NZ TRANSPORT AGENCY
WAKA KOTAHI

TE ARA HAUĀURU NORTHWEST RAPID TRANSIT

ASSESSMENT OF STORMWATER AND FLOODING EFFECTS

PAUL MAY

15 DECEMBER 2025

New Zealand Government

Qualifications and experience of the author

My full name is Paul Clifford May. I am a Principal Civil Engineer – Stormwater at Jacobs. I hold a BE(Civil) from University of Canterbury (1995). I have 30 years' experience in stormwater and flood management. I am a Chartered Member of Engineering New Zealand, Chartered Professional Engineer (CPEng) and International Professional Engineer (IntPE).

My relevant experience includes:

- Eastern Busway – Stormwater Technical Lead and author of Producer Statement 1 (Design) and 4 (Construction) responsible for leading stormwater design, stormwater technical reports for resource consent applications and supporting construction phase services team.
- Let's Get Wellington Moving – Transformational Programme Detailed Business Case – Civil Lead responsible for leading the stormwater, fencing and combined services trench design.
- Northern Corridor Improvements (Peer Review) – Independent peer reviewer responsible for checking the design against the project minimum requirements and providing a Producer Statement 2.
- Waikato Expressway – Huntly Section – Deputy Discipline leader responsible for delivery of six design packages to programme and review construction quality assurance data and author the Producer Statement 4.
- Christchurch Northern Corridor – Deputy discipline lead for main works responsible for leading three culvert packages, preparation of the stormwater specification and providing construction phase services support. Discipline lead for the high occupation vehicle lane variation and responsible for the delivery of the stormwater design and Producer Statement 1.

Although this matter is not before the Environment Court, I confirm that I have read the Code of Conduct for expert witnesses as contained in Section 9 of the Environment Court Practice Note 2023. I agree to comply with that Code. My qualifications as an expert are set out above. I am satisfied that the matters which I address in this report are within my area of expertise, except where I state that I am relying on information provided by another person or expert. I have not omitted to consider material facts known to me that might alter or detract from the opinions I express.

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Acronyms, definitions and abbreviations

Term	Definition
AC	Auckland Council
AADT	Annual Average Daily Traffic
AEE	Assessment of Environmental Effects
AEP	Annual Exceedance Probability
AUP	Auckland Unitary Plan (Operative in Part)
CMA	Coastal Marine Area
Danger Rating	A flood risk rating determined by the assessment process outlined in Framework for Assessing Flood Risk at the Property-level (Auckland Council (August 2025)
FTAA	Fast-Track Approvals Act 2024
GIS	Geographic Information System
GPT	A gross pollutant trap design to remove 50% total suspended solids
Indicative Design	The indicative design of the Project within the Project Area as shown on the Indicative Design drawings in Part 6
LiDAR	Light Detection And Ranging
NZTA	New Zealand Transport Agency Waka Kotahi
Project	Te Ara Hauāuru Northwest Rapid Transit
Project Area	The Proposed Designation and the extent of the coastal occupation permits sought
Proposed Designation	The area defined by the Proposed Designation boundary as shown on the Proposed Designation Plans in Part 6
RAMM	Road Assessment and Maintenance Management
SMAF	Stormwater Management Area Flow
TA	Treatment Area
TPH	Total Petroleum Hydrocarbons
TSS	Total Suspended Solids
SH16	State Highway 16
Western Express	WX1

1. Introduction

1.1 Purpose and scope of this report

This technical assessment has been prepared to inform a substantive application for the Northwest Rapid Transit Project (the Project) under the Fast-Track Approvals Act 2024 (FTAA). It forms part of a suite of specialist reports that collectively support the applications for statutory approvals.

The purpose of this report is to evaluate the actual and potential effects of the Project on the environment in relation to stormwater and flooding. This report addresses the effects of the Project in relation to the following matters:

- Flooding and overland flow paths;
- Water quality; and
- Stream erosion.

The assessment considers the operational phase of the Project, identifying any adverse effects, and assessing their significance. I have recommended measures to avoid, remedy, or mitigate identified effects where I consider necessary.

This report should be read alongside the other parts of the Substantive Application including the Assessment of Environmental Effects (AEE) in Part 4, which contains further details on the context of the Project. The Substantive Application also contains a description of works to be authorised and the typical construction methodologies that will be used to implement this work in Part 2. I have reviewed the Substantive Application and have considered it as part of my assessment of effects. As such, parts of the Substantive Application are not repeated here.

2. Assessment methodology

2.1 General

The following sections outline the methodology I have used to assess the potential stormwater and flooding effects arising from the Indicative Design (the indicative design of the Project within the Project Area as shown on the Indicative Design drawings in Part 6), as well as potential amendments to the Indicative Design within the Project Area (the Proposed Designation and the extent of the coastal occupation permits sought).

My assessment considers the following potential effects:

- Water quality changes as a result of operational stormwater discharges.
- Stream channel erosion from operational stormwater discharges.
- Flood level changes as a result of the Project.

2.2 Water quality

The assessment of potential effects on water quality from stormwater discharges is based on the changes in predicted contaminant loads, expressed as a percentage, discharged to receiving environments prior to (i.e. the existing case) and following construction of the Project (i.e. once the busway and stations are operational).

To maintain flexibility for the Indicative Design and final design within the Project Area, the following approaches have been adopted:

- The change in contaminant loads with and without was predicted for receiving environments rather than specific discharge points or outfalls (i.e. the stormwater discharge locations are not fixed and will be confirmed in future design phases).
- An assessment of the effects was carried out by:

  - Assessing the potential effects of stormwater discharges from the Project based on the potential range of treatment devices the Project could implement in the final design within the Proposed Designation (the area defined by the Proposed Designation boundary as shown on the Proposed Designation Plans in Part 6).
  - Assessing a range of alternative stormwater discharge locations (i.e. a discharge could be to a different location to that shown on the Indicative Design and the different location could be within the same catchment or to another catchment).

2.2.1 Contaminant load model

The contaminant load model (Version 2) developed by the former Auckland Regional Council and documented in Technical Report No.2010/004 (ARC, 2010A) has been used for this stormwater assessment. Contaminant load changes have been modelled using the following data:

- 2016 Impervious surfaces from Auckland Council (AC) GeoMaps and modified in greenfield development areas based on 2024 and 2025 aerial photography.
- Annual Average Daily Traffic count data from:
  - Auckland Transport asset inventory database obtained from Auckland Transport's open Geographical Information System (GIS) which is a granular point data layer. This data layer was merged into Auckland Transport's Road Assessment and Maintenance Management (RAMM) data.
  - NZTA Open data, Mobile Road and Auckland Transport Traffic Count data (July 2012 to May 2025) have been used to verify the modified RAMM data set where data was considered unusual.
  - Note: Although Western Express (WX1) buses already operate on the motorway, I took a conservative approach of not deducting WX1 buses from motorway vehicle counts and instead treated all buses on the Indicative Design as new services.
- Default roof materials from Technical Report No.2010/004 (ARC, 2010A).
- Default treatment device removal rates from Technical Report No.2010/004 (ARC, 2010A), except for Gross Pollutant Traps (GPT).
- The GPT contaminant removal rate is set at 50% for total suspended solids (TSS) based on the adaptability of cascade separators and Vortex separators by Stormwater360 which can be designed to achieve 50% removal (i.e. oversized devices for stormwater catchment to achieve higher contaminant removal rates). Zinc (25%) and copper (31%) removal rates are prorated from removal rates for Catchpit Filters (20% for zinc and 25% for copper) based on the percentage increase TSS removal rates of a GPT.
- Ground slope data from ground surface elevation contours from Auckland Council GeoMaps.
- Any type of pervious surface was assumed to be urban grass lands and trees.
- Existing treatment devices within stormwater catchments were identified in Auckland Council GeoMaps and included in the contaminant load models.

2.2.2 Potential effects

I have assessed potential effects by considering changes to contaminant loads for each receiving environment catchment that may receive stormwater from the Project (i.e. the sub-catchments of nine receiving environments as described in Section 3.1). I assessed a range of potential discharge locations to allow for potential amendments to the Indicative Design within the Proposed Designation. I used the contaminant load model to assess:

- Three contaminants relevant to the discharge of stormwater from the Project with a fleet of electric buses (TSS, zinc, and copper).
- Changes in the contaminant loads discharged from the Project without treatment of stormwater, to understand the scale of the impact that the operation of the Project could have on the receiving environments.

- The impact on contaminant loads discharged from the Project of four potential treatment devices (wetlands (new or upgrades to existing), swales, GPT designed to removal 50% TSS and a GPT with a StormFilter™).

I have not assessed Total Petroleum Hydrocarbons (TPH) because:

- Electric buses will use the busway, and they do not have engine emissions and do not use engine oils for lubrication. Although they do use some lubricants (i.e. sealed or greased bearings) and fluids (i.e. liquid coolant fluid and brake fluids), these oils, lubricants and fluids contribute significantly less TPH than combustion-engine vehicles.
- The contaminant load model does not include TPH generation for impervious surfaces other than roads due to difficulty in calibrating catchments when applying yields to these to other impervious surfaces (i.e. driveways, car parks and commercial and industrial vehicle movement areas). Therefore, if I had assessed replacement of other impervious surface areas within the Proposed Designation boundary by a road (i.e. the busway), the contaminant load model would have produced large errors as stated in Technical Report No.2010/004 (ARC, 2010A).
- Although some existing local bus services may not be electric, they are already included in the existing case (i.e. prior to the Project) vehicle count data for local roads and the motorway. Therefore, TPH for local bus services are already accounted for in the existing case contaminant load model with no change after the Project is built and operational.

I assessed the Project's potential effects based on the following criteria:

- Decreases in contaminant loads because of the Project are assessed as a positive effect.
- Increases in contaminant loads because of the Project are assessed as:
  - Negligible if the increase is between 0% and 2%.
  - Low if the increase is between 2% and 5%.
  - Moderate if the increase is between 5% and 10%.
  - High if the increase is greater than 10%.

2.3 Stream channel erosion

I adopted the following approach to assessing the potential effects of stream channel erosion:

- Identifying indicative discharge locations within the Proposed Designation.
- Identifying where stream channel erosion should be assessed using the following screen tests:
  - If part of the Project is in a Stormwater Management Area, Flow Control - Flow 1 or Flow 2 overlay in the Auckland Unitary Plan (Operative in Part) (AUP) planning maps.
  - If the discharge of stormwater to a stream receiving environment is from an area of additional impervious road greater than 5,000m² (AUP Section E8.6.4.1 (3)).
- Assessing if the stream is erodible and only assessing stream channel erosion if it is.
- Assessing whether providing the following hydrology mitigation is reasonably practicable:
  - Flow 1: provide detention (temporary storage) and a drain down period of 24 hours for the difference between the pre-development and post-development runoff volumes from the 95th percentile, 24-hour rainfall event over the impervious area for which hydrology mitigation is required.
  - Flow 2: provide detention (temporary storage) and a drain down period of 24 hours for the difference between the pre-development and post-development runoff volumes from the 90th percentile, 24-hour rainfall event over the impervious area for which hydrology mitigation is required.
- Assessing the change in stream velocities and existing stream channel erosion condition for streams that may receive stormwater discharges from the Project using:
  - The stream 95^{th} and 90^{th} percentile flows for Flow 1 and Flow 2 overlay areas respectively based on GeoMaps (interpolated flows from 50% AEP event using rainfall for 50% AEP event and rain depths for 95^{th} and 90^{th} percentile events).

- The range of stormwater discharge rates possible from the Project for the 95th or 90th percentile event.
- Stream velocities with and without the Project stormwater discharges following the methodology in Appendix A.
- The percentage increase in the stream velocities during 95th and 90th percentile rainfall events with Project discharges.

- Assessing effects for a range of indicative discharge locations within the Proposed Designation based on the following criteria:
  - If the stream velocities are reduced because of the Project, the potential effects on stream channel erosion are positive.
  - If the screen test identifies stream channel erosion should not be assessed, then the potential effects are negligible.
  - If the screen test identifies stream channel erosion should be assessed for the indicative discharge locations, and based on the increase in stream flow velocities the potential effects of the Project are assessed to be:
    - less than or equal to 2%, potential effects are negligible.
    - greater than 2% and less than 5%, potential effects are low.
    - greater than 5% and 10%, potential effects are moderate.
    - greater than 10%, potential effects are high.
  - The potential effects of the Project are expected to be negligible if Flow 1 or Flow 2 hydrology mitigation is practicable and proposed.

2.4 Flooding and overland flow paths

2.4.1 Flooding and overland flow path management

I assessed potential effects of the Project crossing streams and flood plains by comparing changes to existing flooding extents and depths, and flood Danger Ratings (a flood risk rating determined by the assessment process outlined in AC's Framework for Assessing Flood Risk at Property-Level[1]). Flood extents and depths have been assessed using flood models derived from existing AC catchment flood models.

2.4.2 Flooding catchments

Utilising the existing AC flooding information on GeoMaps, the Proposed Designation is within five catchments with existing flood plains for the 1% Annual Exceedance Probability (AEP):

- Whenuapai.
- Massey.
- Henderson.
- Meola.
- Motions.

Three hydrological catchments either have no interactions or small interactions with the Proposed Designation (Point Chevalier, Lincoln and Te Atatū South) and therefore no flood modelling was carried out for these three catchments.

[1] Framework for Assessing Flood Risk at the Property level 6 June 2025, Version 3.0

2.4.3 Flood modelling

Flood modelling has been carried out in accordance with TP108 Guidelines for stormwater runoff modelling in the Auckland Region (April 1999) and the AC Stormwater Modelling Specification (December 2023). Following the Auckland Anniversary weekend floods in 2023, AC updated its rainfall statistics used in the TP108 guidelines.

Existing 1% AEP event flooding across the five catchments has been assessed for a climate change scenario with a 3.8-degree Celsius increase in temperature, in accordance with the Auckland Code of Practice for Land Development and Subdivision – Chapter 4 Stormwater.

I have presented flood model results based on the following approach:

- Modelled flood depth decreases of 10mm or more are considered to represent actual decreases in flood depth and are highlighted on the flood depth difference figures in Section 5.3.6. Decreases and increases of less than or equal to 10mm have a high degree of uncertainty and are not considered to represent actual changes in flood depth. These very small changes have not been highlighted on the flood depth difference figures included in Section 5.3 and are excluded from my effects assessment.
- Modelled flood depth increases greater than 10mm and less than or equal to 50mm have a moderate degree of uncertainty and may or may not represent a change in flood depth. These locations are generally considered to have actual, small increases in depth when considering the accuracy of ground surface survey models and stormwater asset data. These areas are identified on the flood depth difference figures included in Section 5.3.
- Modelled flood depth increases greater than 50mm and less than or equal to 100mm have a moderate to low degree of uncertainty and are likely to represent a change in flood depth. These locations are generally considered to have actual, small to moderate increases in depth and are identified on the flood depth difference figures included in Section 5.3.
- Modelled flood depth increases of greater than 100mm have a low degree of uncertainty and represent actual changes in flood depths. These actual increases are generally considered to be large increases and are identified on the flood depth difference figures included in Section 5.3.

2.4.4 Criteria for assessment of flooding effects

I assessed flooding effects by:

- Determining locations where a change in flood depth (i.e. decreases and increases greater than 10mm) is predicted outside of the Proposed Designation as a result of the Project.
- Determining the existing flood Danger Rating where there is a predicted increase in flood depth.
- Determining if the existing flood Danger Rating changes as a result of the Project.
- Applying the criteria set out below to identify whether any change in flood Danger Rating and/or flood depth is a positive or adverse (negligible to high) effect.

The approach I used, considered Chapter E36 (Natural hazards and flooding) of the AUP and Plan Change 120. In particular, I have:

- Used best information available (i.e. updated existing TP108 rainfall).
- Carried out a risk assessment of flood hazards.
- The Project will not increase flood hazard categories.

To minimise the risk of damage to buildings and property, the Project aims to ensure that no new floor level inundation occurs, increases in flood depths on affected properties are within thresholds, and any additional inundation for buildings already experiencing floor level flooding remains within thresholds considered to have minor impacts.

Those outcomes are achieved by preventing any increase in Danger Ratings and limiting flood depth increases according to defined ranges for each Danger Rating category. Accurate floor level data is essential for assessing Danger Ratings. However, surveying all buildings within the Project Area is not feasible and therefore I adopted a desktop-based method. In this approach, floor levels are estimated by adding a standard minimum floor level height of 150mm to the adjacent ground level. I derived the estimated floor levels using available data sources such as LiDAR terrain models, aerial imagery, GIS datasets, and building footprint information from the following sources:

- Acceptable Solutions and Verification Methods for the New Zealand Building Code Clause E1 Surface Water which sets the minimum acceptable floor level at 150mm above the ground level adjacent the building.
- Google Street View to estimate floor level or AC held floor level information.
- LiDAR ground level models to identify the highest ground level adjacent to assessed buildings.

I determined the existing Danger Rating for locations where the flood depths outside of the Proposed Designation are modelled to increase (by greater than 10mm) by:

- Assessing the hazard rating to people along the evacuation route (e.g. a driveway or footpath) outside a residential or commercial building for the existing situation by:
  - Producing depth and velocity data from flood models for the 1% AEP event (including climate change).
  - Producing hazard maps (i.e. not property specific with each property potentially having multiple ratings) using GIS to assess depth, velocity and the product of depth and velocity for the 1% AEP event (including climate change) in accordance with the hazard ratings for people outside in Figure 2-2.
  - Assess the evacuation route for each property.
  - Apply hazard ratings for people outside to each property boundary.
- Assessing the hazard rating for people inside a building using the estimated floor level and criteria from Figure 2-1.

I then assessed the potential effects of the Project on people and property outside of the Proposed Designation using the criteria in Table 2-1.

Danger Rating Matrix

Hazard				Hazard to People Outside				
The Danger Rating is determined based on the combination of the assessed Hazard Inside and Hazard Outside in accordance with this matrix.				Assess flood hazard along most likely evacuation route using the Flood Hazard Ratings Chart.				
	Conditions			An evacuation route is available and does not require wading	An evacuation route may be available but requires wading. Hazard is a function of depth and velocity of flooding along the evacuation route. (Refer to Flood Hazard Ratings Chart)			
		Hazard Rating		Very Low	Low hazard for all	Low hazard for adults	Moderate hazard	High hazard for all
			D & V Thresholds	n/a	(Refer to Flood Hazard Ratings Chart)	(Refer to Flood Hazard Ratings Chart)	(Refer to Flood Hazard Ratings Chart)	(Refer to Flood Hazard Ratings Chart)
Hazard to People Inside — Assess flood hazard inside the building based on depth over building flood level (assuming V = 0 m/s inside the building). Building floor levels are to be based on existing available information or desk top assessment methods.	Habitable floor remains dry	Very Low	Floodwaters are NOT touching the building footprint. Nil depth over habitable floor.					
			Floodwaters are touching the building footprint. Nil depth over habitable floor.					
	Habitable floor is wet.	Low hazard for all	Depth (D) over habitable floor: 0 ≤ D < 0.5m					
		Low hazard for able-bodied adults /	Depth (D) over habitable floor: 0.5 ≤ D < 0.85m					
		Moderate hazard	Depth (D) over habitable floor: 0.85 ≤ D < 1.2m					
		High hazard for all	Depth (D) over habitable floor: D ≥ 1.2m					

Intolerable Risk Threshold @ 1% AEP

DANGER RATING KEY: HIGH DANGER; MODERATE DANGER; LOW DANGER

Figure 2-1: Flood Danger Rating (adapted from the Framework for Assessing Flood Risk at the Property-level Version 3 (AC, June 2025))

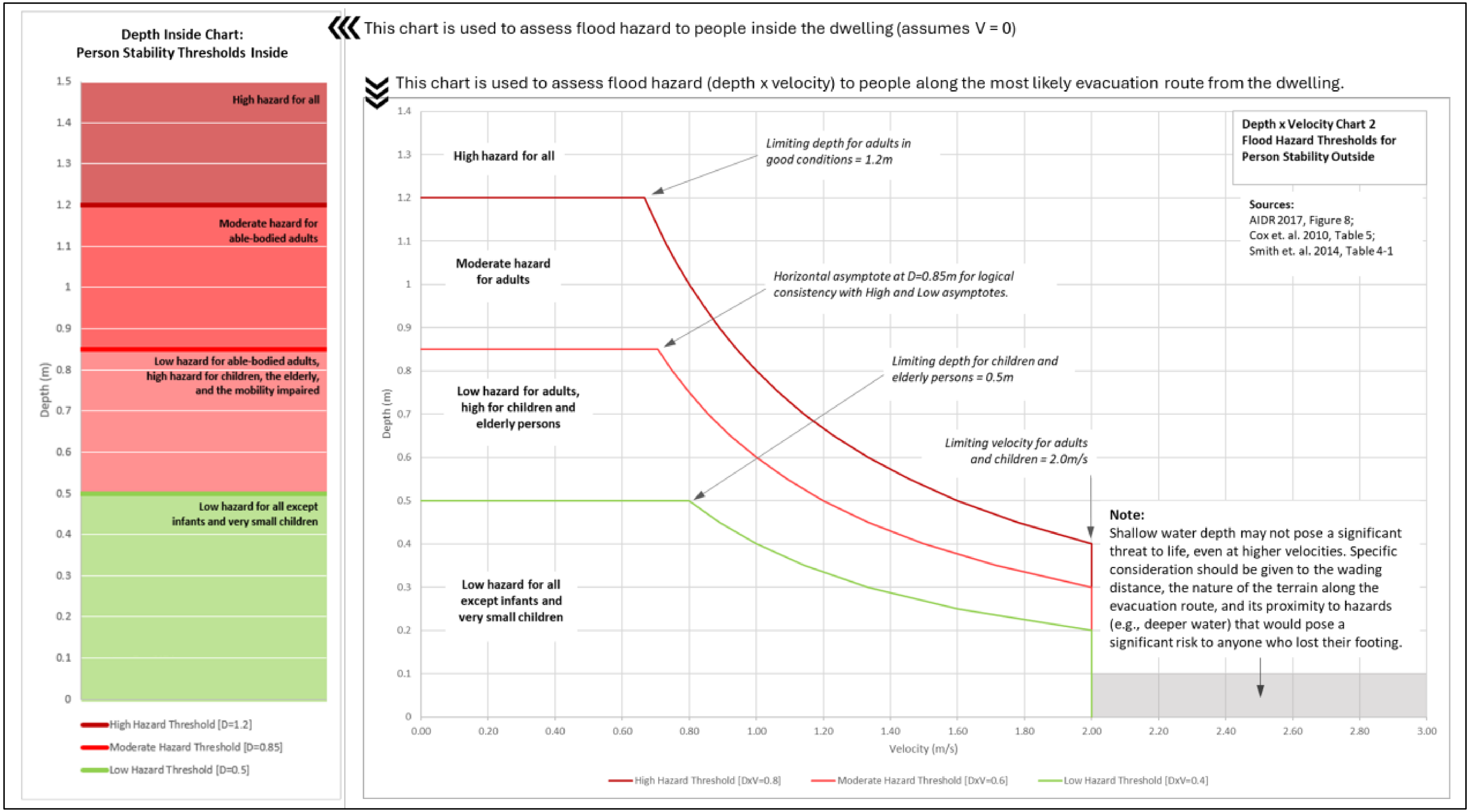


Figure 2-2: Hazard to people outside - depth velocity chart 2

Table 2-1: Flood effect categories

<table>
<tr><th>Existing Danger Rating</th><th>Positive Effect</th><th>No Effect</th><th>Negligible Effect</th><th>Low Effect</th><th>Moderate Effect</th><th>High Effect</th></tr>
<tr><td>Low</td><td rowspan="3">Flood Depth Decrease is > 10mm</td><td rowspan="3">Flood Depth Decrease or Increase is ≤ 10mm</td><td rowspan="2">Flood extent is not touching a building footprint, and the flood depth increase is >10mm and ≤ 50mm</td><td>Existing flood extent touches the building footprint, and the existing Danger Rating is not changed:
▪ For floor levels 150mm above ground level, the flood depth increase is ≤ 50mm.
▪ For floor levels greater than 150mm above ground level, the flood depth increase is ≤ 100mm.
For properties with no buildings the flood depth increase is ≤ 100mm.</td><td>Existing flood extent touches the building footprint, and the Danger Rating is not changed:
▪ For floor levels 150mm above ground level, the flood depth increase is > 50mm and ≤100mm.
▪ For floor levels greater than 150mm above ground level, the increase in flood depth is > 100mm and ≤ 150mm.
For properties with no buildings the flood depth increase is > 100mm and ≤ 150mm.</td><td rowspan="3">High for all other cases</td></tr>
<tr><td>Moderate</td><td>Existing flood extent touches the building footprint, and the Danger Rating is not changed:
▪ For floor levels 150mm above ground level, the floor level is not inundated in the existing case and the flood depth increase is ≤ 50mm.
▪ For floor levels greater than 150mm above ground level, the floor level is not inundated in the existing case the flood depth increase is ≤ 100mm.
▪ For floor levels inundated in the existing case, the flood depth increase is ≤ 100mm.
For properties with no buildings the flood depth increase is ≤ 100mm.</td><td>Where existing flood extent touches the building footprint and the Danger Rating does not change because of the Project:
▪ For floor levels 150mm above ground level, the floor level is not inundated in the existing case and the increase in flood depth is > 50mm and ≤ 100mm.
▪ For floor levels greater than 150mm above ground level, the floor level is not inundated in the existing case the increase in flood depth is > 100mm and ≤ 150mm.
▪ For floor levels inundated in the existing case, the increase in flood depth is > 100mm and ≤ 150mm.
For properties with no buildings the flood depth increase is > 100mm and ≤ 150mm.</td></tr>
<tr><td>High</td><td>The increase in flood depth is ≤ 50mm.</td><td>The increase in flood depth is >50mm and ≤100mm.</td><td>The increase in flood depth is >100mm and ≤150mm.</td></tr>
</table>

3. Receiving environment

3.1 Water quality

There are nine sub-catchments of receiving environments with potential discharge locations from the Project, shown in Figure 3-1 and Figure 3-2. These sub-catchments represent the geographical extent that discharges stormwater to nine receiving environments. The Project may connect to these networks and contribute additional stormwater. Table 3-2 in Section 2.3, provides a description of the existing outfall environment for each catchment.

