Zealand emission factor for emissions per kilogram weight is not currently available. Therefore, emissions were calculated using the UK Department of Environment, Food & Rural Affairs (DEFRA, 2025) primary material production emission factor for paper. As the emission factor is from the UK, there is uncertainty associated with the geographical representativeness as the renewable energy mix in the UK largely differs from New Zealand. There is also uncertainty surrounding the accuracy of the emission factor, as the methodology does not state how the emission factor was calculated. Lastly, there is uncertainty as the weight of paper is not technologically representative of the emission activity of energy consumed in paper production.

Although ICC's consumption of paper has gone down by weight, the emission factor from DEFRA has been updated over the years. In 2022, the emission factor was 919 kgs of CO₂e per tonne of paper production. In 2025, it is now 1345 kgs per tonne. This update to the emission factor has caused the reported emissions from paper consumption to increase despite a decrease in consumption.

4.5.2 Upstream Fuel and Energy-Related Activities

Fuel and energy-related activities captures the emissions from additional electricity and natural gas generated to make up for electricity lost in the transmission and distribution network, as well as upstream emissions from fuel production and distribution. The activity data, therefore, is the same as LPG, fuel, and purchased electricity. The associated uncertainties are the same.

Transmission and Distribution

The emissions from transmission and distribution losses for electricity were specified on Meridian Energy's electricity invoices. As the data comes directly from the supplier, there is little uncertainty associated with this data.

The emission factor from MfE (2025) does not account for the variance in renewable energy mix as an average figure, nor the emissions associated with the extraction, production and transport of fuels burnt to produce electricity. Therefore, there is a degree of uncertainty surrounding the accuracy and technological representativeness of this emission factor.

Upstream Emissions

Although the activity data is the same as mobile fuel combustion, diesel (stationary), and LPG, there is added uncertainty in using this data, as the number of emissions in producing and distributing this fuel can differ depending on the fuel supplier, and depending on the location of the pump used to refuel vehicles. Upstream emissions from LPG have not been included in previous reporting periods.

In absence of New Zealand emission factors for this emission activity, Australian emission factors from DCCEW (2024) were used. This has resulted in uncertainty surrounding the geographic representativeness of this emission factor, as there are likely to be more emissions associated with distributing fuel to New Zealand.

4.5.3 General Waste and Recycling

Waste generated in operations captures the emissions from waste breaking down in landfills, and the energy emissions associated with recycling materials. Emissions from waste generated in operations have increased by 4258 percent against FY22/23. However, this is heavily influenced by an increase in scope of activities reported on, and is not necessarily reflective of an increase in waste produced.

4.0 GHG Emissions Calculations and Results

4.5 Category 4 – Indirect Emissions from Products Used

4.5.3 General Waste and Recycling

The data is retrieved from invoices from Fullcircle, Clearaway, and KiwiSkips, alongside estimations from ICC staff. Much of the data was in the form of number of collected bins of a certain volume, but with no measurement of the weight of the contents. Conversion factors were then applied to conservatively estimate the weight of the waste. Therefore, there is little certainty in the accuracy and the technological representativeness of this data. In FY20/21, financial spend was used to estimate waste emissions; in FY22/23, only 425kg of office waste was reported, based off an estimate of waste produced. The increase in scope of waste reported on has resulted in significantly increased reported emissions; although this reporting period's data is likely more representative of ICC's waste activities, data could be improved in future reporting periods through weighing of the waste, accurate recording of collections, or a waste audit.

The emissions from general waste are largely calculated using the relevant MfE (2025) emission factor. There is uncertainty with this emission factor, and although the guidance states uncertainty of this particularly emission factor is not quantified, other waste emission factors carry an uncertainty of ± 40 percent. A small amount of data was spend-based, and so the waste collection services emission factor from Thinkstep ANZ (2024) was used for this, and it carries with it the uncertainties associated with spend-based emission factors.

The emissions from recycling were calculated using emissions per weight data in a study by David Turner et al. in 2015, as New Zealand currently does not have emission factors for the processing of recycling. This means that there is a high level of uncertainty associated with the technological and geographic representativeness of the recycling emission factors, as the emissions associated with energy consumption overseas will greatly differ from New Zealand's largely renewable energy grid. There is also uncertainty surrounding the age of the emission factors, as they come from a study from 2015. However, in lieu of more recent and geographically representative emission factors, the emissions methodology is currently deemed as best practice.

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4.5.4 Waste Generated in Operations

The disposal of sludge generated by the wastewater treatment plants has emissions that are reported under category 4 rather than Category 1. The associated emissions are calculated using the same methodology as the WWTP emission calculations in Category 1 and, therefore, have the same uncertainties associated with the data.

4.0 GHG Emissions Calculations and Results

4.6 Net Emissions - LULUCF

Although CarbonEES performs gross emission calculations, there are a number of removal or market-based activities that can lead to a different net emission result, including offsets, carbon credits, renewable electricity certificated, and land use, land use change, and forestry (LULUCF). For FY24/25, some forestry data was available, and a light analysis of this has been included here. Note that this is not a complete net calculation of ICC's emissions. Figure 14 shows the forestry emissions and removals for FY24/25, and table 17 shows the net and gross emissions for FY24/25.

Forestry data was provided within a summary table extracted from LUCAS, a stock book report, and emails from ICC contractors. However, the stock book report included only data for Sandy Point, the numbers from the stock book did not align with those from LUCAS, and emails reporting the measurement of harvested areas were not consistent. Therefore, in the interest of conservative reporting, the data from LUCAS and the largest report of harvested areas have been used. There is medium uncertainty in the accuracy and technological representativeness of this data.

As the data from LUCAS is not granular, generic emission factors from MfE (2025) for natural forests (pre-1990 tall natural forests) and planted forest stock change accounting (all planted forests) have been used. These emission factors carry low certainty of relevance and accuracy. MfE attribute uncertainties of $\pm 13.3\%$ for the growth of all planted forests, and $\pm 21.8\%$ for the harvesting of all planted forests. There is no uncertainty for the pre-1990 tall natural forest, as there is no removal associated with it.

