BEFORE A PANEL OF INDEPENDENT HEARING COMMISSIONERS IN THE WAIKATO REGION

I MUA NGĀ KAIKŌMIHANA WHAKAWĀ MOTUHEKE WAIKATO

UNDER	the Resource Management Act 1991 (RMA)
AND	
IN THE MATTER	of Proposed Variation 3 to the Waikato Proposed District Plan (PDP)

STATEMENT OF REBUTTAL EVIDENCE OF ANDREW BOLDERO FOR WAIKATO DISTRICT COUNCIL
(STORMWATER)

Dated 19 JULY 2023

TOMPKINS | WAKE

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INTRODUCTION

1. My name is Andrew Stanley Boldero and I am a Principal Stormwater Engineer at Te Miro Water.

2. My qualifications and experience are set out in my statement of evidence in chief (EIC) dated 20 June 2023.

3. I reaffirm the commitment in my EIC to adhere to the Code of Conduct for Expert Witnesses contained in the Environment Court Practice Note 2023.

4. I have read the evidence provided by the submitters to the Independent Hearing Panel that is relevant to my area of expertise.

5. This statement of rebuttal will respond to the evidence of:

    (a) Mr Matthew Davis (stormwater expert on behalf of Ms Noakes);

    (b) Mr Campbell McGregor (stormwater expert on behalf of Hynds);

    (c) Mr Ryan Pitkethley (stormwater expert on behalf of Havelock Village Limited);

    (d) Mr Warren Boag (stormwater expert on behalf of Harrisville Twenty Three Limited); and

    (e) Mr Phil Jaggard (infrastructure expert on behalf of Kāinga Ora).

6. I attended expert conferencing on stormwater on 11 July 2023, and confirm my position as set out in the joint expert statement.

7. The fact this rebuttal statement does not respond to every matter raised in the evidence of a submitter within my area of expertise should not be taken as acceptance of the matters raised. I have focused this rebuttal statement on the key points of difference that warrants a response.

SUMMARY

8. This rebuttal evidence reconfirms that in my expert opinion:

   (a) The Proposed District Plan (PDP) requires additional work to ensure water quality objectives are met;

   (b) Intensification should only be enabled in areas outside of the flood plain (through a qualifying matter); and

   (c) Ideally, any development within a flood plain should require a resource consent to ensure the potential stormwater effects are appropriately assessed and managed.

CONFIRMING MY POSITION SET OUT IN THE JOINT EXPERT CONFERENCING STATEMENT

9. My views as set out in the joint expert statement, and any further clarifications, are summarised below:

   (a) I remain concerned with how Variation 3 (and the existing PDP rules) align to the principles in Te Ture Whaimana and Te Mana o te Wai. I identified this concern in my initial report and recommended that Council undertake further work on this. The potential adverse effects of intensification enabled by Variation 3 within the riparian margins of rivers, overland flow paths and tributaries will likely have the opposite effect of not enabling space for freshwater protection and rehabilitation. I understand that there are restrictions on what amendments can be made under Variation 3 but continue to recommend that further work be undertaken.

   (b) I agree that the stormwater flooding should be a qualifying matter under section 77I(a) – management of significant risks from natural hazards.

(c) I agree that urban development in a flood plain should be discouraged.

(d) I agree that urban development within an identified flood plain should trigger a resource consent to evaluate the effects. If the effects are more than minor then development should be limited/restricted.

(e) I agree that it is inappropriate to provide for the permitted yield of medium density residential standards (MDRS) (3 units per site) within an identified flood plain and therefore this is an appropriate constraint in Variation 3 to development. I note that Mr Jaggard does not agree with this. His position is that a district-wide plan change is required to address flood hazards. I remain concerned that reliance on a future plan change to manage this hazard is inappropriate, as no plan change is currently scheduled. The time between Variation 3 becoming operative, and a new plan change being notified, may enable infilling of the flood plain. Infilling of the flood plain will have adverse accumulative effects that will be very difficult to reverse. Any works required to reverse this effect (if even possible) would significantly impact the community and rate payers.

(f) We agreed at the expert conferencing that Council should consider the preferred method for incorporating the flooding maps into the PDP. In my EIC, I recommended that Council regularly updates the flood hazard maps, ideally without having to undertake a plan change. This approach remains my preference, but I understand the planners, and legal submissions, will address whether this is possible.

(g) I agree and acknowledge that the scope limitations of Variation 3 mean that an additional wider plan change/variation is required, acknowledging that there are outstanding appeals to the PDP, to comprehensively address the stormwater and flooding issues in urban areas as highlighted in the Te Miro Water report.

(h) No changes are proposed to the impervious surfaces rule. As set out in my EIC, it is my view that Variation 3 will push developers to utilise the maximum 70% coverage areas on MDRS sites.

(i) I agree that, as per Mr Matthew Davis's comments (stormwater expert on behalf of Ms Noakes), that additional provisions would be beneficial if added to the PDP (and Variation 3) to assist in ensuring compliance with the guidelines (and to minimise adverse effects). I consider the aspects of concern relating to assessment and mitigation, as raised by Mr Davis, are adequately covered within the Waikato Regional Council (WRC) guidelines.

(j) In relation to low impact design (LID) and whether more specific references or provisions are required in the PDP, I consider that the reference to LID provision within the WRC guidelines is sufficient to obtain the level of LID required. However, I consider the Variation 3 LID provisions could be amended to refer to external documents, such as the WRC guidelines. The requirements in WWS-RI could also be expanded to include more specific requirements to ensure alignment with the WRC guidelines. I cannot comment on whether these changes can be made through the Variation 3 process, the PDP appeals or a new plan change.

(k) I consider the requirements of Council's stormwater discharge consents and the WRC guidelines adequately cover cumulative effects. However, additional PDP rules that provide additional detail of these requirements would be advantageous in terms of ensuring compliance. Variation 3 does not directly manage cumulative effects from infilling of the flood plain. The proposed rules seek to prevent houses from locating in the flood plain.

(l) I agree with the general premise that additional information in the PDP, that outlines and aligns with other legislative requirements and referenced guidelines (RITS, Stormwater Discharge Consent conditions and the WRC guidelines), will be advantageous in the goal of achieving sustainable development.

RESPONSE TO EVIDENCE OF MR DAVIS ON BEHALF OF MS NOAKES

Lack of assessment of stormwater quality

10. Mr Davis considers that no technical assessment has been undertaken for Variation 3 in relation to stormwater quality impacts that might arise from intensification and that Variation 3 has not outlined or provided details of the level of stormwater treatment required. As set out previously, I recommend that the stormwater treatment requirements wording in the PDP should align with the treatment requirements from the Stormwater Discharge Consents (as per RITS and the WRC guidelines).

11. Mr Davis further states that no evidence has been provided as part of the Variation 3 work that shows the water quality targets can be met through the type of intensification enabled by Variation 3. I remain concerned about the permitted activity rule for managing stormwater and agree that there are limited processes in place for Council to check that compliance with the permitted rule has been met to ensure resilient designs to enable Council to monitor performance and compliance.

12. I have discussed the stormwater quality concerns with Ms Huls, and in her rebuttal evidence she recommends a new stormwater management rule for subdivisions of 4 or more lots in the MRZ2 to ensure compliance with the Stormwater Discharge Consents and RITS. I support this rule and continue to recommend that the Council further investigate whether

other changes are required to the PDP to give effect to Te Mana o te Wai and prioritise freshwater quality.

100-year ARI rain fall event

13. Mr Davis suggests that the 100-year ARI rainfall event may not be sufficient for understanding flooding risk, and that modelling of more frequencies higher should be undertaken. In my view, the 100-year ARI event (+ Climate Change) is the most significant rainfall event relating to the required level of service and design parameters. Increasing the level of services and design parameters will have a direct effect on development costs.

14. The WRC guidelines for stormwater management outline the need in some cases to check secondary flow paths under events greater than the 100-year ARI. This is considered good practice (for information) but is not covered under existing legislation or required to be designed for. Increasing the climate change prediction could be considered given the recent increase in rainfall intensity. This scenario would likely add approximately 15% to the runoff volume.

Ms Noakes's property

15. Mr Davis raises a number of concerns relating to existing approved developments and impacts on his client's land in Pookeno. I have not undertaken a site-specific analysis of Ms Noakes property and therefore cannot comment on the matters raised in Mr Davis's evidence. My role in this hearing has been to identify the potential adverse stormwater effects arising from enabling intensification and recommend changes to address those effects.

RESPONSE TO THE EVIDENCE OF MR MCGREGOR ON BEHALF OF HYNDS

Pre-development flows in Pookeno

16. Mr McGregor requests reference in the matters of discretion to the Pokeno Catchment Management Plan (CMP) to ensure surface flows are mitigated to 70% of pre-development flows. This request relates to the fact that the general RITS standard requires mitigation to 80% of pre-development flows, but the Pookeno CMP recommends 70% to ensure catchment wide stormwater risks are managed. I agree with this recommendation. Ms Huls will comment on the proposed wording.

Impervious coverage in Pookeno

17. Mr McGregor queries the use of 65% impervious coverage for the Pokeno CMP updated modelling. I do not consider the use of 65% in the CMP modelling requires an amendment to the 70% rule in the PDP. The use of 65% in the model is a standardised method for representing urban areas for Maximum Probable Development (MPD), as the urban area does not only consist of urban lots. The inclusion of parks, roads and stormwater reserves means that the total representative impervious area is less than the maximum impervious area of 70% for urban lots. 65% impervious coverage for MPD modelling is consistent with standard hydraulic modelling practice, is within the parameter envelope for MPD and aligns with the WRC modelling guidelines.

RESPONSE TO MR PITKETHLEY ON BEHALF OF HAVELOCK VILLAGE LIMITED

18. Mr Pitkethley states that "a key principle of the stormwater design for Havelock is to attenuate post development peak flows up to and including the 1% AEP to 80% pre-development peak flows". His view is that stormwater management of a greenfield development site (like Havelock) will be part of a site-specific stormwater management plan and refers to a number of the external guidance documents.

19. As I have previously identified, the Pookeno CMP requires attenuation to 70% pre-development flows. Mr Pitkethley's comments illustrate to me the need to add reference to the CMP into the PDP so that developers are aware that a different standard is required compared to the general 80% standard in RITS. RITS is currently referred to in the permitted activity rule in an advice note. I understand that the Havelock area is in the upper Pookeno catchment and therefore it will be required to comply with the 70% pre-development flows (1% + Climate Change).

20. As set out above, Ms Huls is also recommending a new rule for subdivision of 4 or more lots to require compliance with the relevant stormwater discharge consents.

RESPONSE TO MR BOAG ON BEHALF OF HARRISVILLE

21. Mr Boag has provided a copy of the stormwater assessment he undertook for a 14-lot subdivision of the Harrisville property. His evidence refers to a maximum yield of 25 lots through the rezoning to allow for the use of the MDRS. I understand from Ms Hill that potentially more lots than 25 would, in theory, be enabled by the rezoning request, and therefore the current assessment undertaken is not representative of the potential outcomes.

22. I have reviewed the report provided and agree with Ms Hill's review that increasing the lot density and building coverage would increase effects and that the development would require additional mitigation to manage these additional effects.

RESPONSE TO MR JAGGARD ON BEHALF OF KĀINGA ORA

Building coverage

23. Mr Jaggard considers that the building coverage standard is not important to managing stormwater, and that the impervious surface standard is the key control.

24. In my view the building coverage, while not directly related to stormwater effects, does have the ability to adversely and indirectly affect the flood levels and watercourse erosion (due to increased velocity). Increased building coverage standards will more likely result in sites being developed to the maximum impermeable surface limit of 70%.

25. Ultimately, any permitted activity providing for infilling of the flood plain will decrease flood storage volume and increase flood levels. Infilling can also reduce the cross sectional area of an overland flow path. Any reduction in the cross sectional area will increase the water level and velocities which can increase erosion and decrease slope stability.

26. Similarly, it is Mr Jaggard's view that redevelopment of a site into 1, 2 or 3 residential units will likely result in the same or similar stormwater discharges and effects from the site. As I set out above, infilling in the flood plain will have adverse effects to surrounding properties and watercourses.

27. I have discussed this matter further with Ms Huls, and we have agreed that a new rule should be introduced to require a resource consent for earthworks within the flood plain associated with two or more residential units. I understand that all experts would accept this rule as there was agreement in the joint expert statement that a resource consent should be required for development within the flood plain. As a result of this rule, I no longer consider it necessary to reduce the permitted building coverage.

Setbacks

28. In my EIC I supported the retention of the current boundary setback rules to support better stormwater outcomes, including 3 metres from the front boundary and 1.5m from all other boundaries. Mr Jaggard considers that these setbacks could have poorer stormwater outcomes, including directing buildings further into a site and potentially into the overland flow path or flood plain on the site. I agree that the location and size of the setbacks are only relevant to stormwater when they are located within the flood plain (or an overland flow path). Setbacks outside of the flood plain can align with the proposed MDRS rules and will have minimal effects on stormwater quantity management.

29. As resource consent will be required for more than one residential unit in the flood plain, I agree that the boundary setback standard can be reduced to the MDRS standards.

Water quality

30. Mr Jaggard states that the greater the building coverage on a site the lower potential generation of water quality contaminants. While this is not linked to any suggested rule, in my view this is only the case where there is existing old buildings and structures that are contamination generating.

31. This is not the case when the building coverage is replacing vegetated areas such as greenfield developments or larger parent lots that are prevalent in the Waikato District towns. In my experience the scenario outlined by Mr Jaggard is very rare and is a scenario that I have not seen over the last four years of reviewing stormwater consents. The uncontrolled contamination risk from human activities (washing cars, hydrocarbon spills, chemical and fertiliser use) is proportional to the number of people and residences.

REVISED FLOOD MAPS

32. A number of submitters commented on the need to finalise the flood maps that were attached to the draft Te Miro Water Report. As acknowledged in that report, further refinements were required, but given the tight timeframes involved the report needed to be circulated to the submitters. The following refinements have been made to the models:

(a) Infilling of artificial isolated ponding areas caused by the LIDAR processing (removal of buildings);

(b) Further refinement of culverts and pipe networks critical to represent accurate flood levels;

(c) Sensitivity testing of storm duration and stabilisation checks;

(d) The addition of pipes and confirmation of levels provided by Watercare from the latest set of asset data;

(e) Alignment of storm durations for all towns to 24 hours; and

(f) Expanded hydraulic reporting as per review comments.

33. Since the report was first made available, the Council has engaged an independent reviewer. The review found that the methodology undertaken was aligned with the WRC Hydraulic Modelling guidelines and therefore provides good representation of flood risk.