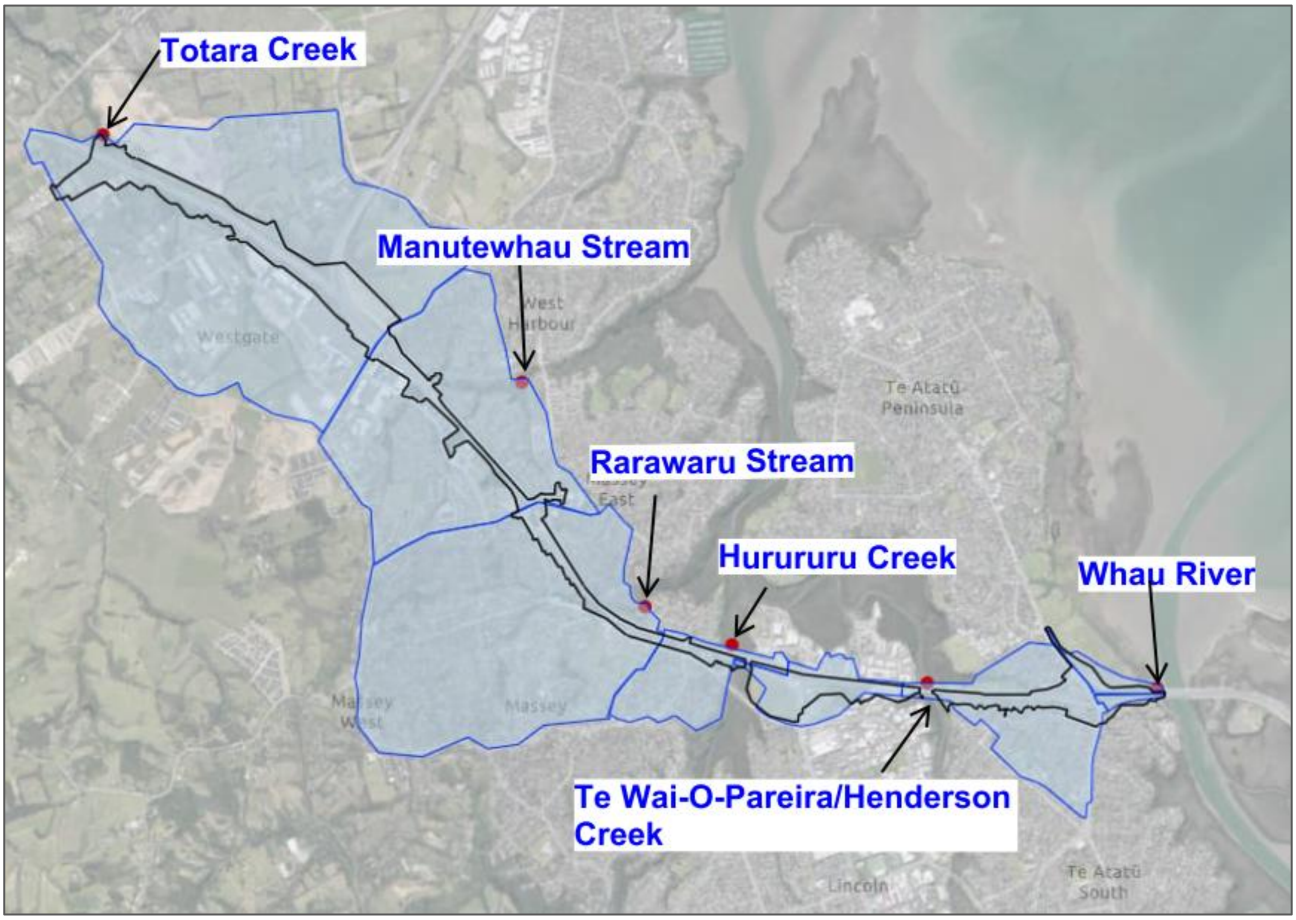


Figure 3-1: Western receiving environments and their sub-catchment

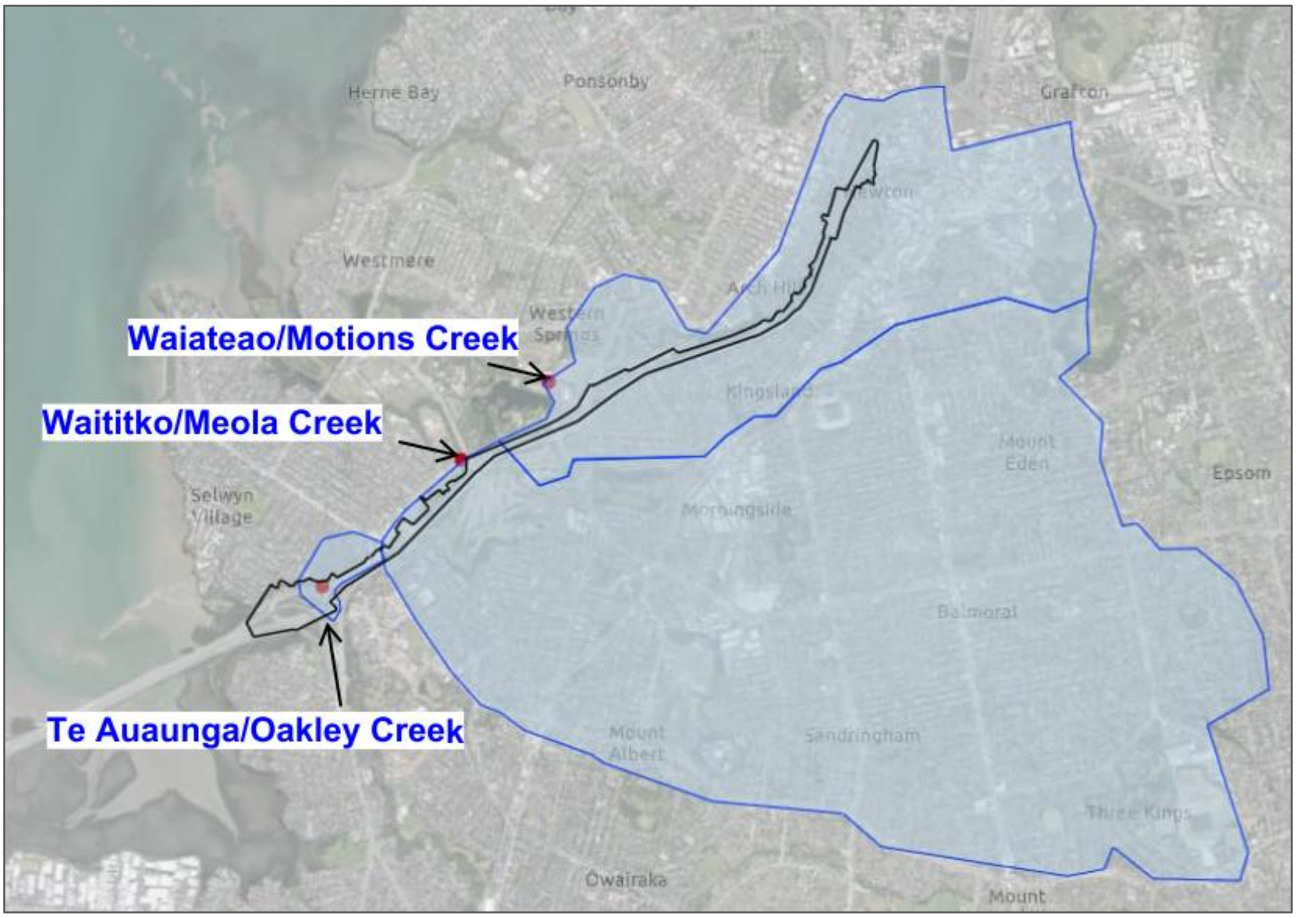


Figure 3-2: Eastern receiving environments and their sub-catchments

Table 3-1: Description of existing stormwater treatment

Outfall / Discharge Location	Description of identified existing stormwater treatment in catchment	Adopted Stormwater Management Plans
Tōtara Creek	Motorway is treated by swales and wetlands. Commercial areas south of Northside Drive are treated in accordance with the Tōtara Creek Stormwater Management Plan (wetlands and raingardens).	Tōtara Creek
Mānutewhau Stream	Motorway is treated by wetlands. Residential and commercial catchments are treated by wetlands and raingardens.	34-36 Westgate Drive
Rarawaru Stream	Motorway is treated by wetlands. Each residential pipe network is treated at the downstream end by either a StormFilter™, debris screen or Up-Flo® Filter.	N/A
Huruhuru Creek	Motorway is treated by wetlands. A debris screen, sandfilter and Up-Flo® Filter is treating small residential catchments.	N/A
Te Wai-o-Pareira / Henderson Creek	The motorway and part of the industrial area is either treated by a StormFilter™ device or various swales and wetlands. No treatment identified for industrial area north of the motorway alignment. No residential treatment.	N/A
Whau River	Motorway lanes and on-ramp is treated by a swale.	N/A
	Motorway offramp is treated by a swale and general traffic lanes by a StormFilter™.	N/A
Te Auaunga / Oakley Creek	No motorway or residential treatment.	N/A

Outfall / Discharge Location	Description of identified existing stormwater treatment in catchment	Adopted Stormwater Management Plans
Waititiko / Meola Creek	No motorway or residential treatment. One debris screen noted at Malvern Road/Fowlds Park	N/A
Waiateao / Motions Creek	No motorway or residential treatment. Multiple soakage devices in residential zones south of the motorway alignment and two debris screens and sediment traps north of the Motorway alignment at Ivanhoe Reserve and at Caltex Western Springs.	N/A

3.2 Stream channel erosion

Part of the Project within the Henderson Catchment is located within Stormwater Management Area Flow Control - Flow 2 as shown in the AUP planning maps and in Figure 3-3.

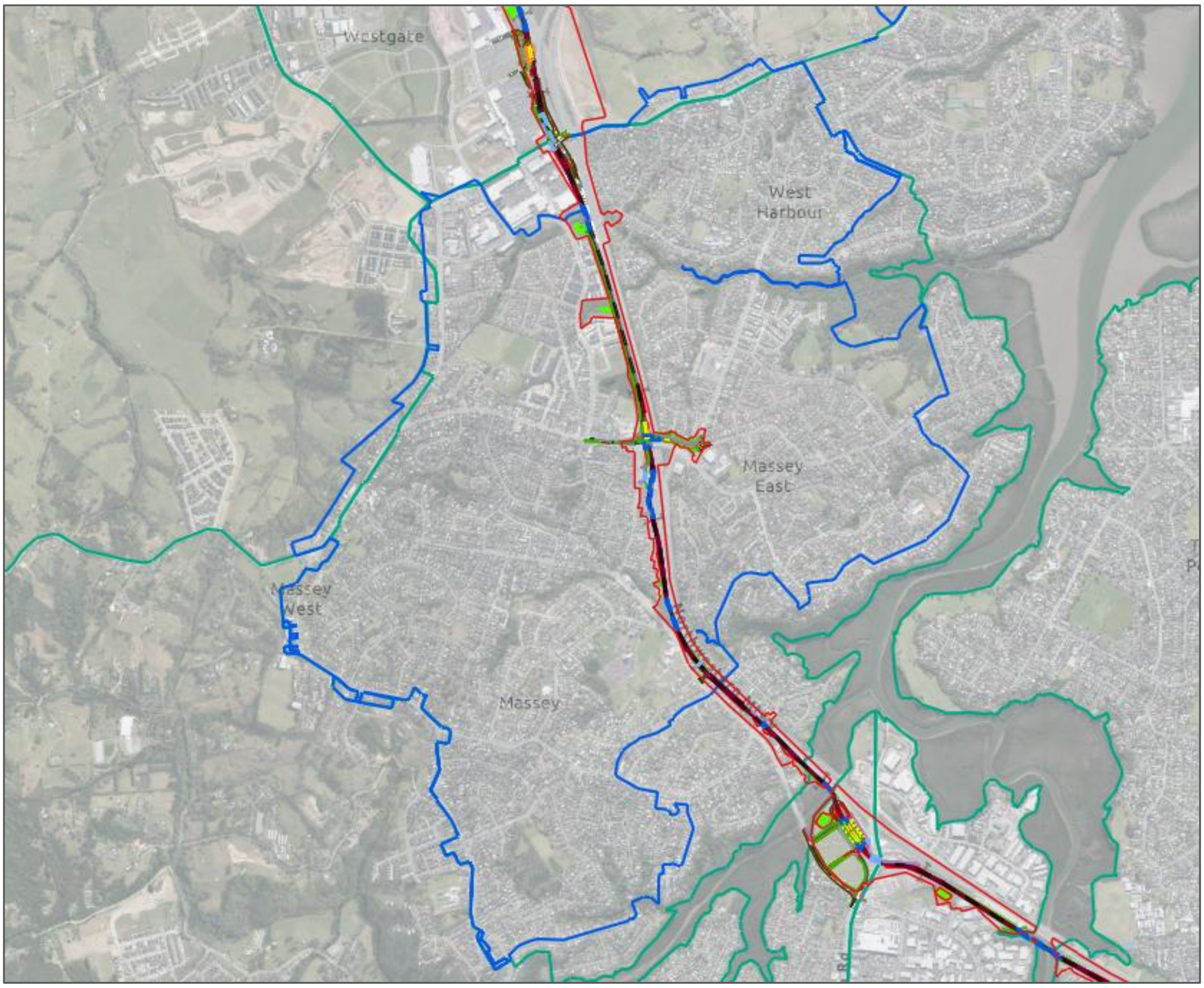


Figure 3-3: Stormwater Management Area Flow Control – Flow 2 (blue outline)

During ecological surveys, some locations where existing stream channel erosion is evident were identified and these have been summarised in Table 3-2.

Table 3-2: Existing stream channel erosion

Treatment Area (Device and Discharge Location)	Outfall Location	Stream Bed Strata Type	Erosion Potential Notes
TA 1	Tōtara Creek	Assumed soft bottom, mainly silt.	Northern side of road not surveyed. Southern side of road shows well vegetated culvert with low erosion potential.
TA 2-4	Tōtara Creek	Soft bottom, mainly silt.	No significant erosion noted based on ecological assessment completed upstream near TA2, TA3 and TA4.
TA 5	Tōtara Creek	Downstream is all silty.	Extensive rip rap present, and concrete near the culverts. No significant erosion.
TA 6	Mānutewhau Stream	Mostly Silt and sand, small medium gravel, and some small and large cobbles.	Eastern outfalls were not surveyed. Western side observations: No significant erosion noted.
TA 7	Mānutewhau Stream	Mostly silt and clay, gravel. Some sections had boulders and bedrock, especially near the downstream culvert.	Eastern outfalls were not surveyed. Western side observations were that no significant erosion noted, riprap is present at outfall.
TA 8	AC Stormwater Network	Silt, sand, small medium gravel, large gravel, boulders.	Area where it connects to council network was not surveyed. The western side of the road was surveyed; a bit of erosion noted in this stream. Some large rocks present at outfall.
TA 9	Rarawaru Stream	Mostly silt/sand and bedrock.	Eastern location not surveyed. Western side of road, where bridge is proposed was surveyed; bit of erosion upstream, undercut banks.

3.3 Flooding and overland flow paths

As shown in Figure 3-4, the Project is located within eight hydrological catchments (shown in black text) and interacts with nine waterways (shown in blue text).

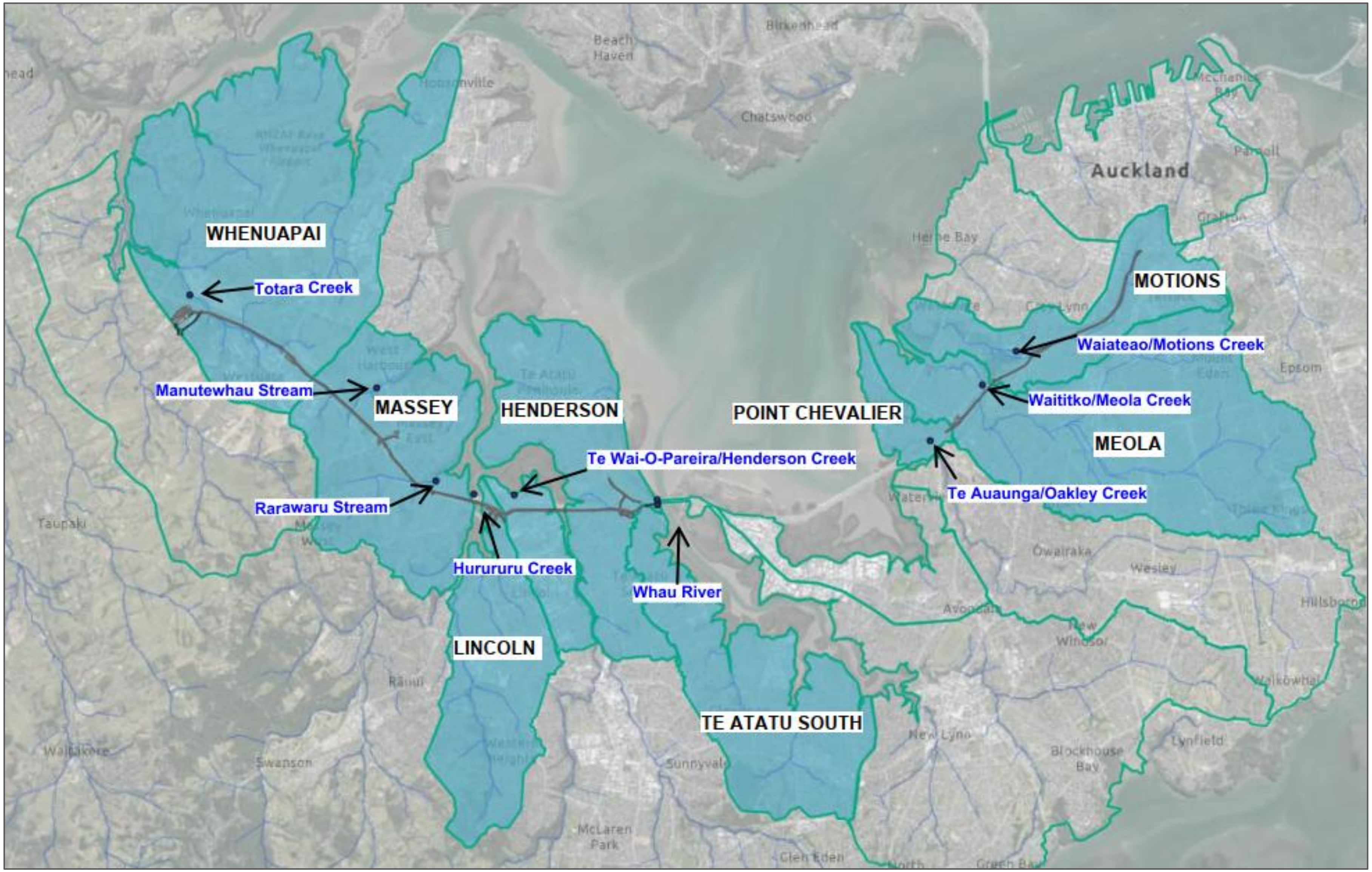


Figure 3-4: Hydrological catchments and waterways

The existing 1% AEP event flood depths for the five catchments I assessed by flood models are shown in Figure 3-5 to Figure 3-9. Areas that have existing flood risks adjacent to the Proposed Designation are:

- Whenuapai Catchment:
  - Areas adjacent to Tōtara Creek: 0.01 - 5 m.
- Massey Catchment:
  - Triangle Road: 0.01 – 5 m.
  - Keegan Drive: 0.01 – 0.75 m.
- Henderson Catchment:
  - West of Milich Terrace: 0.01 - 0.5 m.
  - McCormick Road: 0.01 - 0.5 m.
  - South of motorway towards Central Park Drive: 0.01 – 0.25 m.
- Meola Catchment:
  - Nova Place - 0.01 – 5 m
  - South of Great North Road 0.01 – 5 m
- Motions Catchment:
  - Tuarangi Road: 0.01 – 1.5 m.
  - Ivanhoe Road: 0.01 – 1.5 m.
  - Cooper Street: 0.01 – 0.25 m.
  - Suffolk Street: 0.01 - 2.5 m.
  - Niger Street: 0.01 – 0.5 m.
  - Arch Hill Scenic Reserve: 0.01 – 0.25 m.

The existing 1% AEP flood plain extents from AC GeoMaps for Lincoln, Te Atatū South and Point Chevalier catchments, are shown in to Figure 3-10 to Figure 3-12.

The existing flood hazard ratings (refer to Figure 2-2 for the rating criteria) for the five catchments with moderate to high flood risks are provided in Figure 3-13 to Figure 3-17.

