TABLE OF CONTENTS

EXECUTIVE SUMMARY 1

1 BACKGROUND 3

2 MODELLING INPUTS 4

2.1 EXISTING NETWORK SUMMARY 4

2.2 MODELLED FUTURES 4

2.3 INPUTS 5

2.3.1 DESIGN RAINFALL CONDITIONS 5
2.3.2 CLIMATE CHANGE 6
2.3.3 TIDAL BOUNDARY CONDITIONS 6
2.3.4 GROUND WATER 6
2.3.5 DESIGN LEVEL OF SERVICE 6
2.3.6 EXISTING INFRASTRUCTURE 7
2.3.7 NEW PIPES AND SUMPS 7
2.3.8 NEW STORAGE AND CHANNELS 7
2.3.9 NEW AND UPGRADED PUMP STATIONS 8
2.3.10 RAISED LAND, NEW DEVELOPMENT, AND NEW GREENSPACES 8
2.3.11 SEAWALLS 9
2.3.12 KERBS 9

2.4 METHODOLOGY 10

2.5 MODEL RUNS 10

3 FUTURE OVERVIEWS 12

3.1 MODEL OUTPUTS 12

3.2 SHORT TERM (2025 - 2060) 15

3.2.1 UPGRADES 15
3.2.2 PERFORMANCE 16

3.3 FUTURE 3 - PROTECT 16

3.3.1 MEDIUM TERM (2060 - 2100) 16
3.3.2 LONG TERM (2100 ONWARDS) 17

3.4 FUTURE 4 – RESTORE 18

3.4.1 MEDIUM TERM (2060 - 2100) 18
3.4.2 LONG TERM (2100 ONWARDS) 19

3.5 FUTURE 5 – RESHAPE 19

3.5.1 MEDIUM TERM (2060 - 2100) 19
3.5.2 LONG TERM (2100 ONWARDS) 20

3.6 SENSITIVITY RUNS 21

4 SUMMARY 22

4.1 PIPE NETWORK 22

4.2 PUMP STATIONS....23
4.3 STORAGE AREAS....25
4.4 MANHOLES AND SUMPS....25
APPENDICES A-R: MAPS....27
APPENDIX S: SCHEMA STATEMENT....28

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.

---

[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.

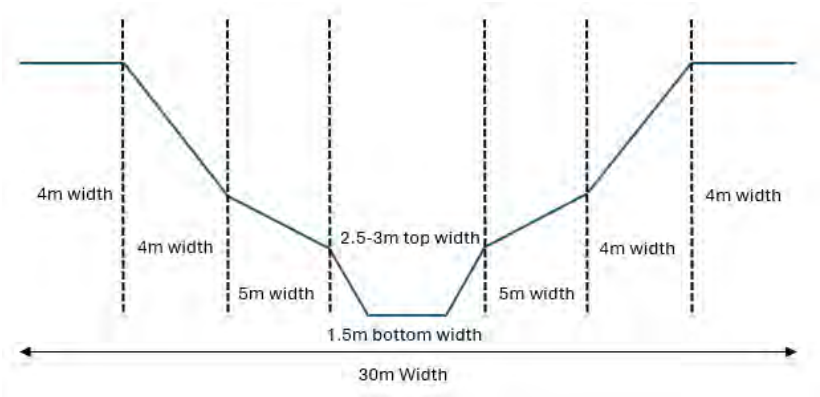


Figure 2-1: Channel cross section as modelled

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	

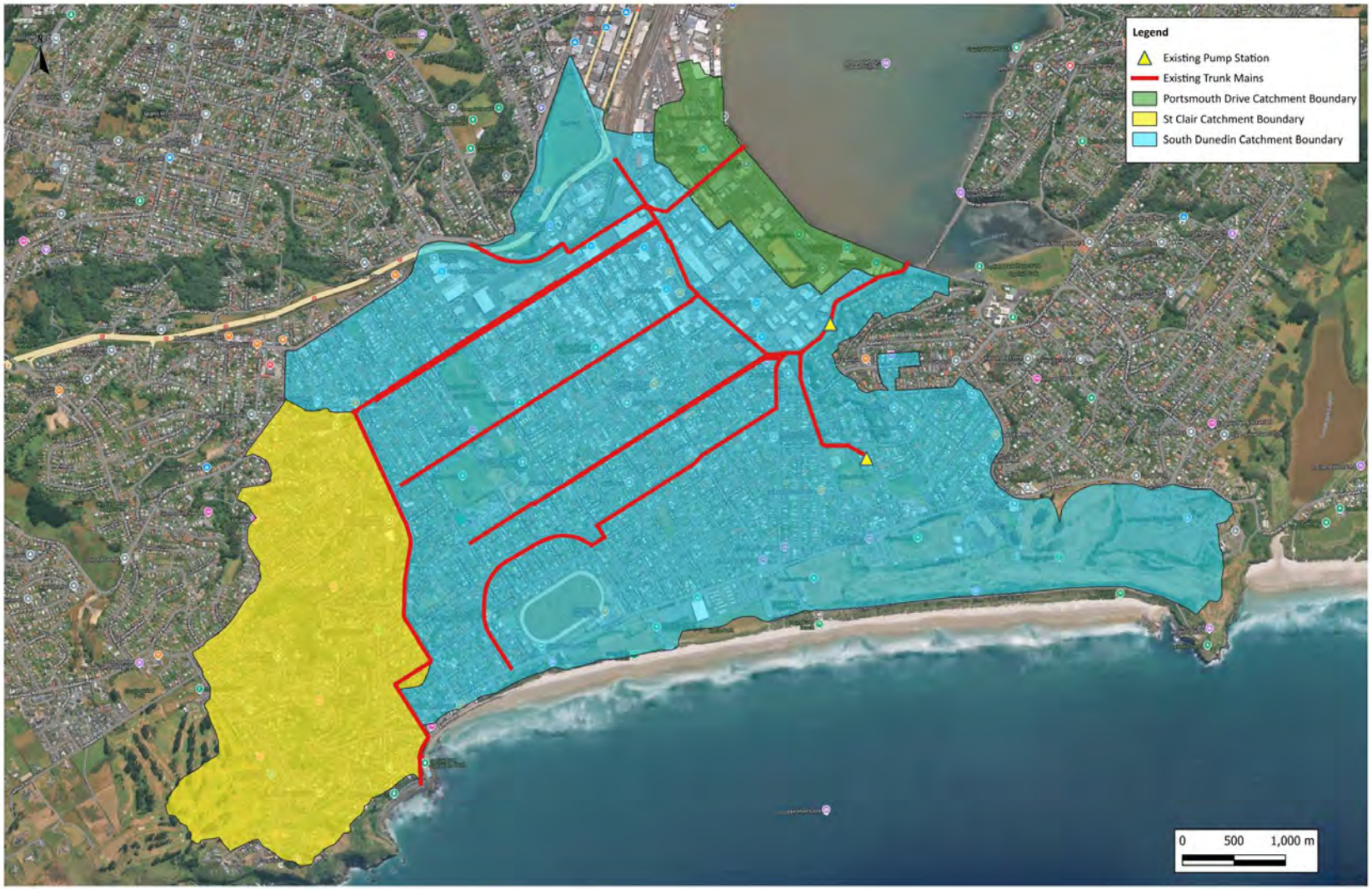
APPENDICES A-R: MAPS

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

Appendix	Map number	Drawing title
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)

MAP NO: 4700990 - 01	REV: B	South Dunedin Futures Table of Maps	DRAWN BY: Apyesh Bhagta DATE: 2026-05-13 CHECK BY: Kit Pascoe DATE: 2026-05-13



