

10.4. Head of Lake Whakatipu Natural Hazards Adaptation Programme

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PURPOSE

- [1] To update Council on the progress related to the development of a natural hazards adaptation strategy for the Head of Lake Whakatipu (Whakatipu-Wai-Māori) area.
- [2] To present the final version of the Head of Lake Whakatipu Natural Hazards Adaptation Strategy, including a ‘Condensed’ version or overview for Council’s consideration and adoption.

EXECUTIVE SUMMARY

- [3] This paper provides an update on the Head of Lake Whakatipu natural hazards adaptation programme’s activities since the Council paper in December 2024<sup>1</sup>, with a focus on public engagement activities, finalising the natural hazards adaptation strategy for the Head of Lake Whakatipu area (the Strategy), and developing a ‘Condensed’ version.
- [4] Following the Council’s endorsement in December 2024 to seek public feedback on the draft Head of Lake Whakatipu Natural Hazards Adaptation Strategy, including ‘Summary and Survey’ document, five public feedback methods were implemented between December 2024 and February 2025. These include an online survey, paper-based survey, email and post submissions, and community engagement events.
- [5] Although the level of participation was relatively low, the feedback received showed strong community support, with 80% of respondents agreeing with the Strategy’s vision. The Strategy is regarded as practical, science-based, and developed through an inclusive, collaborative process. Respondents emphasised the importance of integrating physical and non-physical approaches with policy-driven strategies. The community engagement events were well-received for providing an opportunity for direct feedback and discussing specific concerns.
- [6] Based on community and public feedback, key revisions were made to the draft Strategy, including a new ‘Heritage’ subsection. This highlights the significance of the historic, cultural and archaeological sites at the area and the legal requirements for protecting these sites under the Heritage New Zealand Pouhere Taonga Act 2014.

<sup>1</sup> Conroy A, Nguyen T, van Woerden T and Payan J-L, 2024. Head of the Lake Whakatipu Natural Hazards Adaptation Programme. Report HAZ2406 to the Otago Regional Council, 4 December 2024.

- [7] A final round of review of the revised draft Strategy was completed in March 2025 with Otago Regional Council (ORC) teams, Queenstown Lakes District Council (QLDC), Civil Defence Emergency Management (CDEM) Otago, Aukaha and Dr Paula Blackett (adaptation expert).
- [8] The final Strategy (Appendix 1) reflects all feedback and is ready for Council's consideration and adoption.
- [9] A more accessible 'Condensed' overview is being developed, presenting key parts of the Strategy in plain language with visual elements. Draft text is attached as Appendix 2 for consideration and endorsement. Visual elements will be incorporated in the design stage.

## RECOMMENDATION

*That the Council:*

1. **Notes** this report.
2. **Notes** the progress of the Head of Lake Whakatipu natural hazards adaptation programme.
3. **Endorses** the Head of Lake Whakatipu Natural Hazards Adaptation Strategy detailed report (Appendix 1).
4. **Notes** the actions outlined for ORC in the Strategy Action Plan (Appendix 1, Section 10).
5. **Notes** the 'Condensed' overview document (Appendix 2).

## BACKGROUND

- [10] ORC, in collaboration with programme partners including QLDC, is leading a programme of work to develop a natural hazards adaptation strategy for the Head of Lake Whakatipu area (the Strategy).
- [11] The Head of Lake Whakatipu area is exposed to multiple natural hazard risks, including those due to seismic events, flooding and slope-related processes (e.g., landsliding and debris flow). This risk setting is compounded by a changing climate and large-scale landscape change (e.g., river channel migration and sedimentation) as well as socio-economic changes.
- [12] The adaptation programme progress and completed activities are detailed in a series of papers for the Safety and Resilience Committee and for Council, presented between 2021 and 2024<sup>2</sup>.
- [13] Figure 1 presents an overview of key activities within the Head of Lake Whakatipu adaptation work programme, which is currently in the fourth phase: '*Make it happen*'.

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<sup>2</sup> Reports to Council (27 May 2021, 4 December 2024), the ORC Data and Information Committee (9 June 2022) and the ORC Safety and Resilience Committee (10 May 2023, 10 August 2023, 9 November 2023, 8 February 2024, 8 May 2024, 7 August 2024 and 7 November 2024).

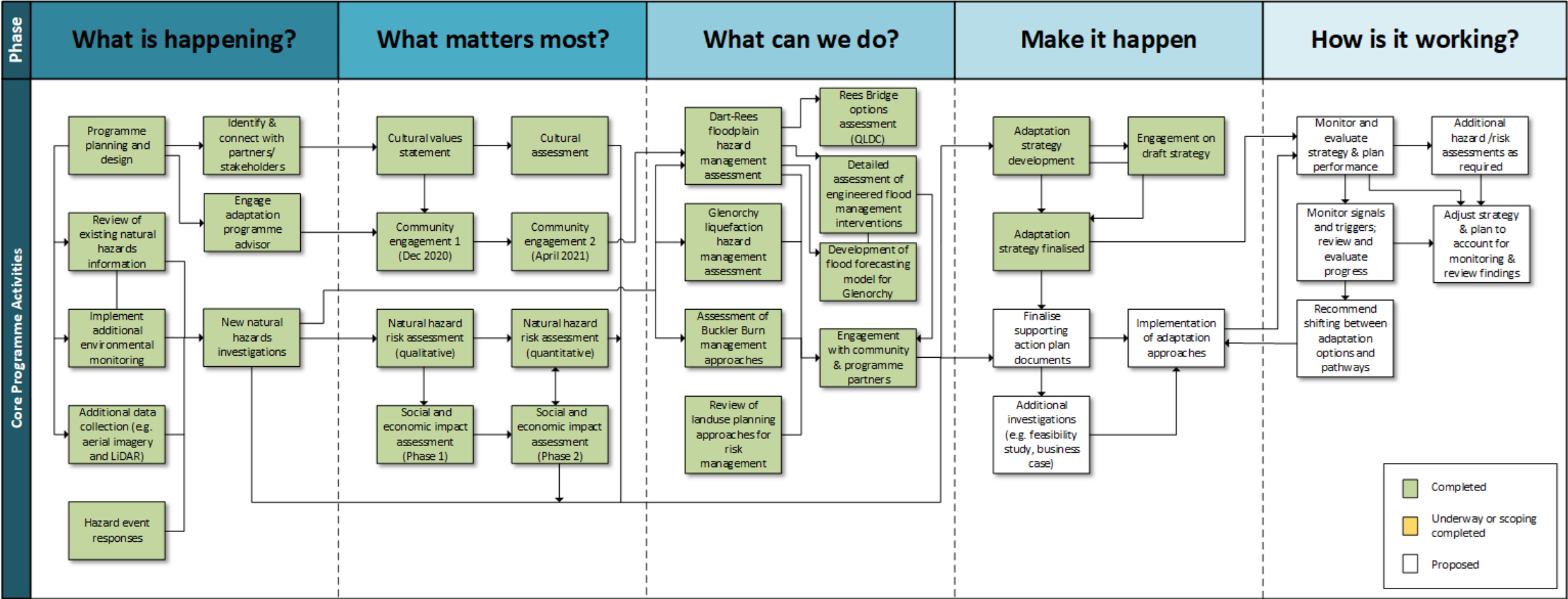


Figure 1: Head of Lake Whakatipu programme overview of key activities.

COMMUNITY ENGAGEMENT

[14] Proposed and completed community engagement activities from late 2024 into 2025 are outlined in Table 1. In addition to these activities, regular programme updates are provided to the community through the monthly newsletter (until June 2025), followed by six-monthly newsletter starting from November 2025, as well as through the programme webpage<sup>3</sup>.

Table 1: Proposed and completed community engagement activities in 2024 and 2025.

Engagement activity (and level of participation) <sup>4</sup>	Purpose	Late 2024- early 2025	Mid 2025
Gain feedback on draft strategy document.  Five feedback methods used.  ➤ Consult	To receive feedback on the draft Strategy, strategic framework and Action Plan.  To consider feedback and adjust so that the Strategy is efficient and works for the community.	✓	
Share first version of the Strategy.  ➤ Inform	Activities to increase awareness of the final Strategy and improve accessibility of the information.		

[15] A multi-method approach was used to gather public and community feedback on the draft Strategy. It includes:

- **Online and paper-based surveys:** The surveys were conducted between December 2024 and February 2025. The online survey was hosted on the ORC website, while paper-based surveys were available at Glenorchy Library and Glenorchy Motors. Both formats included open and closed questions to gather community and public feedback on key parts of the Strategy, including the vision, Action Plan and possible future responses (Future Toolbox). The online survey received five responses from community members and local organisations, while no responses were received via the paper-based surveys.
- **Email and postal submissions:** ORC invited feedback via email and post between December 2024 and February 2025. Copies of the draft Strategy were available both online and in print (distributed in Glenorchy Library and Glenorchy Motors). Four submissions were received from community members and local organisations via email, while no submissions were received by post.

<sup>3</sup> <https://www.orc.govt.nz/get-involved/projects-in-your-area/head-of-lake-whakatipu/>

<sup>4</sup> IAP2 Spectrum of Public Participation (as committed to in He Mahi Rau Rika) describes levels of participation, that define the public’s role in any public participation process Inform → Consult → Involve → Collaborate → Empower.



- ***Community engagement events:***
  - ORC in collaboration with QLDC and CDEM Otago hosted two community engagement events in February 2025 in Glenorchy: a Community Presentation on 13 February and a Drop-in Session on 14 February.
  - The events provided an opportunity for the community to give direct feedback on the draft Strategy as well as discussing specific issues with ORC, QLDC and CDEM Otago staff, and Councillors.
  - The Community Presentation featured an ORC staff-led presentation, followed by an open Q&A session and then an informal discussion. The Drop-in Session featured 'thematic tables and stations' to facilitate discussion. Different teams from ORC and QLDC including Councillors as well as staff from CDEM Otago were at the events to support discussions and respond to questions or concerns from the community.
  - Eight community members attended the Community Presentation, and five visited the Drop-in Session with some attending both events. The Chair of the Glenorchy Community Association participated to the event and provided feedback both verbally and formally.
  - The level of participation was low, but ORC made significant efforts to reach a wide range of people in the community. This included a comprehensive advertising campaign; mailbox flyers; a long notice period before engagement sessions; and an extended feedback period. Although the level of participation is low, it is very valuable, and people can still provide views on this work through the programme email address.

[16] Key results from the engagement activities and feedback on the draft Strategy:

- 14 pieces of feedback were received (summary in Appendix 3).
- Strong acknowledgement of the Strategy as practical, well-researched, inclusive and collaborative.
- High level of agreement (80%) with the Strategy's vision.
- Preference for a mix of adaptation solutions (physical and non-physical), including resilient infrastructure investments and integration of adaptation into everyday decision-making.
- Calls for prioritisation of specific adaptation works such as physical works for immediate implementation.
- Strong interest in the Future Toolbox (possible future responses), particularly physical, nature-based and policy-driven adaptation measures.



**Figure 2: Participants at the Community Presentation on 13 September 2024 at Glenorchy Hall.**

- [17] The next stage of community engagement activities from mid-2025 will focus on increasing awareness of the final Strategy and accessibility. Various approaches will be used to improve accessibility of the information, such as improvements to website content and developing the more accessible ‘Condensed’ overview, presenting key parts of the Strategy in plain language with visual elements.

#### **REVISIONS OF THE DRAFT STRATEGY**

- [18] After the public feedback period closed, ORC carefully reviewed all feedback (Appendix 3) received through the five engagement methods. Most feedback related to the Strategy was incorporated into the final Strategy, while feedback requesting further information on specific risks will be addressed in the upcoming Newsletter in June 2025.
- [19] This process demonstrates ORC’s commitment to taking all feedback seriously and its appreciation for the contributions that helped shape the final Strategy.

#### **COLLABORATION WITH OTHER ORC TEAMS, QLDC AND PARTNERS**

- [20] The revised draft Strategy was shared with other ORC teams, QLDC and other partners such as Aukaha and Dr Paula Blackett for final review from 17 to 21 Mar 2025.
- [21] Additional feedback focused on refining key terms related to mana whenua and ensuring adaptation signals and triggers were well-linked. These refinements were incorporated into the final Strategy.

## FINALISATION OF THE STRATEGY AND DEVELOPMENT OF THE CONDENSED VERSION

[22] The revised draft Strategy was finalised in March 2025. ORC reviewed all feedback and incorporated it into the final Strategy. Additional work included updating content throughout the document. The final Strategy is now a comprehensive report, structured as follows:

- **Vision, goals, principles and scope**
- **Setting the scene** – background and context.
- **Drivers for adaptation**
- **Legislative and strategic context**
- **Strategy governance** – including partnerships, and roles and responsibilities for implementation.
- **Adaptation cycle approach to planning** – guides the reader through the adaptation process using the five key questions as a framework:
  - 1) *What is happening?* – foundation information about natural hazard processes, characteristics, and potential impacts.
  - 2) *What matters most?* – values, aspirations, fears and concerns we have heard from community, partners and stakeholders; socio-economic vulnerability and resilience; Kinloch and Glenorchy risk analysis findings; and tolerability discussion.
  - 3) *What can we do about it?* – long-list of possible response, including existing and possible future responses; high level evaluation of possible responses and mana whenua assessment.
  - 4) *How can we implement the strategy?* – adaptation pathways with signals and triggers; implementation framework.
  - 5) *How is it working?* – a review framework.
- **Action Plan** – outlines the relevant work of strategy partners in progress, planned and committed.
- **Appendices** – including project deliverables, supporting information about existing responses and future toolbox, and summary of feedback on the draft Strategy.

[23] The finalised Strategy was written by the ORC Natural Hazards team with inputs from other ORC teams, QLDC, CDEM Otago and Aukaha. Dr Paula Blackett contributed to its development, providing advice on engagement planning as well as pathways, signals and triggers development. The document incorporates all feedback (attached as Appendix 1) and is now ready for Council's consideration and adoption.

[24] To improve accessibility, a 'Condensed' version of the Strategy is being created. It simplifies complex information, uses plain language, and incorporates visuals to enhance public engagement and understanding.

[25] The 'Condensed' document is structured as follows:

- What is this Strategy?
- What matters most to the community and mana whenua? This is what we heard.
- Why do we need to adapt?
- What do we rely on for natural hazards management now? How are we planning to enhance and improve?
- What might the future look like? Do the same? Do better? Do things differently?

- How will we know when future decisions are needed?
- How will we work together to implement the Strategy?
- How will we review and adjust?

## DISCUSSION

- [26] The Strategy represents the culmination of an over five-year process that included technical investigations, collaborative planning, and inclusive community and stakeholder engagement.
- [27] The Strategy was developed in collaboration with the community as well as with QLDC, CDEM Otago, mana whenua representatives, technical experts and different ORC teams. It reflects shared ownership and coordinated planning, which is critical for implementation success.
- [28] The Strategy has generated a substantial body of knowledge on natural hazards in the area, including updated understanding of seismic risks and flood hazards. It has also established a flexible adaptation process based on signals, triggers and pathways. Together, this evidence base and planning framework support more informed and proactive decision-making on adaptation for the Head of Lake Whakatipu area now and in the future.
- [29] This is ORC's most advanced, comprehensive application of the dynamic adaptive pathways planning (DAPP)<sup>5</sup> approach. It sets a benchmark for future adaptation strategies and risk planning efforts for communities across the region.
- [30] Learnings from this Strategy is informing the design of other ORC adaptation programmes, such as the Clutha Delta and South Dunedin Future programme. This includes enhanced community engagement approaches, a clearer structure and presentation, and the development of both a comprehensive, technical version and a condensed, accessible version to better reach diverse audiences.

## CONSIDERATIONS

### Strategic Framework and Policy Considerations

- [31] The Strategy contributes to Council's Strategic Directions, *"Otago builds resilience in a way that contributes to the wellbeing of our communities and environment through planned and well-managed responses to shocks and stresses, including natural hazards"*<sup>6</sup>
- [32] The proposed Otago Regional Policy Statement June 2021<sup>7</sup>, notified in late March 2024<sup>8</sup>, states that ORC and territorial authorities are both responsible for specifying objectives, policies, and methods in regional and district plans for managing land subject to natural hazard risk. ORC specifically is responsible for *"identifying areas in the region subject to natural hazards and describing their characteristics as required by Policy HAZ– NH–P1, mapping the extent of those areas in the relevant regional plan(s) and including those maps on a natural hazard register or database"*<sup>9</sup>. The Strategy and associated technical work contributes give effects to the RPS.

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<sup>5</sup> <https://environment.govt.nz/publications/coastal-hazards-and-climate-change-guidance/>

<sup>6</sup> ORC Strategic Directions: <https://www.orc.govt.nz/your-council/our-team/strategic-directions/>.

<sup>7</sup> Section HAZ-NH-M1.

<sup>8</sup> Note that the RPS is still subject to appeal.

<sup>9</sup> ORC Natural Hazards Portal: <http://hazards.orc.govt.nz>.



### Financial Considerations

- [33] The budget in the 2024-34 Long Term Plan (LTP) provides funding towards delivery, implementation and monitoring of actions in the Head of Lake Whakatipu natural hazards adaptation strategy.
- [34] The Strategy Action Plan outlines existing and planned actions and specifies the responsible agencies. ORC Actions include existing business-as-usual activities (e.g., flood forecasting and warning), and additional actions planned and budgeted in the 2024-34 LTP (e.g., river management plans).
- [35] The Strategy Future Toolbox describes possible responses that may be useful for future adaptation. These are not commitments, as funding has not been identified. Business cases would be required prior to any future decision-making. The Future Toolbox can be used to inform the preparation of the 2027-37 Long Term plan.

### Significance and Engagement

- [36] Engagement planning considers and is designed to be consistent with organisational commitments made through He Mahi Rau Rika: ORC Significance, Engagement and Māori Participation Policy.

### Legislative and Risk Considerations

- [37] The work described in this paper helps ORC fulfil its responsibilities under sections 30 and 35 of the RMA.
- [38] There is not currently a formalised programme governance agreement between ORC and QLDC for this adaptation programme, although there is a strong collaborative relationship at staff level. It will be critical to the successful delivery and implementation of the strategy that both councils endorse the strategy. ORC and QLDC agreed that having a joint Natural Hazards Steering Group (at staff level) would be useful and staff are working on standing it up.
- [39] Both the QLDC 2024-2034 Long-Term Plan (LTP)<sup>10</sup> and QLDC 30-year Infrastructure Strategy<sup>11</sup> have been approved. The 'Community Associations Work Programme' of the LTP includes support for ORC's Head of Lake Whakatipu natural hazards project. The QLDC Infrastructure Strategy also highlights the area in its key initiatives; for example, Glenorchy/Kinloch area resilience of the transportation network; and Glenorchy adaptation in the response to natural hazard risks and the effects of climate change.
- [40] Central government has repealed the Natural and Built Environment Act and the Spatial Planning Act.
- [41] The Finance and Expenditure Committee has completed its cross-party inquiry into climate adaptation and its final report<sup>12</sup> has been released. The report includes recommendations on adaptation objectives such as minimising expected long-term costs, improving information flows about climate risks and responses; of principles such

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<sup>10</sup> <https://www.qldc.govt.nz/your-council/council-documents/long-term-plan-ltp/>.

<sup>11</sup> [https://www.qldc.govt.nz/media/o5bprma2/qldc\\_infrastructure-strategy\\_2024-2034\\_final.pdf](https://www.qldc.govt.nz/media/o5bprma2/qldc_infrastructure-strategy_2024-2034_final.pdf).

<sup>12</sup> [Inquiry into climate adaptation \(selectcommittees.parliament.nz\)](https://selectcommittees.parliament.nz/inquiry-into-climate-adaptation).

as fairness and equity, local flexibility and co-benefits; of roles and responsibilities of stakeholders as well as adaptation costs and data.

- [42] The National Direction for Natural Hazards<sup>13</sup> is being developed under the Resource Management Act. This is to ensure the risks are handled consistently across the country. It is expected to provide direction to councils on how to identify natural hazards, assess the risk they pose now and in the future, and respond through their planning and consenting processes.
- [43] There is no clear, specific, mandated requirement to reduce risk through planning and implementation of adaptation or relocation. Gaps identified in the current adaptation planning and planned relocation frameworks include the lack of national direction, insufficient powers, tools and mechanisms, and the lack of articulated roles and responsibilities<sup>14</sup>.

### Climate Change Considerations

- [44] The effects of climate change have been considered in flood hazard assessments for Dart and Rees Rivers, and Buckler Burn, and in the assessment of risks and potential hazard management responses for those hazards.

### Communications Considerations

- [45] ORC will continue to make all investigation findings available to the Head of Lake Whakatipu community and provide regular programme updates via the email newsletter<sup>15</sup>.
- [46] A communications plan has been developed as part of this work programme. The programme team is working closely with the Communications team to ensure communications and engagement planning is integrated, complementary and build off each other.

### NEXT STEPS

- [47] The key next-step activities for the work programme which are in progress or scheduled are identified in Figure 1. ORC will develop supporting documents such as specific guidelines to help Strategy partners implement the Strategy. Other activities will be also implemented including feasibility studies for specific physical works or business cases.
- [48] The Strategy (if adopted) will be implemented from mid-year 2025. The Strategy will inform the following activities by the Strategy's partners:
- **Community, individuals, private assets and business owners** are responsible for a range of activities including collaborating on emergency planning, and arranging appropriate insurance for their businesses and properties.

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<sup>13</sup> <https://environment.govt.nz/acts-and-regulations/national-direction/natural-hazards/#:~:text=The%20Government%20has%20since%20decided,National%20Direction%20for%20Natural%20Hazards>

<sup>14</sup> Expert Working Group on Managed Retreat. 2023. Report of the Expert Working Group on Managed Retreat: A Proposed System for Te Hekenga Rauora/Planned Relocation. Wellington: Expert Working Group on Managed Retreat.

<sup>15</sup> <https://www.orc.govt.nz/get-involved/projects-in-your-area/head-of-lake-whakatipu/holw-community-get-in-touch-be-involved/>.

- **QLDC** implements their activities through the Long-term Plan, Spatial Plan and District Plan. This includes assets management, emergency and recovery planning, setting long-term growth vision by identifying where homes, businesses and infrastructure should be located, ensuring development avoids hazard-prone areas, supports community wellbeing, as well as applying landuse zoning, development rules and building controls.
- **ORC** leads river management, monitoring, flood forecasting and warning as well as emergency planning.
- **CDEM Otago** takes lead and coordinates 4Rs (reduction, readiness, response, recovery) and supports for community response efforts.

[49] A high-level timeline for key programme and engagement activities is given in Table 2.

**Table 2: High-level timeline for key programme and engagement activities for the Head of Lake Whakatipu Natural Hazards Adaptation Programme.**

Timeframe	Programme activity	Community engagement
Mid 2025	Publicly release the Strategy documents adopted by Council.	Activities to increase awareness of the final Strategy and improve accessibility of the information.
Mid-End 2025	Support the Action Plan.  Implement the Strategy.	Attending community events or activities including Glenorchy Community Association meetings, as required.

**ATTACHMENTS**

1. Appendix 1 Final Adaptation Strategy for Head of Lake Whakatipu 6 May [**10.4.1** - 166 pages]
2. Appendix 2 Adaptation Strategy Overview Draft Text for Review 17 Apr [**10.4.2** - 21 pages]
3. Appendix 3 Summary Report Public Feedback on Draft 6 May [**10.4.3** - 5 pages]



# Head of Lake Whakatipu Natural Hazards Adaptation Strategy

Version 1 | May 2025



COVER ARTWORK: CONNIE ANDERSON





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**Thank you to everyone whose time, expertise and inputs have helped to shape the Head of Lake Whakatipu Natural Hazard Adaptation Strategy (Version 1).**

**We look forward to working together on implementation and future versions.**

# 1 Introduction

At the Head of Lake Whakatipu (Whakatipu Waimāori)<sup>1</sup> (Figure 1.1), the townships of Glenorchy (Tāhuna) and Kinloch, and surrounding rural areas of the Dart (Te Awa Whakatipu), Rees (Puahiri/Puahere), Paradise and Greenstone valleys are exposed to a complex range of flooding, landslide, and earthquake related hazards. The landscape is very dynamic, and with the changing climate, the natural hazard challenges at the Head of Lake Whakatipu are complex, resulting in no simple solutions.

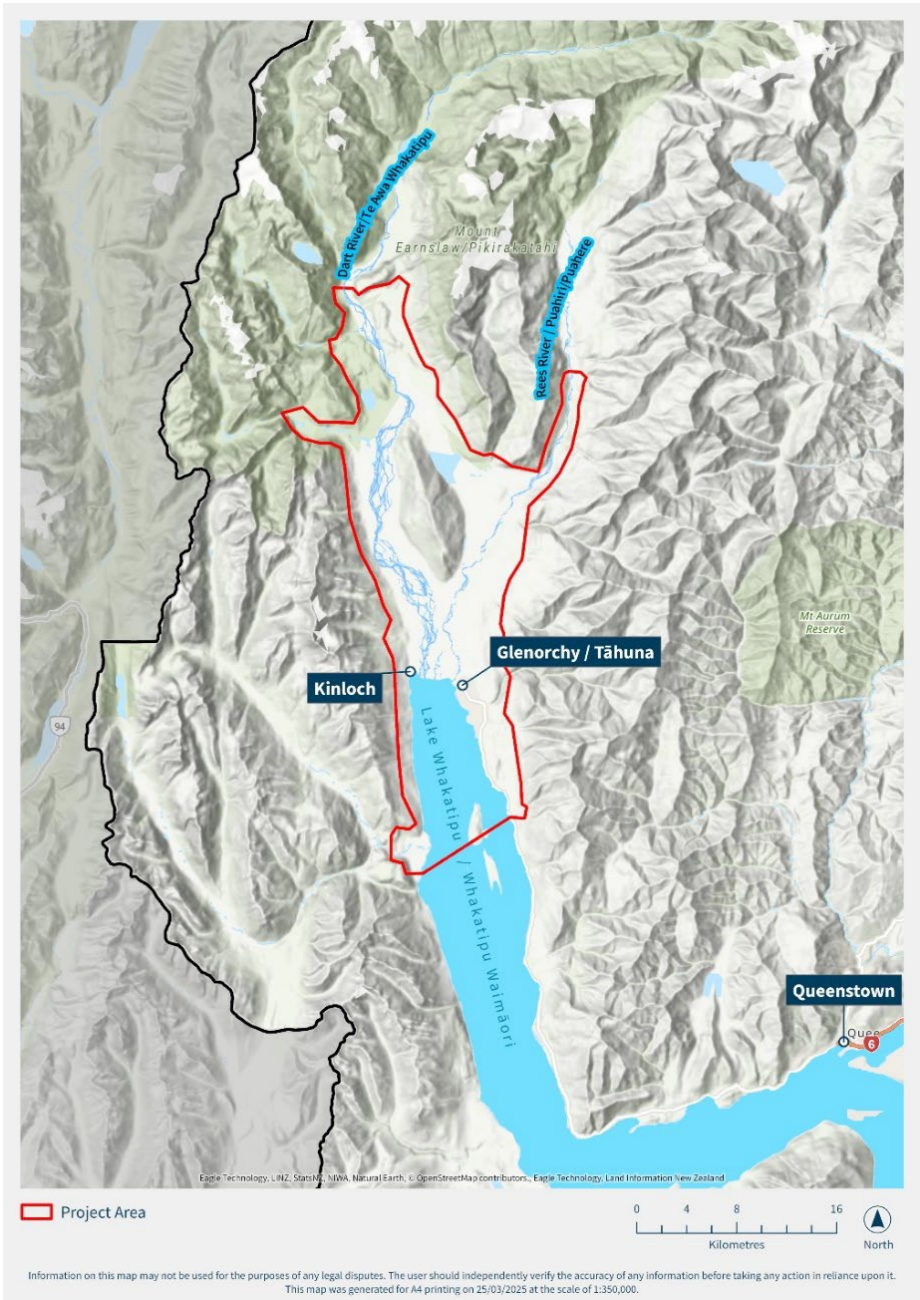


Figure 1.1 Overview of the Head of Lake Whakatipu, showing the programme area of interest outlined in red.

<sup>1</sup> The preferred Kāi Tahu spelling of Whakatipu has been adopted throughout this report.

To develop holistic, longer-term natural hazards management plans, Otago Regional Council (ORC) is using an approach in line with the Ministry for the Environment's 10-Step adaptation cycle. This cycle incorporates a method known as Dynamic Adaptive Pathways Planning (DAPP) or 'Adaptation Pathways.' The cycle has been promoted by the Ministry for the Environment as a blueprint for community-influenced decision-making in areas affected by natural hazards, while considering potential future uncertainties (e.g., landscape and climate changes). Adaptation programmes are also underway for other parts of Otago that also face natural hazards challenges (e.g., South Dunedin and Clutha Delta), and for other communities across the country.

Working together and taking account of natural hazard and climate risk in everything we do sets the foundation for more resilient communities. Current actions form the basis of our efforts to manage hazards, and we will need to adjust or pivot as conditions change. We are inspired by the history of the area, which is full of adaptation stories, as communities have adjusted to changes in economic fortunes and ease of access.

This is the first iteration of a Head of Lake Whakatipu Natural Hazards Adaptation Strategy (the Strategy) and is the result of five years of work. The body of work is broad, covering hazards and risk assessments; possible mitigation and management; place, people, and economy; and feedback and input from community engagement.

This detailed report summarises the work that has been done, integrates the pieces, and places them in a strategic framework that assists implementation through existing systems and processes, as much as possible.

The Strategy is a partnership between ORC, Queenstown Lakes District Council (QLDC), Civil Defence Emergency Management Otago (CDEM) and the local community and has been developed in collaboration with mana whenua representatives. While ORC led the development of this Strategy, it would not be possible without input from our partners, mana whenua, and natural hazards and adaptation experts.

The Strategy is structured as follows:

- Section 2-3 – Defines the vision, goals, and principles to guide natural hazards adaptation.
- Section 4 – Defines the scope of the Strategy.
- Section 5-8 – Describes the background and context information on the importance of tackling natural hazards and the impacts of climate change together.
- Section 9 – Guides the reader through the adaptation process using the five key questions as a framework: 1) what is happening, 2) what matters most, 3) what can we do about it, 4) how can we implement the Strategy, and 5) how is it working?
- Section 10 – Outlines the work that Strategy partners are planning to do.

Appendices cover:

- a) Programme deliverables.
- b) Supporting information about existing responses and future toolbox.
- c) Summary of feedback on the Draft Strategy.



## 2 Vision and Goals

***Our vision is a resilient and sustainable Head of Lake Whakatipu, where proactive natural hazard and climate adaptation enhance community wellbeing and safety, and contribute to a flourishing environment.***

### **Goal 1: Adaptation is woven into our everyday work**

- Make plans and recommendations that align with council strategies, policies and processes, and integrate with business-as-usual workstreams.
- Work in partnership with mana whenua, and coordinate and collaborate with other agencies and communities with a common purpose to incorporate adaptation into what we do.
- Build connections across and between agencies and work together effectively across work programmes.
- Encourage and amplify existing good practice and initiatives.

### **Goal 2: Lay a robust foundation for decision-making**

- Point us in the same direction with a common understanding of the physical environment to build from.
- Continue to build understanding of natural hazard risks, uncertainties, and opportunities now and in the future that come with natural hazards and climate change.
- Increase awareness around current and future natural hazards risks and impacts of climate change as well as effective adaptation responses.
- Build capacity around adaptation and support communities and decision-makers to take advantage of opportunities.
- Consider ways to incorporate mātauraka Kāi Tahu into the decision-making frameworks.
- Share new information as it becomes available.

### **Goal 3: Healthy and resilient communities**

- Lead and support others to actively manage and reduce risk to natural hazard and impacts of climate change.
- Support and enable community-led action and behavioural change.
- Promote community safety by managing and reducing risk from natural hazards and impacts of climate change.
- Strengthen communities, businesses, and organisations so that they are well-prepared for natural hazard events and are better able to cope and recover.

### **Goal 4: Resilient built places, infrastructure, and systems**

- Lead the way and support others to increase the resilience of infrastructure, resources, and systems.
- Encourage responsible management of resources and infrastructure that prioritises resilience, sustainability, and avoids maladaptation, such as unintentional negative outcomes.
- Provide information for individuals, businesses, and agencies to consider natural hazard risks and the impacts of climate change as part of planning and development processes.
- Support integration of traditional and modern local knowledge into planning and development of local infrastructure.

### **Goal 5: A flourishing environment**

- Support and enable nature-based solutions and principles to adapt to natural hazard risks and climate change and deliver other socio-economic and environmental benefits.
- Integrate adaptation across Councils' work programmes to deliver natural hazards, biodiversity, and wider environmental outcomes.

## 3 Principles

In seeking to achieve these goals, the development and implementation of the Head of Lake Whakatipu Natural Hazards Adaptation Strategy is guided by key principles. These principles have been developed with input from best-practice research, national guidance and what we have heard from partners and the community.

Key principles are as follows:

- Take a **holistic and long-term view** of natural hazards risk management and adaptation efforts.
- **Partner and collaborate** with mana whenua, QLDC, Civil Defence Emergency Management Otago (CDEM), communities and stakeholders. Work together to maximise the use of resources, expertise, knowledge, and ideas to achieve better outcomes.
- Make **robust decisions** using the best available evidence including mātauraka Māori, local knowledge, Western-based science, information, and data.
- **Be community-centered** by enabling and empowering the community to actively participate in the process, by being inclusive, accessible, and transparent.
- **Be flexible** and adjust as we go but avoid maladaptation.
- Consider **co-benefits** (such as improving community capacity, enhancing biodiversity, emissions reduction, and celebrating and reinforcing Kāi Tahu connections to place) for adaptation efforts to achieve complementary goals, while avoiding maladaptation.
- Promote **fairness and equity** for and between communities and across generations.
- **Uphold Te Tiriti o Waitangi** – the adaptation Strategy should ensure ORC is fulfilling its obligations as a meaningful Treaty partner, as supported by ORC’s He Mahi Rau Rika: Significance, Engagement and Māori Participation policy.
- **Align with national-level direction and policies**, including the 10-step adaptation cycle approach, Dynamic Adaptive Pathways Planning (DAPP) and best-practice research.
- Adaptation efforts should **work with nature** as much as possible to protect, enhance and restore our natural environment.
- Be **open and accountable**. Ensure progress is transparently communicated to partners, stakeholders, and the community.
- Consider **cost-effectiveness and practicality** to ensure that resources are used efficiently and that they reduce risks to what is reasonable, practicable and acceptable to partners and the community.



## 4 Scope

This first iteration of the Strategy has a defined scope that is tied to what the named partners can implement using current systems and processes.

- The Strategy **does not have any decision-making power or create any obligations**. It is intended to lay a good foundation, provide a common direction and support the integration of adaptation into partners' everyday work.
- The Strategy takes a **multi-hazard perspective** to build a holistic understanding of a complex and highly dynamic environment.
- The Strategy focuses on **adapting to natural hazards only**, as the partner agencies and systems for implementation are best positioned to deliver effective actions for these risks.
- Action plans describe the **current commitments and activities of key partners**, namely ORC, QLDC, CDEM Otago, mana whenua and local communities.
- Action plans focus on **planning time horizons** to align with councils' 10-year Long-Term Plans and 30-year infrastructure strategies. Where appropriate, longer time horizons are considered for natural hazard impacts and climate change information.
- Action Plans are based on **currently defined roles and responsibilities** and are aligned with legislation, systems, processes, and policies.
- The Strategy is **not an equivalent or substitute for people's ability to participate in other statutory processes** (such as the statutory frameworks for Regional Policy Statement, regional and district plans, and councils' long-term plans).
- **Foundational information** will guide and influence a wide range of stakeholders with interests in adaptation, but only the actions of named partners are identified and tracked.
- **Possible responses in the future toolbox** are not commitments, as they do not have business cases or future funding identified at this stage. Some possible responses fall outside the current roles and responsibilities of partner agencies.
- The Strategy is a **result of a collective effort and belongs to everyone**. ORC's lead role in its development will continue for the monitor, review and adjust phases. Mana whenua, key stakeholders and the community are encouraged to influence and advocate throughout its implementation and future iterations. This highlights the collective effort and shared responsibility in managing natural hazards in the area, now and in the future.

## 5 Setting the Scene

### 5.1 Geographical

The ‘Head of Lake Whakatipu’ area or ‘Head of the Lake,’ as referred to in this Strategy, is the area centered on the Rees-Dart floodplain located at the northern end (‘head’) of Lake Whakatipu in the Queenstown-Lakes District of Otago.

The project area considered by the Strategy is approximated by the boundary shown in Figure 1.1 which is designed to include all significant residential and infrastructure locations in the vicinity. The project area boundary is approximated as the 600-metre elevation contour and upstream in the major valleys (Routeburn, Dart, Rees) to the ends of the roads.

The major geographical features at the Head of Lake Whakatipu are the broad braided river systems and floodplains of the Dart and Rees Rivers, which form a combined delta at the lake, lying between the Humboldt and Richardson mountains to the west and east, respectively.

### 5.2 Mana whenua connections to place

Mana whenua are Māori who hold traditional customary authority and are representatives of Treaty partners within an area and whose traditions and histories are as determined by whakapapa, resource use and ahikāroa (the long burning fires of occupation). In Ōtākou (Otago), Kāi Tahu<sup>2</sup> are mana whenua.

The wider Whakatipu Waimāori (Lake Whakatipu) area is of strong significance to mana whenua (Takau, 2021). The histories of Kāi Tahu are embedded throughout the landscapes, as told through creation narratives, pūrakau (stories), ikoa wāhi (place names), and are upheld through values.

According to Kāi Tahu tradition, the Waitaha were the first people to arrive in Te Wai Pounamu (the South Island) (Takau, 2021). It is written that the Waitaha arrived in Te Wai Pounamu on a great canoe called Uruao, which was captained by Rākaihautū. It is said that Rākaihautū used his famous kō (Polynesian digging tool) to form the major lakes of Te Wai Pounamu, which included Whakatipu Waimāori (Takau, 2021). The genealogies of the Waitaha people can be traced from Rākaihautū through to his living descendants, the modern day Kāi Tahu.

- “Ko Rākaihautū te takata nāna i timata te ahi ki tenei motu.” (It was Rākaihautū who lit the first fires on this island.)

Kāi Tahu taoka (treasures) cover the landscape from the ancestral mauka (mountains), large flowing awa (rivers), tūpuna roto (great inland lakes), pounamu (greenstone) and ara tawhito (traditional travel routes/trails), which connected kāika (settlements) and nohoaka (seasonal

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<sup>2</sup> The use of the term ‘Kāi Tahu’ should be considered to include four indigenous iwi to Te Wai Pounamu (the South Island), being Kāi Tahu, Kāti Mamoe, Waitaha and Rapuwai (Takau, 2021). In this Strategy ‘ng’ is changed to ‘k’ as is consistent with Kāi Tahu dialect, unless ‘ng’ is used in the official name of an entity, place name or area, or is directly quoted.

settlements) and mahika kai resources (Takau, 2021). These all make the area immensely significant to mana whenua.

There are many important ikoa wāhi (place names) which are embedded into the landscape of the programme area and beyond. Place names tell stories of Kāi Tahu people. Kā Huru Manu Ngāi Tahu Atlas shows a subset of the traditional names embedded in the landscape of the wider Whakatipu Waimāori delta (Kā Huru Manu Ngāi Tahu Atlas, 2025) (Figure 5.1).

## 5.3 Heritage

The Head of Lake Whakatipu has a rich and diverse historic heritage, reflecting both Māori and European settlement and activity. This includes significant archaeological sites such as Māori pounamu (greenstone) collection and processing areas, early European cottages, mining landscapes and evidence of historic industries. These sites are an important part of the area's cultural identity and provide valuable insights into the past. Figure 5.2 highlights key historical and archaeological sites in the area.

It is important to consider both recorded and unrecorded archaeological sites when planning and implementing adaptation measures. Some sites may not be immediately visible as they include underground remains linked to human activity before 1900. Given the area's long history of occupation, there is a possibility that any works in the area could uncover archaeological material.

Under the Heritage New Zealand Pouhere Taonga Act 2014, any activity that may modify or destroy an archaeological site requires an Archaeological Authority from Heritage New Zealand Pouhere Taonga. An archaeological site is defined as any place connected to human activity before 1900 that may provide evidence of New Zealand's history (Heritage New Zealand Pouhere Taonga Act, 2014).

## 5.4 Community profile

The area at the Head of Lake Whakatipu is home to the close-knit townships of Glenorchy and Kinloch, as well as residents living in Paradise, Rees, Greenstone Valleys, Campbelltown and Wyuna Preserve. The residential population of the Head of the Lake (Glenorchy SA2) is about 522 people (Stats NZ, 2023).

Influences from European settlement and history are visible in the modern community who live at the Head of the Lake. Since early European settlement in the mid-late 19<sup>th</sup> century, scheelite mining, gold mining, sawmilling, farming, and tourism have all supported communities at the Head of Lake Whakatipu (Figure 5.3). Steam ships largely served the community until the construction of the Glenorchy-Queenstown Road in 1962, which was sealed in 1997 (QLDC, 2005 and Glenorchy Community Website, 2018). The environment and relative remoteness of the Head of Lake Whakatipu shaped both the economy of the area and the types of people who lived there.





Figure 5.1 Placenames of significance from Kā Huru Manu Ngāi Tahu Atlas (2025).



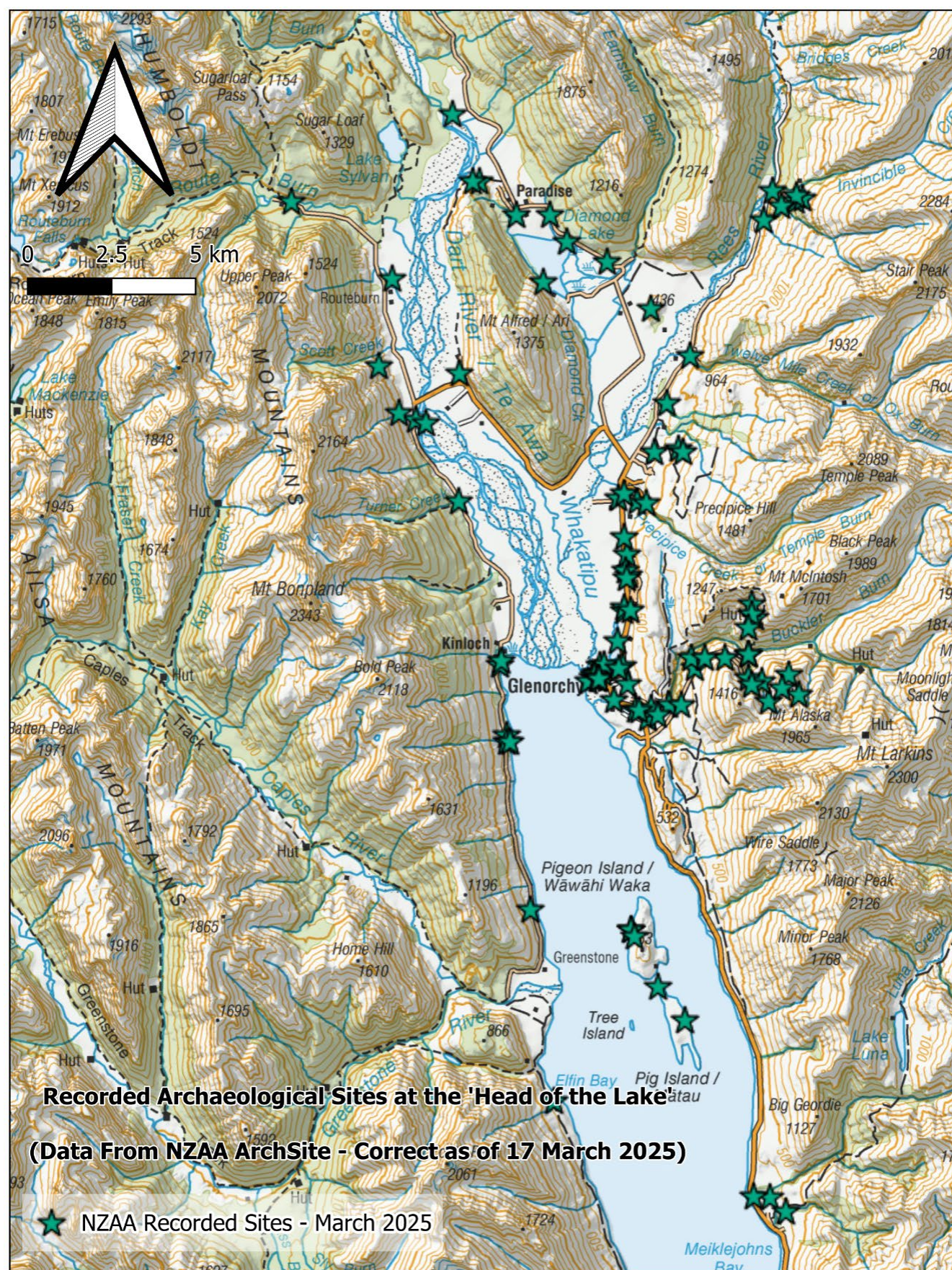


Figure 5.2 Historical and archaeological sites (marked with green stars) at the Head of Lake Whakatipu (Heritage New Zealand Pouhere Taonga, 2025).



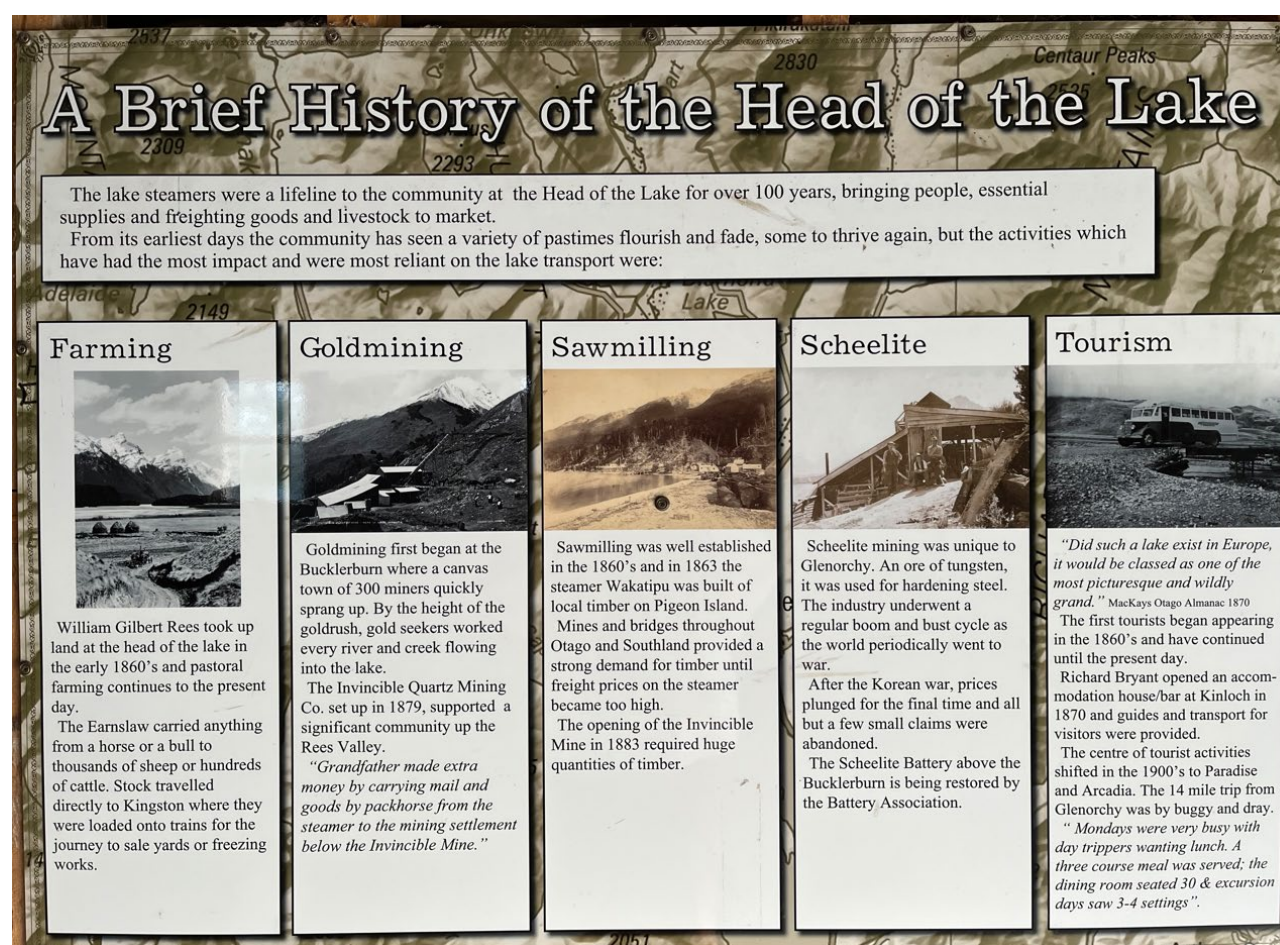


Figure 5.3 Photo of community history poster located in the Glenorchy Wharf Red Shed.

## Population data

The project area overlaps with the statistical area 'Glenorchy SA2' (Stats NZ) (Figure 5.4). This geographic area, defined by Statistics New Zealand, aims to reflect a community that interacts socially and economically. Population and demographic data for the 'Head of the Lake' referred to in this Strategy is reflective of the Glenorchy SA2 area, unless stated otherwise.

Key demographic data is represented in Figure 5.5<sup>3</sup> and is based on 2023 Census data. To summarise, the Head of the Lake is predominately a Pākehā settlement, with a reasonable proportion of residents born overseas. While the median age of 41 is higher than the Aotearoa New Zealand median (38), there are relatively fewer older and younger members of the community (Stats NZ, 2023).

The majority of private dwellings are home to permanent residents. However, over a quarter of the dwellings are 'unoccupied' – which includes vacant houses, holiday homes, huts, and cabins (Figure 5.5). A portion of the community are 'temporary residents' such as holiday-home owners or people who live at the Head of the Lake part-time. Anecdotally, there is a relatively stable core part of the community, but there is some turnover of the population due to the nature of work available in the area (seasonal hospitality and tourism work).

<sup>3</sup> MELAA means Middle Eastern / Latin American / African.



Figure 5.4 Outline of the Glenorchy SA2 statistical area (Stats NZ, 2023).

