ENVELOPE

FLOOD RISK ASSESSMENT

Mt Welcome

DOCUMENT CONTROL RECORD

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APPENDICES

1.0 INTRODUCTION

1.1 GENERAL

The proposed Mt Welcome Development is located south of Pukerua Bay, within the Porirua Northern Growth Area (NGA). The site comprises currently undeveloped land identified for residential development.

This report provides information on the model build used to assess flood risk and overland flow conveyance within the development site. This model was built based on the provided model by Wellington Water Ltd (WWL) which extends from the south of Pukerua Bay to Plimmerton Beach, as seen in Figure 1. The document 'Taupo Stream Stormwater Catchment' model build report describes this model, refer Appendix 1.

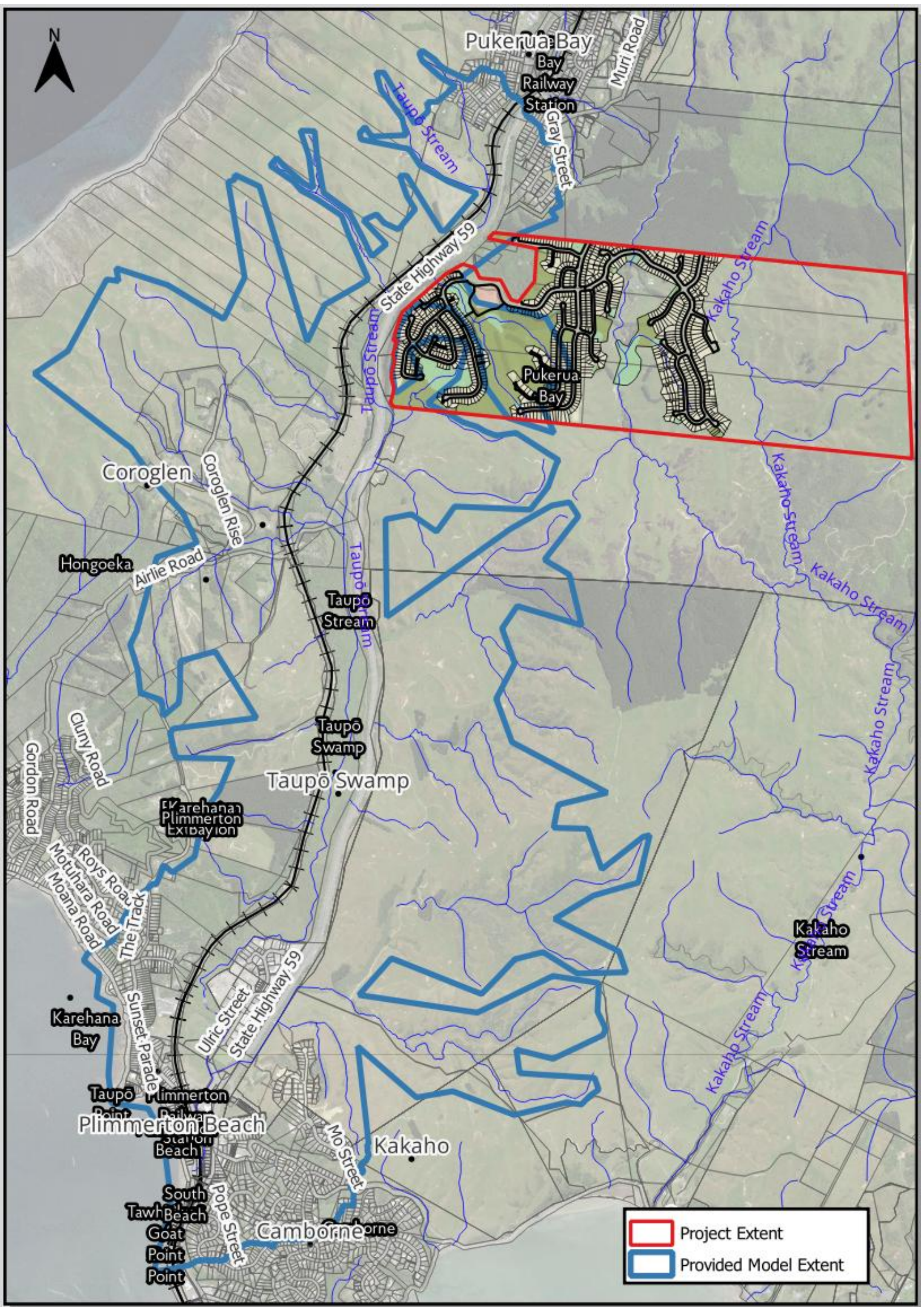


Figure 1. Proposed and provided model extent

It is expected that readers of this report are familiar with the site and proposed development.

1.2 SITE DESCRIPTION

The site is located at 422 State Highway 59, Pukerua Bay, and encompasses a total area of 205.60 hectares. It formally comprises the following land parcels:

- Part Lot 1 DP 89102 (4.38 ha)
- Lot 2 DP 891020 (5.64 ha)
- Lot 1 DP 534864 (55.33 ha)
- Lot 2 DP 534864 (140.25 ha)
- Lot 1 DP 608433, Lot 1000 DP 608433 (34 Muri Road)
- Road Reserve (SH59 Corridor)

References to “the site” within this report refer collectively to all seven allotments, unless stated otherwise.

The site is situated in a rural area south of Pukerua Bay and north of Plimmerton, within the Porirua City Council boundaries in the Wellington region. It is bounded by State Highway 59 to the west and three adjoining land blocks to the north, east, and south.

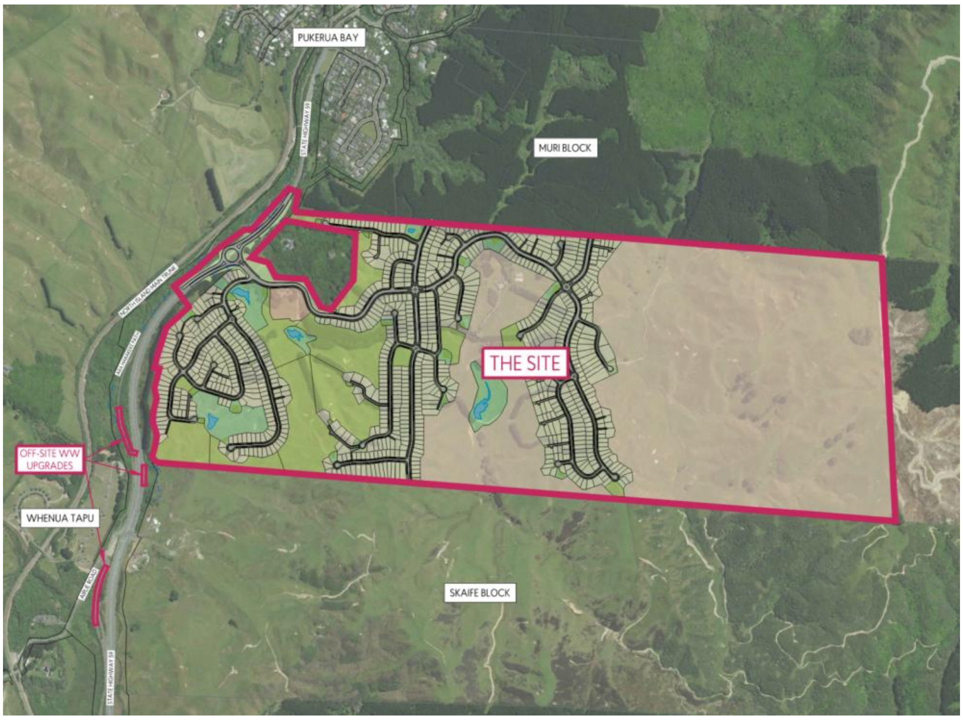


Figure 2. Site Extents Plan – Entire Site.

2.0 MODEL BUILD

2.1 CUT-OFF MODEL

The provided model is useful for catchment wide assessment, as it was intended. However, it is not detailed enough to assess flood effects within the project extents. For this reason, it was decided to cut off the model, which would allow the level of detail to be increased in a defined area. Figure 3 shows the cut-off model extent together with the boundary conditions considered in the simulations.

This has several benefits including allowing faster running times, allowing updates to data (e.g. topographical) and being able to decrease the size of 2D elements to allow for more defined results.

The proposed model is suitable for identifying and assessing the effects on flooding for the proposed development, and it is not intended or suitable to be extrapolated to a wider area.

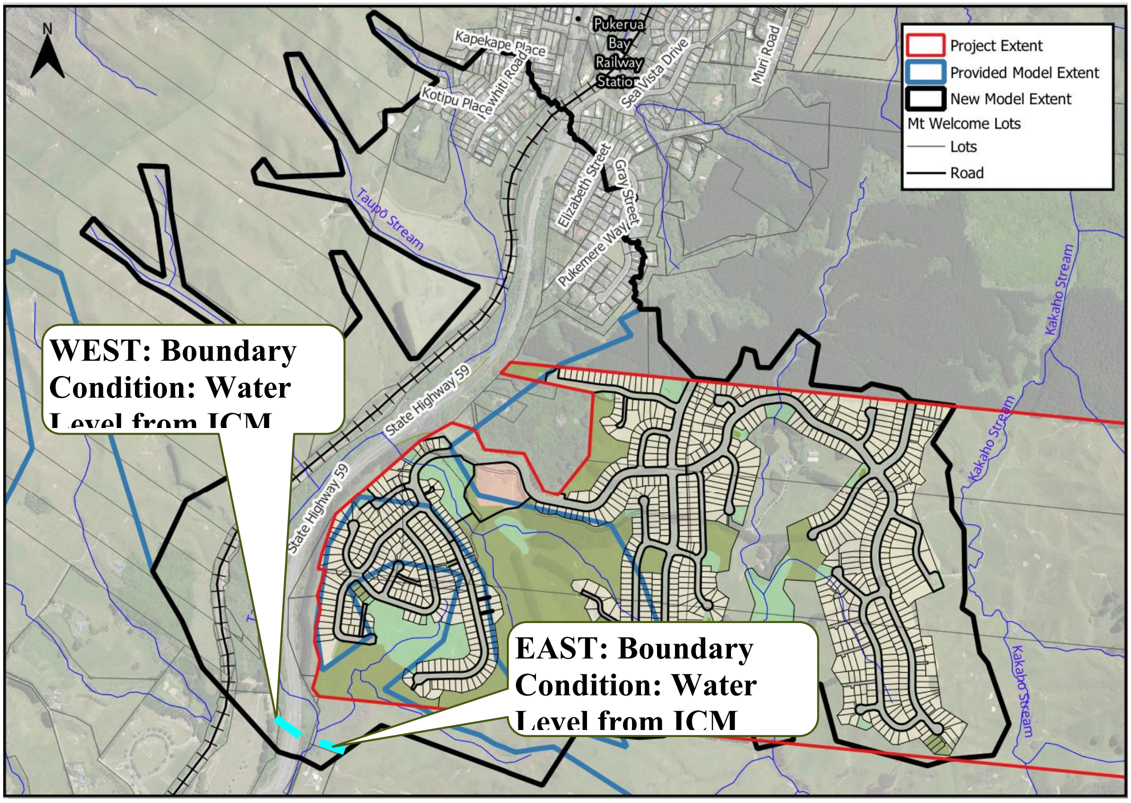


Figure 3. Cut-off model schema

2.1.1 MODEL OVERVIEW

Table 1 summarises some key details for this cut-off model compared with the provided model.

Table 1. Models build comparison - Provided Vs Cut-Off Model.

	Provided Model [ICM]	Cut-Off Model [ICM]
Software	ICM by Autodesk, version 7.5	ICM by Autodesk, version 2024.5.4
Coordinate System	New Zealand Transverse Mercator 2000.	Same as the provided model.
Vertical Datum	Wellington Datum 1953 (WGN53)	Same as the provided model.
Extent	• Upstream: South of Pukerua Bay • Downstream: Plimmerton Beach • Area: 888 ha.	• Upstream: Same as the provided model. • Downstream: Near the intersection of Airlie Road with SH59 (310A State Highway 1, Pukerua Bay, Porirua 5026).
Topography	• 1D river reach. Cross-section data along Taupo River. Total 59 cross sections. • 2D floodplain: 2013 Lidar. 2mx2m resolution.	Same as the provided model

	Provided Model [ICM]	Cut-Off Model [ICM]
Resolution	• 1D cross-sections: same as the provided model, with updates were considered suitable (e.g. due to erosion). • 2D model: Unstructured triangular mesh. Area between 2 m^2 and 4 m^2. Zones with $50m^2$ and $100m^2$.	Same as the provided model
Hydrology	Catchment-based hydrological models were developed in accordance with the Quick Reference Guide for Design Storm Hydrology 3, February 2016. Soil Conservation Services (SCS) unit hydrograph method. Rainfall based on HIRDS V3.	Same hydrology model methodology.
Downstream boundary	Tidal boundary along Plimmerton Beach.	From the provided model results at Taupo River in the south boundary. See section 2.1.2.
Initial Conditions	Conditions set for 118 nodes; 24 river reaches and 35 2D zones.	Same as the provided model.
Modelled Structures	• A 1D pipe network model is used to simulate hydraulics in underground reticulation in the catchment. • 33 river reaches with a total length of 36127 metres. • Culverts modelled within site extents based on site-specific survey.	The following items were removed: • 1211 nodes • 671 pipes. • 115 river reaches • 638 sub catchments • 1'364,441 2D mesh elements.
Simulation Times	37752 seconds (629 min)	3270 seconds (54 min).

