Flood Plain Modelling Report

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Document Contents:

Official Height Standard Change

From 1 July 2024, Auckland Council adopts the official height standard for New Zealand called New Zealand Vertical Datum 2016 (NZVD2016).

This model was carried out prior to the height standard change.

All levels included in this modelling report are in Auckland Vertical Datum 1946 (AUK1946/AVD1946).

Levels in this report can be transformed from Auckland Vertical Datum 1946 into New Zealand Vertical Datum 2016 by applying an offset value.

For example:

$$H_{NZVD2016} = H_{AVD1946} – \text{Offset Value}$$

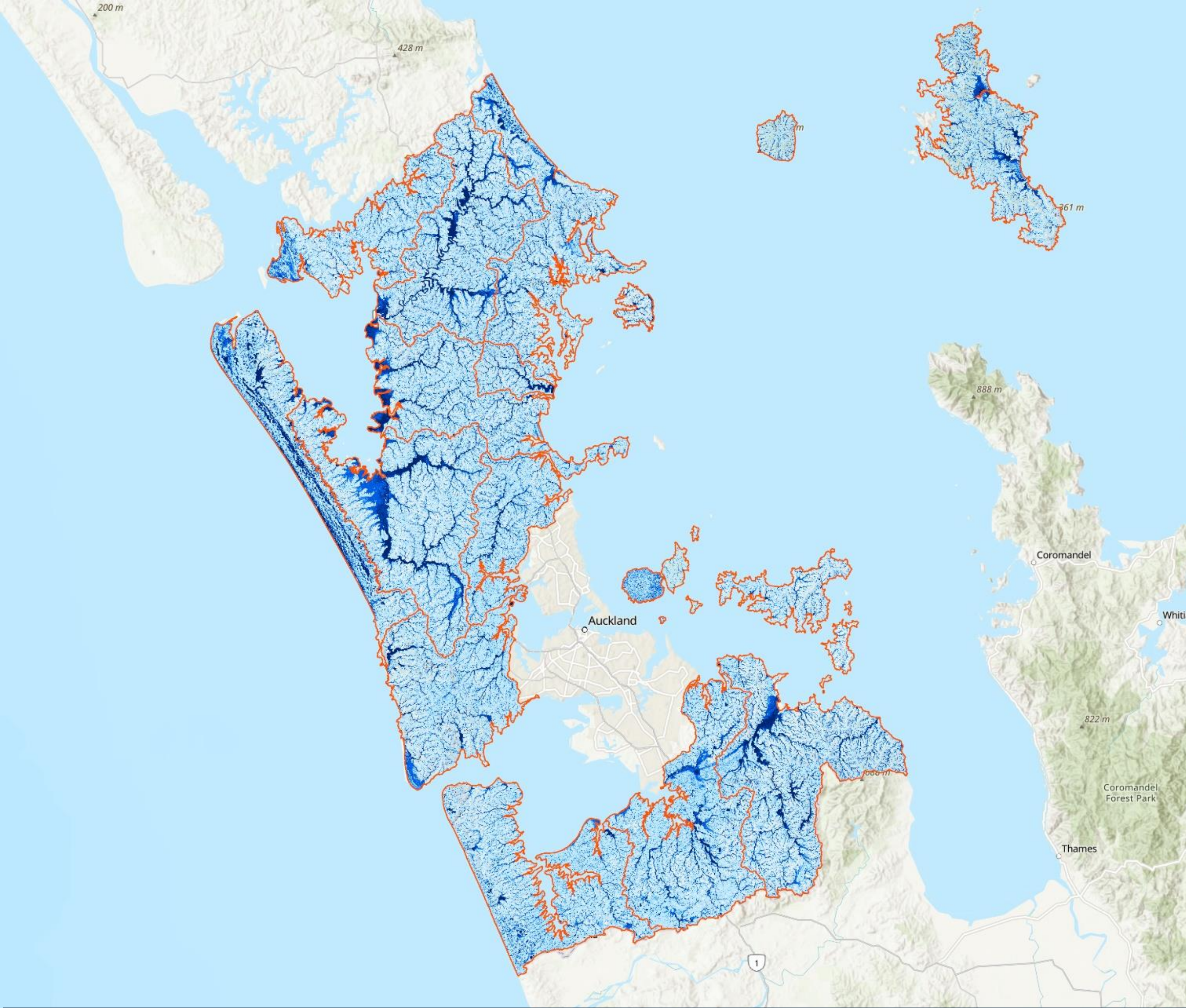
A single offset value has been taken from the Land Information New Zealand (LINZ) Auckland 1946 to NZVD2016 Conversion Raster for each model unit therefore this offset should be taken as an approximation only. The offset values are provided in the table below:

