Mataura River

Flood Modelling

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APPENDIX D – PEER REVIEW

Mataura River Hydraulic Model Review

Report prepared for Environment Southland
by

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Version:	Draft 1.0	
Prepared for:	Environment Southland	
Report prepared by:	Philip Wallace River Edge Consulting	**Date:** 03 May 2024

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1 Introduction

The Mataura River in Southland is fed by a catchment of nearly 5400 km^2, with its headwaters near the southern end of Lake Wakatipu. As the river heads towards its mouth in Toetoes Bay in Foveaux Strait, it passes through the townships of Gore, Mataura and Wyndham. These towns are subject to the risk of inundation during river floods and five events over the last 50 years have led to evacuations in at least one of these towns, the most recent in 2020.

The Southland Regional Council, known as Environment Southland (ES), commissioned Land River Sea Consulting Ltd. (LRS) to prepare a hydraulic model of the Mataura River and floodplain around Gore, Mataura and Wyndham townships. The scope of the project also included calibrating the model to the 2020 flood event, running design scenarios, preparing flood maps for those design scenarios, and modelling stopbank upgrades.

ES has commissioned River Edge Consulting Ltd. to carry out a peer review of the hydraulic modelling. Findings of an initial review were reported in a memorandum in January 2024[1]. A copy of the memorandum is appended (Appendix X). Since that time, LRS has refined the model in light of that initial review and has documented the modelling in an updated draft modelling report (LRS, 2024).

This report summarises the peer review process and findings for the modelling as of April 2024, and makes recommendations for future improvements. The model files and draft report provided are for the calibration simulations, so the peer review is focussed on model calibration. Nonetheless, some discussion of the suitability of the model for design scenarios and assessment of stopbank upgrade options is also provided.

[1] River Edge Consulting (2024); *Mataura Model – Peer Review.* Memorandum from Philip Wallace, River Edge Consulting to Matt Gardner, Land River Sea, 14 January 2024. A copy of this was also provided to Randal Beal of Environment Southland.

2 Review process

The peer review has been an iterative process, with frequent discussions between River Edge Consulting and Land River Sea Consulting during the process of model development and testing. Model files and a draft report were provided to River Edge Consulting in December 2023, after which a memorandum on the findings of the peer review of the modelling at that stage was prepared. Discussions between River Edge Consulting and LRS continued after that, before a set of revised model files and an updated draft report were submitted to REC for peer review.

Table 2-1 summarises the review process.

Table 2-1 Review process and milestones

Date	Milestone
October 2022	LRS commissioned by ES and commences modelling
November–December 2023	LRS seeks occasional advice from REC on model schematisation and build (via emails and phone conversations)
14 December 2023	LRS provides model files and a draft report
14 January 2024	Memo from REC on Findings from initial peer review. Memo provided to LRS and ES in a memo.
February–April 2024	Regular discussions between LRS and REC on model revisions (via emails and phone conversations)
23 April 2024	LRS provides model files and a draft report (v2)
1 May 2024	Report by REC on peer review

3 Model review

3.1 Overall schematisation

Two overlapping models have been prepared for the study. The first, the "Gore" model, covers an approximately 18 km length of river and floodplain centred around Gore, as well as a short length of the Waikaka River. The second, the "Mataura" model, covers an approximately 18 km length of river and floodplain centred around Mataura. The models overlap by around 3–4 km. Figure 3-1 and Figure 3-2 show the extent of the models.

A third model, centred around Wyndham, is planned. That model has not yet been prepared.

Note that the model is designed to consider flooding from the Mataura River. It is not designed to consider flooding from local stormwater runoff. The stormwater network (pipes, manholes etc) would need to be added to the model and ideally a finer resolution used within the towns, if that was required.

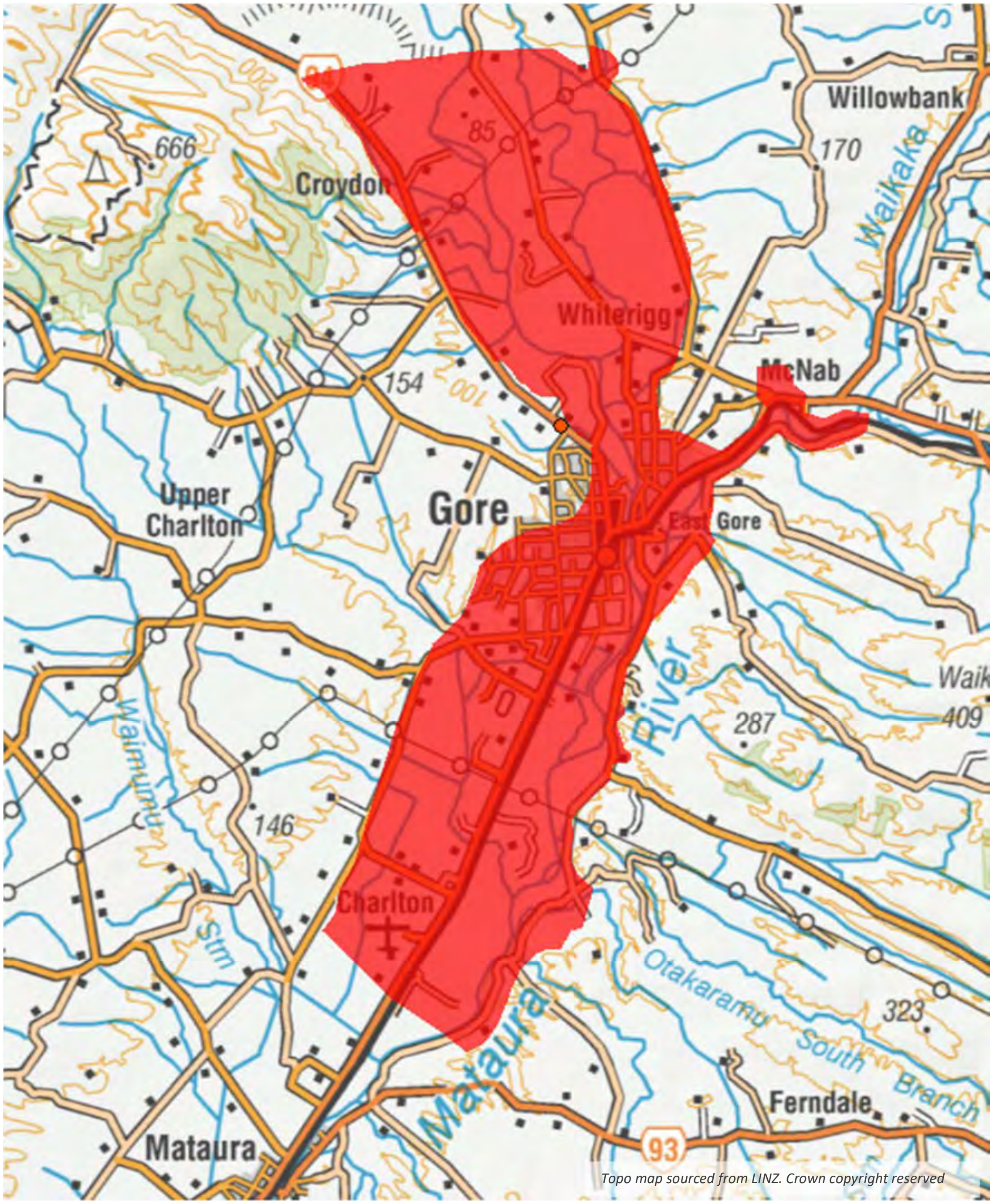

Figure 3-1 Gore model extent

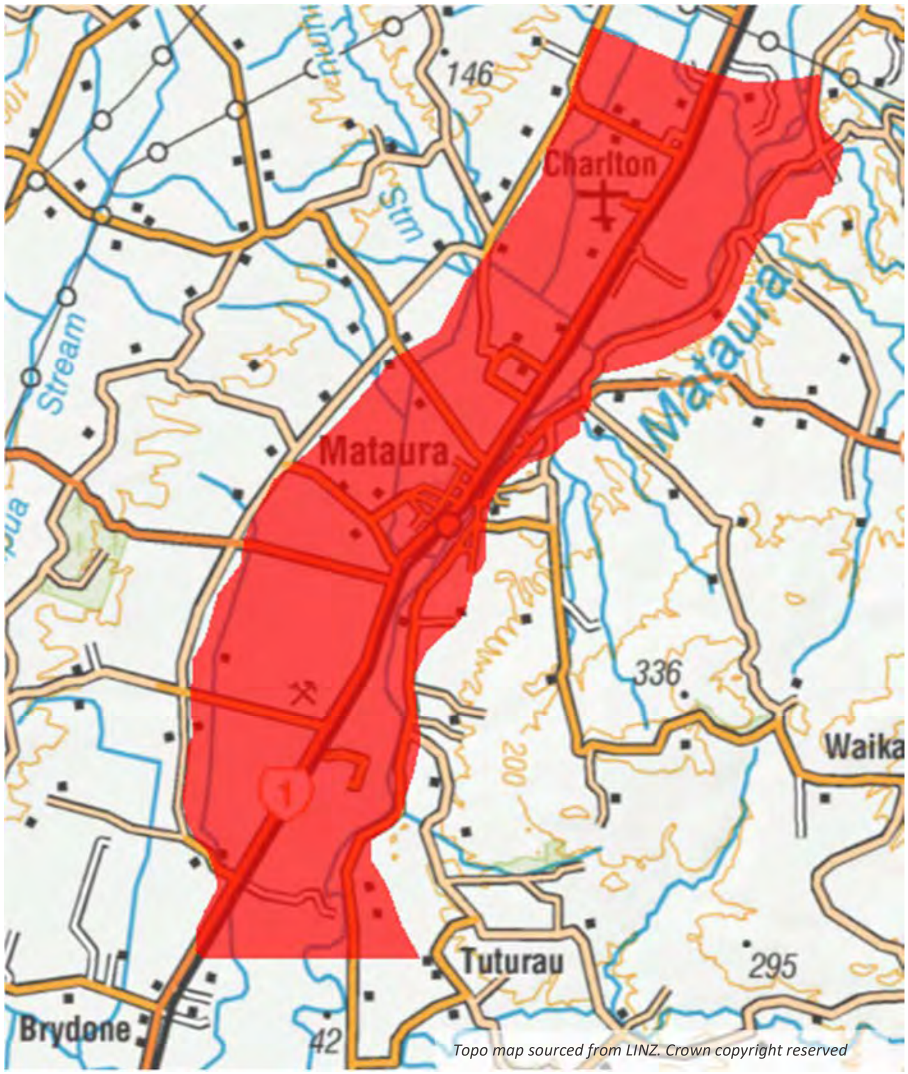

Figure 3-2 Mataura model extent

3.2 Datum and coordinate system

The coordinate system used is New Zealand Transverse Mercator (NZTM).

The vertical datum of the model is New Zealand Vertical Datum 2016 (NZVD 2016).

3.3 Model software

The model uses the 2024 version of the DHI product MIKE+, appropriate for this type of exercise. This software is the latest available from DHI and is a replacement for the MIKE FLOOD software that has had wide-spread usage within New Zealand and worldwide.

MIKE+ allows coupling of river channels, pipe networks (both using the "MIKE1D" engine for one-dimensional (1D) flow) and overland flow (using depth-averaged two-dimensional (2D) flow equations).

Note that "overland" flow can also apply to river channels if specified, as is the case in the Mataura modelling. That allows 2D flow patterns within a river channel to be represented. It also avoids the need to link 1D river components and 2D floodplain components along river banks which does not guarantee momentum conservation and also requires a weir equation, which may not be appropriate.

With the exception of short lengths of 1D river channel as discussed below, the models are entirely 2D.

3.4 1D component and coupling to 2D component

Short lengths (approximately 500 m) of 1D river channel in the Gore model, at the upstream end of the Mataura River and Waikaka River branches, are used to introduce flow into the 2D component. The 1D components represent a simplified river channel, with a cross-section extracted from LiDAR data and applied at each end of the river channel in each location. The calibration flows for each river are applied at the upstream end of each of the two river branches, while the downstream end of each is connected to the 2D model, allowing flow to pass into the 2D domain.

That these 1D channels (effectively, "dummy" branches) are very simplified representations of reality is not a concern; they are outside of the main area of interest and serve only to introduce flow to the 2D component.

Where the ends of 1D components connect with 2D components, it is usual to apply a dummy constant water level boundary at those ends. In this model however, a free outfall boundary is used. Nonetheless, the correct flow appears to be discharging into the 2D component, as shown in the "Discharge to Surface" results in the 1D result file.

The coupling uses a smoothing factor of 0.9, i.e. a strong smoothing (the default, no-smoothing, is 0), presumably to aid with model stability. This is of no concern, given that the area of interest is some distance away.

A simpler way of applying upstream inflows to the 2D model would have been to use external 2D boundaries across the river channels at the relevant locations. That would avoid the need to use the 1D components and the coupling. It is understood however LRS encountered instability issues when attempting that simpler approach and resorted to the coupled 1D branches as a work-around.

3.5 2D component

3.5.1 Model bathmetry/topography

The models use a flexible mesh structure of irregular triangular elements to discretise the topography. Each model is split into a complex set of sub-areas, each with a specified maximum element size (Figures 5-1 and 5-2 in LRS (2024)). The maximum sizes range from 10 m^2 (the Waikaka River channel) to 200 m^2 at the downstream end of each model, but most of the model uses a maximum of 15 m^2 to 50 m^2. Within the Mataura River channel, a 20 m^2 maximum is specified. Typical element sizes are less than these values however, with typical Mataura River element sizes being closer to 10m^2, for example.

Overall, the models have an appropriate resolution considering the size of the modelled area and pick up a good level of detail. One area where a finer resolution might have been considered is in the right bank side channel at the Mataura Alliance freezing works site (Figure 3-3), where the model resolution is not sufficient to fully capture flow into that side channel (Figure 3-4). However, it is possible that this may not be important given that the downstream end of that channel appears to be controlled by a structure (Figure 3-5), and while a flood photo presented in Figure 6-1 of the LRS report shows flow in the channel it also shows a clear downstream constriction where the left and right side channels and the main channel converge.

Figure 3-3 Mataura River at Alliance freezing works site

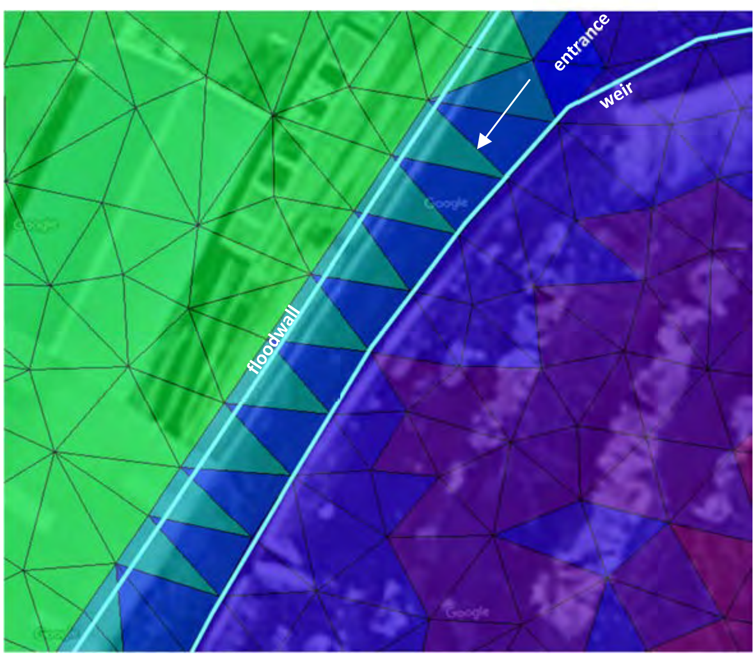

Figure 3-4 Model resolution at entrance to side channel at freezing works site

Figure 3-5 Mataura River channels at Alliance freezing works site

3.5.2 Initial conditions

Initial conditions are specified with *.dfsu* files (unstructured flexible mesh). This was a suggestion made in the initial peer review. Values of the initial conditions (flood depths, velocities) are presumably taken from results of test simulations with low flows, although the LRS report does not provide any details.

In a few locations, the modelled initial conditions include water ponding outside of the main channel, as can be seen in Figure 3-6 to Figure 3-9. The associated loss of storage may have some small impact in the case of the upstream ends of the Waikaka River (Gore model) and the Mataura River (Mataura model). Ideally, the initial conditions could have been manually edited to restrict them to low flows in the river channels only.

The initial conditions at the end of the Gore model give water levels along the boundary that are generally below the specified boundary water level (58 m). That could potentially lead to some instabilities at the start of the simulation in that area. Simulation results were not saved near the boundary to check that, but the model simulation has clearly survived any such instabilities, if they exist, and no evidence of them is seen in the area of interest.

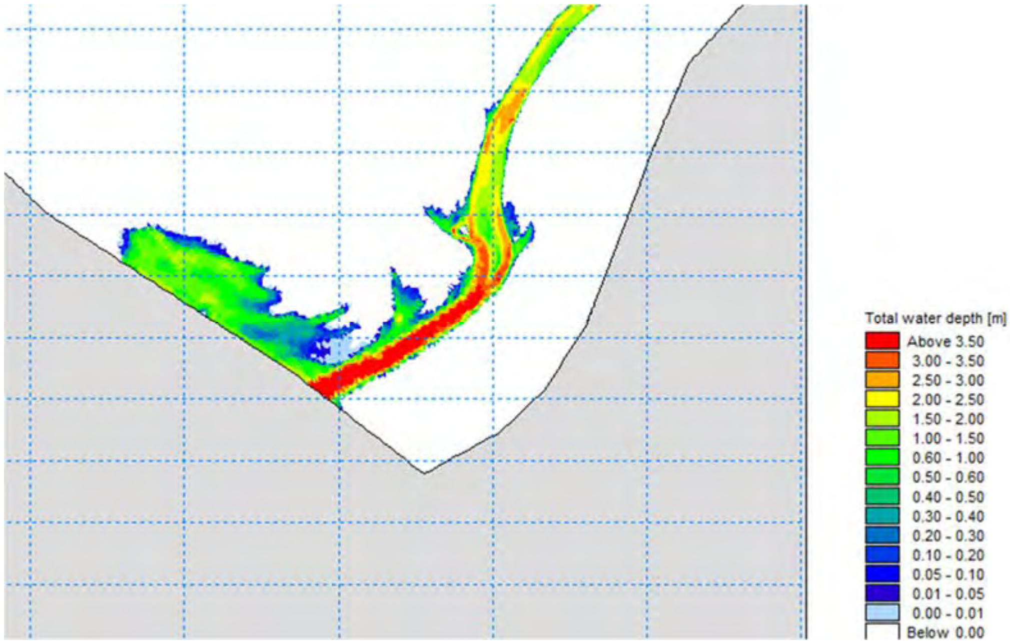

Figure 3-6 Initial conditions at downstream end of Gore model

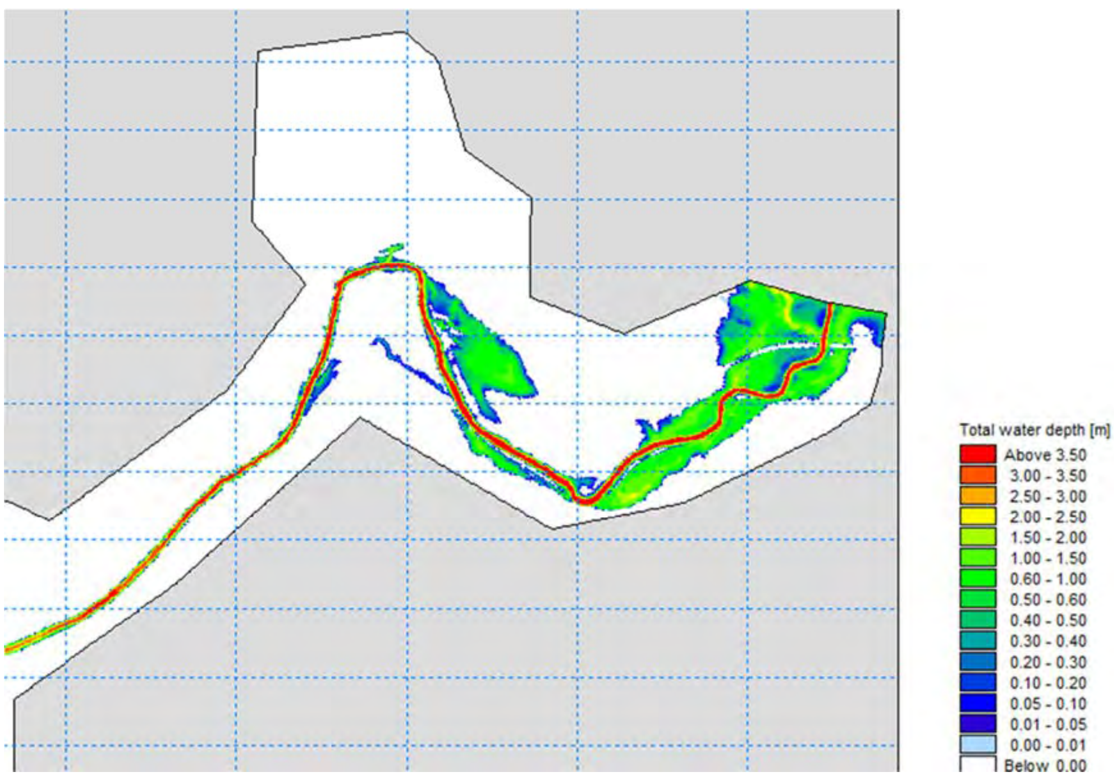

Figure 3-7 Initial conditions at upstream end of Waikaka River, Gore model

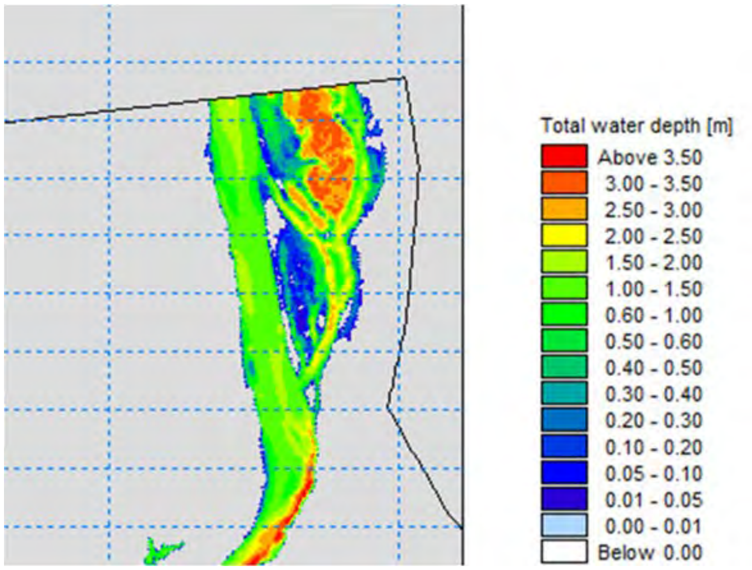

Figure 3-8 Initial conditions at upstream end of Mataura model

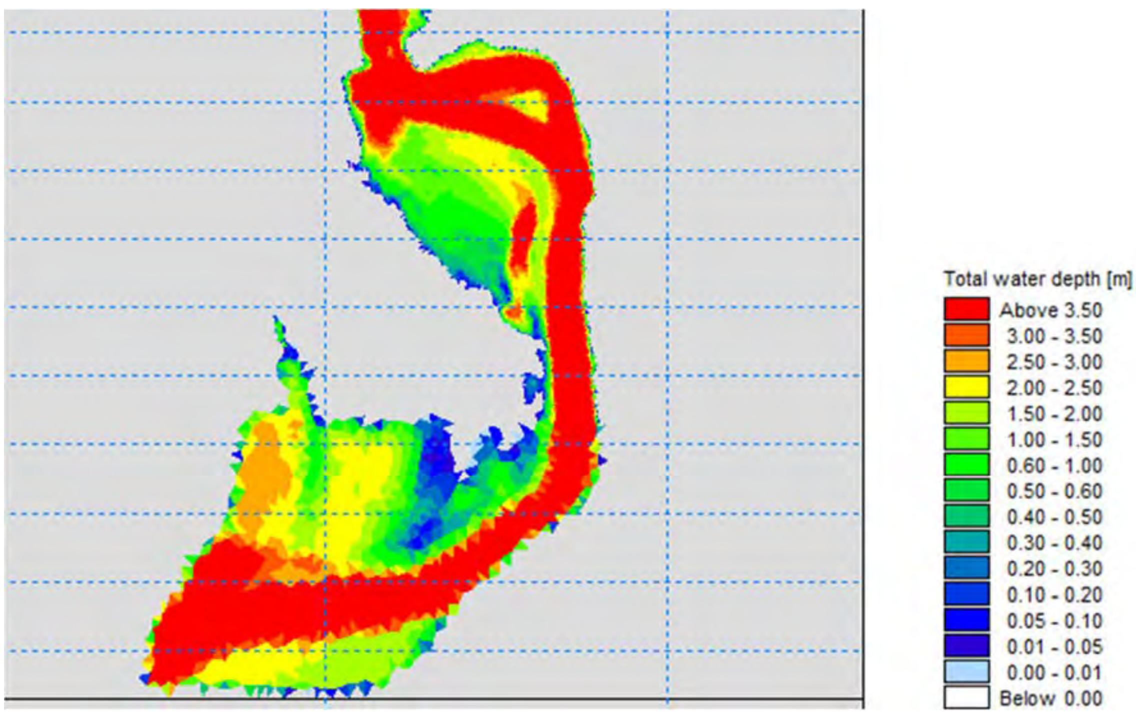

Figure 3-9 Initial conditions at downstream end of Mataura model

3.5.3 Boundary conditions

As noted in section 3.4, flows into the Gore model are applied via dummy 1D river branches.

The downstream boundary for the Gore model is a constant water level (58 m RL), across a wide section. This is a crude assumption, mitigated however by the fact that it is well downstream of where flow results are extracted for use in the Mataura model. Results in the vicinity of the boundary are quite rightly excluded from the model outputs and floodmaps.

Results from the Gore model provide inflows to the Mataura model. Flows have been extracted along four lines roughly perpendicular the flow direction, as suggested in the initial review. These lines are some distance upstream of the Gore model downstream boundary, so are not impacted by the limitations of that boundary.

A free overflow boundary is assumed at the downstream end of the Mataura model. Again, so long as results in the vicinity of that boundary are not used for design or floodmapping purposes, that is a reasonable assumption.

3.5.4 Computational parameters

The computation uses a “low order” formulation. Although in theory, a “high order” formulation should give better results, in practice it makes little difference and results in longer simulation times. DHI release notes for the 2024 software imply that the low order formulation results are significantly improved from previous versions.

The model uses a constant eddy viscosity of 0.5 m^2/s. That is reasonable. However, there are no hard and fast rules and only limited guidance for eddy viscosity, and some sensitivity tests (e.g., using a Smagorinksy formulation) could be made.

“Drying” and “wetting” values of 0.003 m and 0.01 m respectively are appropriate and allow a good resolution for mapping of shallow flooding.

3.5.5 Resistance values

Surface resistance is applied as a spatially-varying dfs2 file, at a fine (1 m) resolution. Good use of manual and automated techniques looks to have been made. LRS notes that 2016-17 imagery was used to assign resistance values. Later aerial photographs are available that in some cases would suggest some slight variations in isolated locations but these are not expected to make any significant difference to model results.

Table 5-2 of the LRS report states that roads were assigned a Manning’s n of 0.020, whereas the supplied model files show that a value of 0.021 was used. That is still acceptable. Rail corridors have been assigned a Manning’s n of 0.051; that could be added to the table.

A large area upstream of the Gore road bridge has been assigned a blanket resistance of 0.033 (Figure 3-10), overriding the values in the LRS table. No explanation is given for that, but presumably it was found to improve calibration results.

The Manning’s n of 0.045 applied in the Waikaka River is perhaps a little high in the reach downstream of the bridge, especially in light of the bridge not being explicitly incorporated into the model (see section 3.7) and the slight overprediction at the bridge shown in the LRS report.

The Manning’s n value of 0.020 used for the entire length of the Mataura River main channel is unexpectedly low. Considering the discussion in s5.3.1 of the LRS report, and the nature of the river bed, higher values and some spatial variation would be expected. The values are particularly low for the reach through the Mataura township (Figure 3-5, Figure 3-11), although possibly more acceptable through Gore (Figure 3-12).

Of course, the calibration also depends on the adopted flows, for which there is clearly some uncertainty (s6.1.2 of LRS report), and so there is a judgement to make on what flows and roughness values to adopt. Several discussions between LRS and River Edge Consulting were held during the calibration process, and a compromise between adopted river flows and Manning's n values has been reached. Ideally, some discussion of the sensitivity of calibration results to the river Manning's n values, particularly for the Mataura model, would have been provided. Further discussion on the calibration is given in section 4 of this report.

Regardless, given the reservations about the low Manning's n, design scenarios simulations should include sensitivity tests on river resistance values.

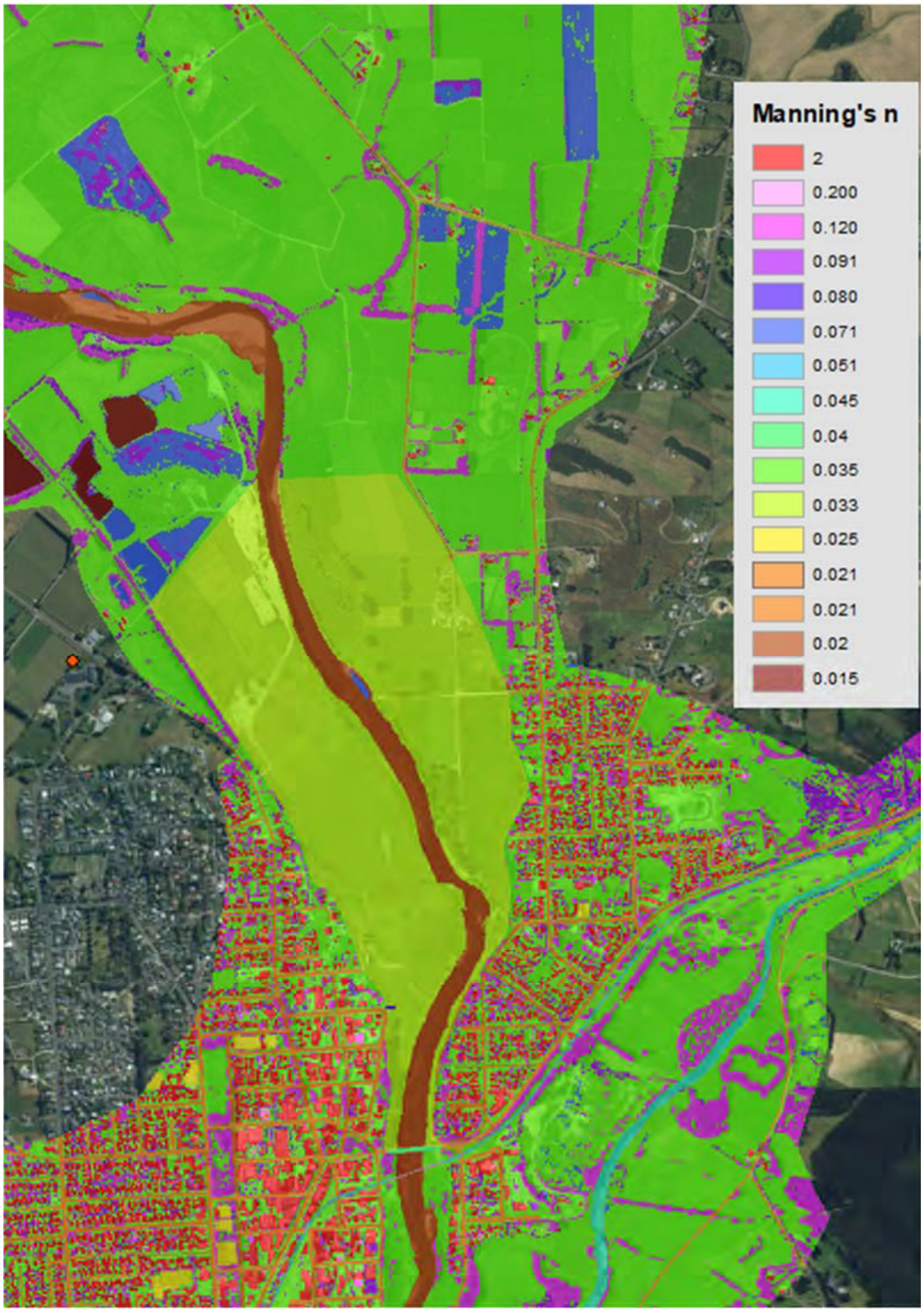

Figure 3-10 Manning's n values in vicinity of Gore

Figure 3-11 Mataura River bed, downstream of road bridge (SH93) at Mataura

Figure 3-12 Mataura River bed, looking upstream towards Gore rail and road (SH1) bridges

3.5.6 Structures - culverts

Each model includes four culverts, three of which are common to both models. These are represented as "long" culverts in the models, to allow flow under the road (SH1) and railway, where backflow from the river and floodplain is suspected. Model outputs suggest that "culvert 2" in the Mataura model is not well-connected to the model topography at its downstream end. That culvert has been better connected in the Gore model. Otherwise, model results suggest that the remaining culverts are well-connected (although all are based on assumed rather than actual invert levels and diameters). Flows of up to 2 m^3/s, in either direction, are predicted.

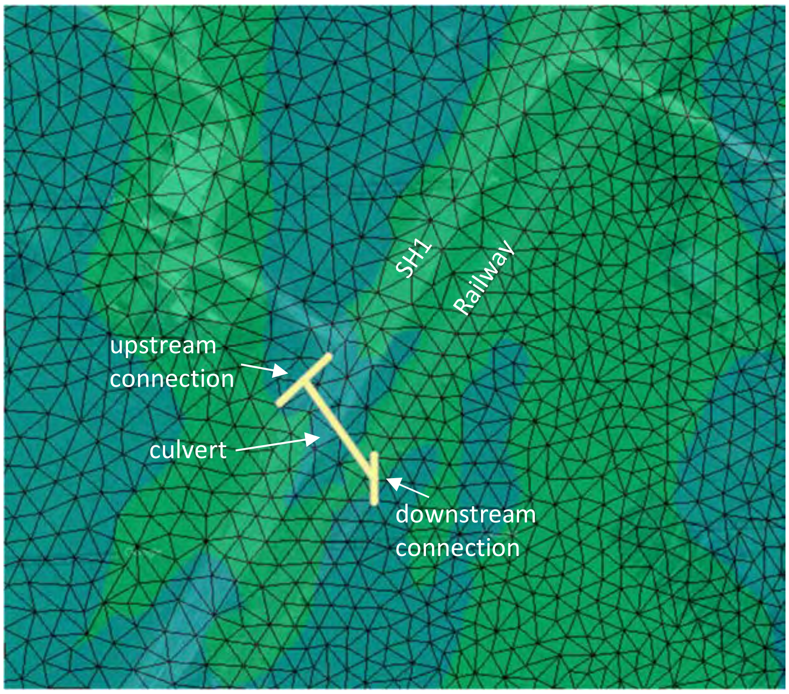

Figure 3-13 Culvert 2 (Mataura model) and connection assumptions

At some point it would be worthwhile splitting the culverts into the component road and rail culverts, allowing flow to fill the areas between the road and railway (perhaps once survey information on the culverts is available).

3.5.7 Structures - dikes

Dike structures represent stopbank crests, floodwalls and other locally higher features (e.g. narrow roads) that would otherwise be missed by the model resolution. A comprehensive set of dikes has been incorporated into the models.

Within the Gore model, the dikes in the model appear to capture the obvious embankments needed, although there are some gaps that may need to be checked

The dikes within the Mataura model capture most of the obvious embankments but, depending on how far the design scenario flood flows are expected to extend, other dikes might be required in the model, as illustrated by Figure 3-14 to Figure 3-17.

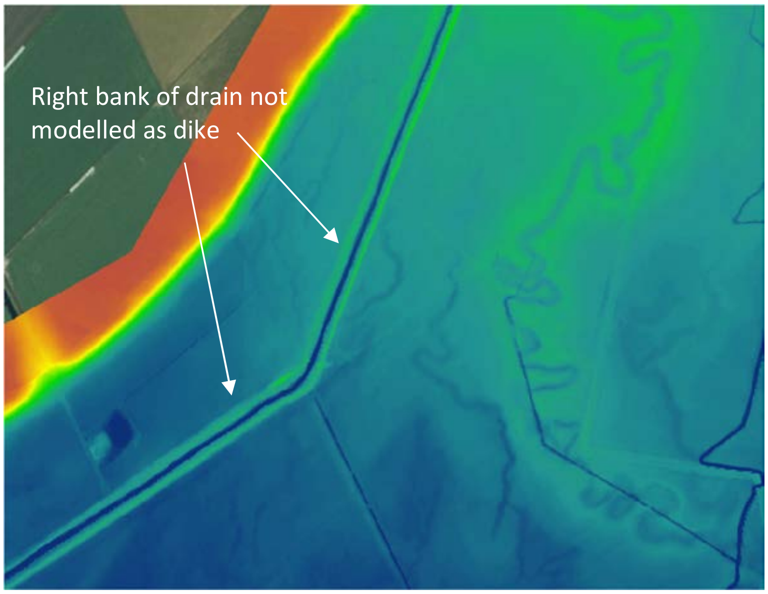

Figure 3-14 Topography in vicinity of drain upstream of Glendhu Road

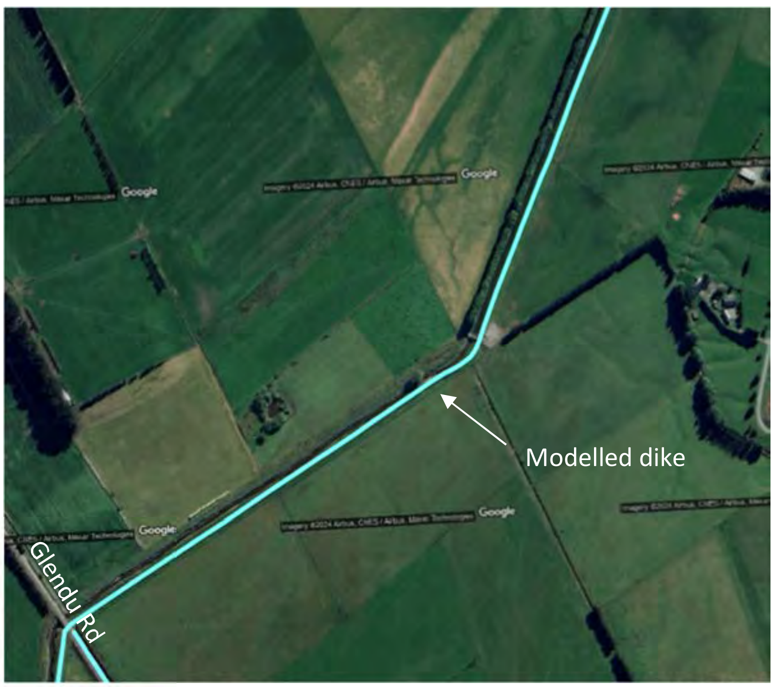

Figure 3-15 Dike included in Mataura model, drain upstream of Glendhu Road

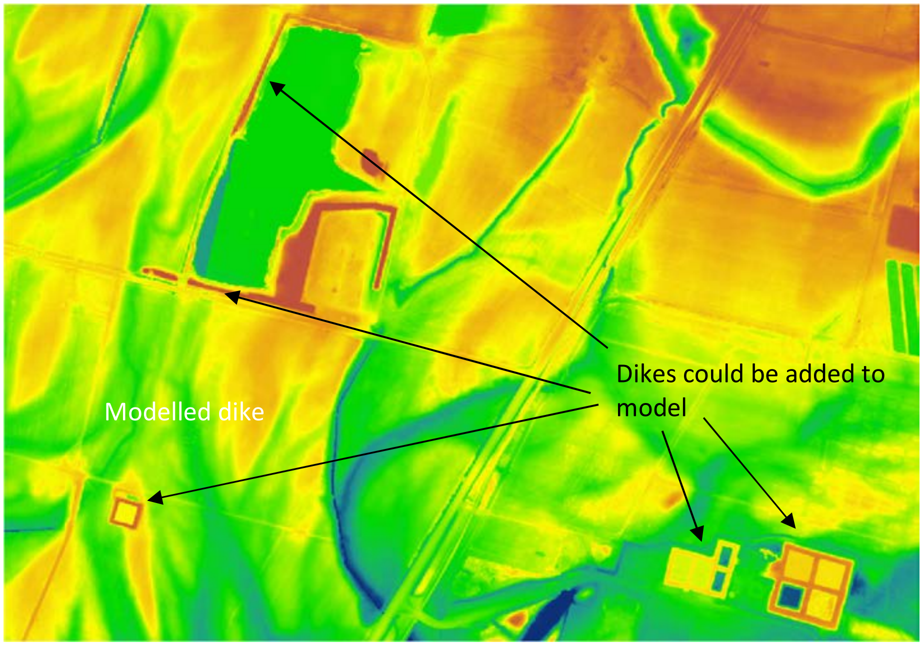

Figure 3-16 Topography in vicinity of Craig Road, substation and Daiken MDF plant

Figure 3-17 Modelled dikes, Mataura model in vicinity of Craig Road, substation and Daiken MDF plant

The dike representing the stopbank upstream of Mataura on the right bank has been given a non-default weir coefficient, although still within reasonable values. Presumably this has been set for calibration reasons, although it is also understood that that there is some uncertainty as to what the true crest levels were during the event.

Of more significance however is the higher weir coefficient (2.8) applied to the weir structure controlling flow at the upstream end of the Mataura Falls and freezing works reach. Furthermore, a low “dampening delta depth[2]” of 0.001 m (the default is 0.01 m) is applied. No explanation of why these values were adopted is given. As discussed in section 4.1, the model predicts a very large and unrealistic drop across this weir.

3.6 Simulation parameters

An adaptive time step has been used, with a minimum of 0.001 s and a maximum of 0.5 s. The specified minimum is very low, but the actual minimum time steps for the calibration scenario were 0.042 s (1/24 s) and 0.083 s (1/12 s) for the Gore and Mataura models, respectively. It is noticed that the maximum CFL number (used to control the adaptive timestep) is set to 0.8 in the Gore model but 1 in Mataura model; that should not be of any significance.

Using the validation tool prior to simulation reveals no issues for either model.

Model log files (produced automatically after a simulation) reveal no error or warning messages of concern.

3.7 Bridge modelling

Bridges within the model area include the road (SH1) and rail bridges at Gore, a road bridge at Mataura (SH93) and a road bridge on the lower Waikaka River. The first two of these have several piers in the waterway and losses would be associated with these.

For the calibration scenario, increased channel roughness is applied locally at the Gore road and rail bridges (Manning’s n values of 0.040 and 0.200, respectively). Calibration model results at the vicinity are close to observed flood levels (Figure 3-18). No increase in channel roughness is applied at the Mataura SH93 road bridge.

Figure 3-18 Difference between model predictions and observed flood levels, Gore bridges, 2020 flood

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[2] The difference in upstream and downstream water levels, below which the discharge gradient is suppressed, to avoid instabilities.

No details on the Waikaka River bridge are provided, nor is the channel roughness modified at that location. Results from the calibration simulation indicate a peak flood level of around 72 m RL, whereas the approaches to the bridge at around 71.7 m RL. Thus overtopping of the bridge is expected and there will be some afflux due to the bridge. Whether this is important or not depends on whether the area upstream of the bridge is of interest to the investigations.

3.7.1 Design scenarios

Gore model

To assess the impact of the soffits of the Gore road and rail bridges on flood levels in large events, LRS has prepared a separate resistance file with higher values at the bridge locations, to be applied once flood levels reach the soffit. That has not been sighted and so has not been reviewed. It is intended that the design scenarios run until the soffit is reached, at which point the model is stopped and then hot-started with the new resistance file. Care will be needed that the model restarts smoothly without any significant instabilities. It is also unlikely that the flood levels will reach the soffit of each bridge at the same time, so the restart time will be a simplification.

As there are no calibration data for the bridges in their submerged state, LRS has "calibrated" the design model by adjusting the higher resistance to reproduce results from a simplified 1D model of the river, with bridge structures modelled that allow submergence and overtopping. MIKE 11 software has been used for this and the MIKE 11 files were supplied for review.

The MIKE 11 model was reportedly calibrated to the 2020 flood, as discussed in s5.5 of the LRS report with results presented in Figure 5-16 of the report. Those results can be reproduced by running the supplied model files (*Mataura_V1_Bridge_FHWA_nopiers.nwk11* and *Mataura_2020_Calib_Q85.bnd11*). However, the bridge setup in the network file does not match the description in the report. The bridge module uses the FHWA-WSPRO method, not the Energy Method and while pier ratios are specified (despite the file name), they less than the documented values (1% for the road bridge and 4% for the rail bridge, compared to 4.7% and 9.4% quoted in the report). Furthermore, the boundary file includes a scale factor of 1.25 for the river inflows, raising the inflow from 2033 m^3/s to 2541 m^3/s. It is unclear why this scaling was used.

The results shown in Figure 5-16 of the LRS report suggest a slight underprediction of flood levels around the bridges, although the losses through the bridges seem about the right order of magnitude. Results for a simulation of the 1999 flood are also presented. These show an overprediction through the bridges. Model files for the 1999 event simulation were not supplied.

A second river network file was subsequently supplied (*Mataura_V1_Bridge.nwk11*). The bridges in that match the description in the LRS report and presumably this network file was used to produce outputs for the design flood (2680 m^3/s) that were subsequently used to calibrate the 2D MIKE+ model at high flows.

The simple MIKE 11 model uses cross-sections extracted from LiDAR data. An issue that may need checking is that while the report states that the skew of the rail bridge has been dealt with, the MIKE 11 model files provided suggest this may not have been the case. The length of the bridge is approximately 195 m but approximately 183 m normal to the river. However the modelled bridge section is 191.5 m.

<u>Mataura model</u>

Notwithstanding that the calibration model appears to overpredict flood levels in the vicinity, the predicted calibration flood levels at the Mataura road bridge (around 50.3 m RL) are approaching the soffit level (50.48 m RL on the left bank). Therefore it would seem appropriate to also consider the effect of the soffit in design flood scenarios for the Mataura model.

4 Calibration and verification

4.1 February 2020 flood

The MIKE+ model has been calibrated against the February 2020 flood event. A number of peak flood levels were recorded over the floodplain and along the river, while aerial imagery and a database of flooded properties provide further calibration data. This event is also of sufficient size to give confidence in extrapolating to design events (flows at Gore being around 75% of the 1% AEP flows).

A flow of 2033 m^3/s has been applied to the upstream end of the Gore model, 85% of the initial peak flow at Gore provided by ES or 94% of a later refined estimate. This scaling factor appears to have been chosen largely on the basis that it improved the calibration but is still likely to be within the margin of error for the actual flow. (Some error bands on the peak flow estimate could be presented.) There is of course some additional catchment between the upstream boundary and the recorder site, which hasn't been allowed for. On the other hand, some attenuation between the upstream boundary and the recorder would also be expected. It is noted that the inflow hydrograph has been shifted in time slightly (starting earlier) to account for the travel time between the model boundary and the recorder. However, a useful output from the simulation would be the flow across a line at the recorder site.

Notwithstanding this, the model produces a good match to recorded water levels and time of peak at the Gore recorder (Figure 6-8 of LRS report).

For the Gore model, as presented in the modelling report show a reasonable match to the recorded values. However, as noted in the LRS report, even with a reduction in flow assumptions, this has required particularly low Manning's n values. The explanation given, that the reduced flow assumption may still be too high is plausible. There are also inherent inaccuracies and some subjectivity in identifying peak debris levels, which could be a contributing factor.

It would also have been useful to present a comparison of the modelled flood extent with the satellite imagery mentioned.

For the Mataura model, the model predicts a greater variation from the observed values. Even with a further reduction in flows (this time, for the Mataura model but this possibly implies a reduction in the Gore model inflows also), the results cannot be considered a good match to the observed values. It is understood that there was some uncertainty in stopbank levels on the right bank upstream of Mataura, which has added to the difficulties of calibration. Furthermore, establishing reliable flood debris marks will have been difficult in the narrow Matuara Falls reach alongside the freezing works, as transient or very localised phenomena (e.g., waves) will have occurred.

Results at the weir controlling flow at the entrance to the Mataura Falls and freezing works reach indicate that more work to understand and better model this area is required. A drop of at least 2 m is predicted across the weir, more than suggested by the aerial photographs taken during the floods given in the LRS reports. Also of note is that water levels in parts of the river channel downstream do not change during the simulation. Figure 4-1 shows predicted peak flood levels near the weir and the locations where hydrographs have been extracted from the results (Figure 4-2). Points 1 and 2 are upstream of the weir and points 3–5 are downstream. Variations in peak flood level can also be seen further downstream of the weir.

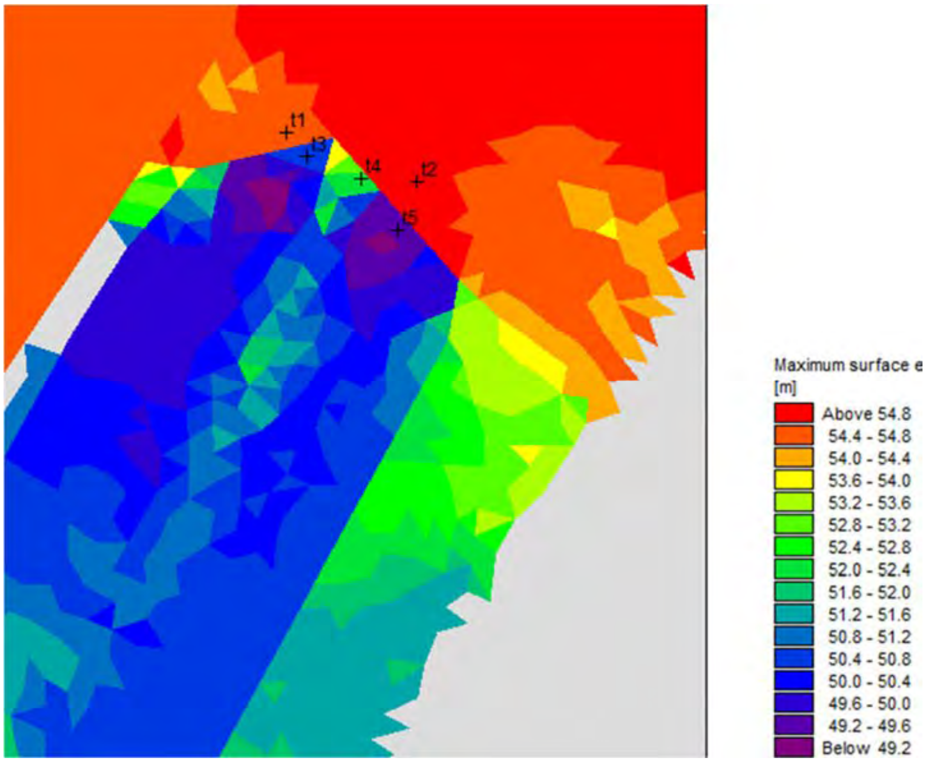


Figure 4-1 Predicted peak flood levels around weir at Mataura, 2020 flood

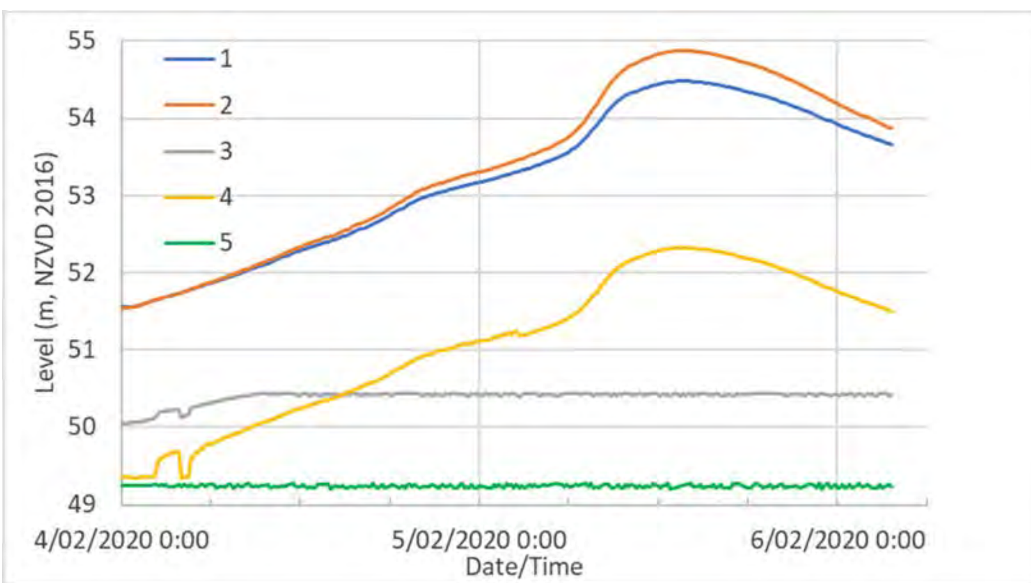


Figure 4-2 Predicted flood level hydrographs at selected points upstream and downstream of Mataura weir, 2020 flood

Model results show other interesting patterns in the Mataura area, which illustrate the complexity of the flow behaviour there. Figure 4-3 shows predicted peak flood levels (red = high, blue = low). As well as the drop across the weir, a localised high spot is predicted on the right bank where flow converges.