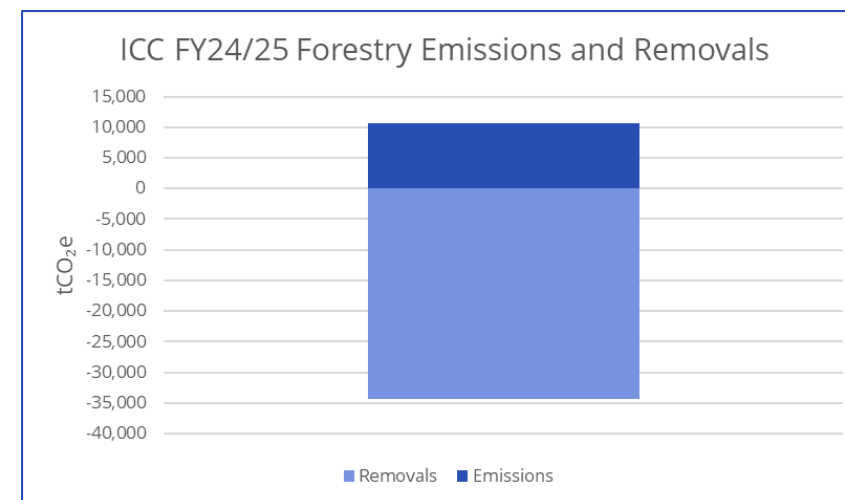
In future reporting periods, if ICC requires a better understanding of its net emissions, greatly granularity of data would be required.

Category 1: Direct Emissions	Category 2 – Indirect Emissions from Imported Energy
Category 3 – Indirect Emissions from Transportation Document Set ID: 2576862 Version: 1, Version Date: 28/01/2026	Category 4 – Indirect Emissions from Products Used by ICC

Table 17: FY24/25 net and gross emission/removal totals.

	Category 1	Category 2	Category 3	Category 4	Forestry Removals	Forestry Emissions	Total
Gross	7,463	1,622	1,298	28,595	NA	NA	38,978
Net	7,463	1,622	1,298	28,595	-34,329	10,676	15,325

Figure 14: FY24/25 forestry emissions and removals.



4.0 GHG Emissions Calculations and Results

4.7 GWP and Other Gasses

ISO 14064-1:2018, 9.3.1 (f, t)

Global Warming Potential (GWP) is a factor that describes the radiative forcing impact of one mass-based unit of a given GHG relative to an equivalent unit of carbon dioxide over a given period (typically 100 years). As GHGs can trap differing amounts of heat in the atmosphere, GWPs are used to make meaningful comparisons between the different gas types.

Although most of the emission factors used to calculate ICC's GHG inventory do not differentiate the different GHGs (i.e. measuring emissions by tCO₂e), emission factors from MfE separate some of these specific emissions, by multiplying the emissions for each non-CO₂ gas by its 100-year time-horizon GWP value from the IPCC Fifth Assessment Report (AR5). Table 18 details the specific gas break down and their associated emissions in tCO₂e.

Table 18: Specific emissions by greenhouse gas in tCO₂e FY25. Emissions presented as unspecified where no breakdown of the emission factor by specific gas is available.

	tCO ₂	tCH ₄	tN ₂ O	Unspecified (tCO ₂ e)
GWP (AR5)	1	28	265	1
tCO ₂ e	2,596	313	42	36,027

4.8 Metrics and Figures

ISO 14064-1:2018, 9.3.2 (g, h)

The FTE for ICC during the FY24/25 reporting period was 382, while the revenue was \$148 million. Table 19 lists these metrics and figures across reporting periods, including emissions intensity figures.

Table 19: Metrics and figures, FTE and revenue against tCO₂e.

	FY20/21	FY22/23	FY24/25
FTE	331	393	382
tCO ₂ e per FTE	47	48	102
Revenue in \$m (from annual reports)	108	122	148
tCO ₂ e per \$m	144	156	263

5.0 References

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6.0 Glossary

- **Baseline** – a reference level of emissions against which future emissions can be measured and assessed.
- **Carbon Dioxide (CO₂)** – a chemical compound that is found in a gas state at room temperature. It is the second most abundant greenhouse gas in the atmosphere, and is the most significant physical driver of climate change.
- **Carbon Dioxide Equivalent (CO₂e)** – A measure of the impact of different greenhouse gases, expressed in terms of their global warming potential.
- **Carbon Footprint** - A measure of the amount of greenhouse gases emitted by an organisation, project, or individual, either directly or indirectly. Within a greenhouse gas inventory report, this is typically expressed in terms of carbon dioxide equivalent and for a 12-month reporting period.
- **Emission** – direct and indirect release of greenhouse gases into the atmosphere by sources.
- **Emission Factor (EF)** - A coefficient used to convert a specific emission source into terms of carbon dioxide equivalent.
- **Financial Year (FY)** – ICC's financial years run from 1 July until 30 June and are referred to by the calendar year in which they end. For example, Financial Year 25 refers to the period that runs 1 July 2024 to 30 June 2025.
- **Greenhouse Gas Inventory** – A list of an organisation, project, or individual's greenhouse gas sources and sinks and their quantified emissions and removals. Typically expressed in terms of carbon dioxide equivalent, and for a 12-month reporting period.
- **Global Warming Potential (GWP)** – A measure of the ability of a gas to trap heat over time relative to carbon dioxide.
- **Greenhouse Gas (GHG)** - Greenhouse gases are gases that absorb and emit specific wavelengths of infrared radiation that has been emitted by Earth, thereby trapping heat in the atmosphere.
- **Greenhouse Gas Protocol** – an international standardised framework used to quantify and report greenhouse gas emissions. Emissions under this standard are categorised into Scope 1, Scope 2, and Scope 3, with Scope 3 then broken down into 15 Categories.
- **International Organisation for Standardisation (ISO) 14064-1:2018** – an international standardised framework used to quantify and report greenhouse gas emissions. Emissions under this standard are categorised into six Categories.
- **Intergovernmental Panel on Climate Change (IPCC)** – the United Nations body for assessing the science related to climate change.
- **Operational Boundary** – the boundary of the emissions activities that are included within the greenhouse gas inventory.
- **Organisational Boundary** – a group of activities or facilities over which an organisation has operational or financial control.
- **Removal** – withdrawal of greenhouse gases from the atmosphere by sinks.
- **Reporting boundary** – the emissions and removals reported within the organisational boundary, as well as indirect emissions that are a result of the organisation's operations and activities.
- **Source** – a process that releases greenhouse gases into the atmosphere.
- **Sink** – a process that removes greenhouse gases from the atmosphere.

