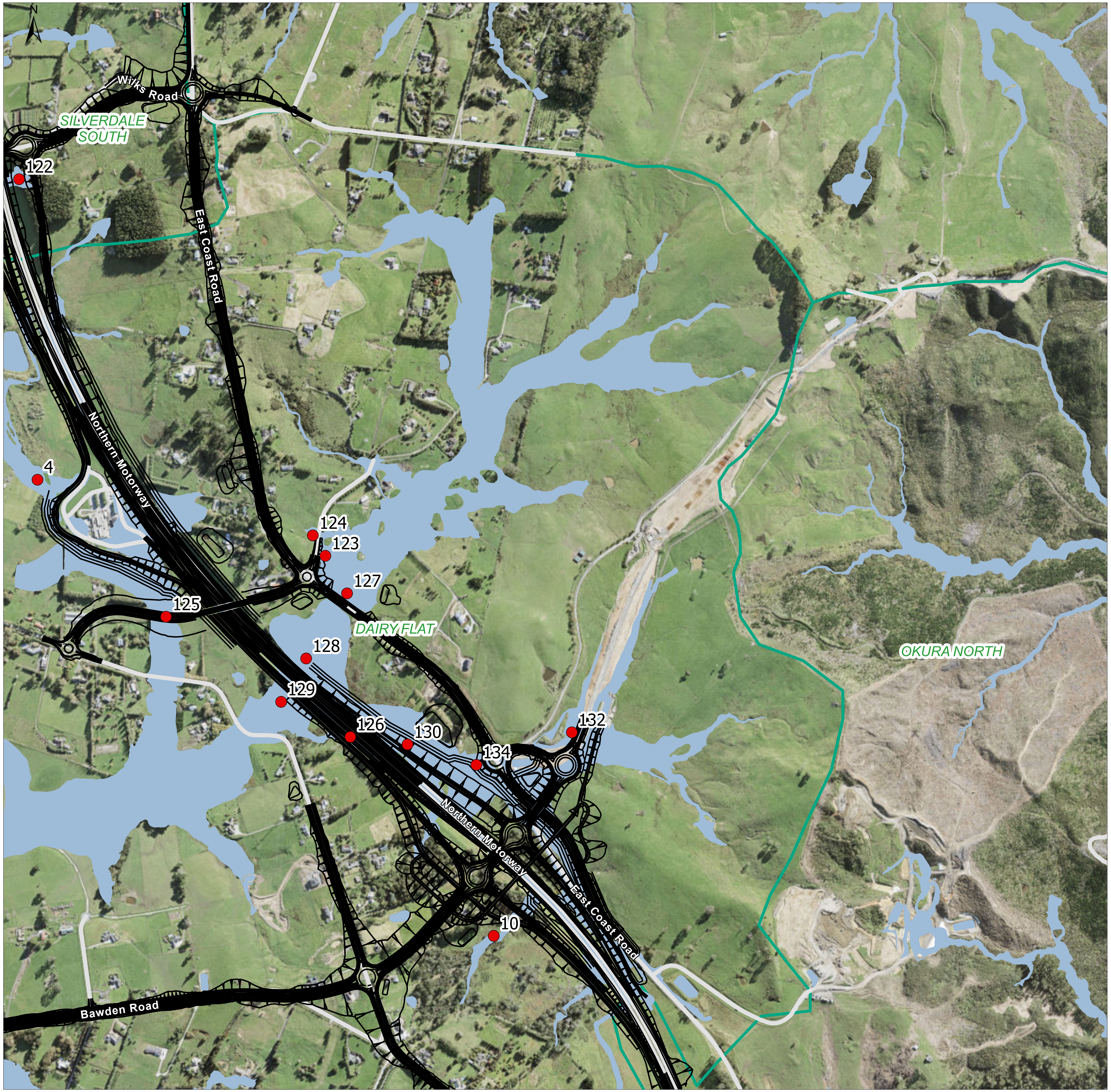


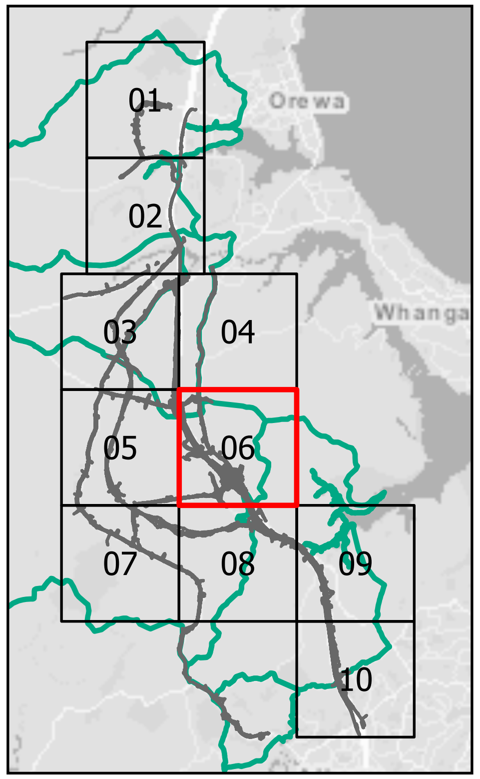

| ID | 100yr 2.1CC Water Level | 100yr 3.8CC Water Level |
|---|---|---|
| 4 | 46.80 | 46.90 |
| 10 | 60.37 | 60.42 |
| 122 | 60.44 | 60.48 |
| 123 | 47.56 | 47.69 |
| 124 | 47.56 | 47.69 |
| 125 | 43.32 | 43.46 |
| 126 | 45.02 | 45.11 |
| 127 | 47.55 | 47.68 |
| 128 | 45.55 | 45.78 |
| 129 | 43.75 | 44.06 |
| 130 | 45.93 | 46.14 |
| 132 | 51.13 | 51.47 |
| 134 | 47.10 | 47.23 |

# Supporting Growth

SGA North pre Project (base case) future 100yr predicted water levels

## Legend

- Pre Project flood level location
- SGA Alignment
- Existing Road
- 2023 AC Geomaps 100yr 3.8° climate change flood plain
- Stormwater Catchments
- New Zealand Imagery

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Map Scale @ A3:1:10,000

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TE TUPU NGĀTAHI
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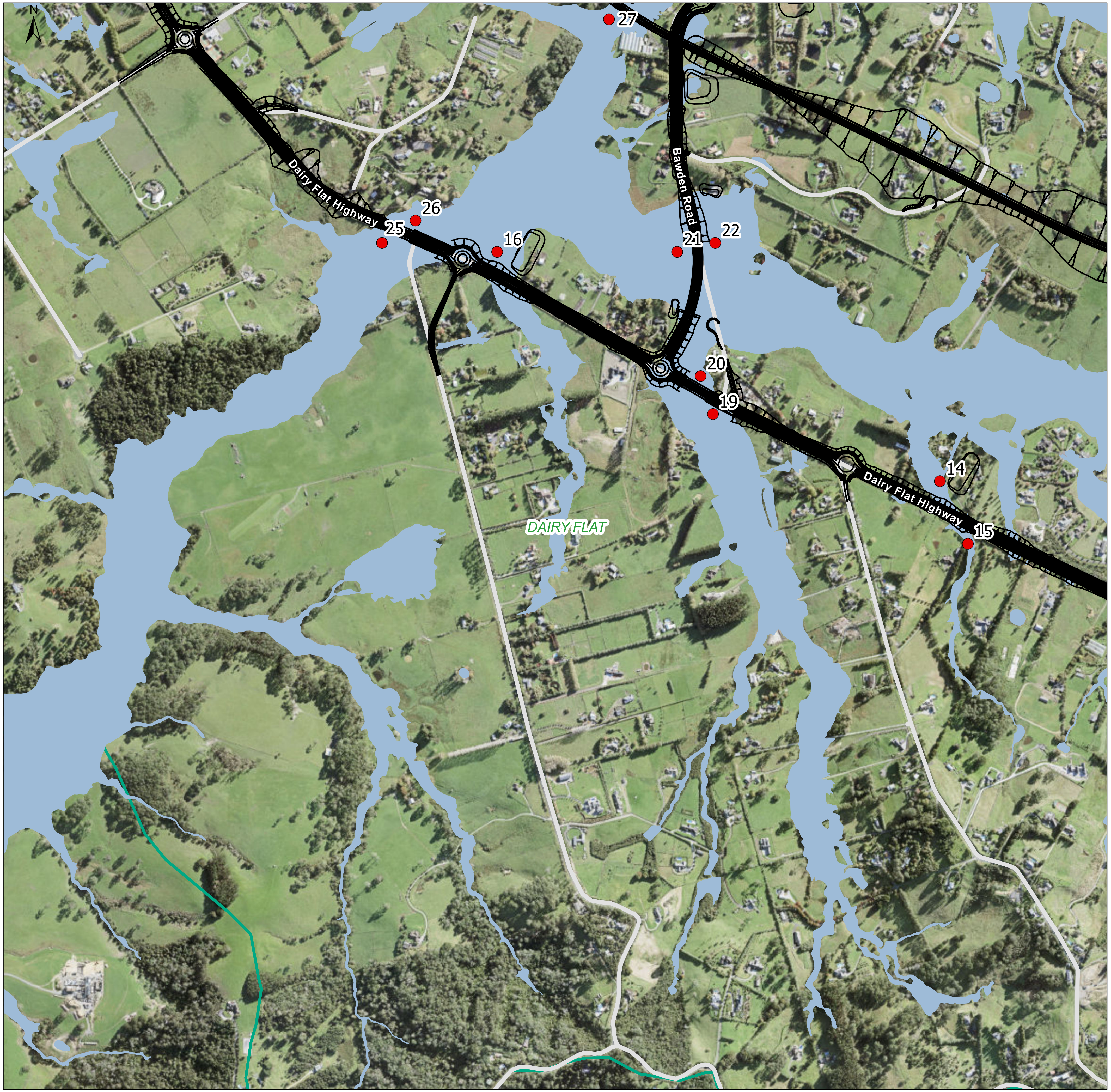