34. The modelling has now been rerun and a series of flood maps for each town are now attached to this rebuttal evidence as Annexure A. There are four maps for each town illustrating:

(a) The extent of the flood plain including flood depths (includes overland flow paths);

(b) The extent of high risk flood risk area as defined by the PDP;

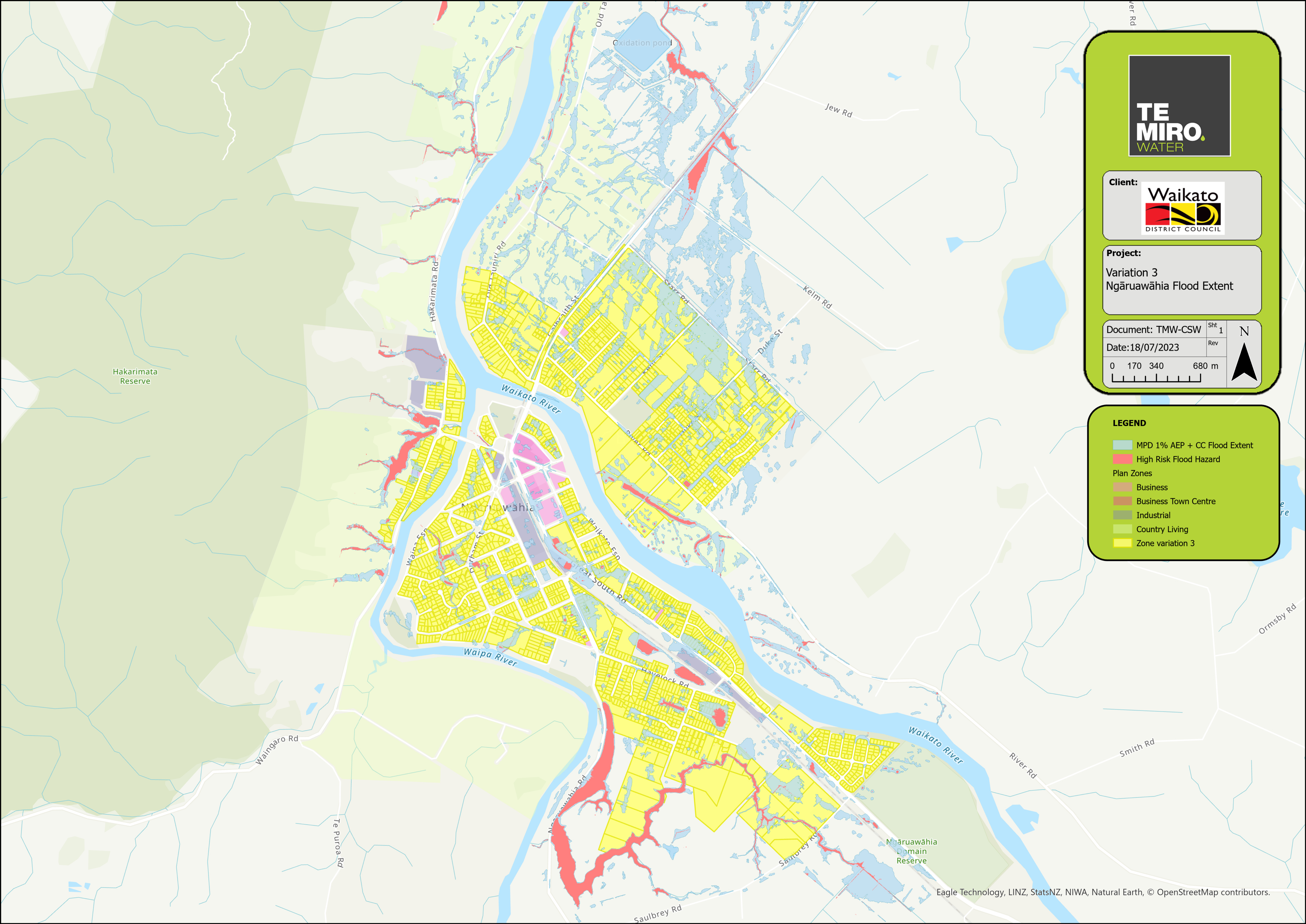
(c) The extent of undersized pipes (installation date based analysis); and

(d) Within the Hydraulic modelling reports, a fourth map is provided showing the network and culverts included in the modelling as requested at the expert conferencing.

35. Attached as Annexure B are the modelling reports supporting the flood maps.

Andrew Boldero
19 July 2023

Appendix A – revised flood maps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Waikato District Council
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Variation 3
Ngāruawāhia Flood Extent
Document: TMW-CSW
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Rev
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0 170 340 680 m
N
LEGEND
MPD 1% AEP + CC Flood Extent
High Risk Flood Hazard
Plan Zones
Business
Business Town Centre
Industrial
Country Living
Zone variation 3
Oxidation pond
Jew Rd
Kelm Rd
Duke St
Hakarimata Rd
Hakarimata Reserve
Waikato River
Waipa River
Waingaro Rd
Te Puroa Rd
Havelock Rd
Great South Rd
Waikato Esp
Waipa Esp
Durham St
Saulbrey Rd
Ngāruawāhia Domain Reserve
River Rd
Smith Rd
Ormsby Rd
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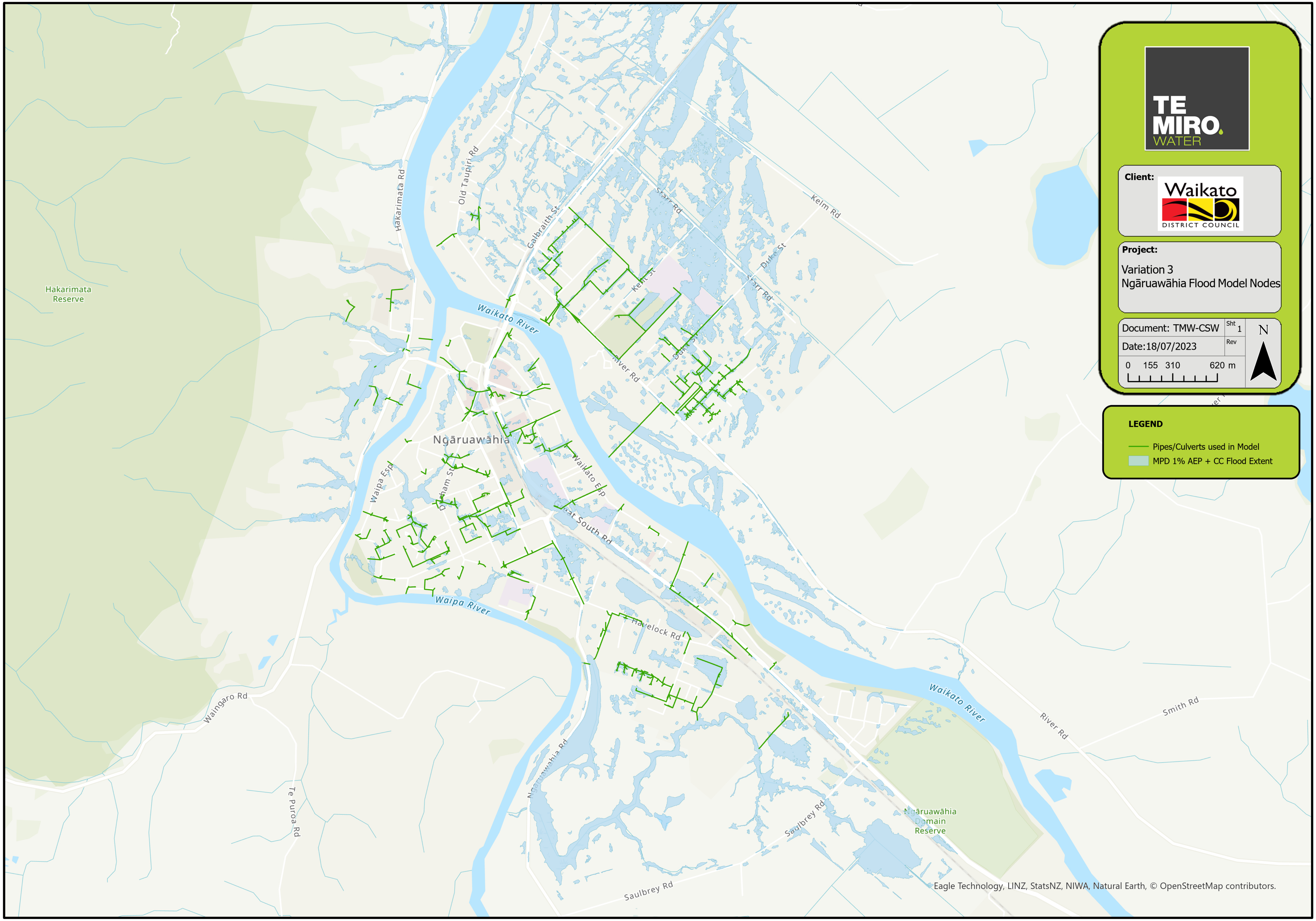
Hakarimata Reserve
Hakarimata Rd
Old Taupiri Rd
Galbraith St
Starr Rd
Kelm Rd
Duke St
Kent St
Waikato River
River Rd
Ngāruawāhia
Waikato Esp
Waipa Esp
Durham St
Great South Rd
Waipa River
Havelock Rd
Waingaro Rd
Te Puroa Rd
Ngaruawahia Rd
Saulbrey Rd
Ngāruawāhia Domain Reserve
Smith Rd
Eagle Technology, LINZ, StatsNZ, NIWA, Natural Earth, © OpenStreetMap contributors.
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Waikato DISTRICT COUNCIL
Project:
Variation 3
Ngāruawāhia Flood Model Nodes
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Date: 18/07/2023
0 155 310 620 m
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LEGEND
Pipes/Culverts used in Model
MPD 1% AEP + CC Flood Extent