Appendix A: Data Uncertainty and Quality

ISO 14064-1:2018, 9.3.1 (p, q)

CarbonEES uses a pedigree matrix for estimating the qualitative uncertainty and quality of activity data and their treatment in GHG inventories and reports. The methodology has been influenced by ISO 14064-1:2018, the Greenhouse Gas Protocol, and the Intergovernmental Panel on Climate Change Task Force on National Greenhouse Gas Inventories. Due to the subjective nature of estimating uncertainty and quality, the results of this tool are imperfect and intended as advisory only.

Data for each activity is measured against ten quality indicators on a scale of one (poor) to five (very good). Five of these indicators are for assessing the quality of the activity data, and five are for assessing the quality of the activity data treatment (i.e., emission calculation methodology and emission factors).

The different assessment criteria used are as follows:

- **Temporal representativeness** – how relevant the activity data or emission factors are to the reporting period.
- **Geographical representativeness** – how relevant the activity data or emissions factors are to the geographic boundary of ICC.
- **Accuracy/precision** – a qualitative assessment of the perceived band of uncertainty of the activity data or emission factors due to assumptions and granularity.
- **Completeness** – how complete the activity data is to the best of CarbonEES' knowledge.
- **Relevance** – how relevant the emission factor is to the type of data.
- **Technological representativeness** – how relevant the activity data or emission factor is to the emissions process.

Activity	Activity Data Quality Assessment					Activity Data Treatment Quality Assessment				
	Temporal	Geographical	Completeness	Accuracy / precision	Technological	Temporal	Geographical	Relevance	Accuracy / precision	Technological
Wastewater Treatment Plants	5	5	5	4	5	3	3	4	2	4
LPG	5	5	5	4	5	3	5	4	4	5
Diesel (stationary)	5	5	5	4	5	3	5	4	4	4
Diesel (fleet)	5	5	5	5	5	3	5	4	4	5
Petrol (fleet)	5	5	5	5	5	3	5	4	4	5
Woodchips	5	5	5	3	4	3	3	4	1	3
Agriculture	5	5	5	5	5	3	3	4	1	4
CO ₂	4	5	5	4	5	5	5	5	5	5
Purchased Electricity	5	5	5	5	5	4	3	4	3	5
Downstream Transportation and Distribution	5	5	5	5	2	3	3	2	2	2
Air Travel (AirNZ)	5	5	5	5	3	4	4	3	3	3
Air Travel (\$)	5	5	5	2	2	3	3	2	2	2
Accommodation	5	5	5	3	3	4	3	3	2	3
Business Travel in Personal Vehicles	5	5	5	2	2	3	3	3	2	3
Rental Car	5	5	5	2	2	3	3	2	2	2
Taxi Travel	5	5	5	2	2	4	3	3	2	3
Employee Commuting	5	5	1	3	3	4	4	3	3	4
Working from Home	5	5	1	3	3	4	4	3	2	4

Appendix A: Data Uncertainty and Quality

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- **Relevance** – how relevant the emission factor is to the type of data.
- **Technological representativeness** – how relevant the activity data or emission factor is to the emissions process.

Activity	Activity Data Quality Assessment					Activity Data Treatment Quality Assessment				
	Temporal	Geographical	Completeness	Accuracy / precision	Technological	Temporal	Geographical	Relevance	Accuracy / precision	Technological
Purchased Goods & Services	5	4	5	4	1	3	3	2	2	2
Paper	5	5	5	5	4	4	2	4	2	4
Capital Goods	5	4	5	4	1	3	3	2	2	2
T&L – Diesel	5	5	5	4	5	4	2	4	1	4
T&L – Petrol	5	5	5	4	5	4	2	4	1	4
T&L – LPG	5	5	5	4	5	4	2	4	1	5
T&L – Electricity	5	5	5	5	5	4	3	4	3	5
Recycling	5	5	4	3	3	1	1	3	1	4
General Waste	5	5	4	3	2	4	4	2	1	3
WWTP Disposal of Waste	5	5	5	4	4	3	3	4	2	4
Forest Growth	5	5	4	3	3	3	4	2	2	3
Forest Harvesting	5	5	4	3	3	3	4	2	1	3

Appendix B: ISO 14064-1 Reporting Index

ISO 14064-1:2018, 9.3.2 (d)

ISO Reporting	Section in this report	ISO Reporting	Section in this report
9.3.1 (a)	1.2	9.3.1 (q)	3.7, Appendix A
9.3.1 (b)	1.3	9.3.1 (r)	1.1
9.3.1 (c)	1.4	9.3.1 (s)	3.2
9.3.1 (d)	2.0	9.3.1 (t)	4.6
9.3.1 (e)	3.1, 3.3	9.3.2 (a)	1.2, 3.4
9.3.1 (f)	4.6	9.3.2 (b)	1.2
9.3.1 (g)	3.5	9.3.2 (c)	N/A
9.3.1 (h)	3.5	9.3.2 (d)	3.4, Appendix B
9.3.1 (i)	3.6	9.3.2 (e)	N/A
9.3.1 (j)	4.0	9.3.2 (f)	4.0
9.3.1 (k)	3.8	9.3.2 (g)	4.7
9.3.1 (l)	3.8	9.3.2 (h)	4.7
9.3.1 (m)	4.0	9.3.2 (i)	3.2
9.3.1 (n)	3.8, 4.0	9.3.2 (j)	4.0
9.3.1 (o)	3.5, 4.0	9.3.2 (k)	4.0
9.3.1 (p)	3.7, Appendix A	9.3.3	N/A