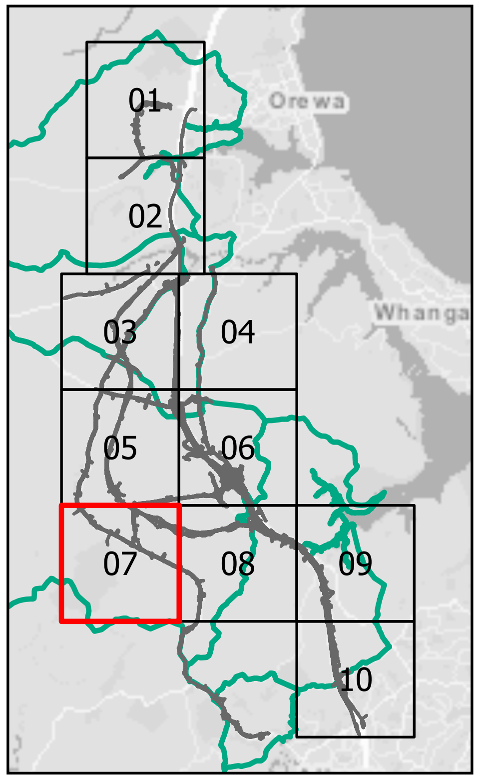

| ID | 100yr 2.1CC Water Level | 100yr 3.8CC Water Level |
|---|---|---|
| 14 | 41.22 | 41.29 |
| 15 | 44.62 | 44.66 |
| 16 | 35.43 | 35.74 |
| 19 | 38.33 | 38.46 |
| 20 | 37.35 | 37.44 |
| 21 | 35.74 | 36.06 |
| 22 | 35.75 | 36.08 |
| 25 | 33.12 | 33.67 |
| 26 | 35.28 | 35.52 |
| 27 | 35.81 | 36.21 |
| 28 | 35.94 | 36.37 |

# Supporting Growth

SGA North pre Project (base case) future 100yr predicted water levels

## Legend

- Pre Project flood level location
- SGA Alignment
- Existing Road
- 2023 AC Geomaps 100yr 3.8° climate change flood plain
- Stormwater Catchments
- New Zealand Imagery






Map Scale @ A3:1:10,000

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TE TUPU NGĀTAHI
SUPPORTING GROWTH
WAKA KOTAHI

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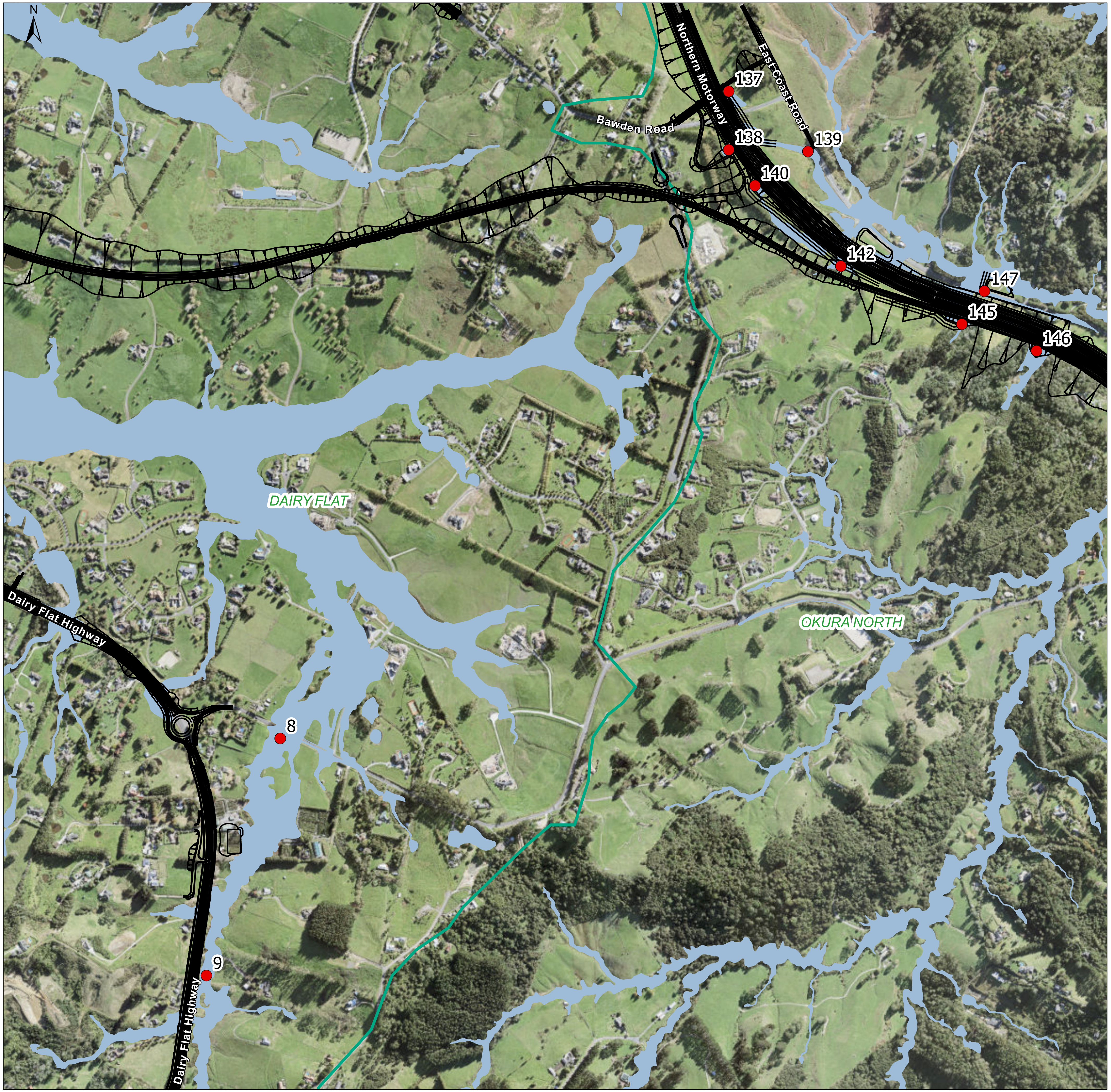
Name: SGA_FHM_North



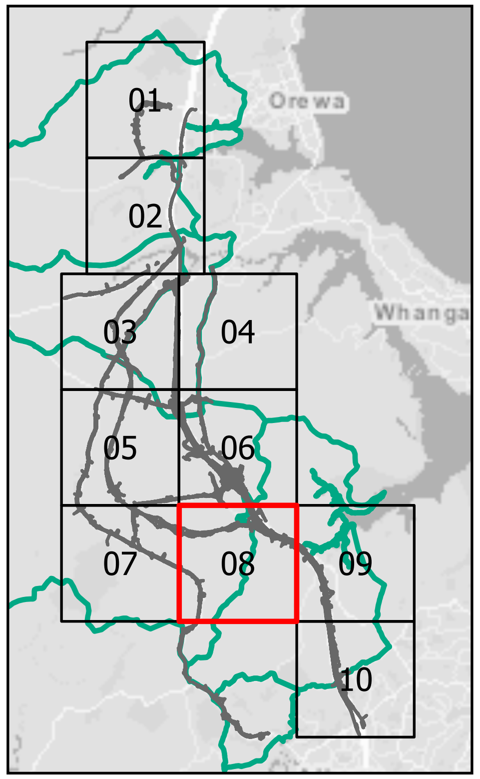

| ID | 100yr 2.1CC Water Level | 100yr 3.8CC Water Level |
|---|---|---|
| 8 | 51.42 | 51.52 |
| 9 | 60.31 | 60.50 |
| 137 | 49.00 | 49.03 |
| 138 | 46.80 | 46.81 |
| 139 | 30.88 | 30.91 |
| 140 | 37.40 | 37.47 |
| 142 | 31.09 | 31.46 |
| 145 | 25.89 | 25.94 |
| 146 | 23.81 | 24.15 |
| 147 | 20.61 | 20.62 |

# Supporting Growth

SGA North pre Project (base case) future 100yr predicted water levels

## Legend

- Pre Project flood level location
- SGA Alignment
- Existing Road
- 2023 AC Geomaps 100yr 3.8° climate change flood plain
- Stormwater Catchments
- New Zealand Imagery

