Notice of Meeting:

I hereby give notice that an ordinary meeting of the Dunedin City Council will be held on:

Date:	**Thursday 25 June 2026**
Time:	**8.30 am**
Venue:	**Council Chamber, Dunedin Public Art Gallery, the Octagon, Dunedin**

Sandy Graham
Chief Executive Officer

Council

SUPPLEMENTARY AGENDA

MEMBERSHIP

Mayor	Mayor Sophie Barker	
Deputy Mayor	Cr Cherry Lucas	
Members	Cr John Chambers	Cr Jo Galer
	Cr Christine Garey	Cr Doug Hall
	Cr Marie Laufiso	Cr Russell Lund
	Cr Mandy Mayhem	Cr Benedict Ong
	Cr Andrew Simms	Cr Mickey Treadwell
	Cr Lee Vandervis	Cr Steve Walker
	Cr Brent Weatherall	

Senior Officer	Sandy Graham, Chief Executive
Governance Support Officer	Lynne Adamson

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Note: *Reports and recommendations contained in this agenda are not to be considered as Council policy until adopted.*

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REPORTS

SOUTH DUNEDIN FUTURE - 3 PROPOSED ADAPTATION FUTURES

Department: Climate and City Growth

EXECUTIVE SUMMARY

1 The purpose of this paper is to provide an outline and update on the South Dunedin Future (SDF) programme, present the latest technical reports relating to the three Proposed Adaptation Futures for South Dunedin, and seek approval of Councils to engage with affected communities and other stakeholders. At this stage, Councils have committed to completing the SDF programme only, with any future decisions on land use, infrastructure, and implementation subject to further consideration by Councils through long-term planning and financial processes.

2 The SDF programme is a joint initiative between the Dunedin City Council (DCC) and Otago Regional Council (ORC) to develop a climate change adaptation masterplan for South Dunedin. The Council-approved programme strategy is guided by the vision of "a safer and better South Dunedin, where sustainable urban regeneration leads to improved community resilience and wellbeing". The SDF programme is on schedule to deliver the final climate adaptation masterplan in the first half of 2027 and to transition to implementation from 1 July 2027.

3 Creating a safer and better future for South Dunedin will require balancing a range of trade-offs, including choices about the scale and rate of change, the affordability of different options, and the level of ongoing risk that may be considered acceptable now and in the future. The SDF programme was designed as a vehicle for facilitating related analysis, discussions, and decisions.

4 Building on previous work and community feedback, the current stage of the SDF programme has undertaken further technical and economic analysis to develop a shortlist of three Proposed Adaptation Futures for South Dunedin. These include:

- Future 3 – Protect (Keep the land dry – raise land and pump water)
- Future 4 – Restore (Make space for water – waterways and wetlands)
- Future 5 – Reshape (Move out of harm's way – raised land and green spaces)

5 Each future outlines a potential approach and proposed set of actions that could be taken over time to reduce flood risk and adapt South Dunedin to the anticipated impacts of climate change. The futures also illustrate the likely consequences of inaction. Findings are presented across four technical reports: on stormwater, groundwater, and economics, and an overview report describing the three proposed adaptation futures.

6 Encouragingly, this work indicates that it is technically feasible to significantly reduce flood risk in South Dunedin over the next 50–100 years, despite the anticipated increase in climate-related hazards. However, achieving this would require extensive and ongoing investment, disruption, and change over that period (and likely beyond). Reducing flood risk would involve a mix of new and upgraded infrastructure, land raising and redevelopment, and the creation of parks,

wetlands, and waterways in some areas of South Dunedin. Implementing these public works would require councils to change planning rules and acquire private property in some areas.

7 The futures combine different adaptation actions across the short term (2025–2050), medium term (2050–2075), and long term (2075–2125). The futures are broadly similar in the short term, focusing on investment in stormwater and groundwater infrastructure and preparing for potential land-use change through planning measures and property acquisition. In the medium term, more substantive changes would be introduced, including land raising, new development patterns, and the creation of parks, wetlands, and waterways, alongside coastal protection and continued infrastructure upgrades. In the long term, major capital works would taper off, while new housing in lower-risk areas would provide additional development capacity.

8 The proposed actions and changes outlined in the three futures are significant, reflecting the scale and nature of the challenges facing South Dunedin. It is therefore important that councillors and the community consider these proposals in their wider context, including the expected benefits of being proactive and taking decisive action, as well as the likely consequences of delay and inaction. While there is acknowledged community frustration regarding the perceived lack of action on flooding since 2015, it has taken time to build a comprehensive understanding of the underlying problems and to identify workable long-term solutions. This analysis confirms there are no quick or simple fixes and that system-scale responses are required.

9 The economic assessment shows that maintaining the status quo in South Dunedin has an estimated cost of $1.45 billion in net present value (NPV) over a 100-year period and likely more than $2 billion once wider factors are considered. All three proposed futures deliver significantly better outcomes, with costs ranging from $1.63 billion to $2.45 billion NPV over a 100-year period. Net costs range from approximately $280 million to $1.112 billion NPV, reflecting the benefits of adaptation action, including avoiding anticipated flood damages and associated disruption over time. While the futures all involve substantial upfront costs, benefits grow over time, and the anticipated costs of inaction are even higher. The cost of implementing the cheapest future (Future 4) is roughly 8 per cent of DCC's annual capital budget of around $200 million, noting South Dunedin comprises around 10 per cent of the city's population.

10 Achieving meaningful flood-risk reduction in South Dunedin over the next 50–100 years will require system-wide interventions and consequential intergenerational decisions. The scale and duration of investment needed may commit future generations to specific adaptation pathways, long-lived infrastructure, and escalating operating costs. Even with decisive action, residual risks associated with sea-level rise and climate change will persist. Decisions made today will therefore shape not only near-term outcomes, but also the choices, obligations, and risks inherited by future communities.

11 Subject to approval by Councils, the next step in the SDF programme is to engage with affected communities and other stakeholders on the proposed futures. Feedback will inform further technical and economic analysis to identify a single preferred future and finalise a climate adaptation masterplan for South Dunedin. However, technical work is now sufficiently advanced for implementation of 'no and low regrets' actions to proceed in parallel to this final stage. This includes DCC continuing delivery of the three stormwater projects already approved by Council, alongside consideration of 10 new initiatives recommended over the next 25 years that are common across all three futures, which could be implemented regardless of which future is eventually selected as preferred. Work to scope, phase, and cost these initiatives could begin immediately, with funding and approval considered through the Long Term Plan (2027–37) process, potentially enabling implementation to commence from 1 July 2027.

RECOMMENDATIONS

That the Council:

South Dunedin Future Technical Reports

a) **Notes** the background of the South Dunedin Future programme, including the Council-approved programme plan and strategy, and the work undertaken since the previous report to Council in September 2025.

b) **Notes** the contents of the attached South Dunedin Future technical reports, including:

   i) *Three proposed adaptation futures for South Dunedin*, which provides an overview of the futures including the key features, actions, and associated costs and benefits;

   ii) *South Dunedin Stormwater Modelling Report*, which describes technical assessments of feasibility of a range of potential stormwater-related interventions intended to mitigate flood and other risks affecting South Dunedin;

   iii) *South Dunedin Groundwater Modelling Report*, which describes early-stage technical assessments to determine the feasibility of groundwater drainage systems aimed at managing risks from shallow and rising groundwater across South Dunedin; and

   iv) *Economic Assessment of the three proposed adaptation futures for South Dunedin*, which evaluates the economic performance of each of the futures against a status quo scenario.

c) **Notes** these four reports have undergone external technical peer review, and where technical issues remain outstanding, these are acknowledged in the reports or will be addressed in subsequent stages of the SDF programme.

d) **Notes** that additional reports have also been completed on the health and equity implications of the three proposed adaptation futures, the potential property implications of various adaptation actions, and on initial due diligence on potential future development in Ocean Beach Domain. Summaries of these reports are included in this paper and the full reports will be available on the South Dunedin Future webpage.

e) **Endorses** the attached South Dunedin Future technical reports for the purposes of community engagement, noting any future decisions on land use, infrastructure, and project implementation would be subject to further consideration by Councils through long-term planning and financial processes.

Community Engagement

f) **Approves** progressing to the next step of the SDF programme, which involves staff engaging with partners, stakeholders and affected communities to seek feedback on the three proposed adaptation futures for South Dunedin and a status quo option.

g) **Notes** the proposed communications and engagement activities, including range of media and public communications, and mix of public and targeted stakeholder engagements planned for early-July to mid-August 2026.

Final stage of the SDF programme

h) **Notes** that following completion of community engagement in August 2026, feedback will be analysed, and key findings reported to Councils in September 2026.

i) **Notes** that community feedback will also inform a multi-criteria assessment of the three proposed adaptation futures against a decision-making framework previously approved by Councils, and that results of this assessment will be reported to Councils in September 2026.

j) **Notes** the final stage of the SDF programme will involve identifying a preferred adaptation future as the basis for finalising a climate adaptation masterplan for South Dunedin for Councils' consideration and approval by 30 June 2027.

k) **Notes** staff will seek to align the final stage of the SDF programme with Council's Long-Term Plan (2027-36), Infrastructure Strategy, and Water Services Strategy processes, to promote coherence and support efficient transition to implementation of the masterplan and related activities from 1 July 2027.

Other Options

l) **Notes** other options explored in this paper, which include:

   i) One or both Councils requesting further technical, economic, or other work on the climate and natural hazard-related risks affecting South Dunedin and potential responses, including those outlined in the proposed adaptation futures, before seeking approval of Councils to undertake planned engagement with partners, stakeholders, and affected communities; and

   ii) One or both Councils directing an alternative course of action from those described in previous options above.

BACKGROUND

12 The South Dunedin Future (SDF) programme is a joint initiative between the Dunedin City Council (DCC) and Otago Regional Council (ORC) to develop a climate change adaptation masterplan for South Dunedin. A programme plan, which outlined the high-level approach for delivering the SDF programme was approved by DCC and ORC Council Committees in July 2022 (refer Part A Item 9, Planning & Environment Committee, 6 July 2022).

13 The SDF programme vision is *"a safer and better South Dunedin, where sustainable urban regeneration leads to improved community resilience and wellbeing"*. The purpose of the programme is to enable South Dunedin to prepare for, and adapt to, the impacts of climate change, while also realising the opportunities that come with change. A programme strategy was approved by Councils in November 2023, which focusses on just transition, community safety, environmental and cultural restoration, social and economic resilience, and sustainable urban development (refer Item 10, DCC Council Meeting, 28 November 2023).

14 The SDF programme has been broken into five phases, five workstreams, and a number of programme actions. The workstreams include: (i) natural hazards; (ii) strategy and programme management; (iii) communications and community engagement; (iv) risk assessment; and (v) adaptation planning. This breakdown has been explained more fully in previous Council papers and workshops, but is also illustrated in the A3 SDF Programme Overview (Attachment A).

External technical assistance

15 The multidisciplinary nature of climate adaptation often requires specialised technical skills and experience, which may need to be sourced externally, where the capability or capacity is not available internally. External technical assistance has been used to support delivery of the SDF programme. In July 2023, following an open tender process, DCC contracted a consultant group comprising engineering, planning, and environmental services firms WSP, BECA and Tonkin & Taylor (collectively known as 'Kia Rōpine'), to support delivery of the SDF programme over the three years (2023/24 to 2025/26). The total value of this contract is presently $2.622 million.

16 In August 2023, DCC also contracted a second consultant group comprising engineering, planning and environmental services firms Jacobs New Zealand Ltd, Royal HaskoningDHV and Bell Adapt Ltd, to undertake technical peer review of the risk assessment and adaptation planning workstreams. The total value of this contract is presently $222,114.

17 External technical assistance has also been sourced to provide specialist advice on specific topics such as natural hazard assessment (ESNZ, $29,050), property analysis and market implications (PWC, $100,000), health and equity assessments (University of Otago, $42,134), physical site assessments (Stantec, $28,972), and mana whenua partnership (Aukaha, $69,560).

SDF programme timeline and key activities

18 The following paras provide a summary of the SDF programme timeline and key activities undertaken to get to the current stage:

a) Identifying risks and possible responses (2023/24)
Using existing natural hazard, asset, and place-based information, an initial risk-screening process was undertaken to identify areas of exposure, vulnerability, and potential risk in South Dunedin requiring further analysis. In parallel, best-practice approaches from comparable international programmes, alongside ideas generated through community and stakeholder engagement, were used to develop an initial list of 16 generic adaptation approaches. Reports on risk identification and these generic approaches were presented to Councils in December 2023 and consulted on in early 2024, with feedback informing subsequent stages of the programme.

b) Risk assessment and development of Potential Adaptation Futures (2024/25)
A detailed risk assessment was then undertaken to identify, classify, and prioritise risks across South Dunedin by assessing hazard exposure, vulnerability, likelihood, and consequences. Responding to this assessment, seven Potential Adaptation Futures were developed, each representing a distinct way of managing and mitigating the identified risks, and outlining the associated characteristics, costs, benefits, and trade-offs. Reports on the risk assessment and seven Futures were presented to Councils in March 2025, consulted on in April–May 2025, and feedback was reported back to Councils in July 2025 and used to inform further analysis.

c) Shortlisting from seven to three Futures (2025)

In mid-2025, a multi-criteria assessment (MCA) was undertaken to shortlist the seven Futures to three, which would then undergo further development. This process involved technical and economic assessments by Council staff, Aukaha, and consultant specialists, drawing on community feedback and applying the programme strategy and decision-making framework previously approved by Councils. The MCA findings, together with additional contextual considerations, informed the shortlisting of Futures 3, 4 and 5, which was reported to Councils in September 2025. Positive community feedback about short-term infrastructure investment in Future 2 was also accommodated by integrating this as design principle for the three shortlisted futures.

d) Developing the three Proposed Adaptation Futures (2025/26)

The current phase of the SDF programme has focused on further technical and economic analysis to develop three Proposed Adaptation Futures. Detailed modelling and economic assessments have been used to identify adaptation actions to manage flood and climate-related risks in South Dunedin, along with indicative locations and timeframes for implementation. This work is documented in four reports: technical reports on stormwater, groundwater, and economics, and an overview report describing the three Proposed Futures. This work is described more fully below.

DISCUSSION

19 There are four key outputs from this stage of the SDF programme, including: (i) an overview of the three proposed adaptation futures for South Dunedin (Attachment B); (ii) South Dunedin stormwater modelling report (Attachments C, D, E and F); (iii) South Dunedin groundwater assessment report (Attachment G); and (iv) and economic assessment of the proposed futures (Attachment H). The key components and findings of these reports are summarised below.

Overview of proposed adaptation futures for South Dunedin

20 This report provides a technical but plain-language overview of three Proposed Adaptation Futures for South Dunedin. It outlines the key features, staging, performance, costs, and benefits of each future, supported by visualisations showing preliminary locations and how South Dunedin could evolve in the short, medium, and long term. The futures draw together findings from the stormwater, groundwater, and economic assessments. The three futures are:

- Future 3 – Protect (Keep the land dry – raise land and pump water)
- Future 4 – Restore (Make space for water – waterways and wetlands)
- Future 5 – Reshape (Move out of harm's way – raised land and green spaces)

21 The report indicates that it is technically feasible to significantly reduce flood risk in South Dunedin over the next 50–100 years, despite the anticipated increase in climate-related hazards. However, achieving these risk reductions would require extensive and sustained investment, as well as significant change over that period and likely beyond. Flood risk is expected to increase over time due to rising sea levels, rising groundwater, and more intense rainfall, compounded by ageing infrastructure, increasing impermeable surfaces, and ongoing urban development. These factors interact in complex ways. While infrastructure upgrades are necessary to manage near-term risks, long-term resilience depends on system-scale interventions that change how land, water, and urban form work together.

22 Each future sets out a coherent approach and suite of actions that could be implemented over time to reduce flood risk and realise a range of opportunities that could accompany adaptation. Guided by design principles developed through technical analysis and community feedback in

earlier stages, the futures combine different adaptation actions across the short term (2025–2050), medium term (2050–2075), and long term (2075–2125). The futures are broadly similar in the short term, focusing on investment in stormwater and groundwater infrastructure and preparing for potential land-use change through planning measures and property acquisition. In the medium term, more substantive changes would be introduced, including land raising, new development patterns, and the creation of parks, wetlands, and waterways, alongside coastal protection and continued infrastructure upgrades. In the long term, major capital works would taper off, while new housing in lower-risk areas would provide additional development capacity.

23 Across all three futures, investment is front-loaded in the short term, while the benefits accrue mainly in the medium and long term through avoided flood damage compared with a status quo future. As a result, flood risk is substantially reduced under all three futures, falling below present-day levels despite the impacts of climate change. For example, the proportion of buildings exposed to flooding above floor level is currently estimated at 23 per cent and is projected to rise to 47 per cent by 2100 under the status quo. Under the three futures, this reduces to around 5–7 per cent by 2100. Average annual damages from flooding and other climate impacts are also projected to fall significantly, from an estimated $11m–$212m per annum under the status quo to $0.6m–$3.3m per annum across the futures.

24 While the futures are effective in reducing flood risk, they involve substantial costs and trade-offs. Estimated implementation costs are approximately $2.1 billion for Future 3, $1.63 billion for Future 4, and $2.45 billion for Future 5. Achieving flood risk reduction outcomes would involve extensive construction activity, major changes in land use, and significant adjustment for communities. Over time, South Dunedin would look, feel, and function very differently than today. Measures could include large-scale upgrades to underground infrastructure, land raising and redevelopment, and the creation of parks, wetlands, and waterways in some locations. Delivery of these interventions may require the acquisition of up to 1,750 private properties across South Dunedin. While this is assessed as necessary to achieve material reductions in risk, it would have a high level of impact on affected communities. Areas that may be subject to acquisition are shown in the report visualisations, noting that final locations would be confirmed later following detailed project design.

25 The futures are grounded in detailed technical analysis of stormwater, groundwater, and economic impacts, while also incorporating mana whenua values, earlier risk assessments, and community feedback. The commentary on each future includes a preliminary assessment against Kāi Tahu Rūnaka values co-developed with Aukaha Ltd and key themes from community feedback in previous stages of the SDF programme. The futures are intended to be pragmatic and to strike a balance between technical feasibility, affordability, and community aspirations. Collectively, the futures are designed to support elected members and the public to better understand the scale of the challenge facing South Dunedin, explore different response pathways, and weigh the costs, benefits, and trade-offs associated with each option, including the consequences of taking limited or no action.

26 The actions set out in the futures reflect the scale of the challenges facing South Dunedin. The report situates these proposals within a wider context that highlights the benefits of early and decisive action, as well as the risks of delay. While there is acknowledged frustration within the community about the time taken to respond to flooding since 2015, the complexity of the issues has required sustained technical work to develop robust, system-wide solutions. The analysis confirms that there are no quick or simple fixes, whole-of-network responses are required.

27 Overall, the report shows that an effective response will require significant and sustained intervention to address current hazards while proactively reducing future risk. However, even

under the proposed adaptation futures, residual flood and groundwater risk remains, particularly under extreme or compound events. Councils therefore retain discretion over the level of risk considered acceptable, the degree of intervention required, and the balance between public investment, private responsibility, and ongoing exposure.

28 Acting now would allow decision-makers and stakeholders to actively shape a safer and more resilient future for South Dunedin. By contrast, a delayed or insufficient response would see flooding become more frequent and severe over time, leading to increasing damage to infrastructure and property, compounding negative social and economic impacts, and leading to long-term decline across the area. In this scenario, water ultimately determines South Dunedin's future, with poor outcomes for communities, the environment, and the city as a whole. Other pathways are possible, such as lower levels of investment or change, but these would likely result in higher ongoing flood risk. The overview report presents a summary of the technical analysis to support informed discussion and decision-making about risks, options, and trade-offs.

South Dunedin stormwater modelling report

29 This report summarises the hydraulic modelling undertaken to design and test the performance of the three Proposed Adaptation Futures, which aim to manage and mitigate flood risk in South Dunedin. The modelling was used to identify systemwide changes required to effectively reduce current and future flood risk, including by determining preliminary infrastructure configurations, sizing, and costing. This work also assessed how each future performs across short- (2025), medium- (2060), and long-term (2100) time horizons, considering climate change, sea level rise, and different approaches to infrastructure and land use change. The modelling used a conservative climate change scenario Representative Concentration Pathway (RCP 8.5), which corresponds to very high greenhouse gas emissions, and is a common standard for designing and stress-testing infrastructure design. Though best practice recommends using a range of scenarios, to account for inherent uncertainty, so the modelling also uses a moderate climate change scenario RCP 4.5 for sensitivity testing. The model builds on an updated Integrated Catchment Model (ICM) completed in 2024 as part of the 3 Waters Integrated System Plan (ISP), which forms the baseline "status quo" scenario and includes the three 'no regrets' stormwater projects approved by DCC Council in 2025.

30 The three futures modelled represent distinct strategic approaches aligned to the three futures shortlisted during previous stages of the SDF programme. Future 3 relies primarily on upgraded pipes, pump stations, and storage facilities; Future 4 shifts toward open waterways and wetlands supported by storage areas, pump and pipe upgrades; and Future 5 combines open waterways with land raising and designated floodable areas, alongside new pipe and pump infrastructure. Reflecting community feedback received in previous stages, all futures include substantial infrastructure upgrades in the short term, sized to manage increased rainfall intensities and duration. This is complemented by green infrastructure (open channels, storage basins, infiltration, and run-off areas) to help deal with higher sea levels, rising groundwater, and more frequent and severe storm events that are expected over time.

31 In the short term, the modelling applies a common package of infrastructure upgrades across all three futures, which is designed to remain in place and complement each of the three Futures over subsequent stages. Medium- and long-term upgrades then diverge as the futures progressively introduce additional infrastructure and land use changes aligned with each design approach. The modelling applied levels of service that reflect community feedback, including allowance for limited road flooding during heavy rainfall events, and balanced flood risk

reduction objectives with technical feasibility, infrastructure scale, implementation challenges, and anticipated costs.

32 The modelling identifies several critical infrastructure measures that drive flood risk reduction across the futures. In addition to short-term upgrades to pumps and pipes, all options include new storage basins at Forbury Park, Tonga Park, and Bathgate Park to temporarily hold stormwater during peak events, with Culling Park added in Futures 4 (Restore) and 5 (Reshape). New and upgraded pump stations are required to manage increased flows and rising sea levels, particularly at key outfalls. Futures 4 and 5 also incorporate open channels where the existing pipe network is shallow and more adaptable, while Future 3 relies more heavily on pipe upgrades.

33 Overall, the modelling shows that all futures substantially reduce flood hazard compared with the existing network, particularly for 10- and 50-year rainfall events, and sensitivity testing indicates the results are robust across different storm durations and climate change scenarios. There are significant reductions in property flooding for both moderate and severe storm events, with fewer than 8 per cent of properties experiencing above-floor flooding in events with a 1% chance of occurring each year. The modelling outputs have been used to inform cost estimates and residual risk assessments and provide confidence that, while no option eliminates risk entirely, each future can materially improve flood outcomes for South Dunedin over the long term.

34 Finally, the stormwater modelling report notes 10 key initiatives recommended over the next 25 years that are common across all three futures and therefore could be implemented regardless of which future is eventually selected as the preferred. This essentially means that technical work is now sufficiently well advanced to consider implementation of ‘no and low regrets’ actions – which could proceed as part and in parallel to the final stage of the SDF programme. This includes DCC continuing delivery of the three stormwater projects previously approved by Council (refer Item 14, DCC Council, 28 January 2025), alongside potentially scoping, phasing, and costing the 10 key initiatives recommended in Attachment 3 with a view to presenting project and funding options for Council consideration as part of the Long Term Plan (2027–37) process. This could enable implementation to commence as early as 1 July 2027.

South Dunedin groundwater assessment report

35 This report presents early-stage technical assessments of groundwater drainage options to manage risks associated with shallow and rising groundwater across South Dunedin. Building on earlier numerical groundwater models developed by Otago Regional Council and subsequently updated by Earth Science New Zealand (formerly GNS), the report assesses how proposed groundwater management options could control groundwater levels compared with drainage currently provided by the existing, leaky stormwater and wastewater networks. The modelling outputs are visualised through maps and cross-sections and include estimates of groundwater inflows to stormwater and groundwater management infrastructure to inform pumping requirements. The findings support initial assessments of technical feasibility, indicative infrastructure configurations, sizing, and order-of-magnitude costing to inform further analysis.

36 The modelling explores the feasibility of introducing a pumped groundwater management system for South Dunedin. Rising sea levels will progressively reduce the effectiveness of gravity-based drainage, necessitating a transition to pumped systems over time. Although the current stormwater and wastewater networks provide some incidental groundwater drainage through leakage and pumped outfalls, South Dunedin already experiences high groundwater levels, which are expected to worsen as sea levels rise. The modelling therefore considers both

short-term measures to address existing issues and longer-term solutions assessed under up to 1.1 metres of sea level rise over approximately the next 100 years. A key conclusion is that an active, pumped groundwater drainage system is fundamental to the long-term habitability of South Dunedin; without intervention, widespread periodic and, in some areas, permanent surface ponding is likely later this century.

37 The modelling assumes an integrated approach to stormwater and groundwater management. It tests whether an upgraded dual-purpose pipe network located within existing road and transport corridors would be sufficient to lower groundwater levels to target levels. Extending a tighter pipe network beneath private property was found to introduce significant additional complexity and cost. Results indicate that a network contained largely within transport corridors would be effective across most of South Dunedin, although challenges remain in the lowest-lying areas of Musselburgh, where groundwater levels are already very shallow.

38 Stormwater flows during major rainfall events are many orders of magnitude greater than groundwater flows, meaning groundwater volumes have only a minor influence on overall stormwater system sizing. The proposed approach centres on a large storage basin at Forbury Park, which would act as the primary collection point for both stormwater and drained groundwater. From there, water would be pumped to sea using high-capacity pumps during storm events, supported by lower-capacity pumps operating continuously to manage groundwater baseflows and maintain drainage capacity across the system.

39 Groundwater drainage would be continuous, with higher inflows following major storm events that gradually reduce over time. To minimise the risk of land settlement, modest groundwater lowering is proposed, reflecting the presence of compressible soils beneath South Dunedin. The assessed groundwater drawdown is generally less than 0.8 metres, with limited areas up to 1.5 metres, and is expected to result in less than 50 millimetres of land settlement. Further site-specific investigations would be required to confirm these effects as options progress to more detailed design.

40 In the short term, the report recommends undertaking a pilot groundwater drainage trial to test a small-scale pumped system and improve understanding of groundwater behaviour, system performance, and design requirements. Further work is also recommended to assess the ecological and infrastructure implications of saline or brackish water in basins and canals, confirm land-settlement assumptions, and address corrosion risks to underground services. Overall, the findings confirm that future stormwater and groundwater management in South Dunedin will rely on pumped systems with increasing operational and maintenance demands over time, reinforcing the need for integrated design and a robust cost–benefit analysis as climate change impacts intensify.

Economic assessment of the three proposed adaptation futures

41 This report evaluates the economic performance of each of the three proposed adaptation futures for South Dunedin. It also considers overall value by comparing these to a status quo scenario that continues existing practices such as reactive maintenance, incremental upgrades and privately-led responses, without coordinated system-scale intervention.

42 A standard cost-benefit assessment framework is utilised following generally accepted best practices outlined by The Treasury, the Commerce Commission, and New Zealand Institute of Economic Research. The primary metric used throughout the economic evaluation is Annual Average Damage (AAD). AAD is the annualised expected cost of pluvial flood and coastal inundation damage across heavy rainfall or storm events that have a 10%, 2%, and 1%

probability of occurring each year, weighted by their likelihood. Put simply, it represents what an insurer would pay each year, on average, if the community was fully insured against all storm events at their expected frequency and severity.

43 The primary economic benefit of each future is avoided AAD – the reduction in expected annual pluvial flood and coastal inundation losses relative to the status quo. The calculation is straightforward in concept: avoided damage equals the difference between what flood events would cost with adaptation (three futures) and what they would cost without it (status quo).

44 Over the full 100-year assessment period, the present value cost of the status quo scenario is assessed as $1.45 billion. This includes anticipated property damage, fatality and injury costs, emergency services, trauma, income loss from displacement, and environmental costs. It excludes infrastructure repair, loss of activity or productivity, event clean-up costs, private property interventions (both proactive and reactive), and the economic consequences of insurance withdrawal. Including these would likely raise the cost above $2 billion.

45 The estimated total implementation costs of the three futures range from $1.63 billion to $2.45 billion over the same period to 2125. Future 4 (Restore) has the lowest total cost, reflecting a greater reliance on green infrastructure, waterway restoration, and natural flood storage, which are generally less capital-intensive than the large-scale land raising and pumping components that characterise Futures 3 and 5. The cost of implementing the cheapest future (Future 4) equates to roughly 8 per cent of DCC's annual capital budget of around $200 million, noting South Dunedin comprises around 10 per cent of the city's population. All three futures generate substantial economic benefits through avoided flooding and related losses, estimated at $1.34–$1.35 billion.

46 The report also assesses the relationship between benefits and costs using a benefit–cost ratio (BCR). The BCR is based on the most directly evidenced impacts, including avoided property damage, avoided injuries and fatalities, reduced emergency and recovery costs, avoided trauma, avoided income loss from displacement, and avoided environmental damage. Broader benefits – such as increased property values, regeneration and redevelopment uplift, ecosystem service gains, reduced network disruption, and the value of maintaining insurability – are not included at this stage. This approach is deliberate and conservative, ensuring the core case is based on the most defensible evidence, with additional benefits transparently identified as potential upside. Benefits, costs, and BCRs are summarised in Table 1 below.

Scenario	Gross Costs ($B)	Benefits ($B)	Net Costs ($B)	BCR (mid)	BCR range (+/- 15%)	Rank
Status quo	$1.45-$2.0	-	$1.45-$2.0	-	-	4
Future 3 - Protect	$2.098	$1.335	$0.763	0.64	0.54 - 0.75	2
Future 4 - Restore	$1.629	$1.351	$0.278	0.83	0.71 – 0.98	1
Future 5 - Reshape	$2.448	$1.336	$1.112	0.55	0.46 – 0.64	3

Table 1: Benefits, costs, and BCRs of Status quo and three futures

47 While the initial whole-of-life BCRs for the three futures are below 1 at this early stage, this is typical of long-lived climate adaptation investments, which involve substantial upfront capital costs, while benefits increase over time as climate risks intensify. This pattern is consistent with other major public infrastructure investments in New Zealand, including transport projects, which often proceed with lower early-stage BCRs where wider resilience, equity, and long-term benefits are recognised. The current results are also based on more commercially weighted assumptions; applying more socially weighted approaches that emphasise broader societal benefits would materially improve the BCRs. Accordingly, these results should be interpreted as

a conservative lower bound on economic performance, rather than a definitive assessment of long-term value.

48 The key finding of the economic assessment is that investing in adaptation delivers significantly better outcomes than maintaining the status quo, even under conservative assumptions. The cost of inaction in South Dunedin under a status quo scenario are estimated at $1.45 billion in net present value (NPV) and likely more than $2 billion once non-quantified factors are accounted for, as noted above. Future 4 (Restore) presents the strongest economic case, with an estimated net cost to the community of $280 million NPV over the next 100 years, compared to $763 million NPV for Future 3 (Protect) and $1.112 billion for Future 5 (Reshape). All these net costs are materially lower than the estimated $1.45-$2.0 billion cost of the status quo, providing a strong, clear-cut case for adaptation investment irrespective of the headline BCR.

49 While the futures all involve substantial upfront costs, benefits grow over time, and are comparable to other major public infrastructure investments at this early stage of development. Long-term modelling and sensitivity testing show that economic performance strengthens over time and that the relative ranking of the futures remains stable under alternative assumptions. The analysis is intentionally conservative, excluding several categories of potential upside benefits, including regeneration and redevelopment uplift, ecosystem services, avoided heritage losses, and the value of maintaining insurability. As the programme progresses toward identifying a preferred pathway and the analysis is refined, the overall economic case for adaptation is expected to further strengthen. Table 2 below illustrates a high-level cost breakdown for the status quo and three futures.

Cost items	**Costs over 100-year timeframe in NPV ($m)**			
	Status Quo	**Future 3**	**Future 4**	**Future 5**
Infrastructure CAPEX (Stormwater and groundwater network; pump stations; outfalls; land raising; open waterways; wetlands, storage, coastal protection)	290	1,220	724	1,287
Property and land acquisition (Property purchase; ~25% uplift)	4	433	447	545
Repurpose land activities (Building demolition; utility removal; site reinstatement)	72	343	338	519
Capital maintenance (35% of CAPEX every 25yrs; once asset it built)	15	33	39	31
OPEX (1.5% of CAPEX per year; builds cumulatively).	31	70	81	66
Total	**411**	**2,098**	**1,629**	**2,448**

Table 2 – High level cost breakdown for status quo and three futures

Technical peer review

50 The four primary technical reports developed by the Kia Rōpine consultant team have undergone several rounds of review, including from staff across DCC and ORC, and by an external independent technical peer review team led by Jacobs NZ Ltd (supported by Royal HaskoningDHV, and Bell Adapt Ltd). The peer review process has been robust, extensive, and has led to many refinements to the reports. However, not all outstanding technical issues have been resolved, and remaining issues are: (i) acknowledged as data gaps, assumptions, limitations, or with disclaimers; (ii) matters that can be addressed in subsequent stages of the

technical work; or (iii) subject to difference of professional opinion (i.e. the experts have agreed to disagree).

Additional technical reports

51 In addition to the four primary technical reports developed by the Kia Rōpine consultant team, additional reports have also been commissioned on specific topics of relevance to climate adaptation in South Dunedin – including health and equity, property implications, and potential development of Ocean Beach Domain. The reports are not included as attachments, but are summarised below, and will be available on the South Dunedin Future website.

Health and equity assessment

52 A team of researchers led by the University of Otago, and comprising staff from Te Whatu Ora, Victoria University of Wellington, Urban Intelligence, Yasmine El Orfi, and Te Pūnaha Matatini Centre for Research into Complex Systems, was commissioned to undertake a review of the three futures through a health and equity lens. This review followed feedback from earlier stages of the SDF programme which identified an overemphasis on technical and economic factors, and limitations in consideration of social factors.

53 The health and equity assessment found that all three shortlisted futures would result in better outcomes than a status quo approach, which would lead to significant and widening harms. These harms are expected to arise primarily through declining housing quality, mental health impacts, and reduced access to the social, economic, and cultural foundations of wellbeing. Across all futures, improved access to public mental health and social support services would be essential, and health equity would need to be central to design and implementation to minimise risks and maximise co-benefits, particularly for groups likely to be disproportionately affected, including disabled communities.

54 As residual flood risk remains under all futures, due to the potential for extreme events, infrastructure failure, and accelerating climate change, some status-quo health risks would persist. Existing inequities by income, ethnicity and disability strongly shape health outcomes, particularly through the housing system, making stronger housing governance and protections for tenants critical. Pathways involving land elevation or new development also carry equity risks unless land value uplift is captured publicly and reinvested to reduce inequities. Tiriti-based approaches and Kāi Tahu values would need to be intentionally embedded in decision-making, and while all futures offer opportunities to reduce emissions, sustained climate mitigation remains the strongest long-term protection for health and wellbeing.

Property analysis and implications

55 PWC was engaged to provide high-level commercial property insights across the three shortlisted futures, focusing on feasibility, sequencing, market response, value creation, and the funding and financing implications of early adaptation interventions, including land raising and redevelopment opportunities. The scope also included provisional analysis of land value uplift, advice on potential delivery and partnership models, and a light-touch review of property and development assumptions used in the cost–benefit analysis to ensure alignment with realistic market conditions.

56 In the report, PWC concludes that all three futures require significant early public investment in infrastructure and property acquisition before private-sector redevelopment can occur, and that most short-term actions (to around 2050) are common and largely “no-regrets”. From a commercial perspective, Future 4 (Restore) is assessed as the most straightforward option due

to its lower overall cost, reduced land repurposing, higher benefit–cost ratio, and avoidance of large-scale land raising, which PWC identifies as the most commercially challenging intervention.

57 The report highlights property acquisition as the single largest near-term cost and a critical enabler across all Futures, noting that delivery at scale is unlikely to be achievable without central government co-investment. Victoria Road (Ocean Beach Domain) sites are identified as the most strategically important early development opportunity, with potential to support relocation, deliver housing supply, and offset programme costs through value creation on council-owned land. Conversely, extensive land raising (particularly at Forbury Corner under Futures 3 and 5) is considered high-cost, long-lead-time and unlikely to be value-positive. Successful delivery would require a clear acquisition funding strategy, early planning certainty, active engagement with development and finance markets, and the establishment of a dedicated delivery entity (such as a CCO or Council–Crown vehicle) with the mandate and capability to manage long-term property acquisition and redevelopment.

Ocean Beach Domain due diligence

58 This stage of the SDF programme technical work considered options for making the best use of available land in South Dunedin, including exploring the possibility of changing land uses, for example of council-owned land such as Ocean Beach Domain. This area is already elevated and has a materially lower risk profile compared to the 'Flat', presenting an opportunity to utilise land more efficiently, potentially reducing or avoiding the more complex and costly process of land raising. Any loss of green space at Ocean Beach Domain could be balanced by proposed creation of new parks, waterways, and wetlands elsewhere in South Dunedin, likely resulting in a net gain in public green space. Developing Ocean Beach Domain would also respond to previous community feedback expressing a desire to stay in the local area (in the event they are required to move). As such, preliminary investigations were undertaken to test development potential of Ocean Beach Domain, including a desktop analysis of natural hazards, geotechnical conditions, and contaminated land. A preliminary legal review of title was also undertaken.

59 The desktop hazards and geotechnical assessment identified a range of physical constraints relevant to any future consideration of medium- to high-density residential development. Much of the site is underlain by loose coastal sands with very shallow groundwater, making some areas susceptible to liquefaction and sensitive to sea-level rise and flooding. Parts of the site, particularly in the western area, sit below the current minimum floor level requirement, meaning any development would require elevated floor levels and specifically engineered foundations to manage natural hazard risk. The assessment also identified contaminated land risks linked to historical land uses, including uncontrolled landfill activities associated with the former Chisholm Park Landfill and past recreational uses. While these issues do not necessarily preclude future development, they would require further detailed investigation, remediation or long-term land management, and may have a material influence on development feasibility.

60 Most of the Ocean Beach Domain land is held by Dunedin City Council under specific statutory regimes, primarily as recreation and local purpose reserves under the Reserves Act 1977. These reserves were originally transferred from the Crown, meaning that revoking reserve status would result in the land reverting to Crown ownership. At that point, the Crown would be required to comply with the right of first refusal provisions for Ngāi Tahu under the Ngāi Tahu Claims Settlement Act. The reserve land is also subject to numerous existing leases with sporting and recreational organisations. Other parts of the domain are subject to separate legal constraints. Tahuna Park, while not subject to the Reserves Act, is considered a public park under the Local Government Act 2002, meaning any sale or long-term lease that restricts public access would trigger formal public consultation. Overall, the title review highlights that land status,

Treaty settlement obligations, and existing leasehold interests are considerations that could materially affect the feasibility, process, and timing of any future redevelopment.

Communications and community engagement

61 The proposed actions and changes outlined in the three futures are significant, reflecting the scale and nature of the challenges facing South Dunedin. It is therefore important that stakeholders consider these proposals in their wider context, including the expected benefits of being proactive and taking decisive action, as well as the likely consequences of delay and inaction. While there is acknowledged community frustration regarding the perceived lack of action on flooding since 2015, considerable time has been required to build a comprehensive understanding of the underlying problems and to identify workable long-term solutions. This analysis confirms there are no quick or simple fixes, rather, that system-wide interventions are required. This means the proposed solutions are complex and are likely to be confronting, hard to process, and potentially unwelcome for many stakeholders.

62 The health and equity assessment highlights that how the proposed futures are communicated and engaged on will directly influence community wellbeing. In particular, clear, transparent, and participatory approaches can help avoid unintended impacts on mental wellbeing in a community already experiencing heightened stress and uncertainty. Building on engagement undertaken during earlier stages of the SDF programme, a comprehensive communications and community engagement approach has been developed for the current stage. The aim is to support partners, stakeholders, and decision-makers to access the latest technical work, understand the potential consequences, and provide informed feedback.

63 A range of communications activities are planned to support the public release of the proposed adaptation futures for South Dunedin. These include media releases and briefings, web and social media content, short videos, a flyer summarising key elements of the futures, and online access to all technical reports. Given the additional detail included in this stage of technical work, it is also proposed that councils provide specific information relating to the potential need for property acquisition to enable a wide range of flood risk reduction actions. Previous engagement has demonstrated high public interest in managed retreat and any associated property acquisition processes. It is therefore critical that councils are clear, transparent, and consistent in communications with affected stakeholders. Specific details on the underlying rationale for property acquisition, the potential implications, and intended process are included in planned communications and collateral.

64 While extensive efforts have been made, and continue to be made, to communicate the key elements of the proposed futures, the complexity and sensitivity of the issues mean they cannot be fully addressed through written communications alone. Experience from earlier stages of the SDF programme indicates that many stakeholders will want and need direct discussions with council staff to better understand what is proposed, reflect on how they may be affected, and provide feedback. Following the public release of the futures, a six-week public engagement process is planned for early-July to mid-August 2026. This would include targeted stakeholder sessions, alongside public workshops and drop-in sessions, supported by online resources and surveys to gather feedback from as many affected stakeholders as possible. To support these discussions, an analysis has been undertaken of the potential impacts of each of the three futures on individual properties across South Dunedin, enabling more tailored and informed engagement with affected stakeholders.

OPTIONS

65 The SDF Programme Plan provides for various decision points at the conclusion of each stage of technical work, where the approval of Councils is sought to proceed to community engagement. Three options are outlined below which involve proceeding with the SDF programme as scheduled, deferring the programme to undertake additional work as may be directed by Councils, or taking an alternative course of action as directed by Councils. The respective advantages and disadvantages of each option are described.

Option One – Recommended Option

66 This option includes proceeding as outlined in the SDF programme plan and according to the high-level schedule in Attachment A. It would involve Councils noting the four technical reports included as attachments to this paper, endorsing the reports for the purpose of community engagement, and providing approval to commence planned communications and community engagement activities with partners, stakeholders, and affected communities.

Advantages

- Enables SDF programme to maintain current scope, schedule, and budget.
- Aligns with operational objectives of SDF Programme, including making well-informed decisions, being community-centred, and mainstreaming climate adaptation by running a robust, transparent, and inclusive process.
- Enables councils to actively facilitate a dialogue with partners, stakeholders, and affected communities on the risks facing the area, potential responses, and to collect feedback.
- Enables staff and consultant teams to direct primary efforts to completing the final stage of the SDF programme, which involves finalising a climate adaptation masterplan for South Dunedin for Councils consideration and approval by 30 June 2027.
- Supports alignment between the final stage of the SDF programme and council's Long-Term Plan (2027-36), Infrastructure Strategy, and Water Services Strategy processes, promoting coherence and a more efficient transition to implementation of the masterplan and related projects from 1 July 2027.

Disadvantages

- Although grounded in extensive analysis and community engagement, the futures rely on assumptions and simplified representations of complex social, economic, and environmental systems over a 100-year period. Adaptation planning can help manage this uncertainty, but not eliminate it. This option therefore requires proceeding with imperfect information and despite a range of information gaps, assumptions, and uncertainties, each of which carries a degree of risk.

Option Two – Defer and undertake additional technical work

67 This option would involve one or both Councils requesting further technical, economic, or other work on the climate and natural hazard-related risks affecting South Dunedin and potential responses, including those outlined in the proposed adaptation futures, before seeking approval

of Councils to undertake planned engagement with partners, stakeholders, and affected communities.

Advantages

- Undertaking additional technical work could enable some existing information gaps to be filled and resolve some outstanding technical issues or remaining uncertainties, thereby increasing confidence in key findings and enabling more informed communications, engagement, and decision-making.

Disadvantages

- Undertaking additional, unplanned technical work would likely disrupt the SDF Programme schedule, may require additional budget, and could generate criticism from partners, stakeholders, and affected communities who may prefer release of the latest technical work.

- This option could delay completion of the current and future stages of the SDF programme, which may have negative implications for coherence with Long-Term Plan (2027-36) processes and delay transition to implementation of the masterplan from 1 July 2027.

- Undertaking additional, unplanned technical work could be perceived by partners, stakeholders, and affected communities as bypassing community engagement and moving straight to the final stage of the SDF programme.

- Adaptation planning will always rely on assumptions and simplified representations of complex social, economic, and environmental systems over an extended period. Additional analysis may help further reduce this uncertainty, but not eliminate it. There will always be a need to make decisions with imperfect information and despite a range of information gaps, assumptions, and uncertainties, each of which carries a degree of risk.

Option Three – Alternate course as determined by Councils

68 This option would involve an alternative course of action from those described in Options A and B above, as determined by one or both Councils. An analysis of potential impacts could be undertaken once details are known.

NEXT STEPS

69 Subject to the decisions of Councils, next steps include:

70 Commencing communications and community engagement activities relating to the 3 Proposed Adaptation Futures for South Dunedin, as described above. These activities are planned to commence in early-July and extend through to late-August.

- Designing and commencing the final stage of the SDF programme, including identifying a preferred adaptation future and finalising a climate adaptation masterplan for South Dunedin. This will include:

    i) analysis of community feedback on the 3 Proposed Futures and status quo option;

ii) undertaking a multi-criteria assessment (MCA) of the 3 Proposed Futures and status quo option, incorporating community feedback and technical assessments against Council approved objectives and decision-making framework;

iii) reporting the outcome of community engagement and the MCA process to Councils;

iv) undertaking more detailed technical and economic work to refine the preferred adaptation future and finalise the adaptation masterplan;

v) aligning technical analysis with workplan and budget development being undertaken by relevant council teams for the Long-Term Plan (2027-36);

vi) producing a climate adaptation masterplan for South Dunedin for Councils approval by 30 June 2027.

71 At present, Councils have committed to completing the SDF programme only, including remaining technical work, economic analysis, and community engagement. Councils have not, at this time, committed to supporting any particular course of action that might be recommended by the SDF programme – including those relating to strategic land use planning, property acquisition, or infrastructure investment. Such decisions, and the roles and responsibilities of respective Councils in implementing them, would be subject to further consideration by respective Councils, including in the context of strategic and financial decisions associated with long term plan processes.

Signatories

Author:	Jonathan Rowe - Programme Manager, South Dunedin Future
Authoriser:	David Ward - General Manager, 3 Waters, Property and Urban Development

Attachments

SUMMARY OF CONSIDERATIONS

Fit with purpose of Local Government

This decision enables democratic local decision making and action by, and on behalf of communities.
This decision promotes the social well-being of communities in the present and for the future.
This decision promotes the economic well-being of communities in the present and for the future.
This decision promotes the environmental well-being of communities in the present and for the future.
This decision promotes the cultural well-being of communities in the present and for the future.

Fit with strategic framework

	Contributes	Detracts	Not applicable
Social Wellbeing Strategy	✓	☐	☐
Economic Development Strategy	✓	☐	☐
Environment Strategy	✓	☐	☐
Arts and Culture Strategy	✓	☐	☐
3 Waters Strategy	✓	☐	☐
Future Development Strategy	✓	☐	☐
Integrated Transport Strategy	✓	☐	☐
Parks and Recreation Strategy	✓	☐	☐
Other strategic projects/policies/plans	✓	☐	☐

The SDF programme is a multi-disciplinary initiative working horizontally across a range of council strategies, groups and budgets and therefore has links to various elements of the strategic framework.

Māori Impact Statement

Accurately reflecting and integrating the principles of the Treaty of Waitangi, and Crown's partnership with Māori, is a central element of the SDF Programme. In relation to the content of this report, this has included incorporating key intents and values from Te Taki Haruru into the SDF programme strategy, reflecting these in the decision-making framework and assessment criteria for shortlisting the three proposed adaptation futures, and incorporating Aukaha-authored narratives into the descriptions of each future.

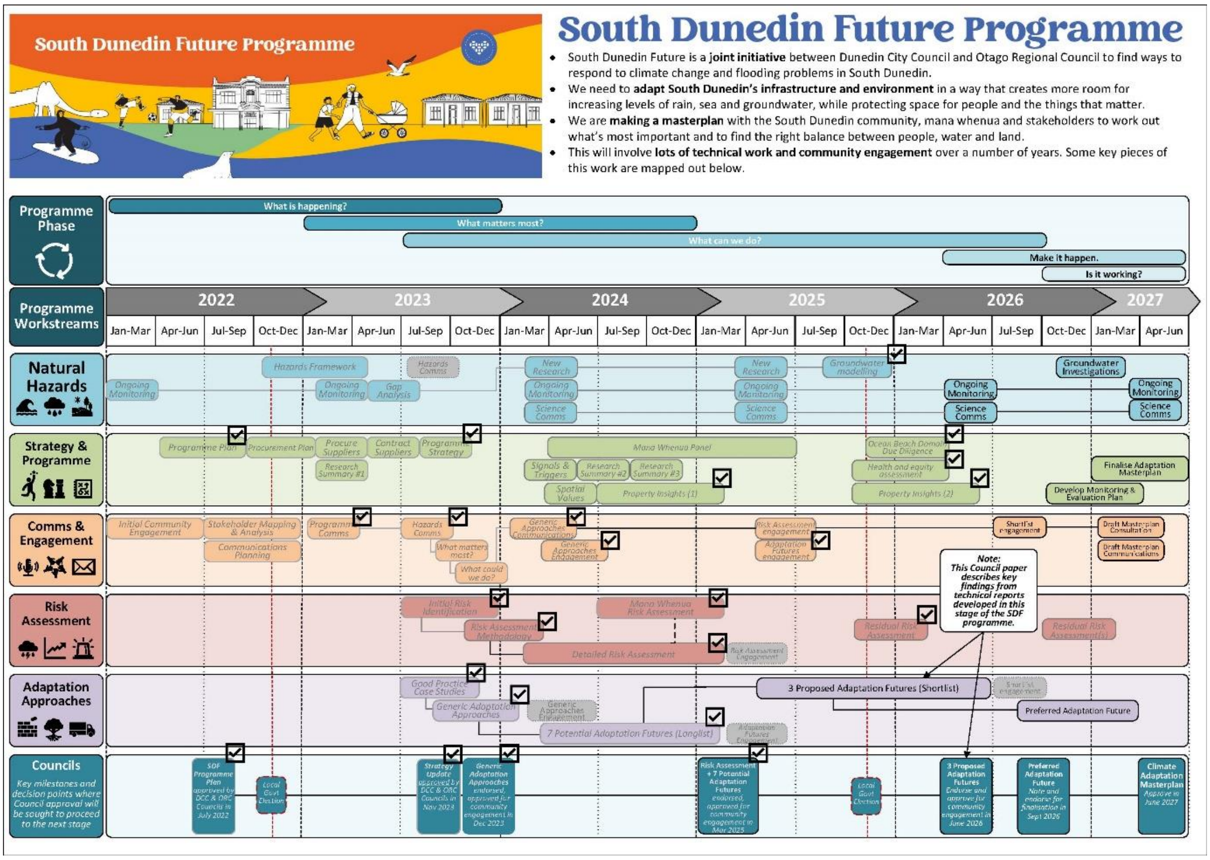
Sustainability

Sustainability is a central component of the SDF programme as it seeks to develop a climate adaptation master plan for South Dunedin covering the next 100 years. The criteria for developing and assessing each of the proposed adaptation futures includes a range of sustainability-focussed criteria, including carbon emissions and waste.

LTP/Annual Plan / Financial Strategy /Infrastructure Strategy

The SDF programme has dedicated resourcing in the current 9-year plan (2025-2034). Selected activities that result from the SDF programme, including mid-scale and medium-term investments in 3 waters (for example), are also included in the 9YP. It is anticipated that the climate adaptation master plan for South Dunedin, scheduled for completion in June 2027, will inform a range of strategic land use-, finance-, and infrastructure-related decisions for South Dunedin as part of the next Long Term Plan process for 2027-37.

SUMMARY OF CONSIDERATIONS
Financial considerations The cost of the SDF programme is fully budgeted for within the existing SDF programme budget. No decisions have been made about funding for potential adaptation work that may arise from the SDF programme (outside of those already in the current 9-year plan).
Significance This topic is considered high in terms of councils Significance and Engagement Policy. Community engagement is and will continue to be a central component of the SDF Programme, and extensive engagement is planned in future stages, in accordance with the approved programme plan.
Engagement – external Extensive external engagement has been undertaken with a range of partners, stakeholders, and affected communities on the topics covered in this paper. Mana whenua have partnered with SDF throughout the development of the programme, including by contributing to assessments described in this paper. Engagement has included (but is not limited to): central government departments, state owned enterprises, crown research institutes; private sector organisations and industry groups; community groups and affected communities.
Engagement - internal A large number of internal subject matter experts, teams, and departments across DCC and ORC have been engaged in development of SDF programme work, including the assessments and design work described in this paper.
Risks: Legal / Health and Safety etc. There are no anticipated legal or health and safety risks associated with this report. Risks relating to the SDF Programme are described in this or previous Council reports.
Conflict of Interest There are no conflicts of interest identified.
Community Boards Community Boards have not been directly involved in development of this report.


South Dunedin Future Programme
South Dunedin Future Programme
South Dunedin Future is a joint initiative between Dunedin City Council and Otago Regional Council to find ways to respond to climate change and flooding problems in South Dunedin.
We need to adapt South Dunedin's infrastructure and environment in a way that creates more room for increasing levels of rain, sea and groundwater, while protecting space for people and the things that matter.
We are making a masterplan with the South Dunedin community, mana whenua and stakeholders to work out what's most important and to find the right balance between people, water and land.
This will involve lots of technical work and community engagement over a number of years. Some key pieces of this work are mapped out below.
Programme Phase
What is happening?
What matters most?
What can we do?
Make it happen.
Is it working?
Programme Workstreams
2022
2023
2024
2025
2026
2027
Jan-Mar
Apr-Jun
Jul-Sep
Oct-Dec
Natural Hazards
Strategy & Programme
Comms & Engagement
Risk Assessment
Adaptation Approaches
Councils
Key milestones and decision points where Council approval will be sought to proceed to the next stage
Groundwater Investigations
Ongoing Monitoring
Science Comms
Mana Whenua Panel
Finalise Adaptation Masterplan
Develop Monitoring & Evaluation Plan
Note: This Council paper describes key findings from technical reports developed in this stage of the SDF programme.
3 Proposed Adaptation Futures (Shortlist)
Preferred Adaptation Future
7 Potential Adaptation Futures (Longlist)
Detailed Risk Assessment
Climate Adaptation Masterplan

Three proposed adaptation futures for South Dunedin

Adapting to our changing climate is a big challenge. South Dunedin Future (SDF) is a programme aimed at better understanding how the environment is changing, considering how those changes will affect us, and looking at what we can do about it.

This is a joint initiative between the Dunedin City Council (DCC) and Otago Regional Council (ORC), working in partnership with mana whenua and local communities.

This document introduces three proposed adaptation futures for South Dunedin and the changes that may be required over time to adapt to a changing climate. The purpose of this document is to help the public and decision makers understand what the route for each future could involve, how the various futures may help to reduce risk in South Dunedin, and what the high-level costs and benefits of each future are.

SOUTH DUNEDIN FUTURE

Interacting council activities

South Dunedin Future is not occurring in isolation – there are a wide range of other council activities that are complementary to this adaptation planning process and will directly or indirectly influence the development of the adaptation masterplan and its subsequent implementation.

These activities contribute to making South Dunedin 'safer and better', by reducing floods and other risks and by helping regenerate different areas.

SOME KEY ACTIVITIES INCLUDE:

Three waters

- Quick-win stormwater projects ($29.2 million) – Three projects underway include:
  - Diverting the Bay View Road and New Street stormwater systems
  - Upgrading the size of the Forbury Road stormwater pipe
  - Disconnecting the Hillside Road stormwater main and pumping it to Orari Street outfall.
- Short-term storm water projects ($15 million) – Funding has been allocated in DCC's current 9-year plan (2025-34) for short-term flood alleviation work in South Dunedin, which will be one of the initial actions to implement the adaptation masterplan.
- Wastewater overflows at Surrey Street – DCC is undertaking renewals work across the three waters network to benefit South Dunedin and Surrey Street, as well as investigating options for addressing network issues contributing to wastewater overflows in and around Surrey Street during heavy rainfall events.

Property

- South Dunedin Library and Community Complex ($22 million) - Te Whata o Kaituna opened in September 2025 and provides flexible reading, learning, creative and community engagement spaces. Located on King Edward Street, the Library contributes to the ongoing revitalisation of South Dunedin's commercial centre.
- Forbury Park purchase and redevelopment ($13 million) – Purchased in February 2024, this 11.76 hectare site provides a wide range of options for DCC, including options for stormwater management. Design work is underway to incorporate the site into a green infrastructure network to support flood alleviation in South Dunedin and provide new community and recreational spaces.

St Clair / St Kilda coastline

- The St Clair to St Kilda coastline experiences coastal erosion. A separate project is currently underway to monitor and investigate how current and future coastal hazards may impact the coastline. The project is refining options for the next 50-year period to manage this erosion. DCC is working to align adaptation actions taken at the coast with those planned for inland areas of South Dunedin, so that they are complementary and lead to a coherent overall approach.
- Kettle Park Remediation ($31-61 million) – DCC is designing a plan for the remediation of the former landfill at Kettle Park. This is expected to involve removing a large amount of contaminated material and changing the profile of the dunes to better protect South Dunedin from coastal erosion.

City development

- Plan evaluation (Natural hazards provisions in South Dunedin) – This project is evaluating the effectiveness of the district plan (2GP) provisions that manage natural hazards in South Dunedin, to determine whether it is necessary to undertake a plan change.

Natural hazards

- Councils continue to actively monitor, investigate, and model natural hazards affecting South Dunedin. This includes monitoring groundwater, sea level rise, and land subsidence, as well as investigating coastal erosion and flooding, and understanding potential changes linked to the anticipated impacts of climate change.

Civil defence and emergency management

- Emergency Management Otago coordinates civil defence readiness, response, and recovery across the Dunedin City area, providing regional hazard information, planning, and support to help communities prepare for and manage emergencies.

Parks and recreation

- Playground upgrades: DCC has been undertaking a range of playground upgrades across South Dunedin, including at Bathgate Park (completed in 2024), St Clair (completed in 2025), and Marlow Park (scheduled for 2026).

What this could mean for different stakeholders

The Council's role is to:

- Coordinate and complete capital works (e.g. stormwater network upgrades, seawall, land raising) and works to enable these (e.g. engagement, changes to planning framework)
- Prepare and implement civil defence and emergency management plans
- Develop and implement plans, policies and regulations for the identification and management of natural hazards
- Facilitate the building of resilience and adaptive capacity within communities
- Where appropriate, work in partnership with communities to identify and manage risks.

While the council, on behalf of the community, is responsible for managing risks posed by natural hazards, **councils do not have an explicit legal obligation to protect privately owned assets from natural hazards.**

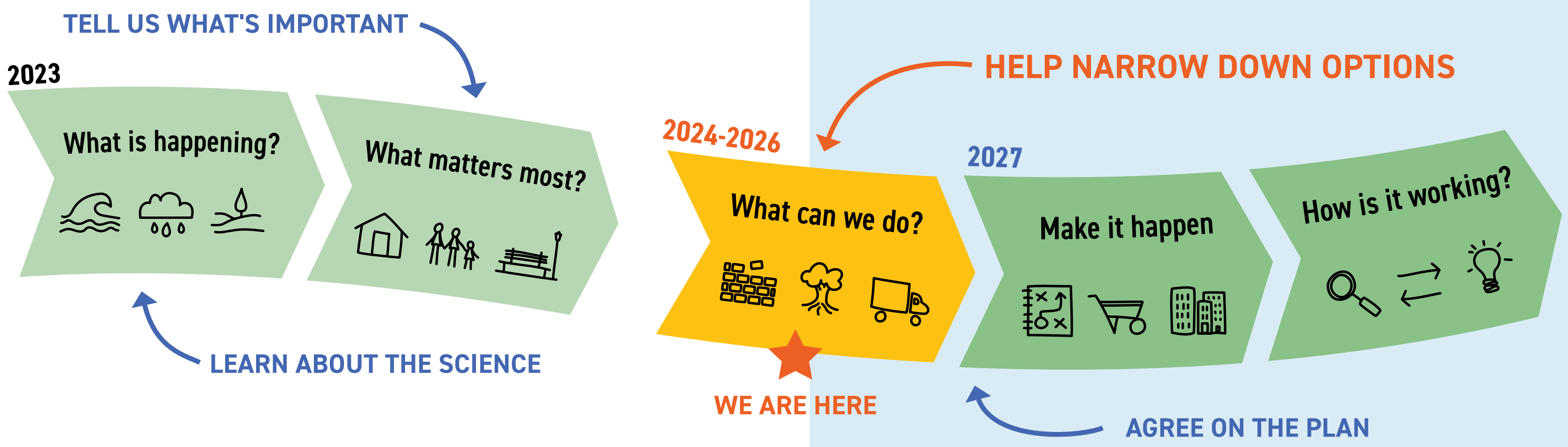
Private asset owners (such as individuals, organisations and businesses) are responsible for managing risks to their assets.

The private assets owner's role is to:

- Be aware of the risks and their responsibility for managing them
- Comply with regulations that apply to their assets and activities
- Take steps to understand the magnitude and nature of the specific risks
- Develop and implement strategies and actions to manage these risks at an individual property level.

Methodology overview

The five stages of the SDF programme are summarised in the ribbon, to the right, which captures the key questions relating to adaptation planning, as outlined in the Ministry for the Environment's Coastal Hazards and Climate Change Guidance (2024). These are described below.



1 What is happening?

The initial stage of the SDF programme involved work to monitor and analyse a wide range of natural hazards affecting South Dunedin, such as flooding from heavy rain, rising groundwater and sea level rise. The South Dunedin Risk Assessment, released in March 2025, summarised our current understanding of how these hazards are expected to change over time. This information is updated as new data becomes available.

2 What matters most?

The Risk Assessment considers South Dunedin's exposure to these changing hazards, the vulnerability of things affected, and analyses the resulting risk – now and in the future. Understanding what is important and why allows an assessment of the consequences of risks to people, places and assets in South Dunedin. This work is informed by community engagement and mana whenua values. The Risk Assessment provides a picture of what could happen to the things we value if appropriate action is not taken.

3 What can we do?

There are many ways to adapt, generally grouped into four categories – protect, accommodate, retreat, and avoid. From the seven Potential Adaptation Futures released in 2025, three have been shortlisted. This phase of the SDF programme develops more detailed descriptions over time for these futures, showing possible actions in the short, medium and long-term. Feedback from the 2025 engagement sessions was used to inform the development of the three Proposed Futures.

4 Make it happen.

After a preferred future is selected and an adaptation masterplan is completed, delivery will occur through standard council processes, such as long-term planning, infrastructure strategies and District Plan changes. While the preferred future will provide a more detailed picture of potential changes in South Dunedin, it is important to note that no decisions have been made about major infrastructure or land use changes. Implementation is expected to take time and will depend on funding, consenting and national reforms.

5 Is it working?

A range of activities will also be put in place to monitor progress, to determine how well the adaptation masterplan is working and whether our actions are effectively managing risk. Based on the results, changes can then be made so that the plan remains fit for purpose.

IMMEDIATE NEXT STEPS

The next steps for the SDF programme include:

- Community engagement on the three proposed futures for South Dunedin.
- Further refinement of the three proposed futures into a preferred future, supported by a final round of community engagement.
- Presentation of the preferred adaptation future in an Adaptation Masterplan for South Dunedin, which is expected by early 2027.

Government guidance

In October 2025, central government released a National Adaptation Framework which sets out the approach to addressing climate-driven natural hazards across four pillars: risk and response information sharing, roles and responsibilities, investment in risk reduction, cost-sharing pre- and post-event.

Under the National Adaptation Framework, the first tranche of council adaptation plans will prioritise locations facing flooding and coastal hazards, reflecting the Government's risk-based approach to implementation. In addition, Civil Defence Emergency Management (CDEM) Group Recovery Plans will be required to "give effect to" the relevant adaptation plan and make sure recovery planning aligns with long-term climate adaptation planning.

The futures provide choices for communities of lower and higher risk areas within South Dunedin, enabling individual decision-making. The futures require council to invest early in infrastructure to manage flooding with a long-term (100-year) view in mind while providing opportunities for partnerships with investors to encourage development in the right places. The futures do rely on the ability to acquire property to transition high risk areas to lower risk uses, which is not explicitly addressed in the National Adaptation Framework.

Refining futures

From 16 adaptation approaches, we developed seven potential futures, then refined these to three proposed futures with actions over time. From here, further analysis and engagement will help select a single preferred future to underpin South Dunedin's climate adaptation masterplan. The process is outlined below.

16 GENERIC ADAPTATION APPROACHES

Drawing on best practice approaches from around the world, and ideas crowd-sourced from the community and stakeholders, an initial list of 16 generic approaches for helping South Dunedin adapt to flooding and future climate change was released in December 2023. These 16 approaches were categorised as one of protect, accommodate, retreat, and avoid, and were consulted on with the community in early 2024, with feedback informing further analysis.

7 POTENTIAL ADAPTATION FUTURES

The 16 approaches were then combined in different ways to form seven Potential Adaptation Futures for South Dunedin, which were released in March 2025. The seven futures included a 'Status Quo' future - essentially the path we're currently on if we don't change anything - and six other futures representing a spectrum of responses, with a focus on infrastructure at one end and land use change at the other. Community engagement on the seven futures was during April and May 2025.

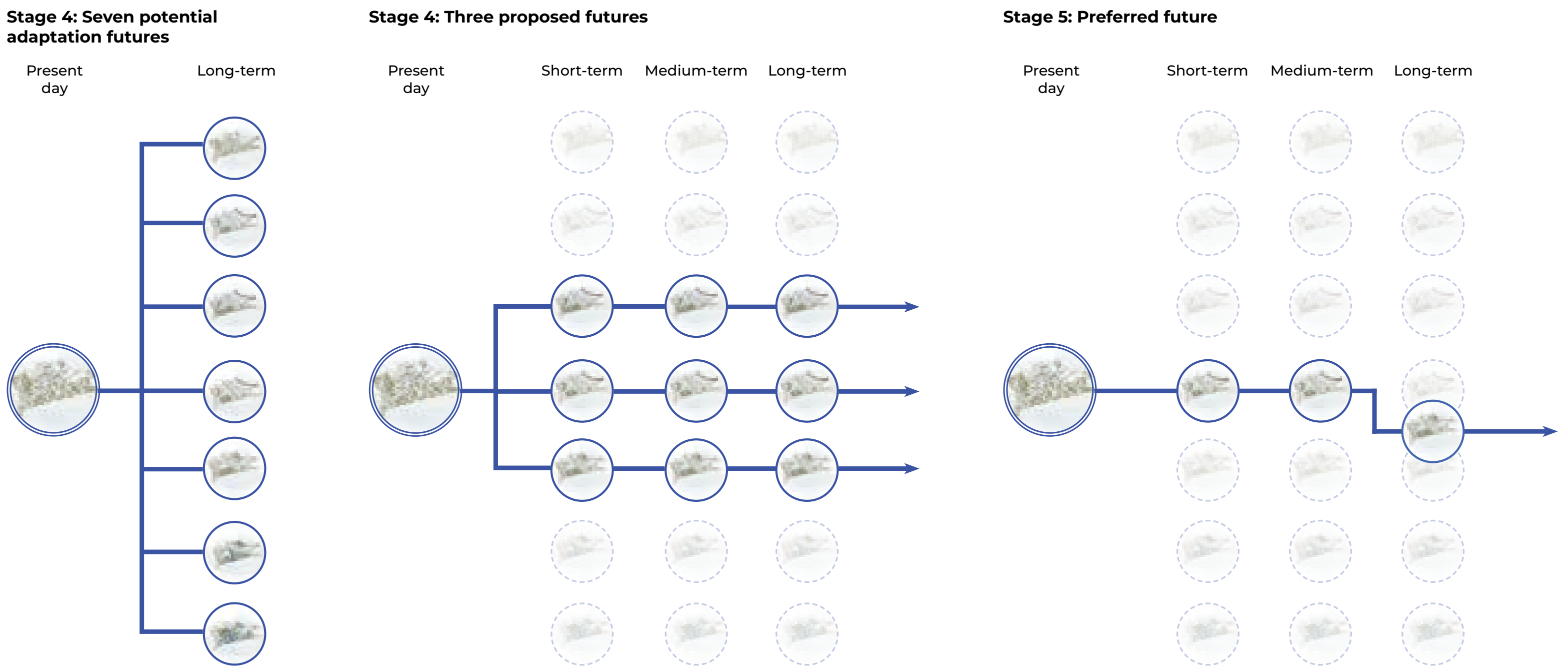
A shortlisting process assessed all seven futures in an effort to determine which ones will best manage the risks facing South Dunedin, while also enabling more opportunities. This process involved technical and economic assessments of each future, against a set of strategic objectives and a decision-making framework previously approved by the Councils. It also considered community feedback. The process proposed Futures 3, 4 and 5 for further development – which was reported to councils and announced to the public in September 2025.

3 PROPOSED ADAPTATION FUTURES

Following the shortlisting process, stormwater and groundwater modelling for each of the three proposed futures was used to determine an appropriate mix of infrastructure, green and blue space, and land use change required to manage risk in different areas of South Dunedin.

The three proposed futures show what type of action we might take over time, covering short (next few decades), medium (mid-century), and long-term (toward the end of the century and beyond).

- **Future 3 – Protect (Keep the land dry – raise land and pump water)**
  Hard infrastructure moves water, supported by wetlands and stormwater reserves. Raised land provides elevated, safer areas for development.



- **Future 4 – Restore (Make space for water – waterways and wetlands)**
  A network of waterways, wetlands, pipes, pumps and coastal protection balances engineering with nature.
- **Future 5 – Reshape (Move out of harm's way – raised land and green spaces)**
  Open waterways, green infrastructure and raised land development combine to manage flooding and groundwater while reshaping a resilient urban form.

REFINING TO A PREFERRED FUTURE

Following community engagement, further assessments, modelling and economic analysis will refine the options and identify a single preferred future that best manages risk while enabling long-term opportunities.

Reader's guide

This document provides an initial assessment of the proposed futures over time. They serve as a tool for informed discussions with the community and decision makers in this phase about how a combination of adaptation actions over time may help reduce risk, as well as what residual risks remain and the high-level costs and benefits.

Visualisations of the three proposed futures are intended to illustrate the potential changes required in South Dunedin to manage flooding and other risks. This provides a sense of what the area could look like in the future and how these changes might play out over the short-, medium- and long-term. The illustrations are based on the best available information and analyses to date and are intended to support further discussions with the community and stakeholders. Further optimisation will be required for exact locations and sizes of infrastructure.

WHAT'S INCLUDED IN THE SUMMARIES?

Future comparisons:

A dashboard summarises costs, social impacts and technical factors, with additional images showing key actions, differences and how risk changes over time.

Future overview:

Each future outlines actions across categories (e.g., pipes/pumps/overland flow paths, managed relocation). The page includes images to show how South Dunedin will look on a 'dry-day' and 'flood-day', where the 'flood-day' is based on a rare event (1% chance of occurring each year).

Objectives assessment:

Subject-matter experts assessed each future over time; these summaries provide the evidence base for decision-making. Communities are welcome to provide feedback if we have missed any key considerations.

Implementation approach:

Technical considerations and potential signals, triggers and adaptation thresholds (STATs) to prompt action are set out as part of the implementation approach.

Economic measures:

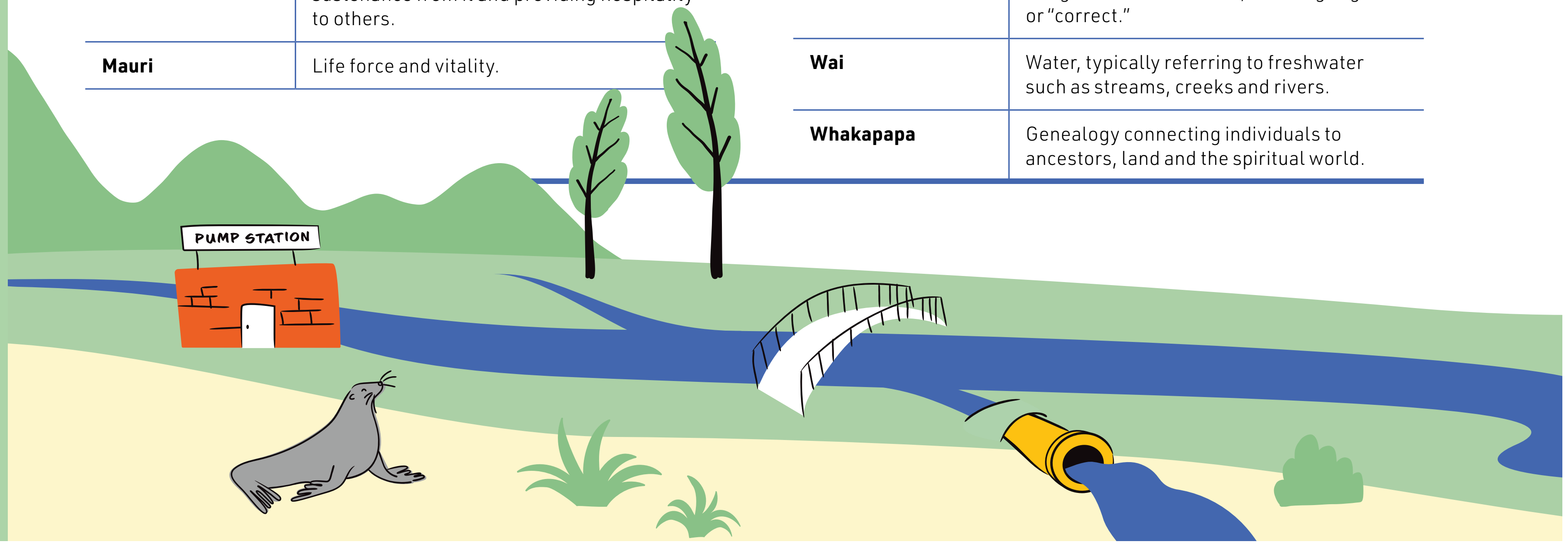
Present-value costs and benefits (in $ billions) inform the estimated benefit to cost ratios (BCRs). A BCR of zero is not viable, and ~1 or higher suggests more positive outcomes. Costs are Council-only and are indicative and have a high uncertainty, based on similar projects. They exclude potential offsets.

Risk assessment:

Maps show residual risk for the present (current level without any intervention), and the short-, medium- and long-term. Residual risk can persist or re-emerge when design levels are exceeded, infrastructure fails, or operations falter (e.g., power outages, inadequate maintenance).

Glossary

Annual Average Damages (AAD)	The annualised expected value of flood damage across all probability events, weighted by their likelihood. AAD is the primary benefit metric in the economic evaluation. It captures both the frequency and severity of flood events and is directly linked to the flood modelling outputs and DCC Flood Damage Assessment methodology.
Benefit Cost Ratio (BCR)	The ratio of present-value benefits to costs; a BCR above 1 indicates benefits outweigh costs, helping compare options.
Challenge of implementation	The practical difficulty of delivering an option, such as technical complexity, consenting, funding, timeframes, land access, and stakeholder alignment.
Hauora	Health and wellbeing.
Kaitiakitaka	Exercise of guardianship by mana whenua. Stewardship and guardianship, typically relating to the care and protection of an environmental area or natural resource.
Ki uta ki tai	"From the mountains to the sea." Describes a holistic, inter-connected and or catchment-wide approach to natural resource environmental management that recognises the interconnectedness of all parts of an ecosystem.
Mana Whenua	Authority and power derived from the land. Refers to Māori who have occupied and cared for a place over generations, drawing sustenance from it and providing hospitality to others.
Mauri	Life force and vitality.
Moana	Sea, ocean or a large lake.
Present risk	The current level of risk before any new interventions, based on existing hazards, exposure and vulnerability.
Properties acquired	The number and type of properties that must be purchased (voluntary or compulsory) to enable an intervention.
Properties added	The number of new properties added through development or redevelopment (e.g., relocation to raised land).
Rakatirataka	Māori sovereignty, leadership, and self-determination.
Residual risk	The risk that remains after interventions, e.g., when events exceed design levels, assets fail, or operations falter.
Social impact	The effects of an option on people and communities, wellbeing, equity, cultural values, access to services, displacement, and disruption.
Te Mana o Te Wai	A foundational concept in Aotearoa New Zealand's freshwater management that protecting prioritises the health and mauri wellbeing of water bodies is paramount to the health of the wider natural ecosystem environment and the health of people above other uses.
Tikaka	Māori customs and correct ways of doing things. Derived from tika, meaning "right" or "correct."
Wai	Water, typically referring to freshwater such as streams, creeks and rivers.
Whakapapa	Genealogy connecting individuals to ancestors, land and the spiritual world.



Understanding futures

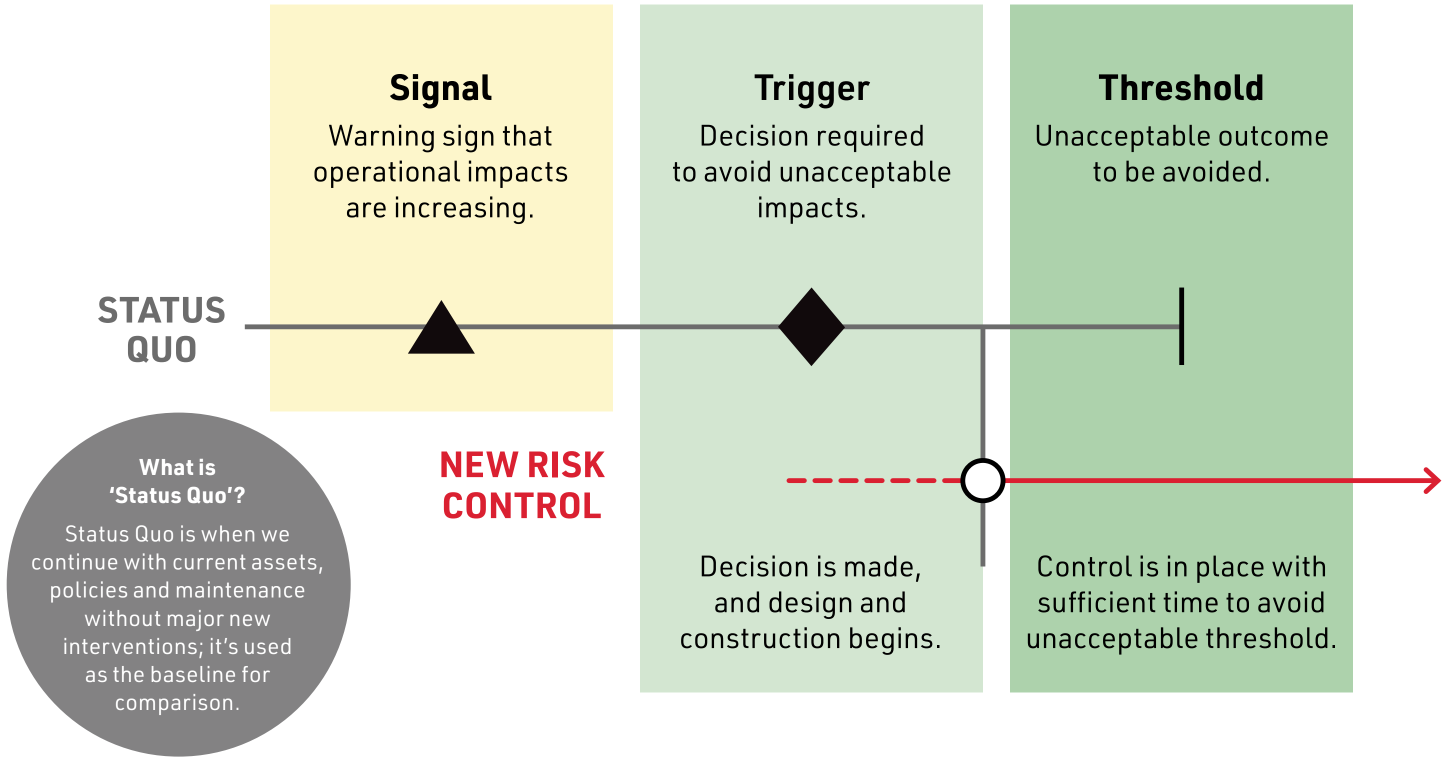
Each of the proposed futures shows the bundling and sequencing of interventions over time, covering short (next few decades), medium (mid-century), and long-term (toward the end of the century and beyond). The timing of adaptation interventions is based on dynamic signals (early warning), triggers (decision points), and thresholds (unacceptable outcomes). The summaries include more detailed information on the useful life of adaptation actions, linking together different actions such as infrastructure investment and creating green space.

An underlying principle of this type of dynamic approach is that interventions are only implemented when and where required. These respond to pre-agreed signals and triggers, so change occurs only if or when necessary to manage risk. The timing of these signals, triggers and associated interventions is indicative only, and in reality, may occur earlier or later depending on the rate of change in climate conditions.