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Version: 1, Version Date: 28/01/2026

LOCAL GOVERNMENT OFFICIAL INFORMATION REQUESTS UPDATE

To:	Risk and Assurance Committee
Meeting Date:	Tuesday 15 September 2026
From:	Clare Sullivan - Senior Governance Specialist
Approved:	Trudie Hurst - Group Manager - Community Engagement and Corporate Services
Approved Date:	Tuesday 8 September 2026
Open Agenda:	Yes
Public Excluded Agenda:	No

Purpose and Summary

The purpose of the report is to provide information to the Risk and Assurance Committee of Council's performance in managing requests for official information.

Recommendations

That the Risk and Assurance Committee:

1. Receives the report "Local Government Official Information Requests Update".

Background

Information on the number of requests made under the Local Government Official Information and Meetings Act 1987 (LGOIMA) has not previously been provided to elected members. It is considered that information on LGOIMAs may be useful and provide the Committee with a further way of monitoring Council's compliance with its statutory obligations and its commitment to transparency and accountability in the provision of official information.

Issues

It is proposed that every six months this Committee will receive a report detailing the numbers received and enable the Committee to monitor trends and any emerging issues or risks.

This initial report will provide limited information on local government official information requests and privacy requests from 1 January 2026 to 30 June 2026.

It is intended that the information in future reports will include, CCTV requests and complaints to the Ombudsman, be presented in a more informative manner and provide comparisons including response times.

Statistics from 1 January to 30 June 2026

LGOIMA Requests

Number received	Completed within statutory timeframe	Completed outside statutory timeframe	Extension provided
78	62	13	3

It is acknowledged that these numbers do not meet the standards we expect. Following the appointment in May 2026 of two Governance Specialists, the processes for how LGOIMAs are processed, tracked, responded to and reported has changed. There are currently no outstanding LGOIMAs.

Of the 78 LGOIMAs received from 1 January to 30 June 2026, 29 were from individuals, 36 from organisations and 12 from media. Topics requested ranged from costs of the former Mayor Sir Tim Shadbolt's funeral, rates and costs of Council, and complaints relating to noise, dogs, and parking. Since May 2026 there have been at least 10 LGOIMAs relating to the streetlights on Elles road. Information on this subject has recently been uploaded to the Council website. There has been a number of follow-up requests or correspondence related to several LGOIMAs, including one correspondent who has sent over 20 follow-up emails.

Staff have noted an increase in the number of LGOIMAs received. In 2024, Council received 134 LGOIMA requests; in 2025, that figure was 136. Since 1 July 36 LGOIMAs have been received. That makes a total for the year to date of 114. It is likely that the numbers of LGOIMAs received will exceed those of the past two years.

Privacy Requests

From 1 January to 30 June 2026 Council received two requests for access to personal information and three other external privacy related items. Staff advise that they have answered a number of enquiries from staff to ensure their compliance with the Privacy Act. There were no reported breaches to the Privacy Commissioner.

Next Steps

Six monthly reporting will provide greater reassurance to this Committee that staff are meeting the statutory timeframes, minimise risk and provide more information on the LGOIMAs received and minimise risk.

Attachments

Nil.

FINANCIAL RISKS UPDATE

To: Risk and Assurance Committee

Meeting Date: Tuesday 15 September 2026

From: Bryan Staunton – Chief Financial Officer

Approved: Patricia Christie - Group Manager - Finance and Assurance

Approved Date: Wednesday 9 September 2026

Open Agenda: Yes

Purpose and Summary

The purpose of this report is to provide an update on Council's financial risks, in particular Treasury and Procurement risks.

Recommendations

That the Risk and Assurance Committee:

1. Receives the report 'Financial Risks Update'.

Background

This report provides the Committee with an update on key financial risks. This quarter's report is focused on Council's compliance with our Treasury policy.

Issues

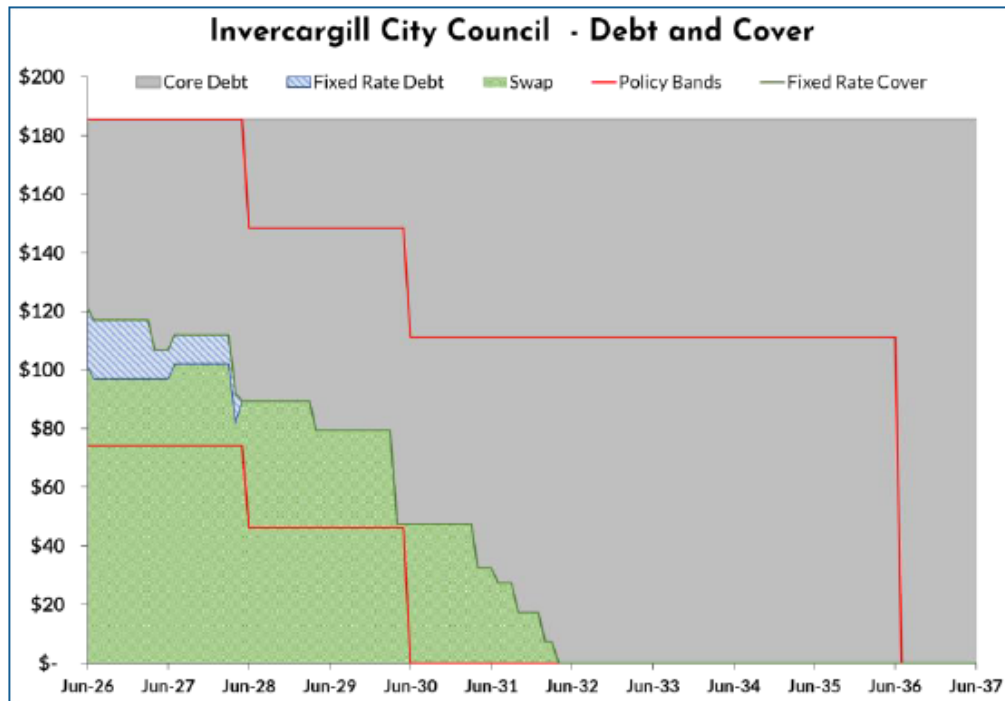
Treasury Risk

Included as Attachment 1 is the June 2026 Treasury Report from Bancorp.