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LEGEND
MPD Flood Model 1% AEP + CC
Maximum Depth (m)
<0.1
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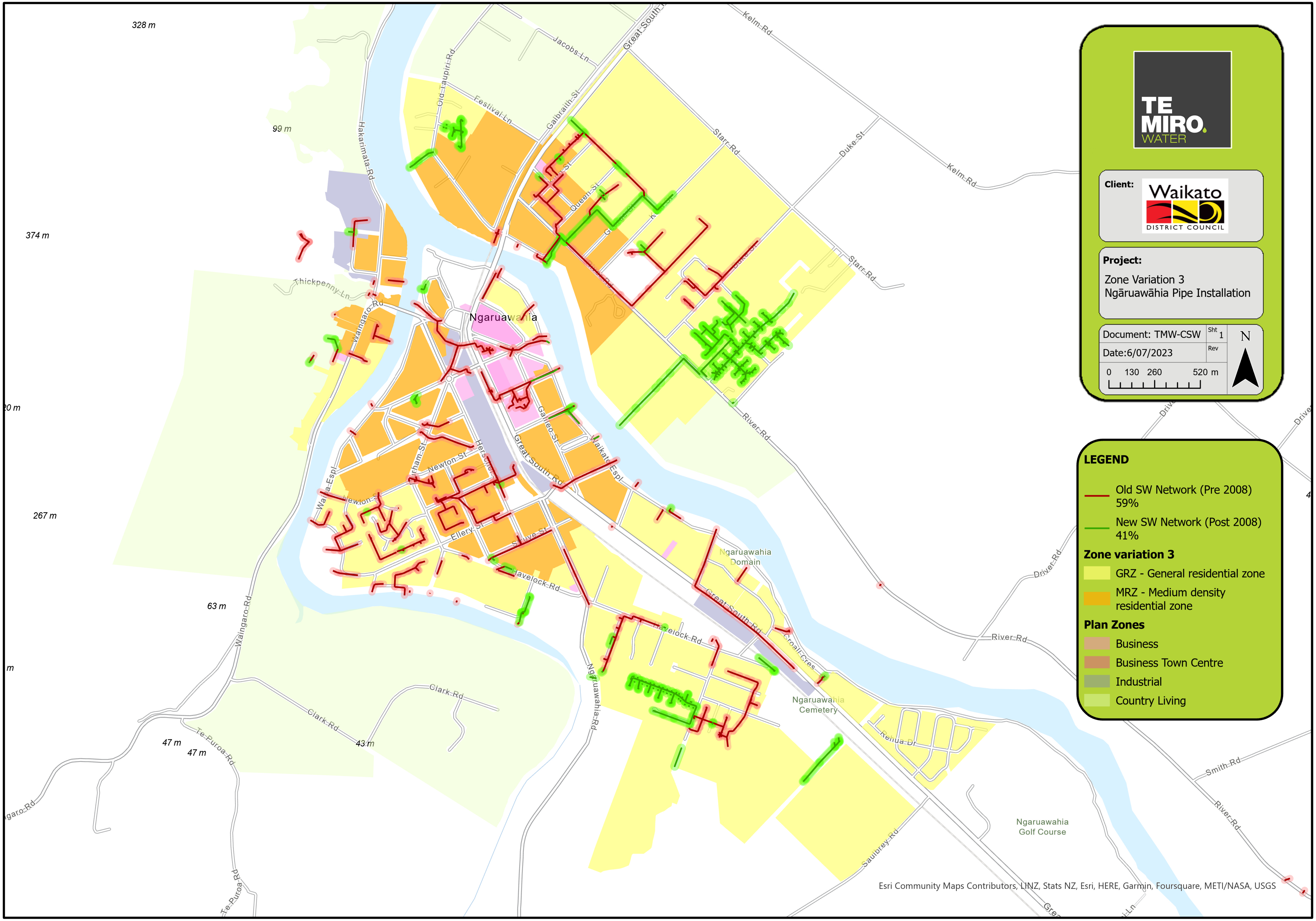
0.40-0.60
0.60-0.80
0.80-1.0
1.0-2.0
>2.0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Zone Variation 3
Ngāruawāhia Pipe Installation
Document: TMW-CSW
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Date:6/07/2023
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N
LEGEND
Old SW Network (Pre 2008) 59%
New SW Network (Post 2008) 41%
Zone variation 3
GRZ - General residential zone
MRZ - Medium density residential zone
Plan Zones
Business
Business Town Centre
Industrial
Country Living
Ngaruawahia
Ngaruawahia Domain
Ngaruawahia Cemetery
Ngaruawahia Golf Course
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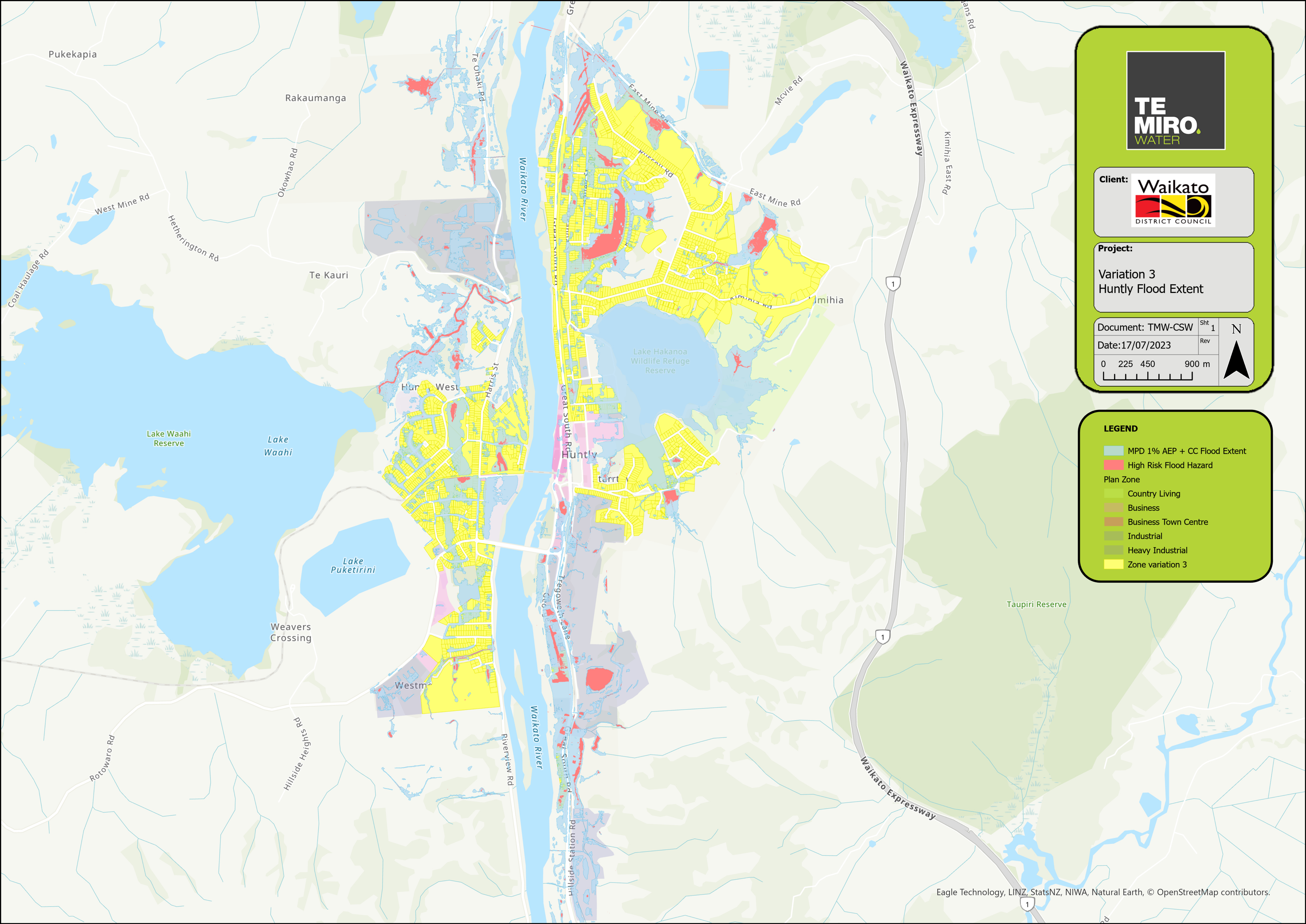
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N
LEGEND
MPD 1% AEP + CC Flood Extent
High Risk Flood Hazard
Plan Zone
Country Living
Business
Business Town Centre
Industrial
Heavy Industrial
Zone variation 3
Pukekapia
Rakaumanga
West Mine Rd
Hetherington Rd
Okowhao Rd
Te Kauri
Coal Haulage Rd
Lake Waahi Reserve
Lake Waahi
Lake Puketirini
Weavers Crossing
Rotowaro Rd
Hillside Heights Rd
Riverview Rd
Waikato River
Te Ohaki Rd
Harris St
Great South Rd
Huntly
Tregoweth Lane
Hillside Station Rd
East Mine Rd
Mcvie Rd
Waikato Expressway
Kimihia East Rd
Lake Hakanoa Wildlife Refuge Reserve
Taupiri Reserve
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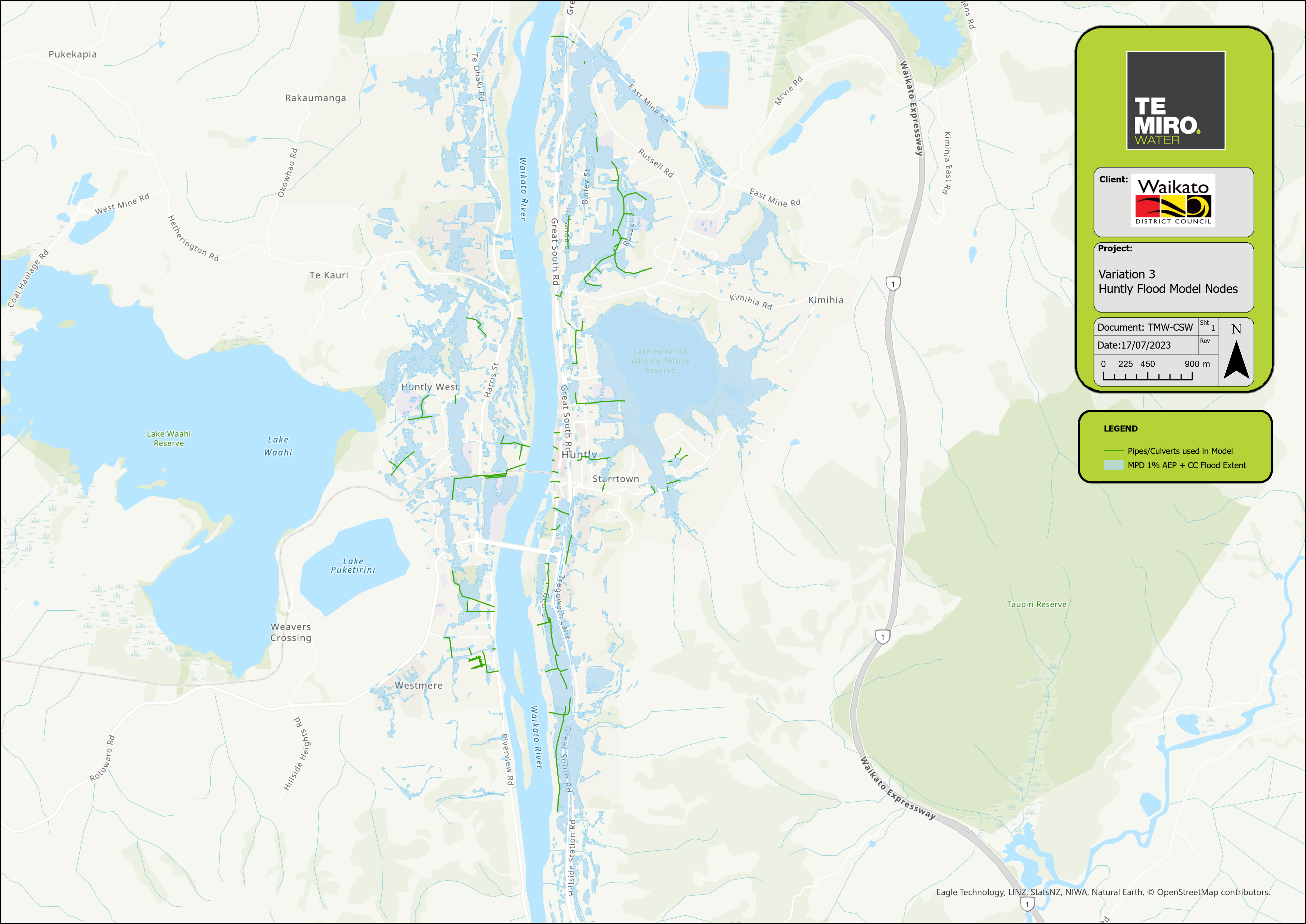

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Waikato DISTRICT COUNCIL
Project:
Variation 3
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Document: TMW-CSW
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Date:17/07/2023
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LEGEND
Pipes/Culverts used in Model
MPD 1% AEP + CC Flood Extent
Pukekapia
Rakaumanga
Te Kauri
Huntly West
Huntly
Huntly
Kimihia
Lake Waahi Reserve
Lake Waahi
Lake Puketirini
Lake Hakanoa Wildlife Refuge Reserve
Weavers Crossing
Westmere
Taupiri Reserve
Waikato River
Waikato Expressway
Great South Rd
East Mine Rd
West Mine Rd
Russell Rd
Kimihia Rd
Hetherington Rd
Okowhao Rd
Coal Haulage Rd
Te Ohaki Rd
Harris St
Bailey St
Mcvie Rd
Kimihia East Rd
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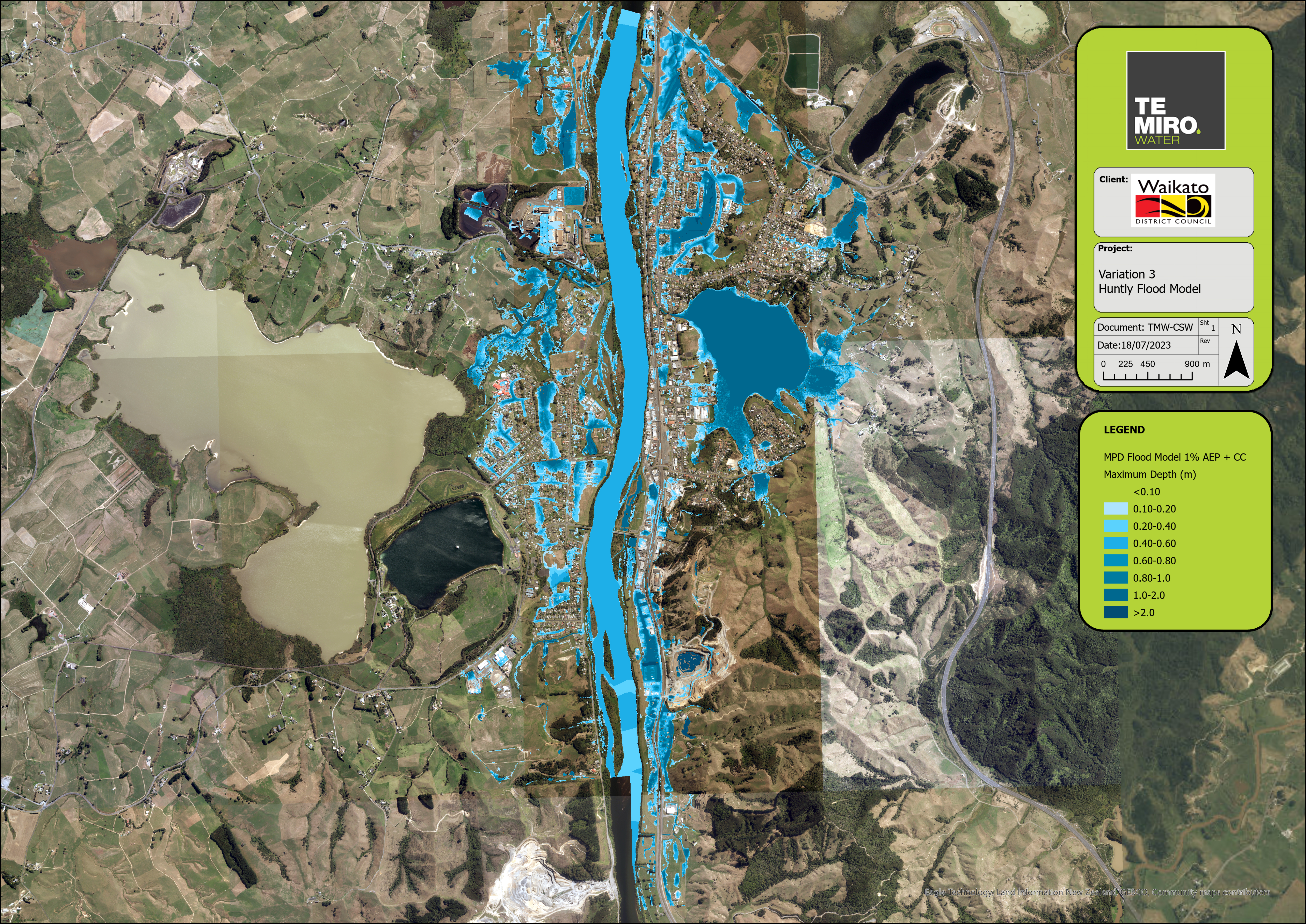
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Document: TMW-CSW
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Rev
0 225 450 900 m
N
LEGEND
MPD Flood Model 1% AEP + CC
Maximum Depth (m)
<0.10
0.10-0.20
0.20-0.40
0.40-0.60
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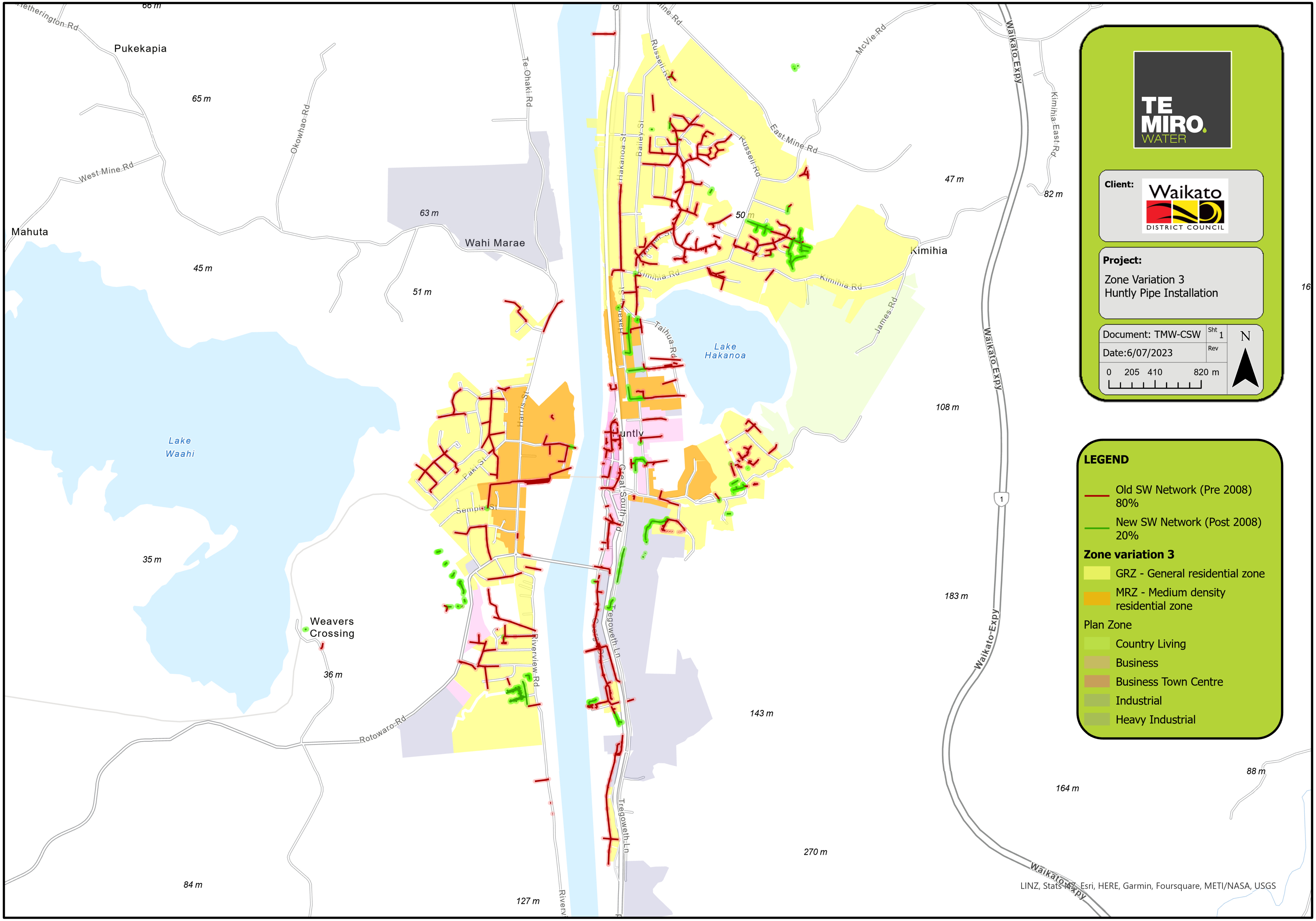
Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors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Date:6/07/2023
Rev
0 205 410 820 m
N
LEGEND
Old SW Network (Pre 2008) 80%
New SW Network (Post 2008) 20%
Zone variation 3
GRZ - General residential zone
MRZ - Medium density residential zone
Plan Zone
Country Living
Business
Business Town Centre
Industrial
Heavy Industrial
Pukekapia
Mahuta
Wahi Marae
Lake Waahi
Weavers Crossing
Lake Hakanoa
Kimihia
Huntly
West-Mine-Rd
Okowhao-Rd
Te-Ohaki-Rd
Russell-Rd
East-Mine-Rd
McVie-Rd
Kimihia-Rd
Taihua-Rd
James-Rd
Waikato-Expy
Kimihia-East-Rd
Great-South-Rd
Tregoweth-Ln
Riverview-Rd
Rotowaro-Rd
Paki-St
Semple-St
65 m
45 m
63 m
51 m
35 m
36 m
84 m
127 m
50 m
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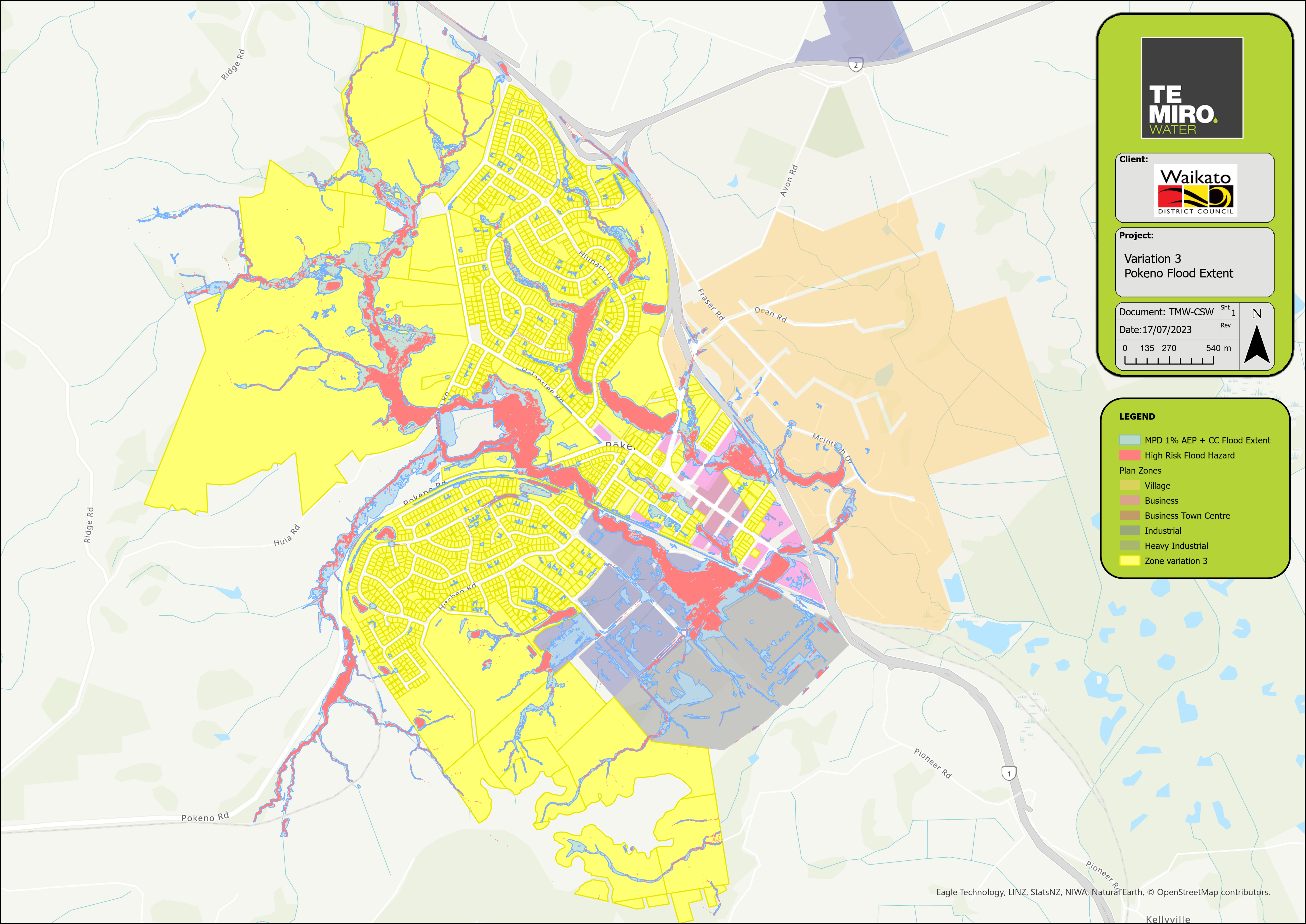

