Waikato DISTRICT COUNCIL

TE MIRO WATER

VARIATION 3 FLOOD MAPS

HOROTIU

UPDATED MAPS - FINAL (NOVEMBER 2023)

Contents:

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- **Flood Depth Map (on aerial photo with model boundary)**
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2023 FLOOD MODEL BUILD REPORT
Horotiu

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

The Horotiu hydraulic model focuses on the catchment within and surrounding Horotiu's main urban and commercial areas. Horotiu is situated adjacent to the Waikato River and is intersected by State Highway (1c) and Great South Road. It is located at the north of the Hamilton City Council boundary (shared catchment). From a hydrological perspective, Horotiu is known for large flat topography on the western side of Great South Road, its proximity to the Waikato River and erosion in watercourses adjacent to the river banks/discharges.

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 residential development may adversely affect (increase flood risk). This includes adverse effects to upstream and downstream properties in regards to erosion and flood levels.

The modelling work undertaken includes:

- Acquire and integrate the most recent data and assumptions with regards to topographic, hydrological, and meteorological data into the TUFLOW hydraulic model.
- Identify and correct inaccuracies or deficiencies in the asset data (WDC's GIS stormwater asset information) related to critical infrastructure and the built environment to improve flood risk assessment.
- Utilise the TUFLOW hydraulic model to estimate the flood extents in the study town(s) under Maximum Probable Development (MPD) conditions, considering the anticipated effects of climate change based on the RCP 6.0 scenario (2.3 degree temp. increase) year 2081- 2100.
- Evaluate the potential impact of future flooding including flood extents, water depths and velocities (flood hazard D x V as per the district plan hazard criteria).
- 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-AE) hydraulic model. Design flood hydrographs (applied as both rain on grid and lumped 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: • Waikato District Council (WDC) asset 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. Sensitivity check runs have utilised a 3m x 3m grid if the model had a long run time or where multiple runs were required. • 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 most water body discharge scenarios and 0.5% for land-based discharge scenarios (modified where considered necessary to represent more closely actual topography). 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 will not restrict (or significantly affect) the outlet capacity of the network (further refinement of the modelling in the future may include a more detailed representation of the Waikato and other river levels).
MODELLING APPROACH	
The model incorporates rain on a grid approach, using global and excess precipitation for Extended Detention (ED and MPD scenarios.	
CALIBRATION	Calibration has not been undertaken on the model as data is unavailable. Calibration and or validation could be undertaken within the stream network if monitoring stations are utilised in the future and survey of debris levels are taken post extreme events.

Hydrologic Assumptions	
HYDROLOGICAL LOSSES	Hydrological losses for the MPD scenario were Calculated using the SCS method, which uses different curve numbers (CN) based on soil drainage and land use. Because of the variety of soils in the area, the CN values were determined for each sub-catchment. Adopted curve numbers have been sourced from S-Map (soil maps) and as per the Waikato Hydraulic Modelling Runoff Guidelines. 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 (includes Roads)	80
Commercial	90
Industrial	90
Existing Roads	Area taken from Road layer and 80% impervious applied

Initial Abstraction (IA) and storage: IA is the amount of rain that soaks into the ground before a rainfall event turns into runoff. This was modelled as per the Waikato Stormwater Runoff Modelling Guidelines. The Waikato utilises a more variable approach than the previous Auckland based standard due to the wider variety of soils. The following equation is utilised to calculate IA in the model.

$$I_a = 0.05 \, x \, S$$

Where storage is required/calculated the TP108 equation below is utilised.

$$S = \left(\frac{1000}{CN} - 10\right) 25.4 \quad (mm)$$

CATCHMENT DELINEATION	Hydrologic sub-catchment delineations were undertaken manually based on topography in the 1d areas. Catchment delineation was not required for the 2d areas as this is automatically undertaken within the modelling process.
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.

