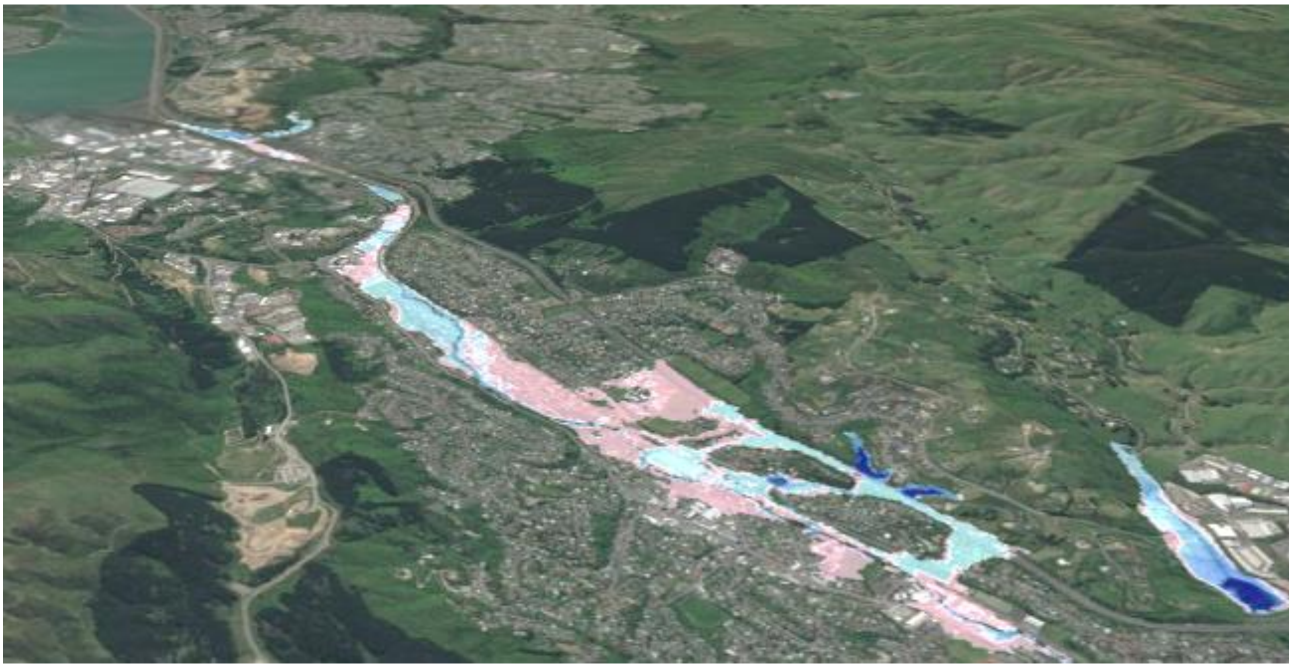
PORIRUA STREAM



April 2018

Hydraulic Model Update and Flood Mapping

Report prepared for Greater Wellington Regional Council

by Matthew Gardner

Land River Sea Consulting Ltd

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REVISION HISTORY

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1. INTRODUCTION

SCOPE OF STUDY

Land River Sea Consulting Ltd has been contracted by Greater Wellington Regional Council, to update and rerun the Porirua Stream hydraulic model based on the most recent Hydrology study which has been undertaken by Tonkin and Taylor (Tonkin & Taylor Ltd, 2017).

The hydraulic model was first built in 2012 (Gardner, 2012). Full details of the original model set up can be found in the published model build report.

The scope of the study is as follows.

- Update the Hydraulic Model, making minor adjustments to the model set up where is seen necessary
- Set up and rerun the model with the newly produced Hydrology input files.
- Produce flood maps for the 100 year event including the effects of climate change.
- Model freeboard / sensitivity is to be mapped based on the methods adopted in the Mangaroa Flood Hazard Mapping study (Abbott, 2015)

LOCATION

The Porirua Stream is located in the Wellington region and drains into the southern arm of the Porirua Harbour approximately 20 km north of Wellington City centre. The stream drains a catchment of approximately 54 hectares with 5 main tributaries, being Belmont, Takapu, Stebbings, Kenepuru and Mitchell's Streams. The catchment topography consists largely of rolling hills with a large area of flat land in the Tawa and Porirua City Centre areas (Gardner, 2012). The approximate catchment area is outlined in red in Figure 1-1 below.

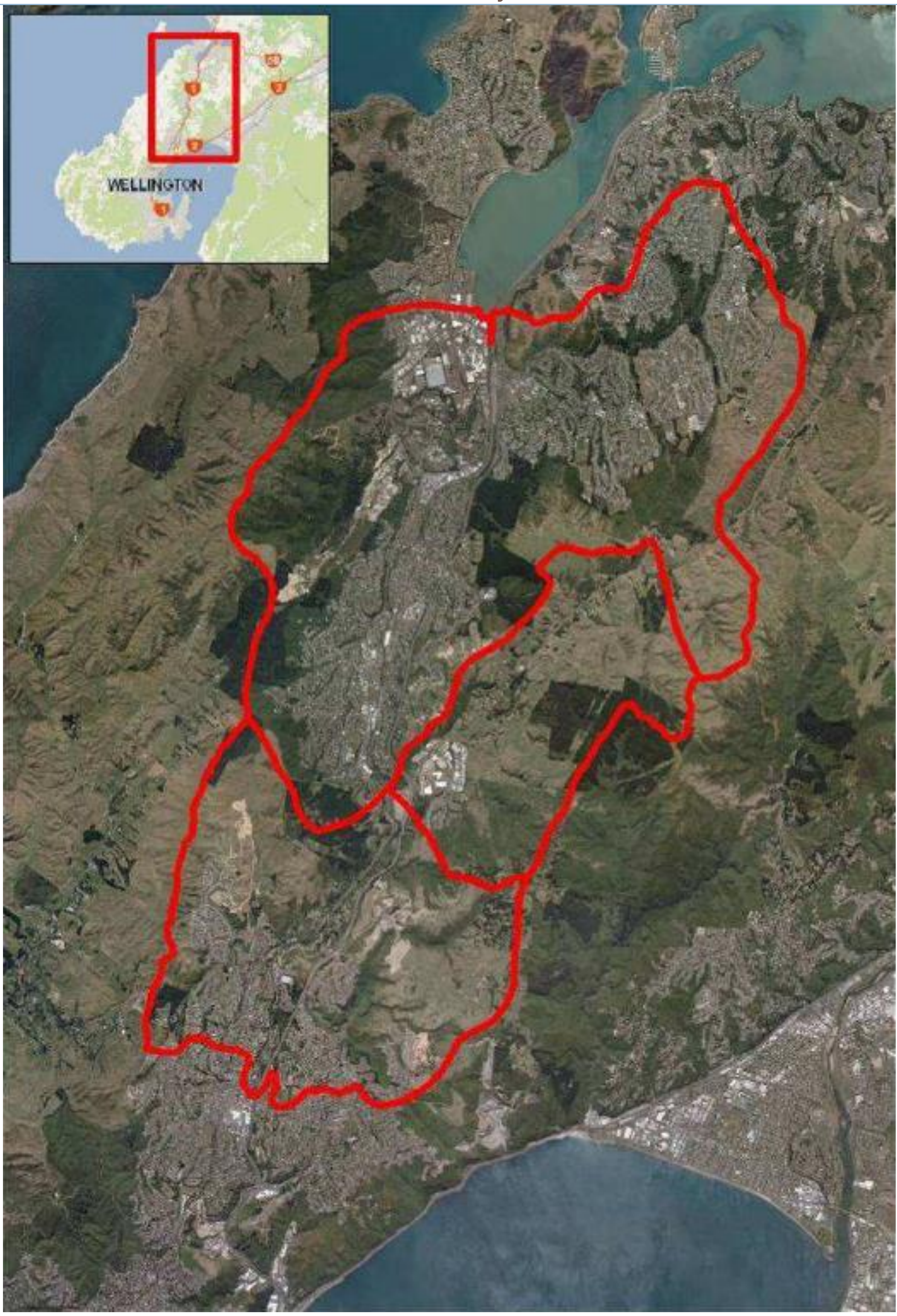


Figure 1-1 – Location map of Porirua Stream (Gardner, 2012)

2. LIMITATIONS OF STUDY

This study has been carried out using the information and data made available to the author at the time of this study. There are a number of uncertainties which should be acknowledged which include but are not limited to:

- Limited calibration and verification data.
- Uncertainty in the LiDAR and cross section survey data

3. HYDROLOGY / BOUNDARY CONDITIONS

Hydrologic inputs for the model have been prepared by Tonkin & Taylor and are detailed in the Hydrology report (Tonkin & Taylor Ltd, 2017).

Hydrographs for the climate change runs have been supplied separately to the hydrology report and have allowed for a 20% increase in peak rainfall, to meet the current GWRC climate change guidelines.

Due to the difference in routing methods between the rainfall runoff model and the MIKE Flood hydraulic model, the hydrographs have had to be scaled to get the peak flow at the location of the Town Centre recorder to match the expected peaks detailed in Table 25 of the hydrology report (Tonkin & Taylor Ltd, 2017). 100 year inflows were increased by 9%.

The final modelled flows are summarised and compared with the frequency analysis range in Table 3-1.

Table 3-1 – Comparison of peak flow

Return Period	**Frequency analysis range**	**Peak Modelled Flow (m^3/s)**
50 year	101 to 106	107
100 year	124 to 131	130
100 including climate change	Not reported	170

Table 3-2 – Modelled Inflows (100 year event)

Subcatchment	50 yr Peak Flow (m^3/s)	100 yr Peak Flow (m^3/s)	Subcatchment	Peak Flow (m^3/s)
Belmont		22.7	**E5**	4.6
Lower Belmont		1.1	**E6**	4.7
Upper Stebbings		20.5	**W1**	4.4
Lower Stebbings		1.5	**W2**	9.5
Mitchell		25.0	**W3**	17.2
Paparangi		11.2	**W4**	3.8
Takapu		33.5	**W5**	3.8
E1		5.2	**W6**	2.7
E2		2.5	**W7**	1.2
E3		19.5	**North-West**	6.7
E4		12.5	**Kenepuru**	54.6

SUB-CATCHMENT INFLOW LOCATIONS

Sub-catchment boundaries were not available in electronic format, however a hard copy map was included in the Hydrology report (Tonkin & Taylor Ltd, 2017). Sub-catchment nodes were placed within ArcGIS manually, trying to match the location to that included in the Hydrology report based on visible features in the aerial photography. The majority of the sub-catchments entered the Porirua Stream in the location of small streams and drains, for the sub-catchments that were not in the vicinity of any waterways, the Porirua stormwater pipe network was inspected and input nodes were moved to the nearest pipe outfall. The location on the sub-catchment nodes as they have been applied with the hydraulic model is presented in Figure 3-1 below.

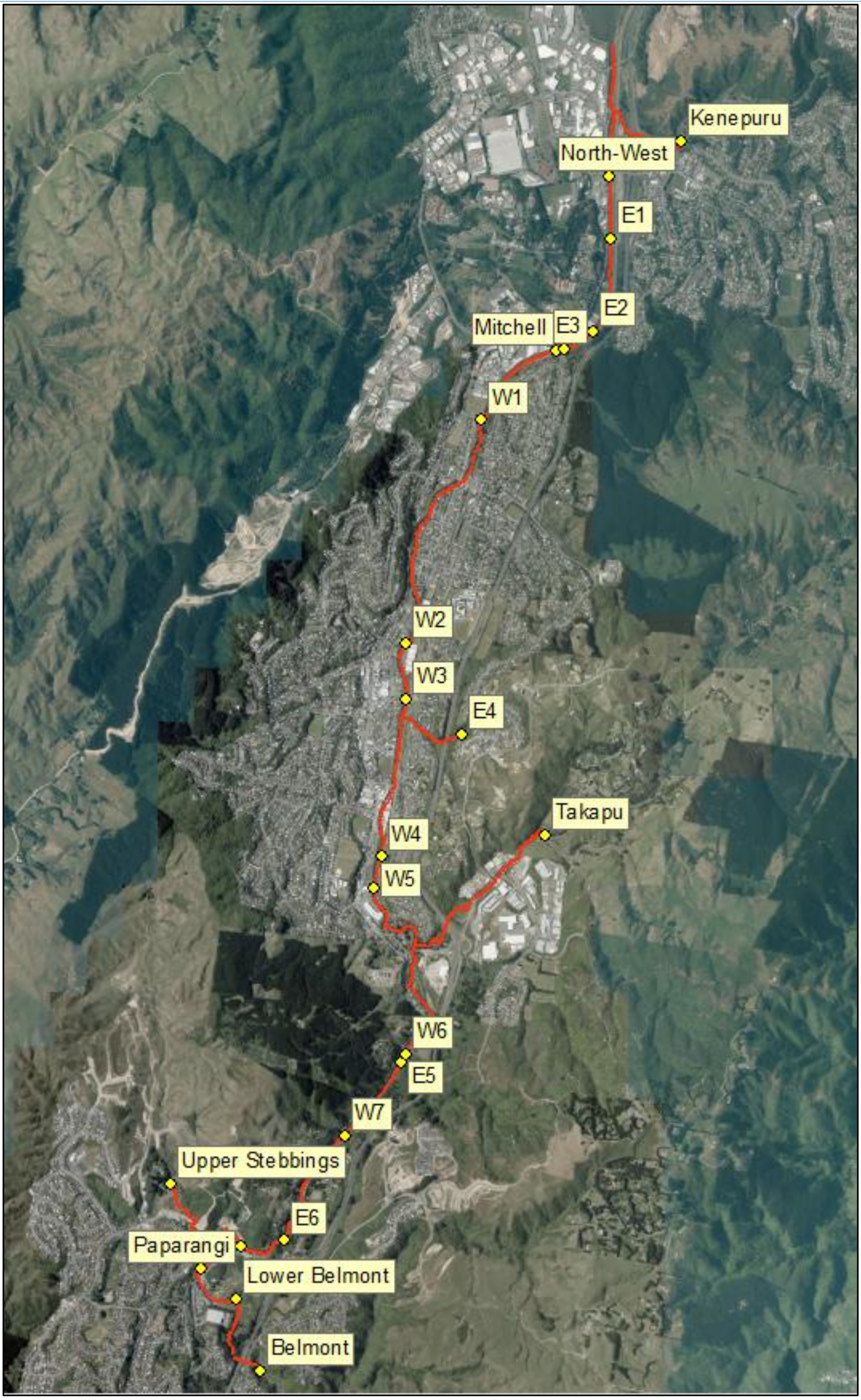


Figure 3-1 – Porirua sub-catchment inflow locations

DOWNSTREAM BOUNDARY CONDITIONS

Downstream boundary conditions have been taken from the previous modelling. The estimates were provided by Dr Iain Dawe (Coastal Scientist, Greater Wellington Regional Council).

The estimates are made up of a low-pressure setup, storm surge component in conjunction with the Mean High Water Spring. Tide levels are summarised in Table 3-3 below.

Table 3-3 – Summary of tide scenarios

Tide Scenario	Peak Water Level (m)
T2	1
T20	1.4
T100	1.7

In addition to the storm surge component, an allowance for increased sea levels due to the impacts of climate change have been included. These allowances have been detailed in each individual run.

4. MODEL SETUP

The model setup has not changed significantly apart from some minor adjustments as detailed below:

i. The naming conventions used in branches have been changed to make the model easier to navigate. The simplified setup has allowed for many of the interpolated cross sections to be removed from the cross-section file (These are automatically interpolated in the model based on the spacing of the relevant dx parameter in the network file anyway).
ii. Lateral links have been slightly altered / refined so that they more accurately represent the connection between the MIKE11 and MIKE21 model where it seemed appropriate.
    - For the Takapu Stream, the links where split into more reaches so that the effects at individual structures could be better represented.
    - For the main Porirua Stream channel, the links have been widened in some locations to better represent the width of the MIKE11 channel, as well as to ensure that the links run along the top of floodwalls / banks where appropriate.
    - Bridge 7 and Bridge 8 had been excluded from the original model and were put back into this version of the model. I cannot remember why the bridges had been left out of the original model.

Blockage Scenarios in Design Scenario

The decision of which culverts to block in the base scenario was made in conjunction with operations staff from the council. The following blockages have been included in the base design scenario as summarised in Table 4-1 below.

Table 4-1 – Baseline Blockage Scenarios

Sub-catchment	50 year	100 year	100 year cc
Belmont	12.3	14.8	22.7
Lower Belmont	0.6	0.7	1.1
Upper Stebbings	12.4	15.0	20.5
Lower Stebbings	1.0	1.2	1.5
Mitchell	15.0	19.2	25.0
Paparangi	5.3	6.4	11.2
Takapu	18.6	22.3	33.5
E1	3.0	3.8	5.2
E2	1.4	1.7	2.5
E3	11.9	15.1	19.5
E4	7.6	9.5	12.5
E5	2.9	3.5	4.6
E6	2.9	3.4	4.7
W1	2.8	3.5	4.4
W2	5.7	7.2	9.5
W3	10.7	13.5	17.2

W4	2.4	3.0	3.8
W5	2.2	2.6	3.8
W6	1.6	2.0	2.7
W7	0.7	0.9	1.2
North-West	4.3	5.4	6.7
Kenepuru	30.9	36.9	54.6

Stream	Model ID	Degree of blockage
Porirua Stream	Bridge 10	50% Blockage
Takapu Stream	Bridge 26-32	50% Blockage

Bridges 26 to 32 on the Takapu Stream have been blocked by representing them as semicircles rather than fully circular culverts, with the bottom 50% blocked off as shown below in Figure 4-1.