For example, we might start to prepare for changes when we see certain signals (like worse or more frequent flooding), then implement agreed interventions when we hit certain triggers (like a certain number or severity of flood events), so we can make the changes before we hit certain thresholds (like insurance retreat).

For South Dunedin, we've already met some of the signals and triggers, and we'll need to start taking action soon to build more resilient communities.

Signals and triggers identified for the proposed futures are high-level at this stage. Measurable signals and triggers will be developed for the preferred future.



SWITCHING BETWEEN FUTURES

Although we will eventually agree on a preferred future, using this adaptive planning approach means we might switch between futures in a proactive, timely, and transparent way, guided by community objectives and data. After a signal is identified, consideration of whether the planned next step along the future is still the right one begins, with a decision made when the trigger is identified.

THINKING BEYOND 2125

To support long-term planning, we undertook preliminary sensitivity testing to understand how the futures perform beyond 2125. The futures have been developed for a very high emissions future (SSP5-8.5, 50th percentile) and are viable through to 2125 under those conditions. If a more extreme scenario were to eventuate (SSP5-8.5, 83rd percentile), the futures would remain effective but only up to approximately 2095.

On the upside, if we follow a 'middle-of-the-road' climate scenario (SSP2-4.5), the futures remain effective for longer, likely through to about 2150.

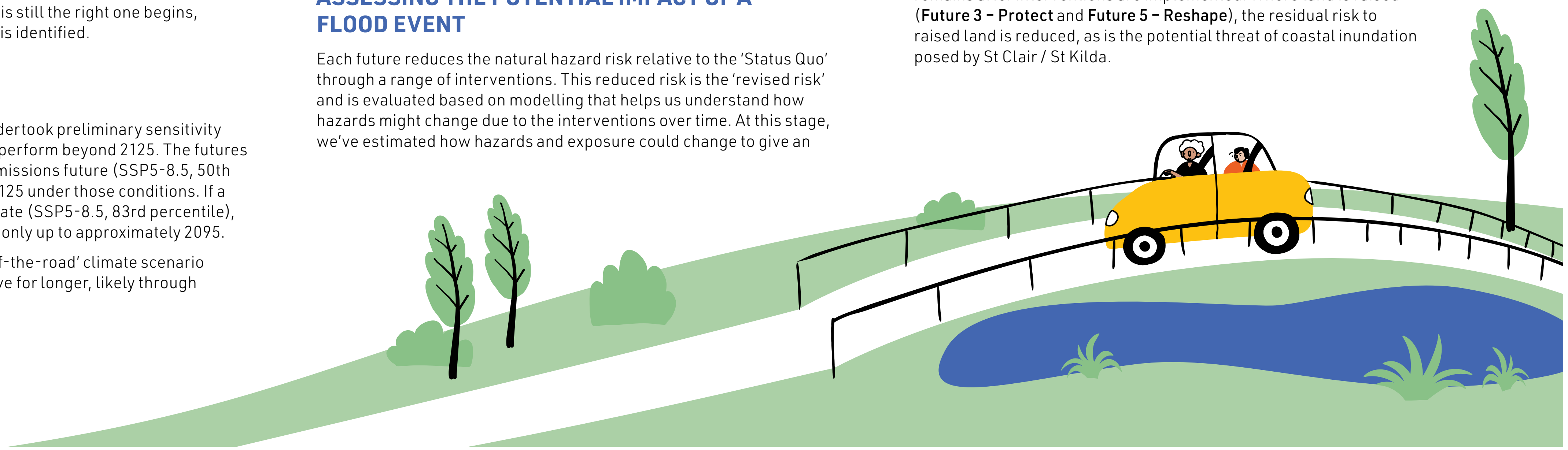
In particular, **Future 3 – Protect** and **Future 5 – Reshape** continue to perform well even under events that exceed their design conditions because development is shifted to higher, lower risk areas. **Future 5 –Reshape** is likely to perform better than **Future 3 – Protect** these over-design events because there is additional capacity to hold water in the waterways as compared to the pipe network. Under any of these futures, there remain options to shift communities to safer areas beyond 2125 or if conditions worsen faster than expected.

ASSESSING THE POTENTIAL IMPACT OF A FLOOD EVENT

Each future reduces the natural hazard risk relative to the 'Status Quo' through a range of interventions. This reduced risk is the 'revised risk' and is evaluated based on modelling that helps us understand how hazards might change due to the interventions over time. At this stage, we've estimated how hazards and exposure could change to give an early indication of potential impacts. More detailed modelling and design work will be carried out later as the preferred future is developed further to optimise and minimise cost while maximising the benefits.

In all futures, short and medium-term interventions achieve drastic reductions in 'revised risk', with minimal difference in risk profile between each future. In the long term, high uncertainty remains regarding the long-term management of coastal hazards at St Clair / St Kilda, meaning coastal flooding poses an unknown level of risk.

In all futures there remains a 'residual risk'. This is the risk that remains after interventions are implemented. Where land is raised (**Future 3 – Protect** and **Future 5 – Reshape**), the residual risk to raised land is reduced, as is the potential threat of coastal inundation posed by St Clair / St Kilda.



Economic approach

This economic evaluation exists to answer a specific question: Does the evidence support investment in adaptation, and if so, which adaptation future delivers the most value for the public dollar? The answer requires holding two things in view simultaneously: what it will cost the community to act, and what it will cost the community not to.

The evaluation covers 100 years from 2027. Infrastructure investment of the kind contemplated in each future has a design life measured in decades. The consequences of under-investing in the past and continuing this through the 2020s will be felt in damage, in lost property value, in deteriorating liveability well into the 2070s and beyond. A 100-year lens is the minimum needed to capture the likely costs and benefits felt across the community.

The primary metric used throughout this evaluation is Annual Average Damage, or AAD. AAD is the annualised expected cost of flood damage across the events with a 10%, 2% and 1% chance of occurrence weighted by their likelihood. Put simply, it represents what the community would pay each year, on average, if it were fully insured against all pluvial flood events at their expected frequency and severity.

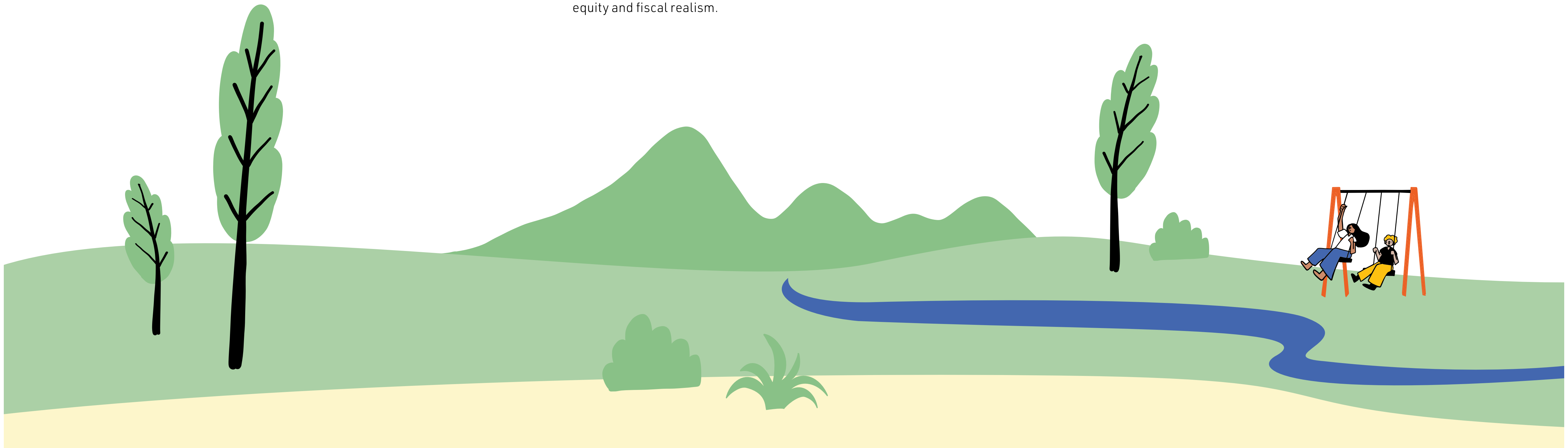
The economic evaluation follows a standard adaptation appraisal framework drawing on national and international guidance for long-term climate investment. The analysis assesses each proposed future by comparing its whole of life costs with the avoided damages and co-benefits achieved relative to the Status Quo baseline. This baseline represents a market driven reactive response to the increasing exposure to hazards and associated increasing AAD over time. By framing benefits as "avoided losses," the evaluation enables a direct and transparent link between the hazard modelling, residual risk results, and the economic outcomes.

The BCR is calculated as the net present value of all the monetised benefits divided by the net present value of all the monetised costs. A BCR of 1 is where the net present value of the monetised benefits equals the monetised costs. If the BCR is less than 1, the costs outweigh the benefits (and vice versa).

The economic evaluation has assessed and compared the expected and indicative whole-of-life costs and benefits of each shortlisted future, relative to the counterfactual of not investing in future adaptation in the existing community. The key driver of this economic evaluation is to provide comparable evidence to DCC and does not represent all costs and benefits from ongoing and future activity in this area.

We relied on the outputs from other models for this work (see Economic Evaluation Report for more details).

Benefit-Cost Ratios are calculated using a central real discount rate of 6% and some sensitivity testing. This range reflects common practice for long-living public infrastructure and climate adaptation investments, where discounting must balance intergenerational equity and fiscal realism.

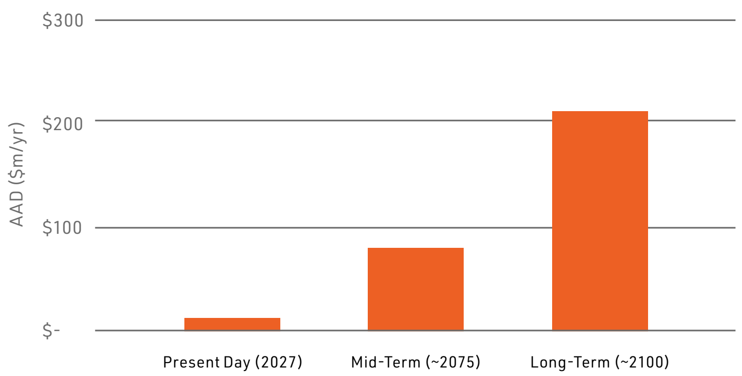


The cost of inaction – Status Quo

The Status Quo trajectory is not a hypothetical. South Dunedin already experiences flooding. The 2015 and 2024 events demonstrated the scale of disruption that moderate events can cause. The modelling underpinning this evaluation projects that the frequency of events of that severity, and worse, will increase substantially over the coming decades, driven by sea level rise, more intense rainfall, and groundwater pressures that are already detectable.

The economic evaluation quantifies this trajectory, enabling decision-makers to consistently compare the costs of acting and not acting. The central finding is clear: the cost of inaction is high and growing, spread across many years as damages to property are increasingly incurred, with its most severe consequences borne by the most vulnerable households. The question is not whether to act, but which action will retain the current community of approximately 13,500 in South Dunedin.

Cost of Inaction: Property-Level Annual Average Damage - Status Quo ($m/yr)



The $11 million to $212 million AAD trajectory captures direct property and building damage from rainfall events and coastal inundation. ***It does not capture the full economic and social cost of inaction, which is substantially larger and more complex***. The true cost of doing nothing includes a set of cascading consequences that compound the primary damage figures over time beyond what is shown here.

Annual Average Damage by Time Period – Status Quo Scenario

Building Level Property Damages - Status Quo	AAD 2025 QV ($m)		
	Pluvial Flood Damages	Coastal Flood Damages	Combined Damages
Short-term (present day)	$11m	$0m	$11m
Medium-term	$43m	$35m	$78m
Long-term	$60m	$152m	$212m

The $1.4 billion and likely $2 billion figure in context

Over the full 100-year assessment period, the present value cost of the Status Quo scenario exceeds $1.4b plus (2025 NPV at a 6% central real discount rate). This includes property damage, fatality and injury costs, emergency services, trauma, income loss from displacement, and environmental costs.

It excludes infrastructure repair, loss of activity/productivity, event clean-up costs, private property interventions (both proactive and reactive), and the economic consequences of insurance withdrawal. Including these would raise the total materially above $2b.

IAG noted that from the 2015 flood event with over 1,200 homes and businesses damaged by water, resulted in insurance payouts being about $28m. They estimated the combined economic cost of $138m (made up of $64m economic damage and $18m social damage).

The $1.4b figure is therefore conservative. It represents the floor of the cost of inaction, not the ceiling.

The table below summarises the broader categories of economic harm that accompany and, in many cases, amplify the direct damage trajectory.

Each of these consequences interacts with the others: insurance withdrawal reduces property values, undermining the mortgage market and accelerating economic decline in the most exposed areas, which in turn makes recovery from flood events slower and more expensive.

Cost category	How it develops (with the Status Quo)	Trajectory
Infrastructure failure	Roads affected by deep flooding increase. Stormwater (pluvial flood events) covering the centreline of the road to a depth over 300mm increases from approximately twenty today to approximately 135 by 2120 for the 10% AEP event. Each failure disrupts access, supply chains, and emergency response. Park areas with 'unplanned' significant inundation increase from 0.5 hectares to approximately 4 hectares. Groundwater and coastal inundation further challenge the future efficacy of infrastructure, with approximately 1,200 properties becoming exposed to emergent groundwater through to 2120.	Rapidly worsening
Business and industrial disruption	Industrial areas face Annual Average Damages rising from $30 million (current) to approximately 90 million per major event in the long term. Loss of trading days, supply chain disruption, and reduced investor confidence follow each significant flood.	Rapidly worsening
Insurance affordability and availability	As flood frequency and severity increase, alongside and increasing impact of groundwater, insurers will raise premiums, impose exclusions (particularly for groundwater, which is already commonly excluded), and in the most exposed areas, withdraw cover entirely. This mirrors patterns seen following recent major flooding events across New Zealand.	Trigger approaching
Mortgage viability and property values	Without insurability, lenders are unwilling to extend mortgages against flood-affected properties. Property values decline, eroding the household wealth that many lower-income homeowners have built over a lifetime.	Worsening
Fatality and injury costs	The frequency of dangerous flood events increases significantly. Fatality and injury costs, valued using Treasury-recommended value of statistical life (VoSL) and injury-cost parameters, constitute a material component of total avoided damages under each adaptation future.	Worsening
Intergenerational equity	Under the Status Quo, residual risk is increasingly privatised: households and businesses in the most exposed areas bear the full cost of flood damage, insurance withdrawal, and asset depreciation. This concentrates harm on those least able to absorb it and transfers the consequences of today's decisions onto future generations.	Growing concern
Coastal exposure	The risk assessment highlights the rising likelihood of coastal inundation occurring from the Medium term onwards. Furthermore, exceedances of the 1% AEP extreme sea level event is identified to be occurring with an almost yearly frequency with 40cm of sea level rise (PCE, 2015).	Rapidly worsening

South Dunedin proposed futures – dashboard

Futures		Main Actions	Costs	Properties acquired and added	Challenge of Implementation	Social Impacts	Residual Risk	Average Annual Damages
Status Quo **Keep doing what we are doing** Total Costs: $0.41B **Total Damages: $1.45B**	Short	Pipes and pumps (minor stormwater network), reactive retreat, individual interventions	$254M	-57*				$11M
	Medium	Pipes and pumps (minor stormwater network), reactive retreat, individual interventions	$115M	-103*				$78M
	Long	Pipes and pumps (minor stormwater network), reactive retreat, individual interventions	$43M	-678*				$212M
Future 3 **Protect** Total Costs: $2.1B Total Benefits: $1.34B	Short	Investment in pipes, pumps, land aquisition and rezoning	$1,598M	-736				$0.6M
	Medium	Raise land, add pipes and coastal protection, expand pumps, create green spaces	$452M	-456/+336				$2.3M
	Long	Increase pump capacity, expand green spaces, develop housing	$48M	+1520				$1.0M
Future 4 **Restore** Total Costs: $1.63B Total Benefits: $1.35B	Short	Investment in pipes, pumps, land aquisition and rezoning	$1,284M	-1162				$0.6M
	Medium	Build canals, wetlands, and coastal protection, expand pumps, add pipes	$287M	+840				$1.6M
	Long	Complete green space transition, add pipes, increase pumping, develop housing	$58M	0				$0.7M
Future 5 **Reshape** Total Costs: $2.45B Total Benefits: $1.34B	Short	Investment in pipes, pumps, land aquisition and rezoning	$1,938M	-1144				$0.6M
	Medium	Raise land, build canals and coastal protection, develop housing	$475M	-594/+336				$2.5M
	Long	Maintain infrastructure, complete green space transition	$35M	+1780				$3.3M

SOUTH DUNEDIN FUTURE

Short - 2025 to 2050
Medium - 2050 to 2075
Long - 2075 to 2125

Pipes and Pumps **Water Storage**
Coastal Protection **Waterways**
Land Raising **Change in Planning Rules**

*Properties that would be impacted by emergent groundwater

Low, Moderate, High, Very High

With high coastal residual risk

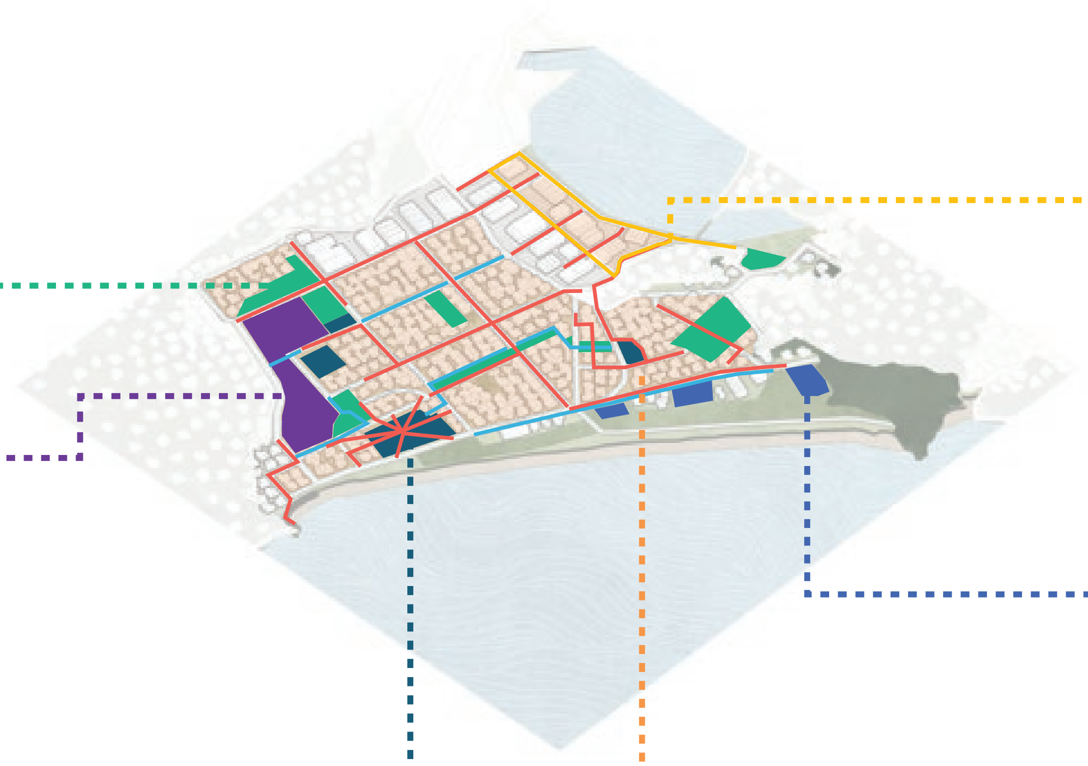
Higher residual risk due to failure or hazard event that exceeds design limits

South Dunedin Proposed Adaptation Futures, Apr 2026

Key actions

The image below depicts key actions that would be taken across all proposed futures. Some actions - including upgraded pipes and pumps and coastal protection - are shared across multiple futures.

Each key action is shown on the central map, illustrating how different parts of South Dunedin would be supported to manage flooding, adapt to climate change and build long-term resilience. Locations and size have been informed by community feedback on what level of flooding is acceptable.



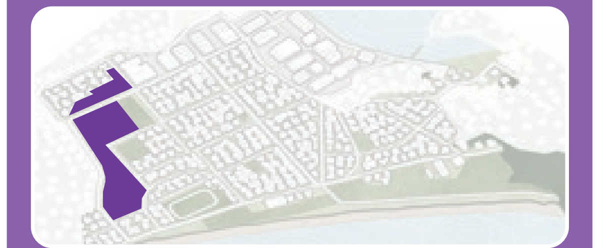
Greenspace

Some areas would need to become greenspace in the future where it is too difficult to manage flooding to keep communities safe. This includes places around the western end of Hillside Road where water naturally flows and areas near King Edward Street or in Musselburugh that are very low-lying.

Coastal Protection

Along Portsmouth Drive, additional coastal protection would likely be required around mid-century to protect from coastal flooding and erosion. This could be via increasing the height of the seawall or constructing an inland bund along Otaki Street. This coastal protection would be designed to protect against a coastal flood from the harbourside with a 1% chance of occurring in 2130.

Land Raising

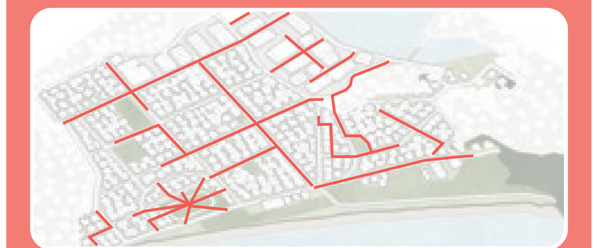


Some futures include land raising to extend the terrace along Forbury Road, building up land so that communities can live in places out of harm's way. This raised land extends areas that are already elevated and near the shops and town centres retaining a compact urban form. This builds up some low-lying areas that would be not otherwise suitable for housing.

New Development

Existing elevated areas may be developed to make space for people in South Dunedin in areas where there is lower risk. These locations are set back from the coast to reduce erosion risk and are presently green spaces to minimise the need for disruption and redevelopment.

Pipes and Pumps

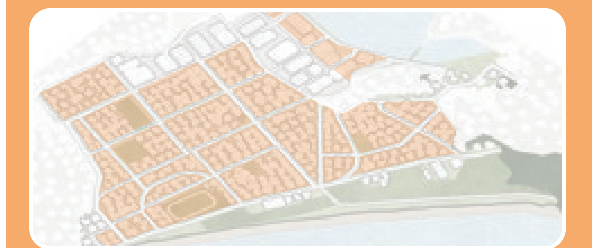


To manage groundwater and reduce flooding when it rains, pipe upgrades within the road corridors and new pump stations would be required. This location of pumps and pipes uses the existing network as much as possible to reduce disruption and enhance cost-effectiveness. The overall strategy was to divide the catchment into smaller sub-catchments with their own outfalls to the harbour to avoid the need for a large ocean outfall.

Water Storage

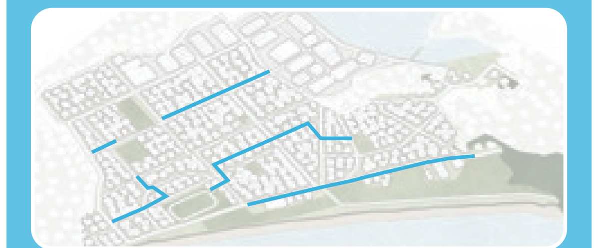
Many open spaces would be designed to collect and hold water when it rains and then slowly release it after the peak passes to reduce flooding. These storage areas were located in existing parks and green spaces to minimise the amount of land acquisition required.

Changes to Planning Rules



To avoid increasing the risk, there may be changes to planning rules required in the future. This could include floodable ground floors near the coast, increased floor level requirements or existing use only in the Flat.

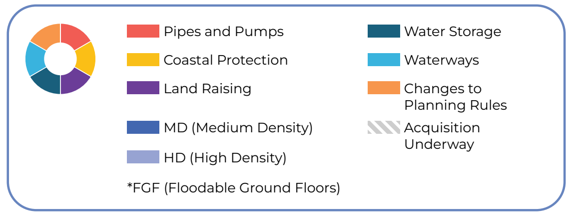
Waterways



Some futures include waterways to capture, temporarily store and move groundwater and stormwater. The waterways are set along existing roads, and alignments were selected to integrate with the existing network where there were low-lying shallow pipes to reduce construction costs and disturbance. These waterways manage groundwater more effectively than a pipe network.

Key differences over time

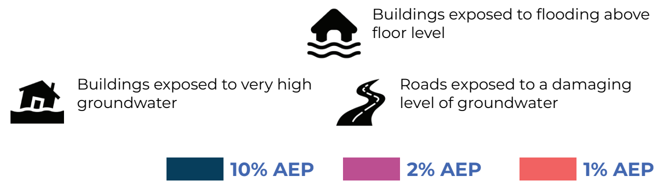
The image below shows how each future evolves over the short-, medium- and long-term.
For each future, the three timeframes show which new actions are added over time.



Residual risk over time

The image below shows how residual risk changes over time across the proposed futures. It compares present day risk with short-, medium- and long-term projections, highlighting the buildings that remain exposed to flooding even after planned actions are implemented.

The maps illustrate the varying levels of risk that persist under each future, highlighting where vulnerabilities continue and where adaptation efforts reduce exposure over time.



Future 3 – Protect

Future 3 – Protect manages stormwater and groundwater mainly via a network of pipes and pump stations to move water out of South Dunedin.

Roads help to direct and hold water during intense rainfall and stormwater reserves or constructed wetlands provide even more storage when required.

To support this, Council would improve the seawall along Portsmouth Drive, and raise an area of Forbury Corner to expand the existing high ground and create intensified space for people to relocate to, away from areas of highest risk. To minimise the amount of land raising required, a new residential development is included in the Ocean Beach Domain area.

KEY PROJECT FEATURES

- TOTAL REPURPOSED LAND 80.7 ha
- 1190 BUILDINGS DEMOLISHED
- 31 km OF PIPING NETWORKS
- 14 ha FOR STORAGE & WETLANDS
- 38 ha OF RAISED LAND
- 2.1 km SEAWALL
- 16 km OF GW PIPE NETWORKS
- 10 NEW PUMP STATIONS
- 4 NEW OUTFALLS
- 0 km OF OPEN CHANNELS
- 1 NEW GW PUMP STATIONS

What we heard about Future 3 – Protect

In 2025, Council asked for feedback from Aukaha (representing Kāi Tahu mana whenua) and the local community. We've used this feedback to inform development of the proposed futures.

KĀI TAHU RŪNAKA

Engagement with Aukaha indicated that Kāi Tahu mana whenua considers **Future 3 – Protect** a modest improvement to the Status Quo, but view it as fundamentally limited by its reliance on hard infrastructure. While the inclusion of larger stormwater retention areas and green spaces offers some ecological benefits, the approach does not fully align with Te Mana o Te Wai (wellbeing of water) or ki uta ki tai (mountains to sea) principles.

Aukaha noted moderate disruption and risks of inequitable transitions, with vulnerable communities potentially disadvantaged. They had favourable perceptions of **Future 3 – Protect** related to general risk reduction and an improvement in community hauora (health). However, the reliance on hard infrastructure rather than natural process limits the ability for mauri (life force) to be enhanced.

Overall, **Future 3 – Protect** is viewed as a compromise: slightly better than Status Quo, but misaligned with best outcomes for mana (recognised authority and prestige), whakapapa (genealogy) and cultural aspirations.

COMMUNITY ENGAGEMENT

South Dunedin communities' perspectives on **Future 3 – Protect** are mixed, reflecting both optimism and caution. Many respondents felt this option was taking South Dunedin in the right direction, with around 39% agreeing and 20% strongly agreeing. People appreciated the inclusion of wetlands, seeing them as visually appealing and beneficial for the area's character.

While **Future 3 – Protect** was seen as empowering by giving people choices about where and how they live, concerns remained about equity and transparency of potential property acquisition.

Overall, **Future 3 – Protect** was viewed as a balanced and cost-effective approach that could improve resilience and quality of life without requiring widespread relocation. However, some respondents expressed uncertainty about details such as how land would be raised, the timeframe for implementation, and what support would be available for affected residents.

FUTURE 3 – PROTECT

Short-term (next few decades)

Pipes, pumps and flow paths

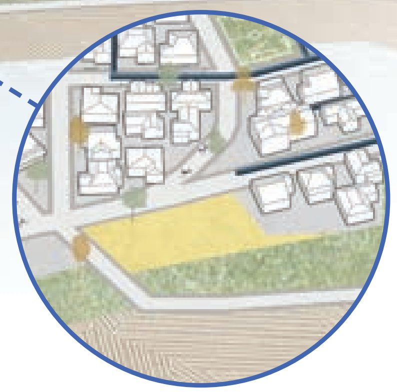
Over the next few decades, Council would invest heavily in pipes and pumps to reduce flooding, including new pump stations lifting peak capacity by 137% and upsizing or adding stormwater pipelines across 25 km of the network. Daily pumping would lower groundwater while providing sufficient capacity to drain rainfall. Roads would still flood periodically, but property impacts are generally avoided in storms with a 2% annual chance of occuring, with some damage risk in rarer 1% chance events.

Property acquisition

Property acquisition (shown in pink areas) would be required in high groundwater zones to prepare for safer development and infrastructure. Changes to planning rules begin in the Flat with changes in development rules to avoid increasing risk.

Storage

Parts of Forbury, Bathgate and Tonga parks would be adapted as stormwater storage, balancing sport, recreation, natural spaces, and water. They would connect to the piped and pumped network, with ponds drained to add system capacity. Most of the time Bathgate and Tonga would be dry, but during major rain they would temporarily store water, which is then pumped out after the peak. More blue-green space will be needed over time, requiring some land acquisition in the short-term.



New development

Areas shown in yellow along Victoria Road would be zoned for medium-density development to provide lower-risk residential development spaces for people to shift to over time. Any loss of existing park space would be balanced by creation of more parks and green spaces in higher risk areas, such as on the Flat. These types of 'land use swaps' would help enable the best use of land in South Dunedin.

Coastal protection

In the short-term, there are no changes to coastal protection along the harbourside.

Working together with the St Clair / St Kilda Coastal Plan: There are a few ways to protect the coast, from hard structures like seawalls and offshore barriers (offshore breakwater) to softer options like adding more sand. Any plan would also deal with the contaminated landfill at Kettle Park. Right now, the quickest and most effective thing to do is protect the area where the St Clair geobags end and the Kettle Park landfill begins. This would mean building an offshore breakwater there, removing some of the landfill, and reshaping the dunes at Middles Beach to help reduce erosion. This intervention is under development and appraisal at this stage.

FUTURE 3 – PROTECT

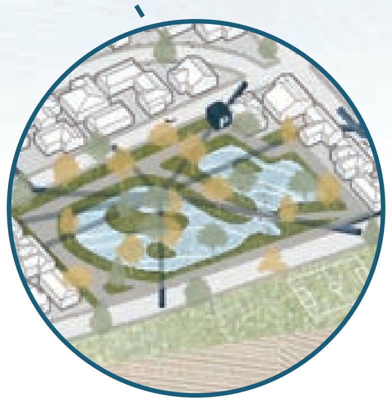
Medium-term (mid-century)

Pipes, pumps and flow paths

Signals and triggers including flood depths greater than 150mm on residential lots or local roads during design events would prompt Council to invest in a further 5km of pipes and increase pump capacity by an additional 12%. Roads would still periodically flood, but impacts to properties are generally avoided during rainfall events with a 2% chance of occurring each year. During extreme events with a 1% chance of occurring each year, there would remain some risk of property damage.

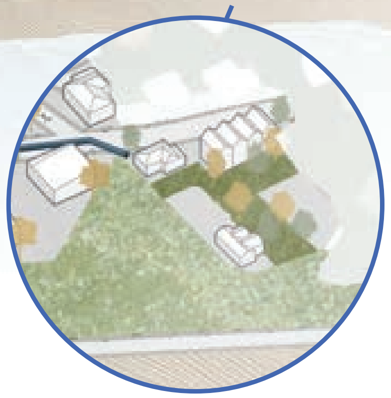
Land raising and development

Property acquisition would be complete by this point and would provide more space to manage stormwater and raise land. The area around Forbury Corner would be cleared and built up to prepare for development in a safe elevated area. Land raising would make ground levels higher through placement of fill material to reduce risk to pluvial, groundwater and coastal flooding and would extend the natural terraced area.



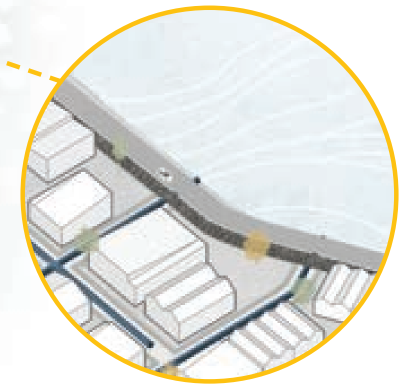
Storage

The existing storage areas have minor expansions in the medium-term. Over time, Tonga and Bathgate Parks are used more frequently to store heavy rainfall.



New development

Medium-density housing would be developed along Victoria Road with on site stormwater management, set back from projected future shorelines. Any park loss would be offset by new green space in higher risk flat areas to optimise land use in South Dunedin. In high groundwater areas (e.g., Musselburgh), converting to open space would enable tighter drain spacing while keeping these areas suitable for sport and recreation. New development along Forbury Road would begin once land raising is complete.



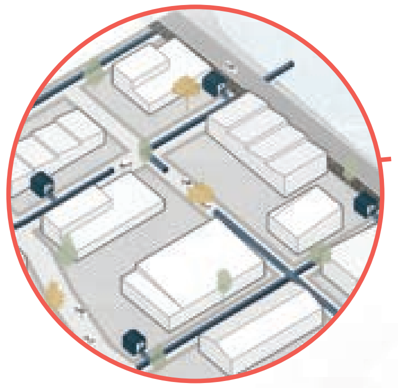
Coastal protection

Once sea level reaches 0.55m above 2005 levels, improved coastal protection along the harbourside would be required, with Council investing in extending the seawall to Bayfield Park and raising road levels to maintain emergency and community access. Construction of the seawall would need to take place during this period along the harbour edge to prevent overtopping into the industrial area and the Edgar Centre.

Working Together with the St Clair / St Kilda Coastal Plan: Rising sea levels and more storms would weaken and undermine the south coast seawall over time. To stop it from failing and to help keep sand on the beach, the seawall would need to be upgraded, shifted and possibly supported with extra sand. In future, buffer zones might be needed along the coast to allow room to move things back if erosion or flooding gets worse.

FUTURE 3 – PROTECT

Long-term (towards the end of the century and beyond)



Pipes, pumps and flow paths

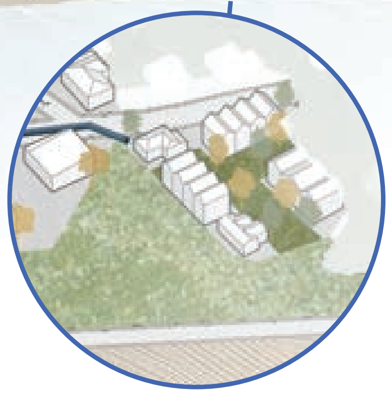
Council would increase pump capacity by a further 19% to keep land dry, with no additional pipes required if maintenance and periodic replacement are sustained. Roads would still flood periodically, but property impacts are generally avoided in storms with a 2% annual chance of occuring, though some risk would remain in rarer 1% events. Groundwater would be managed with daily pumping up to about 1.1 m of sea level rise, but becomes increasingly challenging beyond 2125.

Storage

The scale of storage in green space increases, providing further space for water on low-lying land as groundwater becomes more difficult to manage and rainfall is projected to increase. Water is stored in ponds then discharged when the network has capacity (e.g. after a storm passes).

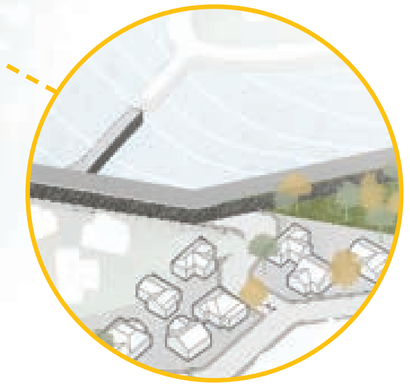
Green space creation

To avoid insurance retreat or unaffordable premiums, all acquired land would either be raised and developed or converted to green space for stormwater and groundwater management, reflecting the area's higher long-term risk. Green space would include reserves, sports fields, and parks - such as transforming the low-lying area behind King Edward Street for market days and community use. Council would keep flexibility to adapt to other futures, with gradual shifts to raised land (Future 6) as a very long-term option if risks become unmanageable.



New development

Medium-density residential space along Victoria Road and Forbury Road would be complete by this stage providing additional space for people in low-lying areas to shift to safer areas.



Coastal protection

In the long-term an extended seawall would provide coastal protection along the harbourside, along with a raised road levels to maintain emergency and community access.

Working Together with the St Clair / St Kilda Coastal Plan: Long term coastal risks on the South Coast are hard to predict, but managing erosion and flooding would likely require a mix of ongoing actions, and engineers would need updated information to decide which options work best. In some places, moving things further back from the coast may be needed.

FUTURE 3 – PROTECT

Objectives assessment

SUSTAINABLE URBAN DEVELOPMENT

Short-term

Early stormwater upgrades and limited uptake of water-sensitive design result in high embodied emissions. Changes to planning rules reduce flood risk and support compact growth.

Medium-term

Medium-density growth in safer areas and coastal protection improve resilience and create a compact urban form. High embodied emissions result from land raising and seawall construction, and there are ongoing operational emissions due to continued pumping.

Long-term

Transforming low-lying areas into greenways and focusing growth in elevated, walkable neighbourhoods improves resilience, while continued pumping results in ongoing emissions.

ENVIRONMENTAL AND CULTURAL RESTORATION

Short-term

Short-term engineered interventions increase stormwater discharges and limit ecological or cultural restoration, offering negligible biodiversity gains now, though changes to planning rules could enable future greenways.

Medium-term

Land elevation and new green spaces create habitat and improve water quality, but seawall expansion impacts nearshore ecosystems and cultural access. Limited co-design and reliance on hard infrastructure constrain deeper cultural restoration despite some alignment with Te Mana o Te Wai.

Long-term

Converting low-lying areas into greenways and wetlands would restore habitats and improve water quality, while cultural regeneration is enabled through natural landscapes; however, historic displacement, land-raising and seawall impacts remain, under-scoring the need for cultural integration to restore mauri and long-term ecological health.

PROMOTE COMMUNITY SAFETY

Short-term

Stormwater upgrades lower risks to homes and essential services, and changes to planning rules support safer choices despite community anxiety. While visible infrastructure boosts confidence even as construction disrupts access, ultimately improving health through reduced dampness and better living conditions.

Medium-term

Elevated land and coastal protection reduce flood exposure while green spaces lower residual risk and enhance recreation. Reliable transport access improves services despite temporary disruption. Ongoing seawall and pump maintenance is required. Overall wellbeing improves though uncertainty may affect psychological resilience.

Long-term

Green infrastructure and elevated land significantly reduce hazard exposure and create healthier living environments. Health improves and psychological resilience grows as communities stabilise, even as some impacts of past relocations persist. Residual risk from extreme events may require ongoing adaptation.

JUST TRANSITION

Short-term

Construction disruptions and buyouts risk stress and displacement, especially for culturally and linguistically diverse communities. While prioritising equity can reduce immediate flood risks for vulnerable groups, buyouts occurring before new elevated housing becomes available could create affordability pressures.

Medium-term

Land raising disrupts social structures and can fragment culturally diverse communities, while expanded elevated housing improves affordability and intergenerational equity. Accessible design supports elderly and disabled residents, and changes to planning rules limit redevelopment in high-risk areas, though relocation processes may still strain cultural ties, particularly for Pasifika and refugee households.

Long-term

Secure, affordable homes in elevated areas and new green spaces in former flood zones improve conditions for vulnerable communities, though past displacement may leave social scars, while long-term protection and amenity support intergenerational equity.

SOCIAL AND ECONOMIC RESILIENCE

Short-term

Upgraded stormwater systems reduce flood-related economic losses and support business continuity despite construction disruptions. Changes to planning rules and early land acquisition strengthen long-term adaptive capacity but create short-term uncertainty. Limited green infrastructure reduces potential amenity and ecological co-benefits.

Medium-term

Medium-density housing and coastal protection strengthen economic stability and reduce property damage, though construction and relocation may temporarily disrupt communities and local economies. Visible resilience measures improve adaptive capacity and public understanding of climate risks.

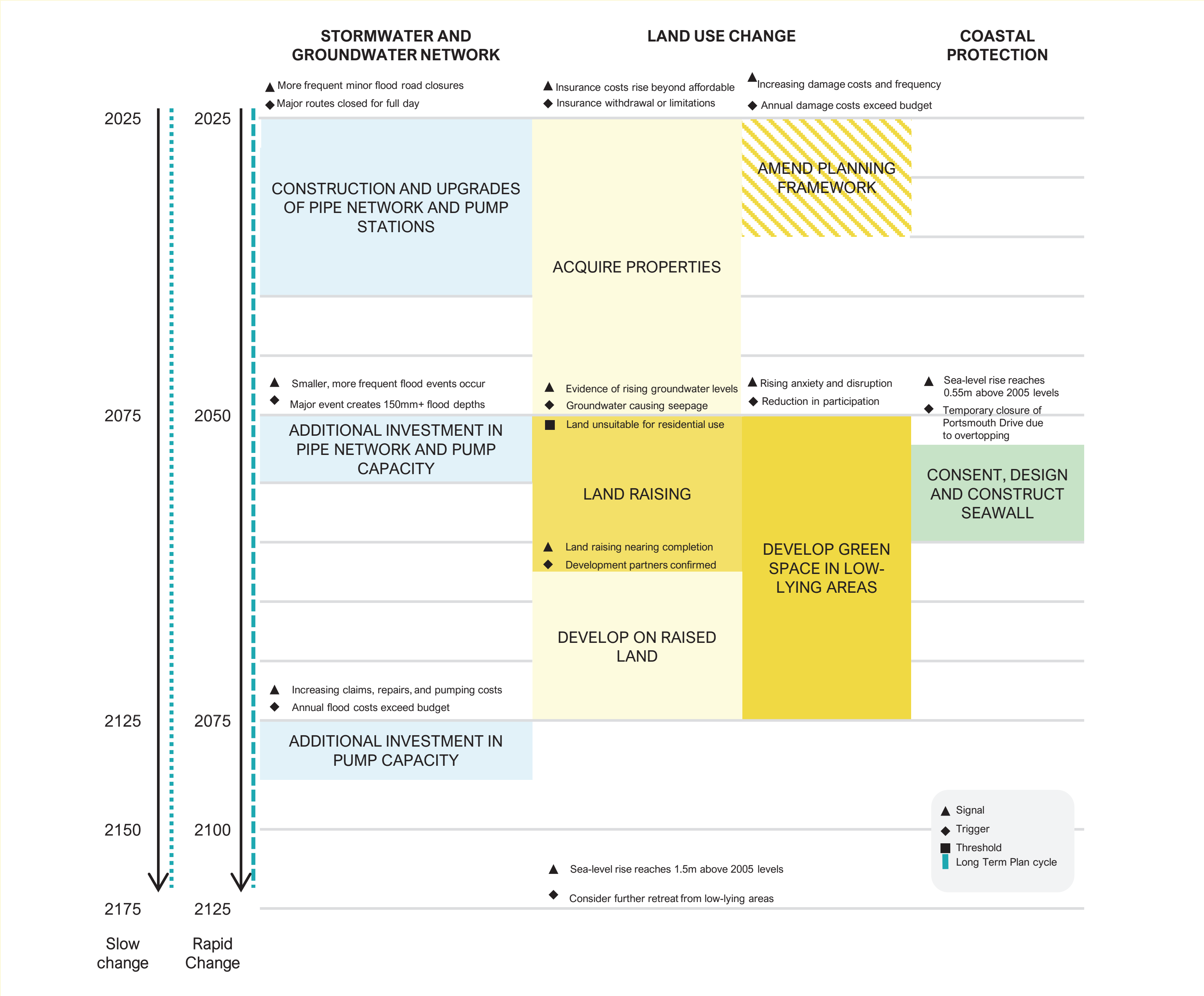
Long-term

Expanded greenways and elevated housing create a resilient urban system where businesses thrive in secure locations and improved infrastructure reduces flood-related losses. Active transport and public spaces foster social cohesion despite earlier fragmentation. Adaptive capacity strengthens through ongoing monitoring and flexible planning.

FUTURE 3 – PROTECT

Implementation approach

Adapting South Dunedin to a changing climate requires a sequence of interdependent actions, as shown below, which illustrates the indicative timeline for implementation. Actions along **Future 3 – Protect** are presented with sample signals (◆) and triggers (▲) representing early warning signs and resulting key decisions or enabling actions. Signals, triggers, and adaptation thresholds may be social, economic, ecological, physical, or cultural. The timing shown for signals, triggers, and actions is indicative only.



In the short-term, Council must first coordinate significant upgrades to the pipeline network and pumps to manage groundwater and stormwater efficiently. These upgrades need to be done simultaneously to avoid added cost and disruptions within the road corridor twice. Once drainage capacity is improved, Forbury Park and part of Tonga Park can be developed into greenspace for stormwater management. Short-term network upgrades have been designed to avoid needing to remove pipes in the future, and in the medium and long-term, increased stormwater capacity is largely provided by additional pumps.

At the same time, future development restrictions and opportunities require changes to the planning framework, which would need to be amended prior to physical works. In parallel, property acquisitions should be opportunistically pursued across Forbury Corner and Musselburgh. Properties acquired during this stage could be rented, leased, or similar until enough land is consolidated to enable large-scale transformation.

Finally, securing funding, consents and development partners would trigger major projects, including housing development at Tahuna and Forbury Corner. Enlargement of the existing seawall at Portsmouth Drive would require significant funds and should be complete prior to 2060 when the risk of overtopping increases due to sea level rise. Each step relies on the successful completion of the previous actions, creating a chain of dependencies that allow South Dunedin to adapt effectively to climate change.

WHAT ELSE DO WE NEED TO ACTION IT?

Changes in zoning: Council would need to make changes for development in the Flat and enable works related to upgrading infrastructure and raising land. This is a critical first step.

Financial incentives or penalties: Financial incentives can positively influence land use change and relocation required. Further work is needed into the mechanisms to achieve this but could include Council providing land-swaps, grants or low-interest loans for households relocating to raised land and development incentives in safer areas.

Property acquisition (buyouts): Land would need to be acquired to make space for pipes, pump stations and green infrastructure (e.g. stormwater management wetlands) which are "public works" because of their flood mitigation and public safety functions. Simultaneously, acquisition across Forbury Corner and Musselburgh would be required to enable land raising and safer development.

Funding mechanisms: Funding mechanisms are crucial for both the development of infrastructure and property acquisition. Further work is required to investigate possible funding mechanisms but could include public-private partnerships or development contributions for infrastructure upgrades (for example). Investigations into potential Central Government support through the Regional Infrastructure Fund (or similar) or protection of Crown assets (like schools) should occur.

FUTURE 3 – PROTECT

Economic measures

The Cost Benefit Assessment work seeks to compare the implications of shortlisted futures for South Dunedin.
Costs and benefits are indicative and intended for comparison at this step of the South Dunedin Future (SDF) Programme.

Time period	Benefits ($m)	Costs ($m)	BCR
Short-term (0 - 25 years)	$452	$1,598	0.28
Medium-term (26 - 50 years)	$372	$452	0.82
Long-term (51 - 100 years)	$511	$48	10.61
Overall	**$1,335**	**$2,098**	**0.64 (0.54 - 0.75)**

Cost estimation approach

Based on spatial mapping of potential scenarios and typical unit rates from similar New Zealand projects. Calculated at 2025 present values, assuming staged implementation across the three time periods identified with construction spread over the first 10 years of each period. Includes:

* Construction (capital, preliminaries, demolition, utilities)
* O&M costs
* Professional fees
* Contingency and optimism bias (+66% per Treasury guidance)
* Proactive Property acquisition – 1,190 properties (residential, commercial, social).

Whole-of-life costs: 25-year maintenance cycles + annual O&M. Pump stations include an allowance for annual electricity charges.

Exclusions: GST, escalation, downtime.

Costs do not account for potential offsets (e.g., land resale) or private owner contributions.

Range: $2.1b ($1.9b – $2.5b), influenced by scale and uncertainty (especially land raising).

Monistised benefits include:

* Avoided fatalities & injuries
* Avoided residential, industrial & commercial property damage
* Avoided infrastructure damage
* Avoided trauma and social cohesion costs
* Avoided water quality impairment
* Avoided income loss and emergency services costs.

Benefits excluded due to data unavailability at this stage:

* Redevelopment potential / Gains in property value
* Avoided loss of open spaces and ecosystem services
* Avoided heritage building damage
* Value of insurability.

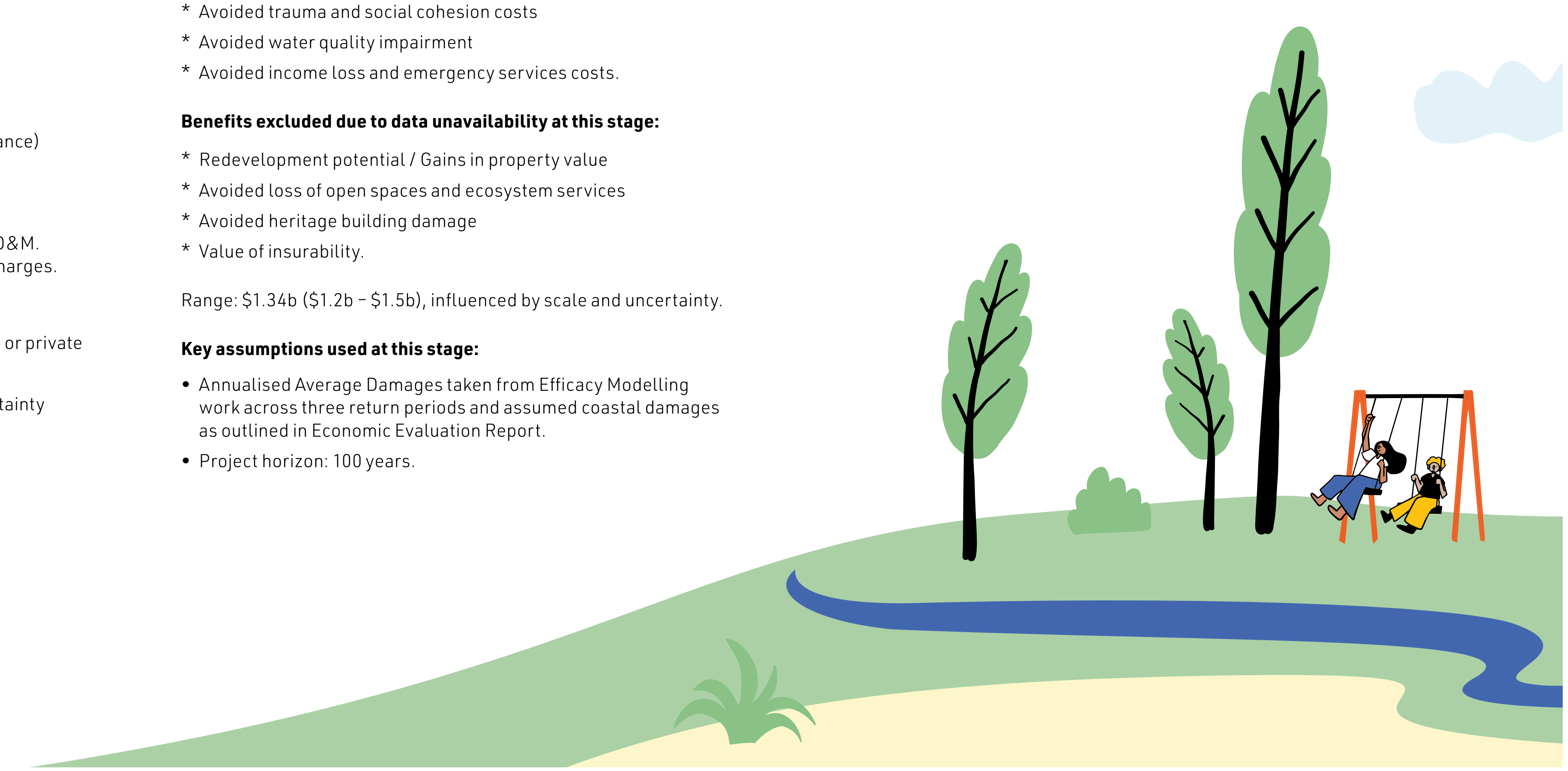
Range: $1.34b ($1.2b – $1.5b), influenced by scale and uncertainty.

Key assumptions used at this stage:

- Annualised Average Damages taken from Efficacy Modelling work across three return periods and assumed coastal damages as outlined in Economic Evaluation Report.
- Project horizon: 100 years.

KEY PROJECT FEATURES

- TOTAL REPURPOSED LAND 80.7 ha
- 10 NEW PUMP STATIONS
- 14 ha FOR STORAGE & WETLANDS
- 1 NEW GW PUMP STATIONS
- 16 km OF GW PIPE NETWORKS
- 31 km OF PIPING NETWORKS
- 0 km OF OPEN CHANNELS
- 2.1 km SEAWALL
- 1190 BUILDINGS DEMOLISHED
- 4 NEW OUTFALLS
- 38 ha OF RAISED LAND



FUTURE 3 – PROTECT

Risk assessment

Future 3 – Protect provides significant reduction in pluvial flooding and groundwater risk in the short-term relative to the baseline risk (present day, unmitigated).

This risk profile would further reduce over the medium-term despite increasing natural hazards. In the long-term, risk associated with most hazards are managed; however, high uncertainty remains regarding the long-term management of coastal hazards at St Clair / St Kilda, and further investigations are underway.

In all timeframes, residual risk remains, which is associated with the consequences of hazard events that exceed as-built design limits, and structural failures (e.g. seawall, groundwater pumping systems). It can also be associated with operational risks (e.g. power failures, lack of maintenance).

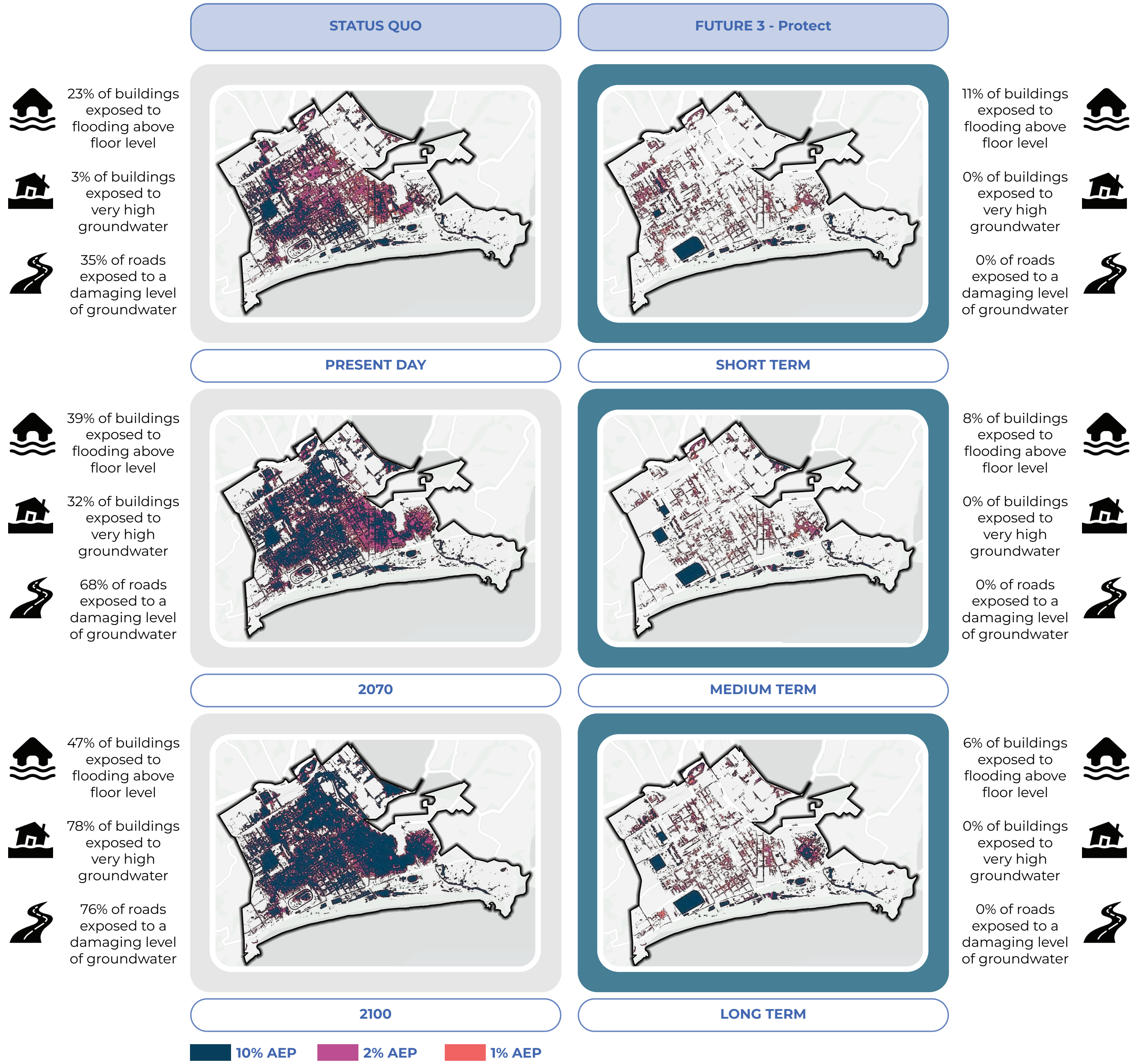
Overall, the **Future 3 – Protect** risk profile is largely similar to the other proposed futures, but has a slightly lower long term risk than **Future 4 - Restore** due to the raising of land that provides additional flood risk reduction benefits and minimizes residual risk.

HOW IT WOULD REDUCE RISK

In the short-term, stormwater infrastructure upgrades are predicted to remove the flood risk associated with frequent events (10% chance of occurring each year) and drive significant reduction of flooding associated with infrequent events (1% chance of occurring each year) across all buildings, lifelines, and critical infrastructure. Up to 33% of buildings may be exposed to infrequent flooding, with 11% of those likely to experience flooding above floor level. Otherwise, flooding would be generally contained within roads posing a low risk. Improved drainage and pumping also lowers groundwater levels so that buildings, parks, and roads are unlikely to be at risk.

In the medium-term, additional measures such as strategic acquisition of land for conversion to green space or raised land, and continued stormwater infrastructure improvements, coastal protection, and management of groundwater further reduce pluvial flood risk, coastal flooding risk and groundwater risk. The percentage of buildings exposed to infrequent flooding above floor level drops to 8%. In the long-term, this drops further to 6% primarily due to high density residential areas re-locating to raised land. This has the added benefit of reducing residual risks in relation to pluvial flooding, groundwater hazards and coastal flooding.

HOTSPOT SUMMARY OF RISKS TO SOUTH DUNEDIN FUTURE 3 - PROTECT: EXPOSURE OF BUILDINGS AND ROADS TO FLOODING AND GROUNDWATER



Future 4 – Restore

Future 4 – Restore makes space for water by creating a network of open waterways and wetlands, supported by pipes, pumps, overland flow paths, and coastal protection.

This future represents a balance between engineered and nature-based solutions and creates the opportunity for an extended town belt-type landscape, integrating South Dunedin into Dunedin's wider green network.

Some property acquisitions is required to create space for these interventions.

KEY PROJECT FEATURES

- TOTAL REPURPOSED LAND 69 ha
- 1162 BUILDINGS DEMOLISHED
- 2.1 km SEAWALL
- 16 ha FOR STORAGE & WETLANDS
- 11 NEW PUMP STATIONS
- 4 NEW OUTFALLS
- 16 km OF GW PIPE NETWORKS
- 1 NEW GW PUMP STATIONS
- 3.5 km OF OPEN CHANNELS
- 32.5 km OF PIPING NETWORKS

What we heard about Future 4 – Restore

In 2025, Council asked for feedback from Aukaha (representing Kāi Tahu mana whenua) and the local community. We've used this feedback to inform development of our futures.

KĀI TAHU RŪNAKA

Engagement with Aukaha indicated that, for Kāi Tahu mana whenua, **Future 4 – Restore** moderately aligns with Te Mana o Te Wai and tikaka (custom) principles because it incorporates more natural systems alongside infrastructure, creating opportunities for ecological connectivity and cultural restoration. This benefits biodiversity, wai (water), and moana (ocean). **Future 4 – Restore** provides scope for mana whenua to re-establish connections, exercise kaitiakitaka (stewardship), and integrate tikaka into environmental restoration.

Additionally, Aukaha noted that lower levels of flooding would result in improved community hauora (health), with wider community benefits related to wellbeing. Therefore, from a te ao Kāi Tahu perspective, **Future 4 – Restore** promotes community safety.

While **Future 4 – Restore** represents strategic and coordinated adaptation, Aukaha stress that its success depends on careful implementation to avoid inequity and to realise cultural aspirations.

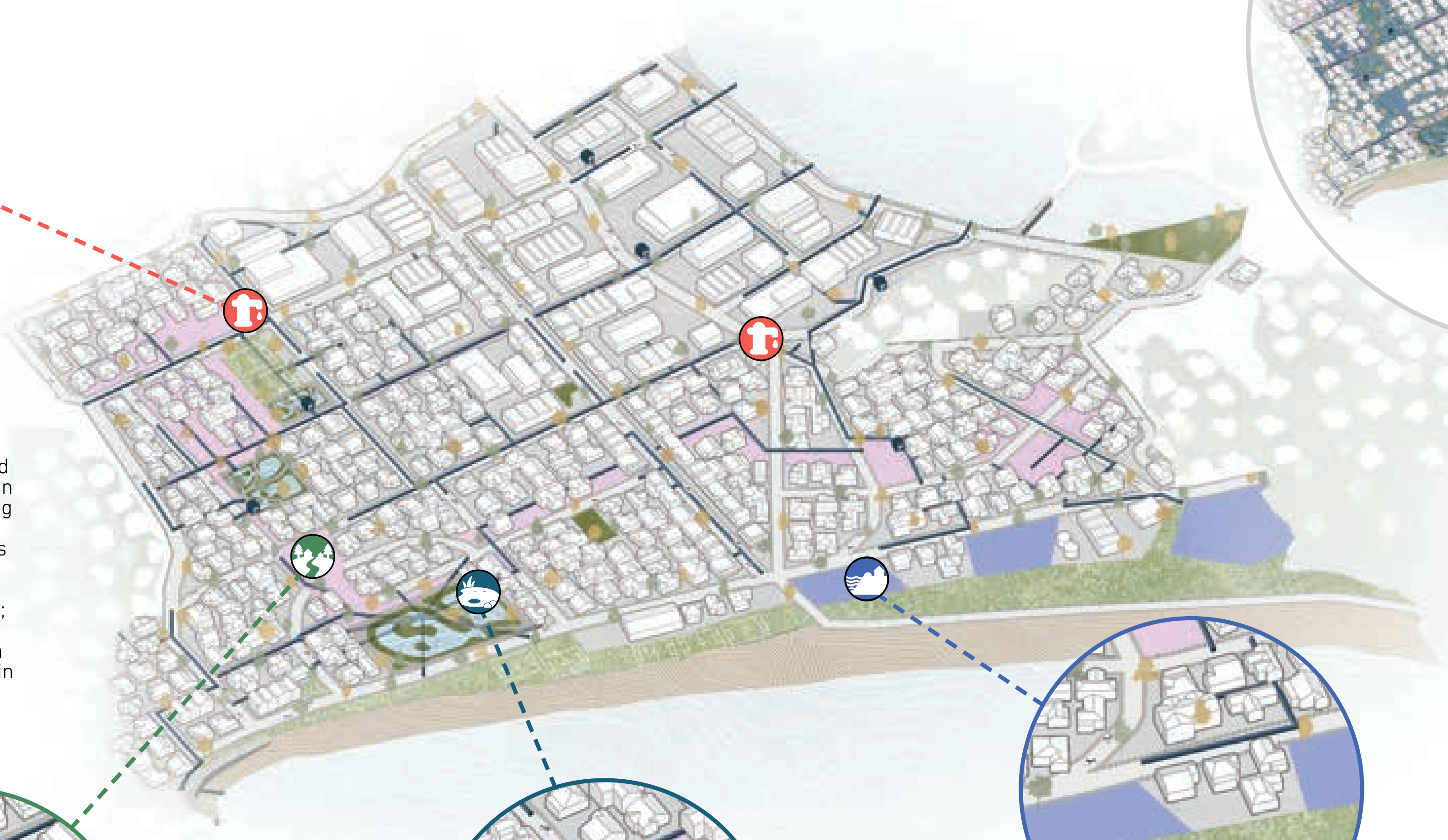
COMMUNITY ENGAGEMENT

The South Dunedin community found that **Future 4 – Restore** is a positive and balanced approach. The largest group of respondents (39%) agree this future takes South Dunedin in the right direction, and a further 20% strongly agree, citing the inclusion of waterways and wetlands for their visual appeal and potential to enhance the area's overall character.

Communities value the creation of multifunctional spaces that support biodiversity, carbon sequestration, and spaces for community, alongside improved access to essential facilities. This future was considered cost-effective and proactive, offering resilience without requiring widespread relocation. However, respondents emphasised the need for clear strategies and transparent communication, particularly around timelines, and safety and maintenance of waterways.

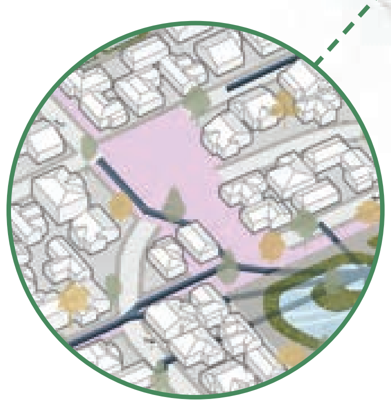
FUTURE 4 – RESTORE

Short-term (next few decades)



Pipes, pumps and flow paths

Given present day flood risk, Council would make short-term, significant investments in pipes and pumps: new pump stations lifting peak capacity by 137% in large storms and upsizing/adding stormwater pipelines across 25 km, designed to integrate with future waterways. Daily pumping would lower groundwater while draining rainfall; roads may still flood periodically, but property impacts are generally avoided in 2% AEP events, with some risk remaining in rarer 1% events.



Property acquisition

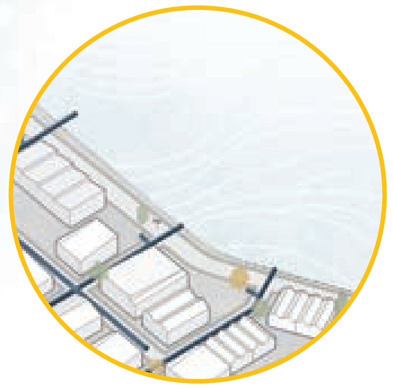
Property acquisition (shown in pink areas) would take place in high groundwater zones to prepare for green infrastructure. Rezoning begins in the Flat for changes in development rules to avoid increasing risk.

Storage

Parts of Forbury, Bathgate and Tonga park are used for stormwater storage balancing space for sports, recreational natural spaces, and water. This storage is connected to a stormwater pumped system, which drains the ponds and adds further capacity to the overall system. More blue-green spaces would be needed in the future requiring some land acquisition (shown in pink).

New development

Areas shown in purple along Victoria Road would be zoned for high-density development to provide lower-risk spaces for people to shift to in the future.



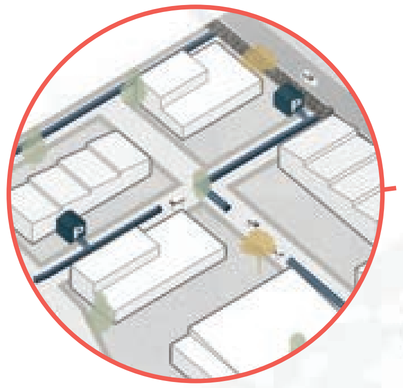
Coastal protection

In the coming decades, there are no changes to coastal protection along the harbourside.

Working together with the St Clair / St Kilda Coastal Plan: There are a few ways to protect the coast, from hard structures like seawalls and offshore barriers (offshore breakwater) to softer options like adding more sand. Any plan would also deal with the contaminated landfill at Kettle Park. Right now, the quickest and most effective thing to do is protect the area where the St Clair geobags end and the Kettle Park landfill begins. This would mean building an offshore breakwater there, removing some of the landfill, and reshaping the dunes at Middles Beach to help reduce erosion. This intervention is under development and appraisal at this stage.

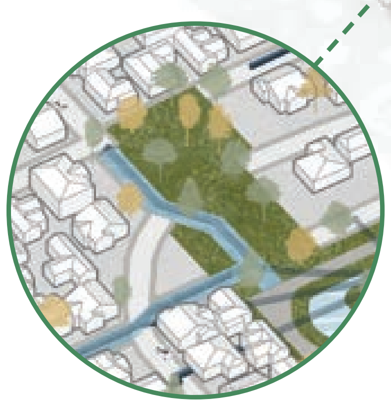
FUTURE 4 – RESTORE

Medium-term (mid-century)



Pipes, pumps and flow paths

Once flood depths greater than 150mm occur on residential lots or local roads, Council invests in a further 5.7km of pipes and increases pump capacity by an additional 21%. Roads still periodically flood, but impacts to properties are generally avoided during rainfall events with a 2% chance of occurring each year. During extreme events with a 1% chance of occurring each year, there remains some risk of property damage.

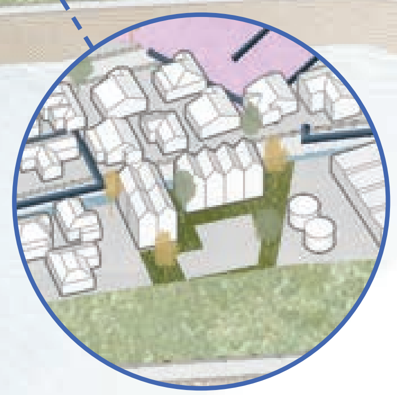


Property acquisition

Property acquisition would be complete by this point and would provide more space to manage stormwater and groundwater flooding.

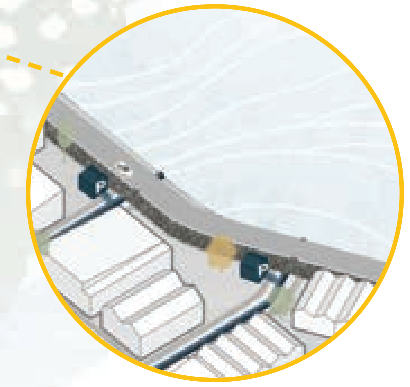
Waterways and storage

The construction of a network of MacAndrew, Kaituna, Victoria, Coughrey, and West waterways occurs in the medium-term. Some of these align with historic natural systems, and multi-use green spaces for stormwater storage and recreation. Victoria waterway in particular helps to manage groundwater, capturing tidally influenced groundwater before it moves inland and helping to manage saltwater intrusion. In some places it is still difficult to manage groundwater though so Council would construct green spaces in areas of persistent groundwater emergence, like in Musselburgh.



New development

High density residential areas would be developed along Victoria Road with on-site stormwater management, in an area buffered from our current understanding of where future shorelines would be. This provides safer areas for people to relocate to. Any loss of existing park space would be balanced by creation of more parks and green spaces in higher risk areas, such as on the Flat, to enable the best use of land in South Dunedin.



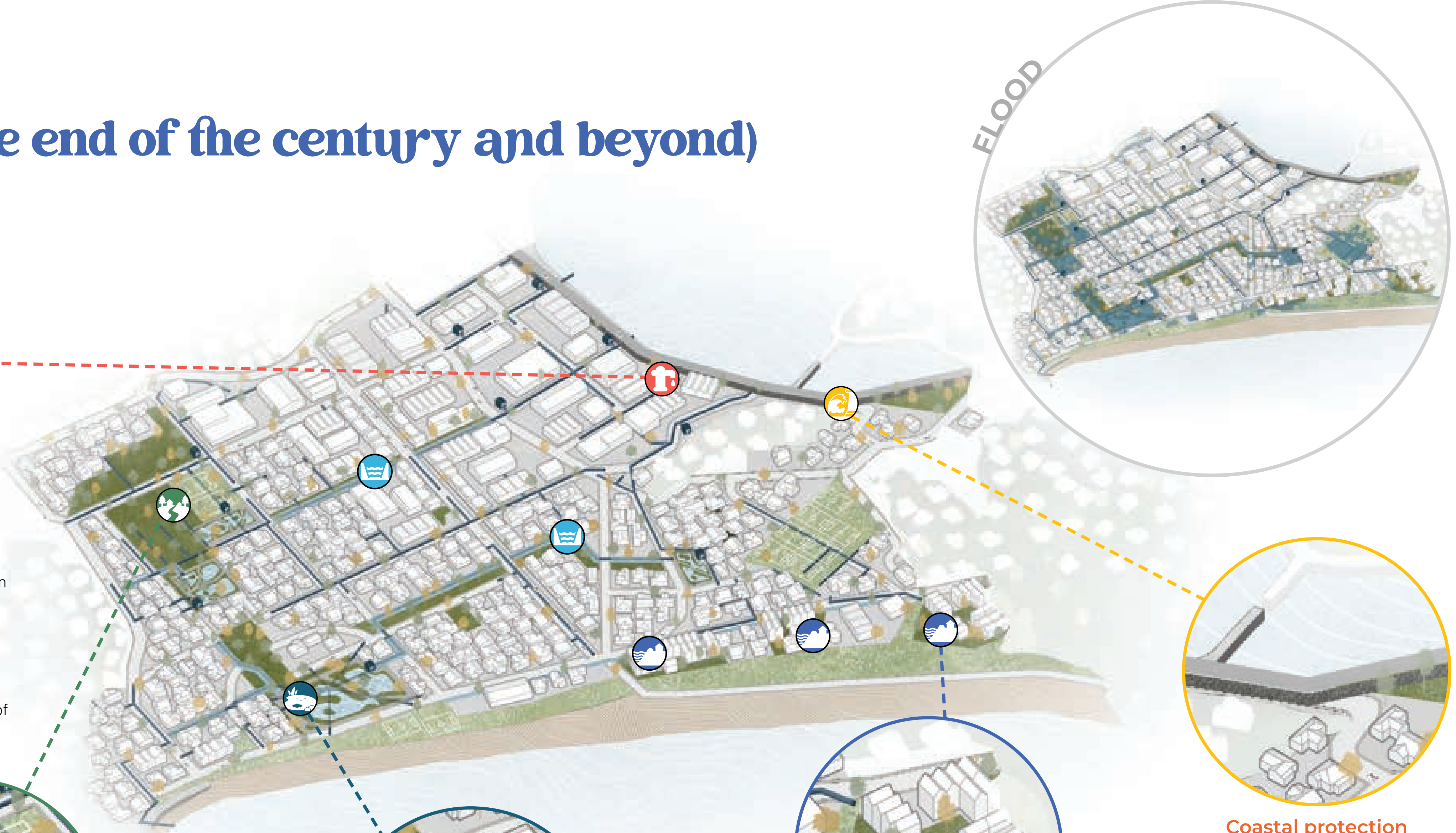
Coastal protection

Once sea level reaches 0.55m above 2005 levels, improved coastal protection along the harbourside would be required, with Council investing in extending the seawall to Bayfield Park to reduce risk to the school and raising road levels to maintain emergency and community access.

Working Together with the St Clair / St Kilda Coastal Plan: Rising sea levels and more storms would weaken and undermine the south coast seawall over time. To stop it from failing and to help keep sand on the beach, the seawall would need to be upgraded, shifted, and possibly supported with extra sand. The contaminated landfill at Kettle Park may also need ongoing remediation to prevent pollution. In future, buffer zones might be needed along the coast to allow room to move things back if erosion or flooding gets worse.

FUTURE 4 – RESTORE

Long-term (towards the end of the century and beyond)



Pipes, pumps and flow paths

To avoid annual flood damage/ response costs compromising delivery of core services, Council invests in a further 1.5km of pipe and increases pump capacity by an additional 10% to continue to allow stormwater and groundwater to flow out during high tides. Roads still periodically flood, but impacts to properties are generally avoided during rainfall events with a 2% chance of occurring each year. During extreme events with a 1% chance of occurring each year, there remains some risk of property damage.

Green space creation

When persistent flooding or groundwater interference begins to limit normal land use, all acquired land at Forbury Corner and Musselburgh would be transitioned to green space for stormwater and groundwater management, recognising the area's high long-term risk. These spaces would include a mix of natural reserves, sports fields, and parks, with sports fields managed via pumped drainage. Council will remain flexible to adapt to other futures, and if risks become unmanageable, a gradual move away from the Flat remains a very long-term option.

Waterways and storage

The waterways and storage systems continue to help manage stormwater and groundwater up to 1.1m of sea level rise.

New development

High density residential space along Victoria Road would be complete by this stage providing space for people in low-lying areas to shift to safer areas.

Coastal protection

In the long-term an extended seawall would provide coastal protection along the harbourside, along with a raised road levels to maintain emergency and community access.

Working Together with the St Clair / St Kilda Coastal Plan: Rising sea levels and more storms would weaken and undermine the south coast seawall over time. To stop it from failing and to help keep sand on the beach, the seawall would need to be upgraded, shifted, and possibly supported with extra sand. In future, buffer zones might be needed along the coast to allow room to move things back if erosion or flooding gets worse.

FUTURE 4 – RESTORE

Objectives assessment

SUSTAINABLE URBAN DEVELOPMENT

Short-term

Short-term strategic planning supports long-term housing and connectivity as stormwater upgrades and changes to planning rules shape a compact urban form, though embodied emissions remain a challenge and reliance on pumping heightens vulnerability. Early land acquisition enables future green infrastructure.

Medium-term

Open waterways, wetlands, and greenways enhance amenity and embed water-sensitive design. Multi-use green spaces provide flood storage and recreation to support a compact urban form, and coastal protection maintains shoreline connectivity.

Long-term

A more resilient urban form emerges through integrated waterways, wetlands and green corridors, with adaptive management and green infrastructure reducing pump reliance. Modular, circular design cuts waste and embodied carbon. Flexible transition planning preserves options for large-scale retreat if future risks escalate.

ENVIRONMENTAL AND CULTURAL RESTORATION

Short-term

Early planning for waterways and wetlands with mana whenua support mauri restoration and kaitiakitaka though short-term ecological gains are limited. Temporary loss of coastal open space poses cultural risks requiring strong engagement.

Medium-term

Wetlands and green corridors improve ecological connectivity, biodiversity, and water quality, while also strengthening rakatirataka (right to exercise authority) and kaitiakitaka through renewed links to historic waterways. Coastal protection supports access to Ōtakou marae, though risks include potential heritage disturbance and loss of some recreational spaces.

Long-term

Restoration enhances green infrastructure, ecosystems and cultural landscapes and while ki uta ki tai connections are limited, a holistic wellbeing focus strengthens Te Ao Māori values and relationships between place and people.

PROMOTE COMMUNITY SAFETY

Short-term

Changes to planning rules and early acquisition lower long-term hazard exposure while stormwater upgrades reduce flooding during frequent events and improve safety and access. Residual groundwater risk and reliance on pumps create vulnerability during extreme events or system failure.

Medium-term

Stormwater, coastal and groundwater interventions would remove flooding from frequent events and reduce impacts from rarer ones, improving access and safeguarding lifeline services. Coastal erosion risk at the St Clair / St Kilda dunes remains and requires ongoing resilience measures.

Long-term

Integrated greenways, modular systems and adaptive land use improve access and reduce hazard exposure. Very high residual coastal-erosion risk at the St Clair / St Kilda Dunedin persists and requires ongoing resilience strategies, with long-term resilience dependent on continual monitoring and adaptive responses.

JUST TRANSITION

Short-term

Reduced flood risk and maintained access improve certainty for vulnerable communities, while changes to planning rules signal long-term affordability gains. Narrowed short-term housing options, property acquisition, and construction disruption may create stress, particularly for low-income and culturally and linguistically diverse households.

Medium-term

Safer development zones and improved housing supply promote fairness, though higher development costs may affect affordability for low-income households. Construction and relocation can disrupt social and cultural ties, requiring inclusive support. Expanded green space enhances equitable access to recreation and amenity in South Dunedin.

Long-term

Gradual relocation helps maintain social cohesion and allows communities to adapt over time, while intensification and adaptative reuse support affordable housing supply; however, escalating risks could prompt further retreat, potentially displacing vulnerable populations and reducing long-term certainty for families.

SOCIAL AND ECONOMIC RESILIENCE

Short-term

Access to social and economic hubs is maintained, supporting business stability and future high-density growth, though construction disruption, acquisition uncertainty, and affordability pressures may strain community cohesion and require proactive support for vulnerable households.

Medium-term

Shared blue-green spaces strengthen community cohesion and enhance amenity and investment, while green infrastructure and coastal protection reduce economic risk, though relocation and affordability pressures still require careful mitigation.