This report shows that as at 30 June 2026 Council had core debt of \$185.50 million in place.

Council is in compliance with all policy measures:

- Transactions have been transacted in compliance with policy.
- Fixed interest rate cover is within policy control limits.
- Funding maturity profile within policy control limits.
- Liquidity within policy control limits.
- Counterparty exposures within control limits.

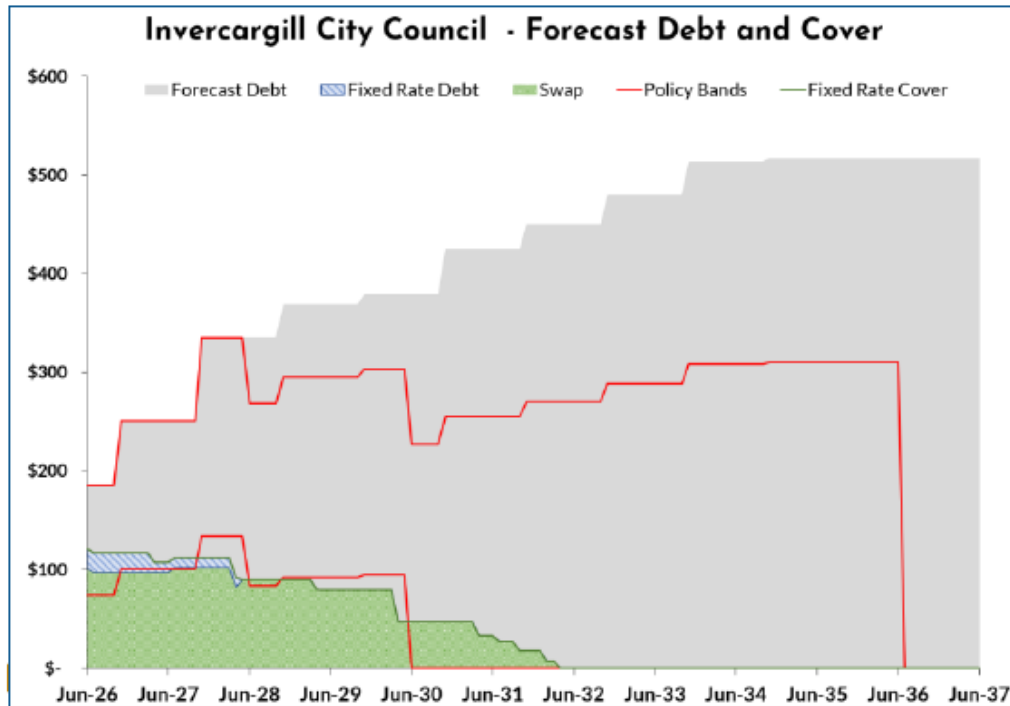


Council's policy bands are:

Period to Maturity	Minimum	Maximum
0 – 2 years	40%	100%
2 – 4 years	25%	80%
4 – 10 years	0%	60%

The below graph represents Council's projected debt compared to the policy bands.

Forecast debt is based upon the 2026-2027 Annual Plan which includes a ten-year debt forecast. The balance includes Three Waters debt based on using an in-house (ring fenced) model.



The above graph shows that there is a potential future breach in December 2027, and again in 2028/2029. Staff continue to monitor the swap markets and plan to rectify this with a future interest rate swap when the interest rates are at an acceptable level. As this is a forecast position, it is not considered a breach in policy but is considered a future breach risk.

It is noted in the Treasury report that Council's average cost of funds is 3.81%, an increase from the 3.44% at March 2026. The increase is reflective of market movements in interest rate, with some very low-rate debt maturing in recent months. LGFA is currently offering fixed rate debt with interest rates varying between 4.07% and 5.44% (depending on the term of the debt) for Councils with credit ratings of AA+ or AA.

Invercargill Central Limited Loan Advance

At 30 June 2026, the balance of the loan to Invercargill Central Limited was \$12.7 million, which is a decrease from \$16.25 million as at 30 June 2025. This is predominantly as a result of principal repayments made by Invercargill Central Limited during the year.

Procurement

Since 1 July 2026, the procurement function has supported procurement, contract management and commercial activities with a combined value of approximately \$18.9 million. During this period, the team has worked on 31 separate procurement and contract-related activities.

Monitoring of different aspects of the procurement framework, including spend without contract, local spend and adherence to the procurement policy is continuing.

Insurance Renewals

The renewal of the Professional Indemnity and Public Liability insurances occurred on 30 June with the London insurers.

Premium for Public Liability is 3.78% lower than last year. Professional Indemnity has increased by 1.84% leaving an overall saving of 1.94%.

Portfolio name	Insurer	What is Covered	Level of Cover	Value of Assets insured	Premium (GST excl)
Liability (June renewal)	London Market Syndicates	Professional Indemnity cover for the activities of building control services of Council	\$15 million in total – excess \$200,000.		\$882,000
	London Market Syndicates	Public Liability claims	\$100 million in total – excess \$200,000		\$394,938

During the 2025/2026 Annual Plan, insurance was identified as one of the areas savings could be possible. A review of the insurance cover was carried out and the Public Liability claim limit has been reduced by \$50 million to \$100 million, saving council \$55,000. This has been offset by an increase in premium in professional indemnity by \$35,000 which reflects claims lodged this period.