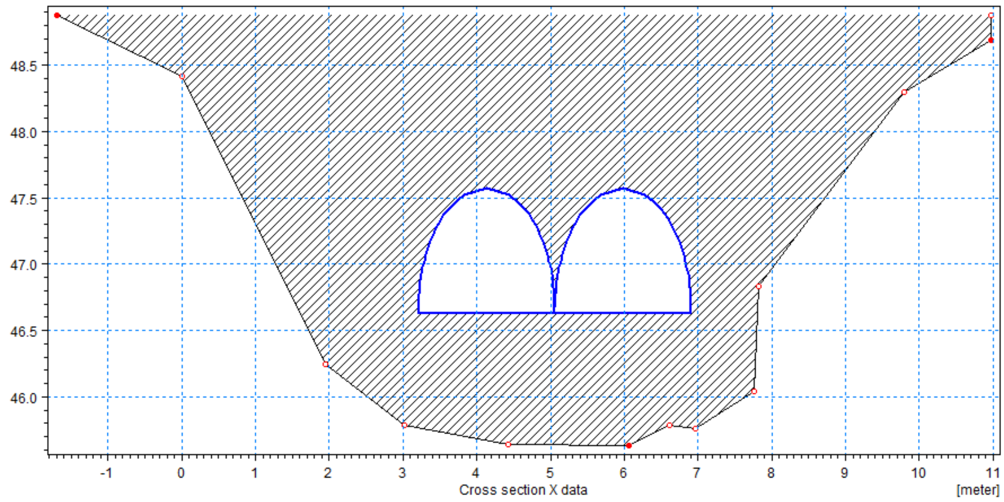


Figure 4-1 – Example of culvert blockage on the Takapu Stream

Bridge 10 has been blocked using a similar method, however as it is a rectangular culvert, the culvert height has simply been reduced and the invert raised.

Location maps showing the location of modelled cross sections as well as Bridges / Culverts is presented in Appendix A.

Model freeboard has been incorporated following a similar methodology to that adopted in the Mangaroa modelling exercise (Abbott, 2015). The method is summarised as follows:

- Identify and quantify hazards that can be represented in the model and can be captured through undertaking sensitivity runs.
- Produce an output which captures the effect of these hazard factors on the flood risk.
- Identify a freeboard which captures factors that are not represented in the model and cannot be accounted for through hazard sensitivity modelling.
- Incorporate the freeboard magnitude above into the mapping process through a dynamic mapping process.

The factors accounted for in the model sensitivity have been developed in conjunction with GWRC with the following factors have been taken into account

Table 4-2 – Factors incorporated into freeboard / sensitivity runs

Factor	Magnitude of Allowance	Reasoning behind choice
Peak Flow	10%	Design flows have been selected from the upper end of the flood frequency estimate in the Hydrology report.
Manning's 'n'	Increase from 20% to 30%	Limited calibration data was available for the initial model study and therefore Manning's 'n' values were increased from the calibration values for the design runs in the original model study by 20% to account for the uncertainty in the values as well as to allow for increased turbulence etc in large flows. Since this has already been accounted for to some degree in the design runs a sensitivity test of increasing the Manning's 'n' by 30% from the base calibrated values has been included as a sensitivity run.
Tidal Boundary	100 year flow in conjunction with a 100 year tide	There is a small probability that this may occur. The difference between the estimated 20 year and 100 year tide is 0.32m.
Blockage	Between 50 and 75% as detailed in Table 4-3.	Blockage factor based on engineering judgement in conjunction with discussions with staff from GWRC

Blockage Sensitivity Runs

A number of simulations have been completed with a range of blockage scenarios as summarised in Table 4-3 below. These locations were determined in consultation with GWRC operations staff as culverts most likely to block or where the consequence of a blockage would likely be most significant.

Table 4-3 – Selected Blockage Scenarios

Stream	Model ID	Degree of blockage
Takapu Stream	Bridge 25	50% Blockage
Takapu Stream	Bridge 26-32	75% Blockage
Porirua Stream	Bridge 35	50% Blockage
Porirua Stream	Bridge 42	50% Blockage
Porirua Stream	Bridge 43	50% Blockage
Porirua Stream	Bridge 46	50% Blockage

Each of the sensitivity scenarios listed in Tables 4-2 and 4-3 have been run individually and the peak water levels from each run have been combined into a single file.

In order to account for general uncertainty factors which cannot be accounted for through hazard sensitivity modelling a number of factors have been considered as summarised in Table 4-4.

Table 4-4 – General Uncertainty Factors

General Uncertainty Factor	Description
LiDAR	LiDAR is generally accepted to have an accuracy of approximately ±100 mm in open, un-vegetated areas. However, the potential for inaccuracy is higher in areas of dense vegetation and at thin linear features e.g. stop banks.
Cross Section Survey	Due to spacing of cross sections, there is potential that some localised features which may impact on flood levels have been missed from the model. These features may impact on localised water levels.
Wave Effects	Waves caused by turbulence, wind action and other disturbances such as vehicles driving through the floodwaters can raise water levels locally.

These general uncertainties have been considered to have an overall combined uncertainty in the order of 0.3m.

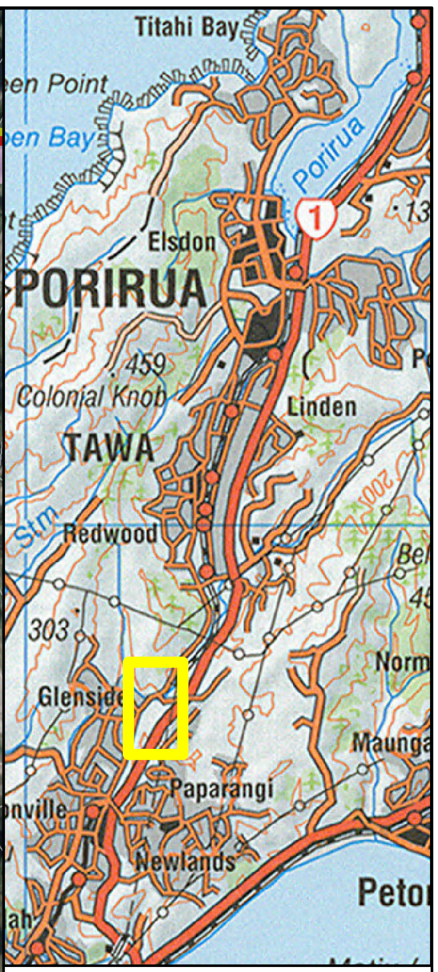
The final freeboard has been developed by combining the peak water levels from each of the sensitivity runs into a maximum elevation file and then adding 0.3m to the file to account for the general uncertainties.

This file has then been used as an initial condition for a separate run which has no additional flow input. The model has been allowed to run for a short period of time so that the additional water can spill over the floodplain and generate a flood extent which has been defined as a flood sensitive area.

5. MODEL RESULTS

Model results are presented as a series of 8 maps in the following pages. The results have separated the base model results from the model freeboard, which has been defined as a flood sensitive area and contains no depth information.

Modelled flood extents differ significantly from the 2012 results in some locations. A comparison of flood extents has been presented in Appendix B.



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Legend

- Property Boundaries
- Flood Sensitive Area
- MIKE 11 Model Extent

Peak flood depth (m)

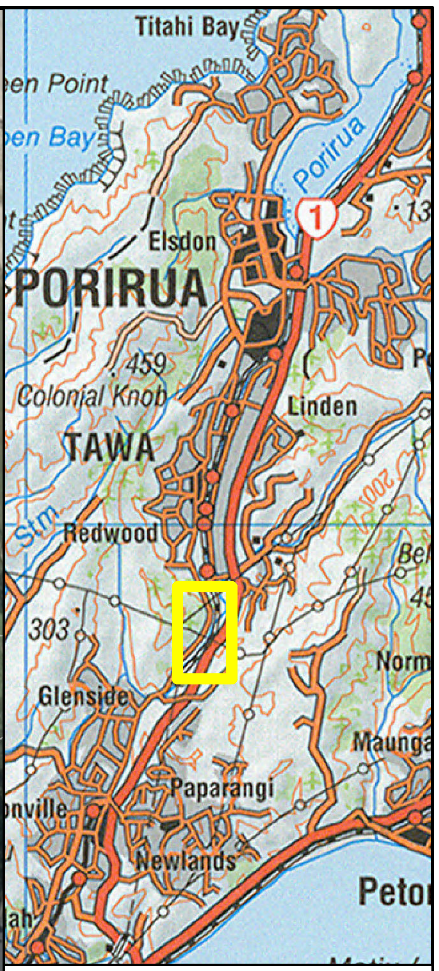
- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- >2

AUTHOR	JOB CODE
Matthew Gardner	GWRC022
DATE	**REV**
1 May 2018	01
N	**A3 SCALE** 1:4000

0 0.05 0.1 0.2km

PROJECT
Porirua Stream Updated Hydraulic Modelling

TITLE
Peak Flood Depth
100 year Climate Change Scenario (Map 1 of 8)



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Legend

- Property Boundaries
- Flood Sensitive Area
- MIKE 11 Model Extent

Peak flood depth (m)

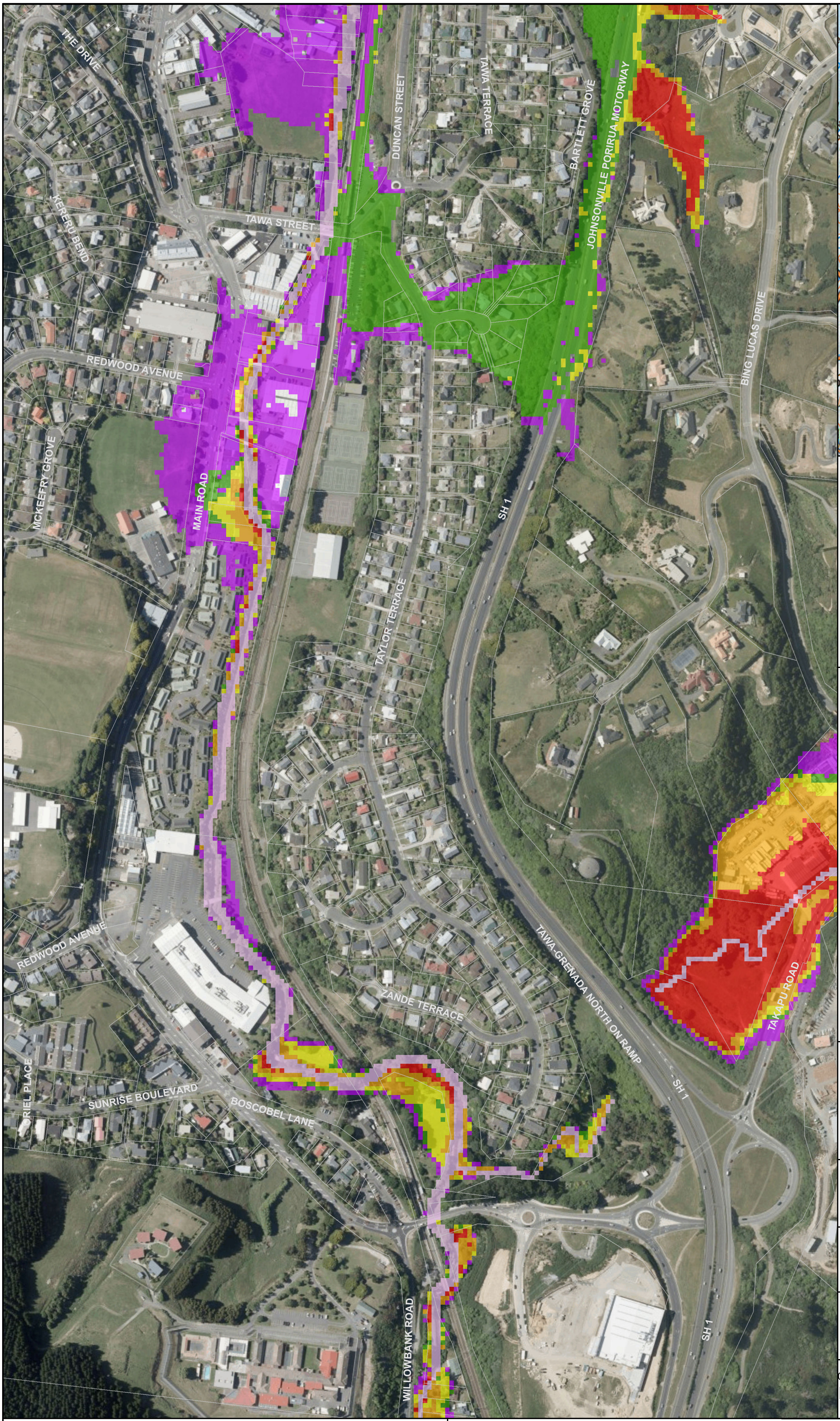
- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- >2

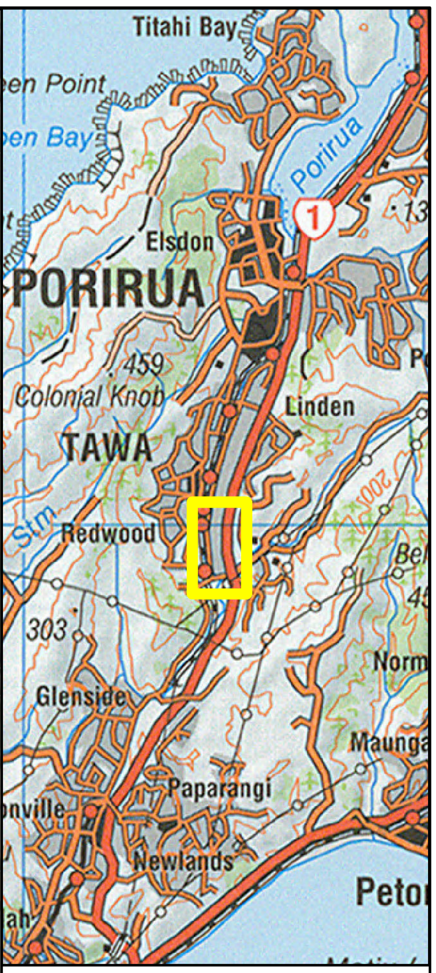
AUTHOR	JOB CODE
Matthew Gardner	GWRC022
DATE	**REV**
1 May 2018	01
N	**A3 SCALE** 1:4000

0 0.05 0.1 0.2km

PROJECT
Porirua Stream Updated Hydraulic Modelling

TITLE
Peak Flood Depth
100 year Climate Change Scenario (Map 2 of 8)





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Legend

- Property Boundaries
- Flood Sensitive Area
- MIKE 11 Model Extent

Peak flood depth (m)

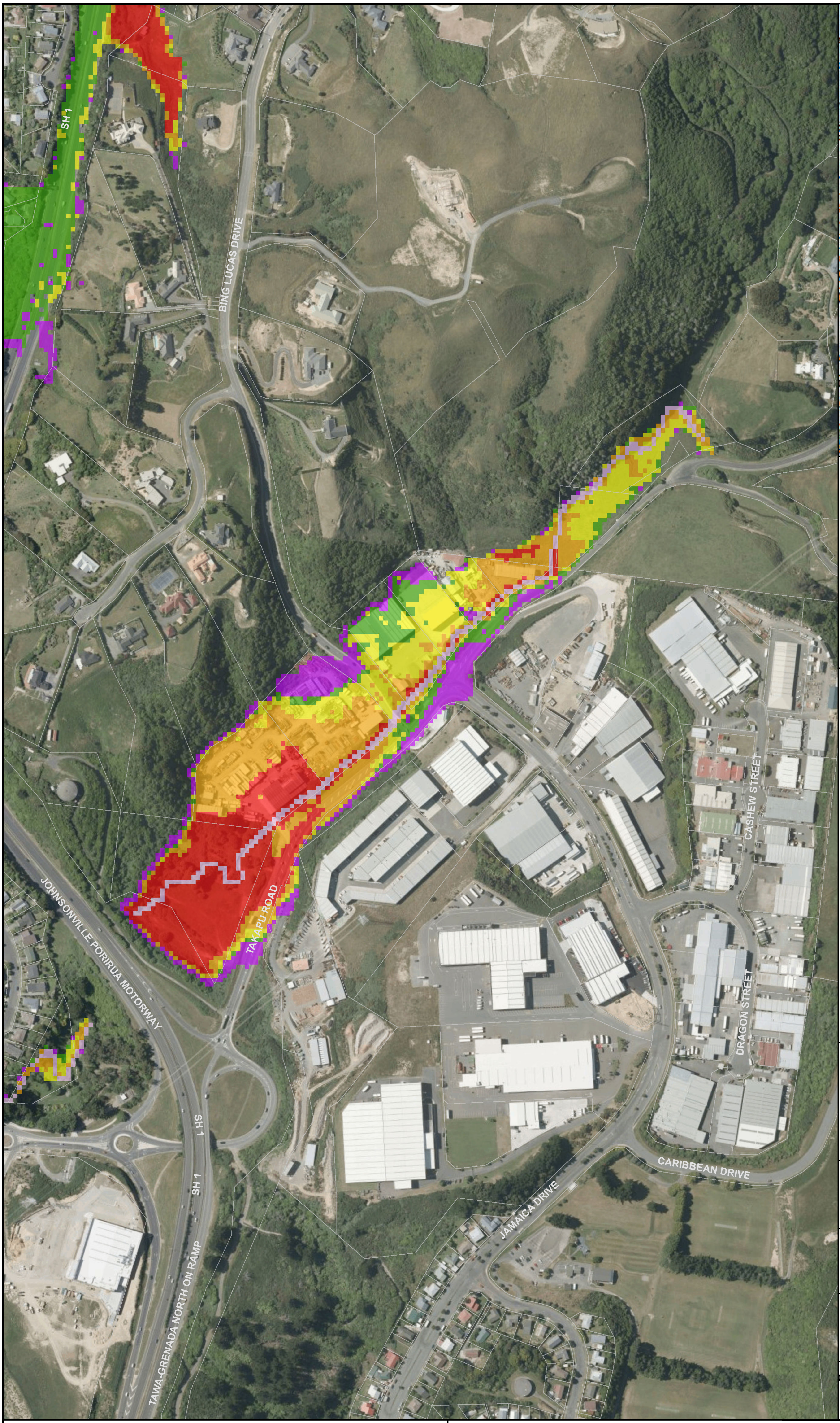
- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- >2