<table>
<tr><td>DESIGN RAINFALL</td><td>
Rainfall data was taken from the existing model which was sourced from the NIWA HIRDS v4 website on the October 2023 and is outlined below. As per the Waikato Stormwater Runoff Modelling Guidelines for infrastructure an RCP 6 year 2081-2100 (as a minimum) has been adopted.
<table>
<tr><th>Town</th><th>Duration / AEP event</th><th>10% AEP*</th><th>1% AEP</th></tr>
<tr><td>Horotiu</td><td>24h - Duration</td><td>109mm*</td><td>170mm</td></tr>
</table>
*Not modelled
</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><th>Houses</th><th>Grass</th><th>Roads</th><th>Water bodies (Low Vegetation)</th><th>Bush (Dense Vegetation)</th><th>Cultivated Areas (Medium Vegetation)</th></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.
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 invert information, then the inverts were interpolated from the ground network as
Invert = Ground level - 0.6m – Diameter of the largest connected pipe
600mm cover was assumed for all the interpolated points

</td></tr>
<tr><td>MANHOLES</td><td>

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.

</td></tr>
<tr><td>CULVERT INPUTS</td><td>Culverts are incorporated in the model where a significant waterway occurs.</td></tr>
<tr><td>LOSSES</td><td>Losses have been applied to inlet and outlet of culverts and pipes – losses have not been applied to the manholes.</td></tr>
<tr><td>LIDAR</td><td>
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*.
*Z lines (channels) were added to the LIDAR topography where channels, crossings and culverts were not considered to be represented accurately or showed connectivity issues.
</td></tr>
</table>

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 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	Downstream boundaries that discharge from the network are set as a normal slope of 0.5%, consistent with the gradient of the land.
RIVERS AND STOP BANKS	Rivers 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 final results.
SENSITIVITY RUNS	Sensitivity analysis has been undertaken using different scenarios. This is outlined in the below Quality Assurance and Sensitivity Checking section.
ASSUMPTION AND LIMITATIONS	The modelling undertaken aligns, as much as practicable within the project scope, with the Waikato Stormwater Runoff Modelling Guidelines (Jun 2018).

Quality Assurance and Sensitivity Checking

This section addresses the additional checking and quality assurance outlined in the TMW evidence prepared for the MDRS Variation 3 hearing. This also aligns with the discussions at the hearing in regard to model confidence and standard practice for urban scale hydraulic models.

Additional model runs were undertaken to test the model's sensitivity to certain parameters. This was to provide an indication of how each model is affected by certain key parameters. Although these parameters are selected by following guidance there is an envelope of interpretation required. This methodology enables confidence in the flood maps if the results are similar to the base run as this shows the factors are less critical. If the results are significantly different this highlights the parameter maybe more critical in which case the parameter is re-considered in more detail to confirm it is correct.

Modelling QA Summary:

1. Base model:
    1. Manual removal of small, isolated ponding areas that were considered to represent errors in topography from LIDAR processing or not relevant to the flooding assessment scope (identification of properties with flooding that requires assessment if developed).
    2. Manual removal of small, isolated ponding areas that were considered unlikely to occur due to potential LIDAR processing areas from vegetation.
    3. Checking of connectivity between large flooding area split by roads or embankments.
    4. Cutting in of channels to represent connection under bridges or channels not considered to be accurately represented by LIDAR.
    5. Checking and inclusion of pipes and culverts in areas considered likely to contain pipes and culverts based on knowledge of areas and surrounding topography.

2. Blockage Scenarios
    1. Base Blockage Scenario (as included in finalised flood maps): Critical pipes only included in model: If pipes are included in model (refer pipes modelled maps) then these are considered to be at 100%

capacity (0% blocked). Initially all pipes below 300mm were excluded, however during the QA stage some pipes 300mm dia and smaller were included if they had potential to impact ponding areas.

2. Blockage Scenario 1: 100% blockage on all pipes within model (Bridges and Z channels = 0% blockage).
3. Blockage scenario 2: Blockage scenario for critical pipes included in model.