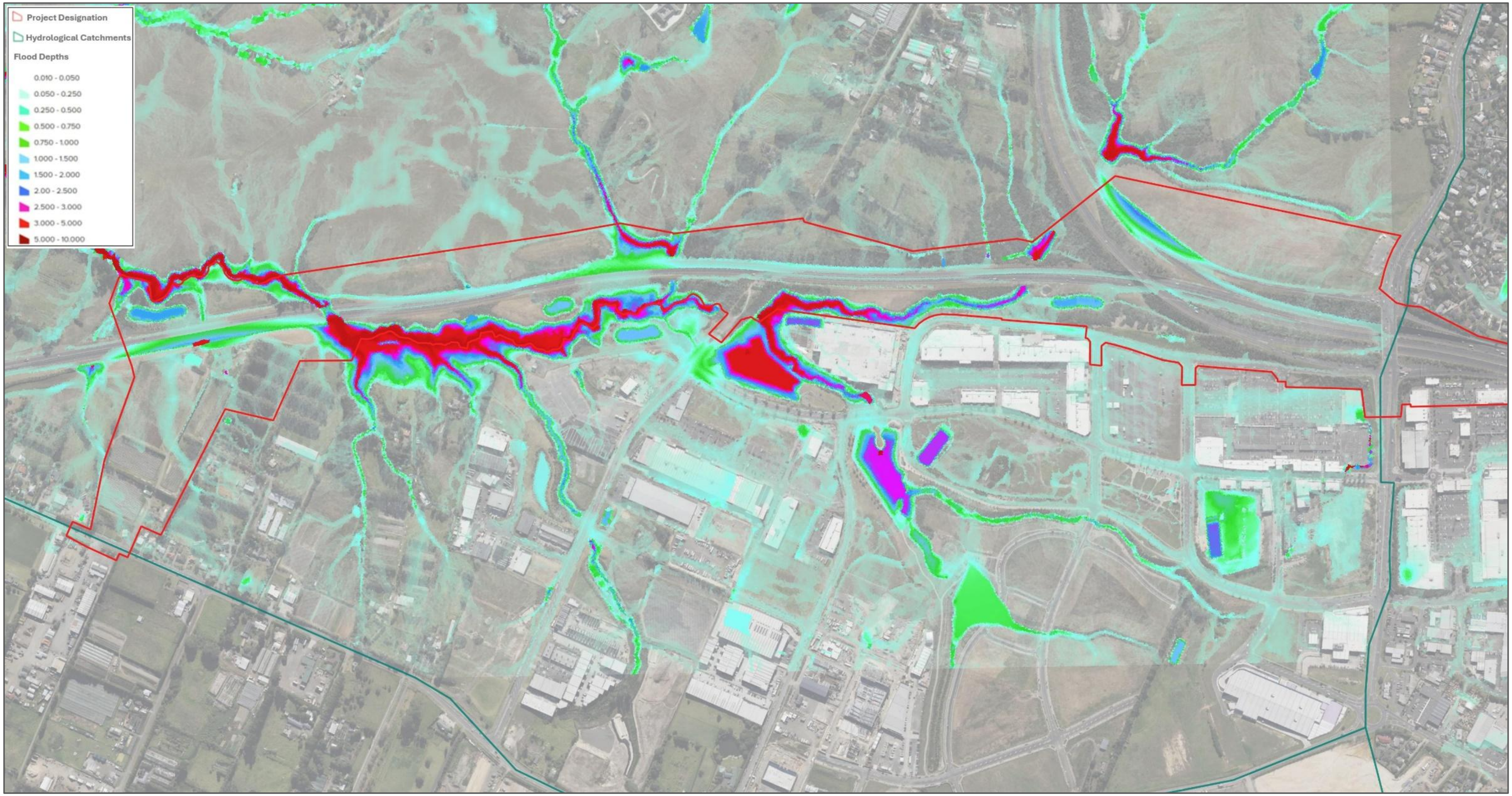


Figure 3-5: Existing flood depths for the 1% AEP event within Whenuapai Catchment

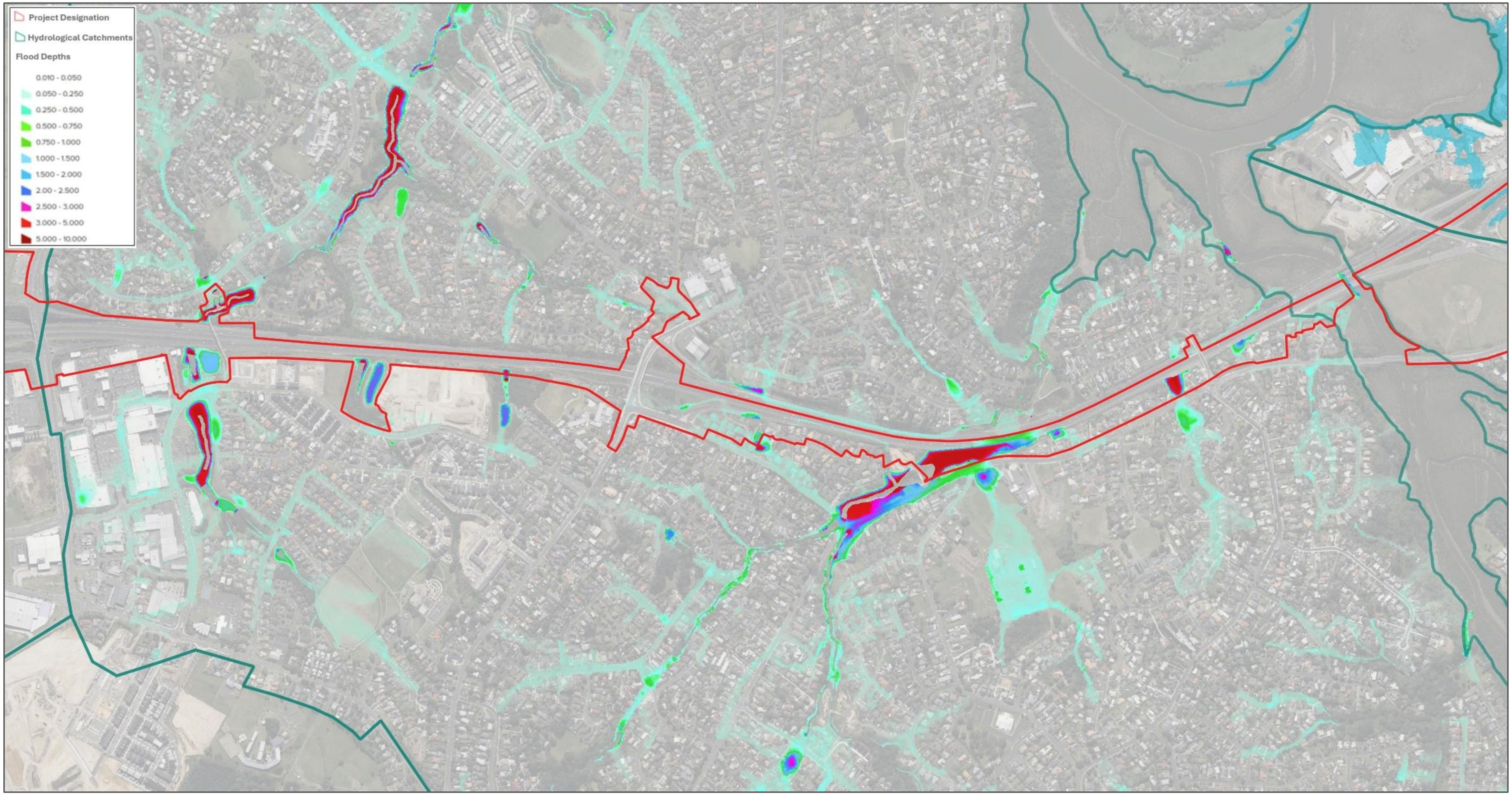


Figure 3-6: Existing flood depths for the 1% AEP event within Massey Catchment

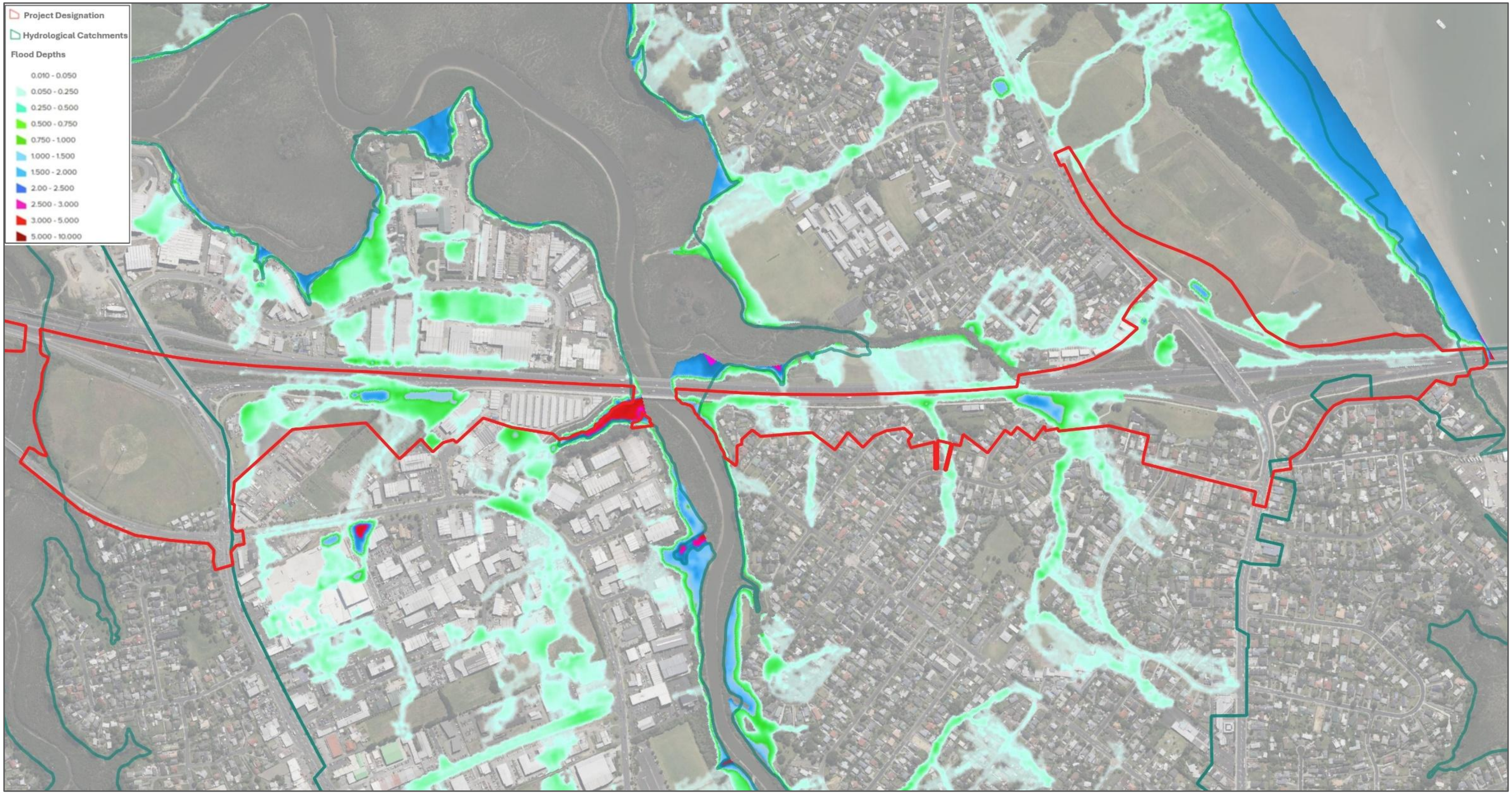


Figure 3-7: Existing flood depths for the 1% AEP event within Henderson Catchment