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Map Scale @ A3:1:10,000

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Name: SGA_FHM_North

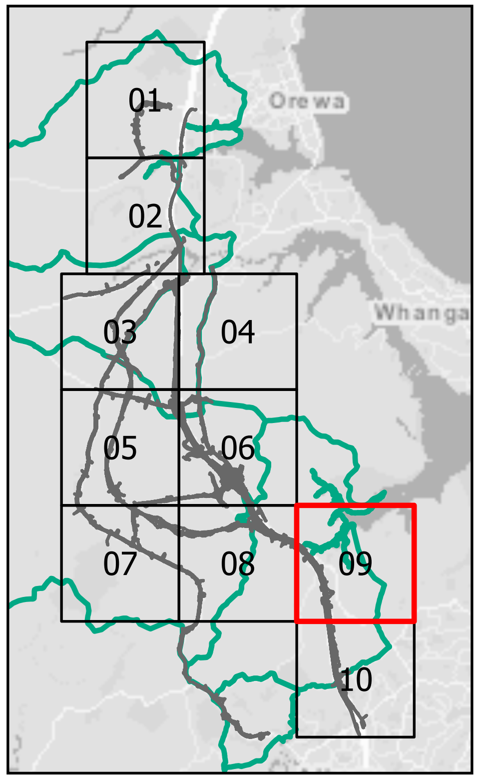
| ID | 100yr 2.1CC Water Level | 100yr 3.8CC Water Level |
|---|---|---|
| 148 | 6.20 | 6.57 |
| 149 | 5.53 | 5.85 |
| 150 | 13.80 | 13.82 |
| 152 | 13.76 | 14.41 |
| 154 | 14.32 | 14.75 |
| 155 | 21.18 | 21.22 |
| 157 | 17.07 | 17.13 |
| 158 | 21.97 | 22.09 |
| 159 | 21.97 | 22.09 |
| 160 | 21.97 | 22.10 |

# Supporting Growth

SGA North pre Project (base case) future 100yr predicted water levels

## Legend

- Pre Project flood level location
- SGA Alignment
- Existing Road
- 2023 AC Geomaps 100yr 3.8° climate change flood plain
- Stormwater Catchments
- New Zealand Imagery

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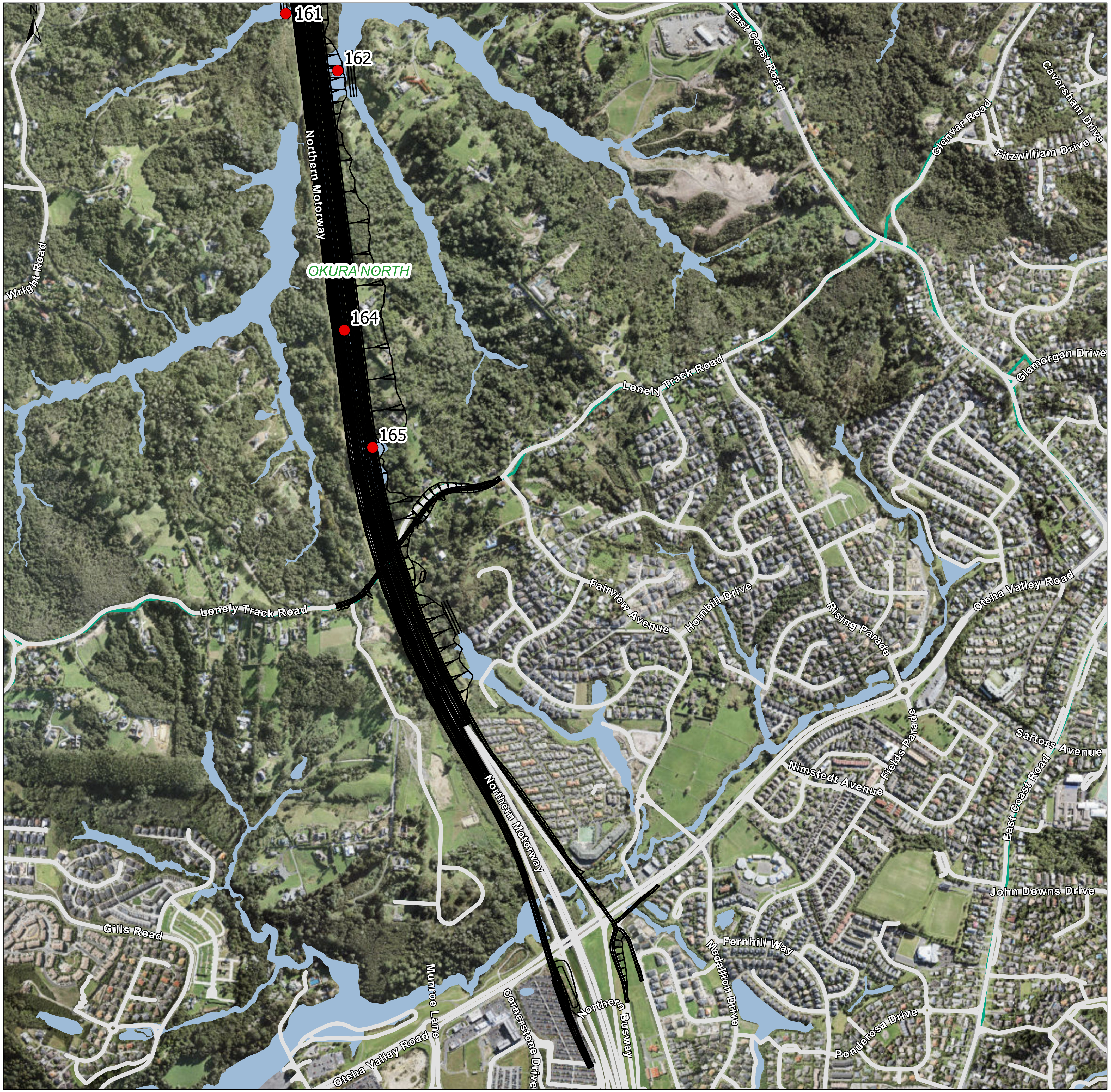
TE TUPU NGĀTAHI SUPPORTING GROWTH



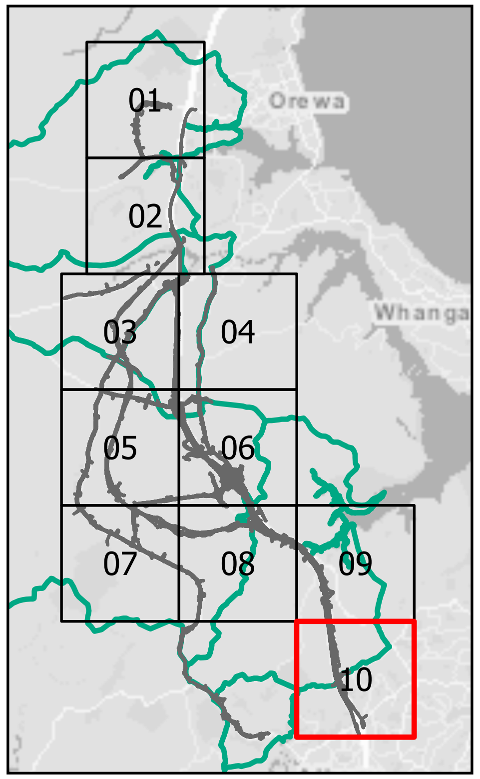

| ID | 100yr 2.1CC Water Level | 100yr 3.8CC Water Level |
|---|---|---|
| 161 | 26.90 | 27.17 |
| 162 | 22.02 | 22.15 |
| 164 | 62.35 | 62.37 |
| 165 | 72.15 | 72.17 |

# Supporting Growth

SGA North pre Project (base case) future 100yr predicted water levels

## Legend

- Pre Project flood level location
- SGA Alignment
- Existing Road
- 2023 AC Geomaps 100yr 3.8° climate change flood plain
- Stormwater Catchments
- New Zealand Imagery

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# 2 Appendix 2 Dairy Flat Highway (NOR8)/ Bawden Road (NOR12) post Project concept design modelling and discussion memo

TE TUPU NGĀTAHI
SUPPORTING GROWTH

# Technical Note

Date Prepared: 31/08/2023

Prepared by: Tom Newman

## Dairy Flat Design Flood Modelling

### Purpose

This technical note has been prepared to provide and compare the flood modelling undertaken in the Bawden Road / Dairy Flat area with and without the Supporting Growth preferred options in this location.

## Document Status

| Responsibility | Name |
|---|---|
| Author | Tom Newman |
| Reviewer | Mike Summerhays |
| Approver | Kathleen Bunting |

## Revision Status

| Version | Date | Reason for Issue |
|---|---|---|
| 1.0 | 31/08/2023 | Final for lodgement |

# Table of Contents



# Figures

TE TUPU NGĀTAHI
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# 1 Introduction

This technical note provides details of the post Project flood modelling and assessment against the pre-Project model results for the Dairy Flat / Bawden Rd intersection area.

## Flood Model Setup

The proposed post Project terrain and bridge opening design was added to the pre-Project flood model for the Dairy Flat catchment model. Bridge openings were added as openings in the design formation with the area between the bridge abutments represented by the existing terrain (ground) levels.

The flood modelling has been undertaken using the 1% annual exceedance probability (AEP) rainfall event with a 3.8° temperature increase for climate change allowance.

The proposed formation design was converted to a grid system from drawing (DWG) files. The flood model extent and design are shown in Figure 1 below. Culverts are not modelled as 1D structures, but the larger ones are represented as openings in the terrain.