2.1.2 BOUNDARY CONDITIONS

The downstream boundary conditions for the cut-off model were extracted from the provided model results for the 100yrCC scenario in the location shown in Figure 3. Figure 4 shows the water levels at the east and west boundary condition.

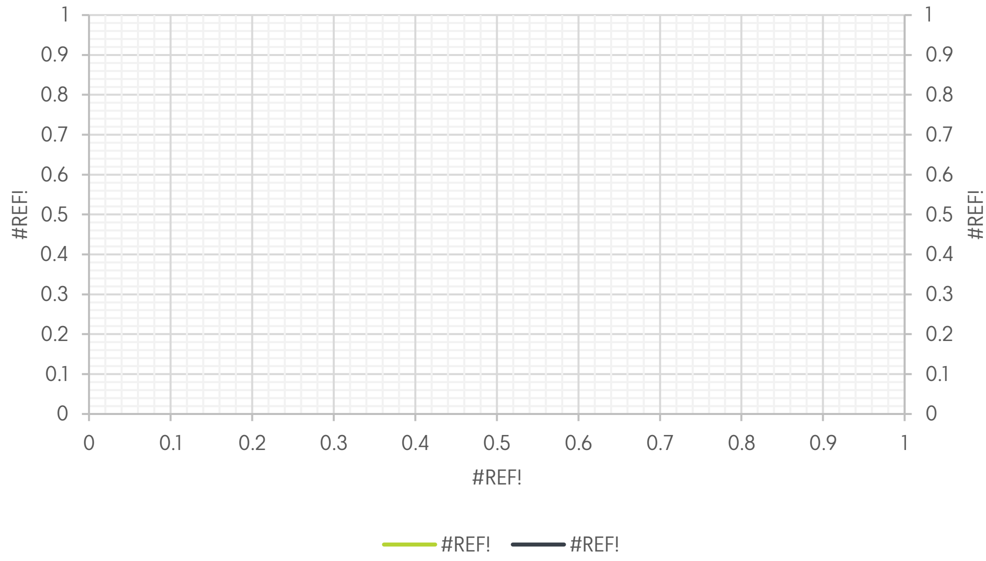


Figure 4. Water Level conditions at model cut off.

2.1.3 CUT-OFF MODEL VALIDATION

Cut-off model results validation was made using the 100yrCC scenario. Figure 5 shows the maximum afflux depth between the provided and the cut-off model, and Figures 4 to 6 show the flow and the depth comparison in four locations. Figure 5 reveals some areas with noise due to the mesh differences. However, we do not consider these to be relevant.. Next to the SH59 some flood depth reductions were found, with maximum values between 0.3 m and 0.5 m. The maximum flow differences are between $1.0 m^3/s$ and $0.82 m^3/s$ for the L01 and L02, respectively.

Overall, the cut-off model predicts slightly lower flood depths, primarily on the western side of SH59. These differences are considered minor. The cut-off model is therefore considered suitable for use in the Mt Welcome flood assessment and is considered to reasonably replicate the results of the WWL model within the study area.

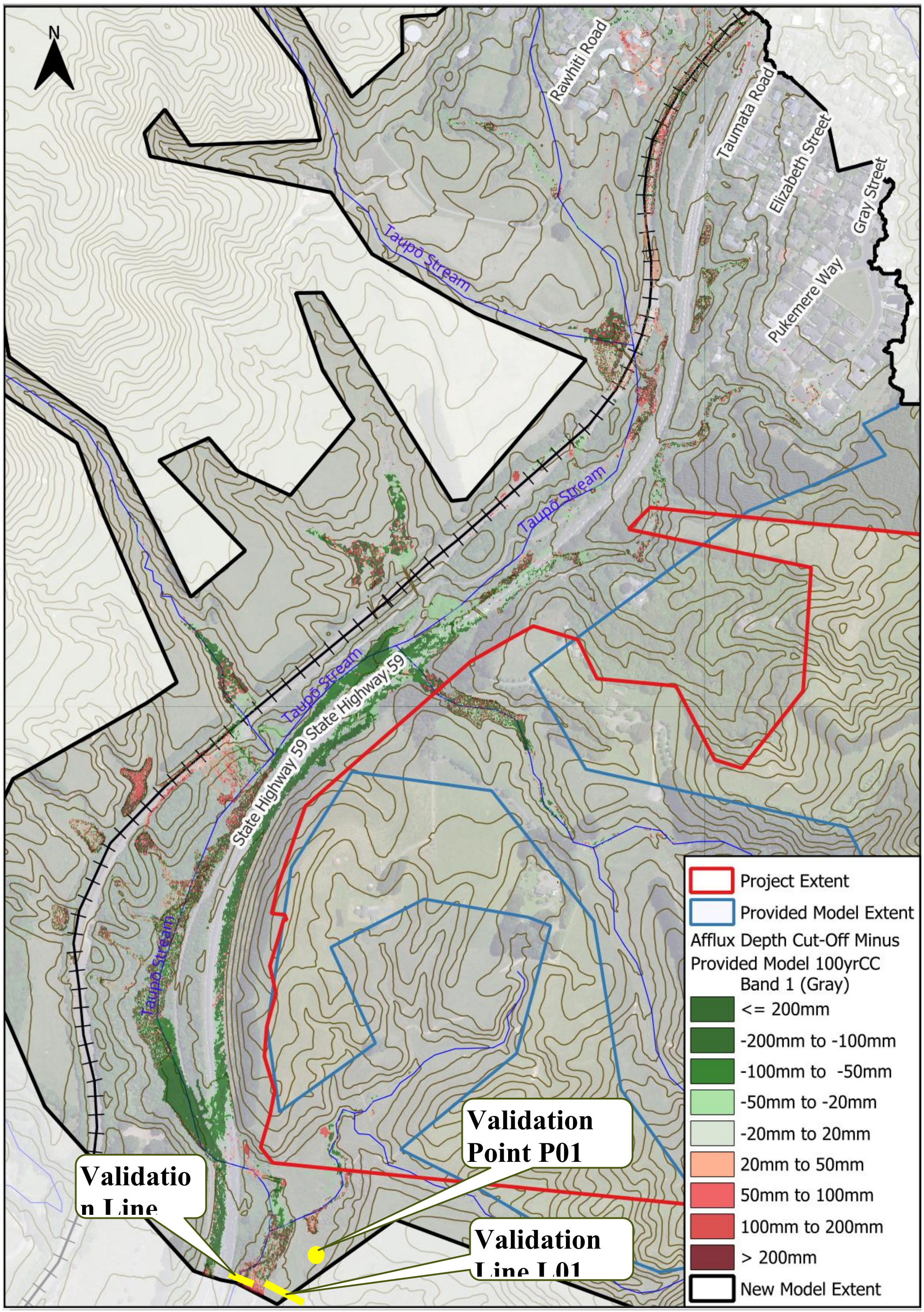
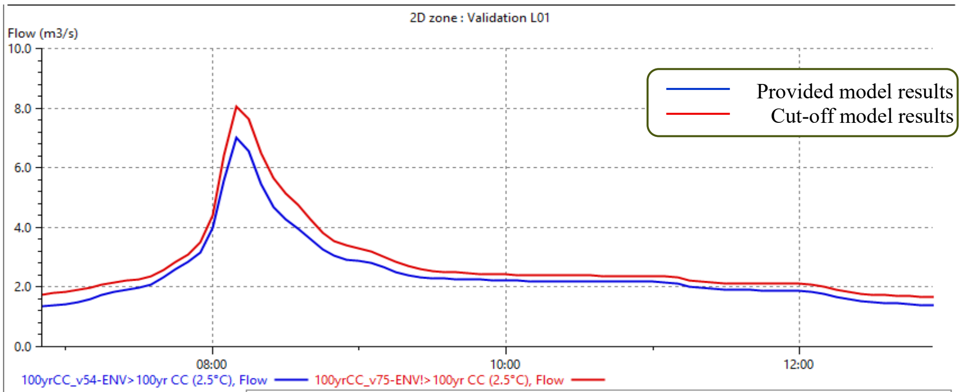
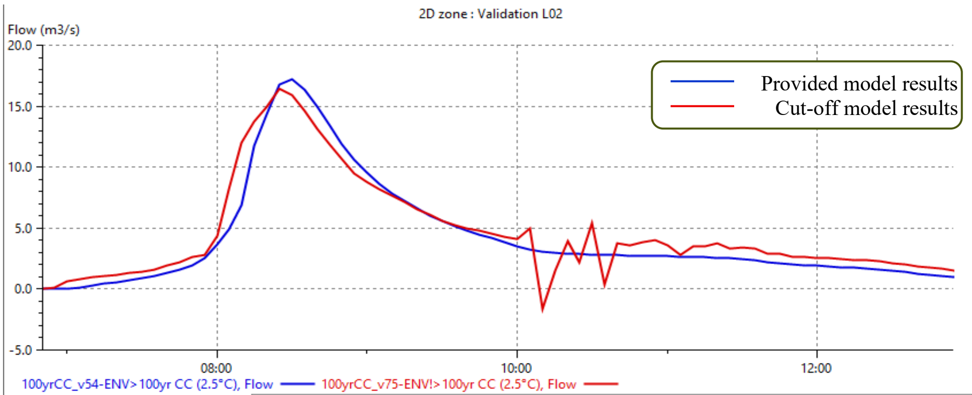


Figure 5. Cut-off model validation – Maximum Afflux Depth 100yrCC.



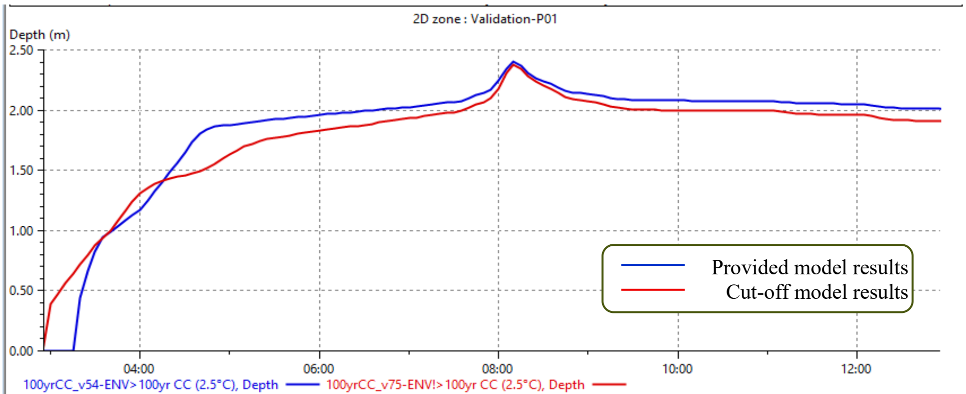
	Flow		
	Min (m3/s)	Max (m3/s)	Volume (m3)
100yrCC_v54-ENV> 100yr CC (2.5°C)	1.383	7.011	53558.565
100yrCC_v75-ENV!> 100yr CC (2.5°C)	1.683	8.047	61000.424

Figure 6. Cut-off model validation – Line L01 flow 100yrCC.



	Flow		
	Min (m3/s)	Max (m3/s)	Volume (m3)
100yrCC_v54-ENV> 100yr CC (2.5°C)	0.000	17.225	93039.136
100yrCC_v75-ENV!> 100yr CC (2.5°C)	-1.573	16.401	101190.561

Figure 7. Cut-off model validation – Line L02 flow 100yrCC.



	Depth	
	Min (m)	Max (m)
100yrCC_v54-ENV> 100yr CC (2.5°C)	0.000	2.406
100yrCC_v75-ENV!> 100yr CC (2.5°C)	0.392	2.377

Figure 8. Cut-off model validation – Line P01 depth 100yrCC.

3.0 MODEL UPDATES

3.1 PRE-DEVELOPMENT

Using the cut-off model as the baseline, updates were undertaken to incorporate the most recent and reliable data available. The scenario builds on the WWL base model and integrates updated topographic data, site survey information, and verified stormwater asset levels, as described below. These updates improve the representation of ground levels, drainage infrastructure, and overland flow paths within the study area.

3.1.1 DATA SOURCE

Table 2 shows the gathered information used to create the pre-development scenario.

Table 2. Data source used in the model.

Data	Details	Data supplied/obtained
Surface	lds-wellington-porirua-lidar-1m-dem-2023 in NZVD16. Resolution 1m by 1m. See section 3.1.2	June 2025
Topography	Envelope site-specific survey gathered in 11 separate areas.	November 2025.
SW existing asset survey	A total of 20 key conduits were surveyed to confirm levels and dimensions. See section 3.1.3.	March 2025
Aerial	Using the most updated public aerial.	February 2025

3.1.2 TOPOGRAPHY

Figure 9 shows the updated with the new topography information. The 2023 LiDAR was merged with the 11 survey surface data. This data was transformed from NZVD16 to WGN53 using a value of +0.3524m, the value was obtained from the public raster named 'wellington-1953-to-nzvd2016-conversion-raster' (by LINZ). The updated surface uses a resolution of 500 mm by 500 mm to get the small level differences from the survey campaign. One important change derived from this new surface is an updated overland flow path that modifies all the elements that connect to the surface, such as river reaches, sub catchments delineations, and outfall elevations.