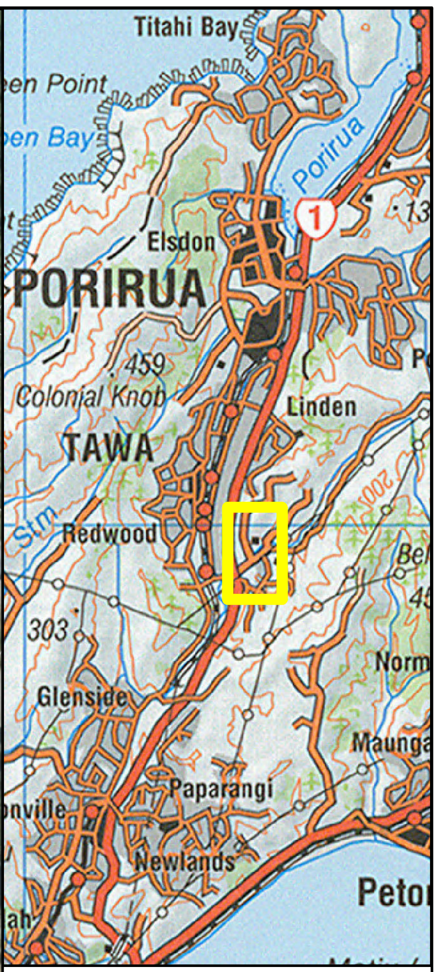
AUTHOR	JOB CODE
Matthew Gardner	GWRC022
DATE	REV
1 May 2018	01
N	A3 SCALE 1:4000

0 0.05 0.1 0.2km

PROJECT
Porirua Stream Updated Hydraulic Modelling

TITLE
Peak Flood Depth
100 year Climate Change Scenario (Map 3 of 8)





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- Property Boundaries
- Flood Sensitive Area
- MIKE 11 Model Extent

Peak flood depth (m)

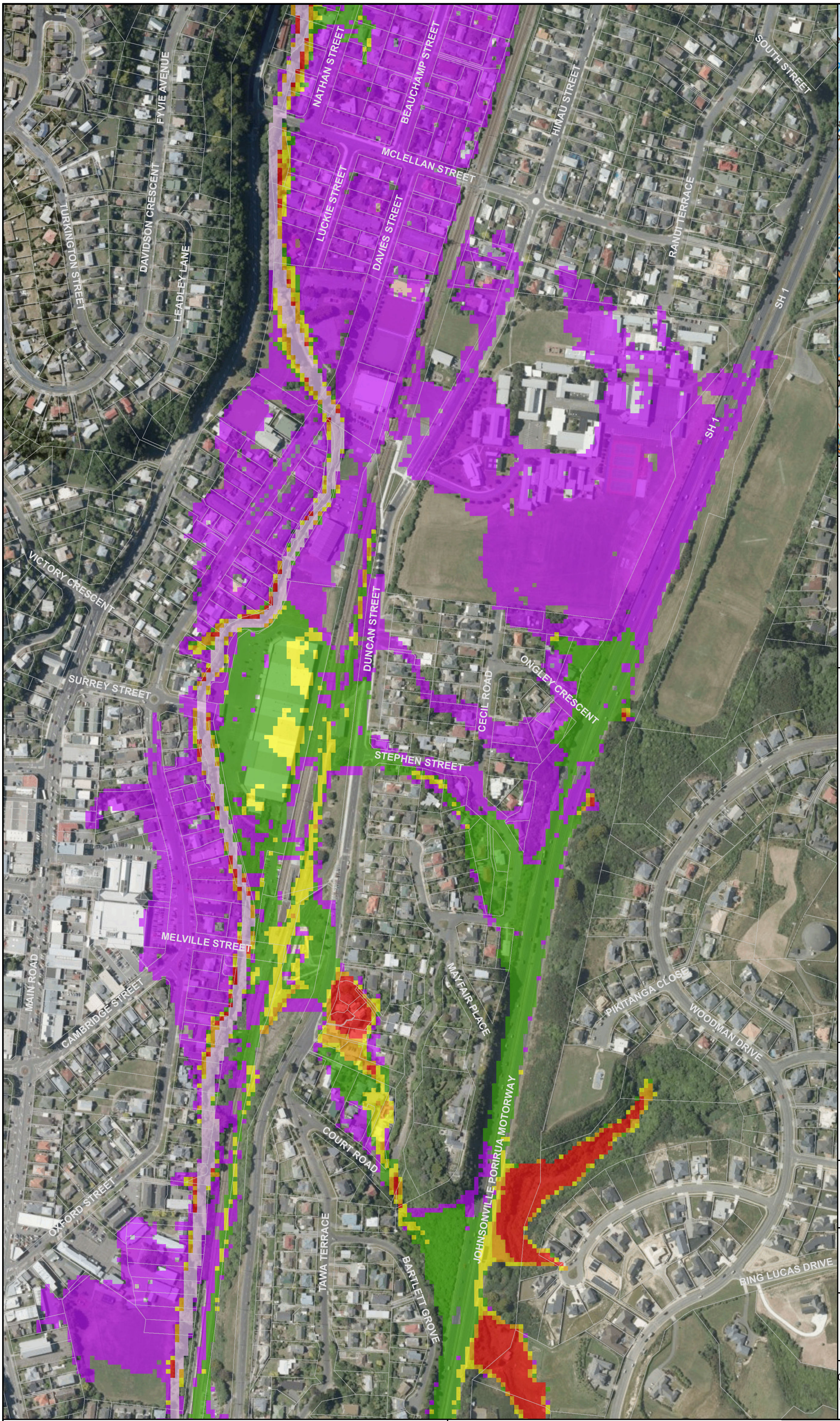
- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- >2

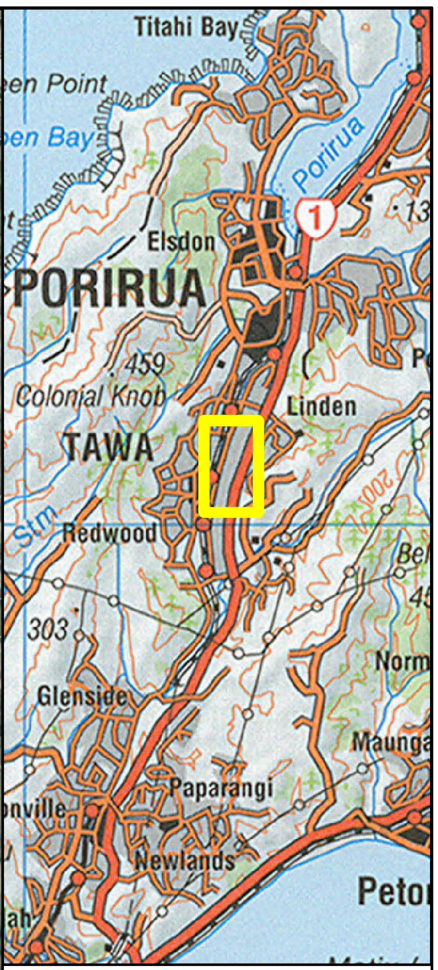
AUTHOR	JOB CODE
Matthew Gardner	GWRC022
DATE	**REV**
1 May 2018	01
N	**A3 SCALE** 1:4000

0 0.05 0.1 0.2km

PROJECT
Porirua Stream Updated Hydraulic Modelling

TITLE
Peak Flood Depth
100 year Climate Change Scenario (Map 4 of 8)





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Property Boundaries

Flood Sensitive Area

MIKE 11 Model Extent

Peak flood depth (m)

0 - 0.05

0.05 - 0.1

0.1 - 0.2

0.2 - 0.3

0.3 - 0.5

0.5 - 1

1 - 2

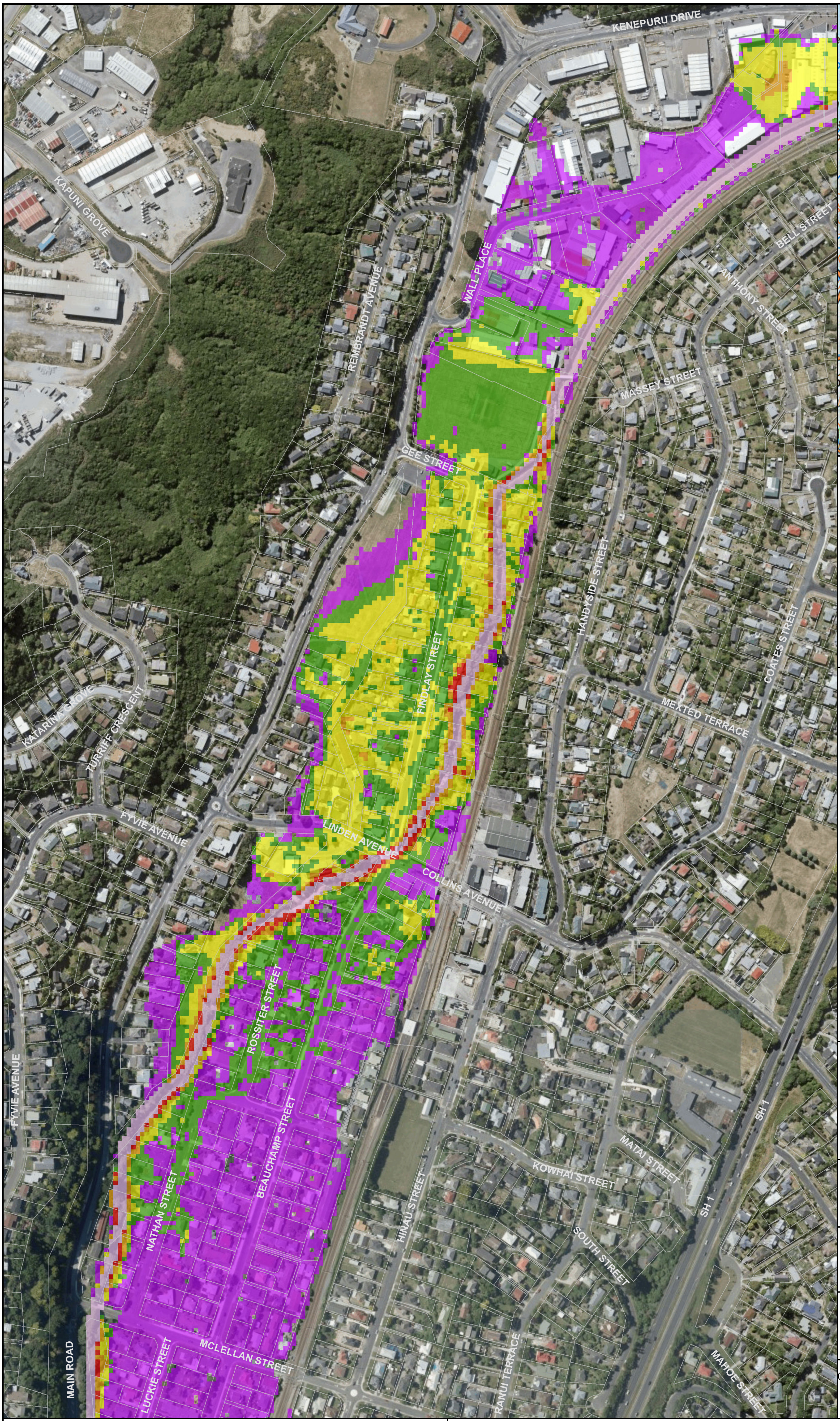
>2

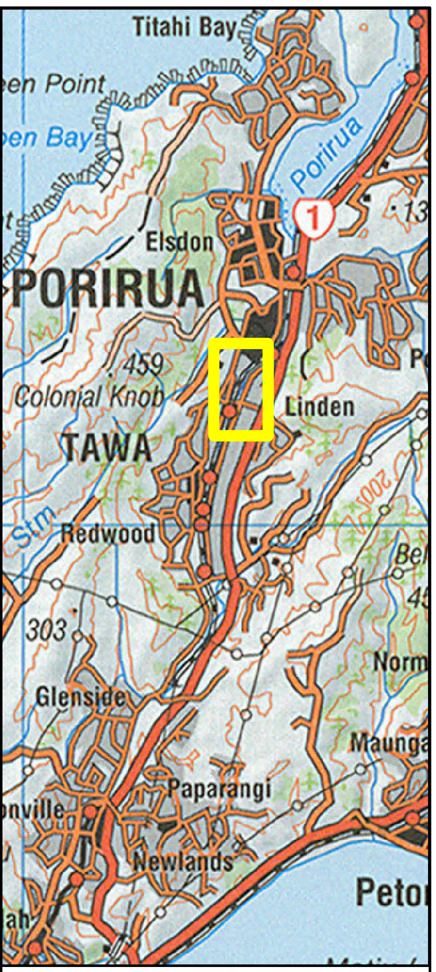
AUTHOR Matthew Gardner	**JOB CODE** GWRC022
DATE 1 May 2018	**REV** 01
N	**A3 SCALE** 1:4000

0 0.05 0.1 0.2km

PROJECT
Porirua Stream Updated Hydraulic Modelling

TITLE
Peak Flood Depth
100 year Climate Change Scenario (Map 5 of 8)





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Legend

- Property Boundaries
- Flood Sensitive Area
- MIKE 11 Model Extent

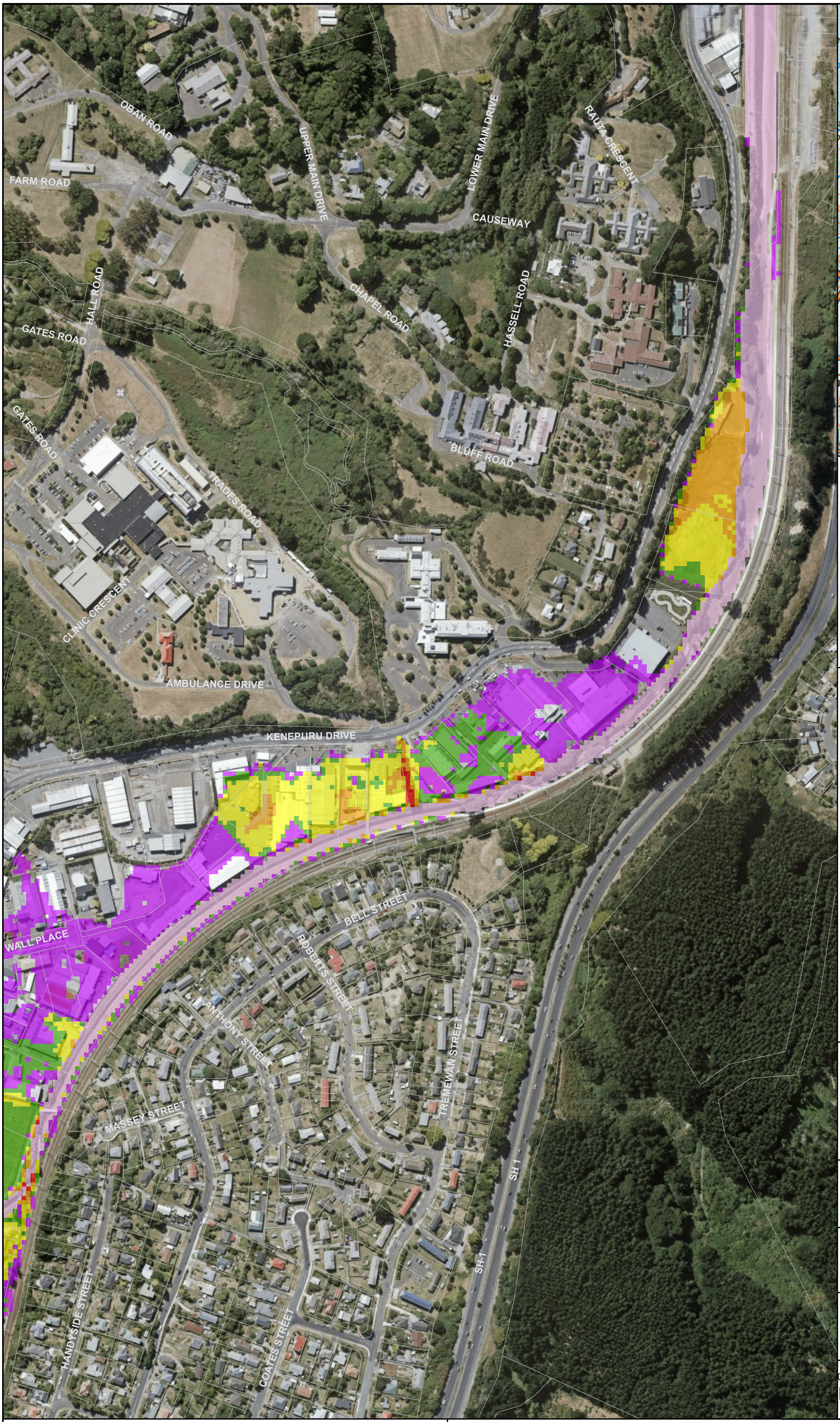
Peak flood depth (m)

- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- >2

AUTHOR	JOB CODE
Matthew Gardner	GWRC022
DATE	REV
1 May 2018	01
N	A3 SCALE 1:4000

0 0.05 0.1 0.2km

PROJECT	TITLE
Porirua Stream Updated Hydraulic Modelling	Peak Flood Depth 100 year Climate Change Scenario (Map 6 of 8)



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Legend

- Property Boundaries
- Flood Sensitive Area
- MIKE 11 Model Extent

Peak flood depth (m)

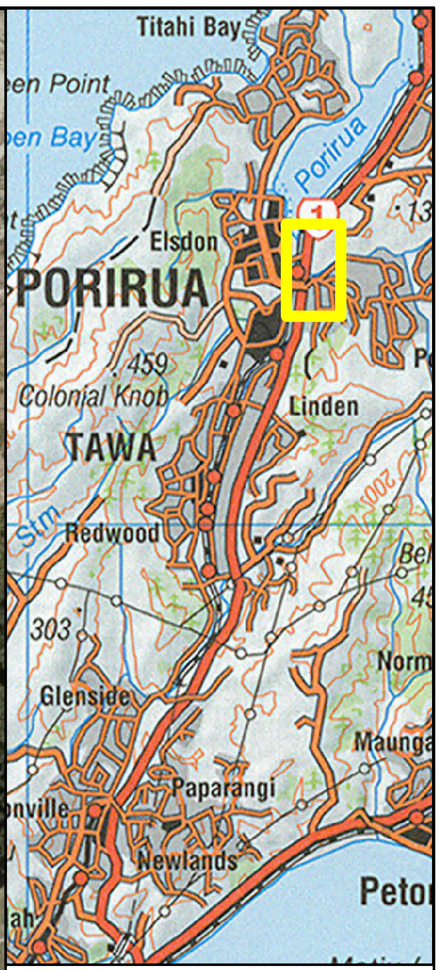
- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- >2

AUTHOR	JOB CODE
Matthew Gardner	GWRC022
DATE	**REV**
1 May 2018	01
N	**A3 SCALE** 1:4000

0 0.05 0.1 0.2km

PROJECT
Porirua Stream Updated Hydraulic Modelling

TITLE
Peak Flood Depth
100 year Climate Change Scenario (Map 7 of 8)



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- Property Boundaries
- Flood Sensitive Area
- MIKE 11 Model Extent

Peak flood depth (m)

- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- >2

AUTHOR	JOB CODE
Matthew Gardner	GWRC022
DATE 1 May 2018	**REV** 01
N	**A3 SCALE** 1:4000

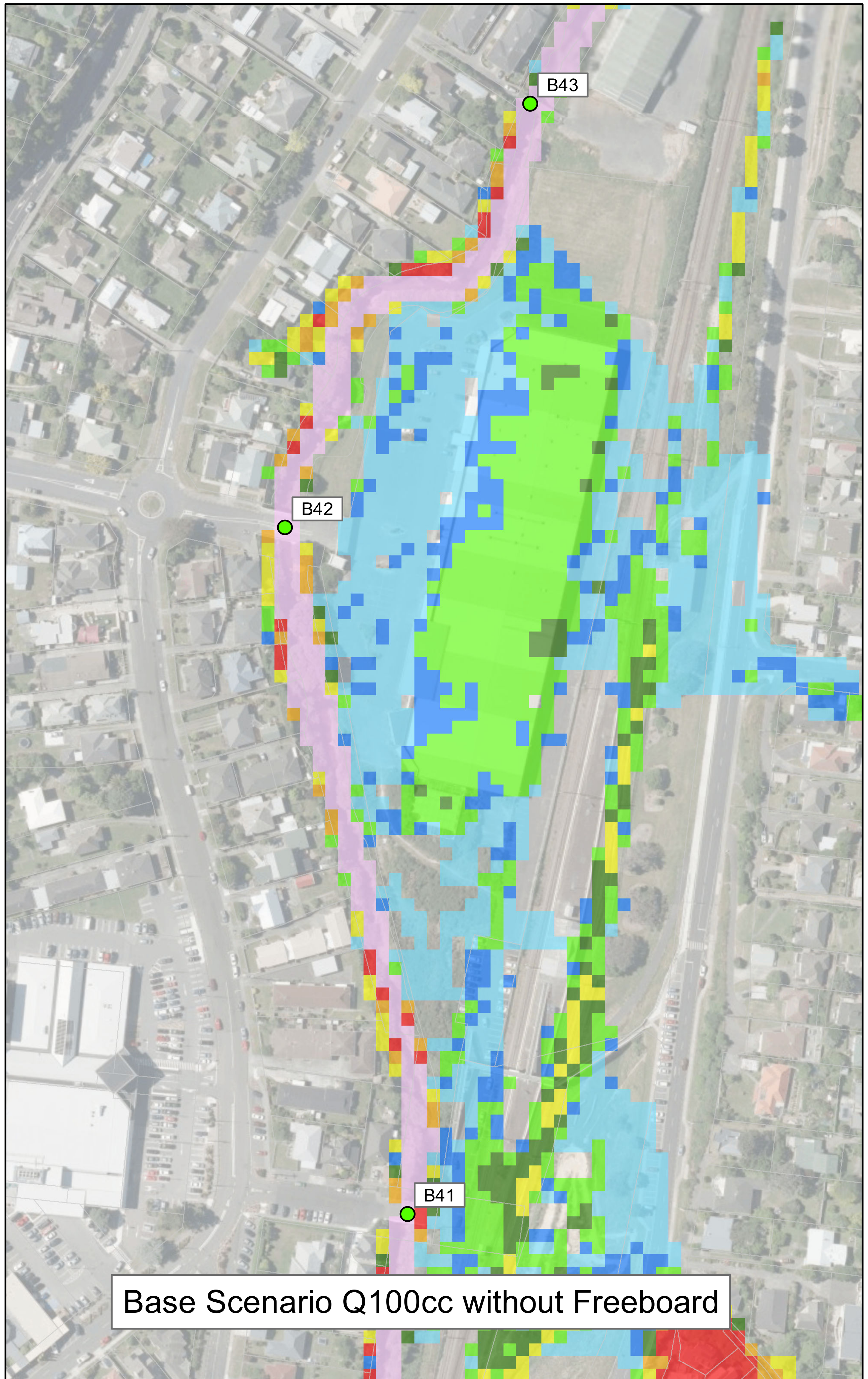
0 0.05 0.1 0.2km

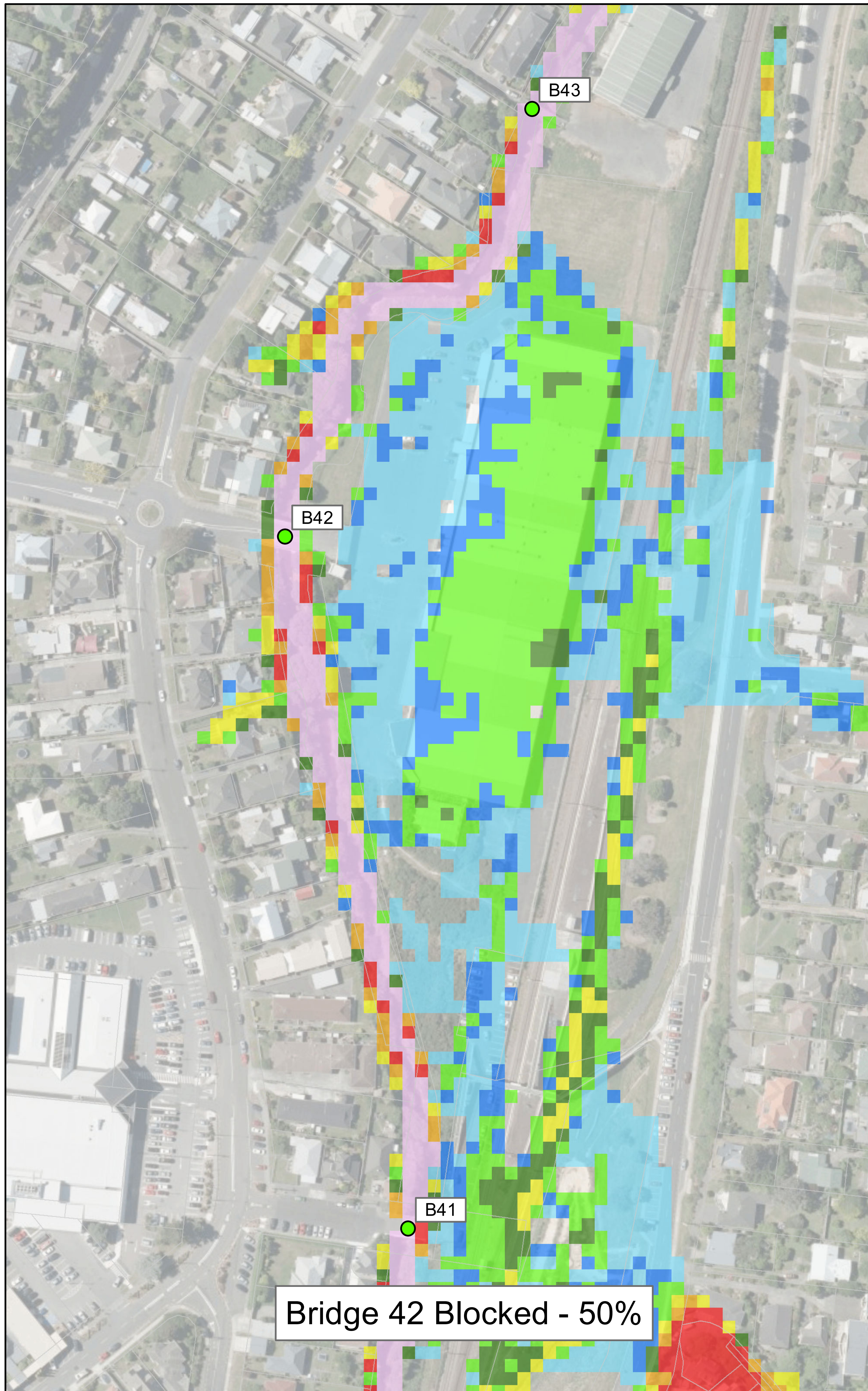
PROJECT
Porirua Stream Updated Hydraulic Modelling

TITLE
Peak Flood Depth
100 year Climate Change Scenario (Map 8 of 8)

6. BLOCKAGE SCENARIOS

The effects of each blockage scenario have been included in the flood sensitive area shown in the model results in the previous section. To present more information about the impacts of the blockage of the modelled structures, model resulted are compared at each structure location and presented in the following figures.





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Legend

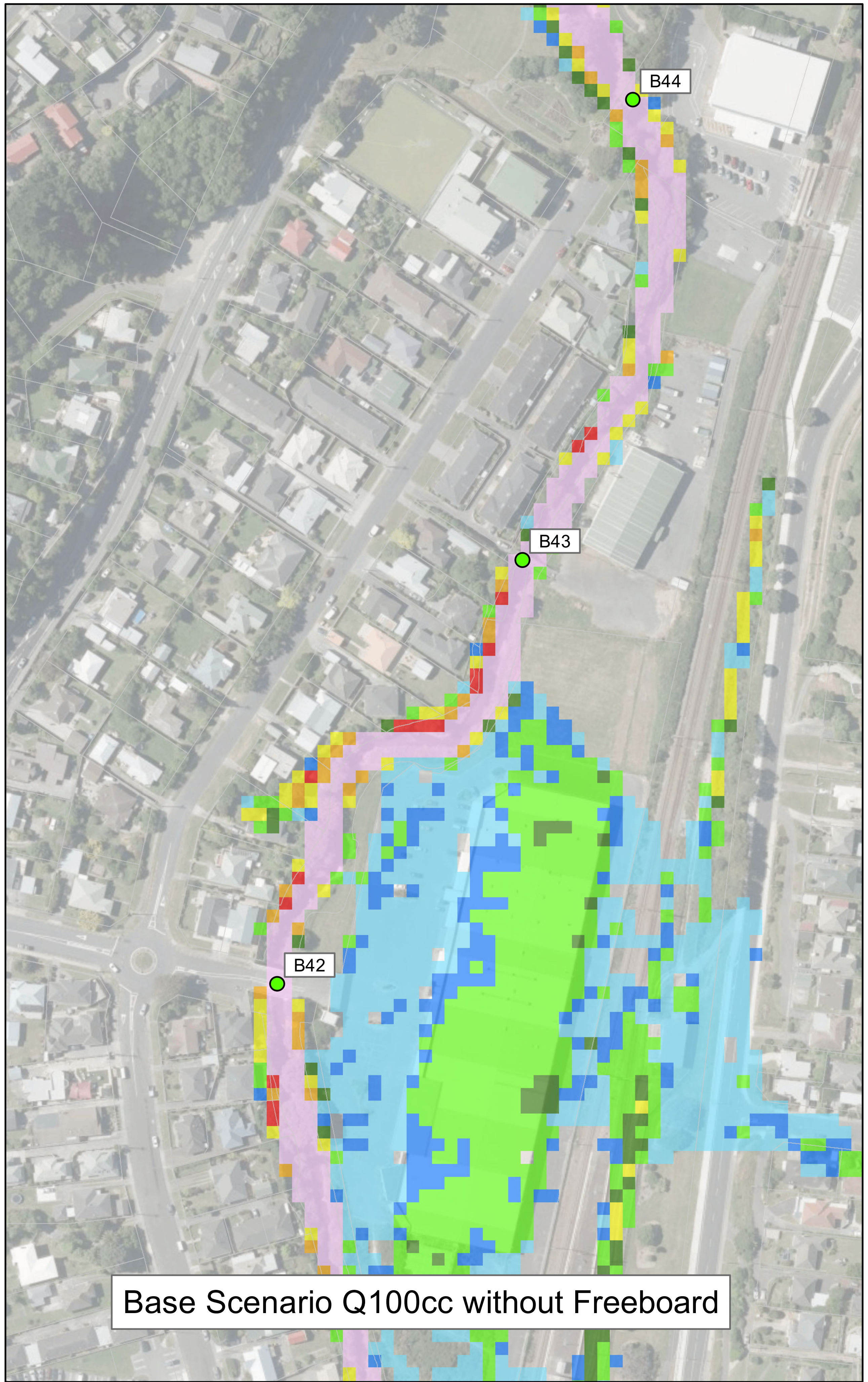
- Structure Locations
- Property Boundaries

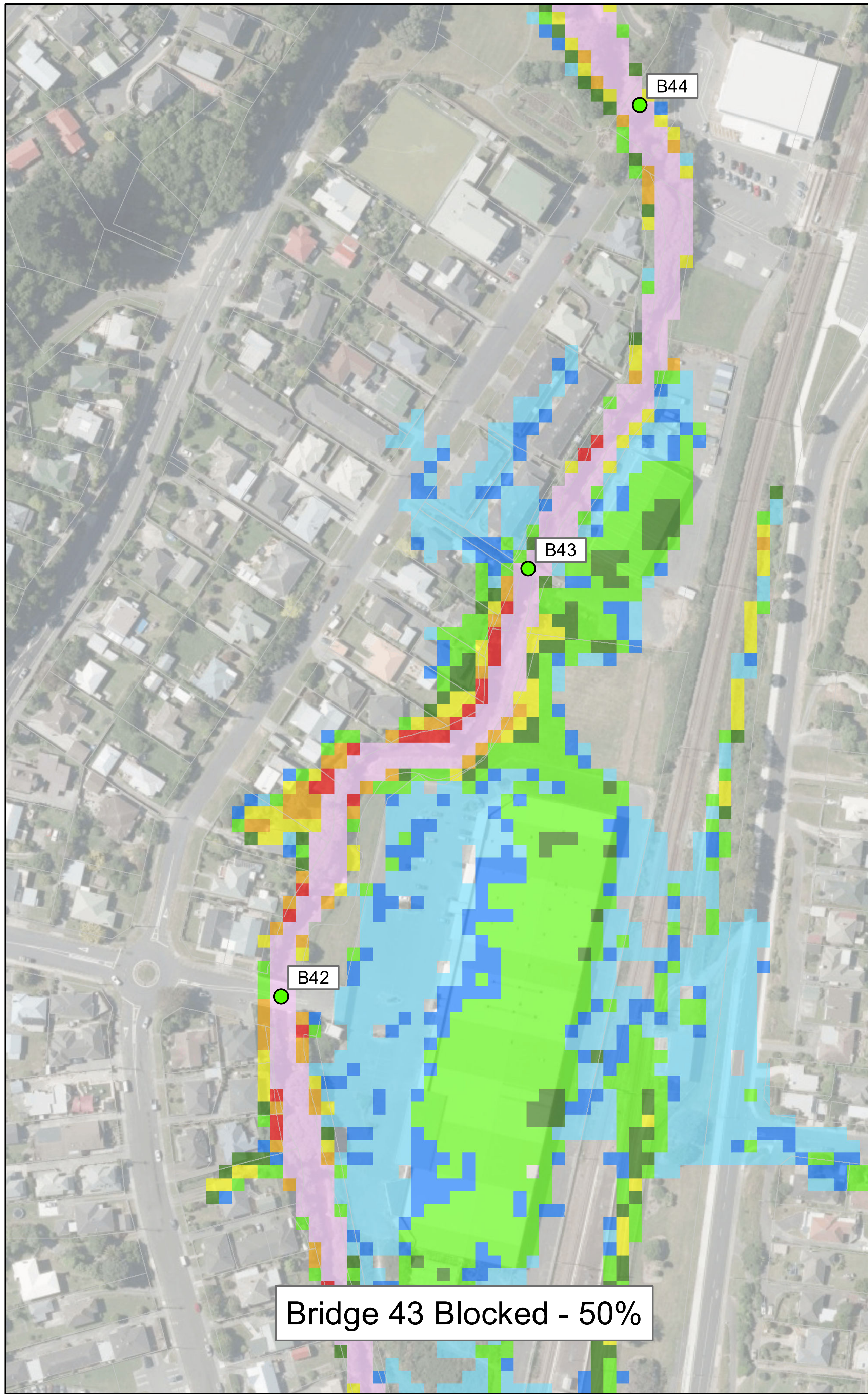
Peak Water Depth (m)