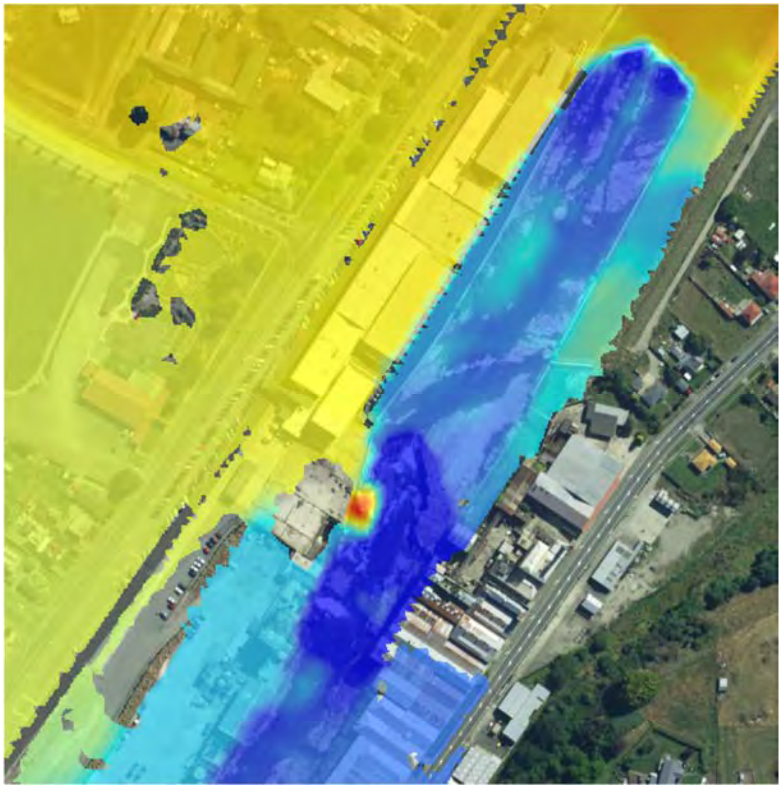


Figure 4-3 Peak flood levels (predicted) through Mataura Falls reach, 2020 flood

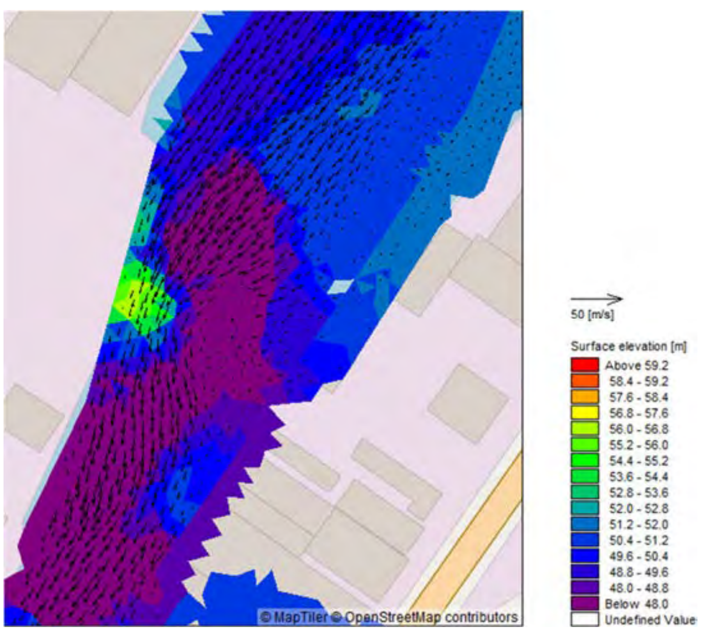


Figure 4-4 Predicted flow patterns, downstream end of Mataura Falls, 2020 flood

The Falls themselves (Figure 4-5) have not been explicitly modelled and a weir structure or similar should be considered, as the 2D flow equations used in the modelling do not deal with such discontinuities in the river bed.

Figure 4-5 Mataura Falls

A further feature of interest is a dip in water levels immediately downstream of the Mataura bridge (Figure 4-6). That can be explained by a rise in bed level (Figure 4-7), with a resulting increase in velocity (Figure 4-8).

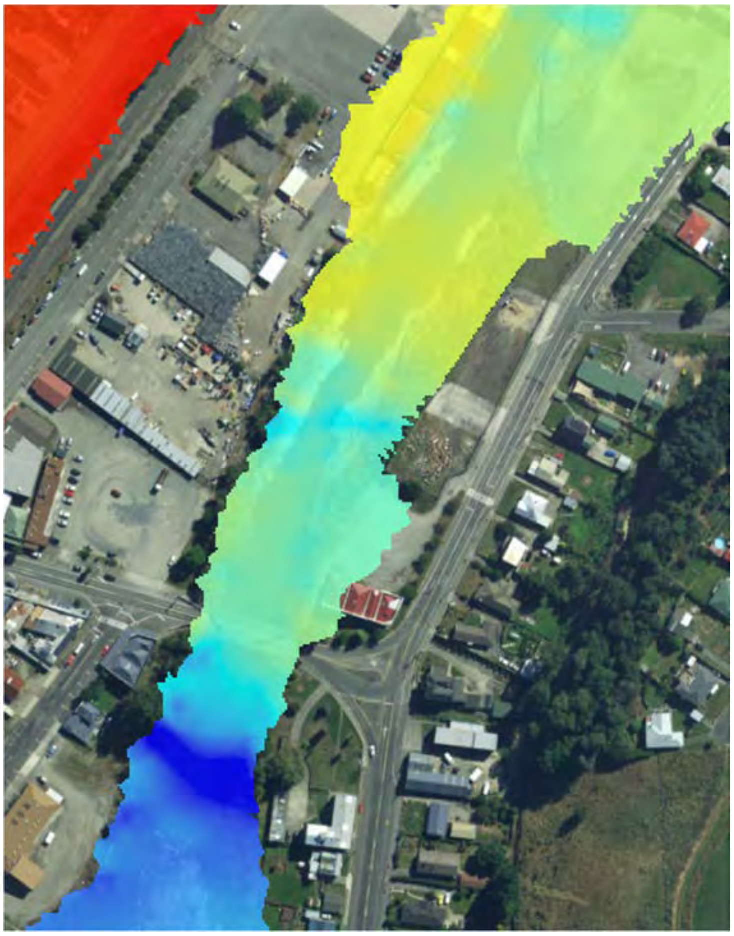


Figure 4-6 Predicted peak flood levels through Mataura bridge reach, 2020 flood

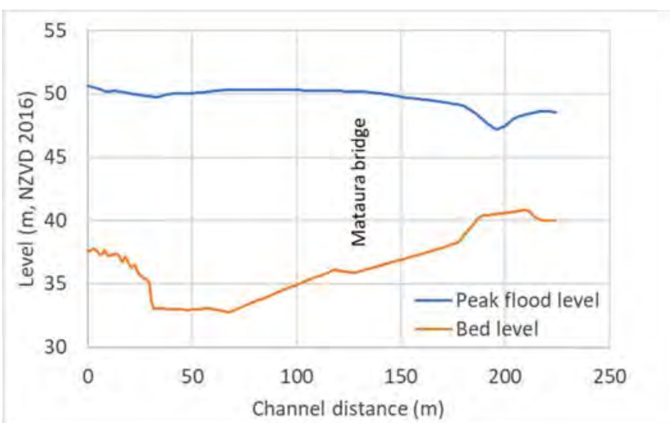


Figure 4-7 Bed levels and predicted peak 2020 flood levels, Mataura bridge reach

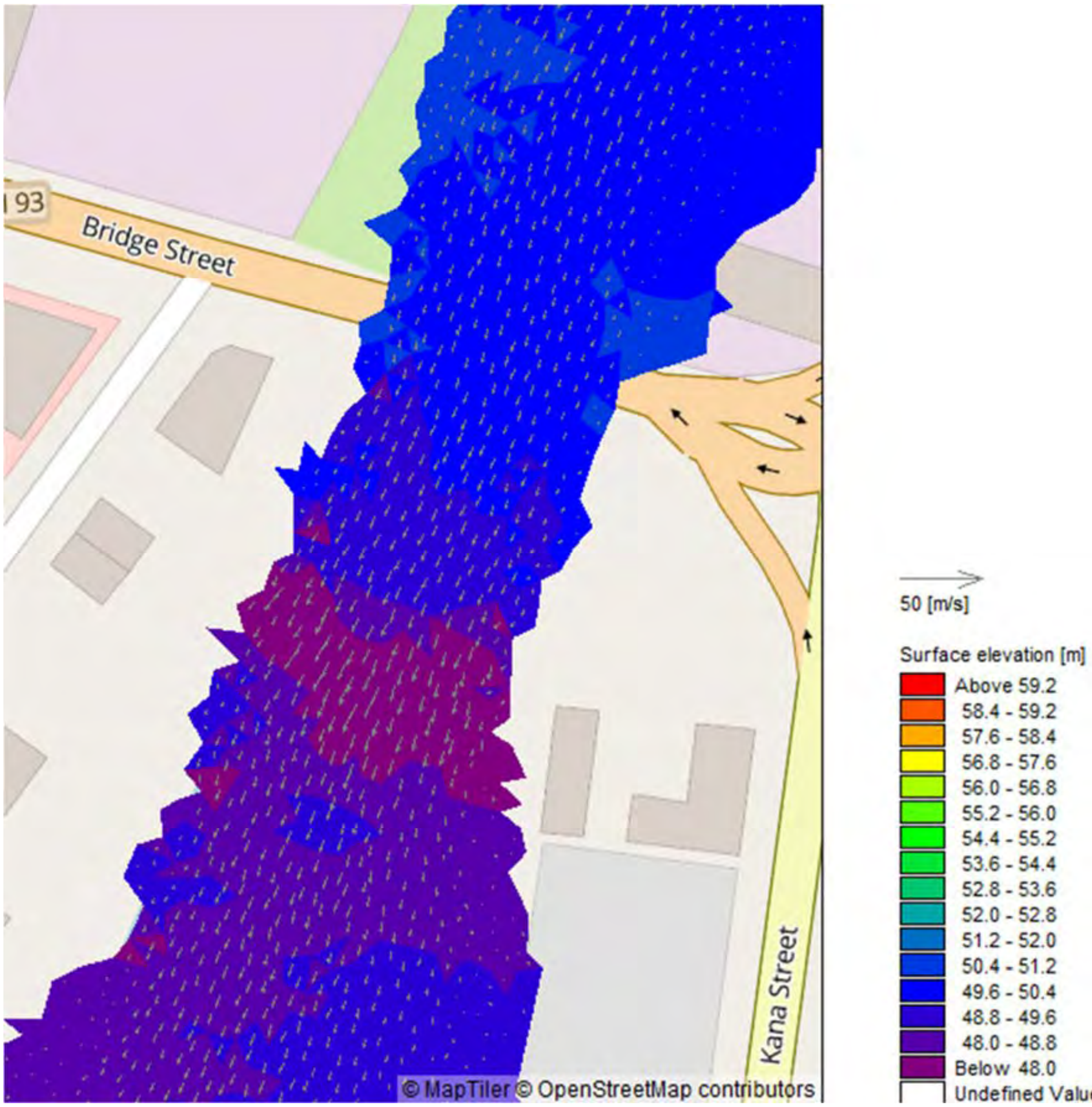


Figure 4-8 Flood levels and velocity vectors around Mataura bridge, 2020 flood (near peak)

4.2 November 1999 flood

Model files for the verification simulation, of the November 1999 flood (with an estimated peak flow of 1784 m^3/s at the Gore recorder) were not provided for review. Results through Gore, as presented in Figure 6-14 of the LRS report, generally show a good match with recorded debris levels. Levels downstream of the bridges show a slight overprediction (Figure 4-9), which at least is a conservative result. However, the model uses river bed levels from a recent survey and the results of this simulation must be tempered with the uncertainty as to what the river bed levels were more than 20 years earlier.

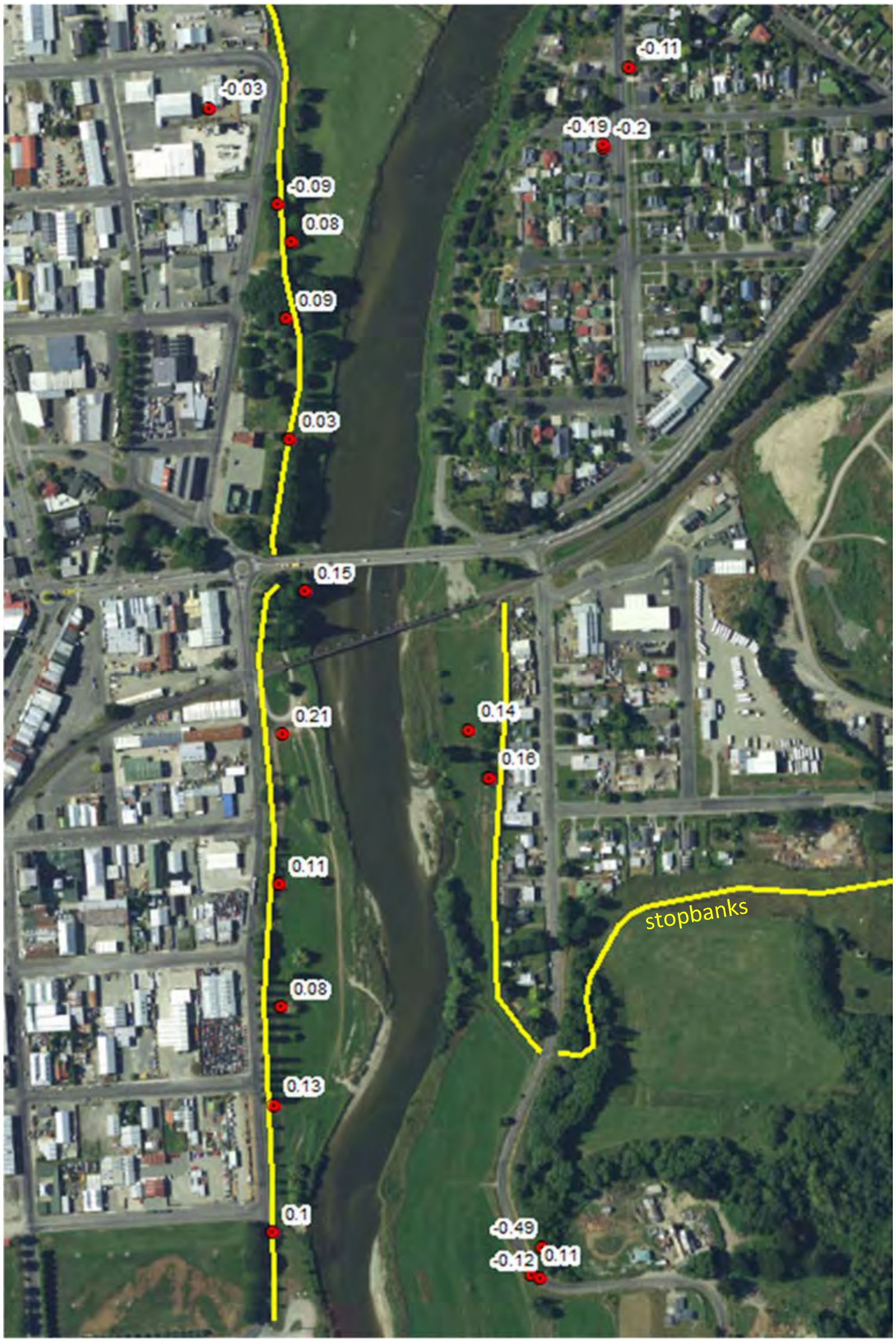


Figure 4-9 Difference between model predictions and observed flood levels, Gore, 1999 flood

5 Design Scenarios

Design scenario simulations are required for the 1% AEP and 2% AEP flows in the Mataura River, with and without climate change allowances. Breach scenarios are also required.

The model setup and results for these events have not been assessed as part of the peer review. However, the 2020 calibration event peak flow was of a similar magnitude to the design flows, being around 75% of the 1% AEP flow (current climate). Thus, a model calibrated to the 2020 event should require only minor refinement (e.g. to allow for the impact of bridge soffits on flow, or addition of some extra dike structures (section 3.5.7)) to be suitable for modelling the design scenarios.

6 Reporting

The draft model report dated 18 April 2024 (LRS, 2024) has been reviewed. Although clearly the report is draft and some sections and figures need to be completed, it does provide a good summary of the modelling process, describes many of the assumptions made and presents results (for calibration runs at least). Various aspects of the modelling where further explanation is required are outlined in section 3 and section 4 above.

Comments on an earlier draft of the report were provided to LRS on 14 January 2024. It is recommended that LRS considers these comments when the final version of the report is prepared.

It is also recommended that the final simulation files be identified in the report, possibly in an appendix.

7 Conclusions and Recommendations

While the Mataura River has helped shape the major towns along its length (Gore, Mataura and Wyndham), the river also presents a threat to these towns. Several large flood events have caused significant disruption to the towns in recent decades. These events demonstrate the urgency and importance of having a robust hydraulic model to assist in emergency management, flood mapping and mitigation option assessment.

Considerable effort has gone into preparing a flood model for the river and floodplain, making use of new and detailed LiDAR data, and taking into consideration available flood records and data. Despite this, model calibration within the Gore model has only been possible with the use of very low Manning's n values. For the Mataura model, those Manning's n values seem even less realistic and the calibration is not as good as would be hoped. The Mataura model also gives unusual results in the vicinity of the Mataura Falls and freezing works, and further work is needed to refine the model in that area.

If the Gore and Mataura model is to be used for design purposes, then thorough sensitivity tests on Manning's n values will be required. The appropriate amount of freeboard should also be assessed; it is likely that a higher amount of freeboard will be needed than is the case for other major river flood protection systems.

It is also important that flood data (debris levels, flood flow gauging, photographs etc) continues to be collected during and after flood events, to allow continued model refinement and improved calibration.

References

Land River Sea Ltd. (2024); *Mataura River: Flood Modelling*. Draft Report prepared by Matthew Gardner for West Coast Regional Council, 18 April 2024.

River Edge Consulting (2024); *Mataura Model – Peer Review.* Memorandum from Philip Wallace, River Edge Consulting to Matt Gardner, Land River Sea, 14 January 2024.

Appendix A Initial Peer Review (January 2024)

Memorandum

To: Matt Gardner, Land River Sea Consulting

Cc: Randal Beal, Environment Southland

From: Philip Wallace, River Edge Consulting

Date: 14 January 2024

Re: Mataura Model – Peer Review

1. Introduction

Environment Southland has requested that I peer review the hydraulic modelling of the Mataura River and floodplain that Land River Sea Consulting (LRS) has undertaken recently. You supplied me with model files (inputs and results) as well as a draft report on the modelling, on 14 December 2023.

We have also had several discussions over the past several months, as you were creating and refining the model, regarding model details, modelling issues and early results.

I have now been through the model report and the supplied model files. As I have not been supplied with model verification or design scenario files, and as the modelling report is draft only, I am not in a position yet to provide a peer review report. However it seems appropriate to provide feedback now, allowing you time to consider this and refine the modelling, as well as to complete the design scenarios and the report.

The following is a summary of my observations and comments on the modelling. I will also provide a spreadsheet with various notes I have made during my initial review, which may be of use to you.

2. Model report

I have provided a "track-changes" copy of your report with a number of comments. Some relate to missing or information that is unclear to me, others to minor edits that may help the text read better. Clearly the report still has sections to be completed and I haven't commented on those.

I've also printed a summary of review comments (from me, and a few from you and your staff that were in the docx file provided). This may or may not be helpful.

2. Model details

2.1 Modelling approach

Modelling is based on a 2D representation of flow and uses the DHI product MIKE 21FM, v2024. Two overlapping models have been prepared: one centred on Gore township and the other on Mataura township. Splitting the model into two makes the model sizes and run times more manageable. The draft report mentions a third model as being under development, covering Wyndham, but no files or other details on that were provided.

However some 1D modelling was carried out, of a section of the river around Gore to investigate bridge losses in more detail. Although you discussed this with me around the time you undertook that, further reporting and model files will be needed before I can give more definitive feedback.

2.2 Model files

Inputs and outputs for the final calibration event simulations (2020 flood) have been supplied for the two models (Gore reach and Mataura reach). No log files were provided for the completed simulations.

No files for the verification or the design scenarios were supplied.

2.3 Mesh definition files and model resolutions

Model meshes use triangular elements. Resolution varies across the models, but typically the element sizes are a maximum of 20 m^2 in the river channels and 50 m^2 on the floodplain. Minimum element size for the Gore model is 2.4 m^2 while it is 1.5 m^2 in the Mataura model. Such resolutions are reasonable.

See comments in report on topo data sources.

Scatter data for the .mdf files were not supplied.

2.4 Upstream inflows

Gore model:

Upstream inflows for the Gore model are applied as point inflows just inside the model extent. A flow of 2033 m^3/s has been applied, 85% of the initial peak flow at Gore provided by ES or 94% of a later refined estimate. This scaling factor appears to have been chosen largely on the basis that it improved the calibration but is still likely to be within the margin of error for the actual flow. (Some error bands on the peak flow estimate could be presented.) There is of course some additional catchment between the upstream boundary and the recorder site, which hasn't been allowed for. On the other hand, some attenuation between the upstream boundary and the recorder would also be expected. A useful output would be the flow across a line at the recorder site (the "*Flow_Gore*" results saved are some distance upstream).

A second point inflow is applied near the upstream end of the Waikaka River in the model. That inflow has not been scaled from supplied estimates (it is noted however that the supplied hydrograph is nonetheless partially synthetic.)

An alternative method of applying the inflows would be to apply them across defined external boundaries in the mesh.

Mataura model:

A point inflow is applied near the upstream end of the Mataura model, taken from flow extracted across a line in the Gore model. (I was confused by the input being *Mataura_Inflow_2020_Q85.dfs0* whereas the output from the Gore model was *Mataura_Model_Inflow.dfs0*, until I realised the input was the same file but renamed.)

The approach is sound but the application is untidy. Ideally the inflow would be made at the exact location where the flow was extracted from the Gore model. As the model stands, the outflow is from a line whereas the inflow is applied at a point a few hundred metres downstream (and even then, not within the main river channel).

I would suggest that the Mataura model be reconfigured to have an external boundary along the line where the Gore model results were extracted, with those results applied as a specified discharge to that line.

In that case, it might also be worthwhile extracting Gore results along a slightly different alignment (possibly along two or more lines) as in Figure 1, so that flows are more confined and normal to the extraction line. Testing with larger or overdesign flows might indicate where appropriate alignments are.

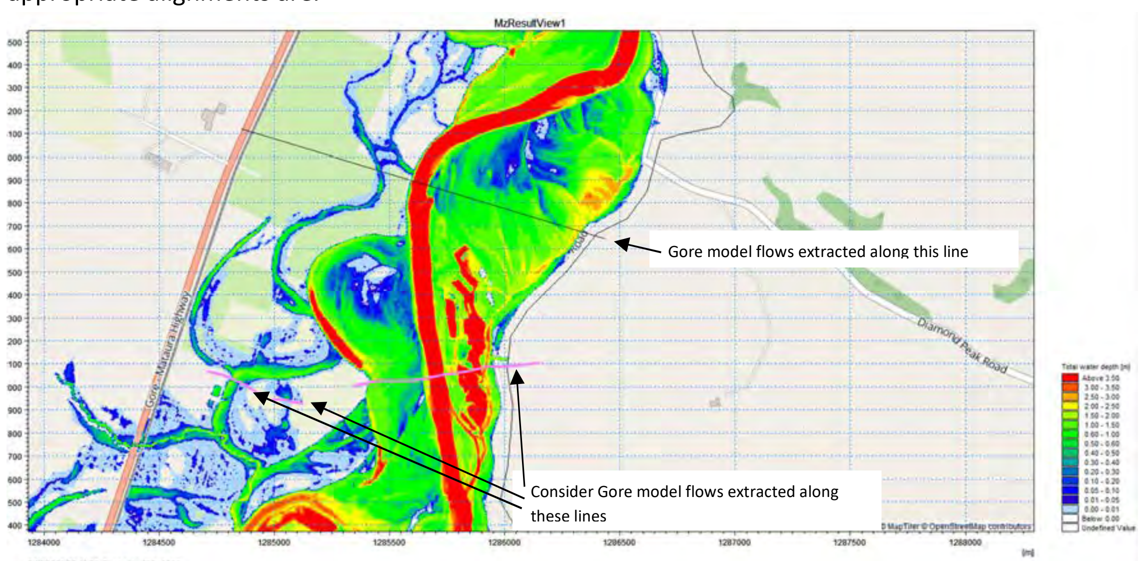


Figure 1 Lines for extracting flows from Gore model, for use as Mataura model inputs

2.5 Downstream boundaries

Gore model:

A constant water level (58 m RL) boundary across a wide section is applied at the downstream end of the Gore model. This is a crude assumption, mitigated however by the fact that it is well downstream of where flow results are extracted for use in the Mataura model. (The area where model results are valid for each of the two models should be assessed and identified, over the model overlap.)

There is a potential danger of instabilities as much of the downstream boundary remains dry during the simulation, although that does not seem to have created problems in the calibration event.

Alternative approaches might have been to apply a .dfs1 file rather than a constant level (varying along boundary so that level is above depth, but constant in time), or to extent the model slightly downstream and have a section of boundary along the stopbanks perpendicular to the river set as "free overflow boundary" and a section of boundary across the river set as a rating curve.

However the present setup could be tested with a large overdesign flow; if it runs without problem then it could be retained.

Mataura model:

Again, a constant water level (42 m RL) is applied across a wide boundary, with some portions of the boundary being dry therefore. Applying a rating curve over a narrower boundary would be an alternative approach. Otherwise, similar comments apply to those for the Gore model, above.

As with the Gore model, some indication needs to be made of where model results in the downstream reaches should not be used.

2.6 Culverts

"Long" culverts are applied within the MIKE 21FM files, to allow flow under the road (SH1) and railway, where backflow from the river and floodplain is suspected. I am not convinced that these culverts are well-connected to the model topography (e.g., topography of connecting elements being above specified culvert invert levels). Outputs for the culverts should be ticked, so that the behaviour of the culverts can be checked. Use of the "non-uniform distribution" option should also be considered, for cases where culvert ends connect to multiple elements.

At some point it would be worthwhile splitting the culverts into the component road and rail culverts, allowing flow to fill the areas between the road and railway (perhaps once survey information on the culverts is available).

2.7 Dikes

An extensive network of dikes is used to ensure more accurate overtopping levels of embankments, stopbanks, roads etc than the triangular mesh can provide. Corrections to two dikes need to be made: Waikaka Dike 2 (Gore model) and Road_RB71 (Mataura model), where loops have been inadvertently created (Figure 2 and Figure 3).

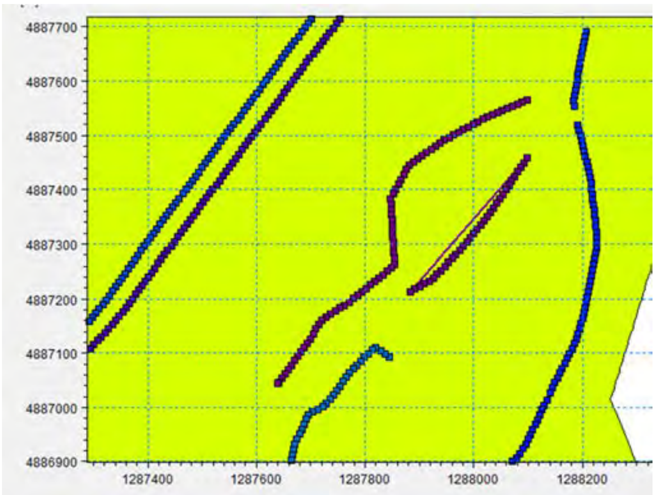


Figure 2 Dike input error, Waikaka Dike 2

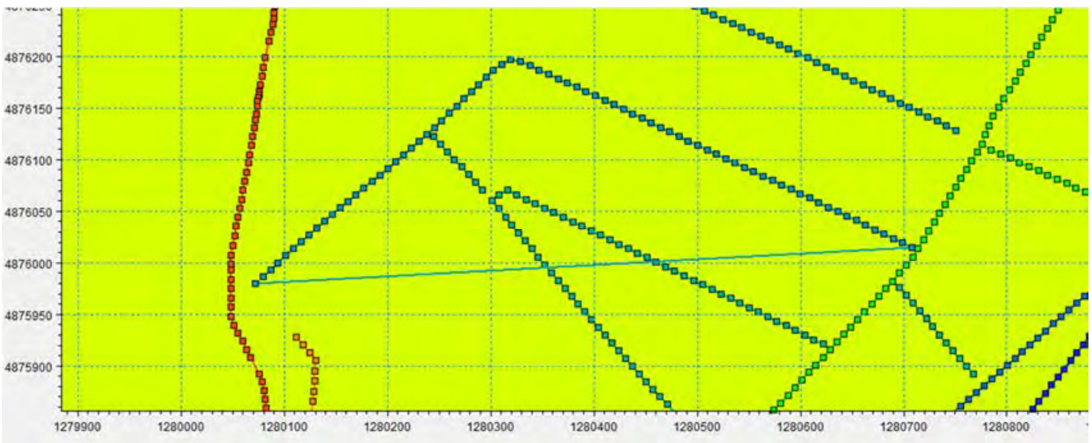


Figure 3 Dike input error, Road_RB71

2.8 Bridges

Bridges within the model area include the road (SH1) and rail bridges at Gore, a road bridge at Mataura and a road bridge on the lower Waikaka. The first two of these have several piers in the waterway and losses would be associated with these. Losses associated with the bridge soffits are briefly discussed in the model report, although more detail is expected to come.

Debris on bridges will be something that you have considered and I expect that you will address in the final report.

The model includes a local increase in surface roughness around the Gore SH1 road bridge (Manning's n = 0.040, compared to the surrounding value of 0.020). A Manning's n of 0.200 is applied at the rail bridge, although it is not known whether this is deliberate or not.

I will await further details in the report before I comment in more detail.

2.9 Resistance

Surface resistance is applied as a spatially-varying dfs2 file, at a fine (1 m) resolution. Good use of manual and automated techniques looks to have been made.

As we have discussed earlier, you needed values of Manning's n that were lower than I might have expected, in order to calibrate the model. For the gravel river bed, you have used a Manning's n of 0.020, even within the Mataura Falls section. Of course, the calibration also depends on the adopted flows, which you have identified as having some uncertainty, and so there is a judgement to make on what flows and roughness values to adopt. You have given it a great deal of thought and testing, and I can accept your conclusions. However the final report should ideally include some further discussion and reporting of the tests, as well as results of any further sensitivity tests on the roughness values.

Other than that, some minor refinements could be considered, although these are unlikely to have a significant impact on results, for example:

- Oxidation ponds – n = 0.070 is too high, although only likely to be flooded in extreme events?
- Roads – I would have put these a little lower, at n = 0.020
- Playing courts and playing fields could perhaps be smoother at say n = 0.020 to 0.030.

2.10 Initial conditions

The models are started in completely dry conditions (initial water level set to well below ground levels). That is reasonable, although it does mean that the models take a few hours of prototype time before a wet channel exists throughout the model reaches. Results for the early part of simulations should therefore not be used (and indeed, are not saved in the Mataura model). Of course such results are not of any interest when considering flood flows, in any case.

An alternative would be to apply an initial condition .dfsu file with shallow depths within the main river bed.

2.11 Computational parameters

The computation uses a "low order" formulation. Although in theory, a "high order" formulation would give better results, it results in longer simulation times and for previous versions it often made little difference. Furthermore, it is our understanding that latest (2024) version of the software has improved results when the low order formulation is used,

An adaptive time step has been used, with a minimum of 0.001 s and a maximum of 0.5 s. The minimum seems very low but without any log files from model runs it is unclear what actual minimum time steps were. I would expect that actual minimum values would be nowhere near that low, but if they were then model instabilities would be a concern and could be investigated by saving CFL values in the model results

“Flood” and “dry” values of 0.003 m and 0.01 m respectively are appropriate and allow a good resolution for mapping of shallow flooding.

The model uses a constant eddy viscosity of 0.5 m^2/s. That is reasonable. However, there are no hard and fast rules and only limited guidance for eddy viscosity, and some sensitivity tests (e.g., using a Smagorinksy formulation) could be made.

2.12 Saved results

I note that the models have been run long enough for peak levels to have been reached and to be receding.

Suggested additional saved results include

- maximum flood depths (in the “inundation” results)
- discharge across the line of the Mataura@Gore recorder, especially for comparing model flows to design flows from the flood-frequency analysis
- u-velocity and v-velocity if hazard maps (combining depth and velocity) are to be prepared at any point in the future
- CFL values (if required for model testing, especially for high design flows)

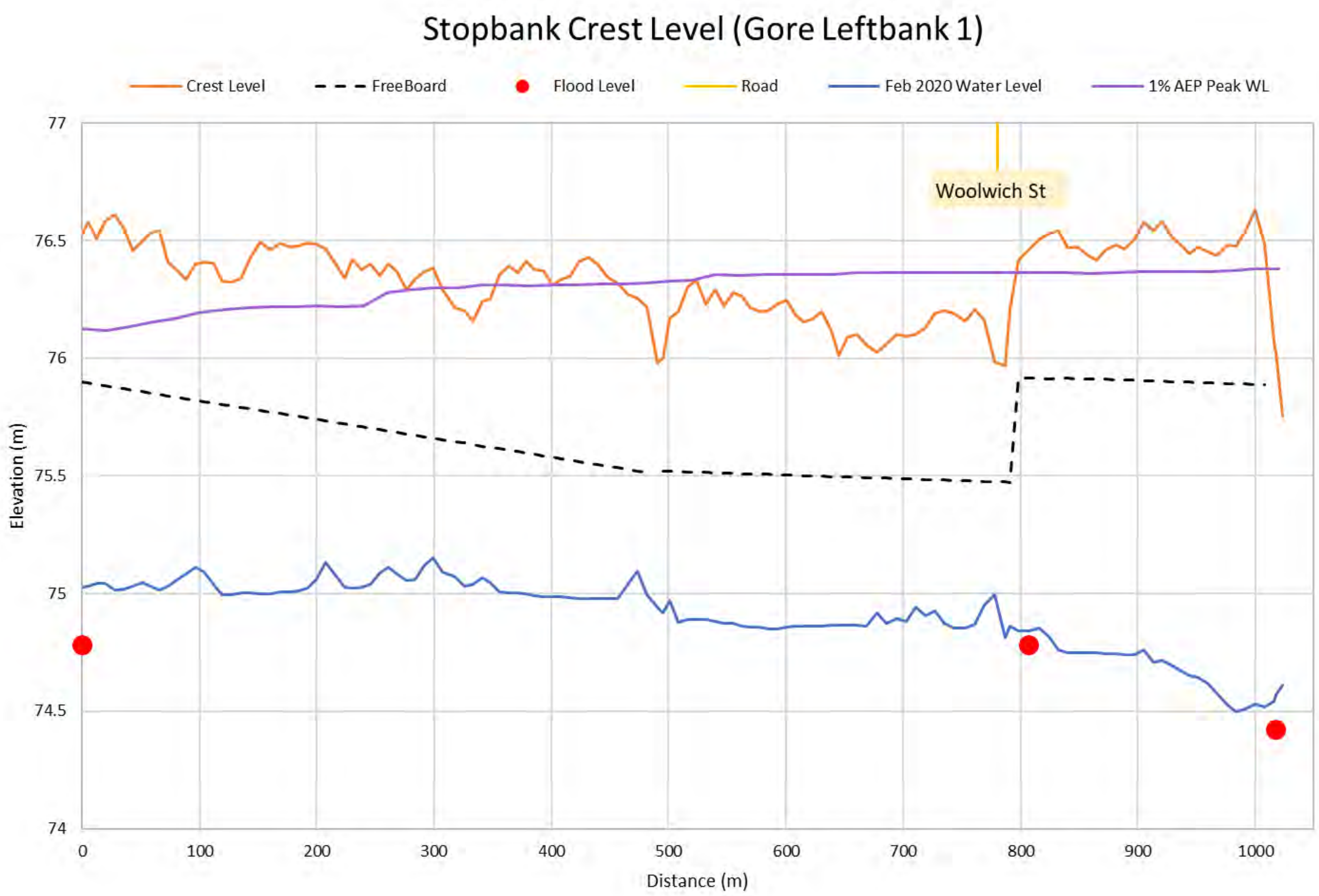
3. Conclusion

No issues of major concern are apparent. The modelling uses sound methods and techniques and calibration results are reasonable (notwithstanding the need to adjust the flows supplied by ES).

However, you may want to consider tidying up how inflows are applied (including reconfiguring the mesh extents and defined external boundaries) and how the downstream boundaries are configured.

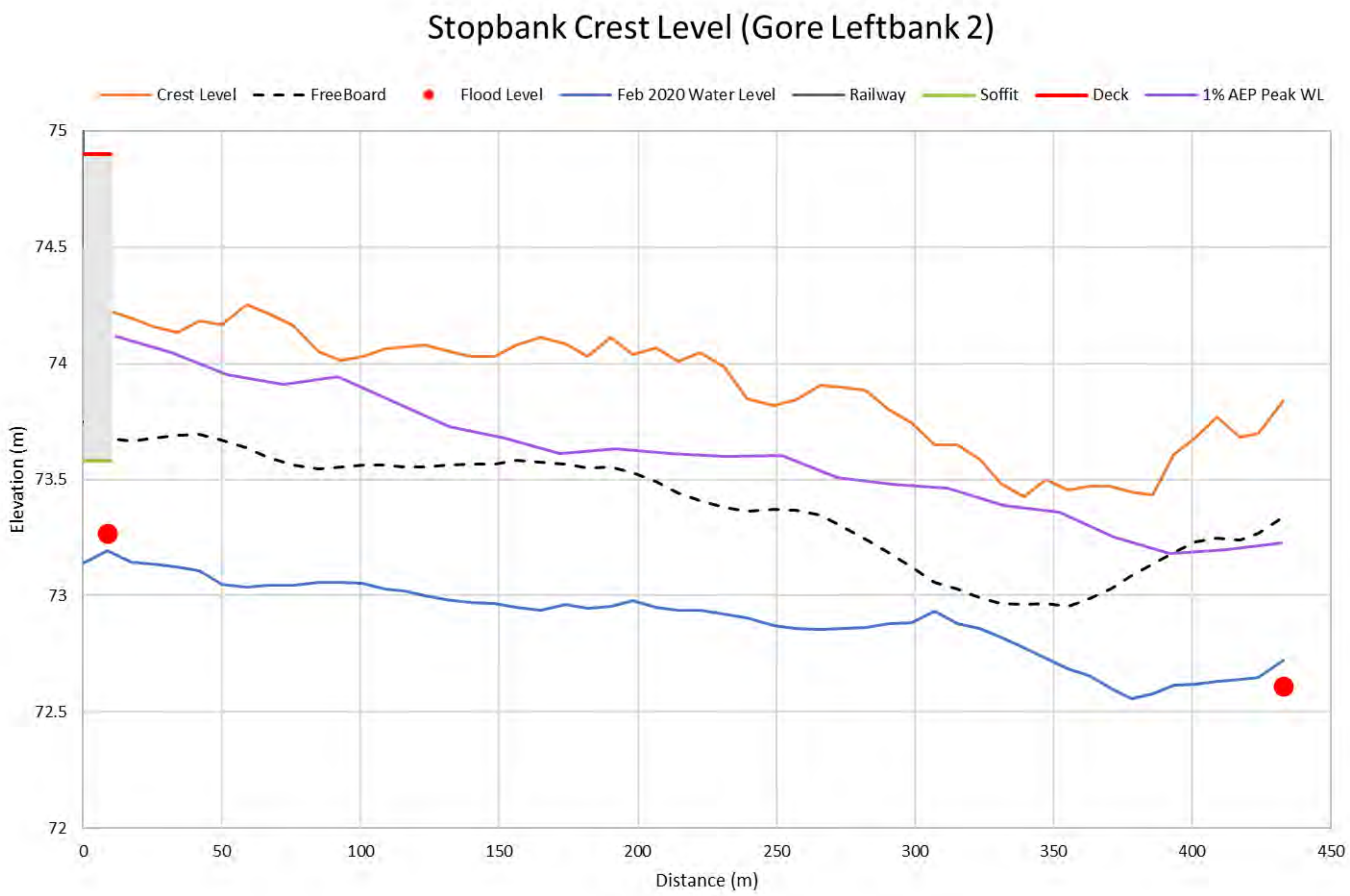
Also some minor tidying up of dikes and culverts (notwithstanding that culvert details sparse) is required (it is possible that would only make minor differences but we cannot be sure until this is done).

No doubt you will want a little time to consider my comments and then discuss them further with me. Please feel free to contact me when you are ready. I will prepare a report on the model review after that, once you have prepared a final version of the model and a revised version of the modelling report.

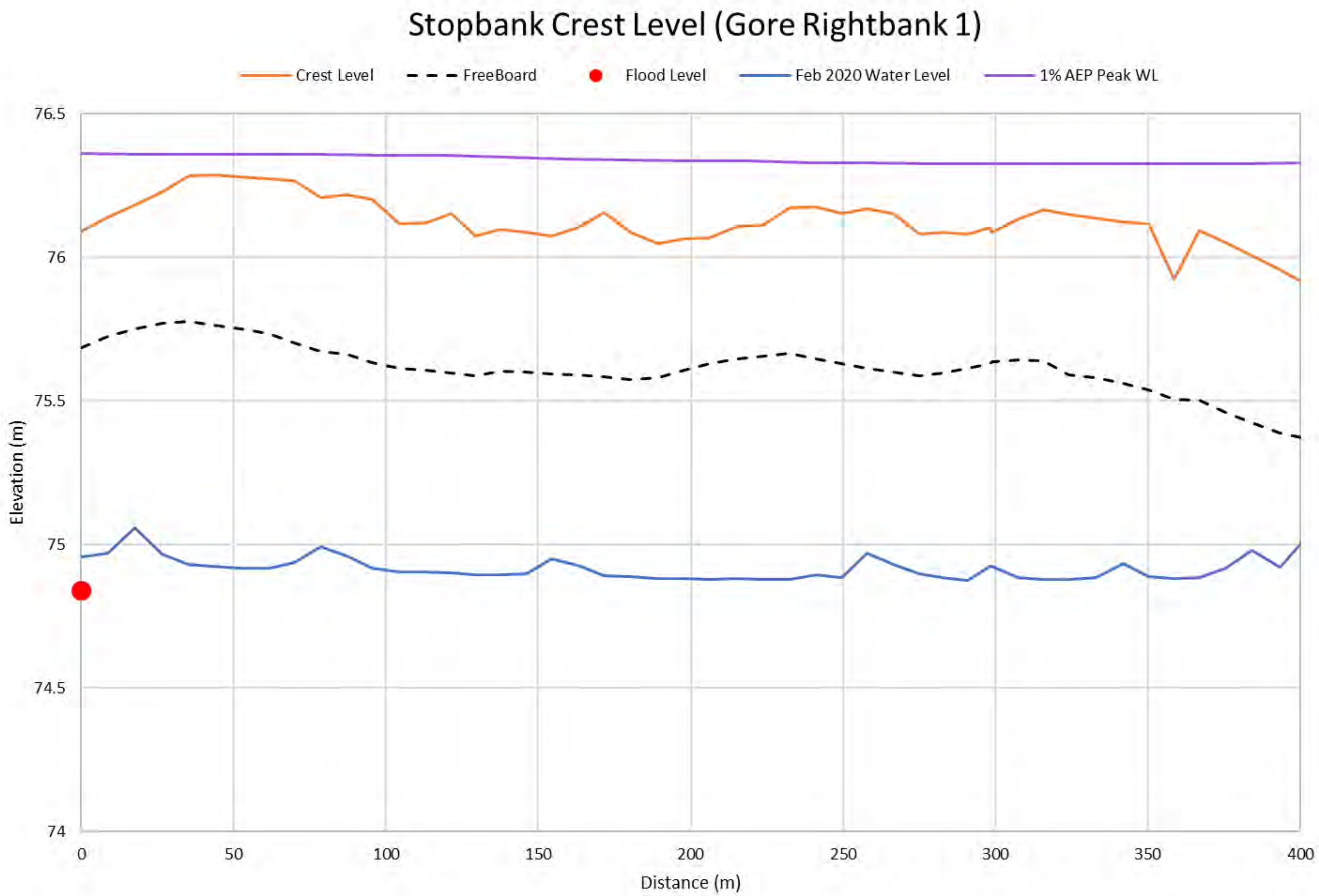


Land River Sea
CONSULTING

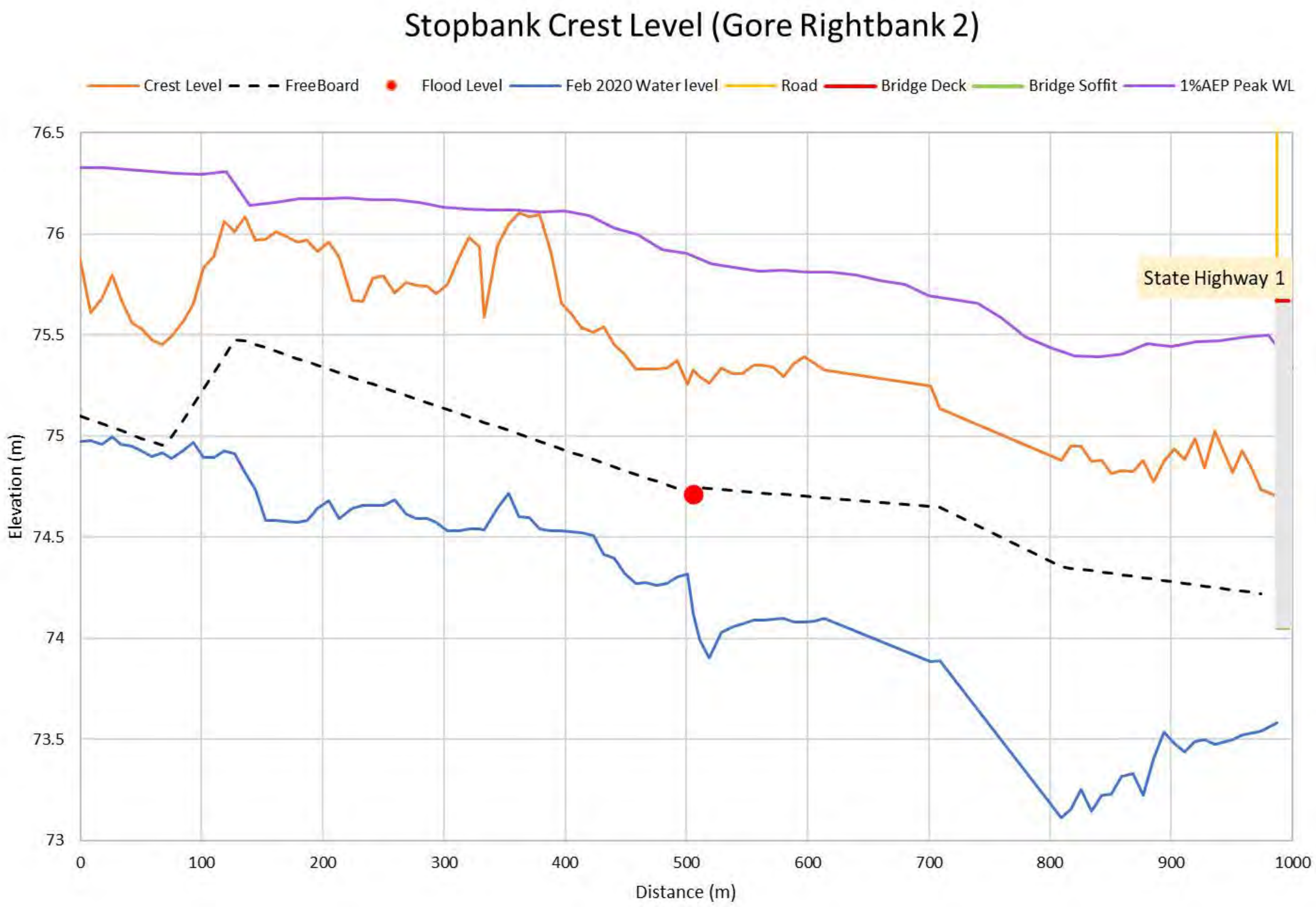
Gore leftbank 2



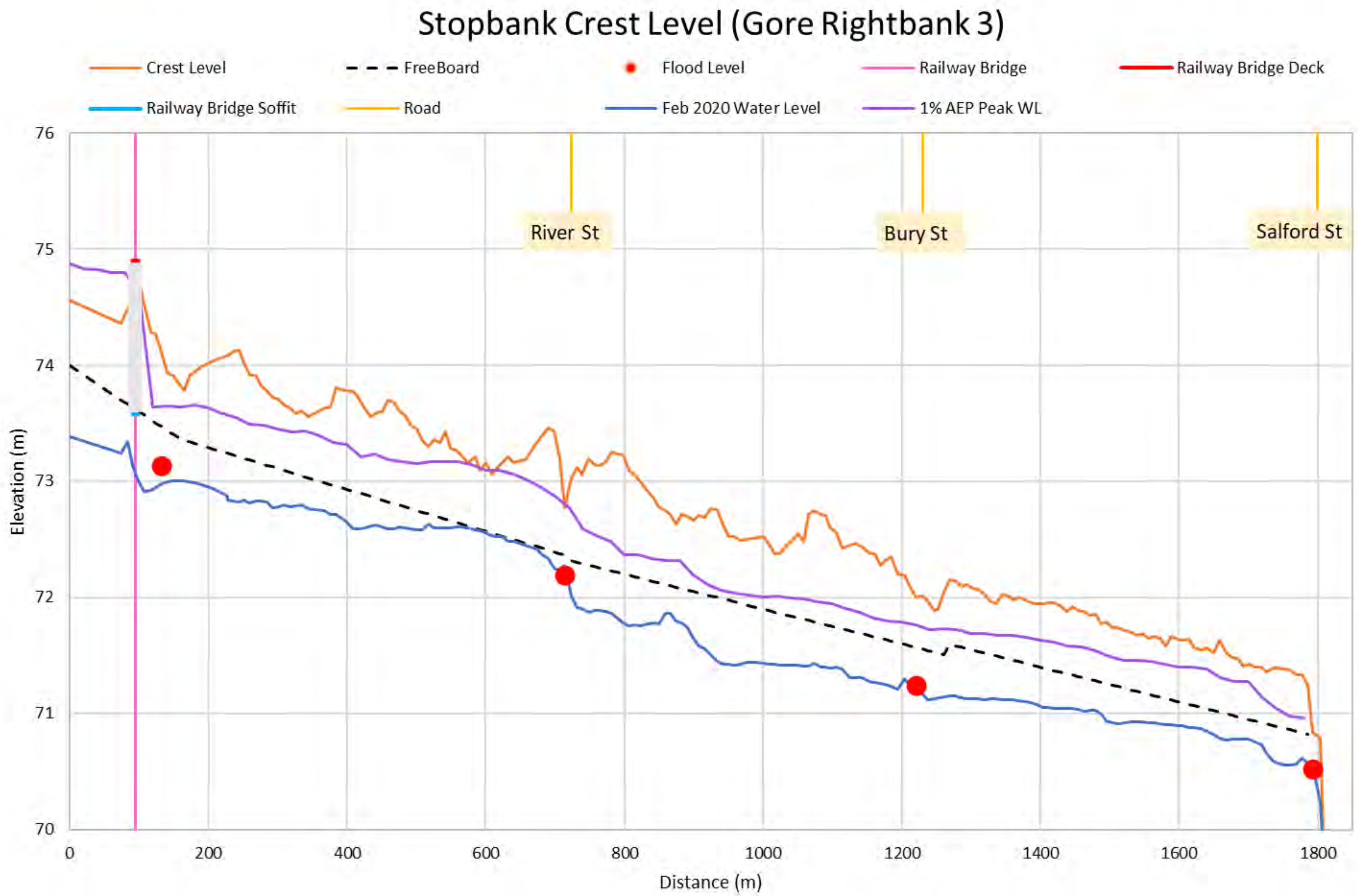
Stopbank Crest Level (Gore Leftbank 2)
Crest Level
FreeBoard
Flood Level
Feb 2020 Water Level
Railway
Soffit
Deck
1% AEP Peak WL
Elevation (m)
Distance (m)