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Rev
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LEGEND
MPD 1% AEP + CC Flood Extent
High Risk Flood Hazard
Plan Zones
Village
Business
Business Town Centre
Industrial
Heavy Industrial
Zone variation 3
Ridge Rd
Avon Rd
Fraser Rd
Dean Rd
Pokeno Rd
Huia Rd
Pioneer Rd
Kellyville
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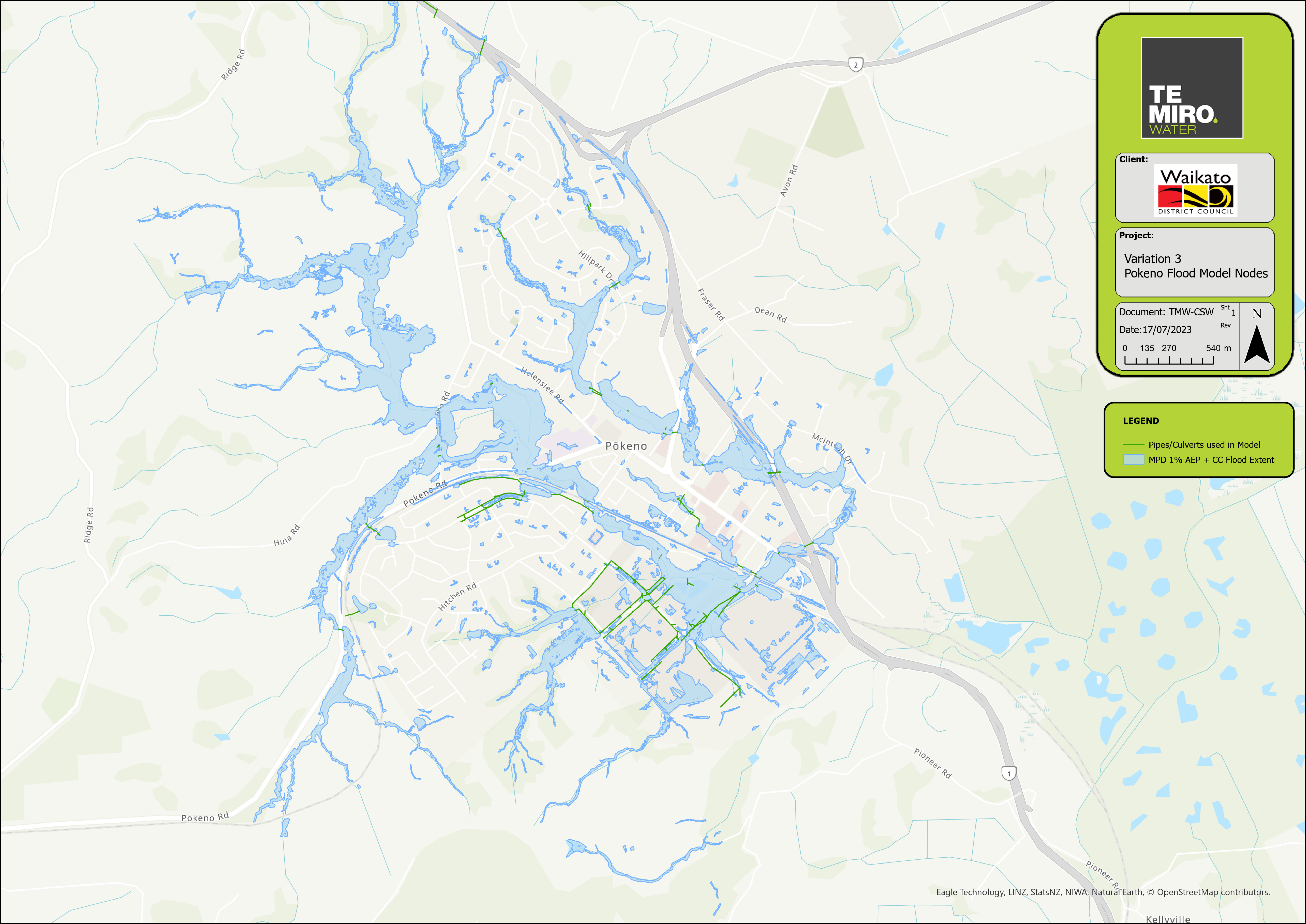
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Pipes/Culverts used in Model
MPD 1% AEP + CC Flood Extent
Pōkeno
Ridge Rd
Hillpark Dr
Helenslee Rd
Avon Rd
Fraser Rd
Dean Rd
Mcintosh Dr
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Huia Rd
Hitchen Rd
Pioneer Rd
Kellyville
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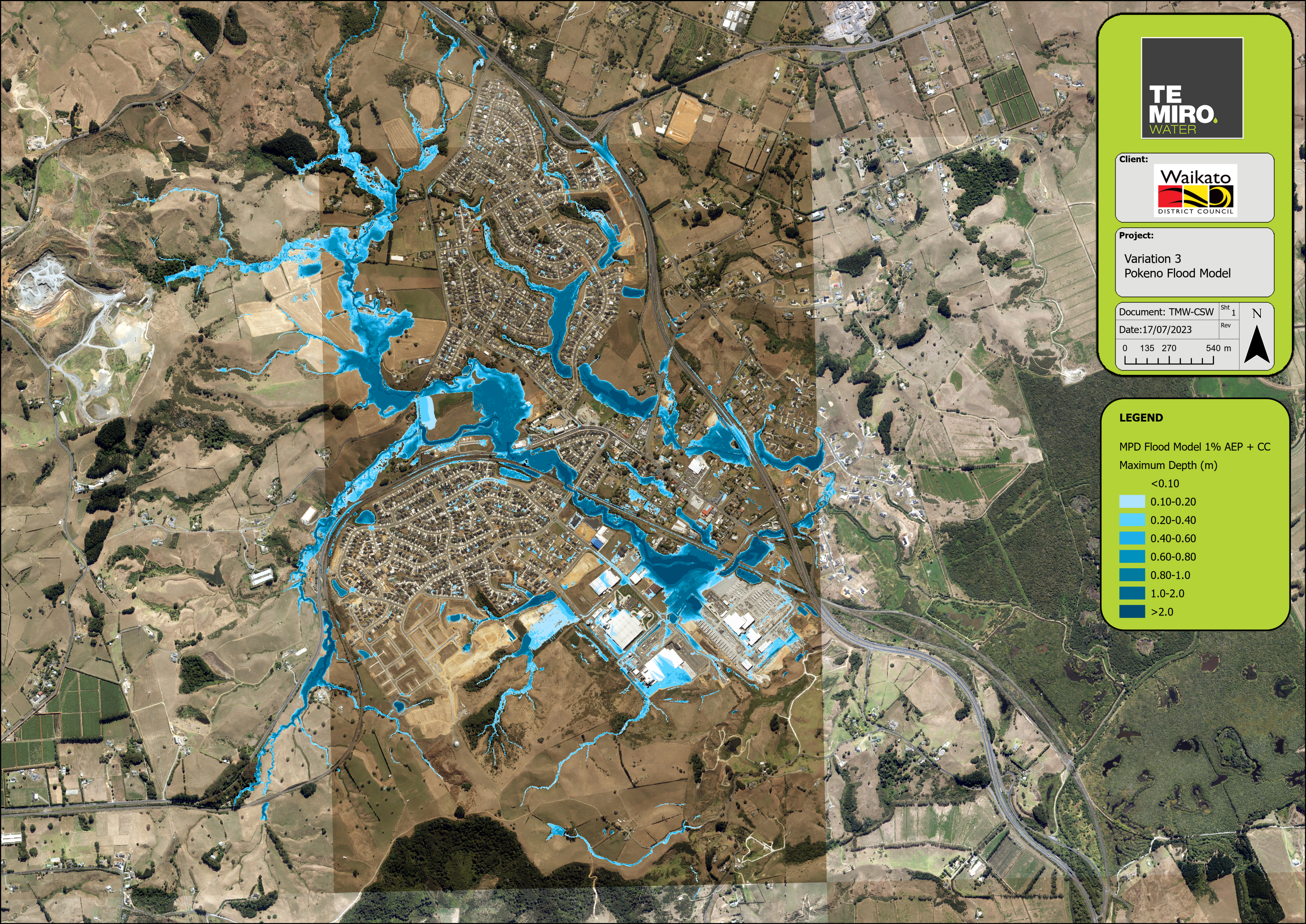
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LEGEND
MPD Flood Model 1% AEP + CC
Maximum Depth (m)
<0.10
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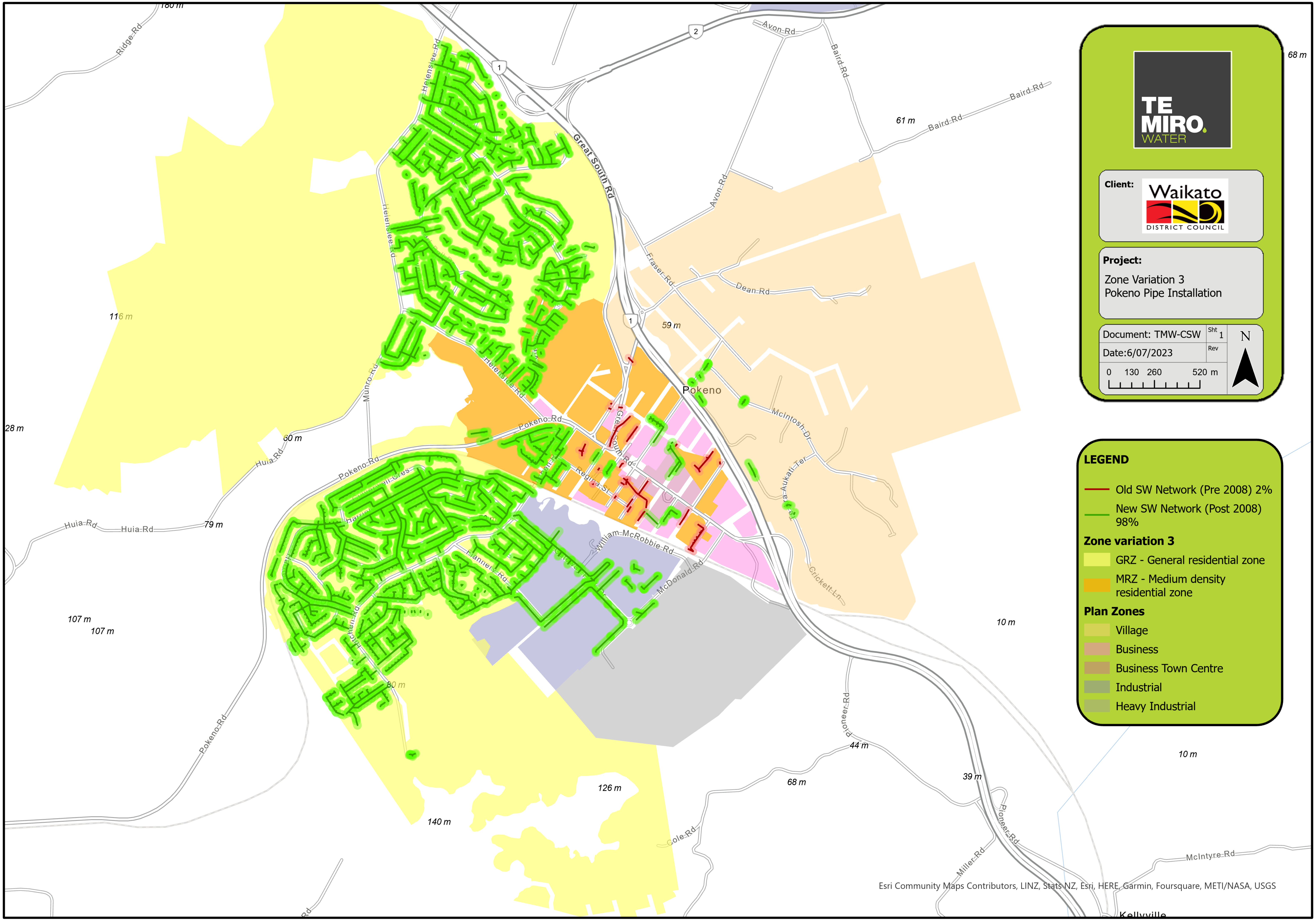
1.0-2.0
>2.0