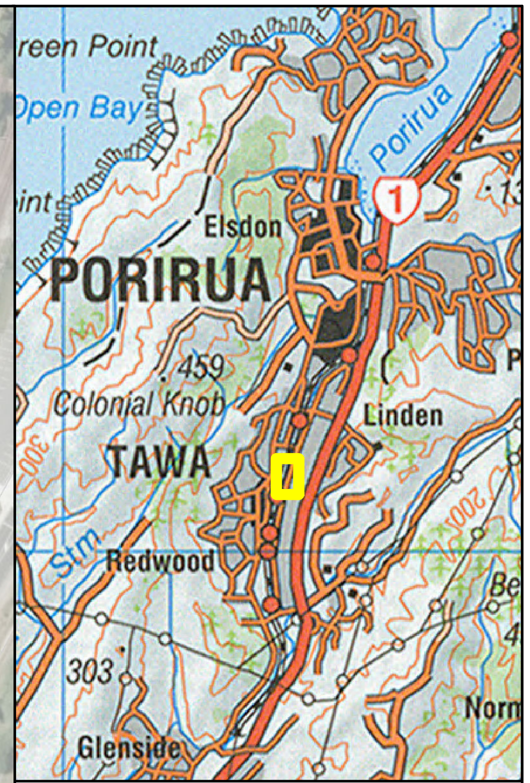
- 0
- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- 2+

- MIKE11 Model Extent

PROJECT **Porirua Stream Updated Hydraulic Modelling**	MAP TITLE **Peak Flood Depth Comparison Bridge 42 Blockage Scenario (50% Blockage)**	REV **01**	DATE **12 April 2018**	N
		A3 SCALE **1:2000**	AUTHOR **Matthew Gardner**	







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Legend

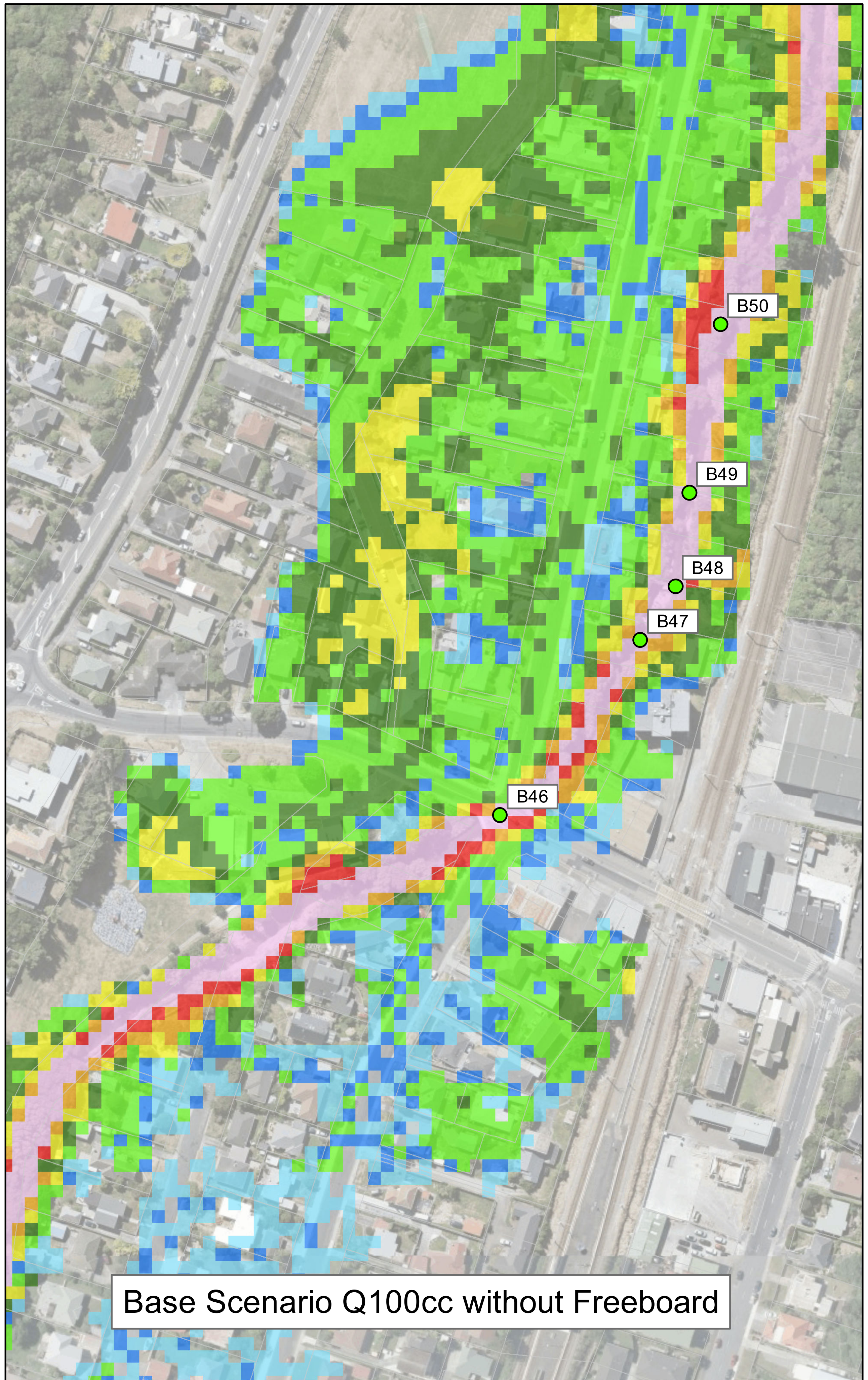
- Structure Locations
- Property Boundaries

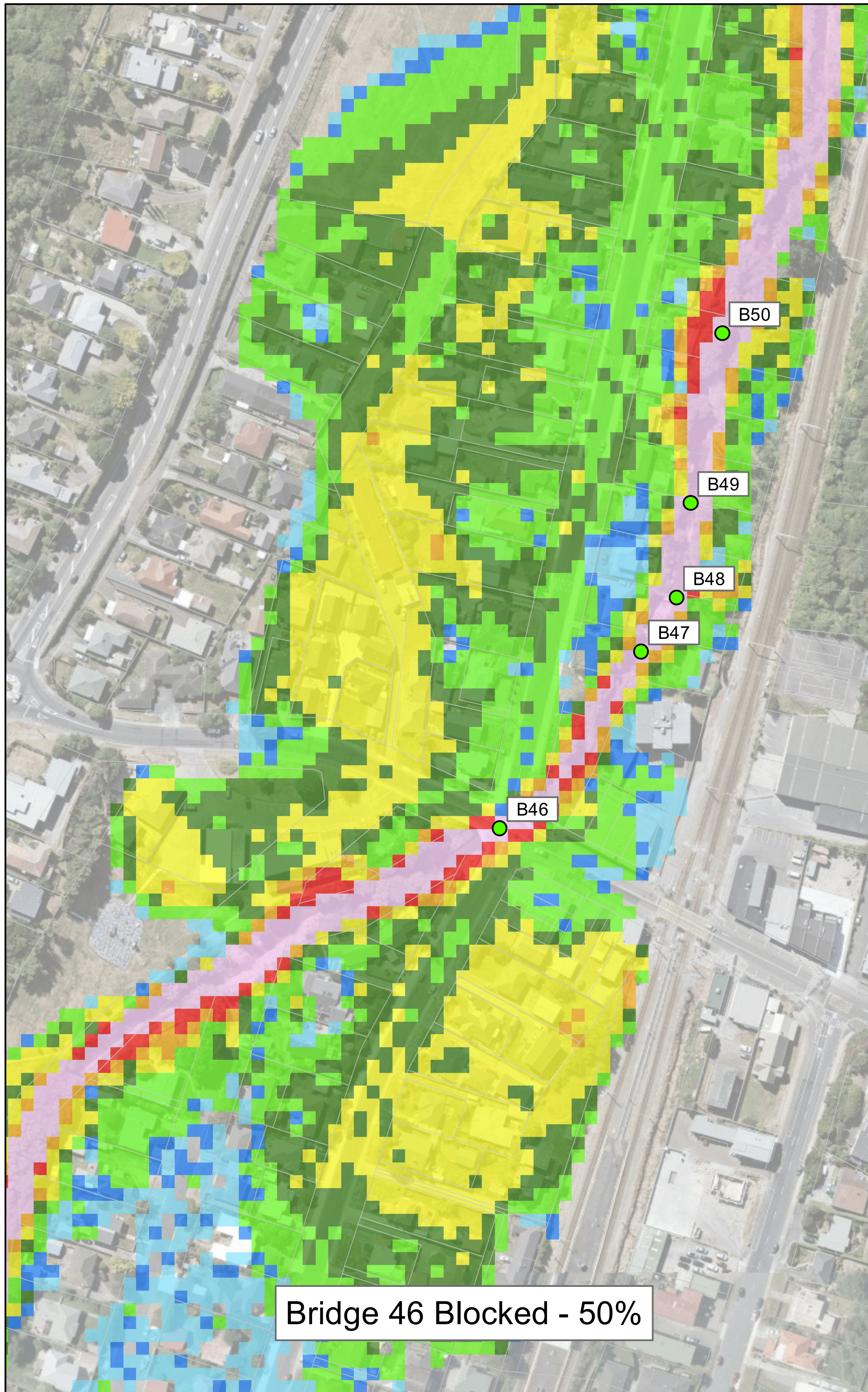
Peak Water Depth (m)

- 0
- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- 2+

- MIKE11 Model Extent

PROJECT	**Porirua Stream Updated Hydraulic Modelling**	MAP TITLE **Peak Flood Depth Comparison Bridge 43 Blockage Scenario (50% Blockage)**	REV **01**	DATE **12 April 2018**	N
			A3 SCALE **1:2000**	AUTHOR **Matthew Gardner**	





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Legend

- Structure Locations
- Property Boundaries

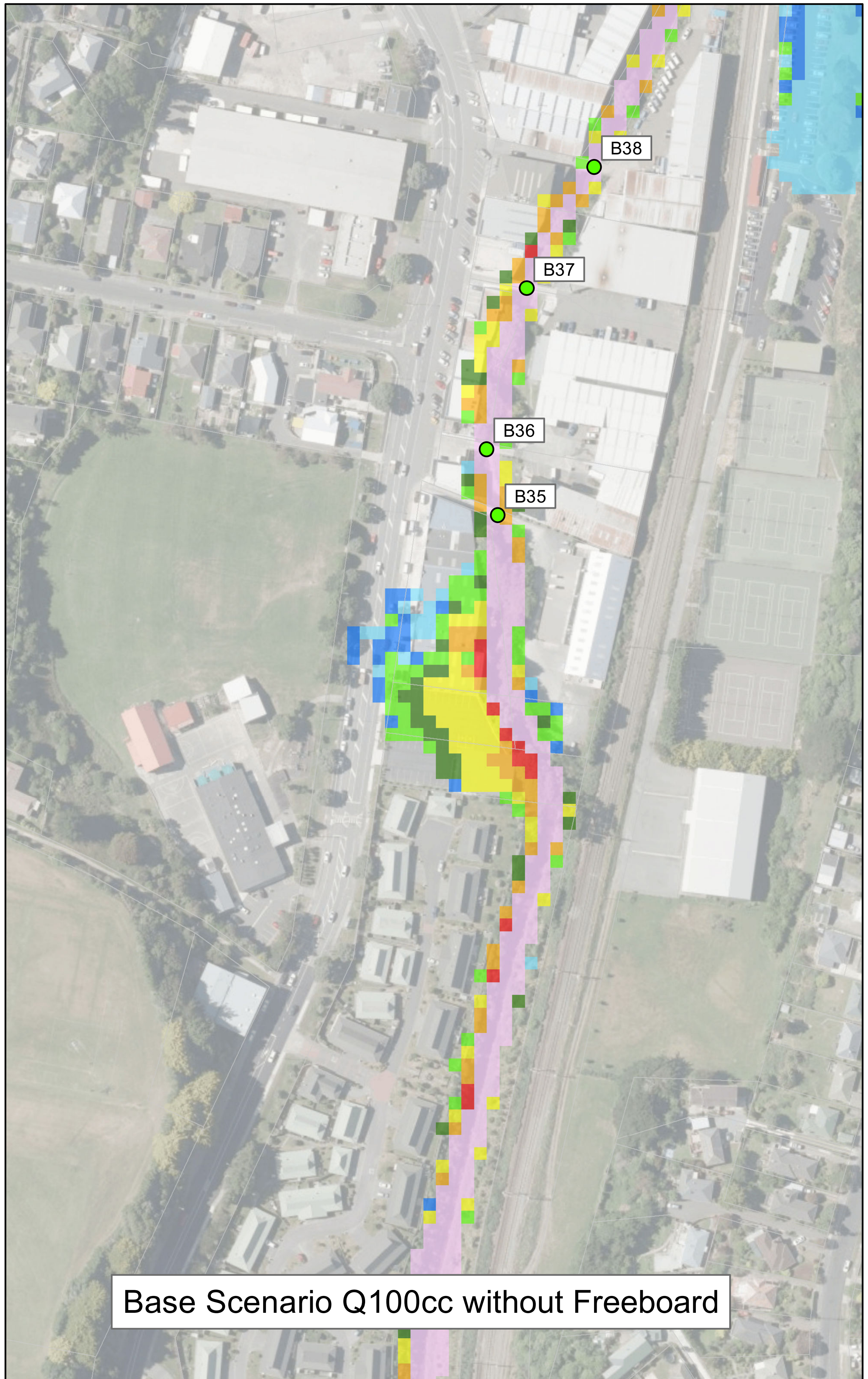
Peak Water Depth (m)

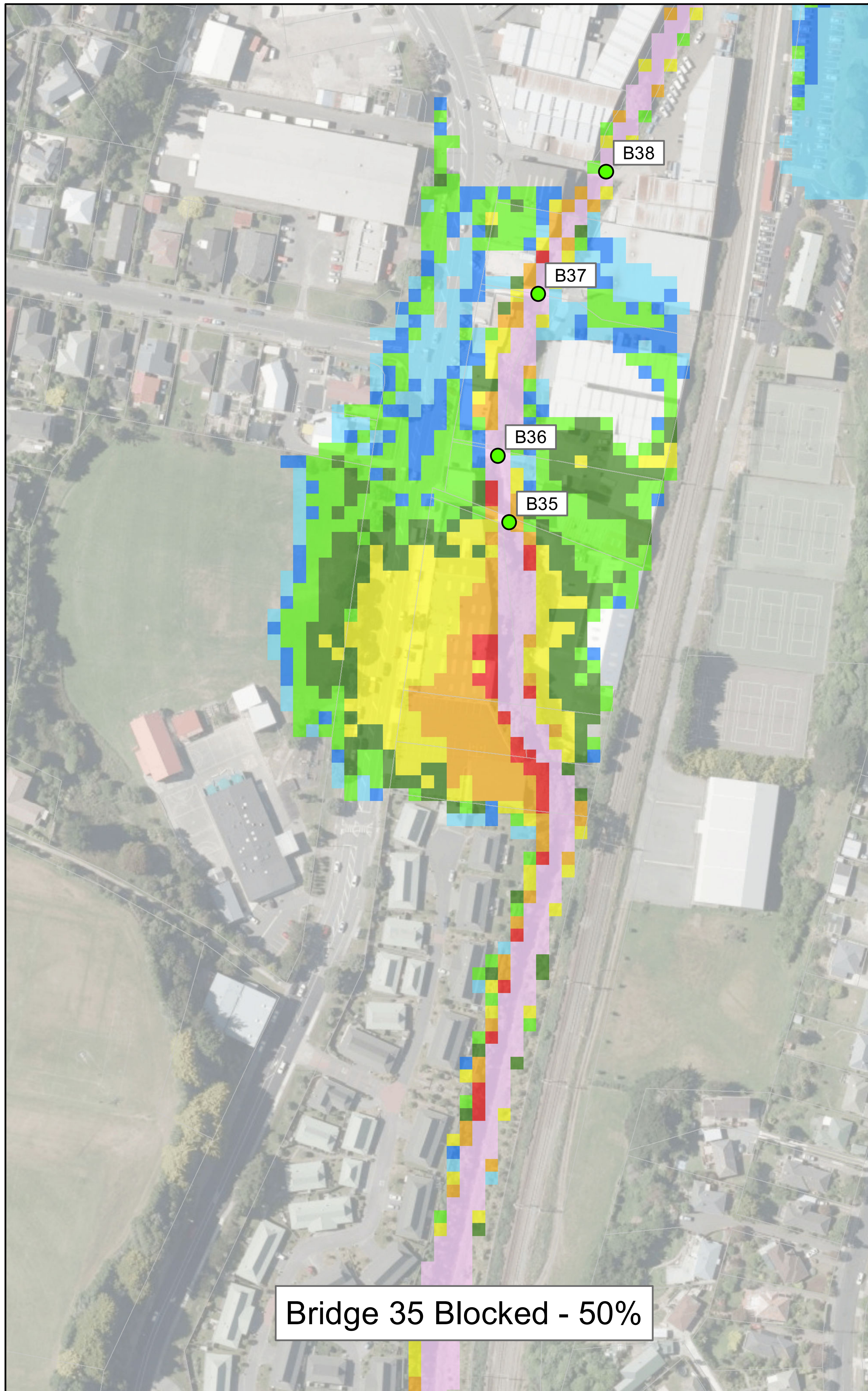
- 0
- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- 2+