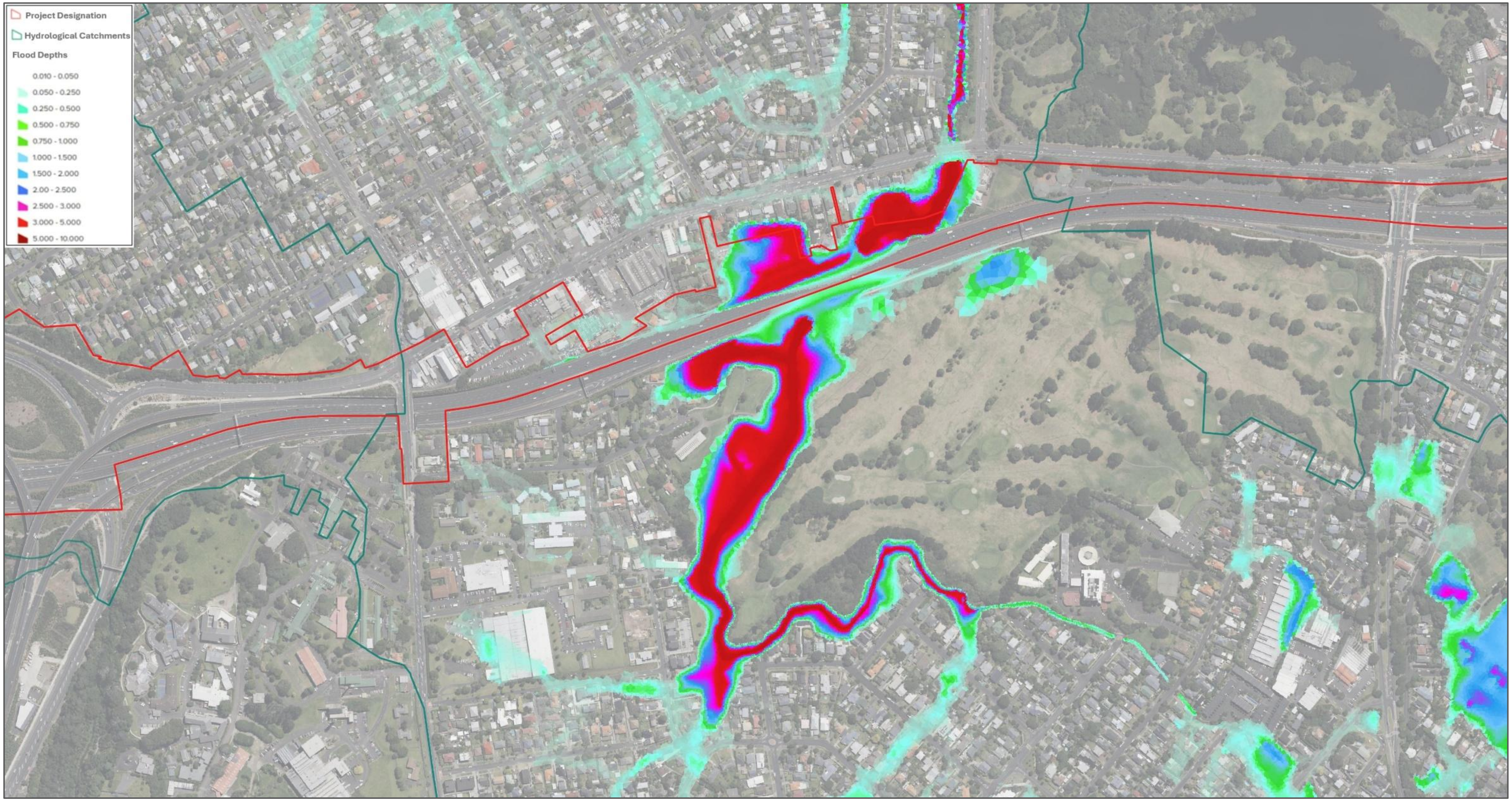


Figure 3-8: Existing flood depths for the 1% AEP event within Meola Catchment

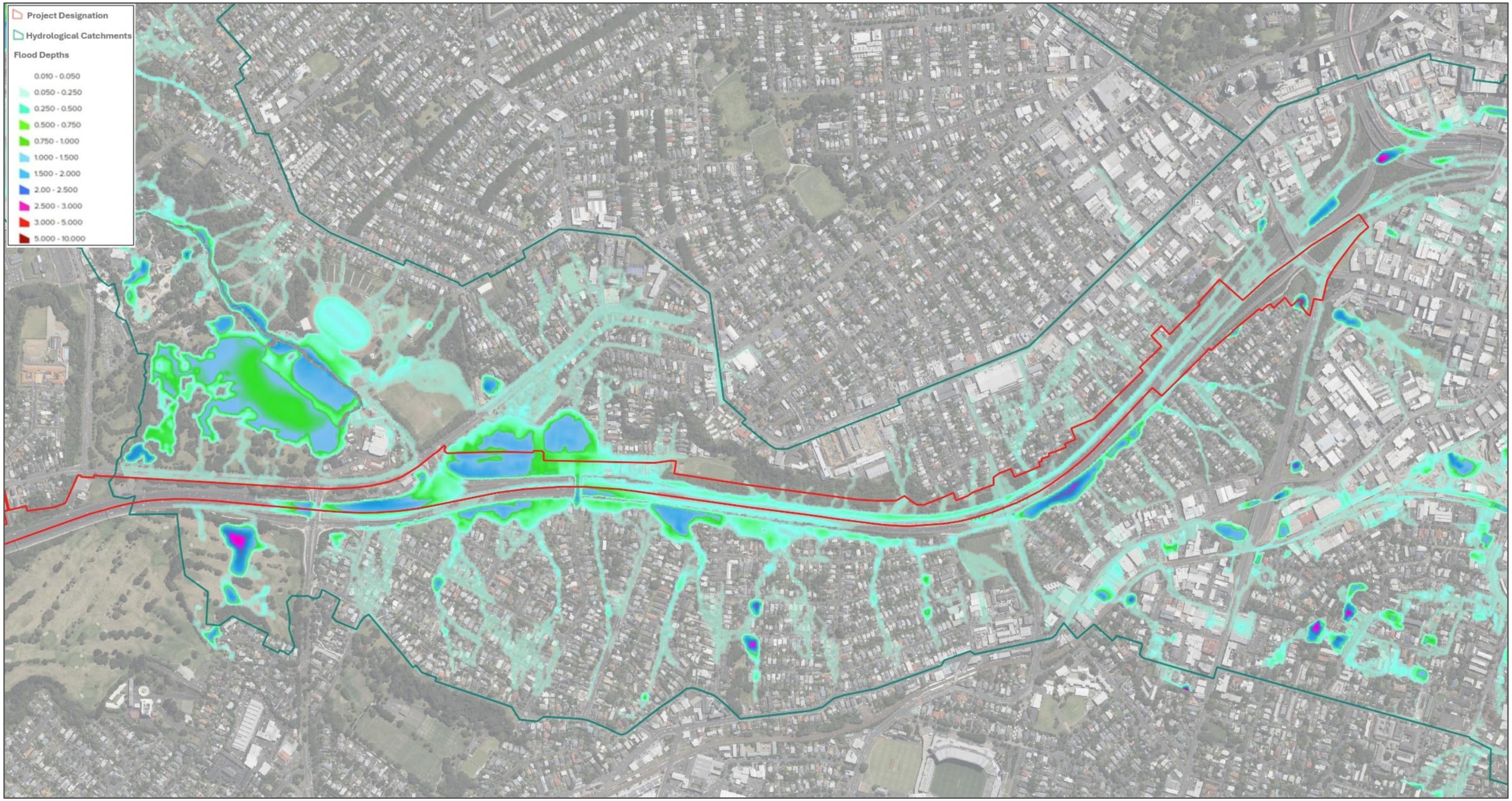


Figure 3-9: Existing flood depths for the 1% AEP event within Motions Catchment

Figure 3-10: Existing flood plain extents within Lincoln Catchment

Figure 3-11: Existing flood plain extents within Te Atatū South Catchment

Figure 3-12: Existing flood plain extents within Point Chevalier Catchment

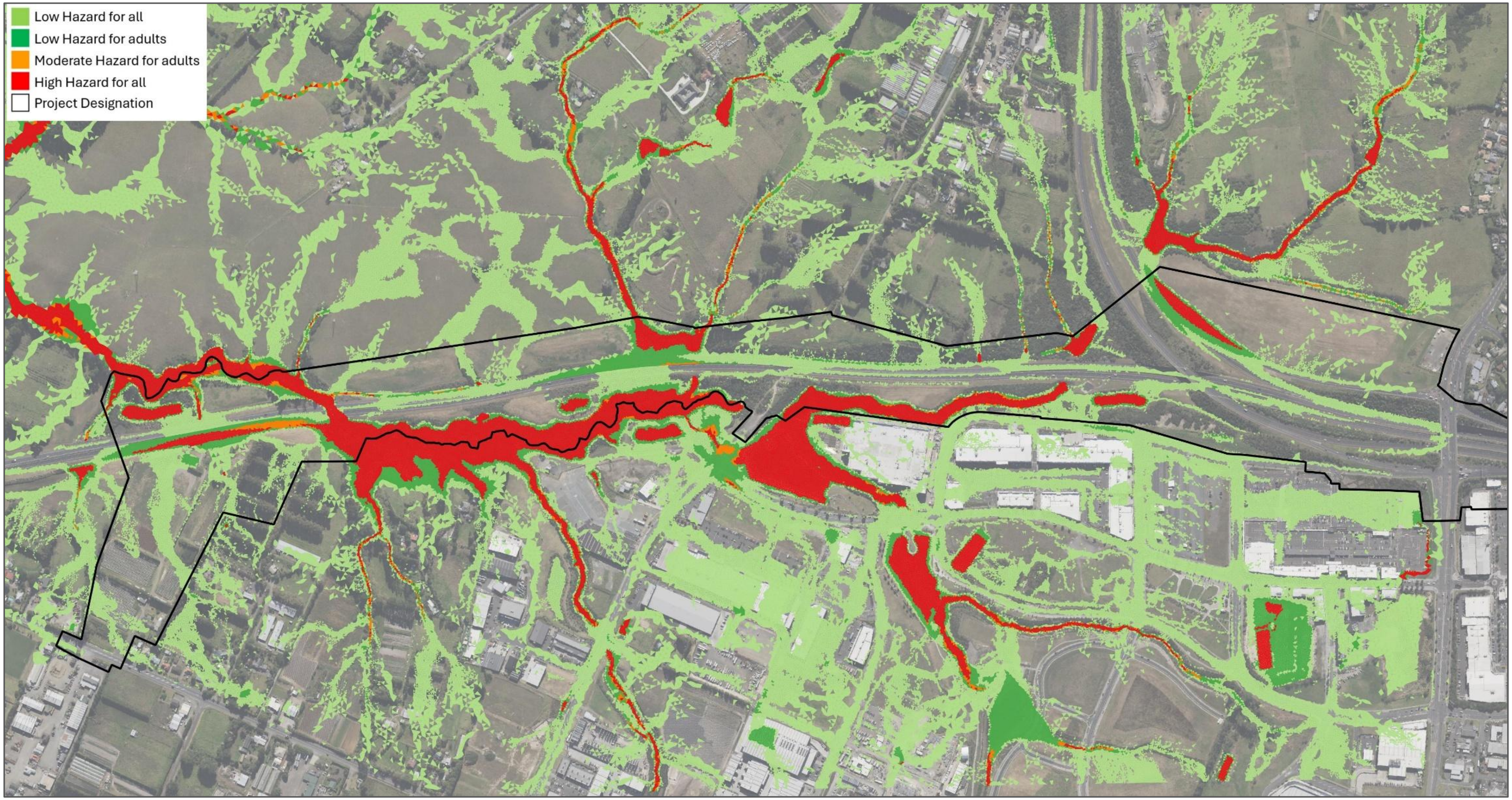


Figure 3-13: Existing flood hazard map within Whenuapai Catchment

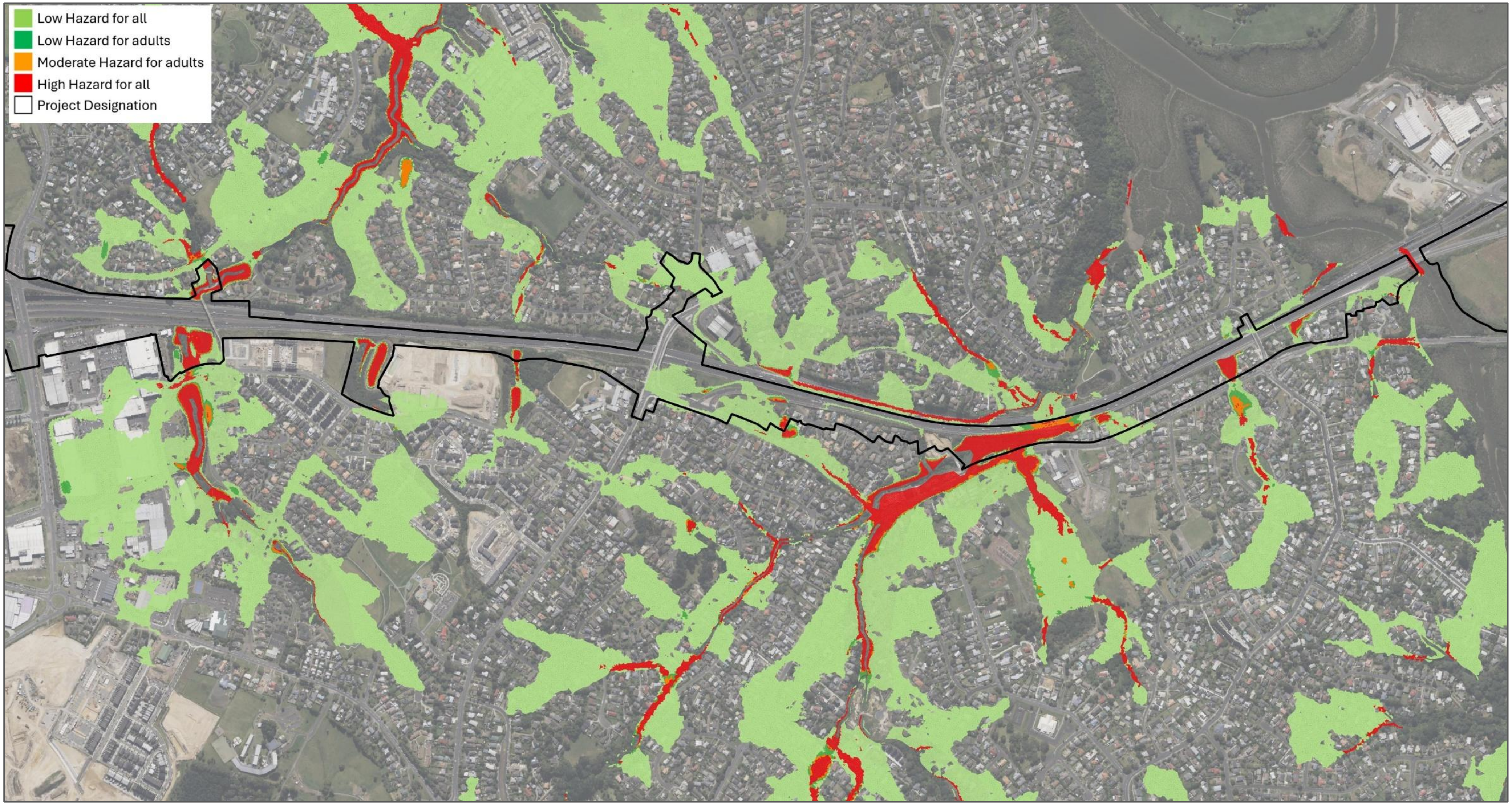


Figure 3-14: Existing flood hazard map within Massey Catchment

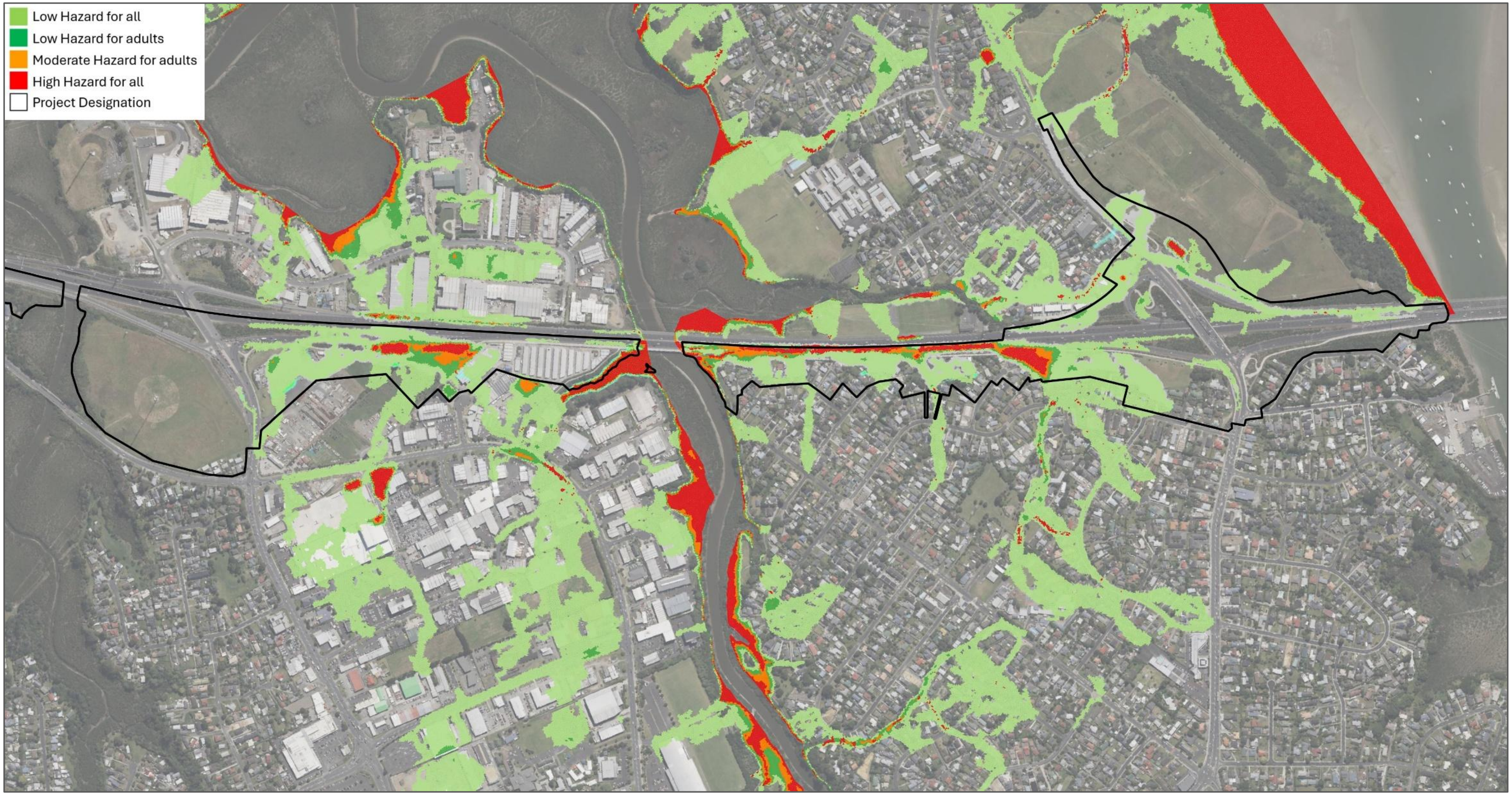


Figure 3-15: Existing flood hazard map within Henderson Catchment

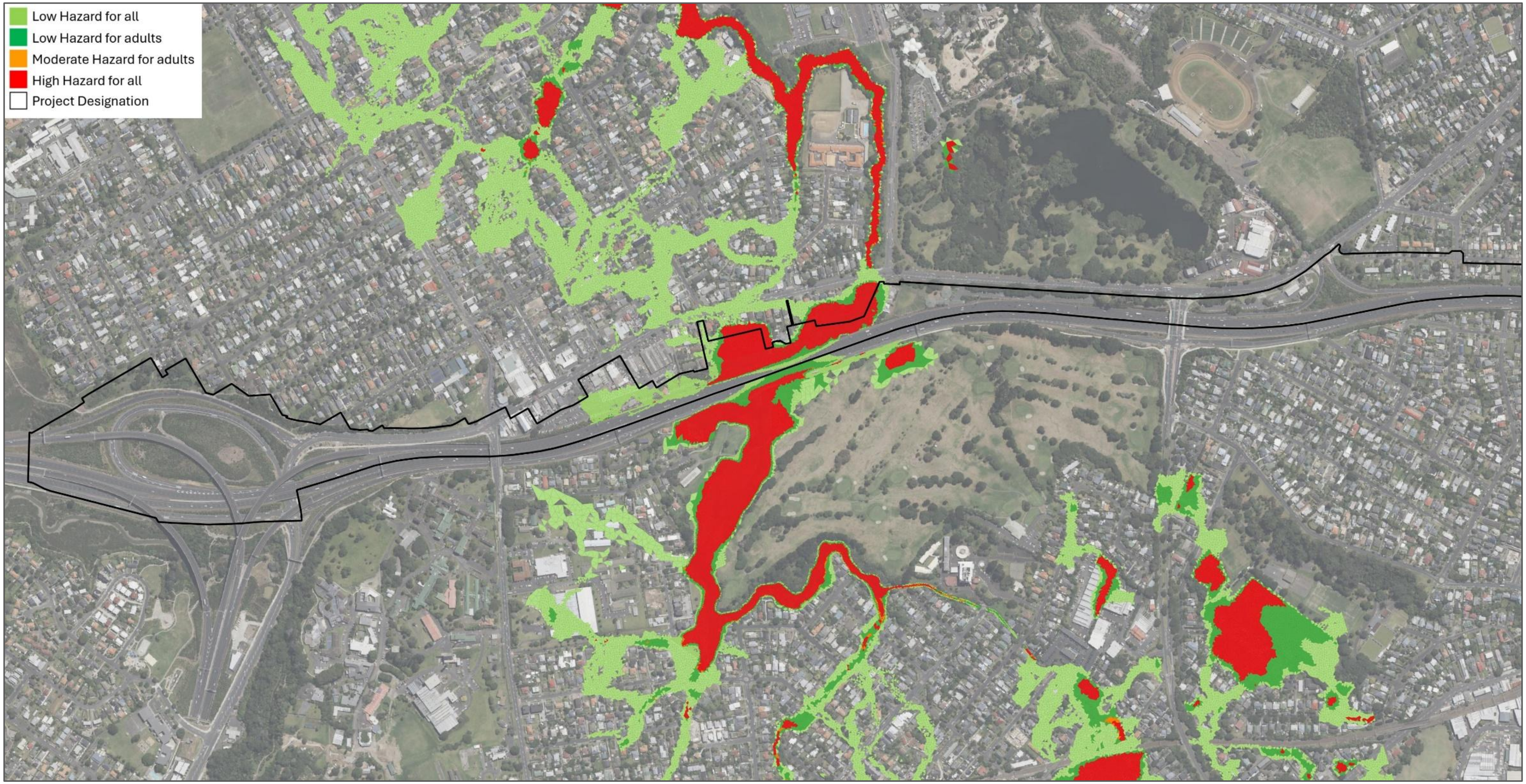


Figure 3-16: Existing flood hazard map within Meola Catchment

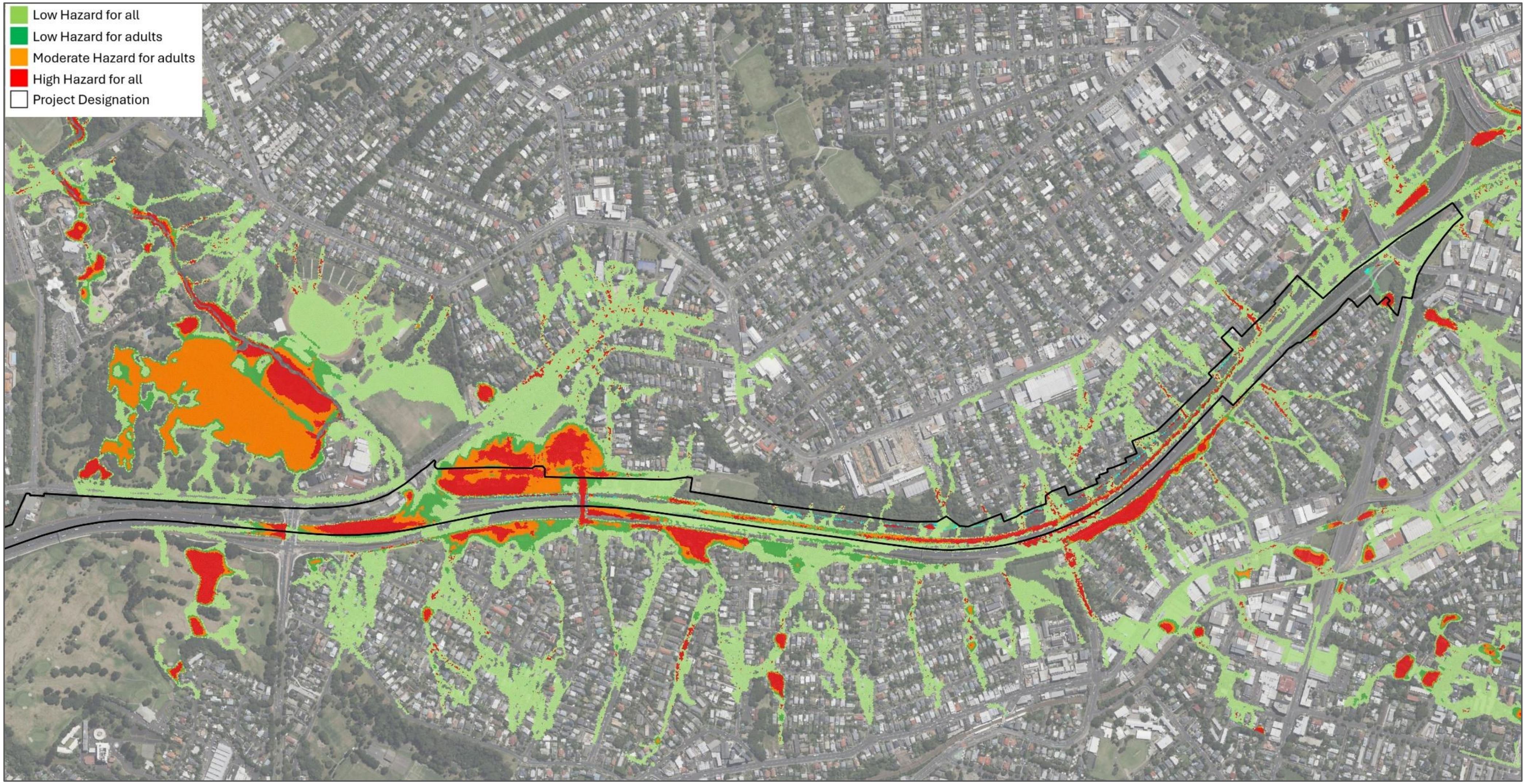


Figure 3-17: Existing flood hazard map within Motions Catchment

4. Indicative Design stormwater features

4.1 Overview

The Indicative Design drawings in Part 6 of the Substantive Application include the key stormwater design elements however the stormwater design will be confirmed in the future design phases.

A range of stormwater management solutions have been assessed and recommended solutions may differ from place to place, based on local constraints and opportunities. Treatment Area 1 (TA1) (shown on Figure 4-1) has sufficient space within the Proposed Designation for a wetland. A key challenge to provide hydrological mitigation in many of the treatment areas is that there is insufficient space within the Proposed Designation boundary to accommodate a wetland. The proposed stormwater management strategy aims to maintain flexibility by allowing a range of treatment devices to be considered during future design stages.

Flood management solutions include extensions of existing culverts, new piped and channelised solutions to support statutory approval applications, with further refinement expected during later detailed design stages.

4.2 Stormwater management solutions

To retain flexibility to determine appropriate solutions during detailed design stages, we have assessed a range of stormwater treatment options at each of the treatment areas within the sub-catchments of receiving environments shown in Section 3. The Indicative Design includes 25 indicative treatment device locations (Figure 4-1 and Figure 4-2).

The following treatment options have been assessed for each treatment area:

- Wetland.
- Swales.
- Gross Pollution Trap (GPT) designed to remove 50% TSS.
- GPT (designed to remove 50% TSS) with a StormFilter™.

The impervious area for each treatment area is summarised in Table 4-1 along with which treatment areas connect to the existing AC stormwater networks and which discharge to streams or the CMA. The indicative locations of the treatment devices for each treatment area are shown in Figure 4-1 and Figure 4-2.

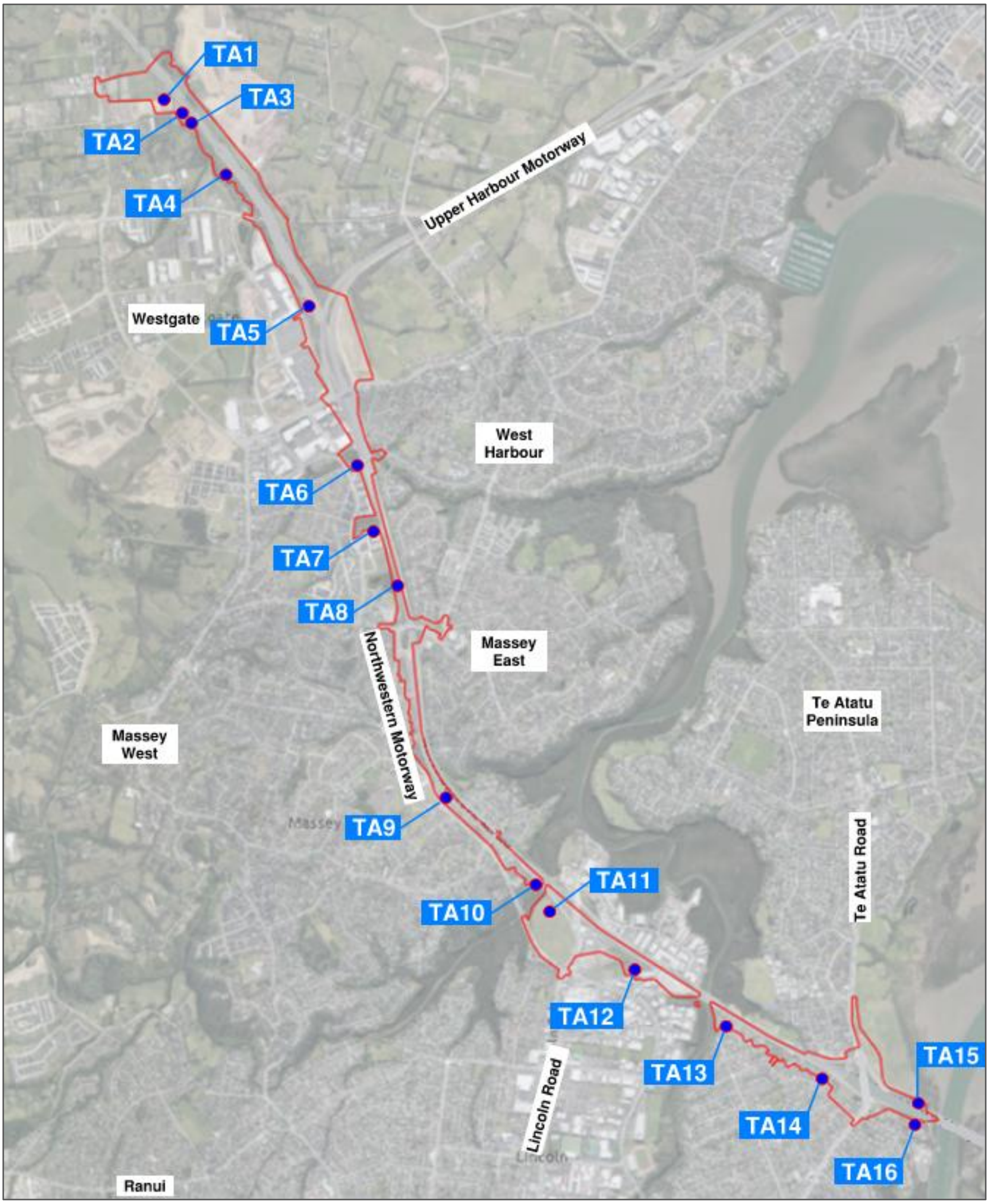


Figure 4-1: Indicative treatment area (device and discharge) locations – west

Figure 4-2: Indicative treatment area (device and discharge) locations – east

Table 4-1: Impervious area in each treatment catchment and discharge description

Outfall / Discharge Location	Treatment Area	Approximate Impervious Area (m^2)	Discharge to	Description
Tōtara Creek	TA 1	73000	Tōtara Creek via existing NZTA culvert	Ex. 1050mm culvert Existing Rip Rap at outfall
	TA2	1200	Tōtara Creek via new outfall	Rip rap at outfall designed as per AC TR2013-018 standards
	TA3	3050	Tōtara Creek via new outfall	Rip rap at outfall designed as per AC TR2013-018 standards
	TA4	12900	Tōtara Creek via existing wetland outfall	No modifications to wetland outfall
	TA5	7500	Tōtara Creek via existing wetland outfall	No modifications to wetland outfall
Mānutewhau Stream	TA 6	7550	Mānutewhau Stream via existing NZTA motorway culvert	No modifications to wetland outfall
	TA7	3600	Mānutewhau Stream via existing NZTA motorway culvert	No modifications to existing outfall
	TA 8	2200	Mānutewhau Stream via existing NZTA motorway culvert	No modifications to existing outfall
Rarawaru Stream	TA 9	24500	Rarawaru Stream via NZTA motorway culvert	No modifications to existing outfall
Huruhuru Creek	TA 10	8150	Huruhuru Creek/CMA via NZTA existing outfall	No modifications to existing outfall
	TA 11	21000	Huruhuru Creek/CMA	Rip rap at outfall designed as per AC TR2013-018 standards
Te Wai-o-Pareira / Henderson Creek	TA 12	7550	Henderson catchment flood solution via existing NZTA motorway culvert	See Rip Rap Length in Table 4-3
	TA 13	9900	Henderson catchment flood solution via existing AC network	See Rip Rap Length in Table 4-3
	TA 14	22700	Henderson catchment flood solution via existing NZTA culvert then a tributary stream	See Rip Rap Length in Table 4-3
Whau River	TA 15	8000	Whau River via existing NZTA outfall	No modifications to existing outfall
	TA 16	2450	Whau River via existing NZTA outfall	No modifications to existing outfall
Te Auaunga / Oakley Creek	TA 17	2200	CMA via existing AC network	No modifications to existing outfall
Waititiko / Meola Creek	TA 18	17750	Waititiko / Meola Creek via existing AC network	No modifications to existing outfall
Waiateao / Motions Creek	TA 19	4050	Waiateao / Motions Creek via existing AC network	No modifications to existing outfall
	TA 20	4050	Waiateao / Motions Creek via existing AC network	No modifications to existing outfall
	TA 21	10650	Waiateao / Motions Creek via existing AC network	No modifications to existing outfall
	TA 22	4200	Waiateao / Motions Creek via existing AC network	No modifications to existing outfall
	TA 23	8200	Waiateao / Motions Creek via existing AC network	No modifications to existing outfall
	TA 24	7950	Waiateao / Motions Creek via existing AC network	No modifications to existing outfall
	TA 25	6100	Waiateao / Motions Creek via existing AC network	No modifications to existing outfall

4.3 Flood management solutions

In the Whenuapai catchment, the Indicative Design includes a diversion channel and a 1200mm pipe on the northern side of the motorway are recommended.

In the Massey catchment, flood modelling has identified high flood hazard zones near the stream, for which the flood management solution included in the Indicative Design is a bridge that is approximately 160m.

The Indicative Design for the Henderson Catchment includes flood management solutions consisting of two diversion pipes. One of the diversions pipes runs along the busway from Te Atatū Road to the east and has diameters increasing from 900mm to 1500mm and the other diversion pipe runs along the busway to the west and has diameters increasing 450mm to 2100mm.

For the Meola catchment, the flood management solution included in the Indicative Design is a bridge which is approximately 150m long.

In the Motions catchment, flood management solutions are included in the Indicative Design, including a cut-off channel and piped solution with diameters ranging from 1350mm to 2100mm to capture overland flows.

Flood management solutions included in the Indicative Design are summarised in Table 4-2.

Table 4-2: Flood management solutions in the Indicative Design

Hydrological Catchment	Pipe	Channel	Bridge
Whenuapai	1200mm diameter north of existing motorway alignment	Diversion channel in combination with pipe.	50m long
Massey	N/A	N/A	160m long - south of motorway
Henderson	South of Indicative Design: Pipe 1 - increases from 900mm to 1500mm diameter. Pipe 2 - increases from 450mm to 2100mm diameter.	N/A	N/A
Meola	N/A	N/A	150m long - north of motorway
Motions	Increases from 1350mm to 2100mm diameter north of the Indicative Design to capture overland flow.	Diversion channels north of the Indicative Design to direct overland flow to pipe inlets.	N/A

The entry and exit points of the overland flow path for the Proposed Designation may be modified because of the Project. The overland flow path management solutions incorporated into the Indicative Design are summarised in Appendix B. Table 4-3 outlines details of locations along the Indicative Design where culverts are either proposed or have been extended, along with rip rap information for each location.

Table 4-3: Indicative culvert and rip rap information

ID	Feature	Catchment	Upstream Or Downstream	Approximate Length of New Culvert/Extension (m)	New Rip Rap Length (m)
1	Culvert Crossing	Whenuapai	Upstream and Downstream	30	N/A
2	Culvert Extension	Whenuapai	Downstream	15	6
3	Culvert Crossing	Whenuapai	Upstream and Downstream	20	20
4	Culvert Extension	Whenuapai	Downstream	10	20
5	Culvert Extension	Massey	Upstream	25	N/A
6	Culvert Extension	Massey	Downstream	30	8
7	Culvert Extension	Massey	Upstream	30	N/A
8	Culvert Extension	Massey	Upstream	25	N/A
9	Culvert Extension	Massey	Upstream	25	N/A

ID	Feature	Catchment	Upstream Or Downstream	Approximate Length of New Culvert/Extension (m)	New Rip Rap Length (m)
10	Culvert Crossing	Henderson	Upstream and Downstream	35	N/A
11	Pipe Extension (not a culvert)	Henderson	Upstream	50	N/A
12	Culvert	Massey	Upstream and Downstream	35	10

4.4 Stormwater management area flow control

The receiving environments were assessed to determine the potential effects of stream channel erosion. Each treatment area has been assessed against Stormwater Management Area Flow requirements as a screening test to identify where stream channel erosion should be assessed. Table 4-4 summarises the key information for the screening test and where stream channel erosion should be assessed. This is based on the AUP (OP) standards, outlined in the methodology.

Table 4-4: AUP hydrology mitigation requirements for treatment areas

Hydrological Catchment	Receiving Environment (Treatment Area)	Should stream channel erosion be assessed (screening test)	Notes
Whenuapai / Totara Creek	Tōtara Creek (TA 1, TA4 and TA 5)	Yes	Impervious areas > 5,000m^2 / discharge to stream
	Tōtara Creek (TA 2 and TA 3)	No	Impervious areas < 5,000m^2 / discharge to stream
Massey	Mānutewhau Stream (TA6 to TA 8)	Yes	In SMAF[1] zone
	Rarawaru Stream (TA 9)	Yes	In SMAF[1] zone
Henderson	CMA - Huruhuru Creek	No	Not in SMAF[1] zone and not discharging to stream
	CMA - Huruhuru Creek	No	Not in SMAF[1] zone and not discharging to stream
	CMA - Te Wai-o Pareira / Henderson Creek (TA12 to 14)	No	Not in SMAF[1] zone and not discharging to stream
	CMA - Whau River (TA 15 to16)	No	Not in SMAF[1] zone and not discharging to stream
Pt Chevalier	Oakley Creek	No	Not in SMAF[1] zone and not discharging to stream
Meola	Waititiko / Meola Creek	No	Not in SMAF[1] zone and not discharging to stream
Motion	Waiateao / Motions Creek (TA 19 to TA 25)	No	Not in SMAF[1] zone and not discharging to stream

Note: [1] SMAF = Stormwater Management Area Flow.