Pipe size(s)	<300mm	300-600mm	600-900mm	>900mm	Bridges/open channels (Z Cuts)
% blockage	100%	75%	50%	25%	0%

Runoff factors:

Current CN Values as included in finalised flood maps

Soil Type	Cover type / Soil Description	CN values				
		Forest	Grass	Dirt	Cropland	Impervious
A	Moderately Well Draining & Well Draining	30	39	72	67	98
B	Imperfectly Well Draining	55	61	82	78	98
C	Poorly Drained	70	74	87	85	98
D	Very Poorly Drained	77	80	89	89	98
Impervious		98	98	98	98	98

Sensitivity check CN Values: 25% added to existing (Existing CN * 1.25 + rounded to nearest whole number to a max of 98). Increased values are in bold.

Soil Type	Cover type / Soil Description	CN values				
		Forest	Grass	Dirt	Cropland	Impervious
A	Moderately Well Draining & Well Draining	**38**	**49**	**90**	**84**	98
B	Imperfectly Well Draining	**69**	**76**	**98**	**98**	98
C	Poorly Drained	**88**	**93**	**98**	**98**	98
D	Very Poorly Drained	**96**	**98**	**98**	**98**	98
Impervious		98	98	98	98	98

4. Hydrology:
    1. Existing = 24 hour rainfall event + 6 RCP climate change scenario (as included in finalised flood maps) for years 2081-2100.
    2. Check = 24 hour event + 8.5 RCP climate change scenario for years 2081-2100.

5. Comparison to existing models
    1. WRC flood model – This comparison shows that in general the low lying areas match with the WRC flood maps, however the methodology is different in terms of modelling the Waikato River and is based on coarse lidar over a much larger catchment area. General correlation only would be expected and was observed during the comparison assessment.
    2. Previous WSP rapid flood hazard modelling. This mapping was based on previous LIDAR which is less accurate than the 2022 LIDAR. This also excluded all pipes. This quick method for flood area identification showed good correlation in the gully areas.
    3. Other (any additional flood information available – if any). No further maps were compared.

6. Sensitivity results comparison:

The following compares the results from each sensitivity run to the base model Each run utilises a 3 x 3m grid and hasn't been cleaned (removal of small isolated ponding areas). Refer to summary table below for results.