TE MIRO WATER
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Project:
Zone Variation 3
Pokeno Pipe Installation
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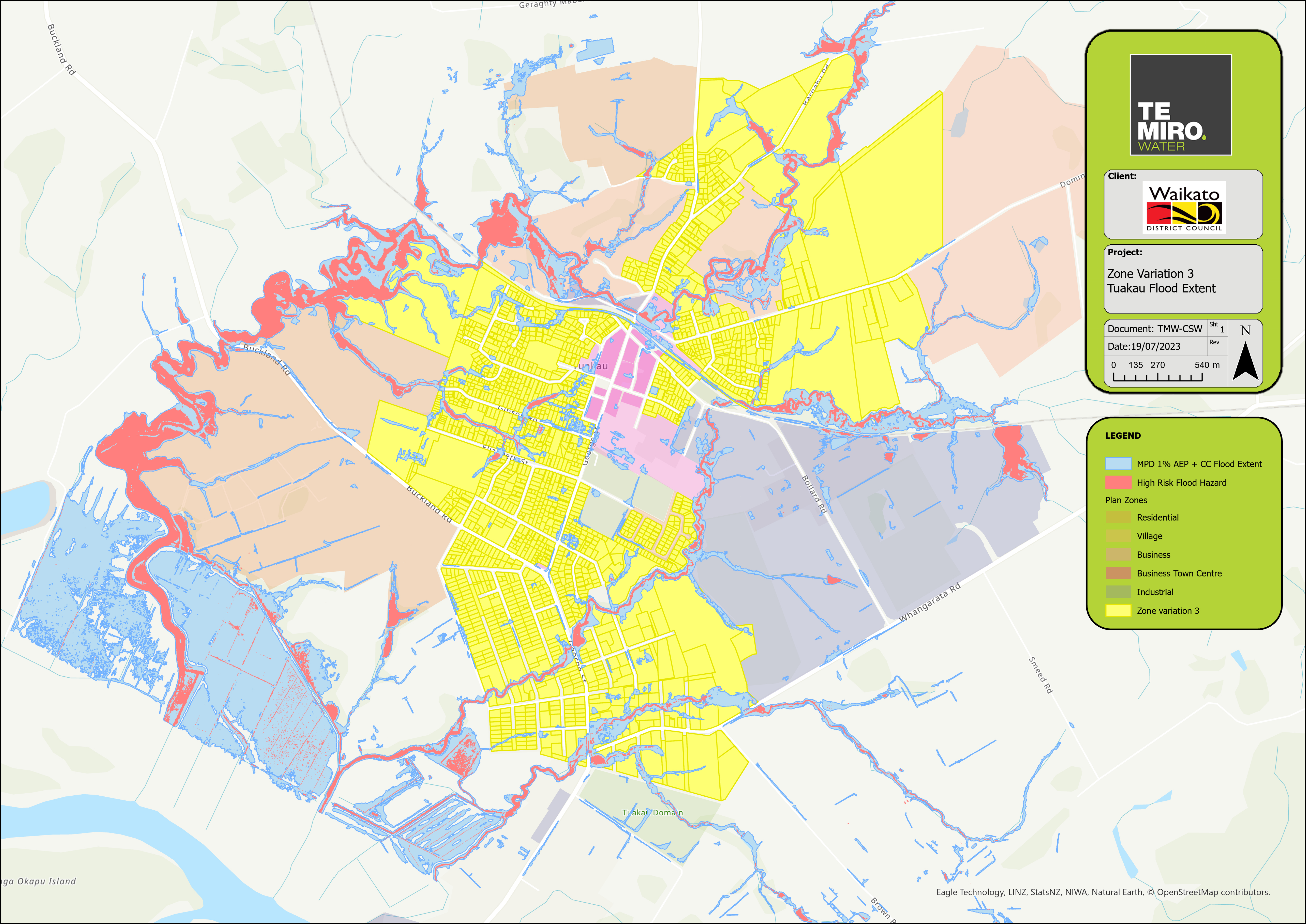
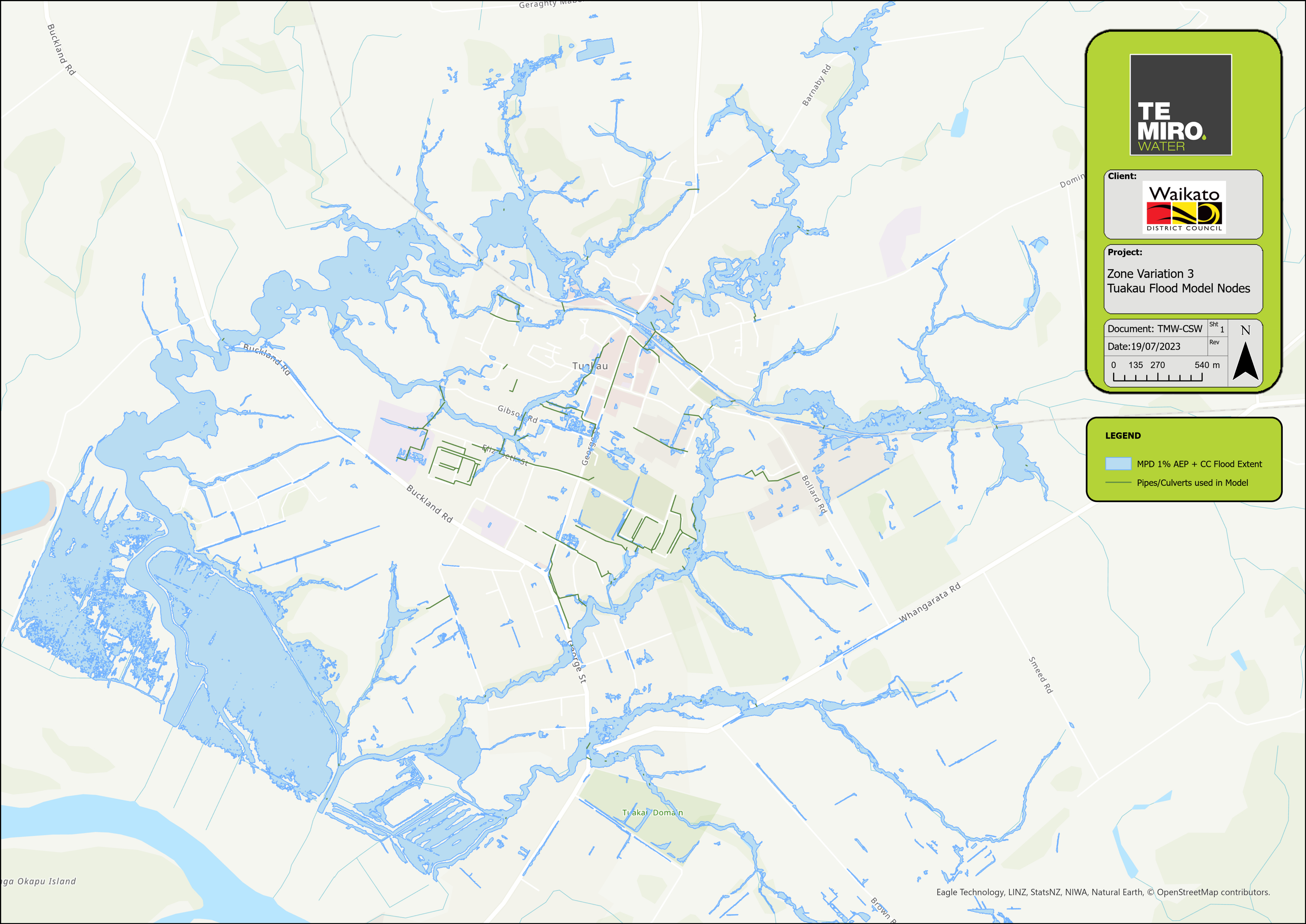
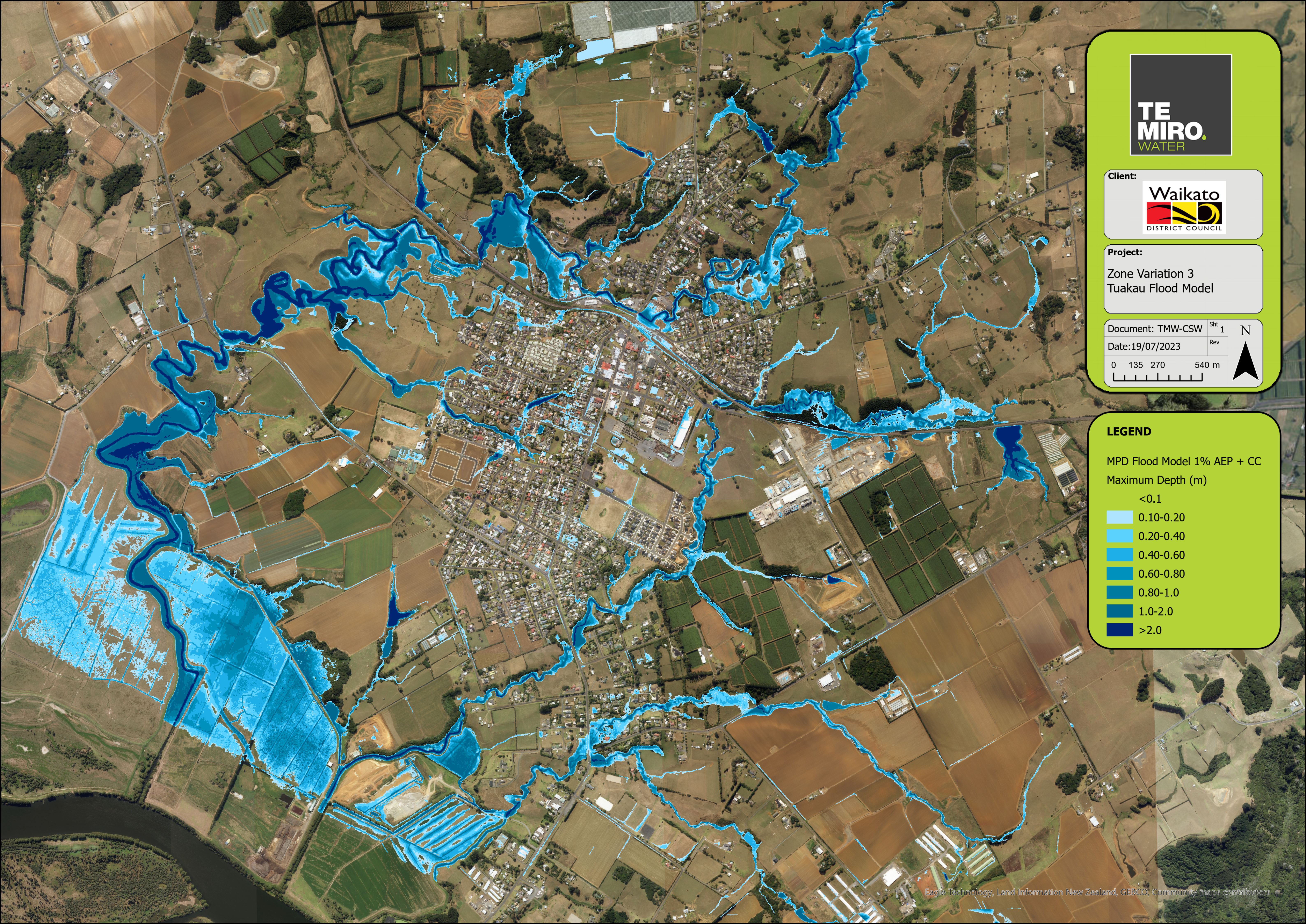
N
LEGEND
Old SW Network (Pre 2008) 2%
New SW Network (Post 2008) 98%
Zone variation 3
GRZ - General residential zone
MRZ - Medium density residential zone
Plan Zones
Village
Business
Business Town Centre
Industrial
Heavy Industrial
Pokeno
Great South Rd
Helenslee Rd
Pokeno Rd
Huia Rd
Munro Rd
Avon Rd
Baird Rd
Fraser Rd
Dean Rd
McIntosh Dr
Crickett Ln
William McRobbie Rd
McDonald Rd
Regina St
Pioneer Rd
Cole Rd
Miller Rd
McIntyre Rd
Ridge Rd
Kellyville
Esri Community Maps Contributors, LINZ, Stats NZ, Esri, HERE, Garmin, Foursquare, METI/NASA, USGS