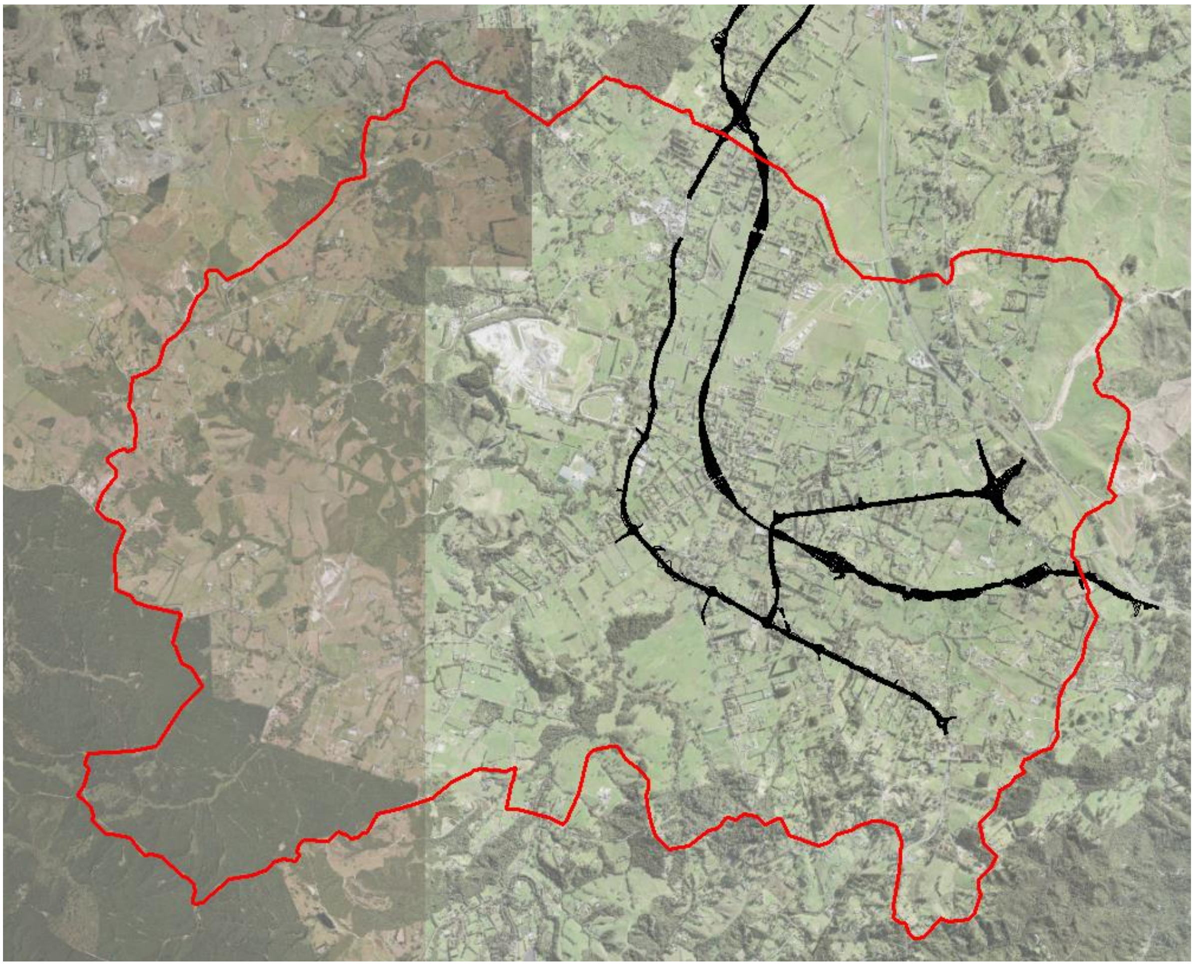

**Figure 1. Dairy Flat flood model extent outlined in red with the proposed design in black.**

# 2 Results

The post Project concept design model was run and water level results compared to the pre-Project water levels as shown in Figure 2. These results show an increase in water level upstream of the proposed bridge openings. The increase in water level is greater than 0.05m for a majority of the area with some areas increasing by 0.5m. The results compared are water levels, therefore where water is on an area where the ground level has been changed (e.g. road level raised), the resulting difference in terms of flood depth may not be as much as the water level difference.

The increase in water level is caused by bridge openings that are not wide enough to accommodate the width of the base case floodplain. This constriction of the floodplain causes water to back up on the upstream side of the bridge openings causing water levels to rise. An example of this is shown in Figure 3. Figure 3 shows the width of a bridge opening on Dairy Flat Highway approximately 95m wide with the road level raised. In comparison the pre-Project floodplain of approximately 220m wide at Dairy Flat Highway is predicted to overtop.