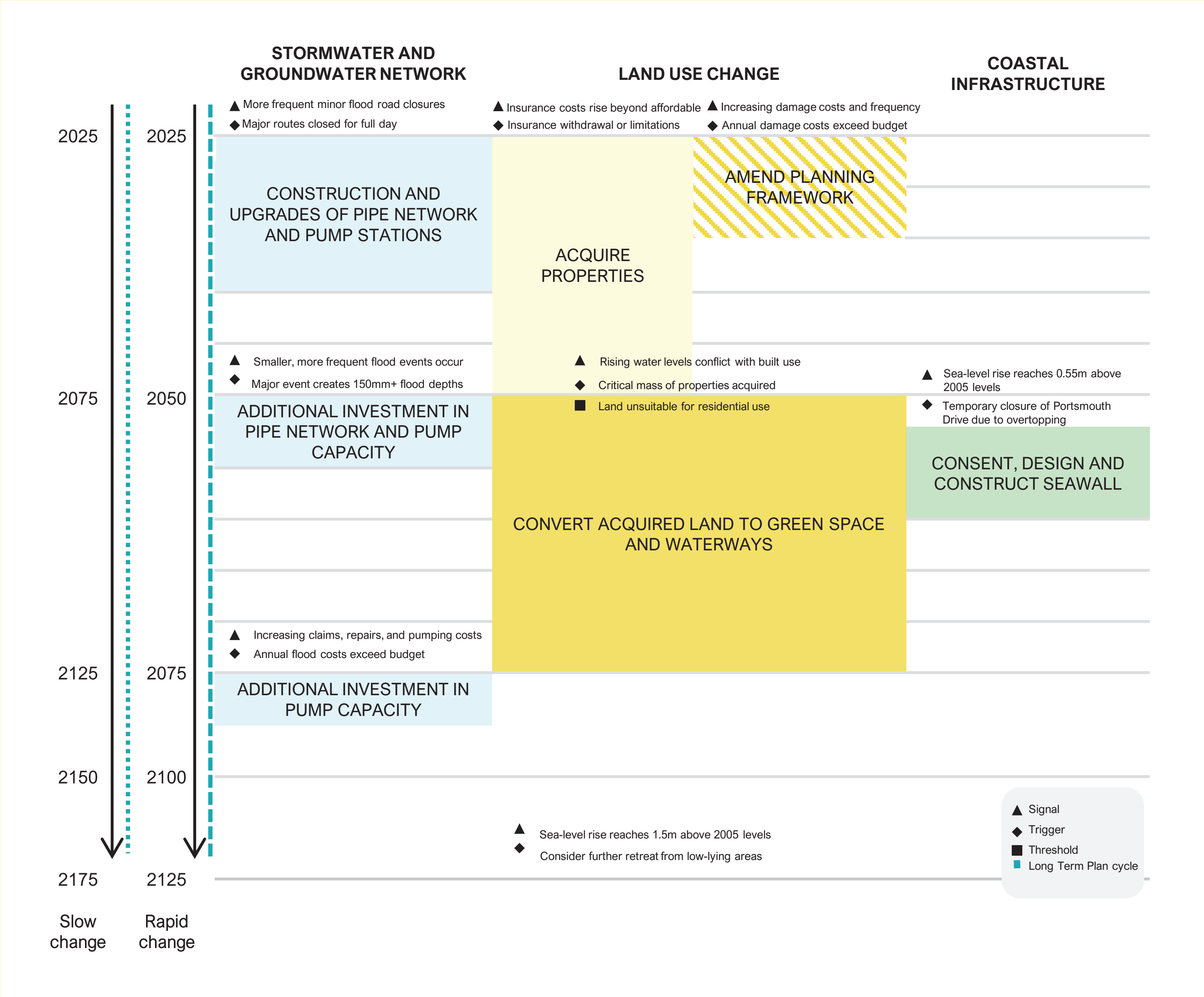
Long-term

Medium-density housing, active transport and mixed-use green spaces strengthen resilience and wellbeing, while reduced climate risk boosts economic stability. Balancing housing supply with green infrastructure needs will require continued innovation and policy support.

FUTURE 4 – RESTORE

Implementation approach

Adapting South Dunedin to a changing climate requires a sequence of interdependent actions, as shown below, which illustrates the indicative timeline for implementation. Actions during Future 4 - Restore are presented with sample signals (◆) and triggers (▲) representing early warning signs and resulting key decisions or enabling actions. Signals, triggers, and adaptation thresholds may be social, economic, ecological, physical, or cultural. The timing shown for signals, triggers, and actions is indicative only.



Early in the short-term, the planning framework must be amended to regulate development. These changes would restrict development in some low-lying areas to avoid exacerbating existing risks and allow for future land acquisition, while enabling development in other areas.

In the medium-term, land acquisition would continue to support later development of green space for stormwater management. Properties acquired during this stage could be rented, leased or similar until enough land is consolidated to enable large-scale transformation.

Where funding and development partners are confirmed, this would trigger major projects, including housing development at Tahuna.

The enlargement of the Portsmouth Drive seawall would be complete to manage the projected increasing coastal risks. In the long- term, all land acquired is expected to be developed into greenspace for stormwater management across low-lying areas, while Tahuna would be intensified into high-density residential developments to house the community. Each step depends on the successful completion of earlier actions, creating a chain of dependencies so that South Dunedin can adapt effectively to climate change.

WHAT ELSE DO WE NEED TO ACTION IT?

Changes in land use regulations: Council would need to make changes for development in the Flat and enable works related to upgrading infrastructu re and developing the area near Tahuna.

Property acquisition (buyouts): Land would need to be acquired to make space for pipes, pump stations and green infrastructure (e.g. stormwater management wetlands) which are "public works" because of their flood mitigation and public safety functions. Areas identified for acquisition are where risk may be too challenging to manage in the long-term or where locations are required to manage risk for the wider area.

Funding mechanisms: Funding mechanisms are crucial for both the development of infrastructure and property acquisition. Further work is needed on possible funding mechanisms but public-private partnerships or development contributions are used for infrastructure upgrades and Central Government may provide support through the Regional Infrastructure Fund (or similar) or protection of Crown assets (like schools).

FUTURE 4 – RESTORE

Economic measures

The Cost Benefit Assessment work seeks to compare the implications of proposed futures for South Dunedin.
Costs and benefits are indicative and intended for comparison at this step of the South Dunedin Future (SDF) Programme.

Time period	Benefits ($m)	Costs ($m)	BCR
Short-term (0 - 25 years)	$457	$1,284	0.36
Medium-term (26 - 50 years)	$381	$287	1.33
Long-term (51 - 100 years)	$514	$58	8.86
Overall	**$1,351**	**$1,629**	**0.83 (0.71 - 0.98)**

KEY PROJECT FEATURES

- TOTAL REPURPOSED LAND 69 ha
- 11 NEW PUMP STATIONS
- 16 ha FOR STORAGE & WETLANDS
- 1 NEW GW PUMP STATIONS
- 16 km OF GW PIPE NETWORKS
- 32.5 km OF PIPING NETWORKS
- 3.5 km OF OPEN CHANNELS
- 2.1 km SEAWALL
- 1162 BUILDINGS DEMOLISHED
- 4 NEW OUTFALLS

Cost estimation approach

Based on spatial mapping of potential scenarios and typical unit rates from similar New Zealand projects. Calculated at 2025 present values, assuming staged implementation across the three time periods identified with Construction spread over the first 10 years of each period. Includes:

* Construction (capital, preliminaries, demolition, utilities)

* O&M costs

* Professional fees

* Contingency and optimism bias (+66% per Treasury guidance)

* Property acquisition – 1162 properties (residential, commercial, social)

Whole-of-life costs: 25-year maintenance cycles + annual O&M.
Pump stations include an allowance for annual electricity charges.

Exclusions: GST, escalation, downtime.

Costs do not account for potential offsets (e.g., land resale) or private owner contributions.

Range: $1.63b ($1.4b – $1.8b), influenced by scale and uncertainty.

Monistised benefits include:

* Avoided fatalities & injuries

* Avoided residential, industrial & commercial property damages

* Avoided infrastructure damage

* Avoided trauma and social cohesion costs

* Avoided water quality impairment

* Avoided income loss and emergency services costs.

Benefits excluded due to data unavailability at this stage:

* Redevelopment potential / Gains in property value

* Avoided loss of open spaces and ecosystem services

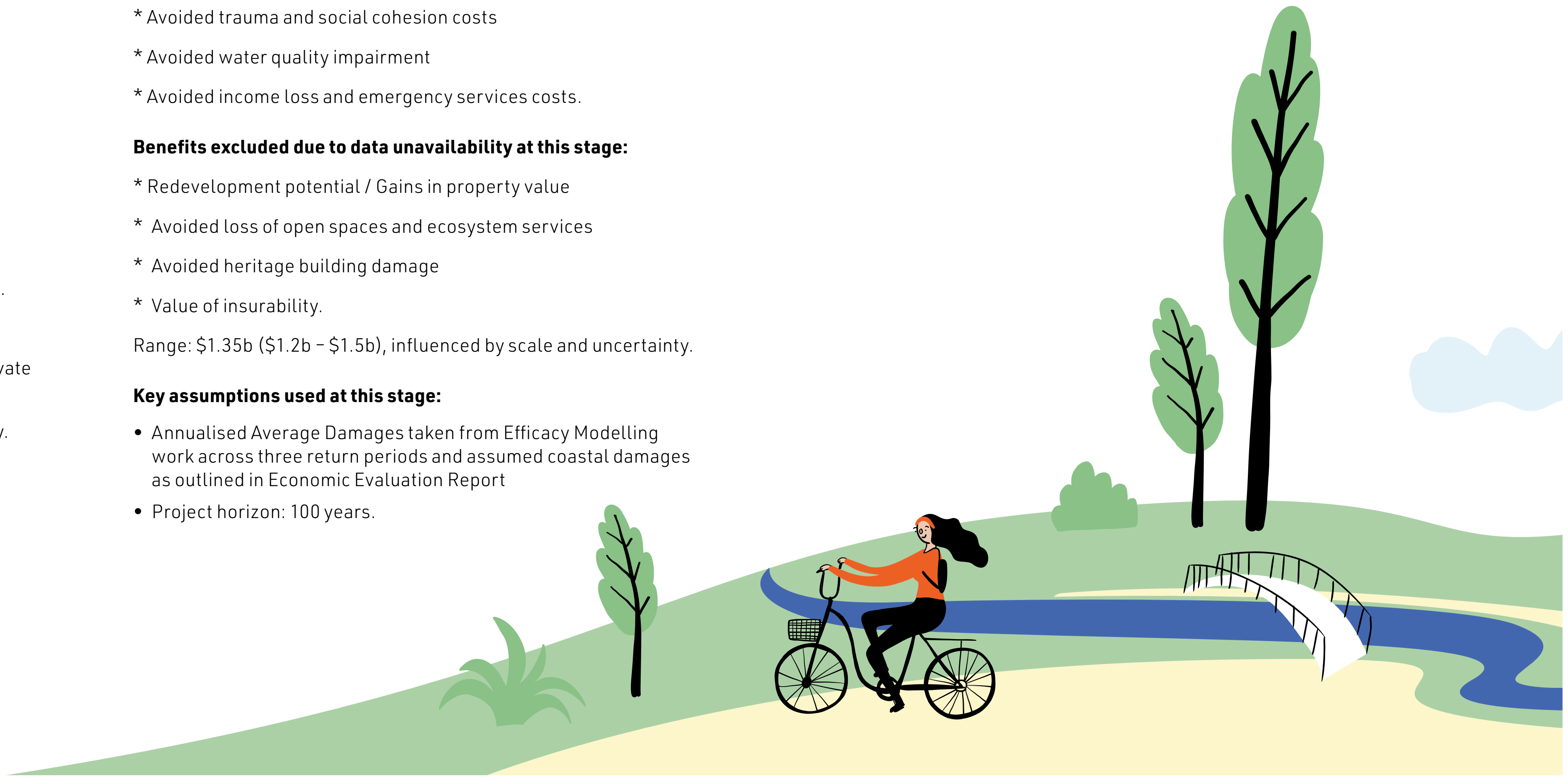
* Avoided heritage building damage

* Value of insurability.

Range: $1.35b ($1.2b – $1.5b), influenced by scale and uncertainty.

Key assumptions used at this stage:

- Annualised Average Damages taken from Efficacy Modelling work across three return periods and assumed coastal damages as outlined in Economic Evaluation Report
- Project horizon: 100 years.



FUTURE 4 – RESTORE

Risk assessment

Future 4 – Restore provides significant reduction in pluvial flooding and groundwater risk in the short-term relative to the Status Quo (present day, unmitigated) risk.

This risk profile would further reduce over the medium-term despite increasing natural hazards. In the long-term, risk associated with most hazards is managed; however, high uncertainty remains regarding the long-term management of coastal hazards at St Clair / St Kilda, and further investigations are underway. In all timeframes, residual risk remains, which is associated with the consequences of hazard events that exceed as-built design limits, and structural failures (e.g. seawall, groundwater pumping systems). It can also be associated with operational risks (e.g. power failures, lack of maintenance).

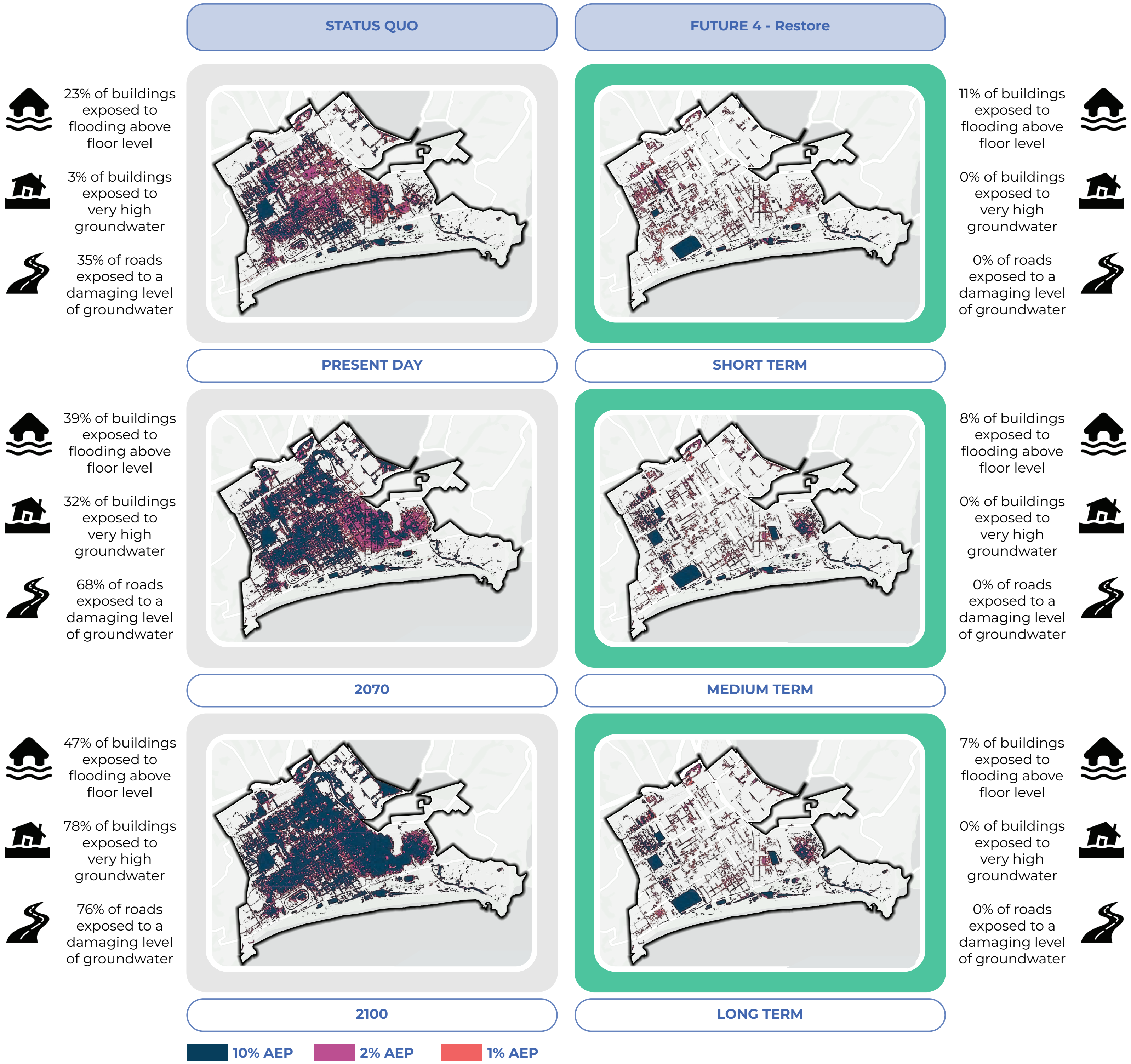
Overall, the **Future 4 – Restore** risk profile is largely similar to the other futures, but has a slightly higher long-term risk than **Future 3 – Protect** and **Future 5 – Reshape** as the other Futures benefit from additional risk reduction associated with raising land. This also means that **Future 4 – Restore** is more prone to residual risk and uncertainty regarding coastal hazards.

HOW IT WOULD REDUCE RISK

In the short-term, stormwater infrastructure upgrades are predicted to remove the flood risk associated with frequent events (10% chance of occurring each year) and drive significant reduction of flooding associated with infrequent events (1% chance of occurring each year) across all buildings, lifelines, and critical infrastructure. Up to 33% of buildings may be exposed to infrequent flooding, with 11% of those likely to experience flooding above floor level. Otherwise, flooding would be generally contained within roads posing a low risk. Improved drainage and pumping also lowers groundwater levels so that buildings, parks and roads are unlikely to be at risk.

In the medium-term, strategic acquisition of land for conversion to green space, and continued stormwater infrastructure improvements, coastal protection, and management of groundwater means pluvial flood risk, coastal flooding risk, and groundwater risk is generally low across all buildings, lifelines, critical infrastructure and roads. The percentage of buildings exposed to infrequent flooding above floor level drops to 8%. In the long-term, this drops further to 7% however, residual risk due to pluvial flooding and groundwater remains, as well as increased uncertainty regarding effective management of coastal hazards increases.

HOTSPOT SUMMARY OF RISKS TO SOUTH DUNEDIN FUTURE 4 - RESTORE: EXPOSURE OF BUILDINGS AND ROADS TO FLOODING AND GROUNDWATER



Future 5 – Reshape

Future 5 – Reshape focuses on creating space for water and people through a combination of open waterways, green infrastructure and raised land development.

It aims to manage flooding and groundwater risks while enabling resilient urban transformation, high-density housing, and long-term community viability while allowing space for water. This space for water provides a town-belt style amenity along the waterways.

KEY PROJECT FEATURES

TOTAL REPURPOSED LAND 102 ha	1738 BUILDINGS DEMOLISHED	34 km OF PIPING NETWORKS
16 ha FOR STORAGE & WETLANDS	44.5 ha OF RAISED LAND	1.5 km SEAWALL
16 km OF GW PIPE NETWORKS	7 NEW PUMP STATIONS	3 NEW OUTFALLS
3.5 km OF OPEN CHANNELS	1 NEW GW PUMP STATIONS	

What we heard about Future 5 – Reshape

In 2025, Council asked for feedback from Aukaha (representing Kāi Tahu mana whenua) and the local community. We've used this feedback to inform development of our futures.

KĀI TAHU RŪNAKA

Engagement with Aukaha indicated that Kāi Tahu mana whenua considers **Future 5 – Reshape** to have moderate to high alignment with Te Mana o Te Wai and a ki uta ki tai approach. Additionally, it was noted that lower levels of flooding would result in improved community Hauora (health), with wider community benefits related to wellbeing.

However, Aukaha stress that these benefits are offset by high levels of disruption to communities and businesses, with risks to a just and equitable transition.

While **Future 5 – Reshape** represents a strategic adaptation response, the views of Kāi Tahu mana whenua were that it is heavily reliant on hard infrastructure and disruptive land-use changes, making cultural and social outcomes dependent on strong equity measures and careful planning.

COMMUNITY ENGAGEMENT

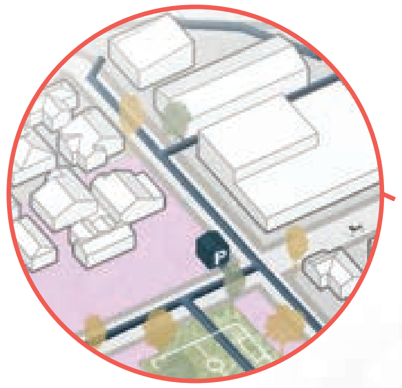
The community expressed mixed views on **Future 5 – Reshape**. Around 35% of respondents agreed it was taking South Dunedin in the right direction, but opinions were divided on whether it offered real choice about where people could live. Many appreciated the option's focus on enhancing natural aspects and creating safer living environments, seeing it as a proactive response to climate risks. However, concerns were significant, with respondents wanting clearer information on how land would be raised, the timeframe for implementation, and what support would be available for affected residents.

While some believed quality of life would remain the same or improve slightly, others worried about social and mental health impacts from displacement and disruption. The perceived cost and loss of community and commercial areas were major drawbacks.

Overall, **Future 5 – Reshape** was seen as promising but challenging, requiring strong planning and equity measures.

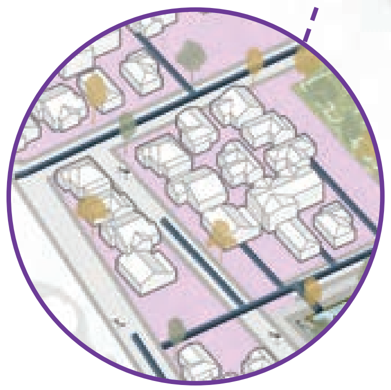
FUTURE 5 - RESHAPE

Short-term (next few decades)



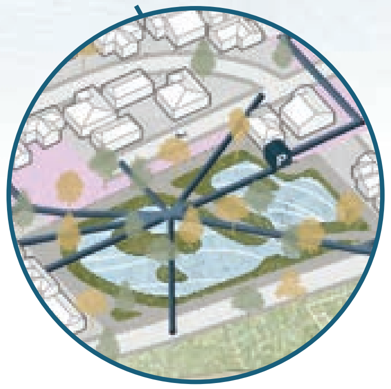
Pipes, pumps and flow paths

Council would make substantial investments in pipe and pump infrastructure. New pump stations would lift peak pumping capacity by 137% in larger rainfall events (more than double current volumes). Upsizing existing stormwater pipes and adding new pipelines across 25 km of the network would increase capacity to better manage rainfall and groundwater. Daily pumping would lower groundwater while also providing sufficient capacity to drain stormwater during rain. Roads may still flood at times, but property impacts are generally avoided in events with a 2% annual chance of occurring, with some risk remaining in rarer 1% events.



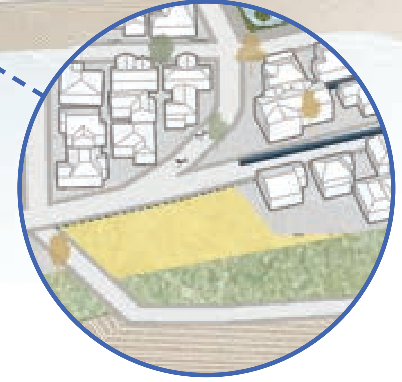
Property acquisition

Property acquisition (shown in pink areas) would take place in zones with combined high groundwater and flood risk to prepare for safer development and infrastructure. Rezoning begins in the Flat for changes in development rules to avoid increasing risk.



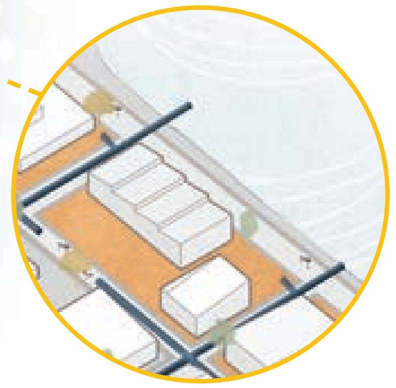
Storage

Parts of Forbury, Bathgate and Tonga park are used for stormwater storage balancing space for sports, recreational natural spaces, and water. This storage is connected to a pumped pipe system, which drains the ponds and adds further capacity to the overall system. More blue-green spaces would be needed in the future requiring some land acquisition (shown in pink).



New development

Areas shown in yellow near Ocean Beach Domain would be zoned for medium-density development to provide lower-risk spaces for people to shift to over time. This would minimise disruption for people wanting to remain in South Dunedin that currently live in areas that need to be converted to space for water or land raising.



Coastal protection

In the coming decades, there are no changes to coastal protection along the harbourside. The area in orange would be zoned for floodable ground floors or other property-level protection to manage future coastal flooding.

Working together with the St Clair / St Kilda Coastal Plan: There are a few ways to protect the coast, from hard structures like seawalls and offshore barriers (offshore breakwater) to softer options like adding more sand. Any plan would also deal with the contaminated landfill at Kettle Park. Right now, the quickest and most effective thing to do is protect the area where the St Clair geobags end and the Kettle Park landfill begins. This would mean building an offshore breakwater there, removing some of the landfill, and reshaping the dunes at Middles Beach to help reduce erosion.

FUTURE 5 - RESHAPE

Medium-term (mid-century)

Pipes, pumps and flow paths

Once flood depths greater than 150mm occur on residential lots or local roads, Council would invest in a further 9km of pipes and increases pump capacity by an additional 18%. Roads still periodically flood, but impacts to properties are generally avoided during rainfall events with a 2% chance of occurring each year. During extreme events with a 1% chance of occurring each year, there remains some risk of property damage.

Coastal protection

To prevent overtopping-related structural failure, road damage, and safety risks, Council would add harbourside protection by building an inland coastal bund near Otaki Road and raising road levels to maintain emergency and community access. By then, Portsmouth properties would have property level adaptation in place.

Working Together with the St Clair / St Kilda Coastal Plan: Rising sea levels and more storms would weaken and undermine the south coast seawall over time. To stop it from failing and to help keep sand on the beach, the seawall would need to be upgraded, shifted, and possibly supported with extra sand. The contaminated landfill at Kettle Park may also need ongoing remediation to prevent pollution. In future, buffer zones might be needed along the coast to allow room to move things back if erosion or flooding gets worse.

Land raising and development

Property acquisition would be complete by this point and would provide more space to manage stormwater and raise land. The area around Forbury Corner would be cleared and built up to prepare for development in a safe elevated area. Land raising would make ground levels higher through placement of fill material to reduce risk to pluvial, groundwater and coastal flooding and would extend the natural terraced area.

Waterways and storage

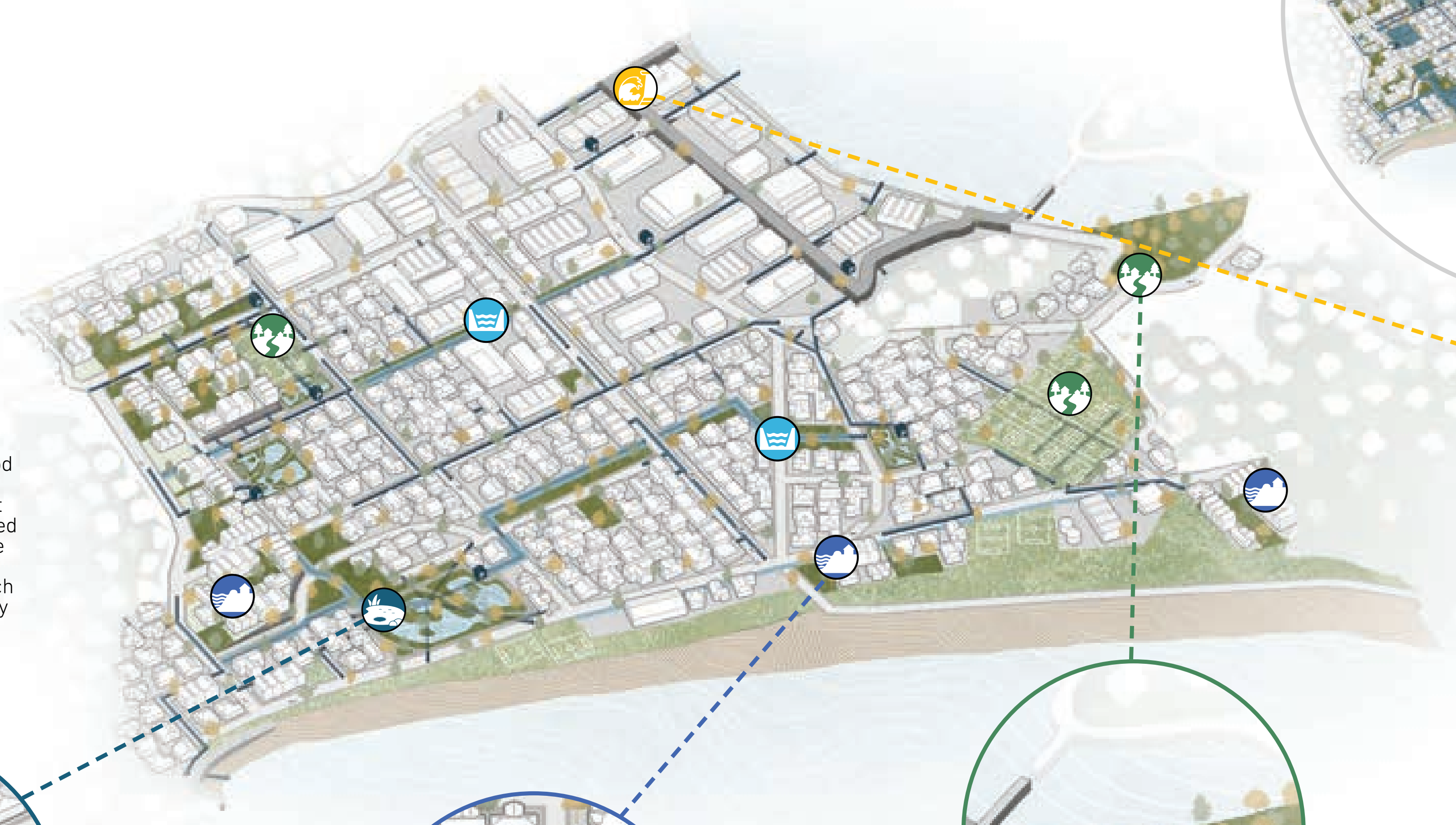
The construction of a network of MacAndrew, Kaituna, Victoria, Coughrey, and West waterways would occur in the medium-term. Some of these align with historic natural systems, and multi-use green spaces for stormwater storage and recreation. Victoria Waterway in particular helps to manage groundwater, capturing tidally influenced groundwater before it moves inland and helping to manage saltwater intrusion. In some places it would still be difficult to manage groundwater though so Council would construct green spaces in areas of persistent groundwater emergence, like in Musselburgh.

New development

Medium-density residential space areas would be developed along Victoria Road with on-site stormwater management, set back from expected future shorelines. Any loss of existing park space would be balanced by creation of more parks and green spaces in higher risk areas, such as on the Flat, to enable the best use of land in South Dunedin. Along Forbury Road, new development begins when land raising is completed.

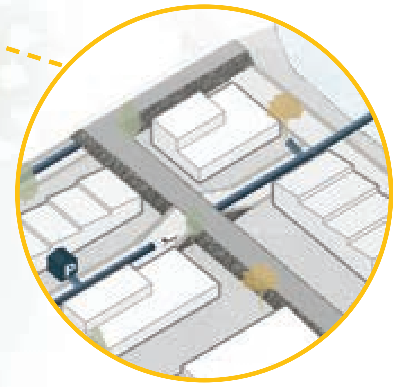
FUTURE 5 - RESHAPE

Long-term (towards the end of the century and beyond)



Pipes, pumps and flow paths

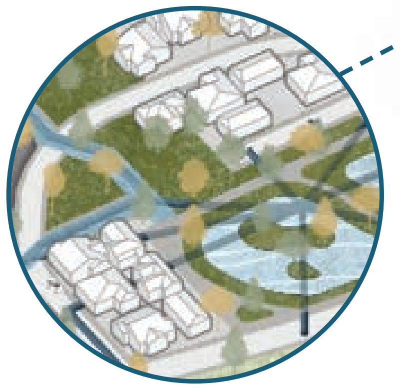
In order to keep land dry, no additional pipes or pumps are needed, provided good maintenance and periodic replacement occurs. Roads still periodically flood, but impacts to properties are generally avoided during rainfall events with a 10% chance of occurring each year. During extreme events with a 1% chance of occurring each year, there remains some risk of property damage.



Coastal protection

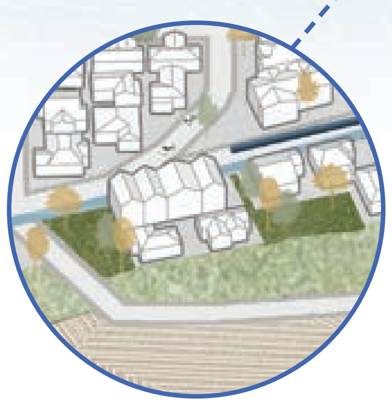
A coastal bund along the commercial area would be installed to reduce recurring overtopping and prevent coastal floodwaters entering the Flat. As coastal storms begin causing periodic seawater inundation in the commercial area, remaining businesses would need property level measures. The proposed bund alignment leaves some critical infrastructure, such as the Transpower substation, outside the protected area; as with the Edgar Centre, property owners would be responsible for their own interventions (for example, site bunds and door floodgates).

Working Together with the St Clair / St Kilda Coastal Plan: Rising sea levels and more storms would weaken and undermine the south coast seawall over time. To stop it from failing and to help keep sand on the beach, the seawall would need to be upgraded, shifted, and possibly supported with extra sand. In future, buffer zones might be needed along the coast to allow room to move things back if erosion or flooding gets worse.



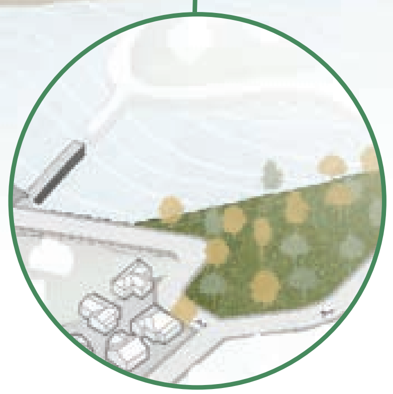
Waterways and storage

The scale of storage in green space increases, providing further space for water on low-lying land as groundwater becomes more difficult to manage and rainfall is projected to increase. Water is stored in ponds then discharged when the network has capacity (e.g. after a storm passes). While groundwater is reasonably well managed with up to 1.1m sea level rise with daily pumping, it becomes more challenging beyond 2125.



New development

Medium-density residential space along Tahuna, Victoria, and Forbury Roads would be complete by this stage.



Green space creation

To limit intolerable flooding of property, acquired land would either be raised and developed or converted to green space for stormwater and groundwater management, reflecting the area's high long-term risk. As the Portsmouth Drive seawall is not extended in this future, the area near Bayfield High School would likely become open space. Green space would include a mix of natural reserves, sports fields, and parks. Council would retain flexibility to adapt to other futures; if risks become unmanageable, a gradual shift to raised land (Future 6) remains a very long-term option.

FUTURE 5 - RESHAPE

Objectives assessment

SUSTAINABLE URBAN DEVELOPMENT

Short-term

Strategic changes to planning rules supports a compact urban form by limiting development in flood-prone areas and enabling higher-density housing. Stormwater capacity upgrades lower emissions from emergency pumping but still require ongoing energy use. Modular, circular infrastructure design minimises waste and supports long-term adaptability.

Medium-term

Raised land and an inland coastal bund create future development opportunities while reducing environmental impacts, with reused aggregates lowering emissions. Expanded wetlands and waterways act as carbon sinks and enable more passive stormwater management, reducing reliance on energy-intensive pumping.

Long-term

High-density, walkable communities reduce transport emissions, while adaptive reuse, modular design, and nature-based solutions minimise waste, sequester carbon and enhance biodiversity.

ENVIRONMENTAL AND CULTURAL RESTORATION

Short-term

There are limited ecological benefits in the short-term, as infrastructure upgrades focus on engineered solutions to move water.

Opportunities for mana whenua to engage in adaptation responses and re-establish connections through enhancement of rakatirataka and kaitiakitaka.

Short-term ecological gains are limited due to a focus on engineered water-management solutions, while adaptation processes provide opportunities for mana whenua to strengthen rakatirataka and kaitiakiaka through renewed connections to place.

Medium-term

New greenways and waterways improve habitat, connectivity, and biodiversity, though construction and land raising may cause temporary environmental impacts without strong erosion control. While interventions begin aligning with Te Mana o Te Wai, some reliance on hard infrastructure remains.

Long-term

Expanded green infrastructure improves mauri, ecological connectivity, and cultural ties, while mixed-use green spaces enhance holistic wellbeing and reinstated waterways and wetlands strengthen ki uta ki tai approaches and support cultural and ecological restoration.

PROMOTE COMMUNITY SAFETY

Short-term

Stormwater upgrades greatly reduce flooding from frequent events and contain rarer floods to roads, while strategic changes to planning rules improves long-term safety by reducing exposure, though residual risk remains due to reliance on pumping systems.

Medium-term

Coastal protection and raised land reduce pluvial flooding and coastal inundation for most buildings and critical infrastructure, though some key assets still require site specific protection. Residual risk persists at the St Clair / St Kilda dunes.

Long-term

Reliable groundwater and stormwater management protects properties, critical infrastructure and access routes, though residual risk from extreme events and coastal hazards still require ongoing monitoring and adaptive management.

JUST TRANSITION

Short-term

Early changes to planning rules and property acquisition increase certainty and protect service access for vulnerable groups, though they may create short-term housing supply constraints and affordability pressures.

Medium-term

Key access routes are protected by the inland bund and raised roads despite construction disruptions. Raised land enables higher-quality and more affordable housing though initial costs may challenge low-income households. Vulnerable groups remain protected but may face social and cultural disruption from relocation, and new green spaces improve equitable access to recreation.

Long-term

Raised neighbourhoods would ultimately provide high-quality housing for the whole community, including vulnerable groups, while relocating schools to safer areas improves education security, though risks of social fragmentation, affordability pressures and uneven transitions would persist.

SOCIAL AND ECONOMIC RESILIENCE

Short-term

Strong transport networks help maintain access to education and key community facilities, though property acquisition may create uncertainty for vulnerable households about continued access to those same services.

Medium-term

Raised land increases community feelings of safety and wellbeing, though coastal flood risk is rising in the area between Ōtaki Street and Portsmouth Drive.

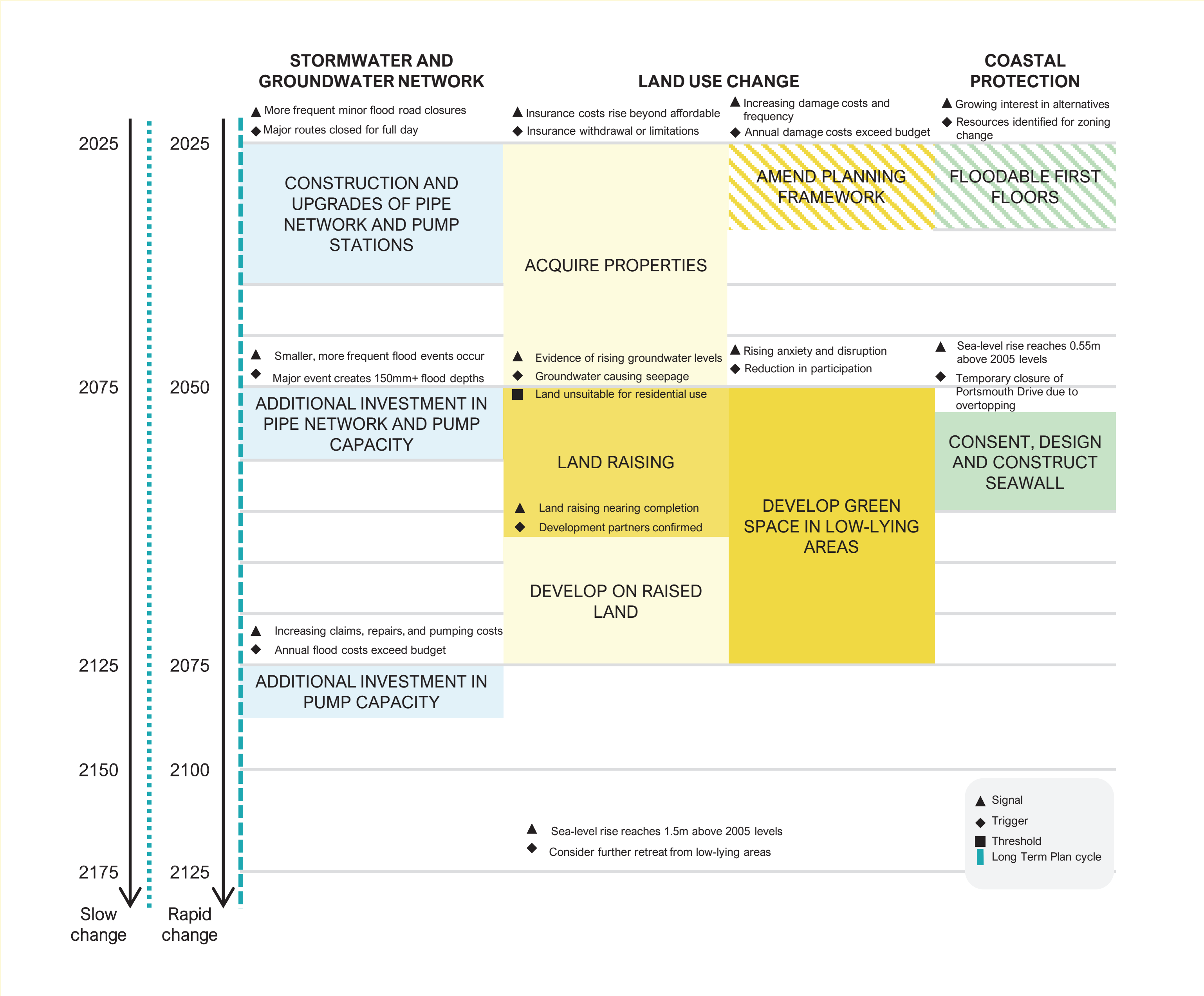
Long-term

More green spaces and relocating schools to safe zones improve wellbeing and long-term educational security, though floodable commercial areas and concentrated high-density housing on raised land may create property value disparities between elevated areas and remaining floodplains.

FUTURE 5 - RESHAPE

Implementation approach

Adapting South Dunedin to a changing climate requires a sequence of interdependent actions, as shown below, which illustrates the indicative timeline for implementation. Actions along **Future 5 – Reshape** are presented with sample signals (◆) and triggers (▲) representing early warning signs and resulting key decisions or enabling actions. Signals, triggers, and adaptation thresholds may be social, economic, ecological, physical, or cultural. The timing shown for signals, triggers, and actions is indicative only.



In the short-term, Council must first coordinate significant upgrades to the pipeline network and pumps to move water efficiently. These upgrades are critical before any stormwater storage areas can be established. Once drainage capacity is improved, Forbury Park and part of Tonga Park can be developed into greenspace designed for stormwater management. This includes waterways to enhance management of groundwater and the stormwater in the medium-term which have been designed to compliment the pipe network.

Early in the short-term, the planning framework must also be amended to regulate development. These changes would restrict development in some low-lying areas to avoid exacerbating existing risks and allow for future land acquisition, while enabling development in other areas. This includes introducing zoning provisions for floodable ground floors along Portsmouth Drive to manage risk.

In the medium-term, land acquisition would continue opportunistically. Properties acquired during this stage could be rented until enough land is consolidated to enable large-scale transformation prior to 2075. An inland coastal bund along Otaki Street constructed by 2060 helps to keep coastal flooding from the harbourside out of the Flat. Each of these steps depends on the successful completion of earlier actions, creating a chain of dependencies that allows South Dunedin to adapt effectively to climate change.

WHAT ELSE DO WE NEED TO ACTION IT?

Changes in land use regulations: Council would need to make changes for development in the Flat and enable works related to upgrading infrastructure and raising land. This is a critical first step.

Property acquisition (buyouts): Land would need to be acquired to make space for pipes, pump stations and green infrastructure (e.g. stormwater management wetlands) which are "public works" because of their flood mitigation and public safety functions. Simultaneously, acquisition across Forbury Corner and Musselburgh would be required to enable safer development. Areas identified for acquisition are where risk may be too challenging to manage in the long-term or where locations are required to manage risk for the wider area.

Financial incentives or penalties: Financial incentives can positively influence land use change and relocation required. Some potential financial incentives could include Council providing land swaps, grants or low-interest loans for households relocating to raised land and development incentives in safer areas.

Funding mechanisms: Funding mechanisms are crucial for both the development of infrastructure and property acquisition. Further work is needed on funding mechanisms, but public-private partnerships or development contributions could be used for infrastructure upgrades.

FUTURE 5 - RESHAPE

Economic measures

The Cost Benefit Assessment work seeks to compare the implications of proposed futures for South Dunedin.
Costs and benefits are indicative and intended for comparison at this step of the South Dunedin Future (SDF) Programme.

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Long-term (51 - 100 years)	$507	$35	14.58
Overall	**$1,336**	**$2,448**	**0.55 (0.46 - 0.64)**

Cost estimation approach

Based on spatial mapping of potential scenarios and typical unit rates from similar NZ projects. Calculated at 2025 present values, assuming staged implementation across the three time periods identified with Construction spread over the first 10 years of each period. Includes:

* Construction (capital, preliminaries, demolition, utilities)

* O&M costs

* Professional fees

* Contingency and optimism bias (+66% per Treasury guidance)

* Property acquisition – 1,738 properties (residential, commercial, social).

Whole-of-life costs: 25-year maintenance cycles + annual O&M. Pump stations include an allowance for annual electricity charges.

Exclusions: GST, escalation, downtime.

Costs do not account for potential offsets (e.g., land resale) or private owner contributions.

Cost range: $2.45b ($2.1b – $2.7b), influenced by scale and uncertainty (especially land raising).

Monistised benefits include:

* Avoided fatalities & injuries

* Avoided residential, industrial & commercial property damages

* Avoided infrastructure damage

* Avoided trauma and social cohesion costs

* Avoided water quality impairment

* Avoided income loss and emergency services costs.

Benefits excluded due to data unavailability at this stage:

* Redevelopment potential / Gains in property value

* Avoided loss of open spaces and ecosystem services

* Avoided heritage building damage

* Value of insurability.

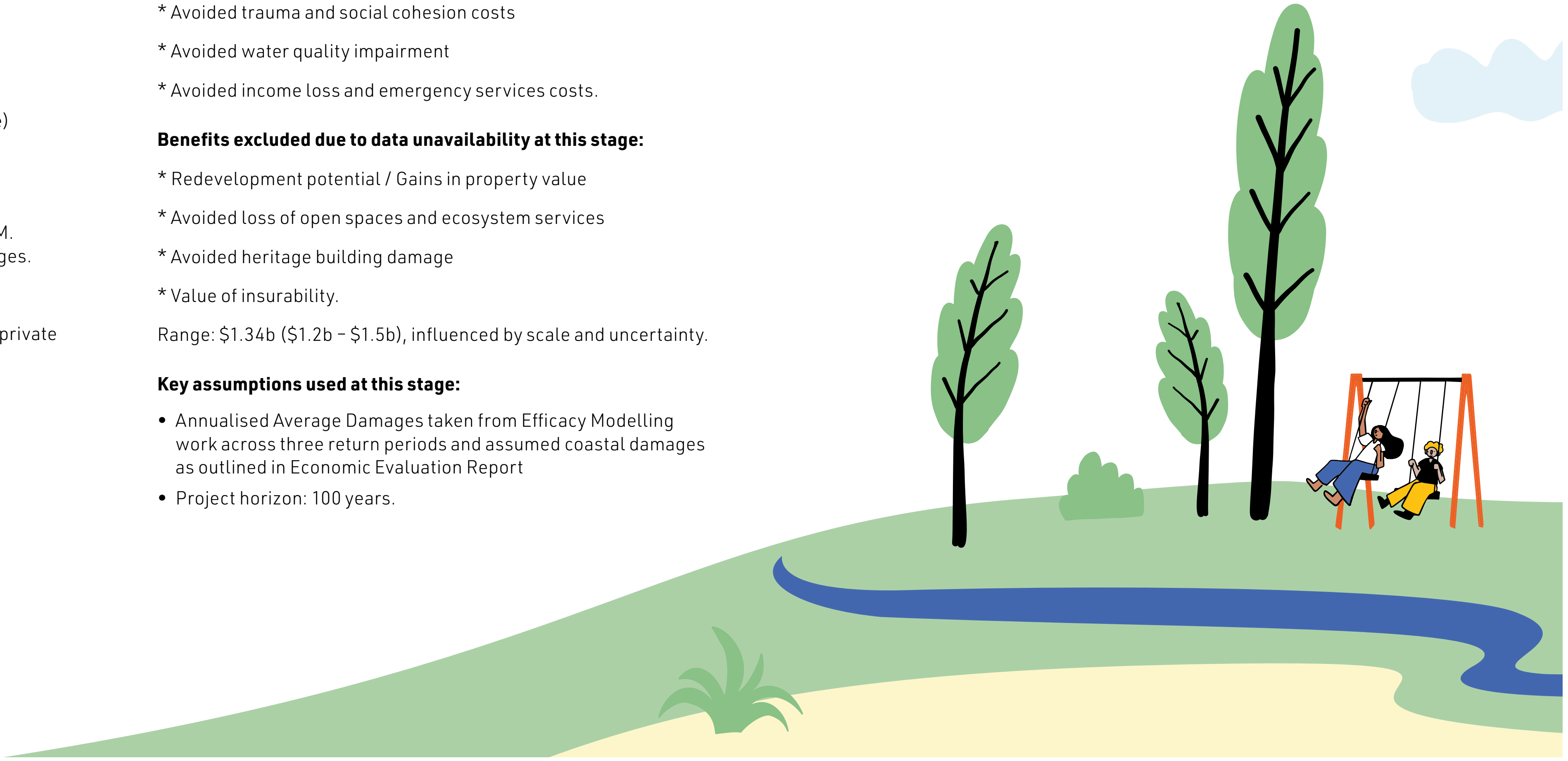
Range: $1.34b ($1.2b – $1.5b), influenced by scale and uncertainty.

Key assumptions used at this stage:

- Annualised Average Damages taken from Efficacy Modelling work across three return periods and assumed coastal damages as outlined in Economic Evaluation Report
- Project horizon: 100 years.

KEY PROJECT FEATURES

- TOTAL REPURPOSED LAND 102 ha
- 7 NEW PUMP STATIONS
- 16 ha FOR STORAGE & WETLANDS
- 1 NEW GW PUMP STATIONS
- 16 km OF GW PIPE NETWORKS
- 34 km OF PIPING NETWORKS
- 3.5 km OF OPEN CHANNELS
- 1.5 km SEAWALL
- 1738 BUILDINGS DEMOLISHED
- 3 NEW OUTFALLS
- 44.5 ha OF RAISED LAND



FUTURE 5 - RESHAPE

Risk assessment

Future 5 – Reshape provides significant reduction in pluvial flooding and groundwater risk in the short-term relative to the Status Quo (present day, unmitigated) risk.

This risk profile would further reduce over the medium-term despite increasing natural hazards. In the long-term, risk associated with most hazards is managed, however high uncertainty remains regarding the long-term management of coastal hazards at St Clair / St Kilda and further investigations are underway. In all timeframes, residual risk remains, which is associated with the consequences of hazard events that exceed as-built design limits, and structural failures (e.g. seawall, groundwater pumping systems). It can also be associated with operational risks (e.g. power failures, lack of maintenance).

Overall, the **Future 5 – Reshape** risk profile is largely similar to the other futures, but has a slightly lower long-term risk than **Future 4 – Restore** due to the raising of land that provides additional flood risk reduction benefits and minimizes residual risk.

HOW IT WOULD REDUCE RISK

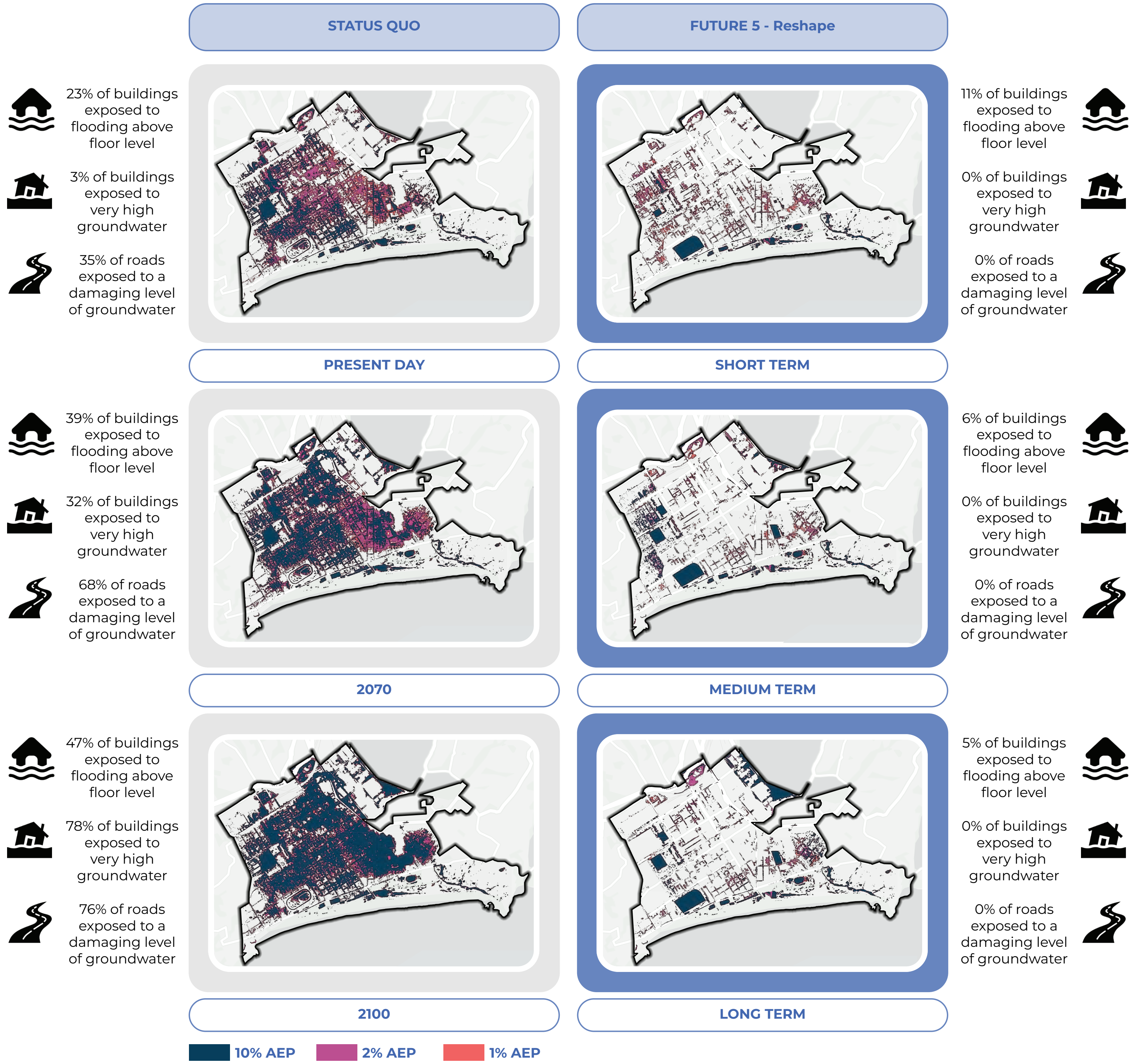
In the short-term, stormwater infrastructure upgrades are likely to remove flood risk associated with frequent events (10% chance of occurring each year) and drive significant reduction of flooding associated with infrequent (1% chance of occurring each year) events across all buildings, lifelines, and critical infrastructure. Up to 33% of buildings may be exposed to infrequent flooding, with 11% of those likely to experience flooding above floor level. Otherwise, flooding would be generally contained within roads posing a low risk. Improved drainage and pumping also lowers groundwater levels so that buildings, parks, and roads are unlikely to be at risk.

In the medium-term, additional measures such as strategic acquisition of land for conversion to green space or raised land, and continued stormwater infrastructure improvements, coastal protection, and management of groundwater means pluvial flood risk, coastal flooding risk, and groundwater risk further. The percentage of buildings exposed to infrequent flooding above floor level drops to 6%, and 5% in the long-term.

The Otaki Street coastal protection means coastal flooding exposure remains around the harbourside. This risk to buildings is managed through raised floors or intentional design of floodable ground floors. Although risk to buildings, roads and parks is generally low, coastal flooding at the harbourside may impact other activities that are carried out within this area and further consideration of safe access and egress may be required.

In the long-term, high-density residential areas located on raised land provides further risk reduction benefits, including reduced residual risk associated with pluvial flooding, groundwater, and coastal flooding.

HOTSPOT SUMMARY OF RISKS TO SOUTH DUNEDIN FUTURE 5 - RESHAPE: EXPOSURE OF BUILDINGS AND ROADS TO FLOODING AND GROUNDWATER



Summary & next steps

South Dunedin is already experiencing the impacts of a changing climate, and the work undertaken so far represents a significant step toward building a safer, more resilient future for the community.

This document has outlined the three proposed futures, **Future 3 – Protect, Future 4 – Restore**, and **Future 5 – Reshape**, and provided an initial picture of how each could unfold over the short-, medium- and long-term. Each future presents different opportunities, challenges, and trade offs, supported by technical analysis, community feedback, and the values of mana whenua.

Council will test the three proposed futures with the South Dunedin community and key stakeholders. This will help make sure that the preferred adaptation future reflects local priorities, cultural aspirations, technical evidence, and long-term wellbeing. Insights gathered during this engagement will help identify a preferred future for residents, mana whenua, businesses, and community groups.

WHAT HAPPENS NEXT

Adaptation Masterplan for South Dunedin

The final stage in the adaptation planning process involves refining the three proposed futures to a single preferred adaptation future. This may involve further detailed technical and economic assessments, additional modelling work, and will consider community feedback. The three proposed futures may be scored and ranked against a set of strategic objectives and decision-making framework previously approved by Councils.

The top ranked future will form the basis for the final climate Adaptation Masterplan for South Dunedin. This Adaptation Masterplan will outline the infrastructure investments, land use changes, and other actions required in South Dunedin to effectively manage the risks associated with a changing climate over the next 100 years and to realise opportunities that might come with change. It is likely there would be a further final community consultation on the Adaptation Masterplan, which may include a hearings process; however, this will be confirmed once the details of government reforms become available. Subject to the outcome of that consultation, a final Adaptation Masterplan would be presented to DCC and ORC for approval by late 2026 or early 2027.

Monitoring and revising the Adaptation Masterplan

Once the Adaptation Masterplan is adopted, it will be important to keep monitoring risk and rates of change to be sure that the plan is still fit for purpose into the future. The timeframes and assumptions in the final Adaptation Masterplan should be revised periodically, and the masterplan updated where needed.

Due to the long-term nature of the Adaptation Masterplan, there are practical risks of delays, funding shortfalls, or dependencies between actions – such as planning and policy changes needing to occur before infrastructure upgrades – that may undermine adaptation benefits if thresholds are exceeded before interventions can be delivered.
To manage this risk, signals should be carefully monitored to enable early planning and preparation of alternative responses if necessary, so that options are ready to progress before triggers – and the thresholds behind them – are met.

Implementation

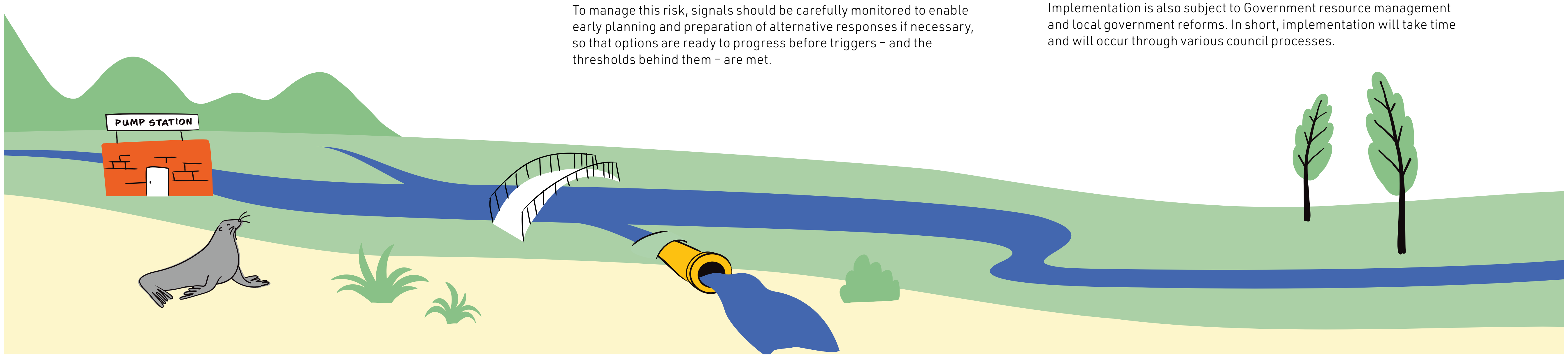
Following completion of the final Adaptation Masterplan for South Dunedin, and conclusions of the South Dunedin Future programme, focus will shift to implementation. This will occur via a range of separate processes. In the first instance, this is expected to be through the DCC's long-term planning processes, which will seek to outline priorities, budgets, and major projects for the 10-year period 2027-36. This may include, for example, infrastructure investments, new council policies, and changes to the District Plan, some of which will be focused on implementing elements of the Adaptation Masterplan.

Major infrastructure investments are typically captured in DCC's 30-year Infrastructure Strategy and then implemented following due diligence and design stages with funding approved in DCC's long-term plan.

Land use and zoning changes can only happen through formal District Plan change processes, which include detailed analysis, public submissions, and a public hearing. It is important to note that the South Dunedin Future programme will not change the zoning of any land. Any zoning change can only happen through a formal plan change process, which includes detailed analysis, public submissions, and a hearing. Once complete, the Adaptation Masterplan for South Dunedin will inform a range of council activities, including decisions and investments relating to transport, property, three waters, land use planning, among others. This will occur through the councils' normal long-term planning and budgeting processes, which include public consultation.

South Dunedin Future will explore options to retain or add housing capacity in South Dunedin and is interested in understanding how important this is for stakeholders. Later in 2026 and into 2027, DCC will be required to work on a Spatial Plan regionally, which will need to balance any options for growth in South Dunedin against citywide considerations, including the results from the city wide housing and business land needs assessment, other areas subject to natural hazard risk, infrastructure investment priorities, and the most effective and efficient way to meet the city's overall housing needs.

Implementation is also subject to Government resource management and local government reforms. In short, implementation will take time and will occur through various council processes.



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The findings in this Report are based on and are subject to the assumptions specified in the Report, the Agreement and associated attachments, and Client Data supplied during the data request phase. WSP accepts no liability whatsoever for any use or reliance on this Report, in whole or in part, for any purpose other than the Purpose or for any use or reliance on this Report by any third party. In preparing this Report, WSP has relied upon data, surveys, analysis, designs, plans and other information ('Client Data') provided by or on behalf of the Client. Except as otherwise stated in this Report, WSP has not verified the accuracy or completeness of the Client Data. To the extent that the statements, opinions, information, conclusions, and/or recommendations in this Report are based in whole or part on the Client Data, those conclusions are contingent upon the accuracy and completeness of the Client Data. WSP will not be liable for any incorrect conclusions or findings in the Report should any Client Data be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to WSP. The work has been delivered alongside DCC and ORC in a collaborative, co-design methodology, and inputs provided by DCC and ORC have not been independently validated.

In addition, climate change is an evolving field, with uncertainty inherent in projections of future conditions, and unknowns which cannot be precisely estimated with present science. These matters should be considered by the Client as part of any decision-making and planning. Regular monitoring of actual data (e.g. sea level rise) and regular review and updates of the work contained in this report to take account of developments in scientific knowledge and changes in international and national guidance should be undertaken. This report is not intended to provide financial, investment, or legal advice. It should not be used as the sole basis for making financial or strategic decisions.

The Client is encouraged to seek professional advice in these areas. Due to the nature and stage of the project, broad assumptions have been made to support costing of options. The status of this cost estimate represents at best a strategic stage. It presents a range of potential future states for South Dunedin for comparative use ONLY. Cost estimates are exclusive of GST, project development, legal or marketing costs, escalation, operational costs/ downtime due to operations, removal of large / unforeseen ground objects, contaminated waste disposal or rebuild of existing properties in new location.

Renders/visuals presented are artist impressions, created for illustrative purposes only and incorporate initial, pre-feasibility engineering input. They serve as conceptual representations and may not accurately depict the final engineered design or construction details.

REV	DATE	DETAILS
V1	3/12/2025	Draft for client review
V2	23/02/2026	Final for client review
V3	31/03/2026	Final
V4	18/05/2026	Minor revisions

Beca, WSP & Tonkin + Taylor. (2026).
Three proposed adaptation futures for South Dunedin.
Prepared for Dunedin City Council and Otago Regional Council.

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SOUTH DUNEDIN FUTURE

SOUTH DUNEDIN FUTURES EFFICACY MODELLING

HYDRAULIC MODELLING REPORT

31 MARCH 2026

SOUTH DUNEDIN FUTURES EFFICACY MODELLING
HYDRAULIC MODELLING REPORT

REV	DATE	DETAILS
A	4/12/2025	For Review
B	20/02/2026	Draft Final
C	31/03/2026	Final
D	18/05/2026	Updated with DCC comments

	Name	Date	Signature
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Reviewed by:	Reviewed By	Elliot Tuck	
Approved by:	Approved By	Cushla Loomb	

18 May 2026

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Beca | South Dunedin Future | DUNEDIN CITY COUNCIL kaunihera a-rohe o Ōtepoti | Otago Regional Council | wsp | Tonkin+Taylor

EXECUTIVE SUMMARY

This report addresses the hydraulic modelling undertaken to assess the efficacy of the three directions for the future for flood management ("Futures") in the South Dunedin catchment for the South Dunedin Future (SDF) project covering:

- Futures and time horizons modelled
- Model build and inputs
- Results, including performance and the required upgrades for each Future.

The South Dunedin model was updated during the Integrated Catchment Model (ICM) project, a part of the 3 Waters Integrated System Plan programme of works in 2024, and forms the basis for all future scenario runs. This updated model includes the "quick win options" proposed by Dunedin City Council (DCC) form the baseline (Status quo) model. The status quo model was then adapted to the Short Term (2025), Medium Term (2060), and Long Term (2100) time horizons, considering climate change and sea level rise.

The three proposed Futures assessed are:

Future 3 – Protect: Focus on elevating land and pumping water, with upgrades to pipe and pump networks, land raising, new storage facilities, and a seawall along Portsmouth Drive to protect the catchment from rising sea levels and coastal flood events.

Future 4 – Restore: Utilizes open waterways for drainage, supported by storage basins, pump stations, and a seawall along Portsmouth Drive.

Future 5 – Reshape: Combines open waterways with land raising, storage basins, pump stations, and a seawall along Otaki Street, with designated floodable areas.

For each proposed Future, the modelling incorporates both upgrades and new infrastructure such as pipes, pump stations, and storage areas, along with land use changes. Infrastructure was scaled to meet increasing rainfall and tidal boundary conditions due to climate change. The Short-term time horizon amalgamates common infrastructure upgrades and is the same across all three proposed Futures, while medium- and long -term horizons for each Future introduce further enhancements and land use adjustments. The design level of service for the pipe network and pump stations was a 6 hour (critical duration) 10-year ARI event for the relevant period and for storage and open channels, the design level of service was a 6 hour 50-year ARI event. The design level of service included allowance for flooding on roads of up to 150mm in depth. This is consistent with 2025 engagement results from questions related to acceptable return periods of flooding.

Infrastructure additions for each of the three proposed Futures were conceptualised based on the applicable strategic approach (i.e. utilising waterways, including greenspace, and/or raising land), balancing infrastructure scale against flood reduction performance, and technical feasibility. Proposed locations of interventions were chosen to integrate as much as possible with the existing network to minimise disruption and enhance cost effectiveness. Optimisation of the exact layouts was not undertaken in this stage and will the subject of future work.

Key infrastructure additions to the network and findings of the modelling assessment are:

- The Catchment was split into smaller portions to decrease the scale of infrastructure required and relieve pressure on the Portobello Road pump station and outfall.

- Storage basins (Forbury Park, Tonga Park, and Bathgate Park across all three proposed Futures, and Culling Park in Future 4 – Restore and Future 5 – Reshape) to attenuate flood flows during the storm peaks and then release water when the network has sufficient capacity to receive it.
- Newly installed and upgraded pump station upgrades are proposed to manage increased flows and sea level rise, particularly at key outfalls.
- Open channels were added to the catchment for Future 4 – Restore and Future 5 – Reshape along alignments where the existing pipe network is shallow and more readily modified, with Future 3 – Protect relying on more extensive pipe upgrades.
- All Futures reduce flood hazard compared to the existing network, with significant reductions in property flooding for 10-year and 50-year rainfall events.
- Sensitivity analysis of duration show that longer duration rainfall events result in less surface flooding but greater storage basin volumes. Testing of RCP 4.5 climate change allowance, in comparison to RCP 8.5 used for the design runs, resulted in less flooding throughout the catchment.

Electronic model results and a summary of infrastructure upgrades were delivered to enable the completion of cost estimates and residual risk assessments for each of the three proposed Futures, supporting decision-making for long-term flood management in South Dunedin. Modelling indicates that the futures perform generally well, with fewer than 10% of properties with above floor flooding in the 100yr event.

1 BACKGROUND

Hydraulic modelling was completed to test the efficacy of the three potential directions for the future of flood management for South Dunedin, referred to as "Futures". This report provides an overview of the modelling inputs and approach, along with the modelling outcomes for the three proposed Futures.

Beca previously completed the *South Dunedin Catchment Stormwater System Performance Report*[1], which investigated the current performance of the system and corresponding flooding. The general level of service for the South Dunedin catchment appeared to be that of a 1 in 5-year ARI rainfall event (with some areas having a lower level of service). This modelling included current and future conditions (varying flood events, land use, and climate parameters) and predicted widespread flooding in Forbury, South Dunedin, St Kilda, and Caversham.

The model inputs developed for that project were carried through to this South Dunedin Futures efficacy modelling.

The three proposed Futures were:

- Future 3 – Protect
- Future 4 – Restore
- Future 5 – Reshape

The three Futures were split into the following time horizons:

- Short Term
- Medium Term – 2060
- Long Term – 2100

For each proposed Future the model assumes that the option is fully developed in the 2100 horizon, with the two preceding timeframes including upgrades to work towards that goal.

For this work, the three Futures were amalgamated for the Short Term time scale with common infrastructure that would then be carried through to the Medium and Long Term for each Future. No upgrades were added to the Short Term model that would then be removed in the Medium and Long Term in any Future.

The aim of this modelling is to demonstrate the efficacy of the three proposed Futures, while providing inputs for further comparison through cost estimates (completed by WSP) and residual risk assessments (completed by Tonkin+Taylor).

[1] (South Dunedin Catchment Stormwater System Performance Report, Beca 2025)

2 MODELLING INPUTS

2.1 EXISTING NETWORK SUMMARY

A summary of the existing hydraulic model and the model update completed in 2024 is contained in the *South Dunedin Catchment Stormwater System Performance Report*. Further changes and additions made to the base model for this work are detailed below.

The South Dunedin hydraulic model utilised for the SDF efficacy modelling includes four main component catchments:

- Portsmouth Drive in the northeast,
- South Dunedin throughout the central and southeast, and
- St Clair in the southwest.
- Orari in the northwest.

The first three of these catchments were included in the model utilised for the system performance modelling. The Orari catchment was added for the SDF efficacy modelling to account for upstream flows into the Wilkie Road Conduit (which conveys flows from the Orari catchment to its discharge location in the Otago harbour), as a new pump station proposed in this modelling discharges to this pipeline.

The upgrades proposed as Quick Wins, which are currently being implemented by DCC, were included in the base model. Some of these upgrades were altered (from the inputs supplied by DCC) or upsized in the efficacy modelling options. These Quick Wins were:

- Upgrade of the Forbury Road aqueduct
- Hillside Road main pump station discharging via a new main to the Orari Street outfall
- Portobello Road pipe bypassing the Portobello Road pump station

For more detailed information on the Quick Wins and the basis for their selection, refer to the DCC paper *South Dunedin Flood Alleviation – Short-term Options* (28th January 2025). This Council Paper is available on the DCC website.

Most model inputs (catchments, hydraulic roughness, infiltration rates etc) were developed during the system performance modelling and are detailed in the *South Dunedin Catchment Stormwater System Performance Report (Beca, 2025)*. An overview of the model inputs particular to this work is provided in Section 2.3 of this report, along with details on the approaches used to represent the upgrades.

2.2 MODELLED FUTURES

The components of the three proposed Futures are described at a high level below:

- Future 3 – Protect:
    - The principal of this Future is to utilise an upgraded network of pipes and pumps to drain South Dunedin, while also increasing resilience by raising and redeveloping land in the west of the catchment. Storage facilities would also be included to provide flow attenuation and reduce the required scale of conveyance infrastructure.

- This is accompanied by new development areas in the east of the catchment and greenspaces to provide infiltration areas and reduce runoff.
- A seawall along Portsmouth Drive, to protect the catchment from rising sea levels and coastal flood events.

- Future 4 – Restore:
  - The principal of this Future is to utilise waterways to provide large drainage capacity. Storage facilities would also be included to provide flow attenuation and increase overall system capacity. Pump stations and network upgrades would be required to support this infrastructure.
  - This is accompanied by new development areas in the east of the catchment proposed in the long term to provide areas for managed relocation and greenspaces to provide infiltration areas and reduce runoff.
  - A seawall along Portsmouth Drive, to protect the catchment from rising sea levels and coastal flood events.
- Future 5 – Reshape:
  - The principal of this Future is to utilise waterways to provide large conveyance capacity and Storage facilities would also be included to provide flow attenuation and increase overall system capacity, while also increasing resilience by raising and redeveloping land in the west of the catchment. Pump stations and network upgrades would be required to support this infrastructure.
  - This is accompanied by new development areas in the east of the catchment and greenspaces to provide infiltration areas and reduce runoff.
  - A seawall along Otaki Street, to protect the catchment from rising sea levels and coastal flood events. The area between Otaki Street and Portsmouth Drive could be redesignated to have floodable first floors or become a greenspace.

These descriptions are based on the Futures as defined for the multi-criteria analysis and shortlisting process. Details on the MCA process are contained in the report to DCC titled *South Dunedin Futures – Shortlist of Potential Adaption Futures*, which can be accessed on the DCC website. The three proposed Futures were further developed to enable them to be input into the model.

Additionally, the three proposed Futures were amalgamated into a single solution for the Short Term time horizon, with each future then modelled separately for the Medium Term and Long Term time horizons.

2.3 INPUTS

2.3.1 DESIGN RAINFALL CONDITIONS

The *South Dunedin Catchment Stormwater System Performance Report* states that the critical duration (rainfall duration that created the greatest depth of flooding) was the 6-hour event. A long duration event (24 hours) was tested in sensitivity runs.

The rainfall return periods to be tested were:

- 10-year ARI – Used to size the pipe network. The network was sized allowing for approximately 150mm (or less if deemed suitable) of water to remain on roads to reduce the cost and extent of the network upgrades.
- 50-year ARI – This was used as the level of service for open channels, storage, and land raising options. Flooding on the roads in this return period may be greater than 150mm.
- 100-year ARI – This is the model that provided results for the residual risk assessment. The model contains infrastructure sized in the 10yr and 50yr ARI events.

2.3.2 CLIMATE CHANGE

Each rainfall event had a climate change allowance added to match the horizon of each Future. This was RCP 8.5 to 2025 for Short Term, RCP 8.5 to 2060 for Medium Term, and RCP 8.5 to 2100 for Long Term.

For the long duration 24-hour sensitivity runs, 10-year ARI and 50-year ARI RCP 8.5 2100 were used. For the 6-hour critical duration sensitivity run, 100-year ARI RCP 4.5 2100 was used.

2.3.3 TIDAL BOUNDARY CONDITIONS

A fixed tide level using the Mean High Water Springs (MHWS) was applied on the critical duration runs as a conservative approach. Allowances for sea level rise (SLR) were included in the medium and long term (0.5m and 1.1m respectively)

- Short Term – Current MHWS
- Medium Term – Current MHWS + 0.5m SLR
- Long Term – Current MHWS + 1.1m SLR

The tide was applied as a sinusoidal time series in the long duration sensitivity runs.

2.3.4 GROUND WATER

The calibrated groundwater parameters developed during the system performance project, which were based on the groundwater levels provided by GNS, were used for the current modelling assessment. For storage areas, it was initially assumed that localised groundwater controls would be implemented to lower existing groundwater levels represented as fixed inflows. However, these fixed inflow values were not available at the time of modelling.

As presented in the *South Dunedin Future Groundwater Drainage Options Assessment*[2], the average day to day groundwater inflows into the system is approximately 21 L/s under present day conditions increasing to 35 L/s with 1.1 m sea level rise. This increases up to a maximum of 65L/s (Future 4 – Protect with 1.1m sea level rise). These values represent the entire South Dunedin catchment therefore the inflow values at the proposed storage areas are expected to be considerably smaller. The groundwater inflows were therefore not applied to the model as they would be orders of magnitude smaller than the runoff flows during a storm event.

2.3.5 DESIGN LEVEL OF SERVICE

The design level of service for the pipe network and pump stations was a 6 hour 10-year ARI event for the relevant period per Section 2.3.1. The 6-hour event was selected as the critical storm

[2](South Dunedin Future Groundwater Drainage Options Assessment, WSP 2025)

duration as noted in Section 2.3.1, and a 10-year return period level of service aligns with the design requirements for primary stormwater infrastructure in new developments per the DCC Code of Subdivision[3],

For storage and open channels, the design level of service was a 6 hour 50-year ARI event. The design level of service included allowance for flooding on roads of up to 150mm in depth. This aligns with the height of kerb and channel per the DCC Code of Subdivision, with the underlying assumption being that water depths of 150mm or less would stay within the road corridor and not flood the surrounding properties. This allowance was included to reduce the scale of upgrades required to meet the level of service targets in order to improve the overall feasibility of the proposed upgrades.

This aligns well with (and typically exceeds) community feedback during the 2025 engagement period. Specifically, when asked about how frequently flooding was tolerable, responses generally indicated that the following was acceptable:

- In homes: every 50-years, or less frequently
- In workplaces and businesses: every 5- to 10years
- On roads and footpaths: between a few times per year to once every 1- to 5years
- On lawns and in fields: up to a few times per year.

2.3.6 EXISTING INFRASTRUCTURE

It is assumed that existing infrastructure that is not explicitly replaced, altered, or upgraded in the modelled Futures would remain as is throughout the time scales examined, with ongoing asset management and maintenance assumed to occur.

2.3.7 NEW PIPES AND SUMPS

New pipes were sized based on typical available pipes sizes, for both circular and rectangular pipes. Alignments generally followed the existing network and road corridors to minimise disruption.

Minimum grade of 1/pipe DN and cover of 750mm on new pipes was followed were possible, but this was often not achievable within the constraints of the existing network. The headloss coefficients were updated based on the inference tool in the ICM.

Megapits were added to the model in some locations to capture more flows. The head discharge table for these were sourced from the *Wellington Water Regional Stormwater Hydraulic Modelling Specification Guide*[4].

2.3.8 NEW STORAGE AND CHANNELS

Storage basins were modelled in 2D with a mesh level zone used to lower the mesh surface to the proposed basin depth. Storage basins have been modelled to be wet only during rain events, however, this configuration may result in basin storage being utilised in more frequent events than those that have been modelled. The model assumes that groundwater management will be in place for the storage basins and channels to maintain groundwater levels below the invert.

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[3] (Dunedin Code of Subdivision and Development, DCC 2010)
[4] (Regional Stormwater Hydraulic Modelling Specifications, Welling Water 2013)

Where pipes discharge to the basins these were connected with a flap gate upstream to prevent backflow from the basins into the upstream network. Channels discharging to basins were represented with large culverts and no flap gates to simulate a direct connection to the basin. The waterways are set along existing roads and alignments were selected to integrate with the existing network where these were low-lying shallow trunk mains.

Channels were modelled as river reaches with the cross section shown in Figure 2-1. Sumps that intercept the proposed channels were relocated to outside the channel to still capture their sub-catchments. The associated sump leads were relocated with invert levels and pipe dimensions kept as-is, but now draining to the new channel. Sub-catchments that intersected with the new channels were trimmed to remove the area now occupied by the channel. 100% impervious sub-catchments were included in the area occupied by the new channels to account for the rainfall directly on them. Mannings roughness coefficient of 0.03 was assumed for all the sections.