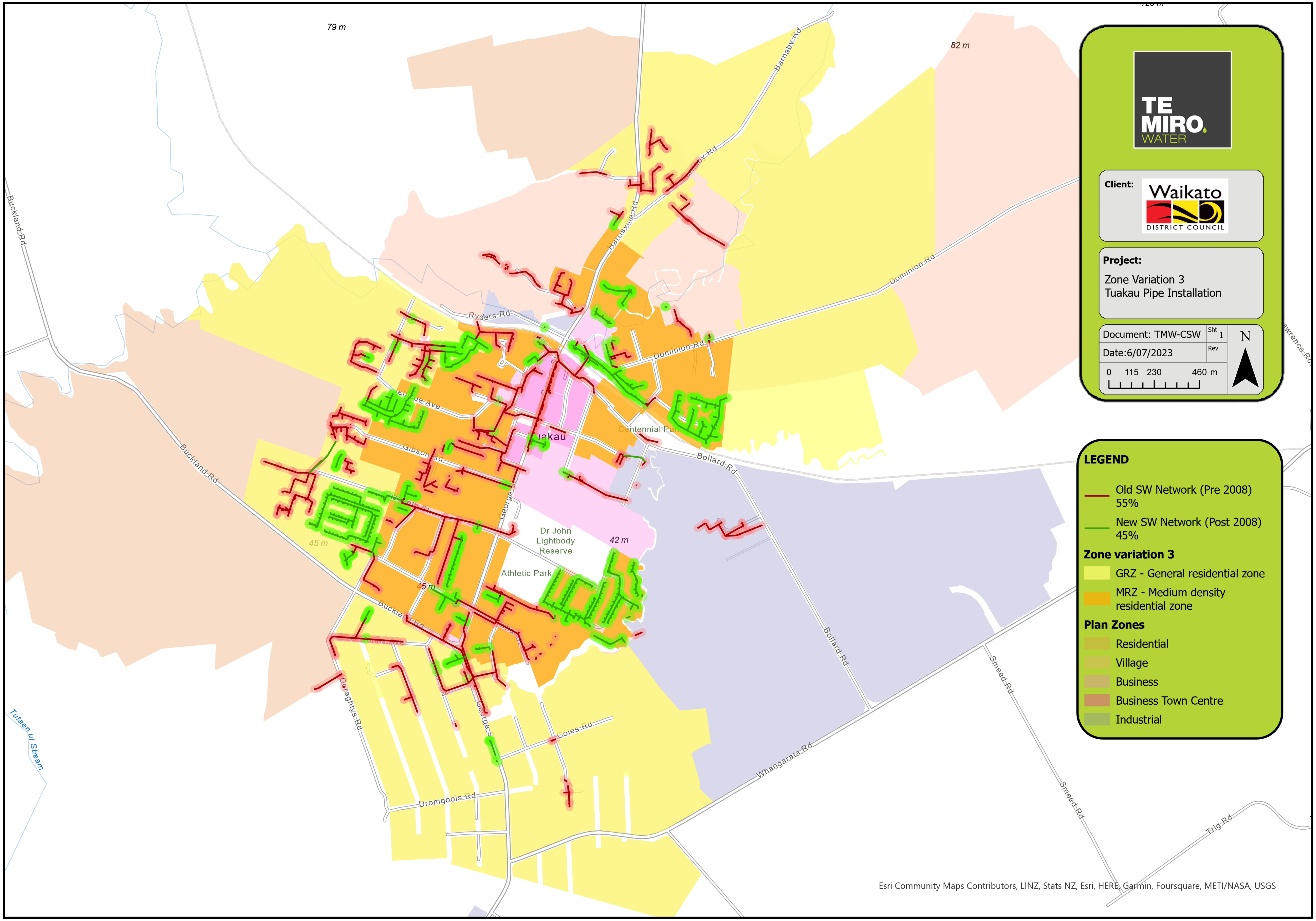

Client:
Project:
Zone Variation 3
Tuakau Flood Extent
Document: TMW-CSW
Sht 1
Rev
Date:19/07/2023
0 135 270 540 m
N
LEGEND
MPD 1% AEP + CC Flood Extent
High Risk Flood Hazard
Plan Zones
Residential
Village
Business
Business Town Centre
Industrial
Zone variation 3
Buckland Rd
Buckland Rd
Buckland Rd
Bollard Rd
Whangarata Rd
Smeed Rd
Eagle Technology, LINZ, StatsNZ, NIWA, Natural Earth, © OpenStreetMap contributors.



Buckland Rd
Barnaby Rd
Buckland Rd
Buckland Rd
George St
George St
Bollard Rd
Whangarata Rd
Smeed Rd
Eagle Technology, LINZ, StatsNZ, NIWA, Natural Earth, © OpenStreetMap contributors.
TE MIRO WATER
Client:
Waikato District Council
Project:
Zone Variation 3
Tuakau Flood Model Nodes
Document: TMW-CSW
Sht 1
Rev
Date:19/07/2023
0 135 270 540 m
N
LEGEND
MPD 1% AEP + CC Flood Extent
Pipes/Culverts used in Model



TE MIRO. WATER
Client:
Waikato DISTRICT COUNCIL
Project:
Zone Variation 3
Tuakau Flood Model
Document: TMW-CSW
Sht 1
Date:19/07/2023
Rev
N
0 135 270 540 m
LEGEND
MPD Flood Model 1% AEP + CC
Maximum Depth (m)
<0.1
0.10-0.20
0.20-0.40
0.40-0.60
0.60-0.80
0.80-1.0
1.0-2.0
>2.0
Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors


TE MIRO WATER
Client:
Waikato DISTRICT COUNCIL
Project:
Zone Variation 3
Tuakau Pipe Installation
Document: TMW-CSW
Sht 1
Rev
Date:6/07/2023
0 115 230 460 m
N
LEGEND
Old SW Network (Pre 2008) 55%
New SW Network (Post 2008) 45%
Zone variation 3
GRZ - General residential zone
MRZ - Medium density residential zone
Plan Zones
Residential
Village
Business
Business Town Centre
Industrial
79 m
82 m
42 m
45 m
Bucklands-Rd
Buckland-Rd
Barnaby-Rd
Harrisville-Rd
Ryders-Rd
Dominion-Rd
Bollard-Rd
Gibson-Rd
Tuakau
Centennial Park
Dr John Lightbody Reserve
Athletic Park
George-St
Geraghtys-Rd
Coles-Rd
Dromgools-Rd
Whangarata-Rd
Smeed-Rd
Trig-Rd
Tutaenui Stream
Esri Community Maps Contributors, LINZ, Stats NZ, Esri, HERE, Garmin, Foursquare, METI/NASA, USGS

Appendix B – modelling reports

2023 RAPID FLOOD MODEL BUILD REPORT
Ngāruawāhia

This report provides a comprehensive overview and critical analysis of the Ngaruawahia TUFLOW hydraulic model.

The Ngaruawahia hydraulic model focuses on the catchment within and surrounding Ngaruawahia. Ngaruawahia is situated at the confluence of the Waikato and Waipa rivers, known for its distinctive floodplain characteristics.

Modelling Goals & Objectives

The main objective of this rapid flood model is to provide the flood extents for maximum probable development (MPD) to identify areas that infilling may adversely affect (increase) the flood risk. This includes adverse effect to upstream and downstream properties in regards to erosion and flood levels.

The modelling work undertake includes:

- Acquire and integrate accurate topographic, hydrological, and meteorological data into the TUFLOW hydraulic model.
- Identify and correct any inaccuracies or deficiencies in the asset data related to critical infrastructure and built environment to improve flood risk assessment.
- Utilize the TUFLOW hydraulic model to accurately determine the flood extents in the study towns under existing conditions.
- Simulate and assess the flood extents for the proposed Maximum Probable Development (MPD) scenario, considering the anticipated effects of climate change based on the RCP 6.0 scenario (2.3 degree temp. increase).
- Evaluate the potential impact of future flooding including flood extents, water depths and velocities (Flood hazard DxV).
- Provide valuable insights and data regarding flood extents to inform decision-making processes related to land use planning, infrastructure development, and flood risk management.

Model Build Assumptions and Methodology

This hydraulic model incorporates various assumptions crucial to understanding its application, scope, and limitations. These assumptions, inherent in all hydraulic models, aim to reduce the complexity of the natural hydrologic and hydraulic processes to a manageable level while ensuring an acceptable degree of accuracy.

The hydrologic and hydraulic model selection and parameters are outlined in Table 1.

Table 1 Hydrologic and Hydraulic Model Parameters

PARAMETERS	DETAILS AND ASSUMPTIONS
SUMMARY	The flood assessment uses a 1D/2D TUFLOW (Version 2020-01-AA) hydraulic model. Design flood hydrographs have been developed using HEC-HMS software for the 1% AEP events including Climate Change to 2120. In summary, the parameters used in the TUFLOW model include: • Survey data was used for dimensions, length, inverts, and roughness. Where insufficient information was not available to define asset data (i.e., pipes inverts not available), assumptions of invert levels where made based on standard cover to top of pipes (600mm) and existing ground topography for grading assumptions. • A Manning's 'n' roughness distribution has been applied to reflect changes in vegetation and land use type within zoned development areas. Roughness values have been determined from the land use coverage from LINZ data in a shapefile format for areas outside of the urban zones. • The 2D TUFLOW model uses a 2m x 2m grid with the ground level applied within each grid cell as the average of the LiDAR points within that cell. • No soil infiltration was considered in the hydraulic model, as this is accounted for in the hydrologic modeling. • The boundary condition downstream consists of a nominal slope, assumed as a 1% in all the scenarios. For streams discharging into the Waikato River, the tailwater level has not been included as it is considered, as per the WRC flood modelling, that the river levels are low enough that once discharged will not restrict the outlet capacity of the network.
MODELLING APPROACH	
The model incorporates rain on a grid approach, using global and excess precipitation for ED and MPD scenarios.	
CALIBRATION	Calibration has not been undertaken as the model uses a combined nested rainfall event, calibration with actual rainfall data is not considered appropriate as doesn't provide increased accuracy. Additional validation analysis could be undertaken as part of future modelling work if needed.

<table>
<tr><td>HYDROLOGICAL LOSSES</td><td>Hydrological Losses for the MPD scenario were Calculated using the Initial and Constant loss methods. The following infiltration values are used for different soil drainage groups.
<table>
<tr><th>Soil Group</th><th>Initial Loss(mmhr)</th><th>Constant loss(mm/hr)</th></tr>
<tr><td>A</td><td>19</td><td>11.4</td></tr>
<tr><td>B</td><td>8.1</td><td>7.6</td></tr>
<tr><td>C</td><td>4.5</td><td>3.8</td></tr>
<tr><td>D</td><td>3.2</td><td>1.3</td></tr>
</table>
Source: Hec.usage.army:
https://www.hec.usace.army.mil/confluence/rasdocs/r2dum/latest/developing-a-terrain-model-and-geospatial-layers/infiltration-methods</td></tr>
<tr><td></td><td>

Hydrological Losses for the MPD scenario were Calculated using the SCS method, which uses different cover numbers (CN) based on soil drainage and land use.
Because of the variety of soils in the area, a weighted CN was determined for each sub-catchment. Adopted curve numbers have been sourced from the HCC GIS curve number dataset developed as part of HCC's stormwater masterplan project (HCC, 2017 – same as the WRC hydraulic modelling guidance parameters).
The weighted curve numbers for developed areas also incorporated another % of impervious areas in the model. The assumptions are based on the table below

<table>
<tr><th>Zone /Area</th><th>% Impervious in MPD</th></tr>
<tr><td>Rural</td><td>AREA TAKEN FROM BUILDING LAYER AND 100% IMPERVIOUS APPLIED</td></tr>
<tr><td>Existing Residential</td><td>70</td></tr>
<tr><td>Residential Growth Cells(incl. Roads)</td><td>80</td></tr>
<tr><td>Commercial</td><td>90</td></tr>
<tr><td>Industrial</td><td>90</td></tr>
<tr><td>Ex. Roads</td><td>AREA TAKEN FROM ROAD LAYER AND 80% IMPERVIOUS APPLIED</td></tr>
</table>
</td></tr>
<tr><td>CATCHMENT DELINEATION</td><td>Hydrologic sub-catchment delineation was initially developed using the watershed definition algorithm within the GIS environment. This tool defines sub-catchment boundaries based on the digital terrain data (LiDAR) analysis and the identification of flow paths based on topography.</td></tr>
</table>

<table>
<tr><td>ROAD CATCHMENTS</td><td>Individual road catchments were delineated for manholes and catch pits inside the road polygon. The catchments were delineated in a way to make sure to have at least one receiving catch pit in each.

Runoff hydrographs for the road catchments were distributed over all the catch pits in a road catchment. Manholes are not linked to the 2D domains, so they cannot receive or discharge water.</td></tr>
<tr><td>External and Internal 1D catchments</td><td>The flows from the external catchments of the model boundary were modelled as 1D flows and applied to the boundaries. A couple of internal catchments-falling outside the growth zones were also modeled as 1D to reduce the computational intensity of rain on the grid region. The losses were calculated in the same manner as the excess rainfall.</td></tr>
<tr><td>DESIGN RAINFALL</td><td>Rainfall data was taken from the existing model – the rainfall was sourced from the NIWA HIRDS v4 website on the 10th of March 2020 and is outlined below.

For infrastructure, however, WRC recommends adopting RCP 6 as a minimum.

<table>
<tr><th></th><th>Duration / AEP event</th><th>10% AEP</th><th>1% AEP</th></tr>
<tr><td>NG</td><td>24h - Duration</td><td>127</td><td>198</td></tr>
</table>
</td></tr>
<tr><td>LAND USE / ROUGHNESS</td><td>The model uses Manning's coefficients to represent energy losses due to channel and floodplain roughness. These coefficients are assumed to be constant across each cell, and spatial variability is handled by using different values in different cells. The area was separated into land cover classifications in QGIS. The remaining areas of the catchment were assumed to be grass cover. Manning's values are consistent with the Waikato Stormwater Management Guideline.
<table>
<tr><td>Houses</td><td>Grass</td><td>Roads</td><td>Water bodies (Low Vegetation)</td><td>Bush(Dense Vegetation)</td><td>Cultivated Areas(Medium Vegetation)</td></tr>
<tr><td>0.5</td><td>0.03</td><td>0.015</td><td>0.025</td><td>0.06</td><td>0.04</td></tr>
</table>
</td></tr>
<tr><td colspan="2">1D Hydraulic Model Assumptions</td></tr>
<tr><td>PIPES</td><td>• The pipes with missing or '0' diameter in the asset were assumed to have the same diameter as the pipe on the immediate downstream.</td></tr>
</table>