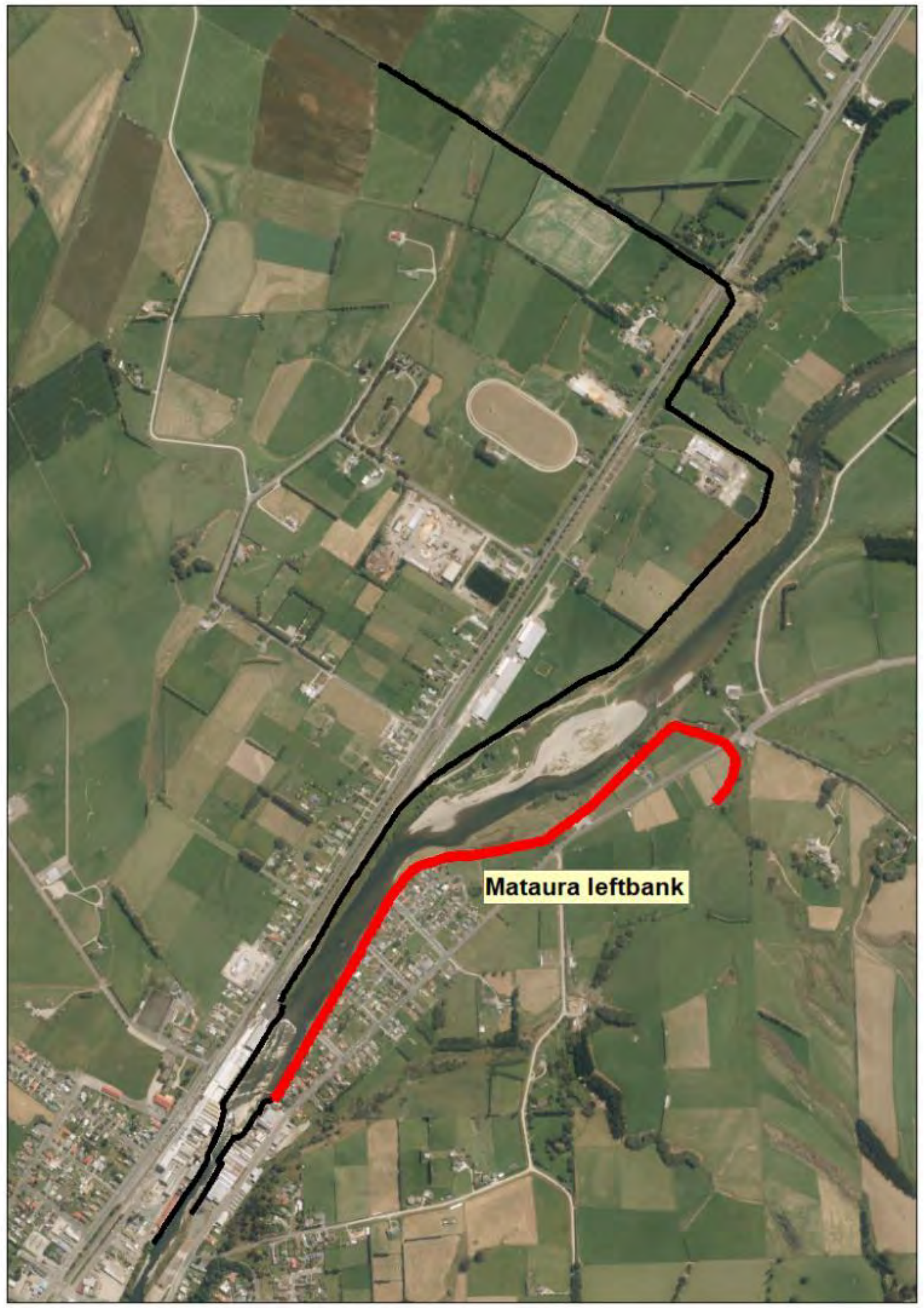
Land River Sea
CONSULTING

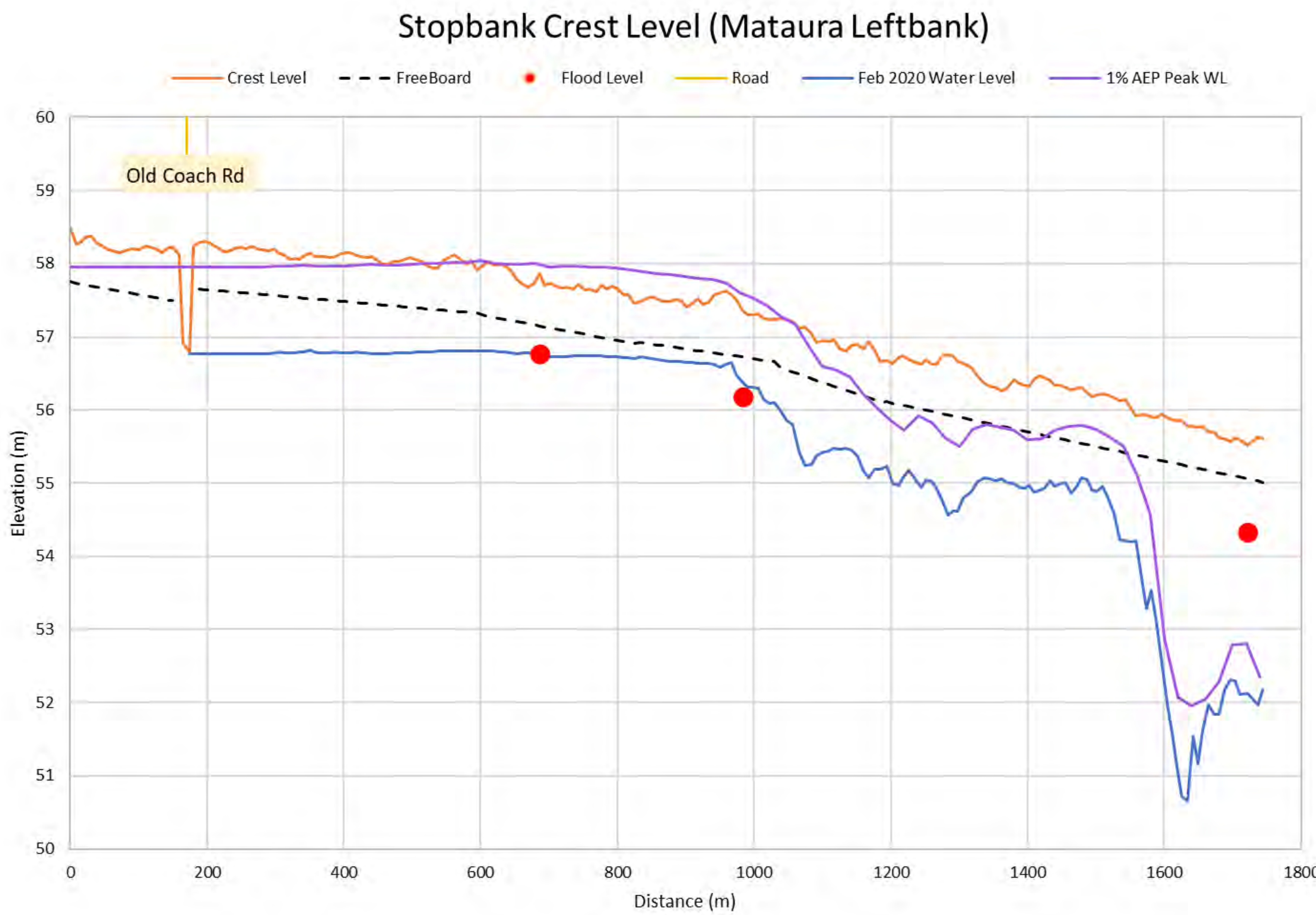


Land River Sea
CONSULTING



Land River Sea
CONSULTING





Land River Sea
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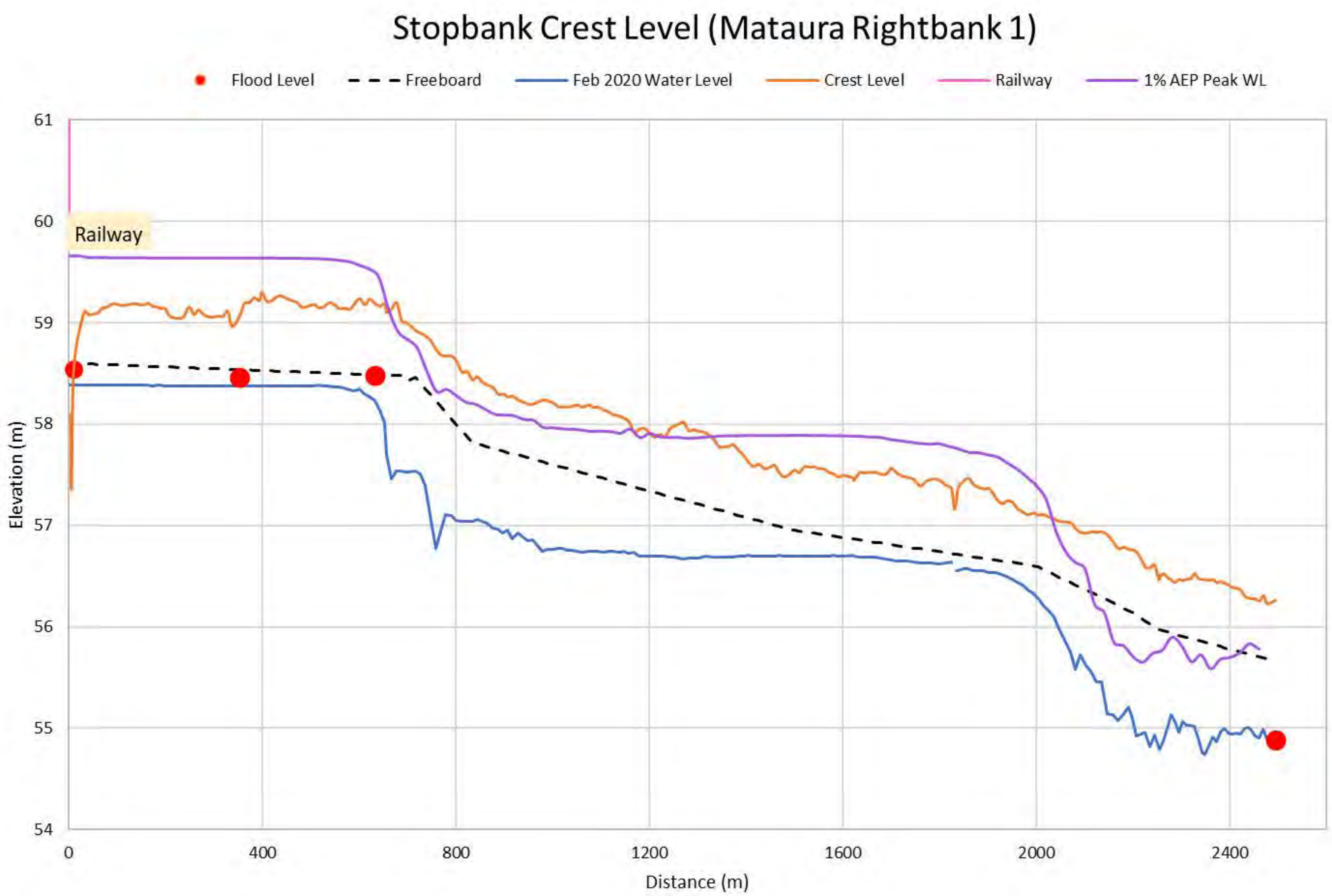
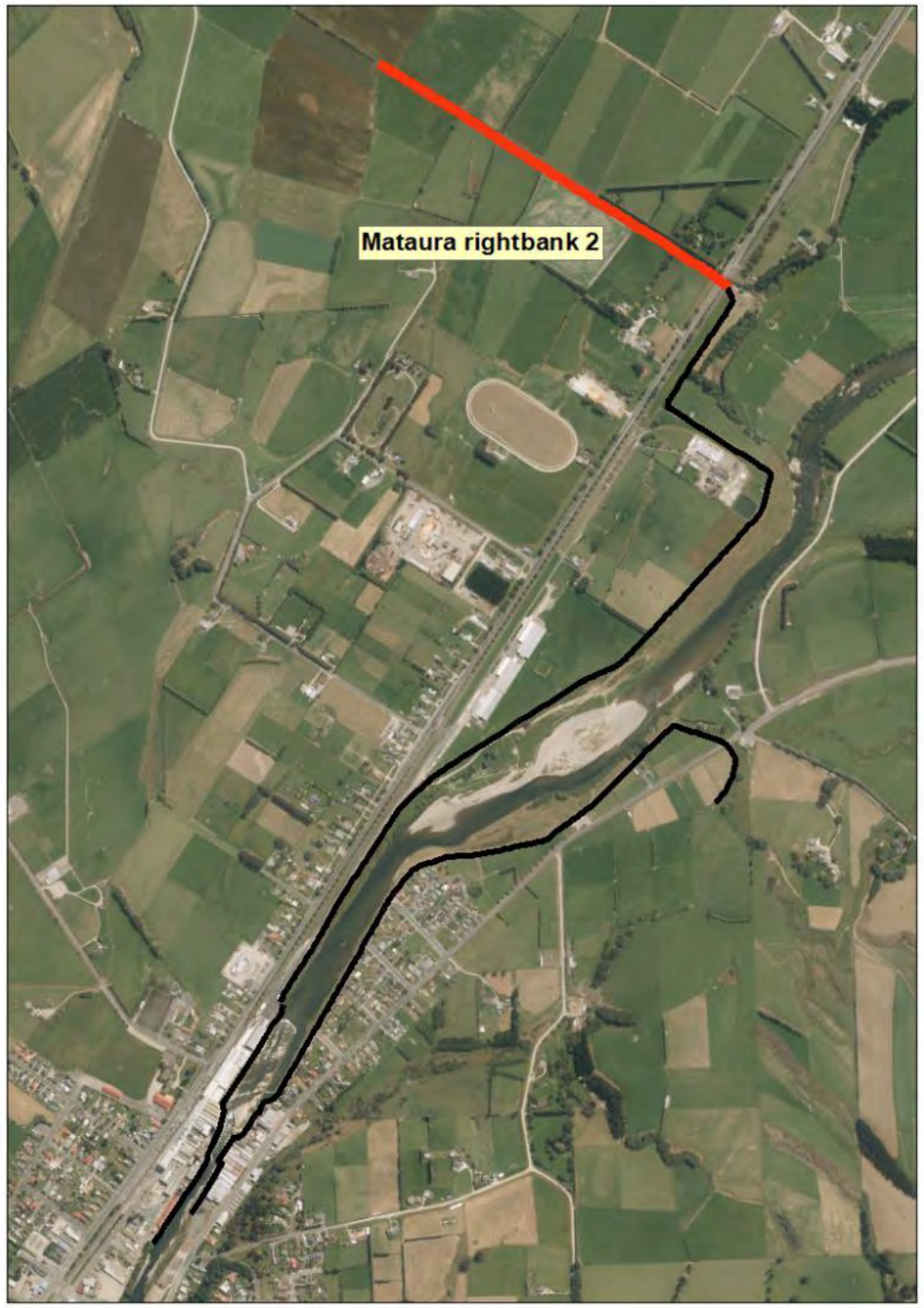
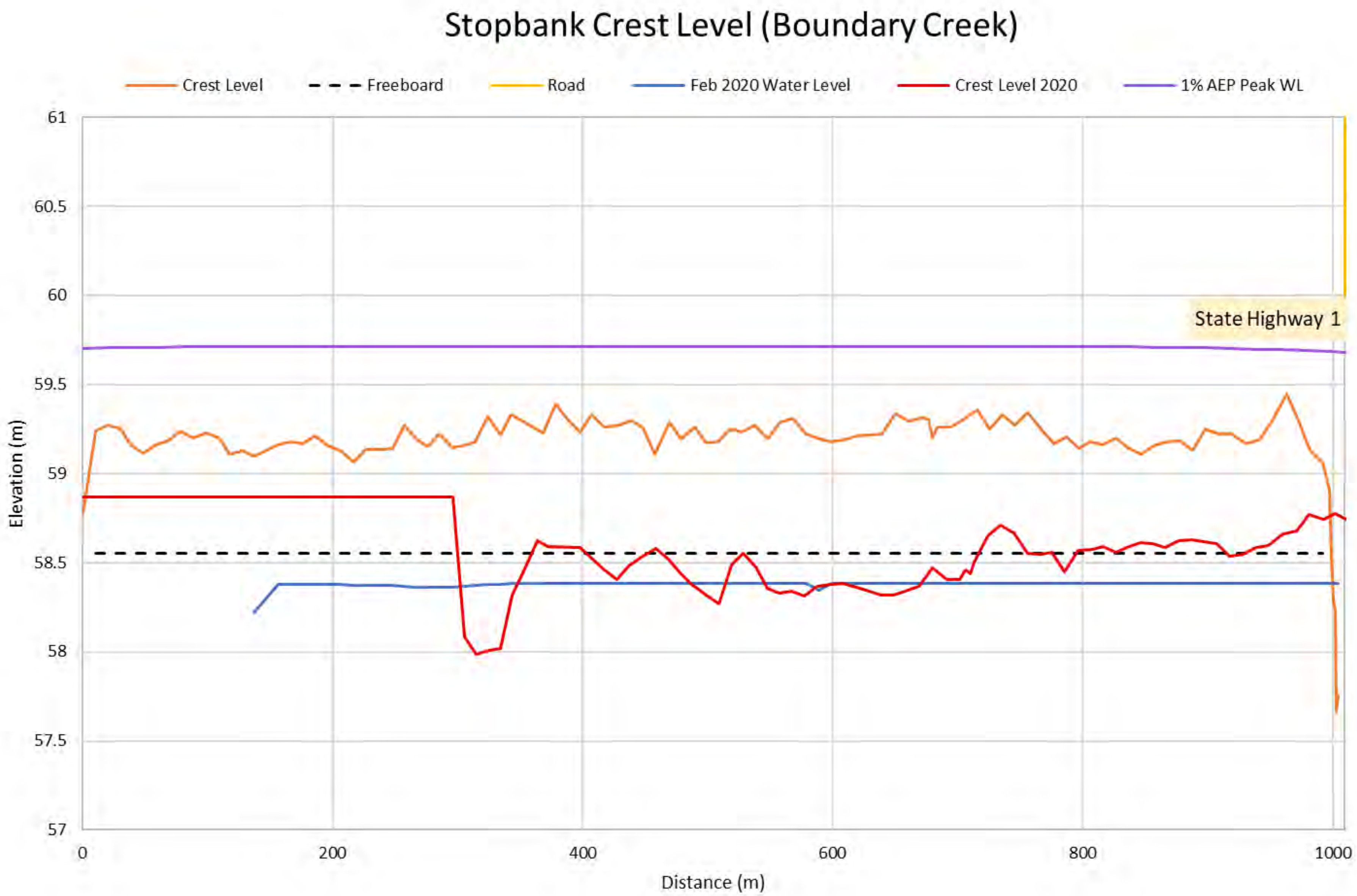
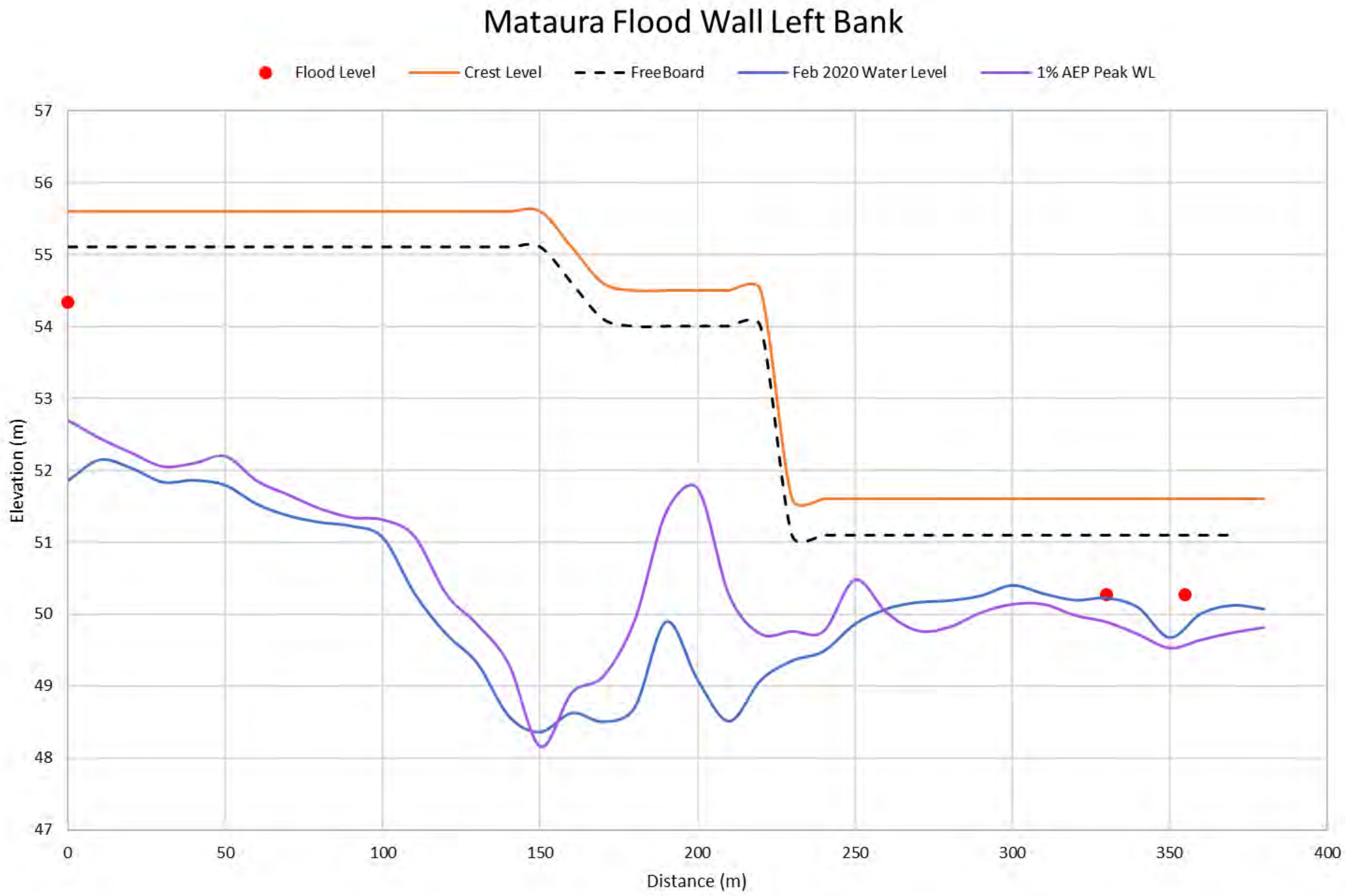


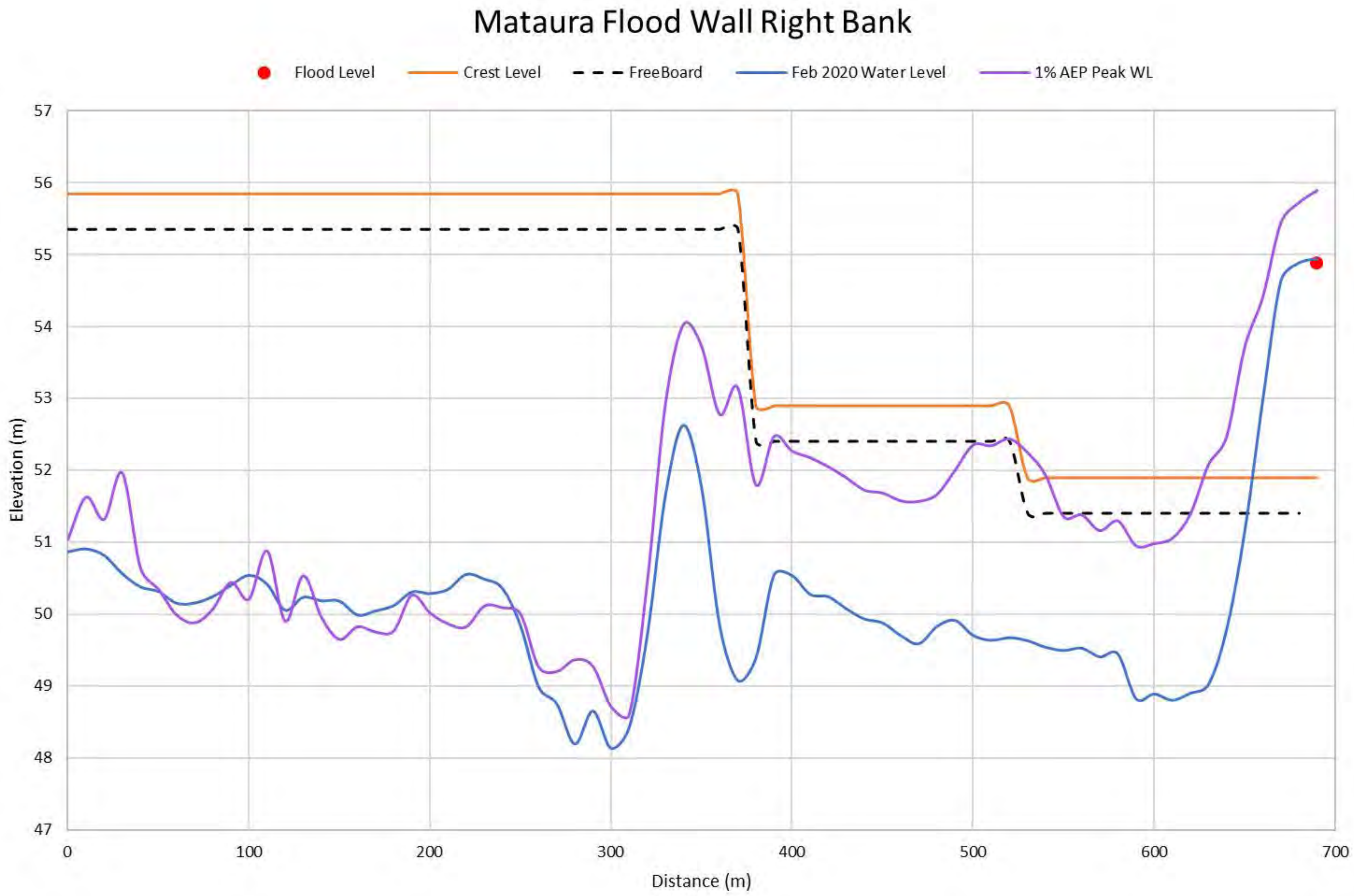
Land River Sea
CONSULTING


Mataura rightbank 2

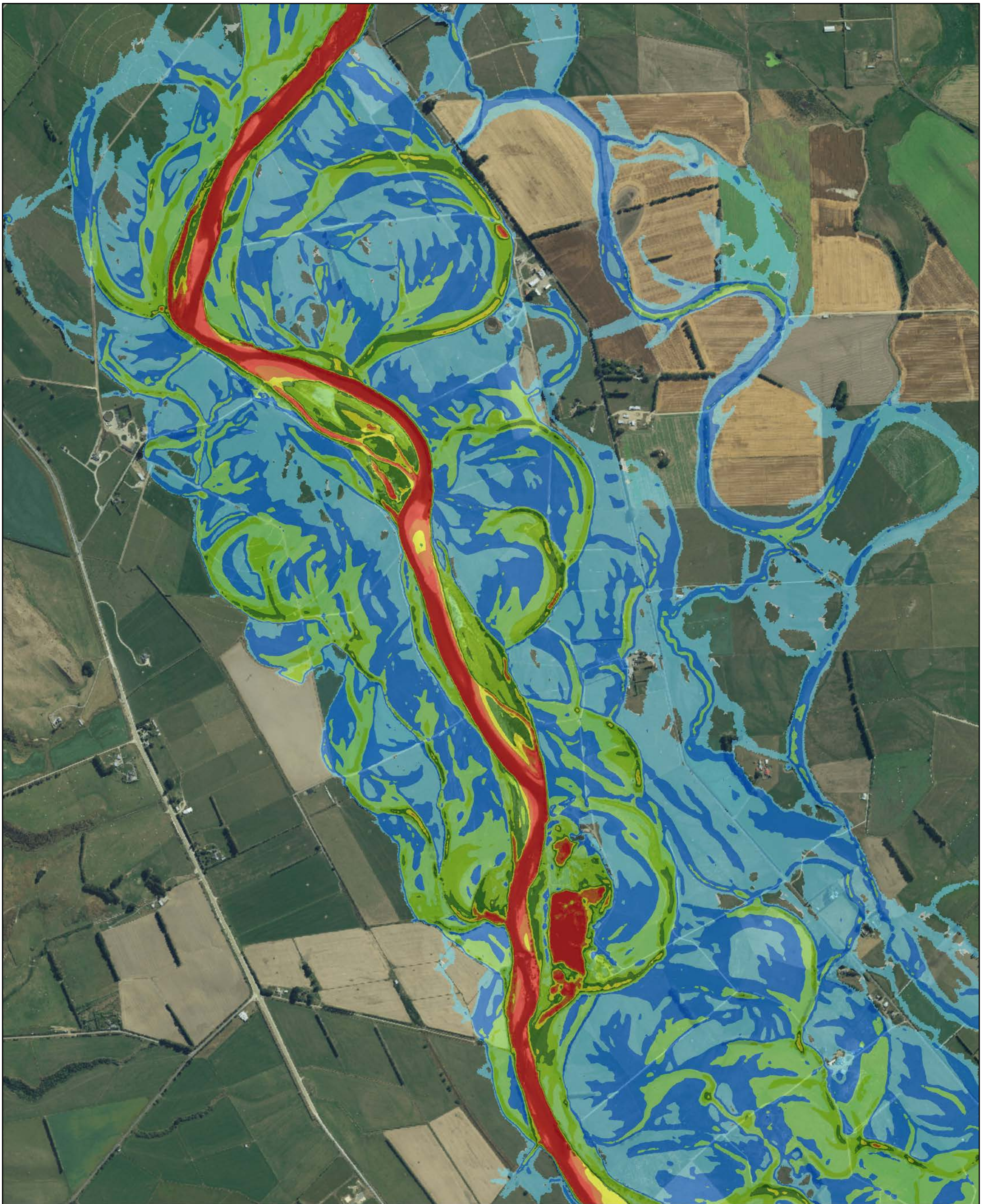

Stopbank Crest Level (Boundary Creek)
Crest Level
Freeboard
Road
Feb 2020 Water Level
Crest Level 2020
1% AEP Peak WL
Elevation (m)
61
60.5
60
59.5
59
58.5
58
57.5
57
Distance (m)
0
200
400
600
800
1000
State Highway 1


Mataura floodwall - left


Mataura Flood Wall Left Bank
Flood Level
Crest Level
FreeBoard
Feb 2020 Water Level
1% AEP Peak WL
Elevation (m)
Distance (m)
57
56
55
54
53
52
51
50
49
48
47
0
50
100
150
200
250
300
350
400



Land River Sea
CONSULTING



Legend

Stopbanks

Depth (m)

- 0 - 0.01
- 0.01 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- 3 - 3.5
- 3.5 +

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environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 125 250 500
Meters

A3 SCALE **1:13,000**

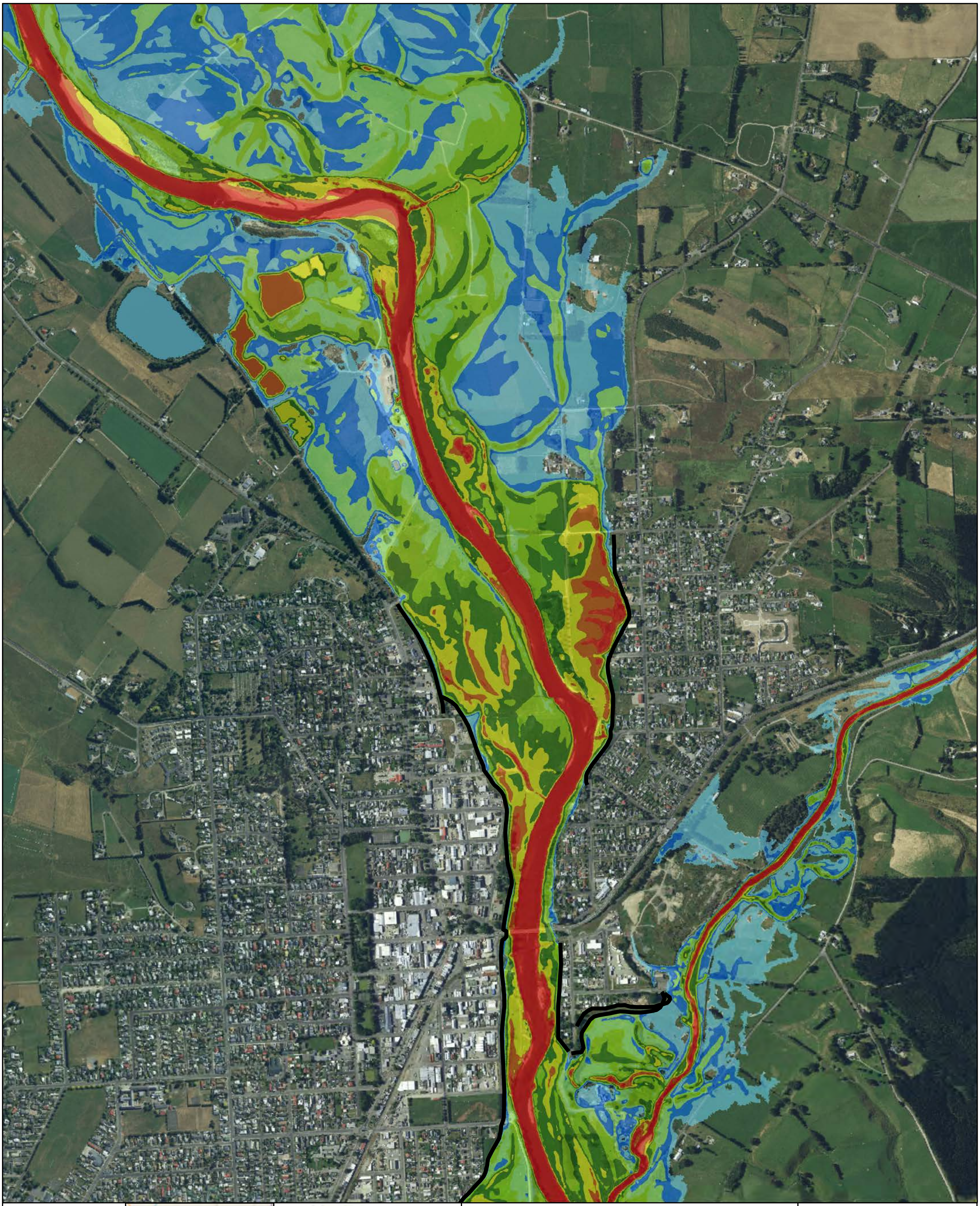
MAP (1 of 3)

PROJECT
Mataura River Modelling

MAP TITLE
PEAK DEPTH MAP
Gore
2% AEP Flow, Historic Climate

REVISION	01	Created By	SP	Reviewed By	MG	N
AUTHOR	Matthew Gardner		DATE	13/06/2024		

Model Information
Coordinate System: New Zealand Transverse Mercator
Vertical Datum: NZVD2016
Model Completed: October 2023



Legend

Stopbanks

Depth (m)

- 0 - 0.01
- 0.01 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- 3 - 3.5
- 3.5 +

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0 125 250 500 Meters

A3 SCALE 1:13,000

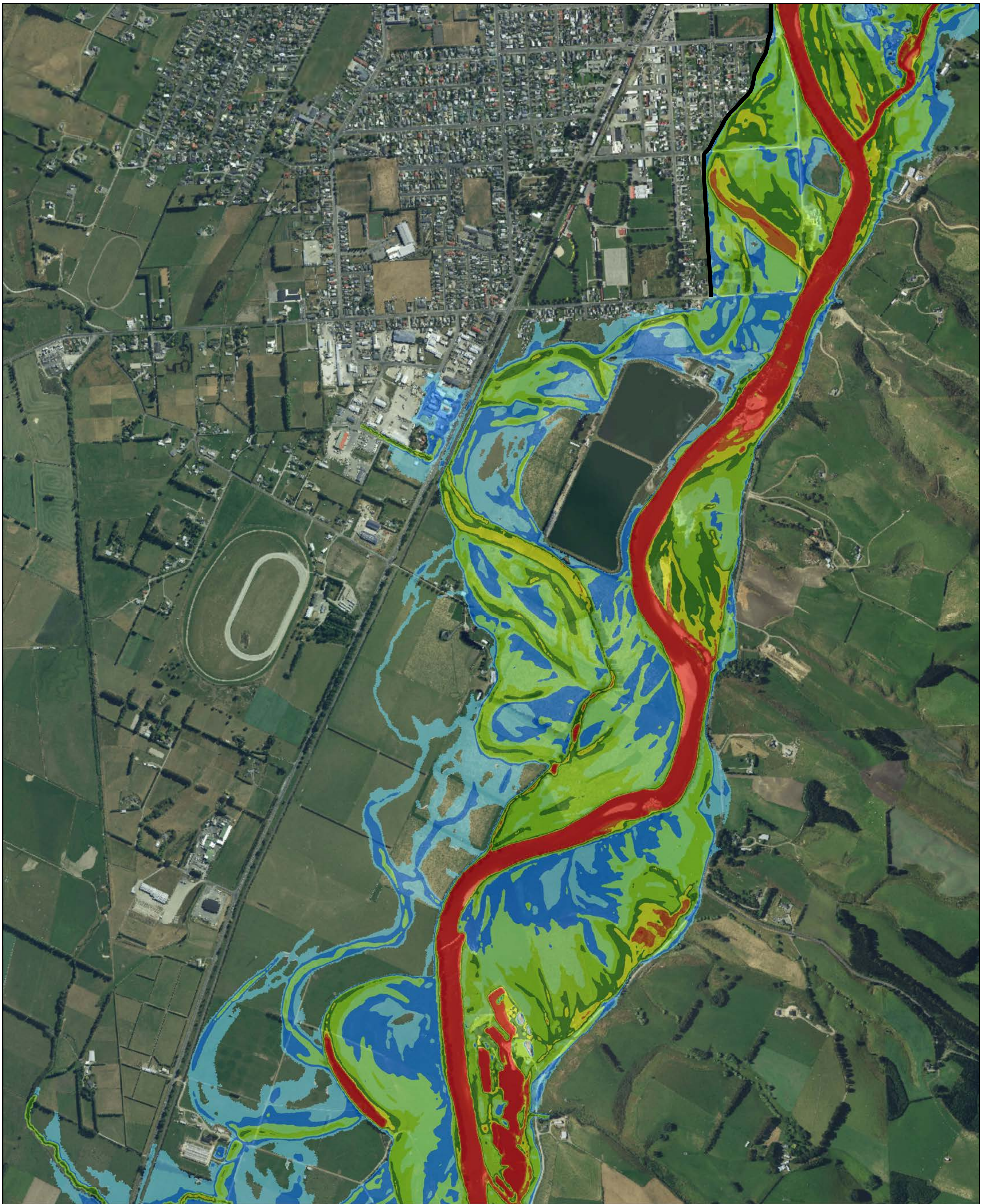
MAP (2 of 3)

PROJECT
Mataura River Modelling

MAP TITLE
PEAK DEPTH MAP
Gore
2% AEP Flow, Historic Climate

REVISION	01	Created By	SP	Reviewed By	MG	N
AUTHOR	Matthew Gardner		DATE	13/06/2024		

Model Information
Coordinate System: New Zealand Transverse Mercator
Vertical Datum: NZVD2016
Model Completed: October 2023



Legend

Stopbanks

Depth (m)

- 0 - 0.01
- 0.01 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- 3 - 3.5
- 3.5 +

Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 125 250 500
Meters

A3 SCALE **1:13,000**

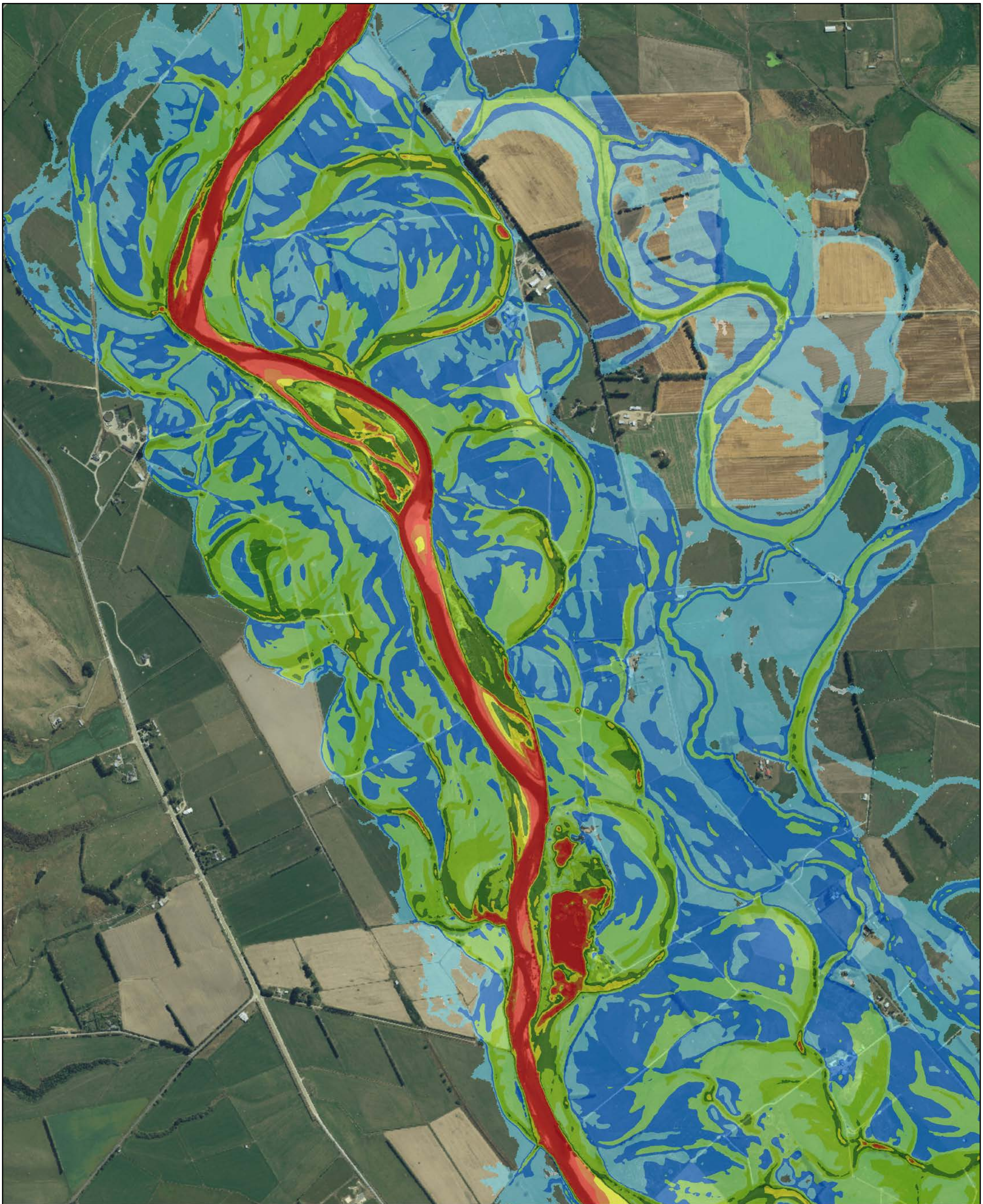
MAP (3 of 3)

PROJECT
Mataura River Modelling

MAP TITLE
PEAK DEPTH MAP
Gore
2% AEP Flow, Historic Climate

REVISION	01	Created By	SP	Reviewed By	MG	N
AUTHOR	Matthew Gardner		DATE	13/06/2024		

Model Information
Coordinate System: New Zealand Transverse Mercator
Vertical Datum: NZVD2016
Model Completed: October 2023

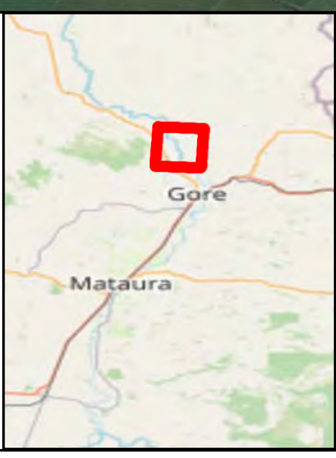


Legend

Stopbanks

Depth (m)

- 0 - 0.01
- 0.01 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- 3 - 3.5
- 3.5 +



Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 125 250 500 Meters

A3 SCALE **1:13,000**

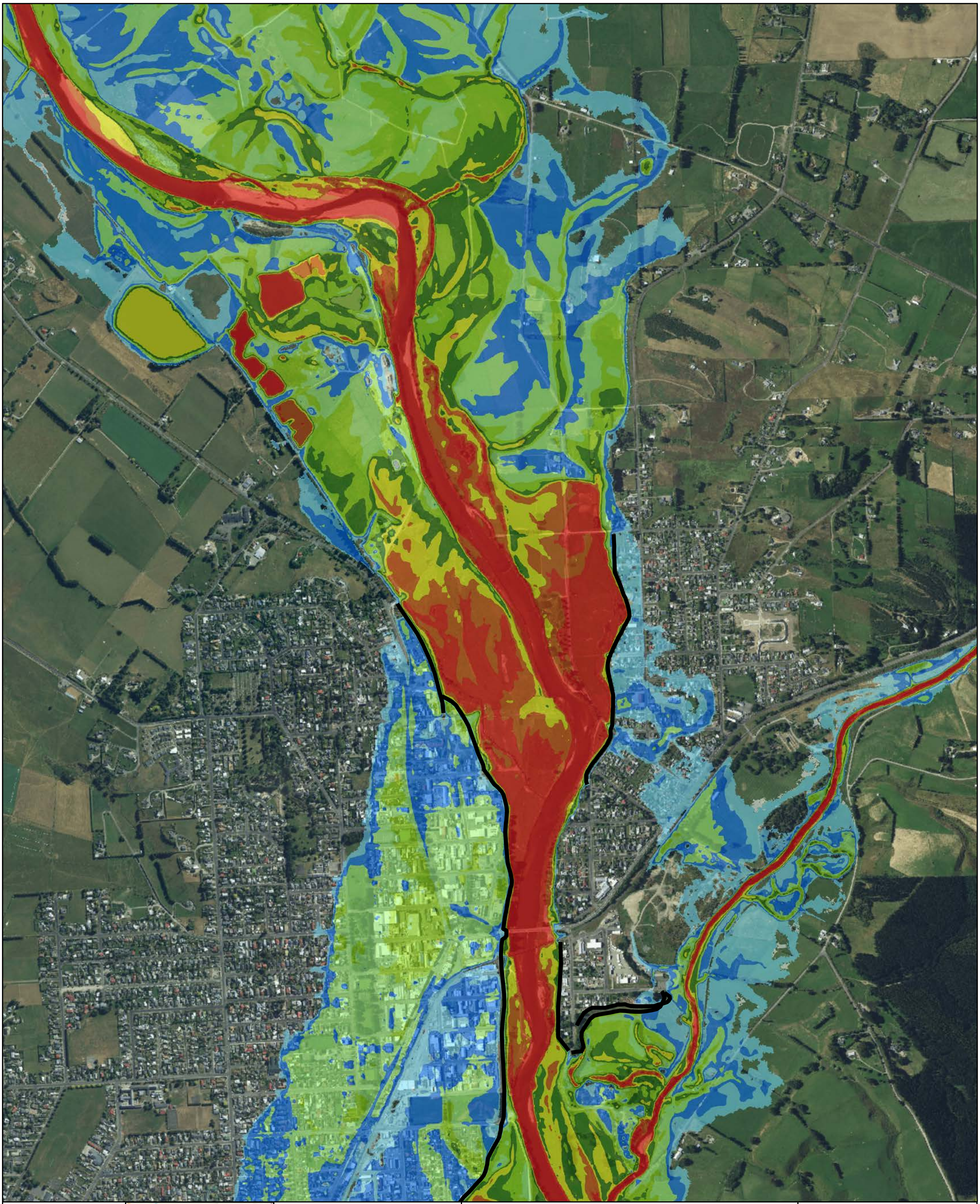
MAP (1 of 3)

PROJECT
Mataura River Modelling

MAP TITLE
PEAK DEPTH MAP
Gore
1% AEP Flow, Historic Climate

REVISION	01	Created By	SP	Reviewed By	MG	N
AUTHOR	**Matthew Gardner**		DATE	**13/06/2024**		

Model Information
Coordinate System: New Zealand Transverse Mercator
Vertical Datum: NZVD2016
Model Completed: October 2023



Legend

Stopbanks

Depth (m)

- 0 - 0.01
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- 0.5 - 1
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- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- 3 - 3.5
- 3.5 +

Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 125 250 500
Meters

A3 SCALE 1:13,000

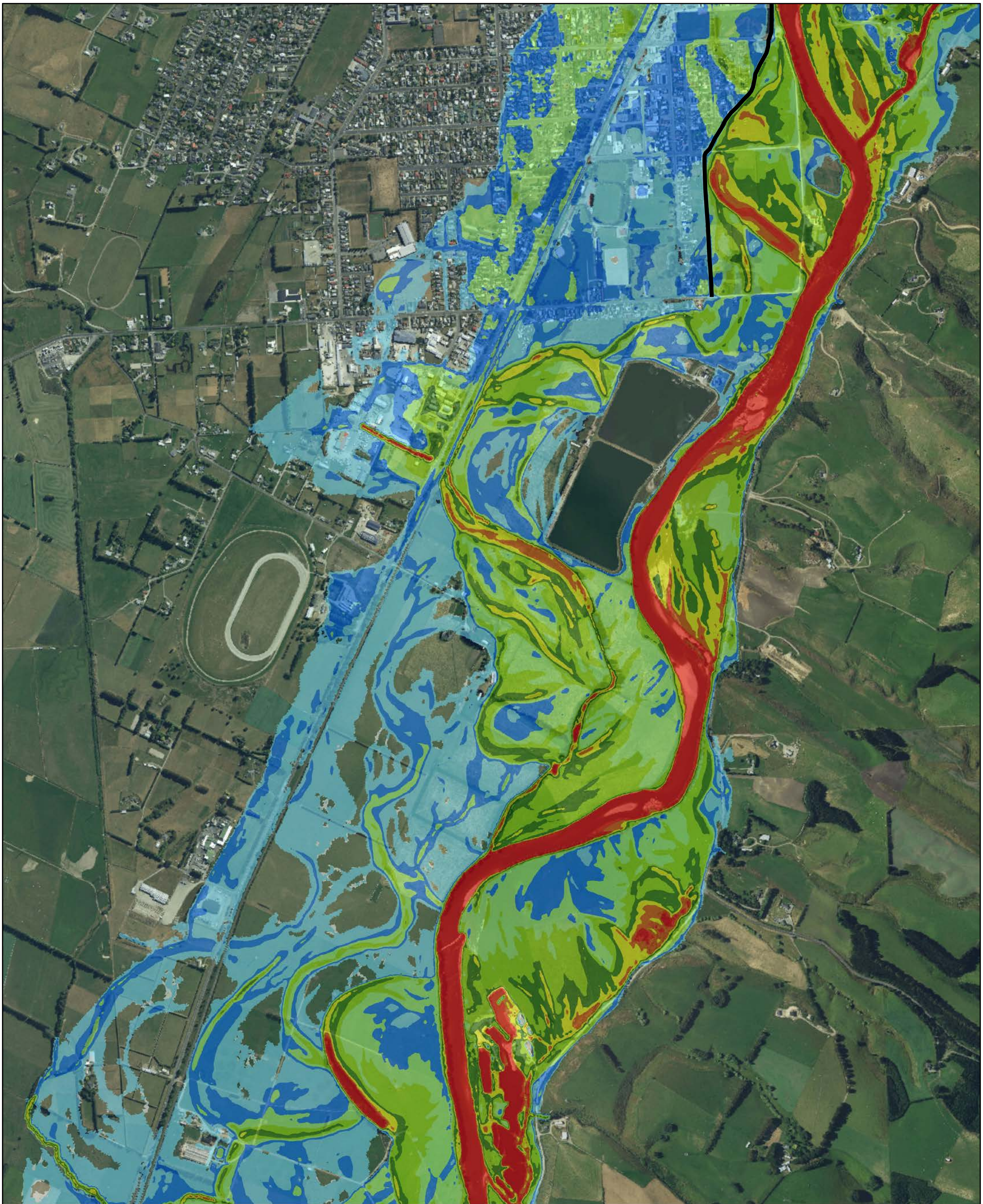
MAP (2 of 3)