Beca, South Dunedin Partners, Otago Regional Council, wsp, Tonkin+Taylor	South Dunedin Existing Network Overview	DRAWN BY: Anvesh Rayula
DUNEDIN CITY COUNCIL kaunihera ā-rohe ō Ōtepoti		DATE: 2025-11-27
		CHECK BY: Kit Pascoe
		DATE: 2025-11-27
MAP NO: 4700990 - A1	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, Kaunihera a Rohe o Otepoti	South Dunedin Baseline Network (Existing Network + Quick Wins)	DRAWN BY:	Anvesh Bayula
DUNEDIN CITY COUNCIL | kaunihera a rohe o Otepoti		DATE:	2026-05-13
MAP NO: 4700990 - B1		CHECK BY:	Kit Pascoe
REV: B		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			DRAWN BY: Anvesh Bayula
DUNEDIN CITY COUNCIL kaunihera o-rohe o Ōtepoti	South Dunedin Short Term Network		DATE: 2026-05-13
			CHECK BY: Kit Pascoe
MAP NO: 4700990 - C1		REV: B	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 o-rotai-o Ōtepoti		South Dunedin Future - Option 3 Medium Term (2060)	DRAWN BY: Anvesh Bayula; DATE: 2026-05-13; CHECK BY: Kit Pascoe; DATE: 2026-05-13
MAP NO: 4700990 - D1	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 o-rotai-o Ōtepoti		South Dunedin Future - Option 3 Long Term (2100)	DRAWN BY: Anvesh Bayula; DATE: 2026-05-13; CHECK BY: Kit Pascoe; DATE: 2026-05-13
MAP NO: 4700990 - D2	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		South Dunedin Future - Option 4 Medium Term (2060)	DRAWN BY: Anvesh Bayula
DUNEDIN CITY COUNCIL kaunihera o-rotai o Ōtepoti			DATE: 2026-05-13
			CHECK BY: Kit Pascoe
MAP NO: 4700990 - E1	REV: B		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			DRAWN BY: Anvesh Bayula
DUNEDIN CITY COUNCIL kaunihera o-rotai-o Ōtepoti			DATE: 2026-05-13
			CHECK BY: Kit Pascoe
MAP NO: 4700990 - E2	REV: B	South Dunedin Future - Option 4 Long Term (2100)	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 o-rotai-o Ōtepoti		South Dunedin Future - Option 5 Medium Term (2060)	DRAWN BY: Anvesh Bayula; DATE: 2026-05-13; CHECK BY: Kit Pascoe; DATE: 2026-05-13
MAP NO: 4700990 - F1	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 - F2	REV: B	South Dunedin Future - Option 5 Long Term (2100)	DRAWN BY: Anvesh Bayula 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 Estuary, Otago Regional Council, wsp, Tonkin+Taylor	South Dunedin - Baseline Network Maximum Flood Depth Map (1 in 10 Year RCP 8.5 2025 MHWS)	DRAWN BY:	Anvesh Ravula
DUNEDIN CITY COUNCIL Kaunihera Dunedin Ōtepoti		DATE:	2025-11-26
		CHECK BY:	Kit Pascoe
		DATE:	2025-11-26
MAP NO: 4700990 - G1	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 Estuary, Otago Regional Council, wsp, Tonkin+Taylor; DUNEDIN CITY COUNCIL Kaunihera Rohe o Otepoti	South Dunedin - Baseline Network Maximum Flood Depth Map (1 in 50 Year RCP 8.5 2025 MHWS)	DRAWN BY:	Anvesh Ravula
		DATE:	2025-11-26
		CHECK BY:	Kit Pascoe
		DATE:	2025-11-26
MAP NO: 4700990 - G2	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.	

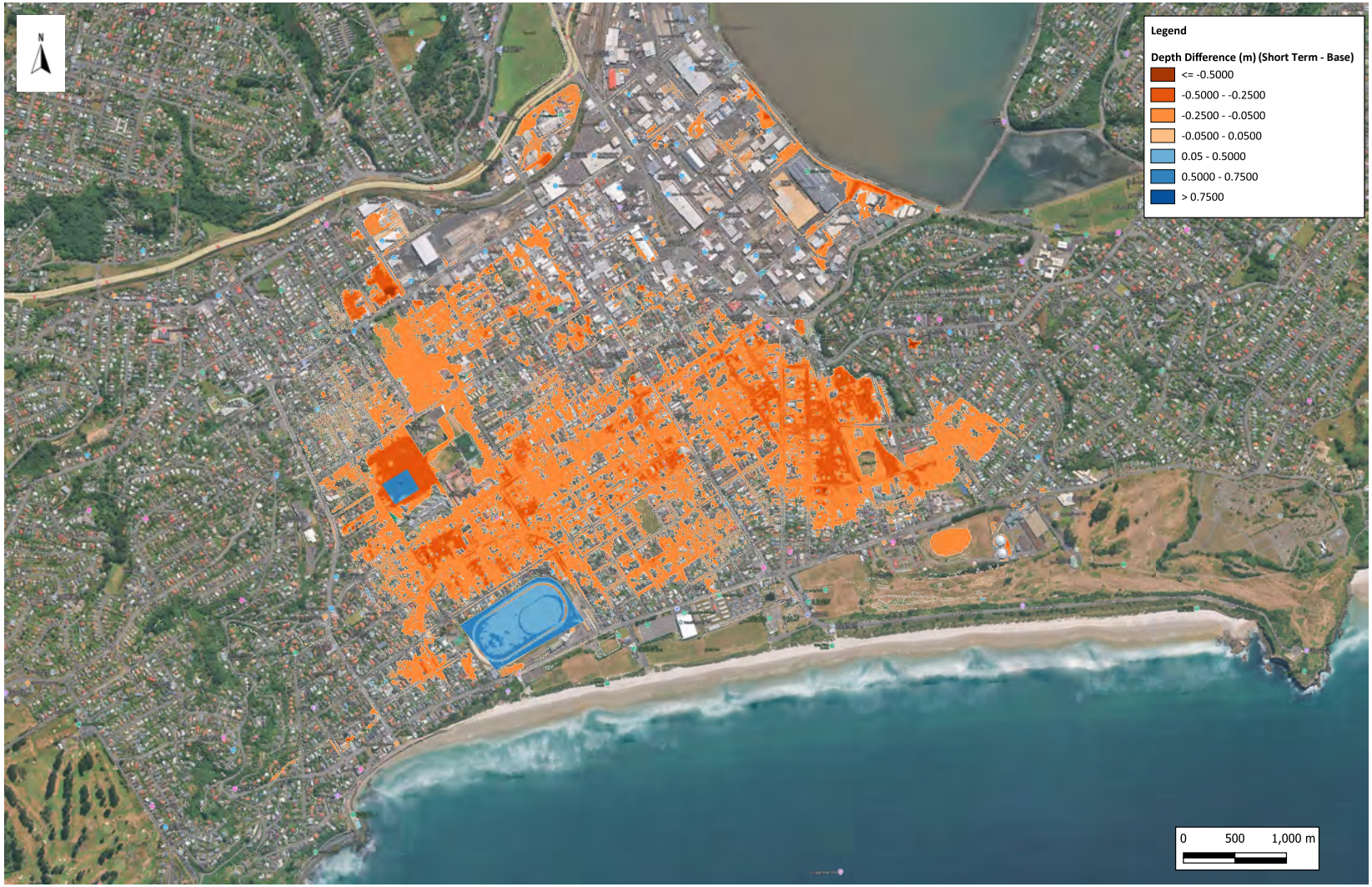
beca, wsp, DUNEDIN CITY COUNCIL	South Dunedin - Baseline Network Maximum Flood Depth Map (1 in 100 Year RCP 8.5 2025 MHWS)	DRAWN BY:	Anvesh Ravula
		DATE:	2025-11-26
		CHECK BY:	Kit Pascoe
		DATE:	2025-11-26
MAP NO: 4700990 - G3	REV: A	Disclaimer: This map contains data derived in part or wholly from 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, wsp, DUNEDIN CITY COUNCIL	South Dunedin - Short Term Maximum Flood Depth Map (1 in 10 Year RCP 8.5 2025 MHWS)	DRAWN BY:	Anvesh Ravula
		DATE:	2026-05-13
		CHECK BY:	Kit Pascoe
		DATE:	2026-05-13
MAP NO: 4700990 - H1	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.	