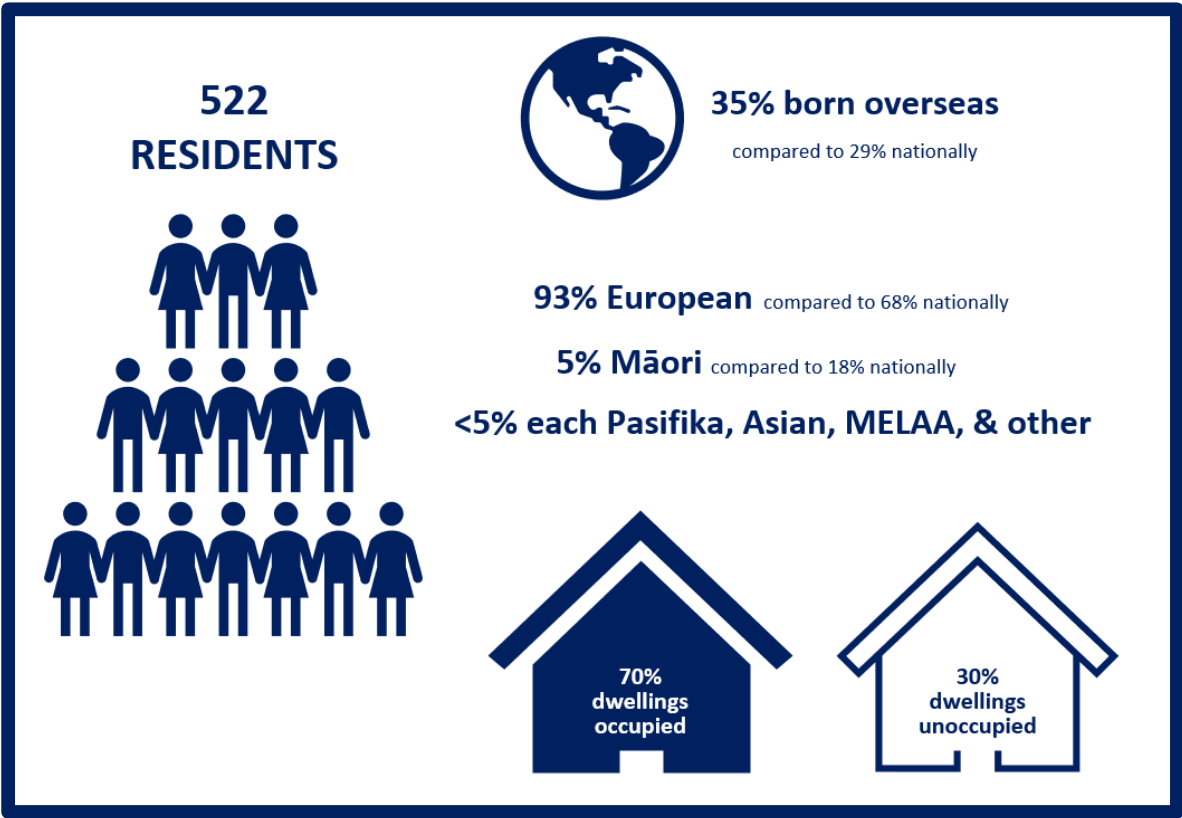


Figure 5.5 Population and demographic data of the Glenorchy SA2 area (Stats NZ, 2023).

## Population growth

There has been rapid growth over time at the Head of the Lake. Between 2006 and 2013 the population grew by 33%, from 272 to 363 people, between 2013 and 2018 it grew by 24% up to 450 people, and between 2018 to 2023 it grew by 16% up to 522 people (Stats NZ, 2023).

The resident population of Queenstown Lakes District grew by 38% from 2013 to 2018, and 22% from 2018 to 2023 (Stats NZ, 2023) as the wider district faced growth and development pressures.

From 2023 to 2053, a pattern of residential growth is expected at the Head of the Lake, with an annual estimated increase of approximately 2.5% over the first decade, and then 1% over the next two decades, under a medium scenario. By 2053, forecasted growth expects to reach 940 residents (QLDC, 2024). With anticipated growth in the resident population over time, there is the potential for increased development and infrastructure needs.

## Health

There is limited physical and mental health data for the Head of the Lake area. About 2% of the Head of the Lake population reported having one or more activity limitations in the 2023 Census, which is lower than reports for the Otago region (7.4%). Similarly, participants in the QLDC 2023 Quality of Life Survey self-reported relatively high levels of physical health (74%), compared to Queenstown (61%) (Versus Research, 2024).

Glenorchy participants in the QLDC 2023 Quality of Life Survey self-reported relatively high levels of mental health (63%), compared to Queenstown (43%) (Versus Research, 2024).

The availability of primary care at the Head of the Lake is limited. Currently, a practice nurse operates a non-funded Registered Nurse-led Health Clinic in Glenorchy fortnightly and provides house visits on request.

## Sense of community

Of Glenorchy respondents to QLDC's 2023 Quality of Life Survey, 100% described their neighborhood as safe, 92% as welcoming, 79% as strong/active, 45% as having a strong sense of belonging, and 33% as having good community participation (Versus Research, 2024). This is supported by community sentiments of the Head of the Lake being a strongly cohesive community.

Community Visioning work completed in 2001 and revised in 2016 sets out a clear set of shared values and aspirations for the future of the Head of the Lake community (Blakely Wallace Associates, 2001 and Shaping Our Future, 2016). Community engagement, as part of the Strategy development, is consistent with these shared values and visions and is elaborated on in Section 9.3.2.



## 5.5 Economic profile

Over its history, the Head of Lake Whakatipu has had a changing economy. Today, tourism is the most significant industry in the area, followed by hospitality, film, agriculture and trade.

In the Head of the Lake area, the local Gross Domestic Product (GDP) for 2022 was estimated to be \$42.42 million<sup>4</sup> with the tourism industry making up a significant portion of this area's GDP (Healy *et al.*, 2024).

The Head of the Lake is a popular tourist destination, hosting activities such as jet boating, tramping (hiking), fishing, hunting, horse trekking, farm tours, 4WD safaris, scenic flights, and Lord of the Rings tours. It also acts as a gateway to Mount Aspiring National Park and some of Aotearoa New Zealand's premier tramping and day-walk attractions, including the Routeburn Track (one of Aotearoa New Zealand's Great Walks), the Rees-Dart Track and the Greenstone and Caples Tracks.

In 2023, the total number of daily visitors for the Head of the Lake area was estimated to be 339 people on an average day and up to 935 people on peak days (QLDC, 2024). Looking ahead to 2053, with a medium growth scenario, the number of average day visitors is projected to increase to 733 people, and 1919 people on peak days (QLDC, 2024).

The Head of the Lake is also a popular location for the film industry. Most production teams are based in Queenstown and travel to and from Glenorchy, while some temporarily base themselves in Glenorchy.

Hospitality is one of the largest industry employers in the Head of the Lake, with a range of accommodation and food services located across the Head of the Lake area (Healy *et al.*, 2024).

Farming in the area is predominately high-country station farming, either in the beef and lamb or wool industries. There are six stations at the Head of the Lake, being a mix of generational family-owned and iwi-owned stations. Most stations have diversified their income in some way, mostly in the hospitality or tourism industries (Healy *et al.*, 2024).

Healy *et al.* (2024) reports that there is a variety of tradespeople operating or employed within the Head of the Lake or travelling to Queenstown for work. This industry has helped to support recent residential developments in the area (Healy *et al.*, 2024).

### Employment and income

Healy *et al.* (2024) reports that in 2022 there are estimated to be 349 people employed in the Head of the Lake, with tourism making up 149 of estimated employees. Figure 5.6 shows the industry contribution to employment in 2022 excluding tourism (Healy *et al.*, 2024).

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<sup>4</sup> The Glenorchy Community Association notes that this assessment may significantly underestimate the true economic contributions of the Head of Lake Whakatipu area. The local GDP figure of \$42.42 million should be considered a lower bound, with actual contributions likely much higher.

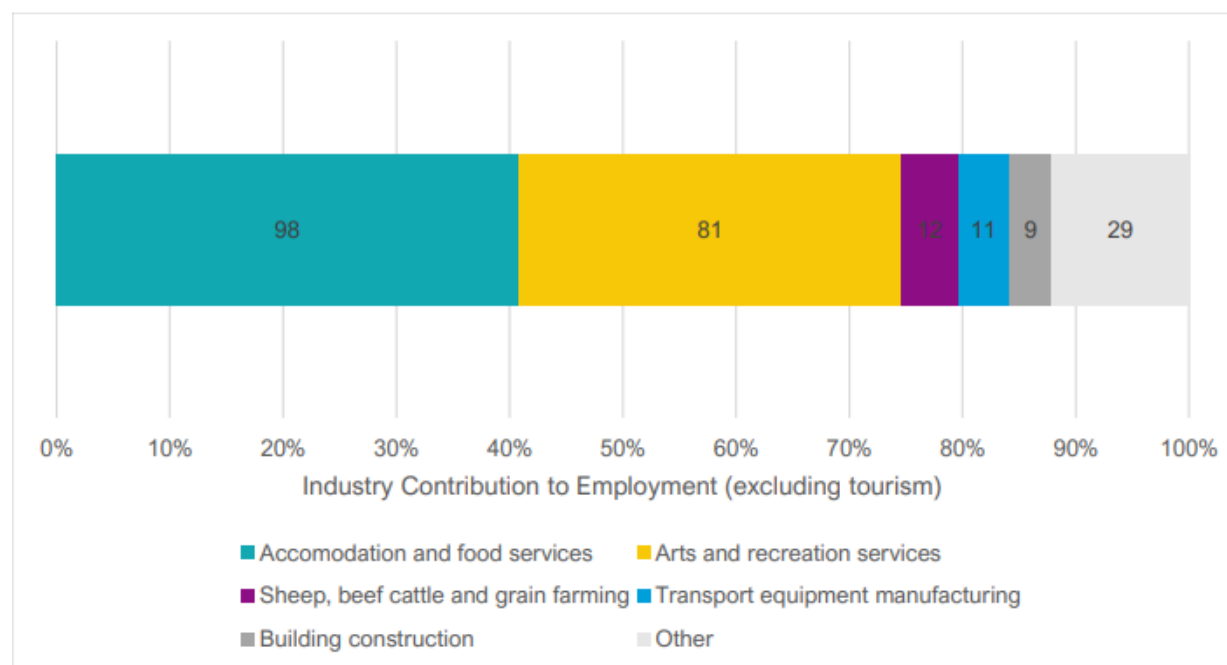


Figure 5.6 Industry contribution to employment in 2022, excluding tourism (Healy *et al.*, 2024).

As of 2023, approximately 64% of the population aged 15 years and older at the Head of the Lake are employed full time, 12% part time, 1.3% are unemployed, and 23% are not in the labour force (Stats NZ, 2023). The largest proportion of workers in the area are categorised as ‘Managers,’ followed by ‘Professionals,’ and ‘Technical and trade workers.’ The occupation profile of the area is reflected in the large proportion of people that work from home (Healy *et al.*, 2024).

As of 2023, the median income at the Head of the Lake was \$44,100, which is higher than the median income of Otago (\$39,100). However, approximately 33% percent of residents above the age of 15 earn less than \$30,000. About 22% of the resident population aged over 15 earn more than \$70,000.

Healy *et al.* (2024) reports that around a third of interviewed residents stated that their property is their main source or supports a portion of their income, including from farming, horticulture or providing accommodation.

## 5.6 Geomorphic

The Southern Alps are an exceptionally dynamic geomorphological terrain, with complex landscape evolution and geomorphic processes (Cook *et al.*, 2014).

The Head of Lake Whakatipu lies east from the main divide of the Southern Alps and is part of a large basin carved out by glacial activity. Lake Whakatipu was formed subsequent to glacial retreat, initially with an outlet at Kingston and a water level of 360 masl (approximately 50 metres higher than present-day lake levels). About 12,000 years ago, the lake outlet switched to drain into the Kawarau catchment and lake levels progressively lowered in response to incision at the outlet, stabilising at its current levels only within the last 500 years (Sutherland *et al.*, 2019). Present-day lake levels have a mean level of approximately 309.95 m.

The Rees and Dart catchments have a very high sediment availability, driven by the very high rates of erosion present throughout the catchment areas. The key factors in erosion rates are the high rates of tectonic uplift (up to 5 mm/year) and orographic precipitation which may exceed 5000 mm

annually in higher-elevation locations, an unstable ‘paraglacial’ landscape characterised by over-steepened slopes, retreating glaciers and abundant active landslides (Brasington, 2024).

The Dart and Rees rivers have been estimated to supply sediment to the lake at an average annual gravel bedload supply rate of 300,000 m<sup>3</sup> (Wild, 2012). Because the volumes of sediment available greatly exceed the capacity of the rivers to transport it downstream, this is considered a ‘transport-limited’ catchment system, with an essentially unlimited sediment availability (Brasington, 2024).

The highly erodible schist bedrock in the Rees and Dart catchments is transported down-valley by the river systems, to be eventually deposited into Lake Whakatipu at the Dart-Rees delta. Sediment deposition infilling the glacially carved bedrock valley over time has formed the broad Dart and Rees floodplains which join together downvalley of Mount Alfred, where the floodplain is up to 4 km in width.

### **Floodplain and delta evolution – aggradation and erosion**

In response to the very high rates of sediment delivery, the braided channel belts, floodplains and delta of the Dart and Rees Rivers are undergoing continuous and irreversible geomorphic change over time. The geomorphic changes observed are described below and are expected natural behaviour for this type of river system.

Analysis of riverbed change between repeated LiDAR surveys has shown that there is a persistent, widespread aggradation trend in the active riverbeds of the Dart and Rees rivers (Brasington, 2024). This trend is driven by rates of sediment deposition generally outweighing the rate of sediment removal (scour/erosion) within the active riverbed (the areas of flowing channels and unstable gravels).

Riverbed aggradation is an accumulation of sediment that raises bed levels. It impacts on flooding hazards through reducing the flood capacity of the active river channels, in turn reducing available freeboard to riverbanks and floodbank structures, while also increasing rates of lateral migration of the braided riverbed’s active channels.

In several locations, the Rees River’s active channel is super-elevated or ‘perched,’ higher than the surrounding floodplain, notably in the right-bank area upstream of the Rees bridge and adjacent to the Glenorchy wetland. As aggradation of the active riverbeds continues, an avulsion (breakout) of the river channel into these lower elevation floodplain areas becomes increasingly likely and an inevitable outcome over time.

An avulsion is the process where a river channel switches location, often suddenly, re-routing river flows through a new, steeper flow path. It may result in the complete or partial abandonment of the formerly active channel. An avulsion event could be triggered by a major high-flow event, or it could result from the cumulative effects of aggradation reaching a ‘tipping point.’

Channel migration and bank erosion is most apparent on the lower Dart River floodplain, where there is a long-term bank erosion trend and where the right bank of the river’s active channel has migrated westwards by >500 metres since the 1960’s. This bank erosion has locally threatened road access to the Kinloch and Greenstone areas by way of Kinloch Road. Potential bank erosion impacts have been managed to date by localised bank protection works, but as bank erosion continues, this may not be a sustainable long-term future approach (Webby, 2022).

## Delta growth

As sediment is progressively deposited into Lake Whakatipu, the shoreline of the Dart-Rees delta is extending lakewards (Figure 5.7), advancing at an average rate of 2 m to 3 m per year since 1937 (URS New Zealand, 2007). Historically, the growth rate of the delta has not been uniform, but it has shown a lot of local variation across the floodplain, due to factors such as the location of the main river channels entering the lake. For example, in the 1890s Kinloch wharf had sufficient depth of water to service the paddle steamer S.S. Mountaineer (Figure 5.8), then the bay at Kinloch was rapidly infilled from the early 2000's and now the Kinloch wharf is unusable due to sedimentation (Figure 5.9).

Delta growth has caused dramatic landscape changes within the Glenorchy area. Much of the delta shoreline has advanced lakeward by 200-250 metres since the earliest European records. Early surveys at Glenorchy show the present-day wetland area was a large lagoon in the 1860-70's (red shoreline in Figure 5.7) which included the first wharf at Glenorchy. The current wharf at Glenorchy is the third constructed in the township's history. The second was located at Jetty Street at the Rees Delta (Figure 5.7).

Modelling of future delta growth by Wild (2012) indicates that over the next 100-120 years the delta shoreline is expected to advance an average of ~165 metres, with actual advances across the delta shoreline ranging from 40 to 300 metres (Figure 5.7).

## Alluvial fans

Alluvial fans are landforms developed by the buildup of river or stream sediments over time, typically at the boundary between hillslopes and valleys, for example where a steep gully merges onto a flatter valley floor (Grindley *et al.*, 2009).

Many alluvial fan landforms have been developed on the Dart-Rees floodplain by sediments deposited from their tributary streams. For example, the Glacier Burn and Scott Creek (Figure 5.10) alluvial fans on the Dart floodplain, and those formed by Precipice Creek and Ox Burn on the Rees floodplain. At Glenorchy (Buckler Burn), Blanket Bay (Stone Creek) and Greenstone (Greenstone River), alluvial fan-deltas have been formed as sediments are deposited directly into Lake Whakatipu.

Alluvial fans may be subject to a range of natural hazards and geomorphic processes, including inundation by floodwater, debris deposition from debris flow and debris flood events, channel migration, deposition, and erosion. Alluvial fan flooding is characterised by a high level of flow-path uncertainty due to the processes of sediment deposition and the lateral displacement of streams during flooding (Grindley *et al.*, 2009).

Figure 5.11 shows an example of extensive flooding and sedimentation on the Earnslaw Burn alluvial fan in the January 1994 flooding event, compared to the narrow stream channel present during non-flood conditions.



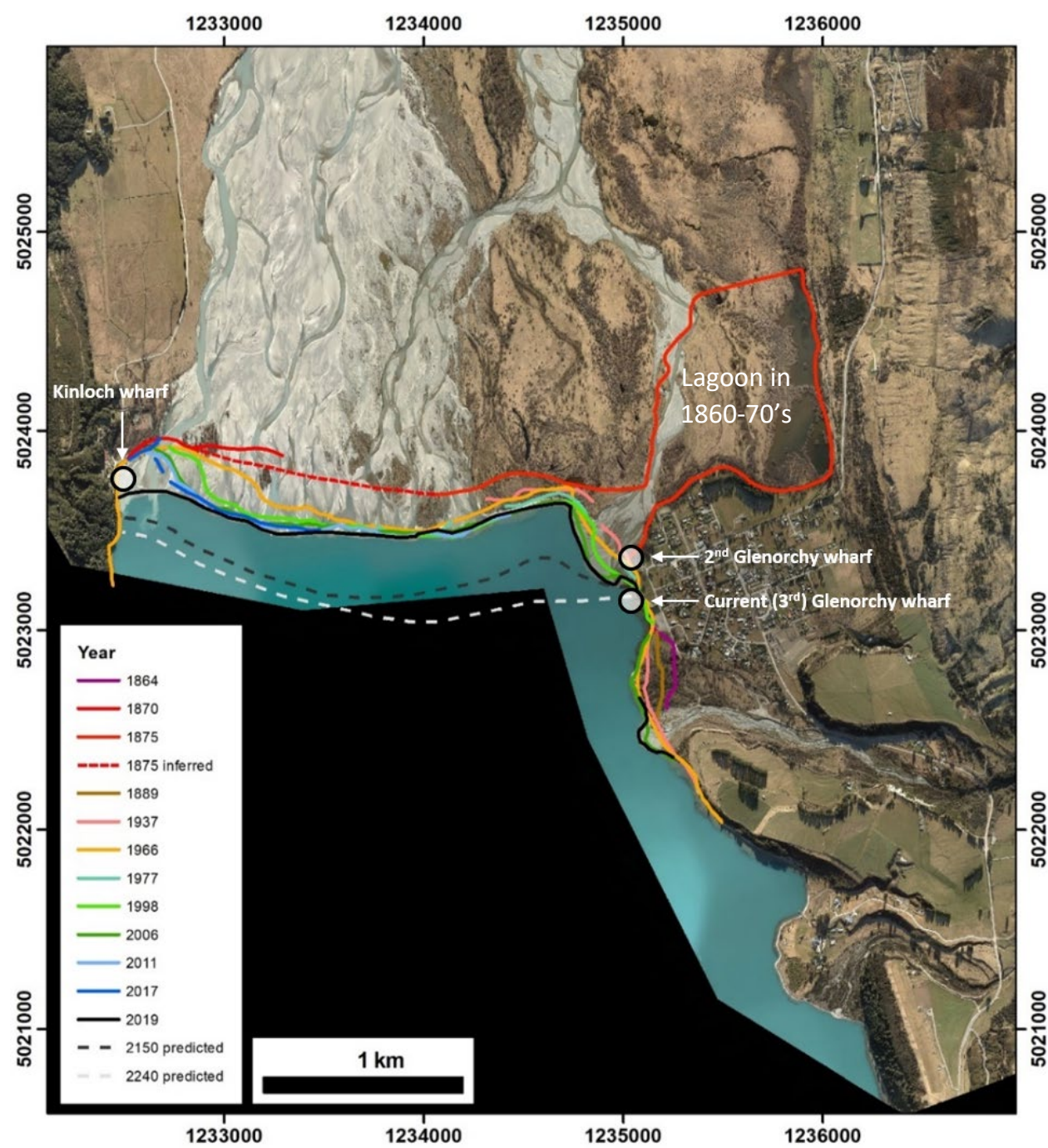


Figure 5.7 Historical and predicted shoreline positions of the Dart-Rees delta, based on compilations of historical maps and photographs by URS (2007) and Wild (2012). Projected delta growth based on modelling by Wild (2012).





Figure 5.8 The S.S. Mountaineer at Kinloch wharf, pictured in the 1890s (Image by Valentine and Sons Ltd, 1892-1893. Hocken collections reference number P2008-073-013).



Figure 5.8 The Kinloch wharf, pictured in October 2019.





*Figure 5.9 Example of an alluvial fan landform – the Scott Creek alluvial fan formed at the base of the Humboldt Ranges onto the Dart floodplain, showing evidence for recent sediment deposition across multiple sectors of the fan surface (photo dated October 2020).*





Figure 5.10 Comparison of the Earnslaw Burn alluvial fan in flood (1994) and non-flood conditions (2021), illustrating the potential for widespread flooding and debris impacts across alluvial fan surfaces.



## 5.7 Meteorological and hydrological

Orographically enhanced precipitation is the dominant climatic feature of the alpine regions of the South Island. Orographic precipitation is produced when moist air is lifted and cools as it moves over a mountain range. Due to the prevailing westerly winds, the majority of the precipitation falls on the windward (western) side of the Southern Alps (Figure 5.12). ‘Spillover’ rainfall occurs on the sheltered (eastern) side of the range when rainfall is blown over from the western side.

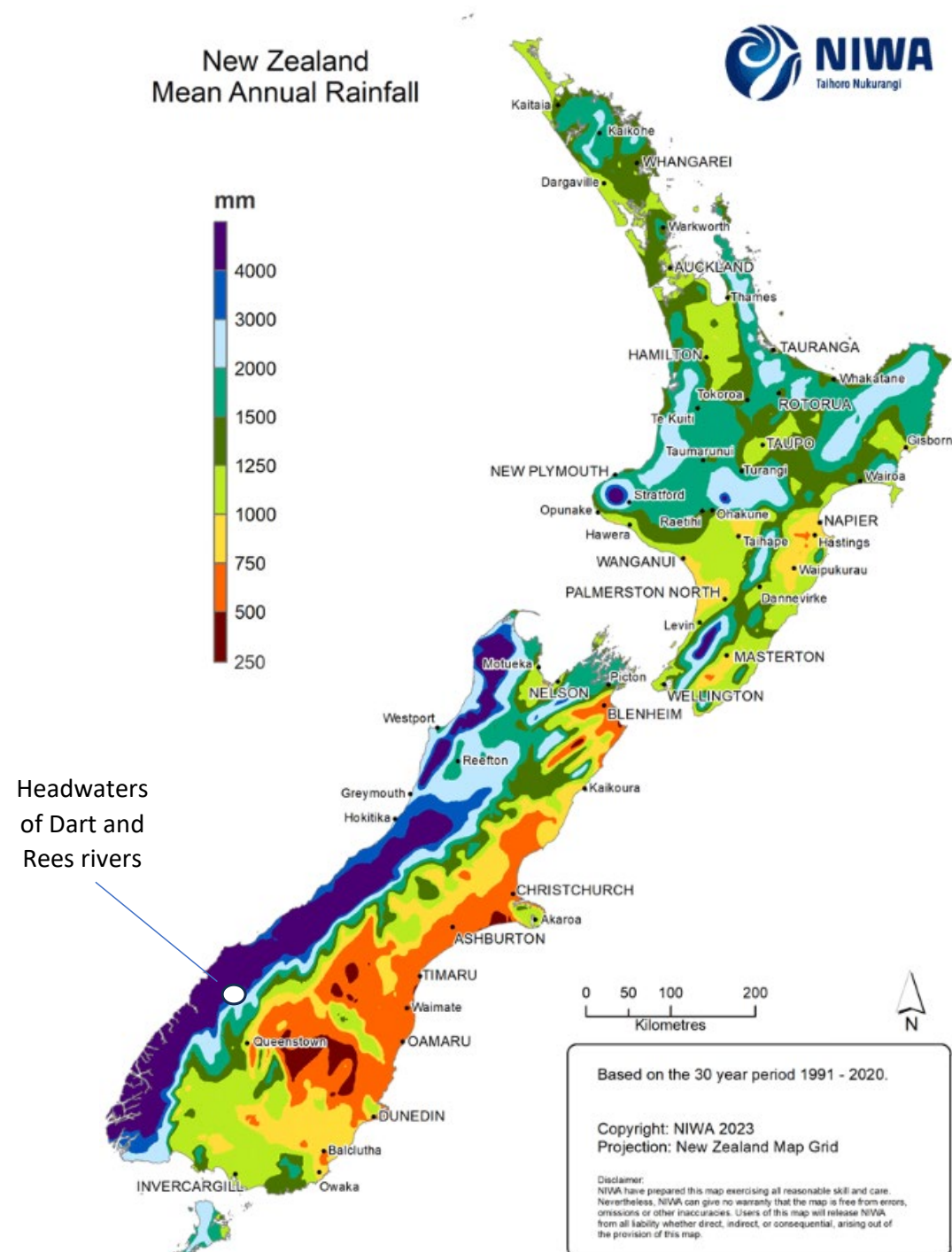


Figure 5.11 Aotearoa New Zealand Mean Annual Rainfall 1991-2020 (NIWA, 2023).



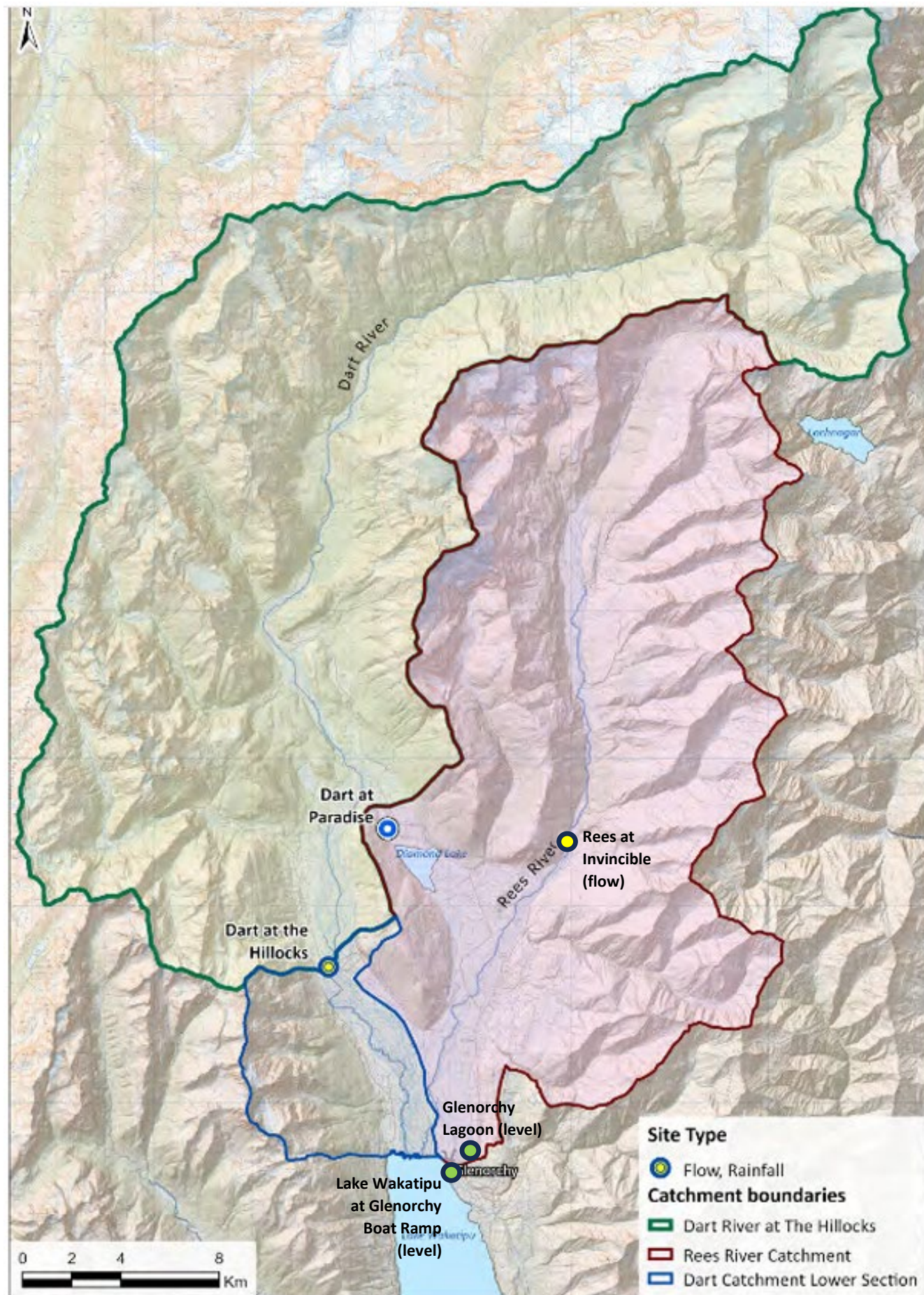


Figure 5.12 Rees and Dart catchments and ORC monitoring sites (Gardner M, 2022).

Dart and Rees Rivers

The two largest river systems are the Rees and Dart Rivers. The Rees (405 km<sup>2</sup>) and Dart (632 km<sup>2</sup>) catchments (Figure 5.13) make up about one third of the total catchment area of Lake Whakatipu.

The catchments have their headwaters in the high elevation ranges east of the main divide. Precipitation can exceed 6,000 mm/year (NIWA, 2023) in the higher-elevation upper portions of the catchments, which regularly receive heavy rainfall as ‘spillover’.

ORC currently monitors rainfall in the Head of the Lake area at Paradise (since 2003) and the Hillocks (since 1997). The locations of the stations are shown in Figure 5.13 . Summary rainfall statistics for these sites are shown in Table 5-1.

The Dart River has a length of approximately 58 km. Dart River flows have been monitored by ORC since 1997, by a monitoring station located at the Dart River bridge at the Hillocks. The highest river flows documented since that date were in March 2019 and February 2020, both events having peak flows of approximately 1800 cumecs and estimated to be events of around 40-year return period, based on flood frequency analysis by Mohssen (2024). Summary flood frequency statistics for the Dart River at the Hillocks are shown in Table 5-2.

Table 5-1 Summary rainfall statistics for ORC sites.

	Dart at The Hillocks (EM759)	Dart at Paradise (EM619)
Period of record:	Aug 1997 to now	May 2003 to now
Elevation	RL 360 m	RL 1300 m
Mean annual precipitation	1706 mm	2057 mm
Maximum recorded yearly precipitation	2191 mm	2742 mm
Maximum recorded daily precipitation	126.0 mm 21/09/2023	146.5 mm 10/09/2013 and 3/2/2020
Estimated 1% AEP, 24-hour rainfall (NIWA HIRDS)	188 mm (historical) 201 mm (RCP8.5 scenario)	225 mm (historical) 242 mm (RCP8.5 scenario)
Annual Exceedance Probability (AEP) is the probability of a certain sized event occurring in a single year. If a rainfall has an AEP of 1%, it has a one in 100 likelihood of occurring in any given year.		
NIWA's High Intensity Rainfall Design System (HIRDS) tool estimates high intensity rainfall at ungauged locations for a range of return periods, event durations and future time periods. Climate change projections are based on Intergovernmental Panel on Climate Change (IPCC) scenarios called representative concentration pathways (RCPs)		
Reduced Level (RL) is a standard term for survey points with reference to a common datum. In this report, the common datum is Dunedin 1958 local vertical datum, unless stated otherwise.		



The Rees River has a length of approximately 41 km. Rees River flows have been monitored by ORC since 2021, by a monitoring station located near the confluence with Invincible Creek. The highest river flow documented since that date was 240 cumecs in September 2023. Higher flows of >475 cumecs in the Rees River have also been recorded during research by Williams *et al.* (2015) and an archived 1974 Otago Catchment Board (OCB) gauging card (Wild, 2012).

Summary flood frequency statistics for the Rees River at Invincible have been estimated by Mohssen (2024) using a rainfall-runoff modelling approach (Table 5-2).

*Table 5-2 Flood Frequency Statistics for Dart and Rees Rivers, Buckler Burn and Bible Stream (Mohssen 2024).*

Location	Catchment area	Frequency Statistics / Design Flows (cumecs)				
		10-year ARI	20-year ARI	50-year ARI	100-year ARI	500-year ARI
Dart at Hillocks station	591 km <sup>2</sup>	1559	1694	1849	1952	2153
Rees at Invincible station	230 km <sup>2</sup>	620	718	855	962	1223
Buckler Burn (at bridge)	51 km <sup>2</sup>	104	121	146	166	217
Bible Stream	0.7 km <sup>2</sup>	1.4	1.7	2.0	2.3	3.0

### **Buckler Burn and Bible Stream**

The Buckler Burn is located immediately south of Glenorchy township and has a catchment of 51 km<sup>2</sup> (Figure 5.14). The burn flows westwards from headwaters in the Richardson Ranges and outflows directly into Lake Whakatipu.

Bible Stream is located immediately east of Glenorchy township and has a catchment of 0.7 km<sup>2</sup> (Figure 5.14). The stream flows over Bible Terrace and towards the township through a gully on the northern side of the terrace. A diversion channel at the base of the gully was constructed in the early 2000s and diverts flows around the eastern margin of the township into Glenorchy Lagoon. The diversion floodbank/channel has been described as ‘poorly formed and not engineered,’ likely to be eroded during high flows and offering very little protection during flood events (Woodmansey, 2001; Whyte, 2007).

There has been no measurement of stream flows for either the Buckler Burn or Bible Stream, but summary flood frequency statistics for both catchments have been estimated by Mohssen (2024) using a rainfall-runoff modelling approach (Table 5-2).

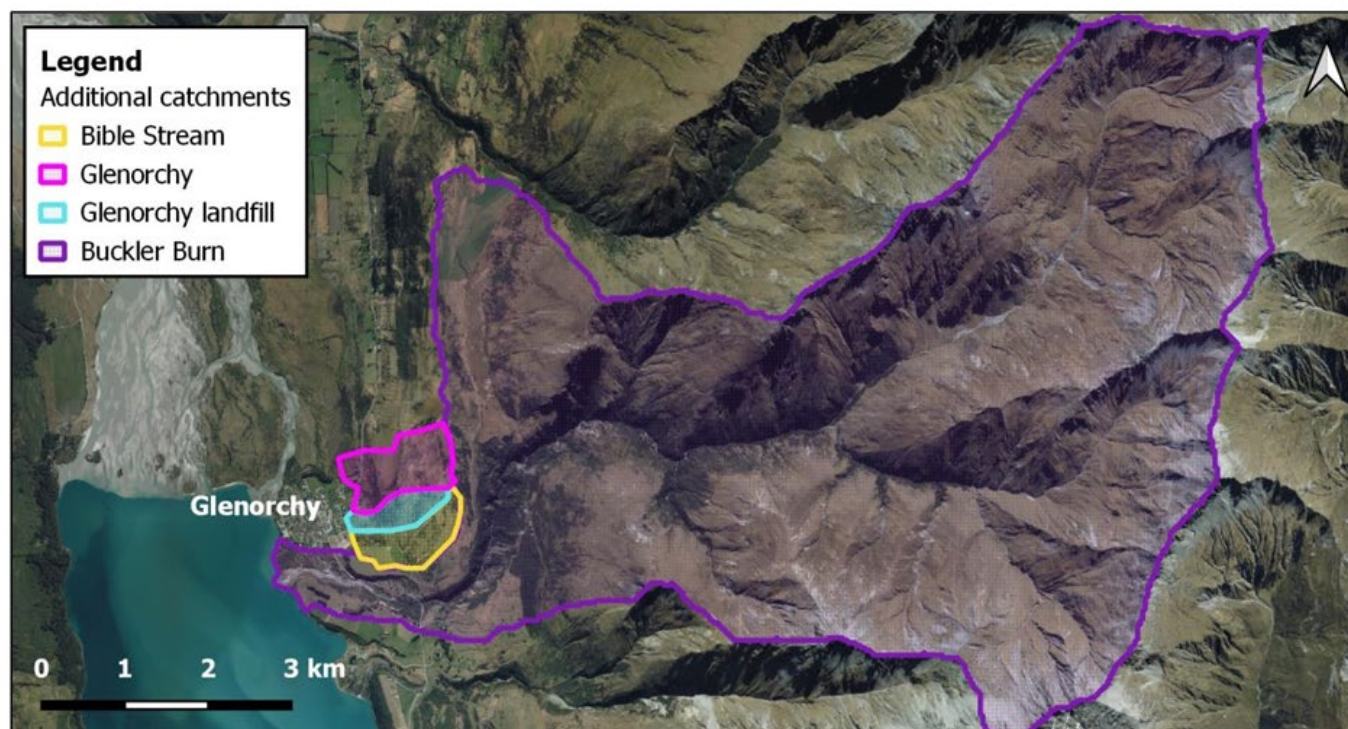


Figure 5.13 Buckler Burn, Bible Stream and local Glenorchy catchments (Beagley R, 2024).

### Glenorchy Lagoon

The Glenorchy lagoon (Figure 5.15) is located immediately north of Glenorchy township and has an area of about 16 hectares (0.16 km<sup>2</sup>). The lagoon is part of a wider wetland area, 350 ha in area, much of which is administered by the Department of Conservation as a Wildlife Management Reserve. The geomorphic history of the lagoon and wetland area is detailed by Whyte (2007).

The lagoon is fed by local runoff from Bible stream and other small catchments on the slopes immediately east of the wetland. While no surface-flow stream channels directly carry flow from the Rees River to the lagoon, several relatively permanent streams fed by groundwater (indirectly sourced from the Rees River) maintain a steady flow. During high river flows, the lagoon is also fed by overbank flows spilling eastwards from the Rees River.

The lagoon outflow is a small stream known as Lagoon Creek, which joins with the Rees River on the delta, a short distance upstream from Lake Whakatipu.

Glenorchy lagoon levels rise in response to rainfall and high Rees River flows, interpreted to be due to the effects of both increased inflows (local runoff, overland flow from Rees) and reduced outflows (backwater effect of high Rees River flows and/or elevated Lake Whakatipu levels on creek outflow). Stream flows in Lagoon Creek may reverse when Rees River flows are high relative to the lagoon water level (e.g., as was observed and reported to ORC in May 2021).

ORC has monitored water levels in the lagoon since October 2020. In that time, the highest recorded level has been 312.49 m in September 2023.

During the February 2020 flooding event, the water level in the lagoon was estimated to have reached 312.7-312.8 m, based on observation of floodwaters overtopping the Rees-Glenorchy floodbank and inspection of silt deposits remaining following floodwater recession.



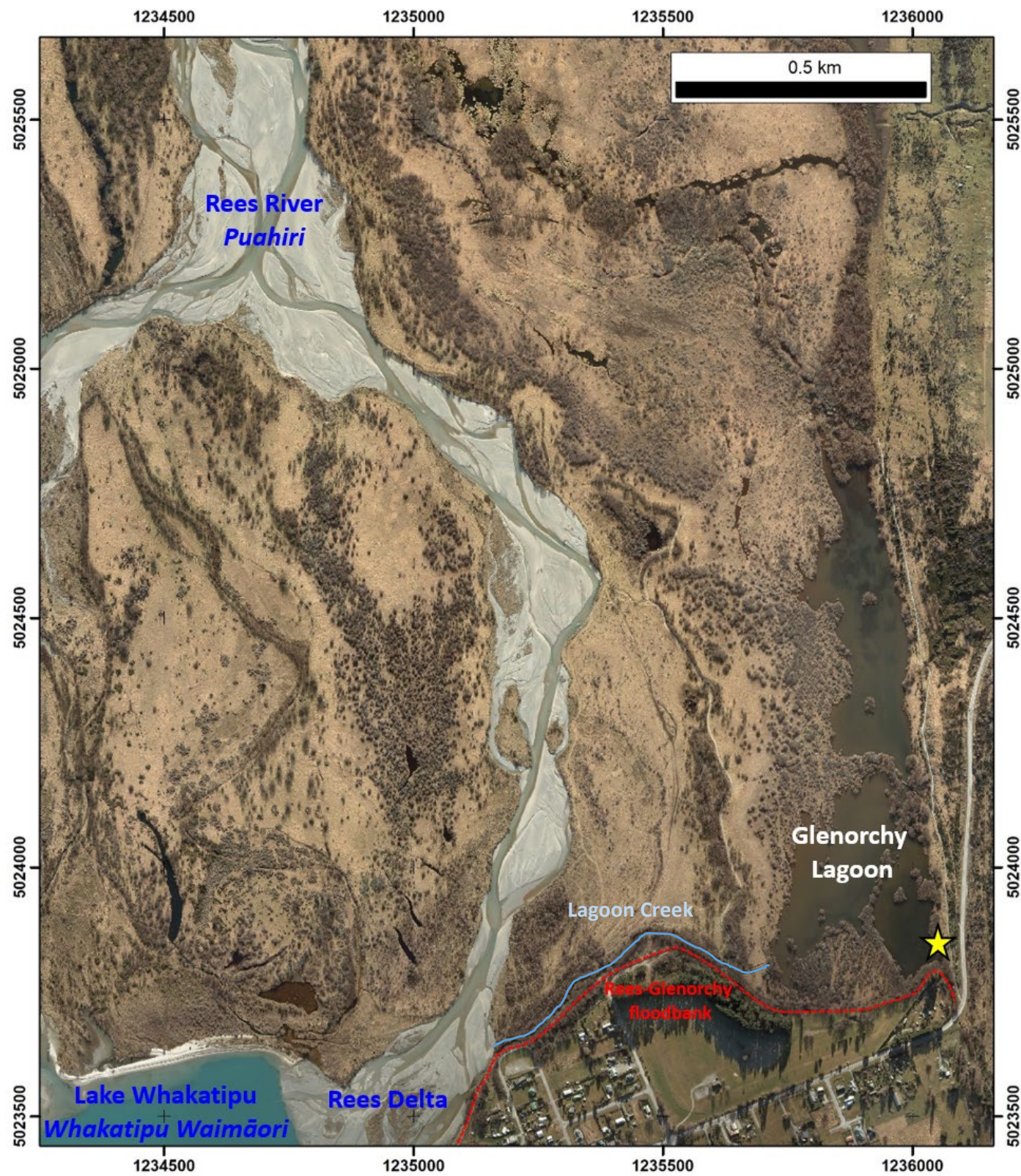


Figure 5.14 Overview map of the lower Rees River and the Glenorchy lagoon/wetland. The locations of the Rees-Glenorchy floodbank (dashed red line) and the ORC water level monitoring station (yellow star) are annotated.



**Lake Whakatipu**

Lake Whakatipu has a catchment of 3,067 km<sup>2</sup>, fed in the main by the Rees and Dart River catchments, with a combined catchment of 1,037 km<sup>2</sup>. The lake outlet, located near Frankton, outflows into the Kawarau River.

The normal water level of Lake Whakatipu is typically at about 310 masl. Historical records show that the level typically fluctuates between about 310 masl and RL 312 masl. Higher levels result in inundation of parts of Glenorchy and Kinloch and elsewhere on the lake, also causing inundation at Queenstown and Kingston.

The main cause of high lake levels in Lake Whakatipu is the natural imbalance between the capacity of the lake outlet (Kawarau River) and the magnitude of inflows during heavy rainfall events. Lake Whakatipu outflows may be further impeded by high flows in the Shotover River, due to the perpendicular configuration of the confluence of the Kawarau and Shotover Rivers.

Despite having a large catchment, due to the large surface area, Lake Whakatipu rises relatively slowly, even when inflows are high. This characteristic of the lake, in which the lake surface rises slowly and in response to particular weather conditions, means that the development of a high lake level flood event can be reliably monitored and the affected communities generally afforded a lead time, typically of several days, in which to prepare for potential inundation.

High lake levels are often associated with a succession of fronts, where rainfall events occur one after another and without sufficient time for the lake levels to recede, causing cumulative increases in lake level. The lake may remain at high levels for prolonged periods of days to weeks.

During the November 1999 flooding event, the lake reached the highest recorded lake level of 312.78 masl and remained at levels greater than 312 masl for around 8 days.

Frequency analysis of Lake Whakatipu levels has been completed by Mohssen (2021), based on a nearly 100-year record of lake levels (continuously monitored since 1962), and daily observations from 1924-1962, plus observations of historical levels in earlier flooding events, such as those occurring in 1878 and 1919 (Table 5-3).

Table 5-3 Frequency Statistics for Lake Whakatipu Water Level (Mohssen, 2021).

Frequency (average recurrence interval, years)	5-year ARI	10-year ARI	20-year ARI	50-year ARI	100-year ARI	150-year ARI
Lake Whakatipu water level (RL, m)	311.13	311.46	311.82	312.38	312.86	313.18



## 5.8 Built environment

The built environment in the Head of the Lake area includes existing man-made structures, features, and facilities that the community relies on for social and economic wellbeing.

**Settlements** – Glenorchy township is the main settlement, and includes critical public infrastructure such as the school, fire station / St John and the community hall. The greater Head of the Lake area includes the surrounding rural areas of Kinloch, Paradise, Routeburn, Greenstone, Caples, Te Awa Whakatipu / Dart River Valley and Puahiri/Puahere / Rees River Valley.

**Dwellings** – At the time of the 2023 Census, there were 261 occupied dwellings, 114 unoccupied dwellings (including residents away and empty dwellings) and 6 under construction (Stats NZ, 2023). More recently residential growth has occurred in Alfred's Terrace, a 60-lot residential development. Some lifestyle blocks have also been developed, particularly around the Glenorchy-Paradise Road area, as well as large homes in private gated communities or estates (largely catering to overseas owners). By 2053, forecasted growth under a medium scenario expects to reach 584 dwellings (QLDC, 2024).

**Glenorchy-Queenstown Road** – Provides the only road access in and out of Head of the Lake area for residents and visitors. The community relies heavily on the road to access goods, services, employment, education, recreation, and health care outside the area. Over the period of 2013-2023, Average Daily Traffic (ADT) ranged from approximately 705 to 5,650 (both lanes) (QLDC, 2023).

**Local roads (such as Glenorchy-Paradise-Kinloch-Routeburn and Rees/Dart bridges)** – Provide an important link to people and businesses located in Paradise and the Rees Valley. Also provide access to Kinloch, and the Routeburn, Rees-Dart, Lake Sylvan and Greenstone Caples tracks via the Glenorchy-Routeburn, Kinloch, and Routeburn Roads, which are popular tourism and recreation destinations. Over the period 2013-2023, Average Daily Traffic (ADT) for Glenorchy-Paradise Road ranged from approximately 121 to 1,211 vehicle movements (both lanes) (QLDC, 2023).

**Wharfs** – Kinloch and Glenorchy both have wharf structures. Sediment builds up has constrained the level of service at Glenorchy Wharf, and Kinloch Wharf is unusable (e.g., Figure 5.9).

**Power** – Aurora Energy is the local electricity distribution company. Aurora Energy is partway through a large, five-year work programme investing over \$500 million to upgrade the electricity network in Otago, including Glenorchy network improvements, which are now completed. The Glenorchy generator is in place and can supply past the township. Pioneer Energy Renewables owns the small Ox Burn hydro power station (Annual Generation: 2.5 GWh).

**Wastewater** – Currently households manage and treat their own wastewater at their properties.

**Drinking water** – Glenorchy has town water supply, and two large water reservoirs have recently been installed on Bible Terrace. Rural properties provide their own water supply.

**Telecommunications** – Service is provided by three telecommunication providers: One NZ, Spark, and Lakes Internet. Service reliability is reported to vary across the area. Some residents have access to Starlink, which provides satellite internet access. Approximately 77% of households have access to telecommunications systems (71% have internet and cellphone access, 16% telephone

access) (Stats NZ, 2023). Approximately 1.3% have no access to telecommunication systems (Stats NZ, 2023).

**Floodbanks** – The existing floodbank at the northern margin of Glenorchy township is owned and managed by QLDC and provides flood protection from low-moderate flood events (Damwatch 2022). Privately-owned floodbanks in the Rees River floodplain provide low-level protection for agricultural land and local roads.

## 5.9 Experience of past natural hazard events

At Glenorchy township, past flooding events have occurred due to various sources of flooding, including high flows in the Rees River, Buckler Burn and Bible Stream, and high-water levels in Lake Whakatipu. Some flood events are due to a combination of sources.

High water levels in Lake Whakatipu can cause flooding issues for the lakeside communities of Glenorchy, Kinloch, Kingston, and the Queenstown CBD (ORC and QLDC, 2006). At Glenorchy, the lakefront reserve and carpark areas begin to be inundated when lake levels reach approximately 311 metres above sea level (masl) (e.g., December 2019). This has happened 32 times since 1878, and there is a 29% chance the lake will rise above this level each year, and a 97% chance it will happen at least once in any 10-year period (ORC, 2013). The lake starts flooding into residential areas when reaching a level of 311.4 masl. There is a 10% chance that the lake will rise to this level each year, and a 67% chance it will happen at least once in any 10-year period (ORC, 2013). In November 1999, Lake Whakatipu reached its highest lake level on record at 312.8 masl (Figure 5.16) (DUN58 vertical datum). The second-highest level recorded was in September 1878 at 312.60 masl.

A notable recent event was in February 2020, when high Rees River flows caused overtopping of a section of the Rees-Glenorchy floodbank, resulting in the flooding of the Glenorchy township residential area (Figure 5.17).

Buckler Burn is a very dynamic alluvial fan with high sediment supply. Historical impacts include flooding of properties in southern parts of the Glenorchy township (late 1970s) and damage to Queenstown-Glenorchy Road (November 1999, Figure 5.18). The present-day alignment of the active channel is along the most southern limit of the fan. The fan surface may build up in the future and, consequently, northwards migration towards the township should be anticipated.

Flooding caused by high flows in the Dart and Rees Rivers can cause widespread inundation of the combined Dart-Rees floodplain area, such as during the January 1994 event (Figure 5.20) and March 2019 event (Figure 5.19). The main impacts of flooding are disruption to road access (e.g., to Kinloch, at the Rees bridge approaches, or at Paradise Road), and damage to infrastructure and land.

In addition to river flooding, major storm events have also caused a range of associated impacts, such as landslide and debris flow activity in January 1994, which also caused disruptions to road access and damage to infrastructure and land (Figure 5.21).

Some community members' experiences of the January 1994, November 1999 and February 2020 flood events are captured in MacKenzie's (2023, p. 97-104) thesis. These stories offer insights into the impacts felt by community members from these events and demonstrate community resilience.



*Figure 5.15 November 1999 – significant flooding of Glenorchy township residential area, due to highest water levels on record in Lake Whakatipu.*



*Figure 5.16 February 2020 – flooding of Glenorchy township residential area, due to high Rees River flows causing overtopping of a section of the Rees-Glenorchy floodbank.*





*Figure 5.17 November 1999 – Buckler Burn flooding and erosion damages to the Queenstown–Glenorchy Road (photos: Kelly Family).*



Figure 5.18 March 2019 – flooding of Dart floodplain, showing inundation of Kinloch Road.



Figure 5.19 January 1994 - disruption to road access and damage to infrastructure and land, caused by flooding of the Rees floodplain, and alluvial fan activity at the Precipice Creek and Ox Burn alluvial fans.





Figure 5.20 January 1994 – disruption to road access and damage to infrastructure and land, caused by flooding of the Dart floodplain and alluvial fan and debris flow activity. Includes Scott Creek, Stockyard Creek, and Kowhai Creek alluvial fans.



## 6 Drivers for Adaptation

Adaptation at the Head of the Lake is driven by several key factors. This section provides an overview of these drivers and explains how they relate to and motivate the adaptation efforts for the area.

**Community interest** – Experience of past flooding events has heightened community interest in hazard management.

**Dynamic landscape** – Delta growth, shifting river channels, ongoing sediment deposition and erosion will continue to put pressure on sites of cultural significance, and the sustainability of infrastructure and land use.