Model Unit	Offset Value (m)
Unit A	0.286
Unit B	0.279
Unit C	0.27
Unit D	0.285
Unit E	0.276
Unit F	0.287
Unit G	0.288
Unit H	0.289
Unit I	0.302
Unit J	0.299
Unit K	0.303
Unit L	0.307
Unit M	0.297
Unit N	0.274
Unit O	0.289

Model Unit	Offset Value (m)
Unit P	0.298
Unit Q	0.307
Unit R	0.303

A more accurate height transformation value can be derived by downloading the conversion raster available on the LINZ website below:

https://data.linz.govt.nz/layer/103953-auckland-1946-to-nzvd2016-conversion-raster/



Auckland Council

Regionwide

Rural Rapid Flood Model

Model Build Report

May 2023

Auckland Council

Ewaters New Zealand Ltd.

Auckland Council

Regionwide Rural Rapid Flood Model

Model Build Report

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Contents

Executive Summary

Auckland Council conducted a regionwide flood modelling study to address flood risk issues in the rural areas of Auckland and provide up-to-date flood information. Ewaters was commissioned by Auckland Council to undertake the study, aiming to improve flood risk management and emergency response in these areas. The existing flood modelling data for rural areas was outdated and of poor quality, dating back to 2009. Therefore, Auckland Council developed new flood models to generate and update flood plains covering the entire rural area of the Auckland Region.

The project covered a total of 4,428 km² of rural land areas, divided into 18 model units. The flood models were built using Tuflow software and the project incorporated various activities to assure model and mapping quality. Model tests were conducted to assess parameters for modelling and mapping performance. Model validation included verifying the model results against TP108 graphical method and the comparisons of gauge data were made over the Kaipara River catchment by running the August 2021 storm event simulation.

The study objectives focused on creating rain-on-grid 2D flood models for the rural areas, producing reliable flood maps, and providing a tool for strategic planning. The models were designed to consider various land use scenarios, such as maximum probable development and existing development. The project also aimed to assess the impact of climate change and land use changes on flood risk.

The hydraulic model used a rain-on-grid approach considering soil characteristics and land use of Auckland Region and utilized 2016 LiDAR data for the ground surface with necessary modification for better topographical representation and included major culverts and bridges. The mapping methodology involved generating a geometric network and utilizing custom GIS tools for efficient mapping. The flood plain maps were thoroughly reviewed and refined to ensure accuracy.

In conclusion, the regionwide rural rapid flood model project by Auckland Council aimed to provide up-to-date and accurate flood information for rural areas. The project successfully developed flood models and generated flood plains for the entire rural area of Auckland Region. The flood maps and models will support flood risk management, emergency response planning, and land use decision-making in the region. However, it is important to consider the limitations of the models and further refine the model as necessary.

1. Introduction

1.1 Background

The existing flood plain extents for most rural areas were produced from a 2009 Rapid Flood Hazard Assessment (RFHA) model completed with DHI software, which fulfilled the previous need for preliminary flood risk assessments and establishing regional flood plain extents. However, these flood plains are either missing in some catchments or showing low confidence in supporting Auckland Council (AC) management for current development due to the availability of better LiDAR data and the improvement of GIS and modelling technologies.

As Auckland's growth pressures increase, having up-to-date flood data for land use planning and development controls is paramount for Council. To provide consistent flood information across the rural area of the region, the regionwide rural rapid flood modelling study was initiated, utilising more recent LiDAR and other new base data. The project was split into two stages, with the first stage piloting and defining the modelling methodology, and the second stage refining the model and producing flood risk data.

The output of this study is expected to be the best flood risk tool for strategic planning in Auckland on a regional scale. It updates the flood plain mapping for the rural area and provides valuable data for error checks and complements the detailed catchment models.

1.2 Study Objectives

The main goal of the project is to create rain-on-grid 2D flood models for rural areas of Auckland Region and produce reliable flood maps. The project places emphasis on detailed modelling features to ensure that the models can be used for other extreme events, for Maximum Probable Development (MPD) and Existing Development (ED) scenarios, and with outputs that are compatible with waterRide and GIS platforms. Additionally, the project aims to provide a useful tool to assess and test regionwide changes, such as the impact of climate change and land use.