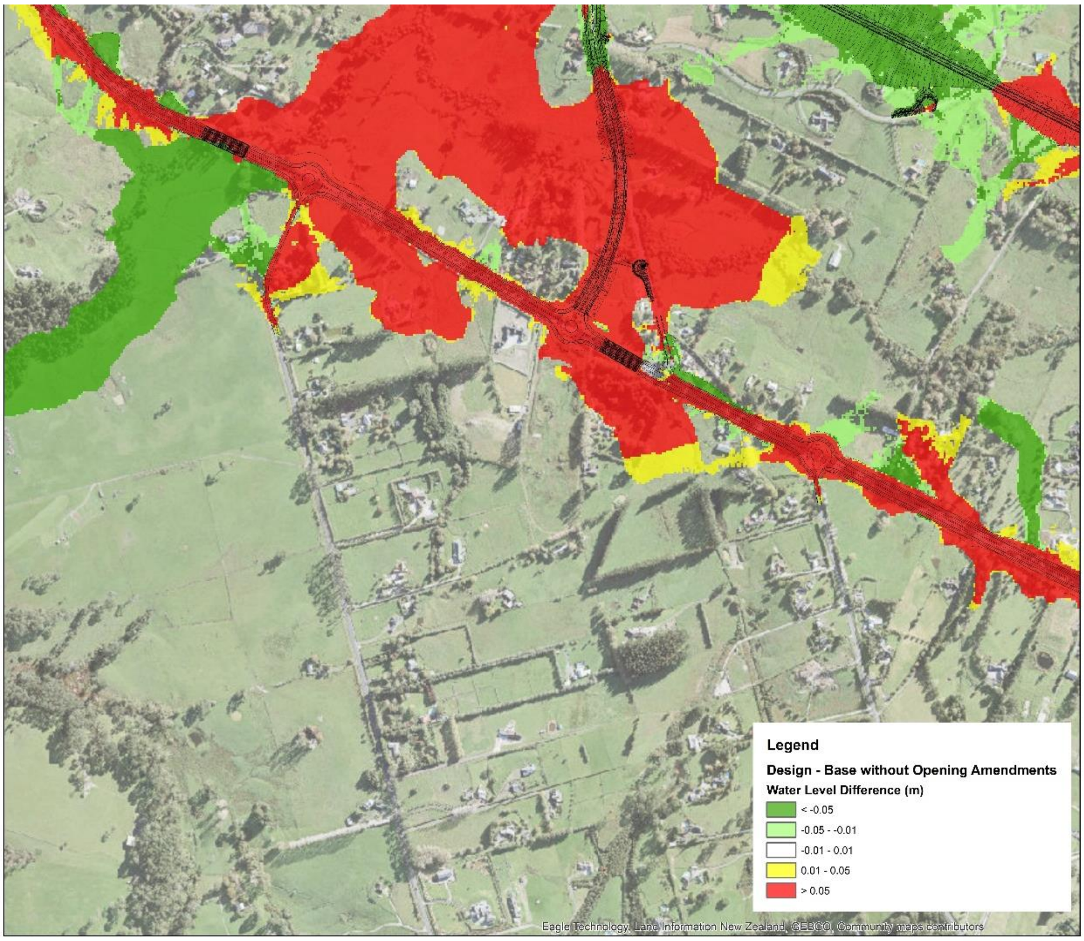


**Figure 2. 1% AEP with 3.8° climate change water level difference between pre and post Project results**

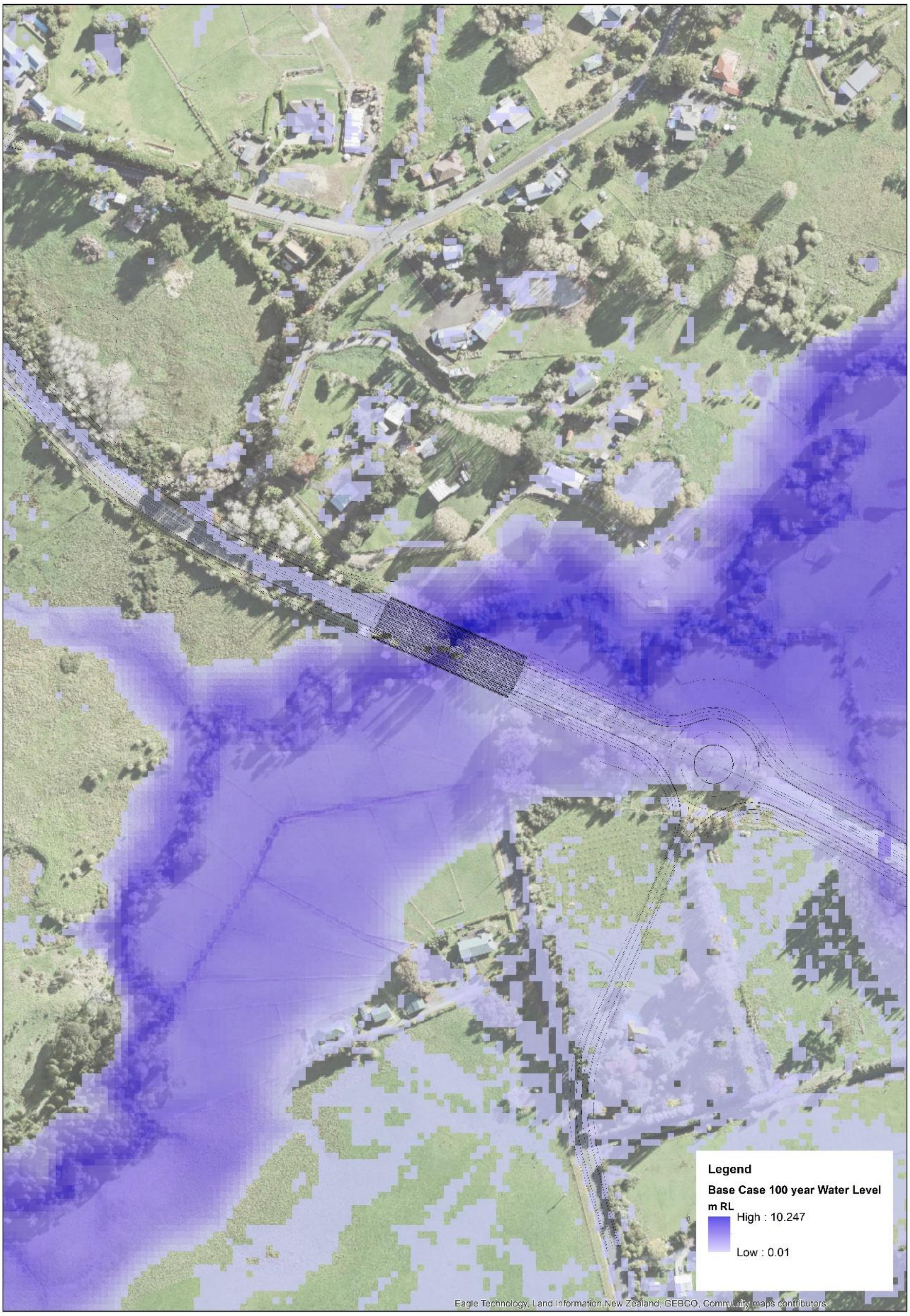


**Figure 3. Base Case 1% AEP with 3.8° climate change through a Dairy Flat Highway bridge opening west of Green Road.**

Amendments to the proposed bridge openings and terrain were modelled to assess the requirements to reduce the impact on flooding to the surrounding area.

Figure 4 shows where terrain openings have been amended. Areas outlined in blue were replaced with the existing LiDAR. In addition to these terrain openings, a channel opening is outlined in red where the terrain has been lowered to allow for the existing stream alignment. An area outlined in green is lowered by 200mm to compensate for the floodplain constriction caused by the design terrain.


**Figure 4. Modelled terrain amendments to reduce the impact on flooding.**

Figure 5 shows the water level comparison between the design results with terrain amendments compared to the pre-Project results. The results show flooding impacts have improved compared to the post Project design case without terrain amendments. The terrain amendment to the west of Green Road was wide enough to accommodate the width of the floodplain which results in no water level difference greater than +/-0.01m.

The floodplain is constrained through the area between the proposed Bawden Road design and the existing Bawden Road cul-de-sac. In the terrain amendments design model, the bridge opening was widened and an area of terrain was lowered to compensate for the width of the floodplain being narrowed by approximately 40m due to the proposed road embankment.

Further flood impact improvements can likely be made with ground level amendments adjacent to the proposed Bawden Road cul-de-sac. This would require the proposed designation to be extended to the left bank of stream adjacent to the cul-de-sac which has been refined in the designation boundary.

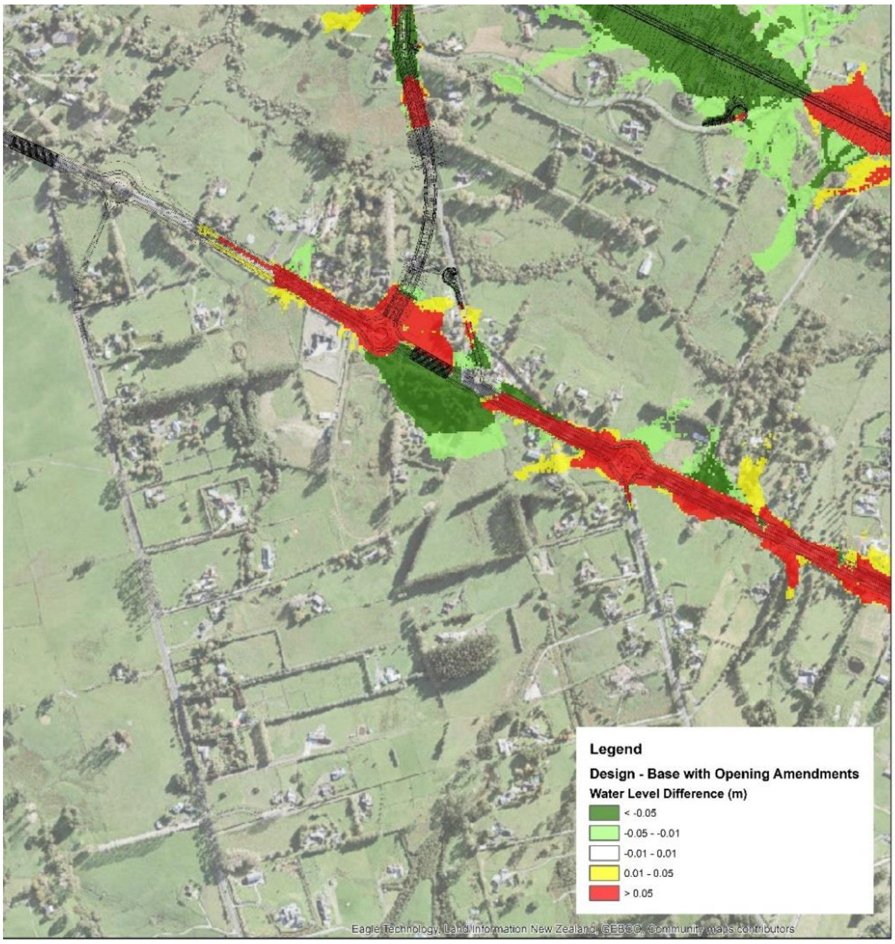


**Figure 5. 1% AEP with 3.8° climate change water level difference with terrain amendments.**

# 3 Conclusions:

The post Project modelling has led to some refinement in the design of Bawden Road and Dairy Flat Highway including:

- Widening of the bridges over the Dairy Stream (both Bawden and Dairy Flat Highway)
- Some further ground level amendments adjacent to the proposed Bawden Road cul-de-sac.
- The designation area is considered appropriate and the flood hazard outcomes in the proposed designation conditions can be met, subject to further design and modelling assessment at Outline Plan stage.

# 3 Appendix 3 SH1 (NOR4) and Pine Valley Road (NOR7) post Project concept design modelling and discussion memo

# Technical Note

Date Prepared: 31/08/2023

Prepared by: Tom Newman

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## Silverdale South - Pine Valley Design Flood Modelling

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### Purpose

This technical note has been prepared to provide flood modelling details and results from the Silverdale South - Pine Valley flood model. The flood model extends across the Pine Valley, Silverdale South, and Silverdale Wade stormwater catchments.

The post Project model assessed the concept Revision B design of the Upgrade to Pine Valley Road (NoR 7) to predict the potential flooding effects compared to the pre-Project scenario for the future 100yr rainfall with 2.1° of climate change scenario. Refinements were subsequently made to the Revision B design with the aim of showing that the flood hazard designation conditions could be achieved.

A comparison between 2.1° and 3.8° of climate change water levels bridge openings is also shown in Appendix A.

## Document Status

| Responsibility | Name |
|---|---|
| Author | Tom Newman |
| Reviewer | Mike Summerhays |
| Approver | Kathleen Bunting |

## Revision Status

| Version | Date | Reason for Issue |
|---|---|---|
| 1.0 | 31/08/2023 | Final for lodgement |

# Table of Contents



# Figures

# 1. Introduction

This technical note provides details of the flood modelling undertaken to assess the post Project concept Revision B design flooding hazard effects when compared to be the pre-Project base case for NOR 7 - Upgrade to Pine Valley Road.

## 1.1 Flood Model Setup

The proposed post Project Rev B concept design was added to the pre-Project base case flood model for Silverdale - Pine Valley. The pre and post Project predicted flood water levels were compared to confirm whether the flood hazard designation condition of no more than 50mm change could be achieved.

Details of the Silverdale - Pine Valley Base Case model can be found in the report SGA North Strategic Silverdale South - Pine Valley Base Case Stormwater Model Build (October 2020, Version 1.0).