**Complex hazardscape** – Since 2019, we have greatly enhanced our understanding of the natural hazards' challenges in the area. The complexity and future uncertainties mean that there are no simple solutions.

**Future growth** – Population numbers at the Head of the Lake and in the district are expected to keep rising (QLDC, 2024). This is expected to increase demand for infrastructure, housing, and services. We need to ensure that future growth happens in the right place and that land use activities are appropriate.

**Climate change** – Projections of climate variables for the Otago region have been developed by NIWA (2019), under a range of future time periods (mid-century and late-century) and emissions scenarios (Representative Concentration Pathways, RCPs). For the Head of Lake Whakatipu catchments, these projections show significant increases in both rainfall and river flow variables, where increases in average temperature due to climate change are expected to produce a 20-40% increase in winter rainfall and more intense storms by 2090, with up to a 100% increase in the mean annual flood flow and up to 15 additional heavy rain days (>25 mm).

Estimations of the climate change effects on flood flows for the Rees and Dart Rivers, are for the 1% AEP flood flows to increase in magnitude by approximately 20% by 2090 under a RCP8.5 scenario, and 13% under a RCP6.0 scenario (Mohssen, 2021)<sup>5</sup>.

It is inferred that the projected future increases in mean river flows and flood magnitudes from the Lake Whakatipu catchments will cause an increase in mean and in-flood lake levels and, therefore, an increased likelihood of the lake reaching levels where it has an effect on lakeside communities. Detailed analysis to understand or quantify the potential climate change effects on lake levels has not yet been carried out.

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<sup>5</sup> If a flood has an AEP of 1%, it has a one in 100 likelihood of occurring in any given year. Climate change projections are based on Intergovernmental Panel on Climate Change (IPCC) scenarios called representative concentration pathways (RCPs).

## 7 Legislative and Strategic Context

Natural hazards and associated risks in Aotearoa New Zealand are not managed under a single statute. Rather, their effective management relies on the interplay of many statutes and requires those agencies exercising powers and responsibilities to do so in a coherent and coordinated way (Figure 7.1). These statutes include:

- Civil Defence Emergency Management Act 2002 (CDEMA).
- Resource Management Act 1991 (RMA).
- Local Government Act 2002 (LGA).
- Soil Conservation and Rivers Control Act 1941 (SCRCA).
- Local Government Official Information and Meetings Act (section 44A) 1987 (LGOIMA).
- Building Act 2004.

### 7.1 Otago Regional Policy Statement

The Otago Regional Policy Statement (RPS) provides an overarching policy framework that identifies and drives progress on significant resource management issues facing the region.

The RPS aims to achieve long-term environmental sustainability by integrating the protection, restoration, enhancement, and use of Otago's natural and physical resources at a region-wide level. It also gives effect to statutory requirements set out in the Resource Management Act 1991 (RMA), as well as various other statutes, national direction instruments and iwi authority planning documents.

District and regional plans in Otago need to give effect to an operative RPS when setting objectives, policies, methods, and rules for managing activities and resources. If there is a proposed RPS being developed, district and regional plans need to have regard to that document too.

The Strategy addresses objectives and policies outlined in the ORC's Otago Regional Policy Statement (RPS) 2019, specifically focusing on:

- Objective 4.1: Risk that natural hazards pose to Otago's communities are minimized.
- Objective 4.2: Otago's communities are prepared for and able to adapt to the effects of climate change.

Also relevant are objectives in the proposed Otago RPS 2021, which was notified in March 2024 and subject to appeal<sup>6</sup>.

- HAZ-NH-01 – *Natural hazards: Risks to people, communities, and property from natural hazards within Otago are maintained where they are acceptable, and managed to ensure they do not exceed a tolerable level.*
- HAZ-NH-02 – *Adaptation: Otago’s people, communities, and property are prepared for and able to adapt to the effects of natural hazards, including natural hazard risks that are exacerbated by climate change.*

Objectives outlined in the RPS 2019 and proposed PRS 2021 are supported by a number of policies to provide guidance for local communities to address challenges posed by natural hazards and climate change.

## 7.2 Queenstown Lakes District Council District Plan (2015)

The Queenstown Lakes District Council addresses natural hazards in Chapter 28 of the Proposed District Plan (2015) which contains the following natural hazards objectives:

- 28.3.1 A: The risk to people and the built environment posed by natural hazards is managed to a level tolerable to the community.
- 28.3.1 B: Development on land subject to natural hazards only occurs where the risks to the community and the built environment are appropriately managed.
- .....
- 28.3.1.5: Recognise that some areas that are already developed are now known to be subject to natural hazard risk and minimise such risk as far as practicable while acknowledging that the community may be prepared to tolerate a level of risk.
- ....
- 28.3.2: The community’s awareness and understanding of the natural hazard risk in the district is continually enhanced.

Chapter 20 of the Proposed District Plan notes that the low-lying areas at Glenorchy, Kinloch and Kingston that are susceptible to flooding are shown as ‘Historical Flood Zone’ on the Planning Maps and specifies a minimum floor level for management of lake level flooding risk in those communities. This rule states that:

- ‘Buildings with a gross floor area greater than 20m<sup>2</sup> shall have a ground floor level not less than RL 312.8 masl (412.8 Otago Datum) at Kinloch, Glenorchy and Kingston. (20.5.20).’

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<sup>6</sup> The proposed RPS is subject to appeal, which means the provisions around natural hazards may change through mediation or hearing.



## 7.3 Learning to Live with Flooding Strategy (2006)

In 2006, ORC and QLDC jointly developed:

- Learning to Live with Flooding: A Flood Risk Management Strategy for the communities of Lakes Wakatipu and Wanaka.

The objective of the Strategy is to manage the community's exposure to lake flooding risk and equip Wānaka, and the Whakatipu communities of Queenstown, Glenorchy and Kingston to understand and learn to live with lake flooding. Development of the Learning to Live with Flooding Strategy was a response to the severe 1999 lake flood, which was the highest lake level on record for Lake Whakatipu.

QLDC and ORC outlined an approach to manage the impacts and risks of lake flooding, rather than trying to avoid or limit them through engineered alteration of the physical environment. This approach, to learn to live with lake flooding at a strategic, local, and individual level, is a key principle of both councils' strategic, joint approach to lake flooding.

## 7.4 Other plans and guidance

Climate change and adaptation planning is informed by these plans:

- National Adaptation Plan (2022).<sup>7</sup>
- Otago Regional Council Strategic Climate Action Plan (2024)<sup>8</sup>
- Queenstown Lakes District Council Climate and Biodiversity Plan (2022)<sup>9</sup>
- Te Rūnanga o Ngāi Tahu - Climate Change Strategy<sup>10</sup>

Natural Hazards Commission Toka Tū Ake (formerly EQC) is Aotearoa New Zealand's natural hazards insurance agency, with a primary objective to 'reduce the impact of natural hazards on people, property and the community.' The following research and guidance published by the NHC has informed this Strategy:

- Natural hazard risk tolerance literature review (2023).
- Risk tolerance methodology (2023).

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<sup>7</sup> <https://environment.govt.nz/publications/aotearoa-new-zealands-first-national-adaptation-plan/>

<sup>8</sup> <https://www.orc.govt.nz/media/4alnenfa/draft-strategic-climate-action-plan-scap-august-2024.pdf>

<sup>9</sup> <https://climateaction.qldc.govt.nz/our-plan/>

<sup>10</sup> <https://ngaitahu.iwi.nz/assets/Documents/Ngai-Tahu-Climate-Change-Strategy.pdf>



## 8 Strategy Governance

### 8.1 Partnerships and collaboration

Key partners in the Strategy are Queenstown Lakes District Council, Civil Defence Emergency Management Otago, and the local community. The Strategy has been developed in collaboration with Aukaha and Te Ao Mārama Inc as the mana whenua representatives.

### 8.2 Roles and responsibilities for implementing the Strategy

This section outlines the existing roles and responsibilities of partners, community, and other agencies in reducing risks and impacts, implementing the Strategy, and working collaboratively to manage risks and build resilience.

#### 8.2.1 Otago Regional Council

The ORC looks after Otago's environment, ensuring activities comply with legislation. ORC is responsible for sustainably managing Otago's natural resources of land, air, and water on behalf of our community. ORC works to identify natural hazard risks and help communities coordinate, prepare, respond in emergencies, and recover. The ORC's role is to reduce the impact of natural hazards through hazard identification and providing information about the likelihood of an event occurring.

Key responsibilities include:

- Monitoring and maintaining a network of rain and river flow gauges and sharing the data.
- Analysing incoming information to provide early warning and awareness of flood events.
- River management activities, such as vegetation and gravel management.
- Investigation and decision-making around new flood mitigation measures (including hard or nature-based protection), alongside other parties.
- Conducting planned and reactive monitoring activities to collect up-to-date information on natural hazards, their impacts, and geomorphic changes.
- Updating natural hazard and risk analyses and sharing results with partners and the community.

ORC also has responsibilities as a member of the Otago Civil Defence and Emergency Management Group.



### 8.2.2 Queenstown Lakes District Council

QLDC is a territorial authority which has responsibility for making decisions about the effects of land use, activities on the surface of rivers and lakes, providing for sufficient development capacity for residential and business growth, noise management and subdivision. This work is guided through QLDC's [strategic framework](#) and investment priorities, and supported through the Queenstown Lakes Operative and Proposed [District Plan](#), [Spatial Plan](#), [Climate & Biodiversity Plan](#), [Infrastructure Strategy](#), and various asset management plans and master plans. Funding and investment decisions for projects, activities and services for the district are set out in the [10 Year Long Term Plan](#) which is reviewed every 3 years, with an Annual Plan completed in the years between.

At the Head of Lake Whakatipu, for example, QLDC is responsible for maintaining public roading and Three Waters assets, the Glenorchy marina and jetty, the Glenorchy flood bank, and ensuring appropriate land use activities through implementation of the [District Plan](#). Natural hazard information for individual properties is provided on the property LIM report.

QLDC is a member of the Otago CDEM Group, which is coordinated by Emergency Management Otago. Emergency Management Otago employs Emergency Management Advisors who are assigned into the district to support emergency planning, deliver training and public education campaigns, lead the development of community response groups and support Council to build its response capability. Council officers support these efforts by volunteering for the Council's Emergency Operations Centre (EOC) and by delivering a broad range of activities that help with community risk reduction and resilience building. These activities include land-use planning, resource and building consenting, resource management engineering, infrastructure planning and operations, climate adaptation planning, and community partnership development.

In the event of a major emergency event, the QLDC Emergency Operations Centre is activated to lead a coordinated, multi-agency response in collaboration with Emergency Services and partner organisations. For major emergency events this may involve a Declaration of a State of Local Emergency which provides access to a range of emergency powers to help coordinate the response and fulfil the objectives outlined in the CDEM Act 2002, National Disaster Resilience Strategy (2019), National CDEM Plan (2015), and Otago CDEM Group Plan.

### 8.2.3 Head of the Lake community

The community is responsible primarily for ensuring their own safety, the protection of any dependants and property, reducing their potential for loss, maintaining readiness, and responding appropriately during an event. This requires awareness of both the greater hazards and their specific risk exposure, and adoption of practices and measures to manage this risk (ORC and QLDC, 2006).

### 8.2.4 Mana whenua

ORC's commitment is to partner with mana whenua and make mātauraka Kāi Tahu (knowledge, wisdom and understanding) an integral part of our decision-making. Within this Strategy, the roles and responsibilities of mana whenua are represented by two organisations: Aukaha and Te Ao Mārama. In the development of this Strategy, ORC have worked with and through Aukaha and Te Ao Mārama (the Papatipu Rūnaka consultancy services, Aukaha, representing Kāi Tahu ki Ōtākou, and Te Ao Mārama Inc, representing Ngāi Tahu ki Murihiku) to ensure the traditions and values of mana whenua and mātauraka Kāi Tahu are embedded in the Strategy and actions.

Some specific responsibilities of Auhaka and Te Ao Mārama for the Strategy:

- Ensure that cultural values and practices of mana whenua are embedded and upheld throughout the Strategy’s planning, decision-making processes, as well as implementation phases.
- Provide mana whenua with up-to-date information and knowledge of natural hazard risks at the Head of Lake Whakatipu.
- Work closely with mana whenua to foster collective adaptation efforts across the area as well as build trust and relationships.
- Engage with mana whenua to gather input and feedback to ensure their voices are reflected in adaptation strategies and actions within this Strategy.

### **8.2.5 Civil Defence Emergency Management Otago**

The main role of Otago CDEM is safeguarding communities across the Head of the Lake area in emergencies.

CDEM Otago has specific responsibilities:

- Take the lead on preparedness, response, and recovery from natural hazards events, including development of emergency plans and early warnings.
- Conduct emergency drills and raising awareness of the importance of preparedness for emergency events.
- Coordinate emergency response efforts as well as mobilising resources and providing logistical support to affected communities in the area.
- Monitor impacts and damage caused by natural disasters as well as developing evacuation and recovery plans.
- Provide essential support to affected communities including food and medical assistance.
- Implement recovery work for affected communities at the Head of the Lake.

### **8.2.6 Central Government**

Central Government has roles and responsibilities that contribute to the Strategy:

- Provide legislative and policy frameworks and direction.
- Provide information, guidance, and tools to support effective adaptation planning for natural hazards and climate change impacts.
- Publish information on climate change projections and natural hazards impacts.
- Publish funding opportunities and tools to support adaptation.
- Respond to major natural hazards events.

## 9 Adaptation Cycle Approach to Planning

The approach selected by ORC to develop holistic, longer-term natural hazards management plans in line with the Ministry for the Environment's **10-Step adaptation cycle**. This adaptation approach is often shown as a circular 10-step decision cycle and can also be simplified as the sequence of five phases shown in Figure 9.1. This process has been promoted by the Ministry for the Environment as a blueprint for community-influenced decision-making in areas affected by natural hazards, while considering potential future uncertainties (e.g., landscape and climate changes).

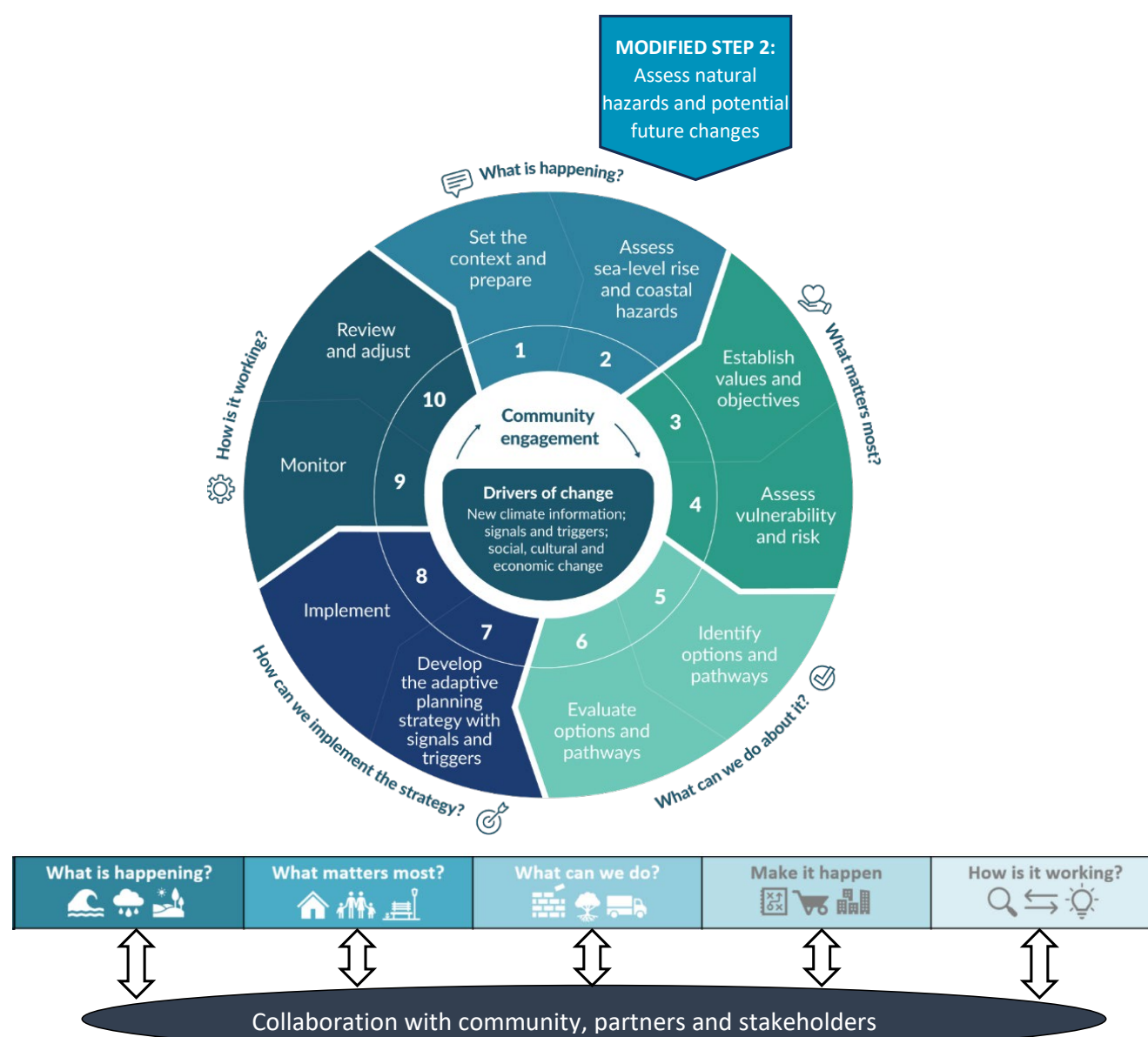


Figure 9.1 The 10-step decision cycle framework (modified from MfE 2024) and a simplified sequence of activities making up the approach.



## Adaptation pathways

Within the adaptation cycle is a method known as Dynamic Adaptive Pathways Planning (DAPP) or ‘Adaptation Pathways.’ A conceptual outline of the adaptation pathways decision-making process is included as Figure 9.2. By using a pathways approach, it becomes clear what suite of adaptation actions can be implemented as change occurs, or when a previous adaptation option stops working as it was intended. In situations like at the Head of Lake Whakatipu, it is very likely that a series of actions (rather than just a single action) will be needed as the hazards and landscapes change. This means it is important to know how and when to transition between the different responses.

ORC is applying the adaptation pathways approach in a variety of local areas in Otago with complex natural hazard challenges, including the Head of Lake Whakatipu, South Dunedin and Clutha Delta. The adaptation pathways approach is also supported by programme partners. Other regions are also applying the approach, including Hawkes Bay, Wellington, and Waikato.

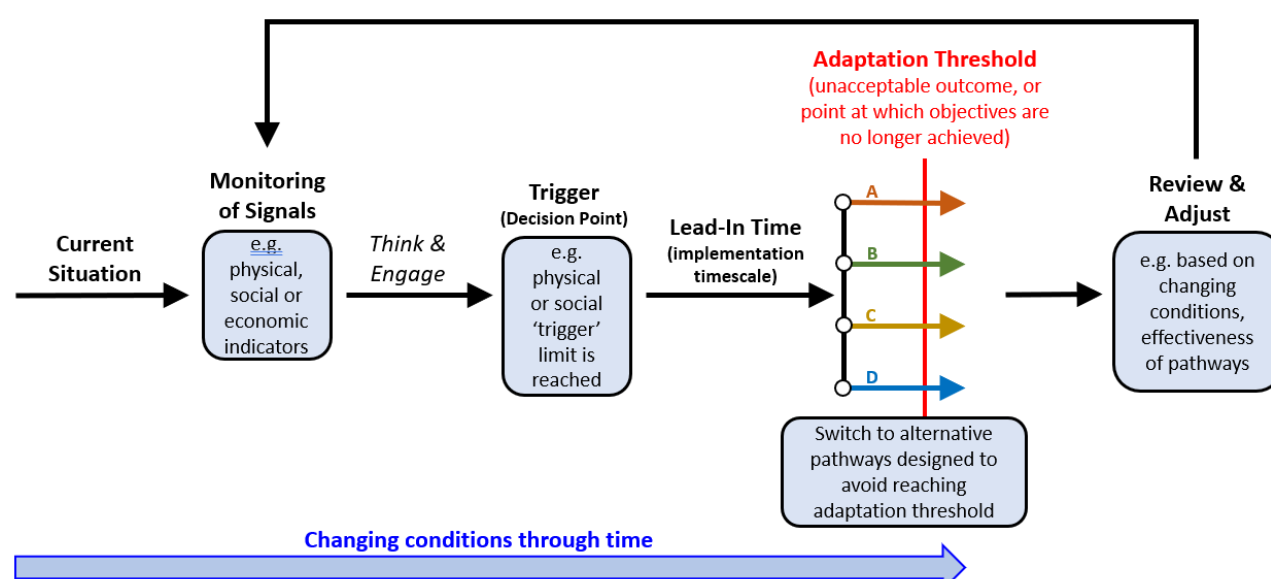


Figure 9.2 Conceptual outline of the adaptation pathways decision-making process.

## 9.2 Phase 1: What is happening?

The previous sections have set out the context for the Strategy, which is Step 1 of the adaptation cycle approach. This section is focused on modified Step 2: *assessing the natural hazards and potential future changes* (Figure 9.3).



Figure 9.3 'What is happening?' Steps 1 & 2 of the adaptation cycle (modified from MfE 2024).

### 9.2.1 Natural hazard processes, characteristics and potential impacts

A thorough understanding of natural hazard processes, characteristics and their risks is required to ensure a robust basis for decision-making regarding the most appropriate hazard management and adaptation approaches.

To this end, ORC has undertaken more than twenty technical and supporting studies to build the body of knowledge, detailed in Appendix A. These investigations, with detailed modelling and analysis, provide a much better understanding and modelled data of the area's natural hazards challenges. Key studies were externally reviewed by independent experts.

It is important to be aware that multiple hazards can occur at the same time and that one hazard can trigger another in a cascade. Some relevant examples for the Head of Lake Whakatipu area include:

- Major storms could cause flooding, riverbank erosion and debris flow.
- Earthquakes could trigger landslides and liquefaction.
- Landslides could increase sediment supply and disrupt access.
- Liquefaction could cause land subsidence, increasing subsequent flood hazard.

### 9.2.2 Geomorphic processes

Geomorphologic processes in the area are highly dynamic and can be a key influence on natural hazard characteristics. Collection of aerial imagery, LiDAR and on-ground survey information enables comparison with prior surveys, and analysis of change.

For parts of the Glenorchy and Rees River area, archive aerial imagery dates to 1937, so provides an 80+ year record of geomorphic changes in this location. For the Dart River floodplain, archive imagery dates to 1966 so covers a 50+ year period.

LiDAR surveys were collected for the lower Rees and Dart floodplains by ORC in 2011 and 2019. Additional LiDAR surveys were collected by the University of Canterbury for research purposes in 2021 and 2022, with data made available to ORC. The high-resolution topographic information provided by LiDAR survey enables geomorphic change analysis (e.g., Figure 9.5) and provides a detailed topographic base for hydraulic modelling projects (e.g., Gardner, 2022; Beagley and Gardner, 2023; Beagley, 2024).

Geomorphic analysis and assessments for the Dart-Rees floodplain and delta have been completed by Brasington (2021, 2024), and findings from these analyses are also included within T+T (2021) and Webby (2023). These studies build on earlier geomorphic assessments by URS (Mabin, 2007) and Wild (2012). These geomorphic assessments have included description of the geomorphic context (drivers, processes, and responses), and influences on natural hazards, review of historical changes, and quantification of rates of change. Key outputs from geomorphic analysis are relative elevation modelling, and mapping of geomorphic changes.

Relative elevation models compare the elevation of the valley floor to the adjacent average level of the active river channel (Figure 9.4). This analysis highlights two locations where the floodplain is notably lower in elevation than the adjacent active riverbed and, therefore, vulnerable to a channel breakout event (avulsion):

- the right bank upstream of the bridge (Diamond Creek area).
- left bank downstream of Precipice Creek (Glenorchy wetland area).

Geomorphic change detection (GCD) analysis is used to compare differences over time between repeat LiDAR topographic surveys (e.g., Figure 9.5). Analysis findings can be used to identify the locations of sedimentation or erosion/scour and to quantify the rates of these processes.

For example, Figure 9.5 illustrates the widespread bank erosion on the right bank of the lower Dart floodplain and the dominant aggradation trend in the lower Rees River. Estimation of net changes provides an indication of the mean rate of aggradation (e.g., ‘cm per decade’ rate), or the net volume changes between repeat surveys (sedimentation minus erosion, in cubic metres per year).

Maintaining an up-to-date understanding of current conditions is of high importance. The acquisition of up-to-date geomorphic datasets enables:

- revision of geomorphic analysis.
- identification and proactive response to potential issues.
- enables the updating of flood hazard assessments to ensure they provide accurate representation of current conditions (e.g., riverbed levels).



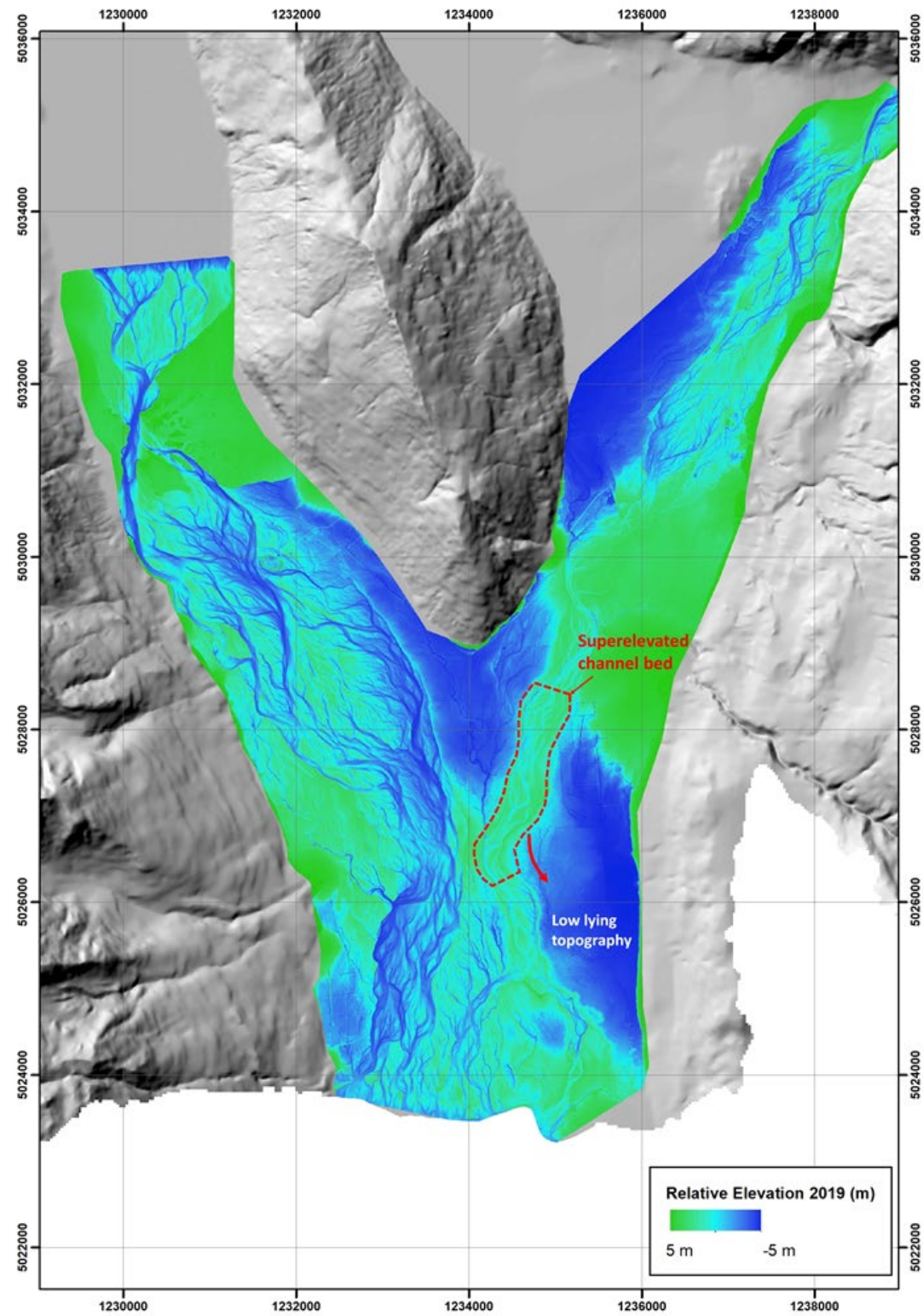


Figure 9.4 Relative elevation model of the Rees-Dart valley floor. This is computed by comparing the valley floor elevations to the adjacent average level of the riverbed. The section of super-elevated riverbed highlighted is the likely source for a potential channel breakout flood eastwards into the lower-lying topography of the wetland and lagoon area. The analysis is based on a 1 m resolution lidar topographic dataset acquired in 2019 (Analysis by J Brasington).

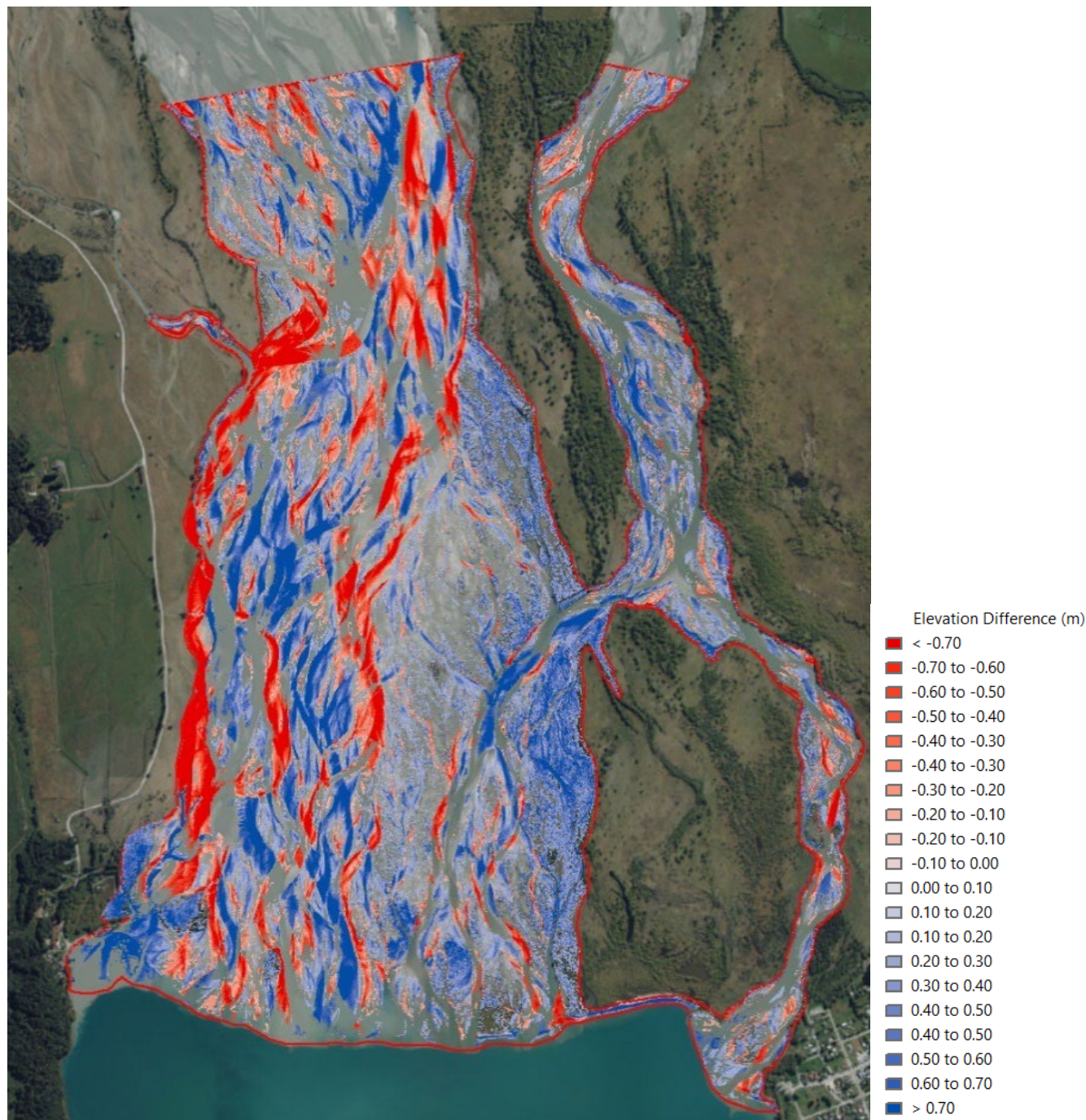


Figure 9.5 Geomorphic change for the lower Dart and Rees rivers (2011-2019). Blue is sedimentation, red is erosion. Showing westwards erosion of the lower Dart floodplain.



### 9.2.3 Hydrological and flood hazard assessments

Detailed flood hazard analysis has been carried out to understand flood hazard characteristics and the findings were used to inform risk assessment and engineering studies.

Hydraulic modelling and flood hazard analysis has been completed for the Rees and Dart Rivers (Gardner, 2022) and the Buckler Burn (Beagley and Gardner, 2023). In 2024, further hydraulic modelling was undertaken using the previously developed models, to assess a wider range of flooding magnitudes and a combined ‘all source’ model scenario which included inflows from the Dart and Rees Rivers, Buckler Burn and Bible Stream (Beagley, 2024).

For the Rees-Dart Rivers, modelled flooding scenarios included combinations of large (up to 100-year ARI) river flows and lake levels, and the effects of climate change on future river flows and flood events. Additional factors modelled include an avulsion of the lower Rees River channel, and a breach of the Rees-Glenorchy floodbank (Gardner, 2022). For the Buckler Burn, modelled flooding scenarios considered a range of river flows, and the effects of alluvial fan aggradation on fan morphology.

Model outputs from these flood hazard assessments typically include floodwater elevation, depth, velocity, and a classification of flood hazard as a function of floodwater depth and velocity. Findings from the Dart-Rees (2022) and Buckler Burn (2023) flood hazard assessments can be viewed in the ORC Natural Hazards Portal.<sup>11</sup>

Key findings from flood hazard assessments include:

- In larger-magnitude Dart-Rees flooding scenarios, there is widespread overtopping by floodwaters over the Glenorchy floodbank and floodwater inundation of a large northern portion of the township (e.g., Figure 9.6 and Figure 9.7). It is estimated that the Rees-Glenorchy floodbank structure will not prevent flooding in the township for river flow events of a 20-year ARI (average recurrence interval) or greater.
- In the larger-magnitude Buckler Burn flooding scenarios, there is some floodwater spillover northwards from the stream into the township area (e.g., Figure 9.7). However, modelled floodwater depths in the residential parts of the township are generally relatively shallow (<0.5 metre depth), even in the largest magnitude scenarios modelled.
- The Buckler Burn active channel is in close proximity to Queenstown-Glenorchy Road (Figure 9.7) and bank erosion is a threat to access.

These flood hazard assessments represent a significant increase in understanding from the previous flood modelling study at Glenorchy (Whyte and Ohlbock, 2007), which used a 1D modelling approach and was completed prior to the availability of LiDAR-derived topography.

Several supporting studies have been undertaken to inform flood hazard assessments:

- Hydrological analysis by Mohssen (2021, 2024). Including flood frequency analysis for Dart River flows and Lake Whakatipu levels, development of rainfall-runoff models for the Rees River and Buckler Burn, analysis of climate change impacts on flows.

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<sup>11</sup> <http://hazards.orc.govt.nz>



- Geotechnical assessments by T+T (2021) to inform modelling of floodbank breach scenarios at Glenorchy. These build on earlier floodbank stability assessments completed in response to concerns regarding bank erosion and floodbank stability (Jaquin, 2020, 2021).

Additional hydraulic modelling analysis has also been carried out as part of assessments by:

- Wong *et al.* (2023): A study completed for QLDC to inform a structural options assessment for the Rees River bridge structure, to help provide direction and guidance towards a long-term asset management strategy. The findings are summarised in Appendix B.
- Damwatch Engineering Ltd (2024): Assessments completed to inform review of potential floodplain hazard management approaches. The findings are summarised in Appendix B.

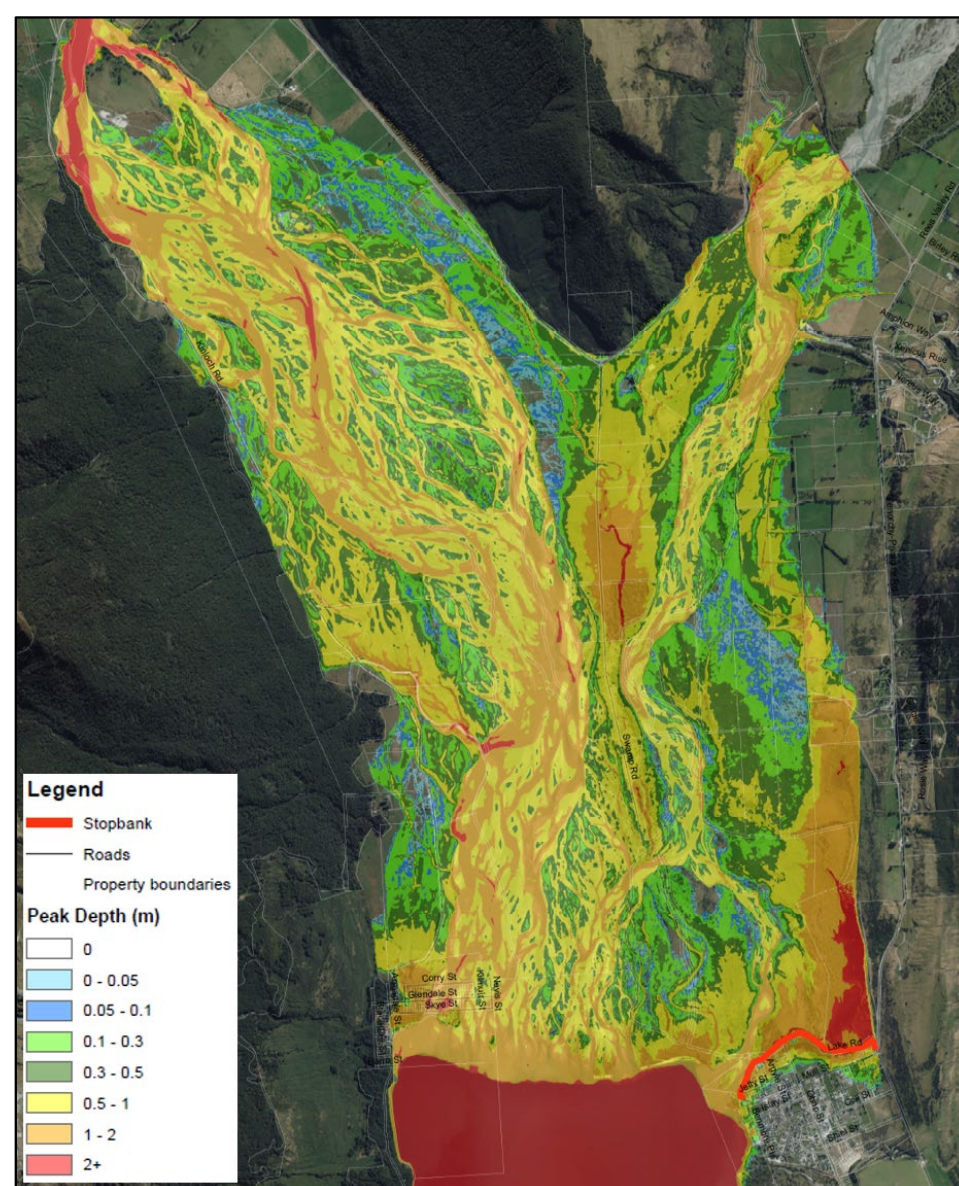


Figure 9.6 Model results for a Dart-Rees flooding scenario with 100-year ARI river flows, and Lake Whakatipu at 10-year ARI levels. Colouring shows peak floodwater depths according to the included legend. Figure 9.7 shows details of the Glenorchy township area for this scenario.



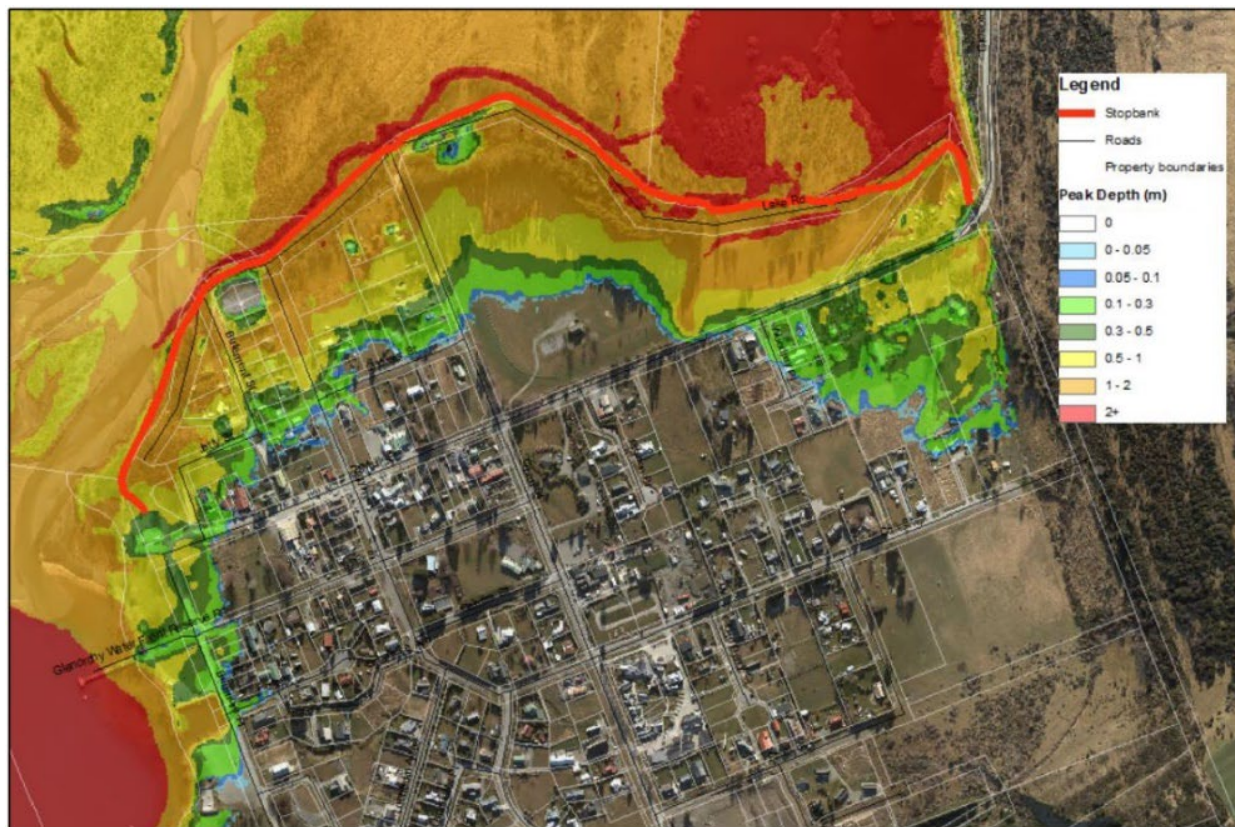


Figure 9.7 Model results for a Glenorchy flooding scenario with 100-year ARI river flows, and Lake Whakatipu at 10-year ARI levels. Colouring shows peak floodwater depths according to the included legend.



Figure 9.8 Model results showing floodwater depths for a Buckler Burn flooding scenario with a 300 m<sup>3</sup>/s peak flow. In this scenario, minor floodwaters flow into the township area, mainly flowing northwards along Oban Street and around the eastern margin of the township.

### 9.2.4 Alluvial fan hazards

The focus of alluvial fan hazard assessments for this work programme has been the Buckler Burn alluvial fan, on which the Glenorchy township is constructed. In addition to the flood hazard assessments completed for the Buckler Burn alluvial fan by Beagley and Gardner (2023), a preliminary assessment of debris flood and debris flow potential was completed by Fuller and McColl (2021). This assessment considers debris flows unlikely to be a threat to Glenorchy but identified possible high-energy debris flood deposits in drill core from within the township area.

Debris flow hazard modelling for the Buckler Burn using RAMMS software was reported by Faulkner (2021) and Faulkner and Rogers (2021) but was completed only as a test of sensitivity to factors such as failure locations, debris volumes and release mechanisms.

Other alluvial fans in the Head of the Lake area are mapped by Grindley *et al.* (2009) and Barrell *et al.* (2009),<sup>12</sup> with some known to be subject to flooding or debris inundation (e.g., Figure 5.20 and Figure 5.21), but these hazards have not been assessed in detail.

In April 2022, a debris flow event occurred at Shepherds Hut Creek, located about 8 km southwards from Glenorchy on the Queenstown-Glenorchy Road. Following the event, an assessment was completed by Shaw (2022) to review the event and comment on the debris flow hazard characteristics and risks.

Between Queenstown and Glenorchy, the road also traverses many other locations exposed to debris flow, flooding or landslide/rockfall hazards, but these hazards have not yet been assessed in detail.

### 9.2.5 Seismic hazard assessments

#### Seismic shaking

Seismic shaking hazards were summarised by Menke *et al.* (2024) in the Glenorchy and Kinloch Risk analysis. Aotearoa New Zealand is seismically active, with a high frequency of earthquakes. Earthquakes induce strong ground motion (earthquake shaking) in response to rapid release of built-up strain along fault lines. The intensity of shaking depends on the severity of the earthquake, distance from the epicentre, specific ground characteristics and local topography.

Numerous mapped fault systems are present in the wider area and influence seismicity in Kinloch and Glenorchy. Nearby possible active faults include the West Whakatipu Fault located approximately 2 km west of Kinloch and the Moonlight Fault approximately 15 km east of Glenorchy (Barrell, 2019).

The most notable fault in the area is the Alpine Fault, some 55 km to the nearest point from Glenorchy, due to the anticipated magnitude of earthquake and low recurrence interval. The likelihood of an earthquake triggering at some point along the 800 km long Alpine Fault over the next 50 years is 75%, with an 80% chance that the earthquake event would exceed magnitude 8 ([www.af8.org.nz](http://www.af8.org.nz)). The potential AF8 hazards and impacts for Central Otago include strong shaking triggering snow/ice avalanches, landslides and rockfalls on mountain and hill slopes, making some roads impassable and potentially isolating communities in the area. Central Otago lakes

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<sup>12</sup> This mapping can be viewed in ORC's Natural Hazards Portal: <http://hazards.orc.govt.nz>.



could be affected by landslide-triggered tsunami, making it important for communities to know the ‘Long or Strong, Get Gone’ messaging. Thousands of tourists may be stranded in the area, unable to get home and will need to be looked after for days due to damage to roads. Some areas may lose power and telecommunication services.

Assessment of shaking hazard for the risk assessment considers a range of probabilistic earthquake scenarios rather than specific fault rupture scenarios.

Menke *et al.* (2024) reports that seismic shaking hazard at Kinloch and Glenorchy is expected to pose the greatest risk to buildings and lifelines infrastructure through structural damage, compared to relatively few injuries or deaths. During the 2010/2011 Canterbury earthquakes, no deaths were attributed to structural failure of light weight timber frame buildings (being the typical building form within Glenorchy). However, one fatality occurred associated with collapse of a chimney induced by strong ground motion (Canterbury Earthquakes Royal Commission, 2012).

### **Liquefaction and lateral spreading**

Liquefaction and lateral spreading can occur when strong ground shaking during an earthquake disturbs ground sediments, causing them to behave as fluid. This can deform the surface of the ground, affecting buildings, roads and underground infrastructure such as water supply and septic systems at varying degrees (Figure 9.9).

Mapping of liquefaction susceptibility (Barrell, 2019b) has been completed for the Otago region, providing an overview at a regional scale of the hazard susceptibility. The regional-scale liquefaction hazard assessment is classed as a Level A investigation in accordance with MBIE/MfE (2017) guidance.

For the Glenorchy township area, a more detailed (Level C) investigation was undertaken by T+T (2022). This study included geotechnical field investigations (boreholes and CPT), and geotechnical analysis for a range of seismic scenarios including an Alpine Fault rupture.

The geological investigations show that the Glenorchy township is underlain by a thick sequence of delta and alluvial sediments, overlain by a surficial layer (3-7m thick) of gravels deposited by the Buckler Burn. All of the sediments underlying the surficial Buckler Burn gravels are highly susceptible to liquefaction.

The assessment developed a liquefaction vulnerability categorisation map for the Glenorchy township study area (Figure 9.10 and Figure 9.11), intended to show broad trends in liquefaction vulnerability. For strong earthquake shaking, significant and widespread liquefaction land damage may occur across all the lower lying areas of Glenorchy in the north and west.

Findings show the potential for lateral spreading damage is highest near the lake edge and decreases with an increasing distance from the lake. The magnitude of potential lateral spreading damage increases with earthquake shaking at larger return periods, and stronger shaking may be comparable or worse to that observed in parts of the residential red zone in Christchurch, which was typically in the order of 1m to 3m.

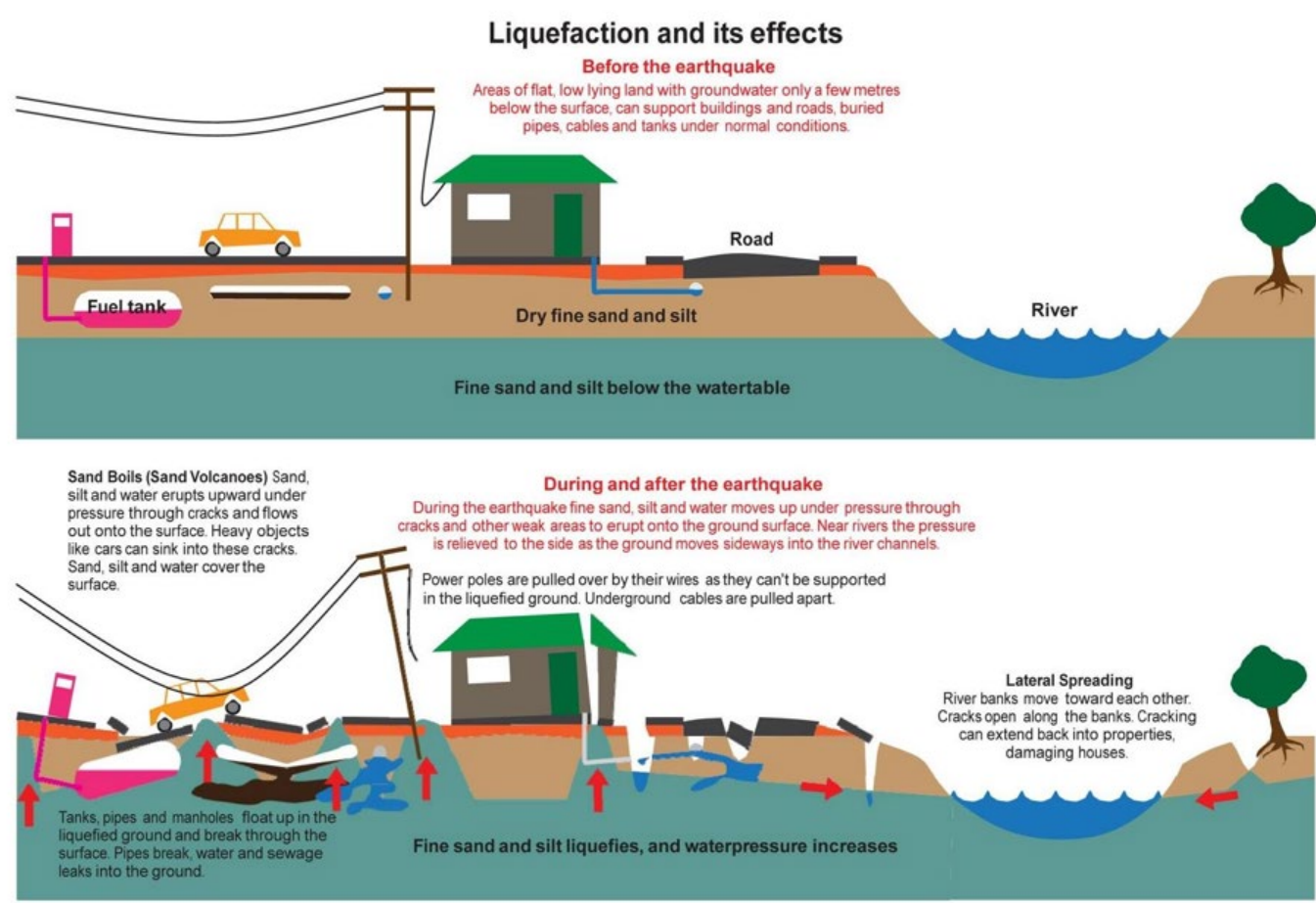


Figure 9.9 An illustration of liquefaction and lateral spreading processes and their effects (IPENZ, 2012).