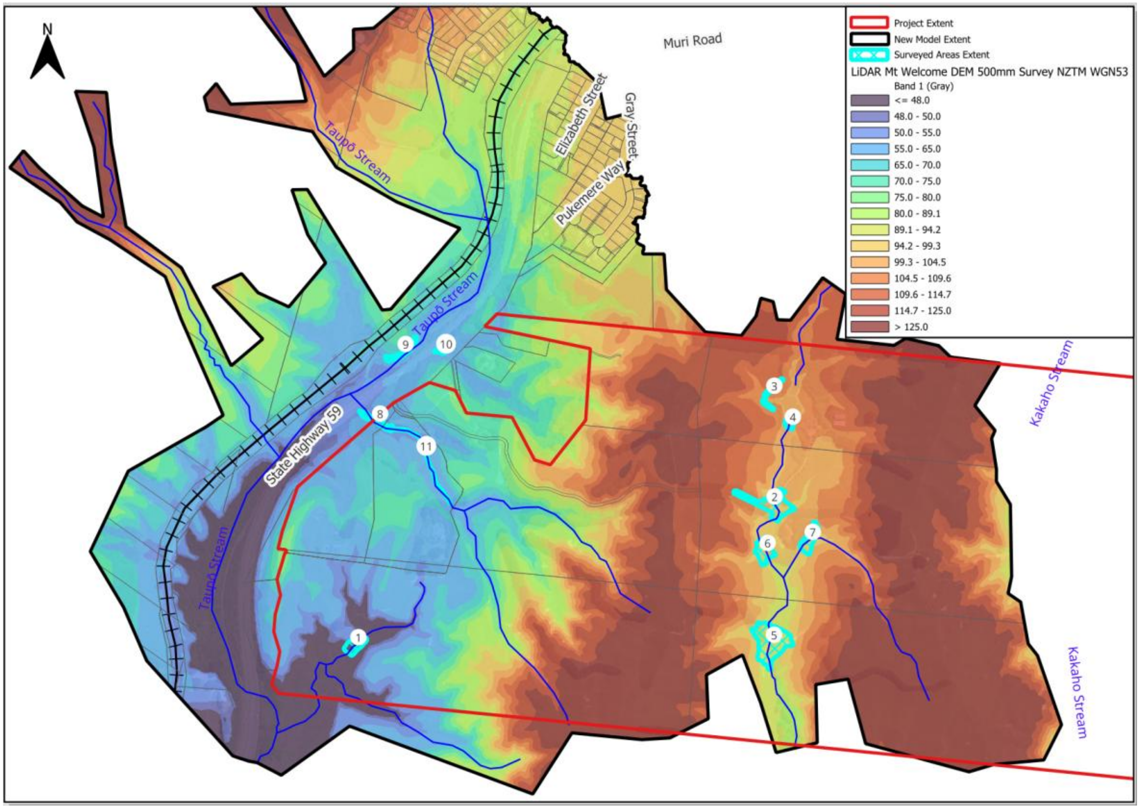


Figure 9. Pre-development topography updates.

3.1.3 EXISTING STORMWATER ASSETS

A total of 20 stormwater assets were surveyed during the site-specific topographical survey. These are listed in Table 3 and the locations are shown in Figure 10.

Table 3. Pre-development - Surveyed SW assets.

US node ID	Shape ID	Width (mm)	US invert level (m AD-WGN53)	DS invert level (m AD-WGN53)
EX-SWCP-02	CIRC	225	47.252	47.092
EX-SW-IN-03	CIRC	450	46.952	45.952
EX-SW-IN-02	CIRC	600	49.652	47.812
EX-SWMH A	CIRC	300	55.277	54.352
SWMH 258	CIRC	750	89.1	89
EX-SW-IN-05	CIRC	675	51.252	50.722
SWMH 260	CIRC	750	89.4	89.3
SWMH 262	CIRC	675	93.7	93.6
SWMH 264!	CIRC	675	95.402	95.402
SWMH 266	CIRC	750	95.372	94.982
SWMH 268	CIRC	900	95.892	95.682
SWMH 270	CIRC	450	96.632	95.892
SWMH 272	CIRC	375	96.332	96.092
EX-CP-01	CIRC	225	51.845	50.752
EX-SW-IN-04	CIRC	900	50.632	50.42
EX-SWMH A IN	CIRC	300	55.352	55.277
SW-IN-94-1	CIRC	375	57.632	56.932
SW-IN-95-2	CIRC	900	56.102	55.932
EX-SW-IN-06	CIRC	900	51.622	51.362
EX-SW-IN-08	CIRC	375	55.532	54.892

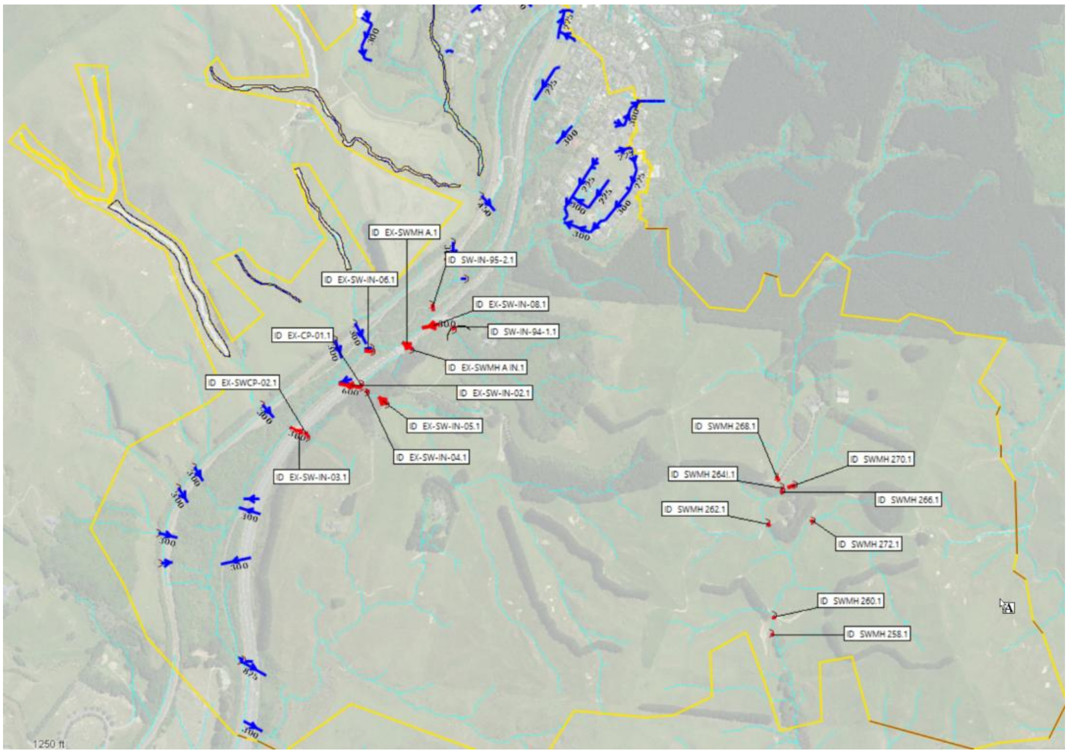


Figure 10. Pre-development – surveyed stormwater network.

Other important changes in the 1D elements are described below.

- 144 nodes were edited on the ground level and invert levels () with the updated surface.
- From the 10 river reaches located on the west side of the SH59, 3 were deleted. All the 8 river reaches on the east side of the highway were deleted. In total, 11 river reaches were deleted due to the surface update, and because some of them caused instabilities in the debugging process.
- From the remaining 7 river reaches, 131 cross sections were edited in levels and in length in order to align with the updated surface.

These reasons of the previous changes are described below:

- Changes in the surface (2013 LiDAR to 2023LiDAR) makes that the cross sections (river reach) superseded.
- New overland flow paths change the draining discharge.
- 2D Outlet levels of many dummy nodes would change due to the new surface.
- A direct discharge onto 2D point source made the model computational stable.
- Also this project scope does not need any hydraulic parameters in the deleted river reaches.

3.1.4 INFILTRATION

No infiltration has been considered within the grid extent, as volume loss to infiltration is considered to be a minor contributor in the design event. This approach is also considered in the provided model. All the losses come from the hydrology methodology (catchment-based).

3.1.5 ROUGHNESS

Table 3 shows the adopted Manning values for the existing scenario. These values were taken from the provided model build report and updated using the aerial image from 2025. Figure 11 Illustrate the roughness area in the predevelopment scenario.

Table 4. Adopted Manning's values from T&T (2024).

Ground cover	Manning Roughness Coefficient n	Comment
Water Body	0.01	Water Body
Roads and footpaths	0.02	Upper limit from Regional Specification (value indicated by Wellington Water)
Vegetation: urban open space	0.05	Urban open space can be any of forest/open field/landscaped garden/pavement
Vegetation: scrub/flax	0.08	Maximum value of light brush and trees in summer in Ven Te Chow table (value indicated by Wellington Water)
Vegetation: forest	0.1	Medium to dense brush in summer in Ven Te Chow table (value indicated by Wellington Water)
Residential properties: building	0.2	Porirua for residential properties
Swamp	0.3	Swamp (according to the validation section)

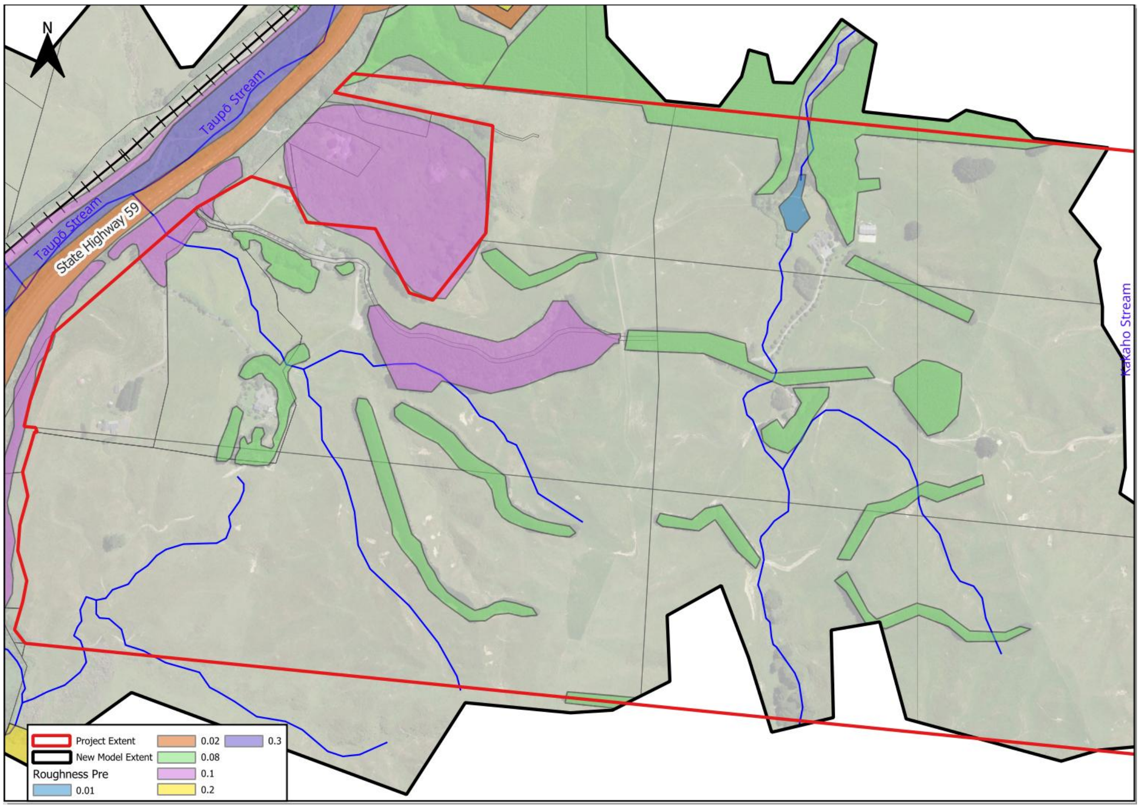


Figure 11. Pre-development - Roughness map.

3.1.6 HYDROLOGY

For the sub catchments out of the project extent, the same hydrological model was used as described in the model build report provided (refer Appendix 1) that follows the Quick Reference Guide for Design Storm Hydrology 3 (February 2016).

Given that the model extent was revised and the ground surface representation updated, the following modifications were made to the sub catchments to more accurately reflect the existing conditions scenario.

- 21 sub catchments were changed to drain to a 2D point source. This due to many river reaches were deleted mainly in the west side of the highway. On these sub catchments the hydrology method did not change and the discharge points are
- 13 sub catchments were deleted. Corresponding to the Mt Welcome extent as they were large and did not provide enough accuracy for the future comparison.
- 113 sub catchments were added. Corresponding to the east side of the highway, providing more accuracy and following the most updated surface.

Figure 12 shows the new sub catchment delineation based on the updated surface.