PROJECT
Mataura River Modelling

MAP TITLE
PEAK DEPTH MAP
Gore
1% AEP Flow, Historic Climate

REVISION	01	Created By	SP	Reviewed By	MG	N
AUTHOR	Matthew Gardner		DATE	13/06/2024		

Model Information
Coordinate System: New Zealand Transverse Mercator
Vertical Datum: NZVD2016
Model Completed: October 2023



Legend

Stopbanks

Depth (m)

- 0 - 0.01
- 0.01 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- 3 - 3.5
- 3.5 +

Land River Sea
CONSULTING

environment SOUTHLAND
REGIONAL COUNCIL
Te Taiao Tonga

0 125 250 500
Meters

A3 SCALE **1:13,000**

MAP (3 of 3)

PROJECT
Mataura River Modelling

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1% AEP Flow, Historic Climate

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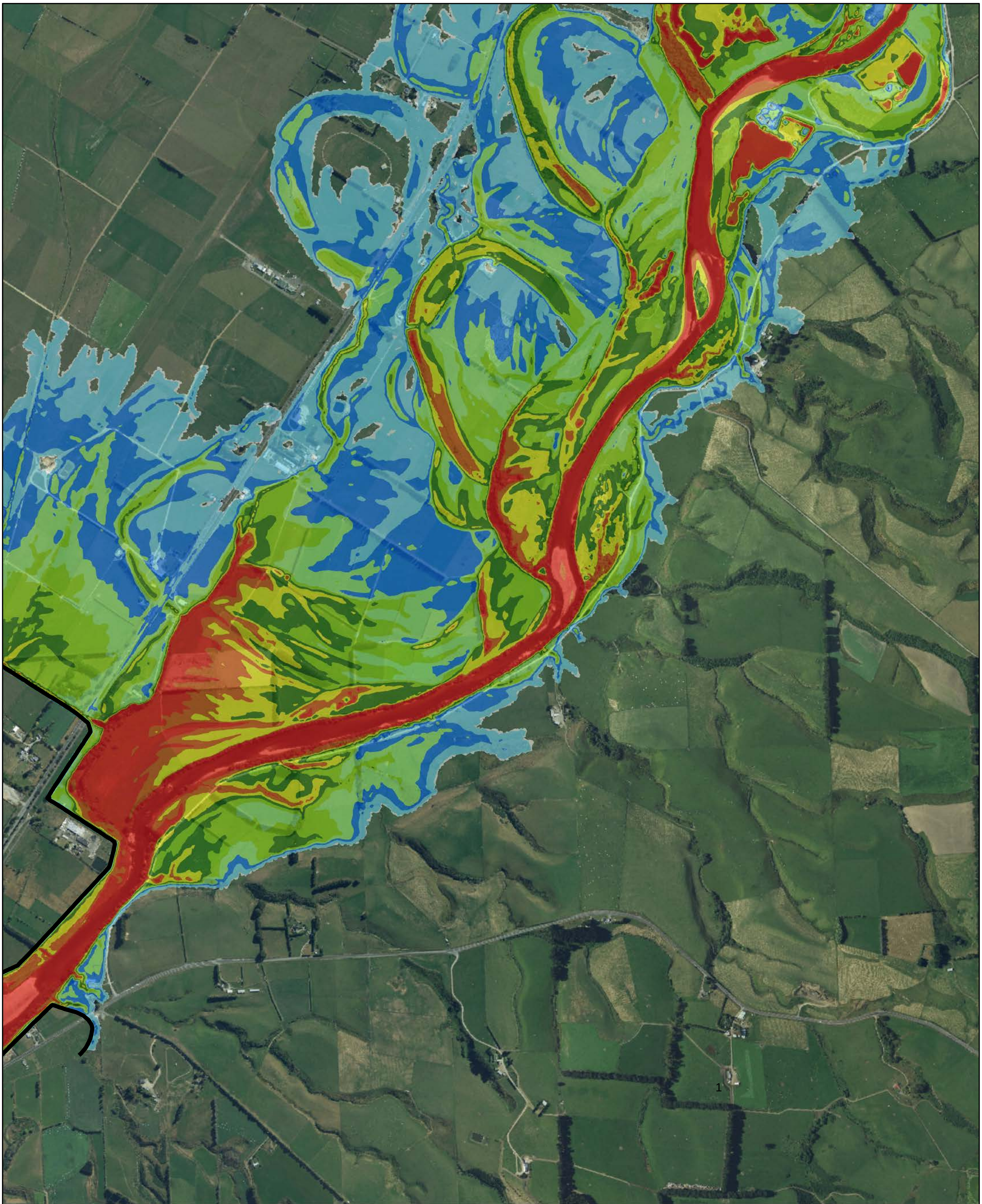

Legend

Stopbanks

Depth (m)

- 0 - 0.01
- 0.01 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- 3 - 3.5
- 3.5 +

Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 125 250 500 Meters

A3 SCALE **1:13,000**

MAP (1 of 3)

PROJECT
Mataura River Modelling

MAP TITLE
PEAK DEPTH MAP
Mataura
2% AEP Flow, Historic Climate

REVISION	01	Created By	SP	Reviewed By	MG	N
AUTHOR	**Matthew Gardner**		DATE	**19/06/2024**		

Model Information
Coordinate System: New Zealand Transverse Mercator
Vertical Datum: NZVD2016
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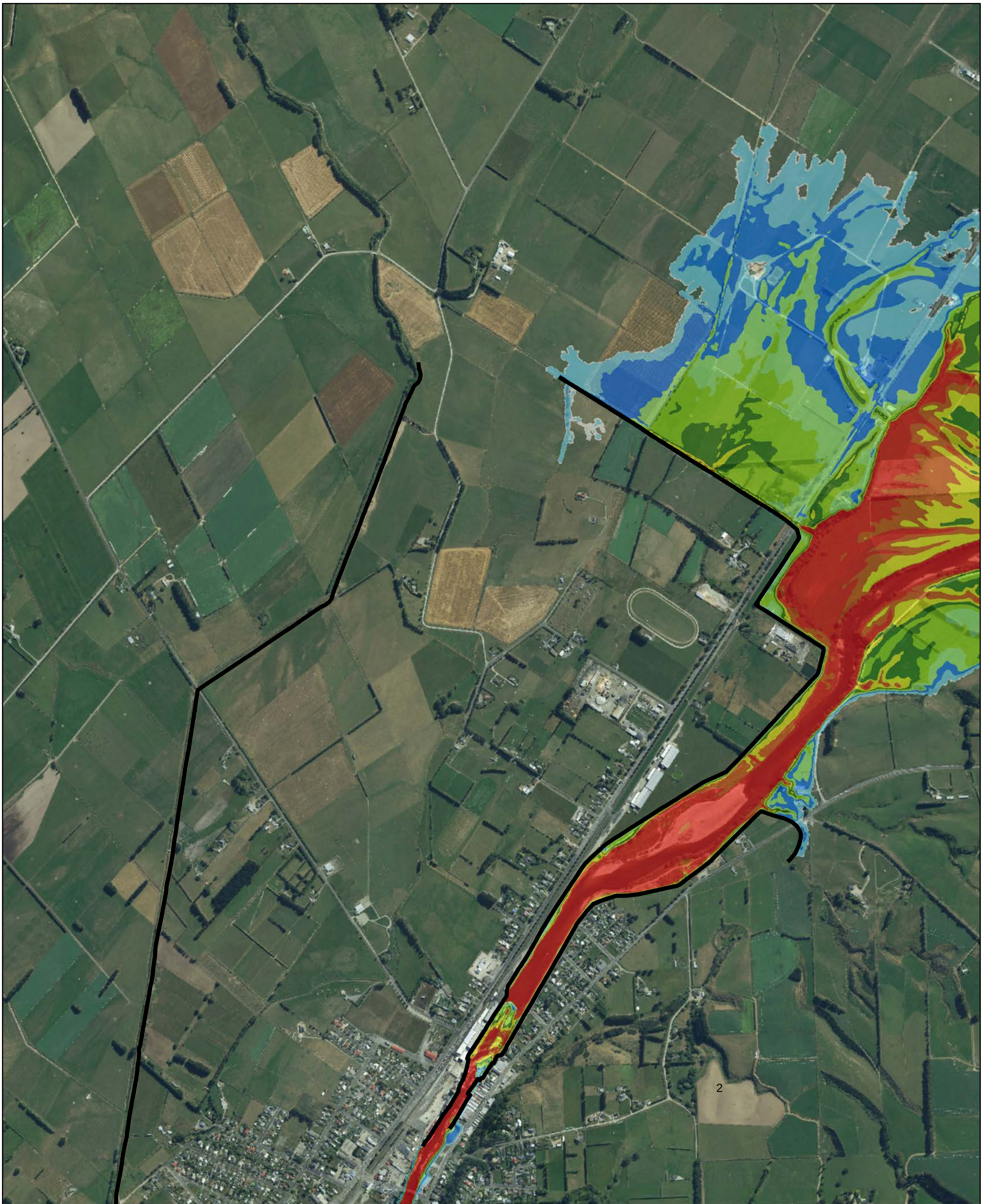

Legend

Stopbanks

Depth (m)

- 0 - 0.01
- 0.01 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- 3 - 3.5
- 3.5 +

Land River Sea CONSULTING

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0 125 250 500
Meters

A3 SCALE 1:13,000

MAP (2 of 3)

PROJECT
Mataura River Modelling

MAP TITLE
PEAK DEPTH MAP
Mataura
2% AEP Flow, Historic Climate

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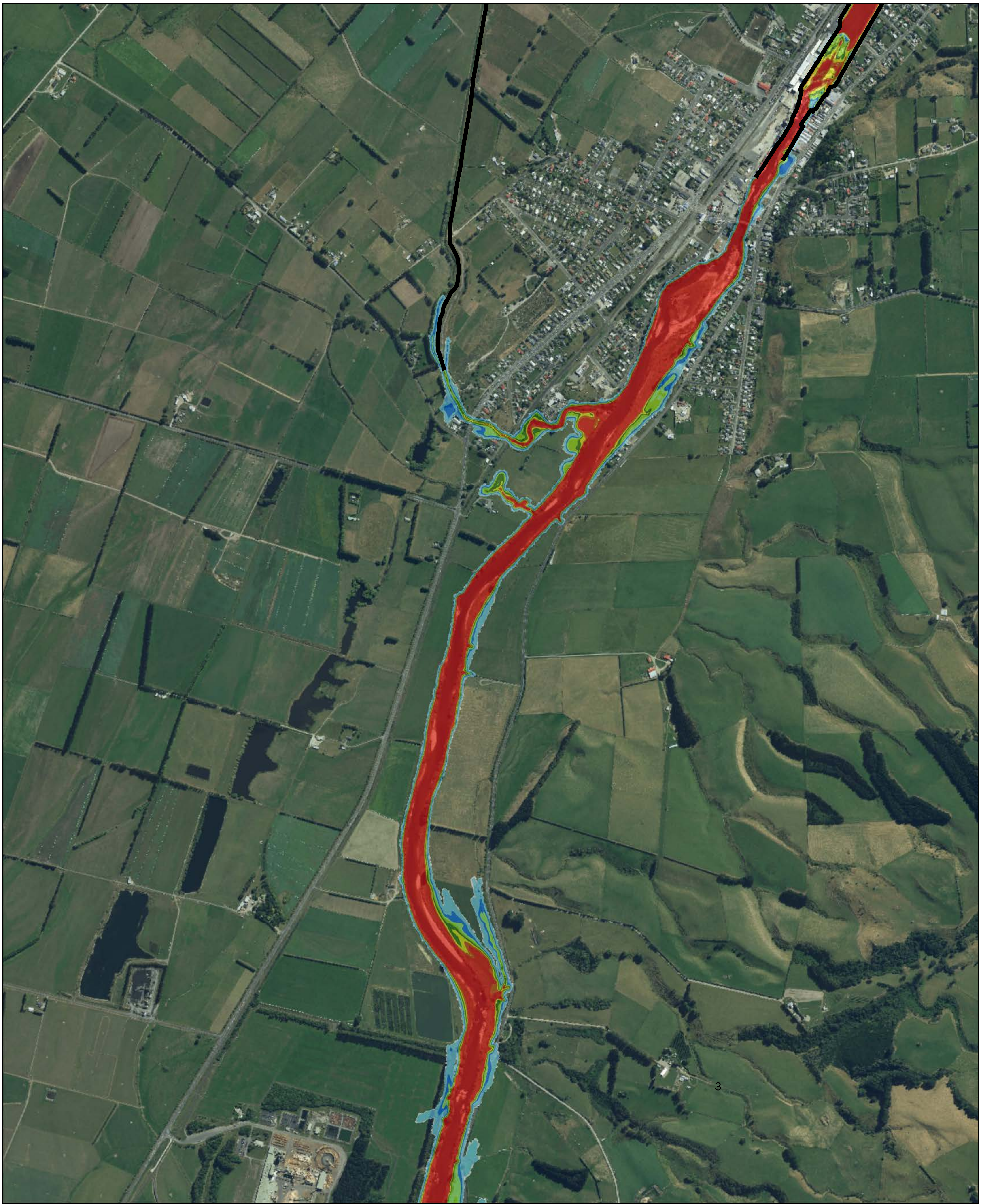

Legend

Stopbanks

Depth (m)

- 0 - 0.01
- 0.01 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
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- 3.5 +

Land River Sea CONSULTING

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0 125 250 500
Meters

A3 SCALE **1:13,000**

MAP (3 of 3)

PROJECT
Mataura River Modelling

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2% AEP Flow, Historic Climate

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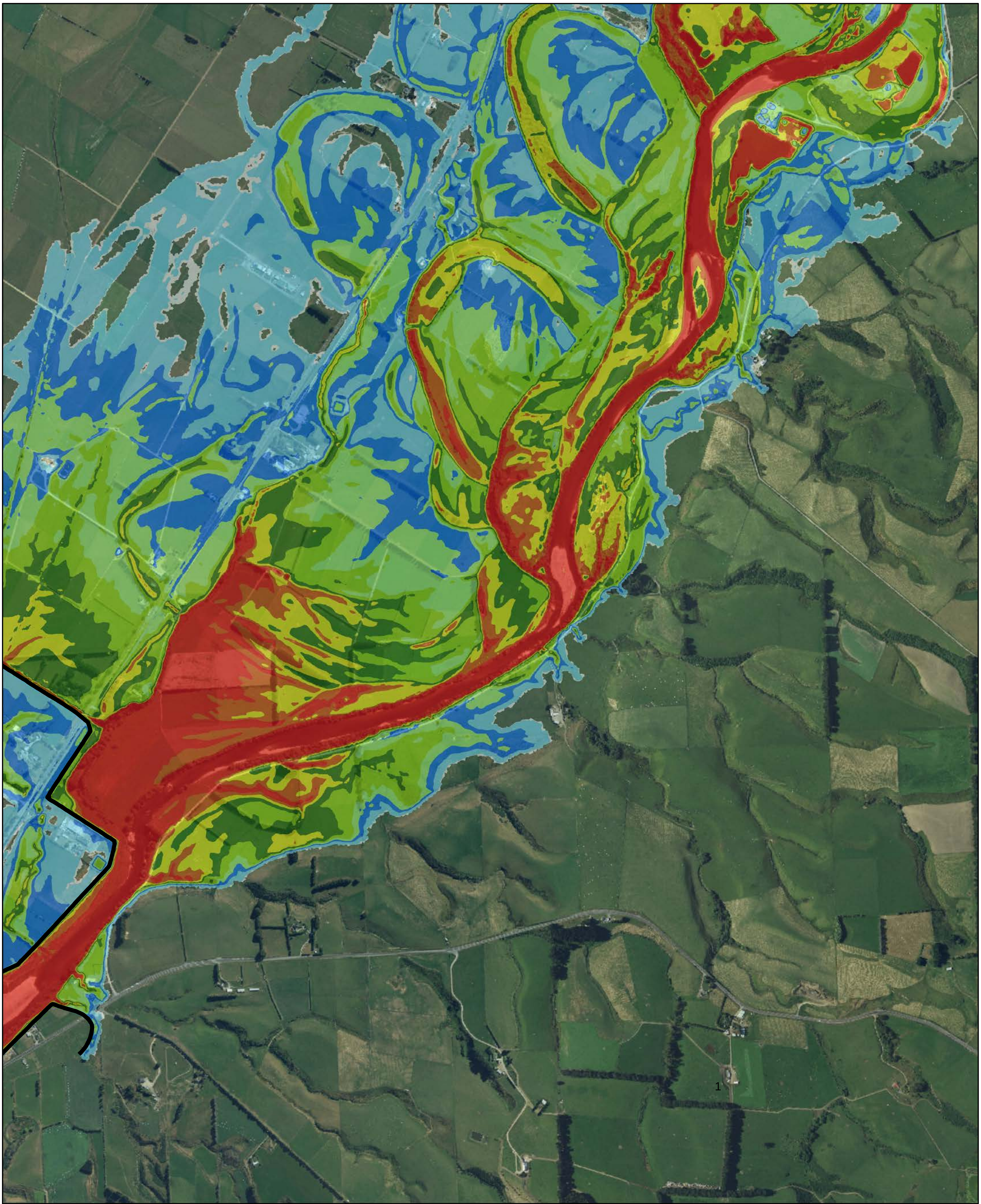

Legend

Stopbanks

Depth (m)

- 0 - 0.01
- 0.01 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- 3 - 3.5
- 3.5 +

Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 125 250 500
Meters

A3 SCALE **1:13,000**

MAP (1 of 3)

PROJECT
Mataura River Modelling

MAP TITLE
PEAK DEPTH MAP
Mataura
1% AEP Flow, Historic Climate

REVISION	**01**	Created By	**SP**	Reviewed By	**MG**	N
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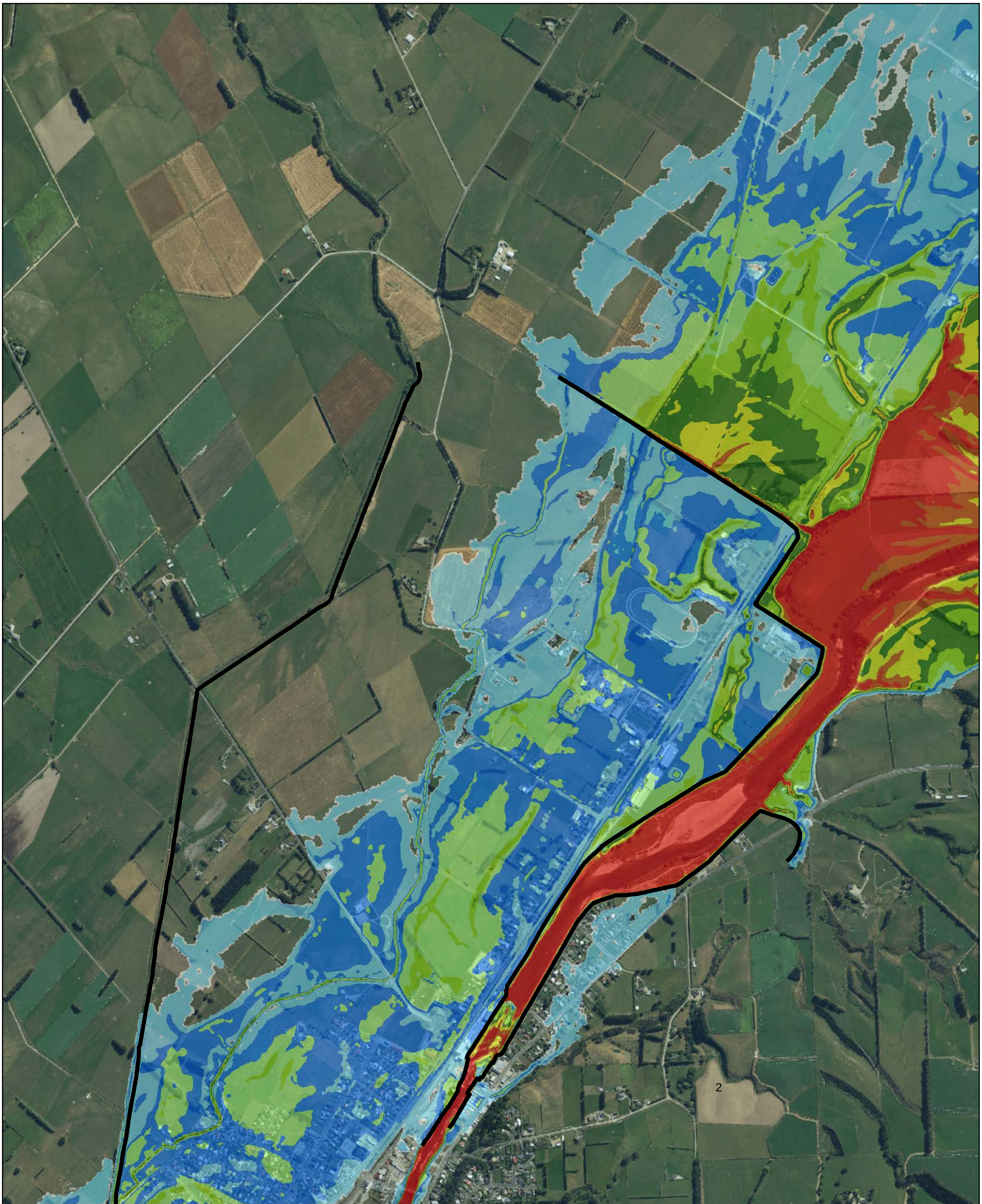

Legend

- Stopbanks

Depth (m)

- 0 - 0.01
- 0.01 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- 3 - 3.5
- 3.5 +

Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 125 250 500 Meters

A3 SCALE **1:13,000**

MAP (2 of 3)

PROJECT
Mataura River Modelling

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1% AEP Flow, Historic Climate

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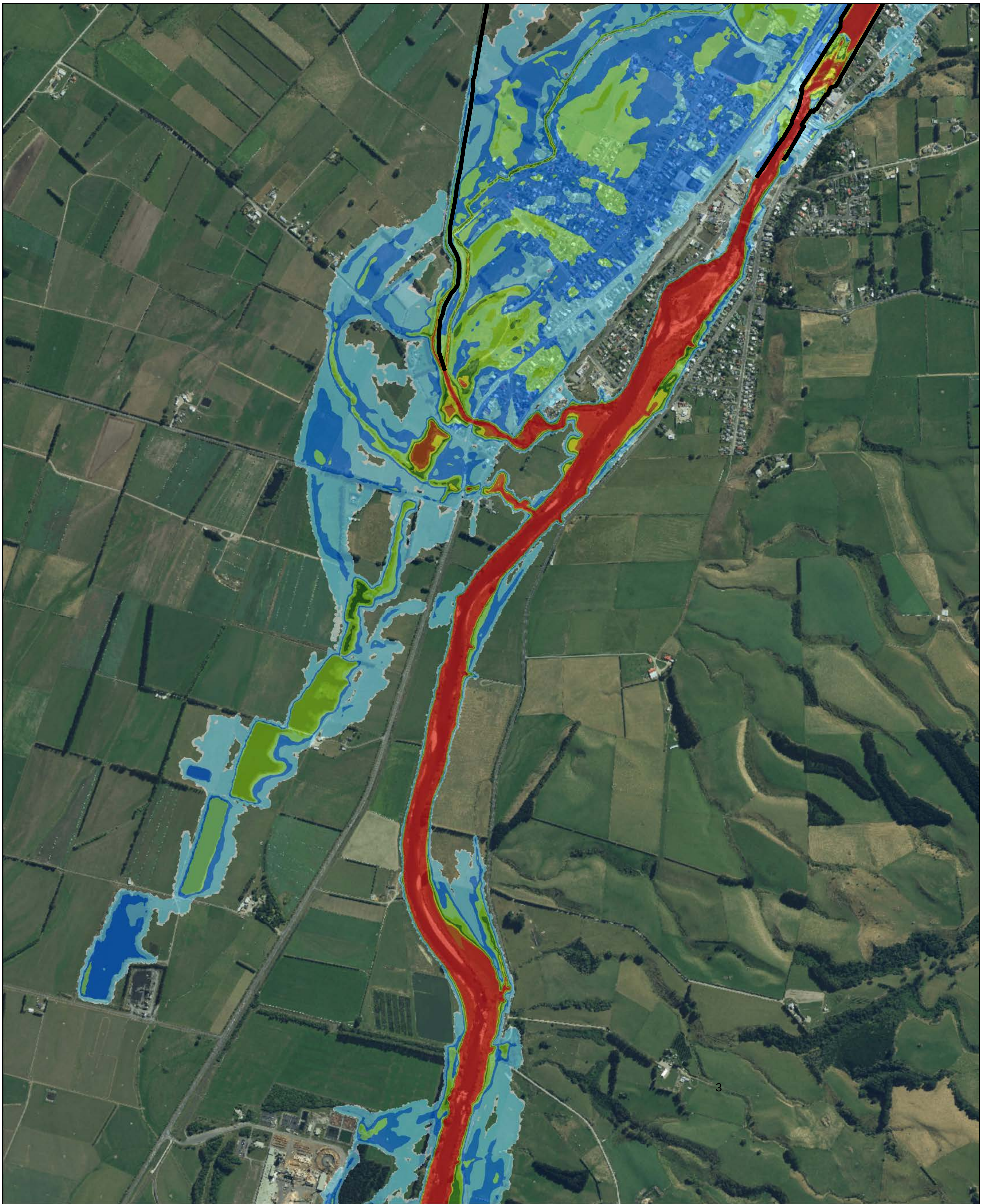

Legend

Stopbanks

Depth (m)

- 0 - 0.01
- 0.01 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- 3 - 3.5
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Land River Sea
CONSULTING

environment SOUTHLAND
REGIONAL COUNCIL
Te Taiao Tonga

0 125 250 500
Meters

A3 SCALE **1:13,000**

MAP (3 of 3)

PROJECT
Mataura River Modelling

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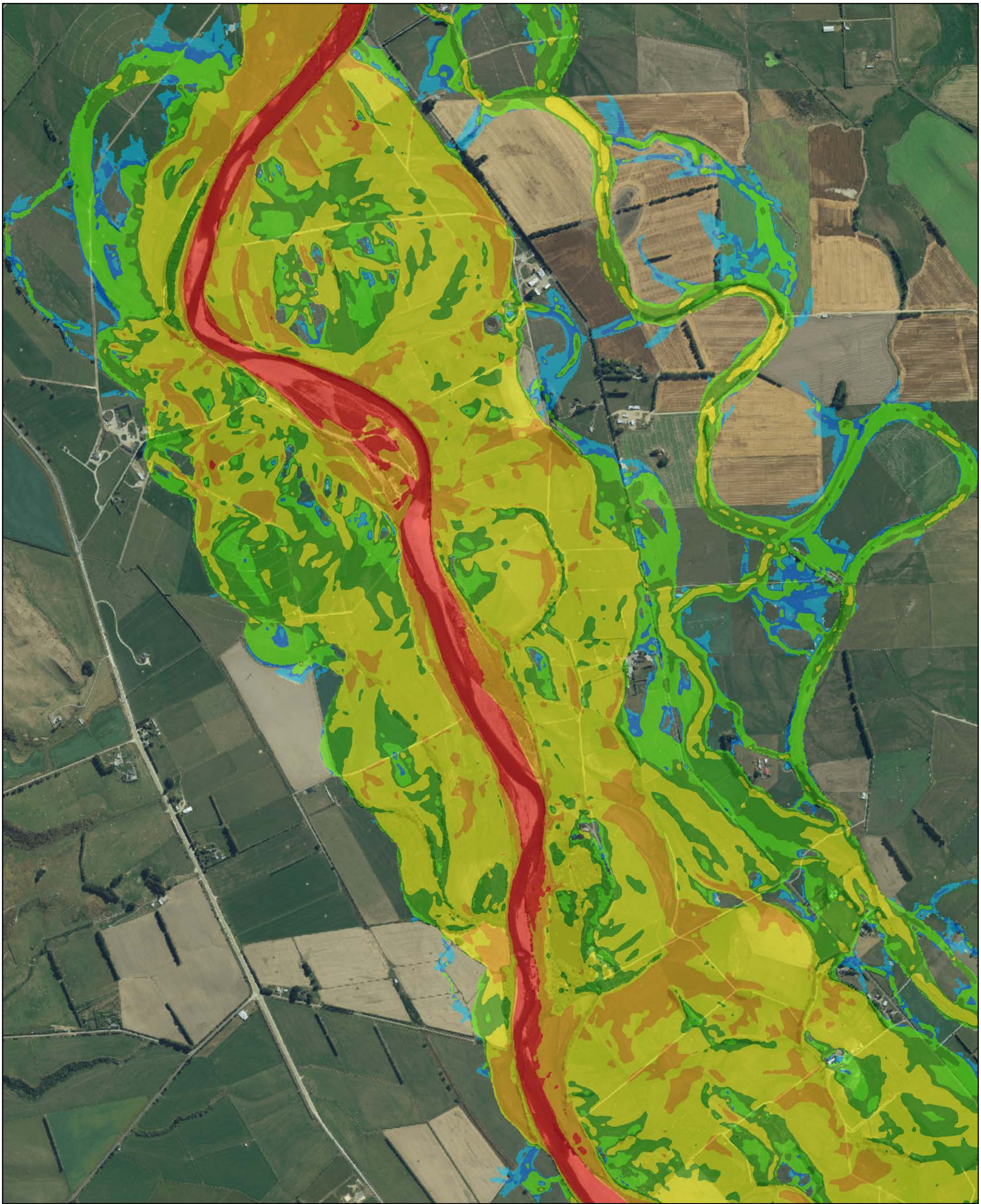


Legend

Stopbanks

Speed (m/s)

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

Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 125 250 500
Meters

A3 SCALE **1:13,000**

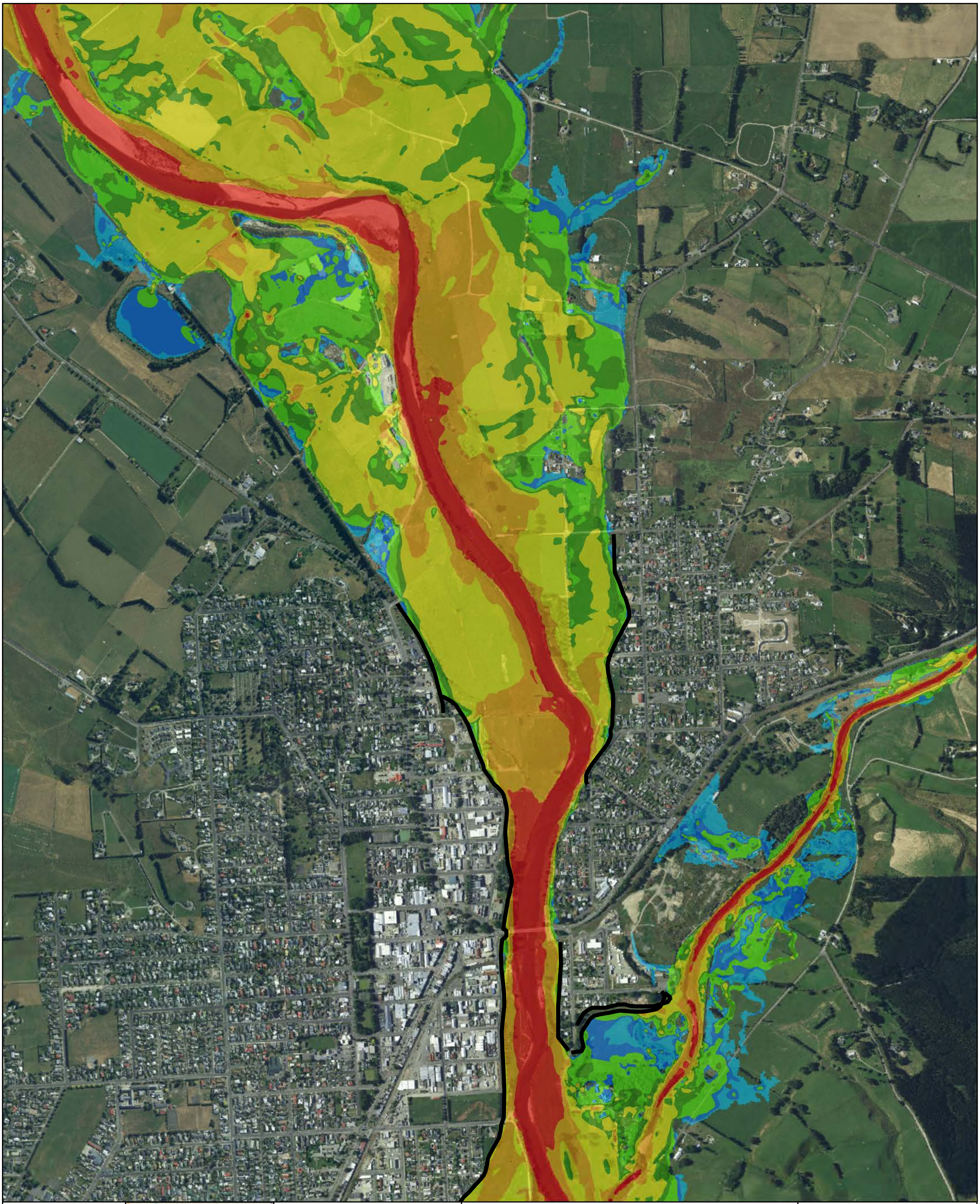
MAP (1 of 3)

PROJECT
Mataura River Modelling

MAP TITLE
PEAK SPEED MAP
Gore
2% AEP Flow, Historic Climate

REVISION	01	Created By	SP	Reviewed By	MG	N
AUTHOR	Matthew Gardner		DATE	17/06/2024		

Model Information
Coordinate System: New Zealand Transverse Mercator
Vertical Datum: NZVD2016
Model Completed: October 2023



Legend

Stopbanks

Speed (m/s)

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

Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 125 250 500 Meters

A3 SCALE 1:13,000

MAP (2 of 3)

PROJECT
Mataura River Modelling

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PEAK SPEED MAP
Gore
2% AEP Flow, Historic Climate

REVISION	01	Created By	SP	Reviewed By	MG	N
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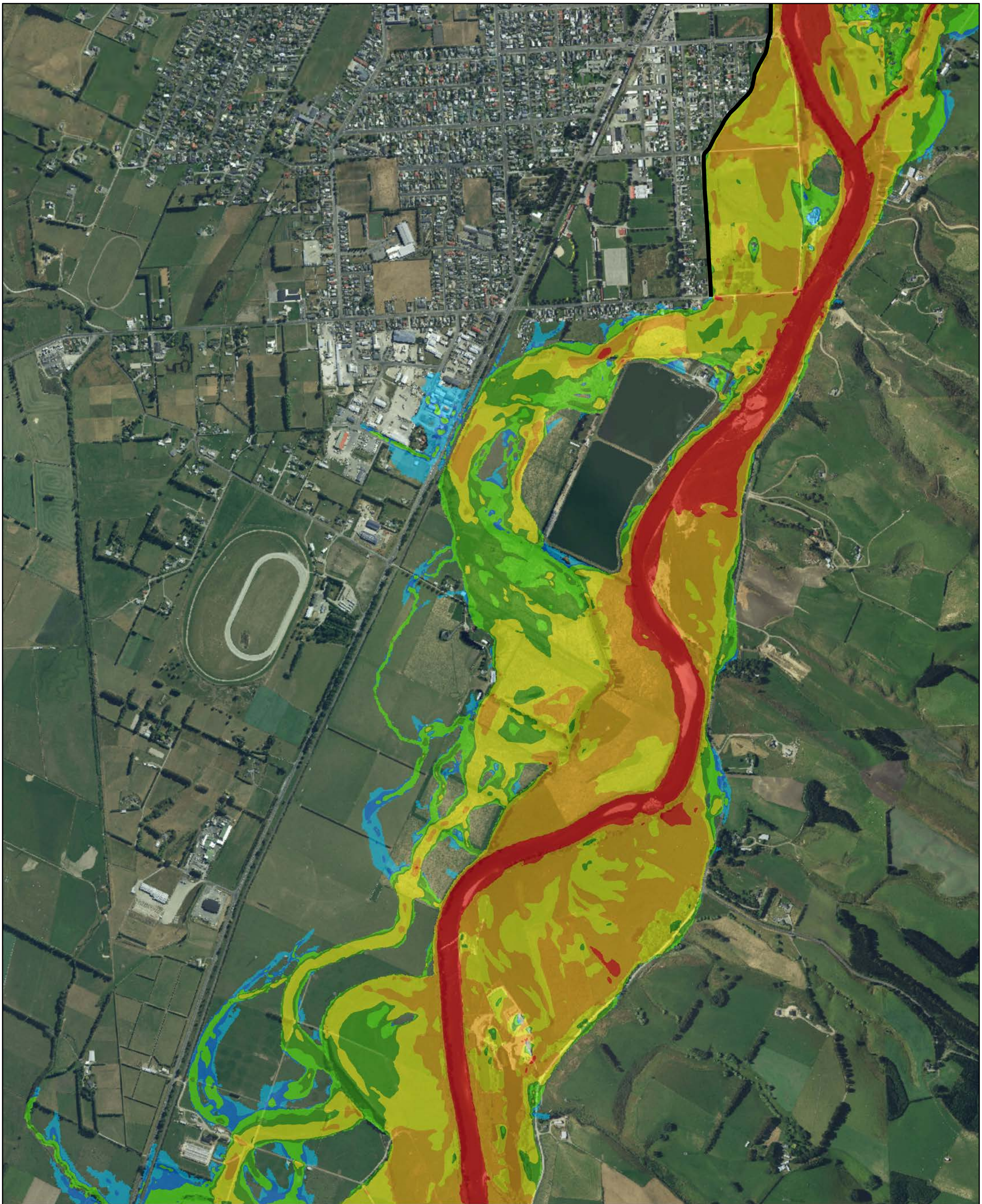

Legend

Stopbanks

Speed (m/s)

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

Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 125 250 500 Meters

A3 SCALE **1:13,000**

MAP (3 of 3)

PROJECT
Mataura River Modelling

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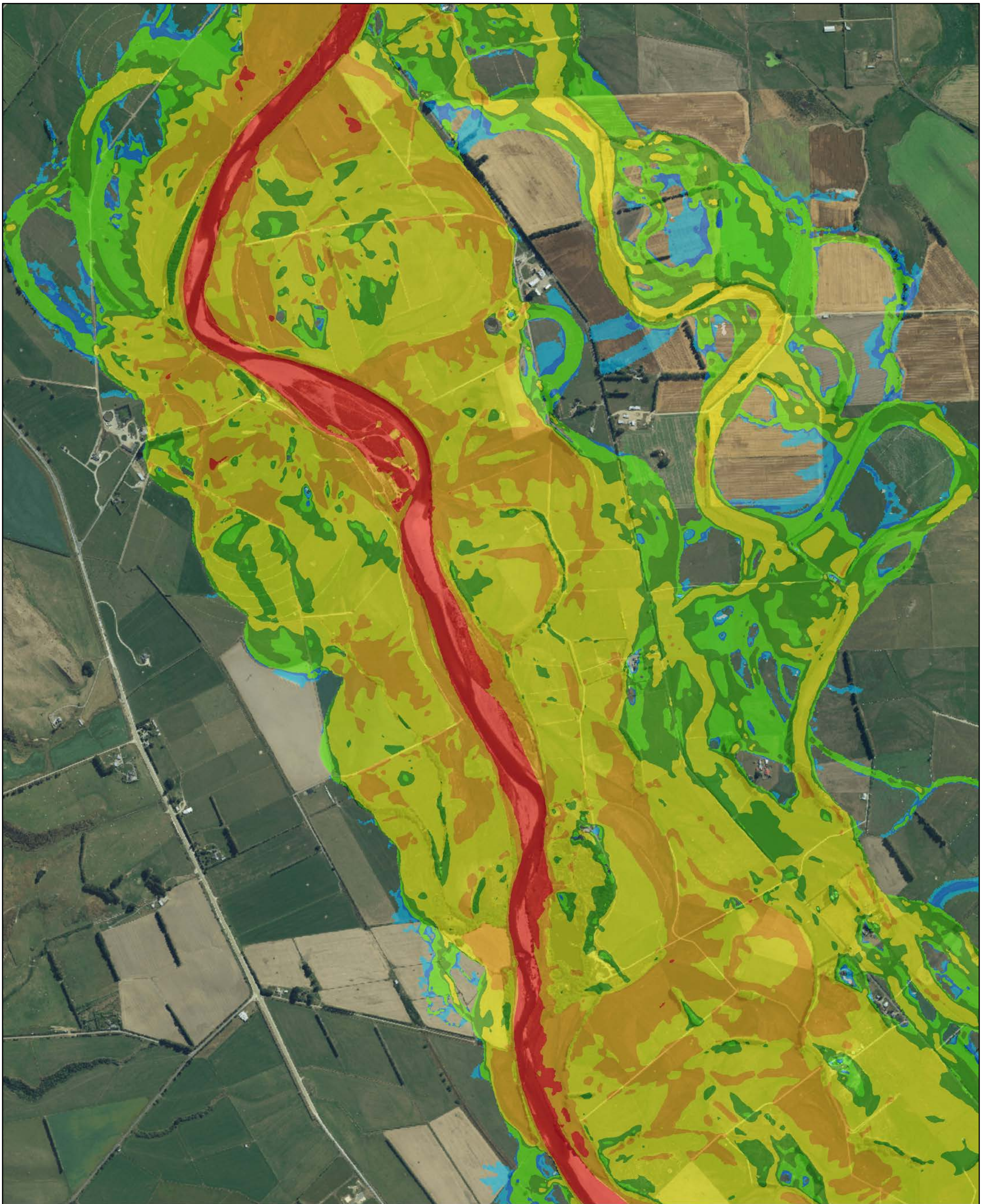
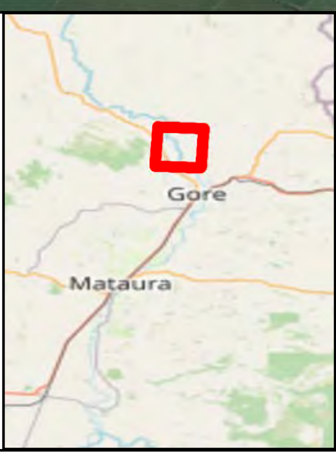


Legend

▬ Stopbanks

Speed (m/s)

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



Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 125 250 500
Meters

A3 SCALE **1:13,000**

MAP (1 of 3)

PROJECT
Mataura River Modelling

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PEAK SPEED MAP
Gore
1% AEP Flow, Historic Climate

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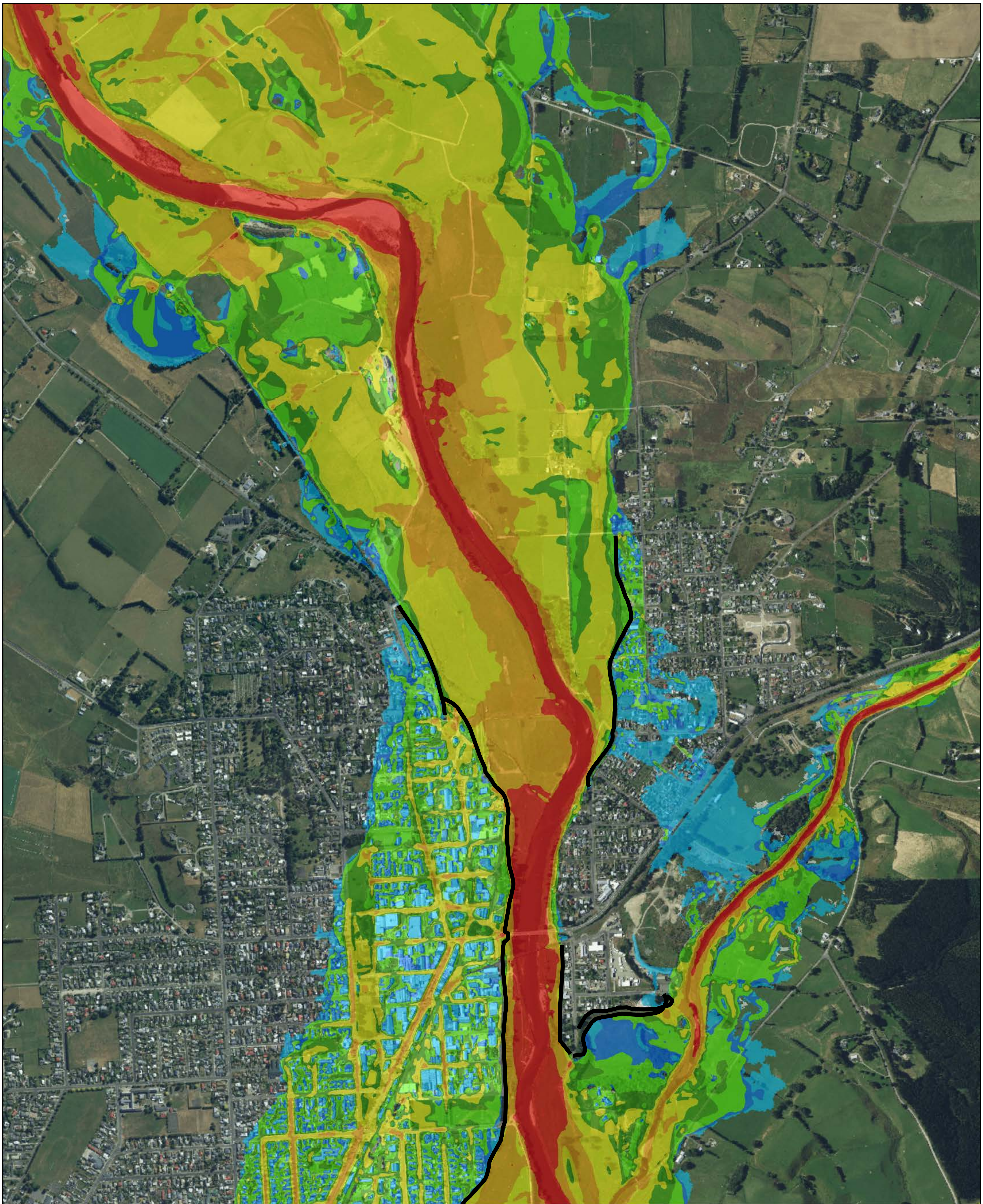

Legend

Stopbanks

Speed (m/s)

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

Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 125 250 500
Meters

A3 SCALE **1:13,000**

MAP (2 of 3)

PROJECT
Mataura River Modelling

MAP TITLE
PEAK SPEED MAP
Gore
1% AEP Flow, Historic Climate

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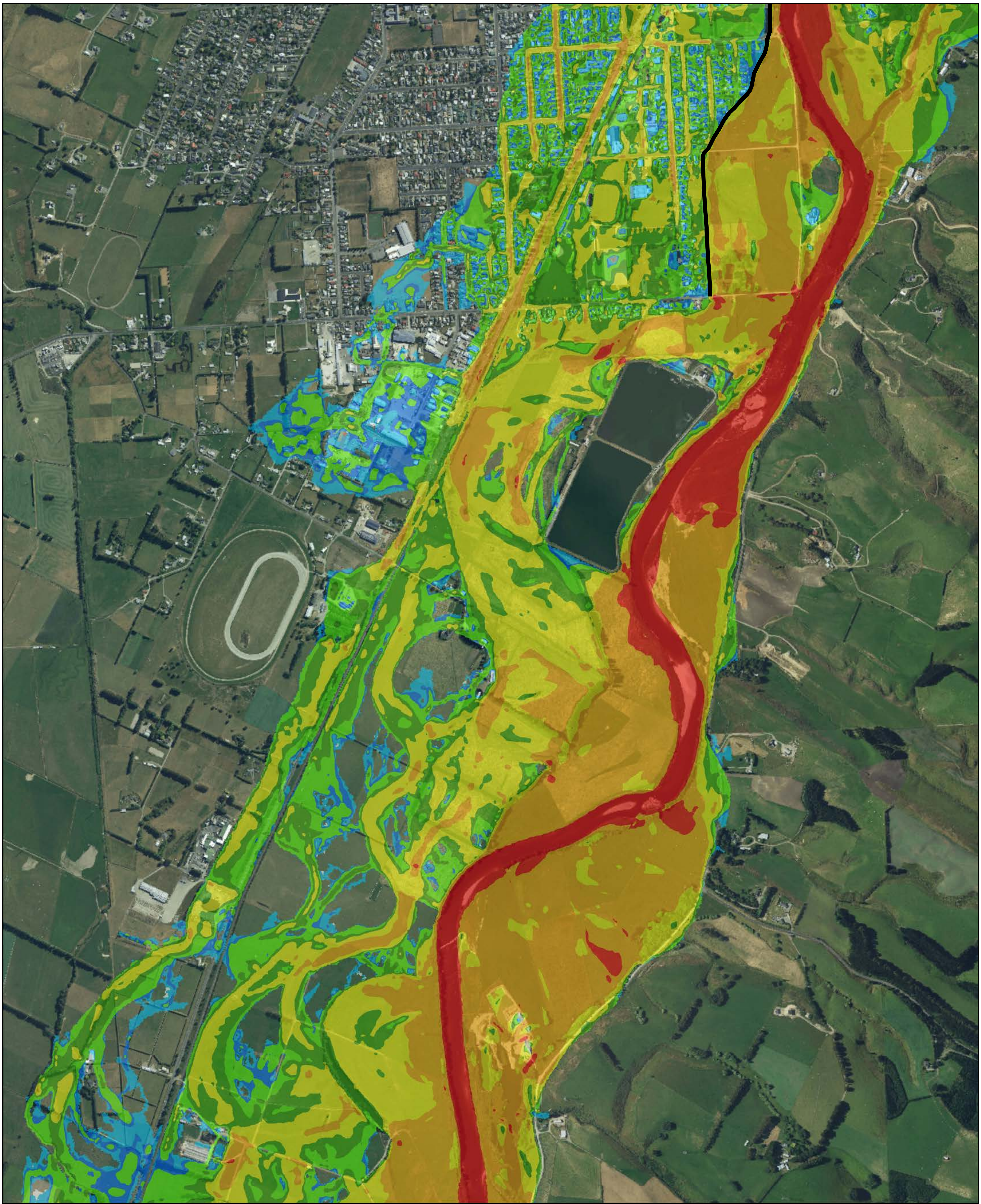

Legend

Stopbanks

Speed (m/s)

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

Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 125 250 500 Meters

A3 SCALE **1:13,000**

MAP (3 of 3)

PROJECT
Mataura River Modelling

MAP TITLE
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1% AEP Flow, Historic Climate