- MIKE11 Model Extent

PROJECT	MAP TITLE	REV	DATE
Porirua Stream Updated Hydraulic Modelling	**Peak Flood Depth Comparison Bridge 46 Blockage Scenario (50% Blockage)**	01	12 April 2018
		A3 SCALE 1:2000	AUTHOR Matthew Gardner

N





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Legend

- Structure Locations
- Property Boundaries

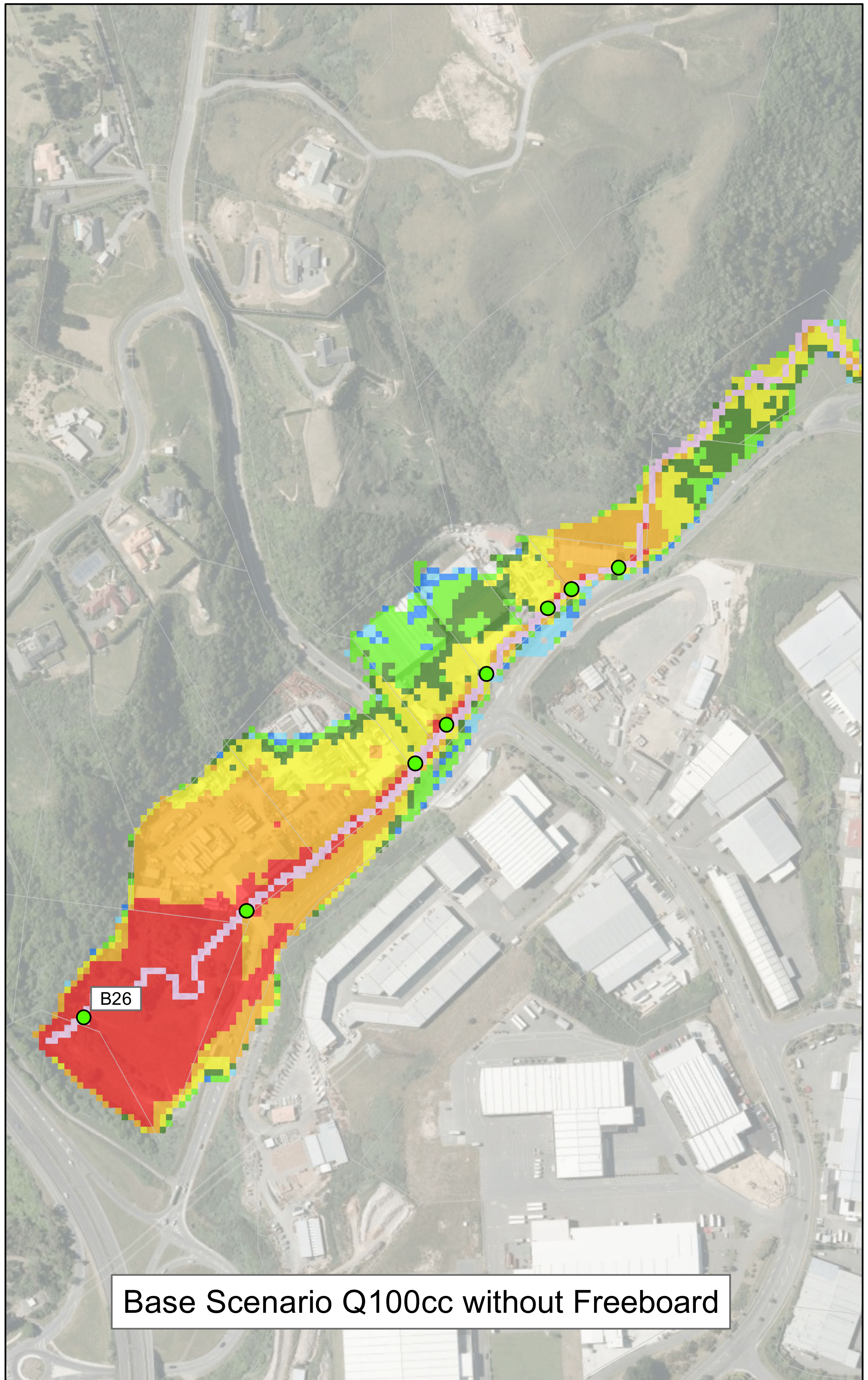
Peak Water Depth (m)

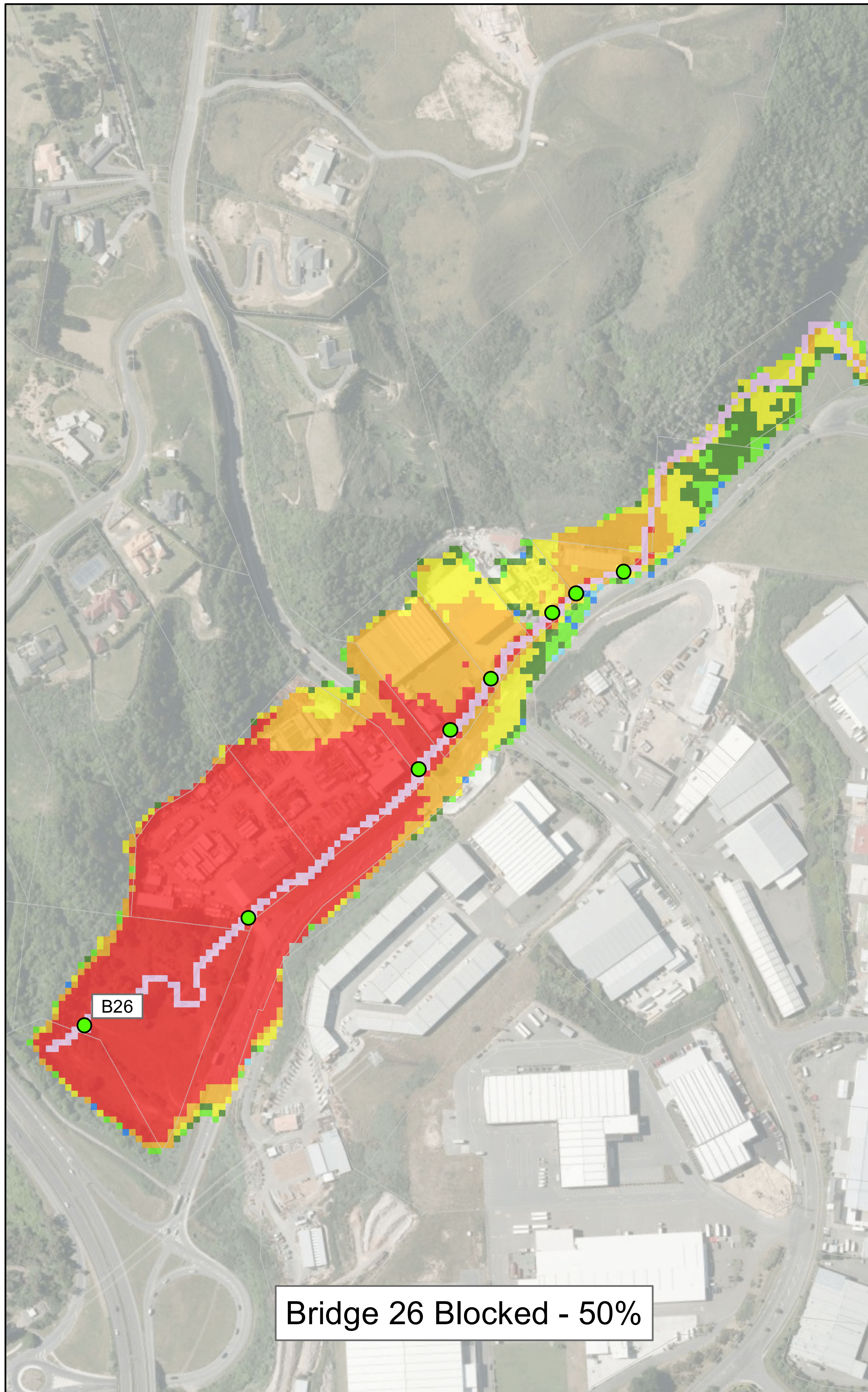
- 0
- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- 2+

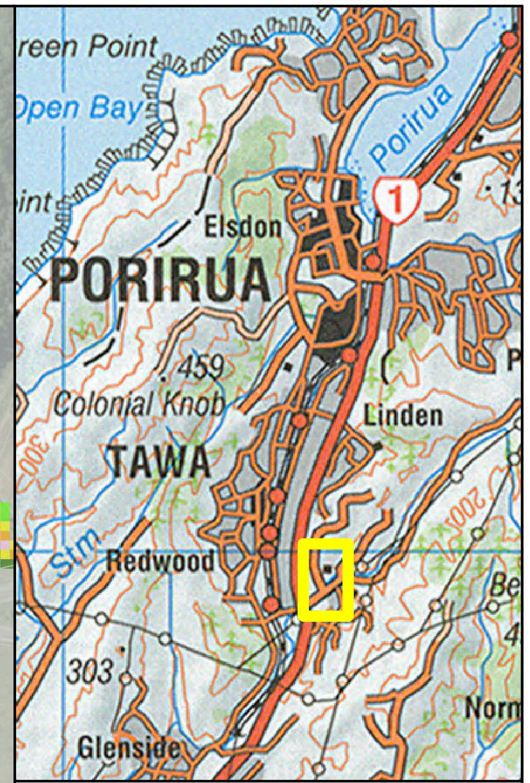
- MIKE11 Model Extent

PROJECT **Porirua Stream Updated Hydraulic Modelling**	MAP TITLE **Peak Flood Depth Comparison Bridge 35 Blockage Scenario (50% Blockage)**	REV **01**	DATE **12 April 2018**
		A3 SCALE **1:2000**	AUTHOR **Matthew Gardner**

N







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Legend

- Structure Locations
- Property Boundaries

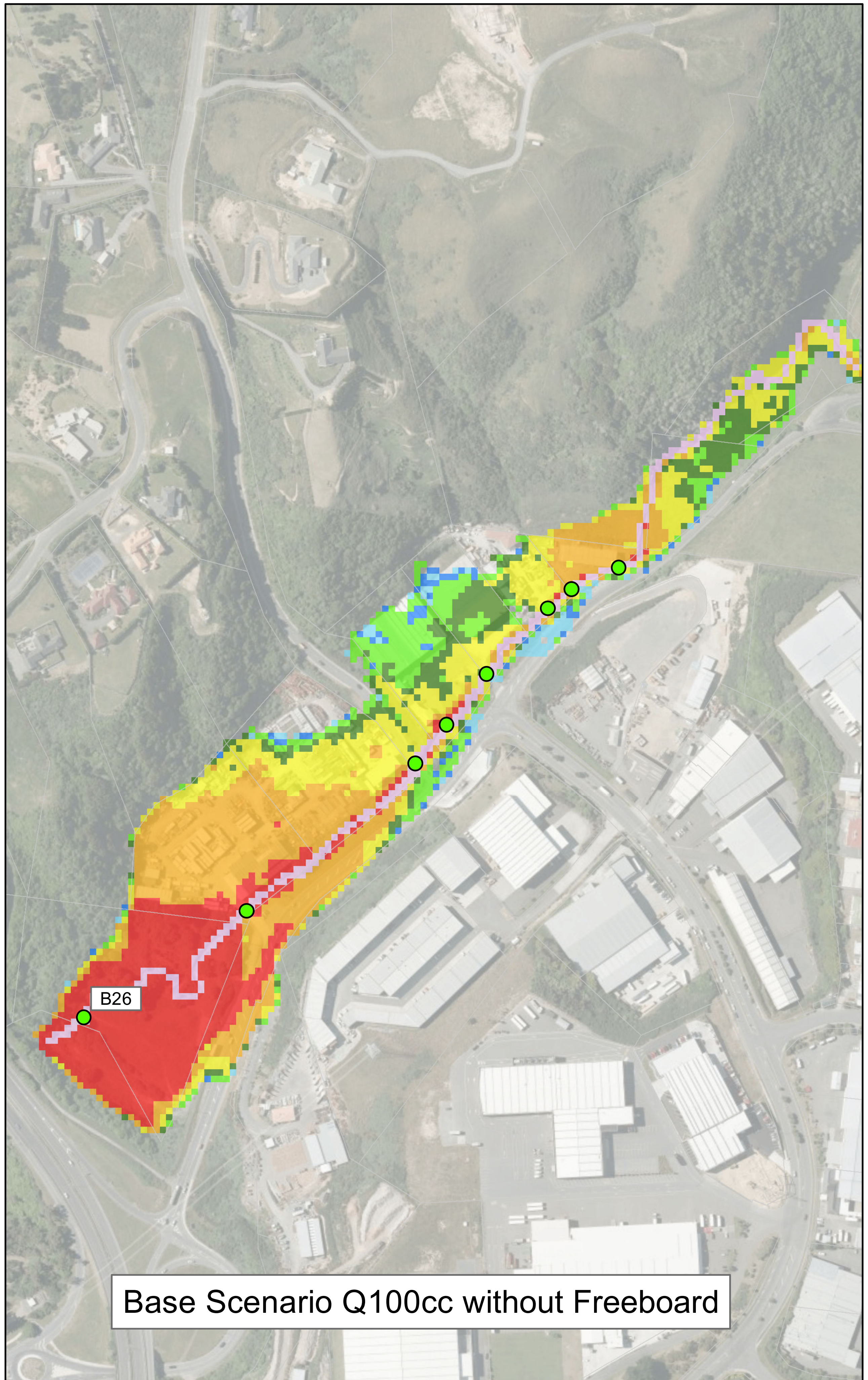
Peak Water Depth (m)

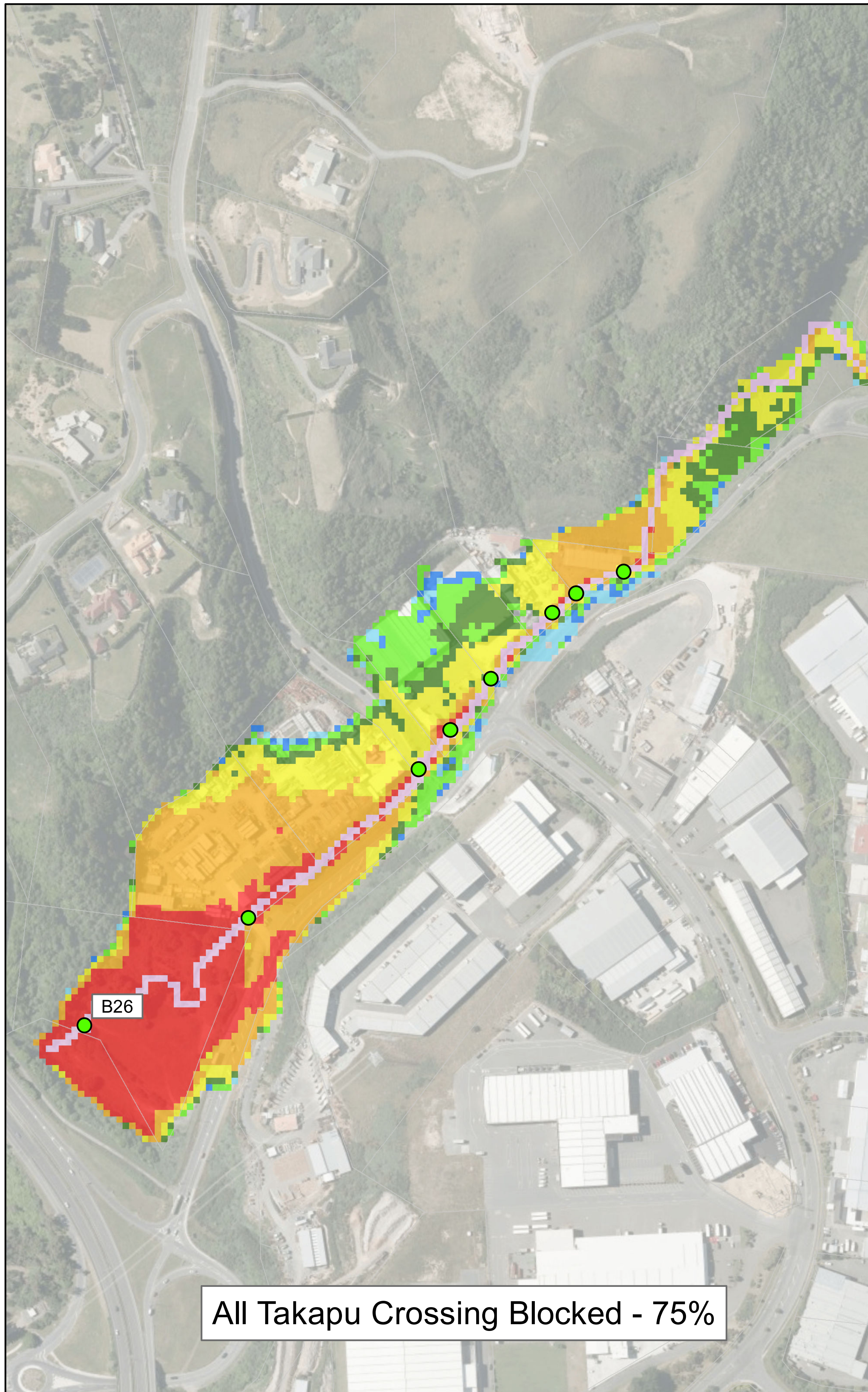
- 0
- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- 2+