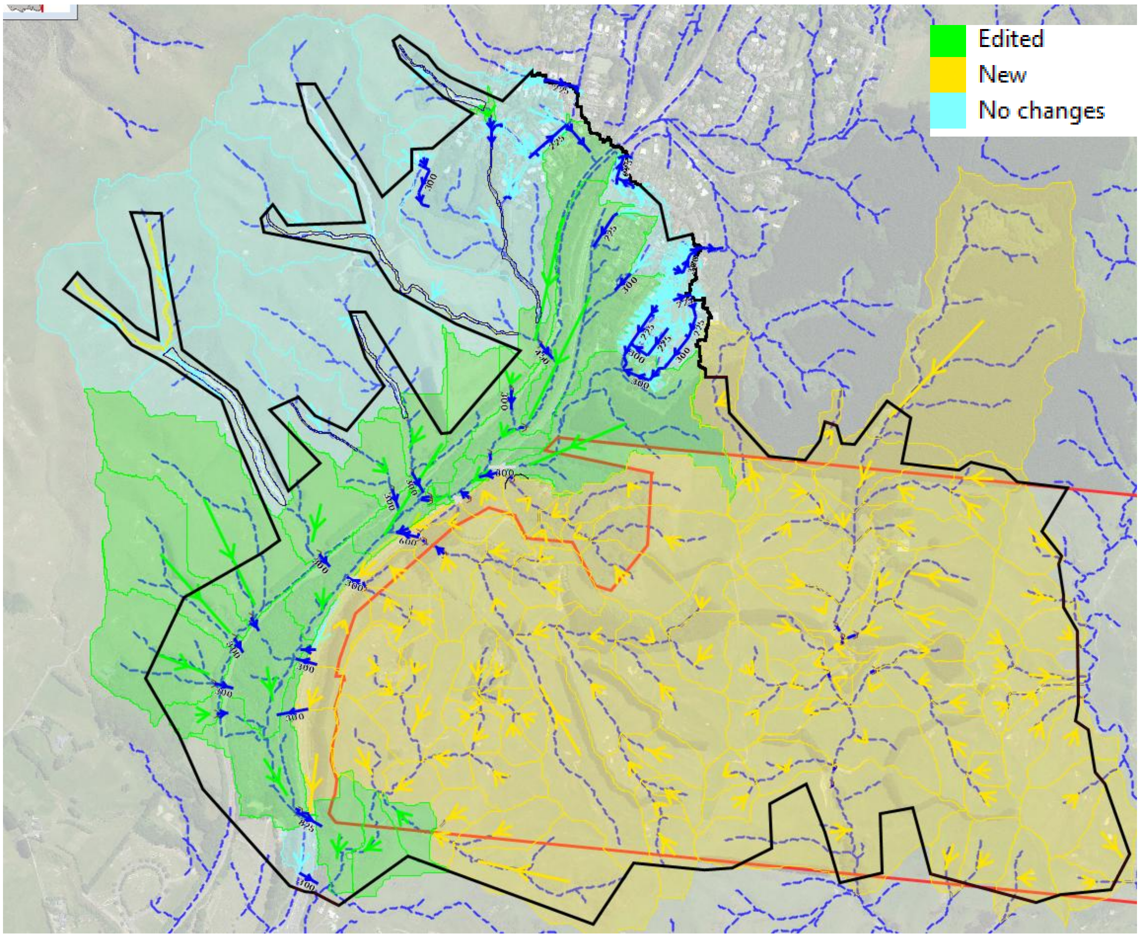


Figure 12. Pre-development – Sub catchments delineation

For the west side of the highway, curve number, initial losses and Tc are the same as provided. Within the project extent (east side of the highway), the hydrology model was changed to use the SCS routing model with constant initial loss values. The following hydrology parameters were updated in this process:

- Curve number. For the pervious areas, a curve number of 75 was used, and for the impervious areas, 95. These values follows the Appendix B on the 'Reference Guide for Design Storm Hydrology'.
- Initial losses of 5 mm were used for the all the pervious areas on the east side of the highway.
- Time of concentration. Calculated with the updated surface considering changes in length and slope. Values from 7 to 23 minutes were adjusted.
- It was considered a full pervious area (100%) for the pre-development scenario on these sub catchments.

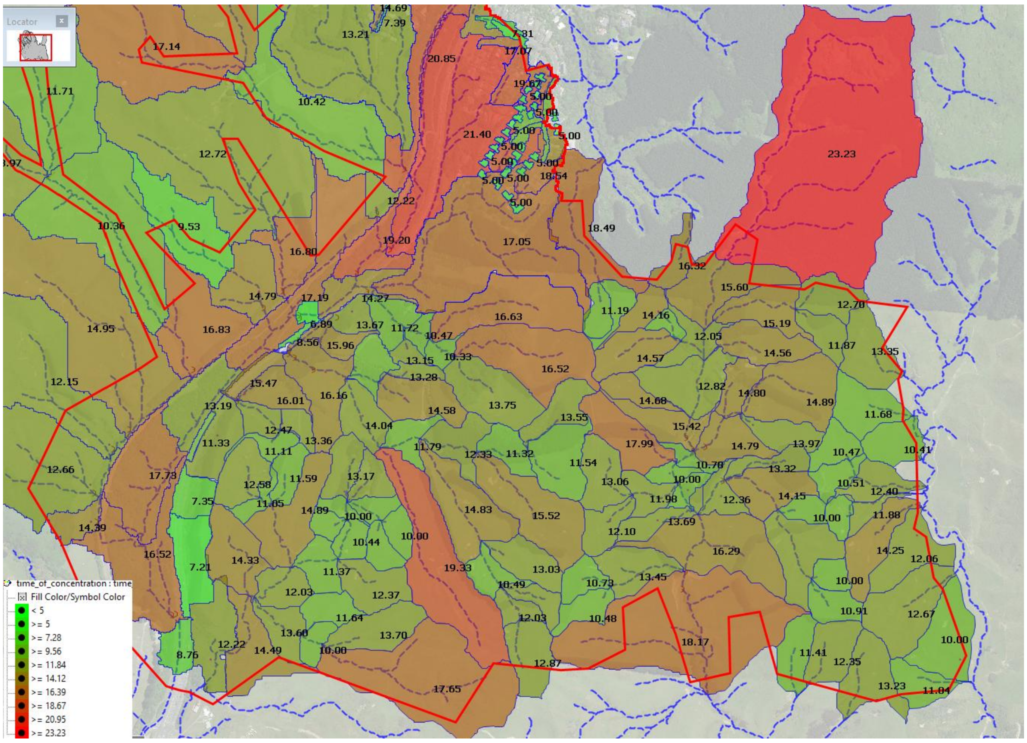


Figure 13. Pre-development – Time of concentration in minutes.

3.1.7 2D ELEMENTS

The following changes have been made to add more accuracy to the model mesh:

- 35 new mesh zones to allow a better interchange between the 1D outlets and the mesh.
- 16 new mesh level zones to allow a better interchange between the 1D outlets and the mesh.
- 130 breaking lines that consider the updated overland flow path and the SH59.

4.0 MODEL SCENARIOS

4.1 MODEL SCENARIOS

Hydraulic modelling was undertaken to assess the site under a range of development scenarios and operational conditions. The model scenarios assessed, including storm event, climate change allowances, and boundary conditions, are summarised in Table 3 below.

Table 5. Model Scenarios.

No	Development Scenario	Storm Event (ARI)	Climate Change	Other condition
1	Existing Development	Designed 100yr -12hr duration	Rainfall depths increased by 20% (2.5° temperature increase). HIRDSv3.	Boundary water level conditions at the Taupo River from the provided model (100-year CC scenario).
2	Proposed Development (options testing)	Designed 100yr -12hr duration	Rainfall depths increased by 20% (2.5° temperature increase). HIRDSv3.	Boundary water level conditions at the Taupo River from the provided model (100-year CC scenario).
3				Blocked scenario according to the Auckland Council code of practice.

5.0 PRE-DEVELOPMENT FLOOD HAZARD

5.1 EXISTING MAPPED HAZARD

There is an identified flood hazard across parts of the site, and this is represented by the current Porirua City Council hazard map shown in Figure 14. From the project extent 70.7% (145.2 ha), drains to Kakaho Stream, 27.9% (57.29 ha) to Taupo Swamp and 1.3% (2.72 ha) to Pukerua Bay Catchment. Due to the mountainous topography (steep, high altitude), small flood hazard areas are represented in this map. Around 9.5% (19.52 ha) of the site extent is under a flood hazard due to the proximity to three stream corridors.

Specifically, the project is covered by ponding (9.65ha – 4.7%), overland flow (0.91ha 0.44%) and stream corridor hazards (8.95 ha – 4.36%). Below is a description of each hazard:

- **Ponding:** These are areas where slower-moving flood waters could pond either during or after a flood event. A ponding area may be affected by a direct flood risk. Ponding can be associated with rivers and streams as well as the piped stormwater network. Ponding is a direct risk
- **Overland flow:** Overflow paths generally occur in lower-lying areas on the floodplain which act as channels for flood waters. They can be natural, or artificially formed, and are often characterised by fast-flowing water during a flood event. An overflow path is a direct hazard.
- **Stream corridor**: This is the minimum area able to contain a flood of up to a 1% AEP event magnitude and enable flood water to safely pass to the stream confluence or the sea. It includes flood and erosion-prone land immediately adjacent to the stream.

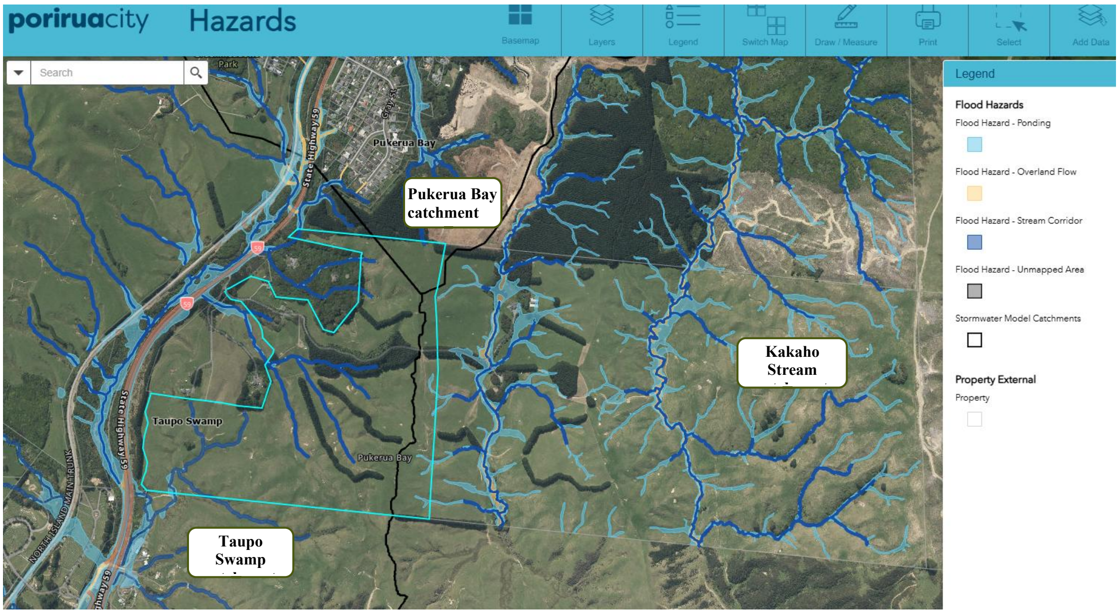


Figure 14. Flood hazard areas (Porirua City – local maps viewer)

5.2 MODELLED EXISTING FLOOD HAZARD

The updated cut-off model results for the site under the existing scenario are shown in Figure 15 and Appendix 2. These show that there is a flood hazard across the site. Broadly, this can be summarised into several discrete components:

- In the Taupo Swamp catchment area within the project extent, some flood accumulation was found upstream of the culverts that cross the SH59. Maximum depths of 3.56 m and 3.03 m were found upstream of culvert EX-SW-IN-05 and EX-SW-IN-08, respectively.
- Along the Kakaho Stream within the project extent, some flood accumulation was found mainly in the water body (pond) in the 422A lot with a maximum depth of 0.55m.
- Broadly, the flood hazard is concentrated in the lower part of the valleys with some accumulation in the concentrations generated by the small culverts.
- SH59 overtopping. Existing scenario model results show 3 locations where the flood covers the highway. From north to south, the maximum flood depths are 0.08 m, 0.14 m and 0.11 m.