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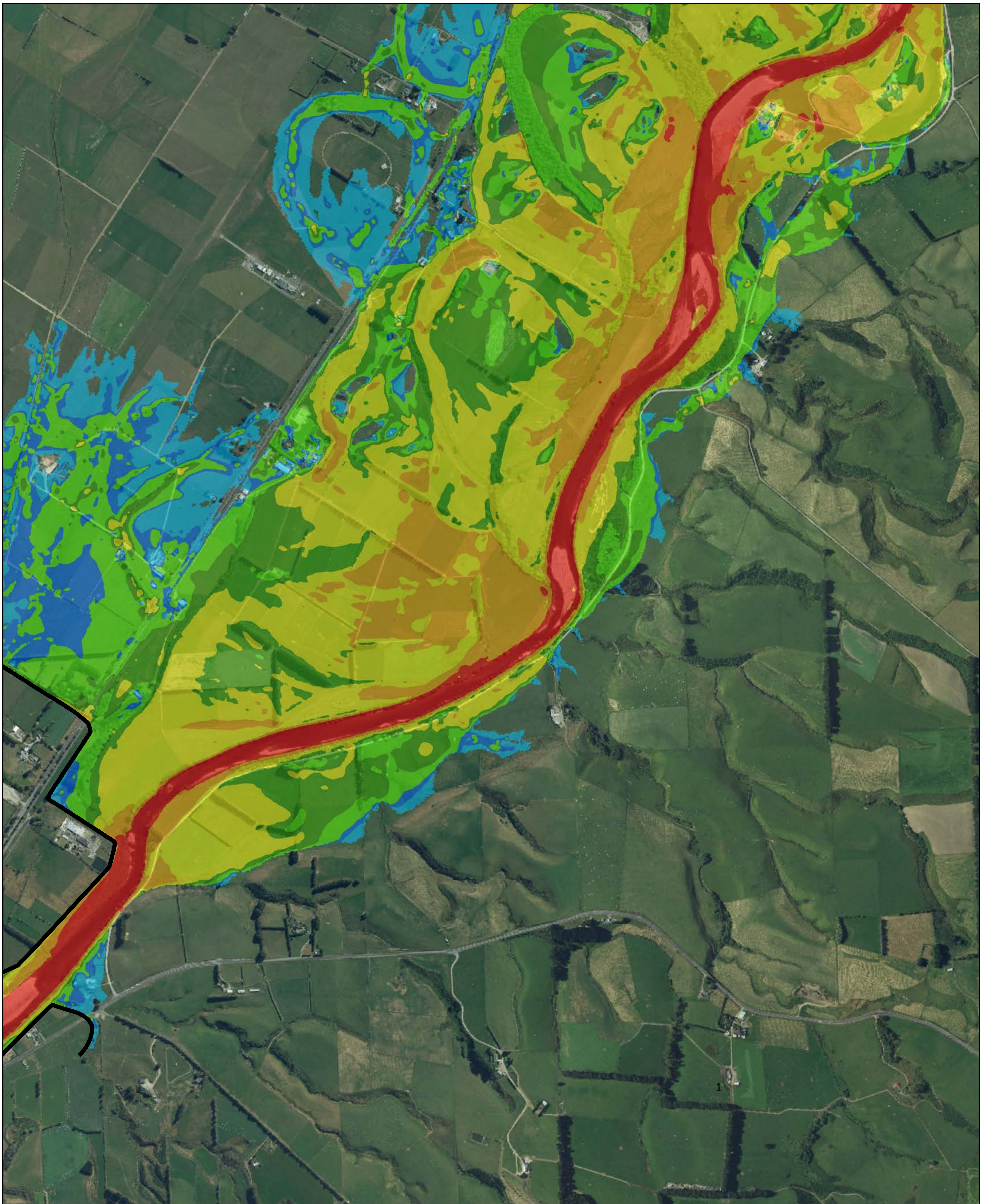


Legend

Stopbanks

Speed (m/s)

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

Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 125 250 500 Meters

A3 SCALE **1:13,000**

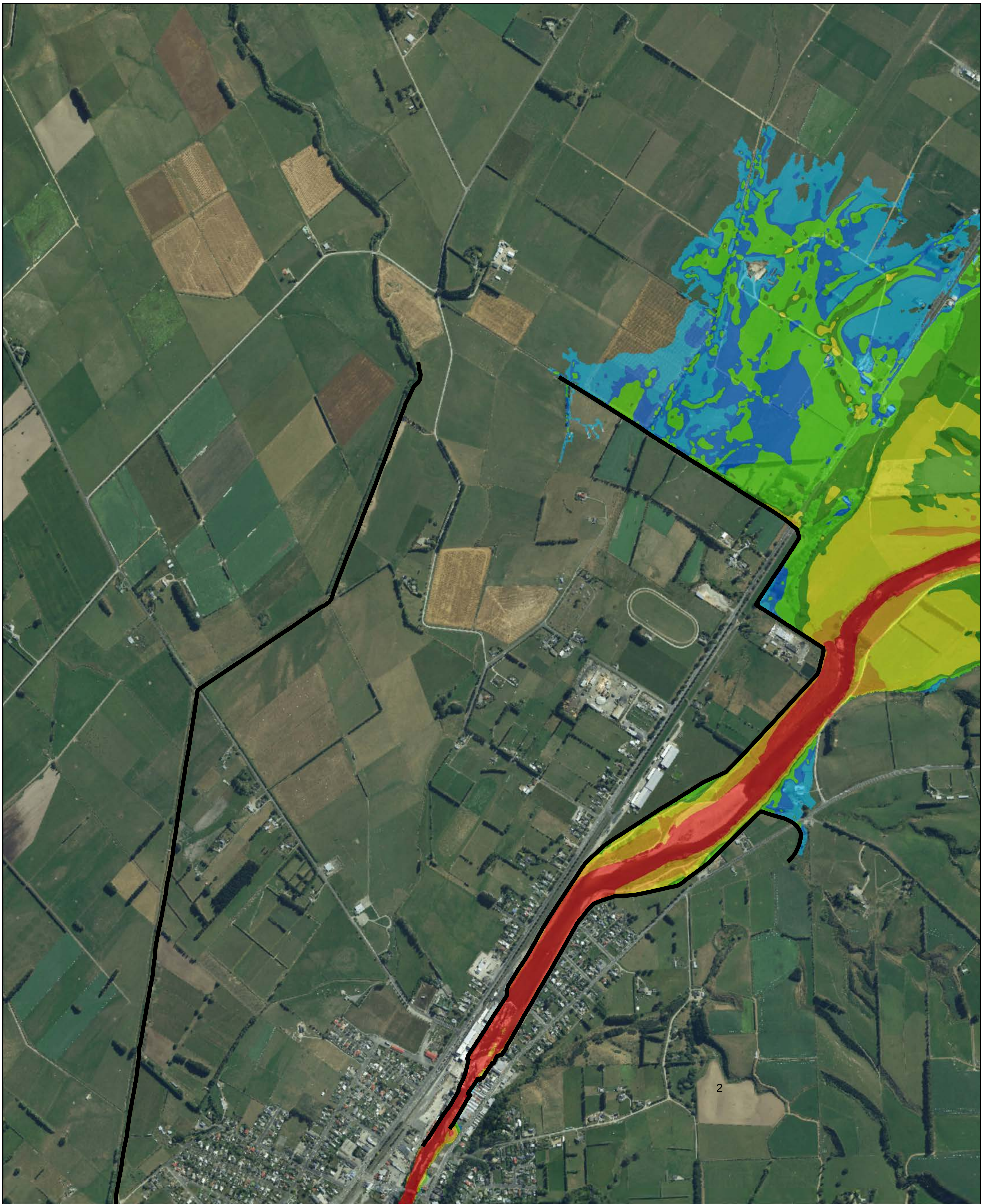
MAP (1 of 3)

PROJECT
Mataura River Modelling

MAP TITLE
PEAK SPEED MAP
Mataura
2% AEP Flow, Historic Climate

REVISION	01	Created By	SP	Reviewed By	MG	N
AUTHOR	Matthew Gardner		DATE	19/06/2024		

Model Information
Coordinate System: New Zealand Transverse Mercator
Vertical Datum: NZVD2016
Model Completed: October 2023



Legend

Stopbanks

Speed (m/s)

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

Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 125 250 500
Meters

A3 SCALE **1:13,000**

MAP (2 of 3)

PROJECT
Mataura River Modelling

MAP TITLE
PEAK SPEED MAP
Mataura
2% AEP Flow, Historic Climate

REVISION	01	Created By	SP	Reviewed By	MG	N
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- 0
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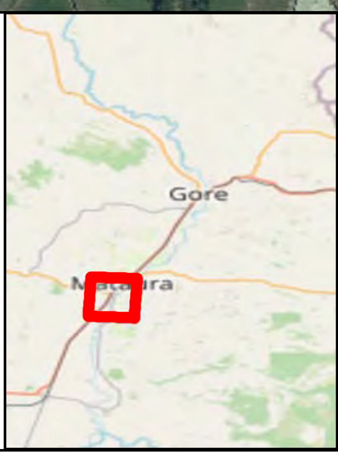

Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 125 250 500
Meters

A3 SCALE **1:13,000**

MAP (3 of 3)

PROJECT
Mataura River Modelling

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Mataura
2% AEP Flow, Historic Climate

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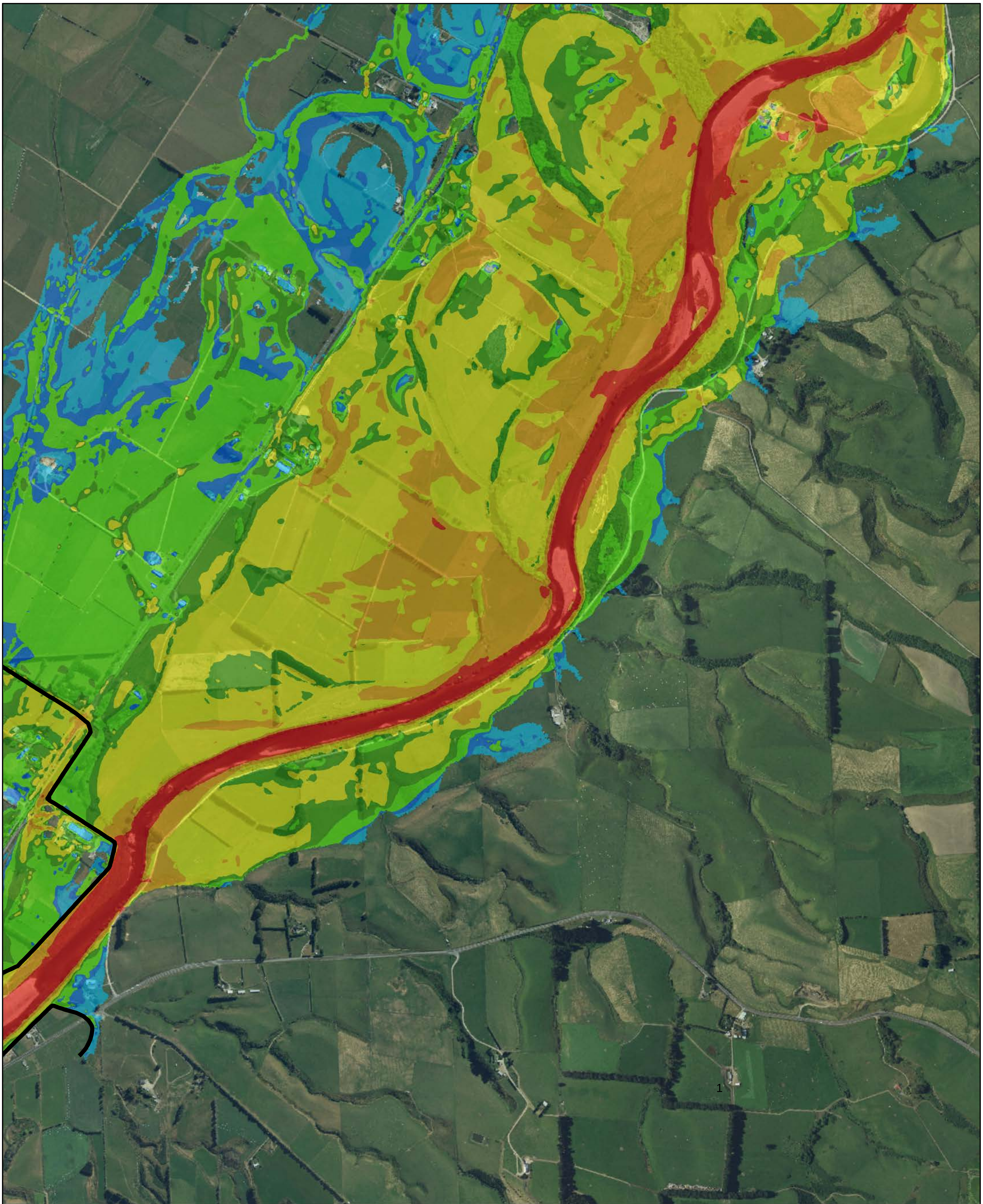

Legend

Stopbanks

Speed (m/s)

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

Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 125 250 500 Meters

A3 SCALE **1:13,000**

MAP (1 of 3)

PROJECT
Mataura River Modelling

MAP TITLE
PEAK SPEED MAP
Mataura
1% AEP Flow, Historic Climate

REVISION	01	Created By	SP	Reviewed By	MG	N
AUTHOR	**Matthew Gardner**	DATE	**19/06/2024**			

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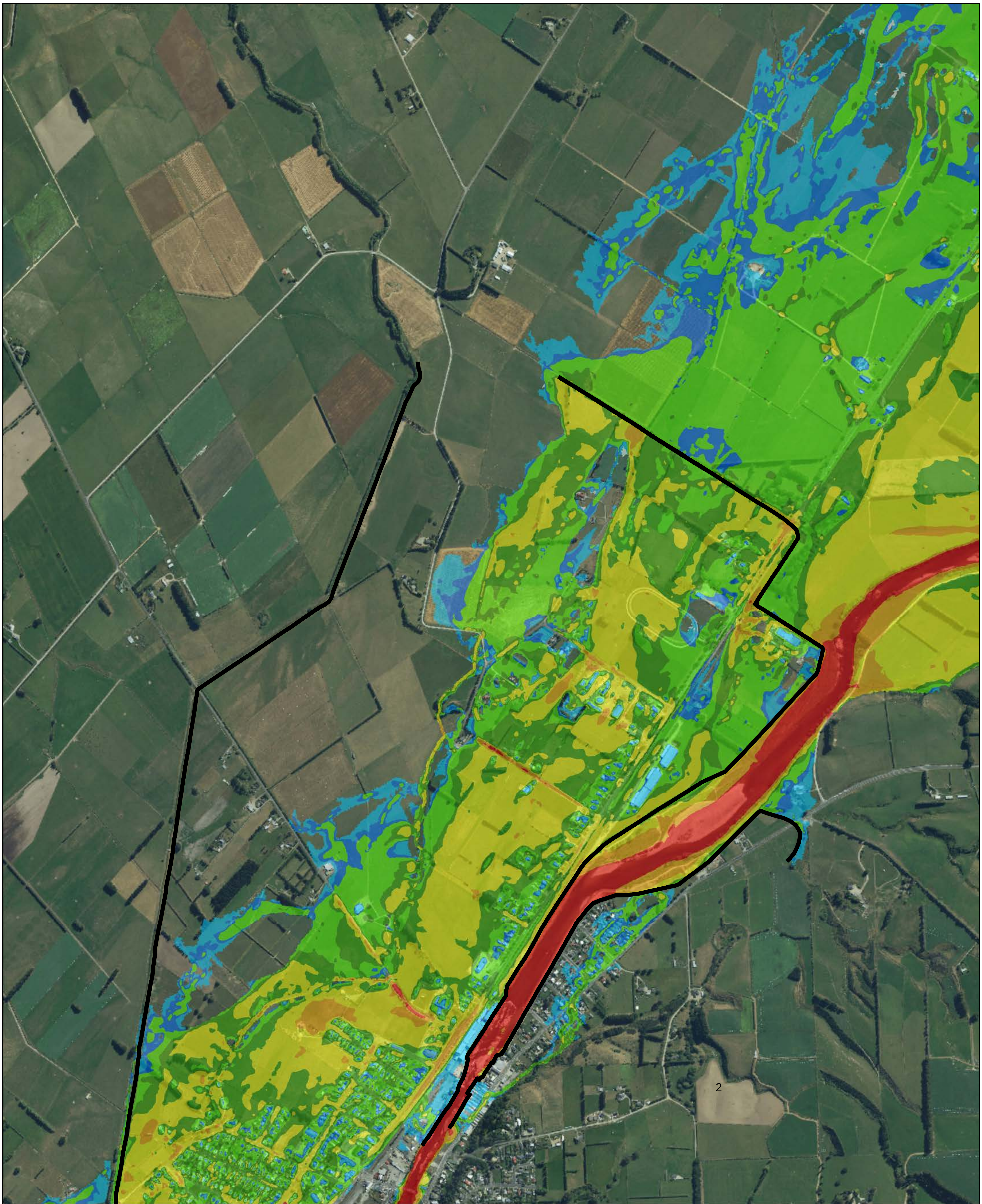

Legend

Stopbanks

Speed (m/s)

- 0
- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- 0.5 - 1
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Land River Sea CONSULTING

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0 125 250 500
Meters

A3 SCALE **1:13,000**

MAP (2 of 3)

PROJECT
Mataura River Modelling

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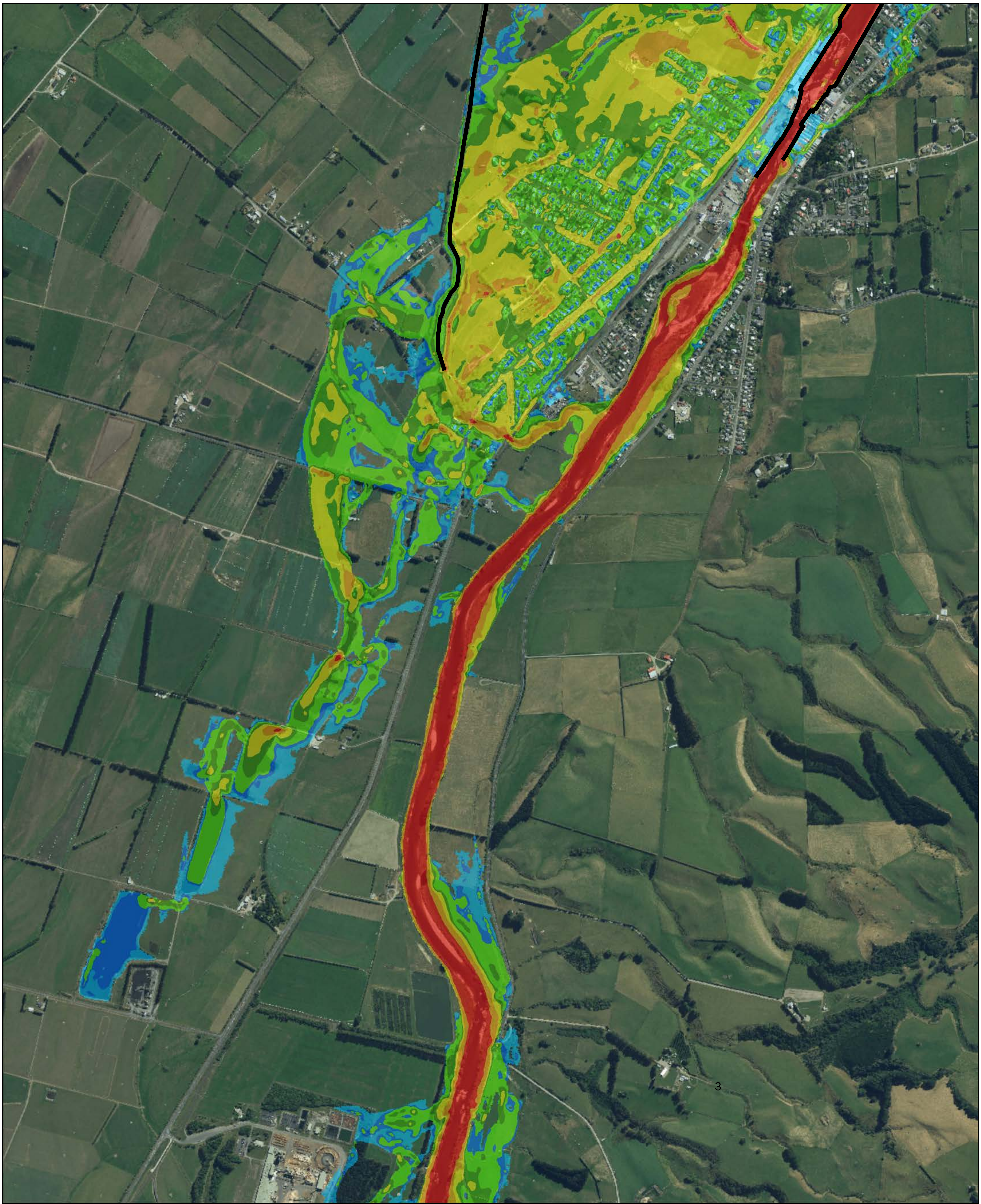

Legend

Stopbanks

Speed (m/s)

- 0
- 0 - 0.05
- 0.05 - 0.1
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Land River Sea CONSULTING

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MAP (3 of 3)

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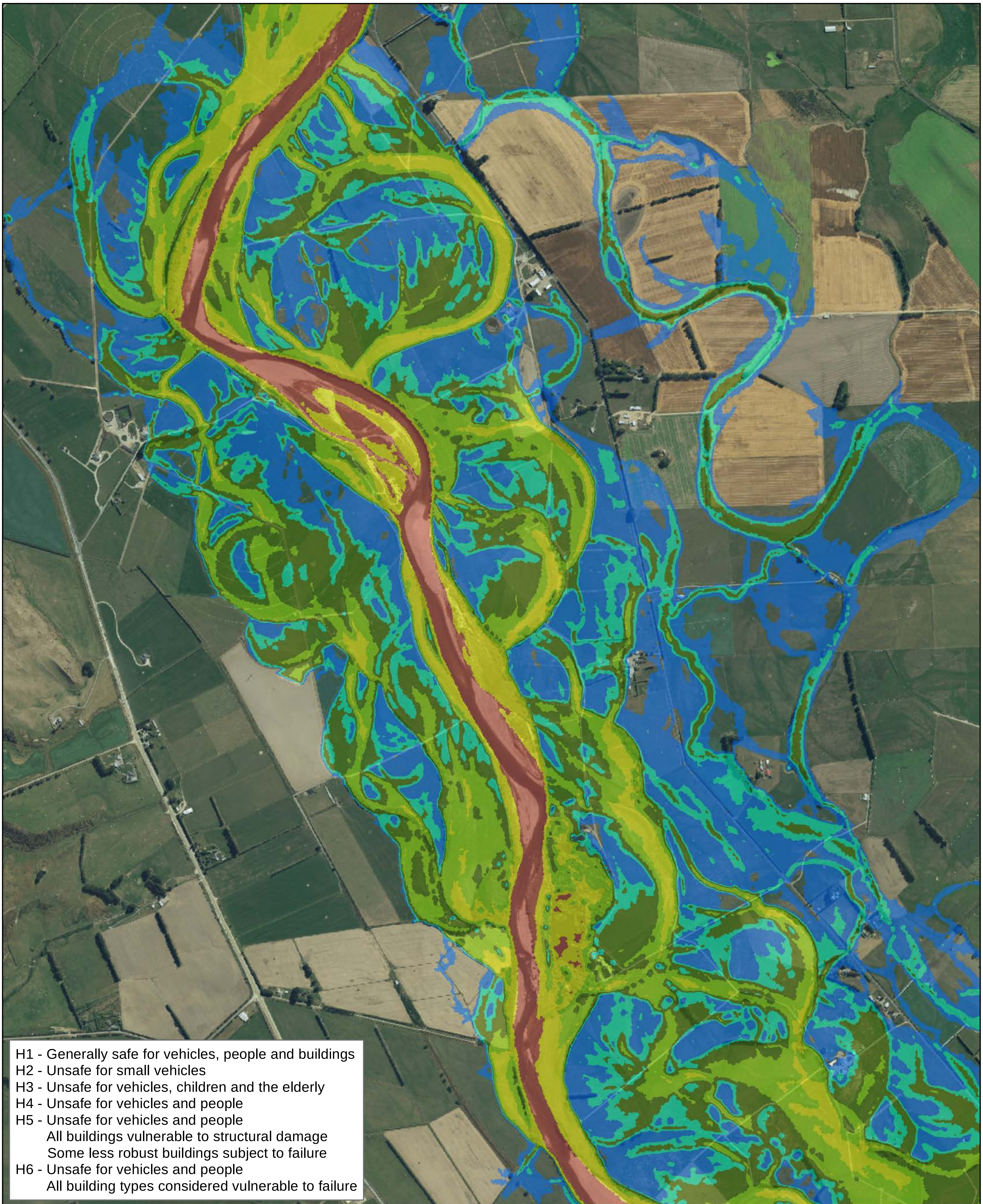
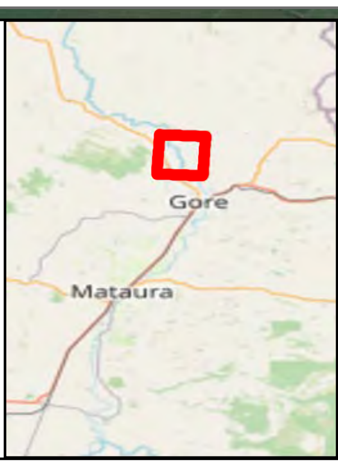


Legend

Stopbanks

Hazard Category

- H6
- H5
- H4
- H3
- H2
- H1



Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 125 250 500 Meters

A3 SCALE **1:13,000**

MAP (1 of 3)

PROJECT
Mataura River Modelling

MAP TITLE
PEAK HAZARD MAP
Gore
2% AEP Flow, Historic Climate

REVISION	01	Created By	SP	Reviewed By	MG	N
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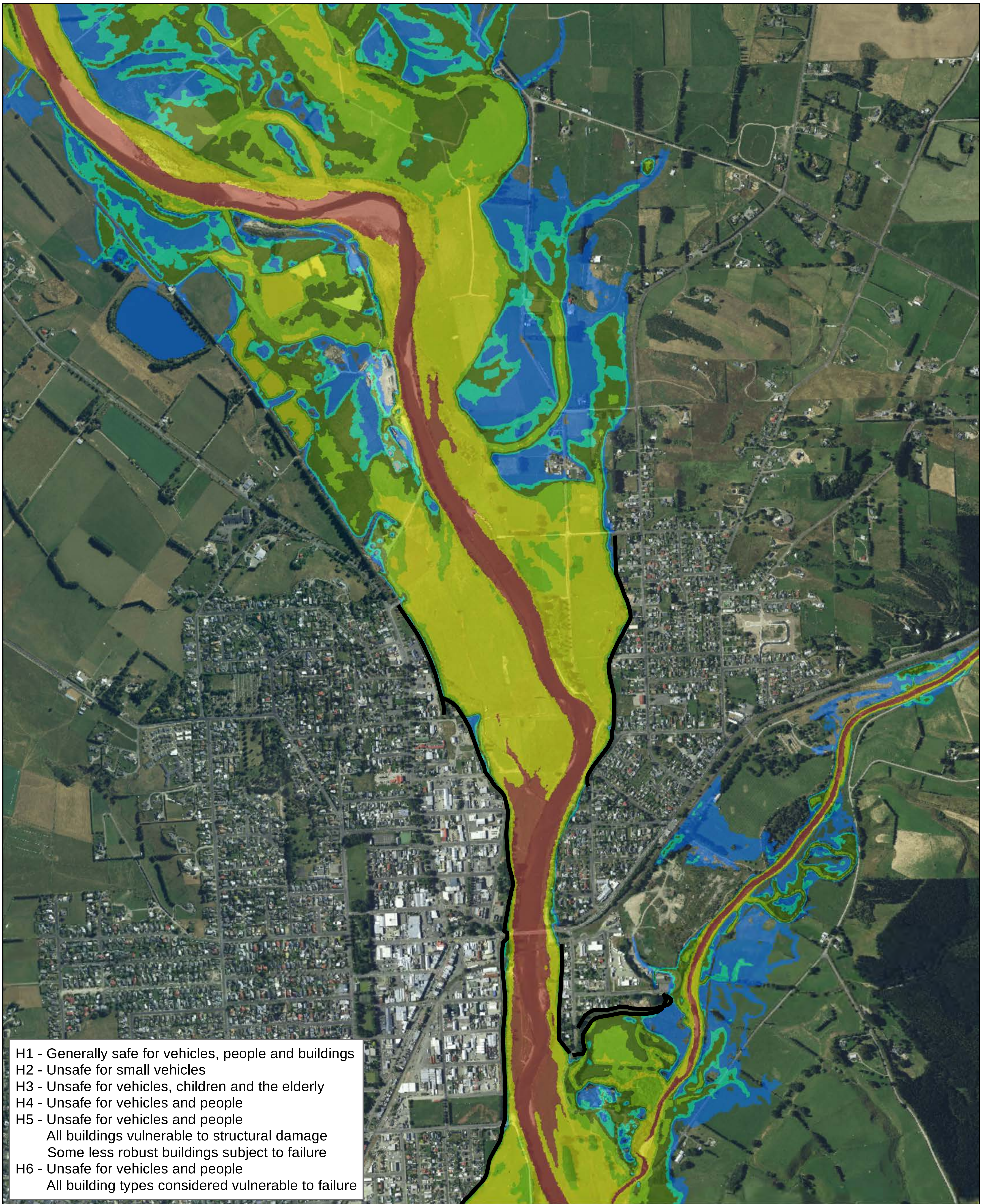

Legend

Stopbanks

Hazard Category

- H6
- H5
- H4
- H3
- H2
- H1

Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 125 250 500 Meters

A3 SCALE **1:13,000**

MAP (2 of 3)

PROJECT
Mataura River Modelling

MAP TITLE
PEAK HAZARD MAP
Gore
2% AEP Flow, Historic Climate

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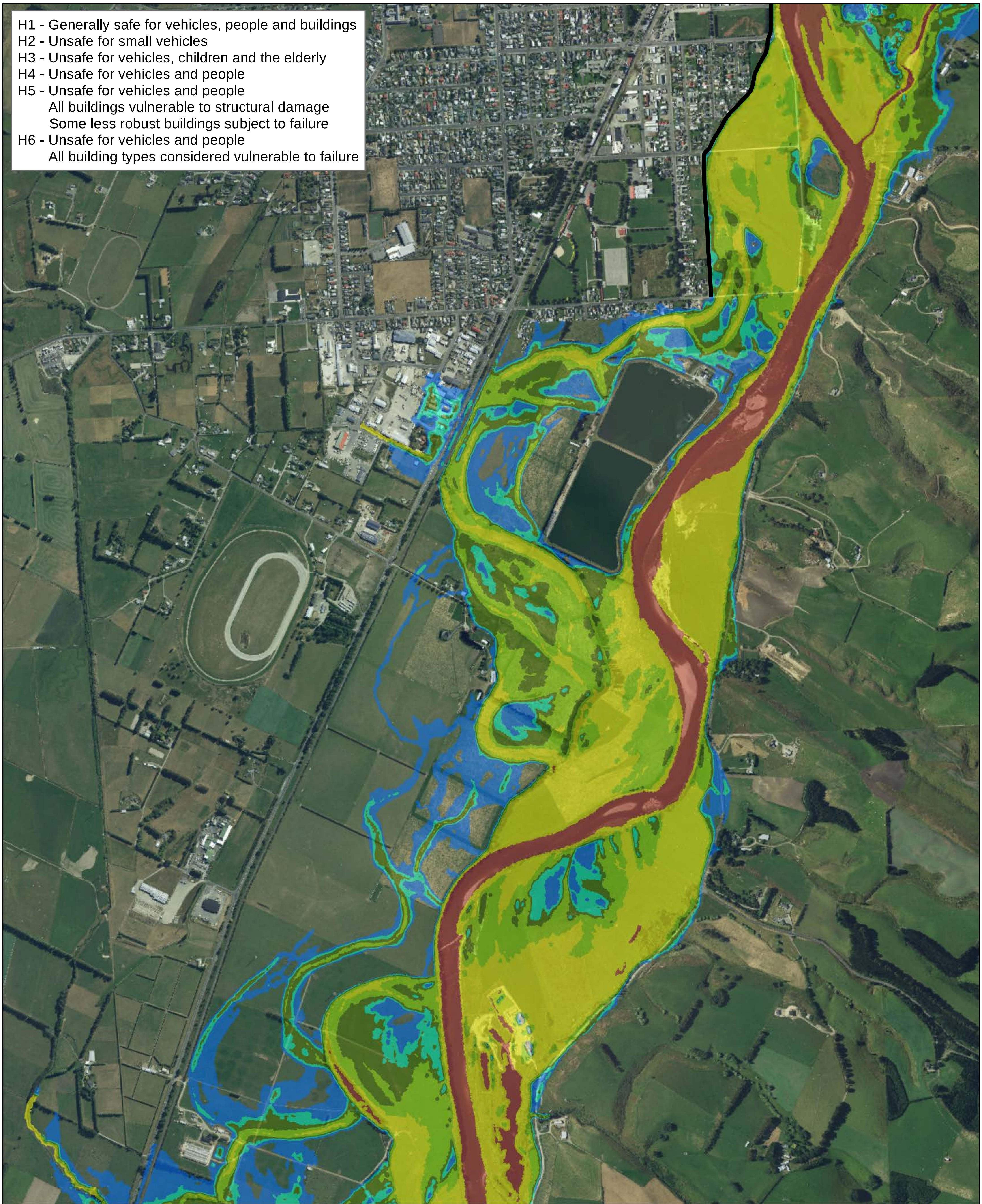

Legend

Stopbanks

Hazard Category

- H6
- H5
- H4
- H3
- H2
- H1

Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 125 250 500 Meters

A3 SCALE **1:13,000**

MAP (3 of 3)

PROJECT
Mataura River Modelling

MAP TITLE
PEAK HAZARD MAP
Gore
2% AEP Flow, Historic Climate

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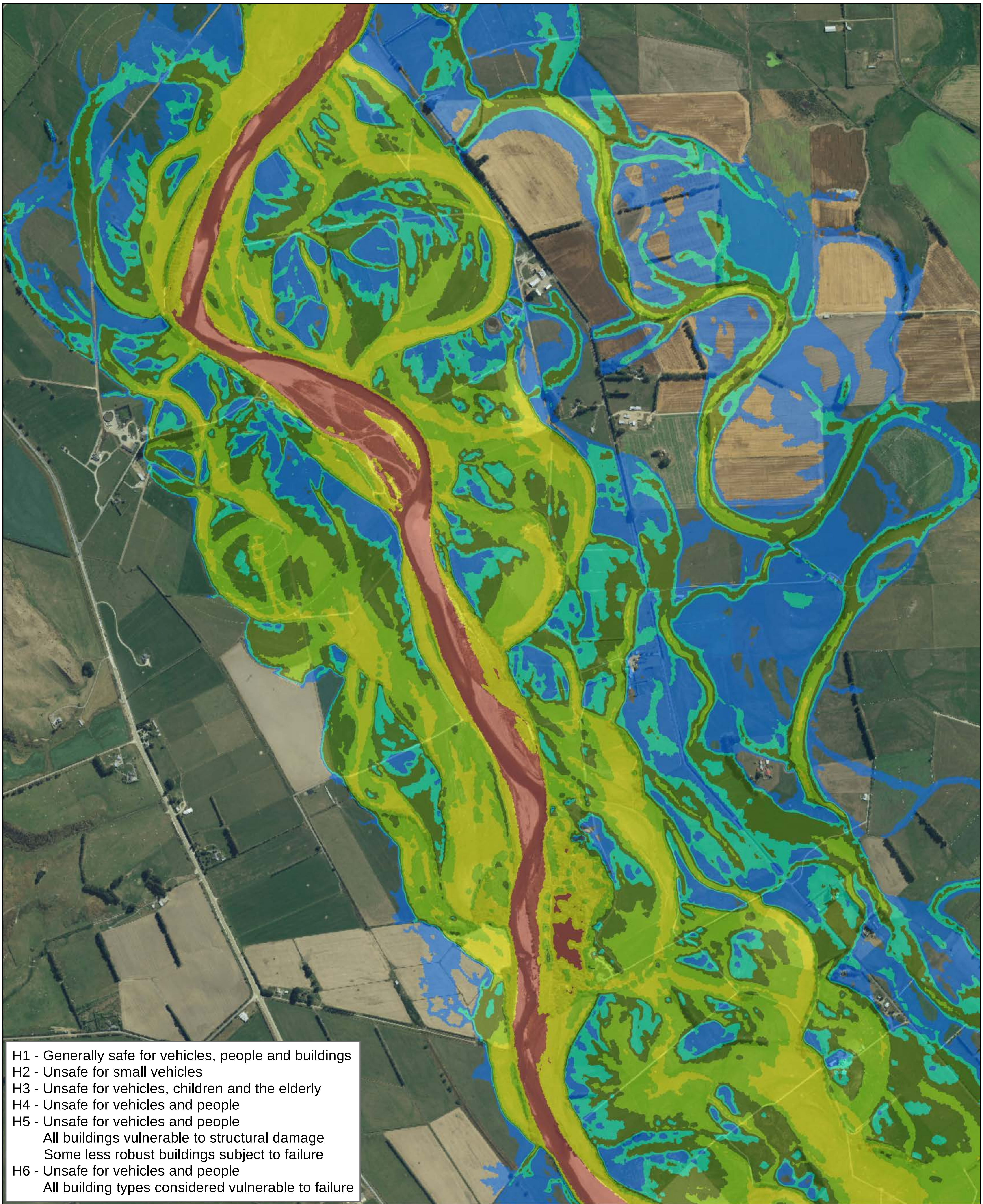
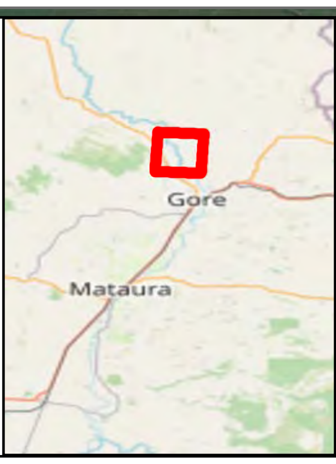


Legend

Stopbanks

Hazard Category

- H6
- H5
- H4
- H3
- H2
- H1



Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 125 250 500 Meters

A3 SCALE **1:13,000**

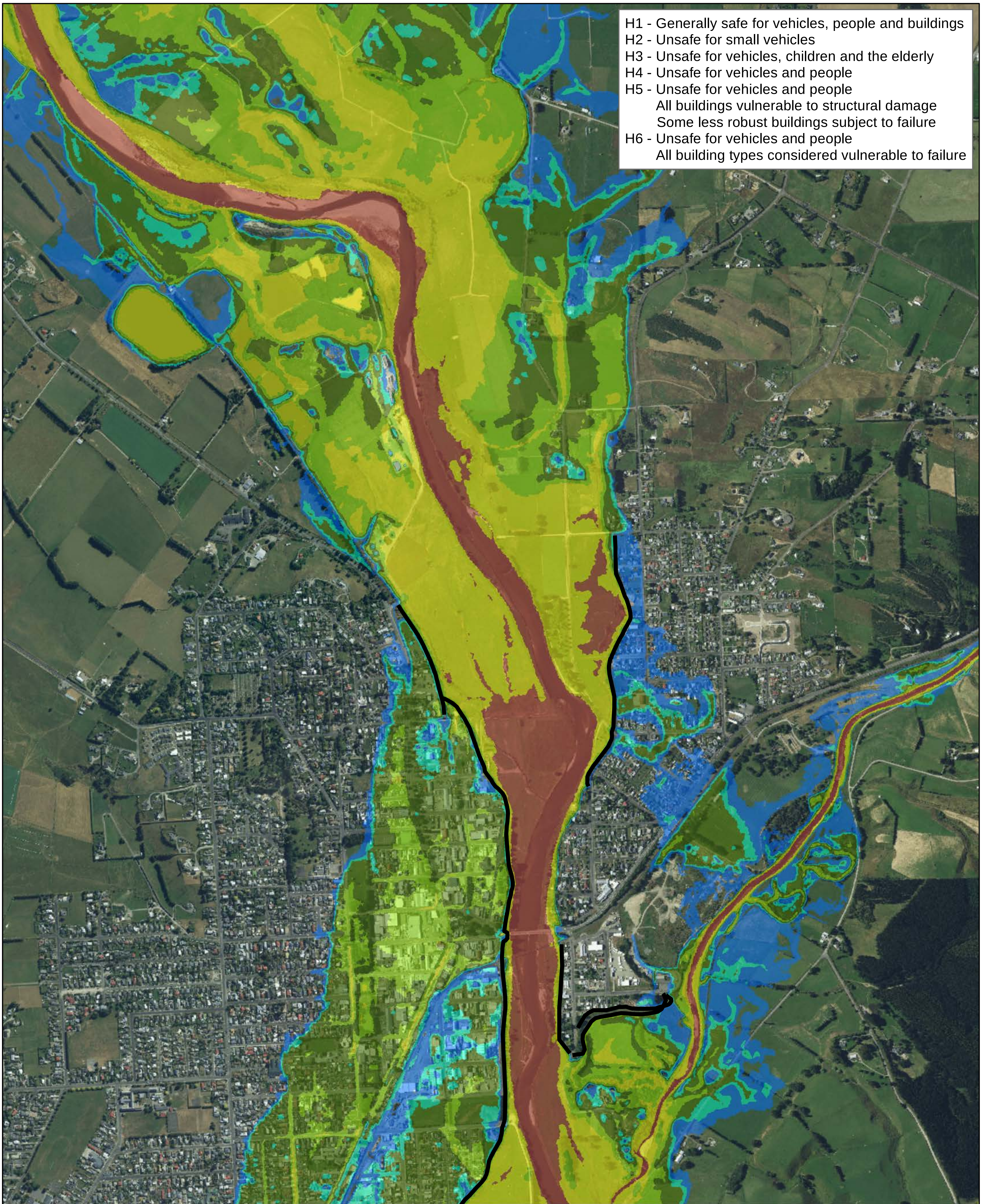
MAP (1 of 3)

PROJECT
Mataura River Modelling

MAP TITLE
PEAK HAZARD MAP
Gore
1% AEP Flow, Historic Climate

REVISION	01	Created By	SP	Reviewed By	MG	N
AUTHOR	Matthew Gardner		DATE	17/06/2024		

Model Information
Coordinate System: New Zealand Transverse Mercator
Vertical Datum: NZVD2016
Model Completed: October 2023

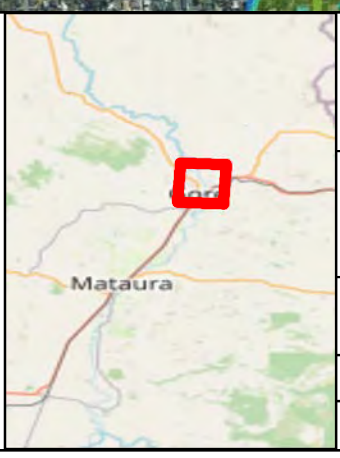


Legend

Stopbanks

Hazard Category

- H6
- H5
- H4
- H3
- H2
- H1



Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 125 250 500 Meters

A3 SCALE **1:13,000**

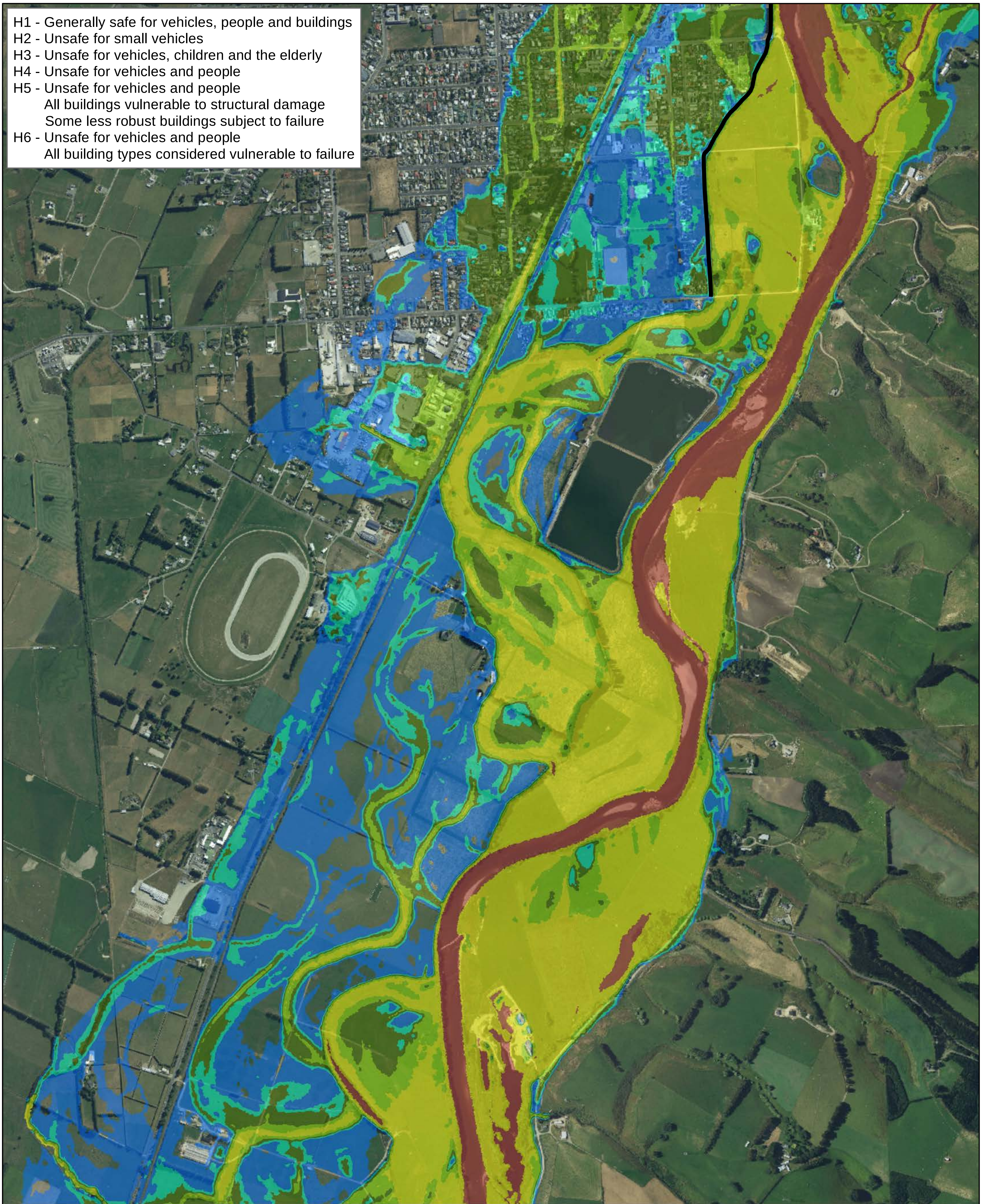
MAP (2 of 3)

PROJECT
Mataura River Modelling

MAP TITLE
PEAK HAZARD MAP
Gore
1% AEP Flow, Historic Climate

REVISION	01	Created By	SP	Reviewed By	MG	N
AUTHOR	Matthew Gardner		DATE	17/06/2024		

Model Information
Coordinate System: New Zealand Transverse Mercator
Vertical Datum: NZVD2016
Model Completed: October 2023



Legend

Stopbanks

Hazard Category

- H6
- H5
- H4
- H3
- H2
- H1

Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 125 250 500
Meters

A3 SCALE **1:13,000**

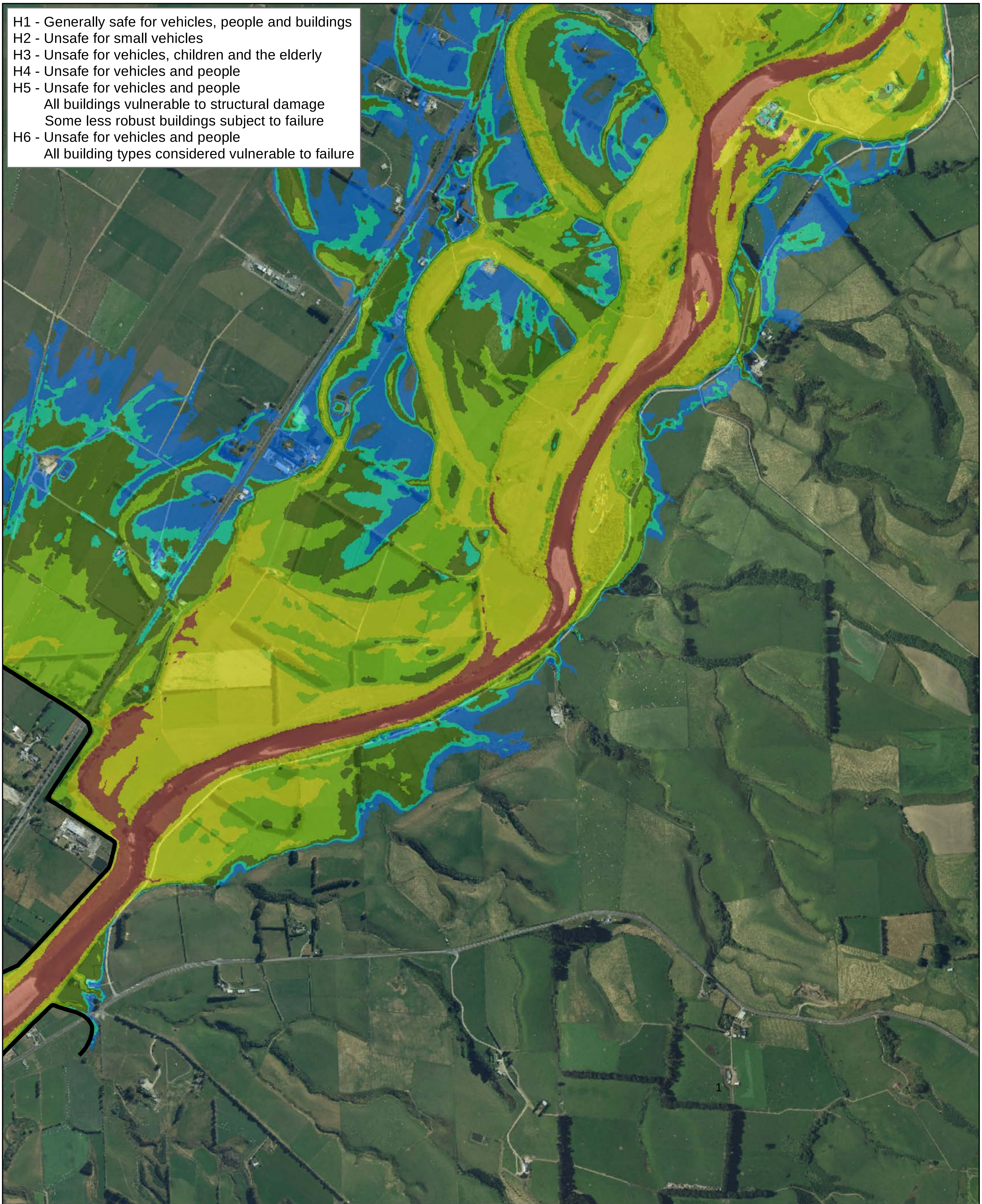
MAP (3 of 3)

PROJECT
Mataura River Modelling

MAP TITLE
PEAK HAZARD MAP
Gore
1% AEP Flow, Historic Climate

REVISION	01	Created By	SP	Reviewed By	MG	N
AUTHOR	**Matthew Gardner**		DATE	**17/06/2024**		

Model Information
Coordinate System: New Zealand Transverse Mercator
Vertical Datum: NZVD2016
Model Completed: October 2023