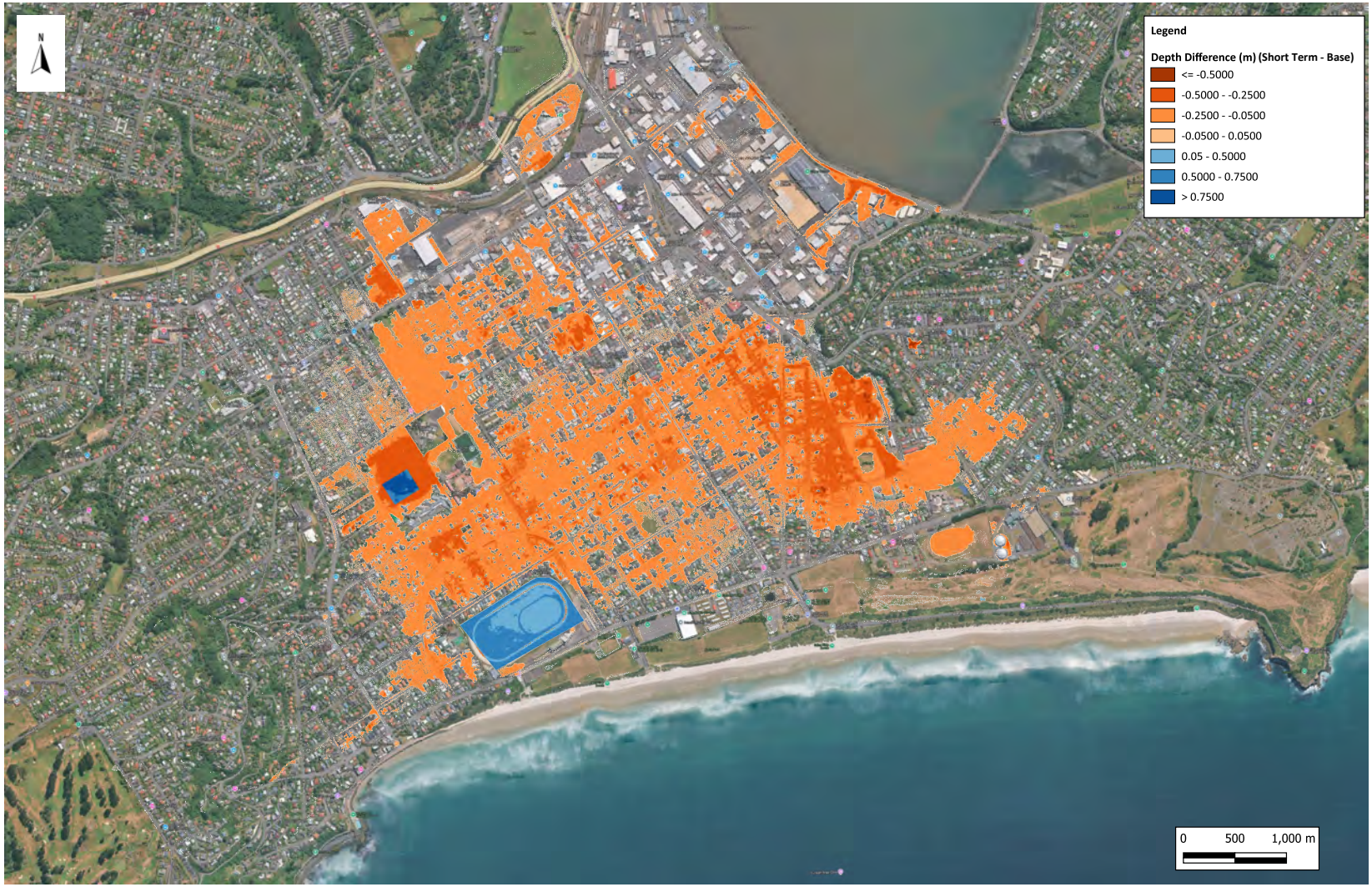
beca / wsp / DUNEDIN CITY COUNCIL	South Dunedin - Short Term Maximum Flood Depth Map (1 in 50 Year RCP 8.5 2025 MHWS)	DRAWN BY:	Anvesh Ravula
		DATE:	2026-05-13
		CHECK BY:	Kit Pascoe
		DATE:	2026-05-13
MAP NO: 4700990 - H2	REV: B	Disclaimer: This map contains data derived in part or wholly from sources 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 / wsp / DUNEDIN CITY COUNCIL	South Dunedin - Short Term Maximum Flood Depth Map (1 in 100 Year RCP 8.5 2025 MHWS)	DRAWN BY:	Anvesh Ravula
		DATE:	2026-05-13
		CHECK BY:	Kit Pascoe
		DATE:	2026-05-13
MAP NO: 4700990 - H3	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 Factors, Dunedin Digital Council, wsp, Tonkin+Taylor	South Dunedin - Short Term Flood Depth Difference Map Between Short Term & Base (1 in 10 Year Design Storm)	DRAWN BY:	Anvesh Rayula
DUNEDIN CITY COUNCIL Kaunihera Āmanaki o Ōtepoti		DATE:	2026-05-13
		CHECK BY:	Kit Pascoe
		DATE:	2026-05-13
MAP NO: 4700990 - 11	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 Factors, Dunedin Digital Canvas, wsp, Tonkin+Taylor	South Dunedin - Short Term Flood Depth Difference Map Between Short Term & Base (1 in 50 Year Design Storm)	DRAWN BY:	Anvesh Ravula
DUNEDIN CITY COUNCIL Kaunihera Ārahi o Ōtepoti		DATE:	2026-05-13
		CHECK BY:	Kit Pascoe
		DATE:	2026-05-13
MAP NO: 4700990 - 12	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 Futures, Otago Regional Council, wsp, Tonkin+Taylor; DUNEDIN CITY COUNCIL Kaunihera Rohe o Ōtepoti	South Dunedin - Short Term Flood Depth Difference Map Between Short Term & Base (1 in 100 Year Design Storm)	DRAWN BY: Anvesh Rayula DATE: 2026-05-13 CHECK BY: Kit Pascoe DATE: 2026-05-13	
MAP NO: 4700990 - I3 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, wsp, DUNEDIN CITY COUNCIL	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
MAP NO: 4700990 - 31	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, wsp, DUNEDIN CITY COUNCIL	South Dunedin - Option 3 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 - J2	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 - 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)	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.

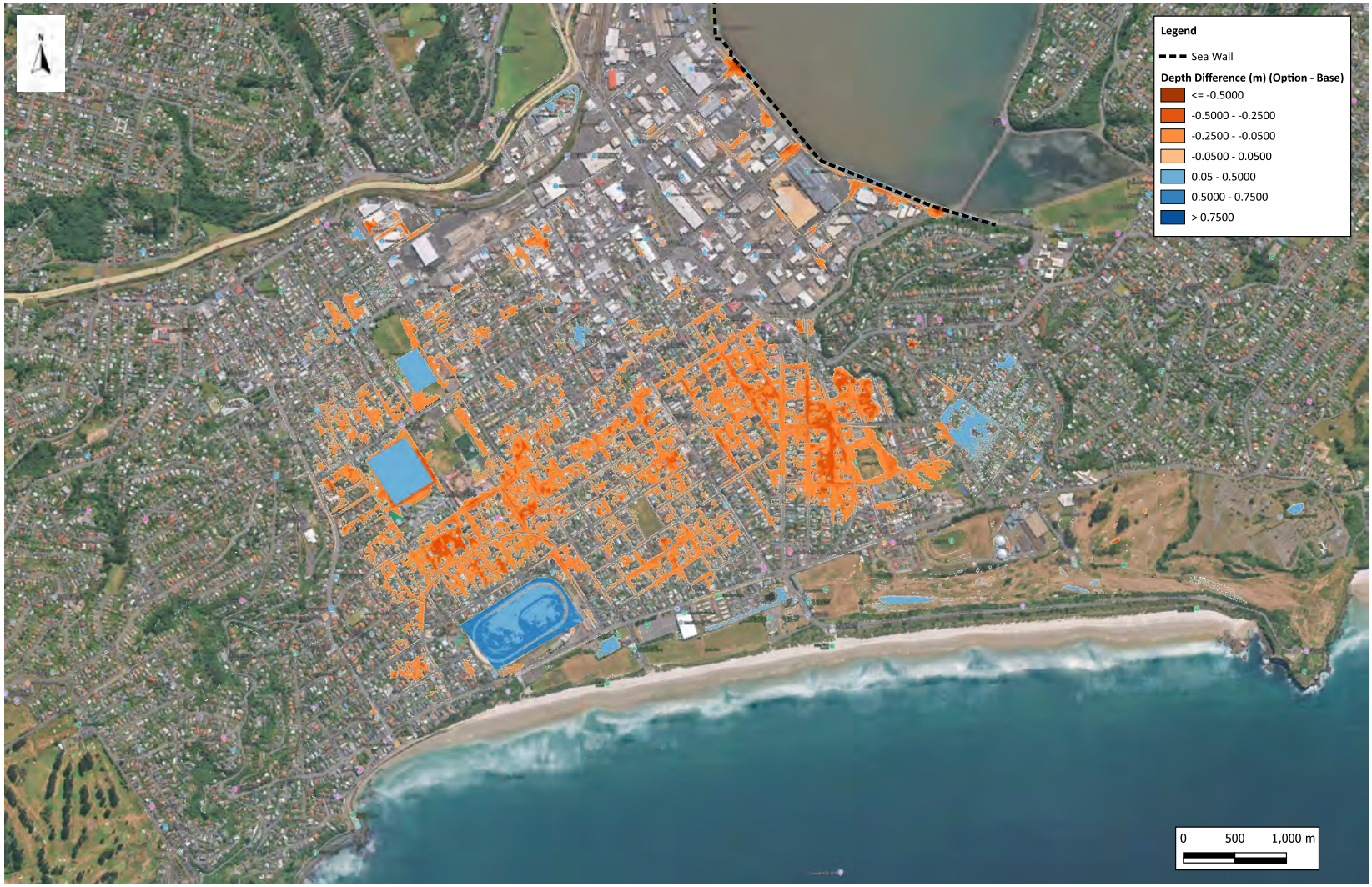
MAP NO: 4700990 - 34	REV: A	South Dunedin - Option 3 Long Term Maximum Flood Depth Map (1 in 10 Year RCP 8.5 2100 MHWS + 1.1 m SLR)	DRAWN BY: Anvesh Ravula DATE: 2025-11-27 CHECK BY: Kit Pascoe DATE: 2025-11-27