Staff are currently reviewing insurance values for Council's assets held for the Property Programme insurances including material damages. We are currently working with our brokers responding to questions. Confirmed insurance cover, values and premiums are expected to be finalised in September/October 2026.

Local Authority Protection Programme (LAPP) insurance for Water, sewerage, stormwater reticulation networks has been renewed in early September. The value of assets insured has increased by 5.9% to \$1,699,240,543. Even though asset value has increased the membership contribution has decreased by 3.8% from last year due to the softening of the insurance market.

Outlined below is more information about each of the types of insurance:

LAPP

- The purpose of the LAPP insurance is to provide an insurance solution to Council funding its 40% of the damage to reticulation infrastructure assets (e.g., pipes) damaged in a natural disaster. With Central Government funding the remaining 60% of damage.
- This is a specialist insurance type product for local government which currently targets small to medium councils.
- The three waters asset revaluation process also includes an insurance valuation for the networks.

Professional Indemnity

- This insurance specifically protects the Planning and building control activities of Council.
- There had been seven notified claims from 2022 to 2026. T Of the seven notified only four are outstanding with a combined estimated value of \$ 640,000
- The largest successful claim lodged against Council was the Stadium Southland collapse. This claim is still a factor in our risk assessment.

Public Liability

- Public liability cover is a requirement of a number of contracts and leases which Council hold. Each contract will dictate what the minimum level of public liability cover Council must hold and annual insurance certificates are provided to the counter-party.
- There have been 16 claims filed from the period between 2022 to 2026. Of the 16 notified claims, 5 are classified as potential claims.

Material Damage

- This is a mix of replacement and indemnity value sum insured. Each year the properties are reviewed to determine what should be replacement and what on indemnity cover.
- There have been a low number of claims between 2021 to 2025, with 41 total claims on the material damage and business interruption policies to the value of \$481,470. The claim from the October 2025 windstorm is still progressing with the overall claim figures yet to be finalised.
- Building insurance valuations are reviewed three yearly and the next revaluation is due this June 2029.

Next Steps

Continue to monitor for any breaches of financial and procurement policies.

Continue to review current forecast capital spend to identify funding needs given current market position.

Attachments

Attachment 1 - Invercargill City Council Treasury Report as at 30 June 2026 (11266496)



Treasury Dashboard Report

30 June 2026



BANCORP

Document ID: 11266496
Version: 1, Version Date: 03/09/2026



Economic Commentary

2

Global

Global economic activity in June quarter was dominated by the ongoing Middle East conflict, particularly disruptions around the Strait of Hormuz, which triggered a sharp energy price shock. The conflict, involving Iran and responses from the US and Israel, led to effective closure or severe restrictions on the Strait of Hormuz starting around late February/early March 2026. This chokepoint normally carries about 20% of the global oil and LNG supply. The resulting supply disruptions drove oil prices sharply higher (Brent crude peaking well above \$100/bbl in parts of Q2 before easing on ceasefire hopes), as well as pushing up inflation expectations, squeezing real incomes, and weighing on growth—especially in energy-importing economies.

Major institutions revised down their 2026 global growth forecasts in response. The World Bank projected global GDP growth to slow to 2.5% for the year (the weakest outside an outright recession in ~20 years). The International Monetary Fund's April World Economic Outlook's assumed a limited conflict and projected 3.1% global growth for 2026 (down from prior steadier ~3.3% paths), with inflation ticking up before declining. The OECD and others similarly highlighted downside risks from prolonged energy shocks, geopolitical fragmentation, and eroded policy buffers.

The key US market showed relative resilience. March 2026 quarter real GDP grew at an annualised rate of 2.0%, supported by solid consumer spending (though softening), strong AI-related non-residential investment/equipment, and a partial recovery in government spending. Q2 faced headwinds from higher energy prices acting as a 'consumer tax,' potentially slowing momentum. Labour markets remained stable with AI productivity gains, but inflation pressures rose. The Fed stayed cautious and held the Fed Funds rate steady amid uncertainty.

Over the last three months, the US 10-year Treasury yield traded in a relatively contained range around 4.50%, ending the period virtually unchanged. The curve dynamics showed some flattening, with the 10-year relatively stable compared to shorter maturities, but overall modestly higher amid volatility driven by the Middle East energy shock, inflation concerns, and shifting Fed expectations.

New Zealand

	OCR	90 day	1 year swap	2 year swap	3 year swap	5 year swap	10 year swap
31-Mar	2.25%	2.54%	2.92%	3.43%	3.69%	3.96%	4.32%
30-Jun	2.25%	2.75%	3.10%	3.35%	3.48%	3.69%	4.06%
Change	Nil	+0.21%	+0.18%	-0.08%	-0.21%	-0.27%	-0.26%