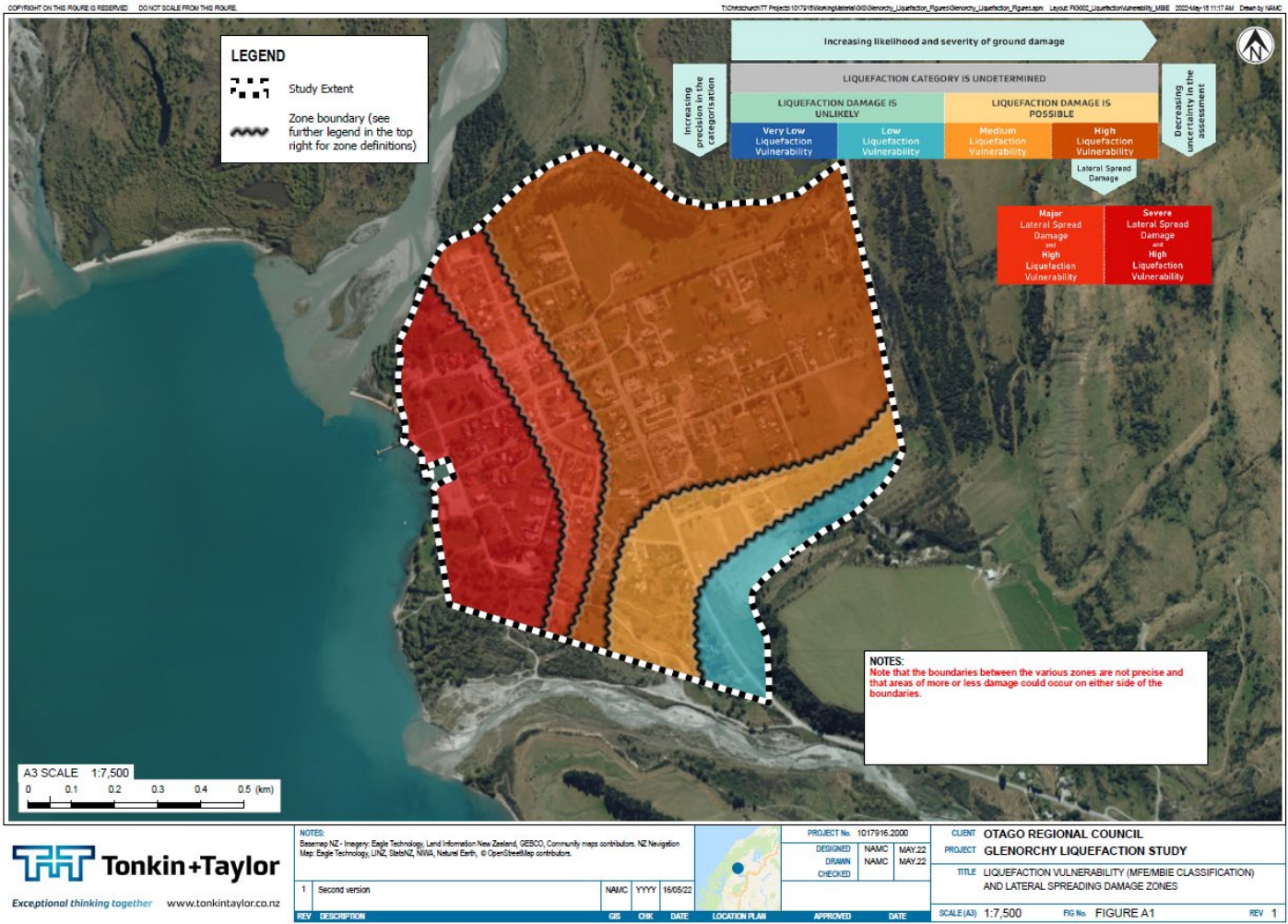


Figure 9.10 Liquefaction vulnerability categorization for Glenorchy township. The boundaries between the hazard categories shown are indicative of the spatial distribution of the liquefaction and lateral spreading vulnerability but are uncertain and not intended as a precise boundary between hazard categories. In reality, areas of damage might well occur on either side of the boundaries illustrated. T+T (2022).

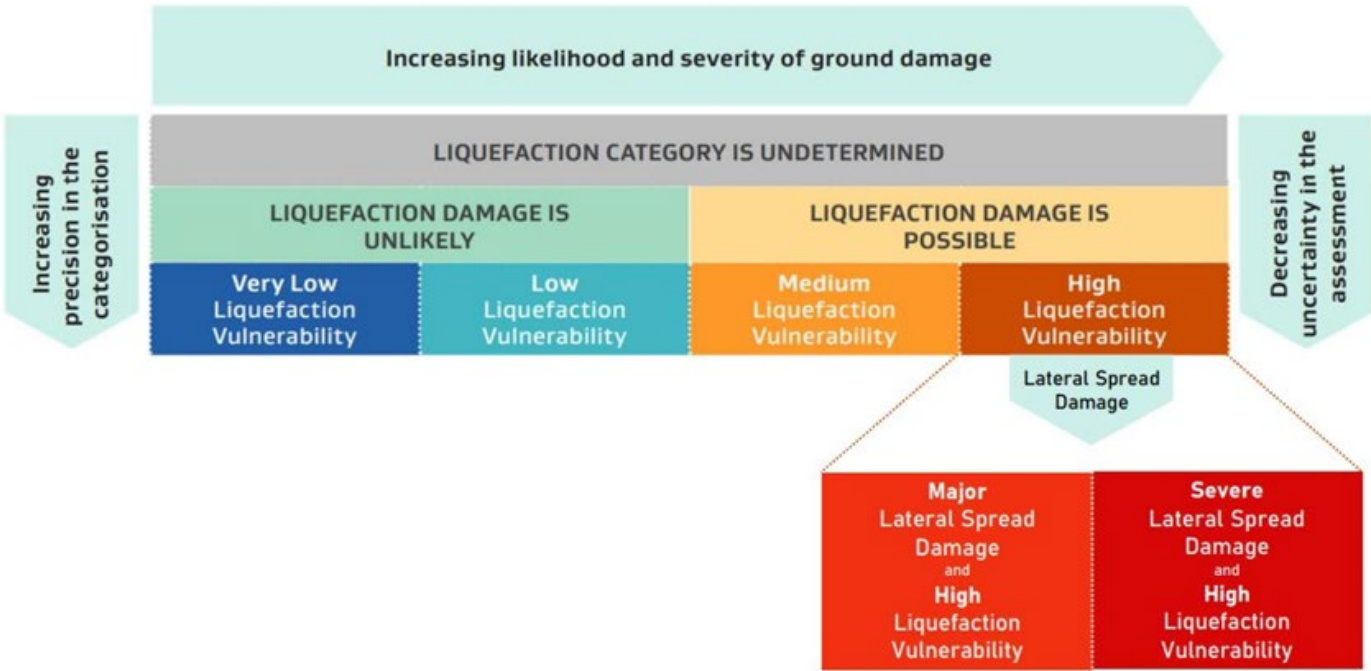


Figure 9.11 Magnified image of the hazard categorisation used for assessment of both liquefaction and lateral spreading hazard. T+T (2022).



## 9.3 Phase 2: What matters most?

This section is focused on Step 3: *establishing values and objectives*, and Step 4: *assessing vulnerability and risk* in the adaptation cycle approach (Figure 9.12).



Figure 9.12 'What matters most?' Steps 3 & 4 of the adaptation cycle (modified from MfE 2024).

### 9.3.1 Collaboration and engagement with community, partners and stakeholders

As highlighted in Figure 9.1, community engagement is central to the adaptation cycle in all steps. The development of the Strategy and ideas for adaptation pathways has involved extensive engagement with communities, experts, mana whenua and partner agencies. We are immensely grateful for everyone who has contributed to this Strategy. Communications and engagement activities are summarised in Table 9-1 below.

ORC is part of a wider network of people and organisations working to adapt to natural hazards and impacts of climate change at the Head of the Lake. To develop this Strategy, ORC has taken a collaborative approach across and between councils, mana whenua, central government, stakeholders, and the local community. These include agencies and organisations such as QLDC, CDEM Otago, Aukaha, Te Ao Mārama, Glenorchy Community Association, Department of Conservation, Enviroschools, as well as consultants and experts.

At an operational level, ORC has encouraged partnership and collaboration through:

- Knowledge and information sharing through regular catch up and programme updates.
- Inviting staff to collaborate and input on various programme workstreams, including programme planning, engagement planning, and an adaptation options assessment.
- Expert advice, input and feedback on hazard investigations and reports.
- Supporting the delivery of technical studies and assessments led by partners.
- Collaborating on the delivery of engagement activities.

Table 9-1 Summary of communications and engagement activities as part of the programme from 2019-2025.

Activity	Date	Summary	Agencies or organisations involved
Presentations to the Glenorchy Community Association	2019-2020	Update the Glenorchy Community Association on ORC’s completed and planned natural hazards activities.	Otago Regional Council Glenorchy Community Association
Community drop-in session	December 2020	Discuss and provide information on the range of natural hazard events the community is exposed to, and how these events and landscape changes have impacted the community in the past.	Otago Regional Council Queenstown Lakes District Council Tonkin + Taylor Glenorchy Community Association Civil Defense Emergency Management Otago
Public presentation	April 2021	Expert (Prof. James Brasington, University of Canterbury) overview of the river processes and changes of the Dart-Rees floodplain, and their implications for natural hazards.	Otago Regional Council University of Canterbury
Community drop-in session	April 2021	Discuss with the community the natural hazards challenges facing this area in the future, and initiate discussions about what adaptation to those challenges could look like.	Otago Regional Council Queenstown Lakes District Council Civil Defense Emergency Management Otago University of Canterbury Tonkin + Taylor NIWA

Activity	Date	Summary	Agencies or organisations involved
Online presentation	June 2022	Present and update on investigation findings into liquefaction and flood hazards.	Otago Regional Council Tonkin + Taylor Land River Sea Consulting
Community drop-in session	July 2022	An in-person opportunity to discuss in more detail the investigation findings into liquefaction and flood hazards.	Otago Regional Council Queenstown Lakes District Council Civil Defence Emergency Management Otago Tonkin + Taylor
Community workshop sessions	August 2023 (Figure 9.13)	To workshop ideas about community aspirations for the future and have discussions about a long list of possible adaptation options.	Otago Regional Council Queenstown Lakes District Council Civil Defence Emergency Management Otago Glenorchy Parent, Teacher and Friends Association NIWA
Community input into Socio-Economic Impact Assessment	July 2023 – April 2024	Community input into scope of assessment, methodology, data collection phase and draft report.	Glenorchy Community Association Beca
Online survey	September 2023	To get feedback on community values and aspirations for the future, and how we should engage in the future.	Otago Regional Council
Stall at Glenorchy Village Fair	November 2023	To initiate discussions about the natural hazards adaptation programme, community resilience and preparedness.	Otago Regional Council Civil Defence Emergency Management Otago



Activity	Date	Summary	Agencies or organisations involved
Adaptation education session at Glenorchy	April-May 2024	To build understanding of landscape changes over time, how people have adapted to these changes in the past and present and what adaptation could look like in the future.	Otago Regional Council Enviroschools
Head of the Lake Youth Art Competition	April-May 2024	To engage children and young people in the programme and better understand their values.	Otago Regional Council
Online presentation	May 2024	To present the findings of socio-economic impact assessment.	Otago Regional Council Queenstown Lakes District Council Beca
Public (in-person and online) presentation	September 2024	To present the findings of risk analysis and assessment of possible Dart-Rees floodplain interventions.	Otago Regional Council Queenstown Lakes District Council Civil Defence Emergency Management Otago NIWA Beca Damwatch Engineering
Community drop-in session	September 2024 (Figure 9.14)	An in-person opportunity to discuss in more detail the findings of the risk analysis and assessment of possible Dart-Rees floodplain interventions. Also, to initiate discussions about what adaptation could look like over the short to long term.	Otago Regional Council Queenstown Lakes District Council Civil Defence Emergency Management Otago NIWA Beca Damwatch Engineering

Activity	Date	Summary	Agencies or organisations involved
Monthly email newsletter	45 editions since August 2020	To provide progress updates for the work programme and give an indication of upcoming project work.	Otago Regional Council
Media releases and media coverage	Ongoing	To provide updates on key milestones in the programme and encourage media interest in aspects of the programme.	Otago Regional Council
Communications and advertising channels	Ongoing	Tailored communication and advertising for programme activities (such as Facebook ads and events, Google ads, flyers, letter drops).	Otago Regional Council
Programme webpage	Ongoing	To provide information about the programme and a site for links and key materials.	Otago Regional Council
Designated programme email address	Ongoing	To provide an easy way for people to contact the team about the programme: <a href="mailto:headofthelake@orc.govt.nz">headofthelake@orc.govt.nz</a> .	Otago Regional Council
Supported two research projects	2021-2023	Master's research project about storytelling and the ORC's community engagement process (MacKenzie, 2023).	University of Otago, Resilience to Nature's Challenges
	2021 - ongoing	Research project about landslide-generated tsunami hazards of the Lake Whakatipu basin.	Massey University, University of Otago, NIWA
Community presentation (in person and online) and drop-in session	Feb 2025	To seek direct feedback from the community on the Draft Head of Lake Whakatipu Natural Hazards Adaptation Strategy.	Otago Regional Council Queenstown Lakes District Council Civil Defence Emergency Management Otago

Activity	Date	Summary	Agencies or organisations involved
Surveys (online, paper-based, email/post)	Feb 2025	To share the Draft Head of Lake Whakatipu Natural Hazards Adaptation Strategy with the community and seek feedback from the community to make the Strategy practical and effective.	Otago Regional Council Queenstown Lakes District Council Civil Defence Emergency Management Otago



Figure 9.13 Community engagement session August 2023.





Figure 9.14 Manager Natural Hazards Jean-Luc Payan at the September 2024 community drop-in session.

### 9.3.2 Values and aspirations for the future

The Head of the Lake community has a strong and clear set of shared values and aspirations for the future, as noted in the ‘Glenorchy – Head of the Lake 2001 Community Plan’ and ‘Shaping our Future: Glenorchy Community Visioning Report 2016’ (Blakely Wallace Associates, 2001 and Shaping Our Future, 2016). Through engagement, people provided many insights into what matters most to them at the Head of the Lake. This has helped to generate a set of shared community values that will provide guidance for decision-making at the Head of the Lake now and into the future.

In the 2001 Community Plan, reinforced in the 2016 Visioning process, core resident values included being safe, caring, self-reliant, welcoming, working together and respecting the environment (Blakely Wallace Associates, 2001). Residents also valued the history of the area, the rural atmosphere, peacefulness, landscapes, and having the wilderness at their doorstep.

The community vision for the area as part of the Shaping our Future (2016) report, is as follows:

- *‘A unique, inclusive community that fosters and embraces individuality, diversity and innovation, encourages resilience and promotes community vitality and collaboration. The Glenorchy community has a collective strong voice that advocates for positive change. Glenorchy has the infrastructure to support a thriving boutique local economy in keeping with the rural landscape, actively respects and enhances the natural environment, collectively works towards providing their own resources (self-sufficiency).’*

The 2001 and 2016 values and vision align closely with feedback elicited as part of the engagement process. From all the feedback and engagement, as part of methods outlined in Table 9-1, the following overarching community values emerged:

- **Lifestyle and wellbeing** – people feel safe to do their day-to-day activities. A sustainable, self-sufficient, and resilient community.
- **Environment** – sense of stewardship and connection to nature – mountains, rivers, lakes. A place for wildlife and biodiversity to thrive.
- **Belonging** – a feeling of home. A strong sense of community where people support and take care of each other.
- **Recreation** – being able to enjoy recreation and links to the broader environment. A place for residents and visitors to enjoy together.

Additionally, the Head of the Lake Youth Art Competition built upon previous engagement about community values and what matters most to people about Glenorchy. The theme was ‘what does the Head of the Lake mean to you?’ Art entries from children and youth emphasised nature, cultural heritage, social connections, and play. These entries are displayed on the front and back cover of the Strategy.

Through the engagement process, we invited people to help develop community outcomes through a workshop exercise and online survey. These outcome statements for the Strategy will inform decision-making and pathways planning discussed in Section 9.5.1:

- Outcome #1 – A community that feels safe and supported from the impacts of natural hazards.
- Outcome #2 – Residents feel at home, connected to their environment and supported by the experience of community.
- Outcome #3 – A beautiful environment and a feeling of connection with nature.
- Outcome #4 – Sustainable, functioning ecosystems.
- Outcome #5 – The opportunity to make a living.
- Outcome #6 – Be resilient and self-determining.
- Outcome #7 – Functional, resilient and accessible infrastructure, support services and emergency response.
- Outcome #8 – Heritage is safeguarded and accessible.
- Outcome #9 – A healthy community that promotes the wellbeing of all.

Takau (2021) outlined key values for mana whenua in a Cultural Values Statement to guide planning and decision-making at the Head of the Lake now and into the future.

Ka Uara – Core cultural values:

- **Mana** – mana whenua are leaders, influencers, and partners.
- **Mauri** – protect and enhance the mauri (life force) of the Head of Lake Whakatipu, now and well into the future.
- **Whakapapa** – The traditional authority of mana whenua at the Head of the Lake is recognised ancestral rights which give mana whenua the mana and kaitiaki responsibilities.

Additional Kāi Tahu values include:

- **Ki Uta ki Tai** – commonly translated to ‘from the Mountains to the Sea’ but means interconnectedness across the whole environment.
- **Kaitiakitaka** – intergenerational and inherited responsibility and stewardship by mana whenua on behalf of future generations.
- **Maanakitaka** – expressing aroha, hospitality, generosity, and mutual respect. Processes and decisions that enable positive social outcomes and support wellbeing.
- **Mahika kai** – ability to, and access to, gather or harvest resources. Ensure a healthy functioning ecosystem and sustainable harvesting practices.
- **Wai Māori and Wai Ora** – importance of protecting and enhancing the wellbeing of all bodies as water is a sacred entity in te ao Māori and is the source of all life.
- **Maumaharataka** – acknowledging and upholding memories of the past and Kāi Tahu pūrakau (stories).
- **Whakawhanaukataka** – relationship and community building, working together for the benefit of the community.

The Head of the Lake area is immensely significant to mana whenua. To uphold the mana of kā rūnaka, it is crucial that mana whenua have authority over how their wawata (aspirations) for the future are portrayed and represented in this Strategy and in future actions (as outlined in Section 9.4.2.1). Councils need to ensure engagement is open and ongoing with mana whenua as the programme progresses.

### 9.3.3 Fears and concerns

As the programme has developed, people have also shared some of their fears and concerns about the programme and potential adaptation actions at the Head of the Lake. Concerns and fears include:

- Impact of natural hazard investigations on property values, property owners’ ability to get property insurance, or result in rising insurance premiums. In particular, focusing on findings before the Strategy has been developed or decisions on adaptation action have been made.
- Media attention about natural hazards and the programme could result in the reluctance of tourists to visit, further reducing the ability of the resident communities to withstand disruption.
- Media attention putting a negative ‘spotlight’ on Glenorchy based on the area’s natural hazard risk profile compared to other areas around the region.
- Some residents have highlighted parts of the community, including youth, parents of young families, and newer residents to the community, who have not been as engaged in the process. Therefore, their voices and perspectives may be under-represented from the development of the Strategy.
- Some residents have highlighted parts of the community, including newer residents to the community, are less informed about natural hazard risks and adaptation, which consequently impacts their ability to respond and be resilient to natural hazard challenges.



This general feedback has informed ORC’s approach throughout the programme and to develop this Strategy. It will continue to inform decision-making and actions relating to the Strategy moving forward.

### 9.3.4 Potential social and economic consequences of natural hazards

In addition to the socio-economic baseline, Healy *et al.* (2024) also examined the potential social and economic consequences of three indicative natural hazard scenarios in relation to the status quo (the current community and the natural hazard management measures currently in place).

#### 9.3.4.1 IN WHAT WAYS IS THE COMMUNITY RESILIENT?

**Local groups** such as Glenorchy Community Response Group and Community Association play a significant role in disaster preparedness and response. These groups, collaborating with CDEM Otago, regularly organise training sessions and awareness activities to enhance community response skills. They provide information to the Emergency Management Advisor and activate a Community Emergency Hub during crises to coordinate local response efforts. Additionally, they fundraise to support community projects, which strengthens resilience and preparedness (Glenorchy Community Response Group, 2022; Healy *et al.*, 2024).

**Social cohesion** is a defining characteristic of the Head of the Lake, where residents frequently unite to achieve common goals and welcome newcomers (Healy *et al.*, 2024). This strong sense of support and cooperation is key to resilience to natural hazards. Social cohesion helps foster networks that aid in adaptation and disaster preparations. It also promotes resource sharing, information exchange and collaboration during emergencies.

#### 9.3.4.2 IN WHAT WAYS IS THE COMMUNITY VULNERABLE?

Healy *et al.* (2024) noted that there are several sectors of the community that are particularly vulnerable to natural hazards. Namely, the high-needs population, elderly, young people and families, tourists/visitors, people with multiple, low-level, low-income jobs and temporary workers.

The demands of living in the Head of the Lake area require a level of health and mobility. These demands are likely to increase in a natural hazard event, therefore those with a high level of physical or mental health needs and disability are likely to be vulnerable. There are currently relatively low levels of physical limitations and disability reported in the community (2.4%) (Stats NZ, 2023). However, research participants noted that mental health was a concern for members of the community.

The Head of the Lake community is a small community and often people ‘wear many hats’. In a natural hazard event, these people would be susceptible to high levels of fatigue from trying to address both their household and community’s challenges.

The Head of the Lake economy is driven largely by tourism, followed by hospitality and film production. This dependency leaves the community vulnerable to external fluctuations, such as visitor numbers, infrastructure, and natural resources. The impact of reduced visitor numbers causes large financial pressure on both the local economy and people’s livelihoods. Most businesses noted a dependency on roading and telecommunications for operations. Many businesses directly or indirectly depend on the Head of the Lake area’s natural resources (e.g., mountains, lake, rivers, landscapes) for the operation of their businesses.

### 9.3.5 Glenorchy and Kinloch Natural Hazards Risk Analysis

Assessments were undertaken by Menke *et al.* (2024) to better understand and characterise the natural hazards risks at Glenorchy (Tāhuna) and Kinloch.

The purpose of the risk analysis was to:

- Provide the Head of Lake Whakatipu community with information on the relative levels of natural hazard risk in the township. This information was specifically requested by the community as feedback during community engagement sessions, and as feedback on behalf of the Glenorchy Community Association.
- To provide a robust evidence base for any future land use decision-making, such as if avoidance approaches may be appropriate for higher-risk areas.
- To provide a greater risk understanding for identification and prioritisation of risks to assist adaptation or risk management activities.

The risk analysis made use of all natural hazards assessments previously completed, particularly the more detailed hazard analysis carried out for flooding hazards (Gardner, 2022; Gardner and Beagley, 2023; Beagley, 2024) and for liquefaction hazard at Glenorchy (T+T, 2022).

The analyses considered the risk to life and property from the following natural hazards:

- River flooding from Rees River, Dart River, and Buckler Burn.
- Lake Whakatipu flooding.
- Seismic shaking.
- Liquefaction and lateral spreading in earthquakes (Glenorchy only).

Risk was initially assessed qualitatively (descriptively), and then quantitatively (providing a numeric risk value) for those hazards warranting further assessment.

A short list of natural hazards potentially impacting Glenorchy and Kinloch was developed and agreed with ORC following a high-level review of hazards and community exposure, as well as suitability of available data to conduct risk analyses.

#### 9.3.5.1 RISK ANALYSIS PROCESS

Qualitative and quantitative risk analyses have been completed for the short-listed natural hazards in accordance with the requirements set out by the proposed Otago Regional Policy Statement (RPS) - Hearing Panel version (ORC, 2022), which has been notified but is subject to appeal<sup>13</sup>. The proposed RPS presents a framework for the assessment of natural hazards in Otago which considers the interaction between a hazard occurring (likelihood) and the effects on life and the built environment (consequence). The proposed RPS requires three scenarios to be considered for each hazard representing median likelihood, high likelihood, and maximum credible event.

The approach uses the following relationship:

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<sup>13</sup> proposed RPS is subject to appeal, which means the provisions around natural hazards may change through mediation or hearing.

**Risk = Hazard (likelihood) x Consequence**

Risk is assessed for the following elements in accordance with (and using the same terminology as) the proposed RPS (ORC, 2022):

- Qualitative risk:
  1. Health and safety (injuries and death)
  2. Built environment
    - Buildings
    - Lifelines (essential infrastructure services e.g., water, transport, power, telecommunications)
- Quantitative risk:
  1. Life
  2. Property

**Qualitative Risk Analysis Process**

Qualitative risk analysis uses professional judgement and qualitative observations to evaluate the potential risks of each hazard against a range of prescribed consequence criteria. It is typically used where there is insufficient data for quantitative analysis or as a preliminary screening tool to determine whether quantitative analysis is required.

Qualitative risk is determined using a matrix of likelihood and consequences, as shown in Table 9-2. Each square corresponds to a different combination of likelihood and consequences. Green squares are *Acceptable* risk, yellow are *Tolerable* Risk and red are *Significant* risk.

Table 9-2 Qualitative risk matrix from proposed RPS (Table 8).

Likelihood	Consequences				
	Insignificant	Minor	Moderate	Major	Catastrophic
Almost certain					
Likely					
Possible			example		
Unlikely					
Rare					
Green, Acceptable Risk: Yellow, Tolerable Risk: Red, Significant Risk					

Proposed RPS appendix (APP6) provides further guidance on how to assess likelihood and consequences of the selected natural hazard scenarios. Guidance on consequence includes descriptions of severity of impact (ranging from insignificant to catastrophic) for Health & Safety (deaths and injuries) and Built Environment (Social/Cultural, Buildings, Critical Buildings and Lifelines) and a list of other considerations.

The first step is to determine the likelihood of a natural hazard scenario; the second step is to determine the consequence; the third step is to plot where they intersect in the Qualitative Risk Category matrix. For the example shown, a scenario with ‘possible likelihood’ and ‘moderate consequences’ gives a yellow ‘Tolerable’ risk category.



### Quantitative Risk Analysis Process

Quantitative risk analyses allow for greater consideration of uncertainty and provide a numerical expression of risk for each hazard scenario. The output is natural hazard risk presented as an annualised probability.

The quantitative assessment of life risk considers the probability that an individual most at risk is killed in any one year as a result of the hazards occurring. This is termed the Annual Individual Fatality Risk (AIFR).

The quantitative assessment of property risk considers the probability of total property (i.e., building) loss in any one year as a result of the hazards occurring and is termed the Annual Property Risk (APR). Total property loss occurs when the cost of repair exceeds the value of the property.

Quantitative risk (AIFR and APR) is calculated from the following equation:

$$\text{Quantitative Risk} = \text{Annual Probability} \times \text{Spatial Probability} \times \text{Temporal Probability} \times \text{Vulnerability}$$

Where:

- The **annual probability** is the risk of the hazard occurring in any one year.
- The **spatial probability** relates to impact by the hazard in a specific location occupied by the person most at risk or occupied by property.
- The temporal probability for
  - **life risk** incorporates the proportion of the time the person most at risk is present and allowing for the possibility that the person may be able to evade the hazard.
    - a) **property risk** is 1.0 (i.e., the house or building is always present).
- The vulnerability for
  - **life risk** is the probability of death of the person most at risk, in the event of an interaction with the hazard.
  - **property risk**, it is the vulnerability of the property to the damage, or the expected proportion of property value lost in the event of being impacted by the hazard (typically termed the damage ratio).

The assessment does not consider specific locations of people or buildings and assumes they could be present anywhere across the study area, to allow for relative comparison of risk levels.

Quantitative risk levels are categorised in accordance with Table 93 following quantitative analysis. The defined risk levels apply to both life (AIFR) and property (APR), for existing developments.

Table 9-3 Quantitative risk levels in accordance with the proposed RPS (ORC, 2022).

Risk Category	Risk Value
Acceptable	Less than $1 \times 10^{-5}$
Tolerable	$1 \times 10^{-4}$ to $1 \times 10^{-5}$
Significant	Greater than $1 \times 10^{-4}$

### 9.3.5.2 RISK ANALYSES RESULTS

A summary showing the risk levels results are shown in Table 9-4. The qualitative analysis was used as a screening tool to identify risks that required further analysis, and these were carried forward to the quantitative analysis.

The qualitative analysis considered:

- All scenarios or scales of hazard,
- Any location within the study area, and
- All built environment sub-categories were assessed (e.g., lifelines, buildings).

**Qualitative analysis findings** include some *Acceptable* and *Tolerable* risks that do not require further assessment:

- Lake Whakatipu flooding health and safety risk is *Acceptable* for all areas due to the slow speed that lake levels typically rise and the prolonged warning times.
- Seismic shaking health and safety risk is *Acceptable*, as the potential for collapse of the typical timber-framed building in Glenorchy and Kinloch is relatively low and would not necessarily lead to fatality or serious injury. Built environment risk is considered as *Tolerable* due to potential for structural damage of lifeline infrastructure, such as water supply wells. Predicted damage to buildings is considered to result in *Acceptable* levels of risk.
- Liquefaction and lateral spreading health and safety risk for Glenorchy is *Acceptable*, as this hazard generally does not cause death or injury.

#### Other qualitative findings:

- Large Buckler Burn flood events are expected to flood Queenstown-Glenorchy Road, cutting off access to Glenorchy and Kinloch.
- Liquefaction is predicted to be widespread for Glenorchy, with lateral spread displacements up to 3m predicted along the shoreline. Such large displacements would lead to the development of both wide and frequent cracking of the ground sub-parallel to the lake edge and lateral stretch across buildings. Such ground displacements would lead to significant structural damage and potential for building collapse. Lifeline risk is also considered *Significant*.

Table 9-4 Summary of risk analysis findings (Menke et al., 2024)

Hazard	Qualitative Assessment		Quantitative Assessment	
	Health and Safety Risk	Built Environment Risk	Life Risk (AIFR)	Property Risk (APR)
River flooding – Buckler Burn	☑	☑	Acceptable	Significant
River flooding – Rees/Dart	☑	☑	Acceptable	Significant
River flooding – Joint (multiple sources)	n/a	n/a	Acceptable	Significant
Lake Whakatipu flooding	Acceptable	☑		Significant
Liquefaction and lateral spreading - Glenorchy	Acceptable	☑		Significant
Seismic shaking	Acceptable	Tolerable		

☑ risks carried forward for quantitative analysis

Acceptable and Tolerable risks that do not require further analysis

Based on the qualitative results, the following **hazards were identified and carried forward to quantitative analysis**, as agreed with ORC:

- Buckler Burn flooding – life risk (AIFR) and property risk (APR)
- Rees/Dart flooding – life risk (AIFR) and property risk (APR)
- Joint flooding scenario – life risk (AIFR) and property risk (APR)
- Lake Whakatipu flooding – property risk (APR)
- Liquefaction and lateral spreading (Glenorchy) – property risk (APR)

Note, the ‘joint flood’ event is a modelled scenario where Buckler Burn, Dart/Rees Rivers, Bible Stream, and two small Glenorchy catchments flood at the same time. This was assessed during the quantitative analysis only due to the availability of additional flood modelling data.

The impacts of liquefaction in Kinloch were not assessed as there is insufficient data available to inform a risk assessment.



A summary of the quantitative analysis results is shown in Table 9-4 and discussed below. Quantitative risk levels are categorised in accordance with the proposed RPS defined risk levels for existing developments (Table 9-3).

**Annual Individual Fatality Risk (AIFR) - River Flooding**

Results of the river flooding life risk (AIFR) analysis are shown in Figure 9.15. Each map shows the combined risk, being the sum of risk from all three scenarios assessed for each hazard.

The risk to life (AIFR) from river flooding hazards has been assessed as *Acceptable* for developed areas in Glenorchy and Kinloch. The *Significant* effects of flooding are concentrated on the margins adjacent to the rivers and lake, and outside the developed areas. This lower level of risk is partly a function of the ability of people to evade slowly rising floodwaters.

In Glenorchy, the primary river flooding risk comes from flooding of the Rees/Dart Rivers. However, Buckler Burn also poses some risks within the township. The areas with the highest life risk (AIFR) are the Glenorchy lagoon, the lakefront (including Jetty Street and Benmore Place), and the Glenorchy golf course. Areas behind the floodbank, near the confluence of the Rees River and the lagoon, show the highest estimated AIFR values but are considered *Acceptable*.

The highest risks in Kinloch are also caused by Rees/Dart flooding. Existing buildings west of the Kinloch Road are in low flood risk areas. Areas east of the Kinloch Road have the highest life risk (AIFR) values but are still considered *Acceptable*.

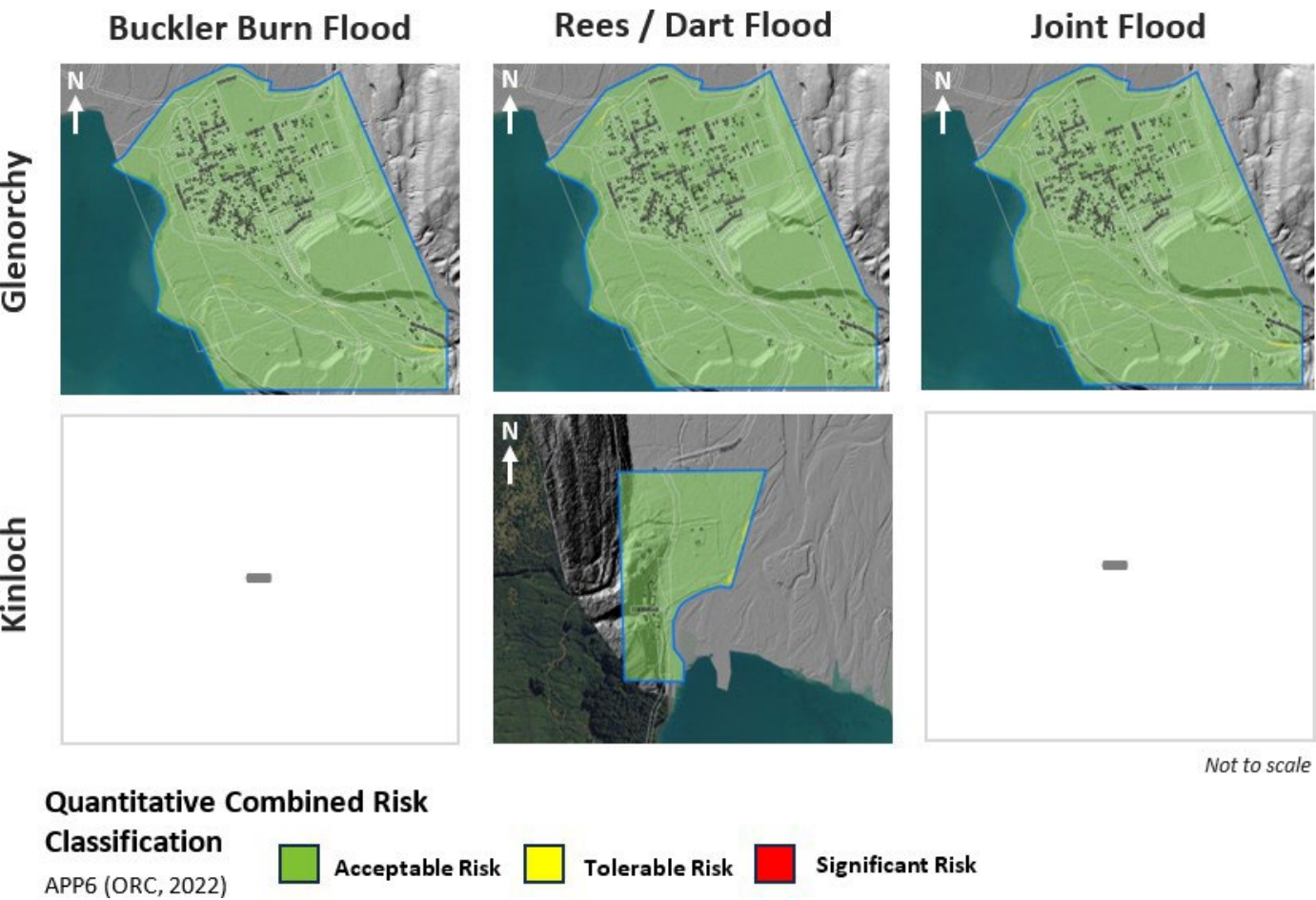


Figure 9.15 River flooding life risk (AIFR) levels.

Annual Property Risk (APR) - River Flooding

Results of the combined river flooding annual property risk (APR) analysis are shown in Figure 9.16. Quantitative property risk levels vary spatially between hazards, with the risk to property being *Significant* along the river and lake margins, and *Acceptable* outside of these areas. A large proportion of the land area that is most prone to flooding and within the *Significant* risk categorisation is used for community recreation and does not house a permanent population (including recreation reserve/parks and the golf course).

A Dart/Rees River flood poses the highest risks to property, having the highest APR values and the greatest extent of potential damage to property. In Glenorchy, this leads to potential damage around the lagoon and the Rees River mouth, with the highest property risk (APR) values on the golf course, in areas of *Significant* risk. In Kinloch, a Rees/Dart River flood could potentially damage areas to the east of Kinloch Rd with APR calculated to be *Significant*.

The potential damage caused by the Buckler Burn is limited to a few areas within its modelled overland flow path along the Glenorchy-Queenstown Road and Shield Street. Overall, the Buckler Burn has low property risk (APR values) and a small flood extent within the township area. Consequently, the additional damage caused by flooding from the Glenorchy catchments and the Buckler Burn in a joint flood scenario is minimal. The joint flooding scenario shows higher property risk (APR) values along Coll Street and the Glenorchy Cemetery, resulting in areas of *Significant* risk.

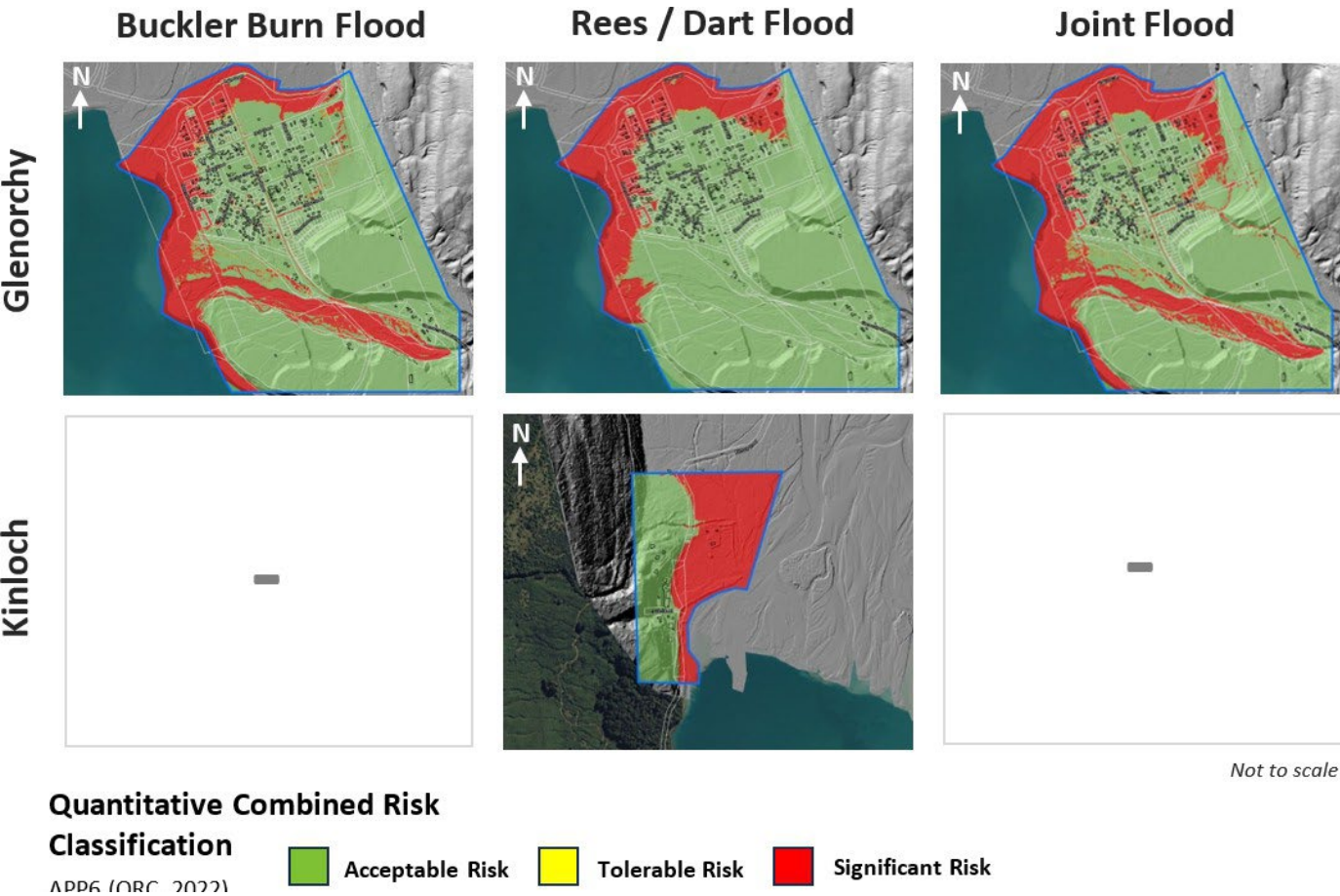


Figure 9.16 River flooding property risk (APR) levels.

Annual Property Risk (APR) - Lake Flooding

Results of the lake flooding property risk (APR) analysis are shown in Figure 9.17. Quantitative property risk levels show areas of *Significant* risk along the lake front at both Glenorchy and Kinloch, and the Rees River margin in Glenorchy.

The level of damage caused by a lake flood follows the topography of Glenorchy and Kinloch. IN Glenorchy the low-lying areas along the Rees lagoon and the lake are the areas most affected (e.g., Jetty Street and Butement Street). In Kinloch, APR values on Kinloch Road equate to a *Significant* risk.

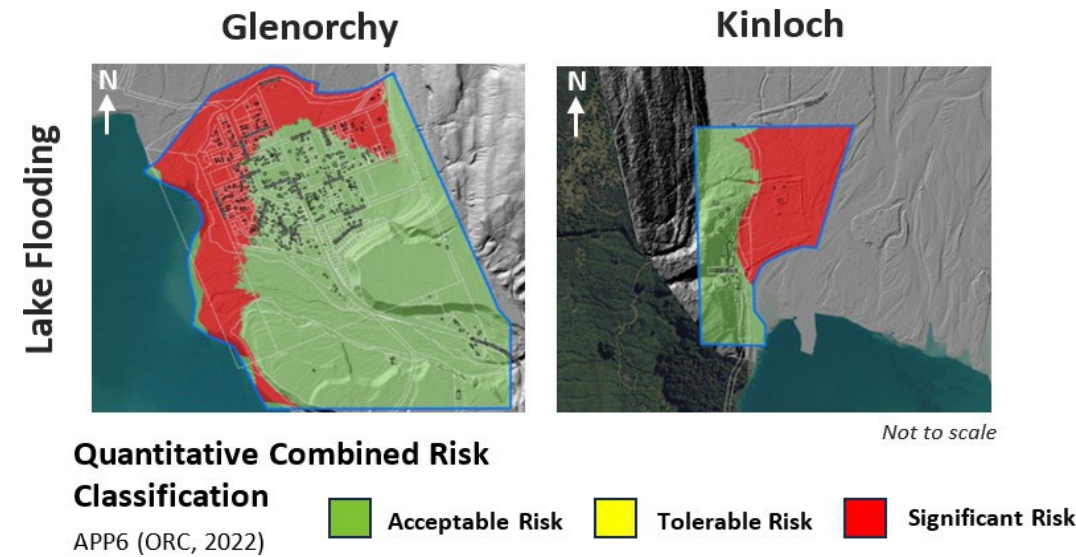


Figure 9.17 Lake flooding property risk (APR) levels.

Annual Property Risk (APR) - Liquefaction and Lateral Spread

Results of the liquefaction and lateral spread property risk (APR) analysis for Glenorchy are shown in Figure 9.18. Quantitative property risk levels from liquefaction and lateral spread are *Significant* for the whole of Glenorchy township.

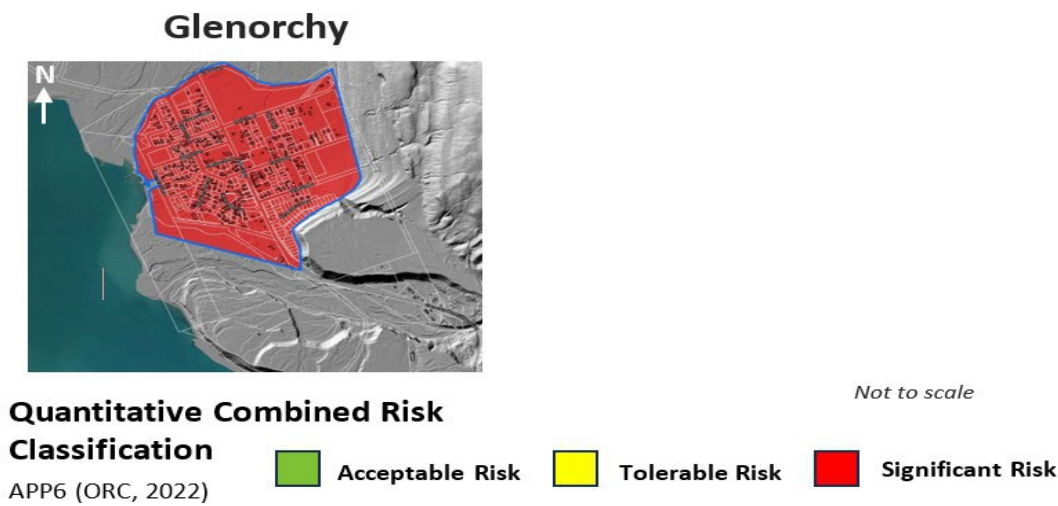


Figure 9.18 Liquefaction and lateral spread property risk (APR) levels.



The hazards that affect the greatest area to the built environment in Glenorchy are liquefaction and lateral spread-inducing land damage affecting property. While damage associated with liquefaction is expected to be substantial, lateral spreading is anticipated to result in the most significant damage focused along the lake margins, due to an approximately 25m high free face (where the land is not physically constrained and extends down to the lakebed).

### 9.3.6 Risk tolerability

Risk to property (APR) from flooding and liquefaction hazards exceeds the Tolerable threshold listed in the proposed RPS (ORC, 2022) in parts of both Kinloch and Glenorchy. It is noted in the proposed RPS that it is ultimately the responsibility of local authorities (i.e., both ORC and QLDC) to undertake a consultation process with communities, stakeholders, and partners regarding risk level thresholds. The Action Plan (Section 10) outlines the next steps for ORC and QLDC.

#### How much risk is tolerable?

Toka Tū Ake Natural Hazards Commission (2023) notes that ‘once we understand a risk, we must consider whether we are willing to tolerate the consequences’, and offers guidance on assessing tolerance to risk, as shown in Figure 9.19.

T+T (2023) makes the following points about risk tolerability and liquefaction hazard management:

- Before discussing potential options for managing liquefaction hazard, it is useful to ask the question ‘how much risk is tolerable.’ This helps to set a benchmark level of performance that the various options can be compared against.
- When it comes to natural hazards risk management and adaptation planning, there are no fixed rules about exactly how much risk is tolerable. Rather than being a purely technical engineering or legal question, this becomes a balance between costs and benefits, recognising that communities have many other objectives in addition to managing natural hazards. Finding the balance that best suits a particular situation requires a collaborative approach including the community, stakeholders, technical experts, and decision-makers. To help with these discussions, Table 9-5 includes various factors that may be relevant when deciding how much liquefaction-related risk is tolerable.
- ‘Residual risk’ is the risk that remains even after all adopted risk management measures are implemented. It is usually not practical or affordable to completely eliminate all risks. One of the goals of risk management is to find the point where the residual risk is reduced to a level which is acceptable, or the point of ‘diminishing returns’ where further investment in risk management measures does not give a worthwhile reduction in the overall level of residual risk.

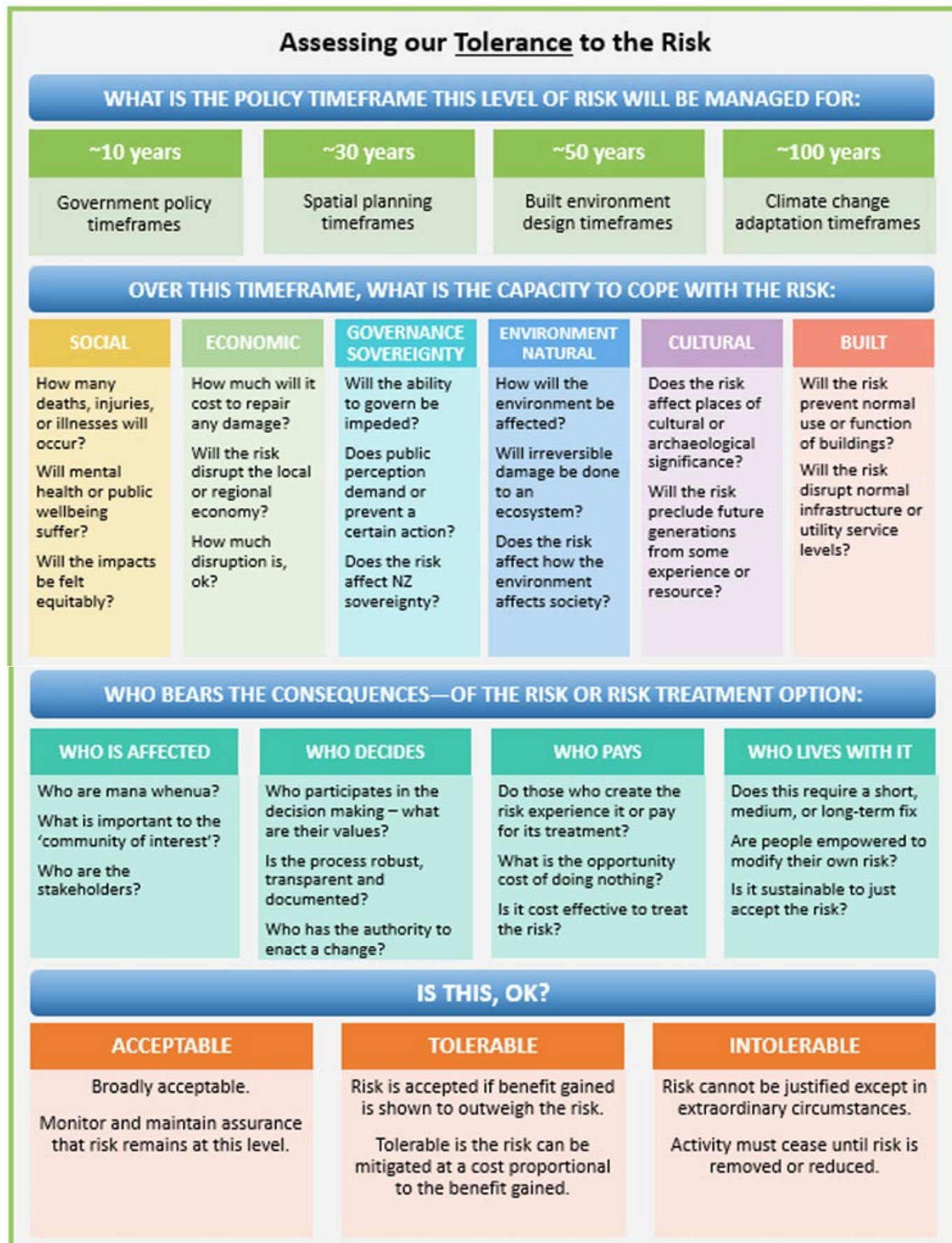


Figure 9.19 Assessment of Risk Tolerance (Toka Tū Ake Natural Hazards Commission, 2023).