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 - 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

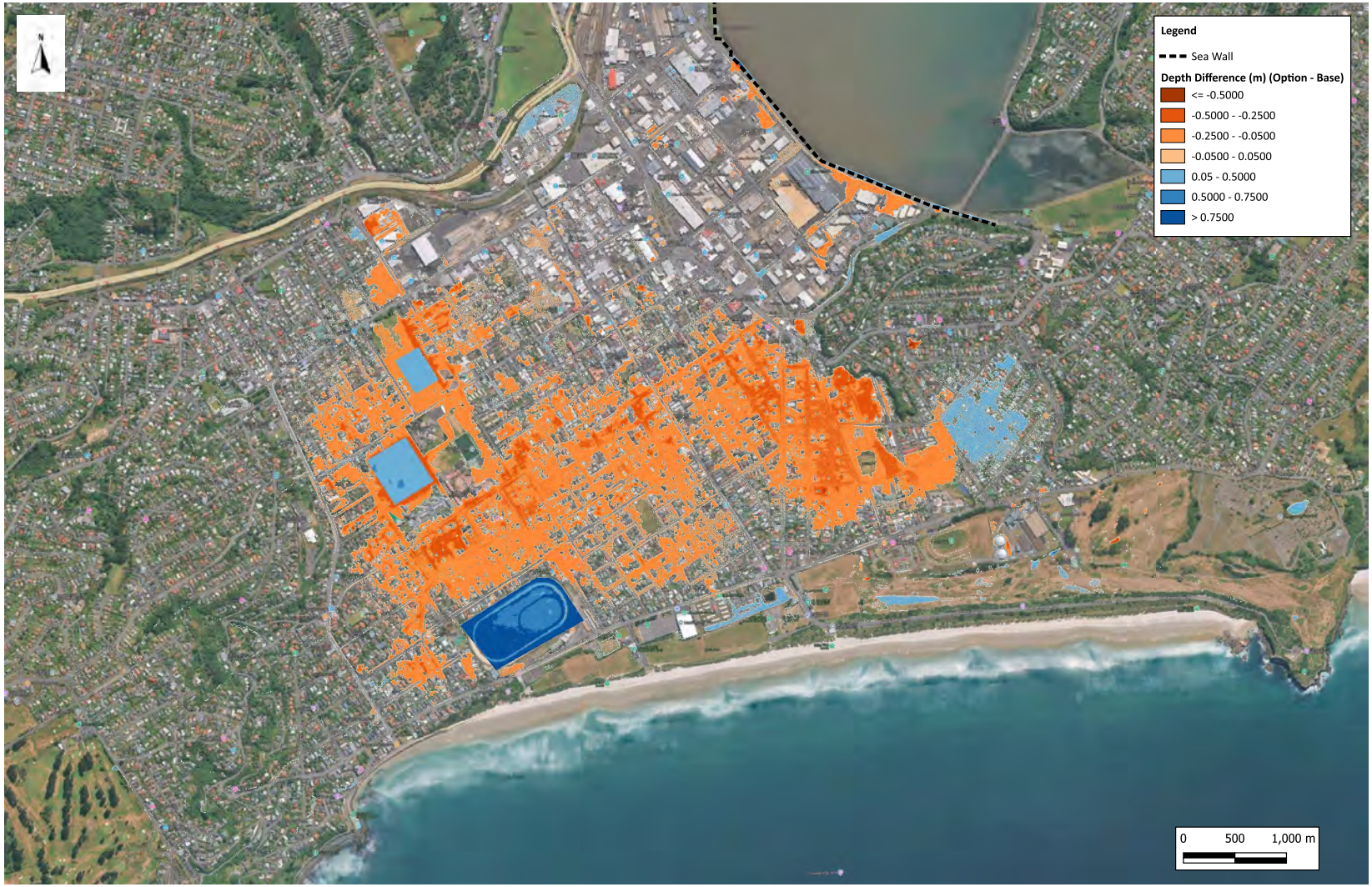
Disclaimer:
This map contains data derived in part or wholly from sources other than Beca. No representations or warranties are made by Beca as to the accuracy or completeness of this information. The map is intended for distribution as a PDF document. The scale may be incorrect when printed.

beca, DUNEDIN CITY COUNCIL, wsp	South Dunedin - Option 3 Long Term Maximum Flood Depth Map (1 in 100 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
MAP NO: 4700990 - 36	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 - K1	REV: A	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

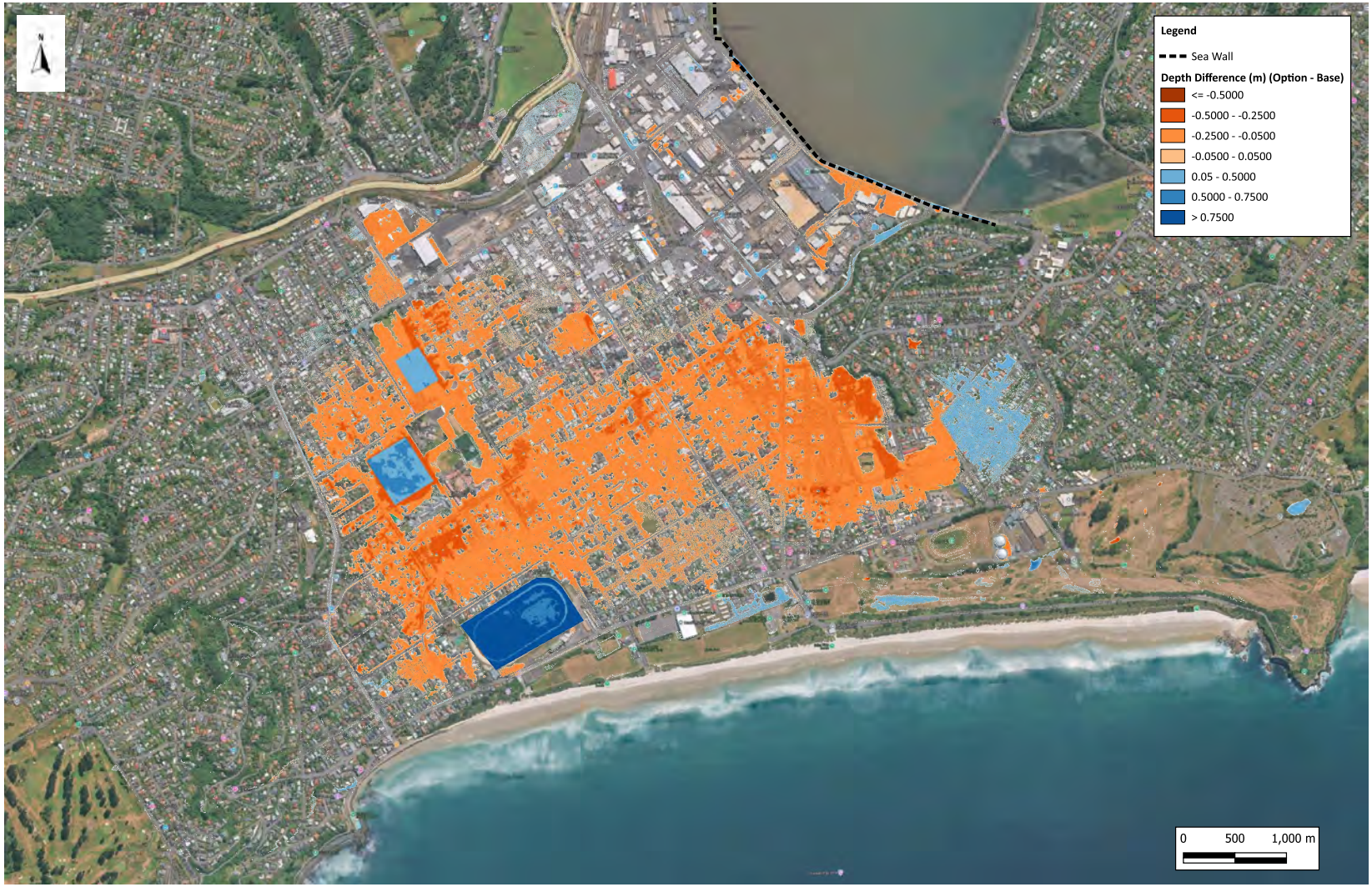
Disclaimer:
This map contains data derived in part or wholly from sources other than Beca. No representations or warranties are made by Beca as to the accuracy or completeness of this information. The map is intended for distribution as a PDF document. The scale may be incorrect when printed.