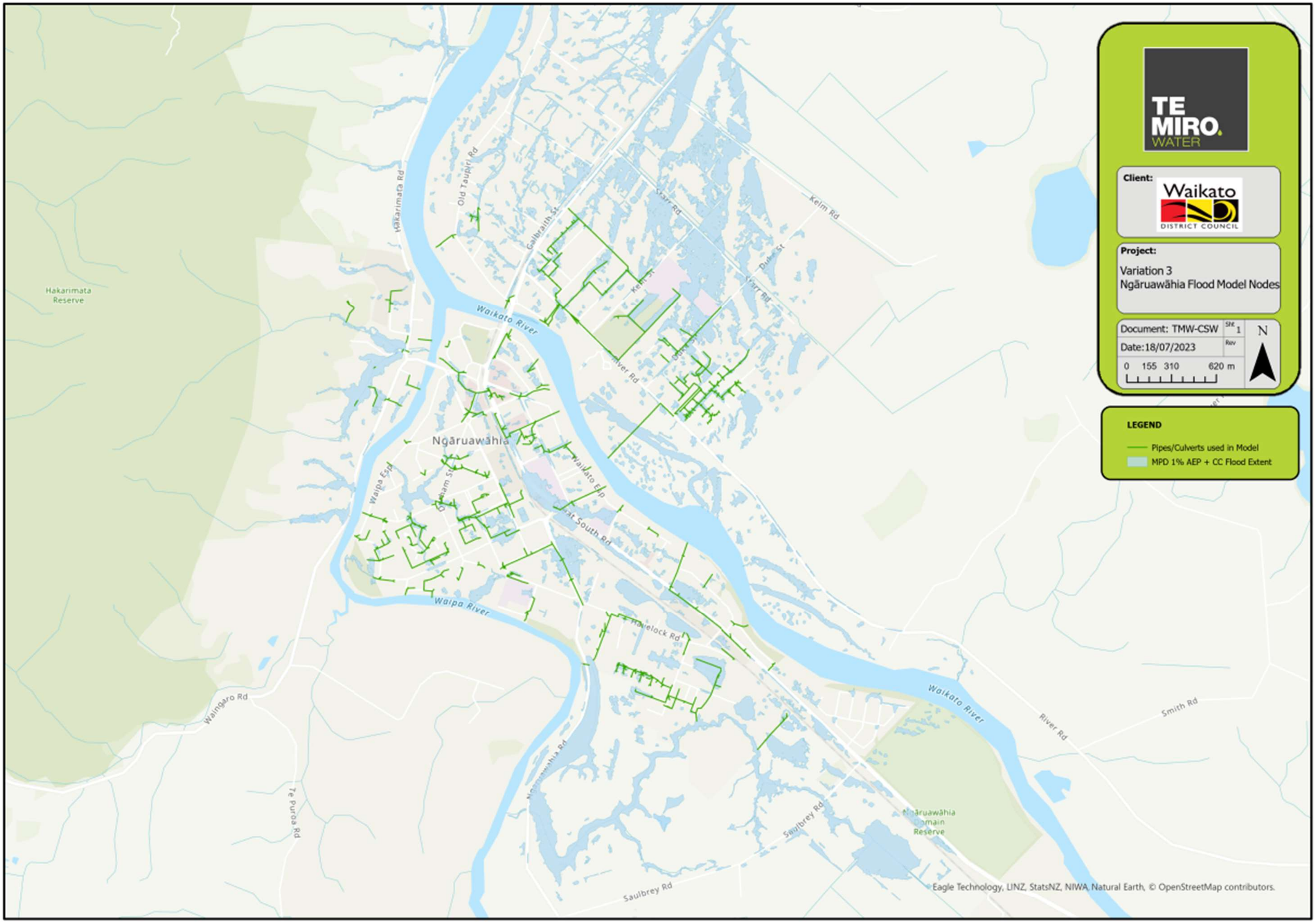
	• Pipes with missing inverts were assigned the invert levels from the surrounding manholes or pipes. • In case none of the connected manholes and pipes have any inverts, then the inverts were interpolated from the ground network as *invert = ground level - 0.6 – diameter of the largest connected pipe* A 600mm cover was assumed for all the interpolated points
MANHOLES	• Diameters for Manholes with missing diameters were assumed to be 1050mm dia unless connected pipe(s) sizes warranted an increased diameter. • Missing manhole inverts were taken from the invert of the lowest connected pipe.
CULVERT INPUTS	Culverts are incorporated in the model where a significant waterway occurs.
LIDAR	The DEM provided had a resolution of 1m x 1m that forms the base information for the hydraulic model. This data was assumed to be accurate*, and no adjustments have been made to the LIDAR topography data provided. *Hydraulic infilling (pre-event base flow) was run to remove the storage volume created by LIDAR processing (removal of houses) that artificially created some ponding areas not connected to main overland flow areas. This was to ensure the volume retained within the catchments is not represented by reducing the downstream flood levels, volumes or flows.
GRID SIZE	The 2D TUFLOW model uses a 2m x 2m grid with the ground level applied within each grid cell as the average of the LiDAR points. The Sub-Grid Sampling (SGS) approach has been utilized in the TUFLOW software for the model. The SGS approach samples the bathymetric data at a finer resolution than the 2D grid (0.5m x 0.5m), generating depth-varying hydraulic properties for each cell.
BOUNDARIES	A downstream boundary was set as a normal slope of 0.5%, consistent with the area's slope.
RIVERS AND STOP BANKS	River Bodies were excluded from the modeling. A normal depth boundary condition with a slope of 1% was assumed along the river stop banks. No abnormal ponding or glass wall effect were seen in the result.
SENSITIVITY RUNS	Sensitivity analysis has been undertaken using different ARI rainfall events. This showed progressively increasing/decreasing flood levels as expected for various ARI rainfall events. Further, sensitivity checks were done by running 48hr of the model with artificial rainfall in the first couple of hours to fill depressions and applying the original nested storm during the second half of the simulation.

ASSUMPTION AND LIMITATIONS	The modelling undertaken aligns, as much as practicable within the project scope, with the Waikato Stormwater Runoff Modelling Guidelines (Jun 2018).

Author:	Reviewer:
Waqas Sawar	Andrew Boldero
17/09/2023	19/09/2023

TE MIRO WATER

APPENDIX A: Culverts and Stormwater Network utilised by the hydraulic model



2023 RAPID FLOOD MODEL BUILD REPORT
Huntly

This report provides a comprehensive overview and critical analysis of the Huntly TUFLOW hydraulic model.

The Huntly hydraulic model focuses on the catchment within and surrounding Huntly. Huntly is situated at the along side the Waikato rivers and, known for its distinctive floodplain characteristics including stop bank protection and urban lakes.

Modelling Goals & Objectives

The main objective of this rapid flood model is to provide the flood extents for maximum probable development (MPD) to identify areas that infilling may adversely affect (increase) the flood risk. This includes adverse effect to upstream and downstream properties in regards to erosion and flood levels.

The modelling work undertake includes:

- Acquire and integrate accurate topographic, hydrological, and meteorological data into the TUFLOW hydraulic model.
- Identify and correct any inaccuracies or deficiencies in the asset data related to critical infrastructure and built environment to improve flood risk assessment.
- Utilize the TUFLOW hydraulic model to accurately determine the flood extents in the study towns under existing conditions.
- Simulate and assess the flood extents for the proposed Maximum Probable Development (MPD) scenario, considering the anticipated effects of climate change based on the RCP 6.0 scenario (2.3 degree temp. increase).
- Evaluate the potential impact of future flooding including flood extents, water depths and velocities (Flood hazard DxV).
- Provide valuable insights and data regarding flood extents to inform decision-making processes related to land use planning, infrastructure development, and flood risk management.

Model Build Assumptions and Methodology

This hydraulic model incorporates various assumptions crucial to understanding its application, scope, and limitations. These assumptions, inherent in all hydraulic models, aim to reduce the complexity of the natural hydrologic and hydraulic processes to a manageable level while ensuring an acceptable degree of accuracy.

The hydrologic and hydraulic model selection and parameters are outlined in Table 1.

Table 1 Hydrologic and Hydraulic Model Parameters

PARAMETERS	DETAILS AND ASSUMPTIONS
SUMMARY	The flood assessment uses a 1D/2D TUFLOW (Version 2020-01-AA) hydraulic model. Design flood hydrographs have been developed using HEC-HMS software for the 1% AEP events including Climate Change to 2120. In summary, the parameters used in the TUFLOW model include: • Survey data was used for dimensions, length, inverts, and roughness. Where insufficient information was not available to define asset data (i.e., pipes inverts not available), assumptions of invert levels where made based on standard cover to top of pipes (600mm) and existing ground topography for grading assumptions. • A Manning's 'n' roughness distribution has been applied to reflect changes in vegetation and land use type within zoned development areas. Roughness values have been determined from the land use coverage from LINZ data in a shapefile format for areas outside of the urban zones. • The 2D TUFLOW model uses a 2m x 2m grid with the ground level applied within each grid cell as the average of the LiDAR points within that cell. • No soil infiltration was considered in the hydraulic model, as this is accounted for in the hydrologic modeling. • The boundary condition downstream consists of a nominal slope, assumed as a 1% in all the scenarios. For streams discharging into the Waikato River, the tailwater level has not been included as it is considered, as per the WRC flood modelling, that the river levels are low enough that once discharged will not restrict the outlet capacity of the network.
MODELLING APPROACH	
The model incorporates rain on a grid approach, using global and excess precipitation for ED and MPD scenarios.	
CALIBRATION	Calibration has not been undertaken as the model uses a combined nested rainfall event, calibration with actual rainfall data is not considered appropriate as doesn't provide increased

	accuracy. Additional validation analysis could be undertaken as part of future modelling work if needed.
HYDROLOGICAL LOSSES	Hydrological Losses for the MPD scenario were Calculated using the *Initial and Constant loss* methods. The following infiltration values are used for different soil drainage groups.

Soil Group	Initial Loss(mmhr)	Constant loss(mm/hr)
A	19	11.4
B	8.1	7.6
C	4.5	3.8
D	3.2	1.3

Source: Hec.usage.army: https://www.hec.usace.army.mil/confluence/rasdocs/r2dum/latest/developing-a-terrain-model-and-geospatial-layers/infiltration-methods

- Hydrological Losses for the MPD scenario were Calculated using the SCS method, which uses different cover numbers (CN) based on soil drainage and land use.
- Because of the variety of soils in the area, a weighted CN was determined for each sub-catchment. Adopted curve numbers have been sourced from the HCC GIS curve number dataset developed as part of HCC's stormwater masterplan project (HCC, 2017 – same as the WRC hydraulic modelling guidance parameters).
- The weighted curve numbers for developed areas also incorporated another % of impervious areas in the model. The assumptions are based on the table below

Zone /Area	% Impervious in MPD
Rural	AREA TAKEN FROM BUILDING LAYER AND 100% IMPERVIOUS APPLIED
Existing Residential	70
Residential Growth Cells(incl. Roads)	80
Commercial	90
Industrial	90
Ex. Roads	AREA TAKEN FROM ROAD LAYER AND 80% IMPERVIOUS APPLIED

CATCHMENT DELINEATION	Hydrologic sub-catchment delineation was initially developed using the watershed definition algorithm within the GIS environment. This tool defines sub-catchment boundaries based on the digital terrain data (LiDAR) analysis and the identification of flow paths based on topography.
ROAD CATCHMENTS	Individual road catchments were delineated for manholes and catch pits inside the road polygon. The catchments were delineated in a way to make sure to have at least one receiving catch pit in each. Runoff hydrographs for the road catchments were distributed over all the catch pits in a road catchment. Manholes are not linked to the 2D domains, so they cannot receive or discharge water.
External and Internal 1D catchments	The flows from the external catchments of the model boundary were modelled as 1D flows and applied to the boundaries. A couple of internal catchments-falling outside the growth zones were also modeled as 1D to reduce the computational intensity of rain on the grid region. The losses were calculated in the same manner as the excess rainfall.
DESIGN RAINFALL	Rainfall data was taken from the existing model – the rainfall was sourced from the NIWA HIRDS v4 website on the 10th of March 2020 and is outlined below. For infrastructure, however, WRC recommends adopting RCP 6 as a minimum.

Town	Duration / AEP event	10% AEP	1% AEP
Huntly	24h - Duration	111	175

LAND USE / ROUGHNESS	The model uses Manning's coefficients to represent energy losses due to channel and floodplain roughness. These coefficients are assumed to be constant across each cell, and spatial variability is handled by using different values in different cells. The area was separated into land cover classifications in QGIS. The remaining areas of the catchment were assumed to be grass cover. Manning's values are consistent with the Waikato Stormwater Management Guideline.

Houses	Grass	Roads	Water bodies (Low Vegetation)	Bush(Dense Vegetation)	Cultivated Areas(Medium Vegetation)
0.5	0.03	0.015	0.025	0.06	0.04

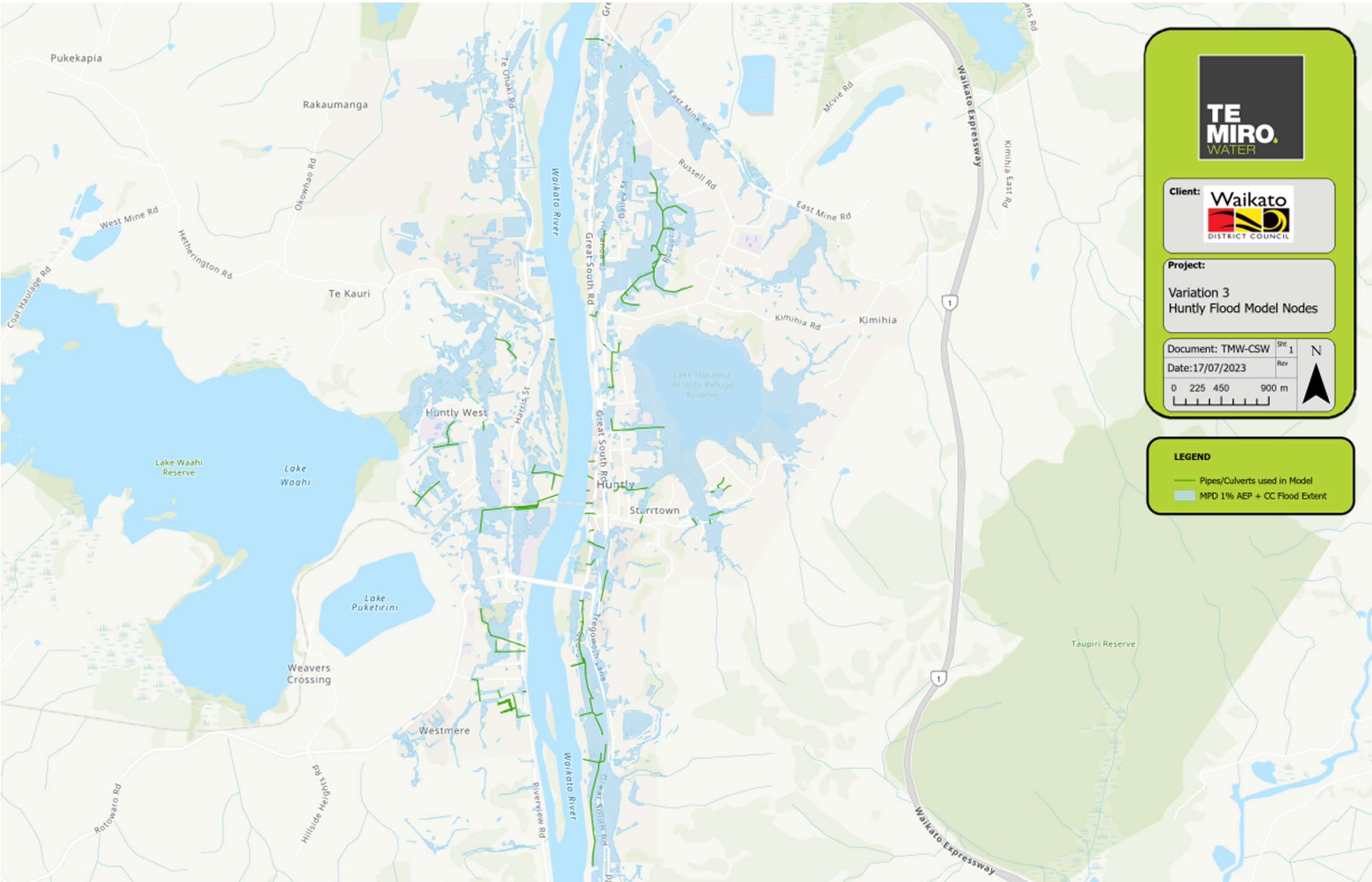
1D Hydraulic Model Assumptions

PIPES	• The pipes with missing or '0' diameter in the asset were assumed to have the same diameter as the pipe on the immediate downstream. • Pipes with missing inverts were assigned the invert levels from the surrounding manholes or pipes. • In case none of the connected manholes and pipes have any inverts, then the inverts were interpolated from the ground network as *invert = ground level - 0.6 – diameter of the largest connected pipe* A 600mm cover was assumed for all the interpolated points
MANHOLES	• Diameters for Manholes with missing diameters were assumed to be 1050mm dia unless connected pipe(s) sizes warranted an increased diameter. • Missing manhole inverts were taken from the invert of the lowest connected pipe.
CULVERT INPUTS	Culverts are incorporated in the model where a significant waterway occurs.
LIDAR	The DEM provided had a resolution of 1m x 1m that forms the base information for the hydraulic model. This data was assumed to be accurate*, and no adjustments have been made to the LIDAR topography data provided. *Hydraulic infilling (pre-event base flow) was run to remove the storage volume created by LIDAR processing (removal of houses) that artificially created some ponding areas not connected to main overland flow areas. This was to ensure the volume retained within the catchments is not represented by reducing the downstream flood levels, volumes or flows.
GRID SIZE	The 2D TUFLOW model uses a 2m x 2m grid with the ground level applied within each grid cell as the average of the LiDAR points. The Sub-Grid Sampling (SGS) approach has been utilized in the TUFLOW software for the model. The SGS approach samples the bathymetric data at a finer resolution than the 2D grid (0.5m x 0.5m), generating depth-varying hydraulic properties for each cell.
BOUNDARIES	A downstream boundary was set as a normal slope of 0.5%, consistent with the area's slope.
RIVERS AND STOP BANKS	River Bodies were excluded from the modeling. A normal depth boundary condition with a slope of 1% was assumed along the river stop banks. No abnormal ponding or glass wall effect were seen in the result.
SENSITIVITY RUNS	Sensitivity analysis has been undertaken using different ARI rainfall events. This showed progressively increasing/decreasing flood levels as expected for various ARI rainfall events. Further, sensitivity