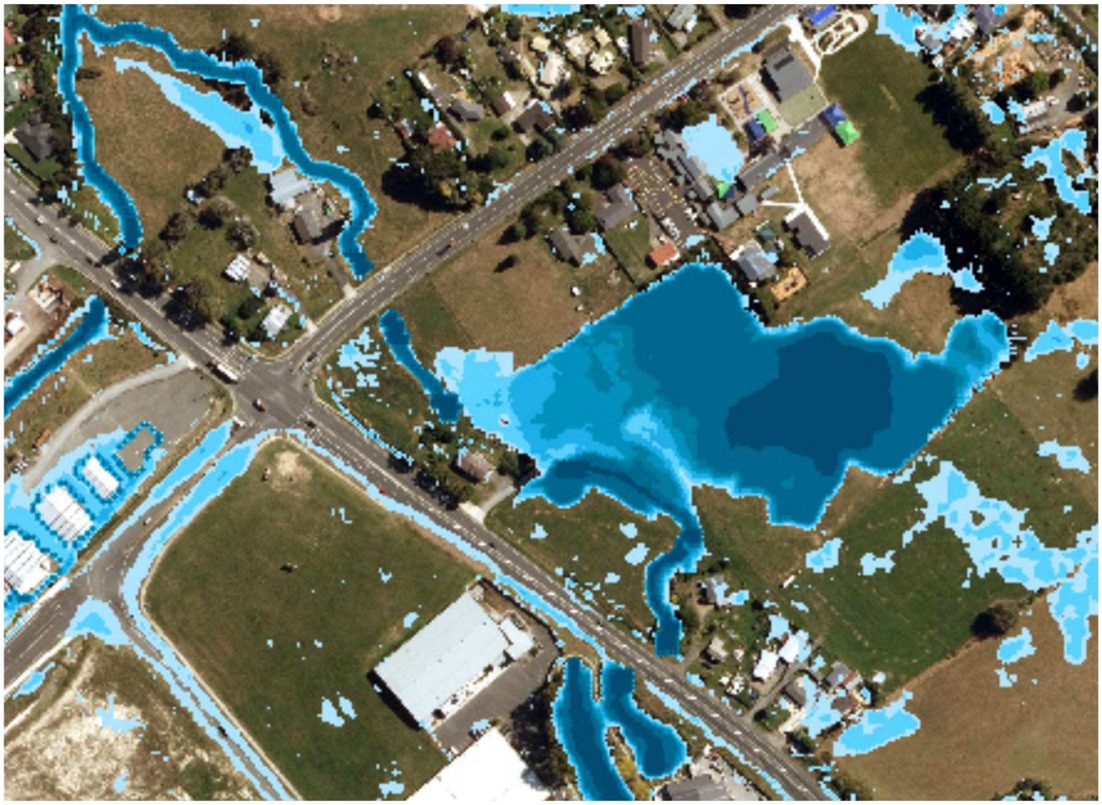


Figure 1: Base map (Flood depths)

Figure 2: Blockage Scenario 1 – Shows increased flooding from 100% blockage scenario. Critical in areas upstream from large culverts but unlikely to occur as these large culverts are less likely to completely block. No difference in areas that are not constrained by culverts.

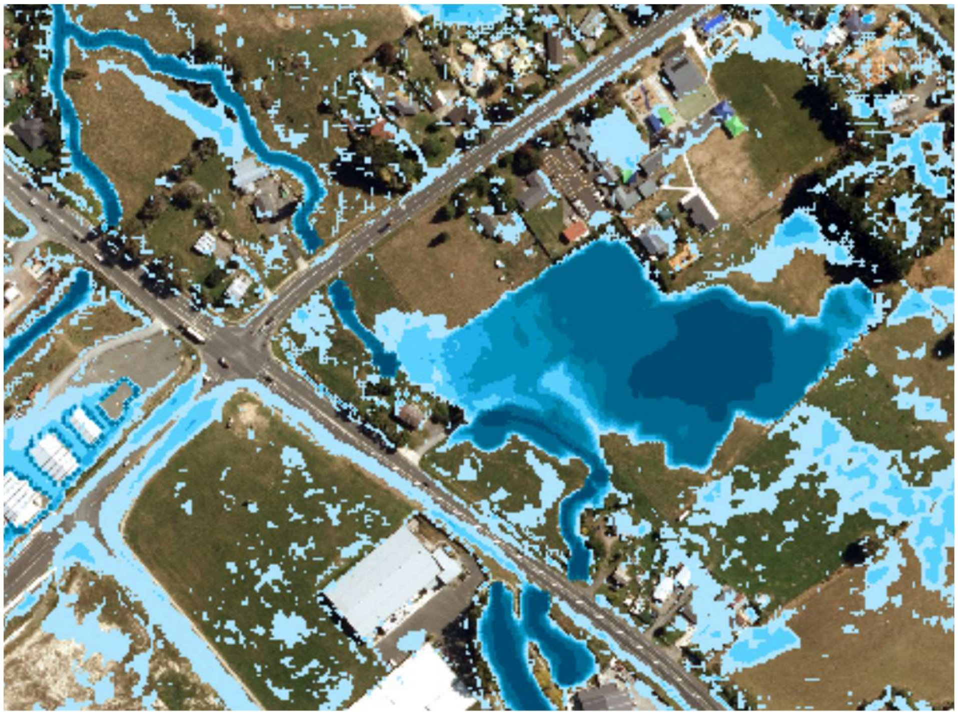


Figure 3: Blockage Scenario 2 – Shows a slight increase in flooding from the partially blocked scenario (small isolated flooding areas not cleaned). Result: Not a critical factor in the flood model as very similar to base model.