The flood modelling has been undertaken using the 100year ARI with a 2.1° temperature increase to account for the medium level of climate change allowance.

The proposed formation design was converted to a grid system from drawing (DWG) files.

The overall Silverdale South - Pine Valley catchment and proposed Rev B Pine Valley upgrade location are shown in Figure 1 below.

Proposed bridges were left open in the 2D terrain.

Pre-Project culverts greater than 600mm are modelled as 1D structures and were included in both the pre and post Project models; however, additional post Project culverts or upsized were not modelled.

Figure 1. Silverdale South - Pine Valley catchment (in red) with the Rev B Pine Valley design (in black).

# 2. Results

The post Project model was first run with the Rev B design with the proposed bridge openings. Existing culverts in the pre-Project model were retained.

In the pre-Project case, flood water levels are predicted to overtop the existing Pine Valley and Young Access Roads where existing culverts and bridges do not have capacity.

In the post Project case the proposed road level is raised to reduce the risk of the road overtopping but the existing bridges or culverts were retained, which then increases flooding upstream of the roads due to the road acting like a stopbank and overtopping occurring in different locations as the pre Project overtopping is now protected due to increased road level.

A comparison between the pre and post Project water levels along Pine Valley and Young Access Roads is shown in Figure 2. Figure 2 shows the location of four areas discussed in further detail below.

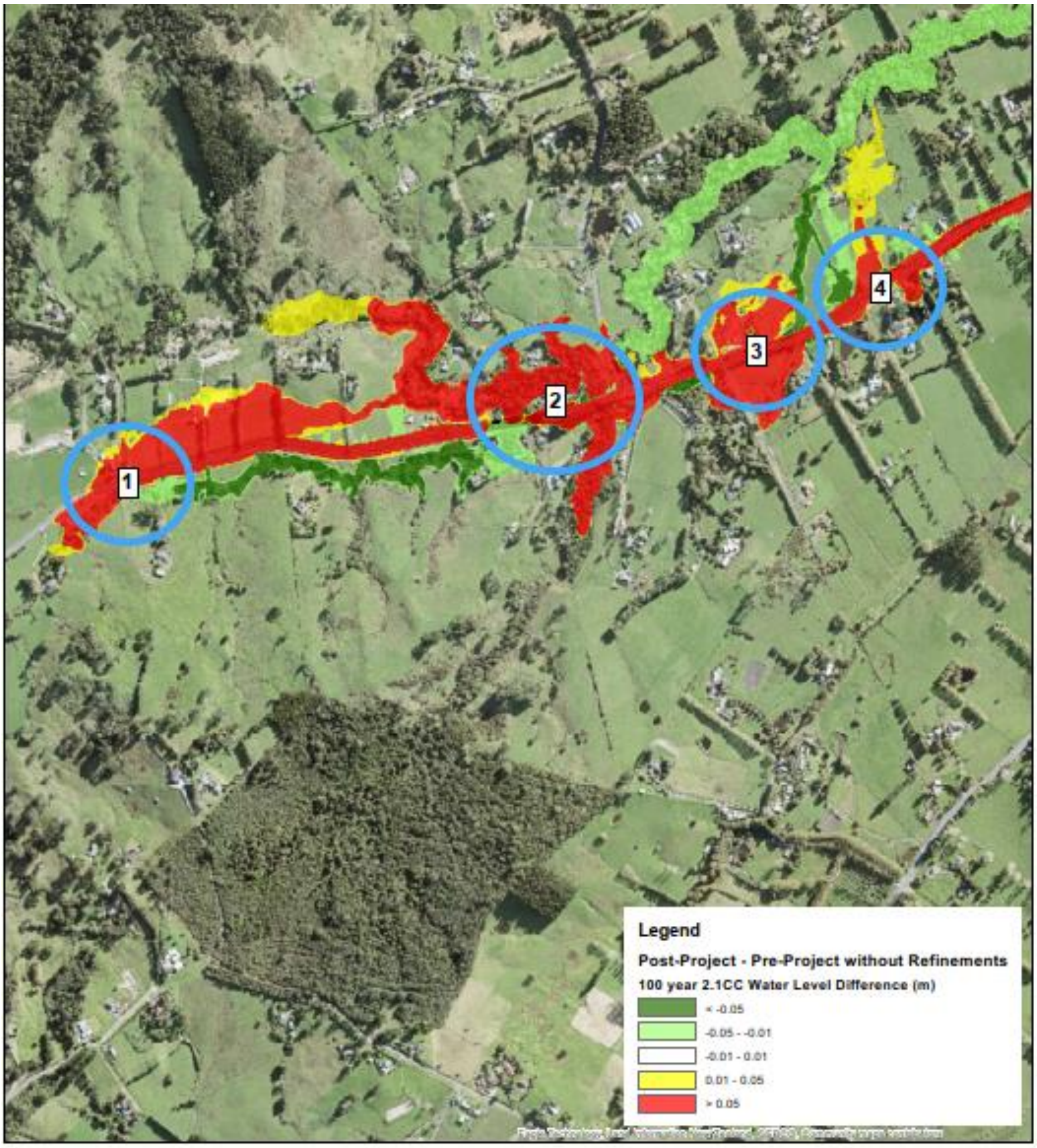



**Figure 2. Predicted post Pine Valley Road upgrade future 100yr 2.1° climate change water level difference and location plan of areas discussed in detail.**

## 2.1 Location Plan Area 1

Figure 3 shows the pre-Project flood extent with the concept design. This shows the Rev B road embankment encroaching into the watercourse causing the post-Project flow to overtop Pine Valley Road and flow along the northern side of Pine Valley Road. This is shown by the red areas upstream of the embankment encroachment, downstream of the road overtopping with the pre-Project stream downstream of the embankment encroachment showing a reduced water level difference (green).

A retaining wall to prevent the embankment encroaching into the watercourse or a stream realignment will allow for flow to continue through the stream reducing this change in water level.

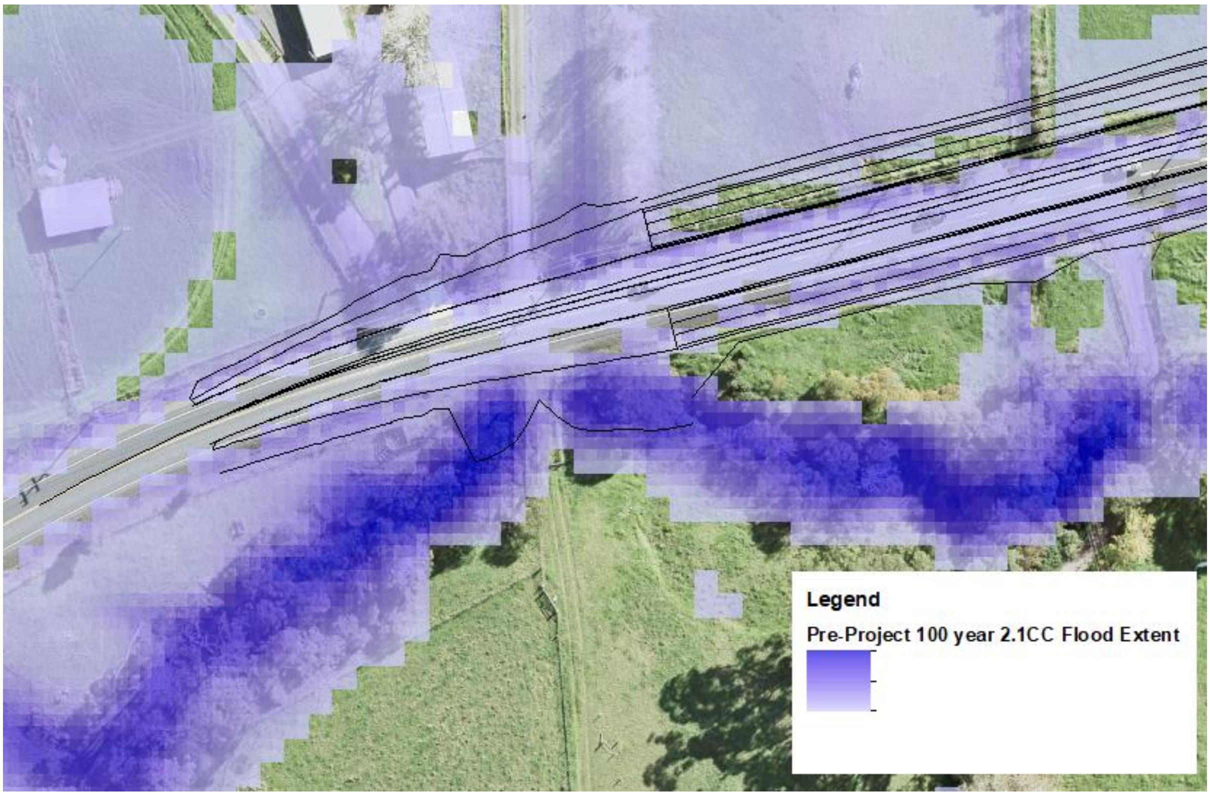



Figure 3. Area 1 location showing the design road embankment encroaching into the watercourse

## 2.2 Location Plan Area 2

Figure 4 shows the pre-Project flood extent in relation to the concept design.

A bridge on Pine Valley Road is shown to be wide enough to convey the pre-Project floodplain and as such does not constrict flow.