beca, DUNEDIN CITY COUNCIL	MAP NO: 4700990 - K2	REV: A	South Dunedin - Option 3 Flood Depth Difference Map Between Option 3 & Base (1 in 50 Year Design Storm)

DRAWN BY:	Anvesh Rayula
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.



beca, DUNEDIN CITY COUNCIL	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, DUNEDIN CITY COUNCIL		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, DUNEDIN CITY COUNCIL	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.

beca, DUNEDIN CITY COUNCIL	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
MAP NO: 4700990 - L3	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 / DUNEDIN CITY COUNCIL	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 Rayula
		DATE:	2026-05-13
		CHECK BY:	Kit Pascoe
		DATE:	2026-05-13
MAP NO: 4700990 - L4	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.	

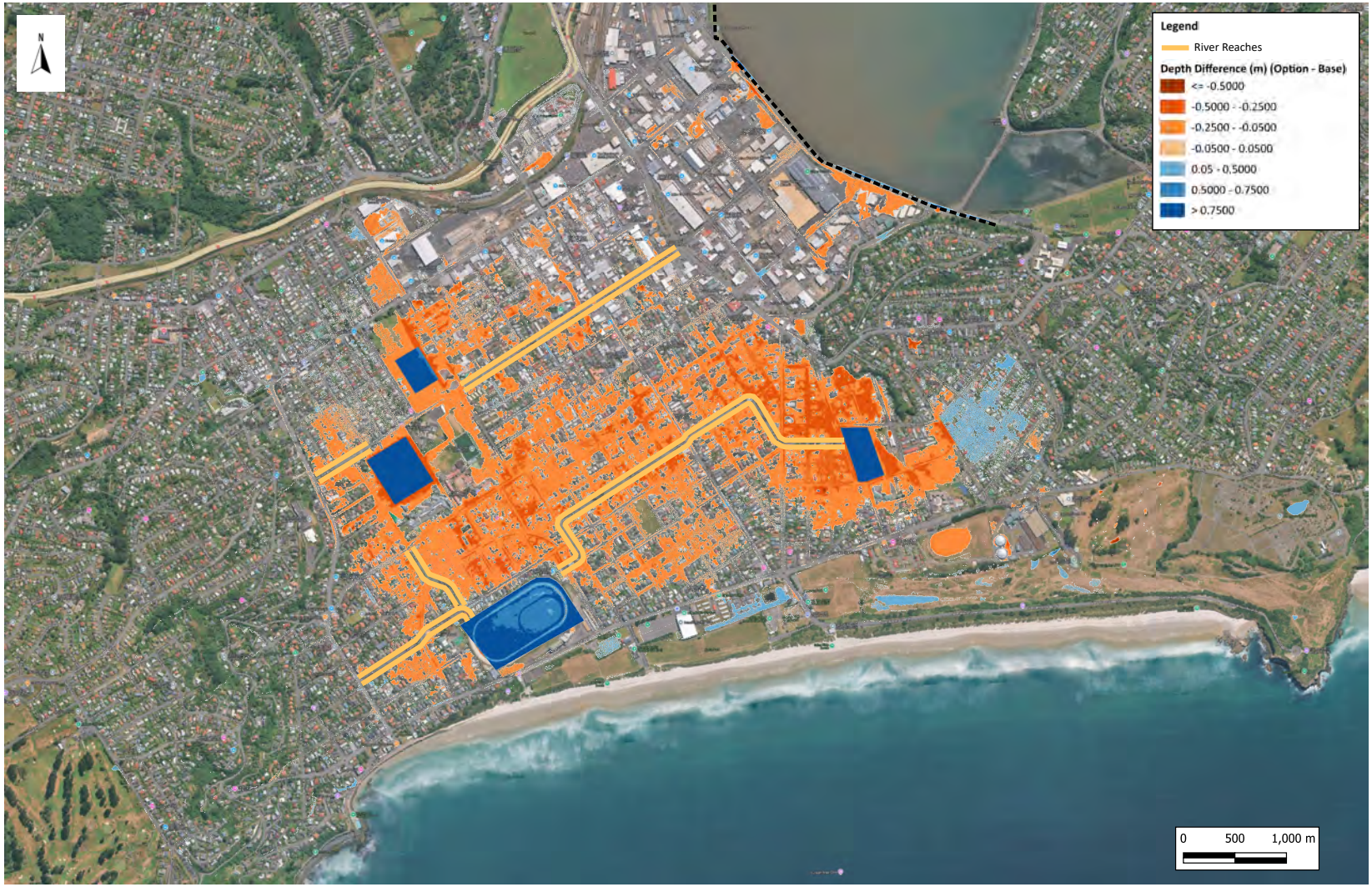
beca / DUNEDIN CITY COUNCIL		South Dunedin - Option 4 Long Term Maximum Flood Depth Map (1 in 50 Year RCP 8.5 2100 MHWS + 1.1 m SLR)	DRAWN BY: Anvesh Rayula DATE: 2026-05-13 CHECK BY: Kit Pascoe DATE: 2026-05-13
MAP NO: 4700990 - L5	REV: B		Disclaimer: This map contains data derived in part or wholly 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 Factors, Dept Degrees Cancer, wsp, Tonkin+Taylor	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
DUNEDIN CITY COUNCIL Kaunihera Rohe o Ōtepoti		DATE:	2026-05-13
MAP NO: 4700990 - L6		CHECK BY:	Kit Pascoe
REV: B		DATE:	2026-05-13