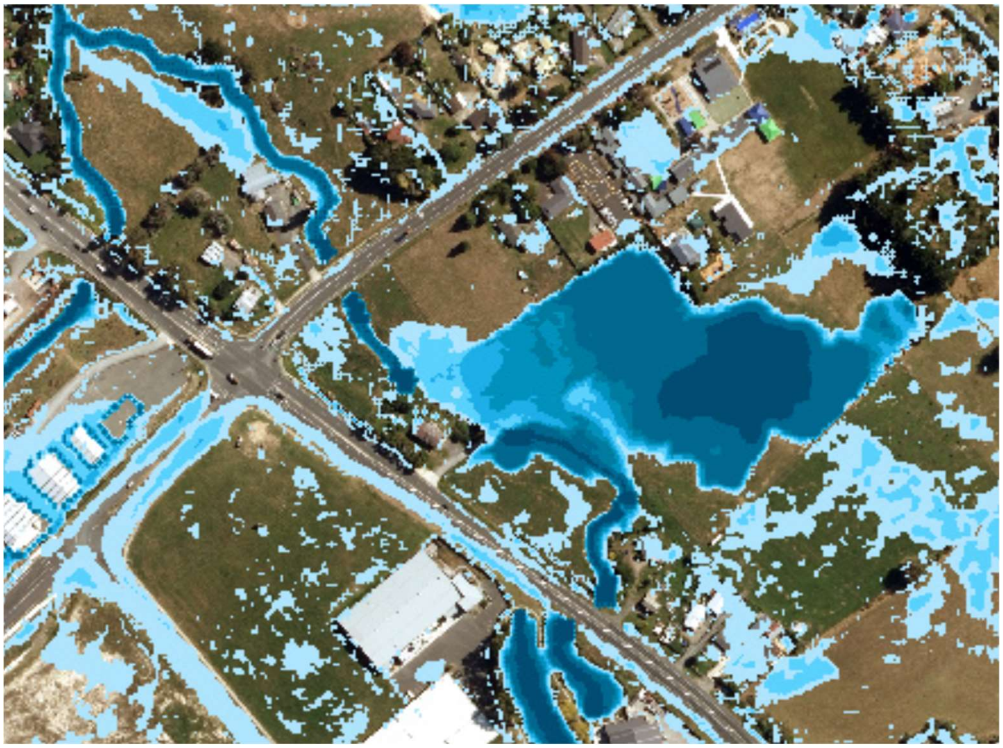


Figure 4: CN Increased Scenario: Shows slight increase from base model (small isolated flooding areas not cleaned). Result: Not a critical factor in the flood model as very similar to base model.