For those treatment areas where stream channel erosion should be considered (from column 3 in Table 4-4), I have assessed the feasibility of providing hydrology mitigation (i.e. attenuation in a wetland or swale with check dams and orifices or slot weirs) for Flow 1 and Flow 2 devices based on the Indicative Design and potential for modifications to the Indicative Design within the Proposed Designation. The results of this feasibility assessment are summarised in Table 4-5.

Table 4-5: Indicative feasibility of providing hydrology mitigation

Treatment Area	Feasible Y/N	Notes
TA 1	Y	Hydrology mitigation could be provided via a wetland
TA 4	Y	Hydrology mitigation could be provided via new or upgraded wetland

Treatment Area	Feasible Y/N	Notes
TA 5	Y	Hydrology mitigation could be provided via new or upgraded wetland
TA 6	Y	Hydrology mitigation could be provided via upgraded wetland
TA 7	Y	Hydrology mitigation could be provided via upgraded wetland
TA 8	N	TA8 location is space constrained to provide any storage devices. The only possible location for a storage device is in a significant ecological area.
TA 9	Y	Hydrology mitigation could be provided via upgraded wetland or swales with check dams

5. Assessment of effects

5.1 Receiving environment water quality

5.1.1 Assessment of water quality effects

I developed a contaminant load model to compare changes in contaminant loads resulting from the Project and to assess the potential effects of the Project's stormwater discharges on water quality. My assessment considers four treatment options to determine if a particular option needs to be specified or there is flexibility to identify an option at a later design stage.

I consider the contaminant load model results in Table 5-1 are conservative, as they only account for changes in existing land use under the Indicative Design. The remaining land within the Proposed Designation retains its existing land use in the model. In reality, some of the Proposed Designation is likely to convert from commercial and industrial use to vegetation cover because of landscaping for the Project, and if that was included in the model, greater improvements in contaminant loads would be predicted due to the enhanced filtering and reduced runoff associated with vegetated areas.

Table 5-1: Contaminant load changes

Receiving Environment	Treatment Area	Treatment Device	% Change		
			TSS	Zinc	Copper
Tōtara Creek	TA 1- 5	Nothing	0.22%	0.31%	2.24%
		GPT	-1.13%	0.13%	1.52%
		GPT + StormFilter™	-2.15%	-0.08%	0.88%
		Swale	-1.81%	0.03%	1.09%
		Wetland (New / Upgrade)	-1.95%	-0.12%	0.63%
Mānutewhau Stream	TA 6 – 8	Nothing	-0.82%	-0.27%	-0.18%
		GPT	-1.24%	-0.31%	-0.36%
		GPT + StormFilter™	-1.55%	-0.36%	-0.51%
		Swale	-1.44%	-0.33%	-0.46%
		Wetland (New / Upgrade)	-1.48%	-0.36%	-0.58%
Rarawaru Stream	TA 9	Nothing	-0.15%	0.41%	1.43%
		GPT	-0.49%	0.37%	1.26%
		GPT + StormFilter™	-0.74%	0.32%	1.11%
		Swale	-0.65%	0.35%	1.16%
		Wetland (New / Upgrade)	-0.69%	0.31%	1.05%
Huruhuru Creek	TA 10 - 11	Nothing	3.34%	0.99%	3.02%
		GPT	0.89%	0.68%	2.06%
		GPT + StormFilter™	-0.95%	0.31%	1.22%
		Swale	-0.33%	0.49%	1.49%
		Wetland (New / Upgrade)	-0.58%	0.25%	0.88%
Te Wai-o-Pareira / Henderson Creek	TA 12 - 14	Nothing	-4.21%	-3.73%	0.05%
		GPT	-5.56%	-3.80%	-0.41%
		GPT + StormFilter™	-6.57%	-3.88%	-0.82%

Receiving Environment	Treatment Area	Treatment Device	% Change		
			TSS	Zinc	Copper
		Swale	-6.23%	-3.84%	-0.69%
		Wetland (New / Upgrade)	-6.37%	-3.89%	-0.99%
Whau River	TA 15 – 16	Nothing	-0.41%	-0.46%	1.16%
		GPT	-2.22%	-1.16%	0.23%
		GPT + StormFilter™	-3.57%	-2.00%	-0.58%
		Swale	-3.12%	-1.58%	-0.33%
		Wetland (New / Upgrade)	-3.30%	-2.14%	-0.92%
Te Auaunga / Oakley Creek	TA 17	Nothing	-0.82%	0.48%	0.59%
		GPT	-1.25%	0.42%	0.40%
		GPT + StormFilter™	-1.57%	0.35%	0.24%
		Swale	-1.47%	0.38%	0.29%
		Wetland (New / Upgrade)	-1.51%	0.33%	0.17%
Waititiko / Meola Creek	TA 18	Nothing	0.00%	-0.01%	-0.07%
		GPT	-0.05%	-0.02%	-0.10%
		GPT + StormFilter™	-0.09%	-0.02%	-0.13%
		Swale	-0.08%	-0.02%	-0.12%
		Wetland (New / Upgrade)	-0.08%	-0.03%	-0.14%
Waiateao / Motions Creek	TA 19 - 25	Nothing	-0.70%	-0.01%	0.34%
		GPT	-1.05%	-0.05%	0.21%
		GPT + StormFilter™	-1.32%	-0.09%	0.10%
		Swale	-1.23%	-0.07%	0.14%
		Wetland (New / Upgrade)	-1.26%	-0.10%	0.06%

I have assessed the potential effects of the Project based on the criteria in Section 2.2.2 with the degree of effect allocated to a discharge based on the highest containment load increase out of TSS, zinc and copper. I consider almost all options will have positive or negligible effects (refer to Table 5-2) on the receiving environment. I consider the Huruhuru Creek outfall has a low effect, due to copper being slightly over the negligible effect classification, if a GPT is proposed. I consider my effects assessment to be conversative because:

- Existing bus services including the WX1 service operating on the motorway have been duplicated by also including them in the predicted traffic count on the busway and stations, which results in a higher road traffic count category in the contaminant load model (i.e. using the 1,000 to 5,000 vehicles per day category, instead of the lower contaminant generating less than 1,000 vehicles per day category).
- The land use was only changed for the Indicative Design, rather than the whole Proposed Designation.
- The receiving environments are generally part of much larger catchments, and the Project would not change existing contaminant loads if the entire receiving environment was modelled and assessed.

Table 5-2: Effect of Project on receiving environment

Outfall / Discharge Location	Treatment Area	Treatment Device	Effect
Tōtara Creek	TA 1- 5	Nothing	Low
		GPT	Negligible
		GPT + StormFilter™	Negligible
		Swale	Negligible
		Wetland (New / Upgrade)	Negligible
Mānutewhau Stream	TA 6 – 8	Nothing	Positive
		GPT	Positive
		GPT + StormFilter™	Positive
		Swale	Positive
		Wetland (New / Upgrade)	Positive
Rarawaru Stream	TA 9	Nothing	Negligible

Outfall / Discharge Location	Treatment Area	Treatment Device	Effect
		GPT	Negligible
		GPT + StormFilter™	Negligible
		Swale	Negligible
		Wetland (New / Upgrade)	Negligible
Huruhuru Creek	TA 10 - 11	Nothing	Low
		GPT	Low
		GPT + StormFilter™	Negligible
		Swale	Negligible
		Wetland (New / Upgrade)	Negligible
Te Wai-o-Pareira / Henderson Creek	TA 12 - 14	Nothing	Negligible
		GPT	Positive
		GPT + StormFilter™	Positive
		Swale	Positive
		Wetland (New / Upgrade)	Positive
Whau River	TA 15 – 16	Nothing	Negligible
		GPT	Negligible
		GPT + StormFilter™	Positive
		Swale	Positive
		Wetland (New / Upgrade)	Positive
Te Auaunga / Oakley Creek	TA 17	Nothing	Negligible
		GPT	Negligible
		GPT + StormFilter™	Negligible
		Swale	Negligible
		Wetland (New / Upgrade)	Negligible
Waititiko / Meola Creek	TA 18	Nothing	Positive
		GPT	Positive
		GPT + StormFilter™	Positive
		Swale	Positive
		Wetland (New / Upgrade)	Positive
Waiateao / Motions Creek	TA 19 - 25	Nothing	Negligible
		GPT	Negligible
		GPT + StormFilter™	Negligible
		Swale	Negligible
		Wetland (New / Upgrade)	Negligible

5.1.2 Water quality effects – conclusion

Overall, the contaminant load model results show reductions in TSS for most receiving environments regardless of treatment device or whether treatment is provided due to the Project generating less overall TSS than the existing land use type. The model results also show decreases in zinc and copper in some locations where the Project replaces roofs, commercial and industrial areas. In other areas, minor increases in Zinc and Copper are observed, but I consider those increases still result in negligible effects, based on the criteria in Section 2.2.2. In conclusion, my assessment shows that either not treating stormwater or treating it with any of the options assessed results in effects that range from positive to low.

5.2 Stream channel erosion

5.2.1 Assessment of stream channel erosion effects

The Project will increase impervious surfaces, which will lead to higher flows and velocities in some streams, with the potential to impact stream stability. I have assessed the existing (i.e. before the Project) and design case (i.e. after the Project) stormwater management area flows and corresponding velocities and the change in velocity between the existing and design cases and summarised the results in Table 5-3. I have also assessed effects and stated the degree of effects for each treatment area with and without hydrology mitigation in Table 5-3.

Based on the velocity change, I consider the Project will have negligible effects on stream channel erosion in all cases, except TA1 where I consider the Project will have a moderate effect without hydrology mitigation or other measures (such as armouring) due to a 6.5% increase in velocity. The channel TA 1 discharges to an engineered channel that converges with Tōtara Creek.

Table 5-3: Stream erosion effects summary

Treatment Area	Existing Stormwater Management Area Flow Rate (m^3/s)	Design Stormwater Management Area Flow Rate (m^3/s)	Existing Velocity (m/s)	Design Velocity (m/s)	Velocity % Change	Effect without hydrology mitigation	Effect with hydrology mitigation
TA 1	0.76	0.98	0.91	0.97	6.5	Moderate	Negligible
TA 4	4.70	4.76	0.96	0.97	1	Negligible	Negligible
TA 5	1.28	1.32	0.49	0.50	2.0	Negligible	Negligible
TA 6	1.63	1.67	0.55	0.56	1.8	Negligible	Negligible
TA 7	0.67	0.69	1.57	1.59	1.3	Negligible	Negligible
TA 8	0.33	0.35	1.00	1.00	0	Negligible	Negligible
TA 9	5.20	5.24	1.97	1.98	0.5	Negligible	Negligible

5.2.2 Stream channel erosion effects – conclusion

Overall, I consider the Project's potential stream channel erosion effects are negligible for all locations without hydrology mitigation, except for TA 1 where there would be a moderate effect without hydrology mitigation (or other measures such as armouring) and negligible with mitigation.

5.3 Flooding and overland flow paths

5.3.1 Assessment of flooding effects – approach

The effects assessment in the following sections demonstrates that the Indicative Design can be implemented within the Project Area to manage flooding effects on people and property so that:

- There is no new inundation of floor levels due to the Project; and
- Additional damage to property already inundated in the existing case/environment is minimised.

As set out later in my report, I recommend flooding outcomes are specified in the designation conditions so that the final design can be tested against those outcomes rather than specifying flood mitigation measures at this stage.

5.3.2 Assessment of flooding effects – Whenuapai Catchment

Figure 5-1 illustrates the flood depth differences between the existing and design cases across the Whenuapai catchment. The combined effect of the Indicative Design and flood management solutions included in the Design north of the motorway alignment in Table 4-2 result in increased flooding along the Northwestern Motorway and Tōtara Creek up to 80mm (typically 60-100mm) and reductions north of the motorway and adjacent to the proposed Brigham Creek Rarawaru station and Park and Ride facility. The flood management solution north of the motorway partly diverts overland flow to remain on the northern side of the motorway and away from motorway cross culverts. The proposed Brigham Creek station and Park and Ride facility also divert the overland flow path, which results in decreased flooding north of the proposed station. Overall, these results indicate reductions and small increases in flood depths beyond the Project boundary.

I identified two properties with buildings where the Indicative Design will result in increased flood depths in this catchment, with one property with a building with reductions of flood depth between 10 to 50mm. I have assessed all three of these properties to have an existing high Danger Rating (refer to Figure 5-2). The Indicative Design does not alter the Danger Rating (refer to Figure 5-3) for properties in the catchment, although two have increases in flood depth), indicating that the hazard to people and property remains consistent with the existing scenario. Accordingly, I consider the Project will have positive effects on one property and low effects on two properties as shown in Figure 5-4.

Overall, I consider the flooding effects of the Project in the Whenuapai Catchment are positive to low.

Figure 5-1: Whenuapai Catchment 1% AEP flood depth difference map

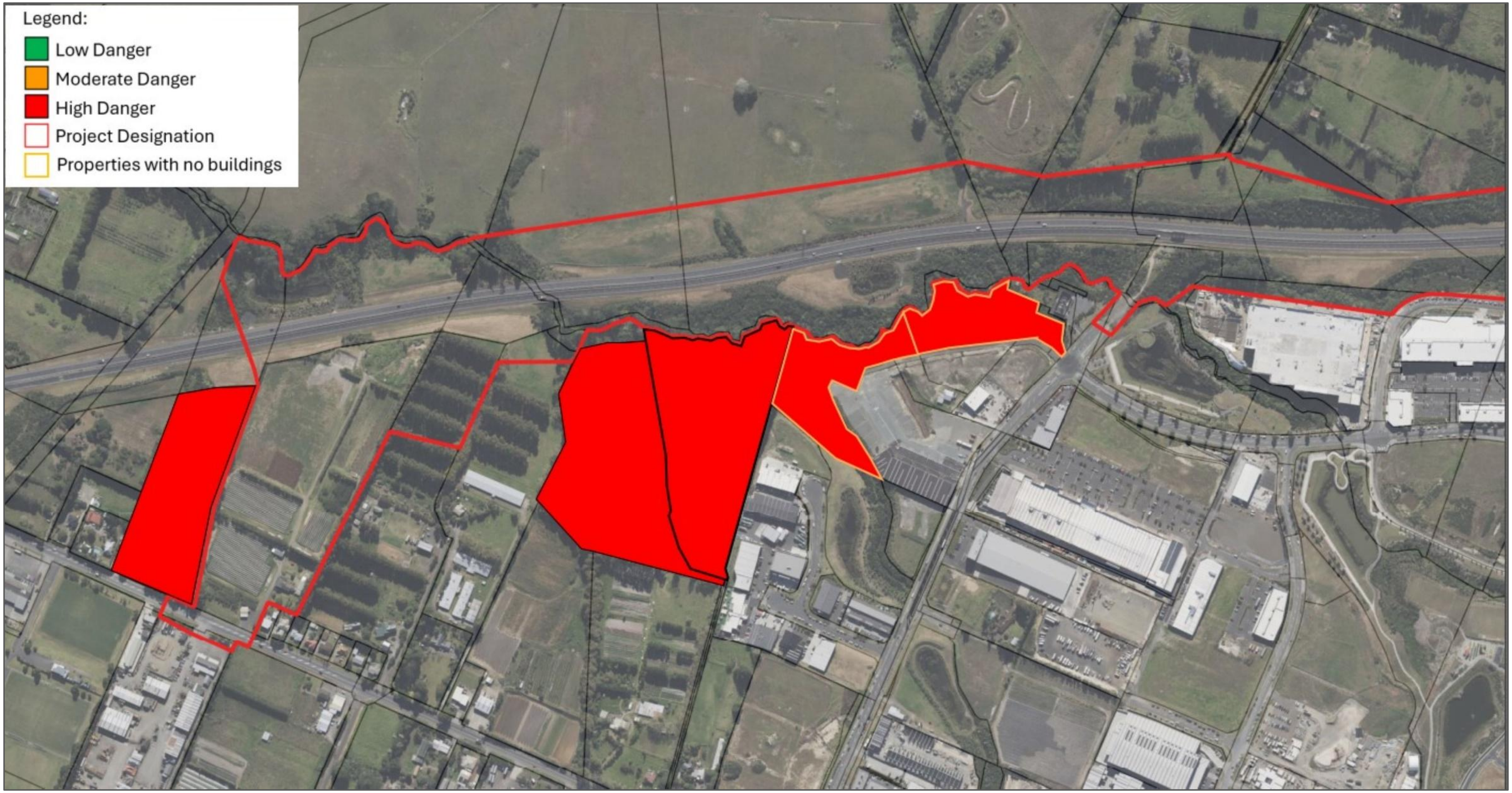


Figure 5-2: Existing Danger Rating for properties with changes to flood depth in Whenuapai Catchment (Area 1)

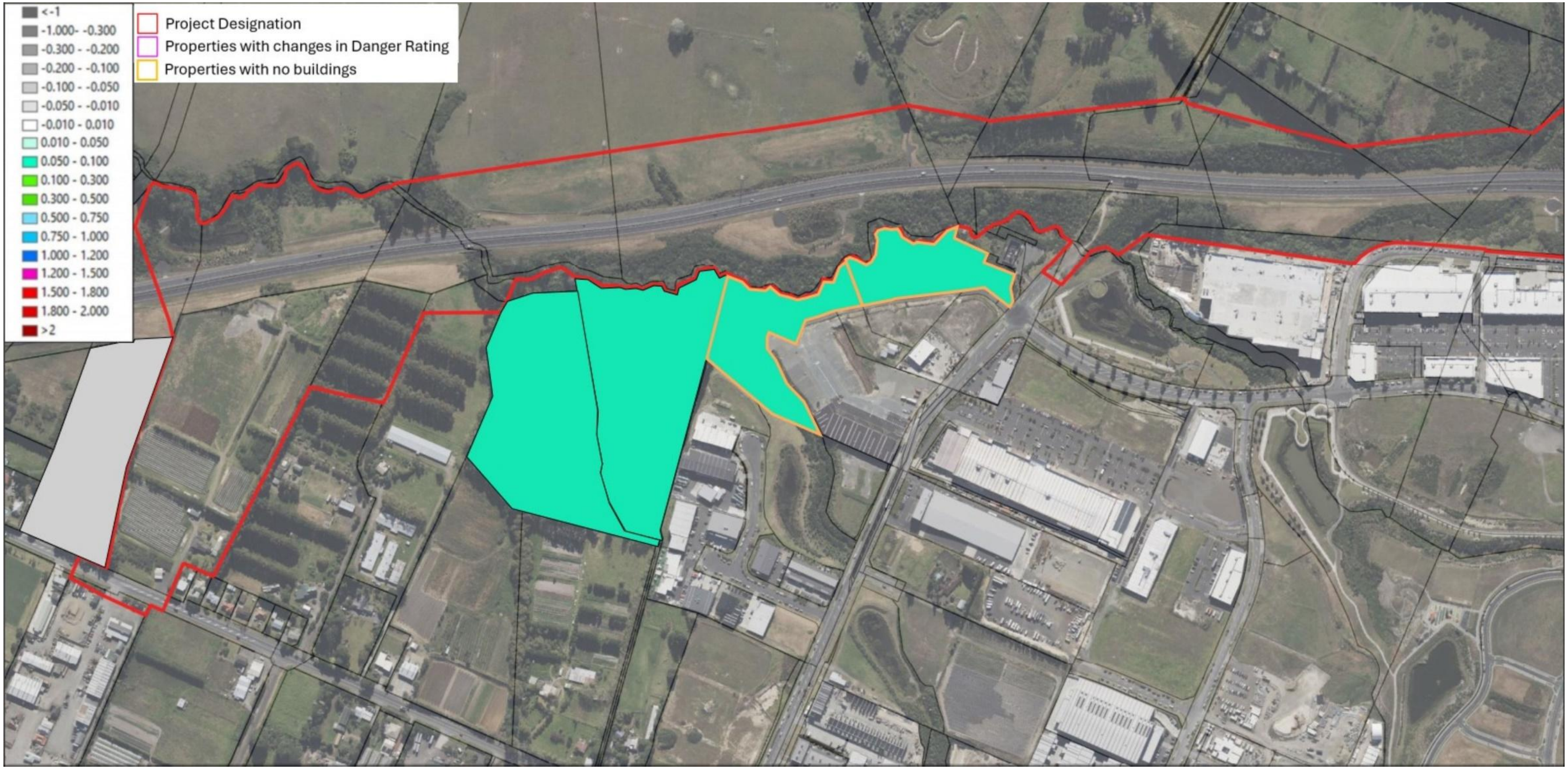


Figure 5-3: Properties with changes to flood depths or Danger Rating in Whenuapai Catchment (Area 1)

Figure 5-4: Whenuapai catchment effects map

5.3.3 Assessment of flooding effects – Massey Catchment

As shown on Figure 5-5, the Project will not increase flood depths outside of the Proposed Designation in the Massey Catchment. Accordingly, I consider the Project will not have any adverse flooding effects in this catchment.

Figure 5-5: Massey Catchment 1% AEP flood depth difference map

5.3.4 Assessment of flooding effects – Henderson Catchment

As shown in Figure 5-6, the Indicative Design (including its flood management solutions) will mostly decrease flooding in the Henderson Catchment, particularly on the south side of the Motorway. There is one area of increased flood depth outside of the Proposed Designation (shown in green in Figure 5-6) but that is contained within a waterway (i.e. not within property).

I identified 21 properties where the Project will result in decreases in flood depths in this catchment, with reductions between 10mm and 300mm. Most of these properties have an existing low Danger Rating, although two have a moderate Danger Rating and one has a high Danger Rating. The Indicative Design does not alter the overall Danger Rating for these properties, indicating that the hazard to people and property remains consistent with the existing scenario.

I have assessed the potential effects of the Project to be positive for all 21 properties as shown on Figure 5-7.

Overall, I consider the flooding effects of the Project in the Henderson Catchment to be positive.

Figure 5-6: Henderson Catchment 1% AEP flood depth difference map

Figure 5-7: Henderson Catchment effects map

5.3.5 Assessment of flooding effects – Meola Catchment

The Indicative Design displaces flood water upstream of Meola Creek resulting in a slight increase in flood depth south of the Northwestern Motorway. The maximum depth range shown on the depth difference map is "50 to 100mm" because of the ranges used on the map. However, the actual maximum modelled depth increase is 55mm. The Indicative Design decreases flood depth downstream of Meola Creek north of the Northwestern Motorway, near Western Springs Garden.

As shown in Figure 5-8, the Project will result in flood depth increases at 38 properties beyond the Proposed Designation.

From my assessment, I consider most of these 38 properties have existing high Danger Ratings (i.e. 30) with seven low and one moderate as shown in Figure 5-9. The properties with high Danger Ratings are not sensitive to increases of 10 to 55mm as either the floor levels are already exceeded by more than 500mm or the floor levels are not inundated and the High Danger Rating relates to property adjacent to the Meola Creek and have a high flood hazard (i.e. high depths, velocities or the product of depth and velocity somewhere on the property).

Figure 5-10 shows the maximum depth differences on the respective properties. My assessment shows the Indicative Design does not alter the overall Danger Rating for those properties, indicating that the hazard to people and property remains consistent with the existing scenario.

I have assessed most properties to have low effects with some showing negligible or positive effects as shown in Figure 5-11.

Overall, I consider the Project will have a low impact in the Meola Catchment in terms of overall flood risk and hazard implications.

Figure 5-8: Meola Catchment 1% AEP flood depth difference map

Figure 5-9: Existing Danger Rating for properties with changes to flood depth in Meola Catchment

Figure 5-10: Properties with changes to flood depths or Danger Rating in Meola Catchment

Figure 5-11: Meola Catchment effects map

5.3.6 Assessment of flooding effects – Motions Catchment

The Indicative Design redirects overland flow paths, resulting in decreased flooding along the Northwestern Motorway and nearby areas, particularly benefiting King Street and Hesketh Street. A reduction in flood depths was observed at the proposed Western Springs station and its vicinity, including Tuarangi Road, Wexford Road, and Ivanhoe Road, through the combined effect of the Indicative Design and its proposed flood management solutions.