To achieve these objectives, the project incorporates a range of activities aimed at assuring model and mapping quality and identifying limitations. These activities include model tests to determine the best parameters for modelling, integration with waterRide and GIS for improved model validation, sensitivity tests, flood plain mapping, output data interrogation, and more.

1.3 Activities and Scope

The activities and scope of the present modelling study includes:

- Model tests and methodology development:
  - Conduct model tests to assess parameters for mapping, grid quality, 1D culvert performance, initial conditions, hotstart simulation, roughness sensitivity, mass balance, number precision computing, sediment and erosion, and others.
- Model validation:
  - Validate models over the Kaipara River catchment (Unit F) for the storm event on 30-31 August 2021.
- Model build:

  - Build models based on lessons learnt from testing stage, and in accordance with AC requirements. Construct 18 model units.
  - Model events set up for ED and MPD scenarios, for 2yr, 5yr, 10yr, 20yr, 50yr, and 100yr ARI design events as per "Guidelines for stormwater runoff modelling in the Auckland Region" (Auckland Regional Council Technical Publication No.108, commonly referred to as TP108).
- Model reviews and final simulations:
  - Conduct model reviews and final simulations for three scenarios:
    - MPD scenario for 100yr plus climate change, considering 2.1°C of warming factor.
    - MPD scenario for 100yr plus climate change, considering 3.8°C of warming factor.
    - Incorporate Sub-Grid Sampling (SGS) functionality in the grid for mapping purposes in the same 100yr/CC 3.8°C simulation.
- Deliverables:
  - Deliver TUFLOW Rain on Grid 2D models with three scenario runs for all 18 model units.
  - Provide a GIS package with peak model result cross sections containing flow and level hydrographs for all 18 model units.
  - Create flood plain mapping objects for all 18 model units contained in this scope, developed as per AC Specifications for publishing on GeoMaps.
  - Produce reporting and other technical documents as appendices of this report.

2. Study Area Description

2.1 Model Coverage

Auckland region is located on the North Island of New Zealand and covers an area of approximately 5,000 km². The mainland region spans from the mouth of the Kaipara Harbour in the north, extending southwards across the southern stretches of the Northland Peninsula, past the Waitākere Ranges and the isthmus of Auckland, and down to the low-lying land surrounding the Manukau Harbour. The region terminates within a few kilometres of the mouth of the Waikato River and is bordered by the Northland region to the north and the Waikato region to the south. In addition to the mainland, the Auckland region also includes the islands of the Hauraki Gulf.

The modelling study focuses on all catchments of the Auckland Region that contain rural land. The total model extent has been divided into 18 model units, covering a total land surface area of 4,428 km². Figure.01 provides a visual representation of the 18 model units and defines the extent of modelling for this project. Each model unit has been named after the first 18 letters of the alphabet, from A to R.

2.2 Topography

The topography of Auckland catchments is typical of hilly terrain, with steep slopes that quickly collect surface runoff into gullies, which then combine to form small streams that eventually join the main channel of the various rivers. Many areas also have large sand dunes and bars located at river mouths and coastal areas.

Figure.02 shows the topography of the Auckland Region.

2.3 Geology and Soils

Auckland's geology is diverse and varies significantly across the region. The entire region is underlain by Mesozoic greywacke basement rock, which is exposed in the Hunua Ranges and some Hauraki Gulf islands.

The soil type classifications are critical for estimating the pervious curve number (CN) values across the region and determining the equivalent CN based on the existing development and the imperviousness of the unitary plan.

Three different hydrologic soil type have been used for this modelling project. Figure.03 shows the modelled soil type classification.

2.4 Existing Land Use

The existing land use was determined by utilising the AC land cover layer 2017 combined with a low flow channel polygon that outlines the main channel of significant streams and rivers. The imperviousness of the existing land use varies from 0.2% to 14.6%, with an average value of 5.1% globally. See table 2.1 for the details.

Figure.04 shows the existing land use applied in the model.

2.5 Future Land Use

The land use for future development was established based on the maximum allowable imperviousness permitted by the current Operative Auckland Unitary Plan (AUP) and the recommended percentage imperviousness for each AUP zone for hydraulic modelling purposes by Healthy Waters.