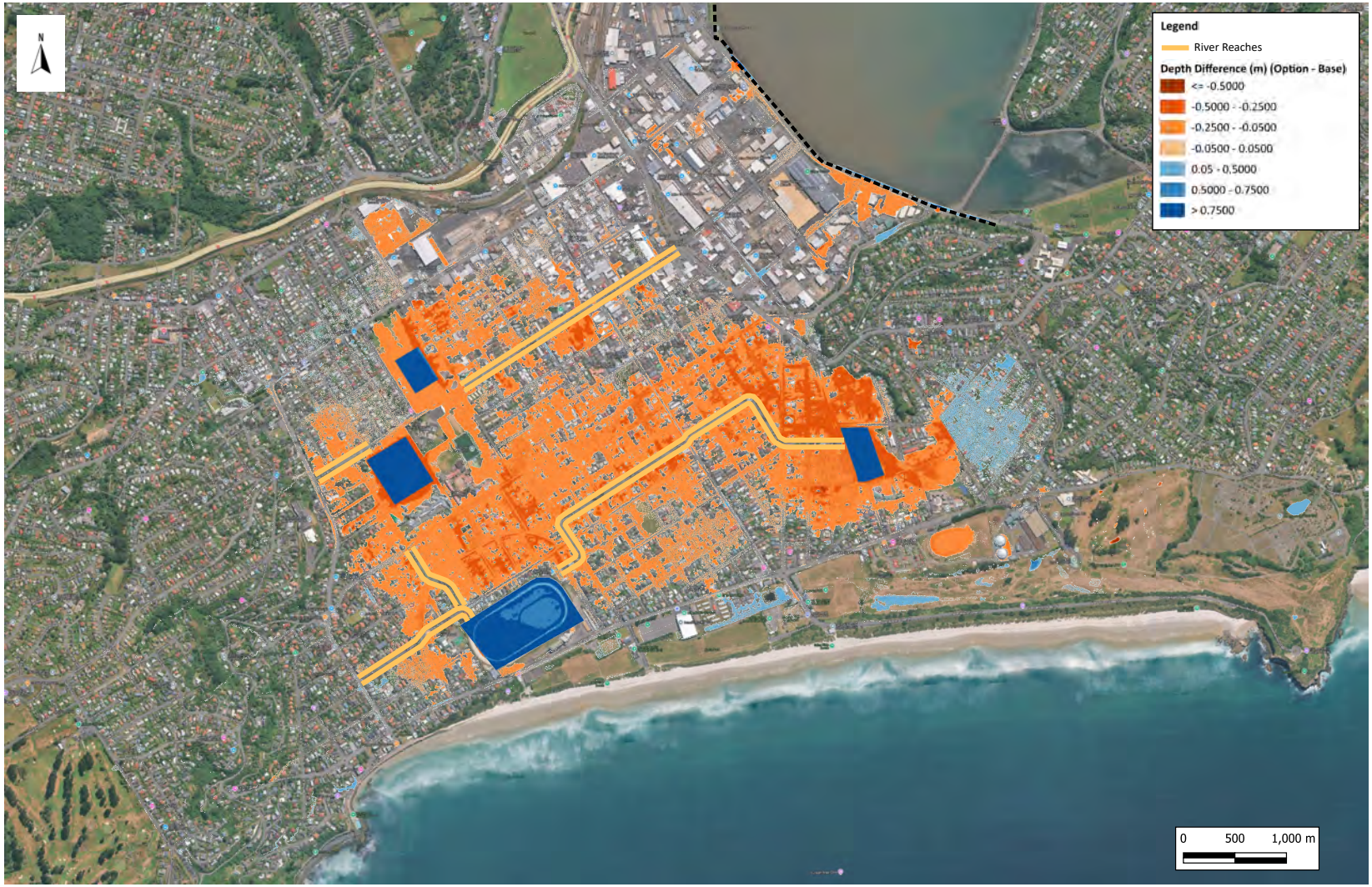
Disclaimer:
This map contains data derived in part or wholly from sources other than Beca. No representations or warranties are made by Beca as to the accuracy or completeness of this information. The map is intended for distribution as a PDF document. The scale may be incorrect when printed.

beca, South Dunedin Factors, Dunedin Digital Canvas, wsp, Tonkin+Taylor	South Dunedin - Option 4 Flood Depth Difference Map Between Option 4 & Base (1 in 10 Year Design Storm)	DRAWN BY:	Anvesh Ravula
DUNEDIN CITY COUNCIL Kaunihera Āmpono o Ōtepoti		DATE:	2026-05-13
		CHECK BY:	Kit Pascoe
MAP NO: 4700990 - M1	REV: B	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 / DUNEDIN CITY COUNCIL	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
MAP NO: 4700990 - M2	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, DUNEDIN CITY COUNCIL, wsp	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
MAP NO: 4700990 - M3	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 - 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

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 / DUNEDIN CITY COUNCIL	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
MAP NO: 4700990 - N2	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, wsp, DUNEDIN CITY COUNCIL	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, DUNEDIN CITY COUNCIL, wsp	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
MAP NO: 4700990 - N4	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 Futures, Dept of Conservation, wsp, Tonkin+Taylor; DUNEDIN CITY COUNCIL Kaunihera Rohe o Ōtepoti	South Dunedin - Option 5 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
MAP NO: 4700990 - N5	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, DUNEDIN CITY COUNCIL	MAP NO: 4700990 - N6	REV: B	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

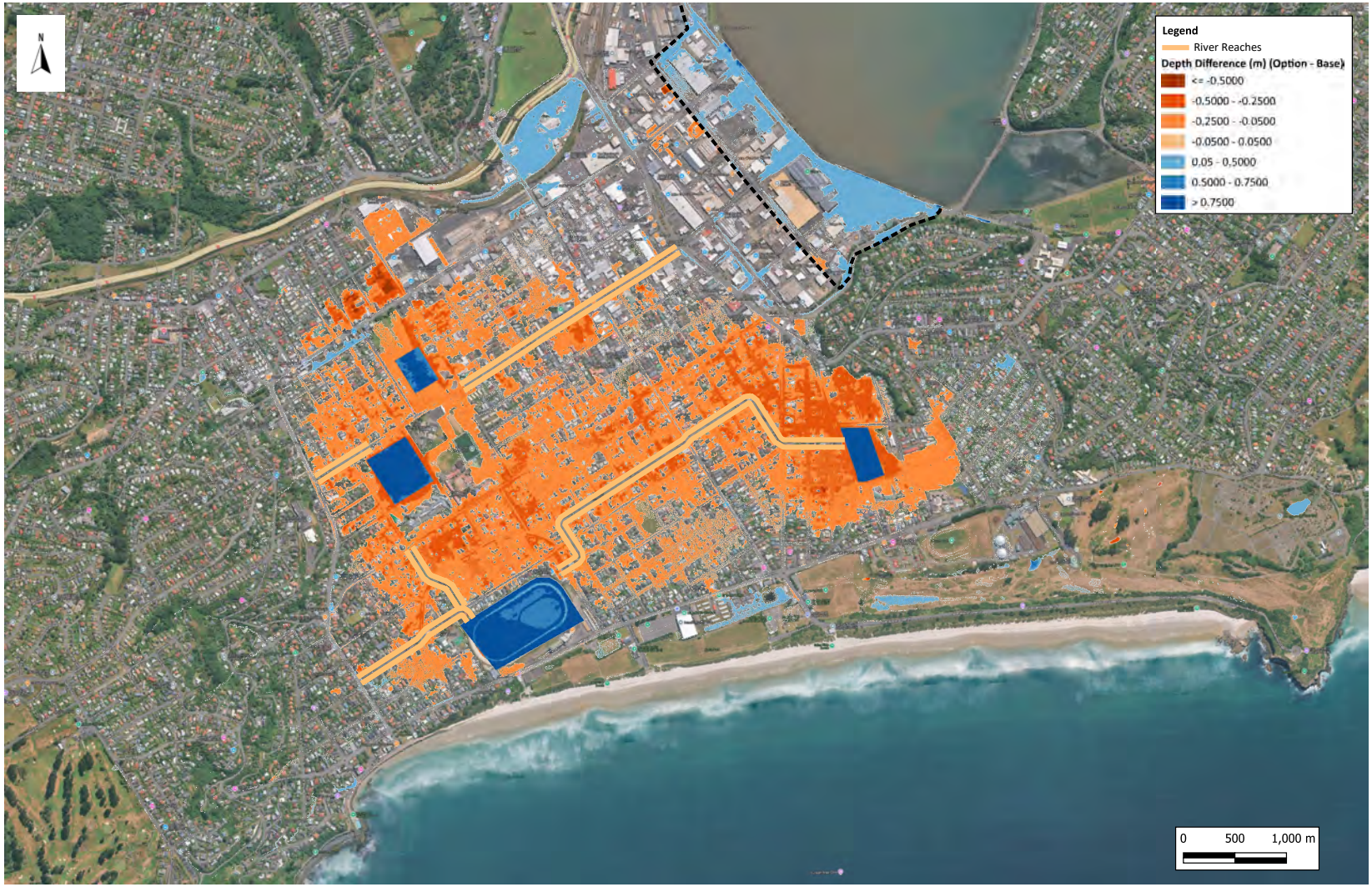
Disclaimer:
This map contains data derived in part or wholly from sources other than Beca. No representations or warranties are made by Beca as to the accuracy or completeness of this information. The map is intended for distribution as a PDF document. The scale may be incorrect when printed.

beca / DUNEDIN CITY COUNCIL		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 - 01	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, Dunedin Drainage Canal, wsp, Tonkin+Taylor	South Dunedin Future	DRAWN BY:	Anvesh Ravula
DUNEDIN CITY COUNCIL Kaunihera Rohe o Ōtepoti	South Dunedin Future	DATE:	2026-05-13
MAP NO: 4700990 - O2	REV: B	CHECK BY:	Kit Pascoe
		DATE:	2026-05-13

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

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.