A culvert under Pine Valley Road (near the proposed roundabout) does not have sufficient capacity for the pre-Project 100year flow rate. This causes the water level to increase upstream of the culvert until it overtops the road. The concept design raises the road level preventing this overtopping from occurring resulting in increased water level upstream of the culvert. To prevent this, the size of the culvert under Pine Valley Road should be increased to convey the flow that was previously overtopping the road.

A bridge opening on Young Access is approximately 30m wide compared to the pre-Project floodplain width of approximately 55m which overtops the existing road level. The concept design raises the road level of Young Access preventing the post-Project water level overtopping the road. As such, the flow is constricted through the bridge opening causing the water level upstream of the bridge to increase.  This can be overcome by increasing the bridge span opening and is shown on Figure 5.

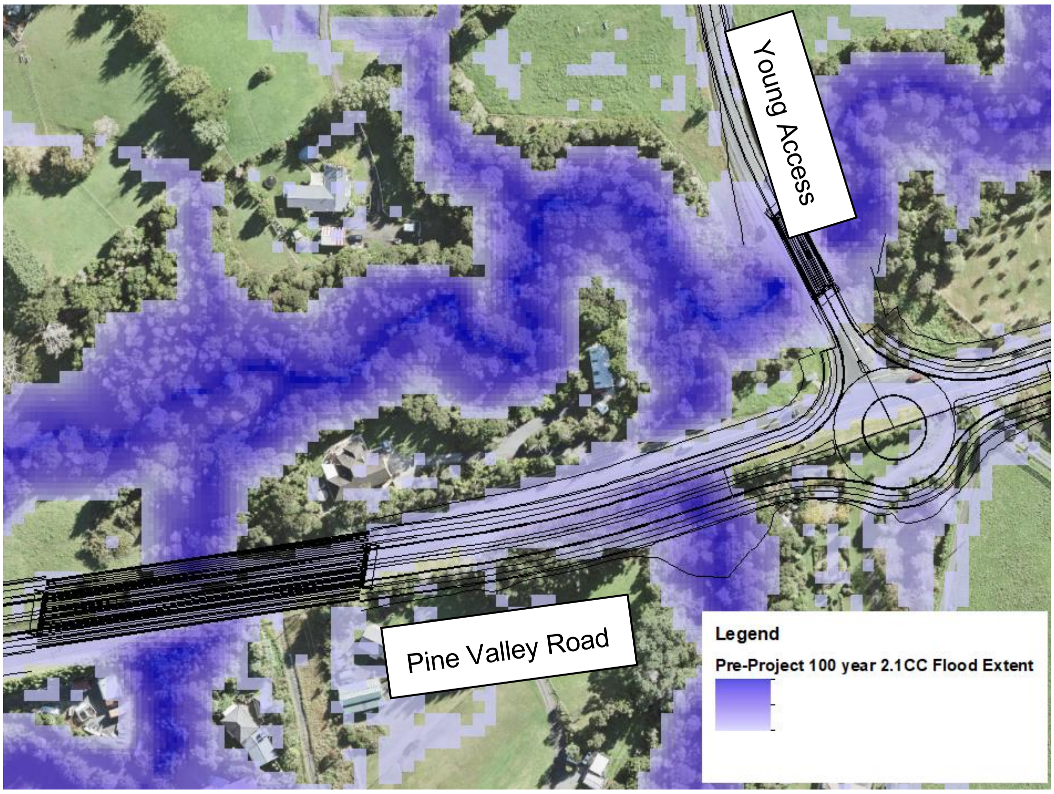



Figure 4. Location Plan Area 2 showing the pre-Project flood extent compared to the concept design.

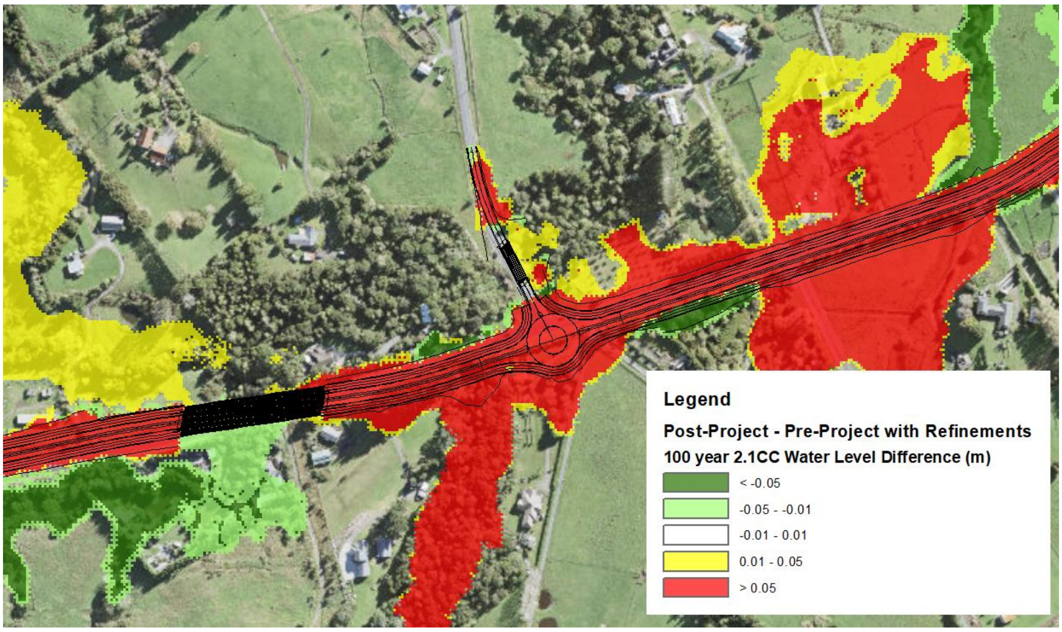



Figure 5. Post-Project water level with refinements compared to Pre-Project water level at Young Access.

## 2.3 Location Plan Area 3

A culvert at area 3 does not have sufficient capacity to convey the pre-Project 100year flow rate resulting in water level increasing until it overtops Pine Valley Road. The pre-Project overtopping flow path is shown by the blue arrow in Figure 6.

The post-Project road level is raised whilst the culvert is existing causing a lower flow rate to overtop the road which increases the water level upstream of the culvert. In addition, the flow path that does overtop the road is predicted to be shifted shown to the red arrow locations shown in Figure 6. This creates areas of increased water level both upstream and downstream of the road (shown as red on Figure 2) while reducing the water level in the stream downstream of the culvert outlet (shown as green on Figure 2).

Increasing the existing culvert capacity to convey the flow that previously overtopped the road in the pre-Project scenario would reduce the change in water levels.

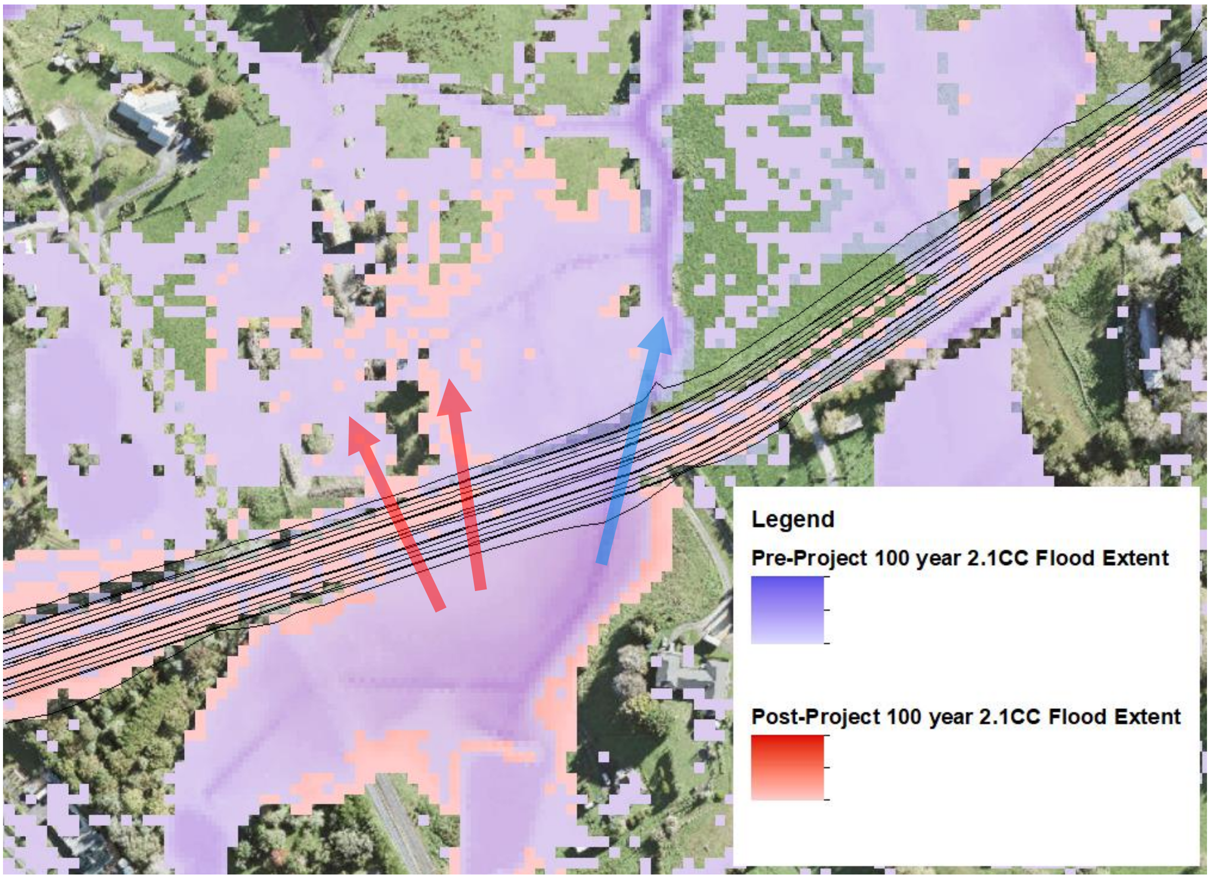



Figure 6. Location Plan Area 3 showing the direction of flow overtopping Pine Valley Road.