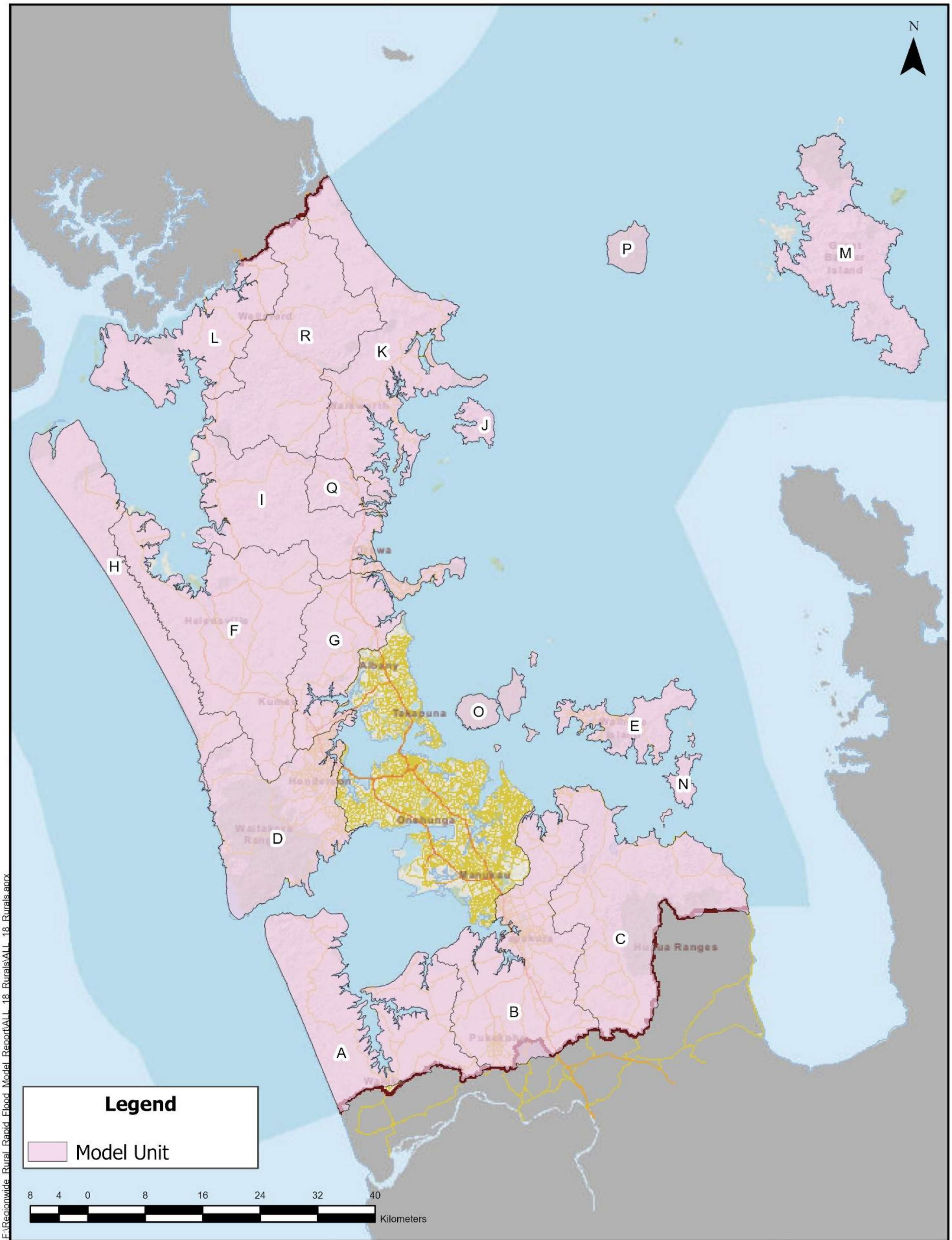
Given that the area is predominantly rural, the MPD imperviousness range is between 9.1% to 37.4%, with an average value of 16.1% globally. See table 2.1 for the details. It should be noted that the Hauraki Gulf Islands Zone does not specify any imperviousness limit, so for the purpose of this project, a conservative estimate of 10% imperviousness was adopted for this zone.

Where the estimated MPD impervious area was less than the ED impervious area, ED imperviousness was adopted as the MPD for that location.

Figure.05 shows the modelled imperviousness of Auckland Unitary Plan land use.