Legend

- Stopbanks

Hazard Category

- H6
- H5
- H4
- H3
- H2
- H1

Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 125 250 500 Meters

A3 SCALE **1:13,000**

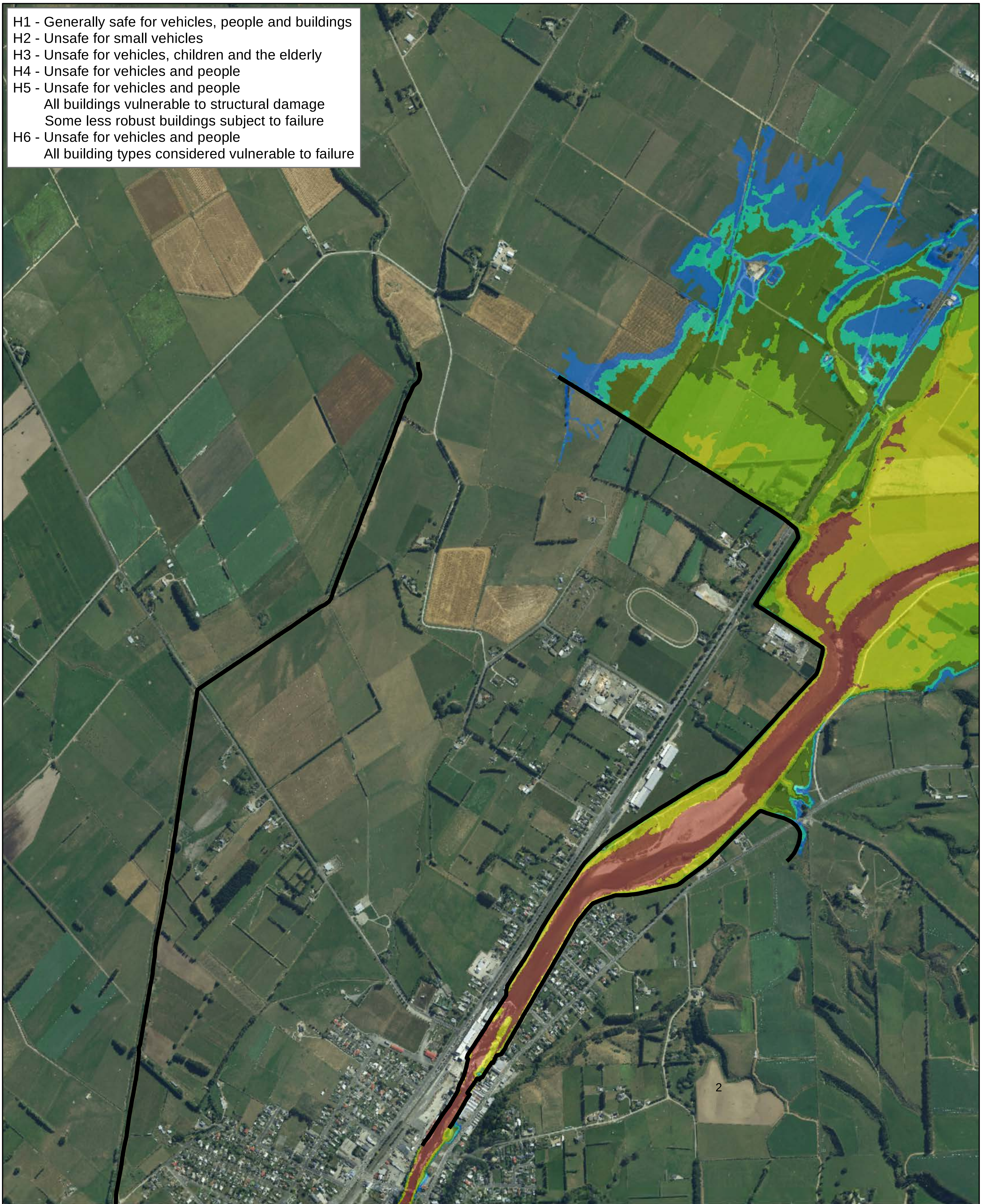
MAP (1 of 3)

PROJECT
Mataura River Modelling

MAP TITLE
PEAK HAZARD MAP
Mataura
2% AEP Flow, Historic Climate

REVISION	**01**	Created By	**SP**	Reviewed By	**MG**	N
AUTHOR	**Matthew Gardner**	DATE	**19/06/2024**			

Model Information
Coordinate System: New Zealand Transverse Mercator
Vertical Datum: NZVD2016
Model Completed: October 2023



Legend

Stopbanks

Hazard Category

- H6
- H5
- H4
- H3
- H2
- H1

Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 125 250 500 Meters

A3 SCALE **1:13,000**

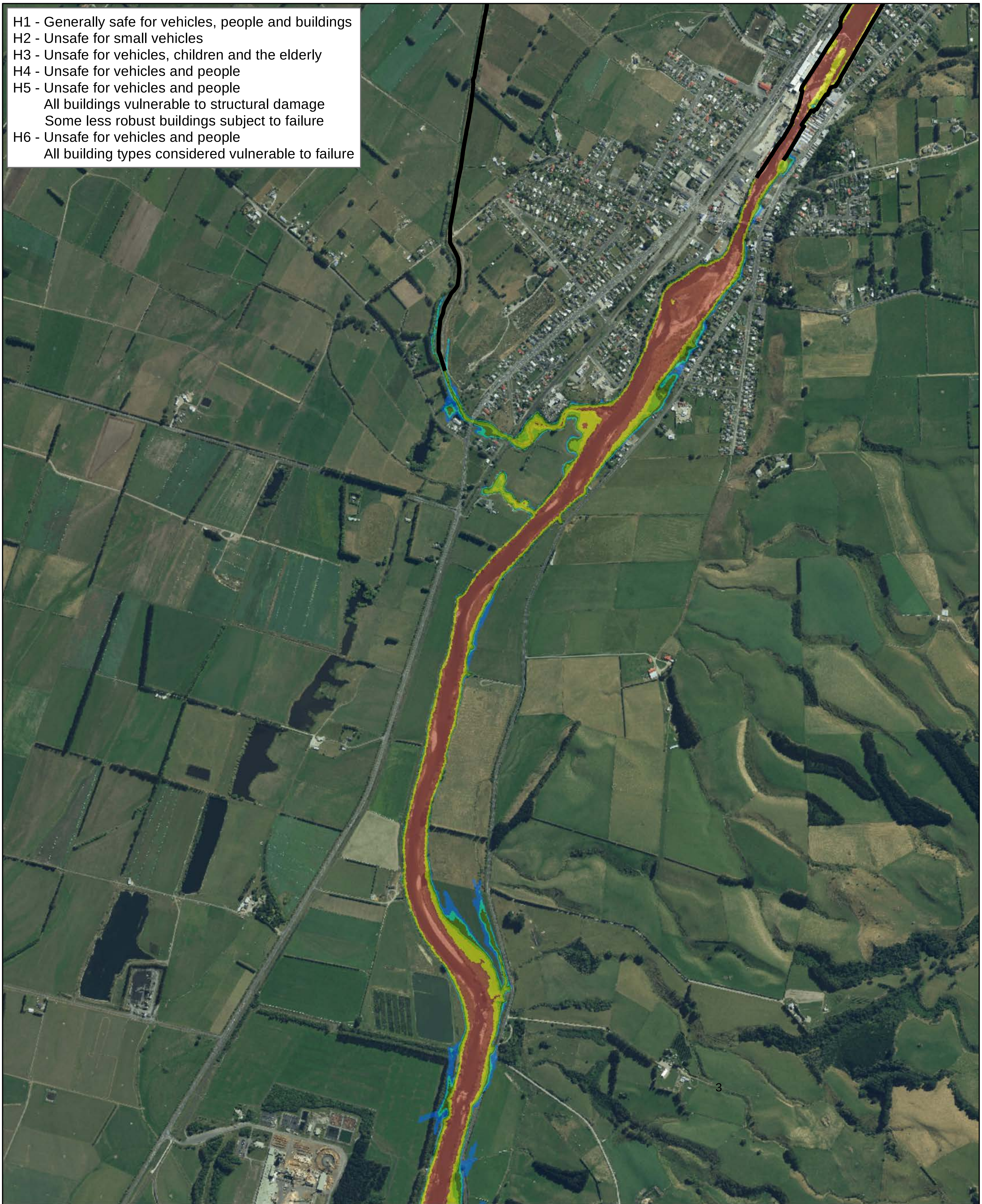
MAP (2 of 3)

PROJECT
Mataura River Modelling

MAP TITLE
PEAK HAZARD MAP
Mataura
2% AEP Flow, Historic Climate

REVISION	01	Created By	SP	Reviewed By	MG	N
AUTHOR	**Matthew Gardner**	DATE	**19/06/2024**			

Model Information
Coordinate System: New Zealand Transverse Mercator
Vertical Datum: NZVD2016
Model Completed: October 2023



Legend

Stopbanks

Hazard Category

- H6
- H5
- H4
- H3
- H2
- H1

Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 125 250 500 Meters

A3 SCALE **1:13,000**

MAP (3 of 3)

PROJECT
Mataura River Modelling

MAP TITLE
PEAK HAZARD MAP
Mataura
2% AEP Flow, Historic Climate

REVISION	01	Created By	SP	Reviewed By	MG	N
AUTHOR	Matthew Gardner		DATE	19/06/2024		

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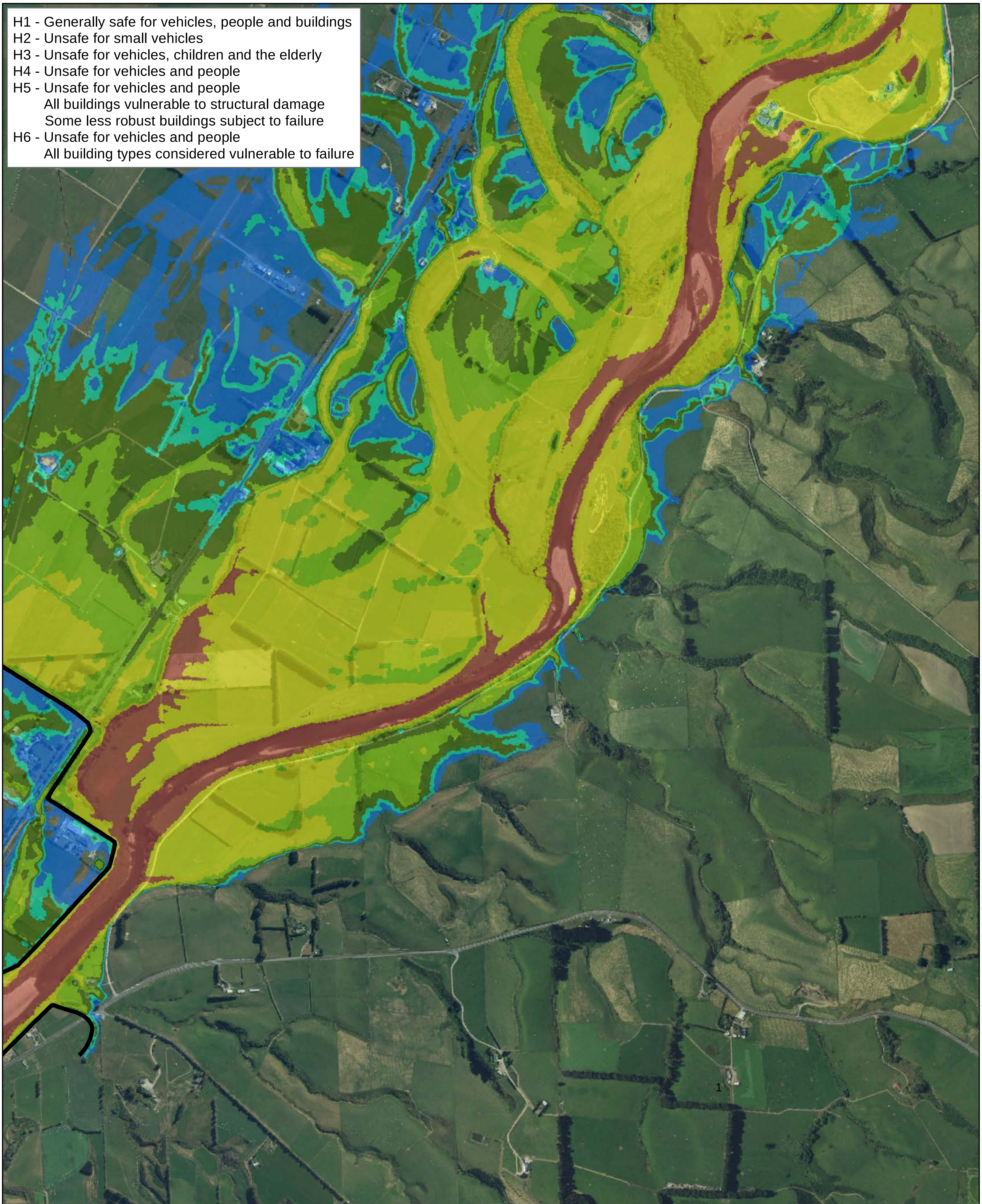

Legend

Stopbanks

Hazard Category

- H6
- H5
- H4
- H3
- H2
- H1

Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 125 250 500 Meters

A3 SCALE **1:13,000**

MAP (1 of 3)

PROJECT
Mataura River Modelling

MAP TITLE
PEAK HAZARD MAP
Mataura
1% AEP Flow, Historic Climate

REVISION	**01**	Created By	**SP**	Reviewed By	**MG**	N
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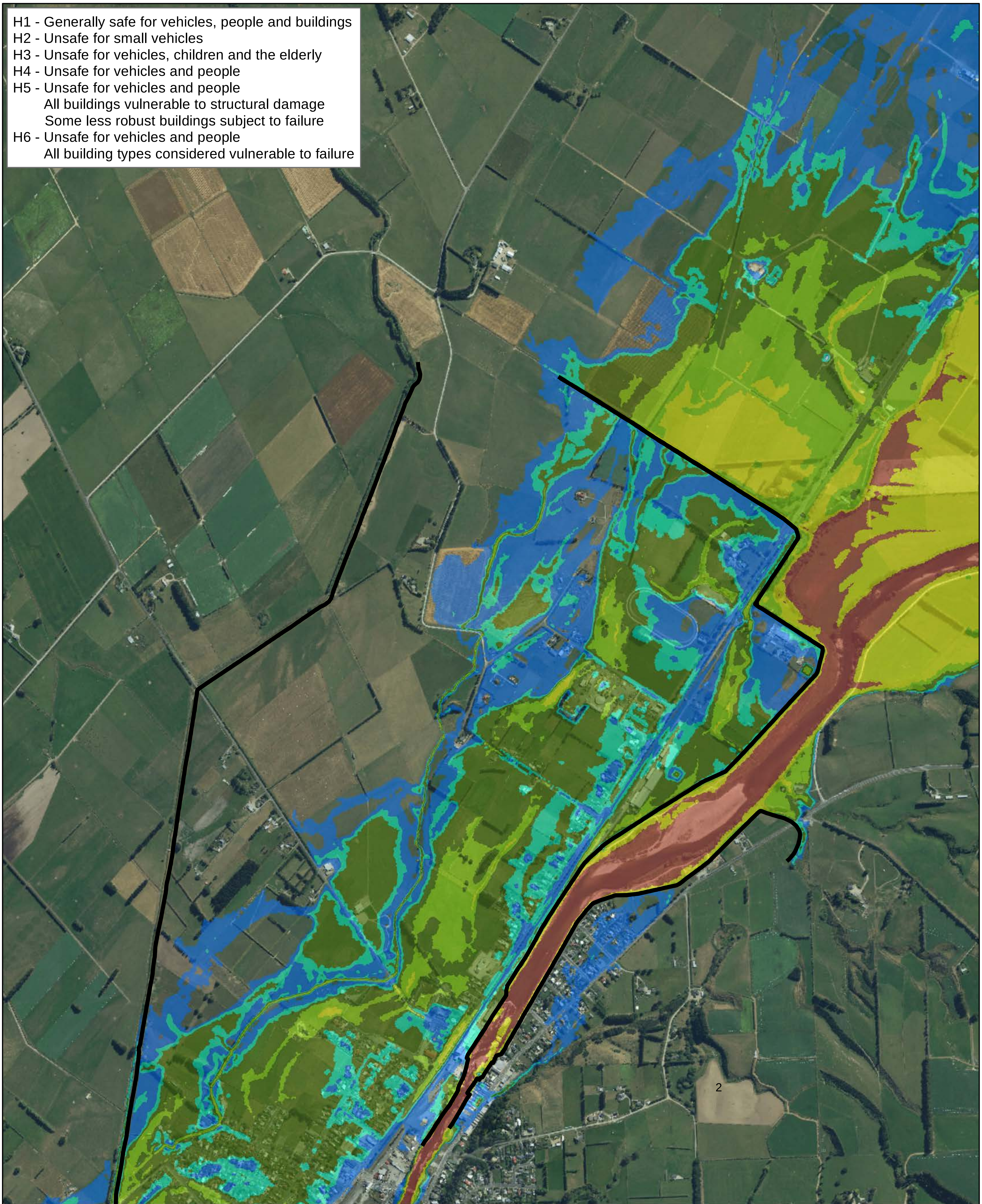

Legend

Stopbanks

Hazard Category

- H6
- H5
- H4
- H3
- H2
- H1

Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 125 250 500 Meters

A3 SCALE **1:13,000**

MAP (2 of 3)

PROJECT
Mataura River Modelling

MAP TITLE
PEAK HAZARD MAP
Mataura
1% AEP Flow, Historic Climate

REVISION	01	Created By	SP	Reviewed By	MG	N
AUTHOR	Matthew Gardner		DATE	19/06/2024		

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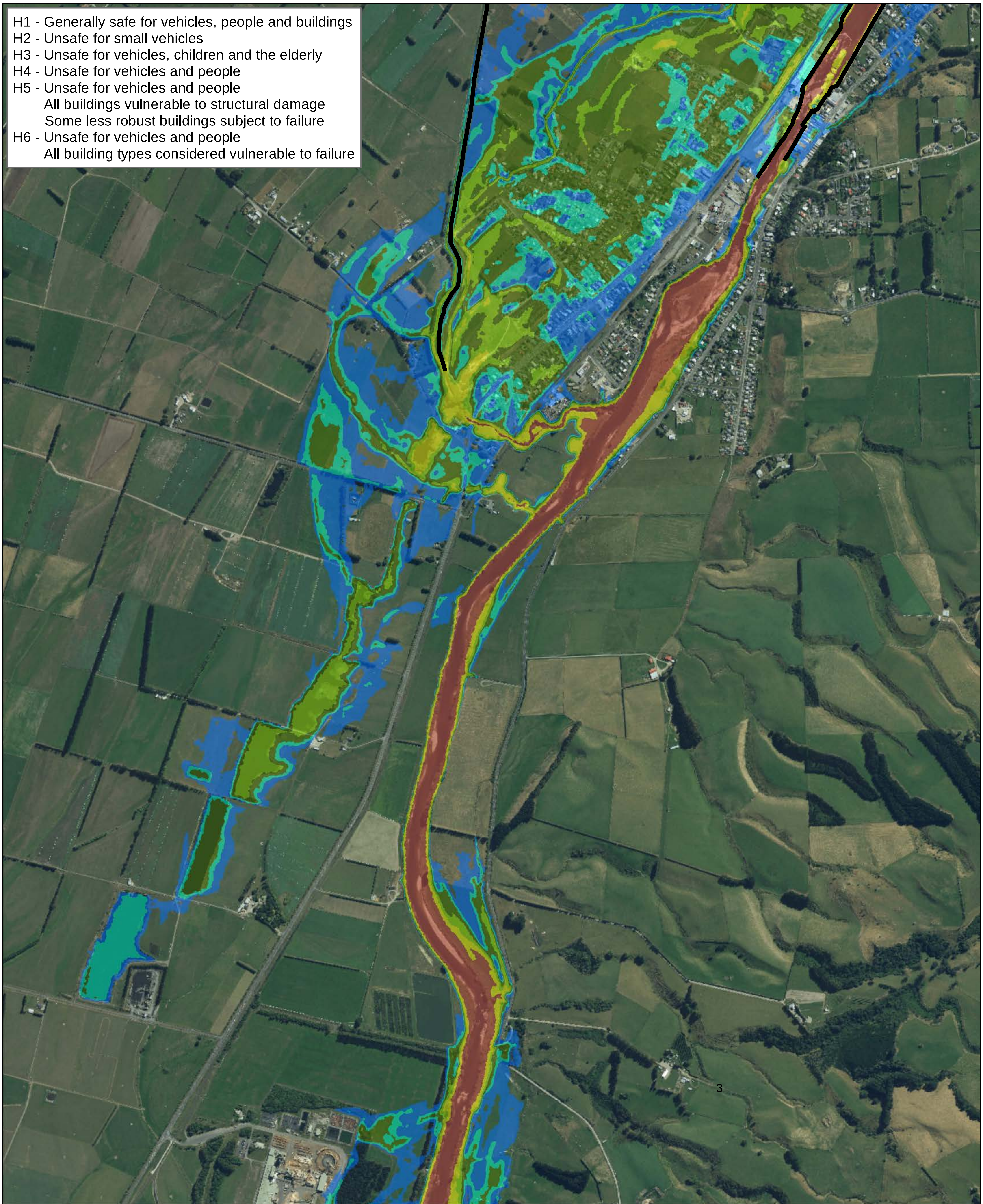

Legend

Stopbanks

Hazard Category

- H6
- H5
- H4
- H3
- H2
- H1

Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 125 250 500 Meters

A3 SCALE **1:13,000**

MAP (3 of 3)

PROJECT
Mataura River Modelling

MAP TITLE
PEAK HAZARD MAP
Mataura
1% AEP Flow, Historic Climate

REVISION	01	Created By	SP	Reviewed By	MG	N
AUTHOR	**Matthew Gardner**		DATE	**19/06/2024**		

Model Information
Coordinate System: New Zealand Transverse Mercator
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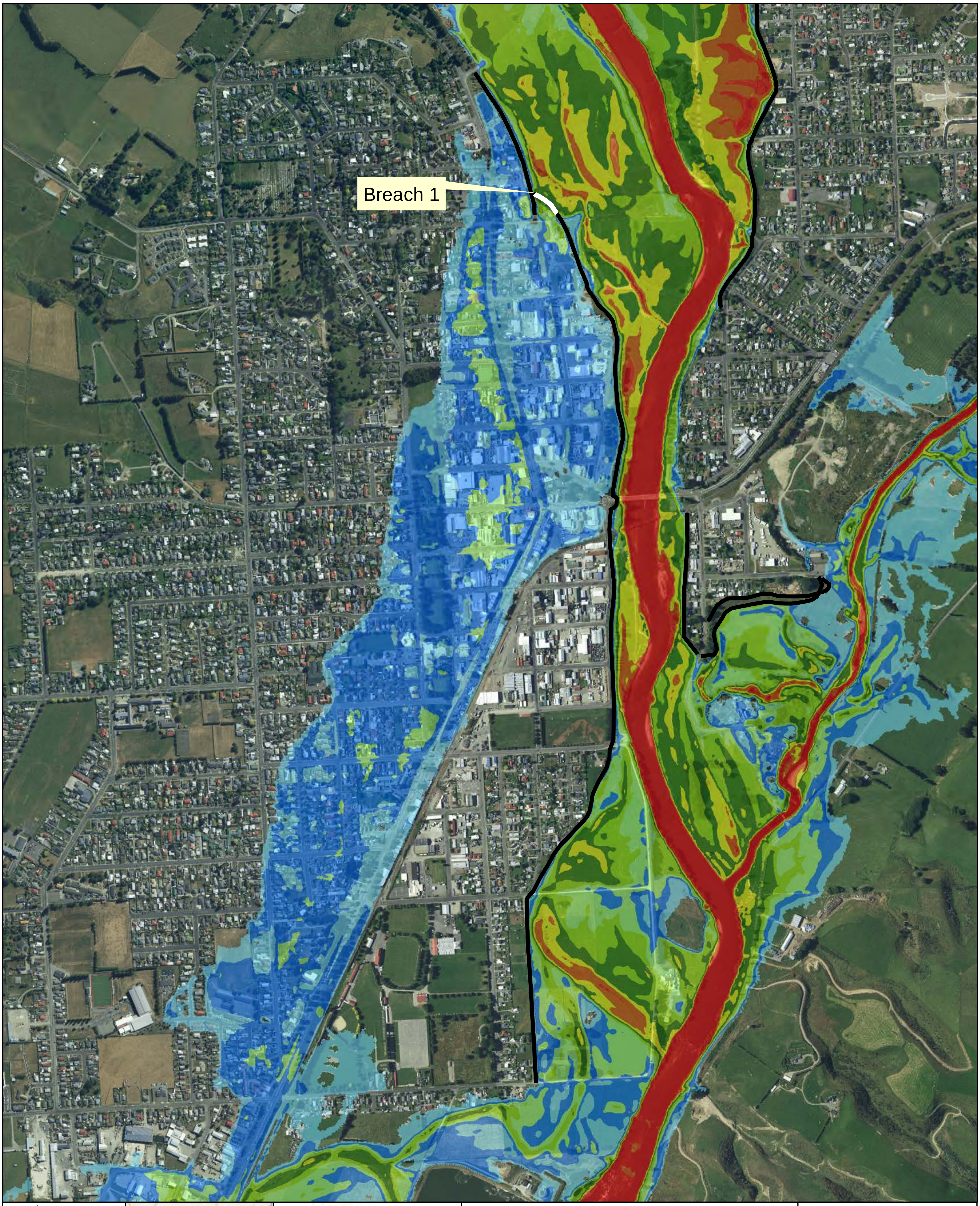


Legend

Breach 1

Stopbanks

Depth (m)

- 0 - 0.01
- 0.01 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- 3 - 3.5
- 3.5 +

Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 125 250 500
Meters

A3 SCALE 1:10,000

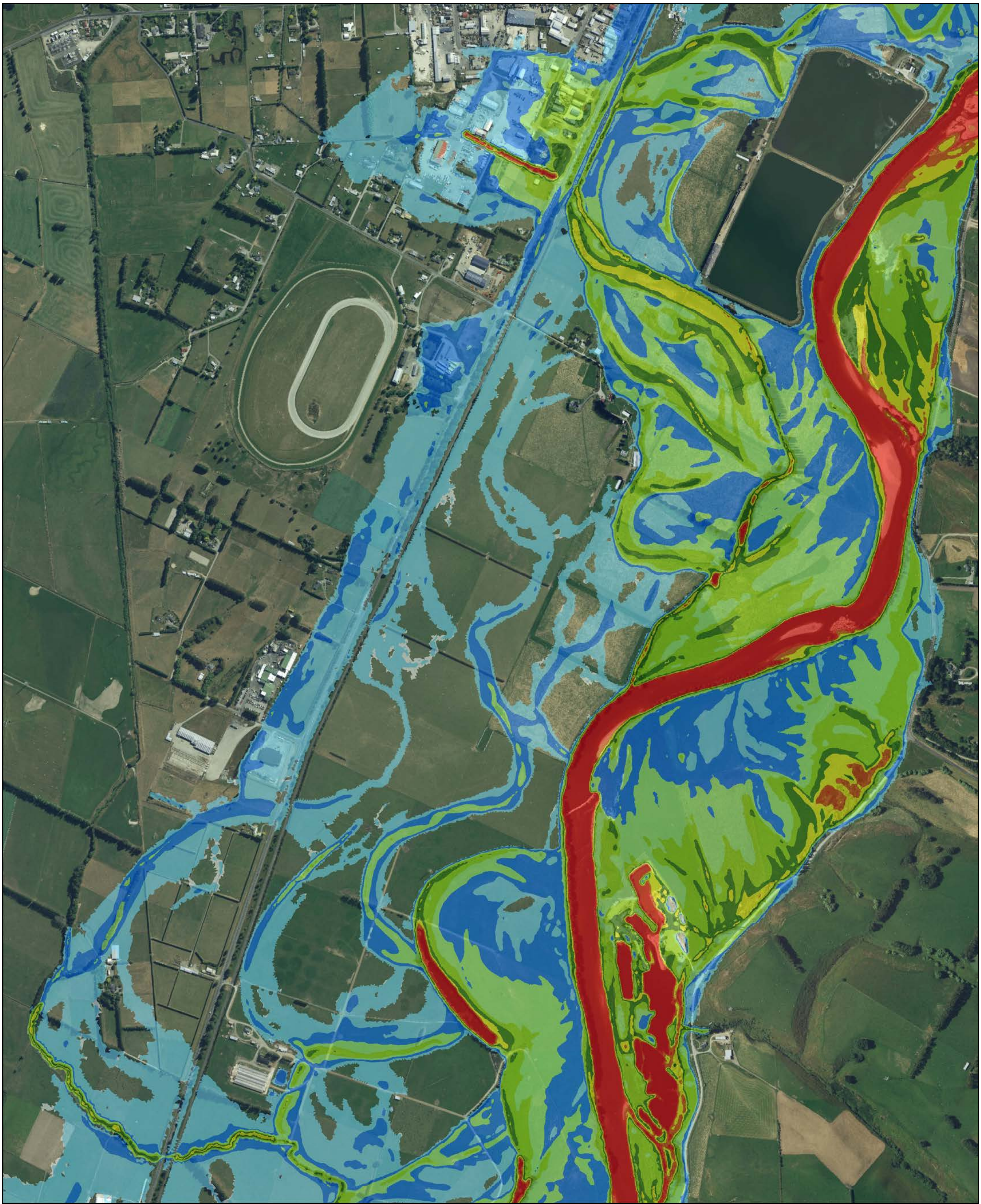
MAP (1 of 2)

PROJECT
Mataura River Modelling

MAP TITLE
PEAK DEPTH MAP
Breach 1
2% AEP Flow, Historic Climate

REVISION	01	Created By	SP	Reviewed By	MG	N
AUTHOR	Matthew Gardner		DATE	13/06/2024		

Model Information
Coordinate System: New Zealand Transverse Mercator
Vertical Datum: NZVD2016
Model Completed: October 2023



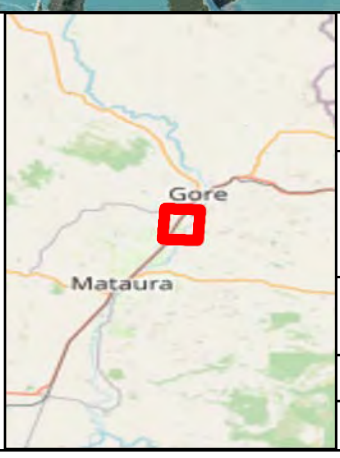
Legend

Breach 1

Stopbanks

Depth (m)

- 0 - 0.01
- 0.01 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- 3 - 3.5
- 3.5 +



Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 125 250 500 Meters

A3 SCALE **1:10,000**

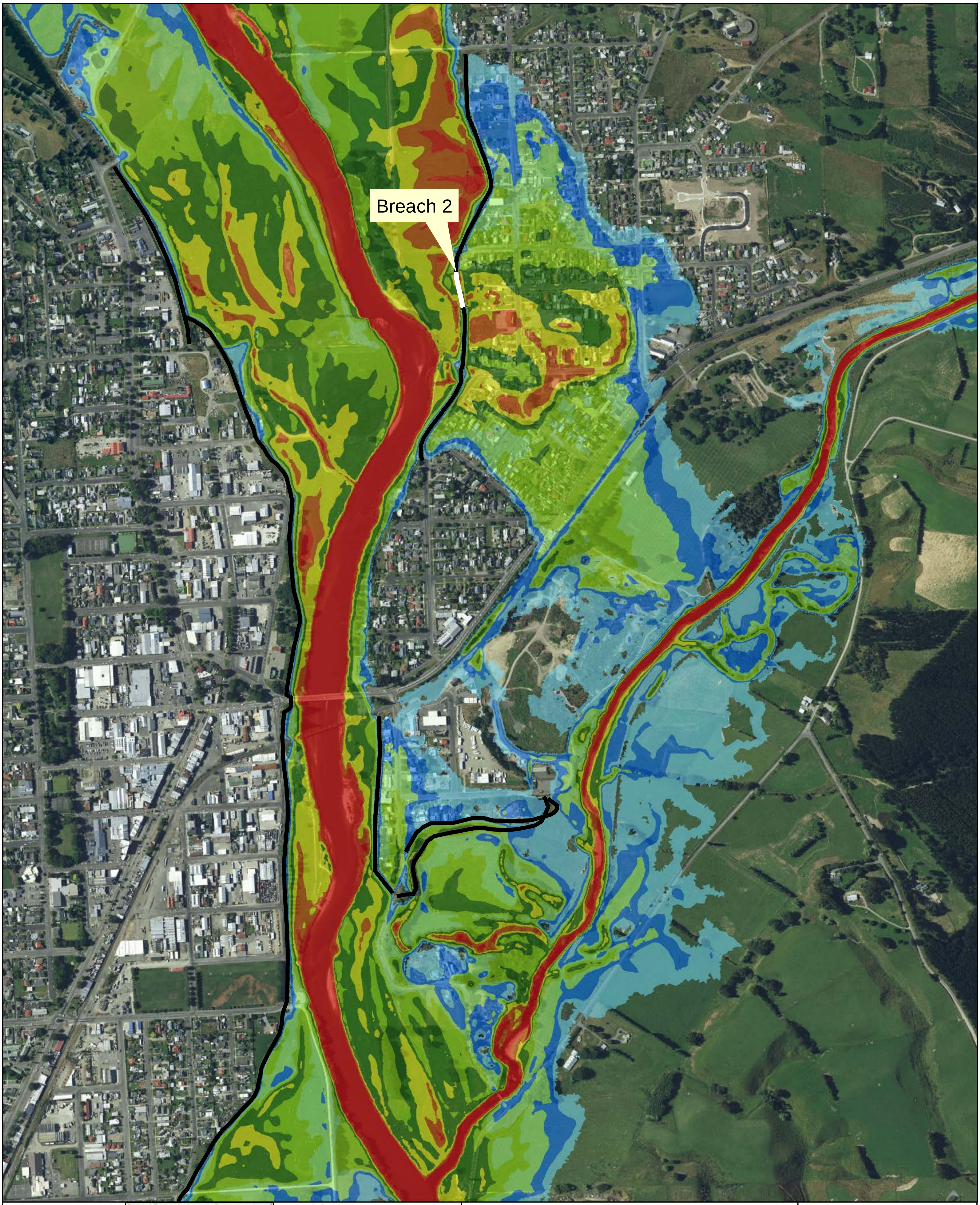
MAP (2 of 2)

PROJECT
Mataura River Modelling

MAP TITLE
PEAK DEPTH MAP
Breach 1
2% AEP Flow, Historic Climate

REVISION	01	Created By	SP	Reviewed By	MG	N
AUTHOR	**Matthew Gardner**			DATE	**13/06/2024**	

Model Information
Coordinate System: New Zealand Transverse Mercator
Vertical Datum: NZVD2016
Model Completed: October 2023



Legend

- Breach 2
- Stopbanks

Depth (m)

- 0 - 0.01
- 0.01 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- 3 - 3.5
- 3.5 +

Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 100 200 400
Meters

A3 SCALE 1:8,000

MAP (1 of 1)

PROJECT
Mataura River Modelling

MAP TITLE
PEAK DEPTH MAP
Breach 2
2% AEP Flow, Historic Climate

REVISION	01	Created By	SP	Reviewed By	MG	N
AUTHOR	Matthew Gardner		DATE	14/06/2024		

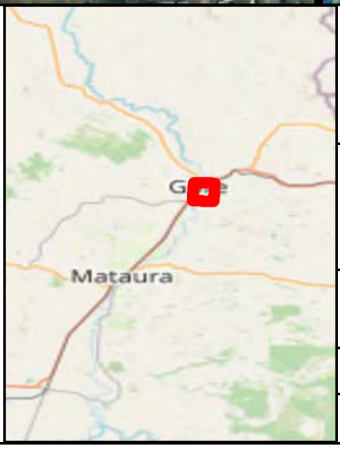
Model Information
Coordinate System: New Zealand Transverse Mercator
Vertical Datum: NZVD2016
Model Completed: October 2023

Legend

- Breach 3
- Stopbanks

Depth (m)

- 0 - 0.01
- 0.01 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- 3 - 3.5
- 3.5 +



Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 75 150 300 Meters

A3 SCALE 1:6,000

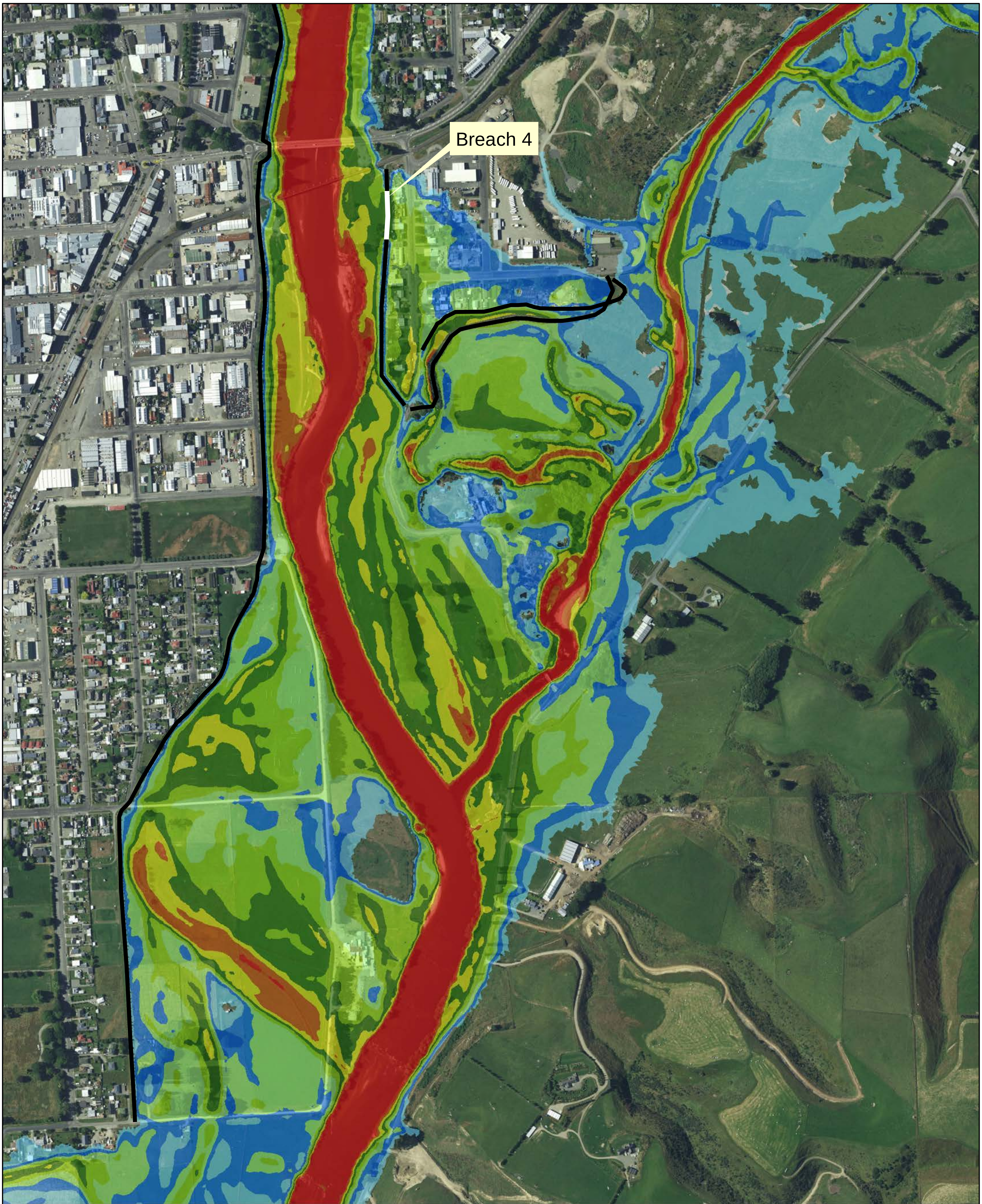
MAP (1 of 1)

PROJECT
Mataura River Modelling

MAP TITLE
PEAK DEPTH MAP
Breach 3
2% AEP Flow, Historic Climate

REVISION	01	Created By	SP	Reviewed By	MG	N
AUTHOR	Matthew Gardner		DATE	13/06/2024		

Model Information
Coordinate System: New Zealand Transverse Mercator
Vertical Datum: NZVD2016
Model Completed: October 2023



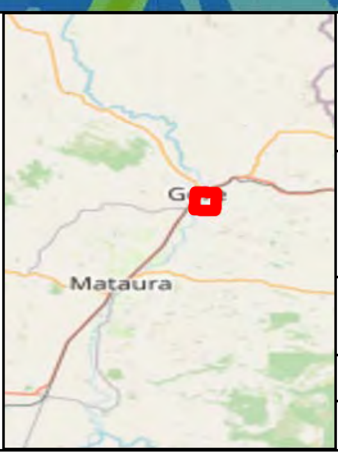
Legend

Breach 4

Stopbanks

Depth (m)

- 0 - 0.01
- 0.01 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- 3 - 3.5
- 3.5 +



Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 75 150 300
Meters

A3 SCALE **1:6,000**

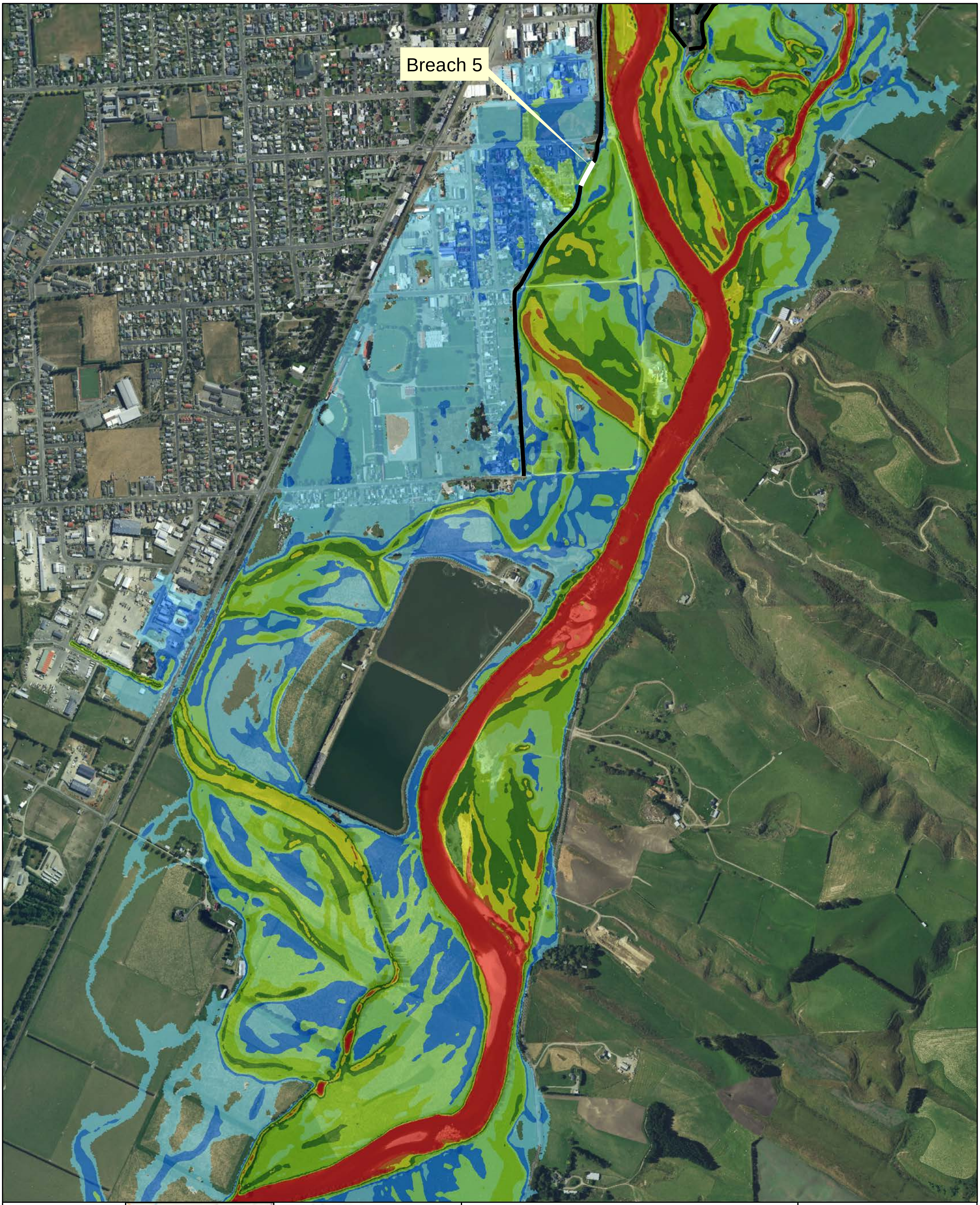
MAP (1 of 1)

PROJECT
Mataura River Modelling

MAP TITLE
PEAK DEPTH MAP
Breach 4
2% AEP Flow, Historic Climate

REVISION	01	Created By	SP	Reviewed By	MG	N
AUTHOR	Matthew Gardner		DATE	14/06/2024		

Model Information
Coordinate System: New Zealand Transverse Mercator
Vertical Datum: NZVD2016
Model Completed: October 2023

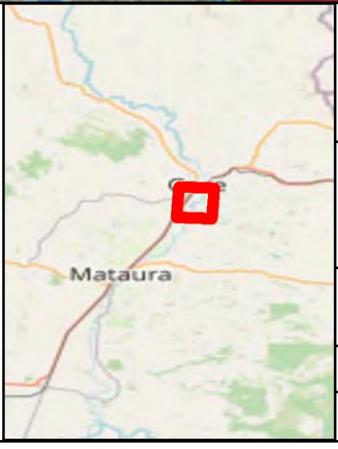


Legend

- Breach 5
- Stopbanks

Depth (m)

- 0 - 0.01
- 0.01 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- 3 - 3.5
- 3.5 +



Land River Sea
CONSULTING

environment SOUTHLAND
REGIONAL COUNCIL
Te Taiao Tonga

0 125 250 500
Meters

A3 SCALE 1:10,000

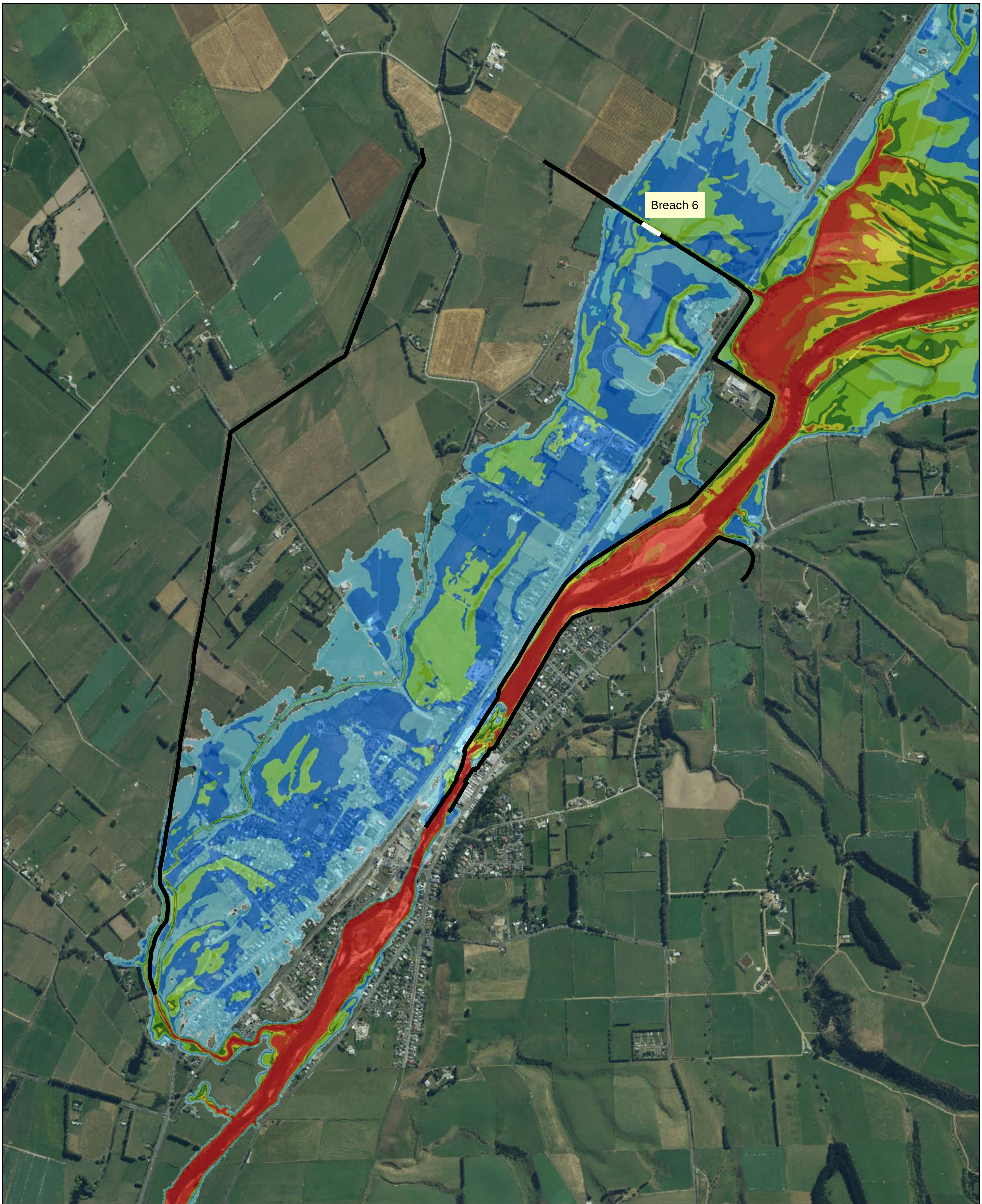
MAP (1 of 1)

PROJECT
Mataura River Modelling

MAP TITLE
PEAK DEPTH MAP
Breach 5
2% AEP Flow, Historic Climate

REVISION	01	Created By	SP	Reviewed By	MG	N
AUTHOR	Matthew Gardner		DATE	13/06/2024		

Model Information
Coordinate System: New Zealand Transverse Mercator
Vertical Datum: NZVD2016
Model Completed: October 2023



Legend

Breach 6

Stopbanks

Depth (m)

- 0 - 0.01
- 0.01 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- 3 - 3.5
- 3.5 +

Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 150 300 600
Meters

A3 SCALE **1:15,000**

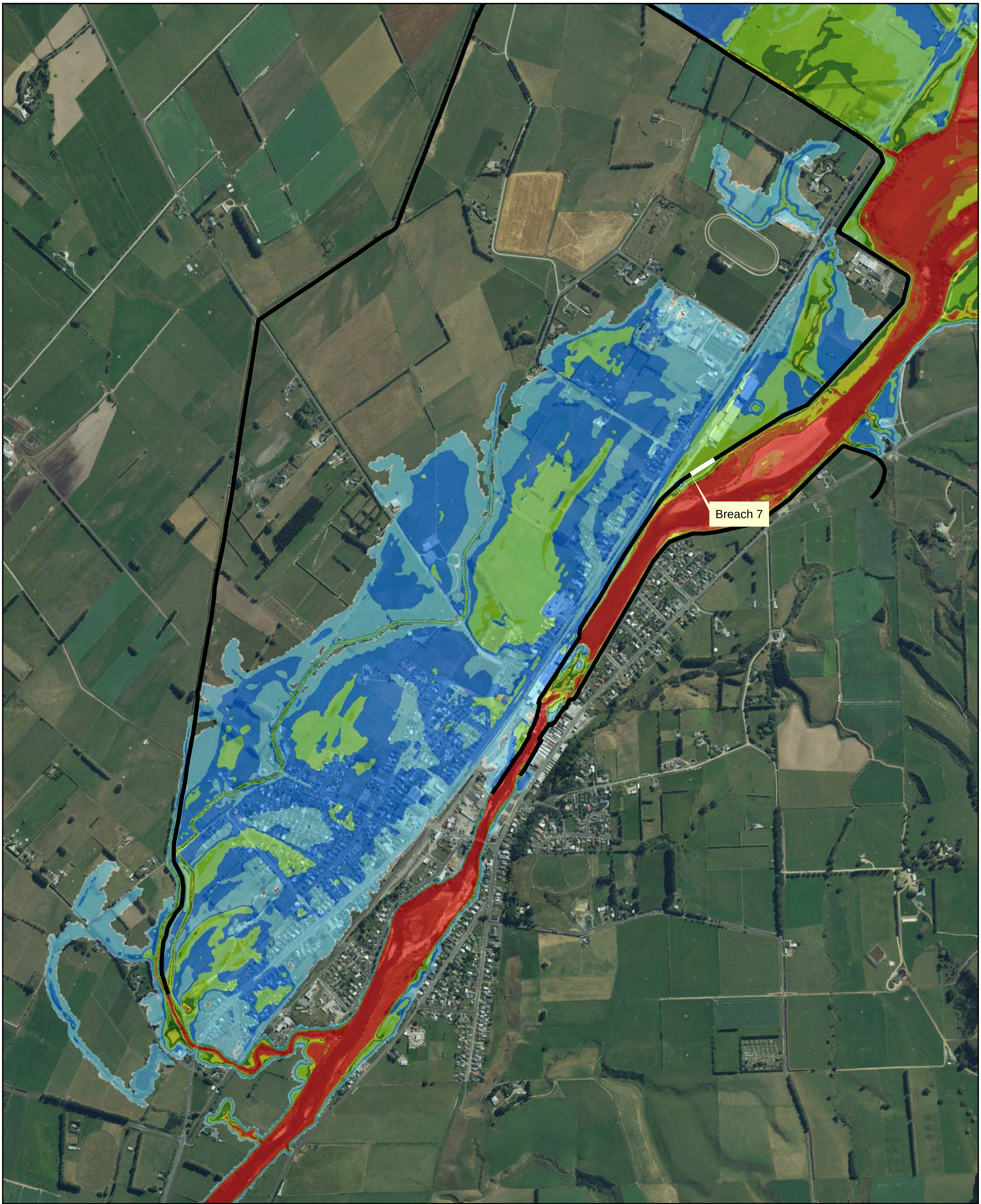
MAP (1 of 1)