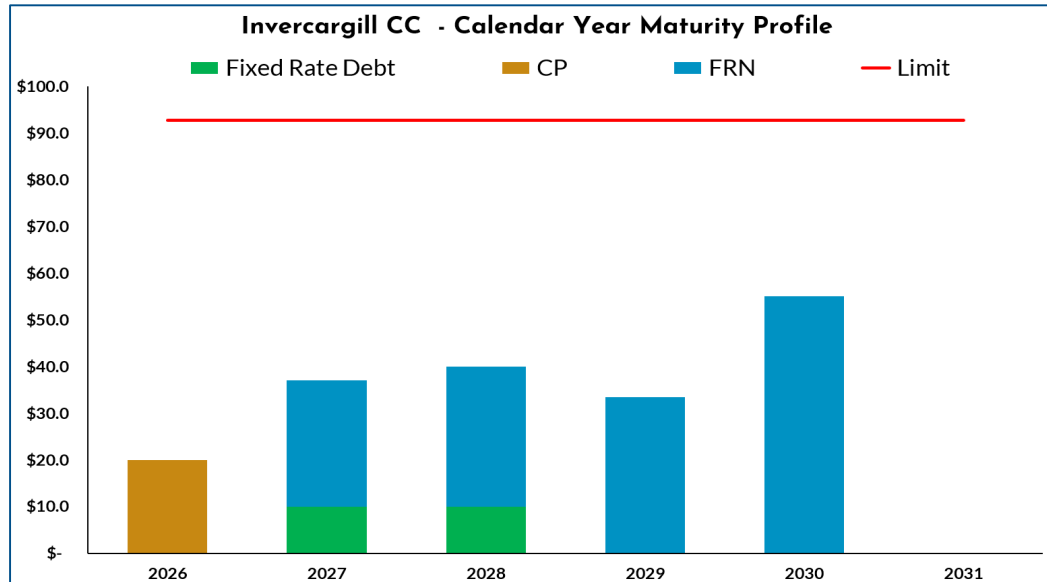
In the June quarter New Zealand's economy showed tentative signs of recovery from prior weakness, but the global conflict in the Middle East and the associated energy price shock posed significant headwinds, delaying momentum and pushing up near-term inflation. The March 2026 Q2 GDP (data released in June) grew 0.8% and 1.5% annually. During the three months ending 30 June economic indicators pointed to softer or flat-to-negative economic growth amid higher fuel costs squeezing real incomes and confidence, plus global uncertainty. However, early resolution signals for the Iran-related disruptions (Strait of Hormuz) by late June improved the outlook. Private forecasters revised up 2026 full-year GDP growth ~2.0%, though still below pre-conflict expectations.

CPI inflation stood at an annualised 3.1% for the 12 months ending 31 March 2026. The Middle East conflict drove fuel and related costs higher, with the RBNZ projecting CPI to reach 4.2% in the June 2026 quarter and peaking around 4.3% in the third quarter. Forecasters noted potential for a June-quarter peak around 4.0–4.4%, with an easing later in the year if oil prices normalised. Underlying pressures were contained by spare capacity in the economy,

The New Zealand swap curve flattened significantly during the quarter with short-term swaps higher and longer-term swap rates down around 25 basis points. The OCR finished June unchanged at 2.25%, but with financial markets pricing in a 68% probability that the RBNZ would increase it to 2.50% on the 8th July review date, which it duly did. At quarter end markets were projecting the OCR to reach 2.75% by the end of 2026, 3.00% by March 2027 and 3.25% by September 2027. Individual bank economists projections for the OCR varied between an increase to just 3.00% in the current cycle (ANZ), 3.25% (ASB) and 4.00% (BNZ and Westpac).

Liquidity and Funding

3



Policy Compliance	Compliant
Have all transactions been transacted in compliance with policy?	Yes
Is fixed interest rate cover within policy control limits based on current debt?	Yes
Is the funding maturity profile within policy control limits?	Yes
Is liquidity within policy control limits?	Yes
Are counterparty exposures within policy control limits?	Yes

Core ICC Debt

\$185.5m

External Council Drawn Debt

Total LGFA debt (includes on-lending)

\$199.9m

Funds Drawn from LGFA

Liquidity = bank facility headroom +
cash in bank + term deposits

\$47.21m

Liquidity Ratio (must be >110%)

123.61%

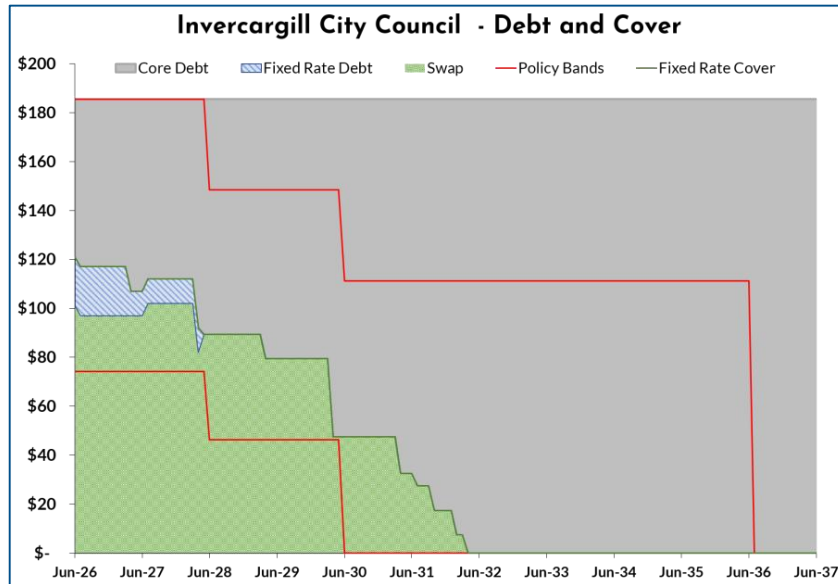
Definition: (Term Deposits + cash in bank +
Lines of Credit + Drawn Debt)/Drawn Debt
which includes on lending