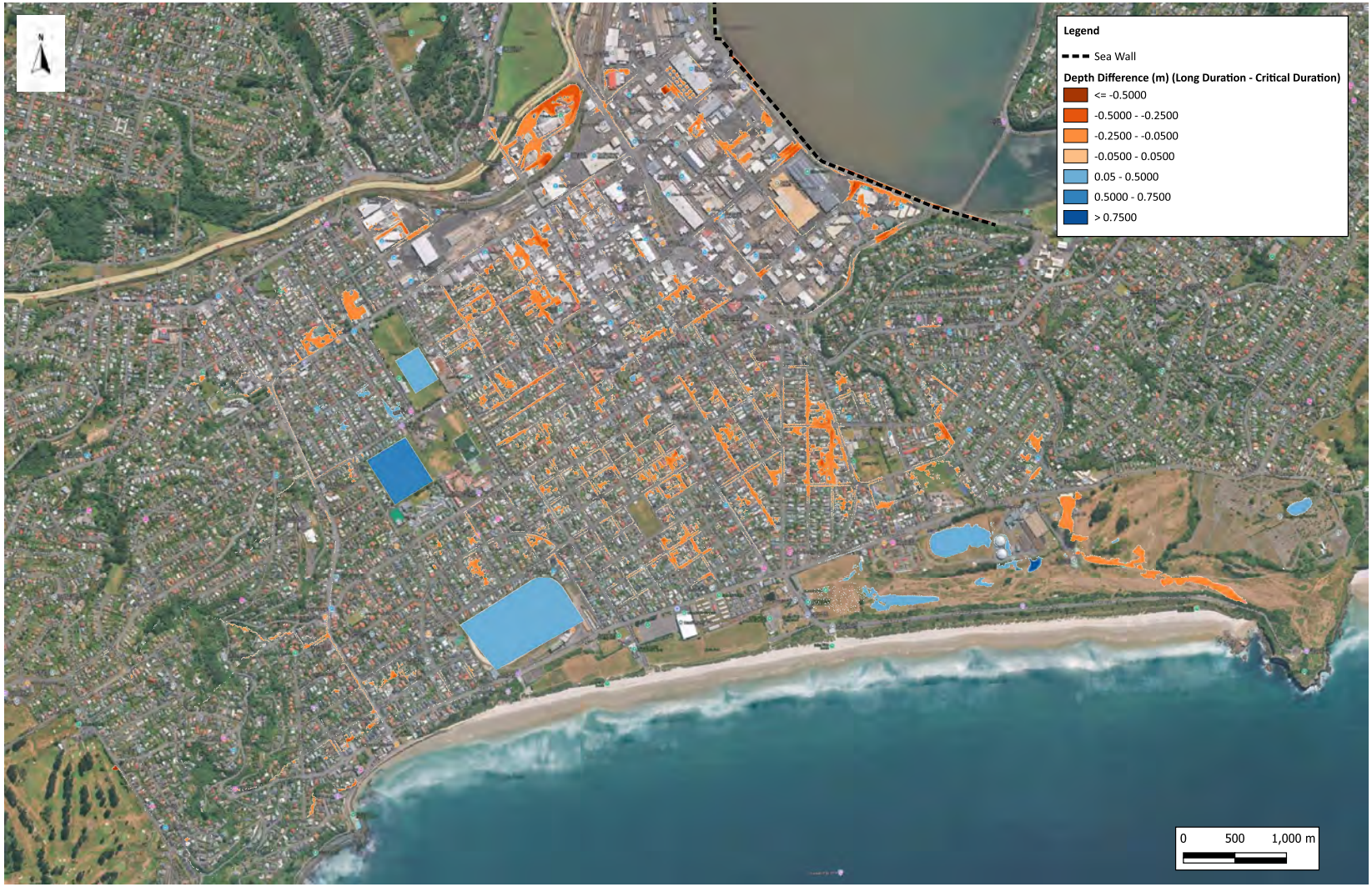


beca, South Dunedin Future, Dept Internal Affairs, wsp, Tonkin+Taylor	South Dunedin Future	DRAWN BY:	Anvesh Rayula
DUNEDIN CITY COUNCIL Kaunihera Āhuriwhenua o Ōtepoti	South Dunedin Future	DATE:	2026-05-13
MAP NO: 4700990 - O3	South Dunedin Future	CHECK BY:	Kit Pascoe
REV: B	South Dunedin Future	DATE:	2026-05-13

South Dunedin - Option 5
Flood Depth Difference Map Between Option 5 & Base
(1 in 100 Year Design Storm)

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, wsp, DUNEDIN CITY COUNCIL	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)	DRAWN BY:	Anvesh Rayula
		DATE:	2025-11-27
		CHECK BY:	Kit Pascoe
		DATE:	2025-11-27
MAP NO: 4700990 - P1	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, wsp, DUNEDIN CITY COUNCIL	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 Rayula
		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.	

beca, wsp, DUNEDIN CITY COUNCIL	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 Rayula
		DATE:	2025-11-26
		CHECK BY:	Kit Pascoe
		DATE:	2025-11-26
MAP NO: 4700990 - P3		REV: A	

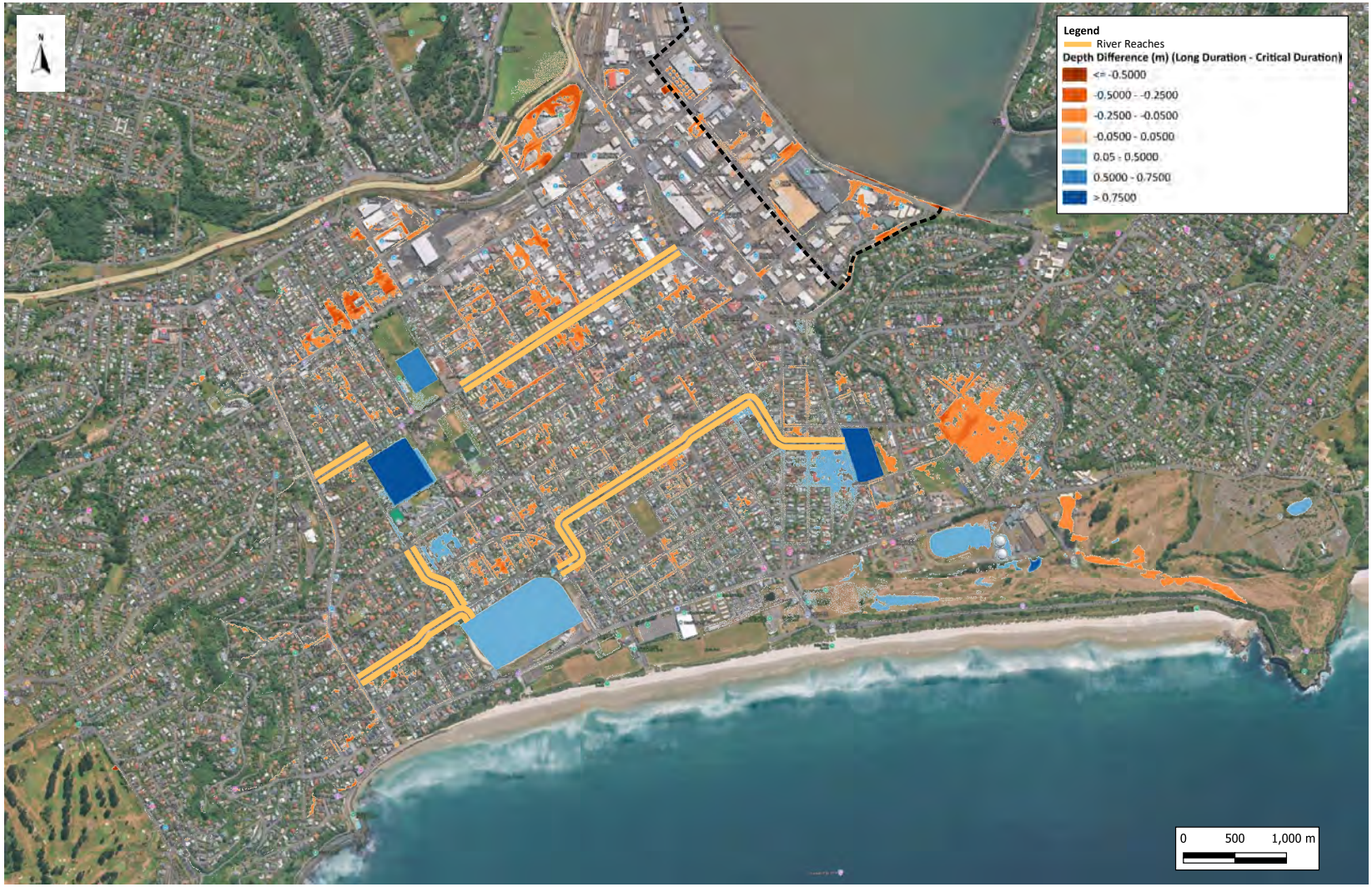
Disclaimer:
This map contains data derived in part or wholly from sources other than Beca. No representations or warranties are made by Beca as to the accuracy or completeness of this information. The map is intended for distribution as a PDF document. The scale may be incorrect when printed.