PROJECT
Mataura River Modelling

MAP TITLE
PEAK DEPTH MAP
Breach 6
2% AEP Flow, Historic Climate

REVISION	01	Created By	SP	Reviewed By	MG	N
AUTHOR	Matthew Gardner		DATE	12-06-2024		

Model Information
Coordinate System: New Zealand Transverse Mercator
Vertical Datum: NZVD2016
Model Completed: October 2023



Legend

- Breach 7
- Stopbanks

Depth (m)

- 0 - 0.01
- 0.01 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- 3 - 3.5
- 3.5 +

Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 120 240 480 Meters

A3 SCALE 1:12,500

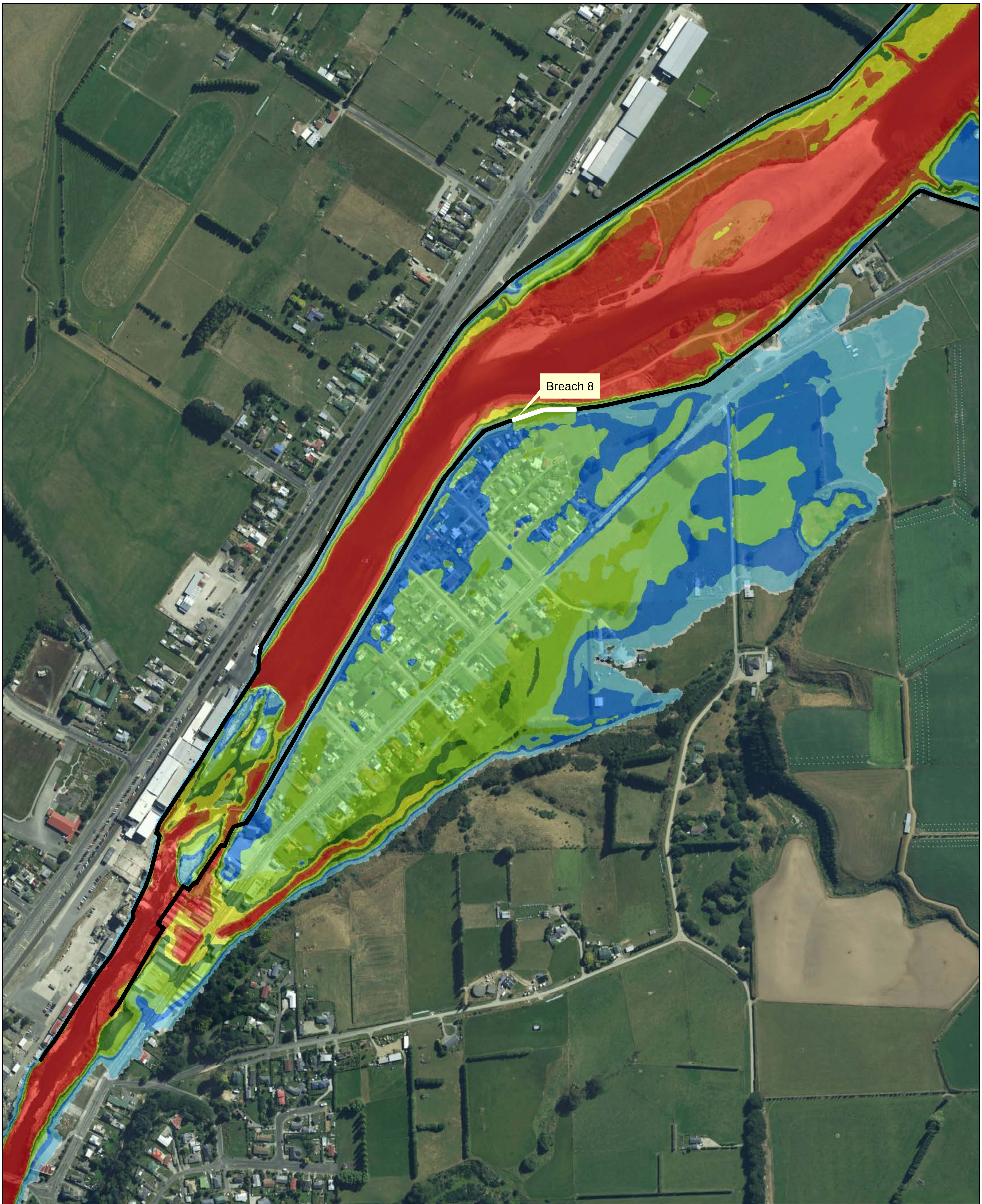
MAP (1 of 1)

PROJECT
Mataura River Modelling

MAP TITLE
PEAK DEPTH MAP
Breach 7
2% AEP Flow, Historic Climate

REVISION	01	Created By	SP	Reviewed By	MG	N
AUTHOR	Matthew Gardner	DATE	12-06-2024			

Model Information
Coordinate System: New Zealand Transverse Mercator
Vertical Datum: NZVD2016
Model Completed: October 2023

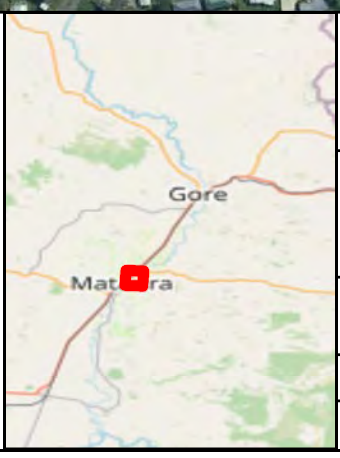


Legend

Breach 8
Stopbanks

Depth (m)

- 0 - 0.01
- 0.01 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- 3 - 3.5
- 3.5 +



Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 50 100 200
Meters

A3 SCALE **1:5,000**

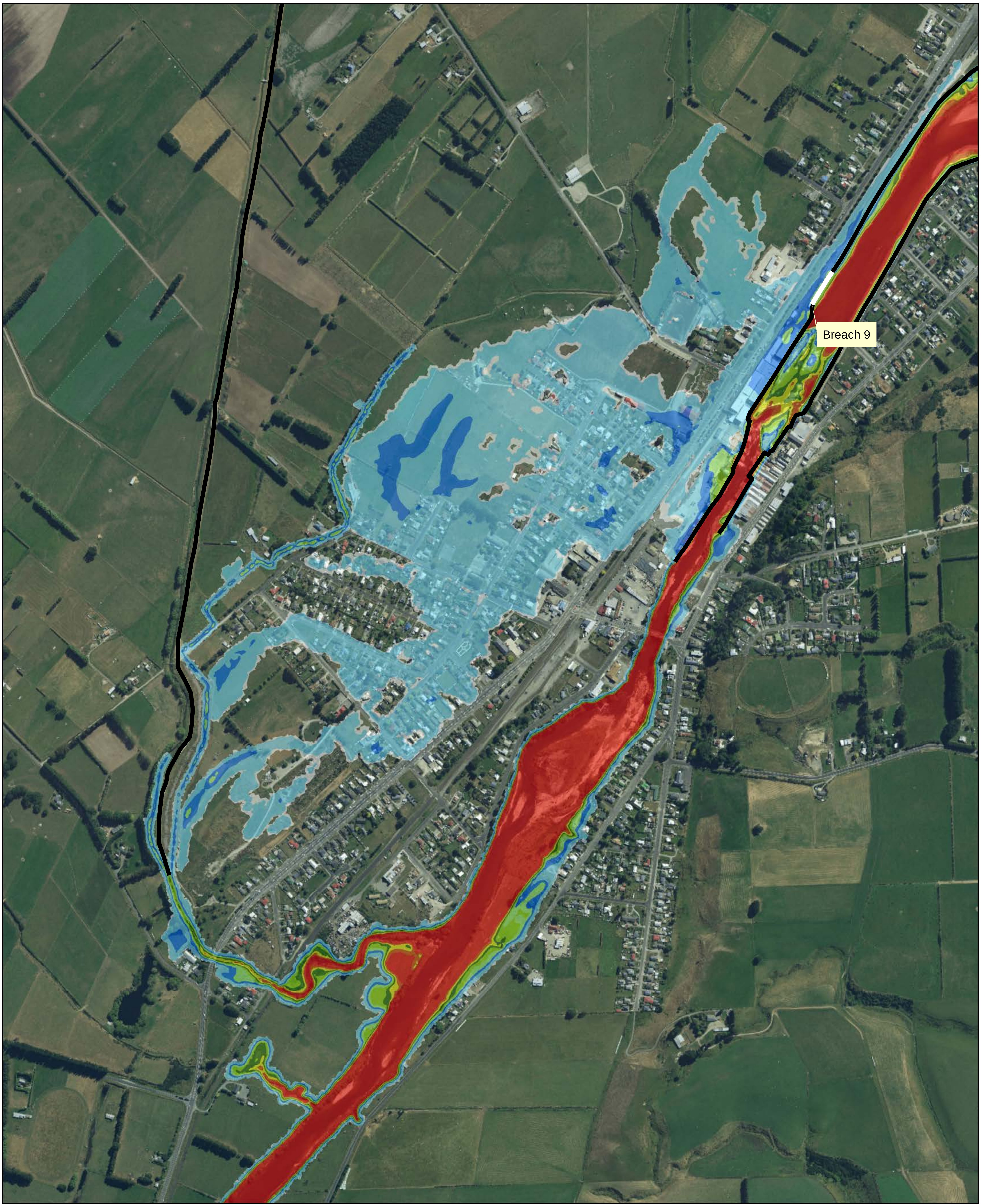
MAP (1 of 1)

PROJECT
Mataura River Modelling

MAP TITLE
PEAK DEPTH MAP
Breach 8
2% AEP Flow, Historic Climate

REVISION	01	Created By	SP	Reviewed By	MG	N
AUTHOR	**Matthew Gardner**		DATE	**12-06-2024**		

Model Information
Coordinate System: New Zealand Transverse Mercator
Vertical Datum: NZVD2016
Model Completed: October 2023



Legend

- Breach 9
- Stopbanks

Depth (m)

- 0 - 0.01
- 0.01 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 3
- 3 - 3.5
- 3.5 +

Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 75 150 300 Meters

A3 SCALE 1:8,000

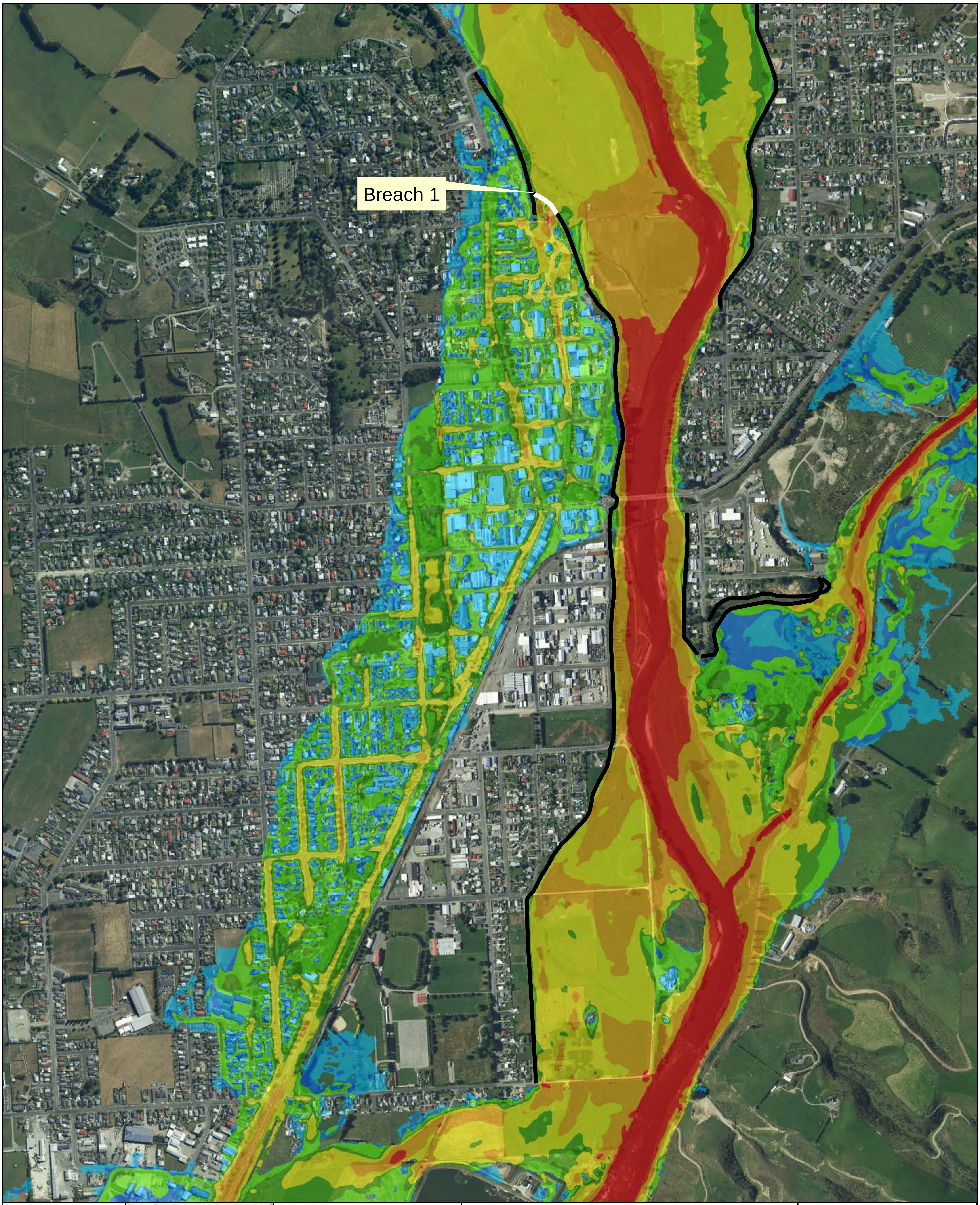
MAP (1 of 1)

PROJECT
Mataura River Modelling

MAP TITLE
PEAK DEPTH MAP
Breach 9
2% AEP Flow, Historic Climate

REVISION	01	Created By	SP	Reviewed By	MG	N
AUTHOR	Matthew Gardner		DATE	12-06-2024		

Model Information
Coordinate System: New Zealand Transverse Mercator
Vertical Datum: NZVD2016
Model Completed: October 2023



Legend

Breach 1

Stopbanks

Speed (m/s)

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

Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 125 250 500 Meters

A3 SCALE **1:10,000**

MAP (1 of 2)

PROJECT
Mataura River Modelling

MAP TITLE
PEAK SPEED MAP
Breach 1
2% AEP Flow, Historic Climate

REVISION	01	Created By	SP	Reviewed By	MG	N
AUTHOR	**Matthew Gardner**		DATE	**13/06/2024**		

Model Information
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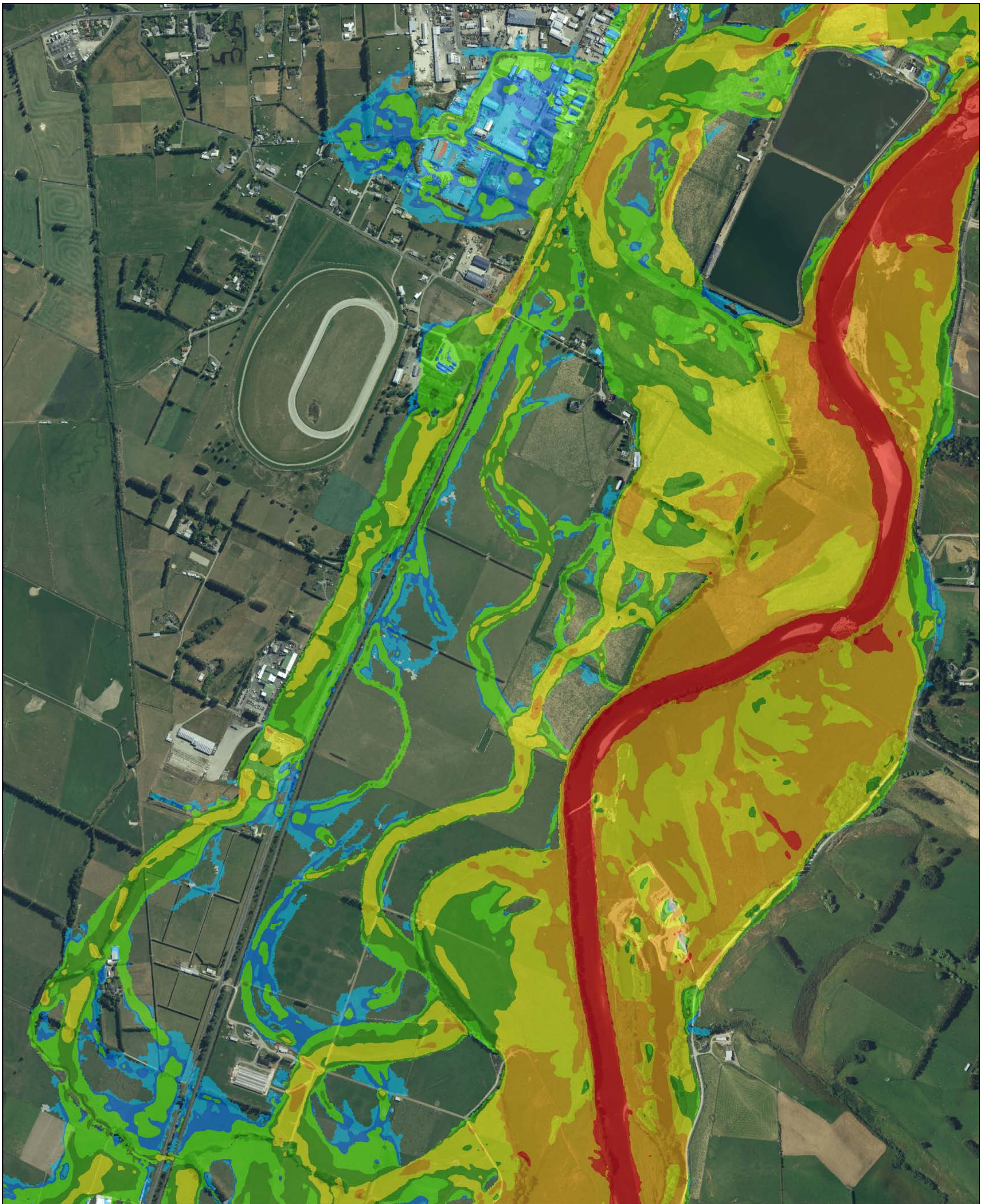
Vertical Datum: NZVD2016
Model Completed: October 2023



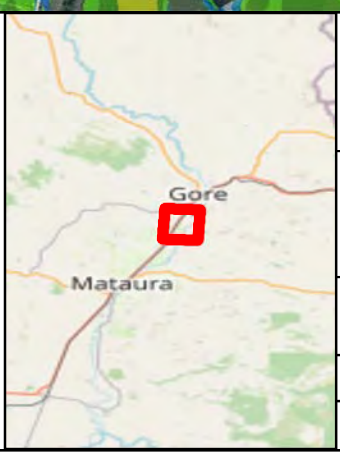
Legend

Breach 1

Stopbanks

Speed (m/s)

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



Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 125 250 500 Meters

A3 SCALE **1:10,000**

MAP (2 of 2)

PROJECT
Mataura River Modelling

MAP TITLE
PEAK SPEED MAP
Breach 1
2% AEP Flow, Historic Climate

REVISION	01	Created By	SP	Reviewed By	MG	N
AUTHOR	Matthew Gardner		DATE	13/06/2024		

Model Information
Coordinate System: New Zealand Transverse Mercator
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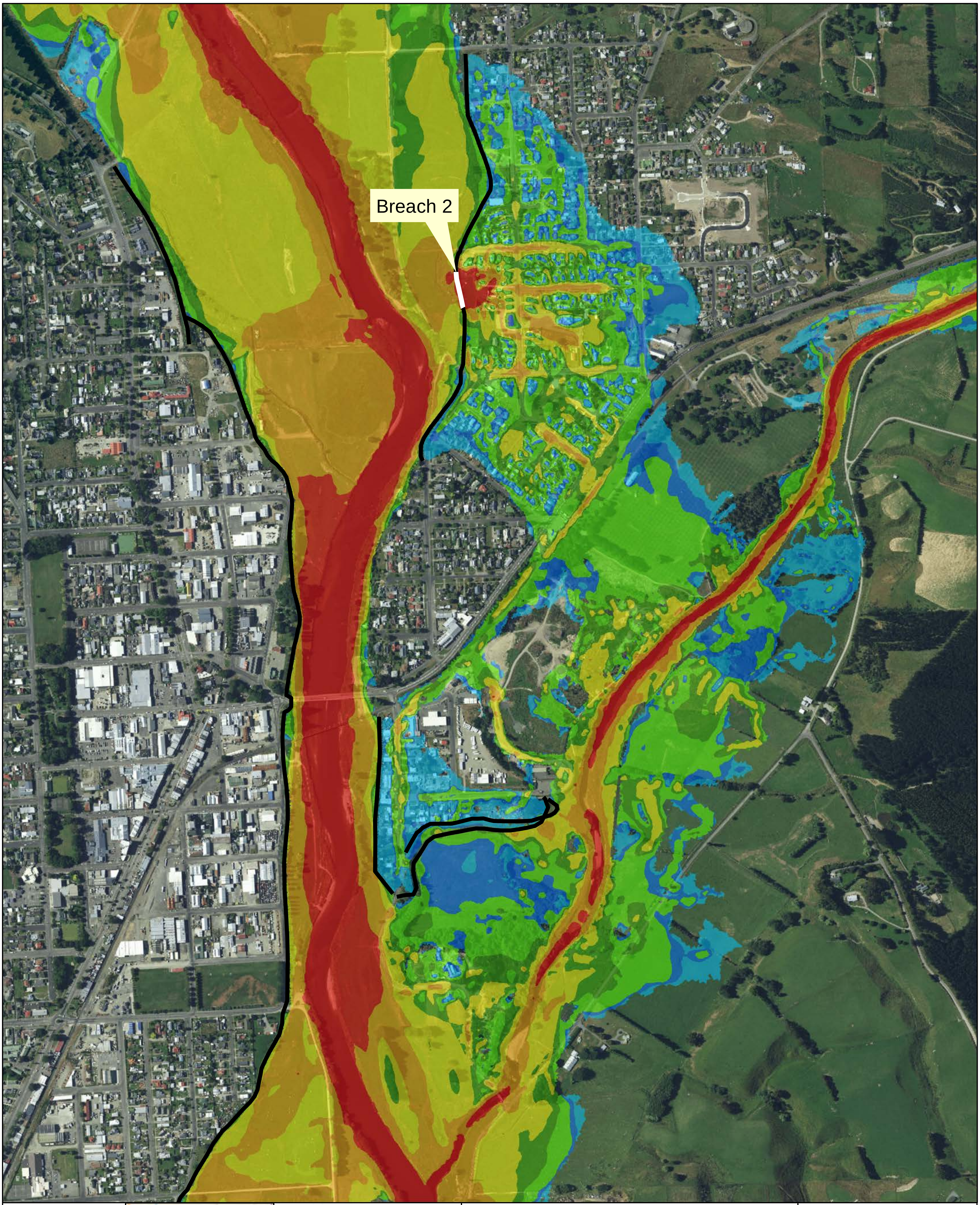
Model Completed: October 2023



Legend

Breach 2

Stopbanks

Speed (m/s)

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

Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 100 200 400
Meters

A3 SCALE **1:8,000**

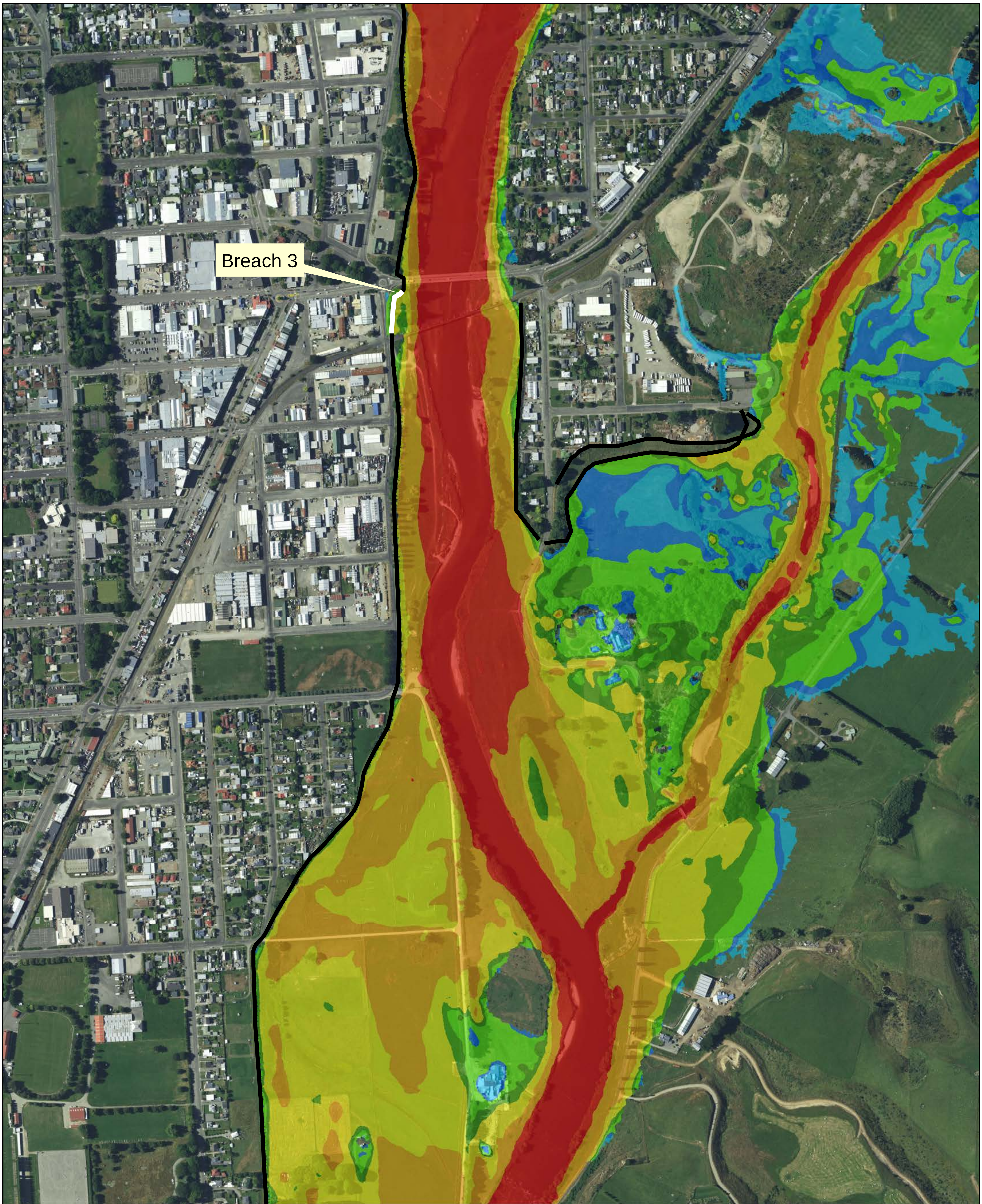
MAP (1 of 1)

PROJECT
Mataura River Modelling

MAP TITLE
PEAK SPEED MAP
Breach 2
2% AEP Flow, Historic Climate

REVISION	01	Created By	SP	Reviewed By	MG	N
AUTHOR	Matthew Gardner		DATE	14/06/2024		

Model Information
Coordinate System: New Zealand Transverse Mercator
Vertical Datum: NZVD2016
Model Completed: October 2023



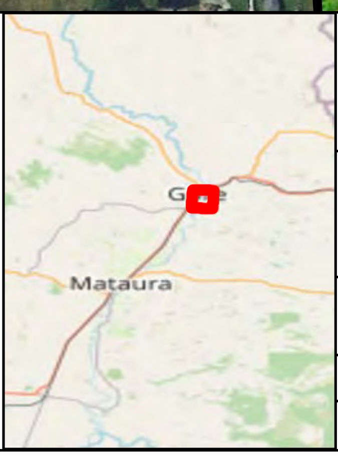
Legend

Breach 3

Stopbanks

Speed (m/s)

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



Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 75 150 300
Meters

A3 SCALE **1:6,000**

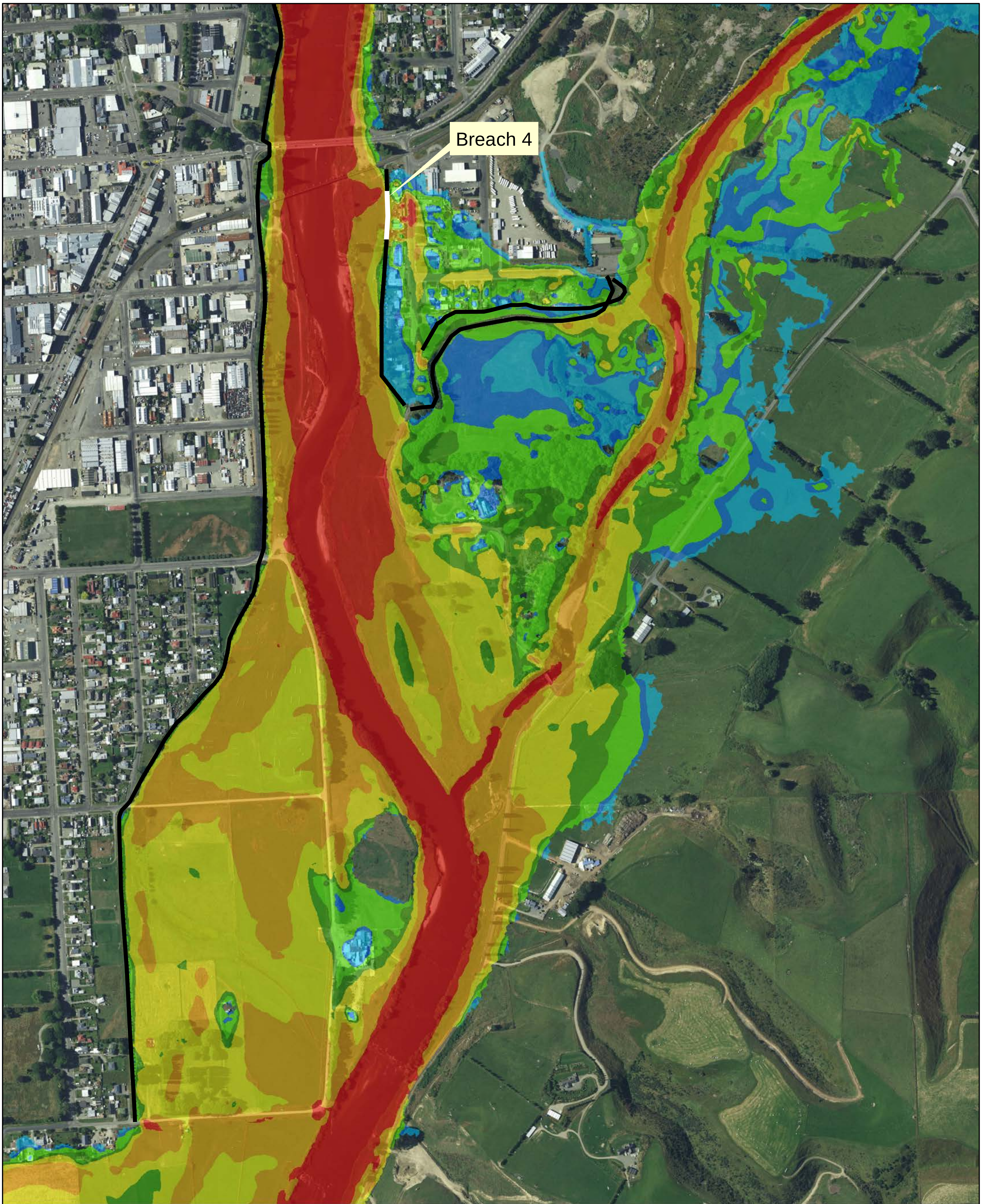
MAP (1 of 1)

PROJECT
Mataura River Modelling

MAP TITLE
PEAK SPEED MAP
Breach 3
2% AEP Flow, Historic Climate

REVISION	01	Created By	SP	Reviewed By	MG	N
AUTHOR	**Matthew Gardner**	DATE	**13/06/2024**			

Model Information
Coordinate System: New Zealand Transverse Mercator
Vertical Datum: NZVD2016
Model Completed: October 2023

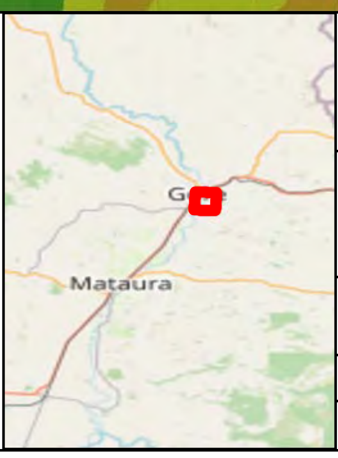


Legend

Breach 4
Stopbanks

Speed (m/s)

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



Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 75 150 300
Meters

A3 SCALE **1:6,000**

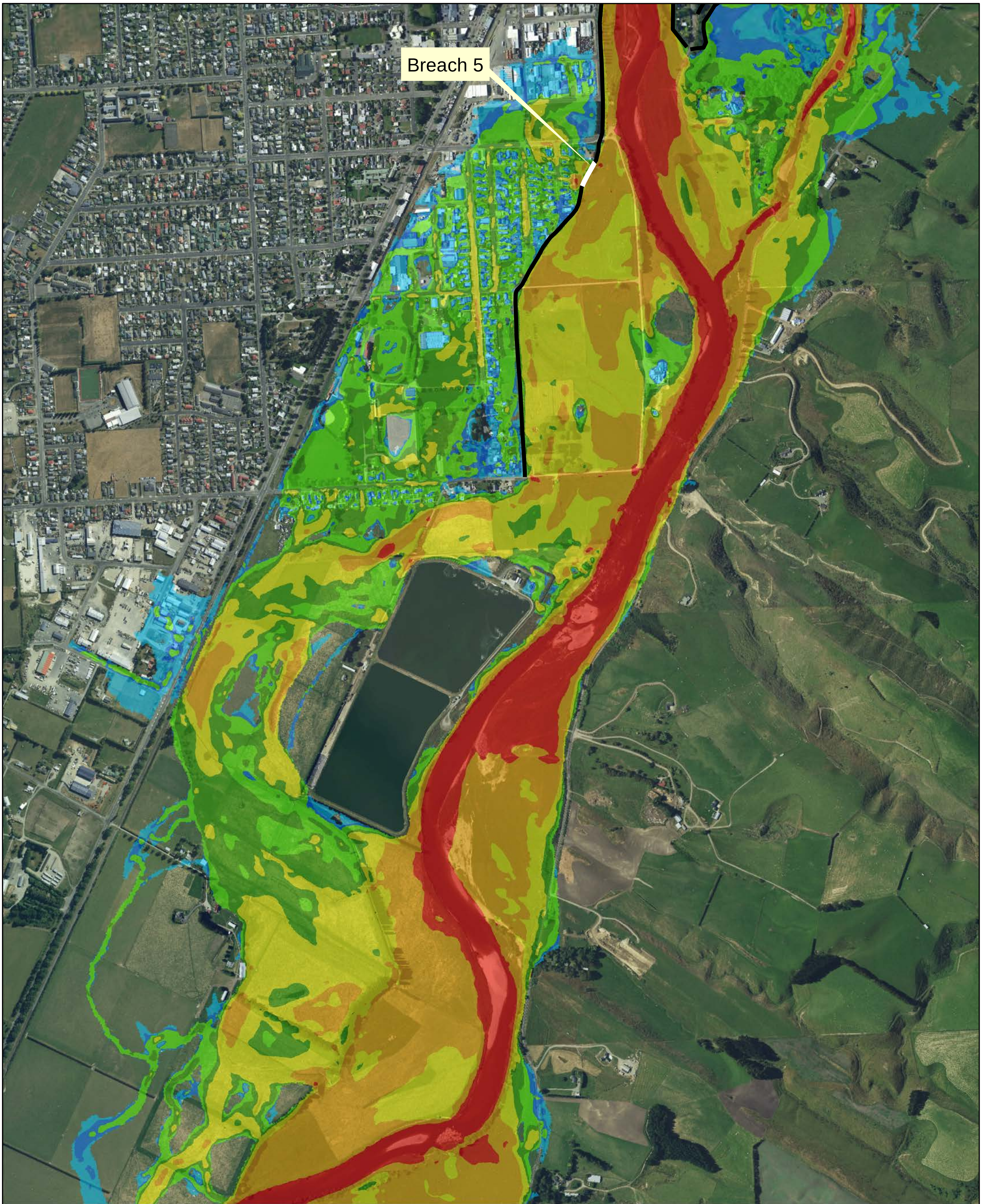
MAP (1 of 1)

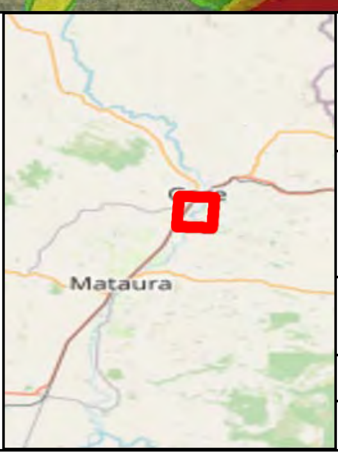
PROJECT
Mataura River Modelling

MAP TITLE
PEAK SPEED MAP
Breach 4
2% AEP Flow, Historic Climate

REVISION	01	Created By	SP	Reviewed By	MG	N
AUTHOR	Matthew Gardner		DATE	14/06/2024		

Model Information
Coordinate System: New Zealand Transverse Mercator
Vertical Datum: NZVD2016
Model Completed: October 2023





Legend

Breach 5
Stopbanks

Speed (m/s)

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

Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 125 250 500 Meters

A3 SCALE **1:10,000**

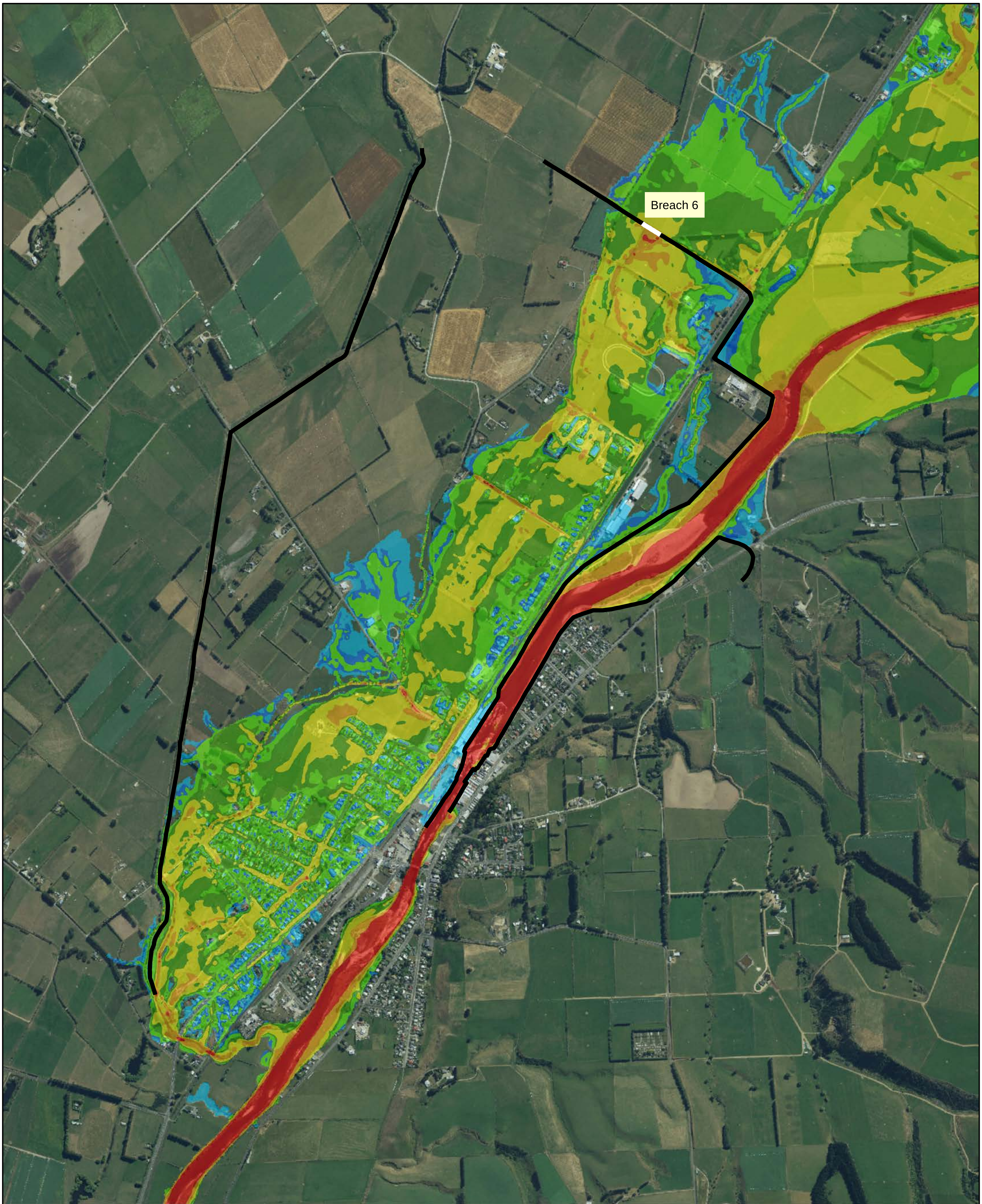
MAP (1 of 1)

PROJECT
Mataura River Modelling

MAP TITLE
PEAK SPEED MAP
Breach 5
2% AEP Flow, Historic Climate

REVISION	01	Created By	SP	Reviewed By	MG	N
AUTHOR	**Matthew Gardner**		DATE	**13/06/2024**		

Model Information
Coordinate System: New Zealand Transverse Mercator
Vertical Datum: NZVD2016
Model Completed: October 2023



Legend

Breach 6

Stopbanks

Speed (m/s)

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

Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 150 300 600
Meters

A3 SCALE 1:15,000

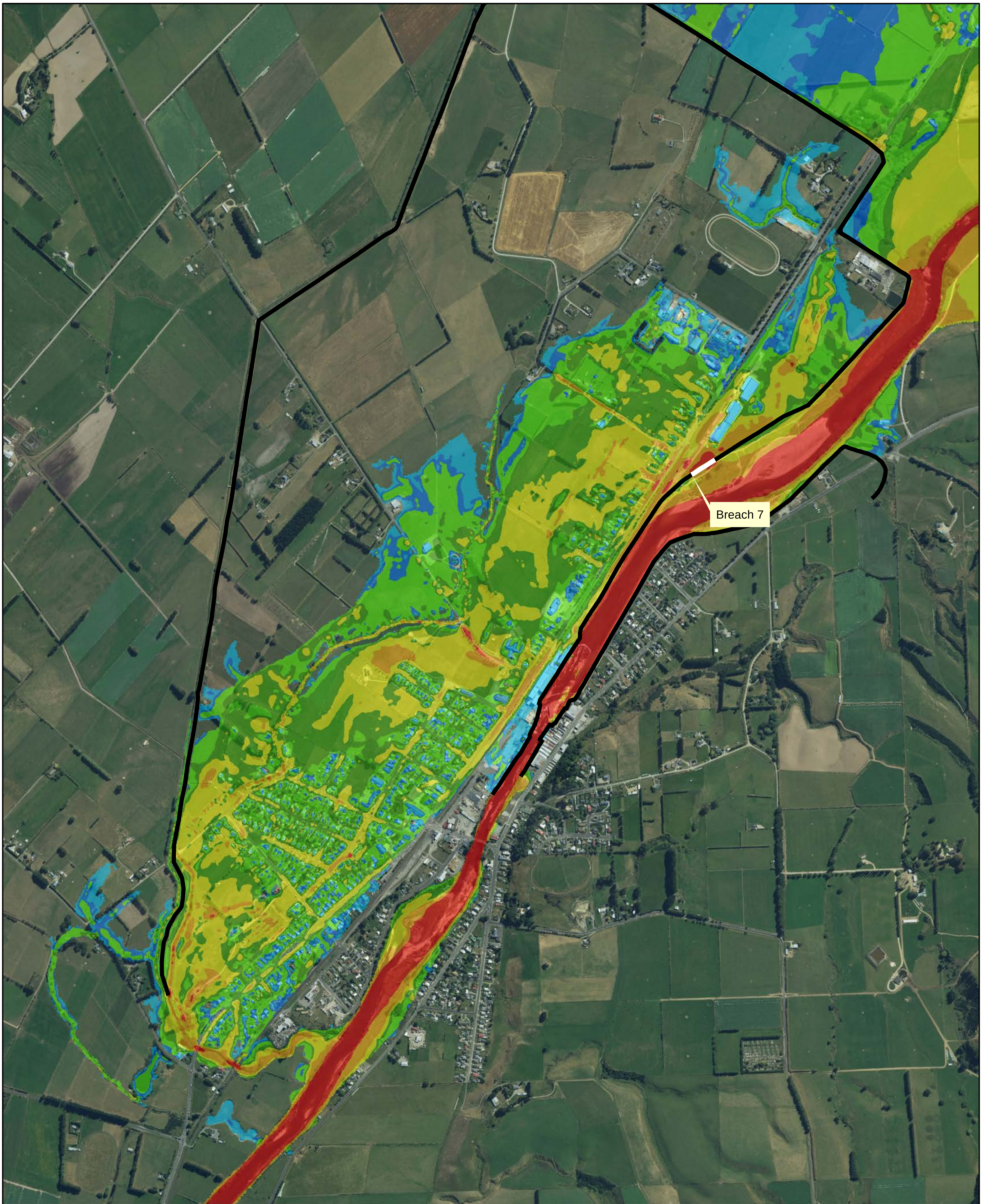
MAP (1 of 1)

PROJECT
Mataura River Modelling

MAP TITLE
PEAK SPEED MAP
Breach 6
2% AEP Flow, Historic Climate

REVISION	01	Created By	SP	Reviewed By	MG	N
AUTHOR	Matthew Gardner		DATE	12-06-2024		

Model Information
Coordinate System: New Zealand Transverse Mercator
Vertical Datum: NZVD2016
Model Completed: October 2023

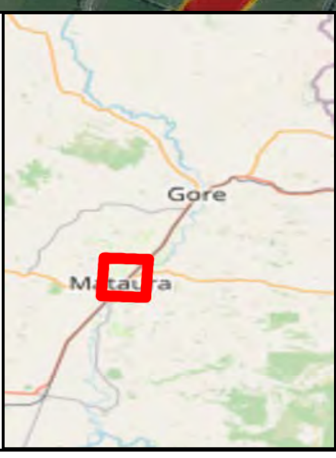


Legend

Breach 7
Stopbanks

Speed (m/s)

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



Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 120 240 480
Meters

A3 SCALE **1:12,500**

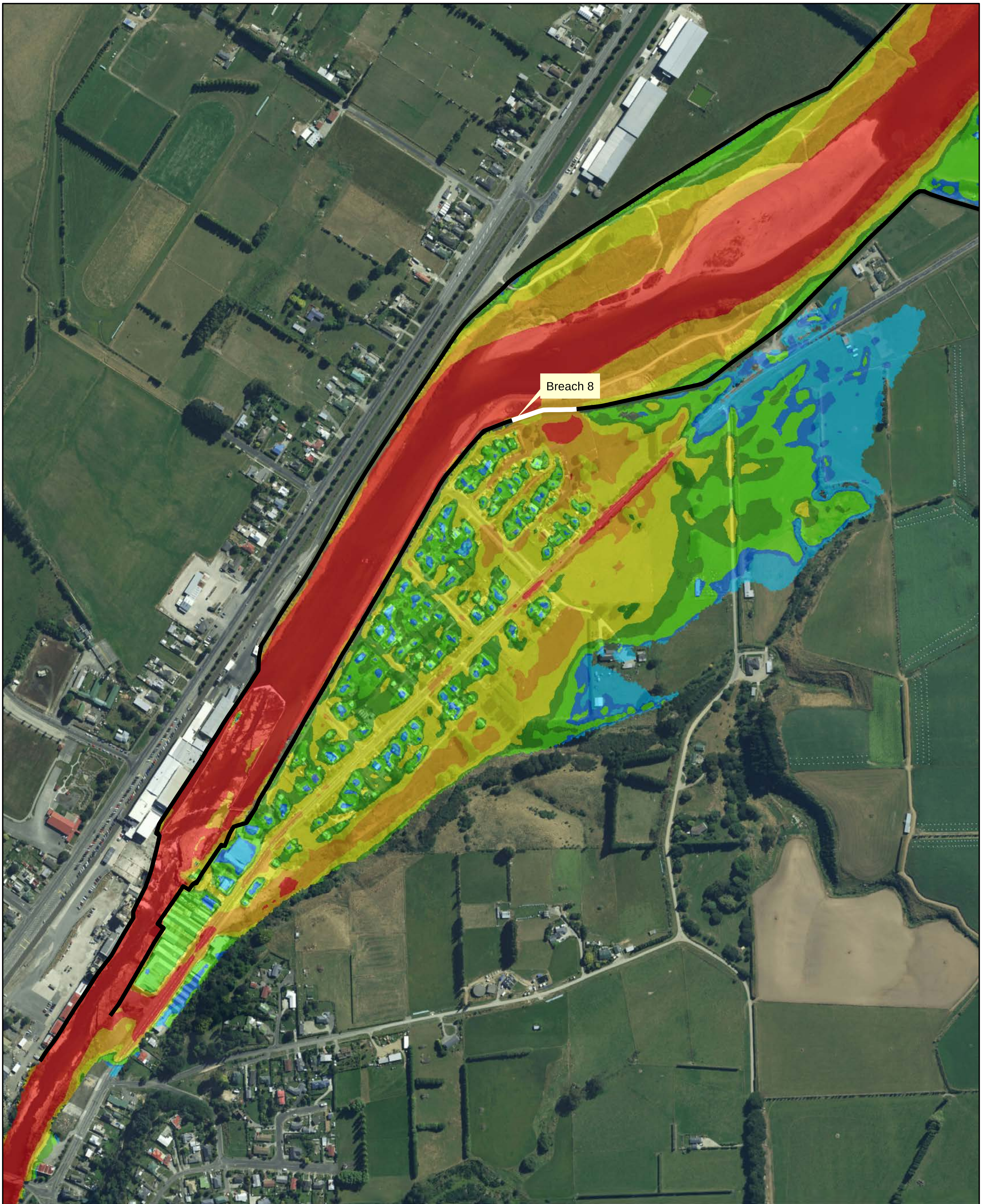
MAP (1 of 1)