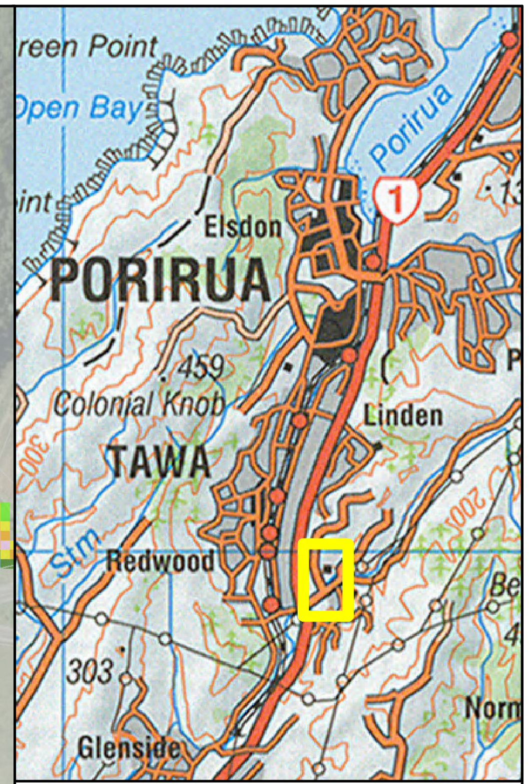
- MIKE11 Model Extent

PROJECT	MAP TITLE	REV	DATE
Porirua Stream Updated Hydraulic Modelling	**Peak Flood Depth Comparison Bridge 26 Blockage Scenario (50% Blockage)**	01	**12 April 2018**
		A3 SCALE 1:4000	AUTHOR **Matthew Gardner**

N







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Legend

- Structure Locations
- Property Boundaries

Peak Water Depth (m)

- 0
- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 2
- 2+

- MIKE11 Model Extent

PROJECT	**Porirua Stream Updated Hydraulic Modelling**	MAP TITLE **Peak Flood Depth Comparison Takapu Blockage Scenario (75% Blockage)**	REV **01**	DATE **12 April 2018**	N
			A3 SCALE **1:4000**	AUTHOR **Matthew Gardner**	

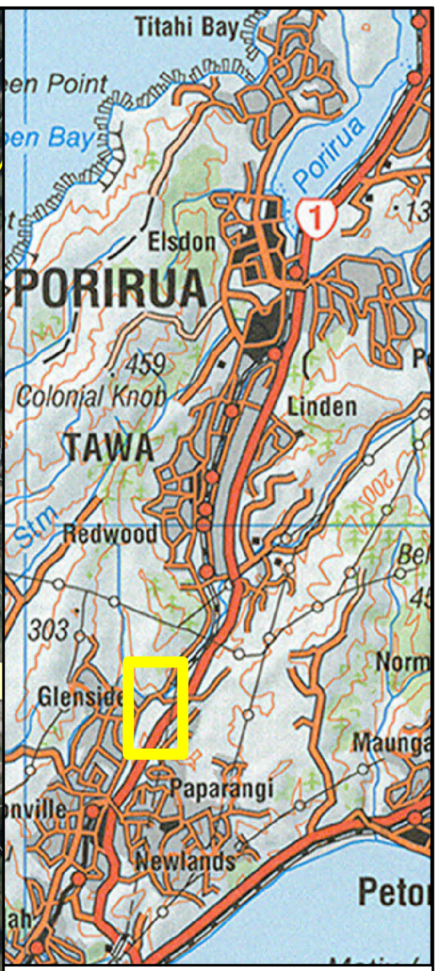
7. REFERENCES

Abbott, R., 2015. *Minutes of Mangaroa Hazard Mapping Workshop held Wed 20th May 2015.* s.l.:s.n.

Gardner, M., 2012. *Porirua Stream Hydraulic Modelling and Flood Hazard Mapping,* s.l.: Greater Wellington Regional Council.

Tonkin & Taylor Ltd, 2017. *Porirua Stream Hydrology Revision,* s.l.: s.n.

APPENDIX A – CROSS SECTION AND MODELLED BRIDGE / CULVERT LOCATIONS



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Legend

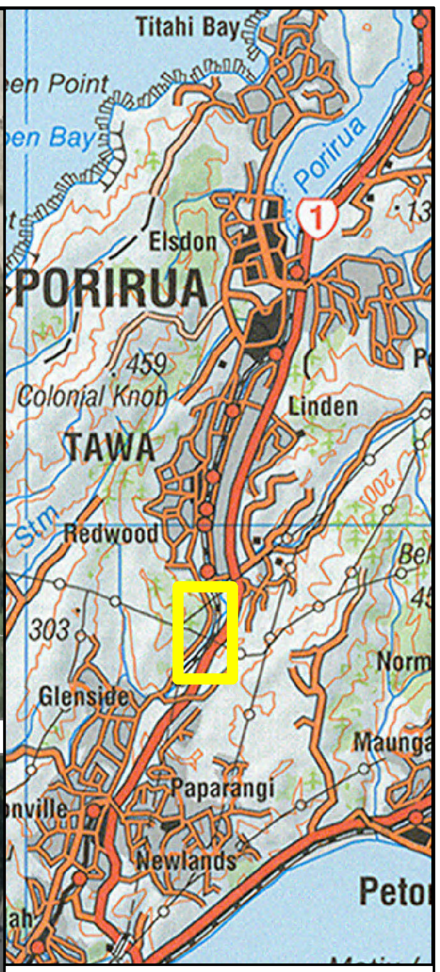
- Structure Locations
- MIKE11 Network
- Cross Sections
- Property Boundaries

AUTHOR	JOB CODE
Matthew Gardner	WCRC004
DATE	REV
18 July 2017	01
N	A3 SCALE 1:4000

0 0.05 0.1 0.2km

PROJECT
Porirua Stream Updated Hydraulic Modelling

TITLE
Cross Section / Structure Locations (Map 1 of 8)



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Legend

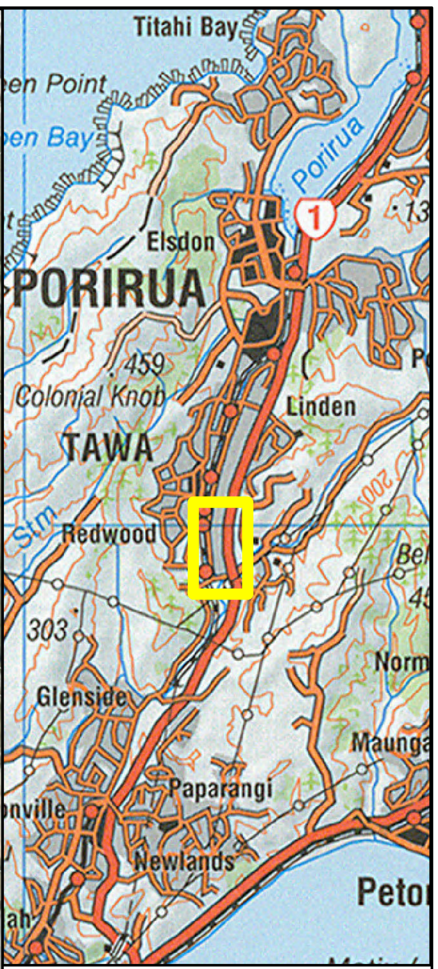
- Structure Locations
- MIKE11 Network
- Cross Sections
- Property Boundaries

AUTHOR	JOB CODE
Matthew Gardner	WCRC004
DATE	**REV**
18 July 2017	01
N	**A3 SCALE** 1:4000

0 0.05 0.1 0.2km

PROJECT
Porirua Stream Updated Hydraulic Modelling

TITLE
Cross Section / Structure Locations (Map 2 of 8)



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Legend

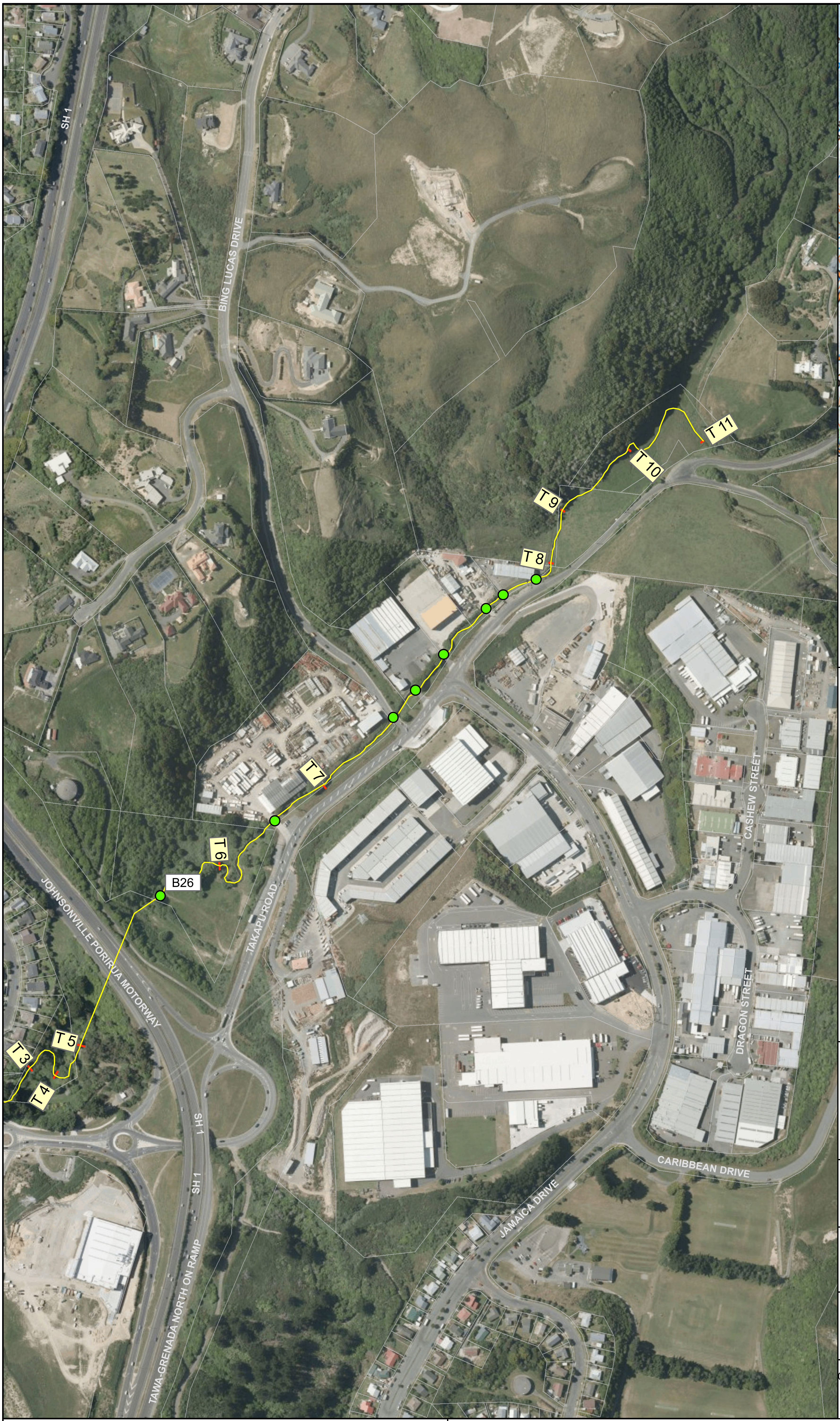
- Structure Locations
- MIKE11 Network
- Cross Sections
- Property Boundaries

AUTHOR	JOB CODE
Matthew Gardner	WCRC004
DATE	**REV**
18 July 2017	01
N	**A3 SCALE** 1:4000

0 0.05 0.1 0.2km

PROJECT
Porirua Stream Updated Hydraulic Modelling

TITLE
Cross Section / Structure Locations (Map 3 of 8)



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Legend

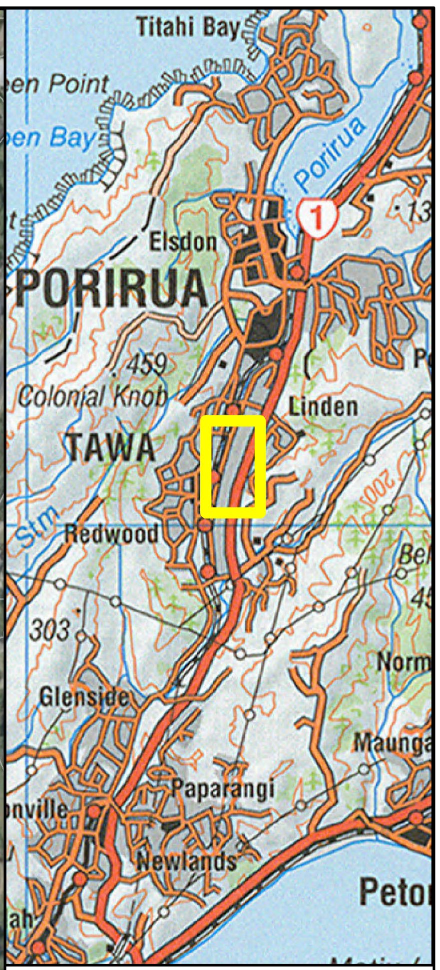
- Structure Locations
- MIKE11 Network
- Cross Sections
- Property Boundaries

AUTHOR	JOB CODE
Matthew Gardner	WCRC004
DATE	**REV**
18 July 2017	01
N	**A3 SCALE** 1:4000

0 0.05 0.1 0.2km

PROJECT
Porirua Stream Updated Hydraulic Modelling

TITLE
Cross Section / Structure Locations (Map 4 of 8)



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Legend

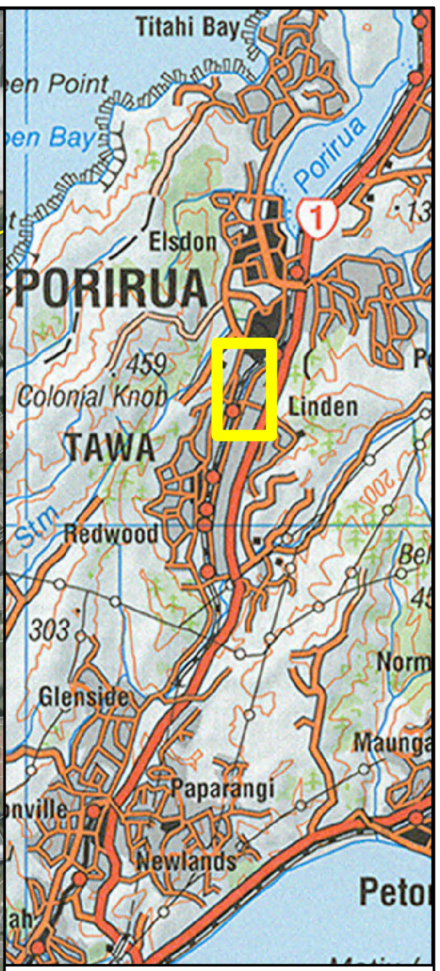
- Structure Locations
- MIKE11 Network
- Cross Sections
- Property Boundaries

AUTHOR	JOB CODE
Matthew Gardner	WCRC004
DATE	**REV**
18 July 2017	01
N	**A3 SCALE** 1:4000

0 0.05 0.1 0.2km

PROJECT
Porirua Stream Updated Hydraulic Modelling

TITLE
Cross Section / Structure Locations (Map 5 of 8)



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Legend

- Structure Locations
- MIKE11 Network
- Cross Sections
- Property Boundaries

AUTHOR	JOB CODE
Matthew Gardner	WCRC004
DATE	**REV**
18 July 2017	01
N	**A3 SCALE** 1:4000

0 0.05 0.1 0.2km

PROJECT
Porirua Stream Updated Hydraulic Modelling

TITLE
Cross Section / Structure Locations (Map 6 of 8)

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Legend

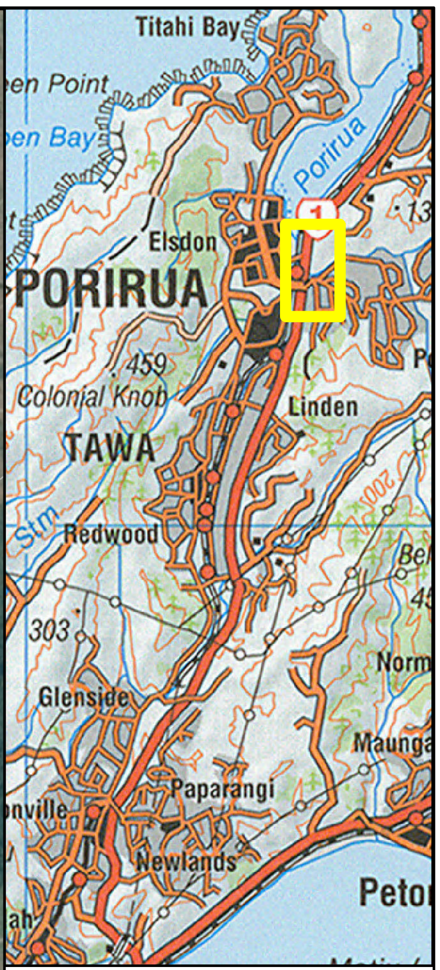
- Structure Locations
- MIKE11 Network
- Cross Sections
- Property Boundaries

AUTHOR	JOB CODE
Matthew Gardner	WCRC004
DATE	**REV**
18 July 2017	01
N	**A3 SCALE** 1:4000