## 2.4 Location Plan Area 4

Area 4 flow paths are shown in Figure 7. Existing culverts in this area do not have sufficient capacity to convey the 100year flow rate causing flow to overtop Pine Valley Road. Again, an increase in culvert diameter will be required where the concept design cuts off flow overtopping the road.

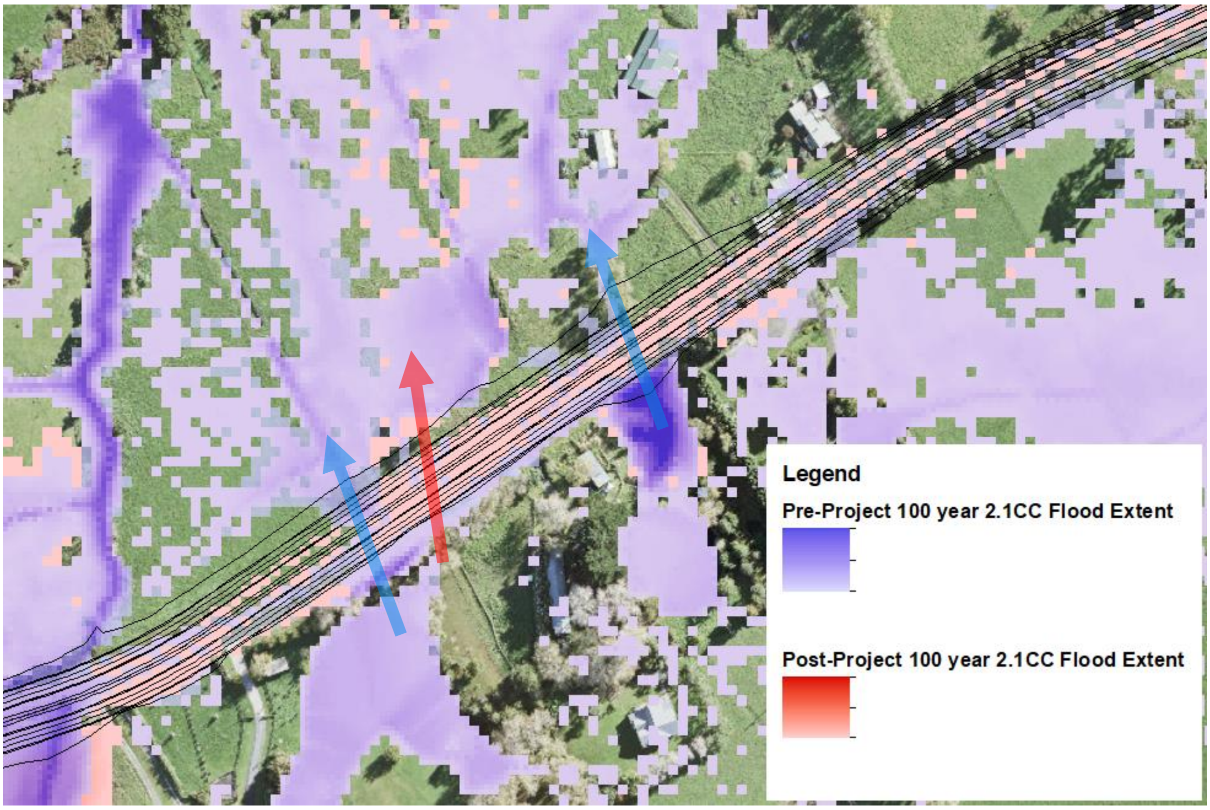



Figure 7. Location plan area 4 showing the direction of flow overtopping Pine Valley Road.

# 3. Conclusions

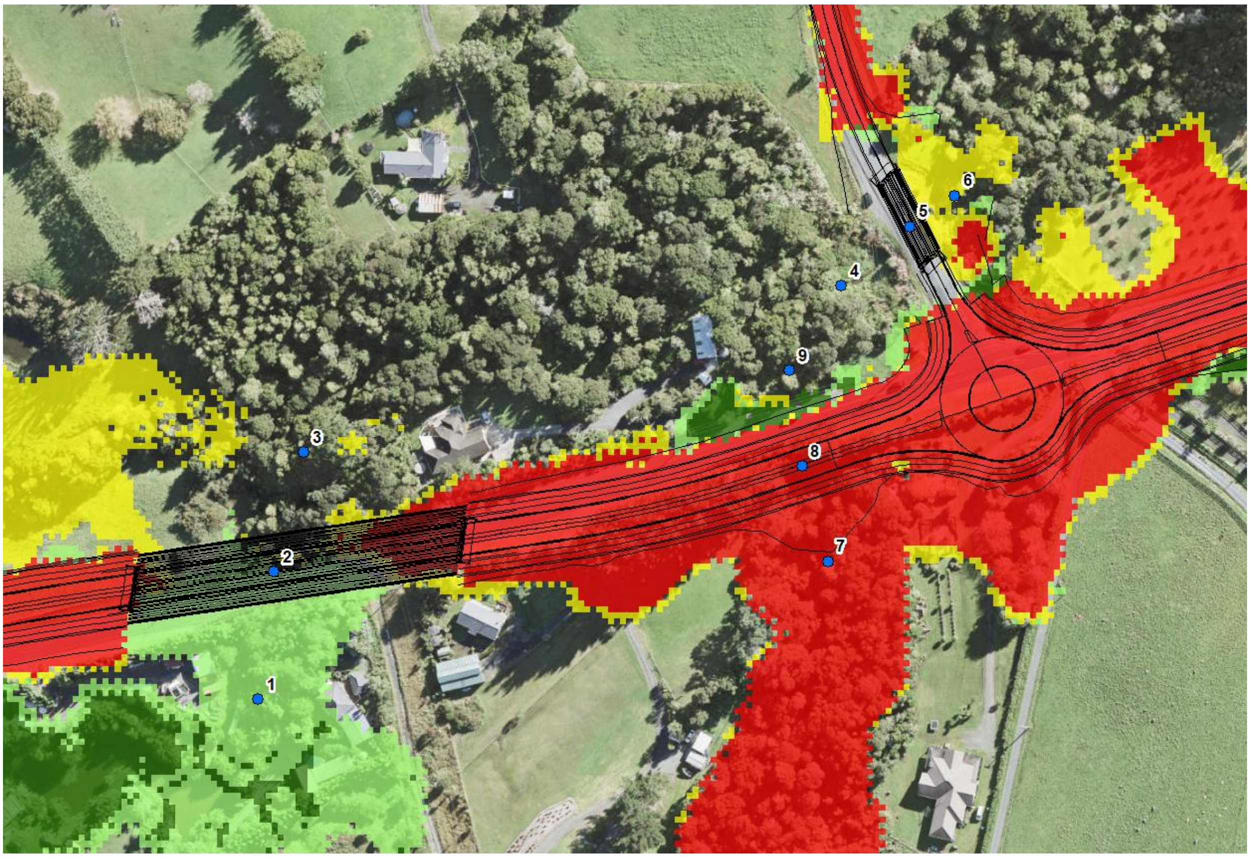
The pre and post Project 100yr flood water level difference shown on Figure 2 indicates there is insufficient capacity beneath Pine Valley and Young Access Roads, particularly with the road level being raised.

Further detailed design modelling of culverts, bridges and stream realignment / retaining wall will improve water level differences along Pine Valley Road by matching the existing culvert / bridge capacity plus overtopping flow rate with the upgraded pipe / bridge capacities.

There is sufficient space within the proposed designation NOR to be able to address flooding issues in the future detailed design and modelling stages.

# Appendix A - Water Levels at Location Plan 2

| Water Level Point | Pre-Project 100 year 2.1CC | Post-Project with refinement 100 year 2.1CC | Pre-Project 100 year 3.8CC |
|---|---|---|---|
| 1 | 27.23 | 27.18 | 27.37 |
| 2 | 26.32 | 26.30 | 26.51 |
| 3 | 25.19 | 25.19 | 25.64 |
| 4 | 24.71 | 24.72 | 25.01 |
| 5 | 24.15 | 24.16 | 24.42 |
| 6 | 23.44 | 23.46 | 24.03 |
| 7 | 26.17 | 27.58 | 26.3 |
| 8 | 26.17 | 27.55 | 26.3 |
| 9 | 24.78 | 24.78 | 25.1 |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