Table 2.1 – Imperviousness of land use

Model Unit	Area, km^2	ED Imp %	MPD Imp %
A	387.2	4.2%	14.2%
B	428.2	11.3%	29.8%
C	450.7	3.4%	10.5%
D	341.5	10.9%	23.0%
E	91.7	6.0%	10.5%
F	486.6	4.6%	13.3%
G	230.9	11.5%	37.4%
H	249.9	2.7%	11.0%
I	299.3	4.3%	13.4%
J	23.3	14.6%	26.4%
K	367.5	4.7%	15.0%
L	239.0	2.5%	10.8%
M	274.1	2.4%	12.6%
N	19.8	4.1%	10.0%
O	42.2	1.2%	10.0%
P	30.7	0.2%	10.0%
Q	55.5	2.2%	10.7%
R	409.8	1.5%	9.1%
Global	4428.0	5.3%	16.1%



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Map Projection is NZTM 2000.

Figure 01. Model units and coverage

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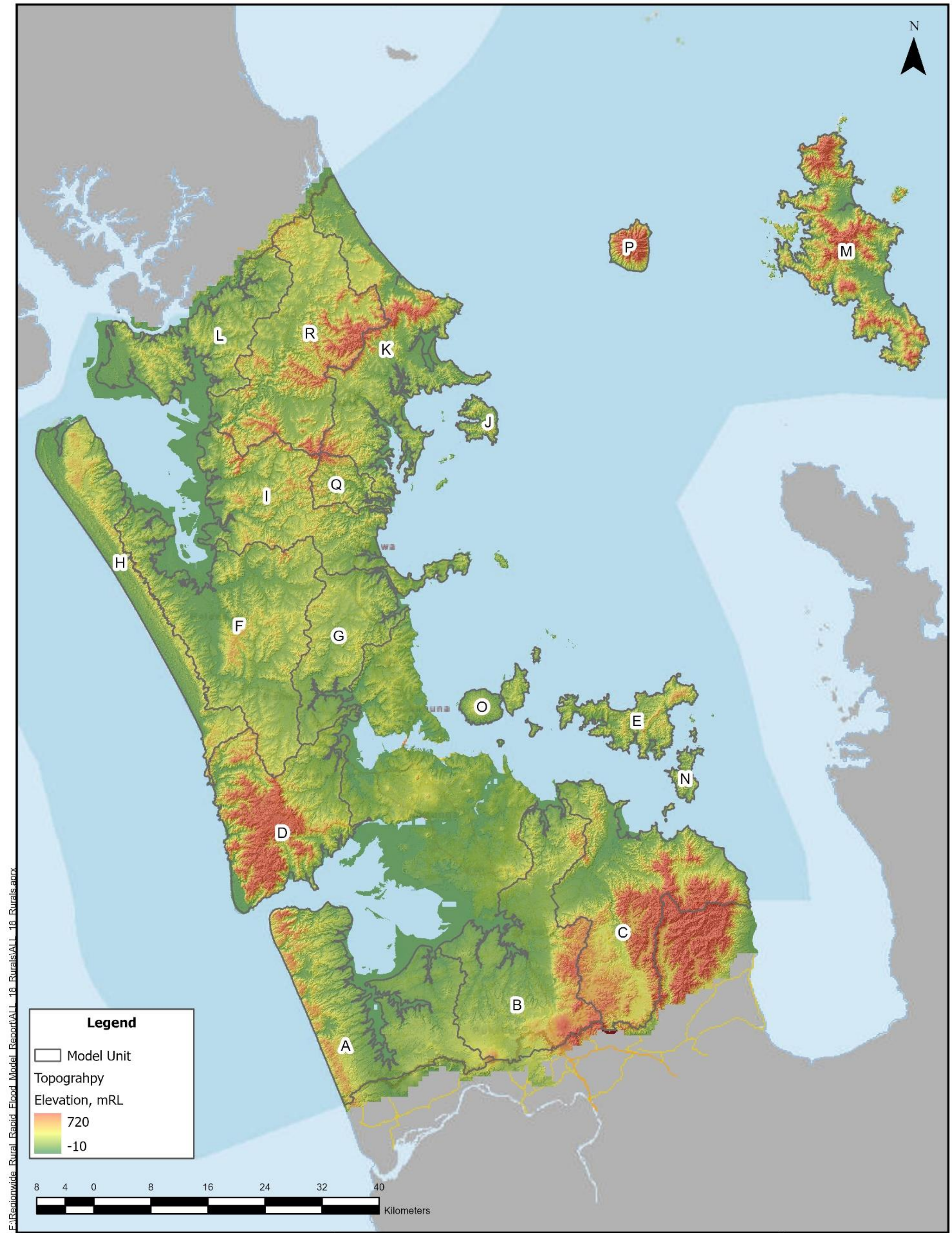

Map Projection is NZTM 2000.