Figure 5-12 illustrates the flood depth differences between the existing and design cases across the Motions Catchment. The combined effect of the Indicative Design and flood management solutions included in the Indicative Design north of the motorway alignment in Table 4-2 result in decreased flooding along the Northwestern Motorway. The flood management solution north of the motorway conveys overland flow to large pipe systems at Western Springs. Overall, these results indicate a reduction in flood depths beyond the boundary of the Project Area.

I identified 58 properties where the Indicative Design will result in decreases in flood depths in this catchment, with reductions between 10 to 50mm. I have assessed eight (8) of those properties as having an existing low Danger Rating, 11 to have an existing moderate Danger Rating and 36 to have an existing high Danger Rating. The Indicative Design does not alter the Danger Rating for properties in the catchment, indicating that the hazard to people and property remains consistent with the existing scenario. Accordingly, I consider the Project will have positive effects on properties as shown in Figure 5-13 and Figure 5-14.

Overall, I consider the flooding effects of the Project in the Motions Catchment are positive.

Figure 5-12: Motions Catchment 1% AEP flood depth difference map

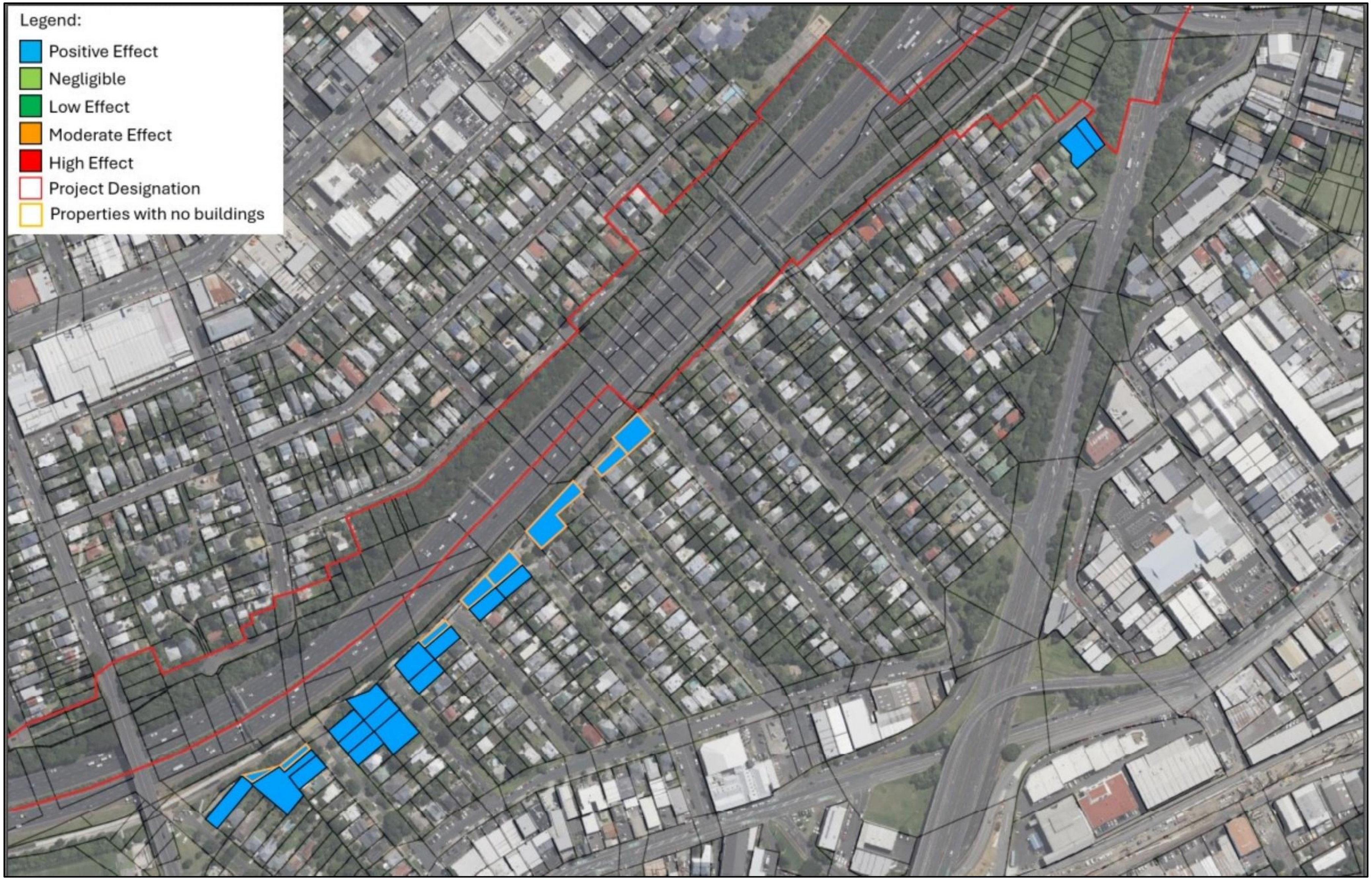


Figure 5-13: Motions Catchment effects map for Area 1

Figure 5-14: Motions Catchment effects map for Area 2

5.3.7 Flooding effects – conclusion

In most locations, I consider the Project is likely to reduce flood depths and therefore have a positive impact. Some localised areas may experience slight increases in flood depth, but I consider the flooding effects to be negligible or minor in those locations.

5.4 Sensitivity testing of Indicative Design

5.4.1 Receiving environment water quality from the discharge of stormwater

As shown in Table 3-1 in Section 3.1, the existing motorway and AC stormwater networks east of the causeway receive minimal to no stormwater treatment and the motorway west of the cause is treated by a range of existing treatment devices. The Project is a low contaminant generating activity due to the low Annual Average Daily Traffic (AADT) and the expectation that electric buses will use the busway. Accordingly, I consider any change to the Indicative Design will have little to no impact on my assessment of water quality effects.

There is also the potential for changes to the Indicative Design to require a different treatment device. For example, it might reduce or eliminate viable land available for a wetland, such that a StormFilter™ may be more appropriate. However, as described in Section 5.1, I consider the effects of the Project will be negligible no matter which of the stormwater treatment options are implemented.

A sensitivity analysis was undertaken on the contaminant load model by assessing the changes to the results if the Indicative Design was moved further away from the existing SH16. Table 5-4 sets out these results for each of the outfall locations. In summary, I have assessed that three locations would be affected by a change in alignment (because of different existing uses), however I consider any changes to contaminant predictions would still result in effects that are negligible.

Table 5-4: Sensitivity analysis in contaminant load model on an alignment adjustment

Outfall Area	Change in Results	Comments
Tōtara Creek	N	The altered alignment would continue to replace greenspace therefore the contaminant load model result would not alter.
Mānutewhau Stream	Y	The altered alignment would replace more buildings in multiple locations therefore the Project would result in a shift to producing more Zinc and less TSS.
Rarawaru Stream	N	The altered alignment would continue to replace buildings. Therefore, the contaminant load model result would not alter.
Huruhuru Creek	N	The altered alignment would continue to replace buildings. Therefore, the contaminant load model result would not alter.
Te Wai-o-Pareira / Henderson Creek	N	The altered alignment would continue to replace green space, buildings and carpark/building area. Therefore, the contaminant load model result would not alter.
Whau River	Y	The altered alignment would replace more buildings in multiple locations therefore the Project would result in a shift to producing more Zinc and less TSS.
Te Auaunga / Oakley Creek	N	The altered alignment would continue to replace the same land types. Therefore, the contaminant load model result would not alter.
Waititiko / Meola Creek	Y	The altered alignment would replace more buildings in multiple locations therefore the Project would result in a shift to producing more Zinc and less TSS.
Waiateao / Motions Creek	N	The altered alignment would continue to replace the same land types. Therefore, the contaminant load model result would not alter.

I have carried out a sensitivity analysis for the Whau River outfall, which is associated with the smallest sub-catchment of a receiving environment in the Project and is therefore considered the most sensitive. The assessment focused on Treatment Area 14, including Te Atatū Ōrangihina station, by changing the discharge location from Te Wai-o-Pareira / Henderson Creek to the Whau River. As shown in Table 5-5, this change results in an increase in contaminants discharging at the outfall. However, the overall catchment contributing to the Whau River is substantially larger than the Treatment Area 14 catchment. Consequently, the increased contaminant loads are dispersed over a wider area, resulting in a negligible risk to the receiving environment. I have assessed this scenario as having a negligible low effect for all treatment options. Without treatment, there would be a moderate effect.

Table 5-5: Whau River outfall with additional treatment area

Name	TSS	Zn	Cu
Nothing	7.5%	5.7%	7.6%
GPT	1.7%	3.4%	4.7%
GPT + StormFilter™	-2.6%	0.8%	2.1%
Swale	-1.1%	2.1%	2.9%
Wetland (New / Upgrade)	-1.7%	0.3%	1.0%

5.4.2 Stream channel erosion

The sensitivity of calculations for changes in stream velocities was assessed as being low and is documented in Appendix A. Overall, stream velocities are not sensitive to changes in discharge location or changes in cross sections downstream of discharge as the cross sections were assessed to be consistent and low risk of resulting in different predictions in velocities increases.

5.4.3 Flooding and overland flow paths

Modifications to the Project's horizontal and vertical alignment may change overland flow paths and flooding patterns. Sensitivity of flooding impacts to changes in the Indicative Design were assessed indirectly during the development of the Indicative Design. There are a multitude of mitigation strategies that could be considered when preparing the final design to ensure the specified flooding outcomes are achieved.

In consultation with Auckland Council Healthy Waters, it the identified that the flood management solutions for the Henderson Catchment should consider the sensitivity of the flooding outcomes to pipe blockages. A sensitivity scenario was run with 10% reduction in pipe capacity in the flood management solution in accordance with Section 4.3.5.6 of the Auckland Code of Practice for Land Development and Subdivision – Chapter 4 Stormwater (Version 4 July 2025). The resulting flood depth differences are shown in Figure 5-15 with following areas with flood depth increases outside the Proposed Designation:

- A stream with Henderson Creek Esplanade.
- Harbourview – Ōrangihina Park (maximum increase in flood depth of 44mm).
- Three properties on Te Atatū Road near Titoki Street (maximum increase in flood depth of 49mm).
- Two properties on Royal View Road near McCormick Road (maximum increase in flood depth of 34mm).

The effects on the five properties with buildings are assessed to be negligible while flooding on the Harbourview – Ōrangihina Park is also assessed to be negligible.

Based on the general project wide sensitivity assessment and the site-specific sensitivity assessment for Henderson Catchment, I consider any flooding effects will be appropriately managed regardless of changes to the Indicative Design or other factors such as flood management solution pipe blockages.

Figure 5-15: Henderson Catchment 1% AEP flood depth difference map

6. Recommended measures to avoid, remedy or mitigate effects

6.1 Water quality

I recommend that stormwater from the impervious surfaces of the Project is treated (via any of the treatment device options assessed) before it is discharged to the receiving environment. Based on my assessment, if the stormwater is treated, the effects on the receiving environment will range from positive to negligible, except for one case assessed which may have a low effect. Even if stormwater isn't treated, based on my assessment, the effects on the receiving environment would range from positive to negligible, except for two cases assessed which may have low effects. Accordingly, I do not consider it necessary to specify particular treatment devices, and they can be selected during future design stages.

6.2 Stream channel erosion

I recommend that stormwater from the impervious surfaces of the Project is managed via attenuation devices that provide hydrology mitigation where the Project discharges to an erodible stream and would overwise increase stream velocities, based on hydraulic assessment, more than 5%, unless a detailed assessment is carried out to demonstrate any erosion resulting from the increase in stream velocity would result in no or a low degree of erosion. Based on the Indicative Design, only one out of the 25 potential treatment areas (i.e. TA 1) along Tōtara Creek requires hydrology mitigation or other measures such as armouring or a detailed assessment to demonstrate no or a low greed of erosion would occur. The remaining locations are in areas where effects have been assessed as negligible without hydrology mitigation.

6.3 Outfall and culvert energy dissipation and scour protection

I recommend, that all stormwater network outfalls and culvert outlets have energy dissipation and scour protection that is designed in accordance with Technical Report 2013/018 (AC, 2013) for the following stormwater events:

- 10% AEP plus 2.1-degree Celsius temperature increase for climate change for stormwater network outfalls.
- 1% AEP plus 3.8-degree Celsius temperature increase for climate change (including updated existing TP108 rainfall data) for culvert inlets and outlets.

6.4 Flooding

I recommend that the Project includes flood and overland flow path management solutions that ensure that increases in flood depth on properties outside the Proposed Designation based on flood modelling and floor level estimates or from available information are:

- no more than 50mm increase in modelled flood level where there is currently no habitable floor flooding.
- no more than 100mm increase in modelled flood level for: where there is existing habitable floor flooding or no building with habitable floor is present.
- no increase in Danger Rating.

I recommend the above outcomes are specified in the designation conditions and the flood and overland flow path management solutions for the Project are identified during future design stages.

7. Conclusion

This assessment evaluates potential stormwater and flooding impacts from the Indicative Design and possible design changes within the Proposed Designation, focusing on water quality, stream erosion, and flood level changes.

Overall, I have assessed the Project to have negligible or low effects on water quality, stream erosion, and flooding.

Appendix A. Stormwater Management Area Flow and stream velocity calculations

The Indicative Design increases the impervious catchment which results in higher flow rates discharging to the receiving environment. To assess the effects off the higher flow rates, the stream velocities increases are calculated to determine the impact to stream erodibility.

Discharges have been assessed at the upper reaches of the streams, where channels are narrower and more prone to erosion. These assessments indicate that the resulting increases in flow velocity are negligible or low. To evaluate sensitivity, multiple locations along each stream were reviewed. It was observed that while the streams generally maintain a consistent cross-sectional profile, they tend to widen as they approach the CMA. As a result, the increase in velocities remains negligible or low along the full length of all assessed streams.

Increase in velocity calculation method

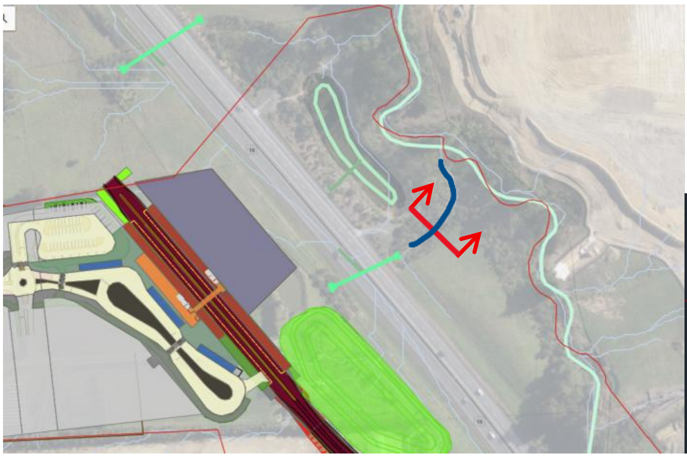
1. Determine if the discharge location is in a SMAF 1 or SMAF 2 area. If it is not in a SMAF area, is there more than 5000m^2 additional impervious surface contributing to an outfall directly discharging to a stream.
2. Determine 90th, 95th and 2 Year, 24-hour rainfall depths from Auckland Council GeoMaps at the locations of each outfall (25mm, 35mm and 83mm respectively).
3. Calculate the ratio between the 90th and 95th depths and the 2 Year rainfall depths (0.302 and 0.4212, respectively).
4. GEOMAPS provide the 2 Year Flow rates in streams. Scale the 2 Year flow rates in the streams by the ratio calculated in step 3 to determine the 95th and 90th percentile flow rates in the streams.
5. Calculate the flow from additional impervious surfaces contributing to the discharge location.
6. Draw cross-sections across the channel upstream, downstream and at the outfall location to determine a cross-sectional area and shape.
7. For streams with consistent cross-sectional shape and area, the potential for sensitive velocity-related impacts is considered low. In such cases, velocity assessments are conducted solely at the discharge (outfall) point. However, where channel geometry varies, additional cross-sectional evaluations are required both upstream and downstream to ensure accurate assessment of flow conditions.

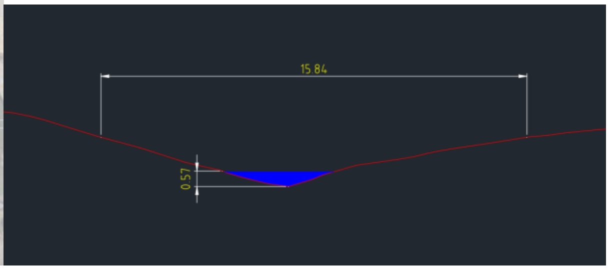
   In this assessment, all reviewed streams exhibited consistent cross-sectional characteristics. Therefore, velocity calculations were performed only at the respective outfall locations.
8. Calculate the grade of the channel.
9. Determine existing flow velocities in channels based on the flow rates calculated in step 3.
10. Determine flow velocities of additional impervious flow rates calculated in step 5.

Stream velocity increases results

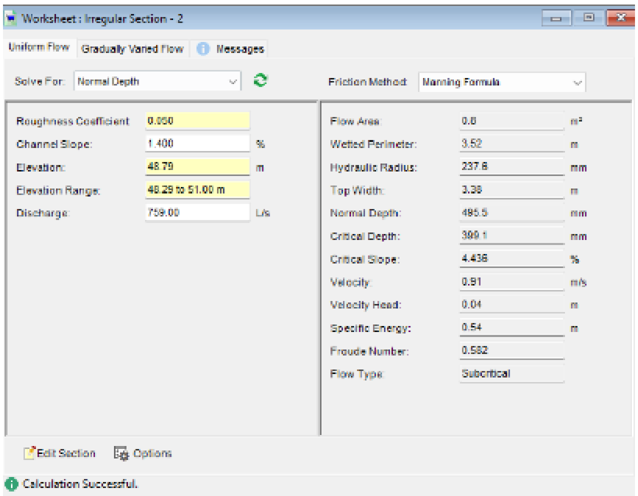
It has been determined that the following areas discharge water in either a SMAF zone or have additional impervious catchments greater than 5000m^2 that discharge directly to a stream: TA1, TA4, TA5, TA6, TA7, TA8 and TA9.

TA1 – Catchment > 5,000 m^2

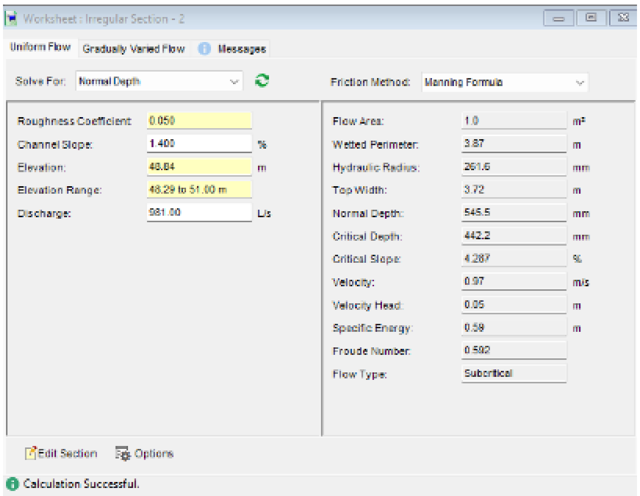




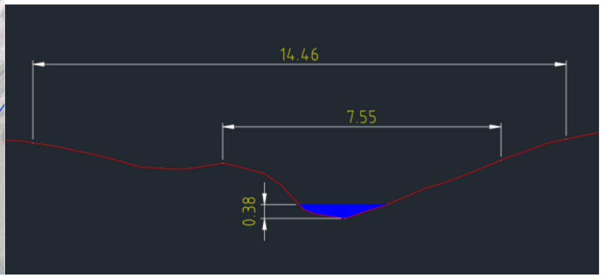
Existing



Proposed

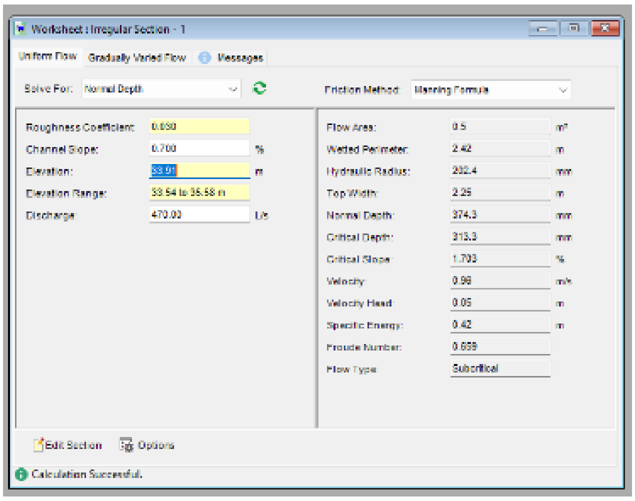


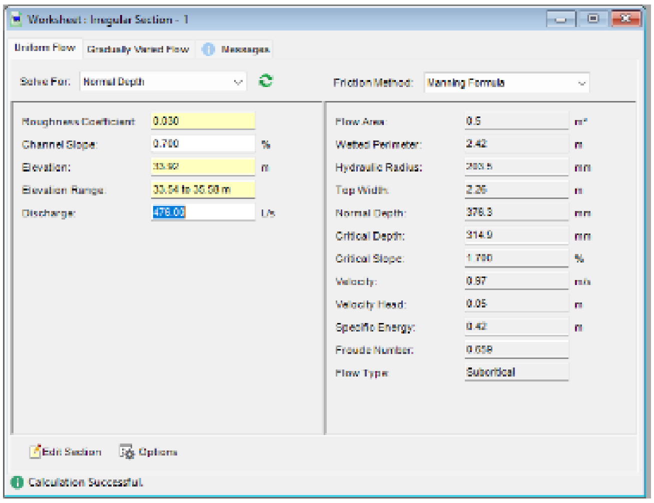
TA4 – Catchment > 5,000 m^2

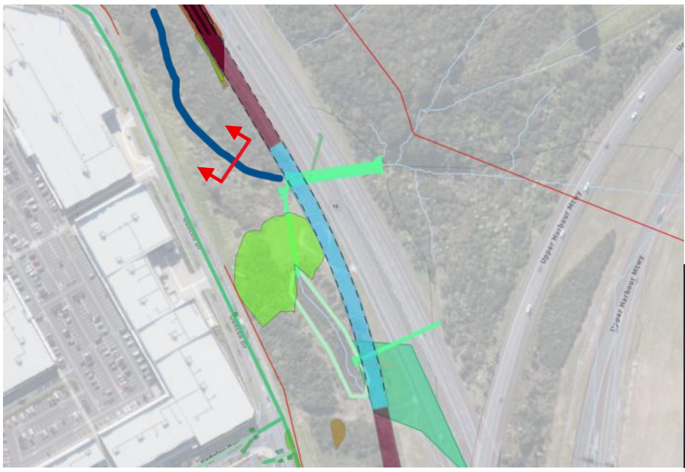
Existing

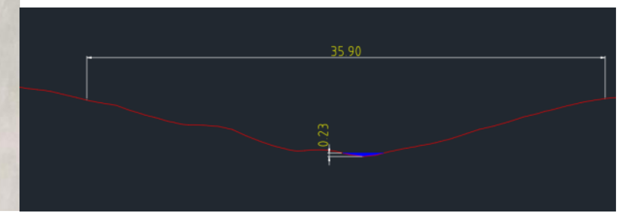
Proposed





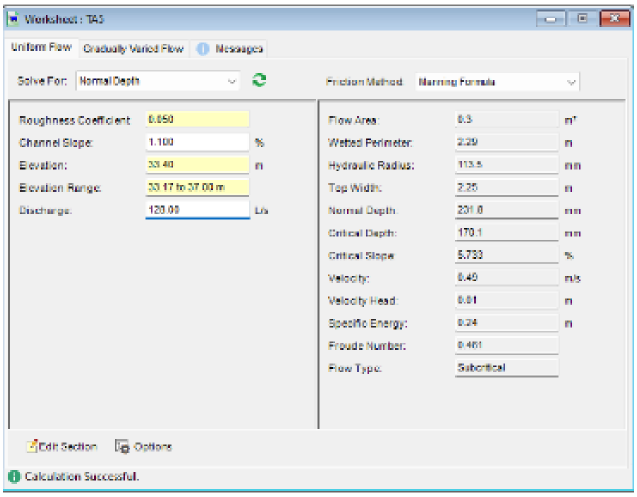
TA5 – Catchment > 5,000 m²





Existing

Proposed



Worksheet : TA5

Uniform Flow | Gradually Varied Flow | Messages

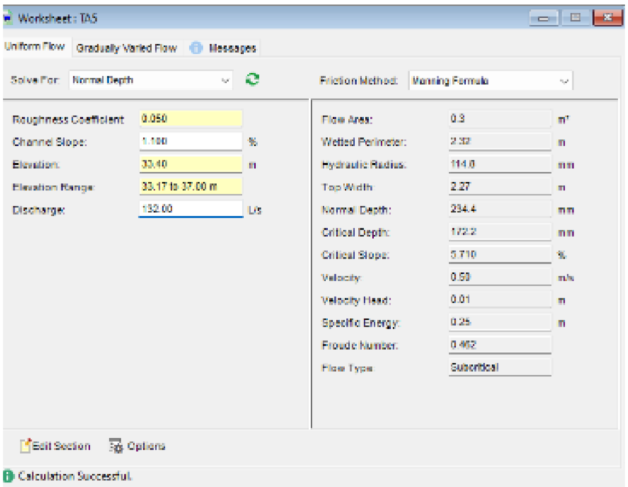
Solve For: Normal Depth — Friction Method: Manning Formula

Roughness Coefficient	0.050	
Channel Slope:	1.100	%
Elevation:	33.40	m
Elevation Range:	33.17 to 37.00 m	
Discharge:	120.00	L/s

Flow Area:	0.3	m²
Wetted Perimeter:	2.29	m
Hydraulic Radius:	113.5	mm
Top Width:	2.25	m
Normal Depth:	231.0	mm
Critical Depth:	170.1	mm
Critical Slope:	5.733	%
Velocity:	0.49	m/s
Velocity Head:	0.01	m
Specific Energy:	0.24	m
Froude Number:	0.461	
Flow Type:	Subcritical	

Edit Section | Options

Calculation Successful.