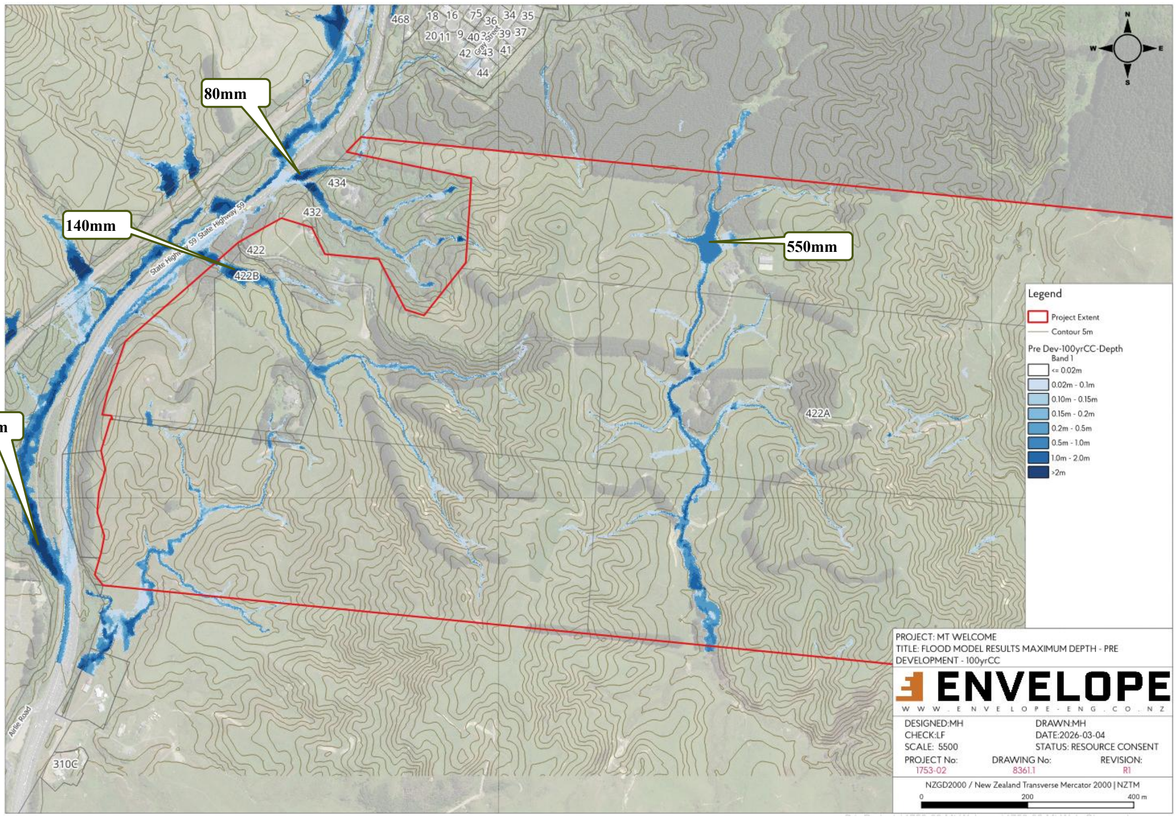


Figure 15. Pre-development flood hazard, 100-year ARI event.

6.0 POST DEVELOPMENT FLOOD HAZARD

6.1 MODEL UPDATES

The following changes have been made to the pre-development scenario:

6.1.1 TOPOGRAPHY

The topography within the model was updated to reflect the changes in landform that will occur as a result of the development, refer Figure 14. The proposed Finished Ground Level (FGL) considers elevation between RL 38.0 m and RL 162 m. In general, the proposed FGL was designed to drain by gravity the primary system overflows to the designed raingardens and retention wetlands in order to attenuate the peak flows from the rainfall. The stormwater design considers 22 raingardens and 5 retention wetlands located as shown in Figure 14. The proposed surface was transformed from NZVD16 to WGN53 (+0.3524) with a resolution of 500mm to aligned with the updated EGL. On the hydraulic model.

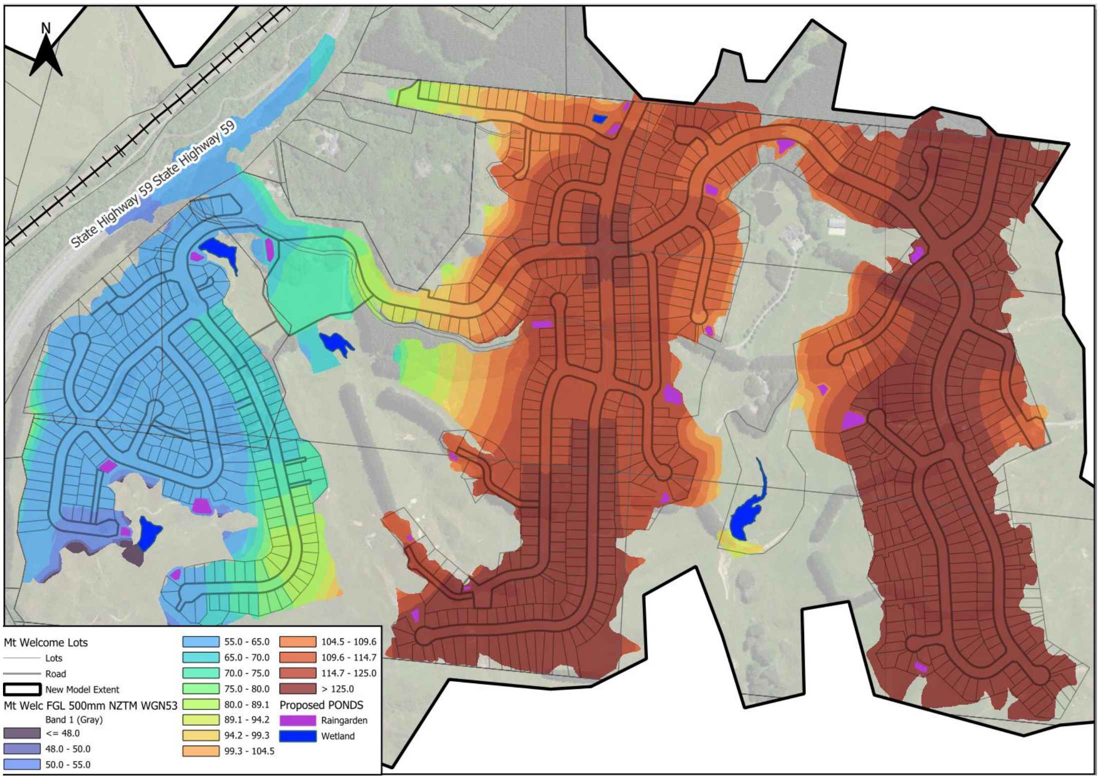


Figure 16. Post development topography.

6.1.2 SW NETWORK

The proposed stormwater network was brought into the post-development scenario. This broadly consisted of:

- 334 manholes.
- 23 scruffy domes.
- 290 sumps between singles, doubles and mega pits.
- 44 outfalls.
- 668 stormwater pipes between 225mm and 1800mm. Slopes between
- Retention Wetlands – modelled as 2D devices, with 1D connections.
- 30 rain gardens and 5 retention wetlands. Modelled as 2D devices.

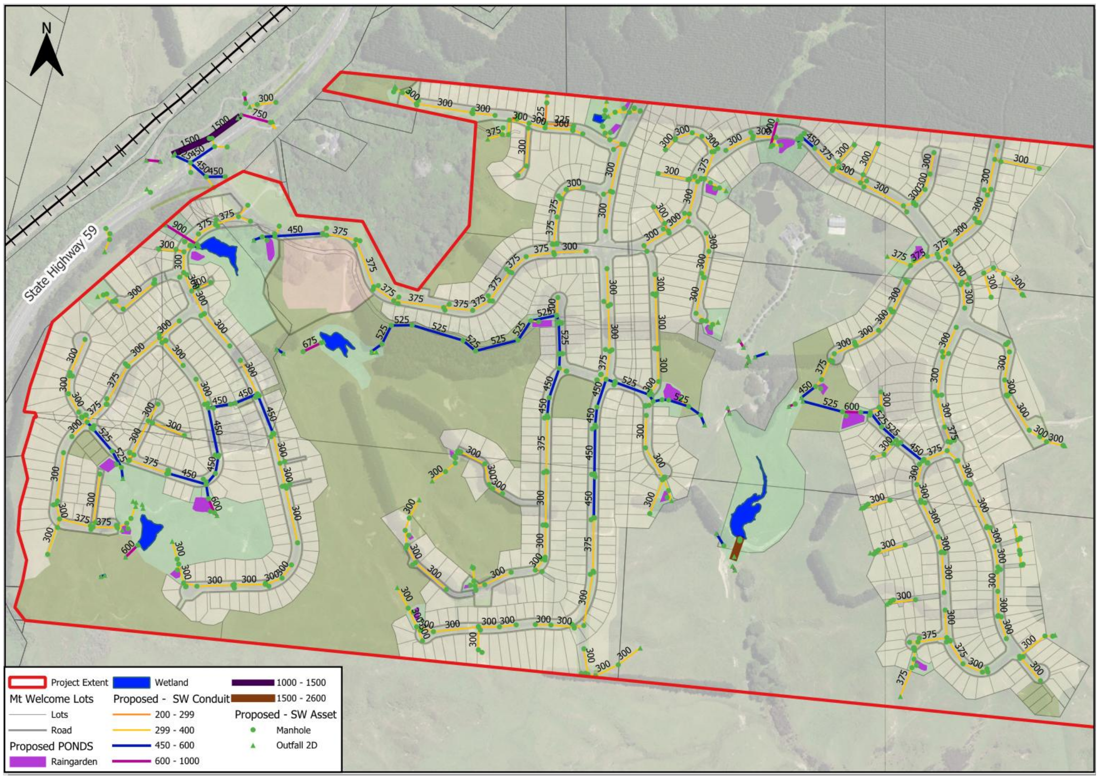


Figure 17. Post development drainage network additions.

6.1.3 ROUGHNESS VALUES

Roughness values have been assigned within the site to accurately match the proposed development, refer to Figure 10 and Table 3. Roughness values are consistent with values used in the provided model.

Table 6. Assigned roughness values.

New Layers	Comment	Roughness
Roads (footpaths, driveways)	Roads and footpaths	0.02
Berm (short grass)	Vegetation: urban open space	0.05
Raingarden	Residential properties: grass	0.04
Residential Lots	Residential properties: building	0.5
Commercial Lot	Non-residential properties: pavement	0.02
Reserve (high Grass)	Recreational area playing field	0.05
Reserve Drainage (more infiltration)	Recreational area playing field	0.05
Ponds (water)	Ponds (water)	0.01
QEII Zone	Vegetation: forest	0.1
Footpaths	Roads and footpaths	0.02

Figure 18. Post development roughness zones.

6.1.4 HYDROLOGY

In total 586 sub catchments were added to represent the lots and the road-draining areas on the proposed project, see red areas in .

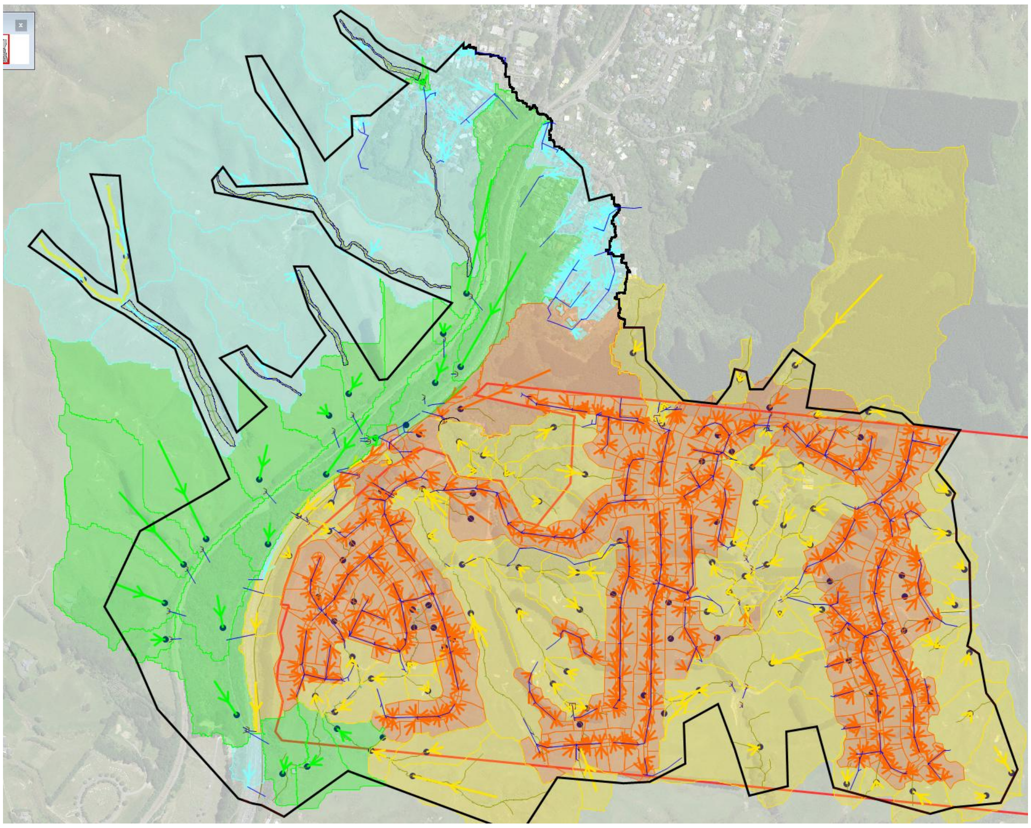


Figure 19. Post-development. Sub catchment loading.

The USCS method was also applied for the new updated sub catchments with the following parameters:

- Curve numbers were got from the public layer 'Curve_Number_Group' and the surrounding. Values from the Appendix B on the 'Reference Guide for Design Storm Hydrology' report. See Table 7 and Figure 20.
- Initial loss on the project extent varies between 1 and 5 mm as seen in Figure 21.
- Time of concentrations were calculated from slope and length with values between 8 min and 22 min. See Figure 22.
- Within the project extent, the impervious percentages were edited as shown in Figure 23 with values between 50 and 100%.

Table 7. Post development – Curve Numbers applied.