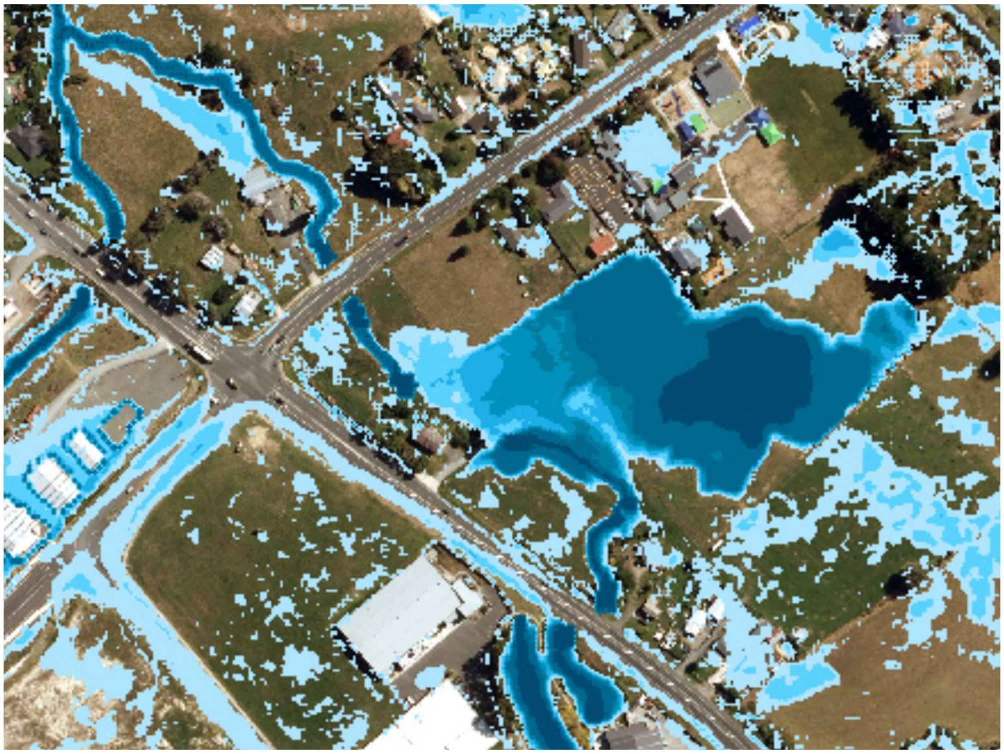


Figure 5: Increased Climate Change Scenario: Shows slight increase from base model (small isolated flooding areas not cleaned). Result: Not a critical factor in the flood model as very similar to base model.

Sensitivity Checking Results summary:

Scenario	Critical	Comment
Blockage 1	**Yes** in areas directly affected by culverts. **No** in areas not affected by culverts (as expected).	Blockage of large culverts is unlikely so not considered a critical issue requiring further testing. Consideration of catchment characteristics in terms of blockage risk could be considered in the future if further refinements are undertaken.
Blockage 2	No	Slight increase only – no additional properties inside flood extent
CN factor increase	No	Slight increase only – no additional properties inside flood extent
Climate change increase	No	Slight increase only – no additional properties inside flood extent

No additional sensitivity checking or changes to the base model parameters are required due to the results above showing that the parameters tested are not critical enough to warrant further testing or adjustments. Any adjustments within the guidance parameters are unlikely to show substantial changes in the flood extent.

Author(s):	Reviewer(s):
Waqas Sawar and Andrew Boldero	Britta Jensen/Ken Williams
3/11/2023	3/11/2023