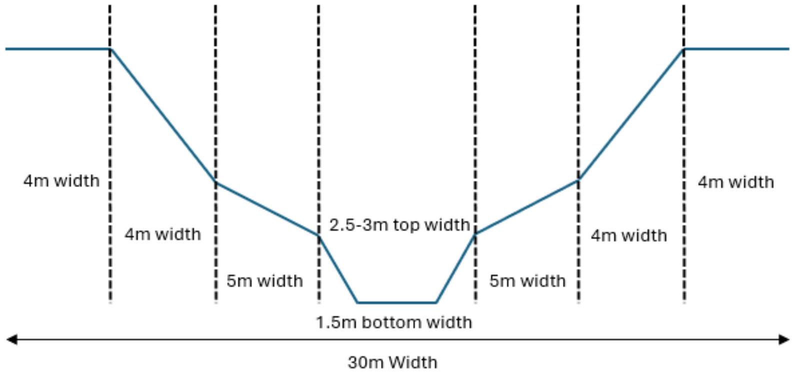

Figure 2-1: Channel cross section as modelled

As a simplification and due to the unknowns around pipe discharge conditions to the channels, pipes in the model were connected directly to river reach break nodes. This does not account for outlet headloss and extends pipe lengths, however, the maximum hydraulic grade in the pipes upstream of the channels is largely dictated by the water level in the channel itself. This is because of the limited grade available in the catchment and efforts to minimise the required channel depth, which means that the pipes discharge to the channel at a low level and these outlets are submerged as the channel fills during a rain event.

2.3.9 NEW AND UPGRADED PUMP STATIONS

The existing pumps in the base model are modelled as rotodynamic pumps with flow/head discharge curves.

All new and upgraded pumps were modelled as fixed flow pumps to inform the required pump station flow capacity only. The discharge head/lift of new pumps was not considered in this modelling.

2.3.10 RAISED LAND, NEW DEVELOPMENT, AND NEW GREENSPACES

Future 3 – Protect and Future 5 – Reshape included raised land. This was achieved by raising the ground model by 1m in the relevant area. In the medium term these raised land areas are undeveloped, with the areas modelled as 2D infiltration zones with a bund to contain any flooding. This raised land extends areas that are already elevated and near the shops and town centres retaining a compact urban form. This builds up some low-lying areas that would not otherwise be suitable for housing.

New developments were modelled as either medium or high density. Pervious-impervious ratios were provided by DCC and are shown in Table 2-1.

Table 2-1: New development permeability percentages.

Density	Pervious	Impervious
Low	36.2	63.8
Medium	25.2	74.8
High	3.6	96.4

It was assumed that all new developments would include storage for flow attenuation. This has been included in the model such that all of the runoff from a single event (up to a 50-year ARI level of service) can be stored. Flows from this storage are then only released to the downstream network when sufficient capacity is available following a rain event.

While the coastal protection, pipes, pumps, storage areas, and waterways help to reduce flooding, there are some areas where high flood risk remains. Some of these higher flood risk areas, (where it is more technically difficult and likely more costly to reduce flooding to target levels) were proposed to be changed into green space. This would reduce the need to develop more complex/costly solutions for those areas and provide additional flood mitigation benefits for surrounding areas, enabling smaller and less costly interventions in those areas and a better overall solution for South Dunedin. These new greenspaces were modelled as 100% pervious 2D infiltration zones. 0.5m bunds were positioned in certain locations accounting for local ground slopes to prevent water flowing into neighbouring properties while allowing water to enter the greenspaces from the surrounding area.

The existing network (sumps and pipes) was removed from raised land and new greenspaces, except for trunk mains with upstream connections.

Raised land, new development, and new greenspace extents were provided by WSP as shapefiles and integrated into the model. Some changes were made to the extent of new greenspaces as required to meet the level of service targets. There are some differences between futures in the exact extent of greenspaces located in the same areas. These are due to the iterative nature of the modelling, and the different extents will not significantly impact flooding in the adjacent areas,

2.3.11 SEAWALLS

The seawall added in the medium and long term for all three proposed Futures was modelled as an impervious wall of infinite height. The level of service of the seawall was not considered as a part of this work, but a nominal defence level of a 100-year coastal flood event (with wave overtopping included) is assumed through other components of this work.

2.3.12 KERBS

Kerbs were added in targeted locations to contain flooding within road corridors and prevent flow into neighbouring properties.

2.4 METHODOLOGY

Upgrades were developed through an iterative modelling process, starting from the principals outlined in the Modelling Schema Statement (Appendix S of this report).

The overall strategy was to divide the catchment into smaller sub-catchments and provide individual outfalls to Otago Harbour for each. This aimed to decrease the scale of key infrastructure and to reduce the impact of bottlenecks in the system. This division of the catchment required the addition of new or upgrade of existing pump stations along with accompanying discharge pipelines. Water storage facilities and increased greenspaces were implemented to attenuate flow peaks and reduce the scale of conveyance infrastructure. New or enlarged trunk mains, and for Future 4 – Restore and Future 5 – Reshape open waterways, were added to convey water to storage and to outfalls. This large, primary, infrastructure was added to the model first, with sizing and location adjusted based on test runs.

Certain land use changes, to enable land raising and new green spaces, were implemented for all three proposed Futures to differing degrees. After the primary infrastructure and land use changes were finalised for each model, network upgrades and kerbs were added to improve areas of localised flooding, These were targeted based on the initial results from the modelling of the primary infrastructure.

Upgrades for each Future were staged over the three time horizons. Upgrades added in earlier horizons were implemented such that they would be utilised in the ultimate long term time horizon. i.e. trunk mains were not added in the Short Term that would then have to be removed and enlarged in the Long Term.

The Short Term upgrades are summarised in Section 3.2, and Sections 3.3, 3.4, and 3.5 outline Future 3 – Protect, Future 4 – Restore, and Future 5 – Reshape respectively for both the Medium and Long Term time horizons. These further break down the approach for each Future and time horizon. The methodology is also covered in *SDF Stormwater Modelling Schema Statement* (refer Appendix S), however, note that this was issued prior to the commencement of modelling and does not reflect changes that were made to the approach during the modelling process.

Further optimisation has not been included at this stage but is recommended in parallel with design or a programme business case.

2.5 MODEL RUNS

The model runs completed for this work are shown in Table 2-2.

Table 2-2: Model Runs proposed for South Dunedin Futures Efficacy Modelling

Model run #	Rainfall Duration		Scenario			Return Period			Climate Change				Tides				Mapping		
	Critical (6hr)	Long Dur (24hr)	Short Term	Medium Term - 2060	Long Term - 2100	10yr	50yr	100yr	RCP4.5 - 2100	RCP 8.5 - 2025	RCP 8.5 - 2060	RCP 8.5 - 2100	MHWS	MHWS + SLR (0.5m)	MHWS + SLR (0.6m)	MHWS + SLR (1.1m)	Residual Risk	Network Sizing	Sensitivity
SD1a	x		x			x				X			X					X	
SD1b	x			x		x					x			x				X	
SD1c	x				x	x						X				X		X	
SD1d	X		x				X			x			X					X	
SD1e	X			x			X				x			x				X	
SD1f	x				x		X					x				X		X	
SD1g	x		X					x		x			X				X		
SD1h	x			x				X			x			x			X		
SD1i	x				x			X				X				x	X		
SD2a	x				x			x	x						x				x
SD2b		X			x	x						x	X						x
SD2c		x			x		x					x	X						x

3 FUTURE OVERVIEWS

3.1 MODEL OUTPUTS

The model outputs are comprised of maps of the catchment displaying maximum flood depths for each model run. The maps are provided in the Appendices listed below in Table 3-1.

Table 3-1: Model Runs proposed for South Dunedin Futures Efficacy Modelling

Appendix	Map number	Drawing tittle
A	A1	South Dunedin existing network overview
B	B1	South Dunedin Baseline (Status quo) network (existing network + quick wins)
C	C1	South Dunedin Short Term network
D	D1	South Dunedin Future O-3 Medium Term (2060)
D	D2	South Dunedin Future O-3 Long Term (2100)
E	E1	South Dunedin Future O-4 Medium Term (2060)
E	E2	South Dunedin Future O-4 Long Term (2100)
F	F1	South Dunedin Future O-5 Medium Term (2060)
F	F2	South Dunedin Future O-5 Long Term (2100)
G	G1	Maximum flood depth map for Baseline (Status quo) network 10-year ARI RCP 8.5 2025-MHWS
G	G2	Maximum flood depth map for Baseline(Status quo) network 50-year ARI RCP 8.5 2025-MHWS
G	G3	Maximum flood depth map for Baseline (Status quo) network 100-year ARI RCP 8.5 2025-MHWS
H	H1	Maximum flood depth map for Short Term 10-year RCP 8.5 2025-MHWS
H	H2	Maximum flood depth map for Short Term 50-year RCP 8.5 2025-MHWS
H	H3	Maximum flood depth map for Short Term 100-year RCP 8.5 2025-MHWS

Appendix	Map number	Drawing tittle
I	I1	Flood Depth Difference between Short Term and Base- 10 yr design storm
I	I2	Flood Depth Difference between Short Term and Base- 50 yr design storm
I	I3	Flood Depth Difference between Short Term and Base- 100 yr design storm
J	J1	Maximum flood depth map for O-3 10 year (MT) RCP 8.5 2060 MHWS + 0.5 m SLR
J	J2	Maximum flood depth map for O-3 50 year (MT) RCP 8.5 2060 MHWS + 0.5 m SLR
J	J3	Maximum flood depth map for O-3 100 year (MT) RCP 8.5 2060 MHWS + 0.5 m SLR
J	J4	Maximum flood depth map for O-3 (LT) RCP 8.5 2100 MHWS + 1.1 m SLR
J	J5	Maximum flood depth map for O-3 50 year (LT) RCP 8.5 2100 MHWS + 1.1 m SLR
J	J6	Maximum flood depth map for O-3 100 year (LT) RCP 8.5 2100 MHWS + 1.1 m SLR
K	K1	Flood Depth Difference between O-3 (LT) and Base- 10 yr design storm
K	K2	Flood Depth Difference between O-3 (LT) and Base- 50 yr design storm
K	K3	Flood Depth Difference between O-3 (LT) and Base- 100 yr design storm
L	L1	Maximum flood depth map for O-4 10 year (MT) RCP 8.5 2060 MHWS + 0.5 m SLR
L	L2	Maximum flood depth map for O-4 50 year (MT) RCP 8.5 2060 MHWS + 0.5 m SLR
L	L3	Maximum flood depth map for O-4 100 year (MT) RCP 8.5 2060 MHWS + 0.5 m SLR
L	L4	Maximum flood depth map for 10 year (LT) RCP 8.5 2100 MHWS + 1.1 m SLR

Appendix	Map number	Drawing tittle
L	L5	Maximum flood depth map for O-4 50 year (LT) RCP 8.5 2100 MHWS + 1.1 m SLR
L	L6	Maximum flood depth map for O-4 100 year (LT) RCP 8.5 2100 MHWS + 1.1 m SLR
M	M1	Flood Depth Difference between O-4 (LT) and Base- 10 yr design storm
M	M2	Flood Depth Difference between O-4 (LT) and Base- 50 yr design storm
M	M3	Flood Depth Difference between O-4 (LT) and Base- 100 yr design storm
N	N1	Maximum flood depth map for O-5 10-year (MT) RCP 8.5 2060 MHWS + 0.5 m SLR
N	N2	Maximum flood depth map for O-5 50-year (MT) RCP 8.5 2060 MHWS + 0.5 m SLR
N	N3	Maximum flood depth map for O-5 100-year (MT) RCP 8.5 2060 MHWS + 0.5 m SLR
N	N4	Maximum flood depth map for O-5 10-year (LT) RCP 8.5 2100 MHWS + 1.1 m SLR
N	N5	Maximum flood depth map for O-5 50-year (LT) RCP 8.5 2100 MHWS + 1.1 m SLR
N	N6	Maximum flood depth map for O-5 100 year (LT) RCP 8.5 2100 MHWS + 1.1 m SLR
O	O1	Flood Depth Difference between O-5 (LT) and Base- 10 yr design storm
O	O2	Flood Depth Difference between O-5 (LT) and Base- 50 yr design storm
O	O3	Flood Depth Difference between O-5 (LT) and Base- 100 yr design storm
P	P1	Sensitivity run 1- Flood depth difference between long duration (24 hr) and critical duration (6 hr) 10 year RCP 8.5 2100 MHWS for O-3 (LT)
P	P2	Sensitivity run 2- Flood depth difference between long duration (24 hr) and critical duration (6 hr) 50 year RCP 8.5 2100 MHWS for O-3 (LT)

Appendix	Map number	Drawing tittle
P	P3	Sensitivity run 3- Flood depth difference between 100 year RCP 4.5 2100 MHWS + 0.6 m SLR and 100 year RCP 8.5 2100 MHWS + 1.1 m SLR for O-3 (LT)
Q	Q1	Sensitivity run 1- Flood depth difference between long duration (24 hr) and critical duration (6 hr) 10 year RCP 8.5 2100 MHWS for O-4 (LT)
Q	Q2	Sensitivity run 2- Flood depth difference between long duration (24 hr) and critical duration (6 hr) 50 year RCP 8.5 2100 MHWS for O-4
Q	Q3	Sensitivity run 3- Flood depth difference between 100 year RCP 4.5 2100 MHWS + 0.6 m SLR and 100 year RCP 8.5 2100 MHWS + 1.1 m SLR for future O-4 (LT)
R	R1	Sensitivity run 1- Flood depth difference between long duration (24 hr) and critical duration (6 hr) 10 year RCP 8.5 2100 MHWS for O-5 (LT)
R	R2	Sensitivity run 2- Flood depth difference between long duration (24 hr) and critical duration (6 hr) 50 year RCP 8.5 2100 MHWS for O-5 (LT)
R	R3	Sensitivity run 3- Flood depth difference between 100 year RCP 4.5 2100 MHWS + 0.6 m SLR and 100 year RCP 8.5 2100 MHWS + 1.1 m SLR for O-5 (LT)

The upgrades for each Future and time horizon are summarised in Table 4-1, Table 4-2, Table 4-3, Table 4-4 covering pipes, channels, pump stations, storage, and manholes/sumps.

3.2 SHORT TERM (2025 - 2060)

3.2.1 UPGRADES

Short Term upgrades included new pipes, new and upgraded pump stations, and new storage basins. The Short Term upgrade model is common to all three Futures being considered. The infrastructure upgrades for the Short Term horizon are shown in Appendix C Map C1.

The approach taken was to split the South Dunedin Catchment into smaller portions to decrease the scale of infrastructure required and relieve pressure on the Portobello Road pump station and outfall:

- New pump stations and discharge mains from the catchment to the harbour were added to capture flows from the lower Hillside Road and MacAndrew Road trunk mains. These were located on existing outfalls from the Portsmouth Drive Catchment but would require outfall upgrades. The Tainui pump station is also proposed to be upgraded.
- The new and upgraded pump stations are all proposed to utilise rising mains for discharge, with new rising mains on Midland Street, Orari Street, and Royal Crescent.
- A new pump station located at the Hillside Road – Burns Street intersection and accompanying rising main discharging to the Wilkie Road Conduit would service the Forbury Corner area. This would split the Hillside Road trunk main and frees up capacity in

the trunk main downstream of the new pump station. The discharge to the Wilkie Road Conduit would require raising the hydraulic grade in this main, downstream of the connection, to above ground level.

- The new pump stations and outfalls are supported by trunk main upgrades on Bay View Road, Marlow Street, and upper Hillside Road in Forbury Corner. A new trunk main on Kirkcaldy Street has also been included, to divert flows from the MacAndrew Road Main and leverage the upgraded Bay View Road main.
- The network in the Rona Street area and between Queens Drive and Royal Crescent that previously discharged to the Royal Crescent trunk main was diverted to upstream of the Tainui Pump Station to facilitate this trunk main being converted to a rising main.
- The Forbury Aqueduct is twinned from the Forbury Road – Bay View Road intersection through to the ocean outfall.
- Forbury Park is proposed as a large new storage basin. A new trunk main on Council Street to service the area around De Carle Park is also proposed, to leverage the Forbury Park storage and relieve capacity on the Bellona Street trunk main
- A small basin in Tonga Park to capture overflows from the Forbury Road Aqueduct is also proposed, with an overflow and main located on Wycolla Avenue.
- Various network upgrades, including mains, sump leads, and megapits were included to further alleviate flooding. These have been developed to effectively utilise the proposed and existing larger infrastructure, such as capacity freed up on the MacAndrew Bay Road main as a result of the new trunk main on Kirkcaldy Street.

3.2.2 PERFORMANCE

The Short Term maps are contained in Appendix H Maps H1-H3.

The upgrades modelled are effective and significantly reduce flooding to meet the targeted level of service for the network of a 10-year ARI event.

Areas where some flooding remains on properties in a 10-year ARI event include Tainui and the Surrey Street – Nicholson Street intersection. There is also some more significant ponding along Portsmouth Drive. Streets throughout the catchment have flood depths up to 150mm.

3.3 FUTURE 3 - PROTECT

3.3.1 MEDIUM TERM (2060 - 2100)

3.3.1.1 UPGRADES

The previous Short Term works were maintained, with no further splitting of the catchment. The infrastructure upgrades for Future 3 – Protect Medium Term are shown in Appendix D Map D1. Additional storage and trunk mains were added along with land raising:

- A new storage basin at Bathgate Park was added along with a pump station to drain it. The Tonga Park storage added in the Short Term model was also enlarged and a pump station added. This provides further flow attenuation and decreases the required scale of downstream infrastructure.
- New trunk mains were added on Coughtrey Street, eastern MacAndrew Road, and Prince Albert Road.

- A further Forbury Road Aqueduct overflow was added at the Coughtrey Street – Forbury Road intersection, discharging to the new trunk main proposed on Coughtrey Street. This in turn connects to the Forbury Park storage, and alleviates pressure on the Forbury Road Aqueduct while limiting impacts on the South Dunedin network by utilising this attenuation.
- Further network upgrades, including mains, sump leads, and megapits were also included to further alleviate flooding and to facilitate delivery of stormwater to the open channels and storage.
- The discharge main from the Portobello Road Pump Station would have the hydraulic grade raised above ground level, in part due to the higher tail water condition at the outfall with sea level rise. To facilitate this, network downstream of the pump station has been diverted directly to the harbour via a new outfall pipe or to upstream of the pump station.
- A seawall was added along Portsmouth Drive in this Future.
- Raised land was added extending east from Forbury Road to Bathgate and Tonga parks. This was considered as undeveloped in the Medium Term.

3.3.1.2 PERFORMANCE

The Future 3 – Protect Medium Term maps are contained in Appendix J Maps J1-J3.

The upgrades and land use changes modelled are effective and significantly reduce flooding to meet the targeted level of service for the network of a 10-year ARI event.

Some flooding remains on properties in a 10-year ARI event in Tainui. There is also flooding on the corner of Grosvenor Street and Bridgman Street, adjacent to an NZ Defence Force site. The flooding in the Portsmouth Drive catchment has also worsened, primarily due to sea level rise increasing the tail-water level at the outfalls. Streets throughout the catchment have flood depths up to 150mm.

3.3.2 *LONG TERM (2100 ONWARDS)*

3.3.2.1 UPGRADES

Changes to Future 3 – Protect in this time horizon were primarily land use changes, with some infrastructure upgrades. The infrastructure upgrades for Future 3 – Protect Long Term is shown in Appendix D Map D2.

- New greenspaces were added in Forbury Corner and in Tainui between Ravelston Street and Magdala Street. These are high risk areas that would require costly solutions to meet the targeted level of service. The development of greenspaces reduces risks whilst also providing flood mitigation benefits for the surrounding areas.
- Medium density developments were added to the raised land, Hancock Park, and Chisholm Links. These are serviced by individual storage basins and downstream network upgrades.
- New pump stations were added at each of the four existing Portsmouth Drive catchment gravity outfalls to allow this water to be discharged against the 1.1m of sea level rise in this time scale
- The Portobello Road Pump Station was upgraded to increase flow capacity.

3.3.2.2 PERFORMANCE

The Future 3 – Protect Long Term maps are contained in Appendix J Maps J4-J6.

The upgrades and land use changes modelled are effective and significantly reduce flooding to meet the targeted level of service for the network of a 10-year ARI event.

The new greenspaces see significant flooding, but it is largely contained to these areas. In Tainui some flooding on properties remains outside of the large new greenspace. The flooding has also worsened on the corner of Grosvenor Street and Bridgman Street. Flooding in the Portsmouth Drive catchment is greatly reduced from the Medium Term with the addition of pump stations on the outfalls.

3.4 FUTURE 4 – RESTORE

3.4.1 MEDIUM TERM (2060 - 2100)

3.4.1.1 UPGRADES

The previous Short Term works were maintained, with no further splitting of the catchment. The open channels for this Future were developed in this time horizon, along with further storage. The infrastructure upgrades for Future 4 – Restore Medium Term are shown in Appendix E Map E1.

- New storage basins, with pump stations to drain them, at Bathgate Park and Culling Park were added, along with the enlargement of and addition of a pump station to the Tonga Park storage added in the Short Term model. These provide further flow attenuation and decreases the required scale of downstream infrastructure.
- New open channels were added on Bellona Street (from Forbury Park to Culling Park storage), MacAndrew Road, Coughtrey Street, and West Avenue. These provide additional stormwater conveyance capacity to the network and provide an opportunity for a nature based solution.
- A further Forbury Road Aqueduct overflow was added at the Coughtrey Street – Forbury Road intersection, discharging to the new channel proposed on Coughtrey Street. This in turn connects to the Forbury Park storage, and alleviates pressure on the Forbury Road Aqueduct while limiting impacts on the South Dunedin network by utilising this attenuation.
- The discharge main from the Portobello Road Pump Station would have the hydraulic grade raised above ground level, in part due to the higher tail water condition at the outfall with sea level rise. To facilitate this, network downstream of the pump station has been diverted directly to the harbour via a new outfall pipe or to upstream of the pump station.
- Further network upgrades, including mains, sump leads, and Megapits were also included to further alleviate flooding and to facilitate delivery of stormwater to the open channels and storage.
- A seawall was added along Portsmouth Drive in this Future.

3.4.1.2 PERFORMANCE

The Future 4 – Restore Medium Term maps are contained in Appendix L Maps L1-L3.

The upgrades modelled are effective and significantly reduce flooding to meet the targeted level of service for the network of a 10-year ARI event.

Some flooding remains on properties in a 10-year ARI event in Tainui. There is also flooding on the corner of Grosvenor Street and Bridgman Street, adjacent to an NZ Defence Force site. The flooding in the Portsmouth Drive catchment has also worsened, primarily due to sea level rise increasing the tail-water level at the outfalls. Streets throughout the catchment have flood depths up to 150mm.

3.4.2 LONG TERM (2100 ONWARDS)

3.4.2.1 UPGRADES

Changes to Future 4 – Restore Long Term: In this time horizon were primarily land use changes, with some infrastructure upgrades particularly due to the additional sea level rise. The infrastructure upgrades for the Future 4 – Restore Long Term are shown in Appendix E Map E2.

- New greenspaces were added to the east of Surrey Street and West Avenue, in Forbury Corner, and in Tainui between Ravelston Street and Magdala Street. These are high risk areas that would require costly solutions to meet the targeted level of service, with the development of greenspaces also providing flood mitigation benefits for the surrounding areas.
- High density developments were added to Hancock Park, Tahuna Park, and Chisholm Links. These are serviced by individual storage basins and downstream network upgrades.
- New pump stations were added at each of the four existing Portsmouth Drive catchment gravity outfalls to allow this water to be discharged against the 1.1m of sea level rise in this scenario.
- Some upstream network upgrades, primarily mains (not trunk mains) and sump leads, were added to further alleviate localised flooding.

3.4.2.2 PERFORMANCE

The Future 4 – Restore Long Term maps are contained in Appendix L Maps L4-L6.

The upgrades and land use changes modelled are effective and significantly reduce flooding to meet the targeted level of service for the network of a 10-year ARI event.

The new greenspaces see significant flooding, but it is largely contained to these areas. In Tainui some flooding on properties remains outside of the large new greenspace. The flooding has also worsened on the corner of Grosvenor Street and Bridgman Street. Flooding in the Portsmouth Drive catchment is greatly reduced from the Medium Term with the addition of pump stations on the outfalls.

3.5 FUTURE 5 – RESHAPE

3.5.1 MEDIUM TERM (2060 - 2100)

3.5.1.1 UPGRADES

The previous Short Term works were maintained, with no further splitting of the catchment. The open channels for this Future were developed in this time horizon, along with further storage and the raising of land. The infrastructure upgrades for Future 5 – Reshape Medium Term are shown in Appendix F Map F1.

- New storage basins, with pump stations to drain them, at Bathgate Park and Culling Park were added, along with an upgrade and addition of a pump station to the Tonga Park storage added in the Short Term model. These provide further flow attenuation and decreases the required scale of downstream infrastructure.
- New open channels were added on Bellona Street (from Forbury Park to Culling Park storage), MacAndrew Road, Coughtrey Street, and West Avenue. These provide additional stormwater conveyance capacity to the network and provide an opportunity for a nature based solution.
- A further Forbury Road Aqueduct overflow was added at the Coughtrey Street – Forbury Road intersection, discharging to the new channel proposed on Coughtrey Street. This in turn connects to the Forbury Park storage, and alleviates pressure on the Forbury Road Aqueduct while limiting impacts on the South Dunedin network by utilising this attenuation.
- The discharge main from the Portobello Road Pump Station would have the hydraulic grade raised above ground level, in part due to the higher tail water condition at the outfall with sea level rise. To facilitate this, network downstream of the pump station has been diverted directly to the harbour via a new outfall pipe or to upstream of the pump station.
- Raised land was added extended east from Forbury Road to Bathgate and Tonga parks, and in Forbury Corner. This was considered as undeveloped in the Medium Term.
- Further network upgrades, including mains, sump leads, and megapits were also included to further alleviate flooding and to facilitate delivery of stormwater to the open channels and storage.
- A seawall was added along Otaki Street in this Future. The properties between the seawall and Portsmouth Drive would have floodable first floors.

3.5.1.2 PERFORMANCE

The Future 5 – Reshape Medium Term maps are contained in Appendix N Maps N1-N3.

The upgrades and land use changes modelled are effective and significantly reduce flooding to meet the targeted level of service for the network of a 10-year ARI event.

Some flooding remains on properties in a 10-year ARI event in Tainui. There is also flooding on the corner of Grosvenor Street and Bridgman Street, adjacent to an NZ Defence Force site.

There is flooding along Portsmouth Drive, which is outside the seawall that is positioned along Otaki Street in this Future.

3.5.2 LONG TERM (2100 ONWARDS)

3.5.2.1 UPGRADES

Changes to Future 5 – Reshape in this time horizon were primarily land use changes. The infrastructure upgrades for Future 5 – Reshape Long Term are shown in Appendix F Map F2.

- New greenspaces were added extending East from West Avenue and in Tainui between Ravelston Street and Magdala Street. These are high risk areas that would require costly solutions to meet the targeted level of service, with the development of greenspaces also providing flood mitigation benefits for the surrounding areas.

- Medium density developments were added to the raised land, Hancock Park, and Chisholm Links. These are serviced by individual storage basins and downstream network upgrades.
- Some upstream network upgrades, primarily mains (not trunk mains) and sump leads, were added to further alleviate localised flooding.

3.5.2.2 PERFORMANCE

The Future 5 – Reshape Long Term maps are contained in Appendix N Maps N4-N6.

The upgrades and land use changes modelled are effective and significantly reduce flooding to meet the targeted level of service for the network of a 10-year ARI event.

The new greenspaces see significant flooding, but it is largely contained to these areas. In Tainui some flooding on properties remains outside of the large new greenspace. The flooding has also worsened on the corner of Grosvenor Street and Bridgman Street.

The area between Otaki Street (the location of the seawall in this future) and Portsmouth Drive sees significant flooding.

3.6 SENSITIVITY RUNS

Sensitivity runs were completed for a long duration event for each of the three proposed Futures and time horizons for the 10- and 50-year rainfall return periods. These were undertaken to test the Futures against a longer duration (24-hour) rainfall event which was chosen as previous flood events in South Dunedin have occurred during long duration events. These were run to check sensitivity of the upgrades. Flood depth results from these runs were compared to the respective design run results. Other aspects such storage capacity utilisation were also checked.

For climate change allowance testing, a sensitivity run was completed for RCP 4.5 to 2100 for the 100-year ARI event for each Future. These were undertaken to test the Futures against a less severe climate change model. Flood depth results from these runs were compared to the respective design run results.

Depth difference maps for the long duration runs are shown in:

- Appendix P Maps P1 and P2 for Future 3 – Protect
- Appendix Q Maps Q1 and Q2 for Future 4 – Restore
- Appendix R Maps R1 and R2 for Future 5 – Reshape.

The results showed less flooding in the catchment but a greater volume of water in the storage facilities, due to the lower intensity but longer duration of the modelled rain event.

Depth difference maps for the RCP 4.5 100-year ARI runs are shown in:

- Appendix P Map P3 for Future 3 – Protect,
- Appendix Q Map Q3 for Future 4 – Restore
- Appendix R Map R3 for Future 5 – Reshape.

As expected, the results showed less flooding throughout the catchment.

4 SUMMARY

This section outlines the key differences between the three proposed Futures.

4.1 PIPE NETWORK

- Upgrades to pipes for Future 3 – Protect were proposed primarily in medium-term which primarily includes trunk mains connecting to storage areas.
- Approximately 3.5Km of open channels are proposed for Future 4 – Restore and Future 5 – Reshape primarily along Bellona street and Macandrew Rd along with the pipes discharging to these open channels and other laterals.

Table 4-1: Summary of pipe upgrades (newly upgraded and added pipes only).

Shape	Size (mm)	Length (m)						
		Short Term	Future 3 – Protect		Future 4 – Restore		Future 5 – Reshape	
			Medium Term	Long Term	Medium Term	Long Term	Medium Term	Long Term
Circular	100				40.1		40.1	
	150	86.4			953.6	26.9	745.1	
	200				74.4		74.4	
	225	702.2	65.9		1068.5	57	1012.6	
	250				18.9		18.9	
	300	1554.3	575.3		997.3		1427.9	
	375	1819.3	439.6		652.7	102	259.6	
	450	3500.8	1350.1		711.2	583.7	1635.1	
	525	3228.4	148.7		164.4		871.2	
	600	1488.1	1263.2		453.7	707.4	1160.6	
	675		168.1		17.5		185.6	
	700	667.4	142.2				423.4	
	750	1391.6	295.8		19.3		65.3	
	900	2095.7	456.3		198.6		855.3	
	1050	1074.2	23				23	
	1200	272.9			171.6		5.6	

Shape	Size (mm)	Length (m)						
		Short Term	Future 3 – Protect		Future 4 – Restore		Future 5 – Reshape	
			Medium Term	Long Term	Medium Term	Long Term	Medium Term	Long Term
	1300	591.4						
	1500	2348.7					1.9	
Rectangular	1200x900				134.1		76	
	1200x1000	17.9						
	1500x1000	253.9						
	1500x1300	47.6						
	1800x700	421.1						
	2000x1000	246.6						
	2000x1500	1167.6						
	2100x1000	2095.9						
	2100x1050	284.3						
	3000x1000		445.4					
	3000x1200				56.2		56.2	
Open Channel		-	-	-	3526		3526	

4.2 PUMP STATIONS

- Future 3 – Protect requires upgrading the pump capacities at Hillside and installing new pumps at the proposed storage basins (Tonga Park and Bathgate Park) during the Medium Term. In the Long Term, the Portobello pumps are upgraded and new pump stations are added at each of the four existing Portsmouth Drive catchment gravity outfalls to discharge the water against the 1.1m of sea level rise.
- Future 4 – Restore increases capacity at Orari (3.5 m^3/s) and Hillside (2 m^3/s) installing new pumps at the proposed storage basins (Tonga Park and Bathgate Park) during the Medium Term and introduces four pump stations (0.5 m^3/s each) at the Portsmouth Drive gravity outfalls in the Long Term.

Table 4-2: Summary of pump upgrades.

Pump Station	Capacity (m^3/s)							
	Existing	Short Term	Future 3 – Protect		Future 4 – Restore		Future 5 – Reshape	
			Medium Term	Long Term	Medium Term	Long Term	Medium Term	Long Term
Portobello	6.4	6.4	6.4	8	6.4	6.4	6.4	6.4
Tainui	0.72	3	3	3	3	3	3	3
Orari	N/A	2.5	2.5	2.5	3.5	3.5	2.5	2.5
Hillside	N/A	1.5	2.5	2.5	2	2	2.5	2.5
Midland	N/A	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Forbury Park	N/A	1	1	1	1	1	1	1
Tonga Park	N/A	N/A	0.5	0.5	0.5	0.5	0.5	0.5
Bathgate Park	N/A	N/A	0.5	0.5	0.5	0.5	0.5	0.5
Culling Park	N/A	N/A	N/A	N/A	1	1	1	1
Portsmouth Drive #1	N/A	N/A	N/A	0.5	N/A	0.5	N/A	N/A
Portsmouth Drive #2	N/A	N/A	N/A	0.5	N/A	0.5	N/A	N/A
Portsmouth Drive #3	N/A	N/A	N/A	0.5	N/A	0.5	N/A	N/A
Portsmouth Drive #4	N/A	N/A	N/A	0.5	N/A	0.5	N/A	N/A

4.3 STORAGE AREAS

- All three proposed Futures expand Tonga Park to 3.5 ha and introduce Bathgate Park (1.5 ha) for the Medium and Long Term.
- Future 4 – Restore and Future 5 – Reshape add Culling Park (2 ha), providing further flood storage resilience.

Table 4-3: Summary of storage areas.

Storage	Area (ha)						
	Short Term	Future 3 – Protect		Future 4 – Restore		Future 5 – Reshape	
		Medium Term	Long Term	Medium Term	Long Term	Medium Term	Long Term
Forbury Park	9	9	9	9	9	9	9
Tonga Park	1	3.5	3.5	3.5	3.5	3.5	3.5
Bathgate Park	N/A	1.5	1.5	1.5	1.5	1.5	1.5
Culling Park	N/A	N/A	N/A	2	2	2	2

4.4 MANHOLES AND SUMPS

- Sumps located along the river reaches in Future 4 – Restore and Future 5 – Reshape have been relocated to drain into the proposed river reaches.

Table 4-4: Summary of manholes and sumps

Type	Diameter (m)	Short Term	Future 3 – Protect		Future 4 – Restore		Future 5 – Reshape	
			Medium Term	Long Term	Medium Term	Long Term	Medium Term	Long Term
Manholes	0.8	10	7		5		5	
	0.9	38	40		14		13	
	1	53	10		39	14	92	
	1.2	75	5		15		21	
	1.3	63	24		9		15	
	1.5	32	4		11	9	13	
	1.6	1	7		1		5	
	1.7	14	2					
	1.8	33	10		1		1	
	1.9		1					
	2.2	45	4		10	1	24	
	2.6	20			2	1	3	
	3	17			10		8	
	3.3	2						

Type	Diameter (m)	Short Term	Future 3 – Protect		Future 4 – Restore		Future 5 – Reshape	
			Medium Term	Long Term	Medium Term	Long Term	Medium Term	Long Term
	4	13			1		1	
	5.2				1			
	6	28						
	6.4	29	5		3			
	10		10		1		2	
Sumps	0.6				2		2	
	0.7	6			50	2	39	
	0.8	22	7		62	8	54	
	0.9	3	2		11		12	
	1	1	1					
	1.2						1	
	1.3						1	
	1.7						1	
	3	1	1				1	
Megapits		27			5		6	

APPENDICES A-R: MAPS

APPENDIX S: SCHEMA STATEMENT

Appendix	Map number	Drawing title
A	A1	South Dunedin existing network overview
B	B1	South Dunedin Baseline network (existing network + quick wins)
C	C1	South Dunedin Short Term network
D	D1	South Dunedin Future O-3 Medium Term (2060)
D	D2	South Dunedin Future O-3 Long Term (2100)
E	E1	South Dunedin Future O-4 Medium Term (2060)
E	E2	South Dunedin Future O-4 Long Term (2100)
F	F1	South Dunedin Future O-5 Medium Term (2060)
F	F2	South Dunedin Future O-5 Long Term (2100)
G	G1	Maximum flood depth map for Baseline network 10-year ARI RCP 8.5 2025-MHWS
G	G2	Maximum flood depth map for Baseline network 50-year ARI RCP 8.5 2025-MHWS
G	G3	Maximum flood depth map for Baseline network 100-year ARI RCP 8.5 2025-MHWS
H	H1	Maximum flood depth map for Short Term network 10-year RCP 8.5 2025-MHWS
H	H2	Maximum flood depth map for Short Term network 50-year RCP 8.5 2025-MHWS
H	H3	Maximum flood depth map for Short Term network 100-year RCP 8.5 2025-MHWS
I	I1	Flood Depth Difference between Short Term and Base- 10 yr design storm
I	I2	Flood Depth Difference between Short Term and Base- 50 yr design storm
I	I3	Flood Depth Difference between Short Term and Base- 100 yr design storm
J	J1	Maximum flood depth map for O-3 10 year (MT) RCP 8.5 2060 MHWS + 0.5 m SLR
J	J2	Maximum flood depth map for O-3 50 year (MT) RCP 8.5 2060 MHWS + 0.5 m SLR
J	J3	Maximum flood depth map for O-3 100 year (MT) RCP 8.5 2060 MHWS + 0.5 m SLR
J	J4	Maximum flood depth map for O-3 (LT) RCP 8.5 2100 MHWS + 1.1 m SLR
J	J5	Maximum flood depth map for O-3 50 year (LT) RCP 8.5 2100 MHWS + 1.1 m SLR
J	J6	Maximum flood depth map for O-3 100 year (LT) RCP 8.5 2100 MHWS + 1.1 m SLR
K	K1	Flood Depth Difference between O-3 (LT) and Base- 10 yr design storm
K	K2	Flood Depth Difference between O-3 (LT) and Base- 50 yr design storm
K	K3	Flood Depth Difference between O-3 (LT) and Base- 100 yr design storm
L	L1	Maximum flood depth map for O-4 10 year (MT) RCP 8.5 2060 MHWS + 0.5 m SLR
L	L2	Maximum flood depth map for O-4 50 year (MT) RCP 8.5 2060 MHWS + 0.5 m SLR
L	L3	Maximum flood depth map for O-4 100 year (MT) RCP 8.5 2060 MHWS + 0.5 m SLR
L	L4	Maximum flood depth map for O-4 10 year (LT) RCP 8.5 2100 MHWS + 1.1 m SLR
L	L5	Maximum flood depth map for O-4 50 year (LT) RCP 8.5 2100 MHWS + 1.1 m SLR
L	L6	Maximum flood depth map for O-4 100 year (LT) RCP 8.5 2100 MHWS + 1.1 m SLR
M	M1	Flood Depth Difference between O-4 (LT) and Base- 10 yr design storm
M	M2	Flood Depth Difference between O-4 (LT) and Base- 50 yr design storm
M	M3	Flood Depth Difference between O-4 (LT) and Base- 100 yr design storm
N	N1	Maximum flood depth map for O-5 10-year (MT) RCP 8.5 2060 MHWS + 0.5 m SLR
N	N2	Maximum flood depth map for O-5 50-year (MT) RCP 8.5 2060 MHWS + 0.5 m SLR
N	N3	Maximum flood depth map for O-5 100-year (MT) RCP 8.5 2060 MHWS + 0.5 m SLR
N	N4	Maximum flood depth map for O-5 10-year (LT) RCP 8.5 2100 MHWS + 1.1 m SLR
N	N5	Maximum flood depth map for O-5 50-year (LT) RCP 8.5 2100 MHWS + 1.1 m SLR
N	N6	Maximum flood depth map for O-5 100 year (LT) RCP 8.5 2100 MHWS + 1.1 m SLR
O	O1	Flood Depth Difference between O-5 (LT) and Base- 10 yr design storm
O	O2	Flood Depth Difference between O-5 (LT) and Base- 50 yr design storm
O	O3	Flood Depth Difference between O-5 (LT) and Base- 100 yr design storm
P	P1	Sensitivity run 1- Flood depth difference between long duration (24 hr) and critical duration (6 hr) 10 year RCP 8.5 2100 MHWS for O-3 (LT)
P	P2	Sensitivity run 2- Flood depth difference between long duration (24 hr) and critical duration (6 hr) 50 year RCP 8.5 2100 MHWS for O-3 (LT)
P	P3	Sensitivity run 3- Flood depth difference between 100 year RCP 4.5 2100 MHWS + 0.6 m SLR and 100 year RCP 8.5 2100 MHWS + 1.1 m SLR for O-3 (LT)
Q	Q1	Sensitivity run 1- Flood depth difference between long duration (24 hr) and critical duration (6 hr) 10 year RCP 8.5 2100 MHWS for O-4 (LT)
Q	Q2	Sensitivity run 2- Flood depth difference between long duration (24 hr) and critical duration (6 hr) 50 year RCP 8.5 2100 MHWS for O-4
Q	Q3	Sensitivity run 3- Flood depth difference between 100 year RCP 4.5 2100 MHWS + 0.6 m SLR and 100 year RCP 8.5 2100 MHWS + 1.1 m SLR for future O-4 (LT)
R	R1	Sensitivity run 1- Flood depth difference between long duration (24 hr) and critical duration (6 hr) 10 year RCP 8.5 2100 MHWS for O-5 (LT)
R	R2	Sensitivity run 2- Flood depth difference between long duration (24 hr) and critical duration (6 hr) 50 year RCP 8.5 2100 MHWS for O-5 (LT)
R	R3	Sensitivity run 3- Flood depth difference between 100 year RCP 4.5 2100 MHWS + 0.6 m SLR and 100 year RCP 8.5 2100 MHWS + 1.1 m SLR for O-5 (LT)

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South Dunedin Futures
Table of Maps

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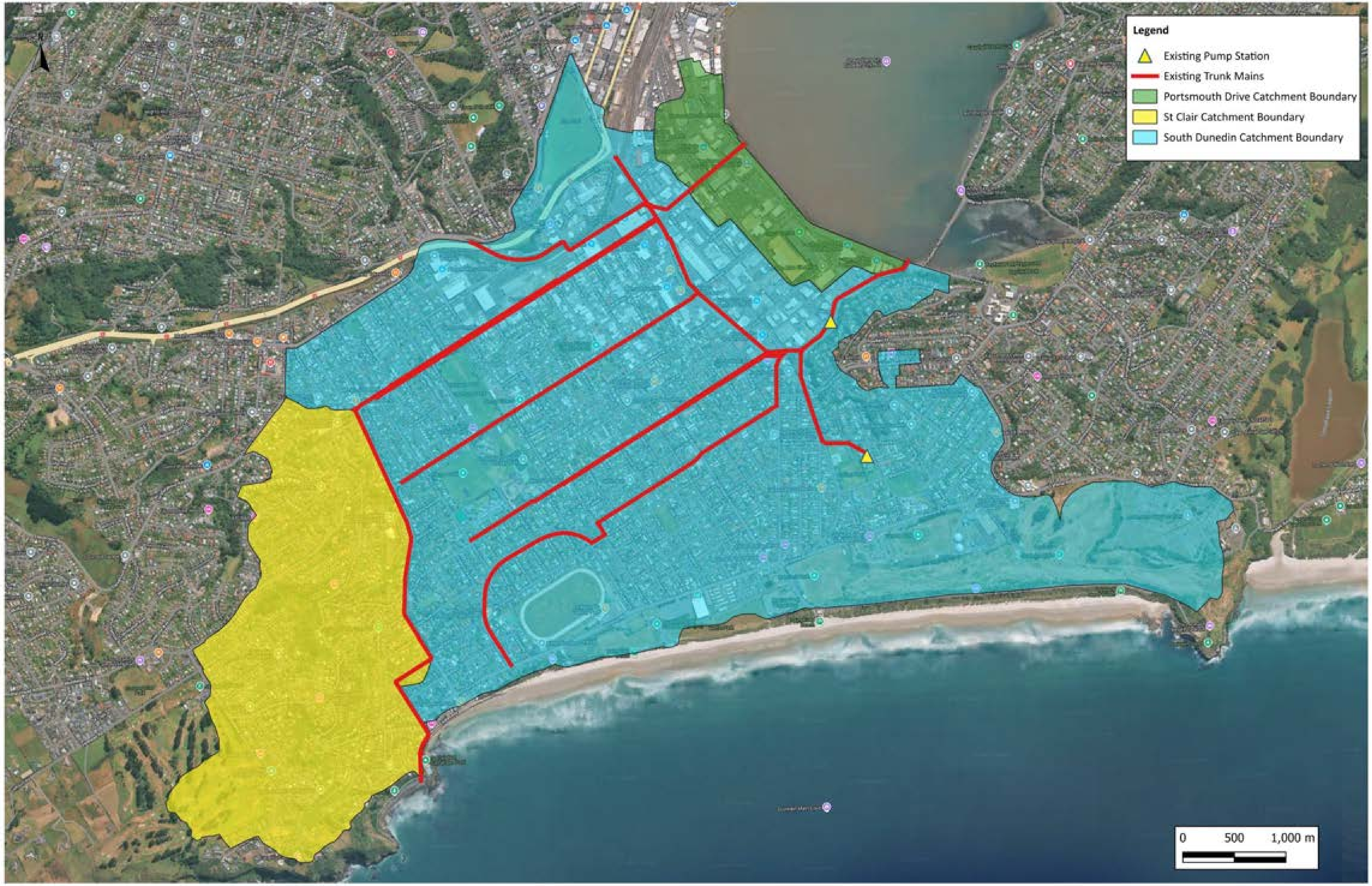

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South Dunedin Existing Network Overview

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DUNEDIN CITY COUNCIL | kaunihera a-rohe o Ōtepoti	South Dunedin Baseline Network (Existing Network + Quick Wins)	DRAWN BY: Anvesh Ravula
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South Dunedin Future - Option 3 Medium Term (2060)

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South Dunedin Future - Option 4 Medium Term (2060)

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South Dunedin - Baseline Network
Maximum Flood Depth Map
(1 in 50 Year RCP 8.5 2025 MHWS)

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MAP NO: 4700990 - G3	REV: A	South Dunedin - Baseline Network Maximum Flood Depth Map (1 in 100 Year RCP 8.5 2025 MHWS)

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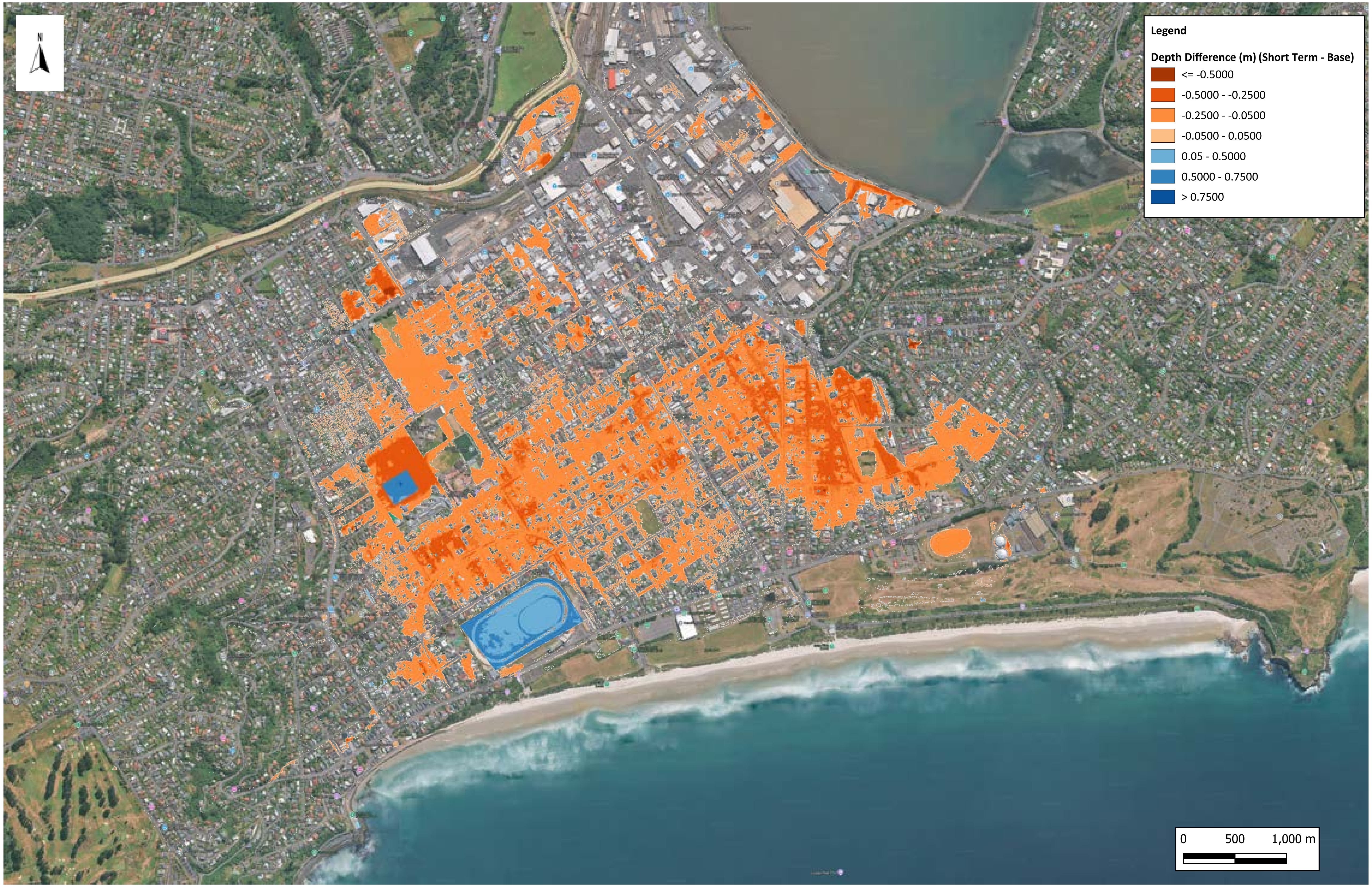

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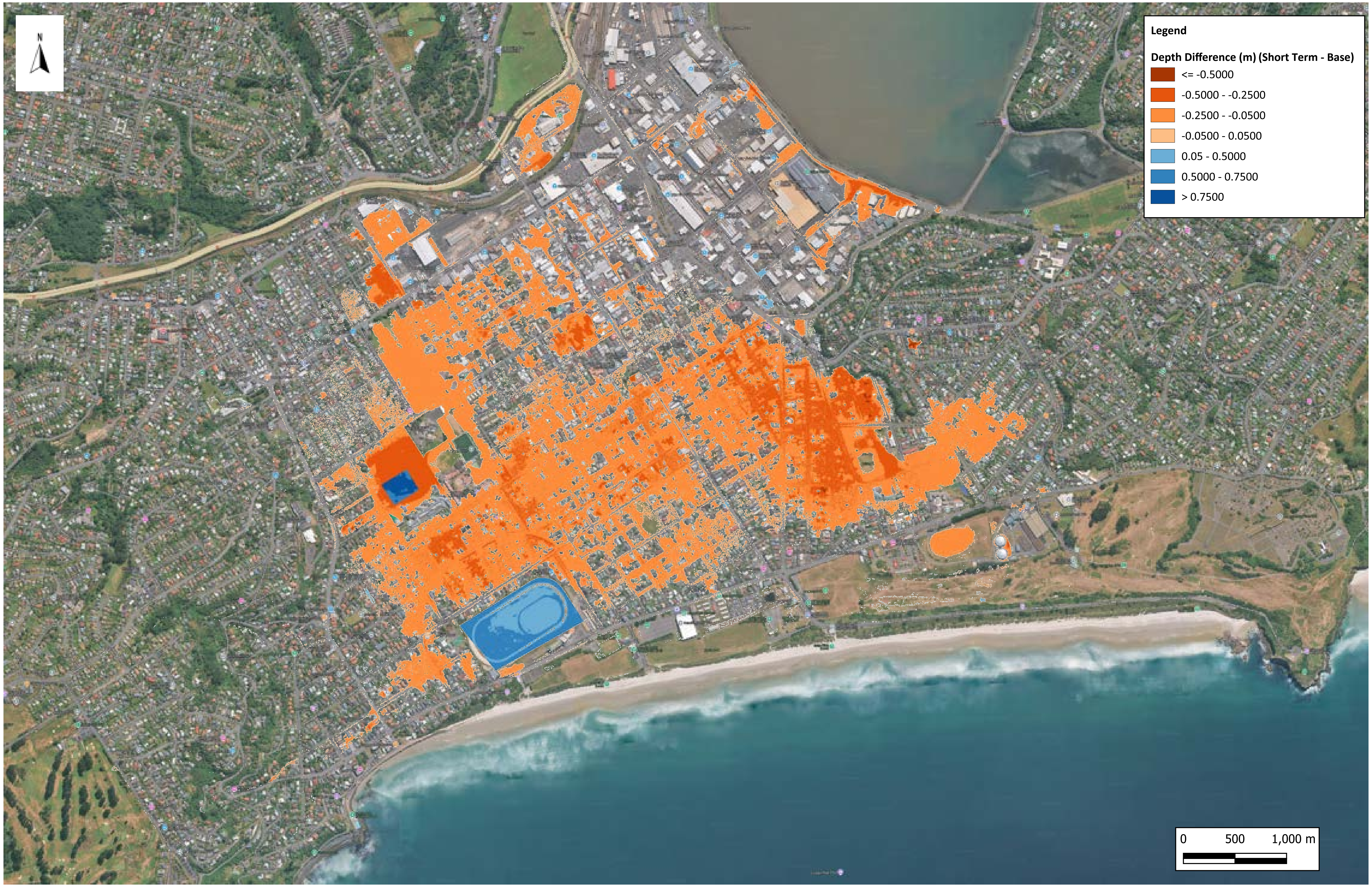

Beca, South Dunedin Future, Otago Regional Council, WSP, Tonkin+Taylor; DUNEDIN CITY COUNCIL kaunihera a-rohe o Ōtepoti	South Dunedin - Short Term Flood Depth Difference Map Between Short Term & Base (1 in 100 Year Design Storm)	DRAWN BY: Anvesh Ravula DATE: 2026-05-13 CHECK BY: Kit Pascoe DATE: 2026-05-13
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MAP NO: 4700990 - J1
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South Dunedin - Option 3 Medium Term
Maximum Flood Depth Map
(1 in 10 Year RCP 8.5 2060 MHWS + 0.5 m SLR)

DRAWN BY:	Anvesh Ravula
DATE:	2025-11-27
CHECK BY:	Kit Pascoe
DATE:	2025-11-27

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MAP NO: 4700990 - J3

REV: A

South Dunedin - Option 3 Medium Term
Maximum Flood Depth Map
(1 in 100 Year RCP 8.5 2060 MHWS + 0.5 m SLR)

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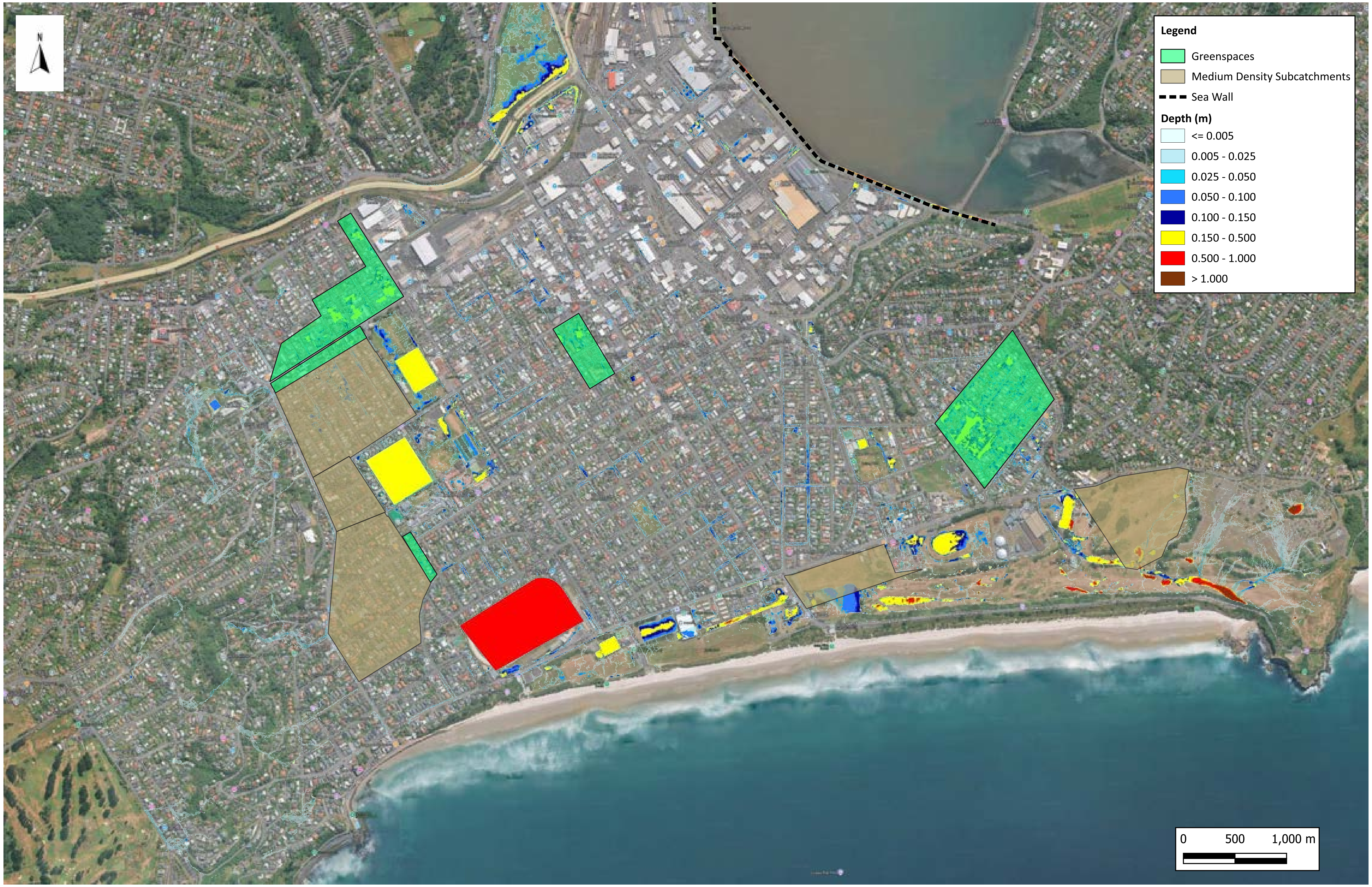

MAP NO: 4700990 - J4 REV: A	South Dunedin - Option 3 Long Term Maximum Flood Depth Map (1 in 10 Year RCP 8.5 2100 MHWS + 1.1 m SLR)	DRAWN BY: Anvesh Ravula DATE: 2025-11-27 CHECK BY: Kit Pascoe DATE: 2025-11-27

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Beca | South Dunedin Future | Otago Regional Council | WSP | Tonkin+Taylor

DUNEDIN CITY COUNCIL | kaunihera a-rohe o Ōtepoti

MAP NO: 4700990 - J5

REV: A

South Dunedin - Option 3 Long Term
Maximum Flood Depth Map
(1 in 50 Year RCP 8.5 2100 MHWS + 1.1 m SLR)

DRAWN BY:	Anvesh Ravula
DATE:	2025-11-27
CHECK BY:	Kit Pascoe
DATE:	2025-11-27

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South Dunedin - Option 3 Long Term
Maximum Flood Depth Map
(1 in 100 Year RCP 8.5 2100 MHWS + 1.1 m SLR)

MAP NO:	4700990 - J6
REV:	A
DRAWN BY:	Anvesh Ravula
DATE:	2025-11-27
CHECK BY:	Kit Pascoe
DATE:	2025-11-27

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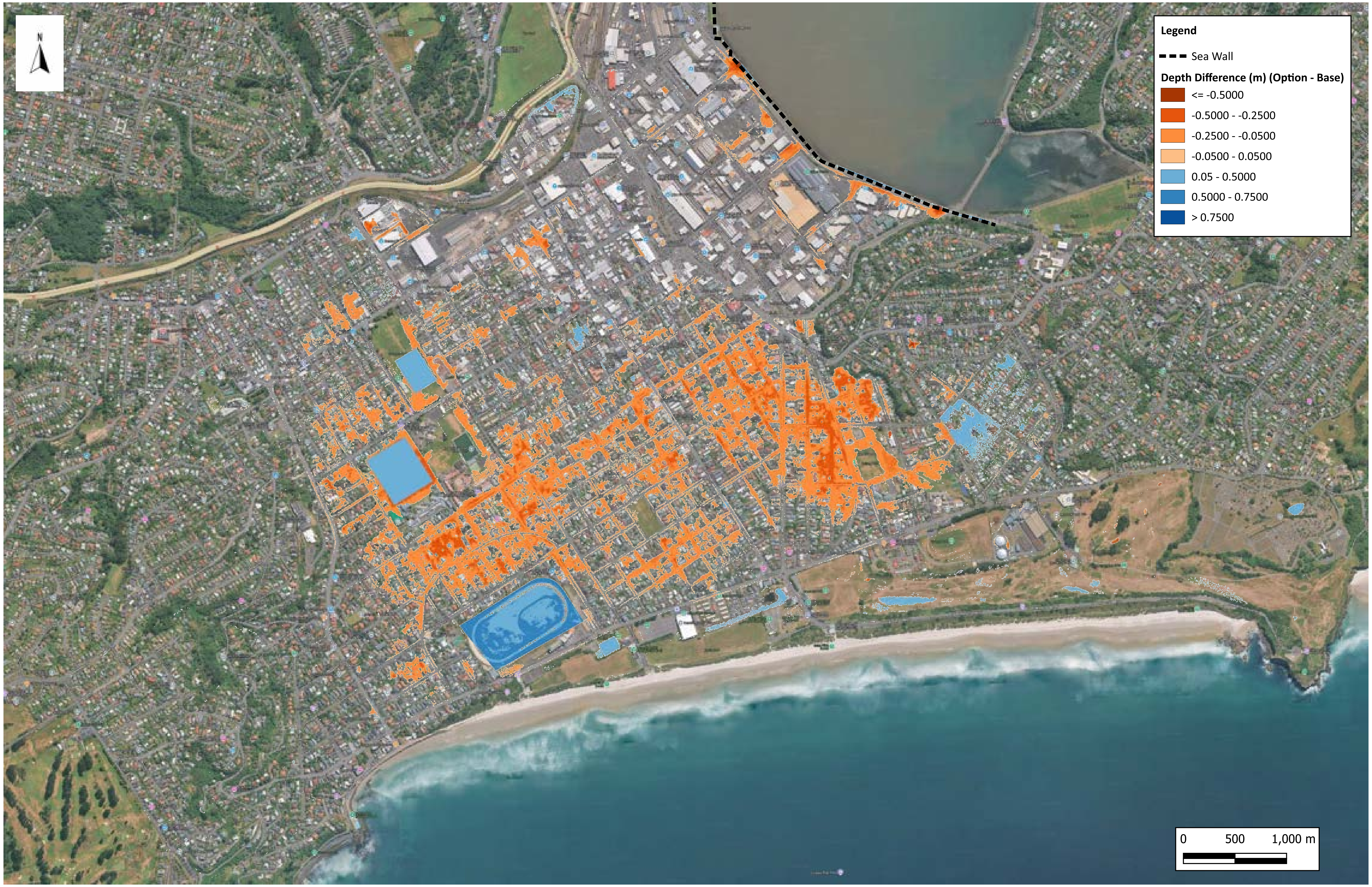
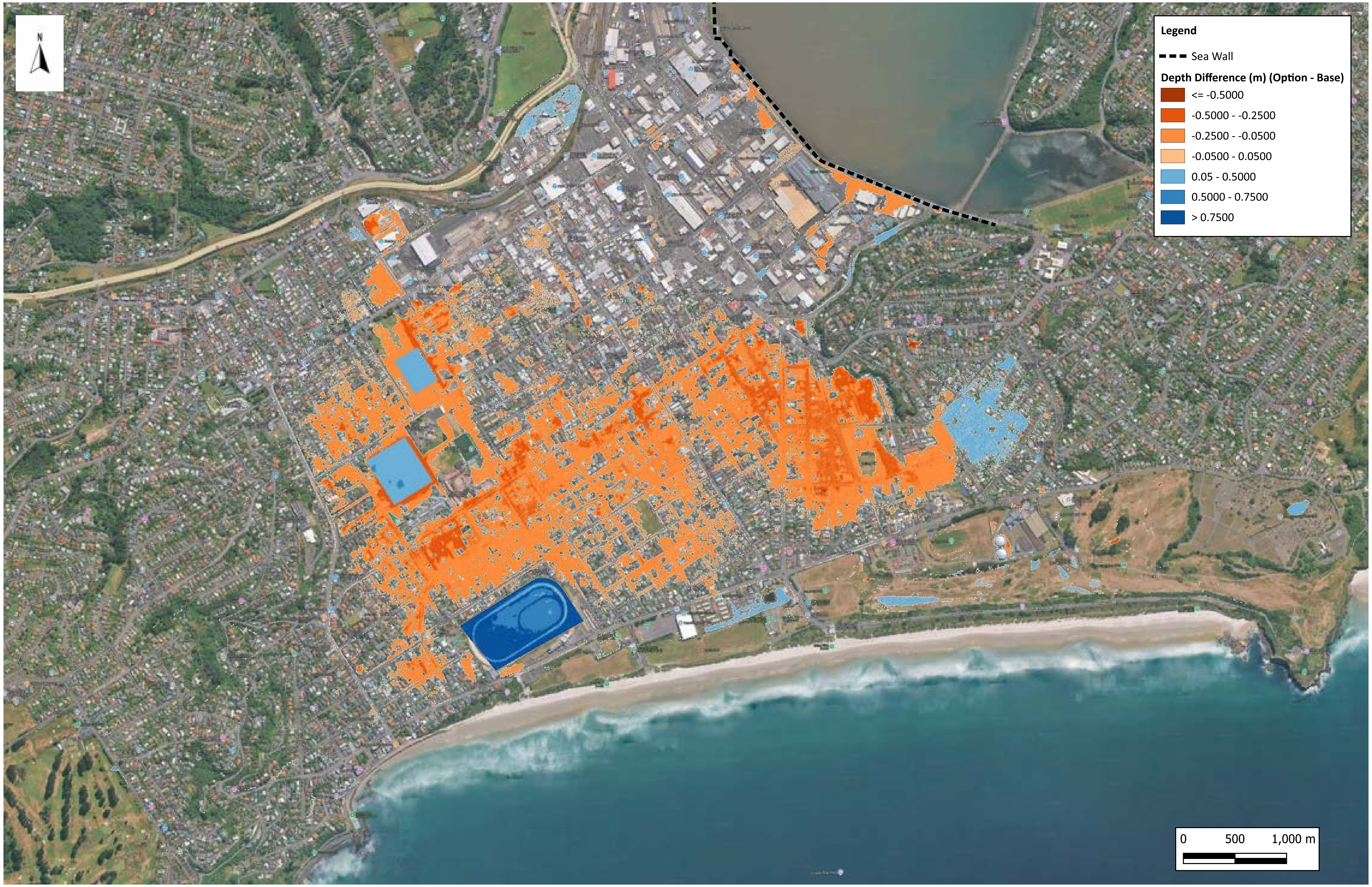
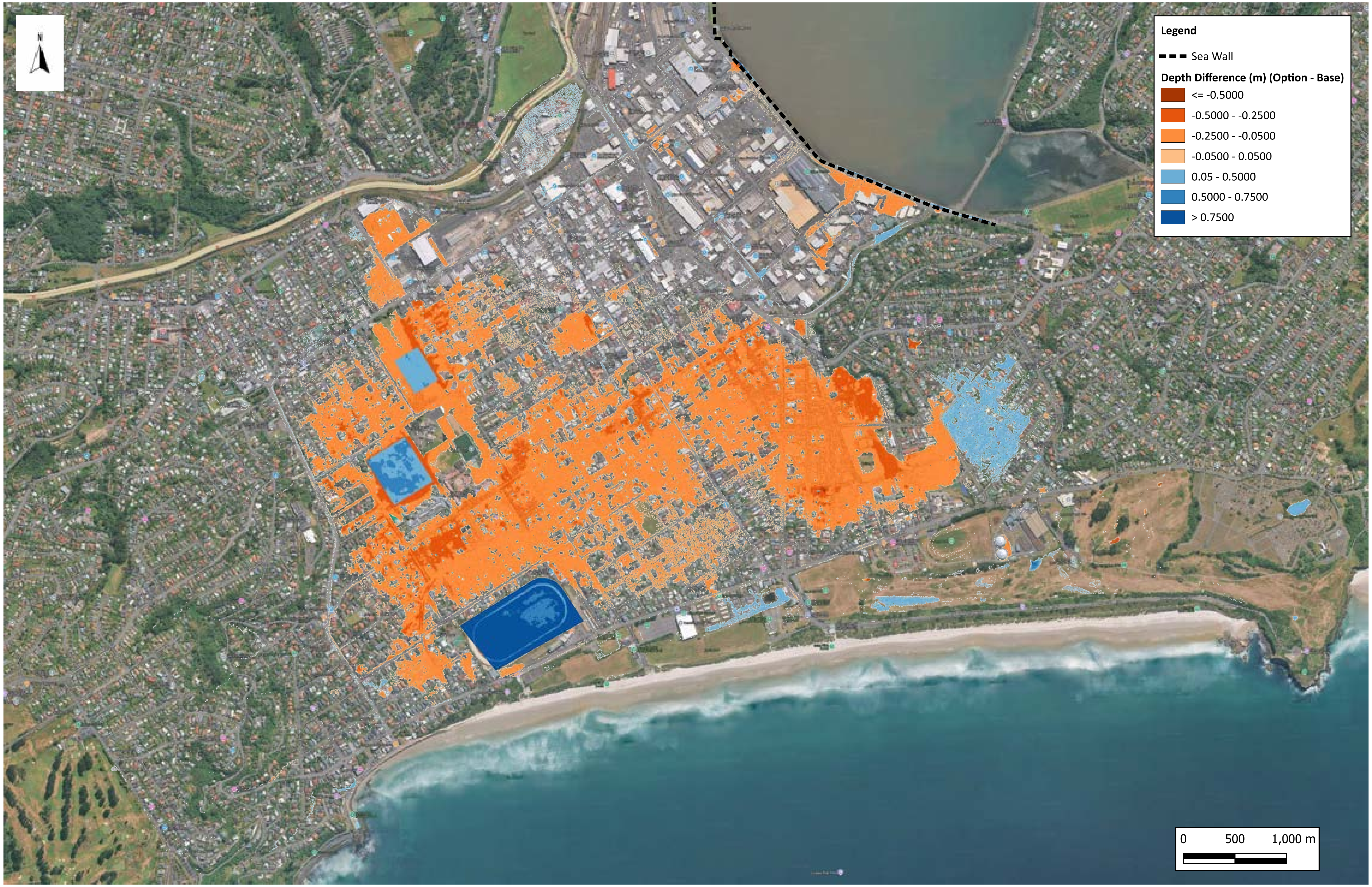


Beca, South Dunedin Future, Otago Regional Council, WSP, Tonkin+Taylor; DUNEDIN CITY COUNCIL kaunihera a-rohe o Ōtepoti	South Dunedin - Option 3 Flood Depth Difference Map Between Option 3 & Base (1 in 10 Year Design Storm)	DRAWN BY: Anvesh Ravula DATE: 2025-11-27 CHECK BY: Kit Pascoe DATE: 2025-11-27
MAP NO: 4700990 - K1 REV: A		Disclaimer: This map contains data derived in part or wholly from sources other than Beca. No representations or warranties are made by Beca as to the accuracy or completeness of this information. The map is intended for distribution as a PDF document. The scale may be incorrect when printed.



Beca, South Dunedin Future, Otago Regional Council, WSP, Tonkin+Taylor; DUNEDIN CITY COUNCIL kaunihera a-rohe o Ōtepoti		South Dunedin - Option 3 Flood Depth Difference Map Between Option 3 & Base (1 in 50 Year Design Storm)	DRAWN BY: Anvesh Ravula DATE: 2025-11-27 CHECK BY: Kit Pascoe DATE: 2025-11-27 Disclaimer: This map contains data derived in part or wholly from sources other than Beca. No representations or warranties are made by Beca as to the accuracy or completeness of this information. The map is intended for distribution as a PDF document. The scale may be incorrect when printed.
MAP NO: 4700990 - K2	REV: A		



Beca, South Dunedin Future, Otago Regional Council, WSP, Tonkin+Taylor; DUNEDIN CITY COUNCIL kaunihera a-rohe o Ōtepoti	South Dunedin - Option 3 Flood Depth Difference Map Between Option 3 & Base (1 in 100 Year Design Storm)	DRAWN BY: Anvesh Ravula DATE: 2025-11-27 CHECK BY: Kit Pascoe DATE: 2025-11-27
MAP NO: 4700990 - K3 — REV: A		Disclaimer: This map contains data derived in part or wholly from sources other than Beca. No representations or warranties are made by Beca as to the accuracy or completeness of this information. The map is intended for distribution as a PDF document. The scale may be incorrect when printed.

Beca, South Dunedin Future, Otago Regional Council, WSP, Tonkin+Taylor, DUNEDIN CITY COUNCIL kaunihera a-rohe o Ōtepoti	South Dunedin - Option 4 Medium Term Maximum Flood Depth Map (1 in 10 Year RCP 8.5 2060 MHWS + 0.5 m SLR)	DRAWN BY: Anvesh Ravula DATE: 2025-11-27 CHECK BY: Kit Pascoe DATE: 2025-11-27
MAP NO: 4700990 - L1 REV: A		Disclaimer: This map contains data derived in part or wholly from sources other than Beca. No representations or warranties are made by Beca as to the accuracy or completeness of this information. The map is intended for distribution as a PDF document. The scale may be incorrect when printed.

Beca, South Dunedin Future, Otago Regional Council, WSP, Tonkin+Taylor; DUNEDIN CITY COUNCIL kaunihera a-rohe o Ōtepoti	South Dunedin - Option 4 Medium Term Maximum Flood Depth Map (1 in 50 Year RCP 8.5 2060 MHWS + 0.5 m SLR)	DRAWN BY: Anvesh Ravula DATE: 2025-11-27 CHECK BY: Kit Pascoe DATE: 2025-11-27
MAP NO: 4700990 - L2 REV: A		Disclaimer: This map contains data derived in part or wholly from sources other than Beca. No representations or warranties are made by Beca as to the accuracy or completeness of this information. The map is intended for distribution as a PDF document. The scale may be incorrect when printed.

MAP NO: 4700990 - L3	REV: A	South Dunedin - Option 4 Medium Term Maximum Flood Depth Map (1 in 100 Year RCP 8.5 2060 MHWS + 0.5 m SLR)

DRAWN BY:	Anvesh Ravula
DATE:	2025-11-27
CHECK BY:	Kit Pascoe
DATE:	2025-11-27

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Beca / South Dunedin Future / Otago Regional Council / WSP / Tonkin+Taylor DUNEDIN CITY COUNCIL kaunihera a-rohe o Ōtepoti MAP NO: 4700990 - L4 REV: B	South Dunedin - Option 4 Long Term Maximum Flood Depth Map (1 in 10 Year RCP 8.5 2100 MHWS + 1.1 m SLR)	DRAWN BY: Anvesh Ravula DATE: 2026-05-13 CHECK BY: Kit Pascoe DATE: 2026-05-13 Disclaimer: This map contains data derived in part or wholly from sources other than Beca. No representations or warranties are made by Beca as to the accuracy or completeness of this information. The map is intended for distribution as a PDF document. The scale may be incorrect when printed.

MAP NO: 4700990 - L5	REV: B

South Dunedin - Option 4 Long Term
Maximum Flood Depth Map
(1 in 50 Year RCP 8.5 2100 MHWS + 1.1 m SLR)

DRAWN BY:	Anvesh Ravula
DATE:	2026-05-13
CHECK BY:	Kit Pascoe
DATE:	2026-05-13

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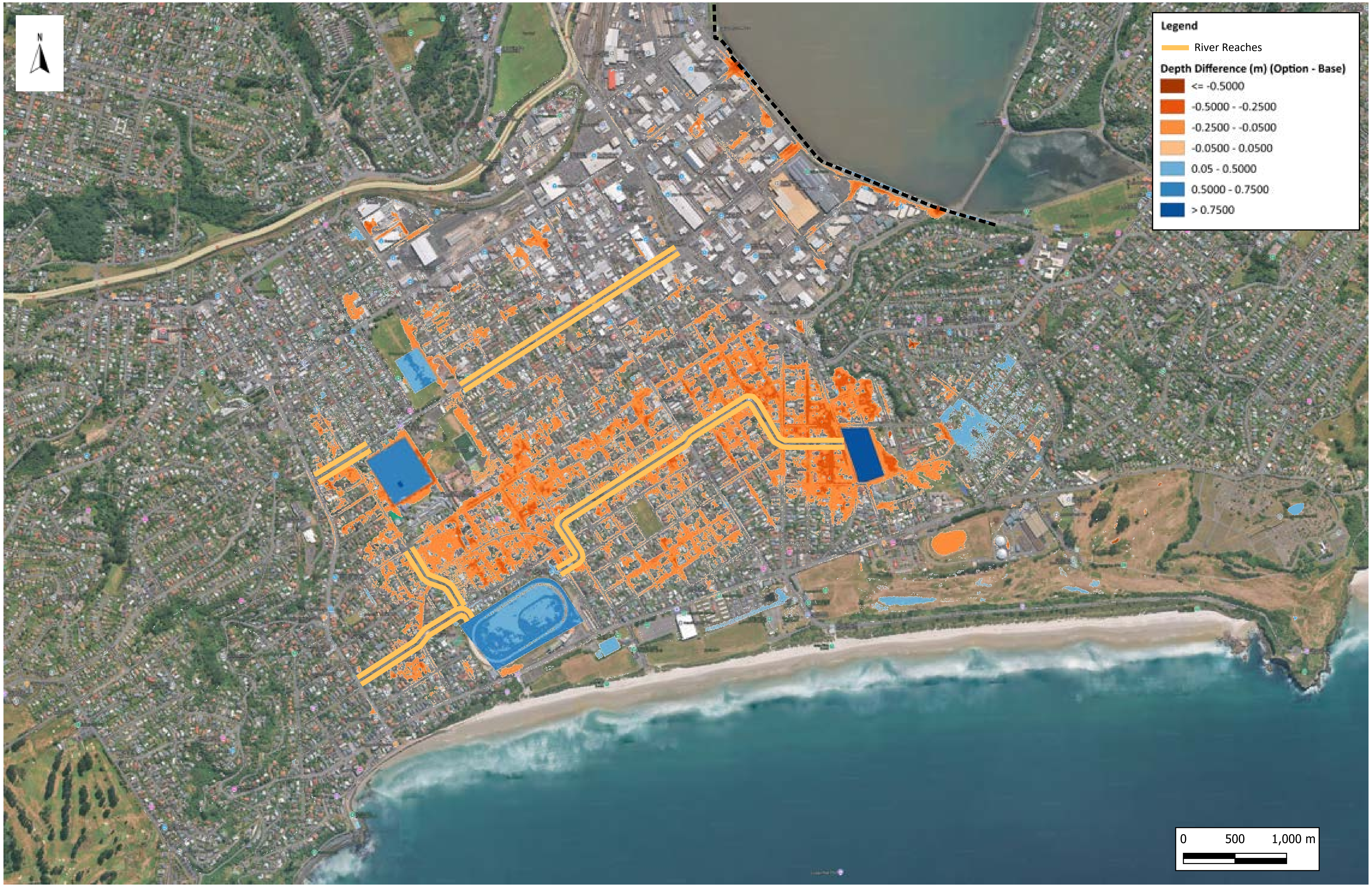
Beca, South Dunedin Future, Otago Regional Council, WSP, Tonkin+Taylor DUNEDIN CITY COUNCIL kaunihera a-rohe o Ōtepoti MAP NO: 4700990 - L6 REV: B	South Dunedin - Option 4 Long Term Maximum Flood Depth Map (1 in 100 Year RCP 8.5 2100 MHWS + 1.1 m SLR)	DRAWN BY: Anvesh Ravula DATE: 2026-05-13 CHECK BY: Kit Pascoe DATE: 2026-05-13 Disclaimer: This map contains data derived in part or wholly from sources other than Beca. No representations or warranties are made by Beca as to the accuracy or completeness of this information. The map is intended for distribution as a PDF document. The scale may be incorrect when printed.