Soil - Land Cover	Curve Number
C - Forest	63
C - Pasture-Crop	72
C - Scrub/Flax	68
C - Urban Open Space	72
C - Impervious	98
B-Post-Pasture-Crop	59
C-Post-Forest	63
B-Post-Urban Open Space	59
C - Scrub/Flax	68

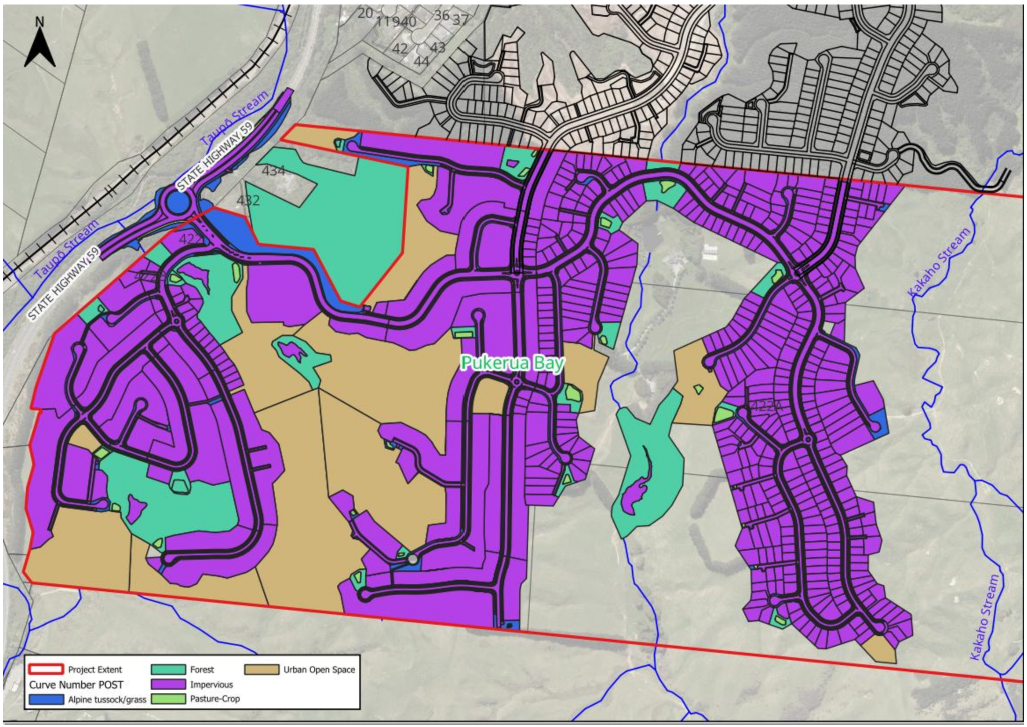


Figure 20. Post development. Curve Number

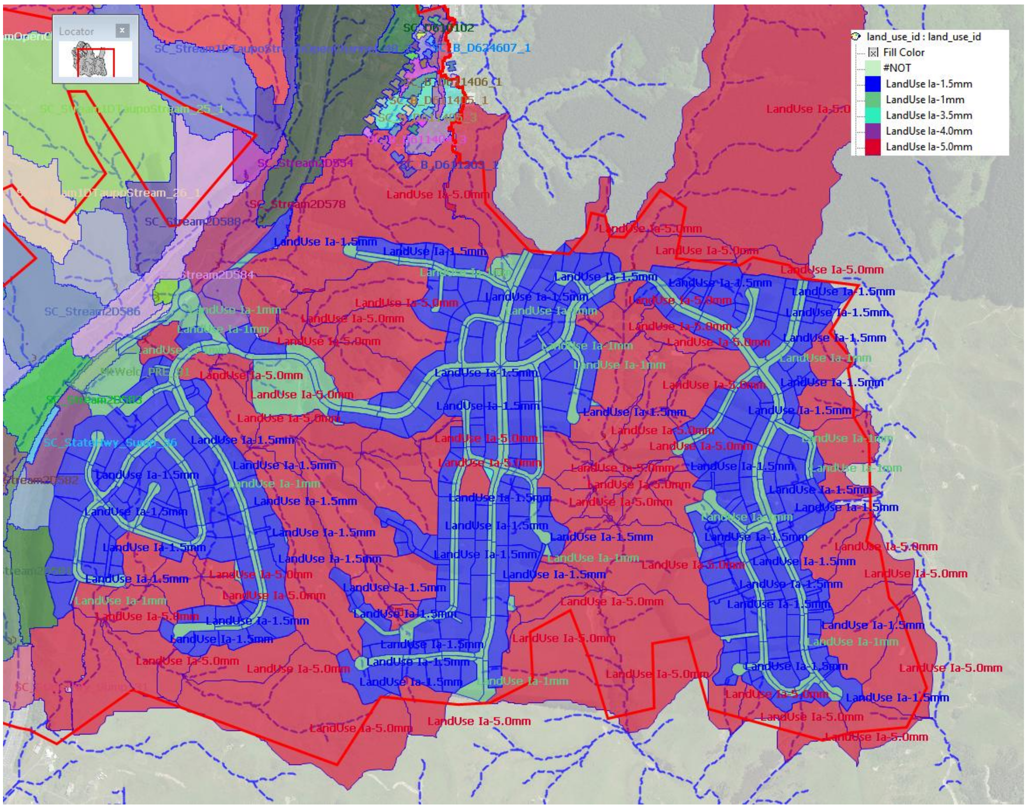


Figure 21. Post development. Initial Loss

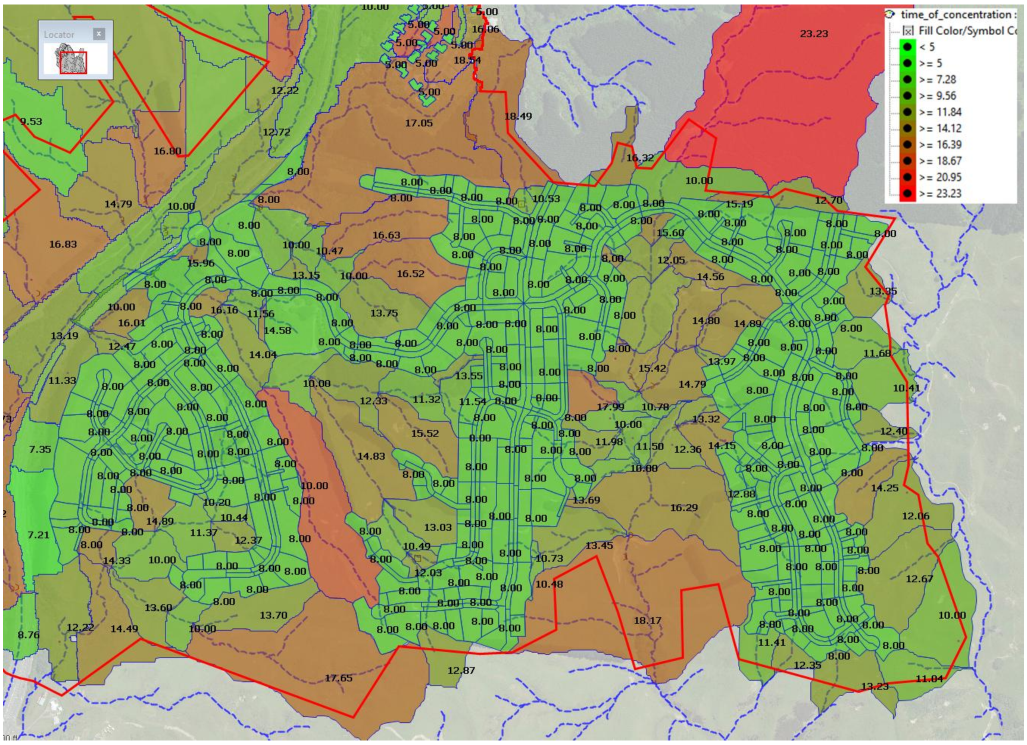


Figure 22. Post-development. Time of concentration in minutes.

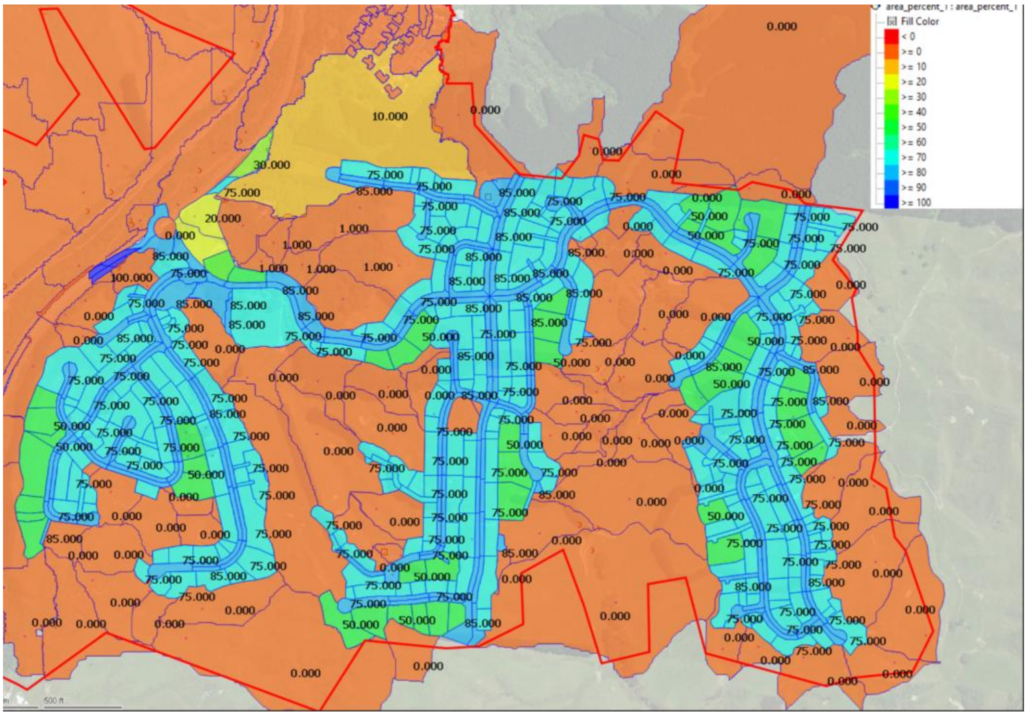


Figure 23. Post-development. Impervious percentage.

6.2 POST-DEVELOPMENT FLOOD MODEL RESULTS

The updated cut-off model results for the proposed development scenario are shown in Figure 20 and Appendix 2. These indicate that flood depths across the developed areas are generally minor and primarily confined to the road network and designated stormwater management areas. The key outcomes are summarised below:

- General shallow surface along the proposed roads with maximum water depths between 0.05 m and 0.20 m.
- No flood hazard within the proposed residential lots.
- SH59 overtopping. The proposed design reduces flooding along SH59, with only one minor overtopping location remaining, where a maximum flood depth of approximately 0.06 m is predicted.
- Retention wetlands: The proposed retention wetlands (Figure 20) provide stormwater storage that attenuates peak flows and reduces downstream flood effects.

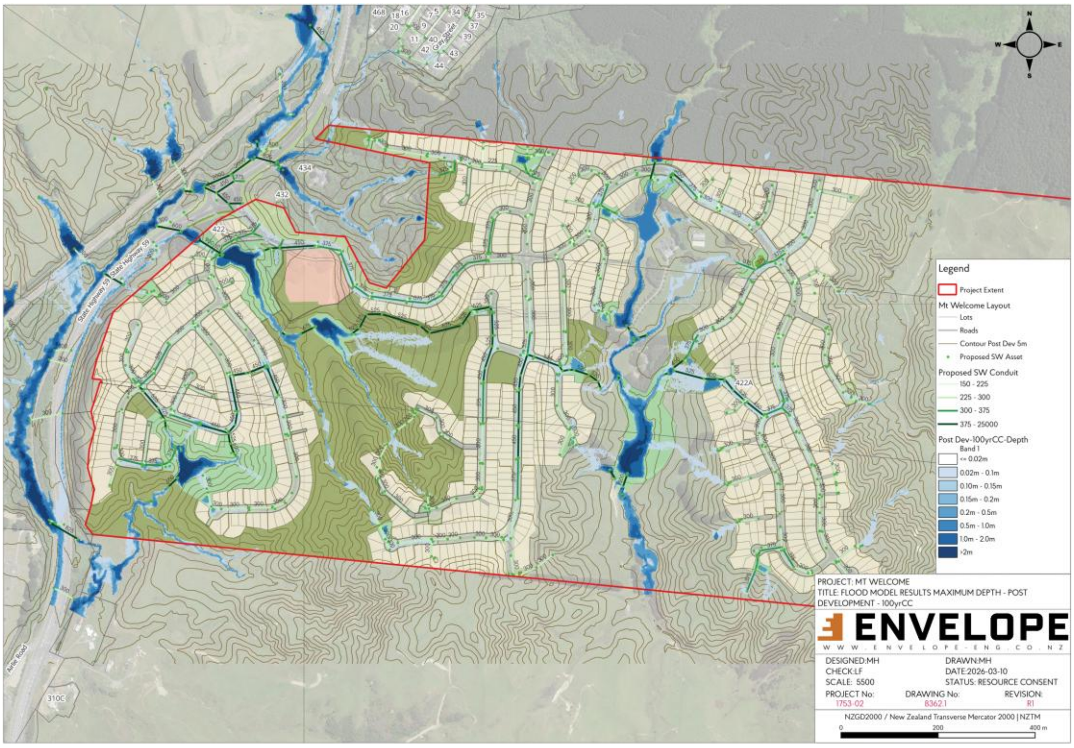


Figure 24. Post-development flood hazard, 100-year ARI event.