*Table 9-5 Relevant factors when deciding how much liquefaction-related risk is tolerable (T+T 2023)*

Factor	Comments
Life safety during an earthquake	Lateral spreading damage to buildings is the main life safety concern related to liquefaction. While there were no deaths caused by lateral spreading in the 2010 – 2011 Canterbury Earthquakes, this was more a matter of good luck rather than good design – if the shaking had been stronger or longer then building collapse could have occurred.
Habitability in the days and weeks after an earthquake	If buildings are severely damaged, it may not be possible to use them after the earthquake so people would need alternative accommodation. Damage to electricity, water supply, stormwater and sewer networks would also impact on habitability, potentially for many months (or longer) after the earthquake. These issues could be worsened if earthquake damage cuts off the only road in and out of the town.
Long term recovery after an earthquake	While it is the most severe damage which often attracts most attention immediately after an earthquake, a more significant issue for long term recovery can sometimes be the minor and moderate damage (as it can be much more extensive). While it may be possible to continue living with this damage until it is eventually repaired, there can be far-reaching economic, social, and environmental consequences.
Other hazards	Some locations may also be exposed to other hazards (e.g., flood) and cascading hazards (e.g., liquefaction settlement leaves buildings more flood-prone).
Building Act	<p>All building work must comply with the Building Code regardless of whether a building consent is required, and irrespective of whether it is to construct a new building or to repair or alter an existing building.</p> <p>In the case of alterations or repairs it is only the new work that must comply with the current Building Code. If existing parts of the building do not comply, then the main requirement (with some exceptions) is that the alterations or repairs do not result in the building complying with the Building Code to a lesser extent than before.</p> <p>The Building Act requires councils to refuse building consent if the land is likely to be subject to natural hazards unless adequate steps are taken to protect against the hazard. However, the Act provides a specific list of hazards that this applies to, and it is unclear whether this includes earthquakes and liquefaction. Nonetheless, it is useful to note that the test of whether a hazard is considered ‘likely’ has been defined as a ‘100 year’ event (which has a 40% chance of occurring over the next 50 years).</p>
Building Code minimum requirements	<p>For most ‘normal’ buildings (and other structures) the Building Code mandates minimum acceptable performance for two earthquake scenarios:</p> <p>The Serviceability Limit State (SLS) is assessed for ‘25 year’ earthquake shaking levels (a 90% chance of occurring over the next 50 years). The building should suffer little or no structural damage and remain accessible and safe to occupy. There may be minor damage to building fabric that is readily repairable.</p> <p>The Ultimate Limit State (ULS) is assessed for ‘500 year’ earthquake shaking levels (a 10% chance of occurring over the next 50 years). The building is expected to suffer moderate to significant structural damage (which might not be repairable), but not to collapse.</p>



Factor	Comments
Resource Management Act (RMA)	The RMA identifies management of significant risks from natural hazards as a matter of national importance, which means it needs to be considered at all levels of planning and decision-making. The RMA also gives councils power to refuse or place conditions on subdivision consents where there is a significant natural hazard risk.
Insurance and mortgages	<p>Insurers each make their own decisions about natural disaster risk, often balancing many different factors. The availability and cost of insurance is subject to these decisions. In Aotearoa New Zealand there is an increasing trend of insurers moving toward more ‘risk-based’ pricing where specific attributes (such as location and presence of hazards) are taken into account in both deciding whether to offer cover, and in determining the cost of providing that cover.</p> <p>Following the Christchurch earthquakes, most insurers adopted an approach where new dwellings would be provided insurance cover on the basis that compliance with the Resource Management Act and Building Act/Code largely provided mitigation of the hazards potentially affecting the dwelling. In general, insurers were more concerned with existing dwellings on land that was revealed to be both liquefaction and flood prone, as there was little opportunity to mitigate the hazards for existing buildings.</p> <p>In the past, banks have typically provided mortgage lending if insurance was in place, but in the future, banks may also undertake their own independent assessment of natural hazard risk before offering lending.</p>
Chance of an earthquake occurring	<p>The T+T May 2022 liquefaction assessment report concluded that significant damage due to liquefaction and lateral spreading could be expected at a ‘50 to 100 year’ level of earthquake shaking (a 40 – 60% chance of occurring over the next 50 years).</p> <p>The Alpine Fault is particularly relevant, as it passes relatively close to Glenorchy (55km at its nearest point). There is a 75% chance of a large earthquake occurring on the Alpine Fault within the next 50 years. It is likely that a large Alpine Fault earthquake would cause significant liquefaction and lateral spreading damage in Glenorchy, however there is some uncertainty in the severity and extent of damage that could occur.</p>
Type of land use activity	There are many different ways that land can be used, such as for housing, commercial activity, infrastructure, recreation, environmental purposes etc. Because each of these different land uses has different consequences if damaged in an earthquake, they each have different risk profiles. This means that a particular degree of liquefaction-induced damage might be tolerable for some types of land uses but not for others.

## 9.4 Phase 3: What can we do about it?

The natural hazard challenges at the Head of Lake Whakatipu are complex and there is no simple solution. The community has a long history of ‘living with the hazards’ and adapting along the way, and this approach will continue to be necessary. This section of the Strategy focuses on identification and high-level evaluation of responses (Figure 9.20). At a high level, Phase 3 involved the following steps:

- Identify a range of possible responses, including crowdsourced ideas from community and local knowledge
- Screen out responses that are not technically feasible
- Develop a ‘long list’ of adaptation responses including existing and planned responses, and a future toolbox with both standard ways to manage hazards, and innovative ideas,
- Community engagement on the long list
- High-level socio-economic screening and mana whenua assessment of possible responses
- Technical evaluation of some responses (i.e., potential responses for liquefaction management and floodplain management).

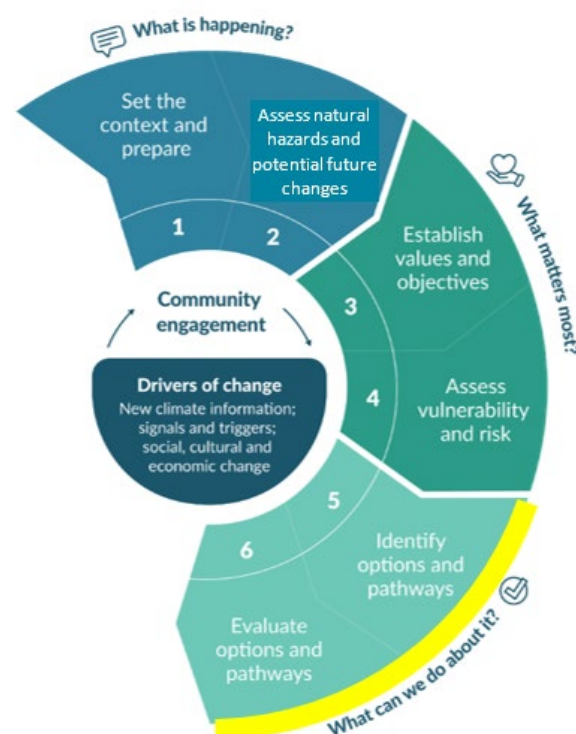


Figure 9.20 “What can we do about it?” Steps 5 & 6 of the adaptation cycle (modified from MfE 2024).

There are a variety of existing and possible future responses that offer potential benefits for adaptation. One framework for understanding some of these responses is: Protect, Accommodate, Retreat, Avoid (PARA) (Figure 9.21).

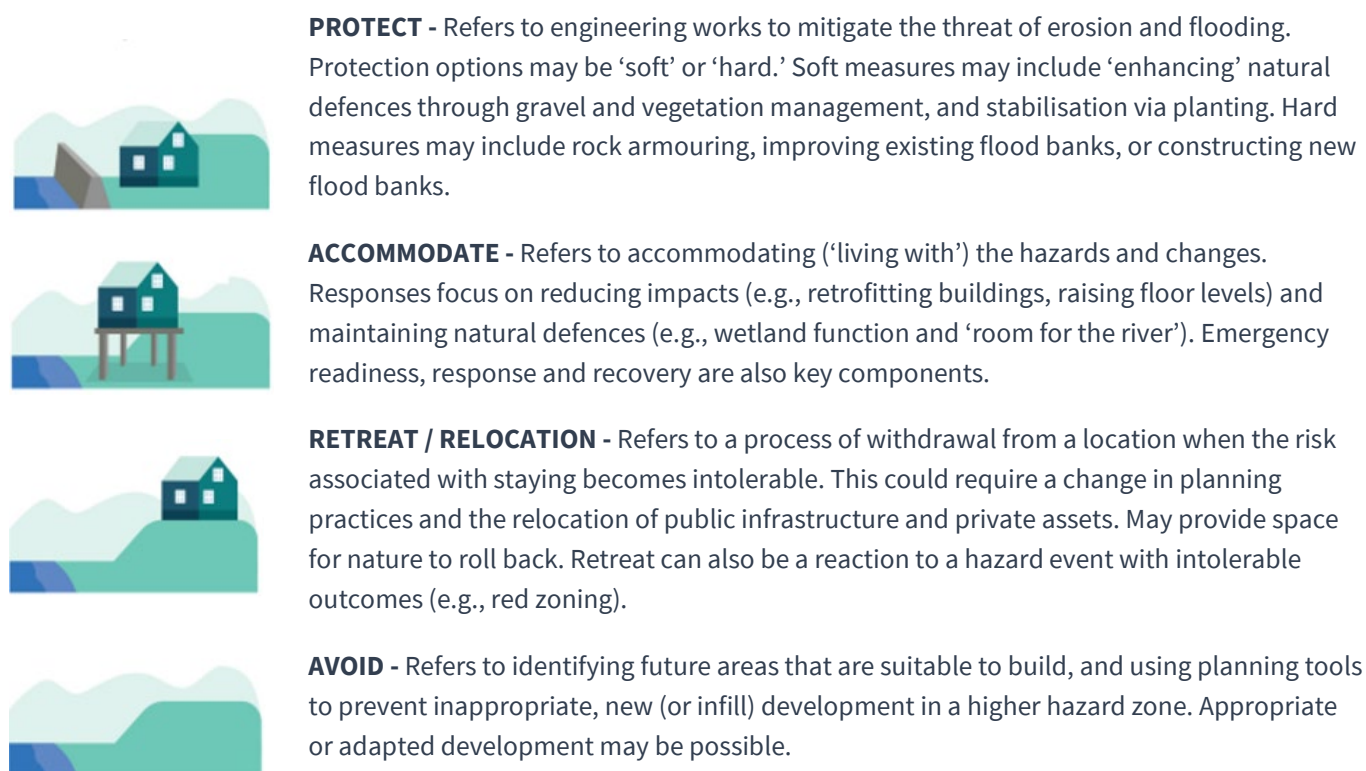


Figure 9.21 The PARA framework; Protect, Accommodate, Retreat, Avoid (MfE, 2023).

## 9.4.1 Identify a range of possible responses

### 9.4.1.1 LOCAL KNOWLEDGE AND COMMUNITY INSIGHTS

We have heard many ideas, insights, and observations from the community about what we can do to adapt to natural hazard challenges and impacts of a changing climate in the Head of Lake Whakatipu area. Thank you to community members for sharing. Appendix B Table 132 collates the ideas and comments on how they were considered further.

Community feedback on possible responses can be grouped in the following general themes:

- Responses that provided more natural solutions such as wetlands, trees and greenspace were liked for their wider benefits to the community.
- Large-scale, engineered responses to manage liquefaction and lateral spreading hazards were not preferred due to their cost and residual risk.
- Significant interest in emergency readiness and response, including community-led action.
- Combination of responses working together.
- Consideration of cost, who will pay for the response and what impact it would have on the individual property owner and the ratepayer in terms of rates increases.
- Generally, people expressed that people living in the area had a high-level of tolerance to flood risk. But that there were more vulnerable parts of the community with lower risk



tolerances, and that the community would still need support in response and recovery to a disaster.

- Retreat was largely considered as a long-term future action, with some opposition to this response as they believe Glenorchy township is worth protection.
- There is a lack of clarity about roles and responsibilities for implementation of any potential managed retreat, and what a proactive or reactive retreat process could look like. People would like further clarity to be able to give more meaningful feedback on this option and how to ensure it is a fair and equitable process for the community.

#### **9.4.1.2 LONG LIST OF RESPONSES**

After screening, sorting, and collating ideas there is a long list of responses (Table 9-6) which includes 13 existing responses, and a future toolbox of 24 responses that might be useful when we face future challenges.

Table 9-6 Long list of responses (October 2024).

CATEGORY	EXISTING OR FUTURE TOOLBOX?	LONG LIST OF RESPONSES (OCTOBER 2024)	TYPE OF RESPONSE	CURRENT AREA OF RESPONSIBILITY	WHAT IS THE MAIN OBJECTIVE OF THE RESPONSE?
Hazard awareness and mitigation	Existing **	Societal, behavioural and institutional changes (improve over time) when considering natural hazards and changes to the physical environment	Accommodate	Everyone	Support awareness and informed decision-making
	Future Toolbox **	➤ Review and accept residual risk for existing development	Accommodate	ORC, QLDC, community	Informed decision-making
	Existing	Emergency readiness and response (improve over time)	Accommodate	CDEM, ORC, QLDC, community	All hazards emergency response
Road access	Existing	Maintenance, reactive repair and planned works for the Glenorchy-Queenstown Road	Accommodate / protect	QLDC	Maintain resilience of regional road access to flood, erosion, and alluvial fan hazards
	Existing	Maintenance, reactive repair and planned works for the Kinloch and Glenorchy-Paradise local road system	Accommodate / protect	QLDC	Maintain resilience of local road access to flood, erosion, and alluvial fan hazards
	Future Toolbox	➤ Small scale improvement to existing Kinloch and Glenorchy-Paradise local road system road (as well as maintenance and reactive repair)	Accommodate / protect	QLDC	Reduce impacts of flood, erosion, and alluvial fan hazards on local road access
	Future Toolbox	➤ Reduced level of service of existing Kinloch and Glenorchy-Paradise local road system (e.g., some parts 4WD only)	Accommodate	QLDC	Maintain local road access at a lower level of service
	Future Toolbox	➤ Major works to increase resilience of Kinloch and Glenorchy-Paradise local road system (e.g., protect, raise, realign)	Protect	QLDC	Reduce impacts of flood, erosion, and alluvial fan hazards on local road access
	Future Toolbox	➤ Reactive re-design Kinloch and Glenorchy-Paradise local road system for changed conditions (e.g., post event)	Protect	QLDC	Post-event replacement to restore local road access
Boat access	Existing	Existing boat access at Kinloch and Glenorchy (limited by existing and ongoing sediment accumulation)	Accommodate	QLDC	Maintain alternative access
	Future Toolbox	➤ Short-term improvements to existing boat access (e.g., dredging)	Accommodate	QLDC	Improve alternative access
	Future Toolbox	➤ Upgrade boat access with resilient solution (e.g. relocatable wharfs)	Protect	QLDC	Provide alternative access with higher level of service
	Future Toolbox	➤ Relocate wharfs periodically to maintain future access	Protect	QLDC	Maintain alternative access with higher level of service
Flood mitigation and protection	Existing	Maintain the flood monitoring network (rainfall and water level stations) and flood data history	Accommodate	ORC	Flood hazard readiness and emergency response
	Existing	Flood monitoring, forecasting and warning (improve over time)	Accommodate	ORC	Flood hazard emergency response
	Existing	Existing low level Rees River flood protection by Glenorchy floodbank (maintenance and reactive repair)	Protect	QLDC	Maintain existing Rees River flood protection
	Future Toolbox	➤ Small scale improvements to Glenorchy floodbank to maintain/reduce flood risk	Protect	QLDC	Increase resilience of Rees River flood protection
	Future Toolbox	➤ Major works to increase level of service of Glenorchy floodbank	Protect	QLDC	Reduce impacts of Rees River flood hazard on Glenorchy township
	Future Toolbox	➤ Redesign Rees flood protection for changed conditions (e.g., post event)	Protect	ORC, QLDC	Post-event replacement to restore protection
	Existing	Existing river management (vegetation and gravel)	Accommodate	ORC, QLDC	Maintain resilience to flood, erosion, and alluvial fan hazards
	Future Toolbox	➤ River management and nature-based interventions (e.g., targeted planting)	Accommodate	ORC	Reduce impacts of flood, erosion, and alluvial fan hazards
	Future Toolbox	➤ Redesign nature-based interventions for changed conditions	Accommodate	ORC	Post-event replacement
	Future Toolbox	➤ Small scale works to reduce Buckler Burn erosion and/or flood risk	Protect	ORC	Reduce impacts of Buckler Burn flood, erosion, and alluvial fan hazards
Public asset resilience	Future Toolbox	➤ Improve resilience of critical assets in higher hazard areas (such as floodproofing, floor raising, ground or structure strengthening, retrofit, move elsewhere)	Accommodate	Asset owner	Reduce impacts on critical assets
Community-wide resilience (public and private)	Future Toolbox	➤ Community-wide improvement works for liquefaction hazard (such as ground improvement and strengthening existing buildings).	Accommodate	Not defined	Reduce impacts from seismic hazards on Glenorchy township
Private property resilience	Existing	Household emergency planning	Accommodate	Household	Reduce impacts on existing development
	Existing	Property and business insurance (adjust coverage as needed)	Accommodate	Property/business owner	Support recovery

CATEGORY	EXISTING OR FUTURE TOOLBOX?	LONG LIST OF RESPONSES (OCTOBER 2024)	TYPE OF RESPONSE	CURRENT AREA OF RESPONSIBILITY	WHAT IS THE MAIN OBJECTIVE OF THE RESPONSE?
	Future Toolbox	➤ Improve property and land resilience (such as floodproofing, floor raising, ground or structure strengthening)	Accommodate	Property owner	Reduce impacts on existing development
	Existing	Consider local risk and hazard information when property decisions are required (e.g., buying/selling) are required	Accommodate	Property owner	Informed decision-making
Policy	Existing	Policy - Existing land use zoning, rules and building controls	Accommodate	ORC, QLDC	Reduce impacts on future development
	Future Toolbox **	➤ Policy – Review hazard and risk information and set appropriate requirements for new development	Accommodate	ORC, QLDC	Reduce impacts on future development
	Future Toolbox	➤ Policy – Strengthen land use controls in higher hazard areas to avoid additional exposure	Avoid	ORC, QLDC	Avoid impacts on future development
	Future Toolbox	➤ Policy and services – identify and make available lower hazard land for new building and/or relocation	Avoid	QLDC	Avoid impacts on future development
	Future Toolbox	➤ Recovery plan improvement	Accommodate	CDEM, QLDC, community	Support effective recovery
	Future Toolbox	➤ Proactive relocation plan	Retreat	Not defined	Support effective relocation
	Future Toolbox	➤ Voluntary proactive relocation from higher hazard areas	Retreat	Not defined	Avoid / reduce impacts on existing community (by relocating before an event)
	Future Toolbox	➤ Voluntary reactive post event retreat from higher hazard areas	Retreat	Multi-agency, property owners	Avoid repeat impacts

\*\* Three additional responses have been added to the long list since March 2024 (when it was shared with Aukaha for mana whenua assessment and Beca for Phase 2 socio-economic impact assessment).



## 9.4.2 Evaluate possible responses and pathways

### 9.4.2.1 HIGH LEVEL EVALUATION

The Coastal Hazard Guidance (MfE, 2024) identifies factors to consider in evaluating responses, depending on the objectives and level of evaluation effort.

At this early stage it is useful to have a high-level evaluation as a basis for further discussion. The following high level evaluation criteria provide a way to compare and contrast the responses in Table 9-7:

- Effectiveness to reduce risk (or achieve main objective).
- Scale of cost.
- Complexity to implement.
- Time frame to implement (after decision).
- Impact on social resilience and adaptive capacity.

Head of Lake Whakatipu Social & Economic Impact Assessment - Phase 2: *Social & Economic Impact Assessment of Existing and Future Potential Natural Hazard Adaptation Responses* was used to inform the evaluation. Healy *et al.* (2024) notes that the existing adaptation responses in the Head of the Lake are likely to have a large, positive impact on social resilience and adaptive capacity. This is because they address multiple vulnerabilities (e.g., resilience of access, household readiness) and hazards (e.g., flooding, earthquakes).

- Phase 1 (Healy *et al.*, 2024) identified the importance of access to the wider community, both in terms of access to/from Queenstown, and around and within the community. Existing responses to maintain and repair the Glenorchy-Queenstown Road, local road system, and boat access are therefore likely to have a large positive impact on the resilience and adaptive capacity of the community. Access to recreation, education, employment, goods, services, and consumers of goods and services (i.e., to support local businesses), supports the social and economic wellbeing of the community. A resilient connection between Queenstown and the Head of the Lake may also increase the resilience and adaptive capacity of the Otago Region, by enabling economic activity in the Head of the Lake to recover quickly following a natural hazard event.
- The impact of road and boat access on resilience and adaptive capacity is further enhanced by existing responses to reduce exposure to natural hazards, such as flood monitoring and protection and building controls in high hazard areas, as well as measures to improve the resilience of critical public building assets (e.g., community facilities). Household-level responses such as property insurance and household emergency planning also contribute to overall resilience and adaptive capacity, as households that are prepared are likely to reduce strain on community resources during and after an event.
- Whilst the existing responses are likely to have a large, positive impact on social resilience and adaptive capacity, a high level of risk still remains, and certain groups have been identified as more vulnerable than others.

Healy *et al.* (2024) assessed the future responses for potential impact on social resilience and adaptive capacity (Table 9-7).

Table 9-7 High level evaluation of responses (October 2024).

Category	Existing or Future Toolbox?	Long list of responses (October 2024)	What is the main objective of the response?	Scale of effectiveness	Scale of cost	Scale of complexity	Time frame to implement (after decision)	Impact on social resilience and adaptive capacity
Hazard awareness and mitigation	Existing	Societal, behavioural, and institutional changes (improve over time) when considering natural hazards and changes to the physical environment	Support awareness and informed decision-making	«	\$	medium		
	Future Toolbox	➤ Review and accept residual risk for existing development	Informed decision-making	«	\$	low	1 year	
	Existing	Emergency readiness and response (improve over time)	All hazards emergency response	«	\$	low		
Road access	Existing	Maintenance, reactive repair and planned works for the Glenorchy-Queenstown Road	Maintain resilience of regional road access to flood, erosion and alluvial fan hazards	«««	\$ \$	low		
	Existing	Maintenance, reactive repair and planned works for the Kinloch and Glenorchy-Paradise local road system	Maintain resilience of local road access to flood, erosion and alluvial fan hazards	«	\$ \$	low		
	Future Toolbox	➤ Small scale improvement to existing Kinloch and Glenorchy-Paradise local road system road (as well as maintenance and reactive repair)	Reduce impacts of flood, erosion and alluvial fan hazards on local road access	«	\$ \$ \$	low	3+ year	Minor improvement
	Future Toolbox	➤ Reduced level of service of existing Kinloch and Glenorchy-Paradise local road system (e.g., some parts 4WD only)	Reduce cost by maintaining local road access at a lower level of service	«	\$	low	1 year	Moderate negative
	Future Toolbox	➤ Major works to increase resilience of Kinloch and Glenorchy-Paradise local road system (e.g., protect, raise, realign)	Reduce impacts of flood, erosion and alluvial fan hazards on local road access	««	\$ \$ \$	medium	5+ year	Major improvement
	Future Toolbox	➤ Reactive re-design Kinloch and Glenorchy-Paradise local road system for changed conditions (e.g., post event)	Post-event replacement to restore local road access	««	\$ \$ \$ \$	medium	5+ years	Moderate improvement
	Existing	Existing boat access at Kinloch and Glenorchy (limited by existing and ongoing sediment accumulation)	Maintain alternative access	«	\$	low		
Boat access	Future Toolbox	➤ Short-term improvements to existing boat access (e.g., dredging)	Improve alternative access	«	\$ \$	medium	3+ year	Minor improvement
	Future Toolbox	➤ Upgrade boat access with resilient solution (e.g. relocatable wharfs)	Provide alternative access with higher level of service	«««	\$ \$	medium	5+ years	Moderate improvement
	Future Toolbox	➤ Relocate wharfs periodically to maintain future access	Maintain alternative access with higher level of service	«««	\$ \$	medium	5+ years	Minor improvement
	Existing	Maintain the flood monitoring network (rainfall and water level stations) and flood data history	Flood hazard readiness and emergency response	«	\$ \$	low		
Flood mitigation and protection	Existing	Flood monitoring, forecasting and warning (improve over time)	Flood hazard emergency response	«	\$ \$	low		
	Existing	Existing low level Rees River flood protection by Glenorchy floodbank (maintenance and reactive repair)	Maintain existing Rees River flood protection	«	\$	low		
	Future Toolbox	➤ Small scale improvements to Glenorchy floodbank to maintain/reduce flood risk	Increase resilience of Rees River flood protection	«	\$	low	3+ years	Minor improvement
	Future Toolbox	➤ Major works to increase level of service of Glenorchy floodbank	Reduce impacts of Rees River flood hazard on Glenorchy township	««	\$ \$ \$	medium	5+ years	Moderate improvement
	Future Toolbox	➤ Redesign Rees flood protection for changed conditions (e.g., post event)	Post-event replacement to restore protection	««	\$ \$ \$	medium	5+ years	Minor improvement
	Existing	Existing river management (vegetation and gravel)	Maintain resilience to flood, erosion and alluvial fan hazards	«	\$	low		
	Future Toolbox	➤ River management and nature-based interventions (e.g., targeted planting)	Reduce impacts of flood, erosion and alluvial fan hazards	«	\$	low	3+ years	Minor improvement
	Future Toolbox	➤ Redesign nature-based interventions for changed conditions	Post-event replacement	«	\$ \$	low	3+ years	Minor improvement
	Future Toolbox	➤ Small scale works to reduce Buckler Burn erosion and/or flood risk	Reduce impacts of Buckler Burn flood, erosion and alluvial fan hazards	««	\$	low	3+ years	Minor improvement
	Future Toolbox	➤ Improve resilience of critical assets in higher hazard areas (such as floodproofing, floor raising, ground or structure strengthening, retrofit, move elsewhere)	Reduce impacts on critical assets	««	\$	low to medium	3+ years	Moderate improvement
Public asset resilience	Future Toolbox	➤ Community-wide improvement works for liquefaction hazard (such as ground improvement and strengthening existing buildings).	Reduce impacts from seismic hazards on Glenorchy township	««	\$ \$ \$ to \$ \$ \$ \$	high	10+ years	Minor improvement
Private property resilience	Existing	Household emergency planning	Reduce impacts on existing development	«	\$	low		
	Existing	Property and business insurance (adjust coverage as needed)	Support recovery	«	\$	low		

Category	Existing or Future Toolbox?	Long list of responses (October 2024)	What is the main objective of the response?	Scale of effectiveness	Scale of cost	Scale of complexity	Time frame to implement (after decision)	Impact on social resilience and adaptive capacity
Policy	Future Toolbox	➤ Improve property and land resilience (such as floodproofing, floor raising, ground or structure strengthening)	Reduce impacts on existing development	«	\$	low to medium	3+ years	Moderate improvement
	Existing	Consider local risk and hazard information when property decisions are required (e.g., buying/selling) are required	Informed decision-making	«	\$	low		
	Existing	Policy - Existing land use zoning, rules and building controls	Reduce impacts on future development	«	\$	low		
	Future Toolbox	➤ Policy – Review hazard and risk information and set appropriate requirements for new development	Reduce impacts on future development	«	\$	low	3+ years	Minor improvement
	Future Toolbox	➤ Policy – Strengthen land use controls in higher hazard areas to avoid additional exposure	Avoid impacts on future development	««	\$	medium	5+ years	Minor improvement
	Future Toolbox	➤ Policy and services – identify and make available lower hazard land for new building and/or relocation	Avoid impacts on future development	««	\$ \$	medium	5+ years	Minor improvement
	Future Toolbox	➤ Recovery plan improvement	Support effective recovery	«	\$ \$	medium	3+ years	Minor improvement
	Future Toolbox	➤ Proactive relocation plan	Support effective relocation	«	\$ \$	medium	3+ years	Minor improvement
	Future Toolbox	➤ Voluntary proactive relocation from higher hazard areas	Avoid / reduce impacts on existing community (by relocating before an event)	«««	\$ \$ \$	high	10+ years	Moderate improvement
	Future Toolbox	➤ Voluntary reactive post event retreat from higher hazard areas	Avoid repeat impacts	«««	\$ \$ \$ \$	high	3+ years	Minor improvement

Notes:

Scale of effectiveness – more stars indicate greater effectiveness at reducing risk (or achieving the main objective).

Scale of cost (10-year CAPEX & OPEX) – scale is non-linear: ‘\$’ less than one million, ‘\$\$’ millions, ‘\$\$\$’ tens of millions, ‘\$\$\$\$’ more than fifty million, typically based on high level relative estimates (Healy *et al.*, 2024).



### 9.4.2.2 HEAD OF LAKE WHAKATIPU WAIMĀORI MANA WHENUA ASSESSMENT

Aukaha carried out a Mana Whenua assessment of an early draft long list<sup>14</sup> of 34 possible responses for the Head of Lake Whakatipu Waimāori adaptation (Aukaha 2024). Three additional responses were subsequently added (Aukaha, email correspondence November 2024).

#### Sites of Cultural Significance

The approximate area within scope for the ORC project includes a number of wāhi tupuna, wāhi tapu and wāhi taoka, including:

- over 20 archaeological sites (Pā, terraces, ovens, middens, pits, tauraka waka, cave shelters, artefacts)
- two Ara Tūpuna (Tarahaka-Whakatipu, Greenstone River)
- two statutory acknowledgement areas (Whakatipu Waimāori, Pikirakatahi)
- the wāhi and awa labelled on Figure 5.1.

#### Analysis of responses

The 34 hazard responses considered by ORC were grouped into the categories shown to the right of Figure 9.22. The relevant mana whenua guiding principles identified by Aukaha are shown on the left.

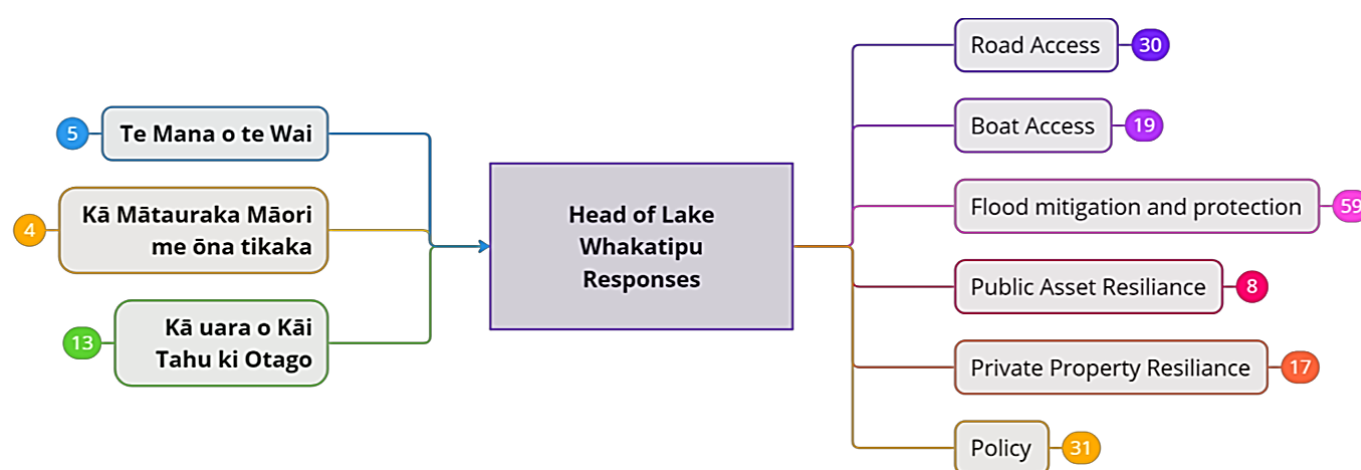


Figure 9.22 Mana whenua principles (left) and ORC adaptation response categories (right) related to the project.<sup>15</sup>

Each response was scored based on its alignment to the mana whenua values, policies, and objectives from the KTKO NRMP 2005, mātauraka Māori and associated tikaka, and with the principles laid out in Te Mana o Te Wai.

<sup>14</sup> The current long-list includes 3 additional responses that were not on the early list.

<sup>15</sup> The numbered balloons in Figure 9.21 represent how many pieces of information are associated with each of the broader categories. These include all responses, response scores, supporting details, and justifications for scoring.

The scoring favoured responses which allowed for mana whenua to maintain rakatirataka and kaitiakitaka, and which abided by the tribal pepeha: mō tātou, ā, mō kā uri a muri ake nei. Scoring factored in the implications of each response on Wāhi Tūpuna, Wāhi Taoka, and Ara Tawhito, including accessibility and preservation of these culturally significant sites. Comments and provisos were made about each individual response, and these were then considered holistically to give an overall score between -3 and +3. The scoring scale is detailed below, with respect to the mana whenua guiding principles.

-3: Strongly misaligned w/	-2: Moderately misaligned w/	-1: Somewhat misaligned w/	0: Unrelated to	+1: Somewhat aligned w/	+2: Moderately aligned w/	+3: Strongly aligned w/
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After analysing all the responses, the following themes were observed across them. The number shown in brackets after each theme indicates that it relates to a specific policy, objective or issue in the KTKO NRMP 2005. These numbers are further referenced below in Table 9-8.

A response which **scored poorly** tended to:

- Consider habitat factors narrowly (1.5-).
- Favour structures which are located close to mahika kai or areas of dynamic river/ coastal processes (3.1-).
- Favour structures to be built right next to river or coastal margins (3.2-).
- Rely on structures and system designs that are no longer fit for purpose (3.5-).
- Promote channel straightening and subsequent flow changes (3.6-).
- Promote short term solutions that lack an intergenerational view.

A response which **scored well** tended to:

- Consider habitat needs holistically (1.5+).
- Provide greater kaitiakitaka opportunities for mana whenua to be involved in the management of wai māori through cultural health monitoring (1.6+).
- Harness the cleansing/ purifying processes of the whenua to remove contaminants (2.1+).
- Promote the use of natural processes for stormwater management (2.2+).
- Locate structures away from culturally sensitive areas (3.1+).
- Design for a changing environment (especially due to climate change) (3.5+).
- Promote water quality in the Otago Catchment that are healthy enough to support Kāi Tahu ki Otago customs (4.2+).
- Reduce the contaminants being discharged directly or indirectly to water (4.4+).
- Be consistent with a long-term view of upholding the environment for following generations (mō tātou, ā, mō kā uri ā muri ake nei).
- Promote natural river flows and movements.

Table 9-8 shows scoring and comments for a response from each different category to demonstrate the analysis conducted. Those examples also show a range of scores. The entire scoring is included in Table 9-9.

### Commentary

Discussion with Rūnaka representatives reinforced the extent of significant sites in the area, and how vulnerable these sites are to flooding and other natural hazard risks. It was acknowledged:

- how sensitive the area is and the difficulty in establishing pragmatic controls and structures.
- the difficulties in planning for a fast-changing mountain environment.
- that ancillary infrastructure would need to be implemented to complement significant infrastructure changes made.

The intention of the cultural scoring by Aukaha was to prioritise cultural links to the roto, awa, wāhi tapu, wāhi taoka, and ara tūpuna. The cultural lens on these would have to be represented through the scoring.

Some responses scored poorly despite providing safeguards for the local community. These responses tended to favour changes which were either not aligned with enhancing the mana of the natural environment or not providing safeguards for the sites of cultural significance.



Table 9-8 Detailed scorings and analysis of one response from each category (demonstrating the analysis conducted).

Category	Response	Score	Provisos, comments, references to guiding principles
Road Access	A2 Small scale improvement, maintenance & reactive repair to existing Kinloch & Glenorchy-Paradise local road system	-1	'Mō tātou, ā, mō kā uri a muri ake nei'.  Acknowledging the pepeha above, this response involves reactive repair work to keep an asset in place that is likely to suffer more flooding inundation over time. It scores higher than A1 as has specific resilience measures in mind, but still accepts the continuing risk of gradual and abrupt river changes. This response does not fully acknowledge the changes that the river is tending toward, and aims to maintain a level of service that prioritises human interests over the natural flow of the river
Boat Access	B2 Improve existing boat access temporarily (e.g. dredge sediment periodically)	-3	Dredging causes continual upheaval and homogenisation of the sediment profile, invertebrate populations will be affected and there will be flow on effects on larger organisms, this pathway does not prioritise the health of the environment over human usages.  Refer to (1.5-), (3.5-)
Flood Mitigation and Protection	F9 River management and nature-based interventions (i.e. targeted planting)	+3	With the requirement that re-vegetation with locally sourced indigenous plants for all disturbed areas. Re-vegetation should be monitored by an assessment of the vegetative cover at one growing season after establishment and again at three seasons from establishment.  Refer to (1.5+), (1.6+), (2.1+), (2.2+), (3.5+), (4.2+)
Public Asset Resilience	PA1 Community-wide improvement works for liquefaction hazard (i.e. ground improvement, strengthening existing buildings)	-2	Highly complex and requires extensive works in and around the buildings. ORC has stated: - this will only be partially effective and not reduce the liquefaction hazard category below 'medium', - the remaining risk is still high. Successful implementation would help reduce impacts of flooding and liquefaction events, but the response is still favouring maintaining the built environment over the direction of the natural environment. Not well aligned with the tribal pepeha written above in A2.
Private Property Resilience	H3 Improve property resilience (such as floodproofing, floor raising, ground or structure strengthening)	-1 / +1	On one hand, it would allow damage and clean-up cost from a flood / storm / weather event to be minimised. Conversely, the climatic impacts are unpredictable and the effectiveness of these (bespoke) solutions would vary by property. Some properties are in locations that will not be viable in the long-term, in which case, these resilience measures will only buy time, not mitigate the risk. It needs to be weighed up whether the resources are best spent here or diverted elsewhere. Refer to the tribal pepeha written above in A2.
Policy	P2 Policy- Strong land use controls in higher hazard areas to avoid additional exposure (e.g. Plan change to restrict activities)	+2	This response is still constrained by existing policy and governance frameworks, but having specific controls in place to restrict activities in higher hazard areas helps to minimise risk exposure to both people and environment. This policy change puts higher priority on appropriate land use than existing policy, and favours the natural form of the environment.  Refer to (3.5+)

Table 9-9 Condensed scoring of each response.

Hazard Category	Code	Individual Response Description	Score
Road access (Kinloch - Glenorchy - Paradise roads)	A1	Continue maintenance, planned works, and reactive repair	-2
	A2	Implement Small scale improvements	-1
	A3	Implement Major protection / raising / realignment works	+1
	A4	Reduce the level of service (i.e., 4WD only)	-3
	A5	Implement reactive (post event) redesign	-2
Road Access (Queenstown - Glenorchy road)	R1	Continue maintenance, planned works, and reactive repair	+1
Boat access	B1	Maintain existing boat access	-2
	B2	Implement periodic improvement (i.e., via dredging)	-3
	B3	Upgrade with resilient solution (i.e., relocatable wharves)	+2
	B4	Periodically relocate wharves	+1
Flooding mitigation and protection	F1	Implement flood network stations	+3
	F2	Integrate flood monitoring, forecasting & warning stations	+3
	F3	Develop emergency readiness and response	+3
	F4	Continue existing maintenance and reactive repair of Rees River	-1
	F5	Implement small scale protective works to reduce Rees River flood risk	-1
	F6	Implement major protective works to reduce Rees River flood risk	-2
	F7	Implement reactive (post event) flood protection for Rees River	+3
	F8	Continue existing river management through vegetation and gravel	-1 / +1
	F9	Implement nature-based river management interventions	+3
	F10	Implement reactive (post event) nature-based interventions	+3
	F11	Implement small scale works to reduce Buckler Burn erosion / flood risk	-2 / +2
Public Asset Resilience	PA1	Improve resilience of critical public building assets in high hazard areas	-1 / +1
	PA2	Implement community wide improvement works for liquefaction hazard	-1
Private Property Resilience	H1	Implement household emergency planning	+2
	H2	Adjustment property insurance cover	0 / +1
	H3	Improve property resilience	-1 / +1
	H4	Provide info. to assist house sales / purchases based on individual risk tolerance	-1 / 0

Policy	P1	Continue with existing land use zoning and building controls	-1
	P2	Implement strong land use controls in higher hazard areas	+2
	P3	Make lower hazard land available for relocation and / or new builds	+1
	P4	Develop and implement a proactive relocation plan	+3
	P5	Promote proactive voluntary relocation from higher hazard areas	+3
	P6	Develop a recovery plan	+1
	P7	Promote reactive (post-event) voluntary relocation from higher hazard areas	+1 / +2
	P8**	Review hazard and risk information and set appropriate requirements for new development (by ORC and QLDC)	+1 / +3
	P9**	Societal, behavioral, and institutional changes (improve over time) (by everyone)	-1 / +3
Other	H5**	Review and accept residual risk for existing development (by agencies and community)	-1 / +1

\*\* three responses added in November 2024.



## 9.5 Phase 4: How can we implement the Strategy?

This section is focused on Step 7: *develop the adaptive planning strategy with signals and triggers*, and Step 8: *implement* in the adaptation cycle approach (Figure 9.23).



Figure 9.23 'How can we implement this strategy?' Steps 7 & 8 of the adaptation cycle (modified from MfE 2024).

### 9.5.1 Adaptation pathways with signals and triggers

An adaptation threshold is 'what people do not want to happen' (an unacceptable condition). Based on what we have heard from the community and partners through this programme, the following adaptation thresholds are unacceptable conditions:

- Extended disruption to road access from Queenstown.
- Frequent or severe damaging or disruptive events.
- Loss of amenity and cultural values.
- Lengthy displacement of people following extreme events.
- Withdrawal of maintenance, decline in levels of service and increasing cost of repairs.
- Unaffordable or high-excess insurance premiums or withdrawal of insurance and bank finance.

An advanced ‘signal’ is something we can monitor that helps to avoid an adaptation threshold being reached and being unprepared. Signals help us get ready to move to new pathways with enough time for decision-making and implementation. They give us a heads up and flag the need for collective effort on social, behavioral and institutional changes to support adaptation. However, surprise situations can still occur, and so signals are not a guarantee that an adaptation threshold will be avoided.

There are numbers of different signals that could be monitored to track change at the Head of the Lake area, across the natural, built, social and economic domains. Guided by our goal of weaving adaptation into our everyday work, and our principle of cost-effectiveness, we have selected relevant and measurable signals that are aligned with current business-as-usual activities for Strategy partners. Signals are also complementary and contribute to a holistic view of changes.

- **SIGNAL #1. Growth in costs to maintain and repair assets.**
- **SIGNAL #2. Lower level of service** (e.g., due to delta growth, riverbed aggradation, channel movement).
- **SIGNAL #3. Frequency, number or impacts of flooding events reaching nuisance level** (this signal includes residential areas, roads, and agricultural land).
- **SIGNAL #4. Movement of active river channel towards high value areas and assets**
- **SIGNAL #5. Negative impacts on community wellbeing** (e.g., concern and anxiety, increased demand for protection or for doing things differently).
- **SIGNAL #6. Insurance affordability or coverage** – this is outside the control of Strategy partners. Regional or national trends could be tracked by discussions and engagement with local government and insurance sector, and local trends with community members and Councillors.

‘Triggers’ denote decision points when a review and decisions are made as to whether to change responses or pathways. Triggers that occur ahead of an adaptation threshold are the most useful for forward planning. Three high-level triggers are identified for the first version of the Strategy.

- **TRIGGER #1. Decision-making cycles (3-year, 10-year, 30-year)** – this is the usual timing to consider partner agencies' priorities, level of investment and business cases for changes. Public consultation is also required by agencies. These timelines are suitable for staying ahead of gradual changes at the Head of the Lake.  
It is important that up-to-date analysis and reporting of signals feed into and inform the decision-making process. Signals can be considered both individually and in combination.
- **TRIGGER #2. Opportunities** – is about keeping adaptation goals in front of mind, looking out for opportunities to take action and make progress. Some examples: funding opportunities; opportunities for integration with other projects; and opportunities to influence other decision-makers.
- **TRIGGER #3. Significant natural hazard event with unacceptable outcomes** – an integrated, multi-agency approach will be required for effective recovery. A one-off plan would be developed to support integrated decision-making.

Other signals and triggers may be selected during implementation of the Strategy and development of operational plans.

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### 9.5.2 Implementation framework

The agencies responsible for the current natural hazard responses already in place are shown in Figure 9.24. The current responses are implemented through well-established planning processes, such as Long-Term Plans, QLDC District Plan and Otago CDEM Group Plan. Flexibility for short-term, small-scale adjustments of responses is available through operational plans, as well as mechanisms like emergency funds and Annual Plan review.

Many of the possible future responses are also standard ways of managing natural hazards. Decisions on continuing and future investment are made by the agencies during regular update cycles for their plans. Council plans typically have 3-year cycles and cover 10 years (e.g., council Long-Term Plans) to 30 years (e.g., council Infrastructure Strategies) periods.

Some possible future responses are out-of-the-ordinary. Implementation of uncommon responses would require one-off, specialised planning, funding, and governance arrangements.

If a natural hazard event causes severe, widespread damage and significant community disruption, a tailored recovery plan would likely be put in place.



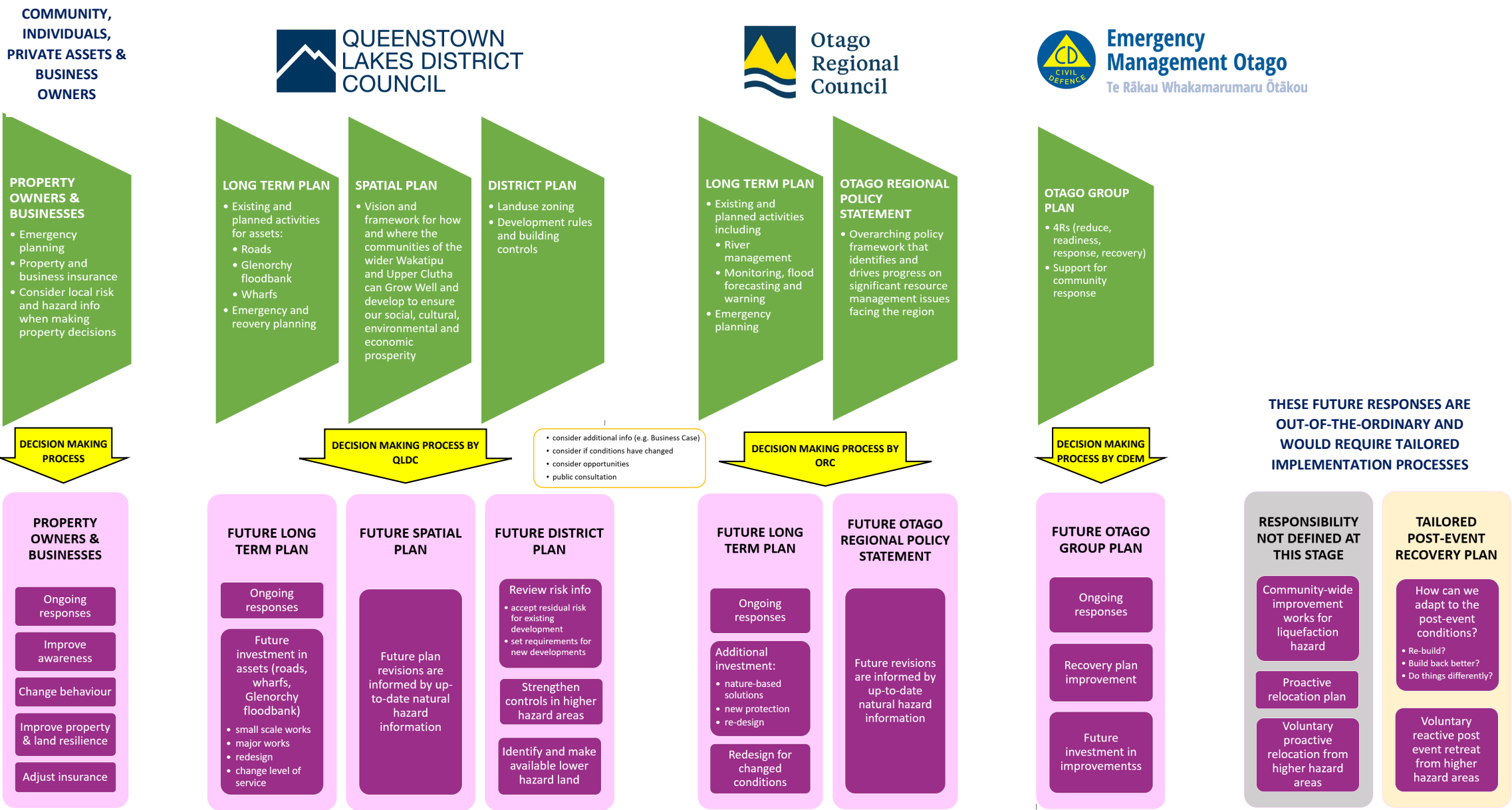


Figure 9.24 Current framework for implementation.