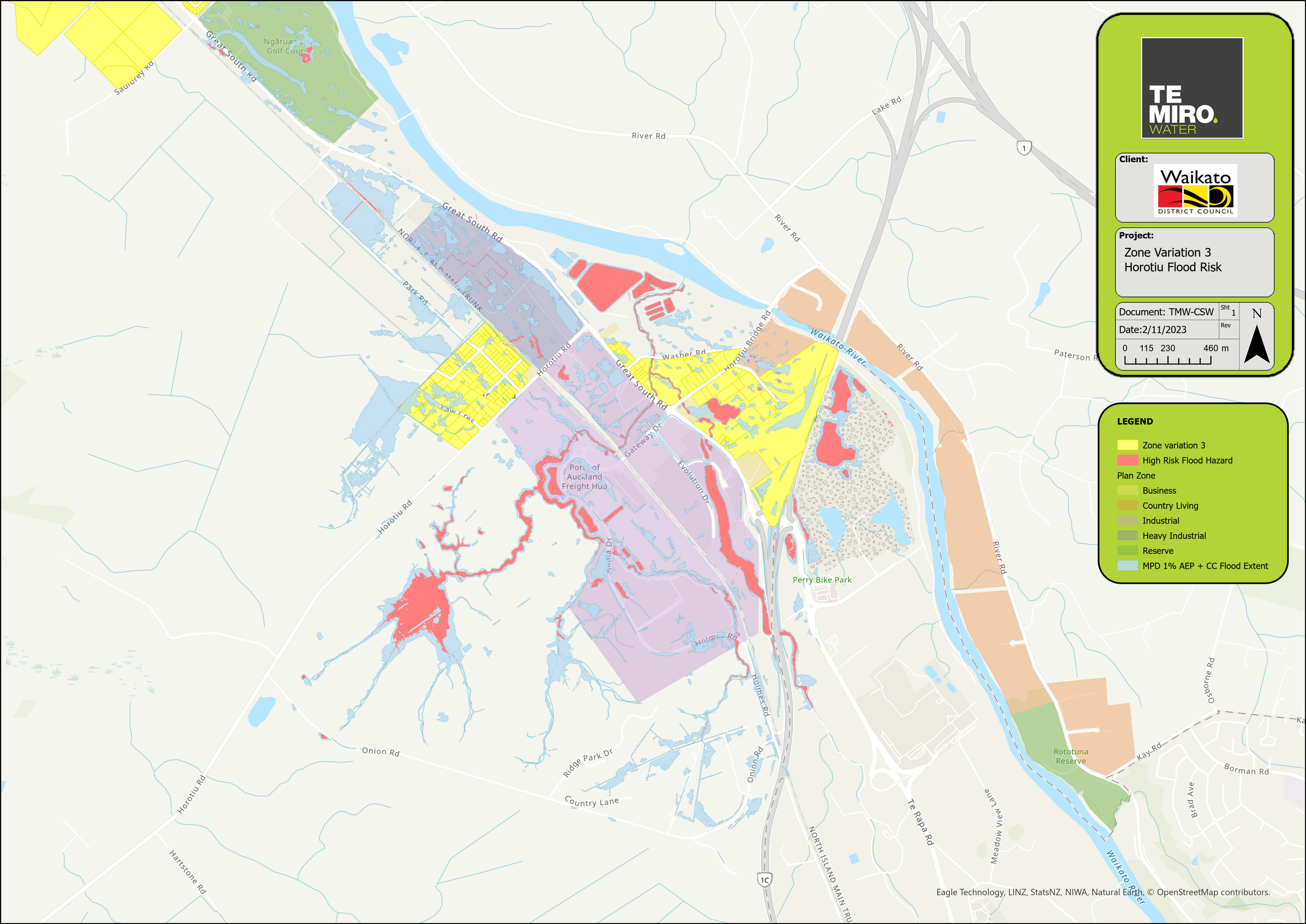
APPENDIX A: Culverts and Stormwater Network utilised by the hydraulic model

VARIATION 3 FLOOD MAPS

HOROTIU

UPDATED MAPS - FINAL (NOVEMBER 2023)


TE MIRO WATER
Client:
Waikato DISTRICT COUNCIL
Project:
Zone Variation 3
Horotiu Flood Model
Document: TMW-CSW
Sht 1
Rev
Date:2/11/2023
0 125 250 500 m
N
LEGEND
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
Model Extent
Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors


TE MIRO WATER
Client:
Waikato DISTRICT COUNCIL
Project:
Zone Variation 3
Horotiu Flood Risk
Document: TMW-CSW
Sht 1
Rev
Date:2/11/2023
0 115 230 460 m
N
LEGEND
Zone variation 3
High Risk Flood Hazard
Plan Zone
Business
Country Living
Industrial
Heavy Industrial
Reserve
MPD 1% AEP + CC Flood Extent
Great South Rd
River Rd
Lake Rd
Paterson Rd
Washer Rd
Horotiu Bridge Rd
Waikato River
Horotiu Rd
Gateway Dr
Evolution Dr
Port of Auckland Freight Hub
Perry Bike Park
Holmes Rd
Onion Rd
Ridge Park Dr
Country Lane
Hartstone Rd
Te Rapa Rd
Meadow View Lane
Rototuna Reserve
Kay Rd
Borman Rd
Osborne Rd
Brad Ave
NORTH ISLAND MAIN TRUNK
1
1C
Park Rd
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