Cost of Funds at 30 June 2026

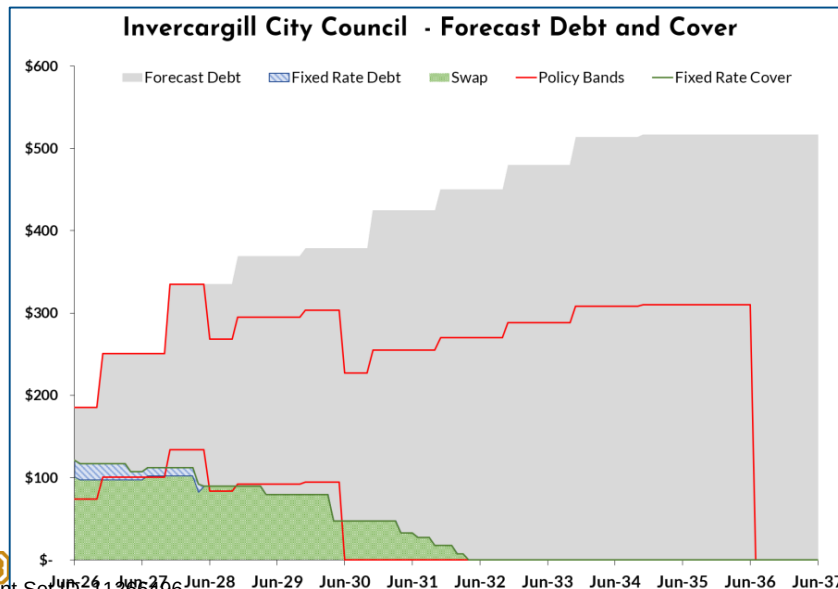
3.81%

Interest Rate Risk Management

4



Current % of Debt Fixed	65.2%
Current % of Debt Floating	34.8%
Value of Fixed Rate (m)	\$121.0
Weighted Average Cost of Fixed Rate Instruments	3.59%
Value of Forward Starting Cover	\$12.5
Value of Floating Rate (m)	\$64.5
Current Floating Rate	2.72%
All Up Weighted Average Cost of Funds Including Margin	3.81%
Total Facilities In Place	\$195.5



Policy Bands based on current debt of \$185.5m

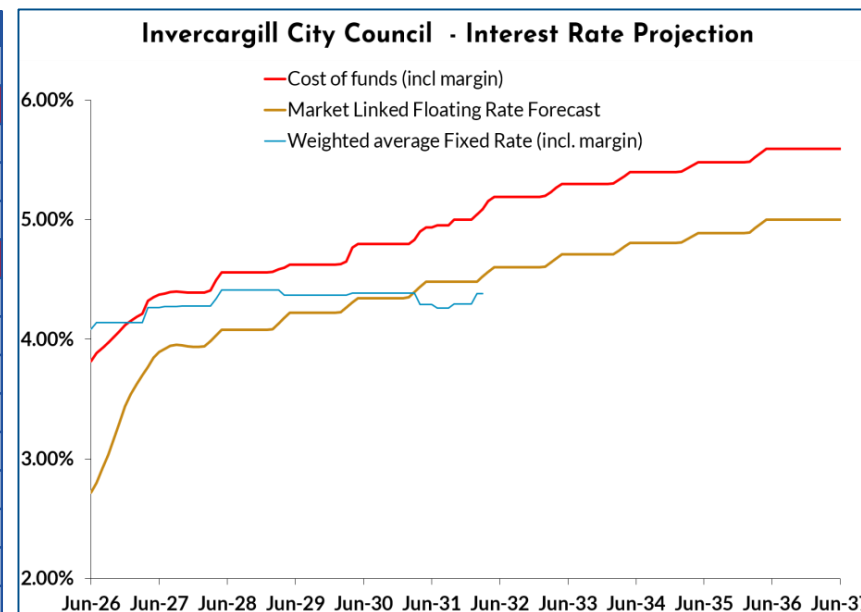
Term	Minimum	Maximum	Policy
0-2 years	40%	100%	Compliant
2-4 years	25%	80%	Compliant
4-10 years	0%	60%	Compliant

Invercargill City Council - Funding and Interest Rate Projection

5

As at 30 June 2026, ICC had \$185.5 million of core debt and \$199.9 of total debt, all of which is sourced from the Local Government Funding Agency ("LGFA") using Commercial Paper ("CP"), Floating Rate Notes ("FRN"), and Fixed Rate Bonds ("FRB"), which are detailed in the table below. The debt highlighted in red has been on-lent to Invercargill Central Limited.

Instrument	Maturity	Yield	Margin	Amount
LGFA CP	28-Jul-26	2.77%	N/A	\$20,163,923
LGFA CP	28-Jul-26	2.77%	N/A	\$4,000,000
LGFA FRB	29-Apr-27	2.62%	N/A	\$10,000,000
LGFA FRN	29-Apr-27	3.20%	0.55%	\$10,000,000
LGFA FRN	29-Apr-27	3.49%	0.84%	\$12,000,000
LGFA FRB	27-Jun-27	5.33%	N/A	\$10,256,410
LGFA FRN	29-Oct-27	3.21%	0.56%	\$5,000,000
LGFA FRN	29-Apr-28	3.21%	0.56%	\$10,000,000
LGFA FRN	29-Apr-28	3.40%	0.75%	\$15,000,000
LGFA FRN	29-Apr-28	3.14%	0.49%	\$5,000,000
LGFA FRN	29-Apr-28	3.03%	0.45%	\$5,000,000
LGFA FRB	15-May-28	4.06%	N/A	\$10,000,000
LGFA FRN	29-Apr-29	3.50%	0.85%	\$10,000,000
LGFA FRN	29-Apr-29	3.37%	0.72%	\$10,000,000
LGFA FRN	29-Apr-29	3.34%	0.69%	\$8,500,000
LGFA FRN	29-Apr-29	3.35%	0.70%	\$15,000,000
LGFA FRN	29-Apr-30	3.33%	0.68%	\$10,000,000
LGFA FRN	29-Apr-30	3.24%	0.59%	\$20,000,000
LGFA FRN	29-Apr-30	3.17%	0.57%	\$10,000,000
				\$199,920,333



LGFA Funding Rates as at 30 June 2026

6

Listed below are the credit spreads and applicable interest rates as at 30 June 2026 for Commercial Paper ("CP"), Floating Rate Notes ("FRN") and Fixed Rate Bonds ("FRB"), at which ICC could source debt from the Local Government Funding Agency ("LGFA").

Maturity	Margin	FRN (or CP Rate)	FRB
3 month CP	0.15%	2.84%	N/A
6 month CP	0.15%	3.09%	N/A
April 2027	0.32%	3.01%	3.29%
May 2028	0.41%	3.10%	3.71%
April 2029	0.46%	3.15%	3.91%
May 2030	0.54%	3.23%	4.11%
May 2031	0.61%	3.30%	4.32%
May 2032	0.67%	3.36%	4.42%
April 2033	0.72%	3.41%	4.54%
May 2035	0.75%	3.44%	4.82%
May 2035	0.86%	3.55%	4.82%
April 2037	0.97%	3.66%	5.05%

Disclaimer

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