Beca | South Dunedin Future | Otago Regional Council | WSP | Tonkin+Taylor

DUNEDIN CITY COUNCIL | kaunihera a-rohe o Ōtepoti

MAP NO: 4700990 - M1

REV: B

South Dunedin - Option 4
Flood Depth Difference Map Between Option 4 & Base
(1 in 10 Year Design Storm)

DRAWN BY:	Anvesh Ravula
DATE:	2026-05-13
CHECK BY:	Kit Pascoe
DATE:	2026-05-13

Disclaimer:
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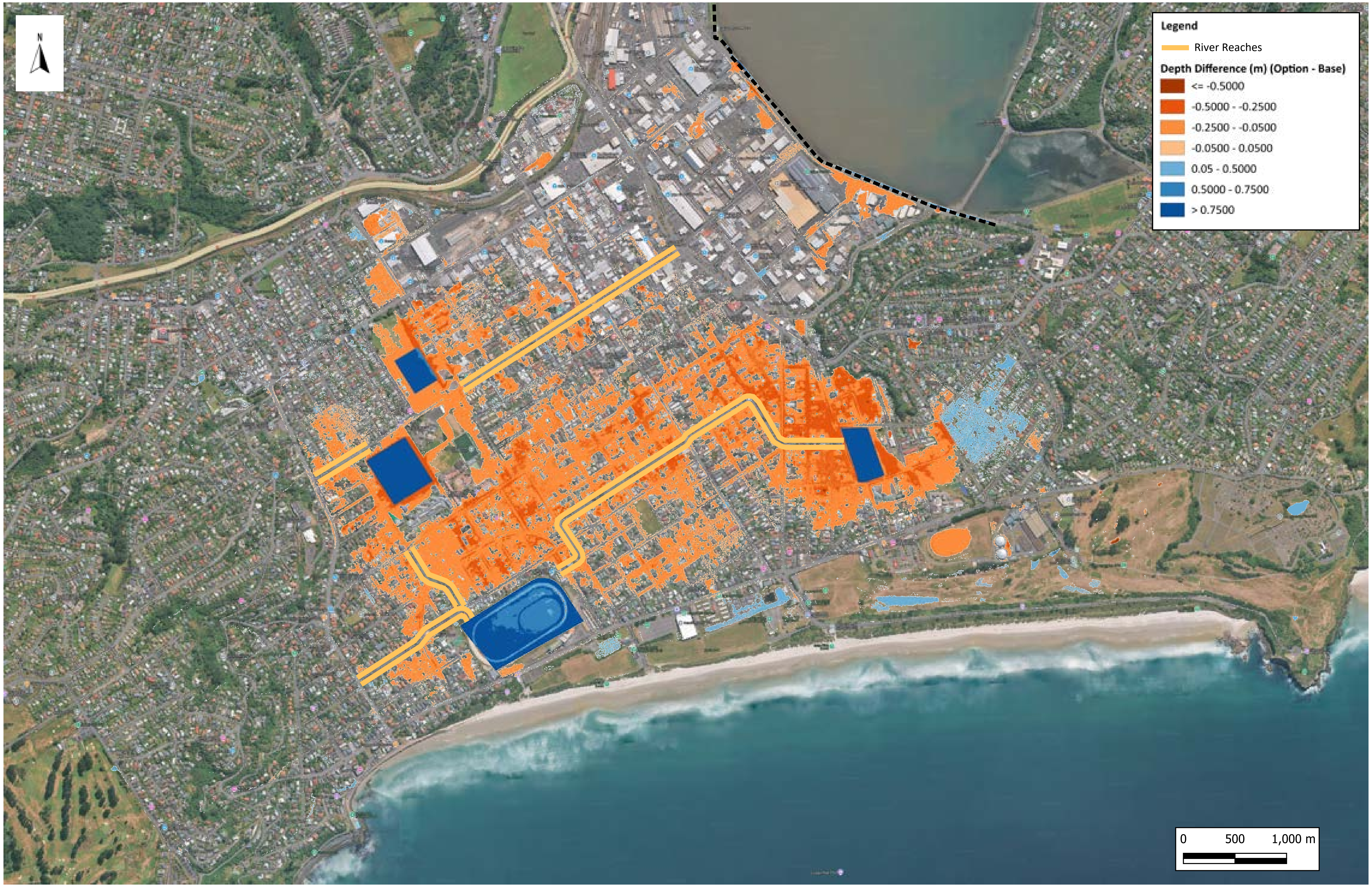
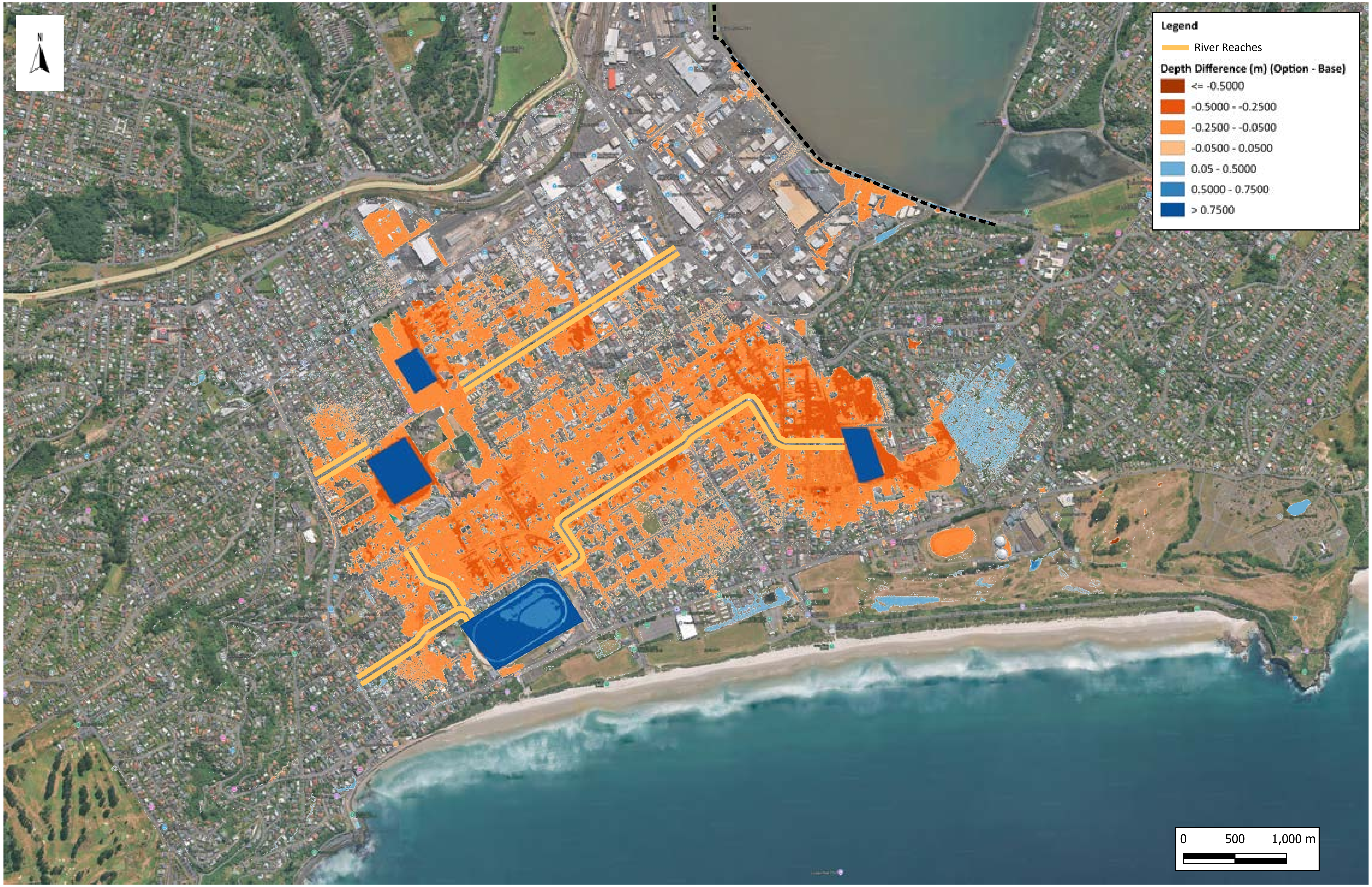


Beca, South Dunedin Future, Otago Regional Council, WSP, Tonkin+Taylor DUNEDIN CITY COUNCIL | kaunihera a-rohe o Ōtepoti MAP NO: 4700990 - M2 REV: B	South Dunedin - Option 4 Flood Depth Difference Map Between Option 4 & Base (1 in 50 Year Design Storm)	DRAWN BY: Anvesh Ravula DATE: 2026-05-13 CHECK BY: Kit Pascoe DATE: 2026-05-13 Disclaimer: This map contains data derived in part or wholly from sources other than Beca. No representations or warranties are made by Beca as to the accuracy or completeness of this information. The map is intended for distribution as a PDF document. The scale may be incorrect when printed.



Beca, South Dunedin Future, Otago Regional Council, WSP, Tonkin+Taylor DUNEDIN CITY COUNCIL kaunihera a-rohe o Ōtepoti MAP NO: **4700990 - M3** REV: B	South Dunedin - Option 4 Flood Depth Difference Map Between Option 4 & Base (1 in 100 Year Design Storm)	DRAWN BY: Anvesh Ravula DATE: 2026-05-13 CHECK BY: Kit Pascoe DATE: 2026-05-13 Disclaimer: This map contains data derived in part or wholly from sources other than Beca. No representations or warranties are made by Beca as to the accuracy or completeness of this information. The map is intended for distribution as a PDF document. The scale may be incorrect when printed.

MAP NO: 4700990 - N1	REV: B	South Dunedin - Option 5 Medium Term Maximum Flood Depth Map (1 in 10 Year RCP 8.5 2060 MHWS + 0.5 m SLR)

DRAWN BY:	Anvesh Ravula
DATE:	2026-05-13
CHECK BY:	Kit Pascoe
DATE:	2026-05-13

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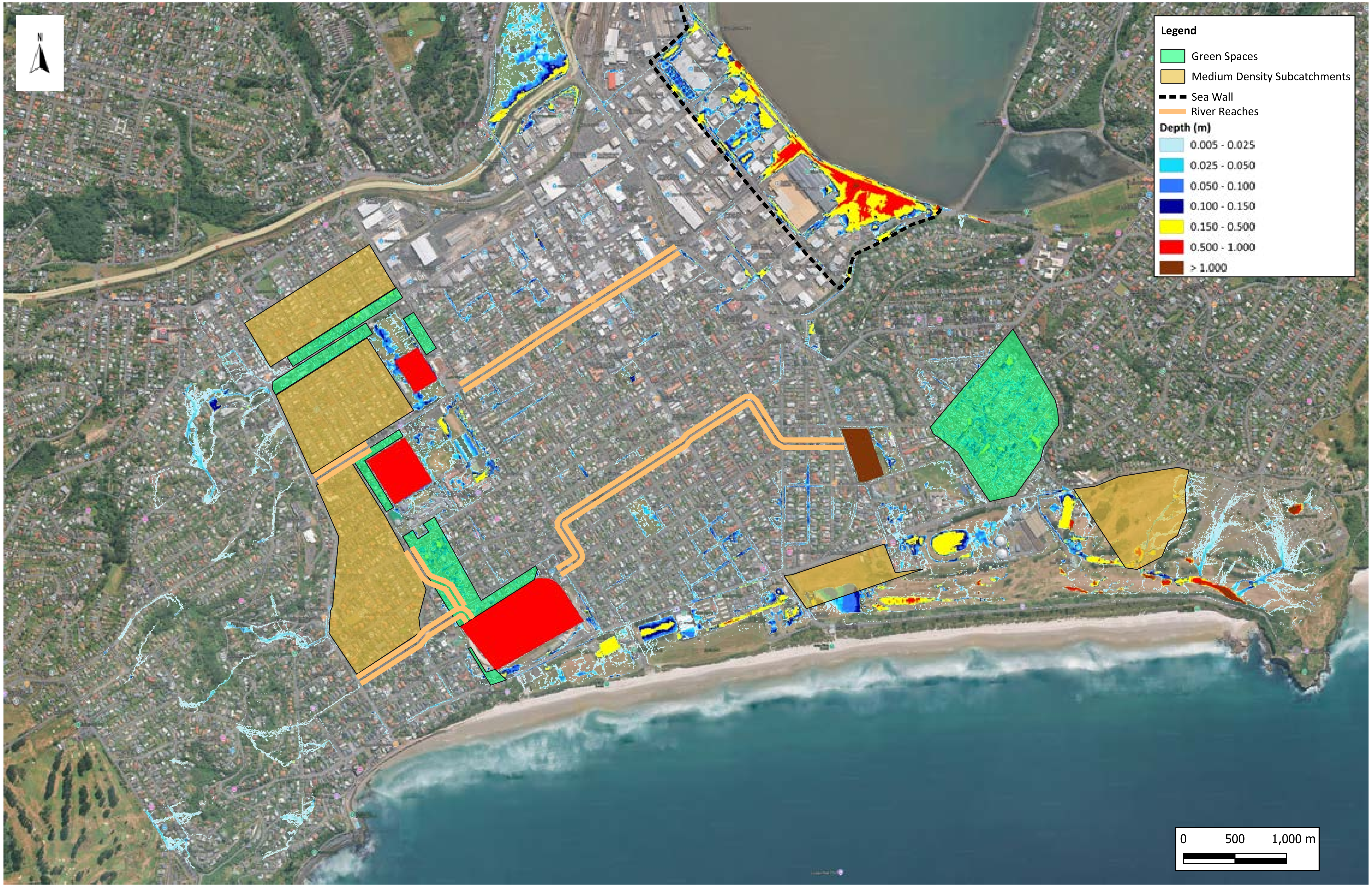
MAP NO: 4700990 - N2	REV: B	South Dunedin - Option 5 Medium Term Maximum Flood Depth Map (1 in 50 Year RCP 8.5 2060 MHWS + 0.5 m SLR)

DRAWN BY: Anvesh Ravula
DATE: 2026-05-13
CHECK BY: Kit Pascoe
DATE: 2026-05-13

DUNEDIN CITY COUNCIL kaunihera a-rohe o Ōtepoti	South Dunedin - Option 5 Medium Term Maximum Flood Depth Map (1 in 100 Year RCP 8.5 2060 MHWS + 0.5 m SLR)	DRAWN BY: Anvesh Ravula DATE: 2026-05-13 CHECK BY: Kit Pascoe DATE: 2026-05-13
MAP NO: 4700990 - N3 REV: B		Disclaimer: This map contains data derived in part or wholly from sources other than Beca. No representations or warranties are made by Beca as to the accuracy or completeness of this information. The map is intended for distribution as a PDF document. The scale may be incorrect when printed.



Beca | South Dunedin Future | Otago Regional Council | WSP | Tonkin+Taylor
DUNEDIN CITY COUNCIL | kaunihera a-rohe o Ōtepoti

MAP NO: 4700990 - N4
REV: B

South Dunedin - Option 5 Long Term
Maximum Flood Depth Map
(1 in 10 Year RCP 8.5 2100 MHWS + 1.1 m SLR)

DRAWN BY:	Anvesh Ravula
DATE:	2026-05-13
CHECK BY:	Kit Pascoe
DATE:	2026-05-13

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South Dunedin - Option 5 Long Term
Maximum Flood Depth Map
(1 in 50 Year RCP 8.5 2100 MHWS + 1.1 m SLR)

MAP NO:	4700990 - N5
REV:	B
DRAWN BY:	Anvesh Ravula
DATE:	2026-05-13
CHECK BY:	Kit Pascoe
DATE:	2026-05-13

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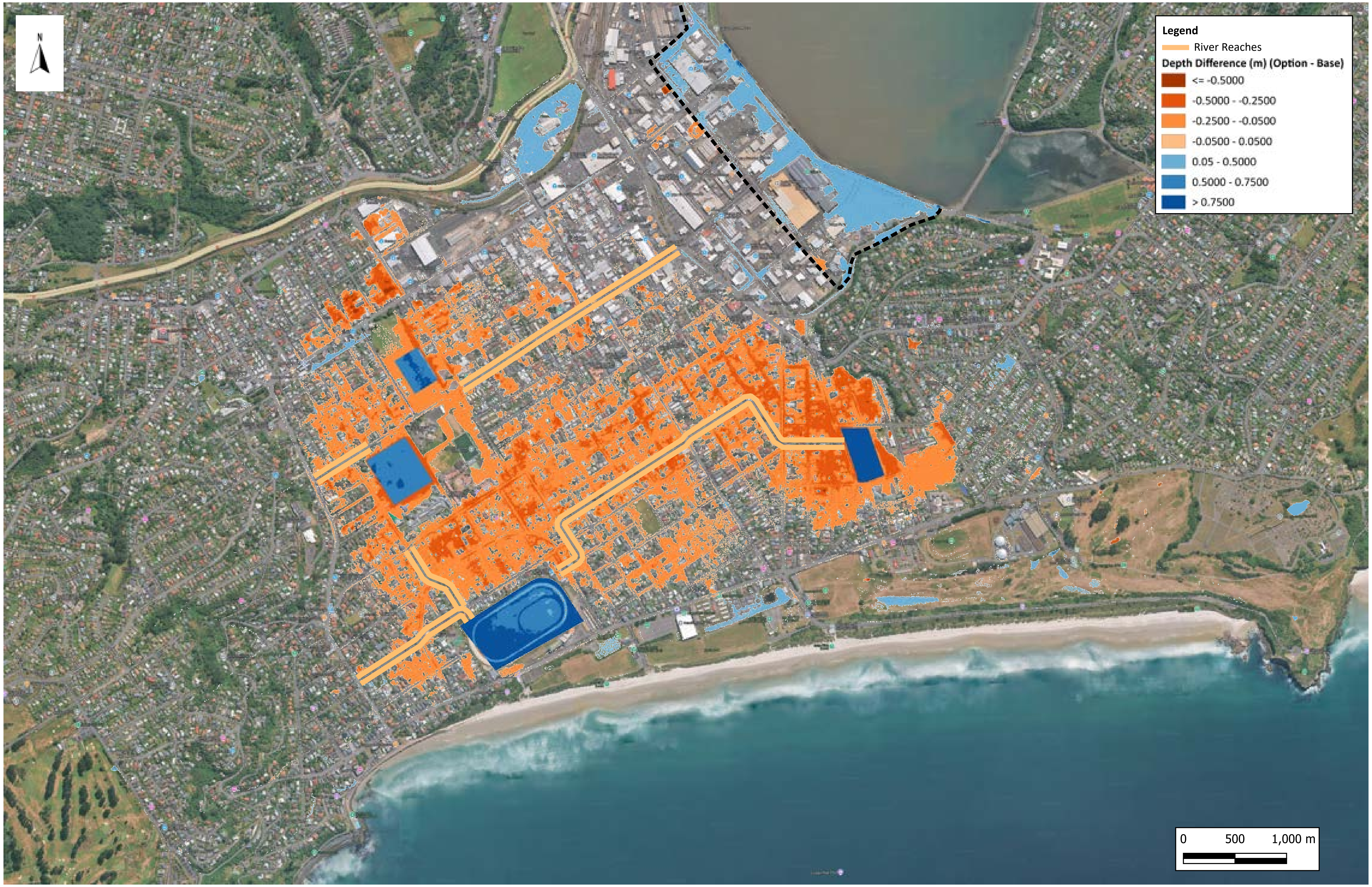
Beca, South Dunedin Future, Otago Regional Council, WSP, Tonkin+Taylor; DUNEDIN CITY COUNCIL kaunihera a-rohe o Ōtepoti	South Dunedin - Option 5 Long Term Maximum Flood Depth Map (1 in 100 Year RCP 8.5 2100 MHWS + 1.1 m SLR)	DRAWN BY: Anvesh Ravula DATE: 2026-05-13 CHECK BY: Kit Pascoe DATE: 2026-05-13
MAP NO: 4700990 - N6 REV: B		Disclaimer: This map contains data derived in part or wholly from sources other than Beca. No representations or warranties are made by Beca as to the accuracy or completeness of this information. The map is intended for distribution as a PDF document. The scale may be incorrect when printed.

Beca / South Dunedin Future / Otago Regional Council / WSP / Tonkin+Taylor DUNEDIN CITY COUNCIL | kaunihera a-rohe o Ōtepoti	South Dunedin - Option 5 Flood Depth Difference Map Between Option 5 & Base (1 in 10 Year Design Storm)	DRAWN BY: Anvesh Ravula DATE: 2026-05-13 CHECK BY: Kit Pascoe DATE: 2026-05-13
MAP NO: 4700990 - O1 | REV: B		Disclaimer: This map contains data derived in part or wholly from sources other than Beca. No representations or warranties are made by Beca as to the accuracy or completeness of this information. The map is intended for distribution as a PDF document. The scale may be incorrect when printed.



DUNEDIN CITY COUNCIL | kaunihera a-rohe o Ōtepoti

MAP NO: 4700990 - O2

REV: B

South Dunedin - Option 5
Flood Depth Difference Map Between Option 5 & Base
(1 in 50 Year Design Storm)

DRAWN BY:	Anvesh Ravula
DATE:	2026-05-13
CHECK BY:	Kit Pascoe
DATE:	2026-05-13

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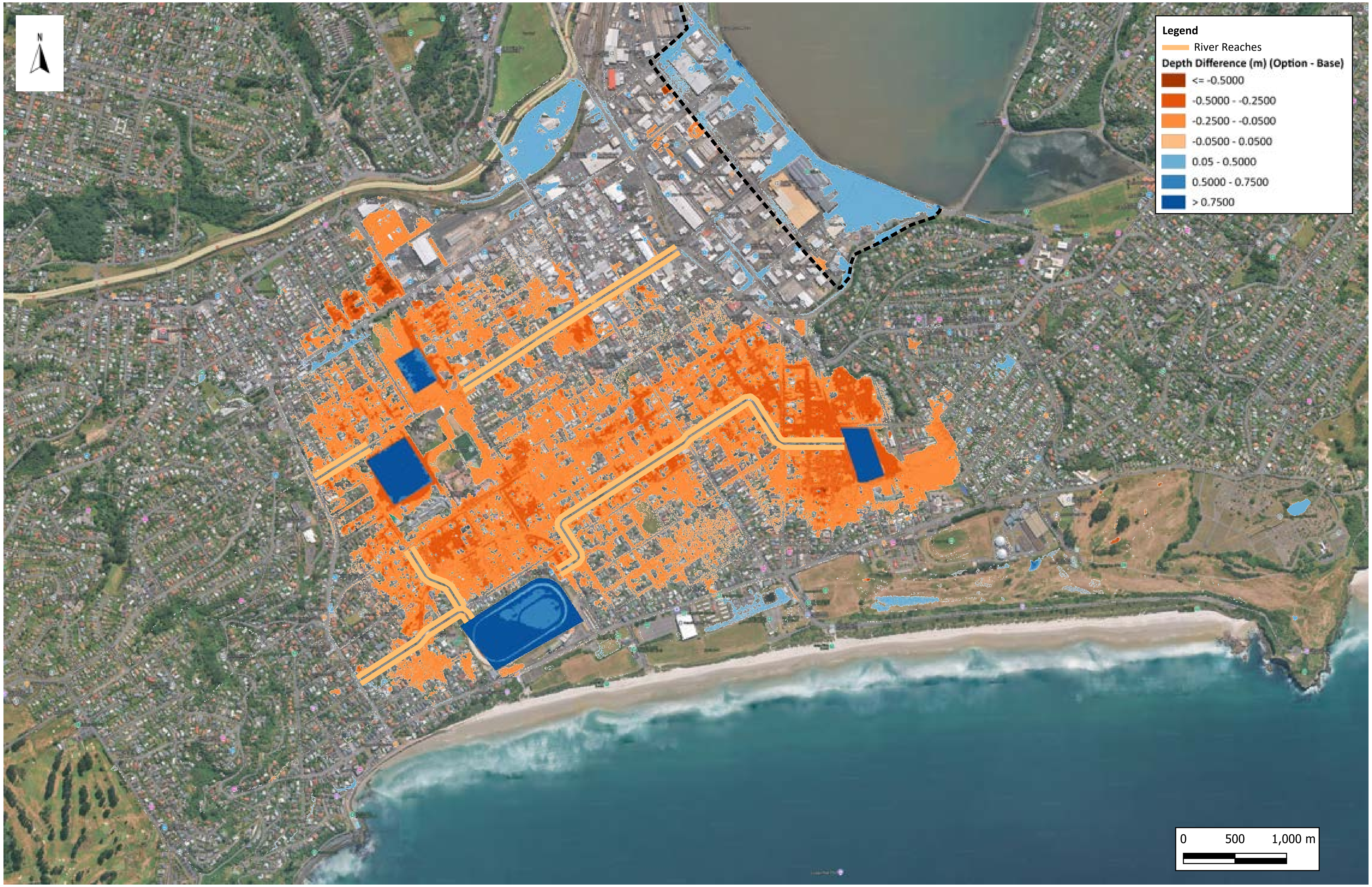

Beca, South Dunedin Future, Otago Regional Council, WSP, Tonkin+Taylor; DUNEDIN CITY COUNCIL kaunihera a-rohe o Ōtepoti		South Dunedin - Option 5 Flood Depth Difference Map Between Option 5 & Base (1 in 100 Year Design Storm)	DRAWN BY: Anvesh Ravula DATE: 2026-05-13 CHECK BY: Kit Pascoe DATE: 2026-05-13
MAP NO: 4700990 - O3	REV: B		Disclaimer: This map contains data derived in part or wholly from sources other than Beca. No representations or warranties are made by Beca as to the accuracy or completeness of this information. The map is intended for distribution as a PDF document. The scale may be incorrect when printed.

Beca | South Dunedin Future | Otago Regional Council | WSP | Tonkin+Taylor
DUNEDIN CITY COUNCIL | kaunihera a-rohe o Ōtepoti

South Dunedin - Option 3 Sensitivity Run 1
Flood Depth Difference Map Between Long Duration (24hr) & Critical Duration (6hr)
(1 in 10 Year RCP 8.5 2100 MHWS)

MAP NO:	4700990 - P1
REV:	A
DRAWN BY:	Anvesh Ravula
DATE:	2025-11-27
CHECK BY:	Kit Pascoe
DATE:	2025-11-27

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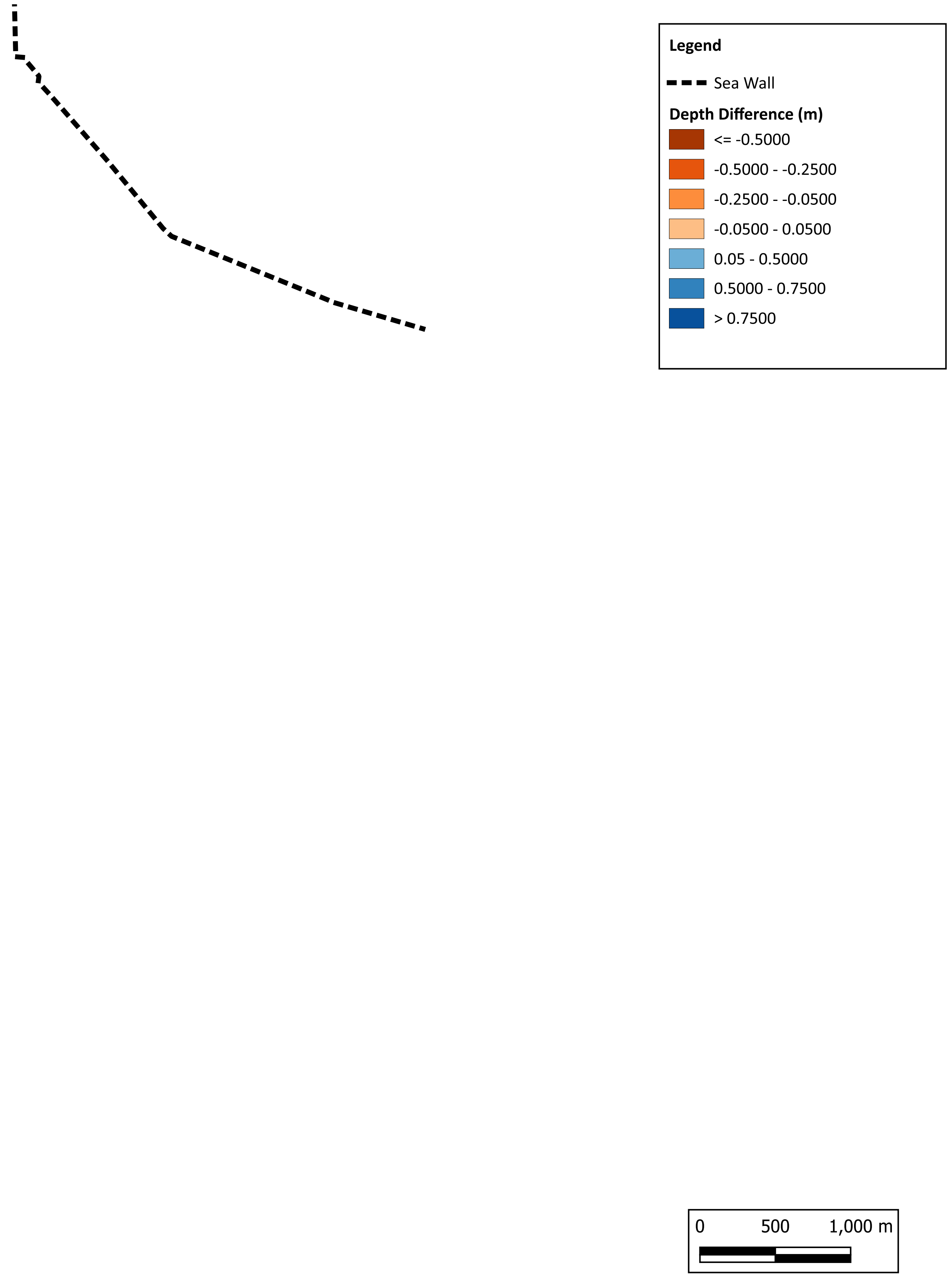
Beca / South Dunedin Future / Otago Regional Council / WSP / Tonkin+Taylor — DUNEDIN CITY COUNCIL kaunihera a-rohe o Ōtepoti	South Dunedin - Option 3 Sensitivity Run 1 Flood Depth Difference Map Between Long Duration (24hr) & Critical Duration (6hr) (1 in 50 Year RCP 8.5 2100 MHWS)	DRAWN BY: Anvesh Ravula DATE: 2025-11-27 CHECK BY: Kit Pascoe DATE: 2025-11-27
MAP NO: 4700990 - P2 — REV: A		Disclaimer: This map contains data derived in part or wholly from sources other than Beca. No representations or warranties are made by Beca as to the accuracy or completeness of this information. The map is intended for distribution as a PDF document. The scale may be incorrect when printed.



MAP NO: 4700990 - P3	REV: A	South Dunedin - Option 3 Sensitivity Run 1 Flood Depth Difference Map Between 1 in 100 Year RCP 4.5 2100 MHWS + 0.6m SLR & Critical Duration 1 in 100 Year RCP8.5 2100 MHWS + 1.1 m SLR

DRAWN BY:	Anvesh Ravula
DATE:	2025-11-26
CHECK BY:	
DATE:	2025-11-26

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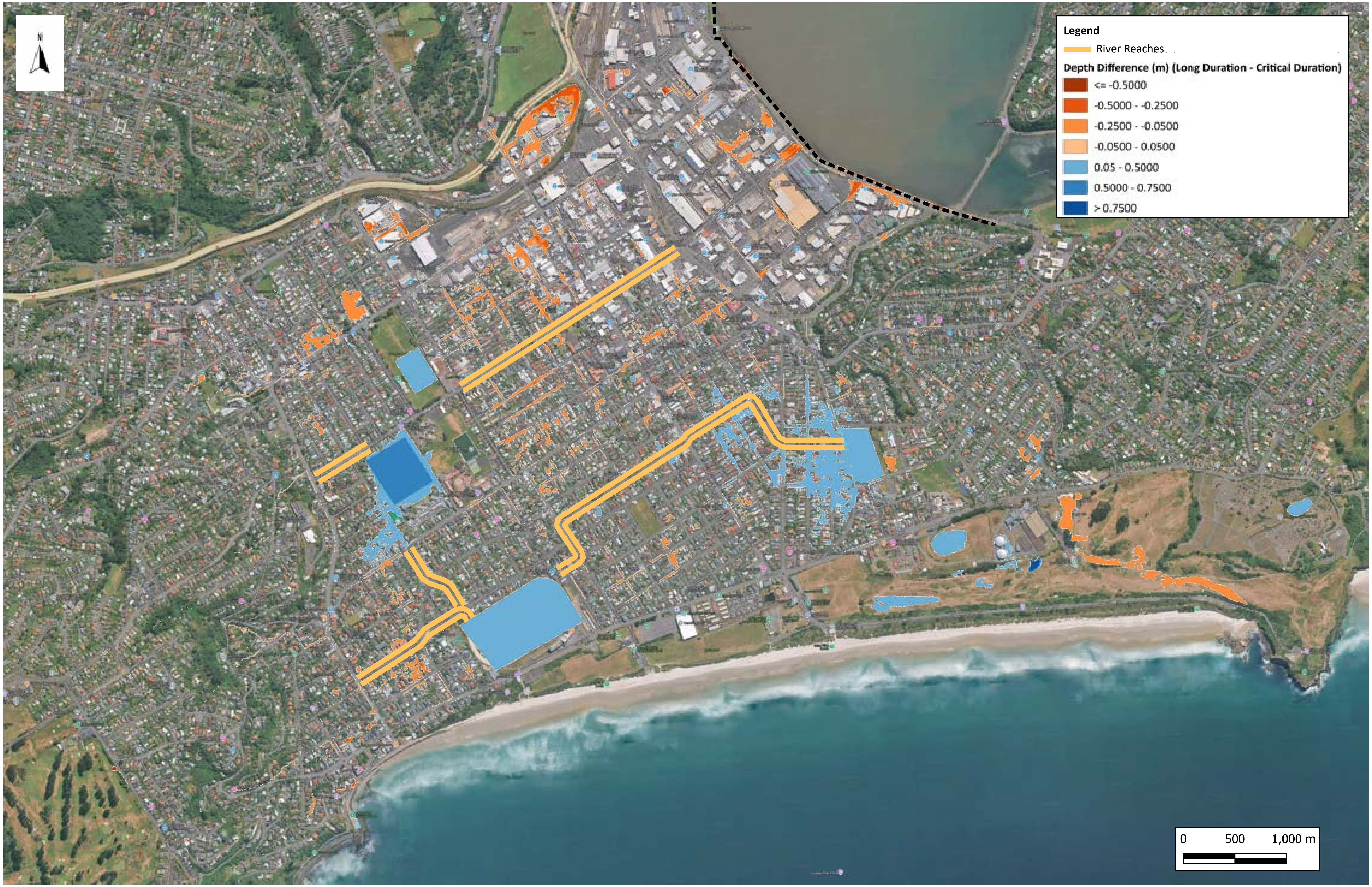
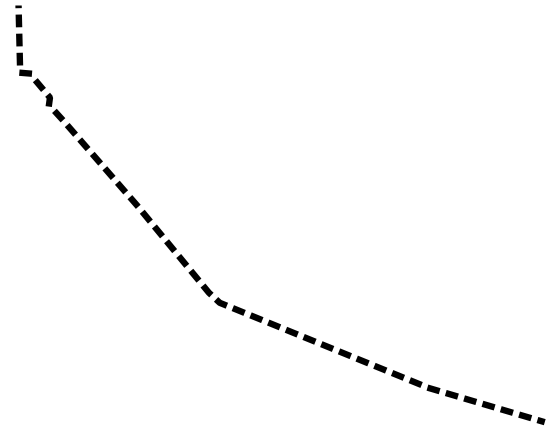
Beca · South Dunedin Future · Otago Regional Council · wsp · Tonkin+Taylor		South Dunedin - Option 4 Sensitivity Run 1 Flood Depth Difference Map Between Long Duration (24hr) & Critical Duration (6hr) (1 in 10 Year RCP 8.5 2100 MHWS)	DRAWN BY: Anvesh Ravula DATE: 2026-05-13 CHECK BY: Kit Pascoe DATE: 2026-05-13
DUNEDIN CITY COUNCIL kaunihera a-rohe o Ōtepoti			Disclaimer: This map contains data derived in part or wholly from sources other than Beca. No representations or warranties are made by Beca as to the accuracy or completeness of this information. The map is intended for distribution as a PDF document. The scale may be incorrect when printed.
MAP NO: 4700990 - Q1	REV: B		



Beca, South Dunedin Future, Otago Regional Council, WSP, Tonkin+Taylor DUNEDIN CITY COUNCIL kaunihera a-rohe o Ōtepoti MAP NO: 4700990 - Q2 REV: B	South Dunedin - Option 4 Sensitivity Run 1 Flood Depth Difference Map Between Long Duration (24hr) & Critical Duration (6hr) (1 in 50 Year RCP 8.5 2100 MHWS)	DRAWN BY: Anvesh Ravula DATE: 2026-05-13 CHECK BY: Kit Pascoe DATE: 2026-05-13 Disclaimer: This map contains data derived in part or wholly from sources other than Beca. No representations or warranties are made by Beca as to the accuracy or completeness of this information. The map is intended for distribution as a PDF document. The scale may be incorrect when printed.



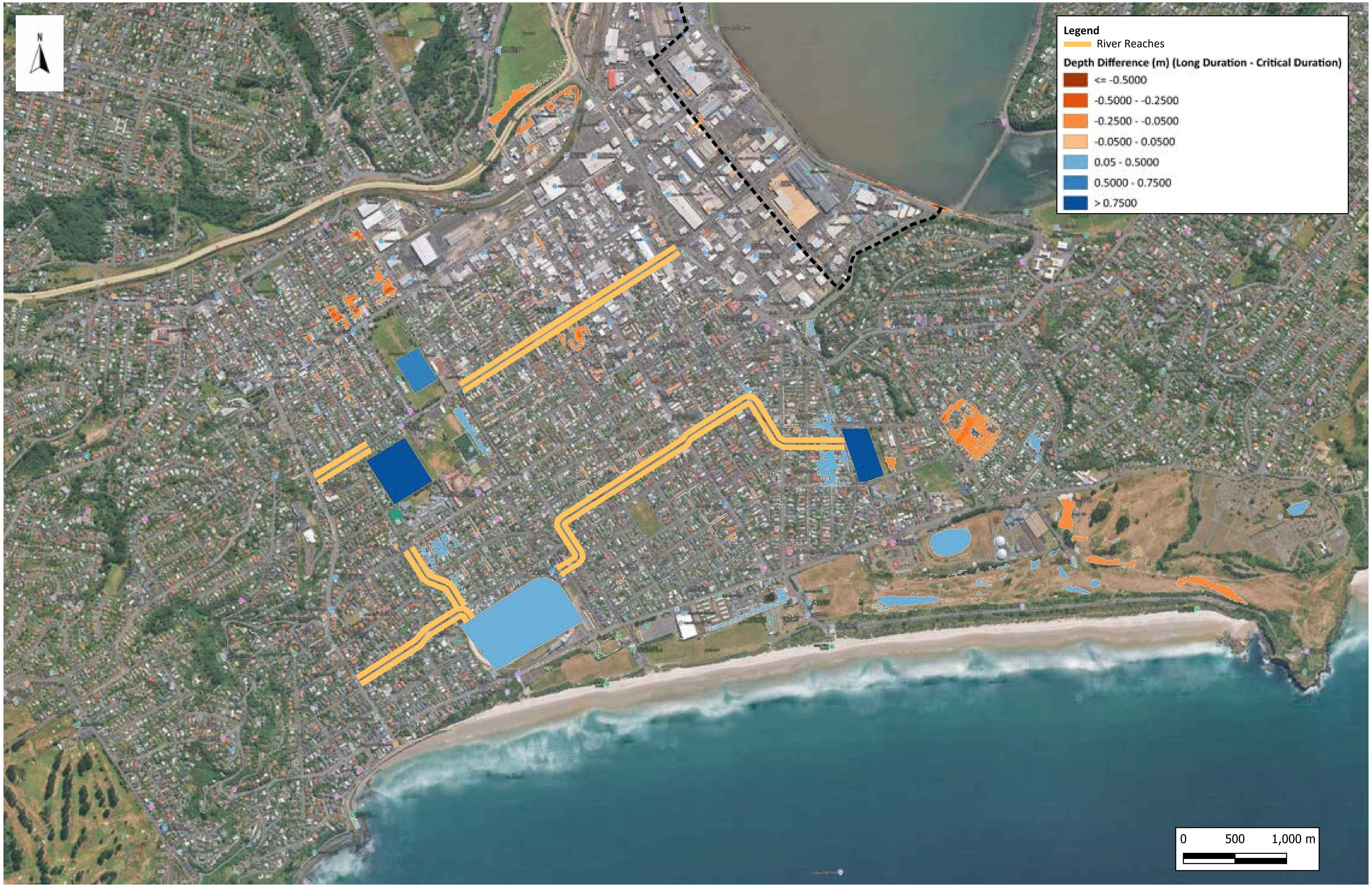
Legend

Depth difference (m)

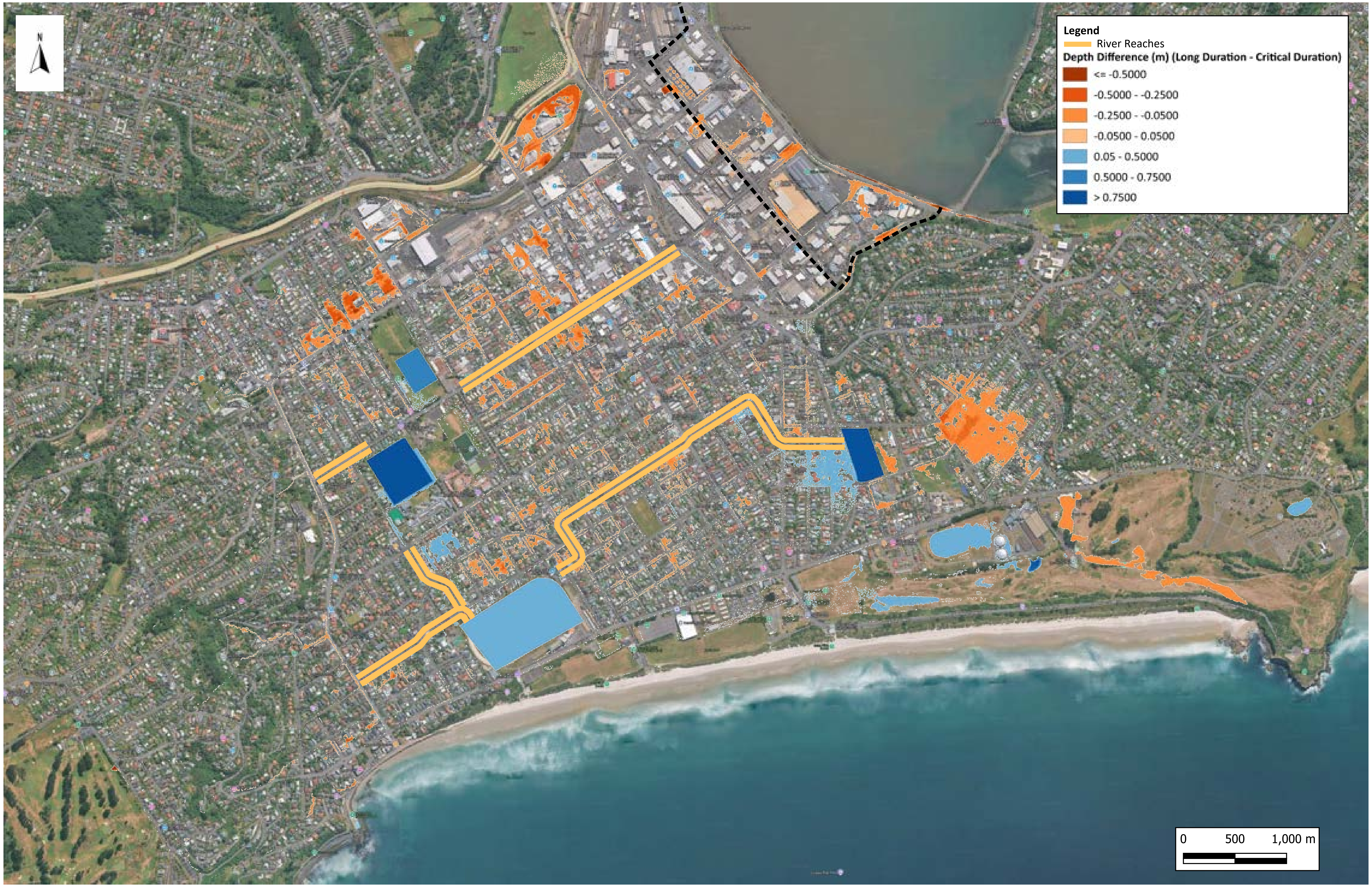
- <= -0.5000
- -0.5000 - -0.2500
- -0.2500 - -0.0500
- -0.0500 - 0.0500
- 0.05 - 0.5000
- 0.5000 - 0.7500
- > 0.7500

0 500 1,000 m

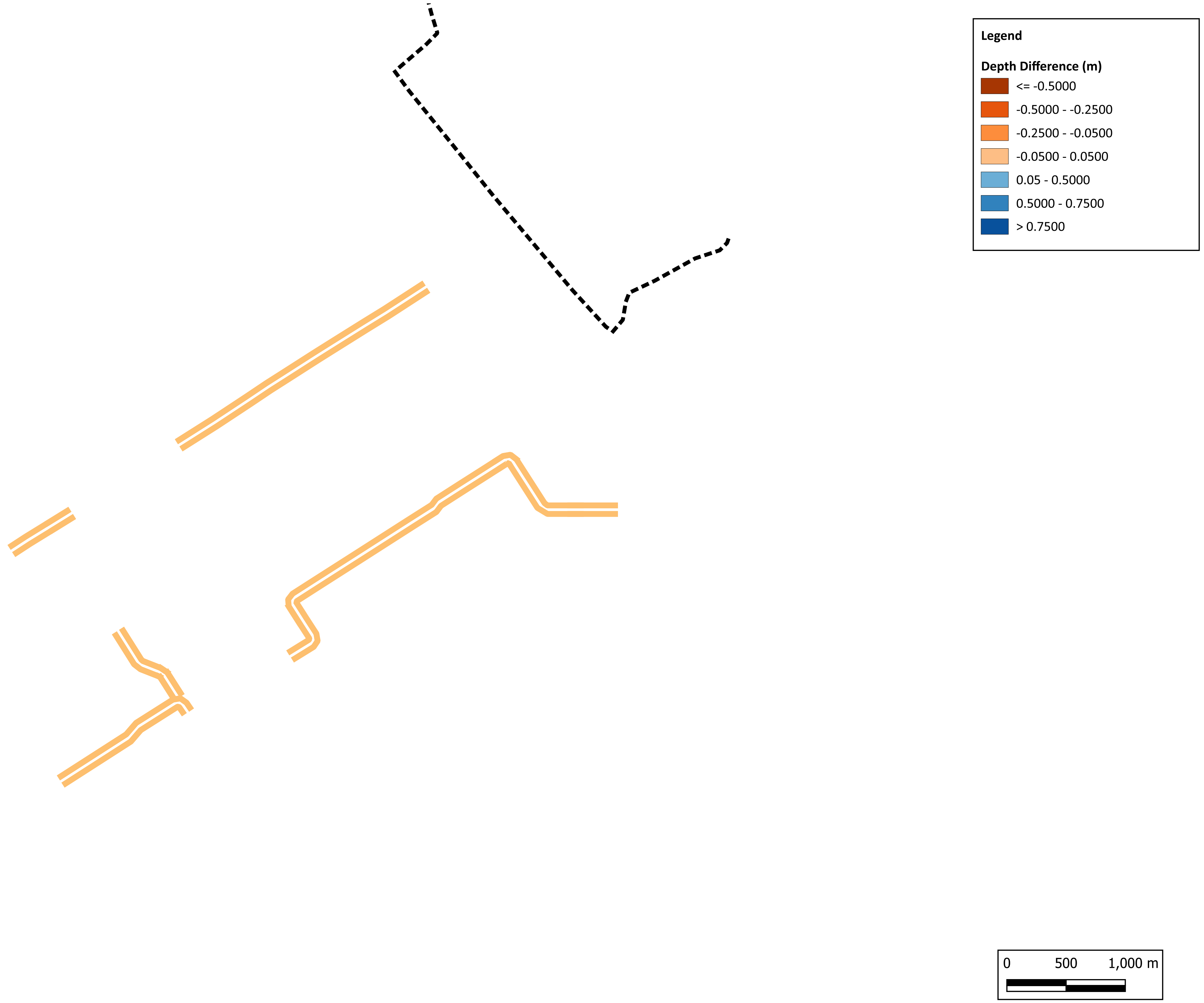
	South Dunedin - Option 4 Sensitivity Run 1 Flood Depth Difference Map Between 1 in 100 Year RCP 4.5 2100 MHWS + 0.6m SLR & Critical Duration 1 in 100 Year RCP8.5 2100 MHWS + 1.1 m SLR	DRAWN BY:	Anvesh Ravula
		DATE:	2025-11-27
		CHECK BY:	
		DATE:	2025-11-27
MAP NO: 4700990 - Q3	REV: A	Disclaimer: This map contains data derived in part or wholly from sources other than Beca. No representations or warranties are made by Beca as to the accuracy or completeness of this information. The map is intended for distribution as a PDF document. The scale may be incorrect when printed.	



Beca, South Dunedin Future, Otago Regional Council, WSP, Tonkin+Taylor DUNEDIN CITY COUNCIL kaunihera a-rohe o Ōtepoti	South Dunedin - Option 5 Sensitivity Run 1 Flood Depth Difference Map Between Long Duration (24hr) & Critical Duration (6hr) (1 in 10 Year RCP 8.5 2100 MHWS)	DRAWN BY: Anvesh Ravula DATE: 2026-05-13 CHECK BY: Kit Pascoe DATE: 2026-05-13
MAP NO: 4700990 - R1	REV: B	Disclaimer: This map contains data derived in part or wholly from sources other than Beca. No representations or warranties are made by Beca as to the accuracy or completeness of this information. The map is intended for distribution as a PDF document. The scale may be incorrect when printed.



Beca / South Dunedin Future / Otago Regional Council / WSP / Tonkin+Taylor DUNEDIN CITY COUNCIL | kaunihera a-rohe o Ōtepoti	South Dunedin - Option 5 Sensitivity Run 1 Flood Depth Difference Map Between Long Duration (24hr) & Critical Duration (6hr) (1 in 50 Year RCP 8.5 2100 MHWS)	DRAWN BY: Anvesh Ravula DATE: 2026-05-13 CHECK BY: Kit Pascoe DATE: 2026-05-13
MAP NO: 4700990 - R2 | REV: B		Disclaimer: This map contains data derived in part or wholly from sources other than Beca. No representations or warranties are made by Beca as to the accuracy or completeness of this information. The map is intended for distribution as a PDF document. The scale may be incorrect when printed.



MAP NO: **4700990 - R3**
REV: A

South Dunedin - Option 5 Sensitivity Run 1
Flood Depth Difference Map Between 1 in 100 Year RCP 4.5 2100
MHWS + 0.6m SLR &
Critical Duration 1 in 100 Year RCP8.5 2100 MHWS + 1.1 m SLR

DRAWN BY:	Anvesh Ravula
DATE:	2025-11-27
CHECK BY:	
DATE:	2025-11-27

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Sensitivity: General

Memorandum

To	Jonathan Rowe and Jared Oliver (DCC)
Copy	Kia Rōpine Workstream Leads
From	Elliot Tuck and Laura Robichaux
Date	25 August 2025
File/Ref	6-CD109.77
Subject	SDF Stormwater Model Schema Statement

Modelling Strategy

For all the solution options being investigated (Future 3, 4 and 5), the strategy proposed is to divide the catchment into parts and provide individual outfalls for each. This aims to decrease the size of key pieces of infrastructure such as trunk mains, outfalls, and major pump stations, along with reducing the impact of bottlenecks such as the existing Anderson Bay Road trunk main. The proposed outfalls are as follows:

- The existing Portobello Road pump station, with any required capacity upgrades, to drain the area between Anderson Bay Road and King Edward Street via the existing network (with upgrades informed by the modelling).
- Isolate the Hillside Road trunk main near Bradshaw Street and pumping this flow to the existing Wilkie Road conduit which currently drains the Orari Street catchment.
- A new outfall to drain the remainder of the catchment, approximately composed of the area between Forbury Road and Bradshaw and Kirkcaldy streets, and the area south of Bay View Road, including the existing Tainui sub catchment. This will comprise of a new outfall running parallel to the existing Portobello Road outfall, or, alternatively, could be discharged to the open ocean on St Clair beach.

For all three options new and upgraded pump stations along with pipes, will be required in certain locations to provide the required conveyance capacity. This will be accompanied by storage facilities and increased greenspace which will attenuate flow peaks and decrease the required scale of infrastructure such as pump stations. Upstream network upgrades (including inlet capacity) and designated overland flow paths (i.e. along roadways) will be required to provide sufficient drainage for individual areas and deliver stormwater to storage and waterways in the larger events. These upstream network upgrades will be targeted at areas where surface flooding still exceeds 100mm (in events greater than the 10 year) even with the primary upgrades (waterways, trunk mains, pumps, and storage).

The construction of each future option will be staged over the short, medium, and long term. The short-term works are common between the three options being investigated and will involve the initial splitting of the catchment, primarily through the installation of new trunk mains and pump stations. Waterways/trunk mains and storage facilities would then be developed and enlarged, along with pump station expansion as required, through the medium and long term.

Sensitivity: General

Future 3 - Network (Pipes and Pumps)

The principle for Future Option 3 is to provide an upgraded network of pipes and pumps in South Dunedin to effectively remove water from the catchment during rainfall events. New and upgraded trunk mains will be installed to convey water to storage and new outfalls:

- A new trunk main to intercept flows from the eastern portion of the catchment will run along Kirkcaldy and Moreau streets from Bathgate Park to Bellona Street.
- Upgrade the existing trunk main on Bellona Street and divert to a dedicated outfall to reduce load on the Portobello Road PS.
- Upgrade the trunk main on Royal Crescent (conveys flows from the Tainui PS) and divert to the new outfall.

Options 4 & 5 - Network (Waterways)

For Future Options 4 and 5, the principle is to provide dedicated space in South Dunedin to accommodate and then remove water in the catchment during rainfall events. A network of waterways will provide large arteries to convey runoff to storage and then to outfalls:

- A primary waterway to convey flows from the southern part of the catchment is proposed to run from near Forbury Park to the intersection of Portobello Road and Anderson Bay Road, along or parallel to Bellona Street, New Street, and Queens Drive. Installed in the medium term
- Additional significant branches, developed in the long term, would be positioned along or parallel to Ajax Street and King Edward Street.
- Waterways will initially be assumed to be two stage channels with a small central channel for low/groundwater flows. Initial overall dimensions will be a total base width of 8m, 1.5m depth, and 1:4 embankment. Channels are assumed to be grassed swales and a Manning's roughness value of 0.03 will be modelled. These waterways will be graded to ensure water will flow along them, this may mean the depth increases as it travels downstream.

Storage

Storage to provide flow attenuation is proposed through the construction of basins and wetlands at existing parks in the east of the catchment (Forbury, Tonga, Bathgate) and adjacent to the existing Tainui stormwater pump station:

- Pump stations will be required at these storage facilities to drain them down following rain events, along with groundwater management.
- Storage will be expanded through the short, medium and long terms.
- Basins and wetlands will be initially assumed to be 1.2m deep, with the ultimate extents being the boundaries of the parks proposed to be utilised.
- It is assumed that storage will be able to be expanded from these extents if required, with storage extent balanced against infrastructure size using engineering judgement considering factors such as reasonable pump station depth.

Land Rasing and Managed Relocation

Some managed relocation will be required for all options:

- For options 3 and 5, land raising will be undertaken in the long-term extending from Forbury Drive west to approximately the western boundary of Forbury, Bathgate, and Tonga parks.
- Managed relocation will be required for all options to provide space for the proposed storage facilities, greenspaces, and waterways. Some of this relocation will be to proposed developments within the catchment on Chisholm Links and Hancock Park.
- New development on relocation areas and newly raised land will be assumed to be medium density residential.
- It is assumed that new developments will use onsite stormwater storage to reduce peak flows

Seawall

A new seawall is proposed for all options to protect from sea level rise:

- For Options 3 and 4, this will be constructed along Portsmouth Drive.
- For Option 5 the seawall will be constructed along Otaki Street, with the existing area between Otaki Street and Portsmouth Drive to have floodable first floors.
- This will be modelled as an impervious barrier.

Sensitivity: General

Memorandum

To	Jonathan Rowe – Programme Manager, South Dunedin Future Programme, DCC
Copy	Kia Rōpine
Date	29 July 2025
File/Ref	6-CD109.77 – South Dunedin Future Programme
Subject	Efficacy Modelling – Task 1 deliverable: Stormwater modelling inputs and outputs
Author:	Elliot Tuck
WS4 Verification by:	Laura Robichaux
Kia Rōpine Verification by:	Joao Machado
Approved for release:	Kevin Wood

1 Background

Hydraulic modelling is required to test the efficacy of each of the shortlisted proposed South Dunedin Futures. This report sets the scene for the modelling to enable it to be as efficient as possible while still meeting the wider SDF teams requirements.

Establishing which configurations of options will be modelled is a key focus. Configurations are likely to include some combination of potential futures (late century) and the short- and medium-term changes in infrastructure that could lead to the potential futures. What is meant by the descriptions of each potential Futures (e.g. 'keep land dry') will be needed prior to developing the short-, medium- and long-term pathways to be modelled. This includes the establishment of the basis for each option in terms of the design 'level of service' to be met by each solution (e.g. rainfall return period), and the model runs required to explore the efficacy of each option in reducing flood risk (e.g. climate change scenario).

It will also seek to define the model outputs required to undertake the residual risk assessments.

The following requirements have been developed in collaboration with Dunedin City Council, Kia Rōpine and Otago Regional Council, including inputs from GNS Science in respect of groundwater modelling.

2 Model scenarios

2.1 Scenarios

The current South Dunedin model was updated during the ICMP project in 2024. The most significant change in this model from the previous (2010 ICMP) is the inclusion of sump/mud pits to assess inlet capacity. The inclusion of sumps resulted in smaller subcatchments draining to them. Newer LiDAR information was also used in the model to represent overland flow. An allowance of groundwater entering the network was added to the model which relates to the groundwater level (supplied by GNS). Therefore, this model should form the basis of the SDF runs.

The base model will include the "quick win options" proposed by DCC. These are described in Section 3. The Base model will then be adapted to meet the following time horizons:

- Present Day
- Medium Term - 2060
- Long Term – 2100

The model for each shortlisted Potential Future will assume the options are fully developed in the 2100 horizon, the two proceeding timeframes will include upgrades to work towards that goal. Model runs are provided in Table 1. Time horizons and climate scenarios have been selected to align with the baseline climate change risk assessment.

2.2 Rainfall

Previous flooding of South Dunedin has occurred during long duration (over 12hrs) rainfall events. The South Dunedin System Performance Report (Beca, 2025) states that the critical duration (rainfall duration that created the greatest depth of flooding) was the 6 hour event. The 6 hours event showed the largest number of surcharging manholes and the largest flood extent. Consideration should be given to testing a longer duration event or the most recent event in October 2024 as a sensitivity (runs SD2b or c). This will be discussed with council before running.

The rainfall return periods to be tested will be:

- 10 year ARI – Used to size the pipe network. As agreed in the meeting (4-7-2025) the network will be sized allowing for approximately 150mm (of less if deemed suitable) of water to remain on roads to reduce the cost and extent of the network upgrades. The stormwater network may require sections that have a greater, than the 10 year, level of service such as conveyance to a storage basin
- 50 year ARI – This will be used to define options that contain formalised overland flow paths. It is also the level of service for storage and land raising options
- 100 year ARI – This is the model that will provide results for the residual risk assessment. The model will contain the infrastructure sized in the 10yr and 50yr ARI events. Consideration will also be given to design to this level of service if the residual risk is considered too high or if the additional upgrades required aren't significant. This will be discussed with DCC/SDF before progressing, therefore no runs haven been allowed for in the scoping.

2.3 Climate change

A climate change allowance will be added to the rainfall event. As agreed in the workshop (13th June 2025) the Scenarios will use SSP5-8.5 with a sensitivity test using SSP2-4.5.

Each rainfall event will have climate change added to match the horizon of each option e.g RCP8.5 to 2025 (Present day), RCP 8.5 to 2060 (Medium Term), RCP 8.5 to 2100 (Long Term).

2.4 Tides

Previous modelling has used the Mean High Water Springs (MWHS)[1] as the tide boundary in the model. It has been applied as a fixed tide level as a conservative approach.

Following this, approach MHWS level will be used alongside an allowance for sea level rise; these are:

- Present Day – MHWS
- Medium Term – MHWS + 0.5m SLR
- Long Term – MHWS + 1.1m SLR (although Long term 100yr is MWHS + 1.5m SLR)

The tide will be applied as a sinusoidal time series in the long duration sensitivity runs and as a fix tide level in the shorter critical duration runs.

2.5 Ground Water

The South Dunedin hydraulic model contains an allowance for the groundwater that infiltrates into the stormwater network. These inputs were developed during a calibration of the system performance project. The groundwater levels that feed into the network model are based on the groundwater levels developed by GNS. These network groundwater levels will align with the sea level rise allowance for each scenario and therefore the hydraulic modelling assumes that no wide-scale groundwater controls will be in place.

Where storage is included (e.g Forbury Park) as a future it is assumed localised groundwater controls will be in place allowing basins to be lowered below current groundwater levels. An allowance (likely a fixed inflow) will be made in the model for the flow generated by the groundwater controls.

[1] MHWS is the average height of the high tides that occur during spring tides.

Sensitivity: General

Table 1 Model run scenario table.

Model run #	Rainfall Duration		Scenario				Return Period			Climate Change					Tides							Mapping		
	Critical	Long Dur (24hr?)	Base + Quick wins	Present Day	Medium Term - 2060	Long Term - 2100	10yr	50yr	100yr	Historic	RCP4.5 -2100	RCP 8.5 -2025	RCP 8.5 -2060	RCP 8.5 - 2100	MHWN + SLR (0.6m)	MHWS	MHWS + SLR (0.3m)	MHWS + SLR (0.5m)	MHWS + SLR (0.6m)	MHWS + SLR (1.1m)	MHWS + SLR (1.5m)	Residual Risk	Network Sizing	Sensitivity
SD1a	x			x			x					X				X							X	
SD1b	x				x		x						x					x					X	
SD1c	x					x	x							X						X			X	
SD1d	X			x				X				x				X							X	
SD1e	X				x			X					x					x					X	
SD1f	x					x		X						x						X			X	
SD1g	x			X					x			x				X						X		
SD1h	x				x				X				x					x				X		
SD1i	x					x			X					X						X		X		
SD2a	x					x			x		x								x					x
SD2b		X				x	x							x		X								x
SD2c		x				x		x						x		X								x
SD3a	X		x	x			x					X				X							X	
SD3b	X		x		x		x						x					x					X	
SD3c	X		x			x	x							X						X			X	
SD3d	X		X	x				X				x				X							X	
SD3e	X		X		x			X					x					x					X	
SD3f	X		X			x		X						x						X			X	
SD3g	X		X	X					x			x				X						X		
SD3h	X		X		x				X				x					x				X		
SD3i	x		x			x			X					X						X		x		

SD1 Runs for each future
SD2 Sensitivity runs, assumed a matching RCP(mid)4.5 and 2 long duration runs
SD3 Base runs for Residual Risk and network comparison. These are run once (9 runs) unlike SD1&2 which are run for each of the 3 Futures (36 runs).

3 Model inputs

The current South Dunedin model produced during the ICMP project is missing the short-term solutions announced by DCC. These are:

- Upgrade of the Forbury Rd aqueduct
- Hillside Rd main pump to Orari St outfall
- Portobello Rd bypass pipe to Portobello pump station.

These options will be included in the base model assuming these will be constructed regardless of the outcome of the SDF work. The inclusion of these projects does create some risk as they are still in the early stages of design and will change as they progress. DCC will provide the model inputs for these upgrades.

Most model inputs (rainfall, tide etc) were developed during the South Dunedin System Performance (2025) so these will be retained. One aspect that needs to be agreed with council is the level of additional development for each of the horizons.

WSP has supplied some general layouts for aspects of some of the options. These will create a starting point for modelling an option unless a more suitable layout if found.

4 Level of service

The level of service (LoS) gives the modellers a target to achieve when developing infrastructure upgrades.

The agreed LoS for upgrades are:

- Primary network (pipes) is the 10 year ARI. This applies to network locations where larger conveyance isn't required for a pump or storage option. Based on previous work upgrading the existing network to capture the full 10 year event with no surcharging may not be feasible therefore an allowance for some surcharging in roads of up to 150mm has been assumed. This may change once modelling has begun but we will inform council on our findings before progressing to far with proposed options.
- Secondary system (overland flow) is the 50 year ARI. This applies to options that contain formal overland flow paths. The 50 year LoS will also apply to main conveyance to storage that will also be sized for the 50 year event. The target for the 50 year is to reduce surface flooding as much as practicable

The infrastructure upgrades will use a model flagging system to enable the easy identification of new network. This will allow for lists of required upgrades to be produced for costs estimate, although not part of this project.

5 Model outputs

5.1 Residual Risk assessment

The critical model results are those that feed into the residual risk assessment. The results required for the assessment are:

- Max velocity
- Max water depth
- Max water surface elevation

These will be exported from the model and converted to .shp files for delivery. The residual risk results are the 100-year long-term scenario only.

5.2 Base and Futures

Maximum depth maps will be made for each of the current, medium- and long-term scenarios (for each Future). The same will be produced for the Base results also. This allows for a comparison to be made between the future and the base model but also between each horizon of a Future.

We have also allowed for 3 difference maps (10 year, 50 year and 100 year) to be produced per Future that compares the Futures runs with the Base model.

If the maps are not suitable to show the scale of change, reporting points within the network (primary and secondary) will be chosen and results tabulated to highlight changes.

5.3 Sensitivity runs

A difference map (of water depth) will be produced to the showing the difference in the flood extent between the sensitivity run and the corresponding Futures run. Differences at key infrastructure will also be tabulated and will feed into the report that will accompany the results. This will be similar process for the long duration event.

5.4 Report

A brief report (est. 10-20 pages) will be produced highlight the modelling work completed for each of the Futures. This will include a brief description of the upgrades required and their performance, using maps and tabulated results. The primary audience is Kia Rōpine (to inform cost estimates) and Dunedin City Council (to inform future stormwater projects).

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TASK 1: REQUIREMENTS SETTING SCOPE, FOR REFERENCE

Establishing which configurations of options will be modelled is a key focus. Configurations are likely to include some combination of potential futures (late century) and the short and medium-term changes in infrastructure that could lead to the potential futures. What is meant by the descriptions of each potential Futures (e.g. 'keep land dry') will be needed prior to developing the short-, medium- and long-term pathways to be modelled. This includes clarification to establish the basis for each option in terms of the design 'level of service' to be met by each solution (e.g. rainfall return period), and the model runs required to explore the efficacy of each option in reducing flood risk (e.g. climate change scenario).

To support requirements, we have proposed a half day, online workshop to discuss the options being modelled in detail. Attendees at the meeting will include DCC SDF programme manager (Jonathan Rowe), DCC 3-Waters lead (Jared Oliver), DCC 3-Waters modeller (Murray McLeod), ORC Natural Hazards lead (Jean-Luc Payan), and GNS Science groundwater advisor (Simon Cox), Kia Rōpine modelling team (represented by Elliot Tuck) and Kia Rōpine key specialist representatives (Laura Robichaux, Joao Machado, Katherine Cowper-Heays, Carrie Hartley and Liam Foster). Alternative attendees may be accommodated in case any of the identified specialists are unexpectedly not available – e.g. due to illness. We will use the indicative spatial layout and sizes of pumps, pipes, channels and detention zones that were produced in the previous phase to support the development of a cost estimate for each potential future. This GIS based layout with sizes will serve as the base for the model schematisation statement for each scenario to be modelled.

A second online meeting is also proposed (2hrs) to define the model outputs required for each of the stakeholders including files required for the residual risk assessment.

Laura Robichaux, as Kia Rōpine Workstream 4 lead, will work collaboratively with the model team (up to 16hrs) to confirm the understanding of the requirements. The options modelled will include short-, medium- and long-term configurations for three shortlisted Futures (e.g. testing a maximum of 9 model configurations representing short-, medium- and long-term components of three shortlisted futures). Time horizons for short, medium and long term will be selected in alignment with the risk assessment to compare to the baseline.

Collaboration with Kia Rōpine throughout the initial stages of the project (12hrs of meetings and provision of data has been assumed in addition to the half day workshop) will be essential to establishing the basis for modelling, and the assumptions to be made. For example, the pipes and pumps option would likely be designed to provide a 1 in 10-year flood Level of Service, and the wetlands and waterways option to a 1 in 50 year flood level of service, representing DCC's required levels of service for primary and secondary networks respectively or the level of service may be based on a reduction of the number of properties flooded.

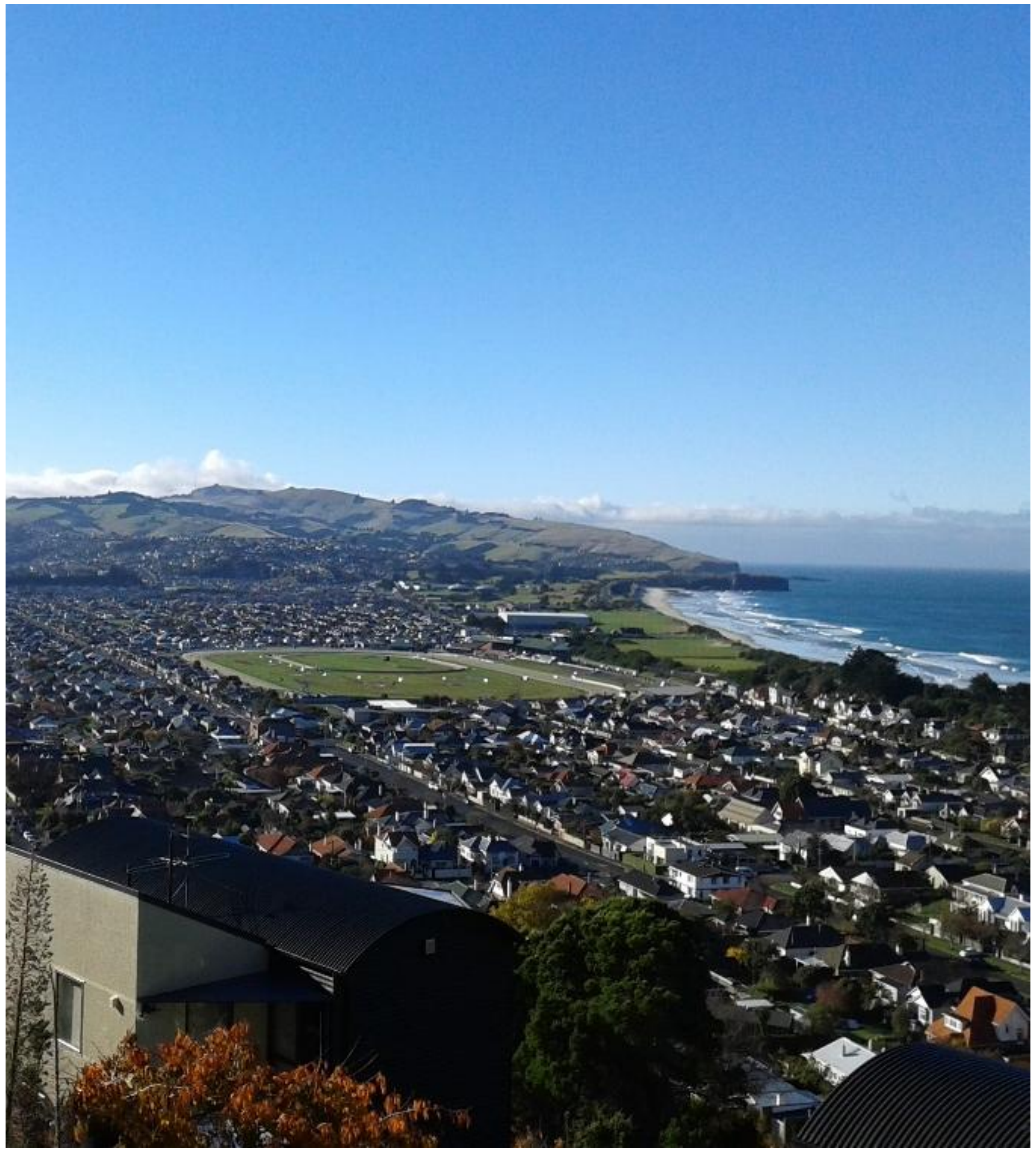
By setting this framework before the models are created, allows minor adjustment to be made to the model to optimise each of the scenarios.

The deliverable from Task 1 will be a summary reports including:

- Model scoping report including the model run table and confirmation of the required model inputs, model outputs and the expected level of service of the model configuration.
- Residual risk assessment scoping report (e.g. number of properties, residual risk maps, inclusion of building floor levels).

There will be one iteration of this deliverable between DCC/ORC and Kia Rōpine.

At the completion of Task 1 there will be a hold point for the SDF council team and Kia Rōpine representatives to redefine Tasks 2-4 as well as time frames and costs based on the outcomes of Task 1.



Confidential

Dunedin City Council

South Dunedin Future

Groundwater Drainage Options Assessment

8 May 2026

6-CD109.77

South Dunedin Future

Groundwater Drainage Options Assessment

Dunedin City Council

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REV	DATE	DETAILS
Rev0	03/12/2025	Draft for client review
Rev1	20/02/2026	Final
Rev2	27/03/2026	Final (minor corrections)
Rev3	08/05/2026	Final (further client review)

	NAME	DATE
Prepared by:	Eric van Nieuwkerk	08/05/2026
Reviewed by:	Andrew Raj	08/05/2026
Approved by:	Kevin Wood	08/05/2026

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1 INTRODUCTION

1.1 GENERAL

As part of the South Dunedin Futures (SDF) programme, WSP has undertaken a groundwater modelling investigation to assess how the future water management options proposed in the SDF programme help alleviate groundwater drainage issues in South Dunedin. The approach and results of this investigation are documented in this report, including a series of maps and cross sections included in Appendix A and B which visualise how effective the various options are to control groundwater levels.

1.2 PROJECT BACKGROUND

South Dunedin is a low-lying coastal part of Dunedin that is vulnerable to multiple natural hazards including flooding from stormwater, persistent drainage issues and water ponding due to high groundwater levels, affecting buildings, services and amenities. The issues are likely to be exacerbated by sea level rise in the future, and this has prompted the Dunedin City Council (DCC) and Otago Regional Council (ORC) to initiate the SDF programme. The SDF programme is aimed at improving the area's liveability and resilience against natural hazards with a key focus on flooding and drainage issues.

Several potential adaptation options to improve the water management of the area have been identified in the SDF programme, which includes options to systematically lower the groundwater levels beneath South Dunedin. These options focus on effective combinations of managing stormwater, groundwater and strategic urban planning. Because South Dunedin is low-lying, there are very limited options to drain water to the sea under gravity in the current state. Future sea level rise will make effective gravity drainage unfeasible, and a pumped scheme would be required to sufficiently drain stormwater and groundwater. The considered potential adaptation options therefore include pumped schemes to alleviate the stormwater flooding and groundwater drainage issues.

1.3 SCOPE AND OBJECTIVES

The scope and objectives of the groundwater modelling investigations presented in this report are as follows:

- Use the existing numerical groundwater model from South Dunedin developed by ORC and updated by GNS[1] to assess the effectiveness of the proposed water management adaptation options identified in the SDF programme (described in Section 3).
- Visualise in overview maps and cross sections how groundwater levels would be controlled by the proposed water management adaptation options, and how these compare to groundwater drainage provided by the current network of leaky stormwater and wastewater pipes.
- Assess potential inflows of groundwater to stormwater and groundwater management infrastructure for the proposed water management adaptation options, to inform pumping requirements for the stormwater design.
- Document the findings in a brief report to inform the cost benefit analysis of the proposed adaptation options for the SDF programme.

[1] GNS Science has merged with NIWA to form Earth Sciences New Zealand (ESNZ)

1.4 BRIEF SITE DESCRIPTION

South Dunedin comprises a low-lying dense urban environment of 600 ha which is less than 3 m above mean sea level, and a large part is below the current high tide mark. Because of the low elevation, stormwater drainage under gravity is challenging in the current state, and this will likely be exacerbated by sea level rise.

South Dunedin is located south of the Dunedin city central business district, between the Otago Harbour Basin and the Pacific Ocean. South Dunedin is mainly a residential area with medium density housing (ORC 2012). Groundwater levels in South Dunedin are high and generally less than 1 m below ground level. Near Tonga Park in the centre of the area, groundwater levels are generally less than 0.5 m below ground level. Current high groundwater issues mainly affect the suburbs Forbury, St Kilda West and Tainui and, to lesser extent, the suburb of South Dunedin (Figure 1).

In recent times before European settlement the area comprised salt marshes, lagoons, dunes and intertidal mudflats. South Dunedin was developed into a predominantly residential and commercial / retail area from the 1800's onward, following land reclamation and land filling. Land filling was often poorly compacted, and some residual land settlement is still occurring (ORC 2016).

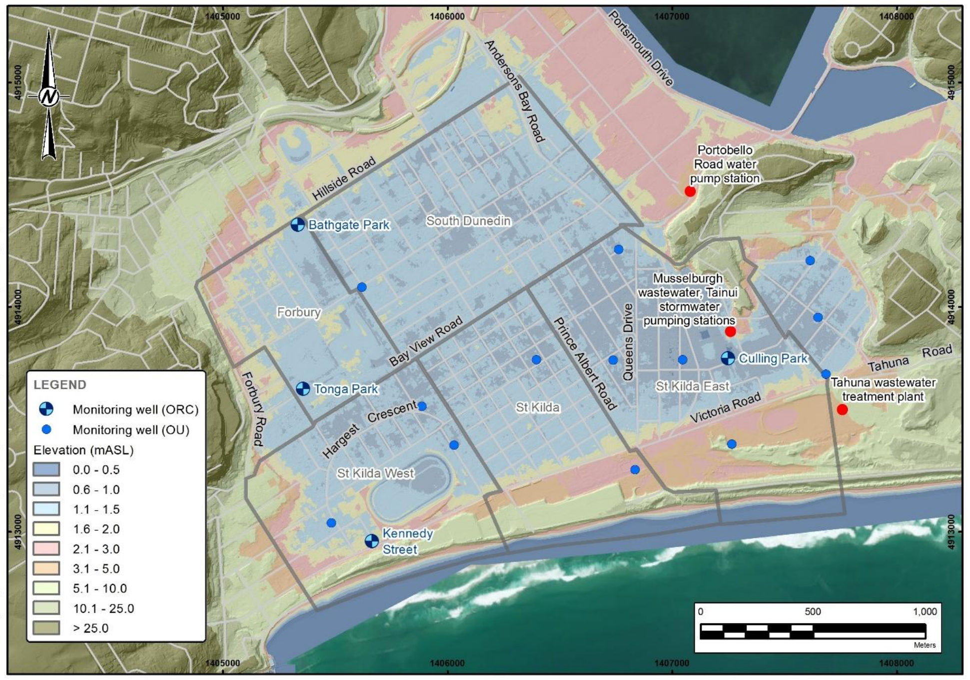

Figure 1: South Dunedin area

The area was once a river valley partly filled with alluvial gravels and sands that has now been buried in soft sediments (sand, silts and clays) forming a land bridge between the surrounding hills as sea levels rose after the last ice age (ORC 2012, ORC 2016 and Fordyce 2013). Glassey *et al* (2021) note that the bedrock geology of South Dunedin and the surrounding area is comprised of Early Miocene Caversham Sandstone and Late Miocene volcanic rocks of the Dunedin Volcanic Group. Caversham Sandstone outcrops in the Caversham Valley area, while the overlying Dunedin volcanic rocks form the hills surrounding the harbour and South Dunedin. Younger Quaternary sediments have filled in the area, comprising sands and silts deposited under marine to estuarine conditions, underlain by sandy and gravelly stream sediments. The total thickness of the Quaternary sediments could be as much as 70 m Glassey *et al* (2021). Large accumulations of dune sand have formed along the southern coast between the Pacific Ocean and South Dunedin. Based on groundwater model calibration, the lateral hydraulic conductivities (i.e., a measure of permeability) of the Quaternary sediments are estimated to range from 2 to 6 m/day with vertical hydraulic conductivity estimates to be 10% of the lateral hydraulic conductivity (Chambers *et al*, 2023).

Groundwater enters old wastewater and stormwater pipes according to DCC (2025) and is accidentally providing some groundwater drainage in South Dunedin. Fordyce (2013) observed high salinity in several groundwater monitoring wells, which may have been caused by the accidental groundwater drainage by the old leaky wastewater and stormwater pipes.

The groundwater system in the dunes south of Victoria Rd may be notably different from that in the rest of South Dunedin. There is limited hydrogeological data and information available for the dunes; however, it could be subject to density-dependent groundwater flow processes. Groundwater in the dunes is replenished with fresh rainfall water, and a fresh groundwater body may have formed that floats on top of much denser salt seawater in the marine sediments beneath the dunes. Freeze & Cherry (1979) describe this as the Ghyben-Herzberg principle, which dictates that the depth of the fresh and salt groundwater interface (z) is roughly 40 times the height of the groundwater table (h), as shown in Figure 2. In practice, the interface may not always be as sharp as assumed in the Ghyben-Herzberg principle, but rather a transition zone has formed. ORC (2012) notes that earth resistivity soundings in South Dunedin roughly conformed to the Ghyben-Herzberg ratios for freshwater and saline water in a coastal aquifer.