	checks were done by running 48hr of the model with artificial rainfall in the first couple of hours to fill depressions and applying the original nested storm during the second half of the simulation.
ASSUMPTION AND LIMITATIONS	The modelling undertaken aligns, as much as practicable within the project scope, with the Waikato Stormwater Runoff Modelling Guidelines (Jun 2018).

Author:	Reviewer:
Waqas Sawar	Andrew Boldero
17/09/2023	19/09/2023

APPENDIX A: Culverts and Stormwater Network utilised by the hydraulic model



2023 RAPID FLOOD MODEL BUILD REPORT
Pokeno

This report provides a comprehensive overview and critical analysis of the Pokeno TUFLOW hydraulic model.

The Pokeno hydraulic model focuses on the catchment within and surrounding Pokeno. Pokeno is situated at the base of the Bombay hills and discharges to the Mangatawhiri River which is a tributary of the Waikato River. Pokeno is known for its high rate of development, its existing flooding and erosion issues.

Modelling Goals & Objectives

The main objective of this rapid flood model is to provide the flood extents for maximum probable development (MPD) to identify areas that infilling may adversely affect (increase) the flood risk. This includes adverse effect to upstream and downstream properties in regards to erosion and flood levels.

The modelling work undertake includes:

- Acquire and integrate accurate topographic, hydrological, and meteorological data into the TUFLOW hydraulic model.
- Identify and correct any inaccuracies or deficiencies in the asset data related to critical infrastructure and built environment to improve flood risk assessment.
- Utilize the TUFLOW hydraulic model to accurately determine the flood extents in the study towns under existing conditions.
- Simulate and assess the flood extents for the proposed Maximum Probable Development (MPD) scenario, considering the anticipated effects of climate change based on the RCP 6.0 scenario (2.3 degree temp. increase).
- Evaluate the potential impact of future flooding including flood extents, water depths and velocities (Flood hazard DxV).
- Provide valuable insights and data regarding flood extents to inform decision-making processes related to land use planning, infrastructure development, and flood risk management.

Model Build Assumptions and Methodology

This hydraulic model incorporates various assumptions crucial to understanding its application, scope, and limitations. These assumptions, inherent in all hydraulic models, aim to reduce the complexity of the natural hydrologic and hydraulic processes to a manageable level while ensuring an acceptable degree of accuracy.

The hydrologic and hydraulic model selection and parameters are outlined in Table 1.

Table 1 Hydrologic and Hydraulic Model Parameters

PARAMETERS	DETAILS AND ASSUMPTIONS
SUMMARY	The flood assessment uses a 1D/2D TUFLOW (Version 2020-01-AA) hydraulic model. Design flood hydrographs have been developed using HEC-HMS software for the 1% AEP events including Climate Change to 2120. In summary, the parameters used in the TUFLOW model include: • Survey data was used for dimensions, length, inverts, and roughness. Where insufficient information was not available to define asset data (i.e., pipes inverts not available), assumptions of invert levels where made based on standard cover to top of pipes (600mm) and existing ground topography for grading assumptions. • A Manning's 'n' roughness distribution has been applied to reflect changes in vegetation and land use type within zoned development areas. Roughness values have been determined from the land use coverage from LINZ data in a shapefile format for areas outside of the urban zones. • The 2D TUFLOW model uses a 2m x 2m grid with the ground level applied within each grid cell as the average of the LiDAR points within that cell. • No soil infiltration was considered in the hydraulic model, as this is accounted for in the hydrologic modeling. • The boundary condition downstream consists of a nominal slope, assumed as a 1% in all the scenarios. For streams discharging into the Waikato River, the tailwater level has not been included as it is considered, as per the WRC flood modelling, that the river levels are low enough that once discharged will not restrict the outlet capacity of the network.
MODELLING APPROACH	
The model incorporates rain on a grid approach, using global and excess precipitation for ED and MPD scenarios.	
CALIBRATION	Calibration has not been undertaken as the model uses a combined nested rainfall event, calibration with actual rainfall data is not considered appropriate as doesn't provide increased

	accuracy. Additional validation analysis could be undertaken as part of future modelling work if needed.
HYDROLOGICAL LOSSES	Hydrological Losses for the MPD scenario were Calculated using the *Initial and Constant loss* methods. The following infiltration values are used for different soil drainage groups.

Soil Group	Initial Loss(mm/hr)	Constant loss(mm/hr)
A	19	11.4
B	8.1	7.6
C	4.5	3.8
D	3.2	1.3

Source: Hec.usage.army: https://www.hec.usace.army.mil/confluence/rasdocs/r2dum/latest/developing-a-terrain-model-and-geospatial-layers/infiltration-methods

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For infrastructure, however, WRC recommends adopting RCP 6 as a minimum.

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MANHOLES	• Diameters for Manholes with missing diameters were assumed to be 1050mm dia unless connected pipe(s) sizes warranted an increased diameter. • Missing manhole inverts were taken from the invert of the lowest connected pipe.
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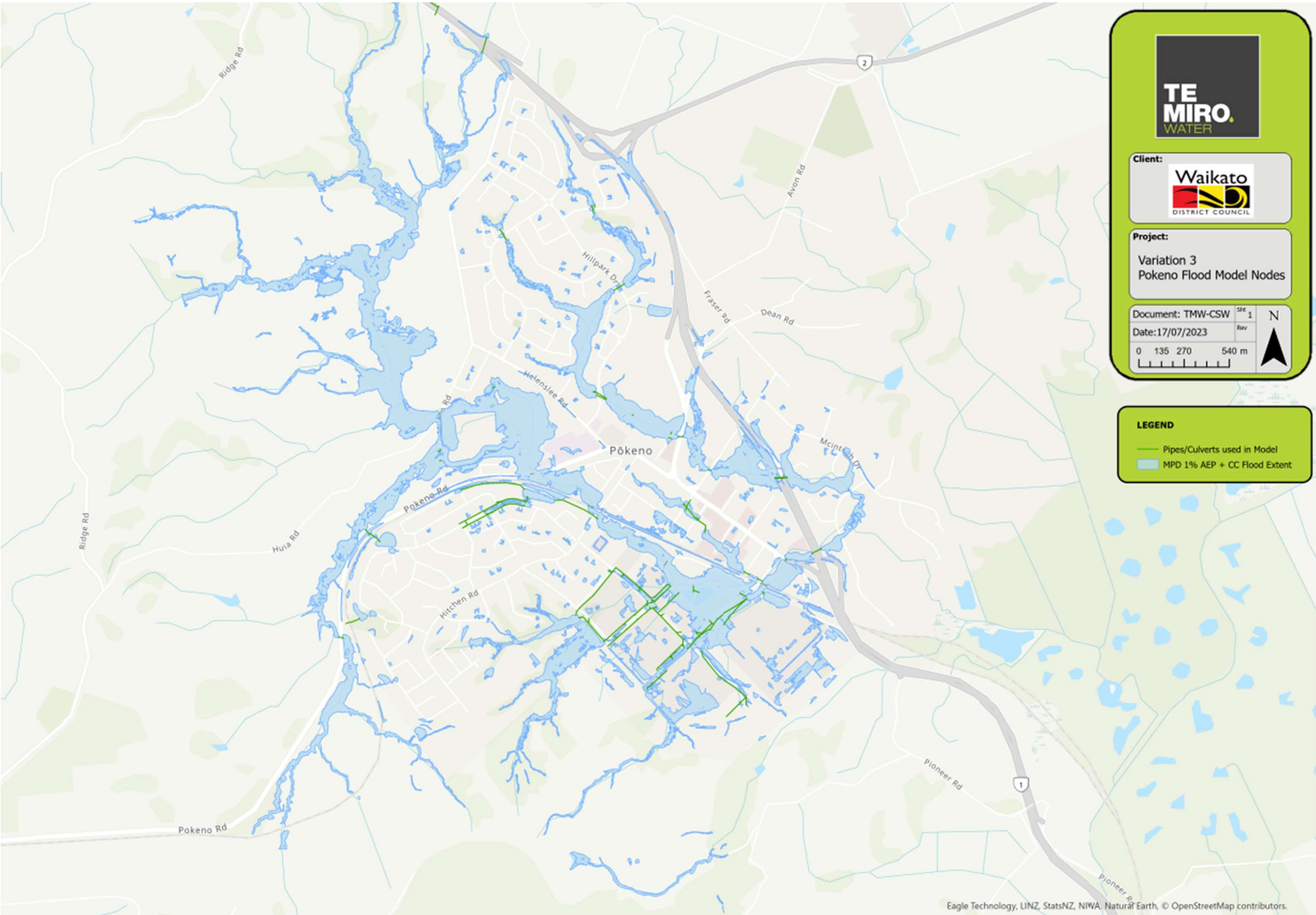
ASSUMPTION AND LIMITATIONS	The modelling undertaken aligns, as much as practicable within the project scope, with the Waikato Stormwater Runoff Modelling Guidelines (Jun 2018).

Author:	Reviewer:
Waqas Sawar	Andrew Boldero
17/09/2023	19/09/2023

APPENDIX A: Culverts and Stormwater Network utilised by the hydraulic model



2023 RAPID FLOOD MODEL BUILD REPORT
Tuakau

This report provides a comprehensive overview and critical analysis of the Tuakau TUFLOW hydraulic model.

The Tuakau hydraulic model focuses on the catchment within and surrounding Tuakau. Tuakau is situated at the base of the Bombay hills and discharges to the Waikato River via an unnamed tributary. Tuakau is known for its farming lifestyle and contains significant low lying farmland adjacent to the Waikato River banks which regularly flood.

Modelling Goals & Objectives

The main objective of this rapid flood model is to provide the flood extents for maximum probable development (MPD) to identify areas that infilling may adversely affect (increase) the flood risk. This includes adverse effect to upstream and downstream properties in regards to erosion and flood levels.

The modelling work undertake includes:

- Acquire and integrate accurate topographic, hydrological, and meteorological data into the TUFLOW hydraulic model.
- Identify and correct any inaccuracies or deficiencies in the asset data related to critical infrastructure and built environment to improve flood risk assessment.
- Utilize the TUFLOW hydraulic model to accurately determine the flood extents in the study towns under existing conditions.
- Simulate and assess the flood extents for the proposed Maximum Probable Development (MPD) scenario, considering the anticipated effects of climate change based on the RCP 6.0 scenario (2.3 degree temp. increase).
- Evaluate the potential impact of future flooding including flood extents, water depths and velocities (Flood hazard DxV).
- Provide valuable insights and data regarding flood extents to inform decision-making processes related to land use planning, infrastructure development, and flood risk management.

Model Build Assumptions and Methodology

This hydraulic model incorporates various assumptions crucial to understanding its application, scope, and limitations. These assumptions, inherent in all hydraulic models, aim to reduce the complexity of the natural hydrologic and hydraulic processes to a manageable level while ensuring an acceptable degree of accuracy.

The hydrologic and hydraulic model selection and parameters are outlined in Table 1.

Table 1 Hydrologic and Hydraulic Model Parameters

PARAMETERS	DETAILS AND ASSUMPTIONS
SUMMARY	The flood assessment uses a 1D/2D TUFLOW (Version 2020-01-AA) hydraulic model. Design flood hydrographs have been developed using HEC-HMS software for the 1% AEP events including Climate Change to 2120. In summary, the parameters used in the TUFLOW model include: • Survey data was used for dimensions, length, inverts, and roughness. Where insufficient information was not available to define asset data (i.e., pipes inverts not available), assumptions of invert levels where made based on standard cover to top of pipes (600mm) and existing ground topography for grading assumptions. • A Manning's 'n' roughness distribution has been applied to reflect changes in vegetation and land use type within zoned development areas. Roughness values have been determined from the land use coverage from LINZ data in a shapefile format for areas outside of the urban zones. • The 2D TUFLOW model uses a 2m x 2m grid with the ground level applied within each grid cell as the average of the LiDAR points within that cell. • No soil infiltration was considered in the hydraulic model, as this is accounted for in the hydrologic modeling. • The boundary condition downstream consists of a nominal slope, assumed as a 1% in all the scenarios. For streams discharging into the Waikato River, the tailwater level has not been included as it is considered, as per the WRC flood modelling, that the river levels are low enough that once discharged will not restrict the outlet capacity of the network.
MODELLING APPROACH	
The model incorporates rain on a grid approach, using global and excess precipitation for ED and MPD scenarios.	
CALIBRATION	Calibration has not been undertaken as the model uses a combined nested rainfall event, calibration with actual rainfall data is not considered appropriate as doesn't provide increased

	accuracy. Additional validation analysis could be undertaken as part of future modelling work if needed.
HYDROLOGICAL LOSSES	Hydrological Losses for the MPD scenario were Calculated using the *Initial and Constant loss* methods. The following infiltration values are used for different soil drainage groups. | Soil Group | Initial Loss(mm/hr) | Constant loss(mm/hr) | |---|---|---| | A | 19 | 11.4 | | B | 8.1 | 7.6 | | C | 4.5 | 3.8 | | D | 3.2 | 1.3 | Source: Hec.usage.army: https://www.hec.usace.army.mil/confluence/rasdocs/r2dum/latest/developing-a-terrain-model-and-geospatial-layers/infiltration-methods
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