beca, wsp, DUNEDIN CITY COUNCIL	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
MAP NO: 4700990 - Q1	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, wsp, DUNEDIN CITY COUNCIL	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
MAP NO: 4700990 - Q2	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 / wsp / DUNEDIN CITY COUNCIL	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:	2026-05-13
		CHECK BY:	Kit Pascoe
		DATE:	2026-05-13
MAP NO: 4700990 - Q3	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, wsp, DUNEDIN CITY COUNCIL	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, DUNEDIN CITY COUNCIL		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 Rayula 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.

beca / wsp / DUNEDIN CITY COUNCIL	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:	2026-05-13
		CHECK BY:	Kit Pascoe
		DATE:	2026-05-13
MAP NO: 4700990 - R3	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.	

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.

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.

Disclaimer and Limitations:

WSP New Zealand Limited ('**WSP**'), Beca Limited ('**Beca**') and Tonkin & Taylor Limited ('**T&T**'), provide the South Dunedin Future Project services in association with each other using the "Kia Rōpine" brand. WSP is engaged by the Dunedin City Council in accordance with the LTES Contract No. 10458 ('**Agreement**') as the lead consultant and each of Beca and T&T are engaged by WSP as subconsultants pursuant to separate subconsultant agreements. Beca and T&T only assume liability to WSP in relation to the services, and only to the extent of the terms of their respective subconsultant agreements. WSP, Beca, and T&T are separate and independent legal entities, and no party is another's agent, partner or joint venture party, nor do they have authority to bind each other or act on each other's behalf.

This memorandum / position paper ('**Position Paper**') 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 – spatial long-list evaluation and short-list adaptation options development stage of the programme ('**Purpose**') and in accordance with the Agreement. The findings in this Report are based on and are subject to the assumptions specified in the Position Paper, 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 Position Paper, in whole or in part, for any purpose other than the Purpose or for any use or reliance on this Position Paper by any third party.

In preparing this Position Paper, 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 Position Paper, 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 Position Paper 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 Position Paper should any Client Data be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to WSP.

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.

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).

Disclaimer and Limitations:

WSP New Zealand Limited ('**WSP**'), Beca Limited ('**Beca**') and Tonkin & Taylor Limited ('**T&T**'), provide the South Dunedin Future Project services in association with each other using the "Kia Rōpine" brand. WSP is engaged by the Dunedin City Council in accordance with the LTES Contract No. 10458 ('**Agreement**') as the lead consultant and each of Beca and T&T are engaged by WSP as subconsultants pursuant to separate subconsultant agreements. Beca and T&T only assume liability to WSP in relation to the services, and only to the extent of the terms of their respective subconsultant agreements. WSP, Beca, and T&T are separate and independent legal entities, and no party is another's agent, partner or joint venture party, nor do they have authority to bind each other or act on each other's behalf.

This memorandum / position paper ('**Position Paper**') 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 – Spatial Short-List Adaptation Options development stage of the programme ('**Purpose**') and in accordance with the Agreement. The findings in this Report are based on and are subject to the assumptions specified in the Position Paper, 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 Position Paper, in whole or in part, for any purpose other than the Purpose or for any use or reliance on this Position Paper by any third party.

In preparing this Position Paper, 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 Position Paper, 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 Position Paper 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 Position Paper should any Client Data be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to WSP.

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

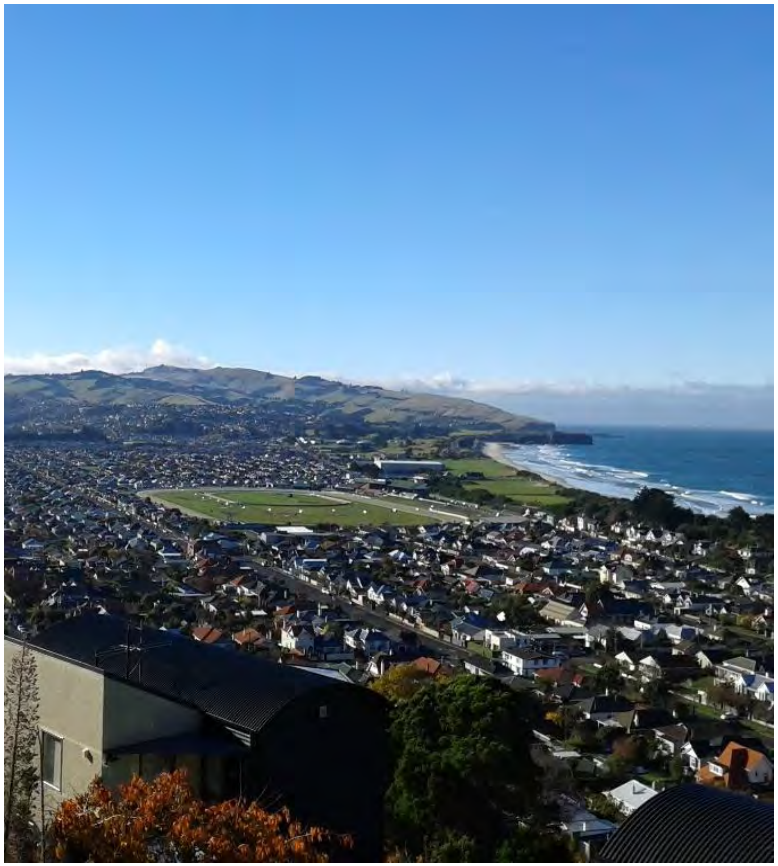
Dunedin City Council

South Dunedin Future

Groundwater Drainage Options Assessment

8 May 2026

6-CD109.77



South Dunedin Future

Groundwater Drainage Options Assessment

Dunedin City Council

WSP
Christchurch
12 Moorhouse Avenue
Christchurch 8011
New Zealand
+64 3 363 5400
wsp.com/nz

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

This document may contain confidential and legally privileged information, neither of which are intended to be waived, and must be used only for its intended purpose. Any unauthorised copying, dissemination or use in any form or by any means other than by the addressee, is strictly prohibited. If you have received this document in error or by any means other than as authorised addressee, please notify us immediately and we will arrange for its return to us.

TABLE OF CONTENTS

1 INTRODUCTION 1
1.1 GENERAL 1
1.2 PROJECT BACKGROUND 1
1.3 SCOPE AND OBJECTIVES 1
1.4 BRIEF SITE DESCRIPTION 1

2 APPROACH 3
2.1 MODELLING TOOLS USED 3
2.2 MODEL UPDATES 3
2.3 MODEL LIMITATIONS 3

3 OPTIONS ASSESSMENT 4
3.1 KEY CONSIDERATIONS 4
3.2 POTENTIAL ADAPTATION OPTIONS CONSIDERED 4
3.3 SUCCES CRITERIA 5
3.4 EVENT-BASED GROUNDWATER DRAINAGE RESPONSE 5

4 FINDINGS 6
4.1 SHORT TERM EFFICACY OF OPTIONS 6
4.2 LONG TERM EFFICACY OF OPTIONS 6
4.3 EXPECTED GROUNDWATER FLOWS TO MANAGE 6
4.4 OTHER CONSIDERATIONS 7
4.4.1 GROUNDWATER QUALITY 7
4.4.2 OPERATION AND MAINTENANCE 7

5 CONCLUSIONS AND RECOMMENDATIONS 8
5.1 CONCLUSIONS 8
5.2 RECOMMENDATIONS 8

6 REFERENCES 10

7 DISCLAIMER AND LIMITATIONS 11

APPENDIX A – GROUNDWATER DRAINAGE OPTIONS MAPS 12

APPENDIX B – GROUNDWATER DRAINAGE RESULTS MAPS AND CROSS SECTIONS 13

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