Worksheet : TA5

Uniform Flow | Gradually Varied Flow | Messages

Solve For: Normal Depth — Friction Method: Manning Formula

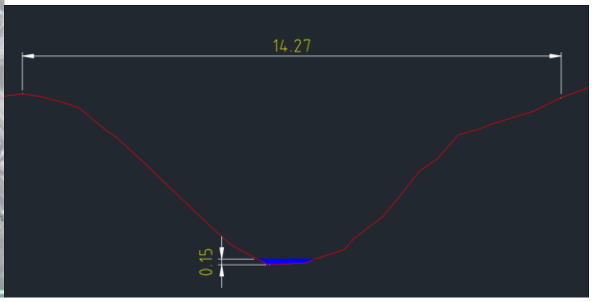
Roughness Coefficient	0.050	
Channel Slope:	1.100	%
Elevation:	33.40	m
Elevation Range:	33.17 to 37.00 m	
Discharge:	132.00	L/s

Flow Area:	0.3	m²
Wetted Perimeter:	2.32	m
Hydraulic Radius:	114.0	mm
Top Width:	2.27	m
Normal Depth:	234.4	mm
Critical Depth:	172.2	mm
Critical Slope:	5.710	%
Velocity:	0.50	m/s
Velocity Head:	0.01	m
Specific Energy:	0.25	m
Froude Number:	0.462	
Flow Type:	Subcritical	

Edit Section | Options

Calculation Successful.

TA6 – SMAF 2



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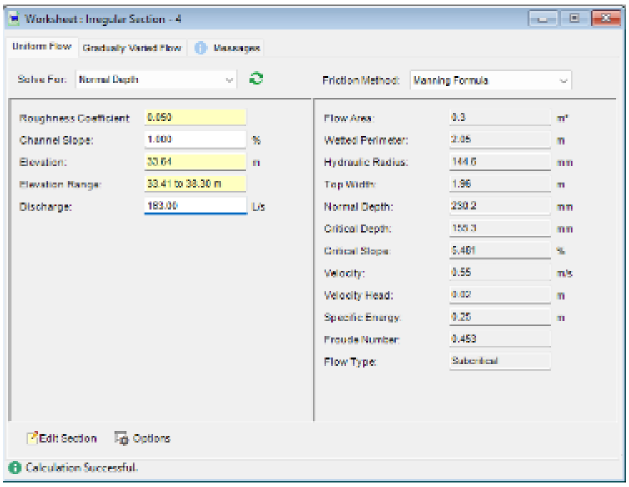

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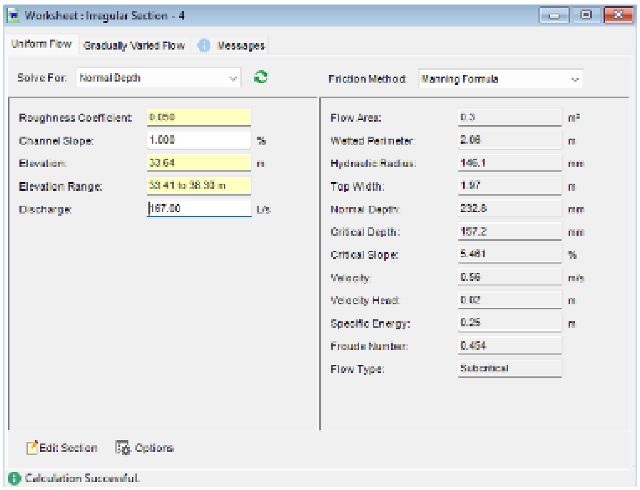
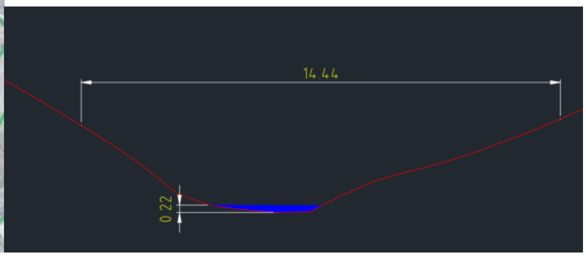
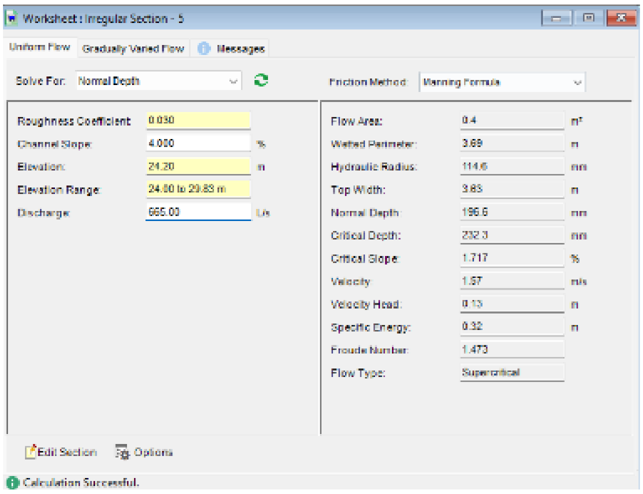


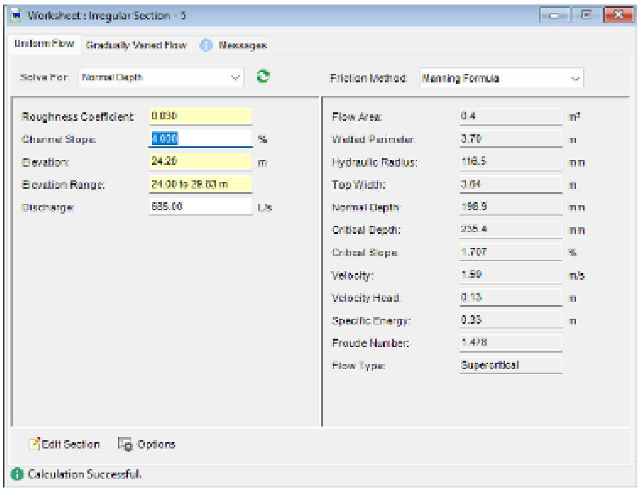
TA7 – SMAF 2



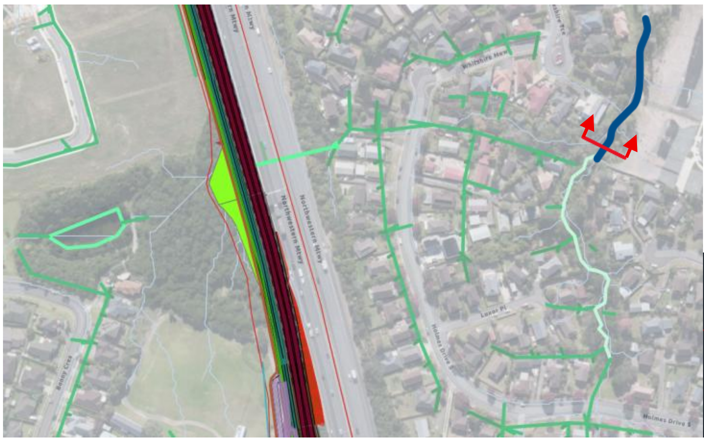
Existing

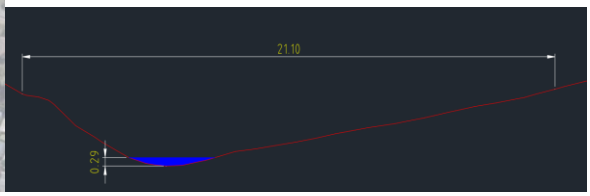
Proposed





TA8 – SMAF 2





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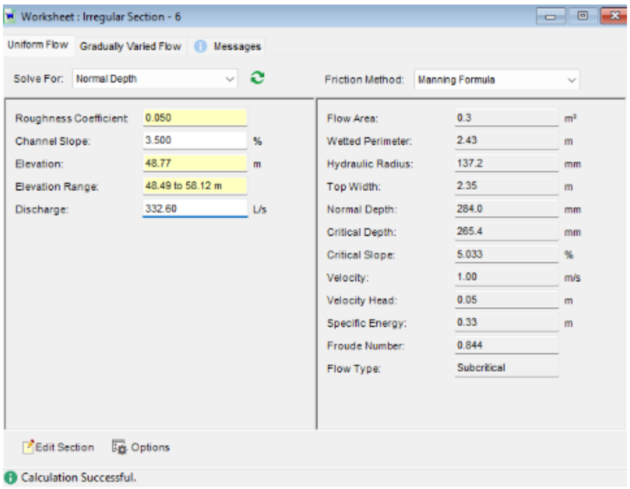


Worksheet : Irregular Section - 6

Uniform Flow | Gradually Varied Flow | Messages

Solve For: Normal Depth — Friction Method: Manning Formula

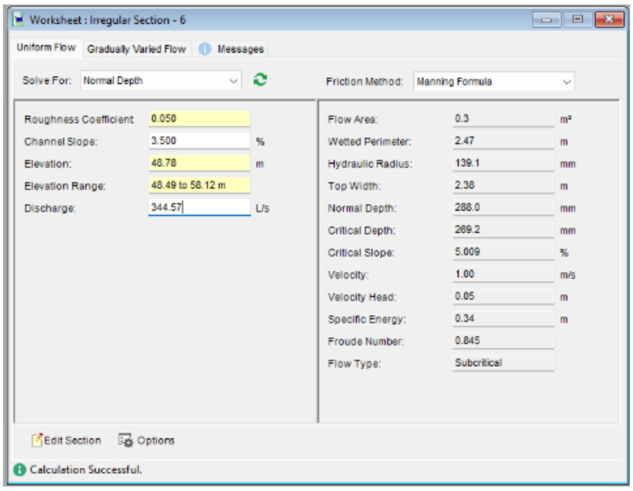
Roughness Coefficient	0.050	
Channel Slope:	3.500	%
Elevation:	48.77	m
Elevation Range:	48.49 to 58.12 m	
Discharge:	332.60	L/s

Flow Area:	0.3	m²
Wetted Perimeter:	2.43	m
Hydraulic Radius:	137.2	mm
Top Width:	2.35	m
Normal Depth:	284.0	mm
Critical Depth:	265.4	mm
Critical Slope:	5.033	%
Velocity:	1.00	m/s
Velocity Head:	0.05	m
Specific Energy:	0.33	m
Froude Number:	0.844	
Flow Type:	Subcritical	

Edit Section | Options

Calculation Successful.

Proposed



Worksheet : Irregular Section - 6

Uniform Flow | Gradually Varied Flow | Messages

Solve For: Normal Depth — Friction Method: Manning Formula

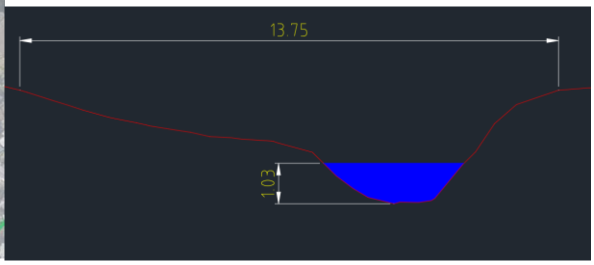
Roughness Coefficient	0.050	
Channel Slope:	3.500	%
Elevation:	48.78	m
Elevation Range:	48.49 to 58.12 m	
Discharge:	344.57	L/s

Flow Area:	0.3	m²
Wetted Perimeter:	2.47	m
Hydraulic Radius:	139.1	mm
Top Width:	2.38	m
Normal Depth:	288.0	mm
Critical Depth:	269.2	mm
Critical Slope:	5.009	%
Velocity:	1.00	m/s
Velocity Head:	0.05	m
Specific Energy:	0.34	m
Froude Number:	0.845	
Flow Type:	Subcritical	

Edit Section | Options

Calculation Successful.

TA9 – SMAF 2



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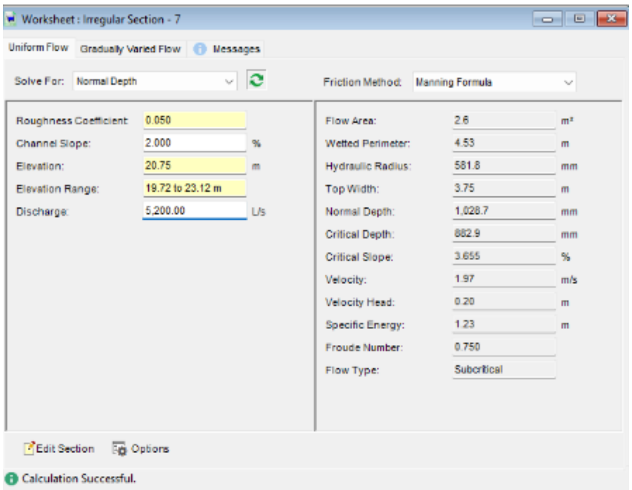


Worksheet : Irregular Section - 7

Uniform Flow | Gradually Varied Flow | Messages

Solve For: Normal Depth | Friction Method: Manning Formula

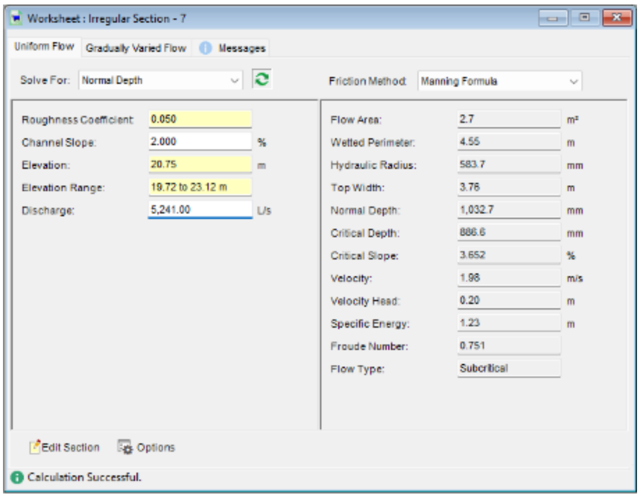
Roughness Coefficient:	0.050	
Channel Slope:	2.000	%
Elevation:	20.75	m
Elevation Range:	19.72 to 23.12 m	
Discharge:	5,200.00	L/s

Flow Area:	2.6	m²
Wetted Perimeter:	4.53	m
Hydraulic Radius:	581.8	mm
Top Width:	3.75	m
Normal Depth:	1,028.7	mm
Critical Depth:	882.9	mm
Critical Slope:	3.655	%
Velocity:	1.97	m/s
Velocity Head:	0.20	m
Specific Energy:	1.23	m
Froude Number:	0.750	
Flow Type:	Subcritical	

Edit Section | Options

Calculation Successful.

Proposed



Worksheet : Irregular Section - 7

Uniform Flow | Gradually Varied Flow | Messages

Solve For: Normal Depth | Friction Method: Manning Formula

Roughness Coefficient:	0.050	
Channel Slope:	2.000	%
Elevation:	20.75	m
Elevation Range:	19.72 to 23.12 m	
Discharge:	5,241.00	L/s

Flow Area:	2.7	m²
Wetted Perimeter:	4.55	m
Hydraulic Radius:	583.7	mm
Top Width:	3.76	m
Normal Depth:	1,032.7	mm
Critical Depth:	886.6	mm
Critical Slope:	3.652	%
Velocity:	1.98	m/s
Velocity Head:	0.20	m
Specific Energy:	1.23	m
Froude Number:	0.751	
Flow Type:	Subcritical	

Edit Section | Options

Calculation Successful.

Appendix B. Overland Flow Path and Treatment Area locations

Overland Flow Path	Change Start Point	Change End point	Requires Design Solution	Design Measure
1	N	Y	Y	Divert to the proposed culvert crossing along southern boundary of bus station to combine with OLFP 2, 5 and 6.
2	N	Y	Y	Divert to the proposed culvert crossing along southern boundary of bus station to combine with OLFP 1, 5 and 6.
3	Y	Y	N	Originates in the Proposed Designation. Captured by the Project station drainage.
4	Y	Y	N	Originates in the Proposed Designation. Captured by the Project station drainage.
5	N	Y	Y	Divert to the proposed culvert crossing along southern boundary of bus station to combine with OLFP 1, 2 and 6.
6	N	N	Y	Combine OLFP 1, 2, 5, and 6. Culvert under Proposed Designation and channel to existing end point of OLFP at the motorway culvert.
7	N	Y	Y	Channelise towards stream at the bridge where it joins OLFPs 8–10.
8	N	N	N	Not changed.
9	N	N	N	Not changed.
10	N	N	N	Not changed.
10a	N	N	Y	Channelise the excess flood water from SC1 to the stream.
11	N	Y	Y	Originates on motorway. To be piped via modification to motorway drainage.
12	N	Y	Y	Originates on motorway. To be piped via modification to motorway drainage.
SC 1	N	N	Y	Dual 1800mm and 1200mm diameter culvert extension in main gully and diversion of excess flood water to OLFP 10a and eventually to the stream via a proposed pipe and channel.
13	Y	Y	Y	Motorway drainage swale. Modification to motorway drainage required.
14	N/A	N/A	N/A	Indicative Design is bridged.
SC 2	N	N	N	Indicative Design is bridged.
15	N	N	N	No mitigation required
16	Y	N	Y	The OLFP should not join OLFP 15 at the toe of the bridge abutment batter. See Westgate design for culvert option.
17	N	N	N	Indicative Design is bridged over the OLFP.
18	N	N	N	Indicative Design is bridged over the OLFP.
19	N	N	N	Indicative Design is bridged over the OLFP.
20	N	N	N	Indicative Design is bridged over the OLFP.
SC 3	N	N	N	Indicative Design is bridged. Possible culvert extension in main gully to be confirmed
21	N	N	N	Project Indicative Design is bridged where OLFP crosses the Project. Upstream section of the OLFP catchment is replaced and captured by Project drainage
SC 4	Y	N	Y	Possible culvert extension in main gully.
22	N	N	Y	Originate on motorway. To be piped via modification to motorway drainage.
SC 5	Y	N	Y	Culvert extension in main gully.
23	N	N	Y	Originate on motorway. To be piped via modification to motorway drainage.
24	N	N	Y	Bus way is bridged for one section. To be piped underneath motorway off-ramp.
25	N	N	N	No mitigation required.

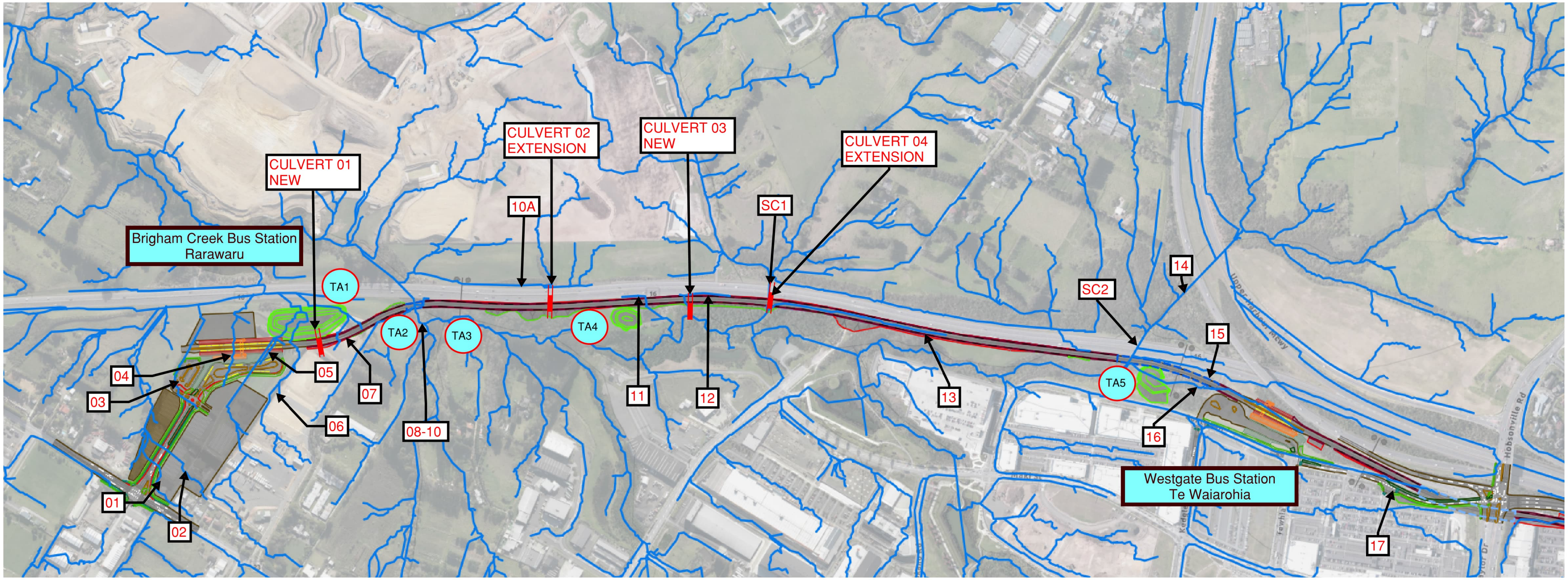
Overland Flow Path	Change Start Point	Change End point	Requires Design Solution	Design Measure
SC 6	N	N	Y	Culvert extension required.
26	N	N	N	Motorway drainage. Indicative Design bridge in this location. No mitigation required.
SC 7	N	N	N	The Indicative Design is bridged over OLFP.
27	N	N	Y	Flooding is confined within the Proposed Designation boundary and released slowly to the existing pipe, crossing the motorway. An additional drainage inlet may be required to be connected to the existing manhole.
28	N	N	N	Flooding is confined within the Proposed Designation boundary and released slowly to the existing pipe, crossing the motorway.
29	N	N	N	Flooding is confined within the Proposed Designation boundary and released slowly to the existing culvert, crossing the motorway.
30	N	Y	Y	Originates from motorway. To be piped via modification to motorway drainage. Note that the current Indicative Design covers the existing wetland. If this section is bridged, then no mitigation is required.
SC 8	N	N	Y	Culvert extension.
31	N	Y	Y	To be channelled or piped and combined with OLFP 28 and 29 on southern side of the Indicative Design to CMA. Note that the current Indicative Design covers the existing wetland. If this section is bridged, then no mitigation is required.
32	N	N	Y	Originate on motorway ramp. Design bridge to allow overland flow to still get to CMA.
33	Y	Y	N	Originates in Project site. Captured by Project station drainage.
34 A	N	N	N	Not affected.
34	N	Y	Y	To be piped on the southern side of the Proposed Designation to join OLFP 35, and 36-39 to the CMA.
35	N	Y	Y	To be piped on the southern side of the Proposed Designation to join OLFP 34 and 36-39 to the CMA.
36	N	Y	Y	To be piped on the southern side of the Proposed Designation to join OLFP 34, 35 and 36-39 to the CMA.
37	N	Y	Y	To be piped on the southern side of the Proposed Designation to join OLFP 34, 35 and 36-39 to the CMA.
38	N	Y	Y	To be piped on the southern side of the Proposed Designation to join OLFP 34, 35 and 36-39 to the CMA.
39	N	Y	Y	To be piped on the southern side of the Proposed Designation to join OLFP 34, 35 and 36-39 to the CMA.
40	N	Y	Y	To be piped on the southern side of the Proposed Designation to join OLFP 41 to 49 to the CMA.
41	N	Y	Y	To be piped on the southern side of the Proposed Designation to join OLFP 40 and 42 to 49 to the CMA.
42	N	Y	Y	To be piped on the southern side of the Proposed Designation to join OLFP 40, 41 and 43 to 49 to the CMA.
43	N	Y	Y	To be piped on the southern side of the Proposed Designation to join OLFP 40 to 42 and 44 to 49 to the CMA.
44	N	Y	Y	To be piped on the southern side of the Proposed Designation to join OLFP 40 to 43 and 45 to 49 to the CMA.
45	N	Y	Y	To be piped on the southern side of the Proposed Designation to join OLFP 40 to 44 and 46 to 49 to the CMA.
46	N	Y	Y	To be piped on the southern side of the Proposed Designation to join OLFP 40 to 45 and 47 to 49 to the CMA.
47	N	Y	Y	To be piped on the southern side of the Proposed Designation to join OLFP 40 to 46 and 48 to 49 to the CMA.
48	N	Y	Y	To be piped on the southern side of the Proposed Designation to join OLFP 40 to 47 and 49 to the CMA.
49	N	N	Y	To be piped on the southern side of the Proposed Designation to join OLFP 40 to 48 to the CMA.
50	N	Y	Y	Pipe to CMA.