## 9.6 Phase 5: How is it working: A review framework

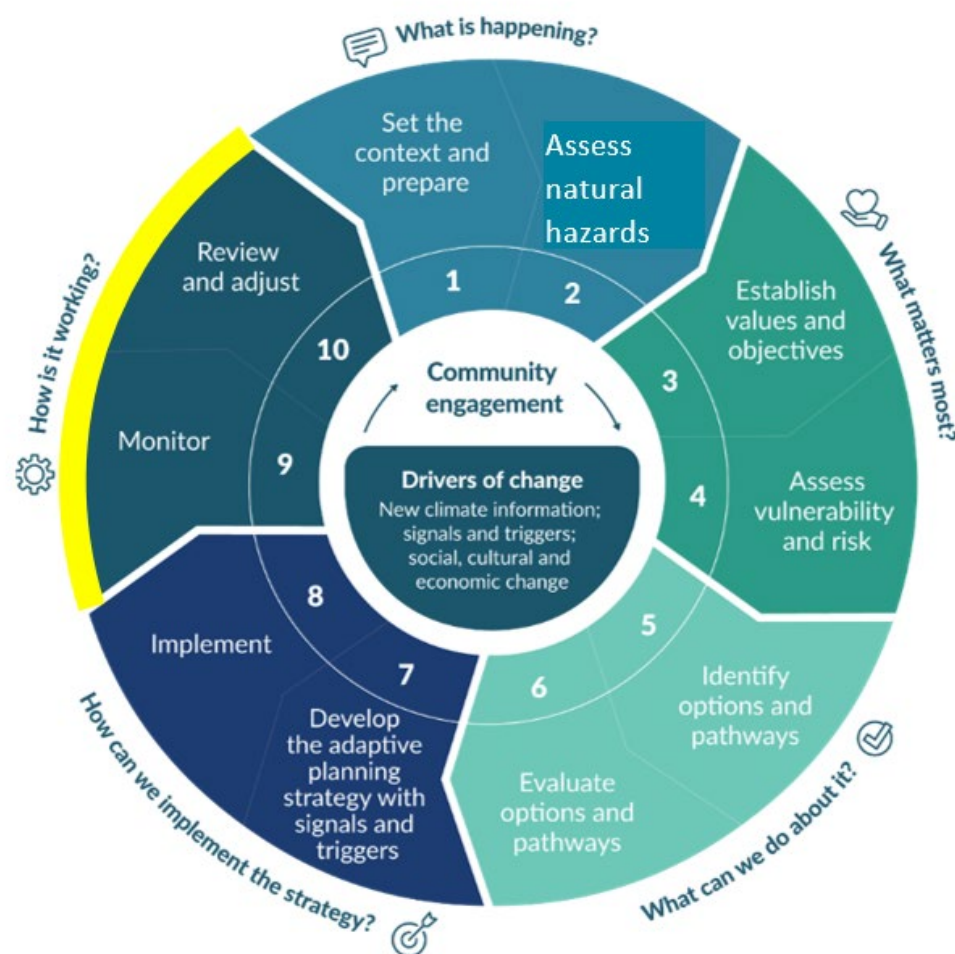


Figure 9.25 ‘How is it working?’ Steps 9 & 10 of the adaptation cycle (modified from MfE 2024).

The adaptation cycle approach (Figure 9.25) ends its loop with Step 9: *monitor* and Step 10: *review and adjust*.

Strategy partners already collect and track most of the information we would need to monitor how the Strategy is working, as part of our existing business practices. The following types of information can be used to track changes of social, economic, institutional, and environmental conditions:

- Wellbeing surveys.
- Community consultations.
- Physical monitoring (e.g., hydrological data, aerial imagery, LiDAR topography, and cross-section surveys).
- Reporting on costs associated with services and activities.
- Emergency and disaster damage/needs assessments.
- Reporting on local disruptions, such as road closures.
- Channels for the community to share observations and concerns regarding adaptive capacities, vulnerabilities, and awareness.

- 
- Updates and analyses of international and national trends on hazards adaptation and resilience.
  - Updates on central government direction or legislation related to natural hazards decision-making and climate change adaptation.
  - Reports on cultural values and aspirations of mana whenua embodied within this Strategy.
  - Community submissions and feedback on ORC and QLDC planning and decision-making processes.
  - Open dialogue on potential changes, risks or opportunities.
  - Updates on insurance policies for property owners.

We will track the progress of the Strategy by monitoring the implementation of the actions listed in the Action Plan (Section 10).

Every six years, ORC will conduct a comprehensive review to ensure the Strategy is updated appropriately in light of new information gathered from monitoring activities, or earlier if there is an urgent need.



## 10 Action Plan

This is the first version of the Action Plan, which shows what Strategy partners are doing and plan to do over current planning time frames, to progress towards our Strategy goals.

Despite the resilience and adaptation work we already do at the Head of the Lake, we may need to do more and do some things differently to adapt to future changes.

We will update this action plan every 6 years, or more often if required, to reflect our progress and adjust. Between updates, we will track progress on actions, and report back to the community via established communications channels (such as the newsletter and website).

Actions are organised by themes:

- Governance and collaboration.
- Advice, information and education.
- Addressing impacts and risks of hazards.
- Emergency Management.
- Information gathering and monitoring.
- Policy and planning processes.

Governance and collaboration					
	Status	Action	Goal this contributes towards	Agency responsible	Time frame
	Underway or planned	ORC and QLDC collaborate to develop a governance framework or memorandum of understanding (MoU) for addressing adaptation issues at the Head of the Lake and/or across the district, including the implementation of adaptation actions to improve resilience.	1	Otago Regional Council (Natural Hazards)  Queenstown Lakes District Council	
	Underway or planned	ORC to partner with mana whenua to ensure mana whenua values and aspirations and mātauraka Kāi Tahu is embedded into decision-making and implementation of the Strategy, following the lead of Aukaha and Te Ao Mārama.	All goals	Otago Regional Council (Natural Hazards)  Aukaha and Te Ao Mārama Inc	
	Underway or planned	Work together with QLDC, Otago CDEM, mana whenua and local community to ensure coordinated and consistent approach to implementation of actions aligning with this Strategy.	All goals	Otago Regional Council (Natural Hazards)  Queenstown Lakes District Council  Civil Defence Emergency Management Otago  Aukaha and Te Ao Mārama Inc  Glenorchy Community Association	
	Underway or planned	Work together to mainstream adaptation across ORC work programmes and ensure our work aligns with this Strategy and towards achieving each goal.	All goals	Otago Regional Council (Natural Hazards, Environmental Implementation, Engineering, Integrated Catchment Management)	Ongoing

Information gathering and monitoring					
	Status	Action	Goal this contributes towards	Agency responsible	Time frame
	Existing	ORC to Investigate hazards and risks as part of usual business.	1, 2	Otago Regional Council (Natural Hazards)	Ongoing
	New	<p><u>Geomorphic change monitoring and assessment</u></p> <p>Maintain an awareness of locations and scale of geomorphic changes (e.g., active river channel position, bed levels and rates of change) which may have direct impacts or exacerbate natural hazard characteristics.</p> <ul style="list-style-type: none"><li>Collect LiDAR, aerial imagery - spatial extent to include at least Dart, Rees, and Buckler (at least extent of 2019 survey).</li><li>Cross section survey and/or bathymetric LiDAR.</li><li>Undertake geomorphic change detection analysis.</li></ul> <p><u>Notes:</u> The monitoring is not restricted to the Head of Lake Whakatipu area and assessments may be at catchment scale, if appropriate.</p> <p>This information will:</p> <ul style="list-style-type: none"><li>Enable proactive response to issues.</li><li>Enable the updating of flood hazard assessments to ensure they provide representation of current conditions (e.g., bed levels).</li></ul>	2	Otago Regional Council (Natural Hazards)  with external support	Periodic (at least every 5 years) or when new LiDAR is available



Information gathering and monitoring				
Status	Action	Goal this contributes towards	Agency responsible	Time frame
Existing	<p><u>Data collection to document major flooding (or other hazard) events</u></p> <p>Improve the recording and understanding of hazard event characteristics (e.g., floodwater extents, depths and flow pathways), and the impacts of those events.</p> <p>The types of data collected will depend on the hazard and the impact and may include the following:</p> <ul style="list-style-type: none"><li>• Post-event LiDAR.</li><li>• During-event or immediately post-event aerial imagery.</li><li>• During-event or post-event observations (on-ground inspections and/or drone imagery).</li><li>• Develop an online data portal to enable collation of crowdsourced natural hazard event observations (e.g., photographs).</li><li>• On-ground post-event survey (debris survey).</li><li>• Assessments/observations of damages/impacts (infrastructure, or residential).</li><li>• Geotechnical assessments.</li><li>• Post-earthquake assessments (e.g., landsliding, liquefaction, subsidence).</li></ul> <p>This information will:</p> <ul style="list-style-type: none"><li>• Assist with hazard/risk assessments by providing ground-truthed observations of hazard events.</li><li>• Be valuable for calibration/validation of future hazard modelling, helping to ensure models represent reality.</li></ul>	2, 3	Otago Regional Council (Natural Hazards)  with external support	After hazard events

	<p><u>Monitoring and analysis of signals/triggers/thresholds</u></p> <p>SIGNALS – give us a heads up about changes</p> <ul style="list-style-type: none"><li>• Growth in costs to maintain and repair assets.</li><li>• Lower level of service (e.g., due to delta growth, riverbed aggradation, channel movement).</li><li>• Frequency, number or impacts of flooding events reaching nuisance level (this signal includes residential areas, roads and agricultural land).</li><li>• Movement of active river channel towards high value areas and assets</li><li>• Negative impacts on community wellbeing (e.g., concern and anxiety, increased demand for protection or for doing things differently).</li><li>• Insurance affordability or coverage</li></ul> <p>TRIGGERS – points where review and decisions are made</p> <ul style="list-style-type: none"><li>• Decision-making cycles (3-year, 10-year, 30-year)</li><li>• Opportunities</li><li>• Significant natural hazard event with unacceptable outcomes</li></ul> <p>THRESHOLDS – unacceptable conditions we are trying to avoid</p> <ul style="list-style-type: none"><li>• Extended disruption to road access from Queenstown.</li><li>• Frequent or severe damaging or disruptive events.</li><li>• Loss of amenity and cultural values.</li><li>• Lengthy displacement of people following extreme events.</li><li>• Withdrawal of maintenance, decline in levels of service and increasing cost of repairs.</li><li>• Unaffordable or high-excess insurance premiums or withdrawal of insurance and bank finance.</li></ul> <p>Other signals and triggers may be selected during implementation of the Strategy and development of operational plans.</p>	2	Otago Regional Council (Natural Hazards)  with input from Queenstown Lakes District Council  and external support	Periodic (at least every 5 years)
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Information gathering and monitoring					
	Status	Action	Goal this contributes towards	Agency responsible	Time frame
		<div>Communication and reporting of physical environment monitoring</div> <ul style="list-style-type: none"><li>• Data collection and analysis findings will be communicated to key project partners and stakeholders.</li><li>• A brief environmental monitoring update report will be prepared every 3 years summarising any notable natural hazards event/impacts (e.g., peak flows/lake levels observed) within that time period, and any post-event data collection or analysis completed.</li><li>• One-off standalone event reports may be prepared for any natural hazards events which causes significant impact – summarising event causes, characteristics, effects/impacts, and ORC responses.</li><li>• Reports will be distributed to key contacts, through existing communication channels (e.g., ORC e-newsletter and project website), and appended to any councillor update reports.</li></ul>	2	Otago Regional Council (Natural Hazards)	<div>3 yearly updates</div> <div>One-off reporting for significant events</div>

Emergency Management					
	Status	Action	Goal this contributes towards	Agency responsible	Time frame
	New	Develop a long-term recovery plan for a potential major hazard event, including ways to minimise maladaptation post-event and ensure recovery considers long-term adaptation opportunities.	1, 3, 5	Otago Regional Council (Natural Hazards)  Civil Defense Emergency Management Otago  Queenstown Lakes District Council	Ongoing
	Existing	Operate a network of near real-time rainfall and water level stations across the region to support flood forecasting and emergency response with a 24/7 duty roster to support forecasting duties and any necessary response.	2, 3	Otago Regional Council (Natural Hazards, Engineering, Environmental Monitoring)  Civil Defense Emergency Management Otago	Ongoing
	Existing	Monitor and ensure ORC’s network of environmental monitoring stations remains fit for purpose, providing information for flood response, for documentation of flood events, and for public awareness of river flow, lake, and lagoon levels). <ul style="list-style-type: none"><li>Review of performance of the flood forecasting systems (lake level and lagoon level forecasting).</li><li>Review of hydrological monitoring network (any opportunities for improvement?).</li><li>New/temporary monitoring in some circumstances (e.g., landslide dam formation).</li></ul> <p>This action is intended to ensure the monitoring network and forecasting systems provide the most suitable coverage.</p>	1, 2	Otago Regional Council (Natural Hazards, Environmental Monitoring)	Periodic reviews  One-off temporary monitoring



Emergency Management					
	Status	Action	Goal this contributes towards	Agency responsible	Time frame
	Existing	Capability development and awareness raising <ul style="list-style-type: none"><li>Undertake public/internal education to develop knowledge and raise awareness of risks and natural hazards to communities and Community Response Group’s members.</li><li>Share lessons learned from emergency response with communities.</li><li>Introduced and organised training sessions for Community Response Group members on how to use Community Emergency Hub Guide.</li></ul>	1, 2, 3	Civil Defense Emergency Management Otago	As needed Annually
	Existing	Engagement with communities and stakeholders <ul style="list-style-type: none"><li>Communicate prior to forecast weather events to have a common understanding around Lake and Lagoon levels, river flows and potential outcomes of the forecast weather.</li><li>Communicate with communities about changes in risk and readiness.</li><li>Work with Community Response Group to coordinate emergency support before, during and after an emergency.</li><li>Organised consultations with communities on emergency proposed plans and guidelines.</li><li>Convene meetings with communities and stakeholders to decide a scale of an emergency event.</li></ul>	1, 2, 3	Civil Defense Emergency Management Otago Community Response Group	As needed Annually
	Existing	Risk communication and early warnings <ul style="list-style-type: none"><li>Provide right and trusted information about natural disasters to communities so that they can prepare effectively for emergency events.</li></ul>	3	Civil Defense Emergency Management Otago Queenstown Lakes District Council	Frequently Per event

Emergency Management					
	Status	Action	Goal this contributes towards	Agency responsible	Time frame
	Existing	<div>Provide community resilience equipment</div> <ul style="list-style-type: none"><li>Provide communications equipment to not only communicate locally but also communicate to the Emergency Operations Centre in Queenstown if BAU communications systems have failed.</li><li>Provided equipment for communities to better prepare for emergency events:<ul style="list-style-type: none"><li>4000W Petrol Inverter Generator</li><li>Petrol Container</li><li>Extension cords</li><li>Multi boxes</li><li>Rechargeable LED light 20Watt Work-lights</li><li>Tripod LED light 60Watt Work-lights</li><li>Handheld torches and spare batteries.</li></ul></li></ul>	3	<div>Queenstown Lakes District Council</div> <div>Civil Defense Emergency Management Otago</div>	<div>As needed</div> <div>One-off</div>
	Existing	<div>Develop and share emergency guides and plans and update annually</div> <ul style="list-style-type: none"><li>Glenorchy Community Resilience Guide (draft in progress).</li><li>Glenorchy Community Response Plan (draft in progress).</li><li>Developed Glenorchy Flood Guide.</li><li>Developed Community Emergency Hub Guide.</li><li>Developed Community Emergency Preparedness Brochure.</li></ul>	3	<div>Civil Defense Emergency Management Otago</div> <div>Community Response Group</div>	<div>Update annually</div>

Emergency Management					
	Status	Action	Goal this contributes towards	Agency responsible	Time frame
	Existing	<div>Training and exercises for Community Response Group and Emergency Hub implementation</div> <ul style="list-style-type: none"><li>• Provided training to help Community Response Group set up Emergency hubs, operate radios, and for community response planning.</li><li>• Exercise the implementation of the Community Emergency Hub to gain an understanding of expectations of the community, emergency services and local government as well as clarify any ambiguity or operational expectations that may present during an actual emergency.</li></ul>	3	<div>Civil Defense Emergency Management Otago</div> <div>Community Response Group</div>	<div>One-off</div> <div>As needed</div>

Advice, information, and education					
	Status	Action	Goal this contributes towards	Agency responsible	Time frame
	Underway or planned	Ensure the ORC <a href="#">Natural Hazards Portal</a> includes up-to-date information on natural hazards and the impacts of climate change, to provide the community with a single location for information.	2, 3	Otago Regional Council (Natural Hazards)	
	Underway or planned	Maintain ORC Head of Lake Whakatipu adaptation webpages with relevant and up-to-date information, including latest reports, Council updates and key programme milestones.	2	Otago Regional Council (Natural Hazards and Communications)	Ongoing
	Underway or planned	Provide newsletter updates about programme milestones and/or progress towards actions to inform community members and be accountable to the Strategy.	2	Otago Regional Council (Natural Hazards and Communications)	As needed
	New	ORC to attend Glenorchy Community Association (GCA) meetings as and when required, at least annually, to provide updates about programme milestones and progress towards actions and act as a check-in with the community.	2, 3	Otago Regional Council (Natural Hazards)	Annually or as needed
	Underway or planned	Ensure that ORC’s messaging about natural hazards adaptation and adaptation workstreams is communicated in a way that is understood by a wide audience.	2	Otago Regional Council (Natural Hazards and Communications)	Ongoing
	Underway or planned	Monitor the <a href="mailto:headofthelake@orc.govt.nz">headofthelake@orc.govt.nz</a> inbox for public enquiries and information relating to the programme. Consider other methods and tools for capturing community feedback.	2	Otago Regional Council (Natural Hazards)	Ongoing



Policy and planning processes					
	Status	Action	Goal this contributes towards	Agency responsible	Time frame
	Underway	Consider natural hazard property information for resource and building consents.	4	Queenstown Lakes District Council	Ongoing (BAU)
	Underway or planned	ORC and QLDC to collaborate to ensure common adaptation priorities, information and actions identified in this Strategy inform and input into the next ORC and QLDC Long-Term Plan, Spatial Plan, District Plan and other relevant policies and plans.	1, 2	Otago Regional Council Queenstown Lakes District Council	Every LTP cycle
		Natural hazard information is included on LIM reports.	1, 2	Queenstown Lakes District Council	
	New	ORC and QLDC to collaborate on path forward for assessing risk tolerance with the community (once the proposed RPS is operative).	1, 2, 3, 4	Otago Regional Council Queenstown Lakes District Council	once the proposed RPS is operative

## Addressing impacts of natural hazards and climate change

Status	Action	Goal this contributes towards	Agency responsible	Time frame
Underway	Routine maintenance of transport network, including QLDC roading assets, Glenorchy jetty and marina.	1, 4	Queenstown Lakes District Council	Ongoing/BAU
Underway	<u>Glenorchy Area Bridge Resilience (24-34 LTP):</u> Non-routine work required to protect the serviceability of the Glenorchy, Paradise, Rees River bridge assets following damage, and to minimise threat of road closure due to natural phenomena.	1, 4	Queenstown Lakes District Council	As required, budgeted biennially
Underway	<u>Raising Kinloch Road (24-34 LTP)</u> Raising Kinloch Road in conjunction with two-yearly gravel extraction under the Rees River bridge.	1, 4	Queenstown Lakes District Council	As required, budgeted biennially
New	Develop Operational River Management Plans, including the Dart and Rees floodplains. <ul style="list-style-type: none"> <li>Operational Management Plans that outline the activities undertaken for river management.</li> <li>These plans will be developed in 2025.</li> </ul>	1, 4	Otago Regional Council (Engineering and Natural Hazards)	2025 Reviewed every 2 years
New	Develop a gravel management plan for the Buckler Burn <ul style="list-style-type: none"> <li>ORC, Engineering held consent of Buckler gravel management plan.</li> <li>This plan will be developed in 2025.</li> </ul>	1, 4	Otago Regional Council (Engineering and Natural Hazards)	2025 Reviewed every 2 years

Addressing impacts of natural hazards and climate change					
	Status	Action	Goal this contributes towards	Agency responsible	Time frame
	Underway	Annual vegetation management, rock armouring and gravel management <ul style="list-style-type: none"> <li>Ongoing river management activities (such as regular vegetation control in Lagoon Creek/Lagoon area).</li> </ul>	3, 4, 5	Otago Regional Council (Engineering)	Ongoing/Annually
	Existing	Maintenance of Rees River floodbanks <ul style="list-style-type: none"> <li>Maintain (not renew or increase) the existing banks – (Rees River floodbanks are not owned by ORC).</li> </ul>	1, 4	Otago Regional Council (Engineering and Natural Hazards)	Every 1 year
	New	Floodplain and rivers <ul style="list-style-type: none"> <li>Create/trial NBS groynes.</li> </ul>	1, 4, 5	Otago Regional Council (Engineering and Natural Hazards)	Every 2 years
	New	<u>Glenorchy Adaptation Pathways (30 Yr Infrastructure strategy)</u> Work on Social Infrastructure required to address selected adaptation pathways, as budgeted in the QLDC 30-year Infrastructure Strategy.	1, 3, 4	Queenstown Lakes District Council	2034-2054
	New	Provide information and support property owners to undertake property-level interventions to improve their resilience to natural hazards risks.	3, 4	Otago Regional Council (Natural Hazards)	
	New	<u>Head of the Lake Adaptation (24-34 LTP)</u> Strategy to inform responses to identified hazards, providing scoped and costed solutions for input to the next LTP (27-37) and other key planning documents.	1, 2, 4	Queenstown Lakes District Council	2034-2054

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# 12 Glossary of Terms

Key Term	Definition
Adaptation	Adaptation in this Strategy is defined as a proactive response to anticipate and adjust to ongoing and future environmental changes. It is an ongoing process that involves identifying, assessing, and managing risk while continually evaluating the effectiveness of actions and making necessary adjustments. This proactive, long-term approach enables planning and response in situations where the future is uncertain including variability in the rate, time frame and magnitude of change.
Adaptation options / responses	The wide range of strategies and measures that are available and appropriate for addressing adaptation. They can take the form of structural, institutional, ecological or behavioural actions.
Adaptive capacity	The ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities or to respond to consequences.
Aggradation	Net accumulation of sediment in the stream channel or land surface.
Alluvial fan	An alluvial fan is a triangle-shaped deposit of gravel, sand and even smaller pieces of sediment, such as silt. This sediment is called alluvium.
Annual Exceedance Probability	<p>Annual Exceedance Probability (AEP) is the probability of a certain sized flood occurring in a single year. For example, a 0.5% AEP flood has a 0.5 per cent, or a 1 in 200 chance of occurring in any year.</p> <p>Large, infrequent floods have a low AEP and smaller, more frequent floods have a higher AEP.</p> <p>200-year ARI and 0.5% AEP are different ways to describe the same event.</p>
Average Recurrence Interval	<p>The Average Recurrence Interval (ARI) is the average time between floods of a certain size. Large, infrequent floods have higher ARIs than smaller, more frequent floods.</p> <p>For example, a 200-year ARI flood will occur on average once every 200 years. A 50-year ARI flood will occur on average once every 50 years and be a smaller flood than a 200-year ARI. While a 200-year ARI flood may happen once every 200 years on average, every year there is still a 1-in-200 chance that a flood of this size might occur.</p> <p>200-year ARI and 0.5% AEP are different ways to describe the same event.</p>

Key Term	Definition
Avulsion	An avulsion is the process where a river channel switches location, often suddenly, and may result in the complete or partial abandonment of the formerly active channel.
Capacity building	The practice of supporting an individual, community, society or organisation to respond to change by enhancing their strengths and attributes and improving the resources available to them.
Climate change	A change in the state of the climate that can be identified (e.g., by using statistical tests) by changes or trends in the mean and/or the variability of its properties, and that persists for an extended period, typically decades to centuries. Includes natural internal climate processes and external climate forcings such as variations in solar cycles, volcanic eruptions and persistent anthropogenic changes in the composition of the atmosphere or in land use. The United Nations Framework Convention on Climate Change (UNFCCC) definition of climate change specifically links it to direct or indirect human causes, as: a ‘change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods’. The UNFCCC thus makes a distinction between climate change attributable to human activities altering the atmospheric composition and climate variability attributable to natural causes.
Co-benefit	A positive effect that a policy or measure aimed at one objective has on another objective, thereby increasing the total benefit to society or the environment.
Cumecs	The unit of volumetric rate of flow, equal to one cubic metre per second.
Delta	Deltas are landforms at the mouths of rivers. They are formed when rivers drop their sediment upon entering another body of water.
Disaster	A serious disruption of the functioning of a community or a society, at any scale, that occurs because hazardous events interact with conditions of exposure, vulnerability and capacity, leading to human, material, economic and/or environmental losses and impacts.
Disaster risk management	Processes for designing, implementing and evaluating strategies, policies and measures to improve understanding of current and future disaster risk, foster disaster risk reduction and transfer, and promote continuous improvement in disaster preparedness, prevention and protection, response and recovery practices. The aim is to increase human security, wellbeing, quality of life and sustainable development.
Dynamic adaptive pathways planning	A framework that supports climate adaptation decision-making by developing a series of actions over time (pathways). It is based on the idea of making decisions as conditions change, before severe damage occurs, and as existing policies and decisions prove no longer fit for purpose.

Key Term	Definition
Flood	An event where the normal boundaries of a stream or other water body overflow, or water builds up over areas that are not normally underwater. Floods can be caused by unusually heavy rain – for example, during storms. Floods include river (fluvial) floods, flash floods, urban floods, rain (pluvial) floods, stormwater floods, coastal floods, and glacial lake outburst floods.
Free face	Regarding liquefaction hazard, a free face occurs where the land is not physically constrained, such as riverbanks and the front face of deltas. Part of the free face may be underwater.
Freeboard	An allowance in engineering design to account for uncertainties and other effects above an estimated floodwater level.
Geomorphic/geomorphology	Geomorphology is the study of landforms and the processes that shape them.
Hazard	The potential occurrence of a natural or human-induced physical event or trend that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources.
Hapū	Within each iwi (tribes) are many hapū (clans or descent groups), each of which is made up of one or more whānau (extended families).
Impact	The consequences of realised risks on natural and human systems. They generally affect human lives, livelihoods, health and wellbeing; ecosystems and species; economic, social and cultural assets; services (including ecosystem services); and infrastructure. They can be harmful or beneficial. Also known as consequences or outcomes.
Iwi	Generations ago, waka sailed by Māori ancestors set out from East Polynesia and landed in New Zealand. From these founding peoples came the iwi (tribes) that form the structure of Māori society. Within each iwi are many hapū (clans or descent groups), each of which is made up of one or more whānau (extended families). The bond that holds them together is one of kinship, both with a founding ancestor and with the many members of their iwi, hapū and whānau today.
Lateral spreading	Lateral spread is defined as the horizontal movement of ground towards the free-face or downslope as a result of the liquefaction of shallow underlying soil deposits. Liquefaction primarily occurs as a result of earthquake shaking of loose sands and soils. Free faces include river channels and fan deltas.
Liquefaction	Liquefaction causes wet, sandy, and silty soils to behave more like a liquid than a solid during strong earthquake shaking. To liquefy, soil must be loose, sandy or silty, and wet (below the water table). Clay and gravel tend not to liquefy.
Maladaptation	Actions that are unsustainable and may lead to increased risk of adverse climate-related outcomes, including increased greenhouse gas emissions, increased vulnerability to climate change and reduced welfare, now or in the future.



Key Term	Definition
	Maladaptation is usually an unintended consequence. Some actions may be effective in some ways but maladaptive in others.
Mana whenua	Mana whenua are Māori who hold traditional customary authority and are representatives of Treaty partners within an area and whose traditions and histories are as determined by whakapapa, resource use, and ahikāroa (the long burning fires of occupation). In Otago, Kāi Tahu are mana whenua.
Mātuaraka Māori	Kāi Tahu knowledge.
Nature-based solutions	Solutions that are inspired and supported by nature are cost effective, and at the same time, provide environmental, social and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features (e.g., vegetation and water features) and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions. For example, using vegetation (e.g., street trees or green roofs) or water elements (e.g., rivers or water treatment facilities) can help reduce heat in urban areas or support stormwater and flood management.
Natural hazard	Natural hazards are defined as environmental phenomena that have the potential to impact societies and the human environment.
Pathways	<p>NIWA describes pathways thinking as follows:</p> <p>Pathways thinking is a planning approach that allows for uncertainty and change by encouraging us to imagine many different futures. It does this by focusing on planning and that there will be many ways to find our way through the challenges of our future climate.</p> <p>It takes into account what is important to individuals, whānau and communities. It helps us to consider the many different options in front of us; how long these might be effective for and when we might need to change tack.</p> <p>Pathways thinking supports decision-making and investments in stages. It encourages people to identify triggers (for example a flood), and to make decisions in advance about what to do if that trigger occurs.</p> <p>Using pathways thinking allows us to develop strategies for expected climate impacts, while not compromising or shutting off other options. This flexible approach recognises that conditions can change and means we avoid being locked into any one course. Pathways thinking is an approach that is in the Ministry for the Environment's coastal hazards guidance and is being used by councils and others around Aotearoa as they plan how to adapt to a changing climate.</p>
Delta growth	Delta growth (progradation) is defined as the forward extension of shoreline systems due to the deposition of sediment.
Qualitative risk	Qualitative risk analysis is a subjective approach based on descriptive measures. It uses words to describe the magnitude of potential consequences, and the likelihood

Key Term	Definition
	that the event will occur. An example of this is a risk matrix, which can be colour-coded to make it easier to understand the level of associated risk.
Quantitative risk	A quantitative risk analysis is focused on numerical values of the risks present, based on quantifiable data.
Reduced level	Reduced Level (RL) is a standard term for survey points with reference to a common datum. In this report, the common datum is Dunedin 1958 local vertical datum, unless stated otherwise.
Resilience	Resilience has a broad range of definitions. In our context, it is the capacity and ability to withstand and/or recover quickly from difficult conditions. It also includes planning for unexpected events and supporting the wellbeing of our communities in adverse times.
Risk management	The process of making plans, actions, strategies or policies to reduce the likelihood and/or scale of potential adverse consequences, based on assessed or perceived risks.
Rūnaka	A Māori tribal council, assembly, board or administrative group.
Te ao Māori	The Māori world.
Te Tiriti o Waitangi	The Treaty of Waitangi.
Tolerable risk	A risk that society is willing to live with to secure certain benefits. Kept under review and may be further reduced as and when possible.
True left bank/true right bank	The sides of the river when facing downstream, meaning the direction the river is flowing.
Uncertainty	A state of incomplete knowledge that can result from a lack of information or from disagreement about what is known or even knowable. It may occur for many reasons. For example, the data may be imprecise, definitions of concepts or terminology may be ambiguous, understanding of critical processes may be incomplete, or projections of human behaviour may be in doubt.
Vulnerability	The conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards.
whānau	Within each iwi are many hapū (clans or descent groups), each of which is made up of one or more whānau (extended families).

List of acronyms and abbreviations

Acronym	Full name
ARI	Annual Recurrence Interval
AEP	Annual Exceedance Probability
GIS	Geographic Information System
ORC	Otago Regional Council
QLDC	Queenstown Lake District Council
CDEM	Civil Defence Emergency Management Otago
LTP	Long Term Plan
LiDAR	Light Detection and Ranging
LIM	Land Information Memorandum
RL	Reduced Level
RPS	Regional Policy Statement

## 13 Appendices



# Appendix A – Programme deliverables

Table 13-1 Deliverables completed for the Head of Lake Whakatipu Natural Hazards Adaptation work programme (February 2025).

Programme Deliverables	Details
3 flooding hazards assessments	<ul style="list-style-type: none"><li>Gardner M, 2022. Dart/Rees Rivers flood hazard modelling. Prepared by Land River Sea Consulting Ltd.</li><li>Gardner M and Beagley R, 2023. Buckler Burn flood hazard modelling. Prepared by Land River Sea Consulting Ltd.</li><li>Beagley R, 2024. Glenorchy flood modelling – flood hazard scenarios. Prepared by Land River Sea Consulting Ltd.</li></ul>
1 liquefaction hazard assessment	<ul style="list-style-type: none"><li>Tonkin + Taylor Ltd (T+T), 2022. Glenorchy Liquefaction Vulnerability Assessment.</li></ul>
9 supporting studies (e.g., hydrology, geotechnical, geomorphic)	<ul style="list-style-type: none"><li>Brasington J, 2024. Geomorphic Character and Dynamics of the Rees-Dart Fluvial Systems. Prepared by the Waterways Centre University of Canterbury for Otago Regional Council.</li><li>Fuller I and McColl S, 2021. Key notes and observations from preliminary assessment of debris flood and flow hazard potential at Glenorchy, Otago, Prepared by Massey University.</li><li>Jaquin P, 2020. Glenorchy Floodbank Rees River. Prepared by WSP.</li><li>Jaquin P, 2020. Glenorchy Rees Floodbank - Floodbank Assessment. Prepared by WSP.</li><li>Mohssen M, 2021. Analysis of Flood Hazards for Glenorchy.</li><li>Mohssen M, 2024. Glenorchy Catchments Hydrology and Design Flows. Prepared by HydroScience.</li><li>Morris T and Ashfield D, 2021. Rees-Glenorchy floodbank structure failure modes assessment. Prepared by Tonkin + Taylor Ltd.</li><li>Shaw M, 2022. Shepherds Hut Creek debris flow hazard report. Prepared by WSP.</li><li>Tonkin + Taylor Ltd, 2021. Head of Lake Wakatipu Natural Hazards Assessment.</li></ul>
1 social and economic impact assessment (two phases)	<ul style="list-style-type: none"><li>Healy J, Stringer K and Goodall, 2024. Socio-economic Impact Assessment - Head of Lake Whakatipu Adaptation Strategy - Phase 1. Prepared by Beca Ltd.</li><li>Healy J, Stringer K and Goodall, 2024. Socio-economic Impact Assessment - Head of Lake Whakatipu Adaptation Strategy - Phase 2. Prepared by Beca Ltd.</li></ul>
1 natural hazards risk assessment	<ul style="list-style-type: none"><li>Menke R, Hoetjes, and Punt A, 2024. Glenorchy and Kinloch Natural Hazards Risk Analysis Report. Prepared by Beca Ltd.</li></ul>

Programme Deliverables	Details
5 natural hazards mitigation studies	<ul style="list-style-type: none"><li>Menéndez Arán D and Shrestha J, 2024. Assessment of Floodplain Intervention Options – Dart River. Prepared by Damwatch Engineering Ltd.</li><li>Veale B and Shrestha J, 2024. Assessment of Floodplain Intervention Options – Lower Rees River &amp; Glenorchy. Prepared by Damwatch Engineering Ltd.</li><li>Veale B, Shrestha J and Webby G, 2024. Assessment of Floodplain Intervention Options – Upper Rees River. Prepared by Damwatch Engineering Ltd.</li><li>Tonkin + Taylor Ltd (T+T), 2023. Engineering Approaches for Managing Liquefaction-Related Risk. Prepared by Tonkin + Taylor Ltd.</li><li>Webby G, 2022. Dart-Rees Floodplain Adaptation - Report on 23-24 February 2022 Workshop.</li></ul>
1 cultural values statement	<ul style="list-style-type: none"><li>Takau Y, 2024. Cultural Values Statement, prepared by Aukaha.</li></ul>
1 mana whenua assessment	<ul style="list-style-type: none"><li>Aukaha, 2024. Head of Lake Whakatipu Waimāori Mana Whenua assessment</li></ul>
10 Otago Regional Council Safety & Resilience Committee papers or workshops	<ul style="list-style-type: none"><li>2021 – May.</li><li>2022 – June.</li><li>2023 – May, August, November.</li><li>2024 – February, May, August (workshop &amp; paper), November.</li></ul>
2 Queenstown Lakes District Council workshop or briefings for councillors	<ul style="list-style-type: none"><li>May 2021 (jointly with ORC).</li><li>September 2024.</li></ul>

Programme Deliverables	Details
18 community engagement activities	<ul style="list-style-type: none"> <li>• 2019-2020 – Updates at Glenorchy Community Association meetings.</li> <li>• December 2020 – Community drop-in session.</li> <li>• April 2021 – Public presentation.</li> <li>• April 2021 – Community drop-in session.</li> <li>• June 2022 – Online presentation.</li> <li>• July 2022 – Community drop-in session.</li> <li>• August 2023 – Community workshops.</li> <li>• July 2023 – April 2024 – Community involvement in SEIA (from scope to review stages).</li> <li>• September 2023 – Online survey.</li> <li>• November 2023 – Stall at Glenorchy Village Fair.</li> <li>• April-May 2024 – Two adaptation classroom sessions at Glenorchy School.</li> <li>• April-May 2024 – Head of the Lake Youth Art Competition.</li> <li>• May 2024 – Online presentation.</li> <li>• September 2024 – Public presentation (in-person and livestreamed).</li> <li>• September 2024 – Community drop-in session.</li> <li>• February 2025 – Community presentation (in-person and livestreamed).</li> <li>• February 2025 – Community drop-in session.</li> <li>• December 2024 – February 2025 – Surveys (online, paper-based, email/post) on Draft Head of Lake Whakatipu Natural Hazards Adaptation Strategy.</li> </ul>
45 editions of a community newsletter	<ul style="list-style-type: none"> <li>• Commencing in August 2020 and ongoing.</li> </ul>
Programme webpage	<ul style="list-style-type: none"> <li>• Webpage on ORC website from December 2020, regularly updated.</li> </ul>
3 environmental monitoring stations installed	<ul style="list-style-type: none"> <li>• Glenorchy lagoon (water level).</li> <li>• Rees River at Invincible (flow).</li> <li>• Lake Wakatipu at Glenorchy marina (water level).</li> </ul>
1 flood forecast model developed and tested	<ul style="list-style-type: none"> <li>• Mohssen M, 2023a. Flood Forecasting for Glenorchy Township. Prepared by HydroScience for Otago Regional Council.</li> <li>• Mohssen M, 2023b. Analysis of Glenorchy Lagoon Levels for Event September 2023 and its FFM Model's Performance. Prepared by HydroScience.</li> </ul>
2 research projects supported	<ul style="list-style-type: none"> <li>• MacKenzie J, 2023. Telling Stories: Community engagement in a complex and dynamic natural hazards adaptation context at the Head of Lake Whakatipu. Master's Thesis, University of Otago.</li> <li>• Coursey S, PhD research project, in progress. Massey University, NIWA, University of Otago.</li> </ul>

Most reports are available online: <https://www.orc.govt.nz/get-involved/projects-in-your-area/head-of-lake-whakatipu/> or can be provided on request.

## Appendix B – Supporting information about existing responses and future toolbox

This appendix provides details and supporting information about responses in three sections:

**a) Local knowledge and community insights**

**b) What responses are already in place?**

- Social, behavioural and institutional changes.
- Current plans and policy that guide land use and development.
- Investment in assets, services and activities.
- Emergency management – reduction, readiness, response and recovery.
- Responses by property owners.

**c) Future toolbox**

- Review and adjust existing responses.
- Investigation of possible engineering and floodplain responses.
- Land use planning and governance measures.
- Retreat / Relocation.

### LOCAL KNOWLEDGE AND COMMUNITY INSIGHTS

We have heard many ideas, insights and observations from the community about what we can do to adapt to natural hazard challenges and impacts of a changing climate in the Head of Lake Whakatipu area. Thank you to community members for sharing. Table 132 collates the ideas and comments on how they were considered further.



*Table 13-2 General community ideas or insights and how they were considered further.*

Type of response	General community ideas or insights	How was it considered?	Is it part of the Strategy?
Protect	Minor repair to Glenorchy floodbank after the February 2020 flood event.	QLDC completed September 2020.	n/a
Protect	Maintenance of existing Glenorchy floodbank.	QLDC maintains the floodbank as asset owner	Yes, existing response in Action Plan.
Protect	Raise existing Glenorchy floodbank.	Considered as a possible future response.	Yes, discussed in Table 9-6 Longlist of response
Protect	New long flood wall alongside the true left bank of the Rees River.	Investigated but found unfeasible (Webby 2022).	Not taken forward.
Protect	Lake flooding protection, including a lake floodbank.	Unfeasible	Not taken forward.
Protect	Floodable infrastructure and dedicated areas for water storage during flood events (wetland, canals or channels, greenspaces).	Existing Glenorchy wetland and lagoon fulfils this role	Yes, retain its function, see Action Plan
Protect	Floodbank, rock revetment or vegetation to prevent erosion of Kinloch Road.	Considered as a possible future response	Yes, discussed in Table 9-6 Longlist of response
Accommodate	Clearance of thick willow growth alongside Lagoon Creek which drains the Glenorchy Lagoon to the Rees River in response to February 2020 flood event.	Completed by ORC in August 2020 in collaboration with DOC.	n/a

Type of response	General community ideas or insights	How was it considered?	Is it part of the Strategy?
Accommodate	Short-term improvements to drainage of Rees River into Lake Whakatipu during high river flows in response to February 2020 flood event.	Short-term, local realignment of the Rees River channel to assist drainage completed in August 2020.	n/a
Accommodate	Install additional lake level recorders and river flow models near Glenorchy, in the Glenorchy Lagoon and at the Rees River.	<p>Lake Whakatipu at Glenorchy marina (water level) site established in January 2021.</p> <p>Glenorchy Lagoon (water level) site established in October 2020.</p> <p>Rees River at Invincible (river flow) site established December 2021.</p>	Yes, existing response and discussed in Table 9-6 Longlist of response
Accommodate	Behavioural and societal changes to help people prepare, respond, cope and recover from natural hazard events.	Ongoing work in collaboration with CDEM Otago to increase community resilience and understanding of natural hazards.	See Action Plan
Accommodate	Create a flood response plan.	CDEM Otago has developed and is developing a number of emergency guides and plans, which are updated annually.	See Action Plan
Accommodate	Install sensors, monitoring recorders or a warning system at the Buckler Burn to warn about heavy rainfall or rapidly rising river levels.	ORC reviews its monitoring network regularly and will consider the case for Buckler Burn monitoring	See Action Plan

Type of response	General community ideas or insights	How was it considered?	Is it part of the Strategy?
Accommodate	Property level improvements and interventions to existing houses (such as raising floor levels, waterproofing).	Considered as a possible future response	Yes, discussed in Table 9-6 Longlist of response
Accommodate	Raise land levels in town and low-lying farmland.	Considered as a possible future response	Yes, discussed in Table 9-6 Longlist of response
Accommodate	Raise and/or realign Kinloch Road.	Considered as a possible future response	Yes, discussed in Table 9-6 Longlist of response  See Action Plan for current commitment
Accommodate	Alternative transport access to Kinloch and DOC tracks.	Considered as a possible future response	Yes, discussed in Table 9-6 Longlist of response
Accommodate	Boat access to Glenorchy and Kinloch.	Considered as a possible future response	Yes, discussed in Table 9-6 Longlist of response
Accommodate	Planting and willow clearing in Rees floodplain.	Considered as part of Upper Lakes Catchment Action Plan (in development)	See Action Plan.
Accommodate	Extract gravel from the Rees River under the Rees Bridge.	QLDC currently extracts gravel periodically	Yes, discussed in Table 9-6 Longlist of response

Type of response	General community ideas or insights	How was it considered?	Is it part of the Strategy?
Accommodate	Gravel extraction in Dart-Rees Delta to re-direct Rees flows through the split or create a secondary channel for high flows.	Not feasible for flood flows	n/a
Retreat	Managed relocation from high-risk areas in the long-term.	Considered as a possible future response	Yes, discussed in Table 9-6 Longlist of response
Retreat	Reactive retreat after a disaster.	Considered as a possible future response	Yes, discussed in Table 9-6 Longlist of response
Retreat	Council(s) should proactively purchase land for future relocation of properties.	Considered as a possible future response	Yes, discussed in Table 9-6 Longlist of response
Retreat	Relocate critical assets in high-risk areas (i.e., fire station).	Considered as a possible future response	Yes, discussed in Table 9-6 Longlist of response.
Avoid	No new development/redevelopment or change of land use that will exacerbate risk.	Considered as a possible future response	Yes, discussed in Table 9-6 Longlist of response
Avoid	More restrictive building development standards in high-risk areas.	Considered as a possible future response	Yes, discussed in Table 9-6 Longlist of response
Avoid	Use planning and zoning mechanisms to define and ‘protect’ areas of low-risk land for future relocation processes.	Considered as a possible future response	Yes, discussed in Table 9-6 Longlist of response



Type of response	General community ideas or insights	How was it considered?	Is it part of the Strategy?
Other	We want to understand our risk in comparison to others.	Refer to Risk Assessment for Glenorchy and Kinloch	n/a
Other	We want the social and economic worth of our community to be considered in decision-making.	Refer to Socio-economic Impact Assessment Phase 1	Yes, discussed in Section 5.5

## WHAT RESPONSES ARE ALREADY IN PLACE?

The long list in Table 9-6 identifies 13 responses that are already in place and contributing to hazard management at the Head of Lake Whakatipu. Further discussion of details and implementation is provided below.

## EXISTING SOCIAL, BEHAVIOURAL AND INSTITUTIONAL CHANGES

There are several ways ORC, partners, community, and stakeholders are improving awareness of natural hazard risks and impacts of climate change. This Strategy recognises that knowledge sharing is a two-way process, and so it is essential to have open and transparent dialogue between councils and communities. These efforts aim to improve individual, community and organisational awareness and build their adaptive capacity to natural hazard risks and future changes. Existing and ongoing actions in this category include:

- Making all information (including technical reports, Council update reports) publicly available on the Head of Lake Whakatipu webpage<sup>16</sup>.
- Making technical reports more accessible for a public audience, by providing ‘plain-language’ summaries.
- Updating the Otago Natural Hazards Portal<sup>17</sup> with the latest natural hazard mapping information.
- Coordinating public talks and recorded presentations on findings of key hazards studies.
- Attending community events to allow opportunities for people to talk with ORC staff and for two-way knowledge sharing and learning.
- Hosting engagement events to provide opportunities for people to talk with ORC staff and consultant experts for two-way knowledge sharing and learning.
- Providing responses to natural hazard enquiries from members of the public.
- Providing QLDC with hazard information, for QLDC to update Land Information Memorandums (LIM).
- Capturing local knowledge, observations and experiences through engagement and feedback from community members.

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<sup>16</sup> <https://www.orc.govt.nz/get-involved/projects-in-your-area/head-of-lake-whakatipu/investigations-reports-and-presentations/>

<sup>17</sup> <https://maps.orc.govt.nz/portal/apps/MapSeries/index.html?appid=b24672e379394bb79a32c9977460d4c2>

## EXISTING PLANS AND POLICY THAT GUIDE LAND USE AND DEVELOPMENT

**Otago Regional Policy Statements (ORC)** – see Section 7.1 for details about operative (2019) and proposed (2021) regional policy statements for Otago.

**2021 Queenstown Lakes District Spatial Plan (the Spatial Plan)** – was developed in partnership with the QLDC, central Government, Aukaha and Te Ao Mārama inc. (Kāi Tahu). It is noted that the ORC has since joined the Grow Well Whaiora Partnership and is jointly responsible for implementing the Spatial Plan. The Spatial Plan sets out a vision and framework for how and where the district will grow through to 2050. It is focused on ensuring that future growth happens in the right place and is supported by the right infrastructure. It does this by:

- Aligns decision-making and investment across local, regional and central government.
- Identifies existing and future urban areas and infrastructure needs.
- Identifies priority areas for investment and action, and other strategically significant priorities.
- Identifies areas to protect and enhance, and areas subject to natural hazards.

**QLDC District Plan (QLDC)** – guides land use and development in the district. It contains objectives, policies and rules for resource management activities. It sets out what activities can be done as of right, what activities need resource consent for, and how certain activities may be carried out. It covers things like residential development, noise, location and height of buildings, activities on the surfaces of rivers and lakes, and protection of indigenous vegetation.

The District Plan defines rules for permitted activities. Chapter 28 of the Proposed District Plan provides a policy framework to address natural hazards throughout the district. Currently, low-lying areas at Glenorchy and Kinloch that are susceptible to flooding from high lake levels are shown as ‘Historical Flood Zone’ on the Planning Maps, with corresponding rules relating to building levels: *‘buildings with a gross floor area greater than 20m<sup>2</sup> shall have a ground floor level not less than RL 312.8 masl (412.8 Otago Datum) at Kinloch, Glenorchy and Kingston’.*

## EXISTING INVESTMENT IN ASSETS, SERVICES, AND ACTIVITIES

Long-term plans (LTP) are Ten Year Plans, adopted by councils every three years. They are the blueprint for investment in the region's (ORC) and district's (QLDC) infrastructure, services, and activities over the next ten years. LTPs also include 10-year Financial Strategies and 30-year Infrastructure Strategies. The current long-term plans that are relevant to this Strategy are:

- [QLDC 2024-2034 Long Term Plan](#)
- [ORC 2024-2034 Long Term Plan](#)

The Action Plan (Section 10) outlines existing and planned actions for the following assets, infrastructure, and activities relevant to the Strategy:

- Road network (including Rees and Dart Bridges) (QLDC).
- Glenorchy floodbank (QLDC).
- Kinloch and Glenorchy wharfs (QLDC).
- River management (ORC).
- Integrated catchment management (ORC).
- Monitoring, forecasting and warning (ORC).

QLDC undertakes asset and infrastructure management activities, such as inspection, operational repair and maintenance, as well as planning and decision-making regarding improvements and renewals. QLDC's Asset and Activity Management Plans (<https://www.qldc.govt.nz/your-council/council-documents/asset-management-plans/>), such as [Land Transport Asset Management Plan 2021-2031](#), provide additional details.

In response to the February 2020 flood event, erosion mitigation actions were carried out for Glenorchy floodbank.

ORC undertakes river and floodplain management activities, such as vegetation and gravel management, as well as associated planning and decision-making.



## EXISTING EMERGENCY MANAGEMENT – REDUCTION, READINESS, RESPONSE AND RECOVERY

In alignment of the four principles of the National Disaster Resilience Strategy (2019) and the National Civil Defence Emergency Management Plan (2015): *reduction, readiness, response and recovery*, Otago CDEM has implemented various actions over recent years to enhance the capacity of communities at the Head of the Lake to manage and recover from emergencies. These principles are presented in the Otago Civil Defence Emergency Management Group 10-year Plan (2018-2028)<sup>18</sup>. Specific actions of Otago CDEM at the Head of the Lake are detailed in Action Plan (Section 10).

To reduce risks from natural hazards, Otago CDEM is collaborating with ORC teams, including the Natural Hazards team, as well as communities and stakeholders, to identify and analyse risks to life and property, lifelines, and critical infrastructure. This is being achieved through a combination of technical studies, workshops and consultations in the area. Otago CDEM is also developing a Catastrophic Event Plan: Alpine Fault (CATPLAN) to assist emergency managers and responding agencies prepare for this complex emergency scenario (Otago CDEM, 2024). This plan is in the consultation phase with stakeholders and is expected to be ratified by Otago CDEM Chief Executive's Group and Joint Committee in March 2025.

To get ready for emergencies, Otago CDEM is collaborating with communities, Community Response Group members and QLDC to develop emergency guidelines and plans. Recent initiatives have been completed, including the Glenorchy Community Response Plan (CDEM and Community Response Group, 2022) and the Community Emergency Preparedness Brochure (CDEM and QLDC, no date). Otago CDEM has also conducted workshops and training sessions to build capacity and improve the emergency preparedness and response skills of communities and community groups.

To respond to emergencies, Otago CDEM has developed evacuation plans to facilitate the safe relocation of people across the Head of the Lake area, including designated evacuation centres in Glenorchy and Kinloch. In the September 2023 weather event, the lagoon reached a high-water level (312.49m) and came close to overtopping the floodbank crest into the township area. A precautionary evacuation of flood-prone properties was undertaken. Although no flooding occurred on that occasion, the event and response provided a test of CDEM planning.

For emergency recovery, Otago CDEM has guided the Community Response Group in incorporating this objective into the Glenorchy Community Response Plan. The recovery plan emphasizes coordinated efforts to support community recovery after an emergency. It also outlines immediate, medium, and long-term outcomes that the community aims to achieve following such events.

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<sup>18</sup> <https://www.otagocdem.govt.nz/media/1388/emergency-manangement-otago-group-plan-adopted-june-2019.pdf>.

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### Environmental monitoring

Timely and relevant flood warning and emergency response can be considered a primary means of increasing the preparedness of the community and thus reducing the economic and social impact of a flood event.

ORC's current environmental monitoring stations in the Head of Lake Whakatipu area are shown in Figure 13.1.