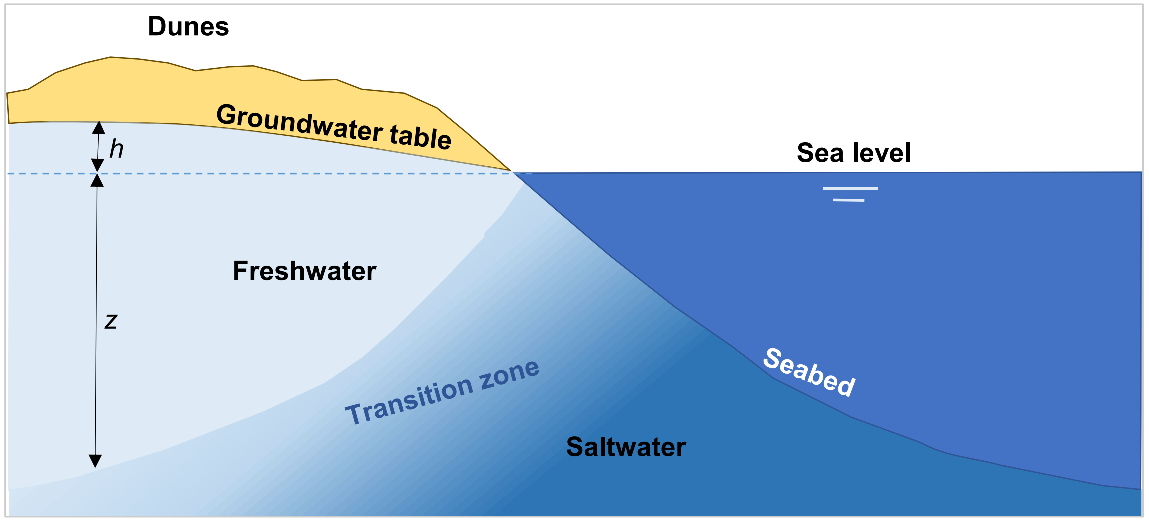

Figure 2: Diagram showing the Ghyben-Herzberg principle

2 APPROACH

2.1 MODELLING TOOLS USED

WSP used the South Dunedin 3-dimensional numerical groundwater model developed by ORC (2012) and updated by GNS (Chambers *et al*, 2023) for the groundwater modelling investigations presented in this report. The key characteristics of this numerical groundwater model are as follows:

- The model is a single layer, steady state model built in MODFLOW. The MODFLOW source code was developed by the USGS (1988). This is a widely used, industry standard, three-dimensional numerical groundwater modelling tool.
- The original model from ORC (2012) was modified and updated by GNS (Chambers *et al*, 2023) as follows:
  - The hydraulic conductivities of the soil materials encountered beneath South Dunedin where optimised in the model, so the model is better capable of simulating recorded groundwater levels. This is an important step in improving the model's accuracy. In addition, GNS improved the estimation of groundwater recharge into the model and optimised the conductance term that governs the flows into the existing leaky stormwater and wastewater network.
  - The model was converted from a 'deterministic' model into a 'stochastic' model. Stochastic modelling involves running the model with various sets of possible hydraulic properties of soil materials, and then analysing the probability of certain outcomes across the various model runs. Instead of simulating a single outcome, a stochastic model simulates the probability that a certain outcome would occur. For example, it simulates the probability of groundwater seepage at the surface causing drainage issues at a certain location and in a certain scenario (e.g., current state or a future state affected by sea level rise). Stochastic modelling aims to capture the uncertainty in groundwater conditions and hydraulic properties of the soil materials.

GNS used the updated model to investigate the probability of the current groundwater drainage issues in South Dunedin being exacerbated due to future sea level rise (Chambers *et al*, 2023).

2.2 MODEL UPDATES

The updated model from GNS (Chambers *et al*, 2023) was further modified by WSP to make it suitable for simulating the efficacy of various groundwater drainage systems to control groundwater levels. The following modifications were made:

- The model was converted to a deterministic model, which means it provides only a single outcome in terms of a groundwater level surface of groundwater flow field for each scenario. This makes it possible to mutually compare the outcomes of various scenarios as described in Section 3. The hydraulic properties and rainfall recharge estimates for the optimised groundwater model by GNS (Chambers *et al*, 2023) were used for the simulations.
- For improved simulation of groundwater gradients, WSP refined the model grid as follows:
  - Reduced grid spacing to 10 m x 10 m (from the original 40 m x 40 m grid) to better simulate groundwater mounding between drainage features. This improves the representation of drainage depth below surface.
  - Increased the number of layers from 1 layer to 4 layers for better simulation of vertical gradients. Each layer has the same lateral and vertical hydraulic conductivity values as the optimised groundwater model by GNS (Chambers *et al*, 2023).
- We rescaled the conductance of pre-existing drainage features in the model (i.e., representing leaky stormwater and wastewater systems) to achieve a consistent water balance with the optimised GNS model (i.e., a uniform conductance value of 0.8 m^2/day was adopted), and assumed new groundwater drainage features would have a conductance twice as high as the leaky stormwater and wastewater systems as they would be specifically designed for groundwater drainage as opposed to the accidental drainage by leaky pipes.

For the assessment of the efficacy testing of the adaptation options (Section 3.2) we used steady state modelling. Steady state modelling assumes the groundwater system is in equilibrium representing average groundwater conditions. We also developed transient (i.e., time dependent) models for high-level assessments of temporal changes in groundwater levels and flows in response to a significant storm event passing the area, or in case of a failure of the pumped scheme which causes groundwater drainage to cease. This is further described in Section 3.4.

2.3 MODEL LIMITATIONS

The South Dunedin 3D numerical groundwater model, built by ORC (2012) and updated by GNS (Chambers *et al*, 2023), has been further adjusted by WSP with the intent to assess changes in groundwater levels and inflows to water management systems as a result of the implementation of various water management adaptation options. However, the model has not specifically been developed to accurately assess groundwater levels and flows at each location at each time. In addition, the model only implicitly accounts for the interaction with stormwater and surface water drainage systems, and does not account for density-dependent flow. The accuracy of the model is limited to the accuracy and completeness of the available hydrogeological and geological data from field investigations and literature, as described in Chambers *et al* (2023). The results presented in this report should therefore be considered as indicative only.

3 OPTIONS ASSESSMENT

3.1 KEY CONSIDERATIONS

Several potential adaptation options are being considered in the SDF programme. The adaptation options entail pumped scheme water management options, because sea level rise will make stormwater and groundwater drainage under gravity unfeasible at some point in time. The leaky pipes from the current stormwater and wastewater network in South Dunedin provide for some 'accidental' groundwater drainage, because those networks are pumped by the Portobello and Tahuna pumpstations. Nonetheless, South Dunedin is already susceptible to stormwater flooding and groundwater drainage issues in the current state, and therefore the adaptation options considered include a short-term solution designed to address current issues. Sea level rise will exacerbate the issues in the future and a sea level rise of up to 1.1 m is assumed to assess the efficacy of the adaptation options in a more distant future (approximately 100 years from the current state).

The potential adaptation options considered assume that the management of stormwater and groundwater will be combined. It should be considered that stormwater flows during significant events are much larger (i.e. multiple orders of magnitude) than groundwater flows, hence the conveyance of groundwater flows has only a minor impact on the stormwater systems design.

A large basin would be built in Forbury Park in the proposed adaptation options, and this basin will be the downstream collection basin where most of the stormwater and drained groundwater will be conveyed. From there, the water will be pumped to the sea by a pumpstation. The pumpstation would have a high-capacity pump that pumps large flows during and directly after significant storm events. A smaller lower-capacity pump would continuously pump water for groundwater drainage. The low-capacity pump is aimed at maintaining the required water level in the basin that allows all stormwater systems to drain to the basin.

It should also be considered that groundwater drainage is continuous (i.e., there is a continuous baseflow) with increased inflows during and directly after storm events and a gradual reduction in flows over several days or weeks thereafter. This is different from stormwater flows that could be very high during and directly after significant storm events but will quickly recede to almost zero during dry conditions. Whilst modelling suggests groundwater inflows could temporarily triple from the baseflows after notable storm events (Section 3.4 and 4.4.2), these flows will always be very modest compared to stormwater flows.

The lowering of groundwater levels by drainage can cause land settlement as a result of reduced pore water pressure and subsequent consolidation of the soil structure. Certain soil materials are particularly vulnerable to settlement, such as unconsolidated and saturated clay and peat, but some land settlement can also occur in sandy and silty soils encountered beneath South Dunedin. Only a modest lowering of the groundwater level across South Dunedin is therefore considered in this investigation, which is generally less than about 0.8 m but locally up to 1.5 m in the adaptation options considered (Section 3.2). This groundwater drawdown is expected to cause less than 50 mm (0.05 m) of land settlement, although further investigations to confirm this are warranted.

3.2 POTENTIAL ADAPTATION OPTIONS CONSIDERED

The following pumped scheme adaptation options (referred to as 'Futures') are considered in the groundwater modelling investigations that aim to increase resilience against groundwater issues:

- **Current systems**: groundwater levels are partially controlled by the current leaky stormwater and wastewater system, which are installed about 1 m deep. This option serves as a comparison, to inform what will happen in the future if no water management changes are implemented.
- **Future 3 – Protect**: improved stormwater and groundwater management with a piped network and in-catchment storage/retention basins installed to a depth of generally 0.8 m, but up to 3 m in some locations. Bespoke infrastructure would be installed that is purposely designed to drain, convey and discharge both stormwater and groundwater effectively. Only limited room for open water at the surface is envisioned, although several storage and retention basins would be installed in Tonga, Bathgate, Forbury and Culling Park. The Tonga, Bathgate and Culling Park retention basins would be designed to avoid interaction with groundwater (i.e., they will be lined or will be installed above the groundwater table). The Forbury Park basin would be excavated and drained to a level of 1 m below the current sea level. The Forbury Park basin would thus drain groundwater, where the other basins would not interact with groundwater. In this option, it is assumed that the drainage provided by the current leaky stormwater and wastewater system will be maintained. This option also includes partially raising the land by 2.5 m in the west of South Dunedin, which provides a greater separation between the ground surface and the groundwater table, thus reducing the exposure to potential groundwater drainage issues.
- **Future 4 – Restore**: this option includes the same stormwater and groundwater management as Future 3, with the addition of open canals that would be constructed in MacAndrew Rd, Bellona St, and Victoria Rd, which would be excavated to a depth of about 1.5 to 3.0 m. The canals proposed in Future 4 should all be fully hydraulically connected to groundwater, so that they are continuously filled with water and drain groundwater (they should not be lined). The open canals also provide for stormwater storage and conveyance. In addition, they form a key opportunity to improve amenity value of South Dunedin by providing for blue and green open spaces in the area.
- **Future 5 – Reshape**: similar to Future 3, this option includes partially raising the land by 2.5 m. In this option the land raising would be in the west and north of South Dunedin. Stormwater and groundwater would be managed the same way as for Future 4.

Overview maps of these three different Futures are included in Appendix A.

For the groundwater modelling the following scenario simulations were developed based on the various options described above, and their outcomes compared as described in Section 4:

- Current State: current sea level and drainage provided by current leaking stormwater and wastewater systems in roads.
- Future 3: current sea level, raised land in the west, a new stormwater system that also drains groundwater, the Forbury Park basin (at -1 m below sea level), and the existing leaky stormwater and wastewater drainage.
- Future 4: current sea level, a new stormwater system that also drains groundwater, the Forbury Park basin (at -1 m below sea level), three new open canals, and the existing leaky stormwater and wastewater drainage.
- Future 5: Stormwater and groundwater managed as per Future 4, and land raising by 2.5 m in west and north of the area.
- Current system with 1.1 m sea level rise: as per Current State but with +1.1 m sea level rise
- Future 3 with 1.1 m sea level rise: as per Future 3 but with +1.1 m sea level rise
- Future 4 with 1.1 m sea level rise: as per Future 4 but with +1.1 m sea level rise
- Future 5 with 1.1 m sea level rise: as per Future 5 but with +1.1 m sea level rise

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The results are shown in Appendix B and discussed in Section 4.

3.3 SUCCES CRITERIA

At this stage the only success criteria considered is the required drainage depth, which refers to the depth below which the groundwater level is ideally maintained. The required drainage depth should be selected so that it avoids water ponding at the surface but also avoids moisture ingress into foundations and crawl spaces beneath buildings, and weakening of soils beneath roads and hardstand areas (which can cause road damage such as potholes). For this investigation a required drainage depth of **0.7 m below ground level** was adopted from SBR (2007). This criteria is based on a 'best practice' approach and is used by councils in The Netherlands for managing groundwater levels in urban areas. The criteria accommodates the capillary rise above the groundwater table, annual groundwater table fluctuations, and the depth to underground services and road foundations, which are often about 0.7 m deep (Figure 3). While there is no single report establishing this criteria as a norm, its effectiveness is documented in various technical standard works that describe the interaction between water, soil, and infrastructure.

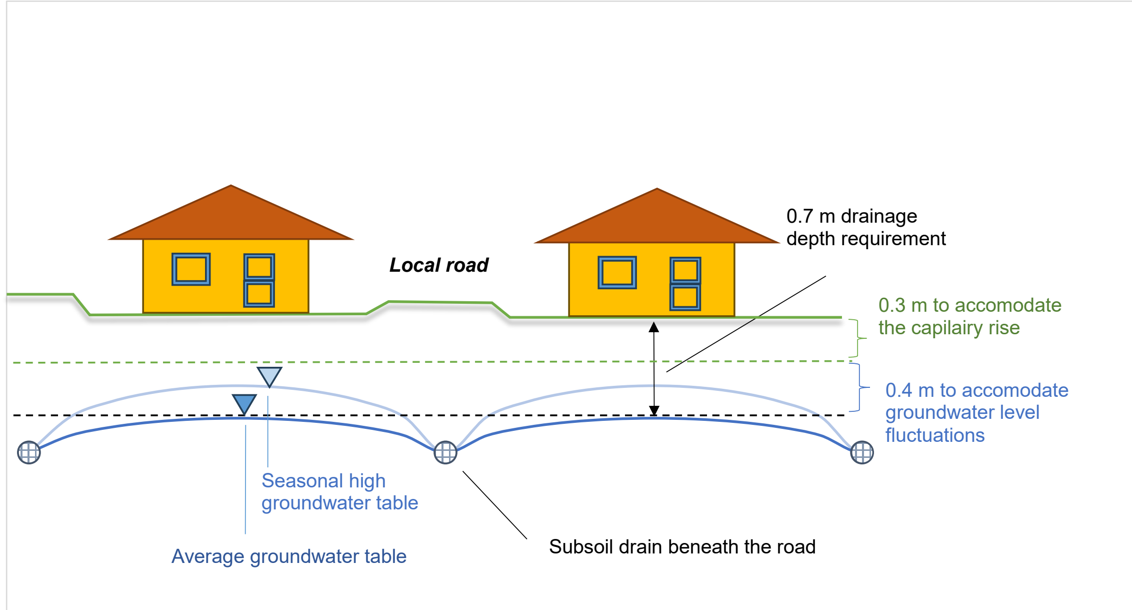

Figure 3: Schematic diagram of required drainage depth

Whilst meeting this success criteria will achieve a liveable area with minimal impacts on buildings, roads and structures, groundwater levels in South Dunedin will always be high and relatively close to the surface. Further lowering the groundwater table by deeper drainage requires more costly pumping and could further increase land settlement, thus it is not recommended.

The high groundwater level also means that the soil's capacity to adsorb rainwater remains very small and that stormwater systems that rely on infiltration to ground, such as soakage pits and infiltration basins, may not be suitable for most of the South Dunedin area.

3.4 EVENT-BASED GROUNDWATER DRAINAGE RESPONSE

The success of the scenarios described above in Section 3.2 are tested for average groundwater conditions. However, during extreme weather events, stormwater and groundwater inflows to the combined stormwater and groundwater systems can rapidly rise and potentially overwhelm the system. Furthermore, pump failure can cause the stormwater and groundwater systems to stop working. Both circumstances can lead to widespread flooding issues.

Indicative transient (i.e., time-dependent) event-based modelling was undertaken to 'stress test' the groundwater management system. This helps to better understand possible groundwater inflows to a pumped combined stormwater and shallow groundwater management system during a major storm event, and how quickly groundwater issues arise after pump failure.

Using the Future 4 scenario with 1.1 m sea level rise, we developed several modelling scenarios with the following key characteristics:

- For the 24-hour storm event we have adopted the 175 mm in 24 hour storm event recorded in June 2015 that resulted in wide-spread flooding in South Dunedin.
- Three different scenarios representing different groundwater recharge rates during the storm event were investigated, with one scenario assuming the combined stormwater and groundwater system can cope with the deluge, and two scenarios in which the system is overwhelmed. In addition, three cases were assessed in which the aquifer storativity[2] varies in one of the scenarios.
- Two different 'pump failure' scenarios were tested (i.e., total cessation of all groundwater drainage, including the drainage provided by the current leaky wastewater and stormwater pipes). With these scenarios we investigated how quickly groundwater levels could rise to the surface and cause water ponding issues due to pump failure. We tested this for a scenario representing average conditions, and for a scenario in which a significant storm event passes the area.

The results are discussed in Section 4.4.2.

As stated, only a high-level event-based modelling was undertaken. We acknowledge further model calibration under transient conditions is required to improve the accuracy of the predictions.

[2] Aquifer storativity represents the volume of water that an aquifer releases from storage under a certain decline in groundwater level (Ritsema, 1994). The aquifer storativity affects the response time of groundwater levels and flows to certain 'stresses', such as increased rainfall recharge or groundwater abstraction through drainage.

4 FINDINGS

4.1 SHORT TERM EFFICACY OF OPTIONS

The first map in Appendix B (slide 1) shows where, in the current state, groundwater levels meet the required drainage depth (i.e., success criteria of 0.7 m below ground level mentioned in Section 3.3). The light-yellow areas do not meet the criteria and are currently susceptible to groundwater drainage issues, even before notable sea level rise has taken effect. The second map in Appendix B (slide 2) shows how the proposed Future 3 stormwater and groundwater systems will notably alleviate the issues, with a much smaller area not meeting the required drainage depth.

The installation of the Forbury Park basin and the new stormwater system that combines stormwater conveyance with groundwater drainage in all three Futures, is expected to achieve a notably improved groundwater outcome in the short term (approximately 10 to 20 years). The partial land raising (by 2.5 m) will improve drainage depth in the west of South Dunedin in Future 3 and 5.

Whilst the Future 4 adaptation option (third map in Appendix B; slide 3), which includes the installation of three canals, will further lower groundwater levels, it may not achieve much more short-term benefits for groundwater outcomes.

4.2 LONG TERM EFFICACY OF OPTIONS

The fourth map in Appendix B (slide 4) shows how almost the entire area of South Dunedin will no longer meet the required drainage depth with a sea level rise of 1.1 m (expected within the next ~100 years) if no adaptation option is implemented (only the existing leaky stormwater and wastewater systems drain some groundwater). Areas that are currently susceptible to drainage issues will have wide-spread persistent water ponding on the surface. Those areas will effectively be uninhabitable swamp areas.

The fifth and sixth map (slide 5 and 6) show the effectiveness of Future 3 and 4 to drain groundwater even when the sea level has risen by 1.1 m. In both options most areas meet the required drainage depth without any persistent water ponding at the surface. However, Future 4 is notably more effective than Future 3 to accommodate the consequences of sea level rise. This is because of the addition of open channels, although we acknowledge that a buried drainage system instead of channels may achieve a similar outcome. Future 5 has the same combined stormwater and groundwater management system as Future 4, but partial land raising (by 2.5 m) will improve drainage depth in the west and north of South Dunedin, as indicated on the seventh and eighth map (slide 7 and 8) in Appendix B.

Compared to the current state (with groundwater levels being controlled solely by a leaky stormwater/wastewater system), the new scenarios may reduce the risks of liquefaction during seismic events because groundwater levels are permanently lowered. Nonetheless, some land subsidence could occur due to the permanent groundwater drainage. Further assessment of the influence on liquefaction and land settlement risks associated with the proposed stormwater and groundwater management in all three Futures is recommended.

Eight cross sections are included in Appendix B following the map series (slide numbers 9 to 16). These provide further insight into how the various drainage features (e.g., stormwater systems, leaky stormwater and wastewater pipes in the roads, basins and canals) will control the groundwater level. It is specifically noted that the drainage features will need to be installed deeper than the required drainage depth of 0.7 m to be sufficiently effective in managing groundwater levels, and this was incorporated in the Future 3, 4 and 5 modelling scenarios (Section 3.2).

4.3 EXPECTED GROUNDWATER FLOWS TO MANAGE

The modelled groundwater balance is shown in Table 1 (note: the modelled groundwater balance has a small discrepancy of ~2% which is common in numerical modelling). The total groundwater recharge from rainfall in the South Dunedin area is estimated to be about 4,900 m^3/day on average, and for this investigation this is assumed to remain the same in the future. In the current state, the groundwater inflows into the existing leaky stormwater and wastewater system are modelled to be about 1,900 m^3/day. The modelling shows this accidental groundwater drainage is causing a small amount of saline intrusion (i.e., saltwater draw-in from the sea) of about 50 m^3/day. The remaining 2,900 m^3/day flows out via groundwater to the sea.

Table 1: Modelled groundwater balance for the current state and future scenarios ('SLR' stands for sea level rise)

Water balance component	Current State	Future 3 - current	Future 4 & 5 - current	Current system + 1.1 m SLR	Future 3 +1.1 m SLR	Future 4 & 5 + 1.1 m SLR
Inflows (m^3/day)						
Rainfall recharge	4,915	4,915	4,915	4,915	4,915	4,915
Inflows from the sea (saline intrusion)	52	321	465	262	1,016	1,516
Total inflows	4,967	5,237	5,381	5,177	5,932	6,431
Outflows (m^3/day)						
Pre-existing road drainage	1,934	907	291	2,693	951	377
New stormwater system	-	1,060	786	-	1,700	1,046
Forbury Park pond	-	733	573	-	1,044	809
Bellona St canal	-	-	316	-	-	359
MacAndrew Rd canal	-	-	390	-	-	440
Nile St canal	-	-	155	-	-	178
Courtney St canal	-	-	100	-	-	162
Victoria Rd canal	-	-	518	-	-	884
Total drainage	1,934	2,699	3,129	2,693	3,696	4,256
Outflows to the sea (via groundwater)	2,917	2,421	2,216	2,401	2,179	2,058
Total outflows	4,851	5,120	5,346	5,095	5,874	6,315

In all adaptation options (Future 3, 4 and 5), if these were implemented in the next decade (short term), the amount of groundwater inflows into the water management systems (i.e., combined stormwater and groundwater drainage) will increase notably to about 2,700 m^3/day in Future 3 and 3,100 m^3/day in Future 4 and 5 according to the modelling. As a consequence, saline intrusion will increase exponentially.

In a climate-changed future with sea level rise of 1.1 m, the amount of groundwater drainage to the stormwater and groundwater drainage systems will increase notably, up to 4,300 m^3/day on average for Future 4 and 5. However, the percentage difference between the three scenarios with sea level rise is the same as for those without sea level rise. Saline intrusion will become considerable with sea level rise of 1.1 m and is expected to contribute 25 to 50% to the groundwater inflows into the stormwater and groundwater management systems.

Inflows from the sea (i.e., saline intrusion) will be about one third larger in Future 4 and 5 than in Future 3, both in the short and long term (Table 1). This is mainly due to the proposed Victoria Rd canal in Future 4 and 5, which will capture most of the inflows from the sea because it is closest to the coast. This also means that much of the saline intrusion would be contained by the Victoria Rd canal, minimising saltwater inflows to the rest of the stormwater and groundwater management system.

4.4 OTHER CONSIDERATIONS

4.4.1 GROUNDWATER QUALITY

As described above in Section 4.3, saline intrusion will increase exponentially across all the scenarios considered (including those without adaptation options implemented) further increasing the existing salinity of the shallow groundwater in South Dunedin. The proposed Forbury Park basin and the Future 4 and 5 canals will become brackish or even saline. The change in salinity and overall water quality will likely influence ecological values in the proposed open water drainage features. The planting of salt tolerant vegetation along open water features is recommended, also noting that brackish water could flood land adjacent to the open water features during a significant storm event. In addition, existing underground services (e.g., cables, pipes, fittings, manholes, etc.) could be affected by the salt water, depending on the materials they are made of. Salt tolerant materials should be used for new underground services installations. What the exact impacts are and whether these are negative is still to be investigated.

4.4.2 OPERATION AND MAINTENANCE

Ongoing and continuous pumping will be required in all scenarios to drain the land from stormwater and groundwater. This means that ongoing operation and maintenance costs will be incurred to keep South Dunedin dry, and these costs are expected to increase over time as more pumping will be required with progressive sea level rise.

It should also be considered that continuous pumping to drain stormwater and groundwater is already taking place in many urban areas and several rural areas across New Zealand, and the world. This will likely increase in the future, and proper operation and maintenance of water management systems will become increasingly more important as well as costly.

South Dunedin is not unique in its vulnerability to stormwater flooding and groundwater drainage issues and both technical and management solutions for designs, operation and maintenance of water management systems could be adopted from international case studies where these have been successfully implemented (Golder and Deltares, 2017).

To better understand the operational vulnerability of the proposed combined stormwater and groundwater management system, we investigated how much groundwater inflows to the system could increase during a significant storm event, and whether this could overwhelm the system. In addition, we assessed how groundwater levels respond to a failure of the pumping system, and within what timeframe this could lead to widespread drainage issues in South Dunedin. The key findings are as follows:

— The proposed combined stormwater and groundwater management system is designed to cope with significant storm events, which is referred to as 'design events'. High-level modelling assessments suggest groundwater peak inflows to the system could increase from 0.05 to 0.17 m^3/sec (or from 5,000 to about 15,000 m^3/day) during those design events, assuming that the system copes and no wide-spread surface flooding occurs. The groundwater peak flow is notably less than the peak stormwater inflow to the proposed Forbury Park basin in a 1 in 100 year storm event, which is 7.5 m^3/sec. It is unlikely that groundwater inflows could overwhelm the stormwater conveyance systems during design events, noting that the proposed combined stormwater and groundwater management system was designed to accommodate the combined groundwater and storm water peak inflows.

— Pump failure will cause groundwater levels to gradually rise reducing the drainage depth. Eventually, the area's drainage depth will resemble the unmitigated drainage depth shown in Map 1 and 4 in Appendix B with widespread drainage issues. The modelling assessment suggest that pump failure would not immediately lead to significant groundwater issues and there will in most circumstances be sufficient time to restore the pumping scheme and avoid issue associated with groundwater levels (i.e., water ponding on the surface). If conditions are relatively dry (only moderate rainfall), it could take more than a year for groundwater levels to reach the surface in susceptible areas. Groundwater levels can reach the surface more rapidly if conditions are wet, although it would still take several months for groundwater issues in the area to be widespread. However, this is heavily dependent on the antecedent conditions. If pump failure occurs during or immediately following significant rainfall and widespread surface flooding, groundwater issues could arise immediately.

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5 CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

South Dunedin is highly vulnerable to flooding and drainage issues due to its low elevation (less than 3 m above sea level) and high groundwater levels (often <1 m below ground). Existing leaky stormwater and wastewater pipes provide some accidental groundwater drainage, but this is insufficient even now. Sea level rise (up to +1.1 m within ~100 years) will make gravity drainage unfeasible. Without intervention, most of South Dunedin will become persistently waterlogged and effectively uninhabitable.

Several future adaptation options have been considered in this groundwater modelling investigation aimed at alleviating stormwater flooding and groundwater drainage issues:

— Current system: Groundwater drainage is only provided by the current leaky stormwater and wastewater system.

— Future 3 – Protect: New piped stormwater system that drains into a Forbury Park basin (excavated into groundwater and with water level maintain at 1 m below sea level), and partial land raising in the west by 2.5 m.

— Future 4 – Restore: Same stormwater and groundwater management as Future 3, but with the addition of open canals (MacAndrew Rd, Bellona St, Victoria Rd) which provides better groundwater drainage and achieves amenity improvements. However, there would be no land raising in this option.

— Future 5 – Reshape: Same as Future 4, but with partially raising the land by 2.5 m in both the west and north of South Dunedin. This option is a hybrid form between Futures 3 and 4, but with additional land raising in the north.

The effectiveness of the investigated future adaptation scenarios is as follows:

— For the short term (10–20 years), Future 3 significantly reduces groundwater issues compared to the current state. Whilst Future 4 and 5 achieve the same, they offer only marginal additional short-term benefit in comparison to Future 3.

— For the long term which includes +1.1 m sea level rise, the current system will fail to provide any meaningful groundwater drainage. Future 3, 4 and 5 are all able to maintain a required drainage depth (0.7 m below ground), preventing surface ponding. In contrast to the short term outcomes, Future 4 and 5 are notably more effective than Future 3 under +1.1 m sea level rise conditions, mainly due to the addition of the Victoria Rd canal in these Futures.

The current accidental groundwater inflow (i.e., drainage) to the leaky stormwater and wastewater system is modelled to be ~1,900 m^3/day. Under current conditions groundwater inflows to the Future 3 water management systems are modelled to be ~2,700 m^3/day, and for Future 4 and 5 ~3,100 m^3/day. The latter will increase to more than 4,300 m^3/day with 1.1 m sea level rise. Saline intrusion will increase significantly, especially with sea level rise (up to 50% of all groundwater inflows to the water management systems).

Overall Conclusion:

— Pumped drainage systems are essential for South Dunedin's future resilience, which are needed to maintain groundwater levels sufficiently below the ground surface in areas that are currently about 2 m below sea level.

— Future 4 (with canals) and Future 5 (same as Future 4, but with partial land raising) provide the best long-term solution for managing groundwater and enhancing amenity, despite higher complexity and cost.

— All options will require ongoing pumping and maintenance, and saline intrusion will be a major factor in future system design.

— Whilst several recommendations for further investigations are outlined in Section 5.2, we are confident that at this stage a sufficient level of knowledge is available to understand how South Dunedin's groundwater system can be effectively managed.

5.2 RECOMMENDATIONS

Several further investigations are recommended to better understand the benefits and pitfalls of the proposed water management adaptation options. The recommendations are listed below with an indication of the level of priority and possible timeline for implementation:

High priority, short term (1-5 years)

— Initiate a pilot trial in which a small-scale groundwater drainage system is installed and tested. Groundwater levels and drainage inflows should be monitored prior to, during and after testing. Groundwater salinity monitoring (in monitoring wells and in the drainage water) is also recommended. This provides valuable information on aquifer permeability, zone of influence of the drainage system, and further insights into the efficacy of groundwater drainage solutions. A pilot trial groundwater drainage test also provides an opportunity for DCC staff and stakeholders to become familiar the concept of groundwater drainage and with the systems involved. We recommend a well-thought-out pilot trial plan is drafted in which the objectives, approach and programme of such a test are clearly described.

— Open water features (Forbury Park basin and proposed canals) will likely become brackish or even saline over time, in all scenarios investigated. The ecological impacts need further assessment, which will inform the design, landscaping (e.g., planting of salt tolerant vegetation) and long-term maintenance of the proposed open water features. Underground services (e.g., cables, pipes, fittings, manholes, etc.) could be affected by salt water, depending on the materials they are made of. A review of ways to mitigate saltwater corrosion of underground services (e.g., use of type of materials) for new underground services installations is recommended.

— Land settlement risks are expected to be minor (<50 mm) due to modest groundwater lowering of the proposed systems (i.e., generally no more than 0.8 m drawdown). However, more detailed investigations are recommended to confirm the magnitude of land settlement and what mitigation options could be considered if this is required.

— An integrated pumped groundwater and stormwater management system will have notable specific design implications (e.g., saline intrusion, varying pump regimes for dry-weather and for storm event control, etc.). An holistic multi-disciplinary approach is required to develop a robust suitable future-ready design of the stormwater and groundwater management system.

— The potential adaptation options considered all require a pumped scheme to be implemented, and this requires ongoing operational and maintenance efforts and costs, which are likely to increase considerably over time when the consequences of climate change and sea level rise become considerable. A comprehensive cost-benefit analysis is recommended based on further design work.

Low priority, long-term (>5 years)

- The saline intrusion that already occurs beneath South Dunedin and likely to increase in the future could be strongly driven by density-dependent flow. This process is currently not explicitly incorporated in the numerical groundwater modelling undertaken to date. Further modelling investigations to improve the understanding of saline intrusion and groundwater processes beneath the dune areas is recommended. These would inform the timeline within which a future stormwater and groundwater management system will become saline, and what measures are most effective to partially mitigate the saline intrusion. This may inform long-term decision making in relation to the stormwater and groundwater management of the area.
- Further investigations into the temporal changes in groundwater levels and flows in response to a significant storm event passing the area, or in case of a failure of the pumped scheme which causes groundwater drainage to cease, could be considered. Transient model calibration is required to confirm representative aquifer storativities to increase the accuracy of the model predictions. However, this may not impact design choices as a combined stormwater and groundwater management system will be designed to accommodate much higher stormwater flows.
- The permanent lowering of the groundwater table by the considered adaptation options could potentially reduce liquefaction effects, and further high-level investigation in the beneficial effects on liquefaction is recommended. However, this investigation may not be required to inform further design work for the pumped stormwater and groundwater management system.
- Additional modelling assuming various sea level rise conditions (i.e., associated with different sea level rise predictions and at different time steps) is recommended to better understand when the tipping points occur at which the subsequent stages of adaptation options are best implemented. Earth Sciences New Zealand (ESNZ) indicated they could provide improved high-resolution vertical land movement estimates to help inform this investigation. This may inform long-term decision making in relation to the stormwater and groundwater management of the area.

6 REFERENCES

Chambers LA, Hemmings B, Cox SC, Moore C, Knowling MJ, Hayley K, Rekker J, Mourot FM, Glassey P, Levy R (2023), Quantifying uncertainty in the temporal disposition of groundwater inundation under sea level rise projections. Front. Earth Sci. 11:1111065. doi: 10.3389/feart.2023.1111065.

Dunedin City Council (DCC), 2025, 3 Waters Integrated System Plan, Water for Generations, Planning for the next 50 years. Prepared as part of the Integrated System Planning programme, which informs the draft DCC Infrastructure Strategy, which in turn informs the draft 9 year plan 2025-2034.

Fordyce E, 2013, Groundwater dynamics of a shallow, coastal aquifer. A thesis submitted in partial fulfilment of the requirements of a Master of Applied Science in Environmental Management at the University of Otago, Dunedin, New Zealand, December 2013.

Freeze, R.A., Cherry, J.A., 1979, Groundwater, Prentice-Hall, Inc., ISBN 0-13-365312-9.

Glassey P, Barrell D, Forsyth J, Macleod R, 2002, The geology of Dunedin, New Zealand, and the management of geological hazards, Quaternary International 103 (2003) 23–40.

Glassey, P.J., Barrell, D.J.A., Smith Lyttle, B., Hornblow, S., Mackey, B., 2021, Characterising subsurface South Dunedin to better define multiple natural hazards, NZGS Symposium 2021, March 2021.

Golder, Deltares, 2017, Protection Options for Managing Rising Groundwater in South Dunedin, Review of International Case Studies, 1671023_7410-004-R-Rev2, July 2017

Otago Regional Council (ORC) 2012. The South Dunedin Coastal Aquifer & Effect of Sea Level Fluctuations, ISBN 978-0-478-37648-7.

Otago Regional Council (ORC) 2016. The Natural Hazards of South Dunedin, ISBN: 978-0-908324-35-4.

SBR 2007. *Ontwatering in stedelijk gebied. GD112-7 Publicatie in kader Beter Bouw- en Woonrijpmaken*. SBR, April 2007 (in Dutch).

Ritzema, H.P., 1994, Drainage Principles and Applications, ILRI Publication 16 Second Edition (Completely Revised), ISBN 90 70754 3 39.

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This report ('**Report**') has been prepared by WSP (via the Kia Rōpine group) exclusively for the South Dunedin Future Programme team (Dunedin City Council and Otago Regional Council) ('**Client**') in relation to the South Dunedin Future Programme – groundwater drainage modelling assessment of shortlisted potential adaptation options for Phase 3.4 - Spatial Short List of Adaptation Options ('**Purpose**') and in accordance with the Agreement. The findings in this Report are based on and are subject to the assumptions specified in the Report, the Agreement and associated attachments, and Client Data supplied during the data request phase. WSP accepts no liability whatsoever for any use or reliance on this Report, in whole or in part, for any purpose other than the Purpose or for any use or reliance on this Report by any third party.

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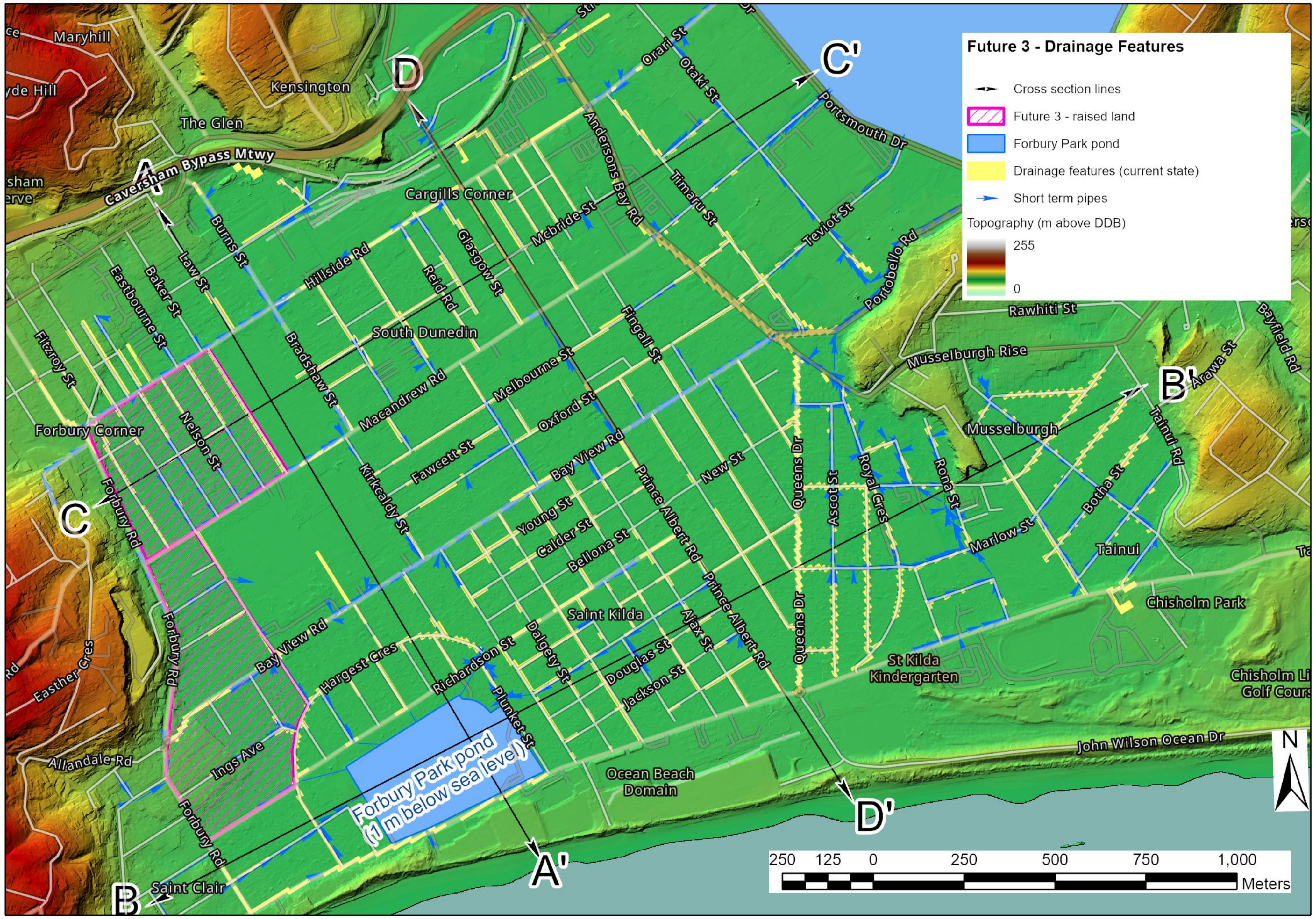
SOUTH DUNEDIN FUTURE
DUNEDIN CITY COUNCIL kaunihera a-rohe o Ōtepoti
Otago Regional Council

APPENDIX A – GROUNDWATER DRAINAGE OPTIONS MAPS


Current State - Drainage Features
Cross section lines
Drainage features (current state)
Topography (m above DDB)
255
0
A
A'
B
B'
C
C'
D
D'
Maryhill
Kensington
The Glen
Cargill's Corner
South Dunedin
Forbury Corner
Sunshine
Rawhiti St
Musselburgh Rise
Musselburgh
Tainui
Chisholm Park
Saint Kilda
St Kilda Kindergarten
Ocean Beach Domain
Portsmouth Dr
John Wilson Ocean Dr
Easther Cres
Allandale Rd
Saint Clair
N
250 125 0 250 500 750 1,000
Meters

1

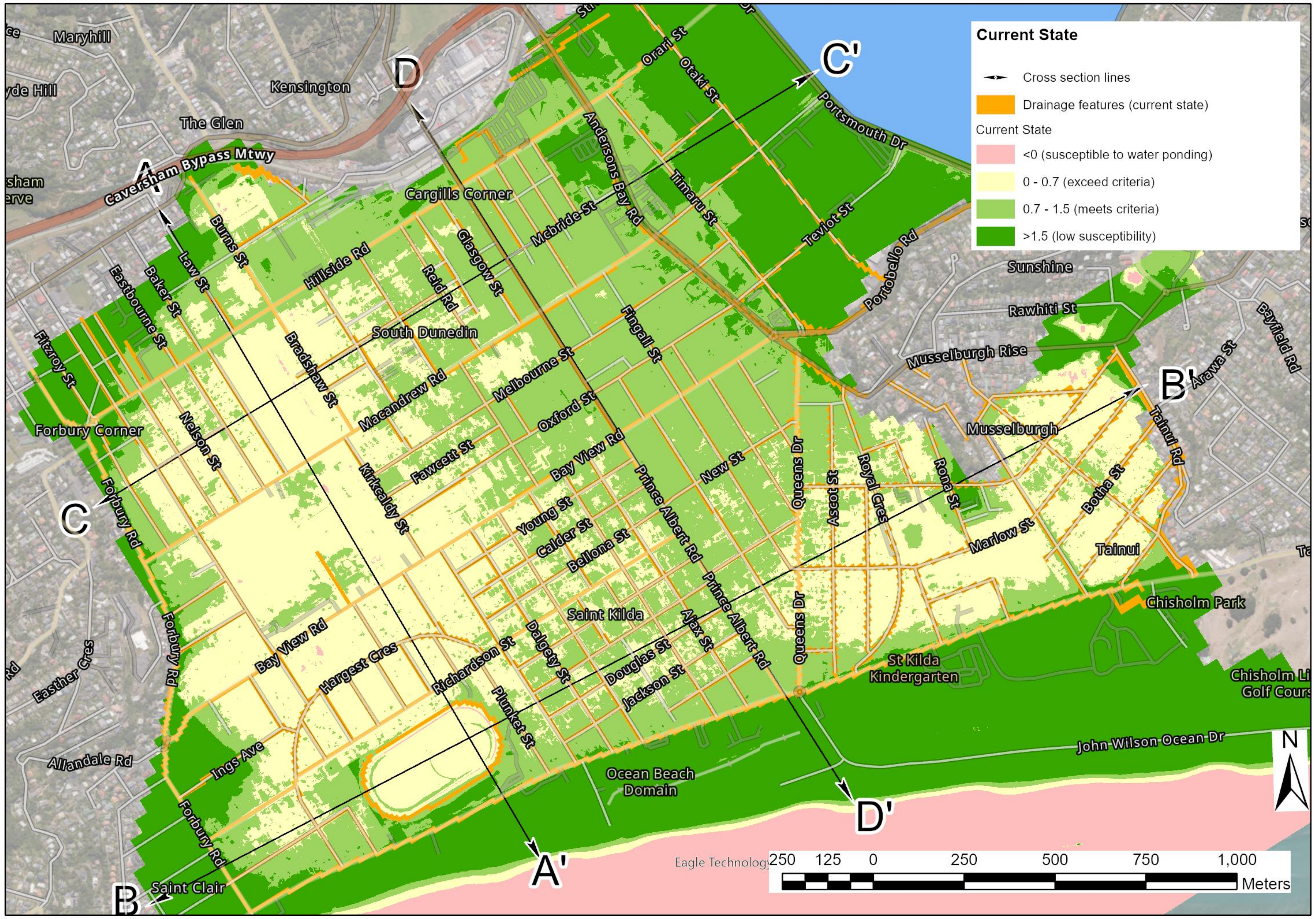

Future 3 - Drainage Features
Cross section lines
Future 3 - raised land
Forbury Park pond
Drainage features (current state)
Short term pipes
Topography (m above DDB)
255
0
Forbury Park pond
(1 m below sea level)
A
A'
B
B'
C
C'
D
D'
Maryhill
Kensington
The Glen
Caversham Bypass Mtwy
Cargills Corner
South Dunedin
Forbury Corner
Saint Kilda
Musselburgh
Tainui
Chisholm Park
St Kilda Kindergarten
Ocean Beach Domain
Saint Clair
John Wilson Ocean Dr
N
250 125 0 250 500 750 1,000
Meters

2


Future 4&5 - Drainage Features
Cross section lines
Future 5 - raised land
Forbury Park pond
Drainage features (current state)
New canals
Short term pipes
Topography (m above DDB)
255
0
MacAndrew canal (0.6 m below sea level)
Bellona canal (0.8 m below sea level)
West canal (1 m below sea level)
Coughtrey canal (0 to 1 m below sea level)
Forbury Park pond (1 m below sea level)
Victoria canal (0 to 1 m below sea level)
A
A'
B
B'
C
C'
D
D'
250 125 0 250 500 750 1,000
Meters
N

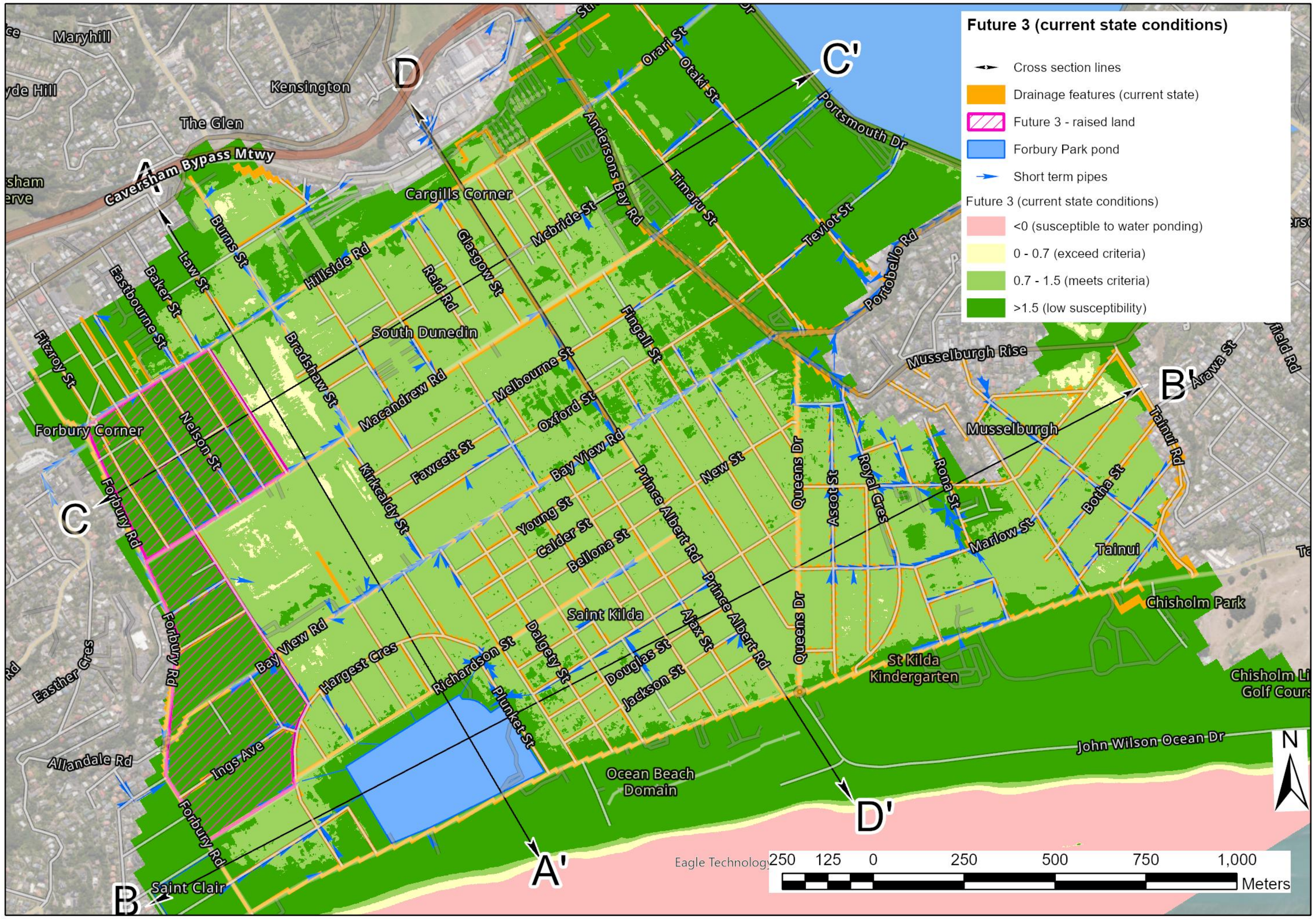
3

APPENDIX B – GROUNDWATER DRAINAGE RESULTS MAPS AND CROSS SECTIONS

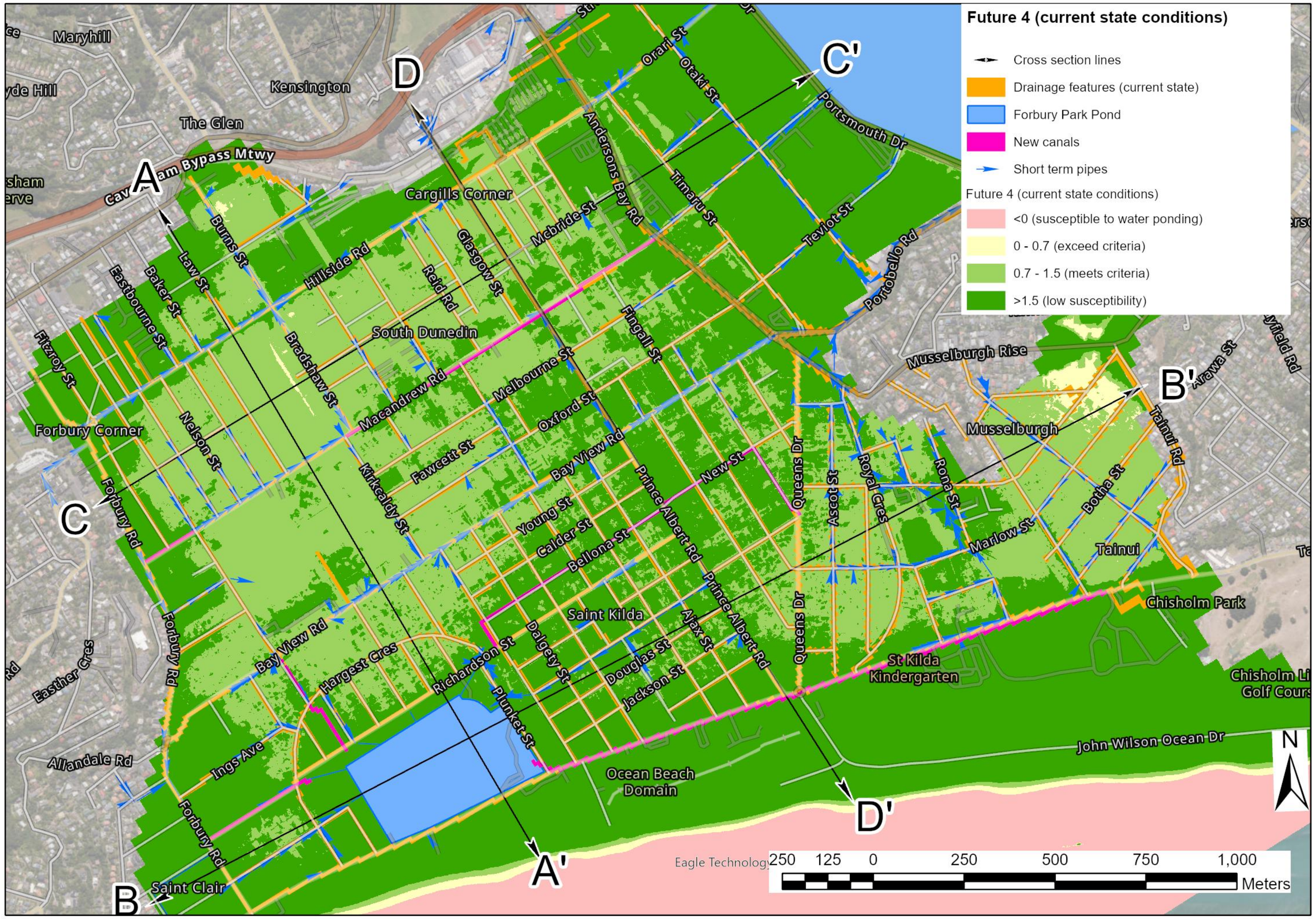

Current State
Cross section lines
Drainage features (current state)
Current State
<0 (susceptible to water ponding)
0 - 0.7 (exceed criteria)
0.7 - 1.5 (meets criteria)
>1.5 (low susceptibility)
A
A'
B
B'
C
C'
D
D'
Maryhill
Kensington
The Glen
Caversham Bypass Mtwy
Cargills Corner
South Dunedin
Forbury Corner
Saint Kilda
Musselburgh
Sunshine
Tainui
Chisholm Park
St Kilda Kindergarten
Ocean Beach Domain
Saint Clair
John Wilson Ocean Dr
Portsmouth Dr
Queens Dr
Prince Albert Rd
Forbury Rd
N
Eagle Technology
250 125 0 250 500 750 1,000
Meters

1

wsp

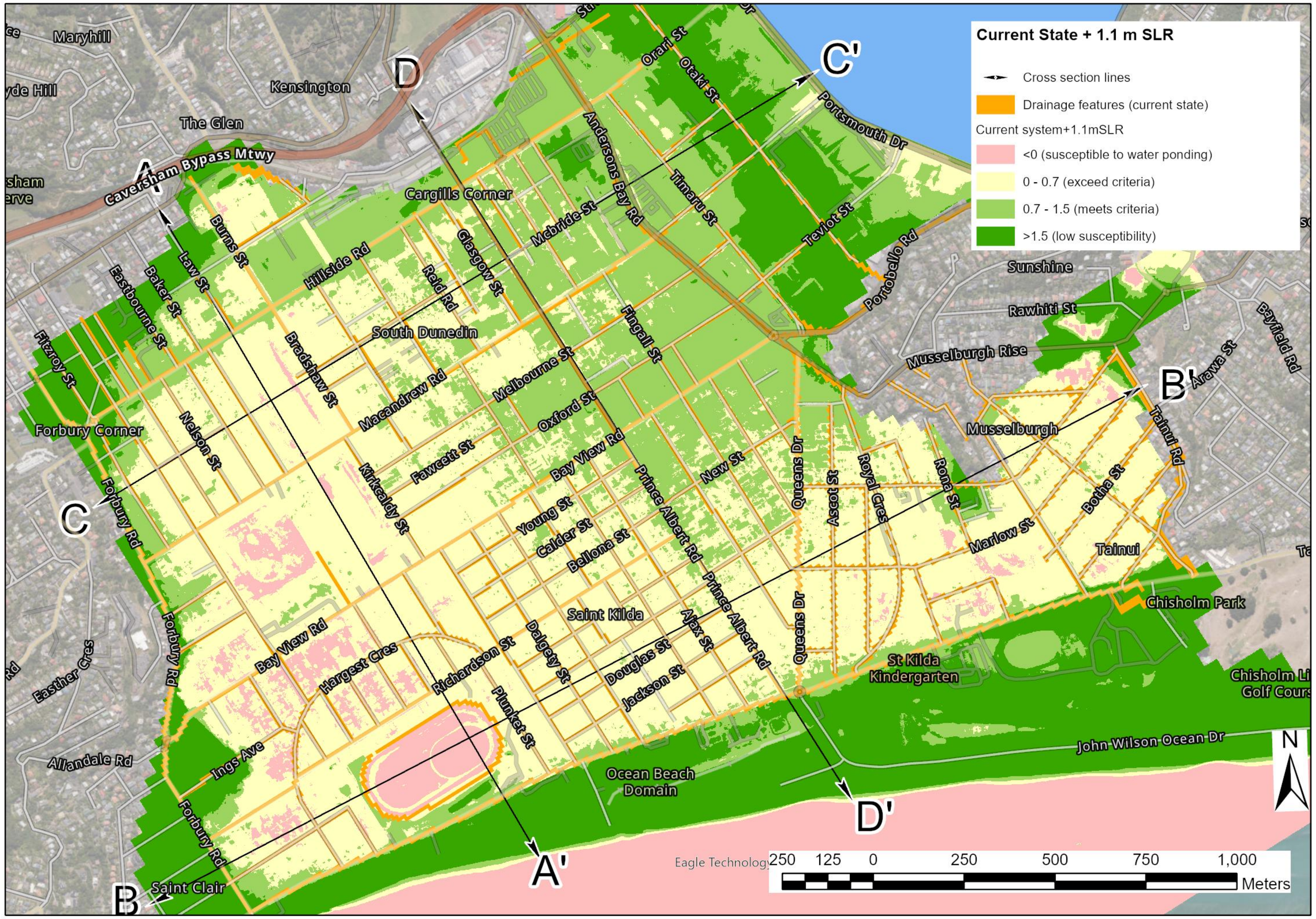

Future 3 (current state conditions)
Cross section lines
Drainage features (current state)
Future 3 - raised land
Forbury Park pond
Short term pipes
Future 3 (current state conditions)
<0 (susceptible to water ponding)
0 - 0.7 (exceed criteria)
0.7 - 1.5 (meets criteria)
>1.5 (low susceptibility)
A
A'
B
B'
C
C'
D
D'
South Dunedin
Saint Kilda
Musselburgh
Tainui
Forbury Corner
Cargills Corner
Kensington
The Glen
Maryhill
Caversham Bypass Mtwy
Ocean Beach Domain
Saint Clair
Chisholm Park
St Kilda Kindergarten
Musselburgh Rise
John Wilson Ocean Dr
Eagle Technology
250 125 0 250 500 750 1,000
Meters
N

2


Future 4 (current state conditions)
Cross section lines
Drainage features (current state)
Forbury Park Pond
New canals
Short term pipes
Future 4 (current state conditions)
<0 (susceptible to water ponding)
0 - 0.7 (exceed criteria)
0.7 - 1.5 (meets criteria)
>1.5 (low susceptibility)
A
A'
B
B'
C
C'
D
D'
Maryhill
Kensington
The Glen
Cargills Corner
South Dunedin
Forbury Corner
Saint Kilda
Musselburgh
Musselburgh Rise
Tainui
Chisholm Park
St Kilda Kindergarten
Ocean Beach Domain
Saint Clair
John Wilson Ocean Dr
Portsmouth Dr
Portobello Rd
Hillside Rd
Macandrew Rd
Bay View Rd
Forbury Rd
Prince Albert Rd
Queens Dr
Allandale Rd
Ings Ave
Hargest Cres
Richardson St
Plunket St
Eagle Technology
250 125 0 250 500 750 1,000
Meters
N

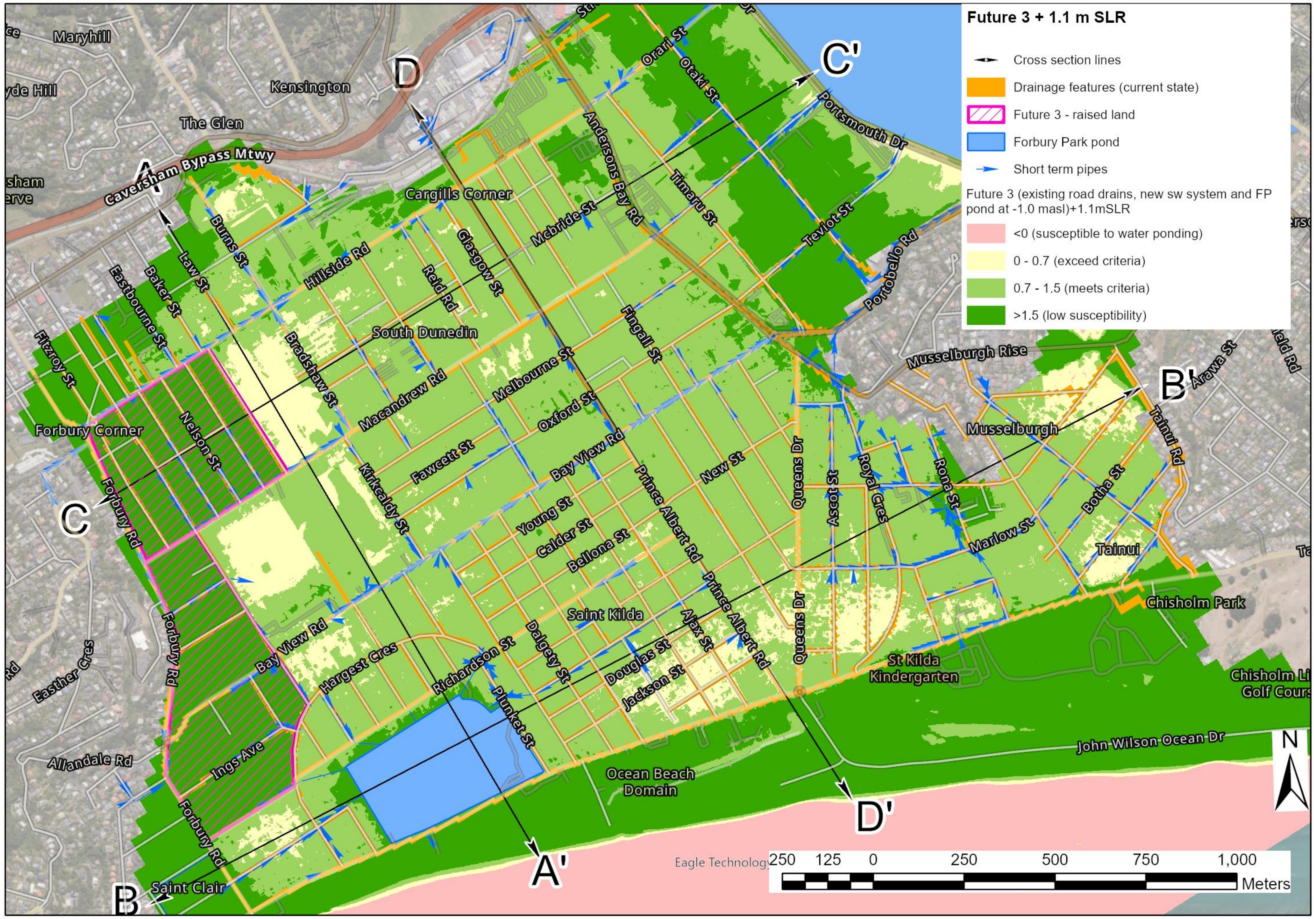
3

wsp

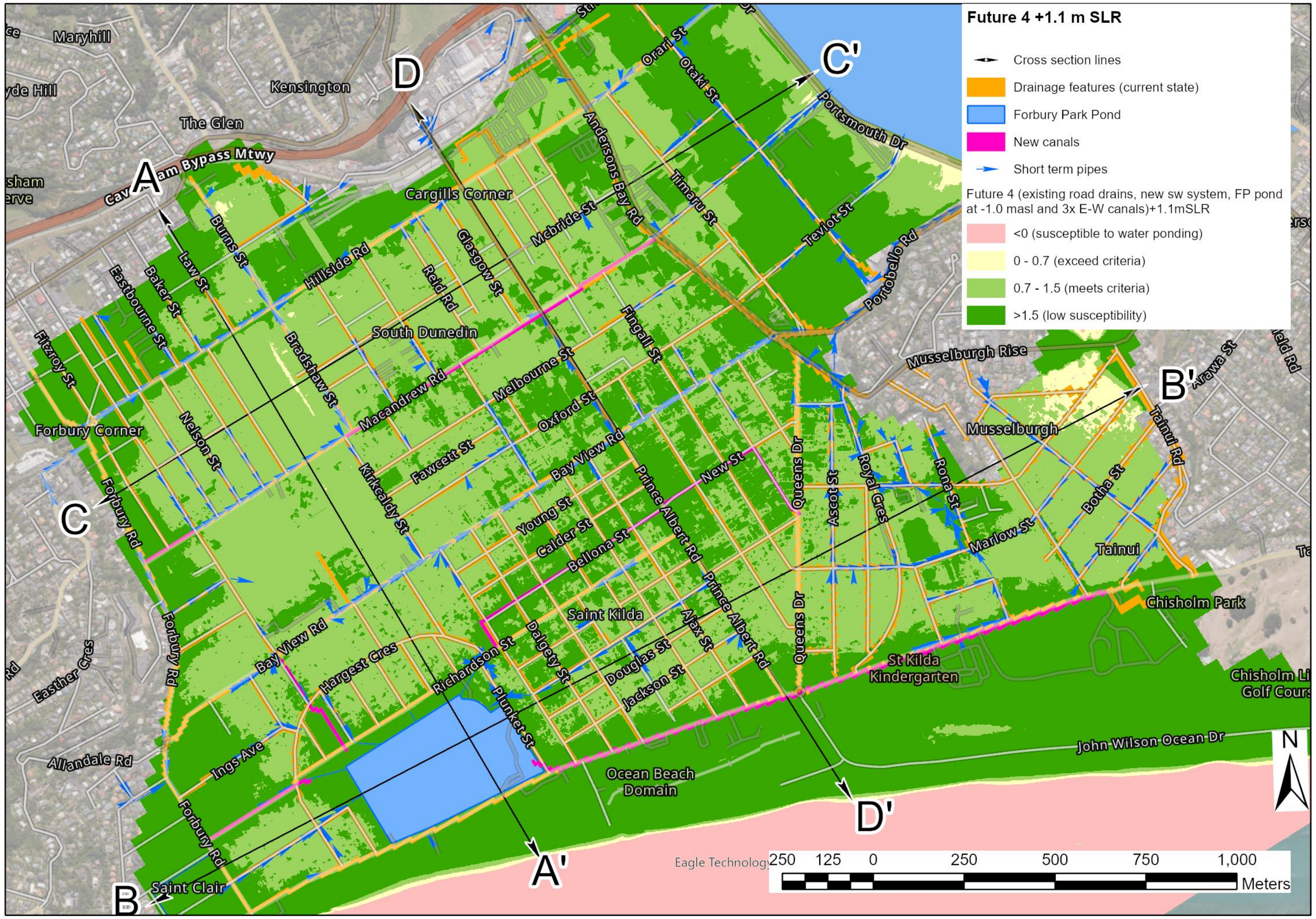

Current State + 1.1 m SLR
Cross section lines
Drainage features (current state)
Current system+1.1mSLR
<0 (susceptible to water ponding)
0 - 0.7 (exceed criteria)
0.7 - 1.5 (meets criteria)
>1.5 (low susceptibility)
A
A'
B
B'
C
C'
D
D'
Caversham Bypass Mtwy
Kensington
The Glen
Maryhill
Cargills Corner
South Dunedin
Forbury Corner
Saint Kilda
Saint Clair
Musselburgh
Sunshine
Tainui
Chisholm Park
Ocean Beach Domain
St Kilda Kindergarten
John Wilson Ocean Dr
Eagle Technology
250 125 0 250 500 750 1,000
Meters
N

4

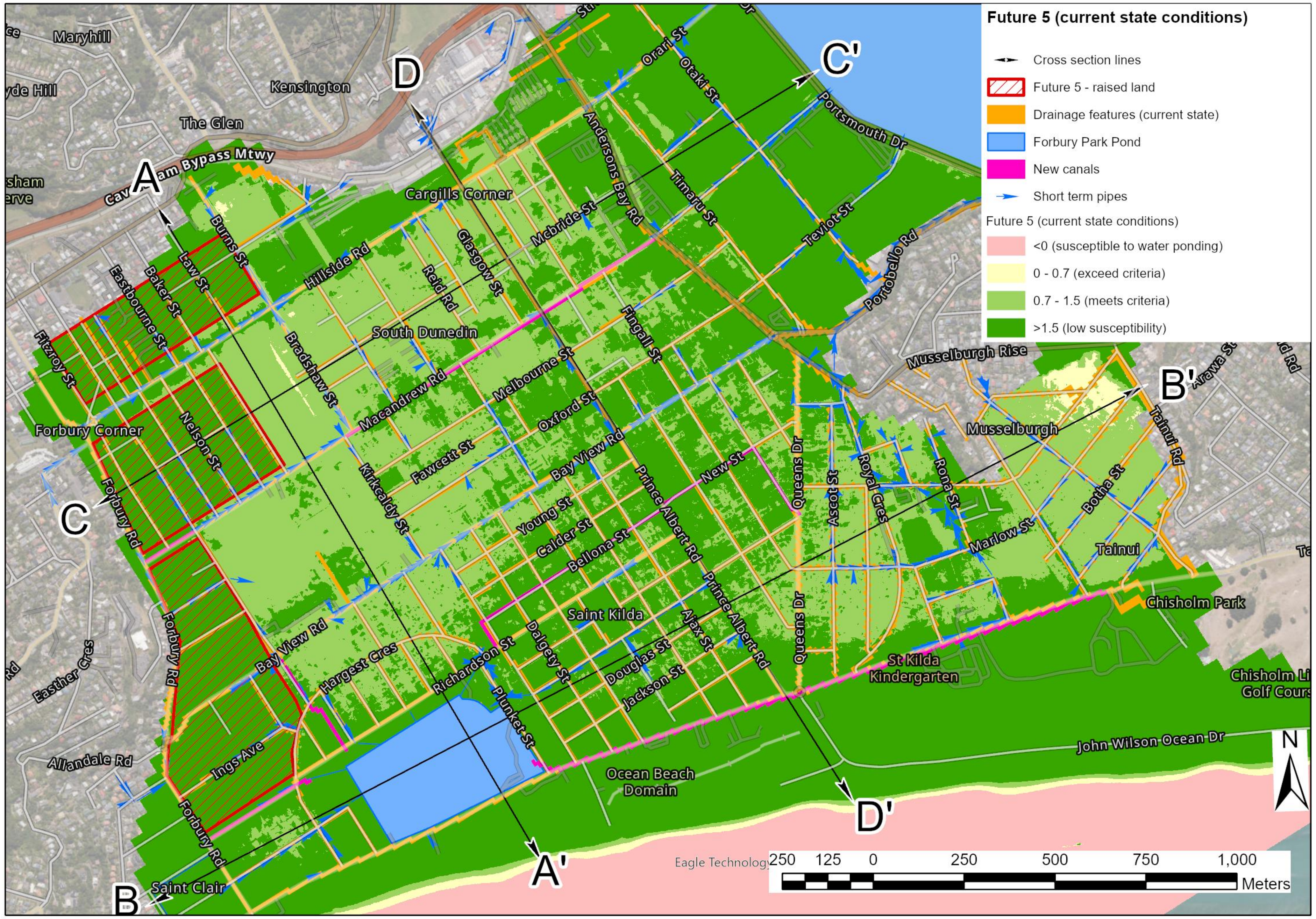
wsp


Future 3 + 1.1 m SLR
Cross section lines
Drainage features (current state)
Future 3 - raised land
Forbury Park pond
Short term pipes
Future 3 (existing road drains, new sw system and FP pond at -1.0 masl)+1.1mSLR
<0 (susceptible to water ponding)
0 - 0.7 (exceed criteria)
0.7 - 1.5 (meets criteria)
>1.5 (low susceptibility)
A
A'
B
B'
C
C'
D
D'
Maryhill
Kensington
The Glen
Caversham Bypass Mtwy
Cargills Corner
South Dunedin
Forbury Corner
Saint Kilda
Musselburgh
Musselburgh Rise
Tainui
Chisholm Park
St Kilda Kindergarten
Ocean Beach Domain
Saint Clair
John Wilson Ocean Dr
Portsmouth Dr
Portobello Rd
Queens Dr
Prince Albert Rd
Forbury Rd
Bay View Rd
Hillside Rd
Andersons Bay Rd
Eagle Technology
250 125 0 250 500 750 1,000
Meters
N

5

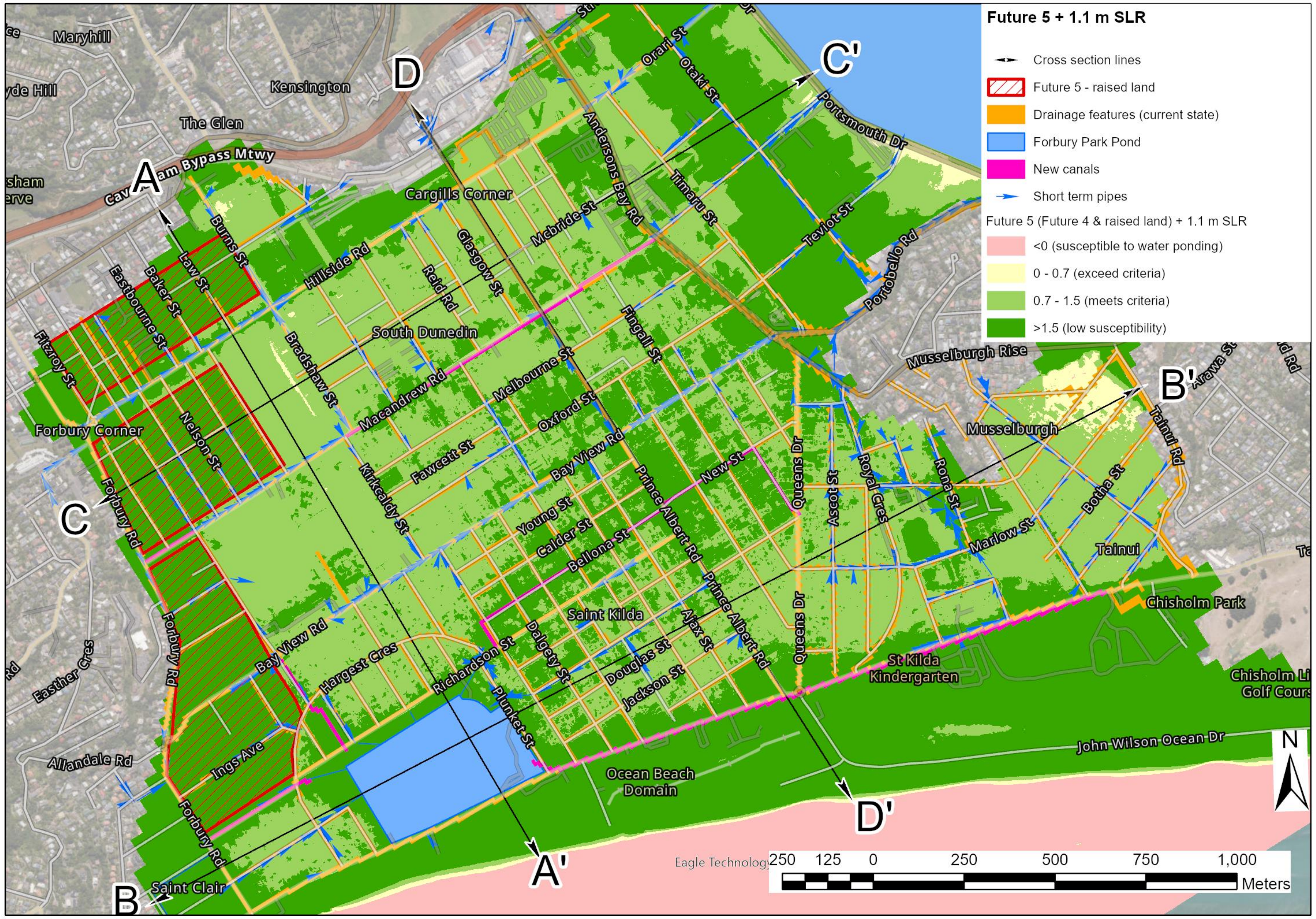

Future 4 +1.1 m SLR
Cross section lines
Drainage features (current state)
Forbury Park Pond
New canals
Short term pipes
Future 4 (existing road drains, new sw system, FP pond at -1.0 masl and 3x E-W canals)+1.1mSLR
<0 (susceptible to water ponding)
0 - 0.7 (exceed criteria)
0.7 - 1.5 (meets criteria)
>1.5 (low susceptibility)
A
A'
B
B'
C
C'
D
D'
Maryhill
Kensington
The Glen
Cargills Corner
South Dunedin
Forbury Corner
Musselburgh
Musselburgh Rise
Tainui
Chisholm Park
Saint Kilda
St Kilda Kindergarten
Ocean Beach Domain
Saint Clair
John Wilson Ocean Dr
Portsmouth Dr
Portobello Rd
Queens Dr
Forbury Rd
Prince Albert Rd
Hillside Rd
Macandrew Rd
Bay View Rd
Andersons Bay Rd
Eagle Technology
250 125 0 250 500 750 1,000
Meters
N

6


Future 5 (current state conditions)
Cross section lines
Future 5 - raised land
Drainage features (current state)
Forbury Park Pond
New canals
Short term pipes
Future 5 (current state conditions)
<0 (susceptible to water ponding)
0 - 0.7 (exceed criteria)
0.7 - 1.5 (meets criteria)
>1.5 (low susceptibility)
A
A'
B
B'
C
C'
D
D'
Maryhill
Kensington
The Glen
Cargills Corner
South Dunedin
Forbury Corner
Saint Kilda
Musselburgh
Tainui
Chisholm Park
St Kilda Kindergarten
Ocean Beach Domain
Saint Clair
Hillside Rd
Forbury Rd
Prince Albert Rd
Queens Dr
Portsmouth Dr
John Wilson Ocean Dr
Eagle Technology
250 125 0 250 500 750 1,000
Meters
N

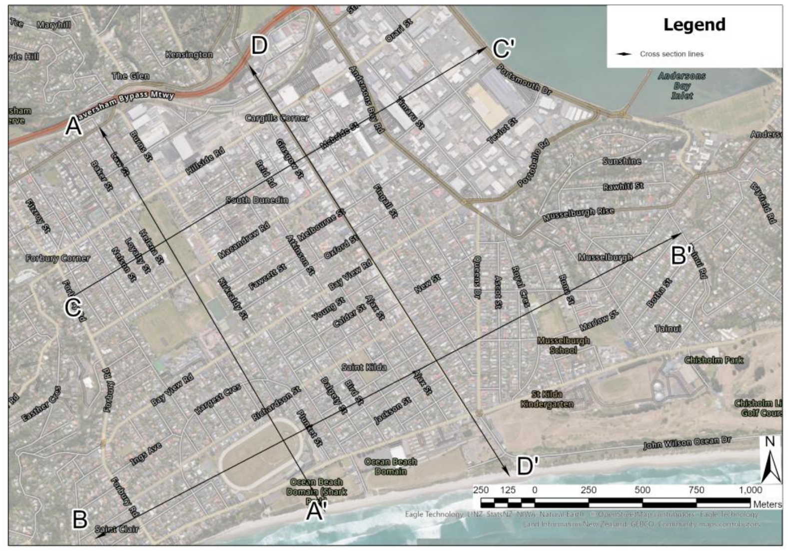
7

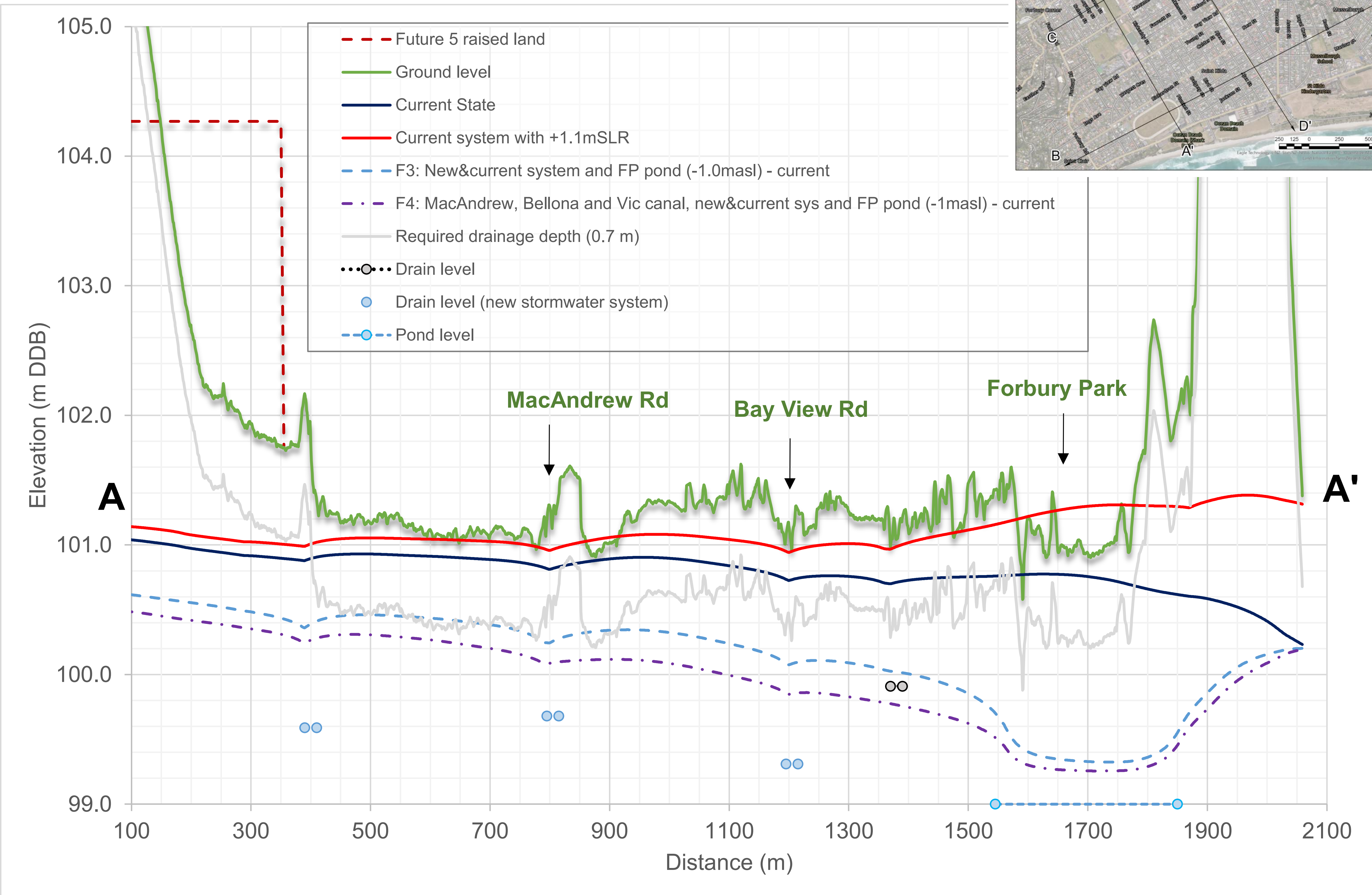
wsp


Future 5 + 1.1 m SLR
Cross section lines
Future 5 - raised land
Drainage features (current state)
Forbury Park Pond
New canals
Short term pipes
Future 5 (Future 4 & raised land) + 1.1 m SLR
<0 (susceptible to water ponding)
0 - 0.7 (exceed criteria)
0.7 - 1.5 (meets criteria)
>1.5 (low susceptibility)
A
A'
B
B'
C
C'
D
D'
N
250 125 0 250 500 750 1,000
Meters
Eagle Technology