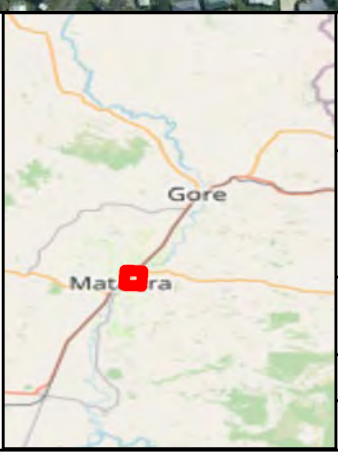
PROJECT
Mataura River Modelling

MAP TITLE
PEAK SPEED MAP
Breach 7
2% AEP Flow, Historic Climate

REVISION	01	Created By	SP	Reviewed By	MG	N
AUTHOR	Matthew Gardner		DATE	12-06-2024		

Model Information
Coordinate System: New Zealand Transverse Mercator
Vertical Datum: NZVD2016
Model Completed: October 2023





Legend

Breach 8

Stopbanks

Speed (m/s)

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

Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 50 100 200 Meters

A3 SCALE 1:5,000

MAP (1 of 1)

PROJECT

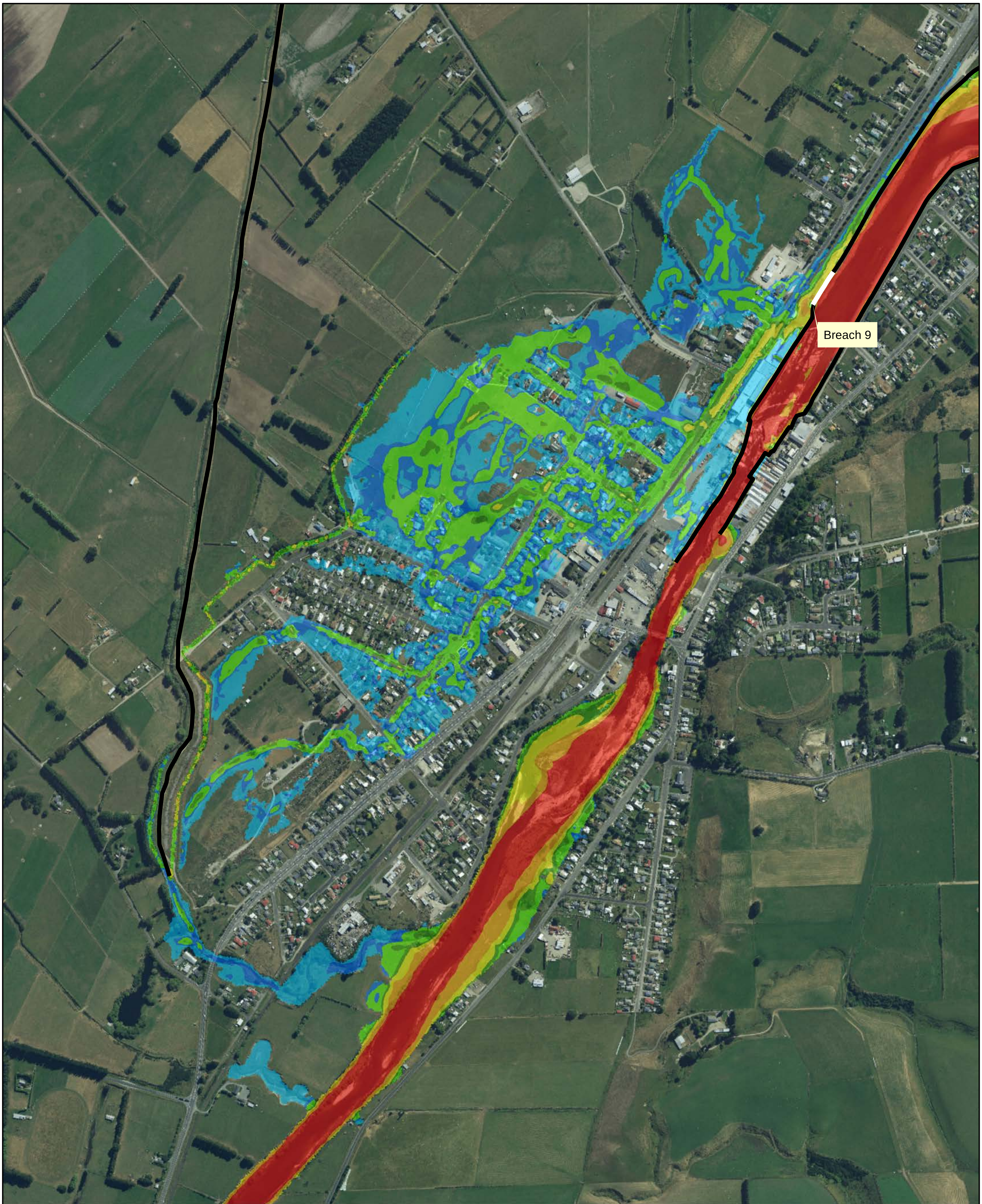
Mataura River Modelling

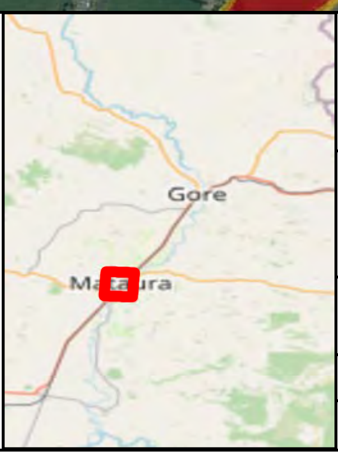
MAP TITLE

PEAK SPEED MAP
Breach 8
2% AEP Flow, Historic Climate

REVISION	01	Created By	SP	Reviewed By	MG	N
AUTHOR	Matthew Gardner		DATE	12-06-2024		

Model Information
Coordinate System: New Zealand Transverse Mercator
Vertical Datum: NZVD2016
Model Completed: October 2023





Legend

Breach 9

Stopbanks

Speed (m/s)

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

Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 75 150 300 Meters

A3 SCALE **1:8,000**

MAP (1 of 1)

PROJECT

Mataura River Modelling

MAP TITLE

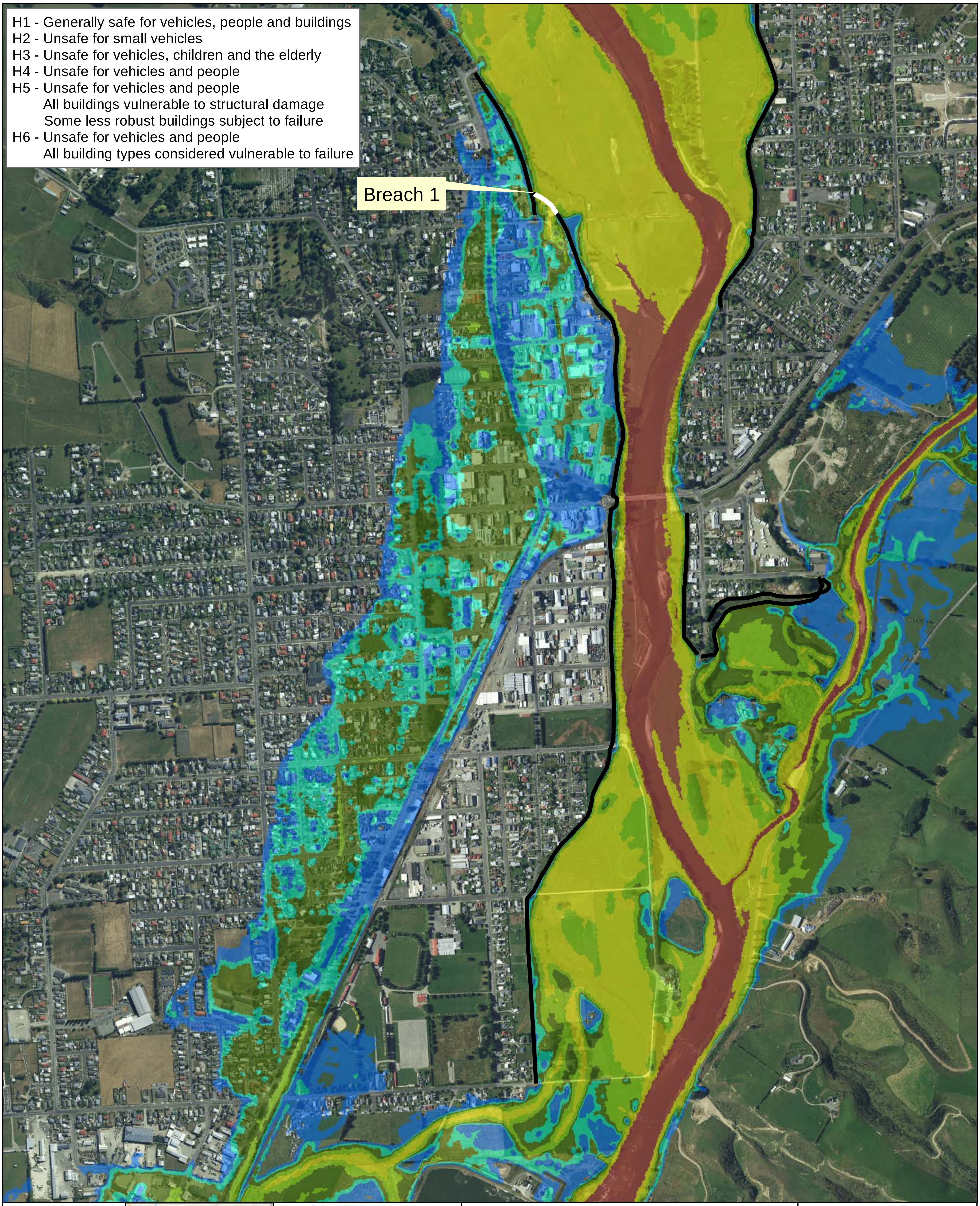
PEAK SPEED MAP

Breach 9

2% AEP Flow, Historic Climate

REVISION	01	Created By	SP	Reviewed By	MG	N
AUTHOR	**Matthew Gardner**		DATE	**12-06-2024**		

Model Information
Coordinate System: New Zealand Transverse Mercator
Vertical Datum: NZVD2016
Model Completed: October 2023



Legend

Breach 1

Stopbanks

Hazard Category

- H6
- H5
- H4
- H3
- H2
- H1

Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 125 250 500 Meters

A3 SCALE **1:10,000**

MAP (1 of 2)

PROJECT

Mataura River Modelling

MAP TITLE

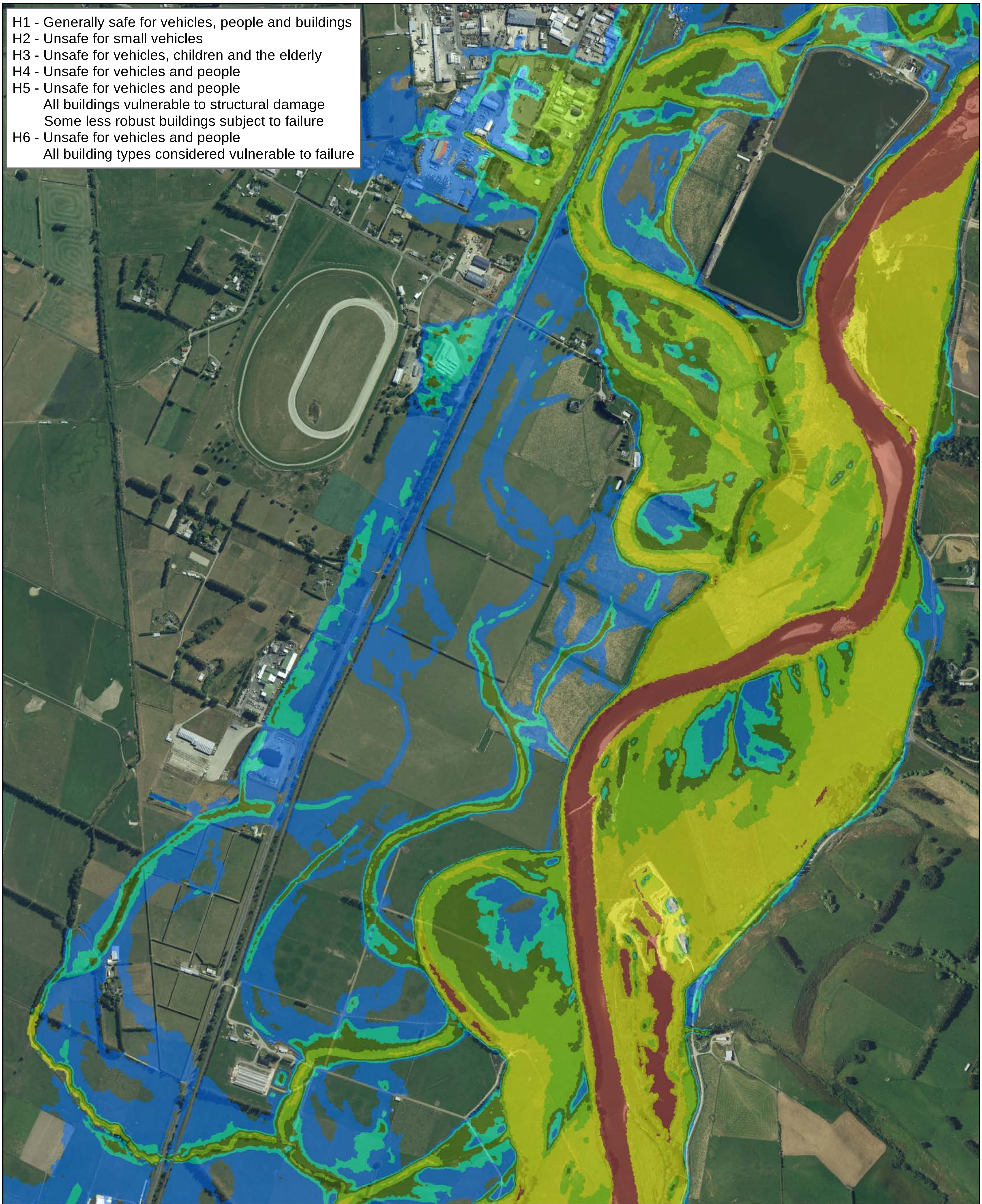
PEAK HAZARD MAP

Breach 1

2% AEP Flow, Historic Climate

REVISION	01	Created By	SP	Reviewed By	MG	N
AUTHOR	**Matthew Gardner**		DATE	**13/06/2024**		

Model Information
Coordinate System: New Zealand Transverse Mercator
Vertical Datum: NZVD2016
Model Completed: October 2023



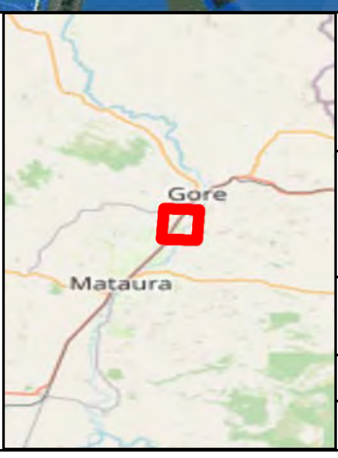
Legend

Breach 1

Stopbanks

Hazard Category

- H6
- H5
- H4
- H3
- H2
- H1



Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 125 250 500 Meters

A3 SCALE **1:10,000**

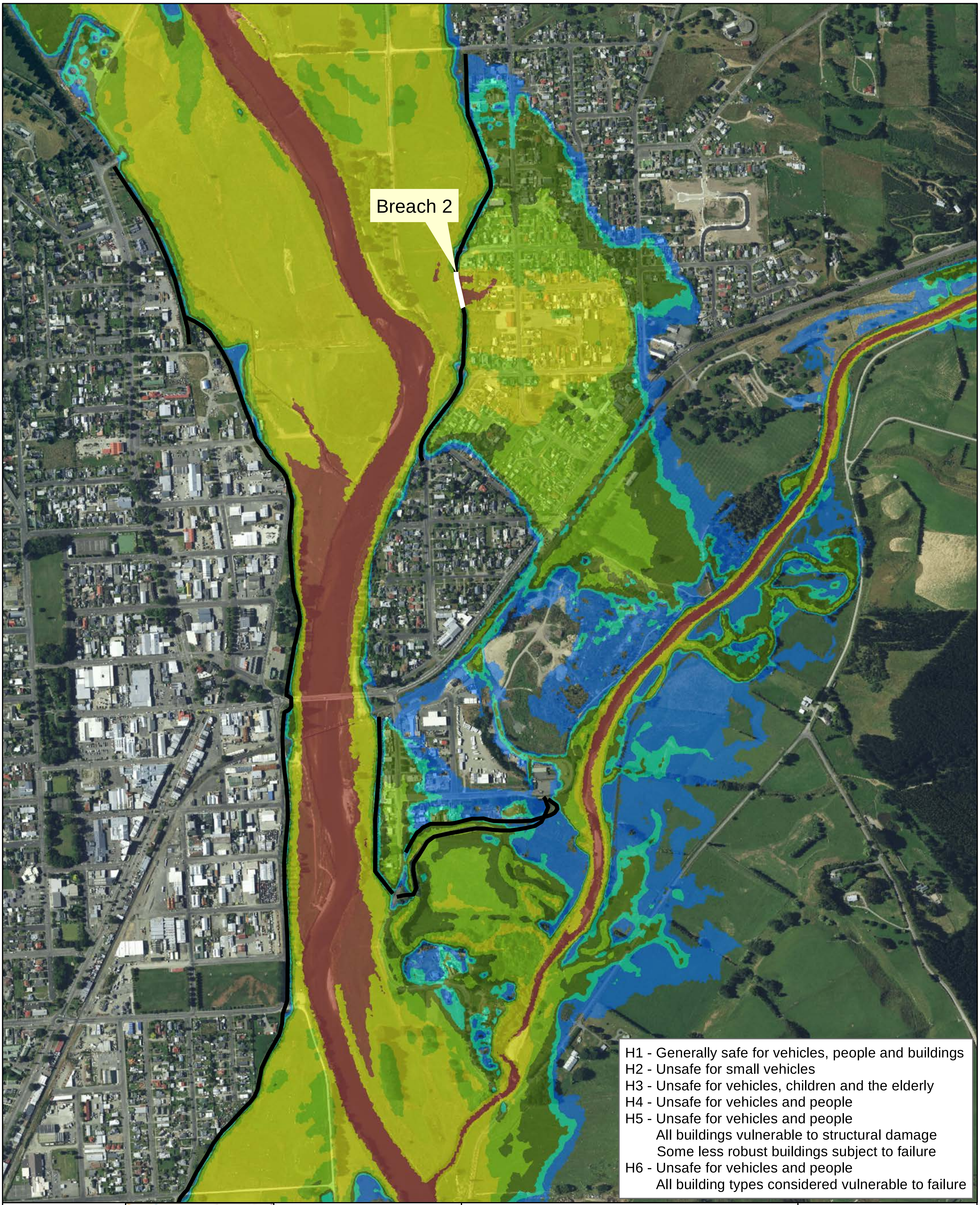
MAP (2 of 2)

PROJECT
Mataura River Modelling

MAP TITLE
PEAK HAZARD MAP
Breach 1
2% AEP Flow, Historic Climate

REVISION	01	Created By	SP	Reviewed By	MG	N
AUTHOR	**Matthew Gardner**		DATE	**13/06/2024**		

Model Information
Coordinate System: New Zealand Transverse Mercator
Vertical Datum: NZVD2016
Model Completed: October 2023



Legend

Breach 2

Stopbanks

Hazard Category

H6

H5

H4

H3

H2

H1

Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 100 200 400 Meters

A3 SCALE **1:8,000**

MAP (1 of 1)

PROJECT

Mataura River Modelling

MAP TITLE

PEAK HAZARD MAP

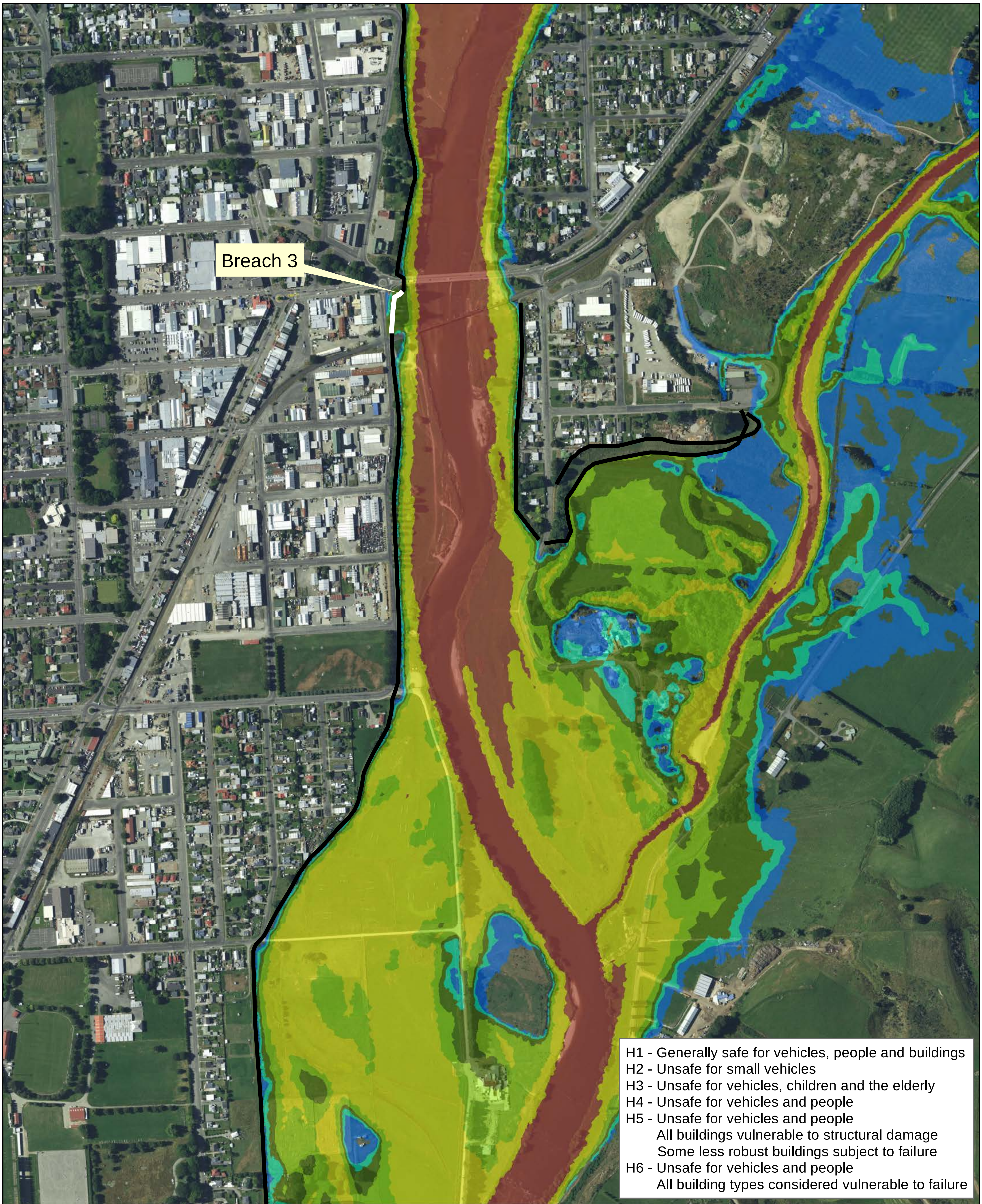
Breach 2

2% AEP Flow, Historic Climate

REVISION	01	Created By	SP	Reviewed By	MG	N

AUTHOR	Matthew Gardner	DATE	14/06/2024

Model Information
Coordinate System: New Zealand Transverse Mercator
Vertical Datum: NZVD2016
Model Completed: October 2023



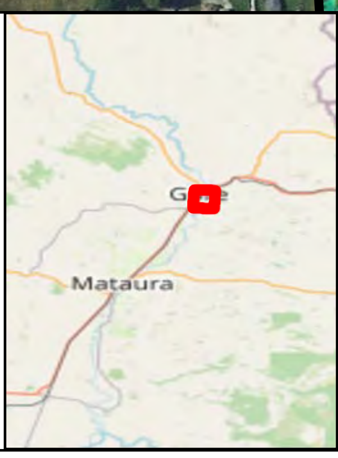
Legend

Breach 3

Stopbanks

Hazard Category

- H6
- H5
- H4
- H3
- H2
- H1



Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 75 150 300 Meters

A3 SCALE **1:6,000**

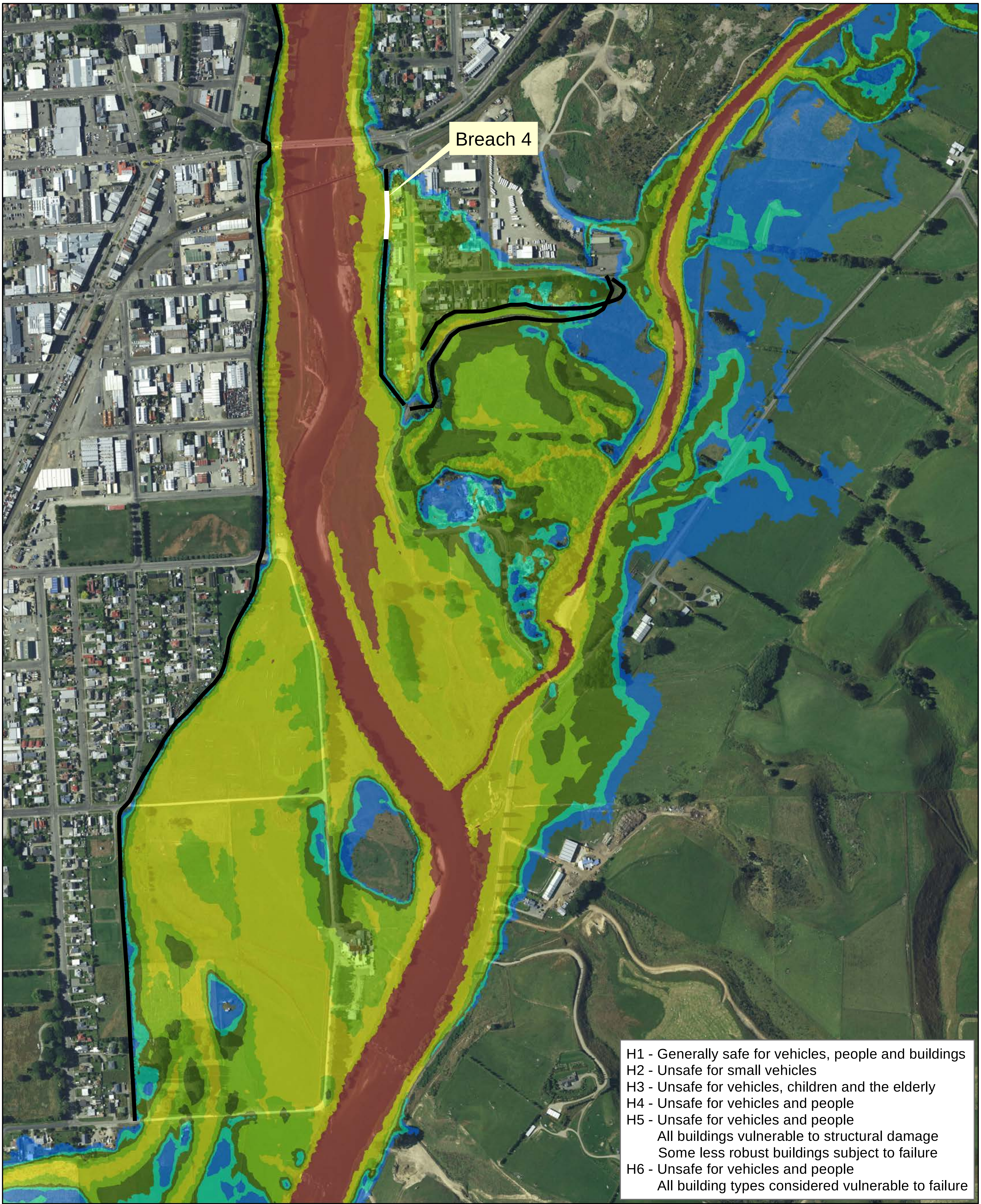
MAP (1 of 1)

PROJECT
Mataura River Modelling

MAP TITLE
PEAK HAZARD MAP
Breach 3
2% AEP Flow, Historic Climate

REVISION	01	Created By	SP	Reviewed By	MG	N
AUTHOR	Matthew Gardner		DATE	13/06/2024		

Model Information
Coordinate System: New Zealand Transverse Mercator
Vertical Datum: NZVD2016
Model Completed: October 2023



Legend

Breach 4

Stopbanks

Hazard Category

- H6
- H5
- H4
- H3
- H2
- H1

Mataura

Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 75 150 300 Meters

A3 SCALE **1:6,000**

MAP (1 of 1)

PROJECT

Mataura River Modelling

MAP TITLE

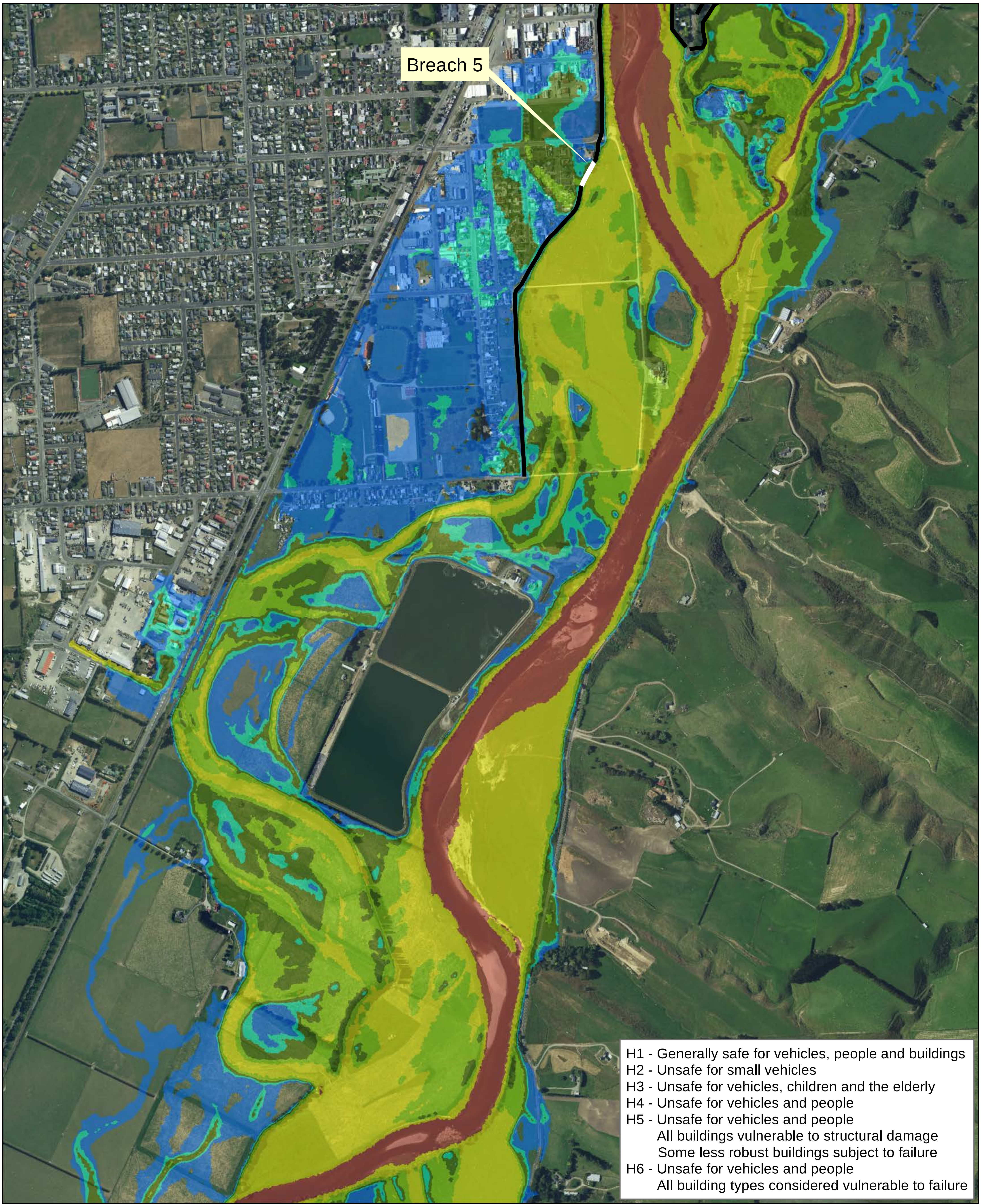
PEAK HAZARD MAP

Breach 4

2% AEP Flow, Historic Climate

REVISION	01	Created By	SP	Reviewed By	MG	N
AUTHOR	**Matthew Gardner**		DATE	**14/06/2024**		

Model Information
Coordinate System: New Zealand Transverse Mercator
Vertical Datum: NZVD2016
Model Completed: October 2023



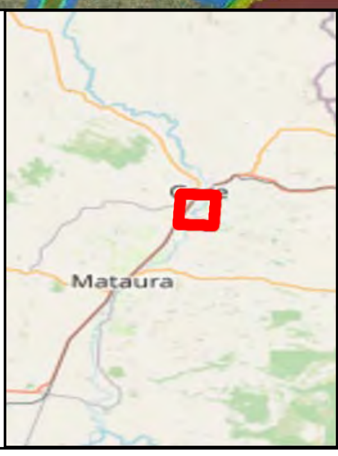
Legend

Breach 5

Stopbanks

Hazard Category

- H6
- H5
- H4
- H3
- H2
- H1



Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 125 250 500
Meters

A3 SCALE 1:10,000

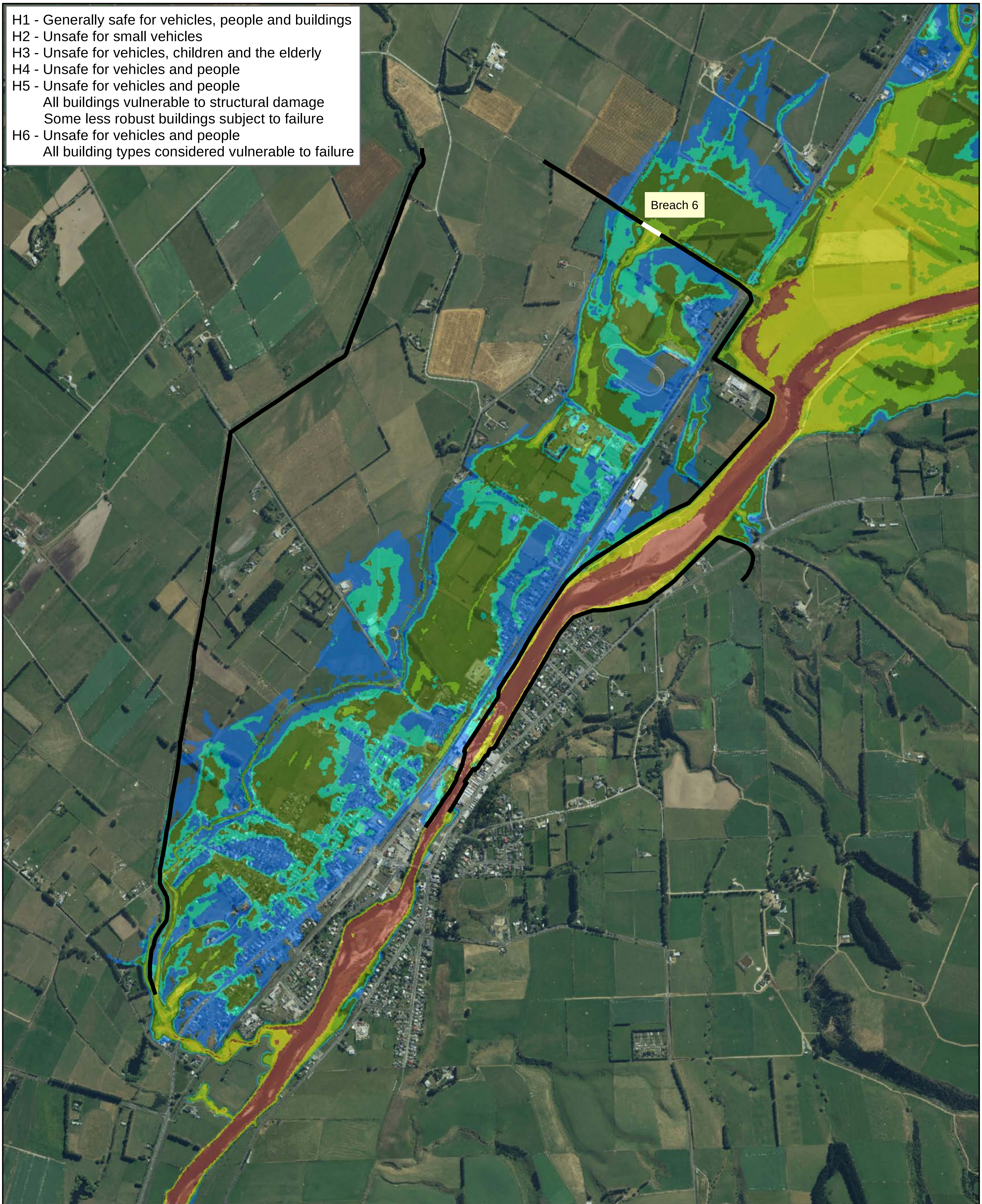
MAP (1 of 1)

PROJECT
Mataura River Modelling

MAP TITLE
PEAK HAZARD MAP
Breach 5
2% AEP Flow, Historic Climate

REVISION	01	Created By	SP	Reviewed By	MG	N
AUTHOR	**Matthew Gardner**		DATE	**13/06/2024**		

Model Information
Coordinate System: New Zealand Transverse Mercator
Vertical Datum: NZVD2016
Model Completed: October 2023



Legend

Breach 6
Stopbanks

Hazard Category

- H6
- H5
- H4
- H3
- H2
- H1

Hazard Category

- H6
- H5
- H4
- H3
- H2
- H1

Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 150 300 600
Meters

A3 SCALE **1:15,000**

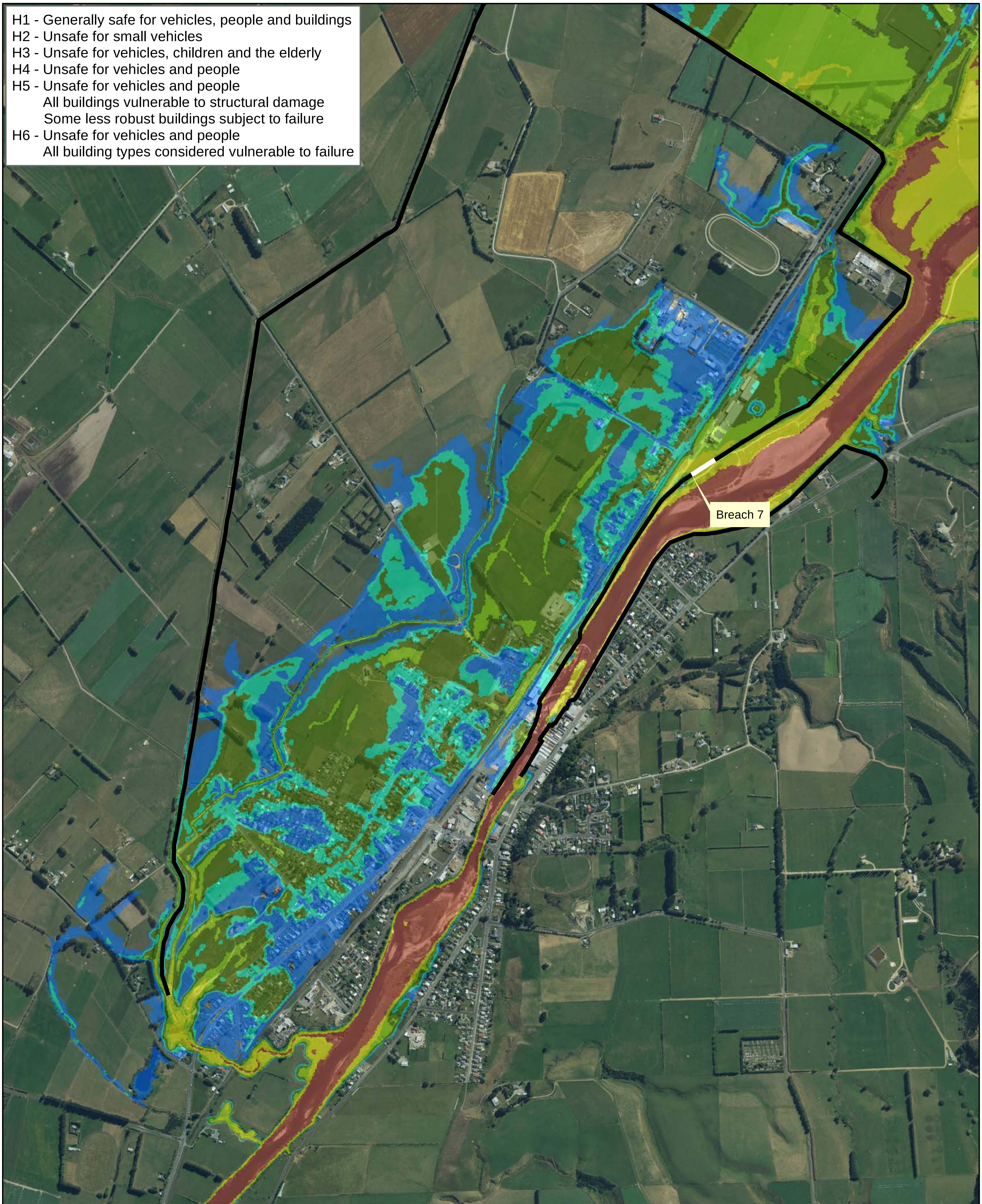
MAP (1 of 1)

PROJECT
Mataura River Modelling

MAP TITLE
PEAK HAZARD MAP
Breach 6
2% AEP Flow, Historic Climate

REVISION	**01**	Created By	**SP**	Reviewed By	**MG**	N
AUTHOR	**Matthew Gardner**		DATE	**12-06-2024**		

Model Information
Coordinate System: New Zealand Transverse Mercator
Vertical Datum: NZVD2016
Model Completed: October 2023



Legend

Breach 7

Stopbanks

Hazard Category

- H6
- H5
- H4
- H3
- H2
- H1

Hazard Category

- H6
- H5
- H4
- H3
- H2
- H1

Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 120 240 480
Meters

A3 SCALE 1:12,500

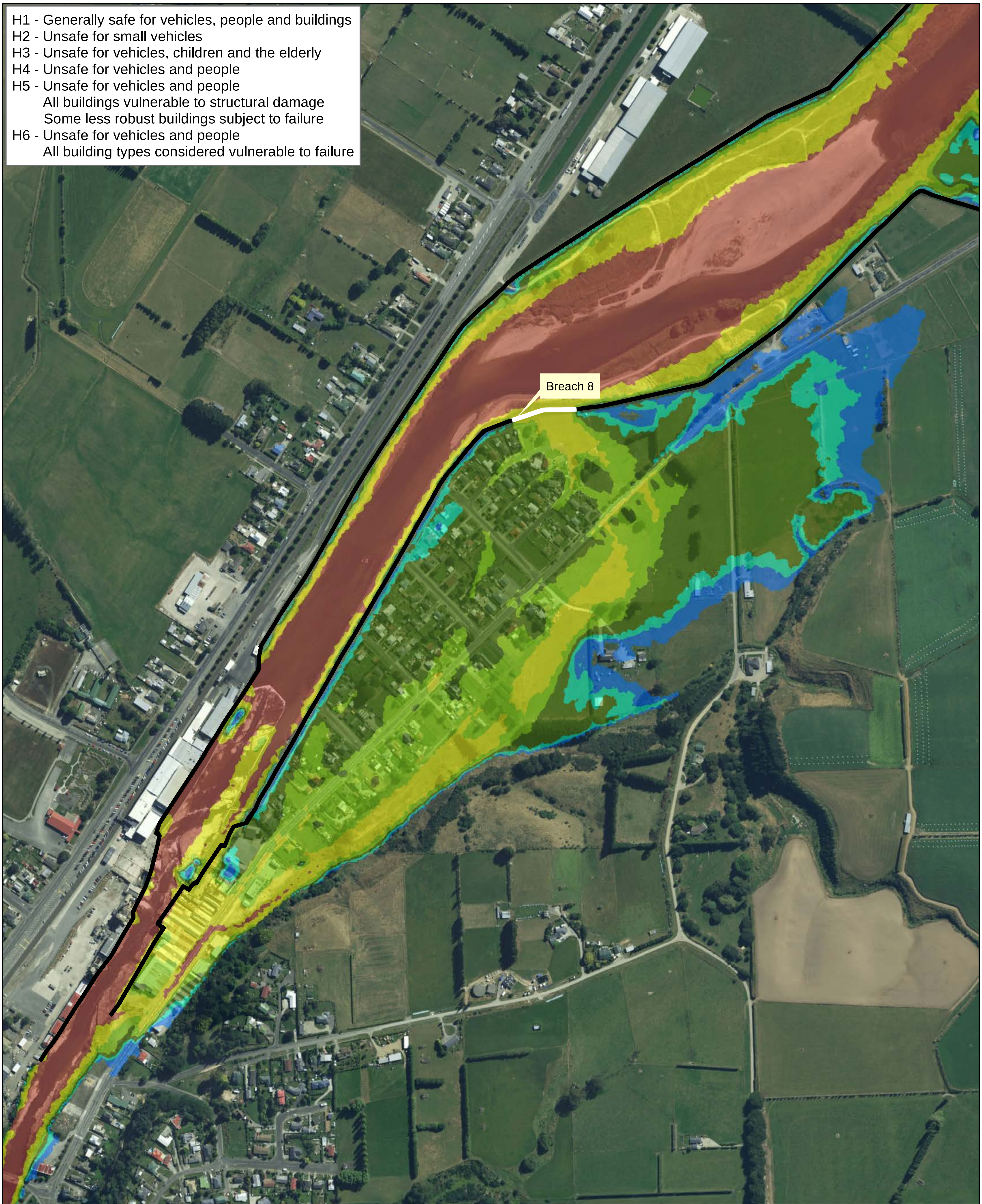
MAP (1 of 1)

PROJECT
Mataura River Modelling

MAP TITLE
PEAK HAZARD MAP
Breach 7
2% AEP Flow, Historic Climate

REVISION	01	Created By	SP	Reviewed By	MG	N
AUTHOR	Matthew Gardner		DATE	12-06-2024		

Model Information
Coordinate System: New Zealand Transverse Mercator
Vertical Datum: NZVD2016
Model Completed: October 2023

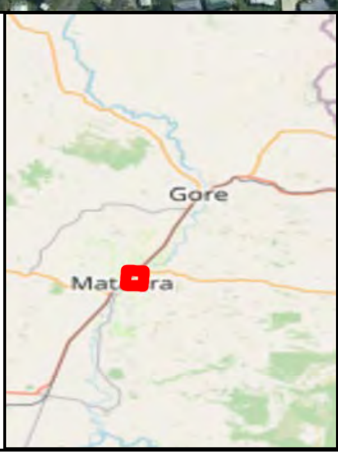


Legend

Breach 8
Stopbanks

Hazard Category
- H6
- H5
- H4
- H3
- H2
- H1

Hazard Category
- H6
- H5
- H4
- H3
- H2
- H1



Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

0 50 100 200 Meters

A3 SCALE **1:5,000**

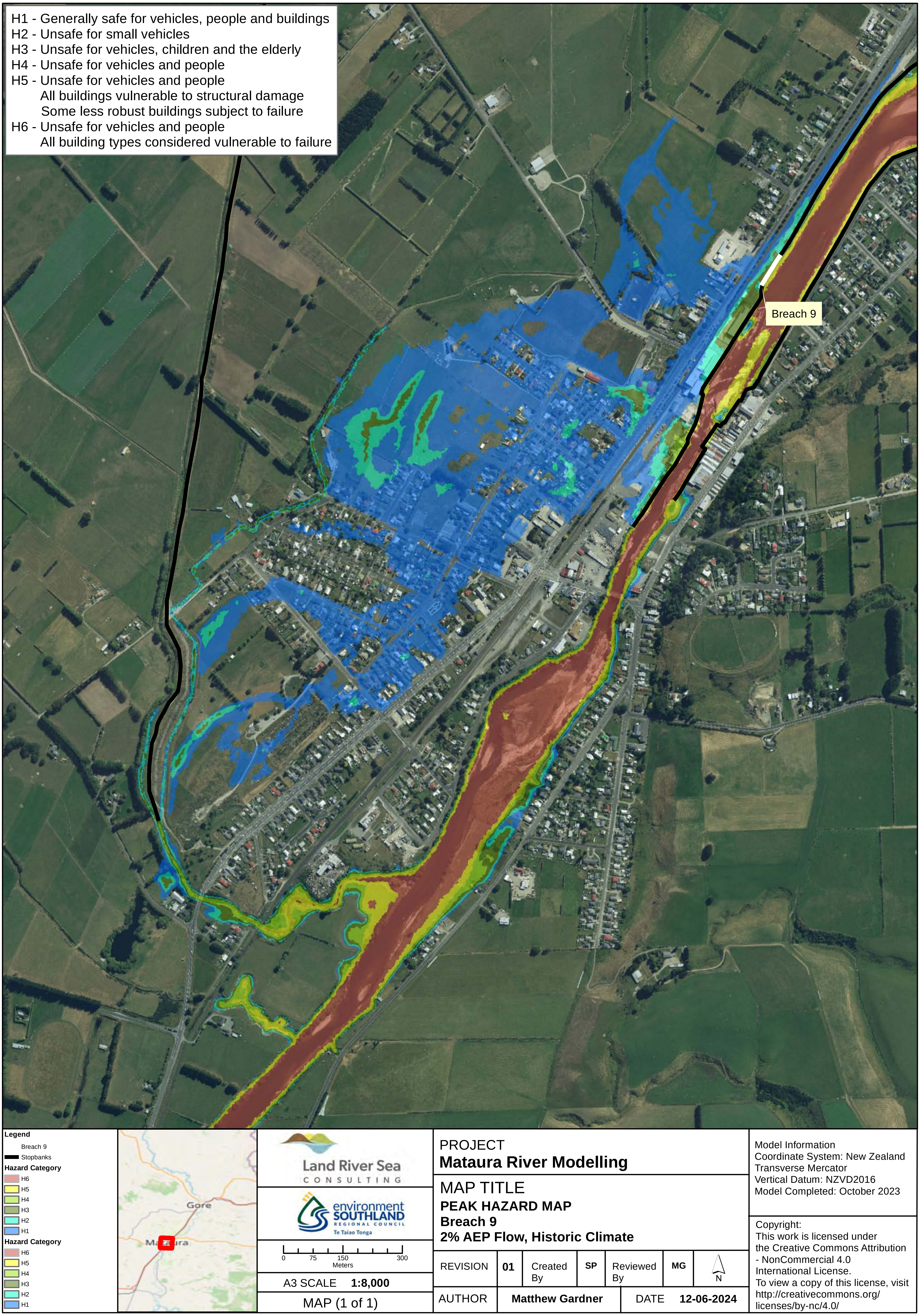
MAP (1 of 1)

PROJECT
Mataura River Modelling

MAP TITLE
PEAK HAZARD MAP
Breach 8
2% AEP Flow, Historic Climate

REVISION	01	Created By	SP	Reviewed By	MG	N
AUTHOR	**Matthew Gardner**		DATE	**12-06-2024**		

Model Information
Coordinate System: New Zealand Transverse Mercator
Vertical Datum: NZVD2016
Model Completed: October 2023



Land River Sea CONSULTING

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

A3 SCALE 1:8,000

MAP (1 of 1)

PROJECT
Mataura River Modelling

MAP TITLE
PEAK HAZARD MAP
Breach 9
2% AEP Flow, Historic Climate

REVISION	01	Created By	SP	Reviewed By	MG
AUTHOR	Matthew Gardner	DATE	12-06-2024		

Model Information
Coordinate System: New Zealand Transverse Mercator
Vertical Datum: NZVD2016
Model Completed: October 2023