All ORC monitoring data is publicly available in near real-time through ORC's online data portal,<sup>19</sup> allowing the community to proactively monitor river/lagoon/lake levels and take action if required. The monitoring data is also invaluable to the ORC flood response team, and to inform hydrological analysis for hazards assessment and development of flood forecasting models.

In response to the February 2020 flooding event, three new environmental monitoring stations were installed in the Glenorchy and Rees River area, designed to provide improved monitoring coverage and understanding of hydrological responses to major weather events.

- Rees River at Invincible (river flow), site established December 2021.
- Glenorchy Lagoon (water level), site established October 2020.
- Lake Whakatipu at Glenorchy marina (water level), site established January 2021.

Following installation of the new Rees River and Glenorchy Lagoon sites, further work was also carried out to increase the resilience of the recorders, such as building redundancy into the station's sensor and communications systems.

Early-warning alarm levels are set for Lake Whakatipu and Glenorchy Lagoon sites to provide near real-time notification to the ORC's flood response team when water level thresholds are exceeded. This supports timely advice to CDEM Otago and complements flood forecasting tools.

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<sup>19</sup> <https://envdata.orc.govt.nz/AQWebPortal/Data>.



Figure 13.1 ORC environmental monitoring stations in the Head of Lake Whakatipu area.

### Flood warning systems

ORC has a key role in the flood monitoring and warning process (Figure 13.2):

- Maintain an operational flood monitoring telemetry network and telemetry base computer.
- Provide near real-time environmental monitoring data.
- Carry out flood forecasting where possible to give greater warning time.
- Provide information on a flood event to territorial authorities, CDEM, community, Councillors and media.
- Answer public enquiries before, during and after a flood event.
- Carry out flood measurements/observations during a flood event.
- Carry out operational works during a flood event.

ORC maintains a 24/7 on-call flood duty team. The role of this team is to liaise with MetService regarding weather forecast information, to monitor and forecast river flows and lake levels, and to provide information to other agencies (e.g., CDEM, QLDC).

For the Head of Lake Whakatipu area, the team makes use of weather forecast, environmental monitoring information, and forecasting tools which enable estimation of likely water levels for Lake Whakatipu and the Glenorchy Lagoon. ORC provides this information to CDEM Otago and QLDC, who provide the communications link to the community.

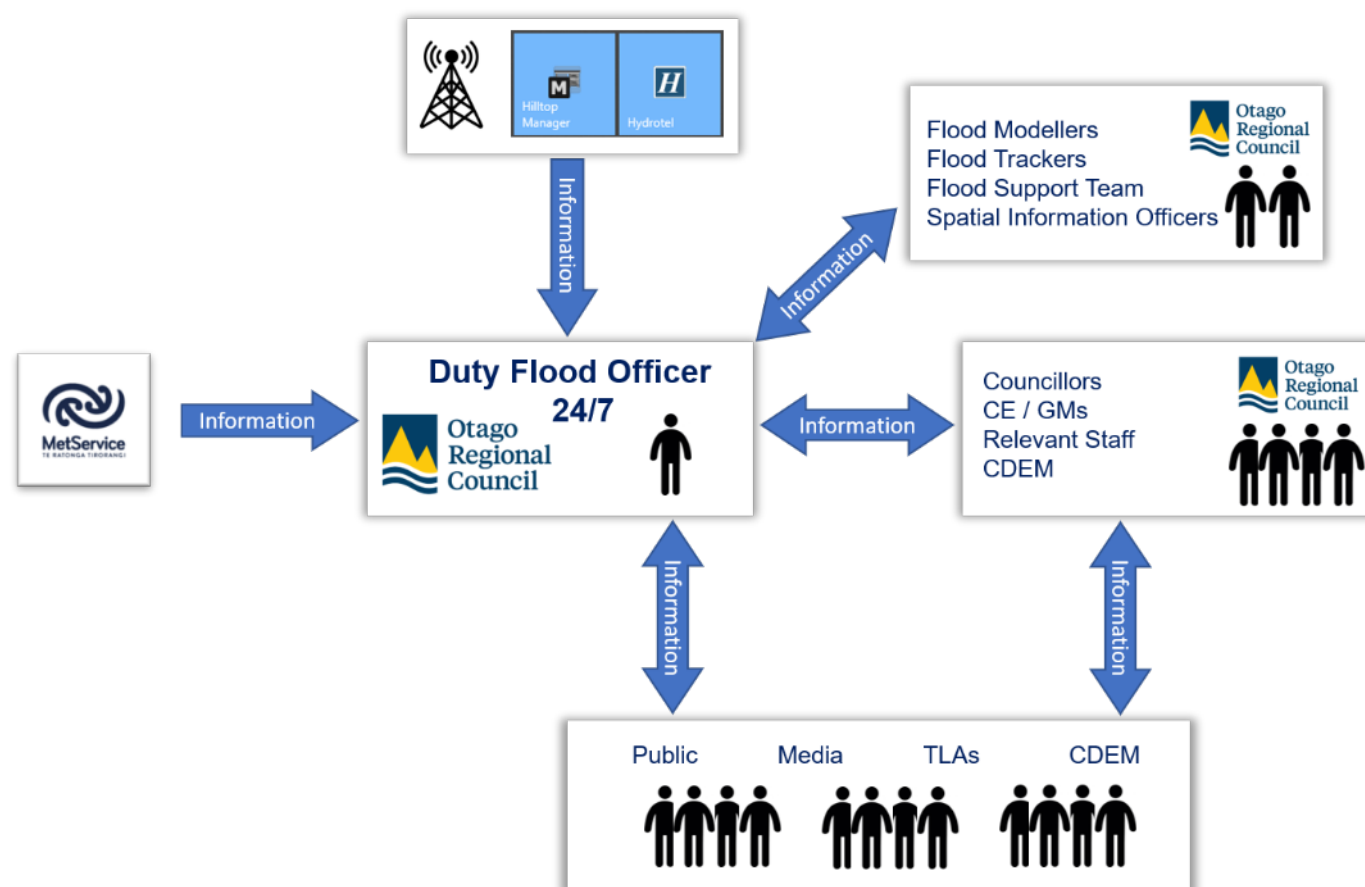


Figure 13.2 ORC role in flood monitoring and warning process.

### Glenorchy Lagoon flood forecasting model

The model is used to forecast possible water levels at Glenorchy Lagoon when significant rainfall totals are forecast for the Rees catchment. The model can provide up to about three days early warning and estimates the final lagoon level for a rainfall event.

This is a relatively new model and still in a testing phase. Consequently, it requires application in a wider range of future rainfall and flood events to better evaluate model performance and accuracy. The model will be evaluated and revised following large flood events and when a longer period of monitoring data is available. For example, the model was evaluated and revised following the September 2023 high-flow event where observed lagoon levels significantly exceeded those used in the model development (Mohssen, 2023b).

**Lake Whakatipu flood forecasting model** – estimates high lake levels for Lake Whakatipu based on forecast or recorded rainfall totals and recorded river flows.



### EXISTING RESPONSES BY PROPERTY OWNERS

Property and business owners make decisions about appropriate levels of insurance coverage for their own situation.

Property owners are free to buy and sell based on their own risk tolerance and make decisions about investment in property-level resilience to reduce potential damages (e.g., retrofit, floor raising, flood proofing).

Household readiness contributes to effective emergency management.

## FUTURE TOOLBOX

The long list in Table 9-6 includes possible responses that make up the future toolbox. Possible responses in the future toolbox are not commitments, as they do not have business cases or future funding identified at this stage. Some possible responses fall outside the current roles and responsibilities of partner agencies. There should be no expectation that the Strategy partners will or will not undertake any particular mitigation work.

## FUTURE TOOLBOX – REVIEW AND ADJUST EXISTING RESPONSES

Reviewing the suitability of existing responses is part of planning processes and happens periodically. Reviews consider factors such as performance, costs and benefits, changes to risks and conditions, opportunities, and sustainability of current responses.

One way to think about the possible future pathways for existing responses:

- **Is it sustainable to keep doing the same?**
- **Are there things we can do better?**
- **Is it time to consider doing things differently?**

Over time we might choose to improve, adjust or expand our current approaches – these are the ‘do better’ responses in our future toolbox (from Table 9-6):

- Small scale improvement to existing Kinloch and Glenorchy-Paradise local road system road (as well as maintenance and reactive repair).
- Major works to increase resilience of Kinloch and Glenorchy-Paradise local road system (e.g., protect, raise, realign).
- Short-term improvements to existing boat access (e.g., dredging).
- Small scale improvements to Glenorchy floodbank to maintain/reduce flood risk.
- Major works to increase level of service of Glenorchy floodbank.
- River management and nature-based interventions (e.g., targeted planting).
- Small scale works to reduce Buckler Burn erosion and/or flood risk.
- Improve property and land resilience (such as floodproofing, floor raising, ground or structure strengthening).
- Improve resilience of critical assets in higher hazard areas (such as floodproofing, floor raising, ground or structure strengthening, retrofit).
- Policy – Review hazard and risk information and set minimum requirements for new development.
- Recovery plan improvement.

In the future we might reach a point where our current approaches are unsustainable or unsuitable for changed conditions and we will need to consider ‘doing things differently’ (from Table 9-6):

- Reduced level of service of existing Kinloch and Glenorchy-Paradise local road system (e.g., some parts 4WD only).
- Reactive re-design Kinloch and Glenorchy-Paradise local road system for changed conditions (e.g., post event).
- Upgrade boat access with resilient solution (e.g., relocatable wharfs).
- Relocate wharfs periodically to maintain future access.
- Redesign Rees flood protection for changed conditions (e.g., post event).
- Redesign nature-based interventions for changed conditions.
- Policy – Strengthen land use controls in higher hazard areas to avoid additional exposure.
- Policy and services – make lower hazard land available for new building and/or relocation.
- Proactive relocation plan.
- Voluntary proactive relocation from higher hazard areas.
- Voluntary reactive post event retreat from higher hazard areas.

## FUTURE TOOLBOX - INVESTIGATION OF POSSIBLE ENGINEERING AND FLOODPLAIN RESPONSES

This section describes investigation reports completed as part of the Strategy work programme, in order to help ORC, QLDC and the local community understand potential engineering responses or interventions for managing the liquefaction and flooding hazards identified in Glenorchy and in the Dart-Rees floodplain area.

The reports do not give recommendations for which hazard management interventions may be feasible or should be investigated further, but for each intervention considered, aims to outline the challenges and constraints as a starting point to inform continued discussions.

### Rees Bridge Options Assessment

The floodplain assessment by Webby (2023) identified potential risks to the Rees River Bridge from continued bed aggradation and the potential for the Rees River to avulse upstream of the bridge.

QLDC engaged WSP (William Sales Partnership Ltd) to undertake a structural options assessment to help provide direction and guidance towards a long-term asset management strategy for the Rees Bridge structure. The study scope included: existing bridge structure, current levels of service, hydraulic assessment (including scour), morphological issues and options, structural options and preliminary planning assessment.

Key findings (Wong *et al.*, 2023):

- There is no simple solution to the sediment transport issue, and it is expected to continue to aggrade and potentially worsen under certain future scenarios (such as a major earthquake effecting the catchment).
- Due to predicted and observed outflanking of the bridge, there is also potential for the approaches to be damaged or washed away. However, this is preferable to a bridge pier being damaged. The approaches (and hence the bridge) should not be raised in the absence of lengthening the total span as this would potentially increase the risk and extent of scour at the bridge itself by forcing more flow through the bridge.
- It is evident that the aggradation risk at the Rees River Bridge is reliant on wider geomorphological behaviours and the hydraulic characteristics of the wider floodplain. While structural options such as raising the existing bridge and early bridge replacement were considered, the feasibility of both options remain subject to further assessment and not considered to be of priority. The bridge raising option is also likely to be cost prohibitive and unlikely to be favoured particularly given the potential closure that would be required given that alternative crossings are not available. A full bridge replacement also carries a significant cost and is unlikely to be favoured given the considerable remaining life (~40 years) of the structure.

Wong *et al.* (2023) recommends ongoing monitoring and data collection, and the following measures to manage the aggradation risk and help inform longer-term plans for the Rees Bridge:

- In the short-term, managing ongoing aggradation through continued gravel extraction measures appears most appropriate to minimise the rate of gravel build up.



- In the short- to medium-term, narrowing the channel (e.g., groynes) in the location of the bridge to increase flood velocity and sediment transport should be considered. This would be expected to provide a short-term benefit in the range of 5 – 10 years.
- In the longer-term, collaboration between ORC and QLDC on a river management plan for the Rees River is recommended.

How does this link with responses in our future toolbox (Table 9-6)?

- Small scale improvement to existing Kinloch and Glenorchy-Paradise local road system road (as well as maintenance and reactive repair).
- Major works to increase resilience of Kinloch and Glenorchy-Paradise local road system (e.g., protect, raise, realign).

### **Floodplain hazards management**

There are three areas of interest on the Dart-Rees floodplain where flooding or erosion may impact the community or infrastructure in the Head of Lake Whakatipu area. These areas are shown in Figure 13.3:

- The lower Rees floodplain and Glenorchy township.
- The Dart floodplain and Kinloch access.
- The upper Rees floodplain and the Rees bridge.

An assessment by Webby (2023) was undertaken to identify and review, at a high-level, the potential engineering or river management responses available for management of flooding and floodplain hazards. This included consideration of suggestions by community members. For each area of interest, the report also outlined information gaps identified and gives recommendations for monitoring and additional analysis to address those gaps.

The Webby (2023) report was followed by more detailed technical feasibility studies (Veale and Shrestha, 2024; Menéndez Arán and Shrestha, 2024; Veale, Shrestha and Webby, 2024) to further explore potential responses. The scope and objectives of the most recent 2024 assessments were to:

- Assess the viability of potential options that mitigate existing flood hazards.
- Provide an evidence base to rule out various floodplain management options.
- Test viable options for their alignment with a Nature-based Solutions (NbS) approach to floodplain management.
- Viable options were taken forward to a concept level design stage (i.e., drawings and costings).

The following items were out of scope: backwater flooding hazard to Glenorchy from high water levels in Lake Whakatipu, options to raise and/or lengthen the existing Rees River Bridge, options to raise or re-route the existing Kinloch Road, and any options previously discounted in 2022 floodplain adaption workshop.

Raising the existing Rees-Glenorchy floodbank structure – was found to be potentially viable as a response for lower Rees floodplain and Glenorchy township flood hazard. Raising the existing

floodbank crest levels by approximately 0.75 to 1.1 m could increase the level of service for Rees flooding to 1 in 100 AEP flood (including climate change and freeboard), potentially reducing the flood hazard extent and depth in the township (Figure 13.4). The concept level design, key benefits, costs, and residual risks for the raising option are shown in Figure 13.5.

How does this align with responses in our future toolbox (Table 9-6)?

- Major works to increase level of service of Glenorchy floodbank

Rockfill and vegetated buffers protections for Kinloch Road erosion hazards – The scale of the flood hazard is very challenging to defend against with conventional engineering solutions (e.g., floodbanks) and so the focus was on mitigation of existing flood hazards and providing room-for-the-river.

The intervention options carried forward were a combination of rockfill and vegetated buffer protections (prioritised to allow staged implementation) (Figure 13.6). These interventions were focused on:

- Mitigating riverbank migration.
- Preventing damage to Kinloch Road.
- Reducing the rate of farmland loss between the road and the riverbank to provide protection for the road.

How does this align with responses in our future toolbox (Table 9-6)?

- River management and nature-based interventions (e.g., targeted planting)
- Major works to increase resilience of Kinloch and Glenorchy-Paradise local road system (e.g., protect, raise, realign)

Managed floodway on north (right bank) approach to the Rees bridge – Under flood conditions, there is insufficient conveyance capacity through the bridge waterway. The river naturally wants to break-out on the true left and right bank floodplains (but primarily on the right bank floodplain). The existing floodbank system on the right bank is outflanked and overtopped in large flood events.

The Rees River Bridge was constructed in c.1950. A floodbank system on the right bank (privately owned) was constructed in c.1980. The floodbank system diverts right bank floodplain flows and increases the flood discharge passing through the Rees River Bridge waterway. In conjunction with channel bed aggradation, this has lowered the level of service of the bridge.

The scale of the flood hazards is very challenging to defend against with conventional engineering solutions (e.g., floodbanks) and so the focus was on the following:

- 1. Providing a managed floodway on the left and/or right bank approaches to the bridge.
- Guide floodplain flows in defined areas past the bridge.
  - Reduce flood discharge through the Rees River Bridge waterway.
- 2. Alignment with NbS (nature-based solution) strategies that provide ‘room for the river’

- Floodplain widening and embankment removal or retreat, rather than construction of new floodbanks.

A right bank floodway was found to be potentially viable and carried forward for costing, with and without road raising.

- Option A - Develop Right Bank Floodway & Raise Roads – indicative cost range \$6,050,000 to \$8,470,000.
- Option B - Develop Right Bank Floodway, No Road Raising – indicative cost range \$470,000 to \$660,000.

How does this align with responses in our future toolbox (Table 9-6)?

- Major works to increase resilience of Kinloch and Glenorchy-Paradise local road system (e.g., protect, raise, realign).



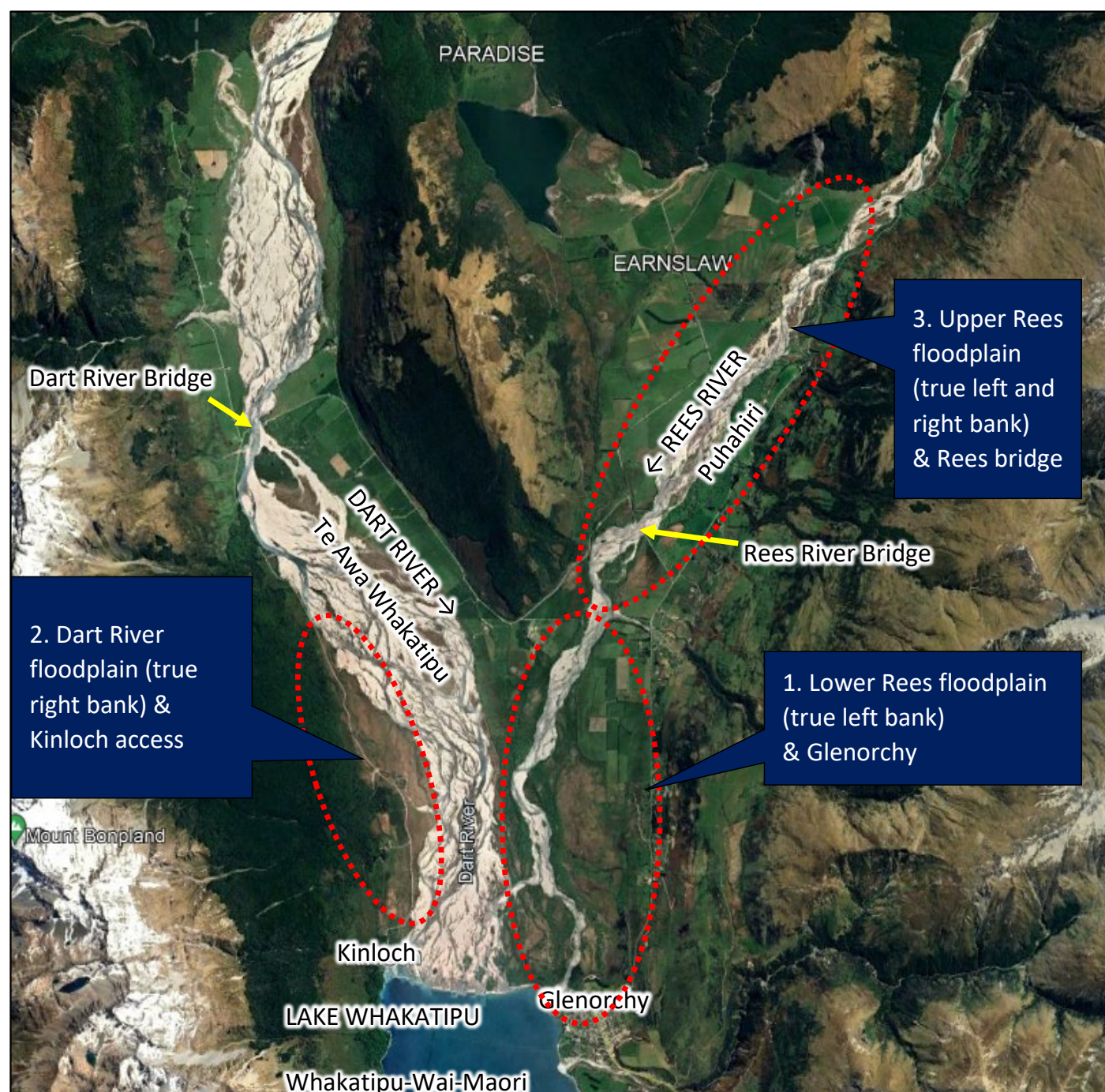
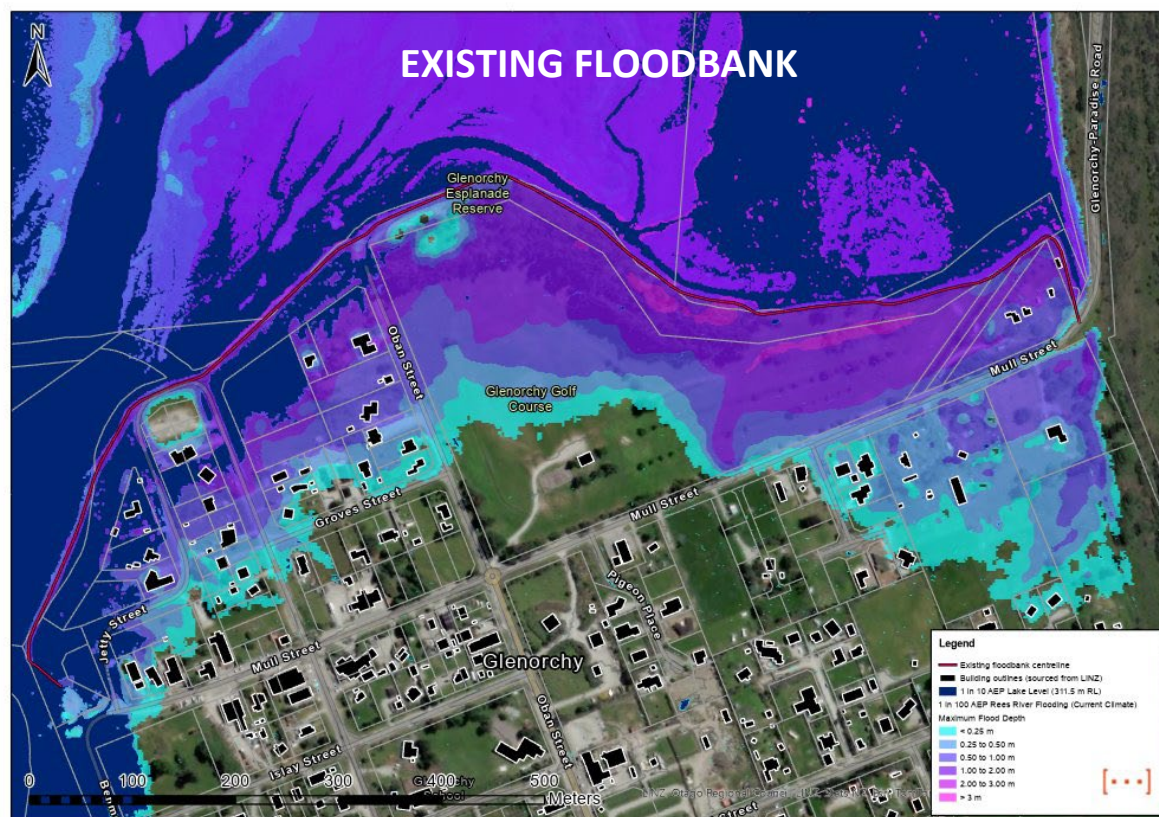
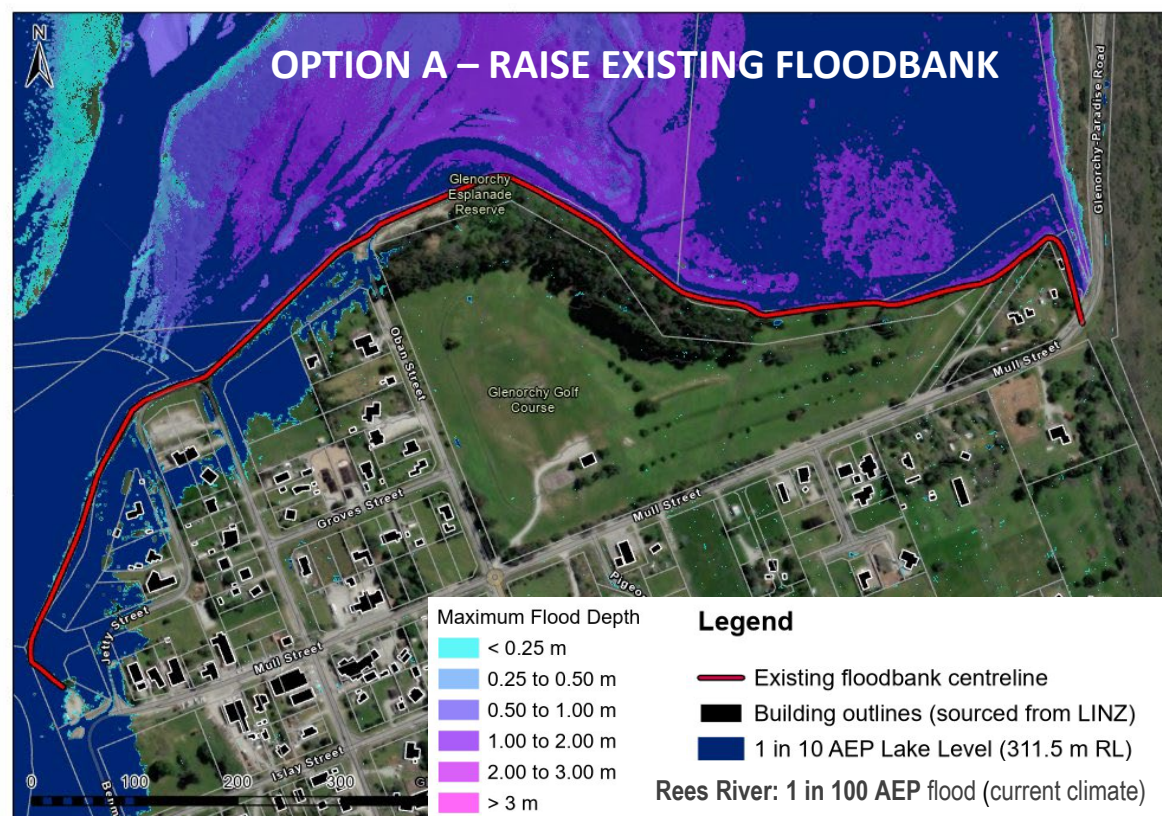


Figure 13.3 Three areas of interest on the Dart-Rees floodplain (modified from Veale presentation 2024).





Flood depth information sourced from:  
2022 Land Sea River report 'Dart / Rees Rivers Flood Hazard Modelling'.



Flood depth information sourced from: Current 2024 Damwatch assessment.

Figure 13.4 Comparing 1 in 100 AEP Rees flood extent and depth with existing floodbank (top) and Option A: Raise Existing Floodbank (bottom) (Veale, 2024).



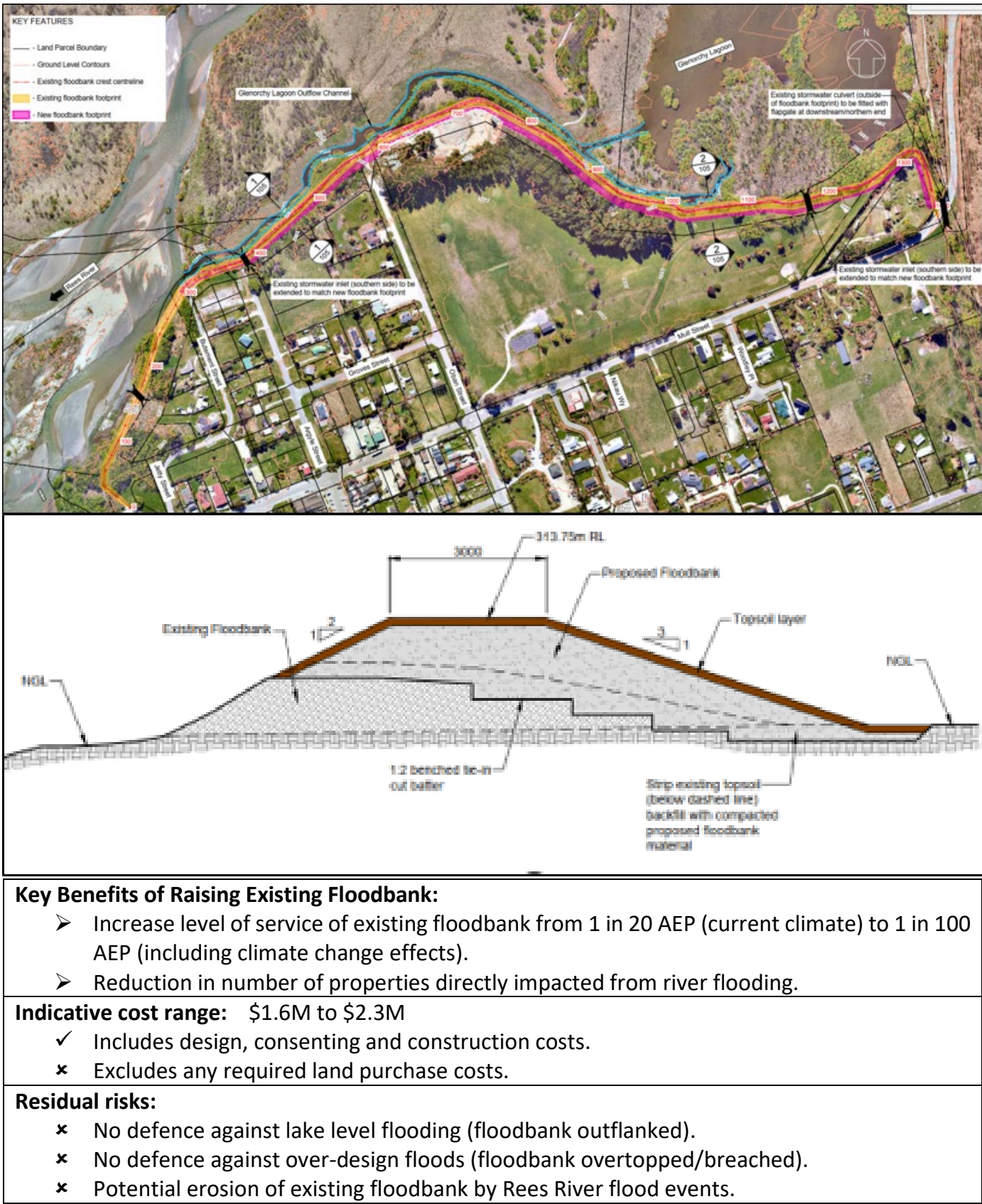


Figure 13.5 C Conceptual design for raising existing Glenorchy floodbank (Veale, 2024).



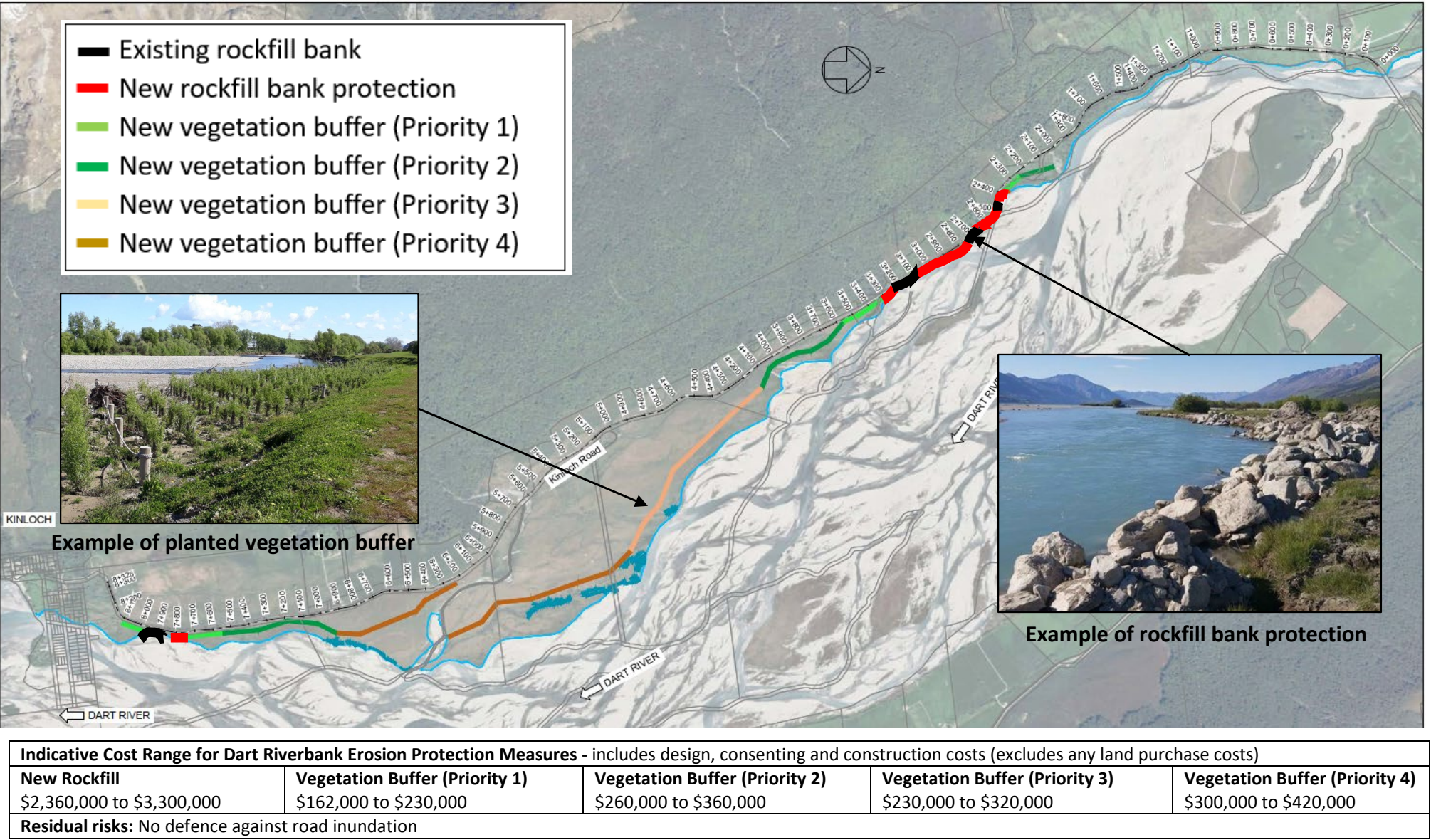


Figure 13.6 Combination of rockfill and vegetated buffer protections (prioritised to allow staged implementation) (Veale, 2024).

### **Liquefaction hazard management**

A report by Tonkin + Taylor (2023) identifies a range of engineering mitigation techniques that could be considered for the management of liquefaction and lateral spreading hazard at Glenorchy township. Mitigation techniques, detailed in Appendix B, focus on reducing damage to land; buildings; and infrastructure; and span from very robust options through to a ‘do nothing’ option:

- deep and shallow ground improvement; and geogrid-reinforced crushed gravel rafts are techniques that can reduce damage to land.
- new TC3-type and TC2-type foundation options; and proactive retrofit strengthening of existing buildings are techniques that can reduce damage to buildings.
- new infrastructure should incorporate resilient detailing to better accommodate displacement; and targeted upgrades of critical weak links can improve overall resilience of existing infrastructure.

The report then shows how these techniques could be applied across the township, provides a preliminary high-level assessment of how effective these mitigation works could be in reducing damage, and an indicative relative cost comparison.

The report notes that the more robust end of the range might be impractical or unaffordable, while the less robust end of the range might not satisfy Building Code or insurability requirements. However, for completeness, the report includes these options to provide context for discussion about the range of potential improvements that could be considered.

At the more robust end of the range, the mitigation options incorporate a strip of deep ground improvement constructed on public land running along the edge of the lake. This ground improvement would need to be in the order of 15 – 20m deep, 30 – 40m wide, and approximately 1.5km in length (information provided by Mike Jacka, T+T). Based on the indicative relative cost estimates presented in the February 2023 T+T report, T+T advises that the construction cost for this edge-treatment work alone would likely be many tens of millions of dollars.

In addition to this, many of the mitigation options include ground improvement across the wider township (under both public and private buildings and infrastructure), and there would also be additional coordination and enabling works costs associated with such a large programme of community-wide works. T+T advises that this could bring the overall cost into the hundreds of millions of dollars.

Aside from cost, these engineered interventions considered also have other significant challenges associated with their implementation and effectiveness:

- These interventions do not provide a complete reduction in the natural hazard impacts. It is estimated that 25-30% of buildings and infrastructure in the lateral spreading hazard areas would suffer severe liquefaction damage in a large earthquake, even if comprehensive mitigation works were undertaken.
- These interventions involve the undertaking of large-scale engineering works and would likely be highly disruptive to the local community.



- Some of the areas vulnerable to liquefaction and lateral spreading damage are also exposed to other types of natural hazard, such as flooding hazards from Lake Whakatipu, the Rees River, or Buckler Burn. Consideration of any potential hazard management interventions for liquefaction and lateral spreading should be part of an integrated response considering the full natural hazard risk profile, not just the seismic-induced hazards.

How does this align with responses in our future toolbox (Table 9-6)?

- Improve property and land resilience (such as floodproofing, floor raising, ground or structure strengthening).
- Community-wide improvement works for liquefaction hazard (such as ground improvement and strengthening existing buildings).
- Review and accept residual risk for existing development.
- Policy – Review hazard and risk information and set minimum requirements for new development.

Table 13-3 Liquefaction mitigation techniques for reducing damage to land (T+T, 2023).

Works	Description of mitigation techniques for reducing damage to land
15 – 20m deep by 30 – 40m wide perimeter treatment ground improvement alongside lake	<p>A long vibrating probe is used to compact the ground and inject gravel to form columns about 1m in diameter, in a grid pattern at about 2m spacings. This strip of very deep improvement along the lake edge acts like an “underground dam” of solid ground which helps to hold back the liquefied ground and reduce lateral spreading ground displacements.</p> <p>Perimeter treatment can help reduce the lateral spreading hazard for areas further inland (but the inland ground could still experience settlement damage if the underlying ground liquefies).</p>
12m deep ground improvement, all land	<p>Ground compaction and gravel columns as above, covering all land in an area (e.g., under buildings, roads, and the land in between). Only 12m deep so there is still potential for the ground deeper than this to liquefy. This means that liquefaction settlement and lateral spreading could still occur, but the magnitude of displacement should be less.</p>
12m deep ground improvement, land under buildings & infrastructure only	<p>Ground compaction and gravel columns as above but only covering land under buildings &amp; infrastructure (no improvement of land in between). This will form individual “islands” of ground improvement which can help to reduce settlement and lateral spreading (but less effective at controlling lateral spreading than the options above).</p>

Works	Description of mitigation techniques for reducing damage to land
12m deep ground improvement, land around buildings & infrastructure where accessible	This ground improvement approach could be considered where there are existing buildings & infrastructure, to avoid the need relocate them to improve underneath. The main benefit of this is reducing lateral spreading by improving a block of surrounding ground. Significant ground settlement could still occur due to liquefaction of the unimproved ground beneath.
4m deep ground improvement, land under buildings & infrastructure only	<p>There are various shallow ground improvement methods which could be used to compact the upper 4m of the soil profile, including gravel columns (as above), dynamic compaction (a crane drops a weight on the ground) and impact compaction (a square roller or hammer hits the ground).</p> <p>This will have little effect on lateral spreading displacements but can help reduce the severity of differential ground settlement due to liquefaction and ejected soil. Therefore, this option is more applicable in areas further inland where less lateral spreading is expected, or in conjunction with perimeter treatment to reduce lateral spreading displacements.</p>
1.2m deep geogrid-reinforced crushed gravel raft, under buildings & infrastructure only	<p>This method provides a stiff platform of well compacted and reinforced gravel beneath buildings &amp; infrastructure. The main benefit of this is to help reduce the severity of differential ground settlement due to liquefaction and ejected soil.</p> <p>The geogrid can help reduce the magnitude of lateral ground stretching to some degree (encouraging cracks to instead form on either side) but is less effective than deep ground improvement for controlling lateral spread. Therefore, this option is more applicable further inland where less lateral spread is expected, or in conjunction with perimeter treatment which reduces lateral spreading.</p>
No improvement	Ground remains in its current state within an area. However, in some mitigation scenarios ground improvement in a neighbouring area may help to provide some reduction in lateral spreading ground displacement, so we have made allowance for this in our damage estimates where appropriate.
<p><b>NOTE:</b> The details quoted in this table (such as depth and extent of treatment) are intended to be indicative only, to provide a general picture of the relative scale of the various options. Actual details would need to be determined as part of the design process, to meet agreed target performance requirements.</p>	

Table 13-4 Liquefaction mitigation techniques for reducing damage to buildings (T+T, 2023).

Works	Description of mitigation techniques for reducing damage to buildings
New TC3 surface structure foundations	<p>The MBIE Canterbury rebuild guidance provides five concepts for raised platform foundations designed to accommodate significant ground settlement and lateral spreading while limiting deformation of the overlying structure. Settlement and damage are still expected to occur, but the aim is for this to be readily repairable.</p> <p>Existing buildings would need to be temporarily lifted, and possibly relocated, for the new foundation to be constructed underneath.</p> <p>This foundation type also has the added benefit of raising floor levels higher above flood levels.</p>
New TC2 waffle slab foundation or enhanced lightweight platform on timber piles	<p>The MBIE Canterbury rebuild guidance provides numerous TC2-type foundation options, but the most commonly adopted are waffle slab foundations (for concrete slabs) and enhanced lightweight platforms (for timber floors).</p> <p>Existing buildings would need to be temporarily lifted, and possibly relocated, for the new foundation to be constructed underneath.</p> <p>Enhanced lightweight platforms also have the added benefit of raising floor levels higher above flood levels.</p>
Retrofit to strengthen existing foundations and buildings	<p>While the primary focus of the MBIE Canterbury rebuild guidance is on robust design of new buildings and repair of damaged buildings, some of the same concepts could be applied for proactive retrofit strengthening of existing buildings. This would avoid the need to lift/relocate existing buildings but might not provide the same performance as a new TC2 or TC3 foundation.</p> <p>For timber floor foundations this could include subfloor sheet bracing, bolt-spliced bearers, and enhanced connections between piles and bearers. Retrofit strengthening may be more difficult for concrete slab foundations but could include internal and perimeter tie beams and edge stiffening.</p> <p>There may also be opportunities to enhance the superstructure, such as sheet claddings/linings, lightweight roof/cladding, stiffening walls, and enhanced connections between walls and roof framing.</p>
No improvement	Foundations and buildings remain in their current state.
<p>NOTE: The foundation concepts in this table are for simple lightweight timber-frame buildings (such as typical houses, or small commercial buildings of similar construction). It might be possible to apply similar concepts to other types of building, but this would need specific engineering assessment. For all buildings, actual details would need to be determined as part design, to meet Building Code performance requirements for building consent.</p>	

Table 13-5 Liquefaction mitigation techniques for reducing damage to infrastructure (T+T, 2023).

Works	Description of mitigation techniques for reducing damage to infrastructure
New infrastructure with resilient detailing	New infrastructure should incorporate resilient detailing to better accommodate displacement. This includes avoiding higher hazard areas, providing redundancy within a system, adopting appropriate technology (e.g., pressure sewer), careful selection of pipe/cable materials, robust/flexible connections, utilising details that resist uplift, and granular/cemented trench backfill.
Retrofit to strengthen existing infrastructure	For existing infrastructure, opportunities to enhance the entire network can be more limited (short of complete replacement). However, detailed assessment of the system may identify critical ‘weak links’ where targeted upgrades can improve the overall resilience of the wider network.
No improvement	Infrastructure remains in its current state.



## FUTURE TOOLBOX - LAND USE PLANNING AND GOVERNANCE MEASURES

The Coastal Hazard Guidance (MfE 2024) identifies planning responses to avoid (or reduce where appropriate) greater exposure to coastal hazards and risk. These responses could also be considered for other natural hazards:

- Down-zoning can prevent intensification or exclude areas from further development or redevelopment (Policy 25, NZCPS, DOC, 2010).
- Create rules to discourage or limit specified activities in identified hazard areas, using the full range of Resource Management Act 1991 activity classifications, including prohibited activities. When used in association with hazard lines, zoning or overlays, this can ensure that development occurs only in accordance with a consenting process and subject to conditions, or it may prohibit further development entirely. For example, ‘restricted’ or ‘full discretionary’ activity status is an opportunity for a consent authority to set controls through conditions on building location or design in specified zones or certain sites, or to decline consent. ‘Prohibited’ activity status means that no consent can be sought for specified activities in the identified locations. The district plan must specify the discretions and prohibitions.
- Land filling and raising floor levels are temporary adaptation measures and can be prohibited in specified locations to avoid further development that will create legacy effects.
- Other methods and techniques that can be used in statutory planning to manage natural hazards and risk include:
  - designation of protection or buffer areas, which may be used to provide for infrastructure.
  - no subdivision areas.
  - temporary development or land-use consents.
  - covenants, easements, and consent notices.
  - specifying types of construction and building design and use (e.g., relocatable buildings)
  - land information memoranda (LIM) or project information memoranda (PIM).
  - bonds.
  - land purchase.
  - special rating areas for funding capital and maintenance of protection, applied under the Local Government Act 2002, could be used to fund capital or maintenance of protection. The areas to which a special rate is applied, and the rate itself, must be justified based on the benefit obtained from the council activity.
- grants and information support.

## FUTURE TOOLBOX - RETREAT / RELOCATION

Retreat (or relocation) is the process of moving away from high-risk areas. There are no current opportunities for voluntary buyouts or funding for land acquisition in the Head of the Lake area. However, these responses remain in the future pathways in case of future need. Responsibilities for retreat are not defined in this first iteration of the Strategy, due to a lack of legislative clarity.

**Reactive retreat** describes retreat from affected (or unsafe) land after a natural hazard event has occurred. Aotearoa New Zealand examples tend to be one-off programmes coming out of disaster recovery:

- Land acquisition in Christchurch residential red zone – in response to the 2010/2011 earthquakes and liquefaction events.
- Future of Severely Affected Locations (FOSAL) buy-out programme – in response to 2023 North Island floods and Cyclone Gabrielle.

**Managed relocation** describes a planned relocation of people, buildings, and infrastructure out of harm's way before damage is suffered.

- Recent review of current law and policy by Environmental Defense Society (EDS, 2022-2024) has identified that the current legislative tools in Aotearoa New Zealand are not fit for the purpose of managed relocation. EDS highlighted various concerns, such as a lack of clear rules around development in areas subject to risk, gaps in responsibilities, lack of a legal framework linking adaptation plans to funding, and problems with acquisition of affected land under current law.

## Appendix C – Summary of feedback on Draft Strategy

*Feedback on the Draft Head of Lake Whakatipu Natural Hazards Adaptation Strategy was gathered from 5 December 2024 to 23 February 2025 through four methods: an online survey, a paper-based survey, email, and post submissions, and in-person community engagement sessions. Below are the key findings and recommendations based on the feedback.*

### **Summary of respondents' feedback**

1. The Strategy is highly valued by respondents. It is seen as practical, grounded in scientific investigations, and developed through an inclusive and collaborative process.
2. The vision of the Strategy aligns with most respondents' perspectives, with 4 out of 5 respondents either fully agreeing or agreeing to some extent. One respondent disagreed.
3. Respondents support a mix of physical and non-physical adaptation approaches, including building resilient infrastructure and integrating adaptation into everyday decision-making.
4. While the Action Plan is comprehensive, respondents recommend prioritizing certain physical works for immediate implementation to address current and future natural hazard risks and climate change impacts.
5. There is strong interest in the Future Toolbox, with preferences for physical, nature-based solutions and policy-driven adaptation measures.
6. The community engagement approach for the programme overall was well-received for providing an opportunity for direct feedback and discussing specific concerns. Community attendance was low for the specific engagement activities around the Draft Strategy. This may be because the community members already understood the Strategy, its development process, and felt less need to engage further.

### **How the feedback was considered in the final Strategy**

1. The following feedback has been used to improve the Strategy:
  - **Section 1– Introduction:**
    - Some feedback questioned why the programme's process was so extensive. We have clarified that the thorough approach was necessary to gather robust information for a complex environment and ensure comprehensive community input through a collaborative and inclusive process that is best practice for New Zealand.
    - Additionally, we have revised the Introduction to highlight that similar programmes are being implemented in other locations across Otago, such as South Dunedin and

Clutha Delta, where different natural hazard challenges exist. This approach is also being undertaken in many communities nationwide.

- **Section 5– Setting the Scene:** Feedback emphasized the importance of protecting historical and archaeological heritage. In response, we have added a new ‘Heritage’ subsection discussing key historical and archaeological sites in the area and the obligations associated with their protection.
  - **Section 5.5– Economic Profile:** Feedback representing that the social and economic impact assessment done by Beca in 2024 underestimated the area's GDP, with actual contributions potentially being significantly higher. We have added a note in this Section to capturing the point of view of Glenorchy Community Association.
  - **Section 5.7– Meteorological and Hydrological (Glenorchy Lagoon):** Feedback reported observations regarding inflows to the Glenorchy Lagoon. We have changed the section to state: ‘While no surface-flow stream channels directly carry flow from the Rees River to the lagoon, several relatively permanent streams, fed by groundwater (indirectly sourced from the Rees River), maintain a steady flow.’
  - **Section 7.1– Otago Regional Policy Statement:** Feedback suggested that more intensive development in Glenorchy is inappropriate because the township face high-risk. We refer to Section 7.1 which presents key principles of the Proposed Otago Regional Policy Statement (June 2021).
  - **Section 10– Action Plan:**
    - Feedback recommended improved monitoring of erosion. We have added a note in the section describing that the monitoring of geomorphic changes and risks will be at a catchment scale when appropriate.
  - **Section 9.4**
    - Feedback highlighted that local people have their own knowledge and practices for adaptation. This viewpoint is considered as part of ‘private property resilience’ in the Table 9.6: Long-list of Adaptation Responses which highlights individual responses for both current and future, including (1) household emergency planning, (2) property and business insurance (adjust coverage as needed), and (3) Improve property and land resilience (such as floodproofing, floor raising, ground or structure strengthening).
  - **Section 13– Appendices:**
    - Feedback provided valuable insights that helped improve the Draft Strategy. To demonstrate how this input has been considered, we have added Appendix C summarizing key feedback and how it has been integrated into the final Strategy.
2. Information about Alpine Fault ([AF8 \[Alpine Fault magnitude 8\]](#)) risks will be shared in upcoming Newsletter so increase community awareness of this information.



3. ORC will discuss residual risks quantifications directly with Glenorchy Community Association.
4. ORC will seek to improve the clarity and accessibility of scientific information and improve livestream audio quality for future community engagement.



## Head of Lake Whakatipu Natural Hazards Adaptation Strategy Overview

Version 1 May 2025

### Contents

1. What is this Strategy?
2. What matters most to the community and mana whenua? This is what we heard...
3. Why do we need to adapt?
4. What do we rely on for natural hazard management now? How are we planning to enhance and improve?
5. What might the future look like? Do the same? Do better? Do things differently?
6. How will we know when future decisions are needed?
7. How will we work together to implement the Strategy?
8. How will we review and adjust?