8

Section A-A'' (current)





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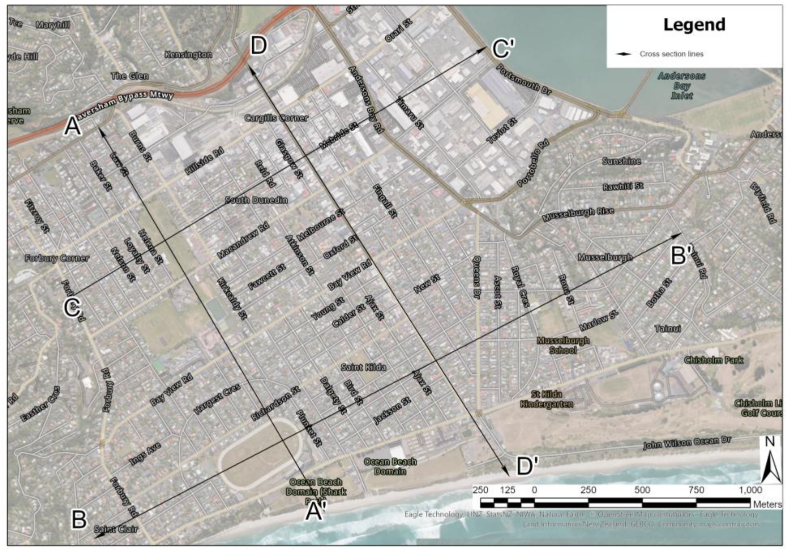
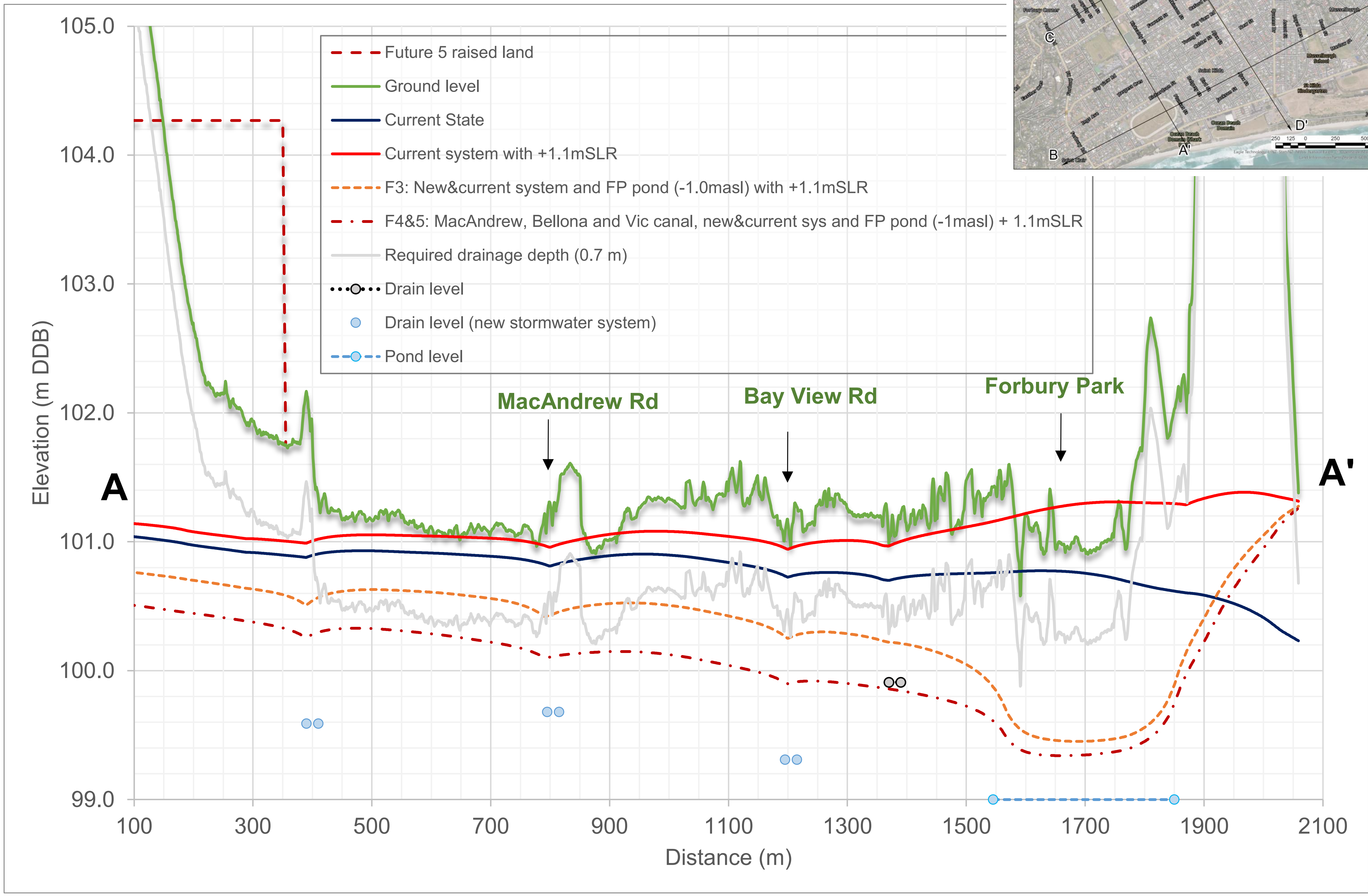
Section A-A" (SLR)





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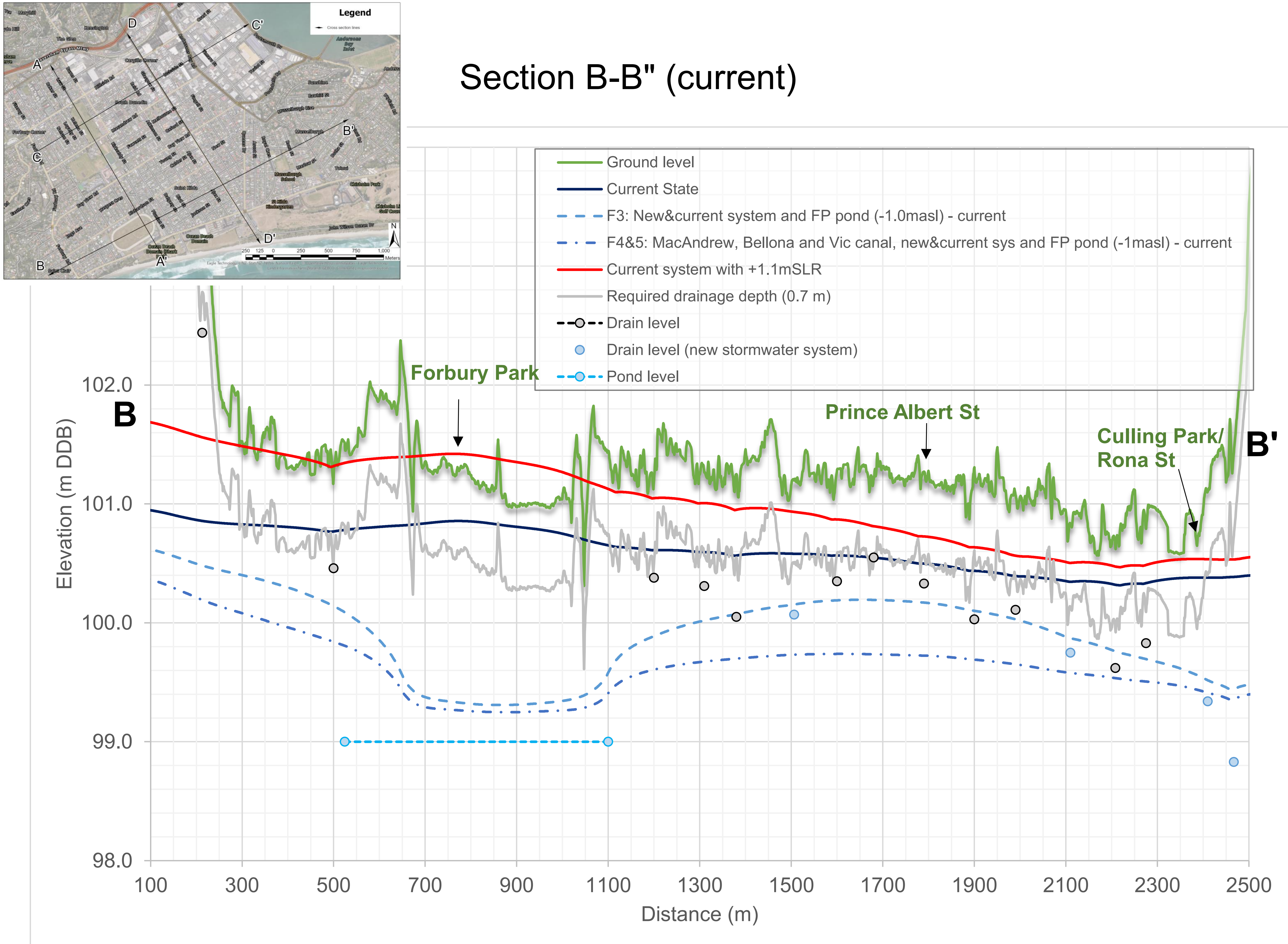

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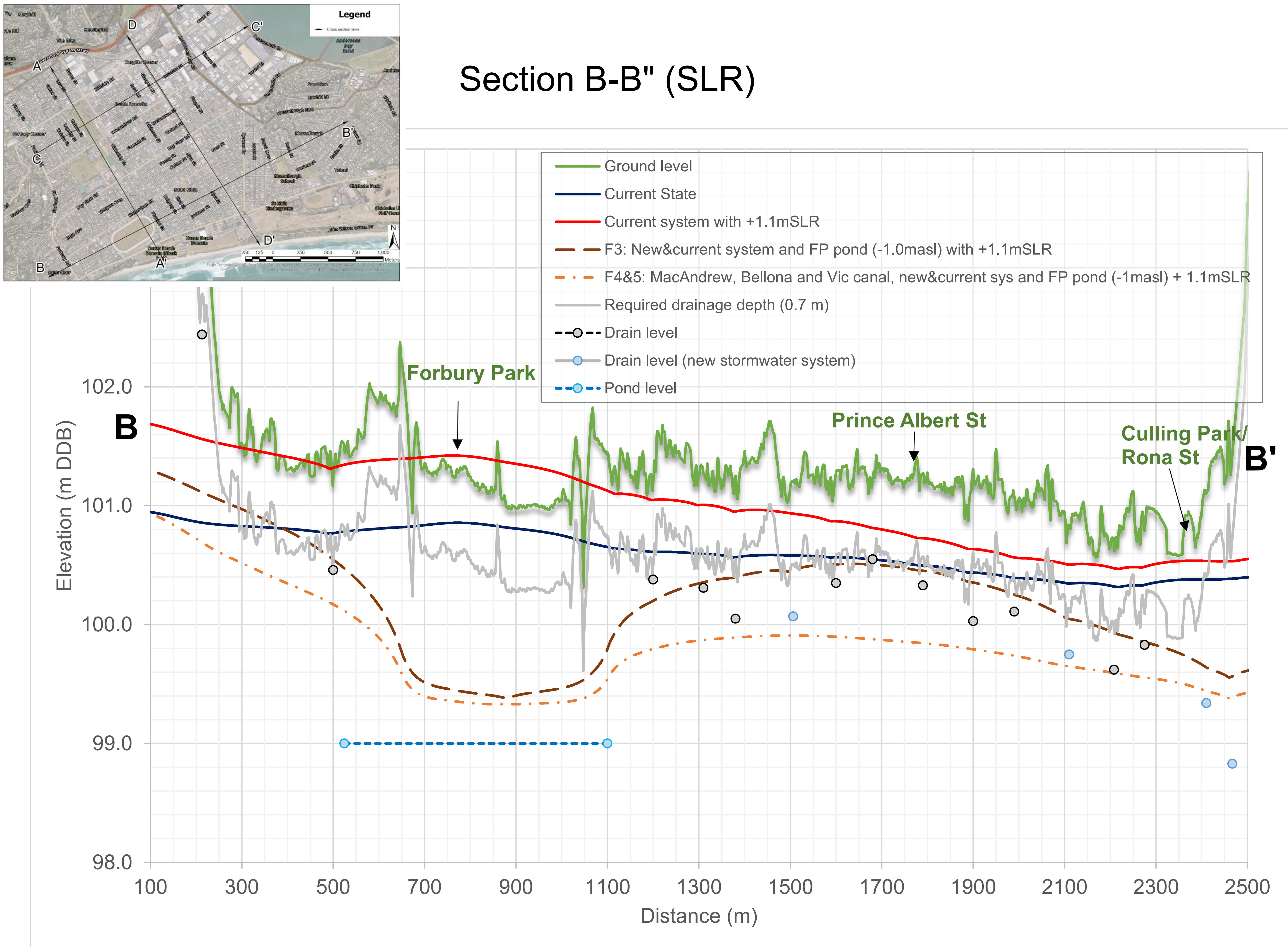

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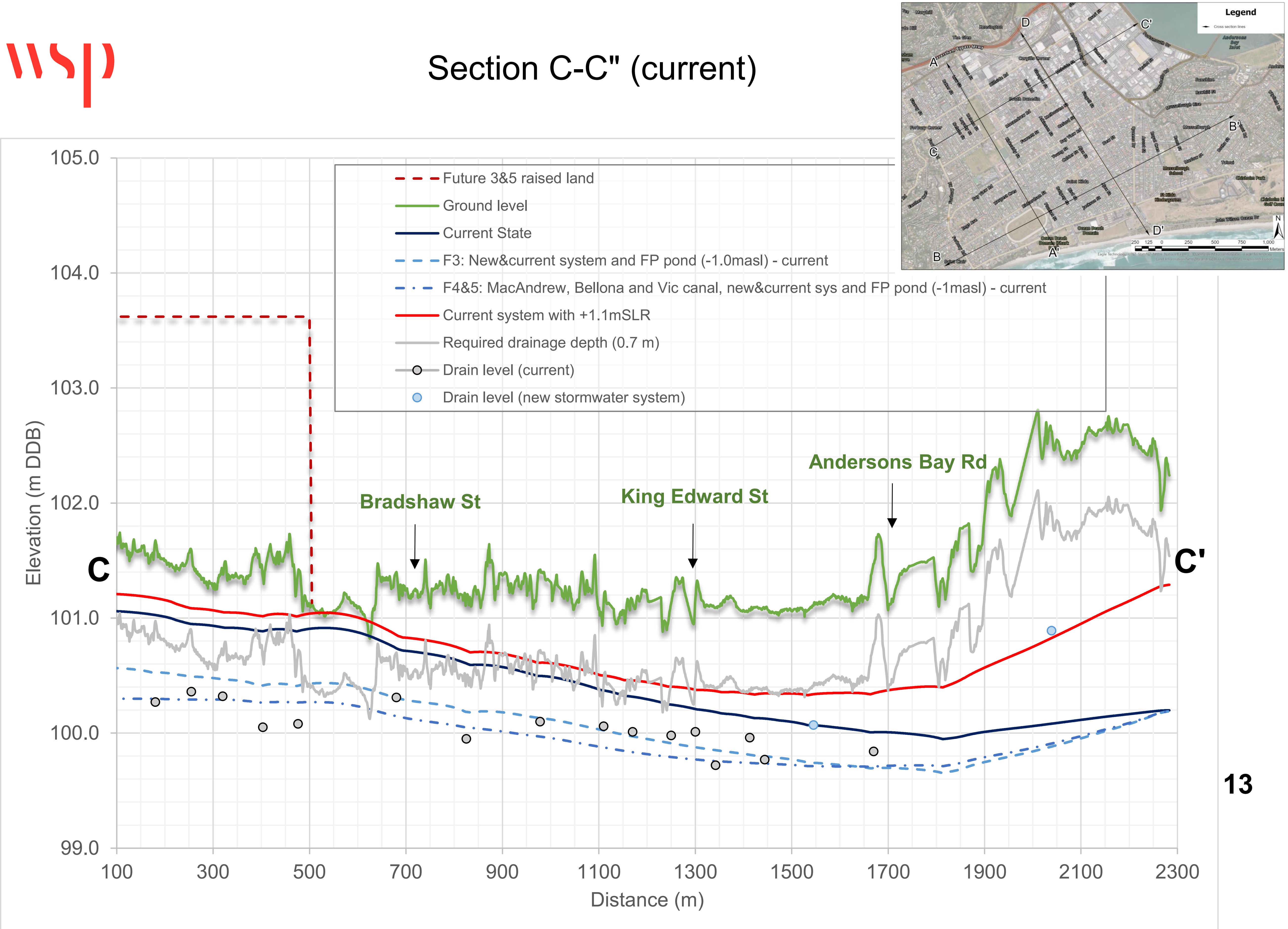

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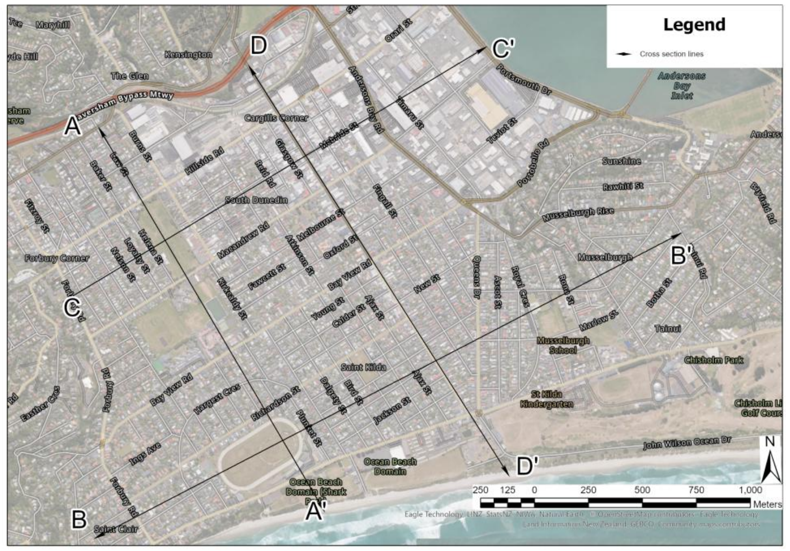
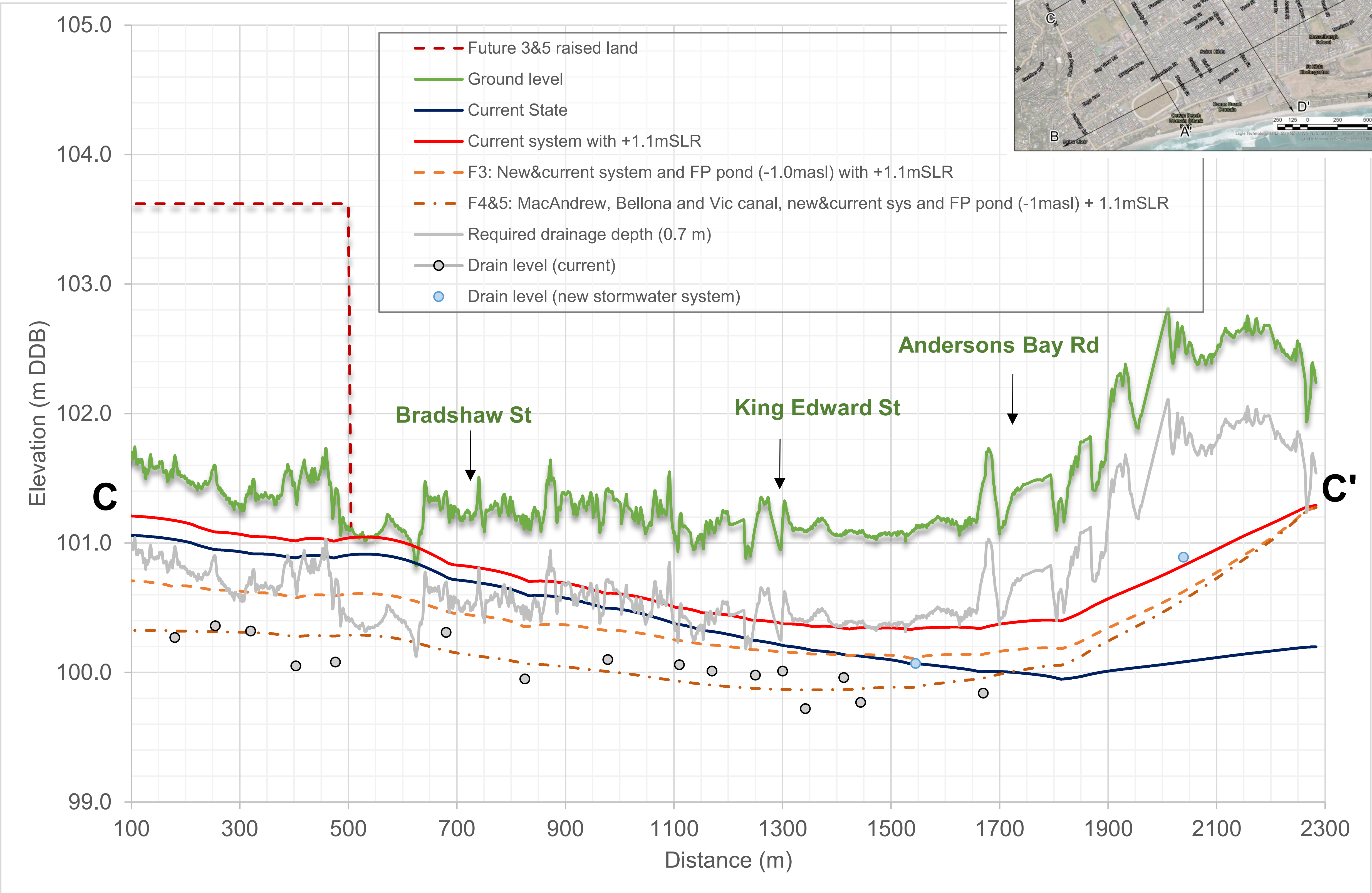
Section C-C" (SLR)





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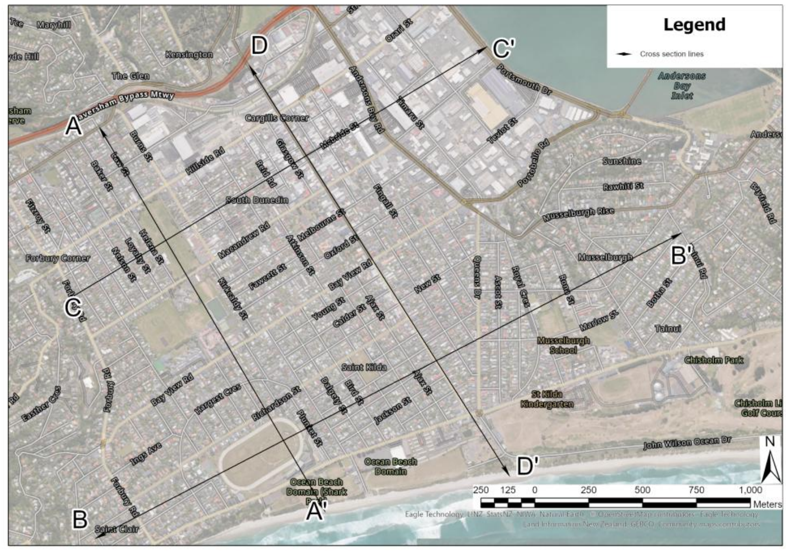

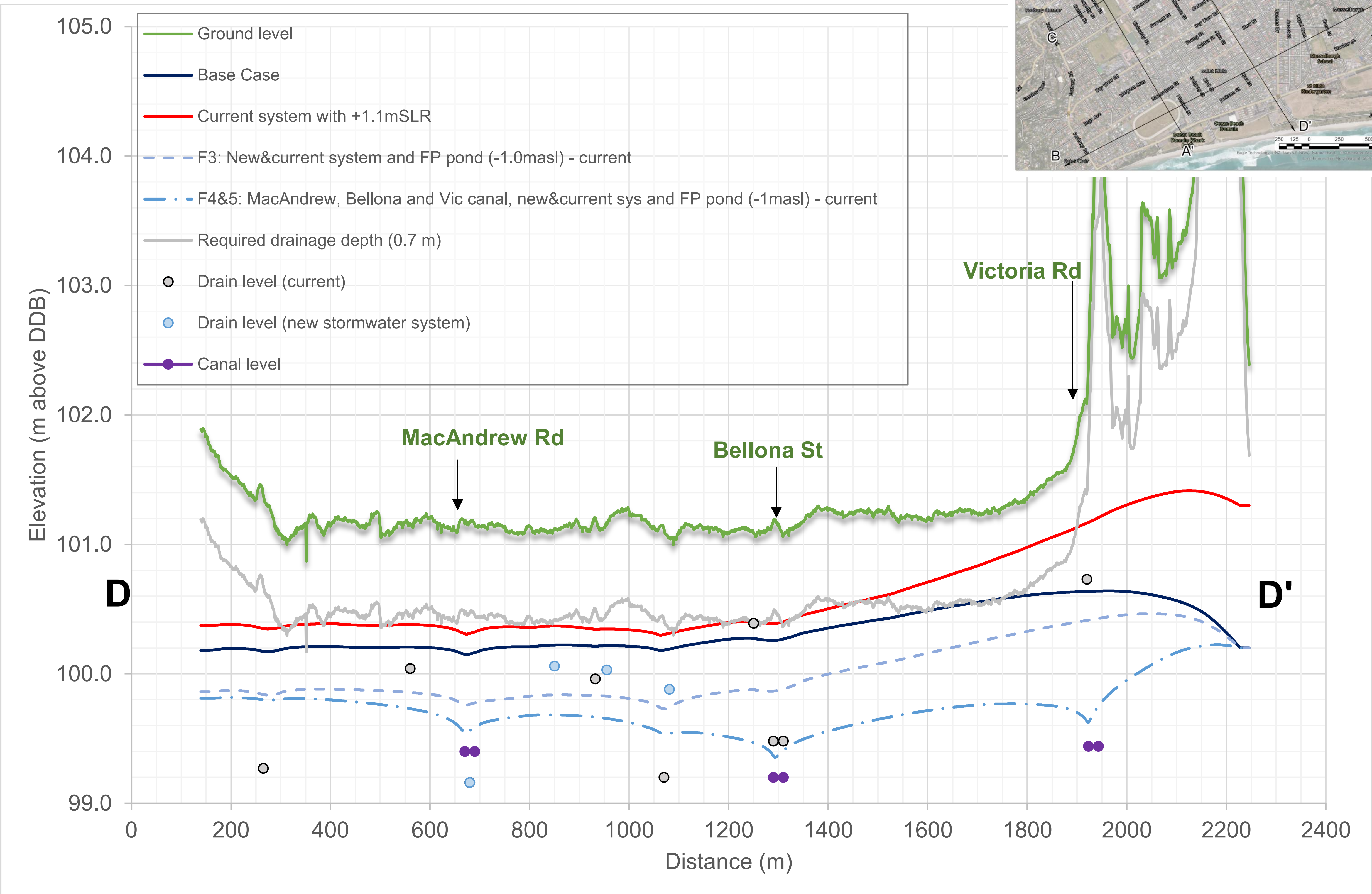

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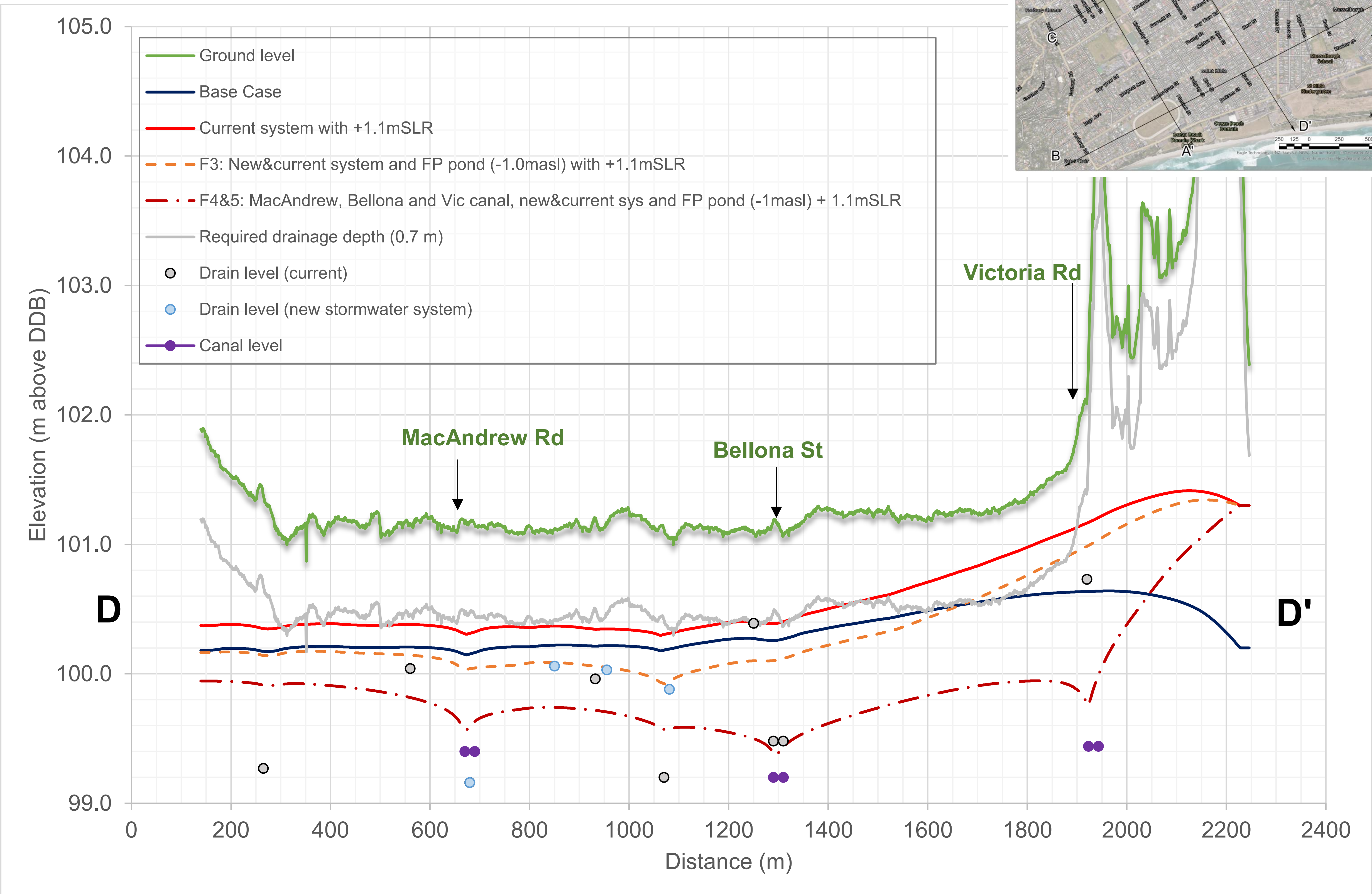
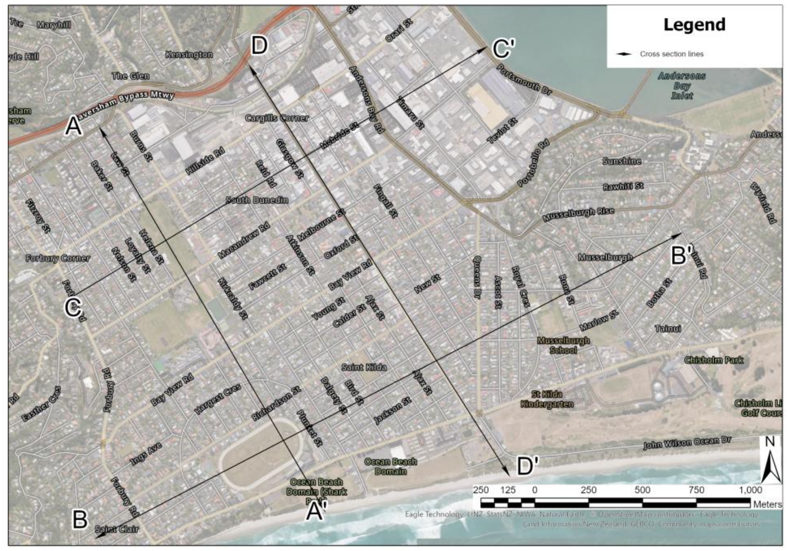
wsp

Section D-D" (SLR)





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SOUTH DUNEDIN FUTURE

SHORTLIST ECONOMIC EVALUATION (REVISION 4.1)

May 2026

SOUTH DUNEDIN FUTURE

SHORTLIST ECONOMIC EVALUATION

REV	DATE	DETAILS
1.0	15/12/25	For Review
2.0	20/02/26	Post Peer Review & Client Comments received and report amended Additional changes to economic modelling to represent Annual Average Damages not the explicit 1% AEP damages and damages avoided.
2.1	25/02/26	Section 2.2 on Discount Rate amended to reflect economic model (as V1). Minor text improvements to - Sections 3.2.6,.3.3, 4, 8.2.1 &8.2.3 - Tables 3-C, 8-E & 8-F
3.0	02/04/26	Further amendments post reviews with Council and Peer Review. - Revisions to BCR following on from further modelling (including changes to costs and modelled benefits. Discount Rate change to SOC from WACC. - Dwelling numbers reduced in line with address point information received – not individual building level costs) - Additional analysis re SRTP (Section 3). - Textual & language changes to support understanding. - Inclusion of coastal damages avoided approach within Core BCR for Medium & Long Term to properties only - Simplification of Assessment against Status Quo ONLY. Do Nothing removed. Modelling received for Status Quo modelling and analysed – Brings economic report into consistency with the other SDF outputs for this phase.
4.0	May 26	Minor consistency changes and typos resolved following further Client Review, alongside other deliverables.
4.1	May 26	Figures 4.1, 4.3 and 4.5 updated

Version 4.1	NAME	DATE	SIGNATURE
Prepared By	Liam Foster	21/05/2026	ON FILE for V4.0
Reviewed by	Quanita Ali	21/05/2026	
Approved by	Kevin Wood	21/05/2026	

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In addition, climate change is an evolving field, with uncertainty inherent in projections of future conditions, and unknowns which cannot be precisely estimated with present science. These matters should be considered by the Client as part of any decision-making and planning. Regular monitoring of actual data (e.g. sea level rise) and regular review and updates of the work contained in this report to take account of developments in scientific knowledge and changes in international and national guidance should be undertaken.

This report is not intended to provide financial, investment, or legal advice. It should not be used as the sole basis for making financial or strategic decisions. The Client is encouraged to seek professional advice in these areas. Due to the nature and stage of the project, broad assumptions have been made to support costing of options. The status of this cost estimate represents at best a strategic stage. It presents a range of potential future states for South Dunedin for comparative uses ONLY. Cost estimates are exclusive of GST, project development, legal or marketing costs, escalation, operational costs/ downtime due to operations, removal of large / unforeseen ground objects, contaminated waste disposal or rebuild of existing properties in new location.

TABLE OF CONTENTS

APPENDICES

GLOSSARY

- AAD (Annual Average Damage) - A long-term annualised estimate of average flood related damages across multiple events and probabilities. AAD is the primary metric for quantifying benefits in the shortlist economic evaluation, replacing single event AEP damage estimates. The reduction in Expected Annual Damage (AAD) delivered by each proposed future relative to the Status Quo baseline. The Status Quo which incorporates current LTP stormwater investment and, from the medium term onwards, coastal inundation exposure is the sole reference comparator in this evaluation. A standalone 'Do Nothing' scenario was included in earlier phases of the programme but has been removed from this shortlist analysis to align with the framing used across all other SDF shortlist outputs. All benefit estimates are therefore measured as damages avoided relative to the Status Quo trajectory, not against a hypothetical zero-investment baseline.
- AEP (Annual Exceedance Probability) -The probability that a flood event of a given magnitude (e.g., 10%, 2%, 1% AEP) will occur in any year. AEP values are used only as modelling inputs, not as the basis for benefit quantification.
- Avoided Damages / Avoided AAD - The difference between the Expected Annual Damage under the Status Quo scenario and the Expected Annual Damage for one of the three future scenarios (Futures 3 – 5). This forms the core economic benefit used in the evaluation.
- BCR (Benefit–Cost Ratio) - The ratio of the present value of benefits to the present value of costs. In the revised framework, headline BCRs reflect Base Case Benefits only (AAD based avoided damages).
- Efficacy modelling – Represents the outputs from the pluvial hydraulic modelling exercise undertaken to support the assessment of the efficacy of the proposed futures against the status quo (also known as stormwater modelling).
- Futures 3, 4, 5 (Proposed Adaptation Futures) - The three futures selected following technical, economic and community assessment. They differ in adaptation strategy, staging, infrastructure mix, and extent of land use change.
- Hedonic Uplift - Increases in land or property values arising from reduced hazard exposure or improved amenity. Treated as Supplementary Benefits, not included in the Core BCR, due to double counting risks.
- LoS (Level of Service) Proxy - A monetised placeholder representing enhanced service or amenity levels (often set as a percentage of CAPEX). Considered a noncore benefit because of uncertain empirical basis and overlap with avoided damages.
- Residual Risk - The remaining level of flood risk after adaptation interventions are implemented, informed by the residual risk modelling inputs memo.
- Status Quo - An intervention scenario based on current LTP funding, used for comparison where proposed short-term and medium-term interventions are undertaken (as included in current Long-Term Plan) – with the remaining area subject to only essential renewals and limited maintenance. This represents the base against which other futures are compared.
- Supplementary Benefits - Benefits such as hedonic uplift (including LoS) that are presented separately to maintain defensibility and avoid inflating BCRs.

KEY FINDINGS

Dunedin City Council (DCC) has engaged Kia Rōpine (KR) to provide an economic evaluation of the short list of possible futures for South Dunedin, as part of the latest stage of adaptation planning work under the South Dunedin Future Programme.

SCOPE

This economic evaluation exists to answer a specific question: Does the evidence support investment in adaptation, and if so, which adaptation future delivers the most value for the public dollar? The answer requires holding two things in view simultaneously: what it will cost the community to act, and what it will cost the community not to.

The evaluation covers 100 years from 2027. This is not an arbitrary timeframe. Infrastructure investment of the kind contemplated in each future has a design life measured in decades. The consequences of under-investing in the past and continuing this through the 2020s will be felt in damage, in lost property value, in deteriorating liveability well into the 2070s and beyond. A 100-year lens is the minimum needed to capture the full arc of both costs and benefits.

Four futures are assessed: the Status Quo, which captures current planned LTP stormwater investments and maintains current assets without major new adaptation; Future 3 (Protect); Future 4 (Restore); and Future 5 (Reshape).

All three adaptation futures are compared against the Status Quo, a scenario in which current proposed projects have been implemented. It is the reference against which avoided damages are calculated, and it represents the possible trajectory of accumulated harm, based on the existing urban form and approved stormwater infrastructure at time of drafting.

Future regeneration use of the land is subject to separate decision-making and investigation with Council and will be assessed separately.

APPROACH

The analysis adopts a societal perspective, sharing the impacts on both individuals and wider society, and it uses a 100-year timeframe. Standard cost-benefit assessment framework using generally accepted best practices outlined by The Treasury, the Commerce Commission and NZIER were used. A sensitivity test has been undertaken for the key variable, real discount rate, with the Benefit Cost Ratio (BCR) tested for a margin of error of ± 15%.

This report summarises the evaluation methodology, key assumptions and exclusions and results, with the following key inputs/outputs:

1. Spatial boundaries and geographical information systems (GIS) approaches for assessing each proposed future.
2. Monetised whole-of-life costs for each proposed future over the return period.
3. Monetised benefits for each proposed future over the return period.
4. BCR for each proposed future.

CORE LOGIC

The primary metric used throughout this evaluation is Annual Average Damage (AAD). AAD is the annualised expected cost of modelled pluvial flood and a geospatial assessment of coastal inundation damage across all probability events, the 10%, 2%, and 1% Annual Exceedance Probability rainfall events weighted by their likelihood. Put simply, it represents what the community would pay each year, on average, if it were fully insured against all flood events at their expected frequency and severity.

AVOIDED DAMAGES – THE CORE BENEFIT

The primary economic benefit of each future is the reduction in expected annual pluvial & coastal flood losses relative to the Status Quo. The calculation is straightforward in concept: avoided damage equals the difference between what flood events would cost without adaptation and what they cost with it.

Avoided property damage is the largest single component, representing approximately 80% of total core benefits across all the three proposed futures (using pluvial flood modelling outputs and DCC's Flood Damage Assessment approach). The remainder comprises avoided injury and fatality costs (approximately 14%), avoided emergency response and recovery costs, and other co-benefits, including trauma, income loss from displacement, and environmental costs.

The dominance of property damage in the benefit profile reflects the density of the exposed building stock, concentrated population and the severity of the projected damage trajectory.

TOTAL BENEFITS OVER TIME

Benefits grow over time as the Status Quo damage trajectory steepens. In the short term, all three adaptation futures deliver identical benefit profiles because the pluvial flood efficacy modelling assumes equivalent near-term reductions in flood risk. The differentiation occurs in the medium and long terms as each future's physical characteristics interact with changing hazard conditions.

Table 1.1 - Total core benefits by future and period (NPV $m, 6% discount rate)

Time Period	Future 3 Protect	Future 4 Restore	Future 5 Reshape
Short-term (0 – 25 years)	$452	$457	$450
Medium-term (26 – 50 years)	$372	$381	$378
Long-term (51 – 100 years)	$511	$514	$507
Total - whole of life	$1,335	$1,351	$1,336

It may seem counterintuitive that the long-term epoch (51–100 years) accounts for such a large share of total benefits despite discounting, which reduces the present value of future cash flows.

Status Quo damage trajectory steepens dramatically over the assessment period. Pluvial & coastal flood AAD rise from ***$11m*** today to ***$212m*** by 2127, indicating that the current proposed initatives will continue to be challenged by growing levels of exposure over the 100 years. The benefits of adaptation grow in proportion to the damages avoided. The damages are largest in the period when climate impacts are most severe.

This timing structure is consistent with international practice in climate adaptation cost-benefit analysis. It is not a reason to delay investment, quite the opposite. The infrastructure that delivers those long-term benefits must be planned and built in the short- to medium-term. Early action captures the full benefit profile and enables infrastructure catch up to occur; delay truncates it.

As hazards intensify, the cost of inaction grows rapidly, meaning the relative benefit of early and sustained adaptation becomes increasingly significant over the medium and long terms, as shown in Figure 1.1 below.

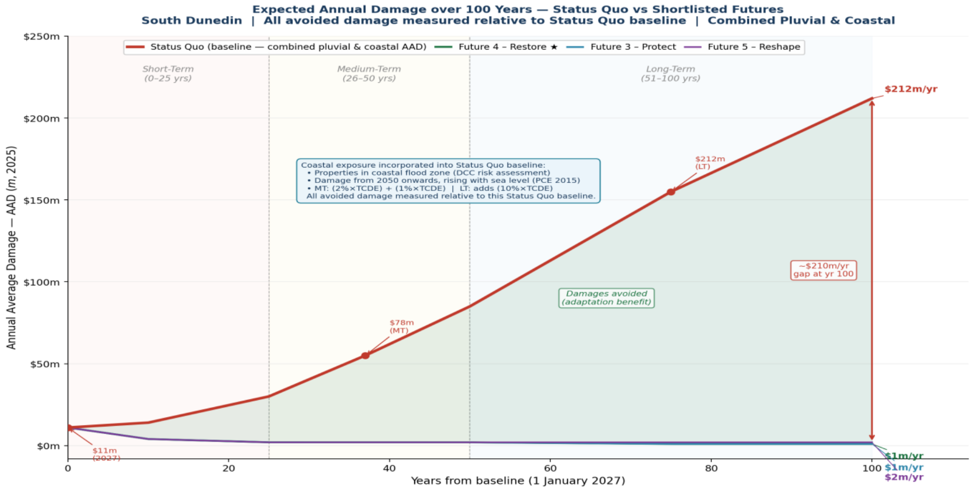

Figure 1-1 -Expected Annual Damage over 100 Years: Status Quo vs Shortlisted Futures.

The analysis distinguishes between core avoided loss benefits and supplementary benefits that reflect a broader level of service gain. This separation supports a transparent, defendable appraisal. The core case demonstrates the minimum likely return from risk reduction, while the supplementary case illustrates the broader opportunities that may enhance the long-term performance of the preferred future. This provides decision-makers with a clear and robust understanding of the economic rationale before considering Benefit–Cost Ratios.

WHAT EACH FUTURE COSTS?

Benefits do not come free. Each adaptation future requires substantial upfront investment in infrastructure, property acquisition and change in use or repurpose, as well as ongoing maintenance and operational expenditure. Understanding the likely cost structure for each future is essential for assessing value for money.

Table 1.2 – Total Costs by future – whole of life (2025 NPV $m, 6% discount rate)

Core component	Status Quo	Future 3 Protect	Future 4 Restore	Future 5 Reshape
CAPEX Investment	$290	$1,220	$724	$1,287
Repurposed Land Activities	$4	$433	$447	$545
Land & Property Acquisition	$72	$343	$338	$519
Capital Maintenance (cyclical)	$15	$33	$39	$31
Operational Expenditure (OPEX)	$31	$70	$81	$66
Total Costs	$411	$2,098	$1,629	$2,448

Future 4 has the lowest total cost of the three possible futures, with an NPV of $1,629 m over the whole of life. Its cost advantage over Future 3 ($2,098m) and Future 5 ($2,48m) reflects a more moderate infrastructure CAPEX programme of $724m, compared to $1,220m and $1,287m, respectively.

Future 4's blue-green approach relies more heavily on waterway restoration and natural flood storage, which are less capital-intensive than large-scale land-raising or pumping infrastructure.

The Status Quo has the lowest absolute cost ($411m) but is shown to not keep pace with the projected challenges facing South Dunedin, leaving flood risk exposure, to pluvial and coastal sources, privately borne with consequential cascading impacts. Furthermore, the groundwater assessment identified 838 properties, whose use is likely to be compromised over the next 100 years, as they become exposed to emergent groundwater.

CORE BENEFIT COST RATIO

In addition to the pluvial and coastal flood AAD driven avoided damages, co-benefits are calculated that are quantitatively assessed and directly linked. The Core BCR (at the central 6% discount rate) ranges from 0.55 (Future 5) to 0.83 (Future 4) across the proposed futures. Under the Social Rate of Time Preference scenario, this midpoint range improves (2.85 – 3.83), with Future 4 exceeding the benefit-cost breakeven threshold. It is presented using a range to avoid overstating certainty. This range is different to the *0.1 – 1.0* in the Long List (See Section 8 for details).

Table 1.3 – Core BCR – whole of life (2025 NPV $m, 6% discount rate)

Future	Benefits	Costs	Core BCR (midpoint)	BCR range (±15%)	Rank
Future 3 - Protect	$1,335	$2,098	0.64	0.54 – 0.75	2
Future 4 - Restore	$1,351	$1,629	0.83 ★	0.71 – 0.98	1
Future 5 - Reshape	$1,336	$2,448	0.55	0.46 – 0.64	3

The Core BCR uses the most directly evidenced, hazard-linked benefit streams: avoided property damage, avoided injury and fatality costs, avoided emergency response and recovery costs, avoided trauma, avoided income loss from displacement, and avoided environmental costs.

It excludes supplementary benefits such as hedonic value uplift and broader ecosystem gains, which are real but carry more uncertainty. This separation is deliberate; it ensures the core case rests on the most defendable evidence. Additional benefits can be transparently presented as upside.

Future 4 is the highest-performing future on the core BCR at 0.83, and is the clear first-ranked future across all primary BCR metrics. Future 3 ranks second at 0.64 and Future 5 third with 0.55.

The relatively low BCR for Future 5 ($2.45b in costs against $1.34b in core benefits) reflects its high capital intensity, as it is the most expensive of the three adaptation futures without a proportionate uplift in core avoided damages. Future 5's cost includes the largest property and land acquisition programmes ($545m and $519m, respectively), which do not directly generate avoided damages but are necessary to enable land-use change.

The whole-of-life BCR is a useful single summary figure. Still, it can obscure important structural features of climate adaptation economics. That costs are typically frontloaded, while benefits are backloaded. The epoch-level BCRs make this visible.

Table 1.4 – BCR by epoch – whole of life (6% discount rate).

Epoch	Future 3 Protect	Future 4 Restore	Future 5 Reshape
Short-term (0 – 25 years)	0.28	0.36	0.23
Medium-term (26 – 50 years)	0.82	1.33	0.80
Long-term (51 – 100 years)	10.61 ★	8.86 ★	14.58★
Core BCR (midpoint)	0.64	0.83 ★	0.55

Long-term BCRs of between *8.9* and *14.6* across Futures 3 - 5 are striking. They are not a modelling anomaly, and they should not be read as suggesting that the economics only work if you wait until the long term. Rather, they reflect a straightforward structural reality.

In the long term, most capital costs have already been incurred, and the infrastructure is delivering risk reduction against a damage trajectory that has become very severe. The marginal cost in the long term is primarily maintenance and operations; the marginal benefit is avoiding property AAD events alone that could occur regularly.

The practical implication is this: the infrastructure that generates those long-term BCRs must be built in the short- to medium-term, when BCRs are lower and uncertainty is higher. Delay does not improve the economics; it defers the benefit while the damage trajectory continues to steepen.

The Long-Term (51 – 100 year) BCRs are notably stronger than the whole-of-life BCRs. This reflects the timing profile of the futures: most capital costs are incurred in the Short- and Medium-Term, while a large share of risk-reduction benefits accrues later as climate hazards intensify. When assessed on a standalone basis, the long-term period shows high value for money because relatively modest incremental costs are used to avoid very large future damages.

The whole-of-life BCR combines all three epochs and is therefore influenced by (i) the concentration of costs in the early decades and (ii) the discounting of distant benefits. This pattern is consistent with international practice in climate-adaptation cost-benefit analysis, where upfront capital investment is compared with benefits that grow over time as hazards intensify.

Higher Long-Term BCRs relative to whole-of-life BCRs mainly reflect timing and discounting effects, rather than a modelling anomaly.

SUPPLEMENTARY EXTENDED BENEFITS

With supplementary benefits included, the BCR ranges from 0.68 (Future 5) to 0.94 (Future 4) at the 6% central rate. These supplementary BCRs are presented for completeness and carry a double-counting risk that is disclosed in Section 5 of this report.

UNQUANTIFIED BENEFITS

Several benefits were not monetised (but could be included in future analyses). All else being equal, these could increase the BCR. The unquantified benefits include:

- Avoided damages to non-council utilities (other than through the CV of each property).
- Reduced congestion and increased accessibility through urban areas.
- Insurance coverage and avoided insurance withdrawal.
- Regeneration benefits associated with urban development uplift of the study area.

NEXT STEPS

A further CBA will be developed for the next phase of the project, Preferred Pathway in 2026, incorporating refined assumptions, broader benefit categories and more detailed modelling. That CBA should result in a narrower BCR range because of higher level of certainty about inputs.

It is worth highlighting, currently, that this economic assessment is not in place to support future business case development, in relation to the implementation of the programme. This would follow on from the current planned activities as part of the South Dunedin Future programme.

1 PROJECT BACKGROUND

1.1 SCOPE

Kia Rōpine, as part of the delivery of the wider South Dunedin Future programme, has undertaken an economic evaluation of the possible futures for South Dunedin. The economic evaluation has been prepared following a standard cost-benefit assessment framework and the generally accepted best practices advocated by The Treasury, the Commerce Commission and NZIER.

The scope of this analysis/phase was confined to the proposed futures work, described in the *Three proposed adaptation futures for South Dunedin", date March 2026.*

The economic evaluation has assessed and compared the expected whole-of-life costs and benefits of each proposed future, relative to the Status Quo condition – where proposed stormwater infrastructure investment, identified within current DCC plans has been implemented and are supporting the existing community. The key driver of this economic evaluation is to provide comparable evidence to DCC and the stakeholders to agree on the most preferred future.

1.2 APPROACH

Our approach was shaped by the relatively short time available. We took a social perspective where possible, including the costs and benefits to individuals and wider society. The work compares the Status Quo future (representing current infrastructure interventions under assessment) to three future scenarios – the Three (3) Proposed Adaptation Futures for South Dunedin (referred to *Proposed Futures* for the rest of the document). The following steps were undertaken:

- Reviewing the CBA done for the Seven (7) Potential Adaptation Futures and Microbusiness Cases (referred to as *Long List* for the rest of the document) and its supporting models.
- Reviewing existing literature about CBAs of pluvial flood protection systems to identify typical costs and benefits, and additional elements that could augment the Long List phase.
- Recreating the CBA, with additional costs and benefits, including further refined flood modelling outputs of the Status Quo and Proposed Futures on flood exposure and depths.
- Assessing model outputs through a sensitivity analysis, accounting for a margin of error, and identifying key variables that have the biggest impact on the assessed benefit-cost ratio (BCR).
- Provide comparable BCR ranges of the proposed futures to support the next phase of the South Dunedin programme – the Preferred Pathway and Adaptation Masterplan development (referred to as *Preferred Pathway* for the rest of the document).

1.3 INTERPRETING THE RESULTS

The BCR is calculated as the net present value of all the monetised benefits divided by the net present value of all the monetised costs.

A BCR of 1 is where the net present value of the monetised benefits equals the monetised costs. If the BCR is less than 1, the costs outweigh the benefits (and vice versa).

The BCR in this report does not include all the costs and benefits.

It includes only those that could be quantified and monetised at this stage. There are other costs and benefits that are generally considered as part of any investment decision. This is detailed in Sections 5 and 6, with the expected implication to the BCR outlined. This will be captured under the parallel process of undertaking a multi-criteria assessment.

1.4 DATA SOURCES

The BCR is based on information that is subject to change, representing three Proposed Adaptation Futures for South Dunedin to address future climate conditions. This will be developed further at the subsequent Preferred Pathway stage.

Much of the information utilised in this analysis was prepared during the development of both the Long and Short-Listing phases and is at a level of detail necessary to assess the overall viability of the futures and their potential for success. Alternative infrastructure arrangements are feasible and would achieve different outcomes, both in terms of the costs and benefits resulting.

We relied on outputs from other models.

As identified within the report, the avoided property damage is the biggest monetised benefit in our analysis. To estimate the value of this benefit, we relied on outputs from:

- DCC provided stormwater models for the study area – taken from recent modelling activities for the Integrated Catchment Modelling Programme. These were updated for the four futures.
- DCC's Flood Damage Assessment approach0F1 was used to estimate the cost of the flood damage to buildings / properties.
- DCC provided coastal mapping outputs to support the identification of properties exposed to likely coastal flooding.
- Other key monetised benefits, such as avoided fatality & injury, avoided emergency services, and gains in level of service, are highly correlated with the outputs listed above2.
- Kia Rōpine identified tactical interventions for each of the futures (see modelling efficacy report for details of these) across three-time epochs (Short-, Medium- and Long Term).

1.5 OUTPUTS

This report describes the modelling methodology, including a clear documentation of the assumptions made and their sources. The key inputs/outputs from this project are:

- Spatial boundaries and geographical information systems (GIS) analysis of each option of each proposed future.
- Monetised whole-of-life costs for each proposed future over the return period.
- Monetised benefits for each proposed future over the return period.
- Benefit-Cost ratio (BCR) for each proposed future.

[1] DCC Flood Risk Assessment Technical Note (February 2025), produced by Stantec as part of the Integrated Catchment Modelling Programme

[2] Note on model outputs: The quantitative results presented in this report are derived from the economic model (version as of 31 March 2026). Tables in the report body represent verified outputs from that model as of the sign-off date. The model is Excel-based, and results are presented as confirmed static values; they are not live-linked. Any subsequent model updates would require corresponding amendments to the report.

2 GENERAL ASSUMPTIONS

This section outlines the general assumptions adopted within the economic evaluation. Other scenario-specific assumptions are set out in the following sections of the report.

2.1 ASSESSMENT TIMEFRAME

Based on a similar study (Auckland Council, 2025[3]), it was found that there is different domestic and international guidance on determining the timeframe for social investment proposals. The UK's flood appraisal guidance recommends a default 100-year timeframe.[4]. The US FEMA Guidance[5] links timeframe to a project's useful life (35 – 100 years for major infrastructure like dams / levees).

From the above, shorter timeframes (e.g. 50 years or less) are likely to miss significant future damage avoidance and climate change impacts, understating benefits, whereas a 101+ year timeframe introduces excessive uncertainty beyond long-term planning capability, such that climate resilience projects could overstate benefits from the accumulation of future gains.

Through a process of elimination, an assessment timeframe of 100 years appeared reasonable as it adequately captures the long-term benefits from the proposed adaptation investments for pluvial and coastal flood mitigations, to support the analysis of the future climate resilience investment.

The economic evaluation is undertaken with a baseline date of 1 January 2027 with a 100-year timeframe, which is segmented into three time periods of short term (0 – 25 years from baseline), medium term (26 - 50 years from baseline), and long term (51 - 100 years from baseline). All costs and benefits are assumed to incur halfway through the fiscal year. All values are presented in Net Present Value (NPV) terms.

2.2 DISCOUNT RATE

Headline Benefit–Cost Ratios in this report are calculated using a 6% discount rate derived from a weighted average of the Social Opportunity Cost of capital (SOC) and the Social Rate of Time Preference (SRTP), consistent with The Treasury's guidance on public sector discount rates for cost–benefit analysis.

The detailed derivation of the underlying parameters is provided in Appendix A for transparency. The approach ensures alignment with Treasury public sector appraisal practice while maintaining consistency with the project's economic modelling framework.

2.3 COST GROWTH

Generally accepted industry practices suggest that sufficient project cost growth should be accounted for to ensure rigorous and evidence-based investment proposals. The general expectation is increasing cost over time (inflation) to reflect rising material costs, consenting fee escalation, wage growth, etc.

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[3] Auckland Council – Cost Benefit Analysis for Wairau Blue Green Network (2025)

[4] Flood and Coastal Erosion Risk Management appraisal guidance (2010). DEFRA/Environment Agency https://assets.publishing.service.gov.uk/media/613205c1d3bf7f05b9705049/The_full_technical_FCERM_appraisal_guidance.pdf, accessed October 2025.

[5] US FEMA (2009). BCA Reference Guide. https://www.fema.gov/sites/default/files/2020-04/fema_bca_reference-guide.pdf , accessed January 2026.

Following The Treasury's guidelines, the assumed short-term, medium-term, and long-term geometric annual cost escalation rate is 2.03%, 2.03% and 2.02%, respectively.

The economic evaluation has sensitivity tested the assumed cost growths under the discount rate sensitivity assessment, with cost growths embedded in the development of the real SOCs and real SRTPs following the Fisher equation, consistent with The Treasury's public sector cost benefit analysis guidance.

2.4 ANNUAL EXCEEDANCE PROBABILITY

Annual Exceedance Probability (AEP) is commonly employed under climate resilience proposals to reflect the likelihood that a specific magnitude of flood will occur or be exceeded in any single year.

To support the economic assessments for benefits calculations relating to fatality, injury and trauma damages, we have used an AEP of 2%, reflecting a flood event that occurs once every 50 years.

AEP values are used in this evaluation as modelling inputs to derive Annual Average Damage (AAD) estimates; they are not used directly as the basis for benefit quantification.

The AAD metric integrates flood damages across three modelled event severities: the 10%, 2%, and 1% AEP rainfall events weighted by their annual probability of occurrence. This probability-weighted approach produces a single annualised damage figure that reflects the full range of likely flood events rather than a single worst-case scenario. It is consistent with The Treasury's guidance for cost-benefit analysis of public investment, which requires probability-weighted (expected-value) loss estimation[6.]

For the purposes of injury, fatality, and trauma benefit calculations, which require a single representative event to estimate population exposure, a 2% AEP event (1-in-50-year flood) has been applied, representing a significant but realistic flood scenario consistent with the modelled efficacy outputs.

[6] The Treasury, 'Guide to Social Cost Benefit Analysis' (2015), p.23: 'Use expected values (probability-weighted outcomes) in preference to single-scenario estimates.'

3 STATUS QUO

3.1 BACKGROUND AND KEY ASSUMPTIONS

We describe the main assumptions and outputs from the Kia Rōpine flood-modelling[7] projections (known as the ***Efficacy modelling***). This Future approximates the current long-term plan thinking for investment in stormwater flood mitigation works (known as the no regret projects). These represent a series of pipe upgrades and new pumping infrastructure added to the current network.

Comparing the futures economically against this baseline is in line with the other assessments undertaken through the programme to determine the proposed futures. This scenario has an important role, given that we compare the alternative futures to it, to understand the potential benefits of the proposed South Dunedin Future investment.

3.1.1 FLOOD RISK – CURRENT PLANS

We have assumed that no further flood mitigation measures will be put in place, other than those currently included within the Status Quo modelling to manage the identified growing coastal, pluvial and groundwater flood exposure for the Status Quo future.

The proposals represent the reference point against which we test the impact of the alternative futures as damages-avoided benefit. ***If no investment is implemented, then the size of the avoided damages benefit would be larger than characterised***.

3.1.2 CLIMATE CHANGE

We assumed that pluvial flooding would become more intense over the 100-year timeframe (with core assumptions / inputs identified (efficacy modelling)). This increase is shown to result in higher levels of flooding, leading to more properties becoming damaged over time and more severe.

3.1.3 COASTAL PROTECTION

We have assumed that no additional coastal protection infrastructure will be added to the harbour edge to manage the future coastal inundation exposure as presented within the risk assessment. For the purposes of this assessment, we have assumed that the St Clair to St Kilda coastal margin remains in place, for the period of the analysis, to protect the low-lying South Dunedin area.

3.1.4 GROUNDWATER

We have assumed that no groundwater management systems are added to the urban fabric to manage the current and future groundwater exposure as presented within the risk assessment, over and above the role that the existing stormwater and wastewater networks play.

3.1.5 BUILDING STOCK

We have assumed no change or improvements to the existing buildings, so we miss items where:

- A property inside the study area is to be sub-divided, then more properties would be exposed to flood damage and benefits would be greater.

[7] Kia Rōpine (2025) – SDF Efficacy Modelling Report_Rev A_signed.pdf

- An existing property is to be upgraded/refurbished over time, then the avoided property damages would be greater than currently modelled, where benefits would be greater.
- Impacts become untenable for property owners (no longer useful) meaning reduced costs, other than the 838 properties[8] identified.

At this stage, we cannot meaningfully forecast changes to housing densities or property values and have not included this in the analysis.

3.1.6 FUTURE LAND USE

We assumed no change to the current pattern of land use through the period of analysis.

3.2 MODELLED IMPACTS – PLUVIAL FLOOD EXPOSURE

Pluvial flood risk is known to be driven by intense rainfall, overwhelming drainage systems. A trend expected to worsen under climate change. The numbers below relate to the total number of buildings, taken from GIS assessments that are flood affected. For the purposes of the economic assessment, duplicated buildings for each land parcel were removed, to avoid double-counting.

3.2.1 INCREASING LEVELS OF FLOOD AFFECTED BUILDINGS

The number of buildings experiencing water around 50% of the building perimeter, and above-floor flooding rises dramatically across all three modelled return periods for all buildings (area > 30m^2).

Table 3.1: All buildings (> 30m^2) - impacts with Status Quo (to nearest 100)

Criteria	Return Period (AEP)	Current Day	2127
Water around 50% of the building	10%	1,000	2,600
	2%	1,900	3,200*[9]
	1%	2,300	3,400
Above floor flooding	10%	600	1,800
	2%	1,200	2,400*[5]
	1%	1,500	2,600

This shift represents a tripling of internal flooding in frequent events and almost doubling in major events, turning today's episodic events into chronic, city-wide disruptions.

3.2.2 LARGE SCALE RESIDENTIAL AND COMMUNITY DISRUPTION

Residential buildings experience the greatest increase in impact:

Table 3.2: Residential buildings (> 30m^2) - impacts with Status Quo (to nearest 100)

Criteria	Return Period (AEP)	Current Day	2127
Above floor flooding	10%	500	1,500
	2%	1,100	2,000*[5]
	1%	1,400	2,300

[8] DCC (2025): South Dunedin Future – Residential Capacity Analysis Storymap
[9] Approximated based on relationship from other events – as no future state 2% AEP case modelling available.

Consequences include:

- Rising displacement and emergency sheltering demand
- Increased mould, dampness, and degradation of building quality
- Greater mental-health impacts, particularly in repeatedly flooded households (recurrent flooding is strongly associated with higher depression, anxiety, and PTSD rates – evidenced in population-level studies from the UK)

Schools, churches, and other community facilities also face growing internal flooding, undermining community cohesion, and recovery.

3.2.3 INTENSIFYING BUSINESS, INDUSTRIAL AND INFRASTRUCTURE LOSSES

Commercial and industrial properties experience sharp increases in above-floor exposure:

Table 3.3: Commercial / Industrial buildings (> 30m^2) - Pluvial flooding impacts (to nearest 10)

Criteria	Type	Current Day	2127
Above floor flooding for 1% AEP	Commercial	50	190
	Industrial	50	150

Implications include:

- Disruption of essential services and supply chains
- Higher cleanup and reinstatement costs
- Loss of trading days and reduced investor confidence

3.2.4 INCREASING EVENT DAMAGES.

The Status Quo represents an estimation of the implications/impacts of the current proposals not being able to keep pace with the myriad of flooding challenges (this work is not inclusive of groundwater flooding exposure – that would further increase the likely future damages). This represents an increasing liability now and into the future that is identified to be in the order of $1.45 billion in 2025 NPV costs to the region, when accounting for:

- Damage to properties (insured & uninsured) with AAD rising from $11m (2027) to $212m (2120).
- Fatality and Injury costs.
- Emergency Service Costs, Trauma costs amongst others.

The $1.45 billion NPV figure reflects modelled direct property and human costs only. When factoring in other potential costs that result from ongoing flood exposure, such as infrastructure repair, private interventions, and the estimated cost of insurance withdrawal (categories that are outside the current quantitative model but are expected to be material), a figure of more than $2 billion of damages is not unrealistic. Both figures are presented to bracket the range of likely inaction costs at a strategic level.

Table 3.4: Pluvial event damages for buildings per return period for the Status Quo Scenario (Base)

Building Level. Status Quo Pluvial Flood Damages ($m) 2025 QV	Return Period (AEP)			AAD
	10%	2%	1%	$m
Short Term (Present Day)	$60	$140	$200	$11
Medium Term	$290	$430*5	$540	$43*5
Long Term	$420	$540*5	$630	$60*5

Table 3.5: Combined Coastal and Pluvial event AAD ($m, 2025 QV)

Epochs	AAD
Short Term (Present Day)	$11
Medium Term	$78*5
Long Term	$212*5

3.2.5 INCREASING PRESSURE ON INSURANCE AFFORDABILITY/AVAILABILITY

As events occur more frequently and internal flooding escalates, insurance impacts become severe:

- Greater claims frequency and severity, mirroring multi-billion dollar claim patterns seen in recent NZ flooding events.
- Higher premiums, larger excesses, and more exclusions, especially for repeat losses and groundwater/seepage pathways.
- Heightened risk of insurance withdrawal or non-renewal in the most exposed pockets. (Groundwater/seepage is already commonly excluded / only partially covered across the motu).

This creates affordability challenges and threatens long-term mortgage viability.

3.2.6 ESCALATING INFRASTRUCTURE AND NETWORK FAILURES

With approximately 4,000 buildings exposed to flooding for a 2% AEP pluvial flood event, there are:

- Increasing numbers of road closures and access failures, with a total road area with over 300mm depth of stormwater increasing from 1.6ha (current day) to 16ha (2100 state) for the 10% AEP event, with the centre line of over 150 roads impacted in the future compared to twenty currently.
- Park areas with stormwater depths over 300mm, increasing from 0.5ha to 4ha, affecting useability for the 10% AEP event.
- More stormwater and wastewater network surcharges.
- Reduced emergency response mobility.
- Decreased community confidence in essential services.

Reviews of pluvial flooding events, underscore that even well-designed networks face substantial residual risk if there are no exceedance pathways or depression areas to temporarily store water. Without intervention, chronic implications could emerge in relation to the liveability of the area.

3.2.7 LONG-TERM DECLINE IN NEIGHBOURHOOD VIABILITY

Without adaptation:

- Flood-prone areas are shown to lose value relative to safer suburbs.
- Rental housing quality declines under repeated damp and deterioration.
- Community out-migration increases, particularly among families.
- Vulnerable populations are disproportionately affected.

Together, these trends drive entrenched inequities, rising public health burdens and declining urban and individual resilience.

3.3 MODELLED IMPACTS - GROUNDWATER

A quick review of the groundwater information shared through the Kia Rōpine report and GNS modelling has been undertaken sharing the implications of groundwater on properties (using the 'no intervention' modelling work).

Work undertaken by DCC[6], identifies that 838 dwellings are predicted to become vulnerable to emergent groundwater over the 100-year period, with 58 likely to become exposed by 2050, a further 103 through to 2075 and then a further 678 by 2120.

Over 2 hectares of roads across the study area are predicted to be vulnerable to emergent groundwater into the future, with an additional 15 hectares lying within the zones predicted to have groundwater within 0 to 0.7m bgl, taking the total to over 58.5 hectares. Additionally, more than four hectares of park are predicted to have emergent groundwater in the future compared to the current state of less than 1,000m².

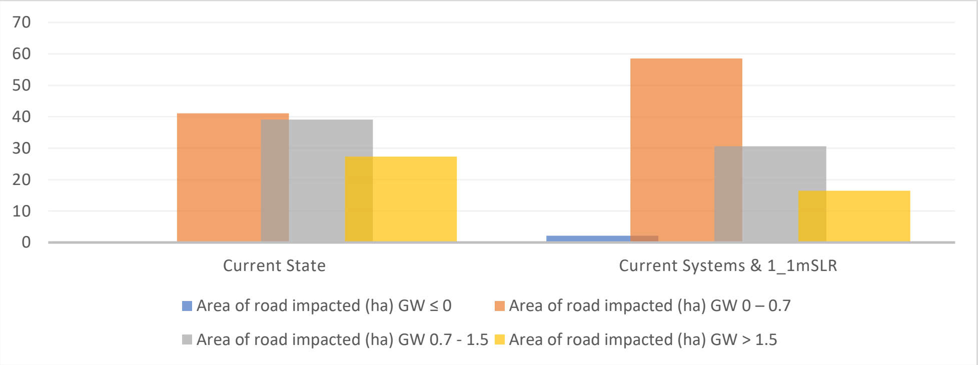

Figure 3-1 - Modelled outputs sharing current / future groundwater levels and road (km) impacted

3.4 CONCLUSION

A Status Quo future helps to reduce current exposure to pluvial flooding, when compared to no intervention. Pluvial flooding over time grows from a disruptive but recoverable hazard into a persistent, systemic, and increasingly unmanageable challenge, exacerbated by a growing groundwater impacts. By long-term horizon:

- Thousands more buildings are regularly affected.
- Internal flooding triples for frequent events.
- Insurance and infrastructure systems weaken under sustained pressure.
- Community wellbeing and economic performance decline.

In short, not investing in adaptation will likely lead to escalating annualised losses, reduced liveability, and diminishing strategic flexibility, making proactive adaptation far more cost-effective than continued inaction.

This evaluation uses the Status Quo as the sole reference baseline against which the performance of each proposed future is measured. A standalone 'Do Nothing' comparator was included in earlier phases of the SDF programme but has been removed from this shortlist assessment to ensure consistency with the other technical outputs produced for this phase, and to reflect the more precise Status Quo modelling now available. All damage estimates and avoided damage benefits presented from this point forward are measured relative to the Status Quo trajectory.

The combined pluvial and coastal AAD figures in Table 3.5 above ($78m mid-term; $212m long-term) reflect a material methodological development from earlier assessment phases. Coastal inundation exposure has been incorporated into the Status Quo damage trajectory. This is the primary driver of the increase from the pluvial-only figures shown in Table 3.4 ($43m and $60m respectively).

Coastal exposure methodology: Properties within the coastal flood zone were identified using DCC-provided coastal mapping outputs consistent with the SDF Risk Assessment. The 'bathtub' flood modelling available for the coastal zone likely overestimates flood depths; the approach adopted therefore, represents a conservative, early-phase approximation reviewed by the specialist team[3]. Damage was applied from 2050 onwards, consistent with Parliamentary Commissioner for the Environment (2015) sea level rise projections, with epoch-weighted annualisation as follows:

- Short Term (0–25 years): No coastal damage included, coastal inundation frequency below threshold for this epoch given current sea level projections.
- Medium Term (26–50 years): Annual average coastal damage = (2% × TCDE) + (1% × TCDE) where TCDE is the Total Coastal Damage Exposure for all affected properties.
- Long Term (51–100 years): Annual average coastal damage = (2% × TCDE) + (1% × TCDE) + (10% × TCDE), reflecting increasing inundation frequency with sea level rise.

Appendix B has further details of coastal damage approach (by building use type) and the TCDE.

3.5 POTENTIAL AREAS FOR FURTHER ANALYSIS

With a relatively short period to undertake the analysis, and knowledge of further stages requiring economic assessments., a more comprehensive CBA would support the development of the subsequent *Preferred Pathway*. In relation to the Counterfactual analysis to date, we recommend:

- Confirming the assumptions for the Status Quo scenario into the future, including whether BAU activities proposed in the current Long-Term Plan would be put in place and built on, to understand the implications of these investments.
- Confirming assumptions about financial implications of increasing levels of flooding on the livability across the area, including implications on insurance availability and as to whether people would self-retreat and leave their homes.

- Undertaking further work on the likely flooding exposure related to coastal inundation to improve confidence in properties exposed to flooding across a 100-year time horizon. A more refined, depth-based assessment could be incorporated during subsequent phases.
- Confirming assumptions made as to whether additional properties, increasing levels of housing density, or changes to the value of existing commercial / industrial stock, could be modelled over the 100-year time, as opposed to assuming the status remains over the period.
- Undertaking further analysis as to the impacts on council infrastructure (over and above the roads and parks undertaken to date).
- Determining the need for capturing other costs, such as:
- Business interruption,
    - Service disruption (including the impacts of roads being closed on network use).
    - Implications for wider region from these changes (both positive and negative).
    - Insurance retreat and implications on asset values.

4 FUTURES DESCRIPTIONS

The GIS information provided by KR and DCC, has been spatially mapped for the Proposed Futures work, under each epoch, are presented in the subsections below.

4.1 FUTURE 3 – PROTECT

Protect manages stormwater and groundwater mainly via a network of pipes and pump stations to move water out of South Dunedin. Roads help to direct and hold water during intense rainfall and stormwater reserves or constructed wetlands provide even more storage when required.

To support this, Council would improve the seawall along Portsmouth Drive, and raise an area of Forbury Corner to expand the existing high ground and create intensified space for people to relocate to, away from areas of highest risk. To minimise the amount of land raising required, a new residential development is included in the Ocean Beach Domain area

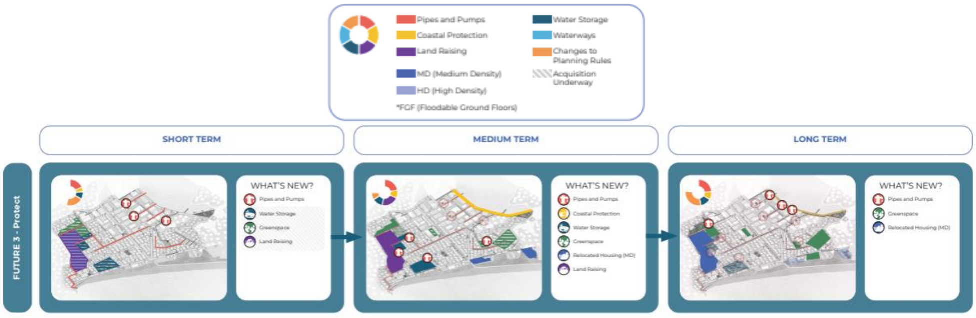

Figure 4-1: Future 3 – Interventions over the three-time epochs

Figure 4-2: Future 3 key details

4.2 FUTURE 4 – RESTORE

Restore makes space for water by creating a network of open waterways and wetlands, supported by pipes, pumps, overland flow paths, and coastal protection. This future represents a balance between engineered and nature-based solutions and creates the opportunity for an extended town belt-type landscape, integrating South Dunedin into Dunedin's wider green network.

Some property acquisitions are required to create space for these interventions

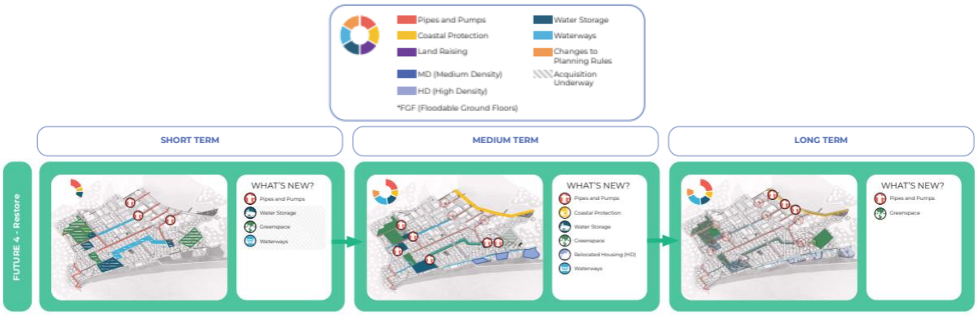

Figure 4-3: Future 4 – Interventions over the three-time epochs

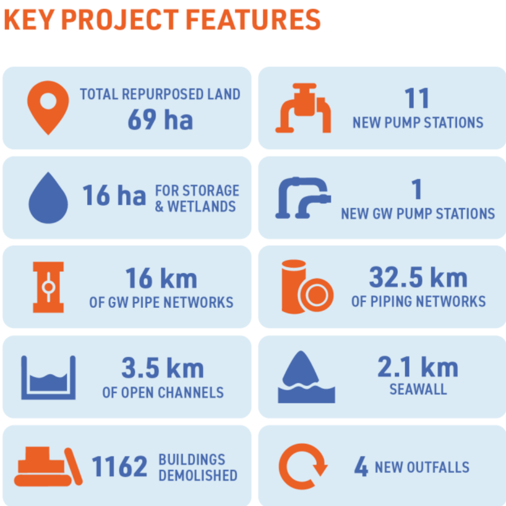

Figure 4-4: Future 4 key details

4.3 FUTURE 5 – RESHAPE

Reshape focuses on creating space for water and people through a combination of open waterways, green infrastructure and raised land development.