0 0.05 0.1 0.2km

PROJECT
Porirua Stream Updated Hydraulic Modelling

TITLE
Cross Section / Structure Locations (Map 7 of 8)



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Legend

- Structure Locations
- MIKE11 Network
- Cross Sections
- Property Boundaries

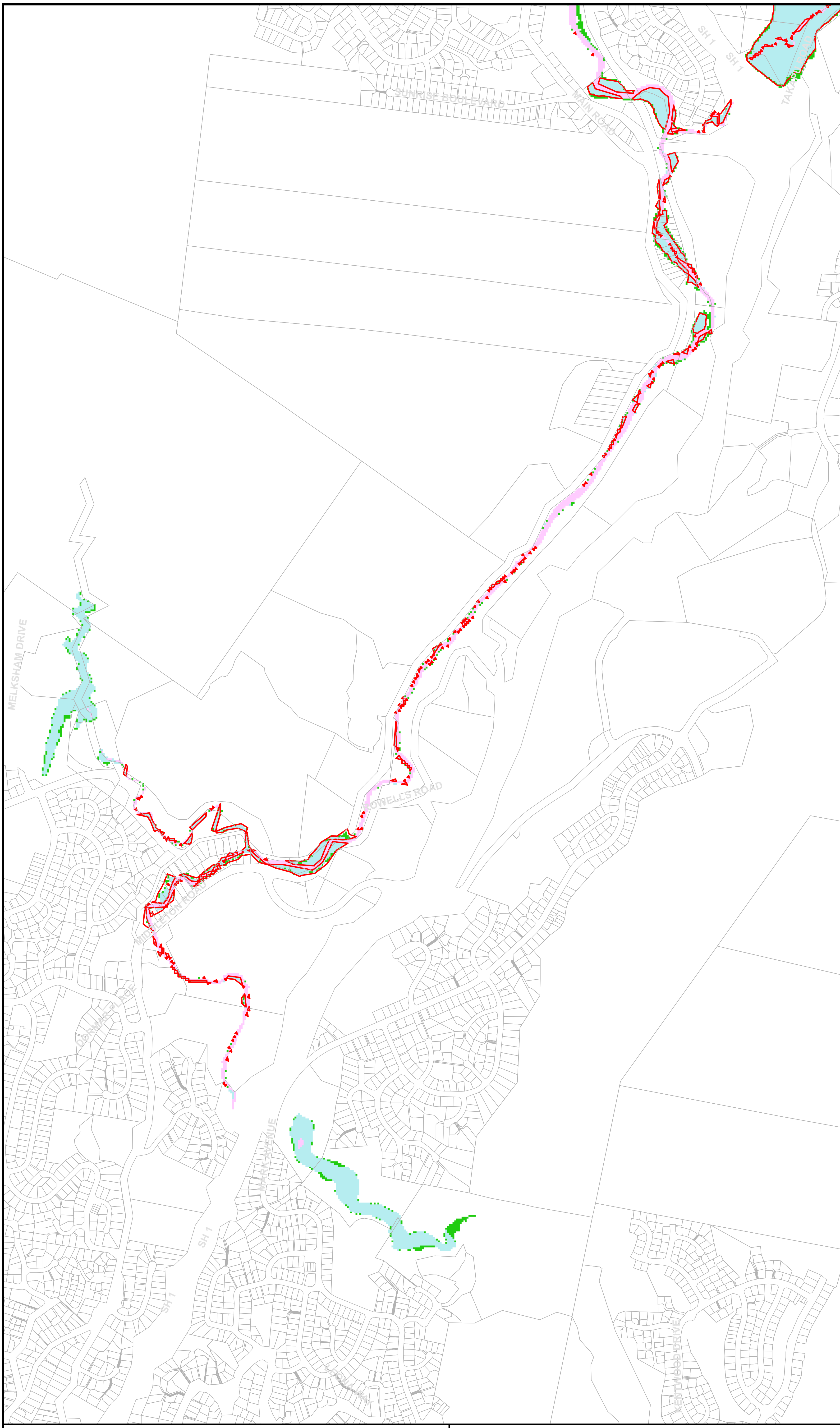
AUTHOR	JOB CODE
Matthew Gardner	WCRC004
DATE	REV
18 July 2017	01
N	A3 SCALE 1:4000

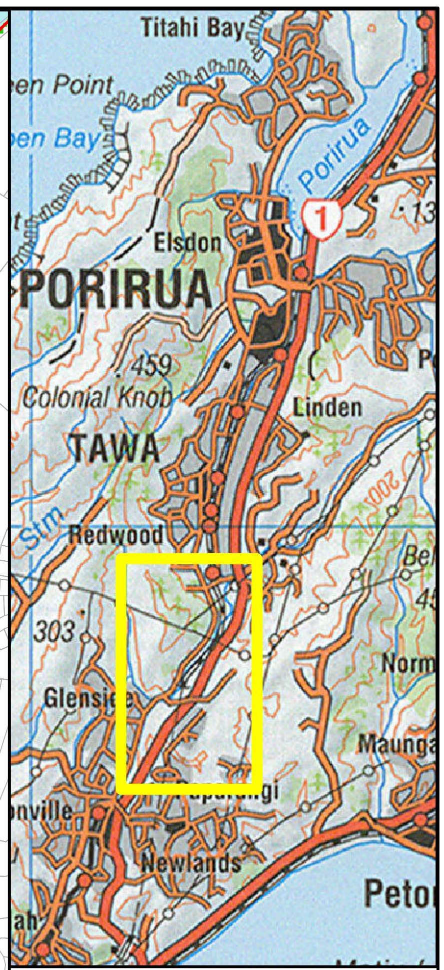
0 0.05 0.1 0.2km

PROJECT
Porirua Stream Updated Hydraulic Modelling

TITLE
Cross Section / Structure Locations (Map 8 of 8)

APPENDIX B – COMPARISON OF 2012 AND 2017 FLOOD EXTENTS





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Legend

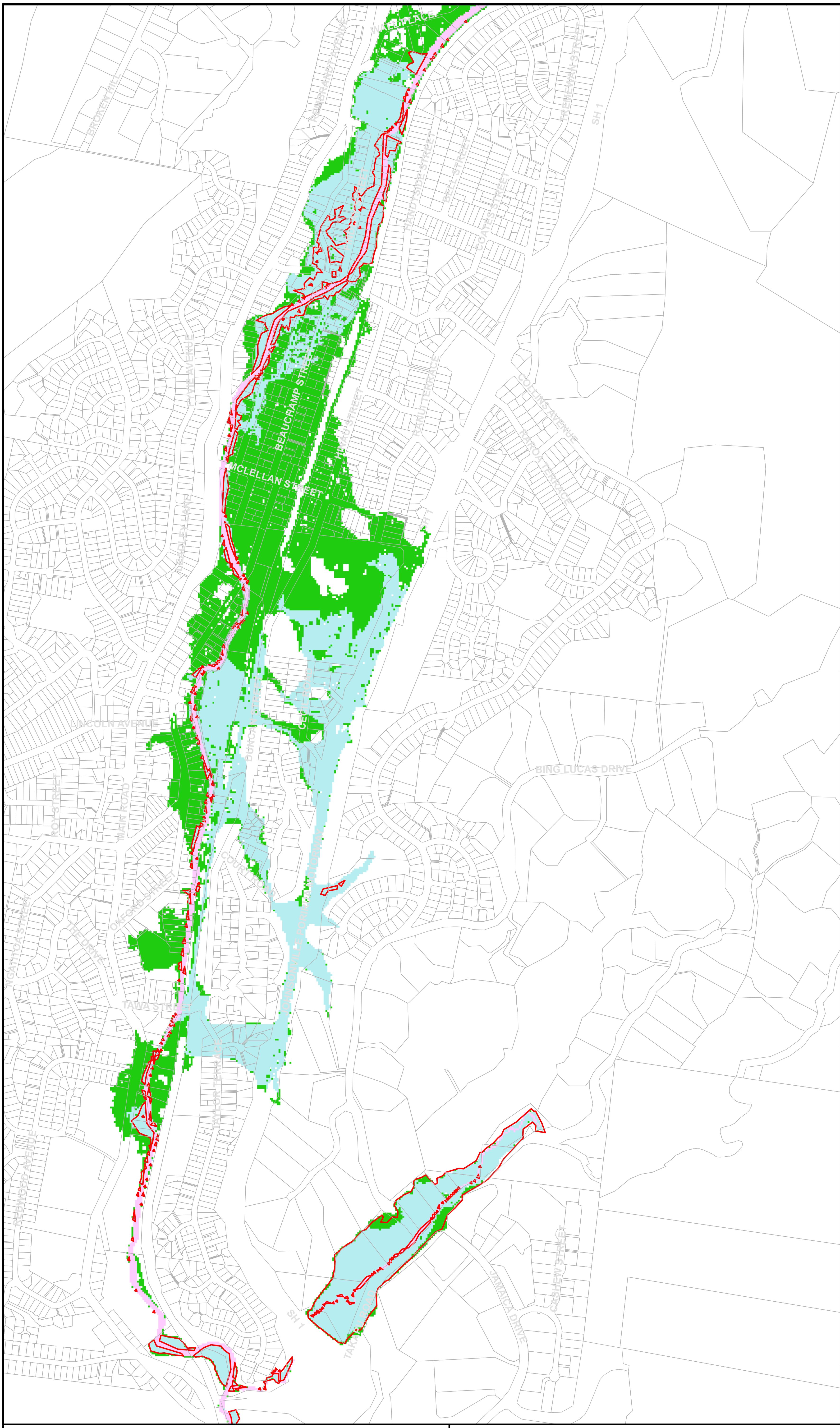
- Property Boundaries
- 2012_Flood_Extent
- 2017 Flood Extent
- 2017 Flood Sensitive Area
- MIKE 11 Model Extent

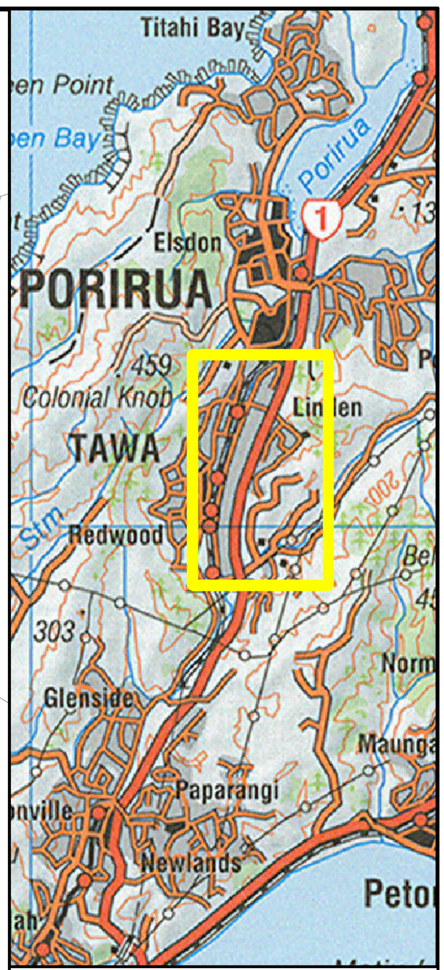
AUTHOR	JOB CODE
Matthew Gardner	GWRC022
DATE	REV
18 July 2017	01
N	A3 SCALE 1:10000

0 0.1 0.2 0.4km

PROJECT
Porirua Stream Updated Hydraulic Modelling

TITLE
1 in 100 year including Freeboard
Comparison of 2012 and 2017 Flood Extents (Map 1 of 3)





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Legend

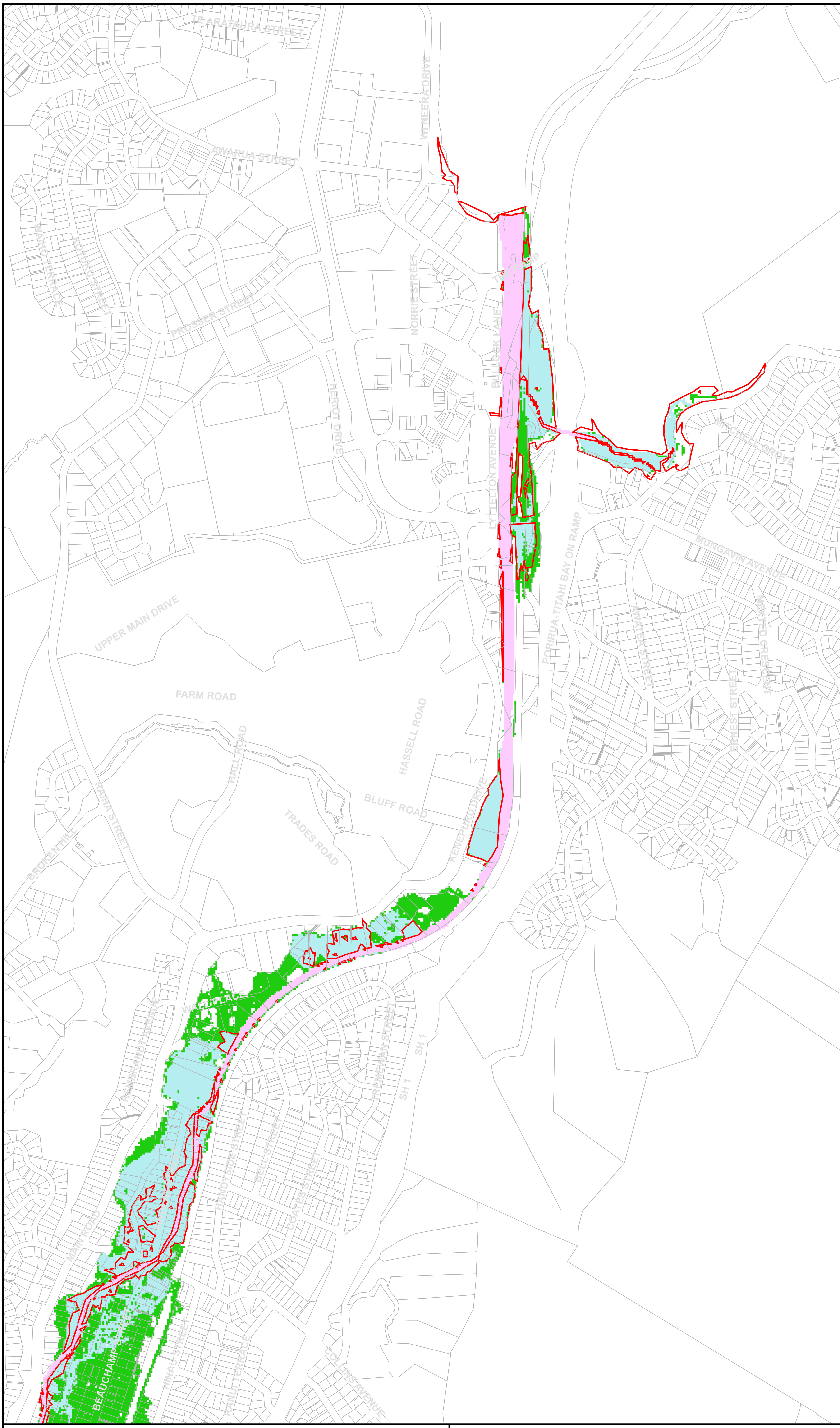
- Property Boundaries
- 2012_Flood_Extent
- 2017 Flood Extent
- 2017 Flood Sensitive Area
- MIKE 11 Model Extent

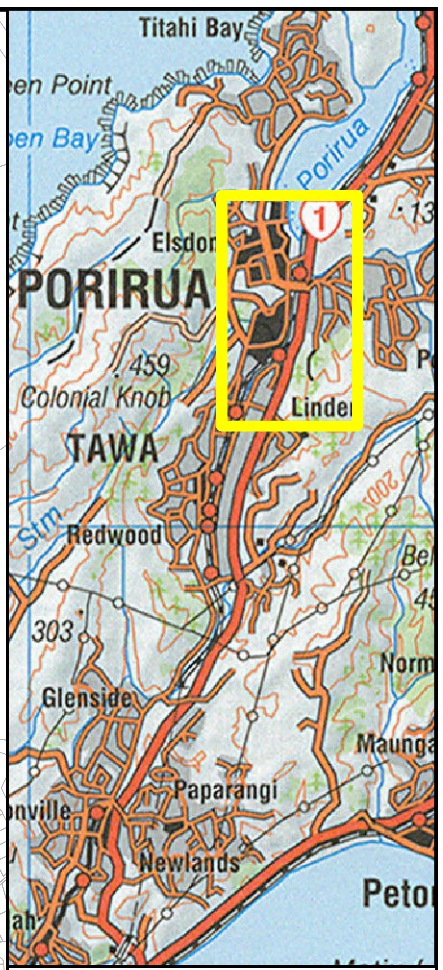
AUTHOR Matthew Gardner	**JOB CODE** GWRC022
DATE 18 July 2017	**REV** 01
N	**A3 SCALE** 1:10000

0 0.1 0.2 0.4km

PROJECT
Porirua Stream Updated Hydraulic Modelling

TITLE
1 in 100 year including Freeboard
Comparison of 2012 and 2017 Flood Extents (Map 2 of 3)





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Legend

- Property Boundaries
- 2012_Flood_Extent
- 2017 Flood Extent
- 2017 Flood Sensitive Area
- MIKE 11 Model Extent

AUTHOR Matthew Gardner	**JOB CODE** GWRC022
DATE 18 July 2017	**REV** 01
N	**A3 SCALE** 1:10000

0 0.1 0.2 0.4km

PROJECT
Porirua Stream Updated Hydraulic Modelling

TITLE
1 in 100 year including Freeboard
Comparison of 2012 and 2017 Flood Extents (Map 3 of 3)