Overland Flow Path	Change Start Point	Change End point	Requires Design Solution	Design Measure
51	N	Y	Y	Proposed culvert crossing.
52	N	N	N	Not affected.
52A	N	N	N	Not affected.
52B	N	N	N	Not affected.
53	N	N	N	Not affected.
54	N	Y	Y	Originates in Proposed Designation. Captured by Project station drainage.
54A	Y	Y	Y	Originates in Proposed Designation. Captured by Project station drainage.
55	N	N	Y	To be channelled on the northern side of the Proposed Designation to join OLFP 56 to 60 to the CMA.
56	N	N	Y	To be channelled on northern side of the Proposed Designation to join OLFP 55 and 56 to 60 to the CMA.
57	N	N	Y	To be channelled on the northern side of the Proposed Designation to join OLFP 55 to 56 and 58 to 60 to the CMA.
58	N	N	Y	To be channelled on the northern side of the Proposed Designation to join OLFP 55 to 57 and 59 to 60 to the CMA.
59	N	N	Y	To be channelled on the northern side of the Proposed Designation to join OLFP 55 to 58 and 60 to the CMA.
60	N	N	Y	To be channelled on the northern side of the Proposed Designation to join OLFP 55 to 59 to the CMA.
SC 9	N	N	Y	The Indicative Design is bridged over the OLFP. Possible Culvert extension.
61	N	N	N	The Indicative Design is bridged over the OLFP.
62	N	N	N	The Indicative Design is bridged over the OLFP.
62A	N	Y	Y	Impacted by the Project’s station design. To be captured by project station drainage.
63	N	Y	Y	To be connected to the proposed pipe on the northern side of the Project that outfalls to the existing manhole with 3060mm dia. pipe
64	N	Y	Y	To be connected to the proposed pipe on the northern side of the Project that outfalls to the existing manhole with 3060mm dia. pipe
65	Y	Y	Y	To be connected to the proposed pipe on the northern side of the Project that outfalls to the existing manhole with 3060mm dia. pipe
66	Y	Y	Y	To be connected to the proposed pipe on the northern side of the Project that outfalls to the existing manhole with 3060mm dia. pipe
67	N	Y	Y	To be connected to the proposed pipe on the northern side of the Project that outfalls to the existing manhole with 3060mm dia. pipe
68	N	Y	Y	To be connected to the proposed pipe on the northern side of the Project that outfalls to the existing manhole with 3060mm dia. pipe
69	N	Y	Y	To be connected to the proposed pipe on the northern side of the project that outfalls to the existing manhole with 3060mm dia. pipe
70	N	Y	Y	To be connected to the proposed pipe on the northern side of the Project that outfalls to the existing manhole with 3060mm dia. pipe
71	N	Y	Y	To be connected to the proposed pipe on the northern side of the Project that outfalls to the existing manhole with 3060mm dia. pipe
72	N	Y	Y	To be connected to the proposed pipe on the northern side of the Project that outfalls to the existing manhole with 3060mm dia. pipe
73	N	Y	Y	To be connected to the proposed pipe on the northern side of the Project that outfalls to the existing manhole with 3060mm dia. pipe
74	N	Y	Y	To be connected to the proposed pipe on the northern side of the Project that outfalls to the existing manhole with 3060mm dia. pipe
75	N	Y	Y	To be connected to the proposed pipe on the northern side of the Project that outfalls to the existing manhole with 3060mm dia. pipe
76	N	Y	Y	To be connected to the proposed pipe on the northern side of the Project that outfalls to the existing manhole with 3060mm dia. pipe

Overland Flow Path	Change Start Point	Change End point	Requires Design Solution	Design Measure
77	N	Y	Y	To be connected to the proposed pipe on the northern side of the Project that outfalls to the existing manhole with 3060mm dia. pipe
78	N	Y	Y	To be connected to the proposed pipe on the northern side of the Project that outfalls to the existing manhole with 3060mm dia. pipe
79	N	Y	Y	To be connected to the proposed pipe on the northern side of the Project that outfalls to the existing manhole with 3060mm dia. pipe
80	N	Y	Y	To be connected to the proposed pipe on the northern side of the Project that outfalls to the existing manhole with 3060mm dia. pipe
81	N	Y	Y	To be connected to the proposed pipe on the northern side of the Project that outfalls to the existing manhole with 3060mm dia. pipe
82	N	N	N	Project is bridged over the OLFP.
83	N	N	N	Indicative Design is bridged over the OLFP.
84	N	N	N	Indicative Design is bridged over the OLFP.
85	N	N	N	Indicative Design is bridged over the OLFP.
86	N	N	N	Indicative Design is bridged over the OLFP.
87	N	Y	Y	To be piped on the southern side of the Indicative Design and connected to existing network
88	N	Y	Y	To be piped on the southern side of the Indicative Design and connected to existing network.

NOTE

THE BUSWAY ALIGNMENT IS NOT FINAL BUT PROVIDES CONTEXT TO THE LOCATIONS OF THE OVERLAND FLOW PATHS



LEGEND

SCX CULVERT STREAM CROSSING

XX OLFP NUMBER

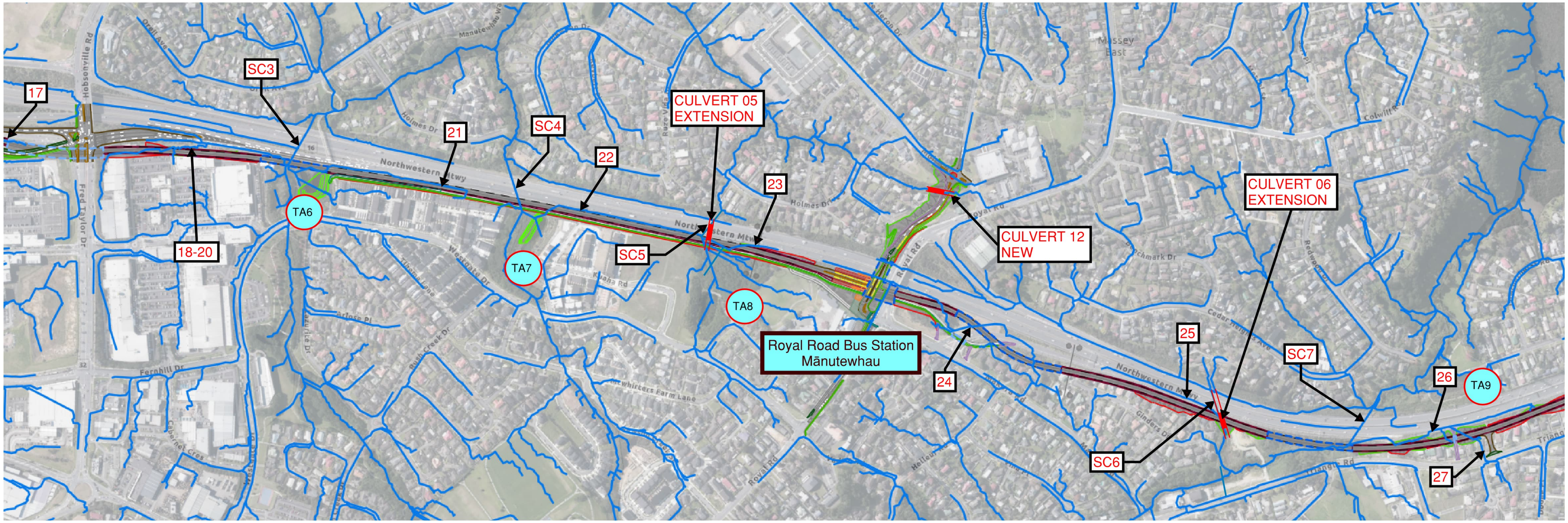
XX TREATMENT AREA

DESCRIPTION:	SCALE:	CLIENT/NAME LOGO:	PROJECT NAME/DRAWING TITLE
	N.T.S	NZ TRANSPORT AGENCY WAKA KOTAHI	NORTHWEST BUSWAY DETAILED BUSINESS CASE OVERLAND FLOW PATHS

DRAWN:	SIZE: A3	COORDINATE SYSTEM: (NZTM2000)	PRINT DATE: 29-07-2025	PROJECT No:	DRAWING No: SHEET 1

NOTE

THE BUSWAY ALIGNMENT IS NOT FINAL BUT PROVIDES CONTEXT TO THE LOCATIONS OF THE OVERLAND FLOW PATHS



LEGEND

SCX CULVERT STREAM CROSSING

XX OLFP NUMBER

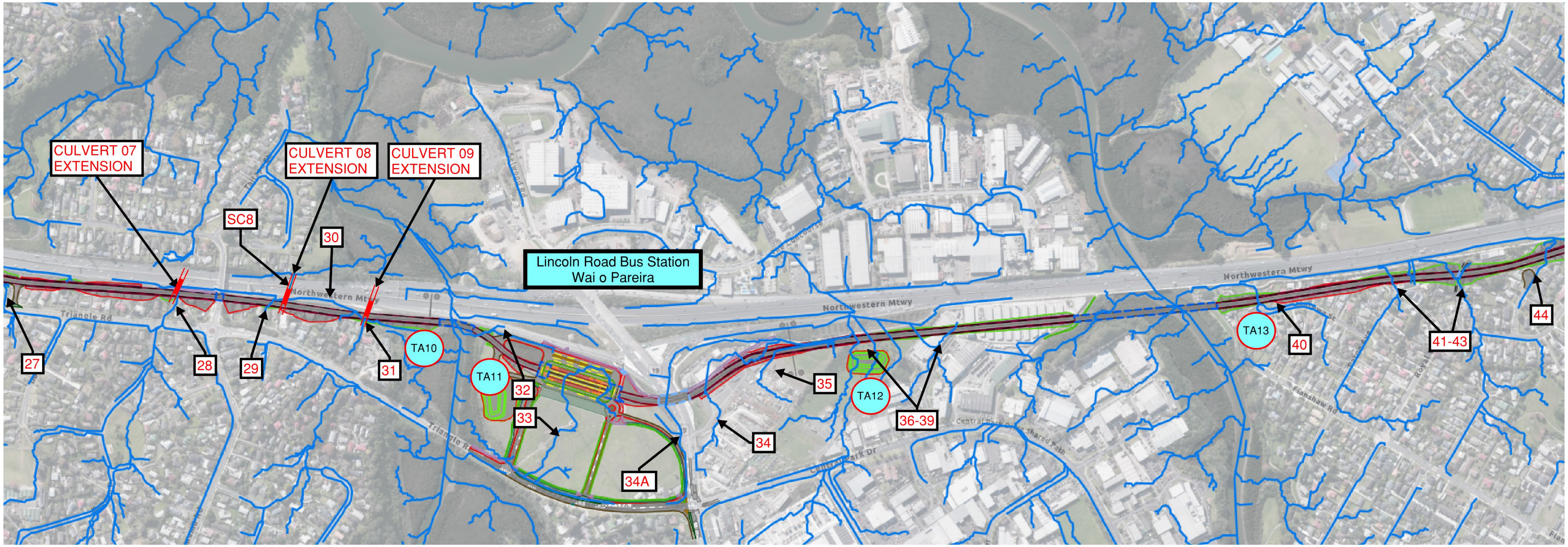
XX TREATMENT AREA

DESCRIPTION:	SCALE:	CLIENT/NAME LOGO:	PROJECT NAME/DRAWING TITLE
	N.T.S	NZ TRANSPORT AGENCY WAKA KOTAHI	NORTHWEST BUSWAY DETAILED BUSINESS CASE OVERLAND FLOW PATHS

DRAWN:	SIZE: A3	COORDINATE SYSTEM: (NZTM2000)	PRINT DATE: 29-07-2025	PROJECT No:	DRAWING No: SHEET 2

NOTE

THE BUSWAY ALIGNMENT IS NOT FINAL BUT PROVIDES CONTEXT TO THE LOCATIONS OF THE OVERLAND FLOW PATHS



LEGEND

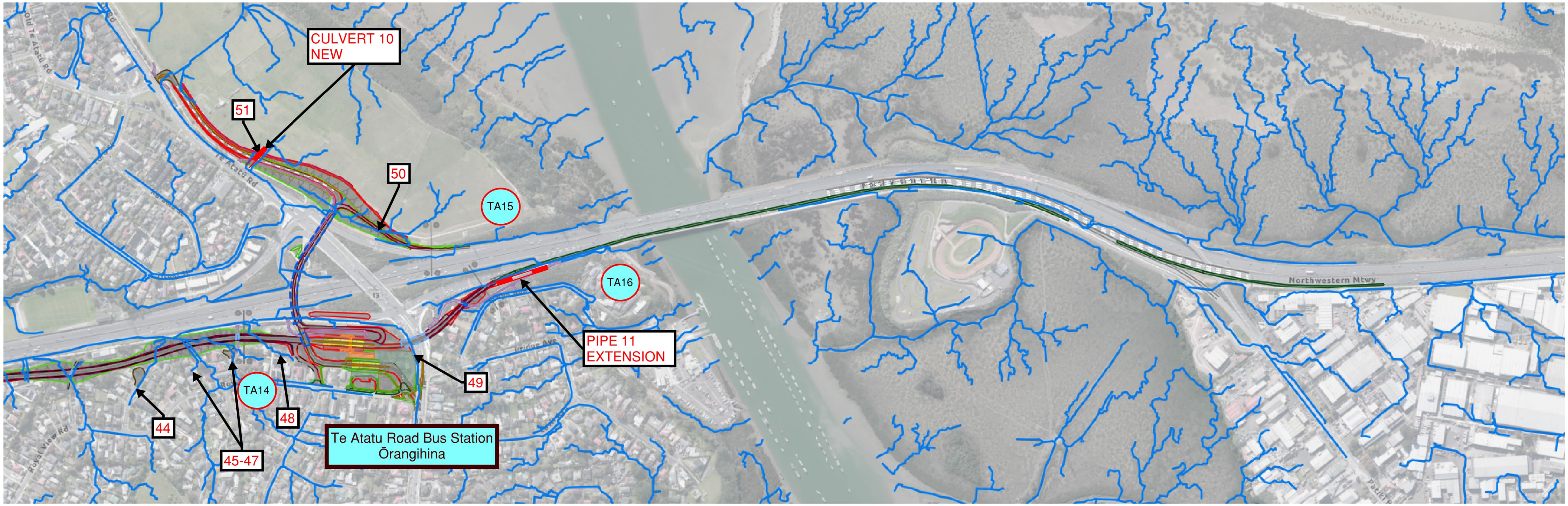
SCX	CULVERT STREAM CROSSING
XX	OLFP NUMBER
XX	TREATMENT AREA

DESCRIPTION:	SCALE:	CLIENT/NAME LOGO:	PROJECT NAME/DRAWING TITLE
	N.T.S	NZ TRANSPORT AGENCY WAKA KOTAHI	NORTHWEST BUSWAY DETAILED BUSINESS CASE OVERLAND FLOW PATHS

DRAWN:	SIZE: A3	COORDINATE SYSTEM: (NZTM2000)	PRINT DATE: 29-07-2025	PROJECT No:	DRAWING No: SHEET 3

NOTE

THE BUSWAY ALIGNMENT IS NOT FINAL BUT PROVIDES CONTEXT TO THE LOCATIONS OF THE OVERLAND FLOW PATHS



LEGEND

SCX — CULVERT STREAM CROSSING

XX — OLFP NUMBER

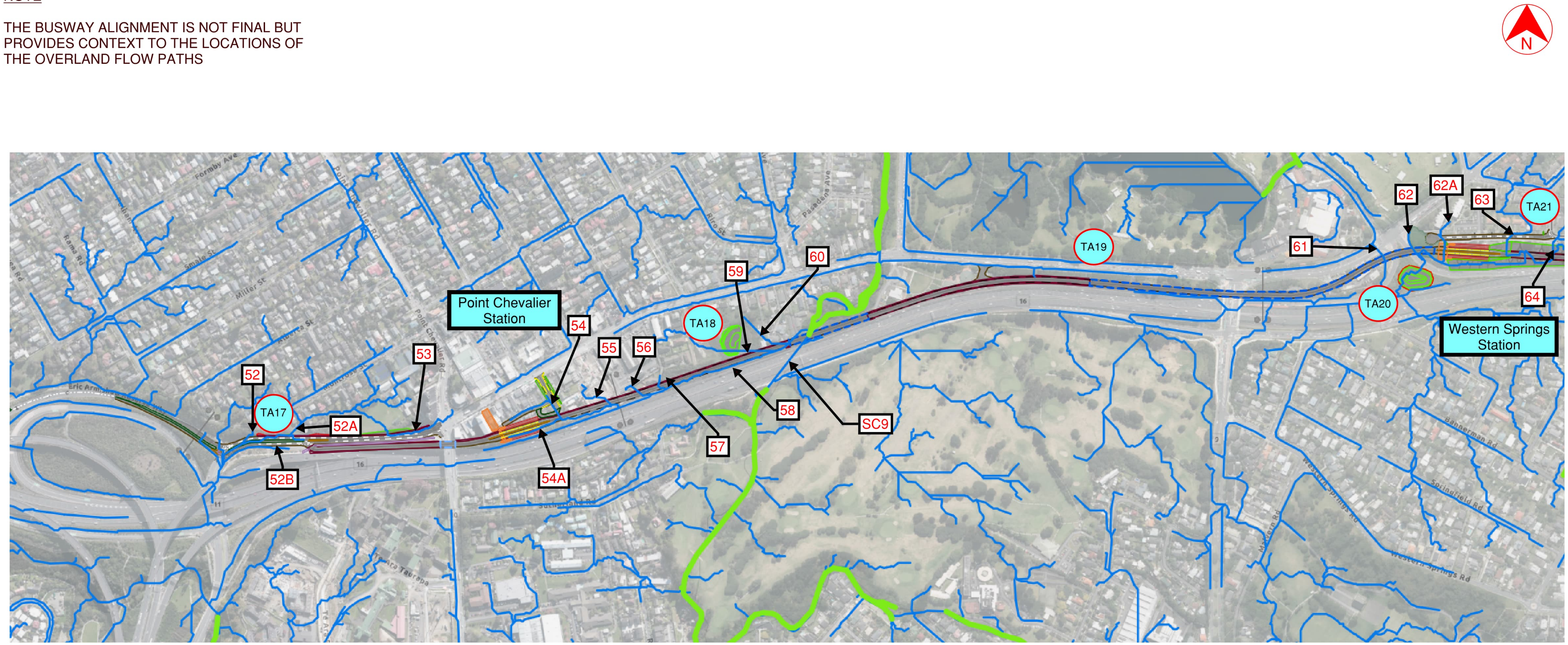
XX — TREATMENT AREA

DESCRIPTION:	SCALE:	CLIENT/NAME LOGO:	PROJECT NAME/DRAWING TITLE
	N.T.S	NZ TRANSPORT AGENCY WAKA KOTAHI	NORTHWEST BUSWAY DETAILED BUSINESS CASE OVERLAND FLOW PATHS

DRAWN:	SIZE: A3	COORDINATE SYSTEM: (NZTM2000)	PRINT DATE: 29-07-2025	PROJECT No:	DRAWING No: SHEET 4

NOTE

THE BUSWAY ALIGNMENT IS NOT FINAL BUT PROVIDES CONTEXT TO THE LOCATIONS OF THE OVERLAND FLOW PATHS



LEGEND

SCX CULVERT STREAM CROSSING

XX OLFP NUMBER

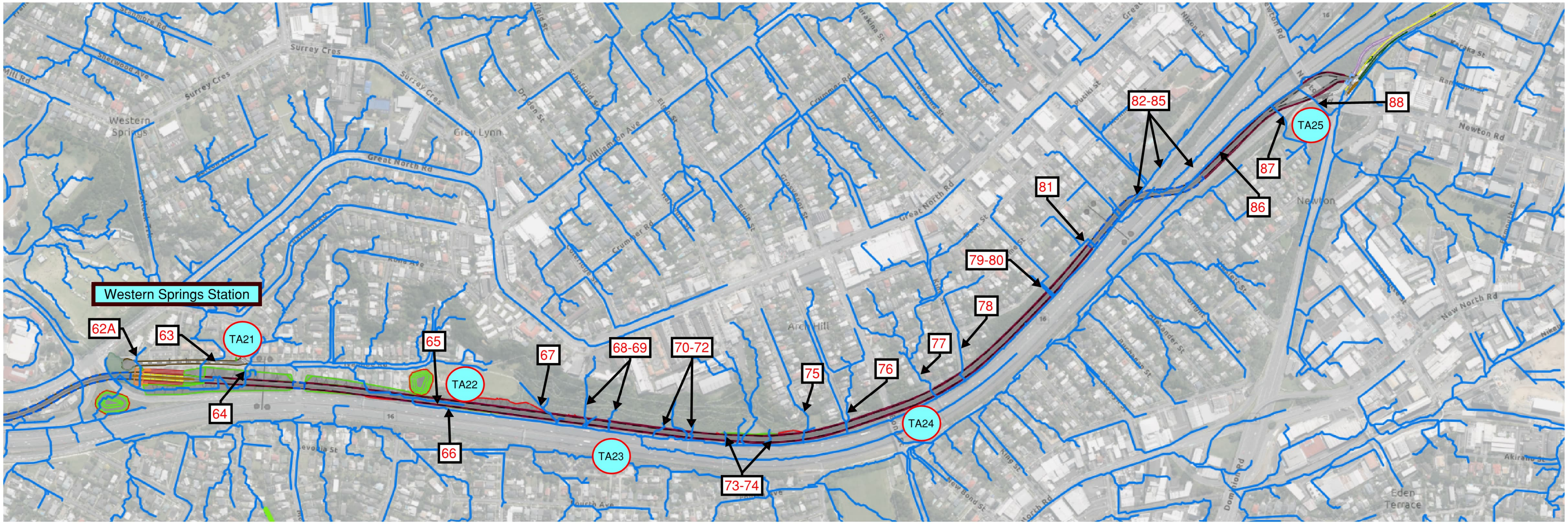
XX TREATMENT AREA

DESCRIPTION:	SCALE:	CLIENT/NAME LOGO:	PROJECT NAME/DRAWING TITLE
	N.T.S	NZ TRANSPORT AGENCY WAKA KOTAHI	NORTHWEST BUSWAY DETAILED BUSINESS CASE OVERLAND FLOW PATHS

DRAWN:	SIZE: A3	COORDINATE SYSTEM: (NZTM2000)	PRINT DATE: 29-07-2025	PROJECT No:	DRAWING No: SHEET 5

NOTE

THE BUSWAY ALIGNMENT IS NOT FINAL BUT PROVIDES CONTEXT TO THE LOCATIONS OF THE OVERLAND FLOW PATHS



LEGEND

SCX CULVERT STREAM CROSSING

XX OLFP NUMBER

XX TREATMENT AREA

DESCRIPTION:	SCALE:	CLIENT/NAME LOGO:	PROJECT NAME/DRAWING TITLE
	N.T.S	NZ TRANSPORT AGENCY WAKA KOTAHI	NORTHWEST BUSWAY DETAILED BUSINESS CASE OVERLAND FLOW PATHS

DRAWN:	SIZE: A3	COORDINATE SYSTEM: (NZTM2000)	PRINT DATE: 29-07-2025	PROJECT No:	DRAWING No: SHEET 6