It aims to manage flooding and groundwater risks while enabling resilient urban transformation, high-density housing, and long-term community viability while allowing space for water. This space for water provides a town-belt style amenity along the waterways.

The economic evaluation has not captured the potential for damages to be avoided through the proposed changes to planning rules to the east of Otaki Street.

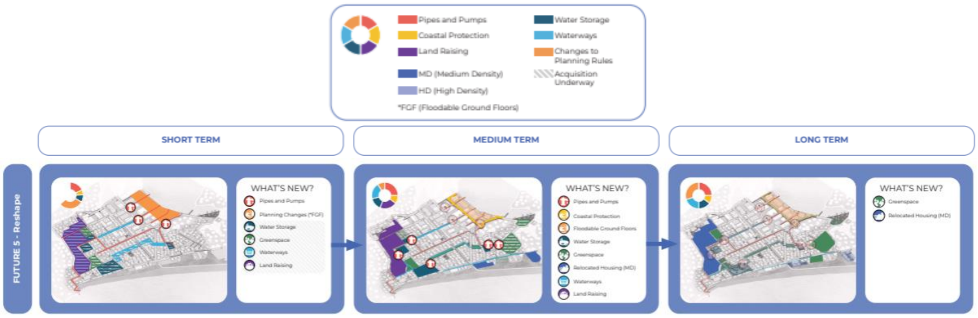

Figure 4-5: Future 5 – Interventions over the three-time epochs

Figure 4-6: Future 5 key details

5 BENEFITS

Consistent with the scope of work, we have sought to monetise the most significant benefits within the time available to do the analysis. We have identified where further effort could be directed for future stages of the SDF programme. We explain the two largest identified benefits below in more detail and share the other benefits that have been analysed at this stage.

5.1 ECONOMIC LOGIC AND TREATMENT OF BENEFITS

The economic evaluation follows a standard adaptation appraisal framework drawing on national and international guidance for long-term climate investment. The analysis assesses each proposed future by comparing its whole-of-life costs with the avoided damages and co-benefits achieved relative to the Status Quo.

This represents the unmanaged trajectory of Expected Annual Damage (AAD) as hazards increase over time. By framing benefits as "avoided losses," the evaluation ensures a direct and transparent link between the hazard modelling, residual risk results, and the economic outcomes.

The core logic of the appraisal centres on AAD as the primary monetised benefit category. AAD captures the annualised value of damage to buildings, infrastructure, and services arising from flooding and groundwater impacts, weighted by their probability.

$$NPV = PV(\text{Avoided Damages}) - PV(\text{Costs})$$

Where:

$$\text{Avoided Damages} = AAD_{DoNothing} - AAD_{Pathway}$$

The use of AAD allows the analysis to reflect both the increasing frequency and severity of hazard events as climate conditions change across the short (0–25 yrs), medium (26–50 yrs), and long (51–100 yrs) terms. AAD based avoided damages therefore provide a consistent, repeatable measure of the risk reduction value delivered by each Future.

While exposure metrics and illustrative maps in this report frequently reference the 2% AEP event for communication and consistency with hydraulic modelling outputs, monetised benefits are not based on a single event scenario. All headline benefit estimates are derived using AAD, which integrates multiple return periods and their associated probabilities. The 2% AEP outputs are therefore used as presentation and exposure proxies, whereas economic valuation is grounded in probability-weighted expected annual losses.

This ensures consistency with Treasury CBA practice, which requires expected-value (probability-weighted) loss estimation rather than reliance on single-event scenarios.

5.1.1 SEPARATION OF CORE AND SUPPLEMENTARY BENEFITS

To maintain clarity and reduce the risk of double counting, the analysis separates benefits into core and supplementary categories:

5.1.1.1 CORE BENEFITS

These are the directly evidenced, hazard-linked benefits that flow from reducing exposure and vulnerability. Core benefits include:

- avoided building and infrastructure damage,
- avoided emergency response and recovery costs,
- avoided health and wellbeing impacts associated with displacement, dampness, and trauma,
- avoided fatalities and injuries.

These benefits collectively represent the conservative, defensible foundation of the economic case. They align most closely with Treasury good practice expectations for climate resilience appraisal.

Care has been taken to avoid double counting across benefit categories. Property and infrastructure damage estimates reflect direct physical losses only. Human health, trauma, and social impacts are monetised separately using welfare-based valuation methods (e.g., Value of Statistical Life), ensuring that asset damage costs are not implicitly capturing these impacts.

5.1.1.2 SUPPLEMENTARY BENEFITS

These benefits are real but more uncertain in magnitude, attribution, or timing. They include:

- potential hedonic uplift from improved amenities (not included in this iteration),
- self-service improvements beyond risk reduction (not included in this iteration),
- level of service improvements beyond risk reduction (including reduced impacts on transport disruption and service outage) – included as a proportional benefit at this stage.
- co-benefits related to ecosystem services, urban regeneration, and long-term redevelopment.

Supplementary benefits are presented transparently as an upside scenario, separate from the core BCR. This approach allows decision makers to understand the minimum guaranteed value (core case) while recognising the potential additional value that may emerge as the programme matures and as further evidence is developed.

This two-tiered structure provides a clear, auditable assessment that supports both conservative decision making and the broader strategic case for multi-benefit adaptation investments.

5.2 AVOIDED PROPERTY DAMAGE

By far, this is the biggest benefit, making up approximately 80% of the total benefits, depending on the assumptions used.

5.2.1 METHODOLOGY

Currently, it is worth noting that natural hazards, such as flooding events, involve high levels of uncertainty around timing, frequency, and severity. To support the assessment, AAD was used.

This approach estimated the present value cost of flood damage to buildings in the catchment area over the 100-year timeframe, where benefits reflect changes in Expected Annual Damage (AAD), informed by modelling across multiple return periods. The calculation relied on the outputs from two models[10]. We took the outputs from both models at face value:

[10] AAD construction: For each epoch, the economic model applies the depth-damage function to the flood modelling outputs at three probability levels: 10% AEP (1-in-10-year event), 2% AEP (1-in-50-year event), and 1% AEP (1-in-100-year event). The resulting property damage estimates at each AEP are then probability-weighted to produce the

- Kia Rōpine provided flood modelling projections (known as the Efficacy modelling) for three flood event severities, undertaken at three different epochs (Present Day (aka Short Term), Medium Term and Long Term inside the study area.
- Depth Damage functions taken from Dunedin Council's Flood Damage Assessment (FDA) report were used to estimate the cost of flood damage to individual commercial and residential buildings and their contents, based on the flood modelling projections.

Approach steps:

- We received modelled outputs from each future for three pluvial flood events (a 10%, 2% and 1% AEP events). A current day and two future climate scenarios (in 2050 and 2080), for the existing urban form and the three potential futures. See Appendix A for the Coastal inundation approach.
- We applied the damage functions from DCC's FDA report to record damage costs for all residential, industrial, and commercial buildings and their contents for each scenario.
- We assessed against the Council's FDA, calculating total net present value but did not annualise.

We note that the use of the 'fixed' damages by depth for residential property is an approximation and doesn't allow for spatial, suburb style variations across the study area. The approach to Commercial and Industrial properties is, on the other hand, proportional to the Capital Value of the property, capturing spatial and asset type differences. This blended approach is likely to simplify the depth-damage relationship and, hence, bring the option-damage differences closer together.

Epoch-level benefit stacking: The 100-year assessment period is divided into three discrete epochs: short-term (0–25 years), medium-term (26–50 years), and long-term (51–100 years), each with its own modelled AAD reflecting the climate and land-use conditions representative of that period. Benefits in each epoch represent the NPV of avoided AAD relative to the Status Quo over the epoch duration. The whole-of-life BCR combines these three epoch-level NPVs.

This epoch-based structure is consistent with Treasury guidance for long-horizon public investment appraisal, which recognises that climate hazard conditions are not static and that benefits must reflect changing exposure over time. It avoids the alternative and less defensible approach of applying a single present-day AAD across the full 100 years, which would significantly understate the benefits of adaptation in the later decades when hazard intensity is greatest[11].

5.3 OTHER BENEFITS INCLUDED

We assessed other benefits after undertaking a further literature review to see if any other benefit types could be included at this stage. Following on from the Peer Review, we have revised the approach to avoid double counting of benefits (as described below).

Expected Annual Damage, using a trapezoidal integration approach consistent with standard flood risk analysis practice and Treasury CBA guidance on expected-value estimation. The AAD is therefore substantially lower than any single AEP event damage (e.g., Short Term AAD of $11m vs a 1% AEP single-event damage of $200m) because it reflects the full distribution of outcomes weighted by their annual probability.

[11] This approach aligns with The Treasury's Guide to Social CBA (2015) requirements for sensitivity testing across scenario conditions and with DEFRA/Environment Agency Flood and Coastal Erosion Risk Management Appraisal Guidance (2010), which recommends epoch-based benefit modelling for long-horizon flood risk investments.

The value of each individual benefit was relatively small compared to the two benefit classes identified above. This section describes each benefit type, with the monetisation approach and sources of assumptions detailed in Appendix A.

5.3.1 AVOIDED HUMAN COSTS

5.3.1.1 AVOIDED INJURY

With the Proposed Futures, it's expected that the various developments/interventions over the return period will gradually reduce the flood severity of a 2% AEP flood event in the South Dunedin catchment. Thus, the expected flood injury rate decreases under the Proposed Futures.

This has been modelled as the monetised cost savings of minor-moderate physical injuries avoided. Severe physical injuries are assumed to be fatal; hence it's captured under avoided fatalities. To avoid double-counting, psychological injuries avoided have been captured under trauma avoided.

The injury and fatality estimates are derived from probability-weighted exposure consistent with the 2% AEP event. Injury and fatality likelihoods are applied to the expected annual population exposure implied by the 2% AEP flood event scenario. This ensures that human impact estimates are aligned with expected-value risk modelling rather than event-based extrapolation.

5.3.1.2 AVOIDED FATALITY

Like the above, the Proposed Futures are expected to have lower flood injury occurrence, hence lower flood fatality occurrence. This has been captured in the economic evaluation as the monetised cost savings of fatalities avoided.

To avoid double counting, fatality and injury costs are treated as welfare losses (Value of Statistical Life and injury costs) and are not embedded within property damage values. Property damage estimates reflect physical asset loss only, while injury and fatality valuations capture societal welfare impacts separately.

5.3.2 AVOIDED RESPONSE AND RECOVERY COSTS

5.3.2.1 AVOIDED EMERGENCY SERVICE COSTS

Emergency service costs represent a legitimate and significant emergency response and recovery spending by the government, covering costs associated with immediate responses, search and rescue, debris removal, temporary accommodation & infrastructure and public cleanup, post a natural disaster.

In alignment with standard modelling practice, we have proxied flood emergency service costs as a constant proportion to total property damages. With the Proposed Futures, it's expected that it reduces both the property flood exposure and flood damage severity, driving down total property damages. This in turn reduces the expected emergency service costs, reflected in the economic evaluation as the monetised emergency service costs avoided.

5.3.2.2 AVOIDED SOCIAL COHESION COST

Extreme weather shocks such as floods likely negatively impact social cohesion (community fragmentation), resulting in economic hardship, increased vulnerability and community isolation. Based on the GIS mapping identified reductions in household flood exposure under each proposed future, the avoided negative social cohesion were monetised.

5.3.3 AVOIDED INCOME LOSS FROM DISPLACEMENT

Income loss from displacement refers to the income that is lost, disrupted and/or diminished when individuals, businesses, or communities are forced to relocate due to factors like natural disasters, environmental degradation, or large-scale development projects.

The GIS mapping for each proposed future identified the reduction in residential properties with exposure to greater or equal to 50% of its perimeter being flooded given a 2% AEP event. These exposure reductions are then used to monetise the aggregate household displacement time avoided within the South Dunedin catchment over the return period, assuming that those who are predicted to have above floor flooding will be displaced for an average of 13 weeks.

5.3.4 AVOIDED DIRECT AND INDIRECT TRAUMA

There are mental health (Trauma) costs associated with flooding. People exposed to the flood risk may worry about themselves being seriously injured (direct), and people connected to those exposed to the flood risk may be concerned about their safety (indirect). Literature concludes that people experience higher rates of anxiety, depression and post-traumatic stress disorder (PTSD) after a flood event.

GIS mapping identified the reduction in the number of residential properties that likely will be damaged by flood (direct) and the number of residential properties exposed to flood risk but unlikely to incur damages (indirect), under each proposed future.

These two GIS mapping identified reductions were adopted as proxies for the reduction in the number of households that would have likely experienced direct trauma (properties identified to be exposed to above floor flooding) and indirect trauma (residential properties with exposure to greater or equal to 50% of its perimeter being flooded given a 2% AEP event minus the direct trauma properties). The economic evaluation has monetised the expected reduction in the number of households exposed to direct and indirect trauma.

Treatment of benefit overlaps: The economic evaluation has been carefully structured to avoid double-counting across benefit categories. Three potential overlaps have been identified and managed as follows:

- Income displacement and direct trauma both draw on the same population of flood-affected households. These benefits are monetised using distinct welfare mechanisms, income displacement captures lost earnings, while direct trauma captures psychological harm – and do not overlap in their unit cost assumptions.
- Fatalities are a subset of the total injury population. Fatality costs use the Value of Statistical Life (VoSL) only; non-fatal injury costs use direct medical and productivity costs only. There is no double-counting between these two categories.
- Direct trauma and indirect trauma represent distinct populations with different flood exposure levels, monetised using different trauma likelihood rates from the literature.

5.3.5 AVOIDED ENVIRONMENTAL COSTS – WATER QUALITY DAMAGES

Water quality often becomes highly contaminated post severe weather events due to sewage overflows, agricultural runoff (sediment, nitrogen, phosphorus), and other pollutants, posing serious health risks and requiring extensive cleanup.

The economic evaluation has adopted household willingness to pay (WTP) to avoid water quality impairment as a proxy for the expected water quality damages resulting from a 2% AEP flood. Based on the GIS mapping identified reductions in the number of households exposed to flood risk, the economic evaluation could monetise the aggregate savings in household WTP.

5.3.6 *AVOIDED PROPERTY, BUILDING & INFRASTRUCTURE DAMAGES*

5.3.6.1 RESIDENTIAL, INDUSTRIAL AND COMMERCIAL PROPERTY DAMAGES AVOIDED

Buildings have been categorised into residential, commercial or industrial. Flood damage was then attached to each building for each flood event scenario assessed (modelled pluvial flood event or by geospatial analysis of coastal inundation exposure).

Multiple buildings are present within a land parcel as per the land use datasets used. GIS tools were used to identify parcels with multiple buildings within. The aggregated damages results removed duplications from the AAD calculation, through selecting the maximum flood affected building in each parcel and using this as the basis of the damage calculation for that address.

5.3.6.1.1 Pluvial Flooding Exposure

Based on GIS mapping, the economic evaluation has examined all properties and buildings exposed to flood risk and identified the buildings that are likely to have greater than 50% of their perimeter flooded during each of the three return periods modelled (the 10%, 2% and 1%AEP events). Flood damage estimates were then assigned to each flood-exposed building, reflective of building type and flood damage severity (See Appendix A for more information).

5.3.6.1.2 Coastal Flooding Exposure

For coastal flooding, the 'bathtub' flood modelling results available, has likely overestimated flood depths, and therefore reasonable approximations were made based on engineering judgement and consistency with the climate change risk assessment. This assumes that there is increasing frequency of coastal flooding over time due to sea level rise, consistent with Parliamentary Commissioner for the Environment (2015) research, and that all properties within the coastal flood zone are impacted to a limited degree from 2050 onwards.

Flood damage estimates were then assigned to each flood-exposed building, reflective of building type with parameters identified in consultation within Kia Rōpine team to reflect an 'appropriate' assessment at this early phase – See Appendix A for more information.

5.3.6.1.3 Summary

The economic evaluation has aggregated the expected total flood related property and building damages under each proposed future as an estimation of the total residential, industrial and commercial property damages with the difference between each future and the Status Quo, representing a benefit, as damages avoided.

5.3.6.2 INFRASTRUCTURE DAMAGES AVOIDED

The economic evaluation has assumed that above-ground infrastructure will be impaired to different degrees depending on the asset type, with respect to a flood level of 2% AEP. Using the GIS mapping identified total length of road that likely will be flooded under each proposed future as a proxy for the quantum of above-ground infrastructure that likely will be damaged under a flood, the economic evaluation has linked this with DCC's network valuation to monetise the likely infrastructure damages avoided.

5.3.7 HEDONIC ANALYSIS

Hedonic uplift represents capitalised increases in land or property value arising from reduced flood exposure. Because these gains can overlap with avoided property damage benefits, hedonic uplift is treated as a Supplementary Benefit. It is excluded from headline BCR calculations and reported separately for transparency only.

5.4 SUMMARY OF BENEFITS

The tables below summarise monetised benefits in present value terms, for each proposed future. A breakdown of these monetised benefits under each epoch are presented in Appendix B.

5.4.1 CORE BENEFITS INCLUDED

Table 5.1: Core monetised NPV benefits of Proposed Futures (Nearest $m).

Benefits – Entire Return Period ($m)	Future 3	Future 4	Future 5
Avoided Injury and Fatality	$416	$423	$426
• Injury	$55	$56	$56
• Fatality	$361	$367	$370
Avoided Response and Recovery Costs	$62	$62	$61
Avoided Income Loss from Displacement	$17	$17	$18
Avoided Trauma	$15	$15	$15
• Direct	$10	$10	$10
• Indirect	$5	$5	$5
• Social Cohesion	$0	$0	$0
Avoided Environmental Costs	$0	$0	$0
Avoided Property, Building & Infrastructure Damages	$825	$833	$816
• Residential, Industrial & Commercial	$822	$831	$813
• Infrastructure	$3	$3	$3
Total Benefits	$1,335	$1,351	$1,336

Taken from 20260331-CoreBCR+Coastal.xlsx

The relatively high value of avoided fatality costs reflects the application of nationally recognised Value of Statistical Life parameters over a 100-year horizon. While low-probability, high-consequence outcomes contribute materially to the monetised benefit stream, these estimates are probability-weighted and consistent with standard public-sector appraisal practice in New Zealand. The magnitude of these benefits reflects long-term cumulative risk exposure rather than frequent annual loss.

5.4.2 WITH SUPPLEMENTARY BENEFITS

Table 5.2: Supplementary monetised NPV benefits of Proposed Futures (Nearest $m).

Benefits – Entire Return Period ($m)	Future 3	Future 4	Future 5
Avoided Injury and Fatality	$416	$423	$426
• Injury	$55	$56	$56
• Fatality	$361	$367	$370
Avoided Response and Recovery Costs	$35	$35	$34
• Emergency Services	$35	$35	$34
Avoided Income Loss from Displacement	$17	$17	$18
Avoided Trauma	$15	$15	$15
• Direct	$10	$10	$10
• Indirect	$5	$5	$5
• Social Cohesion	$0	$0	$0
Avoided Environmental Costs	$0	$0	$0
Avoided Property, Building & Infrastructure Damages	$464	$473	$455
• Residential, Industrial & Commercial	$462	$470	$452
• Infrastructure	$3	$3	$3
Hedonic Analysis	$305	$181	$322
• Level of service	$305	$181	$322
Total Benefits	$1,640	$1,532	$1,657

6 COSTS

6.1 INTRODUCTION AND CONTEXT

To assess the implications of the Proposed Futures, associated costs have been estimated. The cost estimates are based on a high-level optioneering and efficacy modelling exercise undertaken by the Kia Rōpine team, consisting of a series of spatially represented adaptation options/measures that are aggregated up into one of the three proposed future scenarios. This section describes each core cost type, with the approach, unit rates and source, detailed in Appendix A.

6.2 ONE OFF COSTS

The economic evaluation has identified one-off costs as the largest project costs, namely the capital costs associated with the construction of new infrastructure assets to support each future, followed by the acquisition of property and land identified to provide the space for retrofitting the interventions for each future.

6.2.1 INFRASTRUCTURE CAPEX

The identified options/assets incorporated within each Future are based on engineering judgment. They represent ***one potential combination of the quantity and the type of treatment options / assets at specific alignments and locations, to achieve an identified and modelled resulting efficacy***. Based on the agreed engineering judgment and the resulting schedule of quantities and developed unit rates, the economic evaluation has estimated the likely associated costs.

The costs reflect a high-level estimation and are intended to be ***comparative only for this stage***, given the remaining uncertainty, particularly in relation to the selections of short-, medium- and long-term options that may combine as part of the future.

Modelling whole-of-life costs for each future allows a fair comparison of the three proposed futures, as it factors in the timing of cost occurrence. It is expected that the cost estimates will improve further in accuracy as the project progresses to reflect further analysis on costings and timings.

Each option cost estimate is based on a typical detail for that option, calculated in accordance with available rates from a range of recent similar projects across New Zealand. The cost estimates follow established good practice methodologies underpinned by the Treasury's Better Business Case guidance.

Cost timing assumptions are captured in Appendix A, with appropriate inflation, discounted back to the present. ***A formal review of the unit rates has been proposed but not yet commenced.*** We have allowed the whole-of-life costs of:

- Construction capital costs including allowances for demolition, site clearance, utility services replacement, and reinstatement.
- Construction preliminaries and generals (P&G)
- Operation and maintenance costs
- Professional and internal management fees
- Contingency and optimism bias

- Acquisition of properties – purchase of landholdings and buildings

Capital costs have been adjusted to reflect optimism bias consistent with Treasury Better Business Case guidance for non-standard civil engineering projects at this stage of development. Given the early stage of option definition and design maturity, the upper-bound optimism bias adjustment (66%) has been applied to capital costs[12].

This approach aligns with Treasury Better Business Case recommendations for projects at strategic concept stage, where scope definition and risk resolution remain incomplete. The optimism bias allowance can be progressively reduced as design development and cost certainty improve in subsequent phases.

The selected optimism bias percentage reflects the project's current position within the Better Business Case lifecycle and recognises uncertainties relating to scope refinement, geotechnical risk, property acquisition complexity, consenting requirements, and construction staging.

Exclusions at this stage of development include GST, contaminated waste disposal, unexpected ground conditions, rebuild of existing properties in new location, escalation or operational costs/downtime due to operations.

Unit costs do not reflect the potential opportunities to offset costs, for example through property acquisition via renting or through selling land suitable for intensification after elevating it. For this phase of the study, the costs provided are those that are likely to be funded through Council (or rather through 'public funding'), although alternative funding mechanisms could be put in place as opportunities are captured into the future. The cost estimates do not include costs borne by individual property owners to reduce risk.

6.2.1.1 CORE ASSUMPTIONS

- Programme duration for each option has been assumed to be the same for each outcome with the costs identified as being based on current conditions.
- Most construction details have been assumed. We have built up our rates using judgement at this point and using previous projects to guide the ranges being applied.
- Allowances have been made to provide for the mobilisation and demobilisation of key plant and equipment required for each project. As the project progresses, we will get a better understanding of these factors.
- Quantities have been taken from the received layout and draft sizing exercise undertaken as part of the efficacy modelling (see Key Assumptions below).
- Costs only included for the South Dunedin study area. Note that assets that protect the area from coastal flooding/erosion will need to extend beyond the study area. Assumed these costs would be captured in other budgets to reflect the additional lengths of these assets with an appropriate & consistent level of protection for the central Dunedin area. These costs would be additional to the numbers presented.
- No costs included for the protection activities required for the St Clair to St Kilda coastal edge. Should on-going Coastal investigations/assessments identify that further protection is required then this cost would be additional to the numbers presented.

[12] Te Tai Ōhanga | The Treasury – techniques to quantify risk and uncertainty – Optimism Bias - https://www.treasury.govt.nz/information-and-services/state-sector-leadership/investment-management/better-business-cases/additional-better-business-case-guidance/techniques-quantify-risk-and-uncertainty.

6.2.2 PROPERTY & LAND ACQUISITION

The Property and Land Acquisition cost component captures the economic implications of proactive purchase of land and buildings required to enable for repurposing of land, elevated-land development, or blue-green infrastructure interventions. Key inputs include:

- The quantum of buildings identified under each option (residential, commercial, and industrial).
- Property-specific capital values, based on DCC provided 2025 property Capital Value (CV).
- Timing of acquisition aligned with intervention phases.

Acquisition costs grow over time through the same cost escalation factors applied elsewhere in the model, ensuring consistency with long-term general market cost escalation. These costs are allocated based on intervention periods and discounted to reflect present-value terms.

The approach provides a transparent, standardised method to compare acquisition-heavy options (e.g., extensive property repurpose or land regrading) against infrastructure dominant options.

6.2.3 REPURPOSED LAND ACTIVITES

Through the assessment work for each future, including the overlay of specific strategic interventions (options such as Raised Land in Future 3 and 5, or Green Open Space), a geospatial analysis of potential properties (all types) required to be ***proactively repurposed*** to provide space for the delivery of the specific options for each future.

The costs included within this reflect the activities to remove existing assets from the identified future intervention parcels. Further details are presented in Appendix A, capturing

- Removal or demolition of properties
- Land Clearing – removing utilities and other assets.
- Reinstatement of the current property land to green space.

6.3 ONGOING COSTS

The economic evaluation has identified incremental capital maintenance costs and asset operating expenses associated with the construction of new infrastructure assets, recurring over the assessment period.

6.3.1 CAPITAL MAINTENANCE

Capital maintenance represents periodic reinvestment required to maintain asset performance over its designed life. The core assumption being asset capital maintenance cost is equivalent to 35% of the initial capital investment, required every 25 years after the initial capitalisation of the asset. These costs are evaluated at their respective renewal intervals and escalated using the model's scenario-specific cost growth factors before being discounted back to present value.

This generalised approach provides a suitable option-based asset lifecycle maintenance envelope. Ensuring high-capital, long-life structural interventions are evaluated on a like-for-like basis with nature-based or repurpose-heavy Futures. Including these renewal costs avoids underestimating long-run costs of engineered solutions and supports a balanced option comparison.

6.3.2 OPEX

Ongoing operational expenditure (OPEX) covers the recurring activities necessary to operate, monitor, and maintain the performance of implemented interventions, whether blue-green systems, piped networks, pumped drainage, or other structural / non-structural measures.

The OPEX calculation is applied annually across the assessment timeframe, accounting for inflation and discounting back to present value. The core assumptions are that the annual operational costs are allocated as a percentage of the total capital asset worth, set at 1.5% per year. Costs are cumulative, with additional investment resulting in operational expenditure being added.

Additionally, electrical annual line charges and energy costs are included for pump station assets on top of the proportional capital investment. The modelling assumes that the energy demand annually increases into the future.

This produces a lifecycle-based estimate of long-term operational commitments, which is critical when comparing options with high ongoing energy or maintenance loads (e.g., pump-reliant "Keep Water Out" configurations).

6.4 SUMMARY OF COSTS

6.4.1 ENTIRE PERIOD

The table below summarises the monetised costs in present value terms, for each future over the full return period. A breakdown of these monetised costs under each epoch is presented in Appendix B.

Table6.1 – Total Costs by future – whole of life (2025 NPV $m, 6% discount rate)

Core component	Status Quo	Future 3 Protect	Future 4 Restore	Future 5 Reshape
CAPEX Investment	$290	$1,220	$724	$1,287
Repurposed Land Activities	$4	$433	$447	$545
Land & Property Acquisition	$72	$343	$338	$519
Capital Maintenance (cyclical)	$15	$33	$39	$31
Operational Expenditure (OPEX)	$31	$70	$81	$66
Total Costs	$411	$2,098	$1,629	$2,448

7 COMPARISON WITH PREVIOUS STAGES

7.1 THE OUTCOMES

Table 7.1 – Differences between presented Long- & Proposed Futures.

Futures	Long List (2025 -2100)				Short List (2027 -2127) - Core			
	Cost ($B)	Benefits ($B)	BCR	Rank	Cost ($B)	Benefits ($B)	BCR	Rank
Future 3 Protect	5.8 (5.0 – 8.0)	3.8 (3.5 – 4.5)	0.6 (0.4 – 0.8)	*3*	2.1	1.34	0.64 (0.54 – 0.75)	*2*
Future 4 Restore	2.8 (2.0 – 4.0)	2.8 (2.5 – 3.5)	1.0 (0.6 – 1.6)	*1*	1.6	1.35	0.83 (0.71 – 0.98)	*1*
Future 5 Reshape	7.1 (6.0 – 10.0)	4.5 (4.0 – 5.5)	0.7 (0.4 – 0.9)	*2*	2.4	1.34	0.55 (0.46 – 0.64)	*3*

7.2 CORE ASSUMPTION CHANGES

7.2.1 APPROACH TO THE ASSESSMENTS

As part of the Long List phase, no quantifiable assessments or evidence was utilised to assess the potential quantum of properties and infrastructure affected, or likely to be purchased because of various proposed interventions. Engineering judgement was utilised to assess the likely scale of interventions that could yield a suitable improvement in the exposure to both groundwater and stormwater flooding for the current day and future conditions.

The interventions at both Long and Short List were mapped using geospatial information based on the catchment knowledge. The quantity of each asset proposed was then used within the economic assessment to determine the potential costs for each future. Each of the seven futures created a series of interventions that made up each future.

7.2.1.1 LENGTH OF ASSESSMENT

Following discussions with the client and a review of the general practices for social investment proposals and climate resilience investment planning, the economic evaluation has increased the assessment period from 75 years to 100 years to better model long-term flood hazards and adjusted the present term (baseline date) from 30 June 2025 to 1 January 2027 to reflect a more realistic project start date.

7.2.1.2 TIMING OF THE INTERVENTIONS

At the Long List phase, core assumptions as to when costs and benefits would be incurred where simplified, given the status of the investigation at that time. The Short List stage has allowed for further investigation into determining when options would be delivered across the three modelled epochs.

Table 7.2 below captures the core differences between the two phases completed to date

Table 7.2: Monetised Costs of Proposed Futures Over the Entire Return Period

Item	Long List	Short List
Purchase of Properties	• All properties purchased within first 5 - 15 years of each future. • Average property value for South Dunedin - $450k (2022 CV).	• Proactive acquisition distributed into each epoch. Evenly spread across the epoch period. • Asset specific Capital Values (2025 CV)
Included Flooding Damage Assessments	• Qualitative assessment of all forms of flooding and impacts on properties.	• Quantitative pluvial and semi-quantitative coastal property level assessments.
Infrastructure Investments	• Capital investment for each future delivered within the first 5 - 15 years.	• Capital investments for each epoch spread across the first 10 years of each epoch.
Benefits period	• Benefits accrue from year 1.	• Benefits accrue from year 1 of each epoch onwards
Basis of Economic Assessment	• Assumed impacts of 1% AEP event into the future.	• AAD applied as described above.

7.2.2 PROPERTIES TO BE ACQUIRED

At the Long List phase, property acquisition was assessed at a strategic level through the micro-business cases and the seven potential adaptation futures. These early assessments considered indicative numbers of properties requiring purchase under each future, informed by GIS mapping and the initial spatial adaptation envelopes.

The analysis provided high-level, order-of-magnitude estimates to support shortlisting and was not yet linked to hydraulic performance modelling, with the Status Quo using engineering judgement to identify the likely quantum of affected properties.

The modelling at the Short List stage defines spatial exposure for each future, enabling a more defendable, hydraulically-informed count of affected properties and associated acquisition costs.

The cost modelling workbook then applies these property counts, capital values, cost-growth indices, and discounting assumptions to produce monetised acquisition costs consistent with the timing and scale of the actions within each Futures scenario. This represents a progression from high-level strategic estimates (early 2025), to efficacy-aligned and spatially validated cost estimates in the current stage.

Table 7.3: Quantity and monetised costs of properties for acquisition - assumed (Long-List) or assessed (Short-List) – 2025 CV

Futures	Long List		Short List	
	Quantity *1	$ B *3	Quantity *2	$ B *4
Future 3 - Protect	3,450	1.56	1,190	0.59
Future 4 - Restore	1,375	0.62	1,162	0.45
Future 5 - Reshape	3,750	1.69	1,738	0.84

*1 -Assumed number of buildings to be 'no longer suitable for residential purposed' during Long List and for Short List Status Quo – based on a geospatial assessment undertaken that identifies when properties could be exposed to emergent groundwater over the next 100 years[6], with the assumption that land associated with these low-lying buildings would be repurposed, due to anticipated untenable living conditions.

*2 - Buildings calculated using geospatial analysis for proactive acquisition only (because of the identification of land area to be utilised for future options/mitigations).

*3 – Long list costs included assumptions (no quantitative analysis undertaken) identifying the number of buildings to be acquired (proactively – to make space for specific adaptation mitigations being implemented) or through purchase post events (assumed costs worn by mix of public and local/central government), multiplied by an average cost of $450k per property (QV Average CV 2025 for South Dunedin[13]).

*4 – Number of buildings to be acquired proactively taken from geospatial assessment, multiplied by the rateable value for the specific property (taken from DCC dataset received), with a 15% allowance for costs associated with purchasing the property included. Specific assessment identifies that buildings affected represented residential, commercial, industrial, school and church buildings.

7.2.3 MITIGATION OPTIONS HAVE BEEN FURTHER REFINED

There have been further refinements to the likely infrastructure required to achieve the anticipated outcomes in relation to exposure. The efficacy work undertaken has reviewed and iteratively determined a suite of options within a hydraulic model environment, with the quantities and sizes of assets specifically captured. The Long List was a qualitative assessment undertaken in GIS to identify likely needs of infrastructure for each future. Table 7.4 overleaf captures the differences between the two phases.

7.2.4 PROPERTY PURCHASE FOR STATUS QUO

The previous phase included approximately $1.2 billion dollar of reactive property acquisition within the Status Quo costs as properties become more increasing exposed to flooding, more regularly, with expected insurability and mortgage-ability challenges.

In line with recent Government direction changes and an anticipated shift away from purchasing properties damaged by Natural Hazard events, this phase of the assessment does not include these costs within the economic evaluation. With the assumed impacts of exposure for buildings and finances (through the AAD calculation) rising through the Medium- and Long- Term.

Status Quo excludes the financial impacts of these from the overall public finances assessment. These are still expected to occur but will now be borne by the private purse (the property owners themselves) – presenting a considerable equity and intergenerational challenge.

[13] Taken from Figure 1 of DCC Flood Risk Assessment Technical Note (February 2025), produced by Stantec as part of the Integrated Catchment Modelling Programme.

Table 7.4: Comparison of core infrastructure changes between Long and Short List phase

Physical Works	Future	Status Quo		Future 3 - Protect		Future 4 - Restore		Future 5 - Reshape	
	Unit	Long List	Short List	Long List	Short List	Long List	Short List	Long List	Short List
Open Channels	m	0	0	0	0	4500	3526	10000	3526
Overland flow paths	m	0	0	11000	0	7500	0	6500	0
Storage - 1m deep	ha	-	0	-	1	-	1	0	1
Storage - 1.5m deep	ha	40	12	70	4	65	4	75	4
Storage - 2m deep	ha	-	0	-	0	-	2	0	2
Wetlands	ha	0	0	0	9	0	9	0	9
Pump Station - Small (under 1m^3/s)	ea	0	0	0	6	0	6	0	2
Pump Station - Large	m^3/s	2	6	10	12.4	10	12.3	10	11.8
GW Pump Station	ea	1	0	1	1	1	1	1	1
Repurposed Land Area	ha	40	0	125	81	65	69	195	102
Raised Land	ha	0	0	55	39	0	0	120	45
New pipe to outfall	m	0	500	2000	0	2000	0	2000	0
New Outfall	ea	1	1	1	4	1	4	1	3
New seawall (Minimum length in SDF Area)	m	0	0	2000	2100	2000	2100	0	0
Internal sea wall / bund (Minimum length in SDF Area)	m	0	0	0	0	0	0	1500	1500
Groundwater pipes network / inspection vents	m	49000	0	32000	10000	49000	16000	32000	9500
Stormwater Pipes (diameter > 900mm)	m	-	4000	8000	9291		9184		8985
Stormwater Pipes (diameter < 900mm)	m	-	9000	12000	21439		23381		25309
Manholes - Sum (all sizes)	ea	-	540	400	673		821		853
Demolition and Site Clearance	Section	2500	10	3750	1190	3450	1162	1375	1738
Utility services	ha	40	2	125	95	65	85	195	118
Reinstate	ha	0	0	60	81	0	69	120	102
Land Acquistions / Compensation	ea	2500	10	3450	1190	1375	1162	3750	1738
Properties exposed to elevated groundwater	ea		838						
Value (2025) of buildings retreated	$B	$ 1.10	$ 0.94	$ 1.60	$ 0.59	$ 0.60	$ 0.45	$ 1.70	$ 0.84

8 BCR RANGE

8.1 SUMMARY

The analysis for this phase produces a benefit cost ratio for each future (Figure 8-1), showing a significant reduction in the expected annual flood damages of over $810m over the 100-year period.

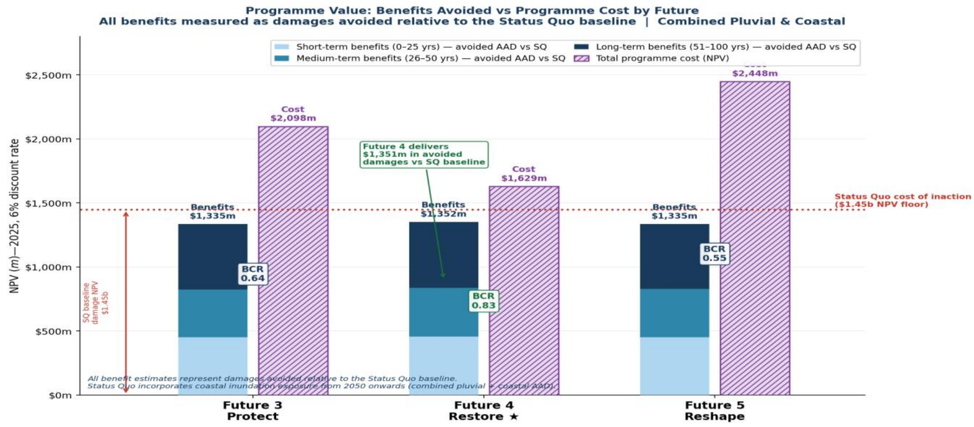

Figure 8-1: Programme Value: Cumulative Avoided Damage (Benefits) vs Programme Cost by Future[14]

8.1.1 CORE BCR

Table 8.1 – Core BCR – whole of life (2025 NPV $m, 6% discount rate)

Future	Benefits	Costs	Core BCR (midpoint)	BCR range (±15%)	Rank
Future 3 - Protect	$1,335	$2,098	0.64	0.54 – 0.75	2
Future 4 - Restore	$1,351	$1,629	0.83 ★	0.71 – 0.98	1
Future 5 - Reshape	$1,336	$2,448	0.55	0.46 – 0.64	3

To date, we present the BCR using a range, sufficient for the high-level concept stage of the analysis, with no design undertaken to date. There is uncertainty about the underlying assumptions and inputs. The range presented at this stage, differs from the ranges presented at Long List phase, dated February 2025, as identified within Section 7.

Further economic evaluation will take place during the subsequent stage, which should continue to narrow the range, as input certainty will start to increase. Appendix B shares the BCR breakdown by each of the three epochs.

[14] All benefits = damages avoided relative to Status Quo baseline (NPV $m, 6% discount rate, 2025 $).Methodology note: Stacked bars show NPV avoided damages by epoch: Short-term (0–25 yrs), Medium-term (26–50 yrs), Long-term (51–100 yrs). Hatched bars show whole-of-life programme costs. Dotted line = Status Quo cost of inaction ($1.45b NPV). All benefit estimates derived from combined pluvial and coastal AAD relative to the Status Quo.

The Long-Term (51–100 year) BCRs are notably stronger than the whole-of-life BCRs. This reflects the timing profile of the Futures: most capital costs are incurred in the Short- and Medium-Term, while a large share of risk-reduction benefits accrues later as climate hazards intensify.

When assessed on a standalone basis, the long-term period shows high value for money because relatively modest incremental costs are used to avoid very large future damages. Higher Long-Term BCRs relative to whole-of-life BCRs mainly reflect timing and discounting effects, rather than a modelling anomaly.

The whole-of-life BCR combines all three epochs and is therefore influenced by (i) the concentration of costs in the early decades and (ii) the discounting of distant benefits. This pattern is consistent with international practice in climate-adaptation cost-benefit analysis, where upfront capital investment is compared with benefits that grow over time as hazards intensify.

Path to benefit-cost breakeven: The current Core BCR for Future 4 is 0.83 at the central 6% rate. For the BCR to reach 1.0, the NPV of benefits would need to increase by $300m from their current modelled value.

This could be achieved through further work through to the subsequent Preferred Pathway, with a combination of:

- quantifying insurance withdrawal avoidance (not currently included, estimated to be potentially material given post-Cyclone Gabrielle insurance withdrawal patterns in low-lying NZ communities);
- including regeneration and urban land value uplift benefits;
- quantifying avoided utility and infrastructure network costs (Chorus and Transpower assets within the study area are not currently included);
- determining additional hedonic analysis values, reflecting enhancements to transport levels of service (such as through reducing potential transport disruption and their impact on the local economy),
- refining the optimism bias downward from 66% as design certainty improves.

The BCR range should therefore be read as a conservative floor, not a ceiling, on the programme's economic performance.

8.1.2 SUPPLEMENTARY BCR

Table 8.2 – Supplementary BCR – whole of life (2025 NPV $m, 6% discount rate)

Future	Benefits	Costs	Core BCR (midpoint)	BCR range (±15%)	Rank
Future 3 - Protect	1,640	2,098	0.78	0.66 – 0.92	2
Future 4 - Restore	1,532	1,629	0.94 ★	0.80 – 1.11	1
Future 5 - Reshape	1,657	2,448	0.68	0.58 – 0.80	3

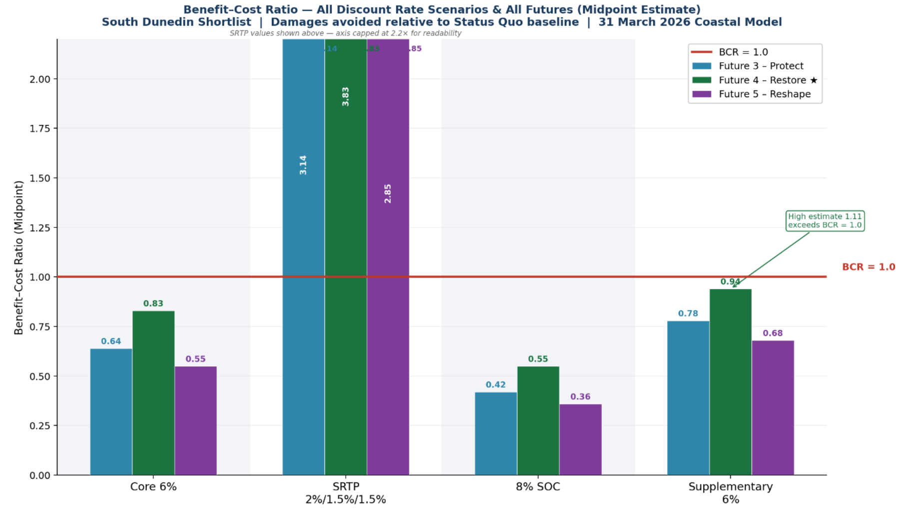

Figure 8-2: Core Benefit-Cost Ratio – All Scenarios & All Futures (Midpoint Estimate)[15]

8.2 SENSITIVITY TESTING

We undertook some sensitivity analyses to identify the assumptions that had the biggest impact on the benefit cost ratio. In this report, the 'Status Quo' future represents a continuation of current and planned BAU/LTP investment, without the additional proposed adaptation interventions, present in Futures 3 - 5. The following sensitivity tests were undertaken to strengthen robustness and address peer-review recommendations:

8.2.1 DISCOUNT RATES

Adopting New Zealand Treasury's suggested 2025 SRTP for non-commercial public-sector proposals as the low-discount-rate scenario, the headline BCRs improve. The following analysis is undertaken using both a low discount rate to represent a Social Rate of Time Preference approach (with a rate of 2% for the short-term epoch, declining to 1.5% for the medium-term and 1.5% for the long-term, consistent with NZ Treasury's public investment discount rate guidance.

Under the SRTP scenario (2%/1.5%/1.5%), all three proposed futures exceed the benefit-cost breakeven threshold. Future 4's Core BCR improves to 3.83, Future 3 to 3.14, and Future 5 to 2.85. This result reflects the incorporation of coastal inundation exposure into the Status Quo baseline, which materially increases the damages avoided under each future scenario and, therefore, the benefits at all discount rates.

[15] This figure presents the midpoint Benefit–Cost Ratio for each proposed future across four discount rate scenarios. All BCRs reflect damages avoided relative to the Status Quo baseline (combined pluvial and coastal AAD). The Status Quo BCR is excluded from the chart as the three proposed futures are assessed relative to it; Status Quo BCR values are provided in the accompanying tables. The core 6% rate is the headline discount rate used throughout this evaluation. The SRTP scenario (2%/1.5%/1.5% declining across short, medium, and long terms) represents the Treasury benchmark for long-lived public investment; under this scenario all three proposed futures exceed the benefit-cost breakeven threshold of 1.0. The 8% SOC scenario represents the high-end sensitivity. The supplementary scenario incorporates a Level of Service proxy in addition to core avoided damage benefits. SRTP bars are truncated at 2.2 for chart readability; actual midpoint values are annotated above each bar.

The finding strongly confirms that the proposed futures deliver substantial positive net social value under the Treasury's public investment discount rate framework and do so by a significant margin above the BCR = 1.0 threshold when assessed on an appropriate intergenerational basis.

Table 8.3 – Low Discount rate applied BCR – whole of life (2025 NPV $m, 2% & 1.5% discount rates)

Future	Benefits	Costs	Core BCR (midpoint)	BCR range (±15%)	Rank
Future 3 - Protect	14,052	4,479	3.14	2.67 – 3.69	2
Future 4 - Restore	14,132	3,685	3.83 ★	3.26 – 4.51	1
Future 5 - Reshape	13,957	4,904	2.85	2.42 – 3.35	3

Adopting New Zealand Treasury's suggested 2025 SOC for commercial public sector proposals as the high discount rate scenario of 8, the headline BCRs worsen.

Table 8.4 – High Discount rate applied BCR – whole of life (2025 NPV $m, 8% discount rate)

Future	Benefits	Costs	Core BCR (midpoint)	BCR range (±15%)	Rank
Future 3 - Protect	707	1,687	0.42	0.36 – 0.49	2
Future 4 - Restore	716	1,298	0.55 ★	0.47 – 0.65	1
Future 5 - Reshape	708	1,986	0.36	0.30 – 0.42	3

This range reflects common practice for long lived public infrastructure and climate adaptation investments, where discounting must balance intergenerational equity and fiscal realism.

8.2.2 PRIVATE LEVEL PROPERTY ADAPTATION UPTAKE

A further sensitivity run was undertaken to determine the impact of an increasing level of property level flood resilience interventions added by a proportion of the property owners (all land use types) over the next 30 – 50 years. To undertake this analysis, we reduced the expected annual average damage per epoch to 85% of the Status Quo expected Annual Average Damages.

The implications of this are that there are marginal reductions in the BCR, but the proportional change for each Future is the same and hence the BCR ranking remains the same.

Table8.5 – Sensitivity applied – 15% reduction in AAD – for Private investment in Property Level adaptations – whole of life (2025 NPV $m, 6% discount rate)

Future	Benefits	Costs	Core BCR (midpoint)	BCR range (±15%)	Rank
Future 3 - Protect	1,206	2,098	0.57	0.49 – 0.68	2
Future 4 - Restore	1,222	1,629	0.75 ★	0.64 – 0.88	1
Future 5 - Reshape	1.206	2,448	0.49	0.42 – 0.58	3

9 CONCLUSION

The economic evidence supports investment in adaptation, and Future 4 (Restore) is the recommended option of the three shortlisted. At a central 6% discount rate, the community would spend approximately $280 million in net present value terms to avoid an estimated $1.45 billion in flood-related damages, plus a further $500–700 million in unquantified consequences such as insurance withdrawal, infrastructure repair, and private adaptation costs that South Dunedin residents would otherwise bear directly.

The relevant comparison is the net cost of action versus the cost of inaction. The programme costs shown in Table 1.2 and Table 6.1 are gross figures and do not net off the avoided damages each future delivers. Once avoided damages are considered, the net cost of each proposed future sits materially below the cost of inaction, as set out in Table 9-1 below.

Table 9-1: Net cost of action versus cost of inaction (NPV $m, 6% discount rate, 100-year period)16

Option	Gross programme cost	Avoided damages	Net cost to the community	Saving versus inaction
Status Quo	—	—	$1,450m+	baseline
Future 3 — Protect	$2,098	$1,335	$763	≈ $687m
Future 4 — Restore ★	$1,629	$1,351	**$278**	**≈ $1,172m**
Future 5 — Reshape	$2,448	$1,336	$1,112	≈ $338m

The cost of inaction should be read as a range: $1.45 billion (the conservative quantified floor) to more than $2 billion (inclusive of unquantified consequences). Both ends of that range exceed the net cost of any of the three proposed futures. Under the Treasury Social Rate of Time Preference framework, which is the appropriate discount basis for long-lived intergenerational public investment, all three futures return Core BCRs above 1.0, with Future 4 at 3.83, Future 3 at 3.14, and Future 5 at 2.85. This confirms that the economic case for adaptation in South Dunedin is robust under the discount rate framework most appropriate to a 100-year climate adaptation programme

While whole-of-life Core BCRs are below 1 in the current shortlisting assessment, long-lived climate adaptation investments are typically characterised by significant upfront capital costs and benefits that increase over time as hazard intensity escalates.

This pattern is consistent with comparable long-lived public infrastructure investments in New Zealand and internationally. For context, NZ transport infrastructure investments routinely proceed with BCRs in the 0.4–0.8 range at the business case stage, on the basis that additional unquantified benefits (network effects, resilience value, social equity) support the investment case.

The long-term (51 – 100 year) BCR results and sensitivity testing demonstrate strengthening economic performance over time and confirm that relative Futures ranking remain stable under alternative discount rate assumptions. It's expected that the BCRs would improve as the economic evaluation develops. The results should therefore be interpreted as indicative of relative economic performance at strategic concept stage, rather than as definitive investment thresholds for final approval.

[16] Cost of inaction is the conservative quantified floor of $1.45 billion NPV. Inclusive of unquantified consequences (insurance withdrawal, wider infrastructure repair, private adaptation), the cost of inaction is likely more than $2 billion, which would widen the saving to community under each future accordingly. Gross programme costs from Table 6.1; avoided damages from Table 5.1.

Further upside has been excluded from the Core BCR work at this time but further effort to understand and appropriately include the potential for regeneration uplift as well as the benefits of avoided losses in open space, avoided losses in ecosystem services, avoided damages in heritage buildings and value of insurability to be included.

Alongside ongoing refinements in the modelling, with the considerations for wider-economic benefits, and potentials for cost efficiencies and optimisation.

Each year without action increases costs: Annual Average Damage rises by roughly $1m per year in the medium term and accelerates as climate risks worsen. Capital costs also rise about 2% annually. Starting early on the preferred plan, even before all details are final, is likely more cost-effective than delaying further.

As the programme progresses, it is expected that the opportunities for further evaluation of redevelopment potential will progress further and will provide more specific analysis for inclusion into the next stage of our assessments. At this stage, we have identified a conservative assessment and have identified the basis of this in this report.

Even if some private adaptation and BAU responses reduce the Status Quo AAD further over time, indicative sensitivity testing suggests that the relative performance and ranking of the Proposed Futures is likely to remain robust under reasonable levels of private intervention.

The shortlist economic evaluation suggests that Future 4 is the most beneficial. Future 4 yields the highest BCR of *0.83* over the full return period, central 6% discount rate, indicating the strongest return of the three proposed futures assessed. Initial sensitivity testing confirms this to be the favoured future, based on the evaluated economics included here.

Furthermore, under the Social Rate of Time Preference (SRTP) scenario, appropriate for long-lived public investment. Future 4's BCR improves to *3.83*, exceeding the breakeven threshold of 1.0. Initial sensitivity testing confirms Future 4 as the preferred future based on the evaluated economics.

Current GIS mapping suggests that, under the Status Quo future, following the assumption of the same level of flood risk within South Dunedin, groundwater levels are expected to gradually increase over the return period. This suggests increasing consequences for maintaining current communities within South Dunedin.

In the absence of further local government interventions than proposed under the Status Quo scenario, South Dunedin is expected to become increasingly intolerable to reside and work in. There will be some level of private sector flood mitigation investment expected, such as property owners paying to raise their own land or relocating their land improvements.

Appendix A – Core Economic Assumptions: Sources and discussion

Discount rate

A discount rate is used to convert flows of costs and benefits over time into a net present value. Following The Treasury's guidelines on determining the discount rate for government projects.[17], a weighted average of the two approaches of social opportunity cost (SOC) and social rate of time preference (SRTP) was deemed most appropriate.

All headline BCRs use a 6% weighted Social Opportunity Cost (SOC), consistent with NZ Treasury public sector guidance for long-lived social infrastructure. Following Treasury's guidance, the economic evaluation has been sensitivity tested using a high discount rate of 8% (representing the real SOC of capital) across the full assessment timeframe, and a low discount rate applying real Social Rate of Time Preference (SRTP) rates of 2%, 1.5%, and 1.5% for the short-term, medium-term, and long-term periods respectively.[18].

These SRTP rates are derived from NZ Treasury's long-term GDP growth projections adjusted for the Fisher equation, reflecting a conservative estimate of the declining real rate of return over the 100-year assessment period. These rates are broadly consistent with international practice for long-lived climate adaptation investment, where declining discount rates over time are increasingly accepted (e.g., UK Green Book declining long-run discount rate framework).

They are marginally below the NZ Treasury standard SRTP of approximately 3–3.5%, which reflects a more conservative treatment of intergenerational equity. The SRTP sensitivity BCR results (Future 4: *3.83*) are therefore based on rates at the lower end of the defensible range.

Benefits

Avoided injury

The National Institutes of Health (NIH) studies concluded minor-moderate physical flood injury rates of between 2% and 4.6%.[19] . The economic evaluation adopted the NIH midpoint injury likelihood of 3% and applied it to the population of exposure under each proposed future. The evaluation assumed an average direct cost per minor-moderate injury of $68,083 as suggested by the NZIER and an average indirect cost per minor-moderate injury of $272,332 (400% of direct cost).[20].

Avoided Injury = NPV of [AEP * population of exposure * injury rate * (direct cost per injury + indirect cost per injury)]

Avoided fatality

The economic evaluation adopted the literature-suggested flood caused minor-moderate injuries to severe injuries ratio of 6028:1075.[21] and applied this to the expected number of injuries under each proposed future over the return period. The evaluation embraced the NZIER and NZTA suggested value of statistical life (VoSL) of $12.5M per life.

The NZ Treasury's 2024 guidance indicates a VoSL range of $12.75m to $14.0m (with a midpoint of approximately $13.375m). The evaluation adopts the conservative NZIER/NZTA figure of $12.5m,

[17] Young, L. (2002). Determining the Discount Rate for Government Projects. Econstor.

[18] Discount Rates. (2025). The Treasury New Zealand. https://www.treasury.govt.nz/information-and-services/public-sector-leadership/guidance/reporting-financial/discount-rates

[19] Bartholdson, S., & von Schreeb, J. (2018). Natural Disasters and Injuries: What Does a Surgeon Need to Know? Current Trauma Reports, 4(2), 103–108. https://doi.org/10.1007/s40719-018-0125-3

[20] Clough, P. 2023. The value of safety improvements." NZIER Insight 107. Available at https://www.nzier.org.nz/publications/the-value-of-safety-improvements-nzier-insight-107

[21] Terti, G., Ruin, I., Anquetin, S., & Gourley, J. J. (2017). A Situation-Based Analysis of Flash Flood Fatalities in the United States. Bulletin of the American Meteorological Society, 98(2), 333–345. https://doi.org/10.1175/bams-d-15-00276.1

which is marginally below the Treasury 2024 lower bound. Updating to the Treasury 2024 midpoint ($13.375m) would increase avoided fatality benefits by approximately 7%, with a marginal upward impact on the overall BCR. This refinement is recommended for the next stage.

Avoided Fatality = NPV of [AEP * population of exposure * injury rate * fatality rate given injury * VoSL]

Avoided emergency services cost

NZIER's economic assessment of flood risk mitigation addressed to the Greater Wellington Regional Council suggested that flood emergency services costs within New Zealand range between 4% to 11% of the total property damages[22]. The economic evaluation has adopted the midpoint flood emergency service cost range in NZIER's study of 7.5% as the assumed flood emergency cost, with respect to total property damages.

Avoided Emergency Service Cost = NPV of [emergency cost% * expected total property damages]

Avoided income loss from displacement

The GIS mapping has identified the likely households exposed to relocation risk with respect to flooding within the model catchment. The economic evaluation has assumed that households subject to flooding will be displaced for, on average, 13 weeks.

It is further assumed that severe injuries are fatal, hence, the associated income losses have already been captured under fatality costs avoided. The average annual household income in Dunedin in present terms, published by Infometrics, is $111,805 per household.

Avoided Income Loss from Displacement = NPV of [AEP * expected number of household displacements * average annual household income * displacement duration]

Avoided trauma

The GIS mapping has estimated the number of households that are likely to be directly and indirectly affected by flooding under the Proposed Futures over the return period, assuming an average household size in Dunedin of 3 people (rounded up from 2.5 per NZ Census data).

Literature review suggests that 22.1% of the exposed households will likely experience direct trauma, with a current monetary cost of $24,200 per person[23], and 32.5%[24] of the connected households will likely experience indirect trauma, with a current monetary cost of $12,100 per person[25].

Directly impacted – Refers to all residential properties identified through the efficacy modelling work to have above floor flooding, given a 2% AEP event.

Indirectly impacted – refers to all residential properties with exposure to greater or equal to 50% of its perimeter being flooded given a 2% AEP event minus the Directly impacted trauma properties.

Avoided Trauma = NPV of [AEP * average household size * (expected households directly impacted * direct trauma likelihood * cost of direct trauma per person + expected households indirectly impacted * indirect trauma likelihood * cost of indirect trauma per person)]

Avoided social cohesion cost

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[22] NZIER. 2024. Economics of Flood Risk Mitigation. A report for Greater Wellington Regional Council and Rivers Group of Regional Councils.

[23] von der Warth, R., Dams, J., Grochtdreis, T., & König, H. H. (2020). Economic evaluations and cost analyses in posttraumatic stress disorder: a systematic review. European Journal of Psychotraumatology, 11(1). https://doi.org/10.1080/20008198.2020.1753940

[24] Terti, G., Ruin, I., Anquetin, S., & Gourley, J. J. (2017). A Situation-Based Analysis of Flash Flood Fatalities in the United States. Bulletin of the American Meteorological Society, 98(2), 333–345. https://doi.org/10.1175/bams-d-15-00276.1

[25] Even, D., Cohen, G. H., Wang, R., & Galea, S. (2024). The cumulative contribution of direct and indirect traumas to the production of PTSD. PLoS ONE, 19(8), e0307593–e0307593. https://doi.org/10.1371/journal.pone.0307593

The economic evaluation has estimated the likely social cohesion cost by assuming a reduction in GDP growth per capita of 2.2%, as suggested by a recent macroeconomic implication study on severe flood events published by the OECD Economics Department[26]. The GDP per capita in Dunedin is presented in current terms by Infometrics as $64,506.

Avoided Social Cohesion Cost = NPV of [AEP * GDP per capita * social cohesion cost factor * population of exposure]

Avoided water quality damage

The economic evaluation has reviewed the findings presented in the New Zealanders Environmental Attitudes 2018 report published by the Ministry for the Environment and has adopted the probability of households concerned for water quality of 82%.

The evaluation has approximated the expected Dunedin resident WTP to avoid water quality damages as $100 per person in current terms, based on an indexation to current values of the New Zealand literature study highlighting the Auckland residents' WTP for moderate water quality improvements of $74.53[27].

Avoided Water Quality Damages = NPV of [AEP * impacted households * probability of households concerned for water quality * average household size * estimated resident WTP]

Avoided residential, industrial & commercial property damage

GIS mapping has modelled the likely flood level for the identified buildings. Where the flood level is above the building's floor level, we have then estimated the likely flood damage severity to the buildings and grouped them on a discrete scale between 0 (low to no damage) and 4 (catastrophic damage).

Flood damage estimates have been assigned to each flood-exposed building, depending on building type and flood damage severity, based on the agreed methodology that DCC have requested for the analysis.

The approach is presented in the Integrated Catchment Modelling Programme output "DCC Flood Risk Assessment Technical Note", published February 2025.The table below shares an example of the damage implications to Residential and Commercial buildings that are exposed to flooding.

Residential (Modal)		
Total Building and Contents		
Flood depth (mm)	Category	Cost
None	0	0
-100 to 0	1	$10,000
0 to 200	2	$45,000
200 to 500	3	$170,000
500 to 2000	4	$300,000

Commercial		
Total Building and Contents		
Flood depth (mm)	Category	Cost
		(* building capital value)
None	0	0
0 to 200	1	0.07
200 to 500	2	0.62
500 to 1000	3	1.58
1000 to 2000	4	1.92

Industrial		
Total Building and Contents		
Flood depth (mm)	Category	Cost
		(* building capital value)
None	0	0
0 to 200	1	0.06
200 to 500	2	0.46
500 to 1000	3	0.85
1000 to 2000	4	1.14

Avoided Property Damages = NPV of [AEP * expected total property damages]

Duplicated buildings - The results from V3 of the work onwards, has reported the most flood affected building in each parcel and captured these within the AAD calculations. Further manual review identified that address points (particularly commercial assets) had several parcels related to

[26] Costa, H., & Hooley, J. (2025). The macroeconomic implications of extreme weather events. OECD Economics Department Working Papers. https://doi.org/10.1787/5e24a2d8-en

[27] Walsh, P. J., Guignet, D., & Booth, P. (2023). Eliciting policy-relevant stated preference values for water quality: An application to New Zealand. Agricultural and Resource Economics Review, 52(2), 347–378. https://doi.org/10.1017/age.2023.20

one address and its capital value. For this assessment, a manual review for properties showing over $3m damage per event was undertaken for each scenario and return period result.

Coastal flooding – All buildings identified within the study area to be exposed coastal inundation (from the Risk Assessment work) were included within the analysis and could have flood damages calculated. Duplicated buildings were screened out so as to report one building per address. Flood damages were assigned to the resulting buildings as follows:

Table A-1: Application of Damages for coastal flooding assessment (Based on DCC FDA, 2025)

BUILDING LAND USE	FLOOD CATEGORY APPLIED	RESULTING COST ADDED TO EACH ADDRESS (DCC, 2025)
Commercial, school & church	2	0.62 x Capital Value
Industrial	2	0.46 x Capital Value
Residential	Floor level dependent	Floor level >= 0.3m - $45,000 Floor level < 0.3m - $170,000

These damages were then summed to deliver the total coastal damage exposure (TCDE). With the identified PCE, 2015 work showing increasing likelihood of inundation with rising sea level, we then applied a weighting to the epoch-based damage assessment to arrive at an annualised damage (in line with the Pluvial approach) with the increasing likelihood of inundation captured over time by the application of proportional exposure, such that:

- Medium Term – Average damages from applying (2% x TCDE) + (1% x TCDE)
- Long Term – Average damages from applying (2% x TCDE) + (1% x TCDE) + (10% x TCDE).

A more refined, depth-based assessment could support the subsequent Preferred Pathway stage.

Avoided infrastructure damage

Upon a review of the flood-related infrastructure repair spending with New Zealand[28], the guide to the cost of road civil construction in New Zealand[29] and DCC's infrastructure portfolio optimised depreciated replacement cost (ODRC), the economic evaluation has assumed an average infrastructure ODRC of $2.5m/km of road.

Avoided Infrastructure Damages = NPV of [expected length of road damaged * infrastructure ODRC per km of road * impairment level]

Gains in land improvement value – For information (not in this phase)

Literature shows a consistent discount in property values near a floodplain. Motu Economics and Public Policy Research suggests that the value discount reflecting proximity to a floodplain ranges between 4% and 8% of the total property value[30]. The economic evaluation has assumed a land improvement value discount of 6% (midpoint).

[28] Selwyn District Council - severe weather - latest updates. (n.d.). https://www.selwyn.govt.nz/news-And-events/news/archived/severe-weather-latest-updates-2021

[29] Ultimate Guide to Cost of Civil Construction NZ - Civil Construction Wellington. Civil Construction Wellington. https://civilconstructionwellington.nz/cost-of-civil-construction-nz/

[30] Storey, B., Noy, I., Owen, S., Townsend, W., Kerr, S., Salmon, R., Middleton, D., Filippova, O., & James. (2017). Insurance, Housing and Climate Adaptation: Current Knowledge and Future Research. Zenodo (CERN European Organization for Nuclear Research). https://doi.org/10.5281/zenodo.842898

Gains in Land Improvement Value = NPV of [expected proceeds from sale of reinstated land improvements * (1 + floodplain improvement premium)]

Gains in land redevelopment premium – For information (not in this phase)

To capture the benefits of land raising, the economic evaluation has assumed a land redevelopment premium of 6%.

Gains in Land Value Premium = NPV of [expected proceeds from sale of raised land * (1 + land redevelopment premium)]

Gains in level of service – For information (not in Core BCR. Shown within Supplementary BCR)

To capture the gains in level of service as a return on new infrastructure capital investment, the economic evaluation has assumed a level of service return of 25% with respect to infrastructure capital investment.

Gains in Level of Service = NPV of [level of service return * infrastructure investment

Costs

Key Cost Assumptions for each Future

Proactive Repurpose - Clearing space for the future interventions to be delivered.

- House Purchase – For the properties identified for removal to make space for appropriate interventions, Capital Valuation of property used for each affected property. 2025 QV values received from Council on September 19th (RateAssessmentProperty_SD.shp)
- Allowances for building removal at $50k per property to move/demolish the building. No allowance for any benefit from resale of the moved properties (e.g., as 'relocated dwellings').
- Removal of utility services – allowance of $2.5m per hectare given the urban nature of the environment. The exact extent, nature, and purpose of these is unknown at this stage and represents a large uncertainty. Including for reasonable costs associated with delivery of an engineered clear surface ready for the overlay of construction activity related to either storage, green open space, raised land or other.
- Costs associated with protecting or removing specific utilities' equipment have not yet been factored into the estimate. Chorus South Dunedin facility and Transpower key substation on Otaki St – are large and important assets to the community and wider South Island.
- Allowances have been made for reinstatement, including removal / replacement of all vegetation including grass, low shrubs, and trees. The exact extent of these is unknown at this stage - $35k per hectare.
- Property Purchase – the 2025 capital value per property has been used, received from DCC during September. An additional allowance of 25% has been included to capture legal costs, above market rate purchase price potential and costs associated with applying potential compulsory purchase orders.

Capital Costs - Options / measures estimates

- Raised Land – Allowance of $10m per hectare raised to capture material, compaction, and reasonable ground engineering requirements. Edge protection of raised land included. Representing a 2.5m average increase in land topography. Effectively $400 / m^2 / m depth.
- Open Waterway - Allowances of $10k per metre, Prices based on recent Blue Green Network cost estimates rounded. Representing a 30m wide corridor with a two-stage channel. Base channel 5m wide and 1.5m deep, side slopes of 1:4 with secondary flood plain used as corridors for paths / vegetation / habitat.
- Pump Stations – Assumed at a rate of $2.5m per m^3/s pumped, for each of the groundwater specific or stormwater asset. Not inclusive of land purchase costs, investigations, or design fees. For pump stations under 1m^3/s a flat rate of $3m applied for that pump station.
  - Annual costs added to the Operational / Maintenance costs – as per rule below. Additional annual cost included (anticipated energy costs for use), following these assumptions.
    - GW – Assumed that will require constant use (52 weeks per annum) from day one.
    - SW – Assumed that the energy use will increase over time, based on
      - ST – 2 weeks per annum
      - MT – 4 weeks per annum
      - LT – 8 weeks per annum
- New outfall to coastal marine environment – allowance of $15m per outfall for an outfall to represent situation of discharge to higher energy environment off south coast.
- Groundwater network – inclusion of appropriate level of network (based on servicing existing public roads within the area identified to be at elevated risk of groundwater emergence with a 1.1m SLR at 2100 – $3.5k per metre (identified core locations for additional network needed (as per each option)). Removed need for GW network in raised areas as under assumption that the land changes do not impact on GW management needs.
- Coastal defences - Internal sea wall – assumed design to be less engineered and consist of raised bund able provided inland of the existing coastline to be able to hold high tidal events out of the South Dunedin area. Allowance of $10k per metre.
- Coastal defences - Engineered sea wall along the inner harbour, rock faced with approximately 3m height with 1:4 slopes and top width able to carry existing roadway around harbour. Allowance of $35k per metre.
- Stormwater storage basins. Costs inclusive of excavation, lining, outlet structures, and appropriate landscaping:
  - 1m deep - Allowance for $3m per hectare.
  - 1.5m deep - Allowance for $4m per hectare.
  - 2m deep - Allowance for $4.5m per hectare.
- Wetlands – Allowance for $5m per hectare with base approximately 1m below current ground surface. Costs inclusive of excavation, lining, outlet structures, and appropriate landscaping.
- Contaminated land & unanticipated large, buried material – Incorporated a proportional increase in the capital costs for each of the mitigation option that interacts with below ground activities. Unit costs escalated by 35% for the options that require digging/trenching.

Table A-2: Stormwater pipe costs

SW PIPES (MM)	SUPPLY COST ($ / METRE)	BASE INSTALL MULTIPLIER*1	DEWATERING ALLOWANCE*2 ($ / METRE)	UNIT COST RATE USED IN ASSESSMENT ($ / METRE)
100	65	2.6	150	319
150	75			345
200	85			371
225	95			397
250	105			423
300	250			800
375	325			995
450	375	3.2	300	1,500
525	425			1,660
600	475			1,820
675	525			1,980
700	550			2,060
750	575			2,140
900	750			2,700
1050	900	4	550	4,150
1200	1,025			4,650
1300	1,100			4,950
1500	1,150	5	900	6,650
1200x900	1,650			9,150
1200x1000	1,750			9,650
1500x1000	1,950			10,650
1500x1300	2,150			11,650
1800x700	2,050			11,150
2000x1000	2,350			12,650
2000x1500	2,750			14,650
2100x1000	2,450			13,150
2100x1050	2,550			13,650
3000x1000	3,150			16,650
3000x1200	3,350			17,650

Notes

*1 *Base install multiplier (excluding dewatering)*: reflects trenching, shoring, laying, bedding, backfill, compaction, pavement reinstatement, TMP, etc., but not dewatering. Multipliers rise with pipe size due to trench width, depth, shoring, and reinstatement effort—typical in urban environments. (Method choice and complexity increase with excavation size and ground conditions.)

*2 *Dewatering allowance* a per-metre figure sized by pipe class (as a proxy for typical trench depths/widths). Higher allowances reflect the need for wellpoints/deep wells, continuous pumping, monitoring, and discharge treatment in high-water-table areas. (Dewatering is a major driver of delays and cost; discharge often requires treatment/consents in urban settings.)

Table A-3: Manhole costs

MANHOLES (MM)	SUPPLY COST ($ / UNIT)	BASE INSTALL MULTIPLIER*1	DEWATERING ALLOWANCE*2 ($ / METRE)	UNIT COST RATE USED IN ASSESSMENT ($ / METRE)
0.8	1,300	4	600	5,800
0.9	1,400			6,200
1	1,500			6,600
1.2	1,700	5	1200	9,700
1.3	2,100			11,700
1.5	2,350			12,950
1.6	2,550	6	2000	17,300
1.7	2,750			18,500
1.8	2,950			19,700
1.9	3,150			20,900
2.2	4,750	7	3500	36,750
2.6	5,750			43,750
3	7,000			52,500
3.3	7,750			57,750
4	11,000	8	6000	94,000
5.2	16,500			138,000
6	20,000			166,000
6.4	23,500			194,000
10	37,500	10	10000	385,000

Table A-4: Sump costs

MANHOLES (MM)	SUPPLY COST ($ / UNIT)	BASE INSTALL MULTIPLIER*1	DEWATERING ALLOWANCE*2 ($ / METRE)	UNIT COST RATE USED IN ASSESSMENT ($ / METRE)
0.6	1,150	3.5	400	4,425
0.7				
0.8				
0.9				
1				
1.2	2,650	4.5	900	12,825
1.3				
1.7				
3	7,000	6	2500	44,500

Notes

*1 *Base install multiplier (excluding dewatering)*: reflects trenching, shoring, laying, bedding, backfill, compaction, pavement reinstatement, TMP, etc., but not dewatering. Multipliers rise with pipe size due to trench width, depth, shoring, and reinstatement effort—typical in urban environments. (Method choice and complexity increase with excavation size and ground conditions.)

*2 *Dewatering allowance* a per-metre figure sized by pipe class (as a proxy for typical trench depths/widths). Higher allowances reflect the need for wellpoints/deep wells, continuous pumping, monitoring, and discharge treatment in high-water-table areas. (Dewatering is a major driver of delays and cost; discharge often requires treatment/consents in urban settings.)

Operational / Maintenance Costs

- Annual maintenance costs for capital options (not including the costs in Section 3.2.2.1) – 1.5% of the discounted Capital Cost per annum.
- Pumping Stations include assessment of annual energy costs based on assumed use per annum and annual line charge.
- Cyclical Capital maintenance costs for capital options (not including the costs in Section 3.2.2.1) – 35% of the discounted Capital Cost every 25 years.

Exclusions

- GST
- Legal or marketing costs
- Operational costs/downtime due to operations
- Rebuild of existing properties in new location.

Appendix B - Summary tables for Benefits and Costs (for the three epochs).

Benefits Tables per Epoch for the Core BCR.

Short-term

Observed from the economic evaluation of the Proposed Futures over the short-term, the avoided costs and damages are all identical under the three futures (the Efficacy modelling (termed as Present Day)), reflecting the evaluation approach of an identical level of flood risk reduction spread over the short-term period, following an equivalent annual annuity (EAA) approach.

Table B-1: Monetised Benefits of Proposed Futures Over the Short-Term (NPV $m)

Benefits Short-Term ($m)	Future 3 - 5
Avoided Injury and Fatality	$262
Injury	$35
Fatality	$227
Avoided Response and Recovery Costs	$12
Avoided Income Loss from Displacement	$10
Avoided Trauma	$9
Direct	$6
Indirect	$3
Social Cohesion	$0
Avoided Environmental Costs	$0
Avoided Property, Building & Infrastructure Damages	$159
Residential, Industrial & Commercial	$158
Infrastructure	$1
Total Benefits	$452

Medium-term

Observed from the economic evaluation of the Proposed Futures over the medium-term, following the consistent application of the EAA approach, the expected costs and damages avoided have dropped compared to the short-term, largely due to the implication of discounting.

Table B-2: Monetised Benefits of Proposed Futures Over the Medium-Term (NPV $m)

Benefits Medium-Term ($m)	Future 3	Future 4	Future 5
Avoided Injury and Fatality	$102	$106	$109
Injury	$13	$14	$14
Fatality	$88	$92	$94
Avoided Response and Recovery Costs	$18	$19	$18
Avoided Income Loss from Displacement	$4	$5	$5
Avoided Trauma	$4	$4	$4
Direct	$3	$3	$3
Indirect	$1	$1	$1
Social Cohesion	$0	$0	$0
Avoided Environmental Costs	$0	$0	$0
Avoided Property, Building & Infrastructure Damages	$244	$248	$242
Residential, Industrial & Commercial	$243	$247	$242
Infrastructure	$1	$1	$1
Total Benefits	$372	$381	$378

Long-term

Observed from the economic evaluation of the Proposed Futures over the long-term, flood exposure and flood consequences have dropped dramatically, as an outcome of the combined capital investments undertaken over the course of the previous epochs.

Table B-3: Monetised Benefits of Proposed Futures Over the Long-Term (NPV $m)

Benefits Long-Term ($m)	Future 3	Future 4	Future 5
Avoided Injury and Fatality	$53	$55	$55
Injury	$7	$7	$7
Fatality	$46	$48	$48
Avoided Response and Recovery Costs	$32	$32	$31
Avoided Income Loss from Displacement	$3	$3	$3
Avoided Trauma	$2	$2	$3
Direct	$2	$2	$2
Indirect	$1	$1	$1
Social Cohesion	$0	$0	$0
Avoided Environmental Costs	$0	$0	$0
Avoided Property, Building & Infrastructure Damages	$422	$422	$415
Residential, Industrial & Commercial	$421	$421	$415
Infrastructure	$1	$1	$1
Total Benefits	$511	$514	$507

Overall

Table B-4: Monetised Benefits of Proposed Futures Overall (NPV $m)

Benefits Long-Term ($m)	Future 3	Future 4	Future 5
Avoided Injury and Fatality	$416	$423	$426
Injury	$55	$56	$56
Fatality	$361	$367	$370
Avoided Response and Recovery Costs	$62	$62	$61
Avoided Income Loss from Displacement	$17	$17	$18
Avoided Trauma	$15	$15	$15
Direct	$10	$10	$10
Indirect	$5	$5	$5
Social Cohesion	$0	$0	$0
Avoided Environmental Costs	$0	$0	$0
Avoided Property, Building & Infrastructure Damages	$825	$833	$816
Residential, Industrial & Commercial	$822	$831	$813
Infrastructure	$3	$3	$3
Total Benefits	$1,335	$1,351	$1,336

Costs Tables per Epoch

*Short-term -*The quantum of capital works is relatively similar across the three Proposed Futures in the short-term, whereby capital expenditure and operational expenditure are roughly identical in present value terms. There is no expected capital maintenance required in the short-term.

Table B-5: Monetised Costs of Proposed Futures Over the Short-Term (NPV $m)

Costs – Short Term ($m)	Status Quo	Future 3	Future 4	Future 5
Infrastructure CAPEX	$216	$912	$486	$992
Repurposed land activities	$0	$384	$436	$477
Property & Land Acquisition	$24	$279	$338	$445
Capital Maintenance	$0	$0	$0	$0
OPEX	$14	$23	$23	$23
Total Costs	$254	$1,598	$1,284	$1,938

Medium-term - The assessed costs in the medium-term are observed to be lower than in the short-term, largely due to the later costs incurring greater discounting.

Table B-6: Monetised Costs of Proposed Futures Over the Medium-Term (NPV $m)

Costs – Medium Term ($m)	Status Quo	Future 3	Future 4	Future 5
Infrastructure CAPEX	$74	$299	$229	$294
Repurposed land activities	$4	$49	$10	$68
Property & Land Acquisition	$18	$64	$0	$74
Capital Maintenance	$7	$13	$13	$13
OPEX	$11	$27	$34	$26
Total Costs	$115	$452	$287	$475

Long-term - Like the above, long-term costs are lower due to the bulk of capital and property repurposing costs incurred in the short to medium term, with greater discounting over time.

Table B-7: Monetised Costs of Proposed Futures Over the Long-Term (NPV $m))

Costs – Long Term ($m)	Status Quo	Future 3	Future 4	Future 5
Infrastructure CAPEX	$0	$9	$9	$0
Repurposed land activities	$0	$0	$0	$0
Property & Land Acquisition	$29	$0	$0	$0
Capital Maintenance	$7	$20	$25	$18
OPEX	$6	$19	$24	$17
Total Costs	$43	$48	$58	$35

Overall

Table B-8: Monetised Costs of Proposed Futures Overall (NPV $m))

Costs – Long Term ($m)	Status Quo	Future 3	Future 4	Future 5
Infrastructure CAPEX	$290	$1,220	$724	$1,287
Repurposed land activities	$4	$433	$447	$545
Property & Land Acquisition	$72	$343	$338	$519
Capital Maintenance	$15	$33	$39	$31
OPEX	$31	$70	$81	$66
Total Costs	$411	$2,098	$1,629	$2,448

BCR tables per epoch for Core BCR assessment

Short-term

Table B-9: Comparison of Futures Over the Short-Term (NPV $m)

FUTURE	BENEFITS ($M)	COSTS ($M)	BCR	RANK
Future 3	$452	$1,598	0.28	2
Future 4	$457	$1,284	0.36	1
Future 5	$450	$1,938	0.23	3

Medium-term

Table B-10: Comparison of Futures Over the Medium-Term (NPV $m)

FUTURE	BENEFITS ($M)	COSTS ($M)	BCR	RANK
Future 3	$372	$452	0.82	3
Future 4	$381	$287	1.33	1
Future 5	$378	$475	0.80	2

Long-term

Table B-11: Comparison of Futures Over the Long-Term (NPV $m)

FUTURE	BENEFITS ($M)	COSTS ($M)	BCR	RANK
Future 3	$511	$48	10.61	2
Future 4	$514	$58	8.86	3
Future 5	$507	$35	14.58	1

Overall

Table B-12: Comparison of Futures Overall (NPV $m)

FUTURE	BENEFITS ($M)	COSTS ($M)	BCR	RANK
Future 3	$1,335	$2,098	0.64	2
Future 4	$1,351	$1,629	0.83	1
Future 5	$1,336	$2,448	0.55	3