6.3 DEPTH DIFFERENCE

A comparison of the peak depth was undertaken for the 100-year event (Figure 25). This shows the following findings:

- Across the final model discharge to the Taupō Swamp (see validation lines in Figure 3), Pukerua Bay, and Kakaho catchments, model results show a reduction in flood depth downstream of the site, reflecting the attenuation provided by the proposed retention wetlands. Maximum reductions in flood depth are approximately 0.10 m, 0.02 m, and 0.12 m.
- Stormwater management measures have been incorporated around the proposed roundabout to avoid flood impacts on SH59. These measures include the use of adjacent reserve areas on the west side of the SH59 to temporarily store peak flows from the upper catchments. Proposed culverts facilitate the flow towards this side, where the flood depth increases between +0.5 m and +0.025 m over a length of 450 m. However, this does not cause any overspill onto the SH59.
- Upstream Kakaho Stream. Due to the proposed culvert (SW-IN 74-2, 900 mmø) near the north boundary, a backflow effect was noticed in the model results, increasing the maximum flood depth for a distance of 56m. This is expected to be resolved through the coordinated development of Muri Road and Mt Welcome catchments as the development progresses.

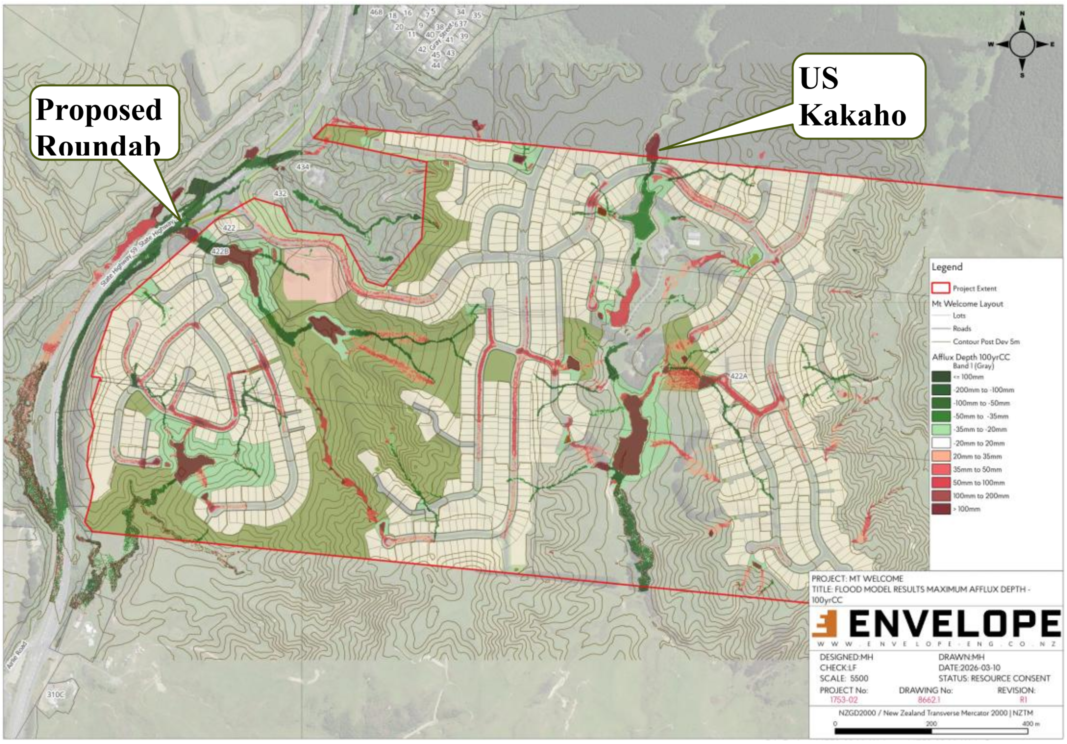


Figure 25. Flood depth comparison, 100-year ARI event.

6.4 VELOCITY DIFFERENCE

A comparison of the peak velocities was undertaken for the 100-year event (Figure 26). This shows the following findings:

- Model results indicate a reduction in flood velocities along the eastern side of SH59 due to upstream detention provided by the proposed retention wetlands. Maximum velocity reductions range between 0.5m/s and 1.6m/s.

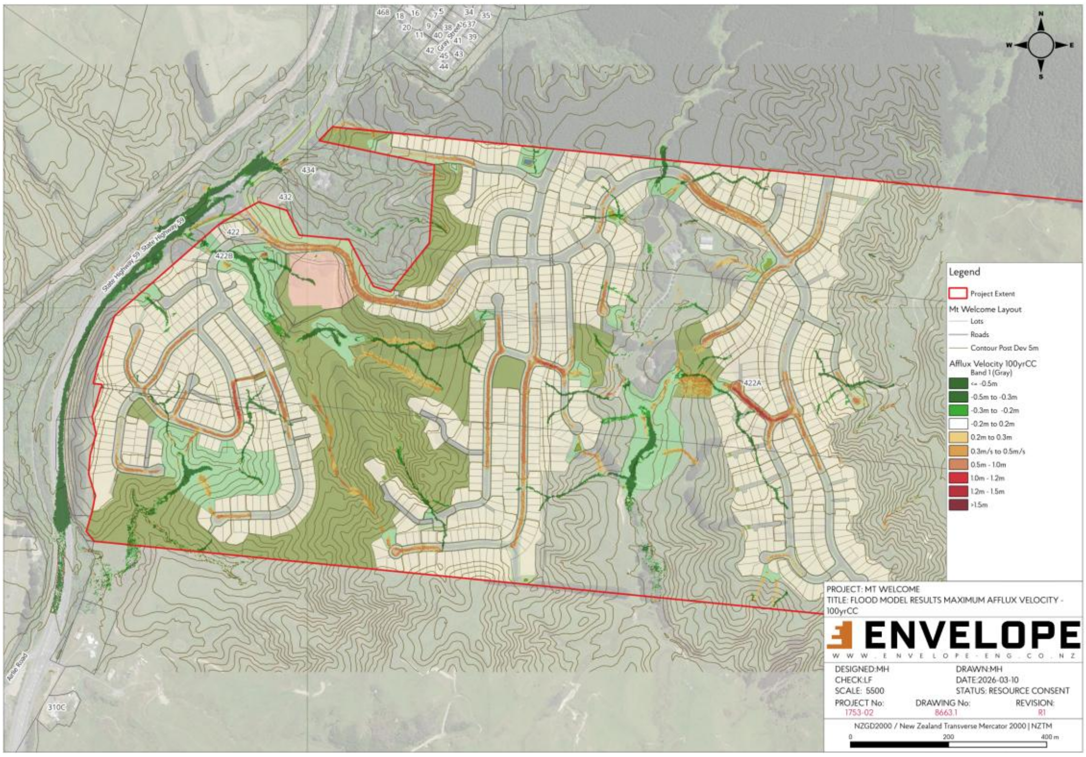


Figure 26. Flood velocity comparison, 100-year ARI event.

6.5 FLOOD HAZARD

The flood hazard at the site was mapped according to the Combined Flood Hazard Curves within the Australian Runoff and Rainfall Guidelines, which consider depth and velocity to assess flood hazard risks. These curves are shown in Figure 27, with the mapped flood hazard shown in Figure 28 and Appendix 2.

The results indicate that the majority of the site is classified as H1, which represents low flood hazard and is generally considered safe for people, vehicles, and buildings. Localised areas of higher flood hazard are identified within drainage channels and designated flood mitigation areas.

Figure 29 shows the comparison of the hazard classification between the existing and post-development scenarios. The results indicate that flood hazard is reduced along SH59 under the post-development scenario.

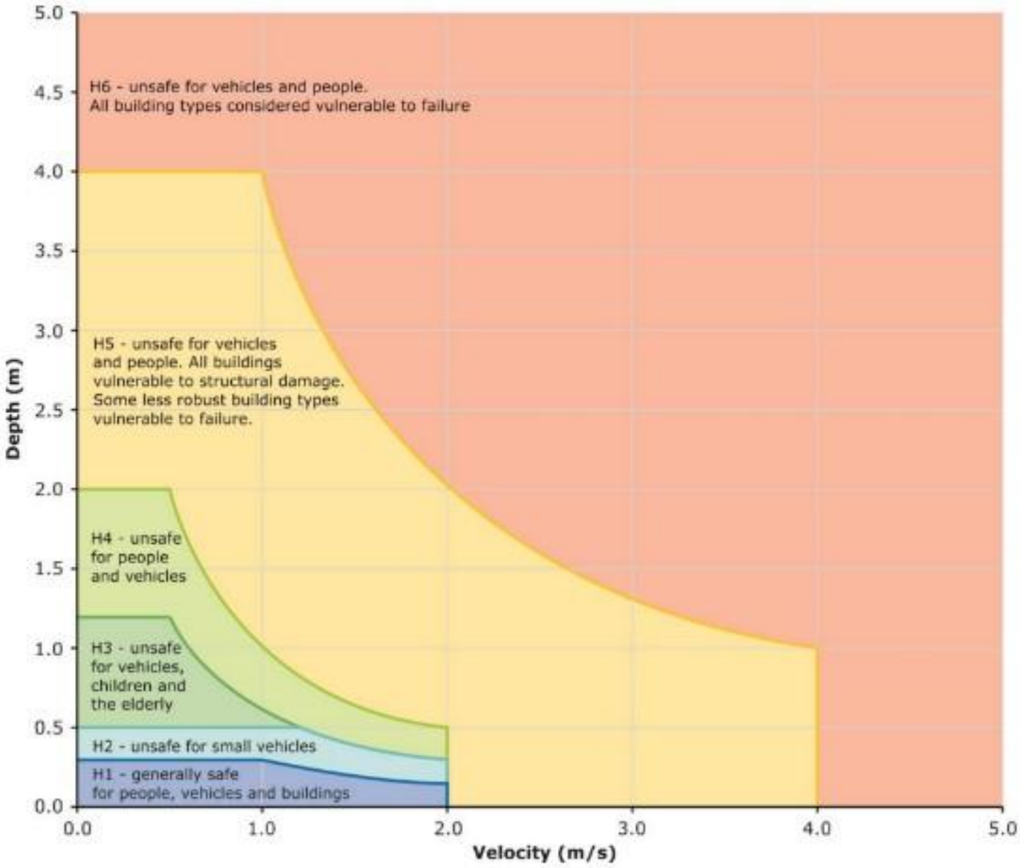


Figure 27. Combined Flood Hazard Curves.

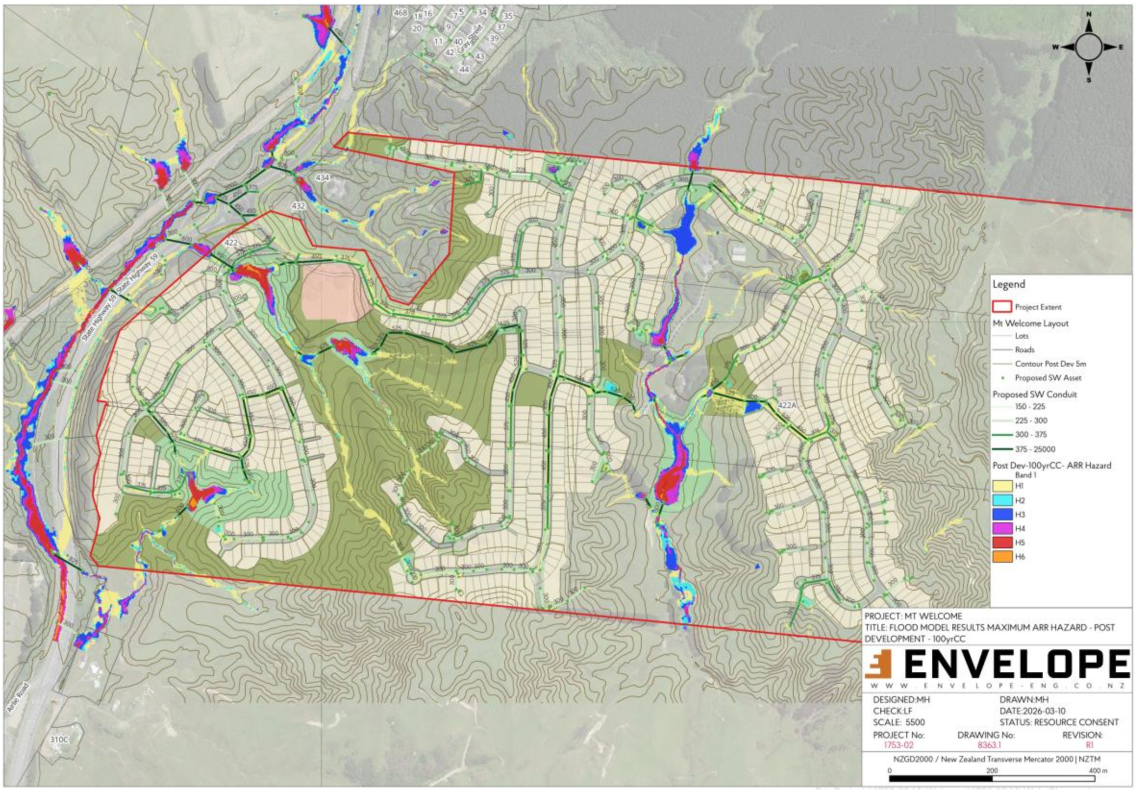


Figure 28. Flood hazard curve, post-development, 100-year event.