Quote:

*‘It’s definitely a unique community and it values its environment. I think underpinning all of this is this understanding that the environment is bigger than us.’*

## 1. What is this Strategy?

### Preface

The Head of Lake Whakatipu Natural Hazards Adaptation Strategy (the Strategy) is a partnership between Otago Regional Council, Queenstown Lakes District Council, Civil Defence Emergency Management Otago and the community. It provides a common direction for our natural hazards management and adaptation planning and decisions at Head of Lake Whakatipu / Whakatipu Waimāori. It also supports everyday decision making by individuals and the community.

The Strategy has been developed over five years and is the result of collective effort. A range of organisations, subject matter experts and individuals have contributed.

Natural hazard resilience at Head of Lake Whakatipu is reliant on a strong foundation of existing responses. Our Action Plan aims to build and improve upon our foundation.

As the landscape and climate change, we may need to consider big questions — do we do the same? Do things better? Do things differently?

Our Future Toolbox contains possible responses that may help us adapt further as we face future changes.

Possible future responses are high-level concepts at this stage (not commitments). More information about detailed costs, benefits and risks would be required to inform future decision making.

Over time we will review, adjust, and improve this first version of the Strategy. We will also track progress on our actions and check in with the community.

Mana whenua, key stakeholders, and the community are encouraged to continue their involvement in implementation and future versions.

The Strategy is a non-statutory plan. It does not carry decision-making power or create any legal obligations. Other statutory processes, such as long-term plans, also offer opportunities for public participation and alignment. This highlights the shared responsibility in managing natural hazards in the area, now and in the future.



\*\*\*these steps will be shown on a journey diagram\*\*\*

## Our adaptation journey

The Strategy has been developed using the Dynamic Adaptive Pathways Planning approach which includes the following steps:

- **What is happening?** Study our changing weather and environment. Assess the hazards and risks facing the Head of Lake Whakatipu. Gain a shared understanding of the science and local knowledge.
- **What matters most?** Work with the community and mana whenua to understand what they value most about the Head of Lake Whakatipu area — including places, things, and other taoka (treasures).
- **What can we do?** Identify a long-list of possible responses for managing risk and adapting to change. Evaluate the high-level pros and cons.
- **Make it happen.** Combine the existing responses that we rely on into a strong foundation and identify possible future pathways (covering different areas and time frames). Agree on signals, triggers and events that mean it's time to put different parts of the plan into action.
- **Create a plan.** Capture everything in an Adaptation Strategy. Action what we can within current constraints. Keep the plan moving forward.
- **Is it working?** Our environment and climate keeps changing and we do too. Keep monitoring for success and for signals that it's time to shift pathways.
- **Improve things bit by bit.** Check in with the community, review and update the Strategy regularly. Take advantage of new opportunities.

## How can we support the community to adapt, live and thrive into the future?

‘The Head of the Lake’ has a strong community spirit and self-organises to meet community aspirations.

We are facing natural hazard challenges and future uncertainties. The area at the Head of Lake Whakatipu is exposed to multiple natural hazard risks, and this risk setting is compounded by landscape-scale changes and a changing climate. There are no simple solutions.

We need to plan for the long term — to work together to build our adaptative capacity — to cope, adjust, respond and transform over time.

This Strategy will help us take advantage of opportunities and to better cope with the consequences now and in the future at the Head of Lake Whakatipu.

### Vision and goals

‘Our vision is a resilient and sustainable Head of Lake Whakatipu, where proactive natural hazard and climate adaptation enhance community wellbeing and safety and contribute to a flourishing environment.’

1. Adaptation is woven into our everyday work
2. Lay a robust foundation for decision-making
3. Healthy and resilient communities
4. Resilient built places, infrastructure, and systems
5. A flourishing environment

### Key principles

Development and implementation of the Strategy is guided by key principles.

- Take a **holistic and long-term view** to natural hazards risk management and adaptation efforts.
- **Partner and collaborate** with mana whenua, partner agencies, communities, and stakeholders.
- Make **robust decisions** using the best available evidence.
- Be **community-centered**.
- **Be flexible** and adjust as we go.
- Consider **co-benefits** for adaptation efforts to achieve complementary goals.
- Promote **fairness and equity** for and between communities and across generations.
- **Uphold te Tiriti o Waitangi**.
- **Align with national-level direction and policies**.
- Adaptation efforts should **work with nature** as much as possible.
- Be **open and accountable**. Ensure progress is transparently communicated.
- Consider **cost-effectiveness and practicality** to ensure that resources are used efficiently and that they reduce risks to what is reasonable, practicable, and acceptable to partners and the community.

Quote:

*‘People come from all walks of life and the community is a lot more diverse than it used to be - community still comes together when it needs to’*

## 2. What matters most to the community and mana whenua?

### This is what we heard...

#### Community Outcome Statements

People provided many insights into what matters most to them at the Head of the Lake. Together, these values make up a set of **community outcome statements** that provide guidance for decision making now and into the future.

1. A community that feels supported and safe from the impacts of natural hazards
2. Residents feel at home, connected to their environment and supported by the experience of community
3. A beautiful environment and a feeling of connection with nature
4. Sustainable, functioning ecosystems
5. The opportunity to make a living
6. Be resilient and self-determining
7. Functional, resilient and accessible infrastructure, support services and emergency response
8. Heritage is safeguarded and accessible
9. A healthy community that promotes the wellbeing of all

#### Values

Some overarching community values emerged from all the feedback and engagement activities over five years:

- Lifestyle and wellbeing — people feel safe to do their day-to-day activities. A sustainable, self-sufficient and resilient community.
- Environment — sense of stewardship and connection to nature — mountains, rivers, lakes. A place for wildlife and biodiversity to thrive.
- Belonging — a feeling of home. A strong sense of community where people support and take care of each other.
- Recreation — being able to enjoy recreation and links to the broader environment. A place for residents and visitors to enjoy together.

The community vision for the area (Sharing our Future 2016):

*“A unique, inclusive community that fosters and embraces individuality, diversity and innovation, encourages resilience and promotes community vitality and collaboration. The Glenorchy community has a collective strong voice that advocates for positive change.*

*Glenorchy has the infrastructure to support a thriving boutique local economy in keeping with the rural landscape, actively respects and enhances the natural environment, collectively works towards providing their own resources (self-sufficiency).”*

In the 2001 Community Plan, core resident values included being safe, caring, self-reliant, welcoming, working together, and respecting the environment (Blakely Wallace Associates, 2001). Residents also valued the history of the area, the rural atmosphere, peacefulness, landscapes, and having the wilderness at their doorstep.

## Mana whenua values

The Head of the Lake area is immensely significant to mana whenua.

To uphold the mana of kā rūnaka, it is crucial that mana whenua have authority over how their manawa (aspirations) for the future are portrayed and represented in this Strategy and in future actions.

Aukaha, as mana whenua representative, identified key values that offer a glimpse into a mana whenua worldview with respect to the area and the programme of work.

### Ka Uara — core cultural values:

- **Mana** — mana whenua are leaders, influencers and partners.
- **Mauri** — protect and enhance the mauri (life force) of the Head of Lake Whakatipu, now and well into the future.
- **Whakapapa** — the traditional authority of mana whenua at the Head of the Lake is recognised ancestral rights which give mana whenua the mana and kaitiaki responsibilities.

### Additional Kāi Tahu values include:

- **Ki uta ki tai** — interconnectedness of the whole environment, commonly translates to ‘from the mountains to the sea’.
- **Kaitiakitaka** — intergenerational and inherited responsibility and stewardship on behalf of future generations.
- **Manaakitaka** — expressing aroha, hospitality, generosity and mutual respect. Processes and decisions that enable positive social outcomes and support wellbeing.
- **Mahika kai** — ability to, and access to, gather or harvest resources. Ensure a healthy functioning ecosystem and sustainable harvesting practices.
- **Wai Māori and Wai Ora** — importance of protecting and enhancing the wellbeing of all bodies, as water is a sacred entity in te ao Māori and is the source of all life.
- **Maumaharataka** — acknowledging and upholding memories of the past and Kāi Tahu pūrākau (stories).
- **Whakawhanaukataka** — relationship and community building, working together for the benefit of the community.

Quote:

*‘There’s something about it. I can’t put my finger on it. It feels like home. Everybody does become like your extended family. That’s the thing — it’s the community and the people for me. Despite the amazing stuff and mountains, it’s the people that have kept me here. It’s small but it’s not constrained either. It’s close to so much that I love — the outdoors.’*



### 3. Why do we need to adapt?

#### History of adaptation

The land and waters of Aotearoa New Zealand are alive and always changing. Natural hazards are everywhere. People have adapted to landscape-scale changes in the past and are currently adapting to and living with natural hazard challenges in the present. We will continue to adapt to the dynamic natural environment into the future.

The challenges at the Head of Lake Whakatipu / Whakatipu Waimāori exist because of its location, history, what the land is made of, and the ways the land has been used in the past and present.

Adaptation to the growth of the Dart–Rees delta has meant that people have moved the location of the Glenorchy jetty so boats could continue to access Head of the Lake communities. The current Glenorchy jetty is the third constructed over the township history. We can tell this from old photos, maps and street names.

Kinloch wharf illustrates a current challenge. In the 1890s Kinloch wharf had sufficient depth of water to service the paddle steamer S.S. Mountaineer; then the bay at Kinloch was rapidly infilled from the early 2000s; and now the Kinloch wharf is unusable due to delta sedimentation.

The Glenorchy School was moved to its present site in 1939 because the old site was exposed to Buckler Burn hazards.

**\*\*photos of Kinloch wharf\*\***

Quote:

*‘Everyone helps each other out like family because if your car broke down on the road, you would hope people stopped for you, and you would stop for people’.*

## Mana whenua history

The landscapes of the Head of Whakatipu Waimāori (Lake Whakatipu) tell generations of Kāi Tahu stories and histories.

### The arrival of Waitaha and Rākaihautu:

According to Kāi Tahu tradition, the Waitaha were the first people to arrive in Te Waipounamu (the South Island).

It is written that the Waitaha arrived in Te Waipounamu on a great canoe called Uruao, which was captained by Rākaihautū. It is said that Rākaihautū used his famous kō (Polynesian digging tool) to form the major lakes of Te Waipounamu, which included Whakatipu Waimāori.

The genealogies of the Waitaha people can be traced from Rākaihautū through to his living descendants, the modern day Kāi Tahu.

“Ko Rākaihautū te takata nāna i timata te ahi ki tenei motu.” (It was Rākaihautū who lit the first fires on this island.)

Kāi Tahu taoka (treasures) cover the landscape; from the ancestral mauka (mountains), large flowing awa (rivers), tūpuna roto (great inland lakes), pounamu, and ara tawhito (traditional travel routes/trails), which connected kāika (settlements) and nohoaka (seasonal settlements) and mahika kai resources.

These all make the area immensely significant to mana whenua.

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## European history

The Head of the Lake community has a long history of resilience. Scheelite mining, gold mining, sawmilling, farming and tourism have all in some way supported the small, close-knit townships of Glenorchy and Kinloch.

While many people are attracted to the area because of its natural beauty, the relative remoteness of the area shaped both the economy and the types of people who lived there.

Community members have long been characterised by a ‘number 8 wire mentality’ and self-sufficiency. The community have a strong sense of identity, cohesion and shares aspirations for the future.

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## Present day community and challenges

The Head of the Lake population has doubled over the last 20 years, with increased land-use and development pressures, and growth in the number of residents who rely on the road to Queenstown for their day-to-day lives.

Some residents may be less aware of the challenges that natural hazards pose in the area. Today, tourism is the dominant industry.

There are further challenges to support tourists and day visitors in the face of potential natural hazard events.

## Natural hazards at the Head of Lake Whakatipu

A dynamic landscape with a wide range of potential natural hazard impacts, including a high potential for cascading hazard scenarios, where one hazard triggers another (e.g. landslides triggered by earthquake shaking). Landscape and climate changes contribute to future uncertainties.

### Terrain/slope hazards

Landslides are a common occurrence in the Dart and Rees catchments, due in part to unstable geology. Rainfall, earthquakes and changes in land use can also trigger landslides.

### Tributary hazards

Side streams that feed into the rivers and lake have local hazards, such as erosion, flooding and sediment deposition. Some streams have the potential for debris floods, which are a fast-moving mix of loose sediment, rock and water, and can be a very dangerous and destructive form of flooding.

### Climate change

By 2090, winter and spring rainfall are projected to increase in the catchments, with more intense storms and additional heavy rainfall days. Flood flows are also projected to increase in magnitude due to climate change.

### Floodplain hazards

The Dart and Rees catchments naturally supply huge amounts of sediment into the rivers. Active river channels and the delta are always changing in response.

Low-lying land adjacent to the Rees and Dart rivers is subject to flooding. Floodwaters can damage land, property and infrastructure, and interrupt local road access. Damage can occur due to erosion, inundation, and sediment left behind by floodwater.

Bank erosion is currently a threat to Kinloch Road, due to the ongoing westwards migration of the Dart River active channel.

Build-up of sediment in the bed of the active channels will continue. Future landscape changes are likely when the rivers break out of current paths, seeking new channels on lower parts of the floodplain.

River delta growth will continue. Areas of higher growth depend on where the main channels are discharging sediment and are likely to vary with future channel movements.

The effectiveness of current Kinloch wharf, Glenorchy jetty, Rees River bridge and floodbanks are all affected by sediment build-up.

### Earthquake hazards

Earthquakes cause ground shaking in response to rapid release of built-up strain along fault lines.

Numerous mapped fault systems are present in the wider area. Nearby possible active faults include the West Whakatipu Fault, located approximately 2 km west of Kinloch and the Moonlight Fault, approximately 15 km east of Glenorchy.

The most notable fault in the area is the Alpine Fault, some 55 km to the nearest point from Glenorchy. The likelihood of an earthquake triggering at some point along the 800-km-long Alpine Fault over the next 50 years is 75%, with an 82% chance that the earthquake event would exceed magnitude 8.

Earthquake shaking can cause damage directly. Strong shaking can also trigger additional cascading hazards in some areas, such as landslides, and liquefaction and lateral spreading.

Liquefaction and lateral spreading hazards can occur when strong ground shaking during an earthquake disturbs ground sediments, causing them to behave as fluid. This can deform the surface of the ground, damaging buildings, roads and underground infrastructure.

An earthquake shaking hazard at Kinloch and Glenorchy is expected to pose the greatest risk to buildings and lifelines infrastructure through structural damage, compared to relatively few injuries or deaths.

All the lower lying areas of Glenorchy township in the north and west are vulnerable to liquefaction, and significant and widespread land damage may occur for strong earthquake shaking. The potential for lateral spreading damage, such as land cracking, is highest near the lake edge and decreases with an increasing distance from the lake

Potential ‘Alpine Fault Magnitude 8 (AF8)’ - A credible science-based hazard scenario developed by AF8 to help us plan and prepare for an Alpine Fault earthquake:

*‘Central Otago will likely experience 2-3 minutes of strong shaking in this South to North rupture scenario. The shaking will likely trigger snow/ice avalanches, landslides and rockfalls on mountain and hill slopes, making some roads impassable and potentially isolating communities in the area.*

*Central Otago lakes could be affected by landslide-triggered tsunami, making it important for communities to know the ‘Long or Strong, Get Gone’ messaging.*

*Thousands of tourists may be stranded in the area, unable to get home and will need to be looked after for days due to damage to roads. Some areas may lose power and telecommunication services.*

*Emergency Management Otago has information to help you plan and prepare for emergency events in your region.’ ([www.af8.org.nz](http://www.af8.org.nz))*

### **Hazards along the Queenstown–Glenorchy Road**

The Queenstown–Glenorchy Road provides the only road access in and out of the Head of the Lake area for residents and visitors.

The community relies heavily on the road to access goods, services, employment, education, recreation, and health care outside the area. The road traverses many locations exposed to debris flow, flooding or landslide/rockfall hazards.

One example is Shepherds Hut Creek, where a debris flow event disrupted road access in 2022.

### **Buckler Burn hazards**

The Buckler Burn is very dynamic, with unstable terrain, a high sediment supply, and channel movement.

Over a very long time, Buckler Burn has deposited sediments directly into the lake, forming an alluvial fan landform and delta. The land under most of Glenorchy township consists of old deposits from Buckler Burn and Rees River.

In large floods, Buckler Burn may break out along Oban Street and cause minor flooding in the township area. Bank erosion is also a threat to a section of Queenstown–Glenorchy Road, which is near the current active channel. However, Buckler Burn debris flows are considered unlikely to be a threat to Glenorchy.



The present-day alignment of the active channel and area of delta growth is along the most southern limit of the fan. The fan surface may build up in the future and northwards migration towards the township should be anticipated.

#### **Dart and Rees river hazards**

The Dart and Rees rivers are very dynamic, with a high sediment supply, active channel movement and continued delta growth into the lake.

Glenorchy Lagoon and the existing Rees–Glenorchy floodbank provide some protection from smaller, more frequent Dart–Rees flood events.

In larger Dart–Rees floods (20-year average recurrence interval and above), the floodbank is overtopped and flooding occurs in northern parts of Glenorchy township.

#### **Lake Whakatipu hazards**

High lake levels can cause flooding of low-lying areas adjacent to Lake Whakatipu, including parts of Kinloch and Glenorchy (alongside the lake and floodbank).

Lake floods are often associated with a series of rainfall events close together, and the lake may remain at high levels for days to weeks.

Lake levels typically rise relatively slowly, with more time to respond than other sources of flooding.

#### **Quotes:**

*‘You can see climate change if you are connected to nature ... you can’t live here and not be aware of it ... you need to be attuned to it.’*

*‘I think what you have is an enormous wealth of understanding; people who are very closely connected with the landscape ... People who are going out after every flood, as they’re watching during every flood and they’re keeping a very close track on what’s happening. You are dealing with a community who are pretty well aware of their landscape and engage with it in so many different facets. They’re not just around the lagoon; these people are riding up the hillsides, they’re tramping everywhere, they’re fishing, they’re boating, and they’re doing the whole gambit of ways of engaging with the natural environment. They’re acutely aware of that.’*

## 4. What do we rely on for natural hazard management now?

Natural hazard resilience at the Head of Lake Whakatipu is reliant on a strong foundation of existing responses.

### How are we planning to enhance and improve?

Existing responses are an important part of the picture and go partway towards addressing the needs of the area. Our Action Plan will build and improve upon this base to increase resilience.

Quote:

*‘Glenorchy has a strong and deep community network that is easily called upon in emergencies.’*

\*\*\*graphic that includes the different aspects of resilience\*\*\*

## 5. What might the future look like?

### Do the same? Do better? Do things differently?

Existing and planned responses are reviewed periodically to assess if they are still working for us.

Over time we might choose to improve, adjust or expand our current approaches. In the future we might reach a point where our current approaches no longer work well for changed conditions and we will need to consider ‘doing things differently’.

Future challenges might require a different set of responses. That is why the ‘Future Toolbox’ includes both standard ways to manage hazards, and innovative ideas.

Possible responses in the Future Toolbox are not commitments at this stage. Some possible responses fall outside the current roles and responsibilities of partner agencies.

There should be no expectation that the Strategy partners will or will not undertake any particular mitigation works.

Quotes:

*“In our existing places, people can work together to reduce risk through social networks, nature-based and hard-engineering solutions, through upgrades to existing buildings and infrastructure to withstand more extreme climatic conditions, and by being better prepared. Councils and communities should consider the full range of adaptation options for areas under threat.” — National Adaptation Plan 2022*

*‘Some are good at leading and mobilising others, and others are good at getting stuff done ...’*

*‘As long as there are still people here, and two thirds of the dwellings are still habitable, I would say we would probably stay put.’*

EXISTING RESPONSES — we currently rely upon as a foundation	FUTURE TOOLBOX (NOT COMMITMENTS)— contains possible responses that may help us adapt further as we face future changes.
<b>ACTION PLAN</b> — to build and improve upon our foundation	
<b>EXISTING RESPONSES - Hazard awareness</b> <ul style="list-style-type: none"><li>Societal, behavioral, and institutional changes (improve over time) when considering natural hazards and changes to the physical environment</li></ul>	<b>Hazard Awareness (possible future responses)</b>  Review and accept residual risk for existing development
<b>ACTIONS: Governance and collaboration</b> <ol style="list-style-type: none"><li>Otago Regional Council (ORC) and Queenstown Lakes District Council (QLDC) collaborate to develop a governance framework or memorandum of understanding (MoU) for addressing adaptation issues at the Head of the Lake and/or across the district, including the implementation of adaptation actions to improve resilience.</li><li>Partner with mana whenua to ensure mana whenua values and aspirations and mātauraka Kāi Tahu are embedded into decision making and implementation of the Strategy, following the lead of Aukaha and Te Ao Mārama (ORC).</li><li>ORC, QLDC, Civil Defence Emergency Management Otago (CDEM), mana whenua and local community work together to ensure on coordinated and consistent approach to implementation of actions aligning with this Strategy.</li><li>Work together to mainstream adaptation across ORC work programmes and ensure our work aligns with this Strategy and towards achieving each goal.</li></ol>	
<b>ACTIONS: Advice, information and education (ORC)</b> <ol style="list-style-type: none"><li>Ensure the ORC Natural Hazards Portal includes up-to-date information on natural hazards and the impacts of climate change.</li><li>Maintain ORC Head of Lake Whakatipu adaptation web pages with relevant and up-to-date information.</li><li>Provide newsletter updates about programme milestones and/or progress towards actions.</li><li>ORC to attend Glenorchy Community Association (GCA) meetings as required, at least annually, to provide progress updates and check in with the community.</li><li>Ensure that ORC’s messaging about natural hazards adaptation and adaptation workstreams is communicated in a way that is understood by a wide audience.</li><li>Monitor the headofthelake@orc.govt.nz inbox for public enquiries and information relating to the programme. Consider other methods and tools for capturing community feedback.</li></ol>	



**EXISTING RESPONSES**

— we currently rely upon as a foundation

**ACTION PLAN**

— to build and improve upon our foundation

**EXISTING RESPONSES - Hazard mitigation**

- Emergency readiness and response (improve over time)

**EXISTING RESPONSES - Flood mitigation and protection**

- Maintain the flood monitoring network (rainfall and water level stations) and flood data history
- Flood monitoring, forecasting and warning (improve over time)

**ACTIONS: Information gathering and monitoring**

1. Investigate hazards and risks as part of usual business (ORC).
2. Geomorphic change monitoring and assessment — maintain an awareness of locations and scale of geomorphic changes (e.g. active river channel position, bed levels and rates of change) which may have direct impacts or exacerbate natural hazard characteristics (ORC).
3. Data collection to document major flooding (or other hazard) events — improve the recording and understanding of hazard event characteristics and the impacts of those events (ORC).
4. Monitoring and analysis of signals/triggers/ thresholds (ORC/QLDC).
5. Communication and reporting of physical environment monitoring — data collection and analysis findings will be communicated to key project partners and stakeholders (ORC).

**ACTIONS: Emergency Management**

1. Develop a long-term recovery plan for a potential major hazard event (ORC/CDEM/ QLDC).
2. Operate a network of near real-time rainfall and water level stations across the region to support flood forecasting and emergency response with a 24/7 duty roster to support forecasting duties and any necessary response (ORC/CDEM).
3. Monitor and ensure ORC’s network of environmental monitoring stations remains fit for purpose; providing information for flood response, for documentation of flood events, and for public awareness of river flow, lake and lagoon levels. Review ‘of’ performance of the flood forecasting systems (lake level and lagoon level forecasting).
4. Capability development and awareness raising — public and internal education, share lessons learned from other emergencies (CDEM).
5. Engagement with communities and stakeholders (before, during and after an emergency) (CDEM/ Community Response Group).
6. Risk communication and early warnings — provide right and trusted information about natural disasters to communities so that they can prepare effectively for emergency events (CDEM/QLDC).
7. Provide community resilience equipment, including equipment for communications and power (generator) (CDEM/QLDC).
8. Develop and share emergency guides and plans and update annually (Community Resilience Guide, Community Response Plan, Flood Guide, Emergency Hub Guide, Emergency Preparedness Brochure) (CDEM / Community Response Group).
9. Training and exercises for Community Response Group and Emergency Hub implementation (CDEM/ Community Response Group).

<div>EXISTING RESPONSES</div> <div>— we currently rely upon as a foundation</div> <div>ACTION PLAN</div> <div>— to build and improve upon our foundation</div>	<div>FUTURE TOOLBOX</div> <div>(NOT COMMITMENTS)—</div> <div>contains possible responses that may help us adapt further as we face future changes.</div>
<div>EXISTING RESPONSES - Flood mitigation and protection</div> <div><ul style="list-style-type: none"><li>Existing low- level Rees River flood protection by Glenorchy floodbank (maintenance and reactive repair)</li><li>Existing river management (vegetation and gravel)</li></ul></div> <div>EXISTING RESPONSES - Road access</div> <div><ul style="list-style-type: none"><li>Maintenance, reactive repair and planned works for the Glenorchy– Queenstown Road</li><li>Maintenance, reactive repair and planned works for the Kinloch and Glenorchy–Paradise local road system</li></ul></div> <div>EXISTING RESPONSES - Boat access</div> <div><ul style="list-style-type: none"><li>Existing boat access at Kinloch and Glenorchy (limited by existing and ongoing sediment accumulation)</li></ul></div> <div>ACTIONS: Addressing impacts of natural hazards and climate change</div> <div><ol style="list-style-type: none"><li>Routine maintenance of QLDC transport network, including roading assets, Glenorchy jetty and marina.</li><li>Glenorchy Area Bridge Resilience (QLDC 24–34 LTP)— non-routine work required to protect the serviceability of the Glenorchy, Paradise and Rees River bridge assets following damage and to minimise threat of road closure due to natural phenomena.</li><li>Raising Kinloch Road (QLDC 24–34 LTP) — raising Kinloch Road in conjunction with two- yearly gravel extraction under the Rees River bridge.</li><li>Develop Operational River Management Plans, including the Dart and Rees floodplains (ORC).</li><li>Develop a gravel management plan for the Buckler Burn (ORC).</li><li>Annual vegetation management, rock armouring and gravel management (ORC)— ongoing river management activities (such as regular vegetation control in Lagoon Creek / lagoon area).</li><li>Maintenance of Rees River floodbanks (ORC) — maintain (not renew or increase) the existing banks (*Rees River floodbanks are not owned by ORC).</li><li>Floodplain and rivers (ORC)— create/trial NBS groynes.</li></ol></div>	<div>Flood mitigation and protection (possible future responses)</div> <div><ul style="list-style-type: none"><li>Small-scale improvements to Glenorchy floodbank to maintain/reduce flood risk</li><li>Major works to increase level of service of Glenorchy floodbank</li><li>Redesign Rees flood protection for changed conditions (e.g. post event)</li><li>River management and nature-based interventions (e.g. targeted planting)</li><li>Redesign nature-based interventions for changed conditions</li><li>Small-scale works to reduce Buckler Burn erosion and/or flood risk</li></ul></div> <div>Road access (possible future responses)</div> <div><ul style="list-style-type: none"><li>Small-scale improvement to existing Kinloch and Glenorchy–Paradise local road system (as well as maintenance and reactive repair)</li><li>Reduced level of service of existing Kinloch and Glenorchy–Paradise local road system (e.g. some parts 4WD only)</li><li>Major works to increase resilience of Kinloch and Glenorchy–Paradise local road system (e.g. protect, raise, realign)</li><li>Reactive redesign Kinloch and Glenorchy–Paradise local road system for changed conditions (e.g. post event)</li></ul></div> <div>Boat access (possible future responses)</div> <div><ul style="list-style-type: none"><li>Short-term improvements to existing boat access (e.g. dredging)</li><li>Upgrade boat access with resilient solution (e.g. relocatable wharfs)</li><li>Relocate wharfs periodically to maintain future access</li></ul></div>

<div>EXISTING RESPONSES</div> <div>— we currently rely upon as a foundation</div> <div>ACTION PLAN</div> <div>— to build and improve upon our foundation</div>	<div>FUTURE TOOLBOX</div> <div>(NOT COMMITMENTS)—</div> <div>contains possible responses that may help us adapt further as we face future changes.</div>
<div>Public asset resilience</div> <div>ACTIONS: Addressing impacts of natural hazards and climate change</div> <div><div>1. Glenorchy Adaptation Pathways (QLDC 30 Year Infrastructure Strategy)—work on social infrastructure required to address selected adaptation pathways.</div><div>2. Head of the Lake Adaptation (QLDC 24–34 LTP) — use Strategy to inform responses to identified hazards, providing scoped and costed solutions for input to the next QLDC LTP (27–37) and other key planning documents.</div></div>	<div>Public asset resilience (possible future responses)</div> <div>Improve resilience of critical assets in higher hazard areas (such as floodproofing, floor raising, ground or structure strengthening, retrofit, move elsewhere)</div> <div>Community-wide resilience (possible future responses)</div> <div>Community-wide improvement works for liquefaction hazard (such as ground improvement and strengthening existing buildings).</div>
<div>EXISTING RESPONSES - Private property resilience</div> <div><div>• Household emergency planning</div><div>• Property and business insurance (adjust coverage as needed)</div><div>• Consider local risk and hazard information when property decisions are required (e.g. buying/selling)</div></div> <div>ACTIONS: Addressing impacts of natural hazards and climate change</div> <div><div>1. Provide information and support property owners to undertake property-level interventions to improve their resilience to natural hazards risks (ORC).</div></div>	<div>Private property resilience (possible future responses)</div> <div>Improve property and land resilience (such as floodproofing, floor raising, ground or structure strengthening)</div>

<div><div><div><div><div><div></div><div>EXISTING RESPONSES</div><div>— we rely upon as a foundation</div></div><div><div>ACTION PLAN</div><div>— to build and improve upon our foundation</div></div></div></div></div></div>	<div><div><div><div><div><div></div><div>FUTURE TOOLBOX</div><div>(NOT COMMITMENTS)—</div><div>contains possible responses that may help us adapt further as we face future changes.</div></div></div></div></div></div>
<div><div><div><div><div><div></div><div>EXISTING RESPONSES - Policy and planning</div><div><ul style="list-style-type: none"><li>• Policy — existing land use zoning, rules and building controls</li></ul></div></div></div></div></div></div>	<div><div><div><div><div><div></div><div>Policy and planning (possible future responses)</div></div><div><ul style="list-style-type: none"><li>• Policy—review hazard and risk information and set appropriate requirements for new development</li><li>• Policy—strengthen land use controls in higher hazard areas to avoid additional exposure</li><li>• Policy and services — identify and make available lower hazard land for new building and/or relocation</li><li>• Recovery plan improvement</li><li>• Proactive relocation plan</li><li>• Voluntary proactive relocation from higher hazard areas</li><li>• Voluntary reactive post- event retreat from higher hazard areas</li></ul></div></div></div></div></div>
<div><div><div><div><div><div></div><div>ACTIONS: Policy and planning processes</div></div><div><ol style="list-style-type: none"><li>1. Consider natural hazard property information for resource and building consents (QLDC).</li><li>2. ORC and QLDC to collaborate to ensure common adaptation priorities, information and actions identified in this Strategy inform and input into the next ORC and QLDC long-term plan, spatial plan, district plan and other relevant policies and plans.</li><li>3. Natural hazard information included on LIM reports (QLDC).</li><li>4. ORC and QLDC to collaborate on path forward for assessing risk tolerance with the community (once the proposed RPS is operative).</li></ol></div></div></div></div></div>	



## 6. How will we know when future decisions are needed?

The Strategy uses an adaptive management approach, which aims to try to avoid unacceptable conditions by monitoring signals and triggers and using these to guide the timing of future decision making.

Adaptation thresholds for the Head of the Lake are based on what we have heard along the way. The selected signals and triggers weave adaptation into our everyday work and build on existing monitoring.

Other signals and triggers may be selected during implementation of the Strategy and development of operational plans.

- An **‘adaptation threshold’** is ‘what people do not want to happen’ (unacceptable conditions).
- An advanced **‘signal’** is something we can monitor. Signals help us get ready to move to new pathways with enough time for decision making and implementation. However, surprise situations can still occur, and so signals are not a guarantee that an adaptation threshold will be avoided.
- A **‘trigger’** is a point to review and make decisions whether to change responses or pathways. Triggers that occur ahead of an adaptation threshold are the most useful for forward planning.

### Adaptation thresholds

- Extended disruption to road access from Queenstown
- Frequent or severe damaging or disruptive events
- Loss of amenity and cultural values
- Lengthy displacement of people following extreme events
- Withdrawal of maintenance, decline in levels of service and increasing cost of repairs
- Unaffordable or high-excess insurance premiums or withdrawal of insurance and bank finance.

### Signals

- Growth in costs to maintain and repair assets
- Lower level of service (e.g. due to delta growth, river bed aggradation)
- Frequency, number or impacts of flooding events reaching nuisance level (includes residential areas, roads and agricultural land)
- Movement of active river channel towards high value areas and assets
- Negative impacts on community wellbeing
- Insurance affordability or coverage

### Triggers

1. Decision-making cycles (3-year, 10-year, 30- year) — the usual timing to consider partner agencies priorities, level of investment and business cases for changes. Public consultation is also required. These timelines are suitable for staying ahead of gradual changes. It is important that up-to-date analysis and reporting of signals feed into and inform the decision-making process. Signals can be considered both individually and in combination.
2. Opportunities — keeping adaptation goals front of mind, looking out for opportunities to take action and make progress.
3. Significant natural hazard event with unacceptable outcomes — an integrated, multi-agency approach will be required for effective recovery.

Quote:

*‘A lot of it is about the physical environment. It is a really beautiful place, it’s a spectacular place to live in. We have a huge amount of opportunities for awesome outdoors stuff. The other part of the equation is the community.’*

\*\*\*signals/triggers/pathways diagram\*\*\*

## 7. How will we work together to implement the Strategy?

The current responses are implemented by agencies through well-established planning processes, such as long-term plans and District Plan.

Many of the possible future responses are also standard ways of managing natural hazards. Decisions on continuing and future investment are made by the agencies during regular update cycles for their plans. Council plans typically have 3-year cycles and cover 10 years (e.g., council Long-Term Plans) to 30 years (e.g., council Infrastructure Strategies) periods.

Some possible future responses are out of the ordinary. Implementation of uncommon responses would require one-off, specialised planning, funding and governance arrangements.

If there is severe damage as a result of a natural hazard event, then it is likely that a tailored recovery plan would be put in place.

\*\*\*strategy implementation diagram\*\*\*

Quote:

*‘The Glenorchy-ites are a special breed. They are a very tight-knit community. There is something quite special in the water up there. They’re actually very knowledgeable people. The people who reside in Glenorchy are this great microcosm of some of the best brains around. Great people.*

*They come together quite nicely in this. They’re a bit of a pioneer spirit anyway. They are used to the idea of living independently up there and being resilient to nature; but also respecting nature and going, “You know what? You can’t build stopbanks and stuff to hold this thing back.”*

## 8. How will we review and adjust?

This is the first version of the Strategy. Over time we will review and adjust to keep up with future challenges.

We already collect information on social, economic, institutional and environmental conditions, as part of our existing business practices. We will use this information to track changes and monitor how the Strategy is working.

Every six years (or earlier if there is an urgent need), Otago Regional Council will conduct a comprehensive review and work with partners and community to ensure the Strategy is updated appropriately in light of new information.

Between updates, we will track progress on Actions and report back through a variety of channels, such as our website.

Quote:

*“We can see what’s happening with the delta advancing. But, to hear the explanation of why that’s happening, how it’s going to change in the future, how it’s only limited by the amount of water that comes down the river, and we know we will get more frequent heavy rain events, which will accelerate that. Then of course, as the land builds up behind it, it’s just going to carry on doing that.”*

## Acknowledgments

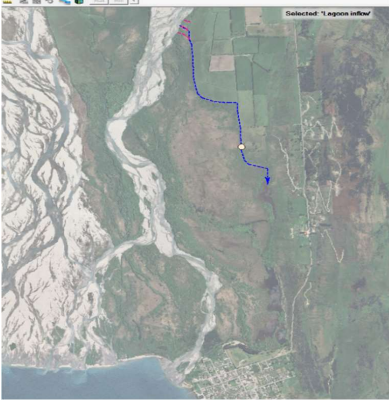
ORC and the Strategy’s partners gratefully acknowledge the many community members who shared their experiences, perspectives and aspirations throughout the development of this Strategy. The quotes included in this document reflect insights shared during our studies and community engagement events. We thank everyone who took the time to engage with us and help shape this work.

### Summary Report of Feedback on Draft Head of Lake Whakatipu Natural Hazards Adaptation Strategy

No.	Method	Theme	Feedback summary	Additional feedback and suggestions
1	Online Survey	Vision	The respondent fully supports the vision of the Strategy.	No further feedback from the respondent.
		Goals	The respondent prefers the goal: Integration of adaptation into everyday decisions.	No further feedback from the respondent.
		Action Plan	The respondent believes that we are doing enough to help the area adapt to natural hazards and climate change.	No further feedback from the respondent.
		Possible Future Adaptation Responses (Future Toolbox)	The respondent prefers that future adaptation responses should be implemented, including: (1) reducing level of service for Kinloch and Glenorchy-Paradise local road systems, (2) relocating wharfs periodically, and (3) improving the Glenorchy floodbank.	No further feedback from the respondent.
2	Online Survey	Vision	The respondent supports the vision of the Strategy to some extent.	No further feedback from the respondent.
		Goals	The respondent supports the following goals: (1) Integrating adaptation into everyday decisions, and (2) building resilient infrastructure.	No further feedback from the respondent.
		Action Plan	The respondent is unsure whether we are doing enough to help the area adapt to natural hazards and climate change.	No further feedback from the respondent.
		Possible Future Adaptation Responses (Future Toolbox)	The respondent recommends that in future, adaptation responses should include: (1) reviewing and accepting residual risk for existing development, (2) increasing level of service for Glenorchy floodbank, and (3) enhancing river management and nature-based solutions.	No further feedback from the respondent.
3	Online Survey	Vision	The respondent argues that the Strategy's vision does not align with their personal vision.	The respondent added: 'We have been adapting just fine for well over 100 years without interference from people and organizations that have no skin in the game'.
		Goals	The respondent believes that we should prioritize building resilient infrastructure.	They added: 'That is your job nothing less nothing more'.
		Action Plan	The respondent thinks that we are not doing enough to help the area adapt to natural hazards and climate change.	Some other feedback from the respondent:  'We are capable of adapting to most situations'.  'The action ORC needs to take is to carry out flood protection in a timely manner and do the work to a high standard not a temporary fix'.  'Spend the majority of our money doing physical work'.  'Hold contractors accountable in force the contract'.  'We require ORC to fix, repair, replace or build the infrastructure they are responsible for'.
		Possible Future Adaptation Responses (Future Toolbox)	The respondent recommends that we should prioritize implementing major works to improve resilience of Kinloch and Glenorchy-Paradise local road systems.	They added: 'The planing, the surveys, the meetings, the press, the investigations, the questions. None of which has resulted in any meaningful physical work to protect our property'.
		Other comments on the Strategy	The respondent provided additional comments on the Draft Strategy (presented in the next column).	'It is all very well forming plans and strategies for the future but in doing so ORC has devalued our properties significantly and dramatically increased our insurance costs all the while demanding increased rates'.  'Just do your job keep the water in the rivers and creek's and maintain the roading'.  'Be 100% transparent and don't waste our money'.  'The information asked for below is none of your business and a waste of our money stick to your knitting'.
4		Vision	The respondent supports the vision of the Strategy to some extent.	No further feedback from the respondent.



Summary Report of Feedback on Draft Head of Lake Whakatipu Natural Hazards Adaptation Strategy				
No.	Method	Theme	Feedback summary	Additional feedback and suggestions
	Online Survey	Goals	The respondent believes that we should prioritize (1) building resilient infrastructure, (2) integrating natural hazard adaptation into everyday decisions.	No further feedback from the respondent.
		Action Plan	The respondent does not believe we are doing enough to support adaptation in the area.	They added: 'Some hard actions now rather than a plan to a plan to make a plan'.
		Possible Future Adaptation Responses (Future Toolbox)	The respondent recommends that we should prioritize (1) implementing major works to increase level of service of Glenorchy floodbank, (2) improving river management and implementing nature-based interventions (e.g. targeted planting), and (3) improving resilience of critical assets in higher hazard areas (such as floodproofing, floor raising, ground or structure strengthening, retrofit, move elsewhere).	No further feedback from the respondent.
		Other comments on the Strategy	The respondent provided additional comments on the Draft Strategy (presented in the next column).	'The Glenorchy Community Association consider the economic assessment in the draft Strategy is inadequate and significantly underestimates the GDP of the head of the lake area and we are disappointed that having roasted this with the ORC it has not been revisited'.
				'We also asked for residual risks to be quantified - ie post intervention - so that we could see the effects of taking certain actions. Again this does not seem to have been acted on'.
				'We request that further engagement is undertaken prior to any work to amend and planning rules for the area'.
5	Online Survey	Vision	The respondent sees the Strategy's vision as aligning with their personal vision to some extent.	They added: 'After climate adaptation add: uses evidence-based information to support and .... This change would enable early separation of the debate into High impact, low frequency events such as an AF8 from low impact, high frequency events such as flooding/ high lake level'.
		Goals	The respondent supports the following goals: (1) building resilient infrastructure, and (2) protecting and enhancing the environment.	They added: 'A simplified hydraulic model (for example take the current hydraulic gradient of the Rees and the location of the entry point into the lake) could give a useful clue as to the value of keeping gravel out of the lagoon by a well designed nature-based solution. The eventual gravel height at Corner cottage if gravel enters the lagoon is likely to exclude the possibility of an effective flood bank'.
		Action Plan	The respondent is uncertain whether we are doing enough to support adaptation in the area.  Some their additional comments are presented in the next column.	'Extend the monitoring to include (at 10 year frequency) erosion processes in the river headwaters. Awareness of these would give advanced knowledge of rapidly rising river bed levels in the future'.
				'I am very keen to see more done on the design of NBS groynes and their potential to control gravel accumulation in critical parts of our flood plains'.
		Possible Future Adaptation Responses (Future Toolbox)	The respondent prefers some future adaptation responses such as (1) redesigning Natural based solutions, (2) implementing land use policy, (3) supporting low hazards risks for new development. They also provided additional comments (presented in the next column).	'More intensive development in Glenorchy is stupid within our high risk profile context. All strategies (including banning a centralized sewerage system) should be within scope'.
				'Similarly, having a retreat area identified now will be very useful if the AF8 makes Glenorchy uninhabitable'.
				'Is making Glenorchy porous to water overflowing our flood bank a Nature-based intervention. There are only about 3 houses that are regularly flooded and need raising above flood level, albeit a few more may have to be vacated for several days in a row every few decades (unless we develop a waste disposal system above flood height - which would be possible)'.
		Other comments on the Strategy	Additional comments on the Draft Strategy are presented in the next column.	'The thread influencing all these comments arise from the inherent difficulty language has in embracing evidence. Everyone would love for someone else to pay for our lives to be stress free, and our economic system would like these high-cost strategies to prevail, in part because there is more lobbying power to train people in certain disciplines that lead to path-dependency and more difficulty to change'.
				'I'm not convinced this is the only path available, hence drawing attention to information feed-back loops which have to potential to get the evidence into our brains without the use of spoken language'.

Summary Report of Feedback on Draft Head of Lake Whakatipu Natural Hazards Adaptation Strategy				
No.	Method	Theme	Feedback summary	Additional feedback and suggestions
6	Email	Setting the scene of the Strategy	The respondent really appreciates the Strategy and supports the current Section 5: Setting the Scene, but recommends that it should include information on historical and archaeological sites in the area and discuss statutory responsibilities for protecting these sites and their significance.	They have additional comments:  'The Section 5- Setting the Scene should have a new chapter which includes:  (1) Discuss about the importance of the archaeological sites at the area and how they should be considered into all our current and upcoming activity planning and implementation to adapt to natural hazards and climate changes'.  (2) Add an advice note to remind the reader that there may be additional obligations to comply with respect to archaeological sites, and thus the requirements under the HNZPTA 2014 prior to any works commencing.
7	Email	Glenorchy Lagoon	<p>The respondent believes that the information provided about the Glenorchy Lagoon may be inaccurate:</p> <p>'From my investigations, the lagoon is primarily fed by the Rees River year round during base flow conditions via seepage through the true left floodbank beginning ~500m south of Scotts Lane (See image attached below). The flow path shown below has a minimum of 0.3 m<sup>2</sup>/s year round and very stable flow'.</p> <p>'The other streams from the hillside to the east only flow in response to heavy rainfall or during prolonged wet periods and rapidly recede. Bible Stream in particular is normally completely diverted into the Buckler Burn upstream and only flows during very prolonged periods of heavy rain'.</p>	
8	Email	Attendance of the Community Presentation	The respondent noted that low attendance at the Community Presentation- Evening Session (compared to earlier community events) suggests that people may have already understood the the Strategy, its process as well as felt less need to engage further.	No further feedback from the respondent.
		The Strategy Development Process	<p>The respondent repeated a question raised by a community member: “Why was Glenorchy undergoing such an intensive process? Was it a trial process?”</p> <p>The questioner expressed concerns that the process appeared extremely expensive and possibly more extensive than what Glenorchy required.</p>	No further feedback from the respondent.
		Presentation of the Community Presentation	The respondent felt that the communication of scientific information and the Strategy was not engaging enough. They suggest improving science communication by using professional communicators and replacing text-heavy presentations with more visuals.	No further feedback from the respondent.
		The Strategy	The respondent found that the Strategy is good- pragmatic and understandable, but it seems to have been an overly intense process to get to what most people were thinking from the beginning.	No further feedback from the respondent.
9	Email	Livestream of the Community Presentation	The respondent appreciated that the community engagement sessions were offered both in person and online, allowing participants who could not attend in person to still be involved.	No further feedback from the respondent.
		Sound of the Livestream of the Community Presentation	The respondent pointed out that the sound quality of the online livestreaming was very poor. Some speakers were impossible to understand and for all speakers, the online participants had to concentrate very hard to follow.	They added that 'Future hybrid meetings, it is essential to ensure that there is good sound, otherwise people online will be frustrated with the process when they have devoted time to attending and that won't be good for their view of the ORC'.

### Summary Report of Feedback on Draft Head of Lake Whakatipu Natural Hazards Adaptation Strategy

No.	Method	Theme	Feedback summary	Additional feedback and suggestions
		Presenters of the Community Presentation	The respondent recommended that more clearly identifying who is speaking during presentations.	No further feedback from the respondent.
		Presentation of the Community Presentation	The respondent noted that there may have been too much detailed information presented at one presentation, making it difficult to absorb.	No further feedback from the respondent.
10	Community Presentation	Scientific Investigations	The participant highly appreciated the scientific investigations we have done over the year. They pointed out that those investigations have been very useful for and helped the community.	No further feedback from the participant.
	Community Presentation	Triggers and Signals	The participant highlighted that the triggers and signals in the Strategy were good because they tell the community an issue.	No further feedback from the participant.
	Community Presentation	Possible Future Adaptation Responses (Future Toolbox)	The participant noted that the Future Toolbox was good and the community was looking for it.	No further feedback from the participant.
			The participant also asked why ORC asked people to say whether they support managed retreat, voluntary or compulsory? when there are no clear government policies on the matter.	No further feedback from the participant.
11	Community Presentation	Action Plan	The participant asked: 'Which new actions in the Action Plan are the most impactful?'	No further feedback from the participant.
			The participant had other questions about the new actions in the Action Plan, including: (1) What's the value of the new actions? (2) how are they, (3) what are the gaps that they're filling? And (4) are they quite self-evident?	No further feedback from the participant.
			A final question from the participant was that 'are there any studies on tsunami?'	No further feedback from the participant.
12	Community Presentation	Natural Hazards Risks	The participant noted that the area is close to open faults and asked whether additional information on this risk is available from ORC or QLDC?	No further feedback from the participant.
13	Community Presentation	Triggers and Signals	The participant stressed that triggers and signals are important for our future adaptation responses because they help us prepare well and in advance the problems which are going to happen.	No further feedback from the participant.
	Community Presentation	Adaptation Pathways and Triggers	The participant asked: 'Whether that pathways process disappeared and if so, why and how do we put triggers in place to make sure we have these tools really when we need them?'	No further feedback from the participant.
14	Email	Strategy Approach and Engagement	The respondent described the Strategy as an 'outstanding and enduring program' that instills confidence in its evidence-based conclusions.	No further feedback from the respondent.
			They also appreciated the Strategy team's diligence and openness in sharing information with the community, noting that the consultation process has been well-received. The involvement of technical experts in geomorphology, hydrology, flooding, and seismic hazards was highlighted as being well-managed.	No further feedback from the respondent.
	Email	Leadership and Stakeholder Coordination	The respondent acknowledged ORC's leadership in bringing key stakeholders (QLDC, Civil Defence, Mana Whenua, and the community) together to achieve practical outcomes. They also noted that ORC and partners' implementation of seven of the Ten Steps in the Adaptation Cycle could serve as a case study for other District Councils.	No further feedback from the respondent.

Summary Report of Feedback on Draft Head of Lake Whakatipu Natural Hazards Adaptation Strategy				
No.	Method	Theme	Feedback summary	Additional feedback and suggestions
	Email	Flood bank	<p>The respondent had some observations on the flood bank:</p> <ol style="list-style-type: none"><li>1. The flood bank is level along its entire length, whereas the gradient should increase to the east to account for the elevation fall from the lagoon to the Rees. This is a contributing factor when the flood bank overtops at the lagoon.</li><li>2. Three trees (willows) on the north side of the flood bank have fallen across Lagoon Creek and are impeding the outlet flow. Other trees are in the process of falling across the river and more are being undermined by the creek flow.</li><li>3. New willows have regrown on the north side of Lagoon Creek since it was cleared by the ORC in 2021. Some volunteer labour from Glenorchy has controlled some of the growth with a spraying campaign, but there is more to be done at the lagoon outlet and confluence of the creek and Rees River.</li><li>4. Since the improvements to the flood bank in 2021, tree growth and tree falls have impeded the Lagoon Creek flow and are likely to contribute to another overtopping of the flood bank near the east end of the golf course fairway.</li><li>5. Authorized dumping of clean fill adjacent to the south side of the flood bank from Oban Street almost to the golf course fairway section has widened and slightly raised the bank with a small berm.</li></ol>	<p>No further feedback from the respondent.</p>
	Email	Other comments on the Strategy	<p>The respondent had other comments on the Draft Strategy. They said:</p> <ol style="list-style-type: none"><li>1. The Strategy (page 65) identifies that flooding from the lagoon has the highest Annual Individual Fatality Rate (AIFR), and the highest Annual Property Risk (APR) values. It is therefore the highest priority to improve the current approach.</li><li>2. The Strategy (page 126) Option A, raising the entire flood bank, has been identified and is estimated to cost \$1.6 to \$2.3 million (page 133). However, this risk can be partially reduced by improving half the flood bank from Argyle Street to the Mull Street corner at little cost to the QLDC because the transport and placing of the fill is already borne by the dumpers.</li></ol>	<p>The respondent recommended some actions:</p> <ol style="list-style-type: none"><li>1. Request that the dumpers place the fill to reinforce the existing flood bank to levels that give a standard freeboard up to the lagoon.</li><li>2. Increase the height of the flood bank with a berm with a height of 0.5 meter and width of 10 meters at the Mull Street corner could be managed by placing gradient pegs and requiring the dumpers to progress the dumping on the south side of the existing flood bank to the level of the gradient pegs.</li><li>3. The lagoon walkway could temporarily be detoured at the Mull Street corner to the cycle track returning to the pathway at Argyle Street.</li><li>4. The annual inspection of the riverbanks also identified in the Strategy could lead to an annual spraying program as the community volunteer sprayers age out.</li></ol>