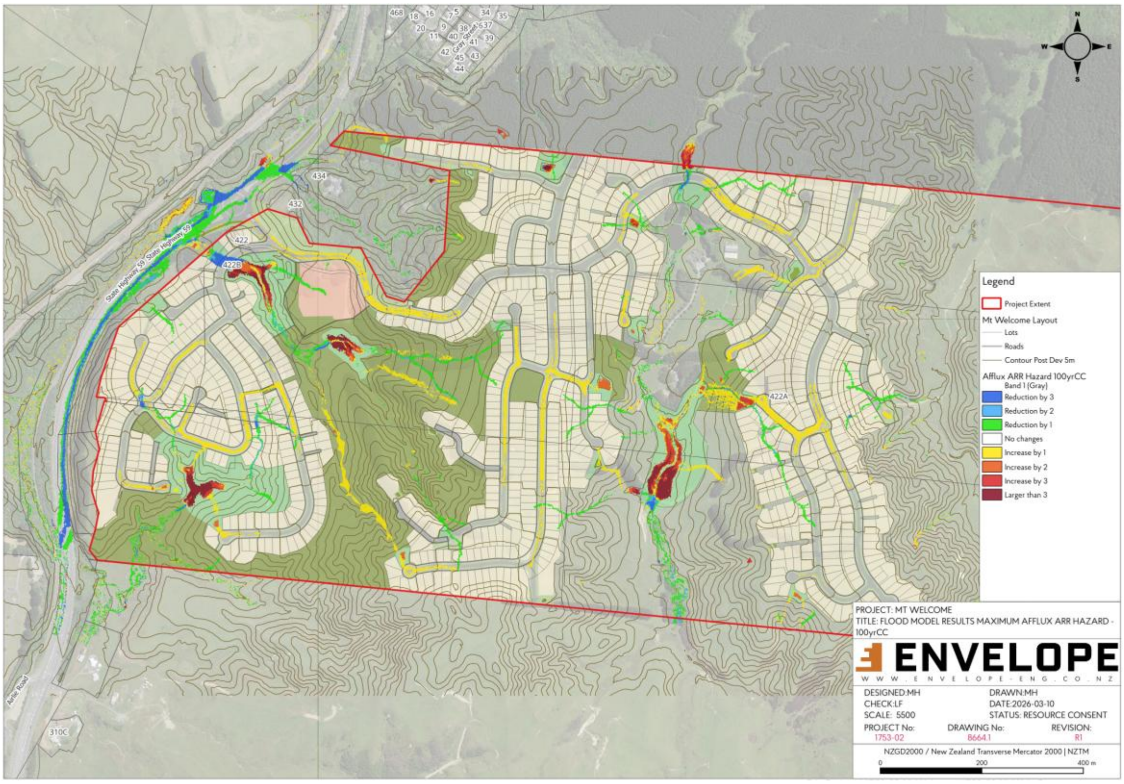


Figure 29. Flood ARR Hazard comparison, 100-year ARI event.

6.6 BLOCKED SCENARIO

A sensitivity test was undertaken to assess the effects of the blockage of key culverts adjacent to and connecting into the site. This assessment assists in informing appropriate freeboard allowances and the establishment of minimum floor levels.

The following blockages of inlets and culverts adjacent to the site were considered:

- Less than 600 mm diameter – 100% blockage.
- 600 mm to 1000 mm diameter – 50% blockage.
- More than 1000 mm diameter – 10% blockage.

Pipes and catchpits within the site were not considered in the blockage scenario as there are suitable overland flow paths available.

The blockage scenario results are shown in Figure 20 and Appendix 1. The area circled in red indicates localised increases in flood depth on some proposed lots under the blockage scenario. These areas should be considered in greater detail during future design stages.

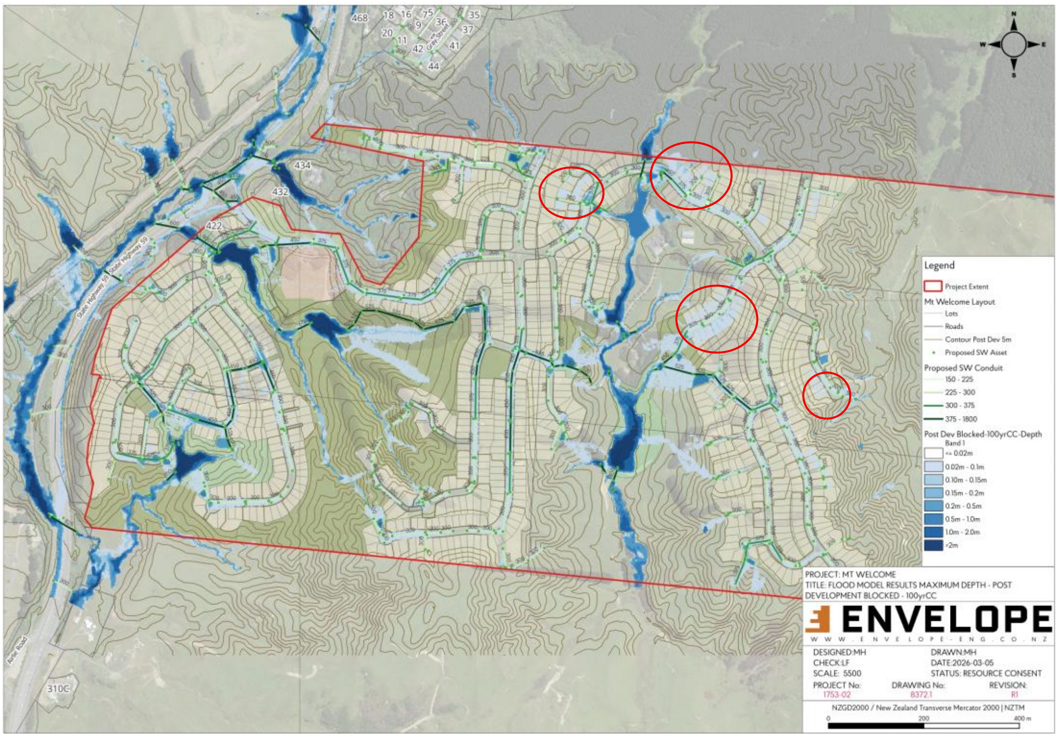


Figure 30. Post-development flood hazard blockage scenario, 100-year ARI event.

7.0 ASSESSMENT OF EFFECTS

The assessment of flood effects has considered the change in flood depth, velocity, and overall flood hazard between the pre-development and post-development scenarios, including a sensitivity test for blockage of key culverts. The assessment is based on the 100-year ARI storm event with climate change applied.

7.1 FLOOD DEPTH

A comparison of the pre-development and post-development scenarios indicates that flood depths are generally reduced downstream of the site due to the attenuation provided by the proposed retention wetlands.

Within the developed parts of the site, flooding is largely contained within the proposed road network and designated stormwater management areas. Surface ponding depths on roads are generally shallow, typically ranging between 0.05 m and 0.20 m, and no flood hazard is predicted within the proposed residential lots under the standard design event.

Localised increases in flood depth are predicted in limited areas. These are primarily associated with:

- Temporary storage of overland flow on the western side of SH59 near the proposed roundabout, where peak flood depths increase locally but remain contained within the intended flow path and do not inundate SH59 or any existing buildings
- A localised backwater effect upstream of the northern boundary associated with the proposed 900 mm diameter culvert, which increases flood depths over a short reach but does not adversely affect existing buildings or roads.

These localised increases are considered acceptable and are expected to be refined as the design is developed.

Flood Velocity

The modelling indicates that the proposed development generally reduces flood velocities downstream of the site, particularly along the eastern side of SH59. This reflects the benefit of upstream detention and controlled discharge from the proposed retention wetlands.

Maximum velocity reductions of approximately 0.5m/s to 1.6m/s are predicted in the main downstream flow paths. This represents a positive effect, as lower velocities reduce erosion potential and improve the manageability of overland flow.

No significant adverse increases in flood velocity are predicted within areas of proposed residential development. Higher velocities remain confined to drainage corridors, culvert inlets and outlets, and other areas specifically designed to convey runoff.

7.2 FLOOD HAZARDS

Flood hazard has been assessed using the combined depth and velocity hazard methodology from the Australian Rainfall and Runoff Guidelines. The results show that the majority of the site is classified as low hazard under the post-development scenario, with higher hazard areas confined to stream corridors, drainage paths, and stormwater management devices.

Compared with the existing scenario, the post-development layout reduces hazard in a number of locations, particularly along SH59, where overtopping is reduced from three locations in the pre-development scenario to one minor localised location in the post-development scenario. The remaining overtopping is shallow and significantly less severe than under the existing condition.

The proposed development therefore improves the management of flood hazard across the site by formalising overland flow paths, and directing runoff to the retention wetlands

7.3 BLOCKAGE SCENARIO EFFECTS

A blockage sensitivity test was undertaken for key culverts adjacent to and connecting into the site to assess the resilience of the proposed development under adverse operating conditions. The results indicate that the site generally maintains appropriate overland flow conveyance under blockage conditions, with exceedance flows directed through road corridors and into stormwater management areas.

Some localised increases in flood depth are predicted on a small number of proposed lots under the blockage scenario. These areas should be considered further during detailed design to confirm finished floor levels, freeboard, and any additional localised mitigation measures required.

Notwithstanding these localised effects, the blockage assessment confirms that the proposed development has been designed with suitable secondary flow paths and that flood risk can be appropriately managed through the detailed design phase.

7.4 SUMMARY OF EFFECTS

Overall, the proposed development results in a neutral to positive flood effect. While some localised increases in flood depth are predicted, these are contained and do not affect existing buildings or roads. The proposed development is therefore not expected to result in any material adverse flood effects on existing or proposed buildings, infrastructure, or surrounding properties.

8.0 CONCLUSIONS

A cut-off model has been developed to provide an updated tool for assessing flood risk within the Mt Welcome project extent. The model is based on the provided WWL model, which has been used as the primary source and updated as described below.

- The cut-off model includes the latest 2023 LiDAR. These elevations affect the bank levels and outlets levels; therefore, the interaction between the river reach (1D) and the surface mesh (2D). All these changes were considered in this assessment.
- The cut-off model provides a better tool to understand the existing and the proposed flood risk scenarios and provides comparable results to the WWL model. It is considered suitable to use for site-specific flood modelling purposes.
- The proposed mitigation measures are suitable to mitigate flood risk within the project extent. Specific matters noted from the modelling include:
    - Stormwater management devices have been incorporated near the proposed roundabout to reduce and avoid flood effects on SH59. The model indicates a localised increase in water level of approximately 0.5 m on the western side of SH59 and is contained within the existing stream. This increase does not result in inundation of any existing buildings or roads.
    - Upstream of the northern boundary, the proposed 900 mm diameter culvert generates a localised backwater effect, increasing flood depths. The current increase does not affect any existing buildings or roads. This will be refined through further coordination with Muri Road as shared infrastructure is developed in this localised area.
- Overland flow paths are conveyed within the proposed road corridors and directed to the retention wetlands. This design also accounts for potential network blockage and avoids flood risk to adjacent dwellings.

Overall, the modelling demonstrates that the proposed stormwater and roading designs are effective and that the proposed development does not result in a material increase in flood risk to existing or proposed buildings, infrastructure, or surrounding properties.

9.0 ADHERENCE TO THE EXPERT CONDUCT CODE.

While this is not a matter before the Environment Court, the author of this report has read the Code of Conduct for Expert Witnesses Contained in the Environment Court Practice Note 2023 ('Code'). The author has complied with the Code in the preparation of this report.

The data, information, facts and assumptions the author has considered as part of this report are set out in this report. The reasons for the conclusions of the report are also set out in this report. Unless stated otherwise, this report is within the author's expertise, and the author has not omitted to consider material facts known to him that might alter or detract from the opinions expressed.

10.0 LIMITATIONS

10.1 LIMITATIONS

In using or assessing the model, the following limitations should be noted.

- Any flooding depths +/- 20 mm have not been shown as these are considered by Envelope to be minor discrepancies outside the tolerances of the model.
- Envelope has reviewed the provided model within the immediate area of the development but has not undertaken a full review of the flood model.
- The cut-off model should be used just within project extent and is not intended to make any assessment outside of the immediate project extents.

10.2 GENERAL

This report has been prepared for the project described to us and its extent is limited to the scope of work agreed between the client and Envelope Engineering Limited. No responsibility is accepted by Envelope Engineering Limited or its directors, servants, agents, staff or employees for the accuracy of information provided by third parties and/or the use of any part of this report in any other context or for any other purposes.

APPENDICES

APPENDIX 1 PROVIDED MODEL BUILD REPORT

APPENDIX 2 CUT-OFF MODEL RESULTS

The flood model results are included as a separate attachment.