Figure 02. Topography

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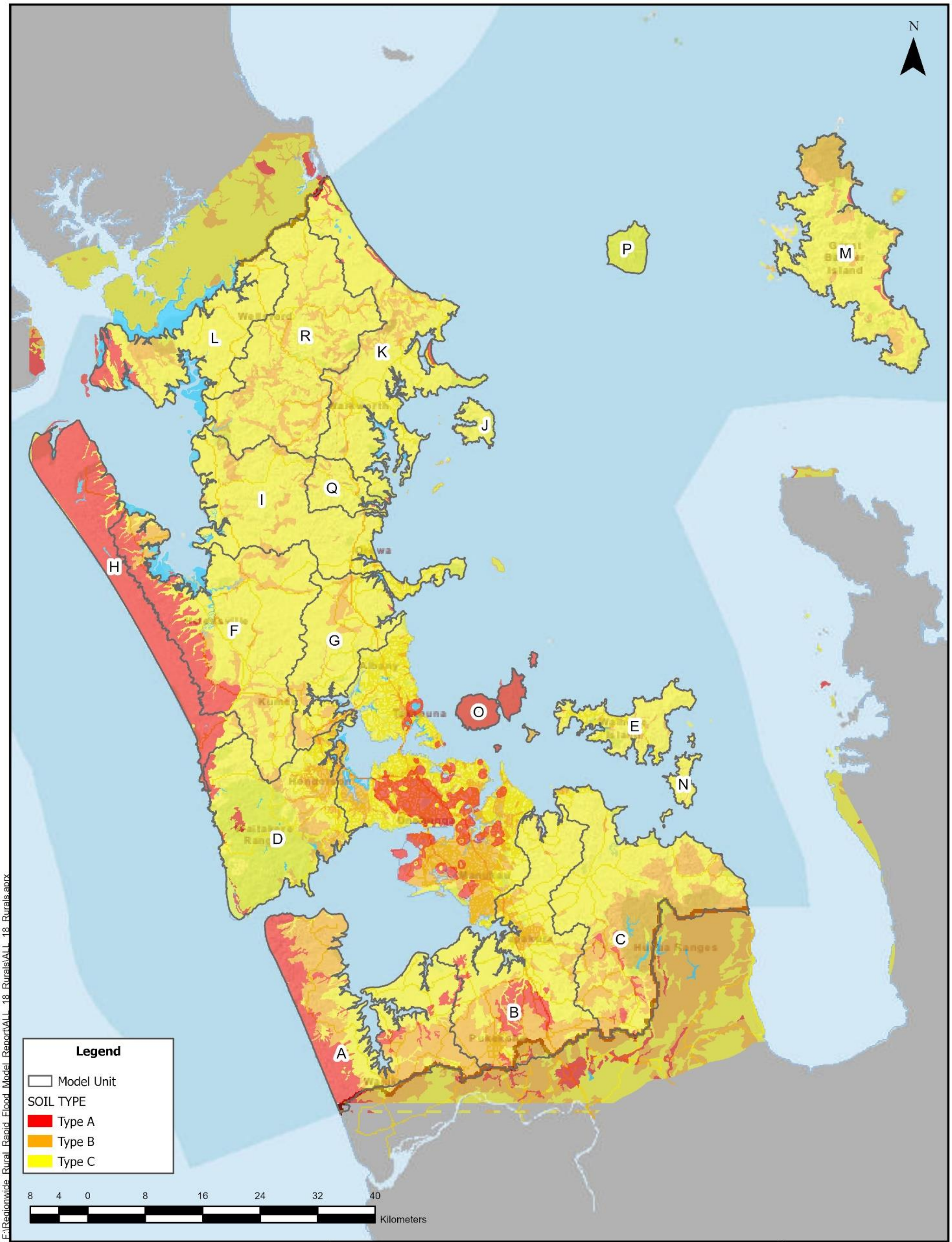

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Figure 03. Soil Type Classification

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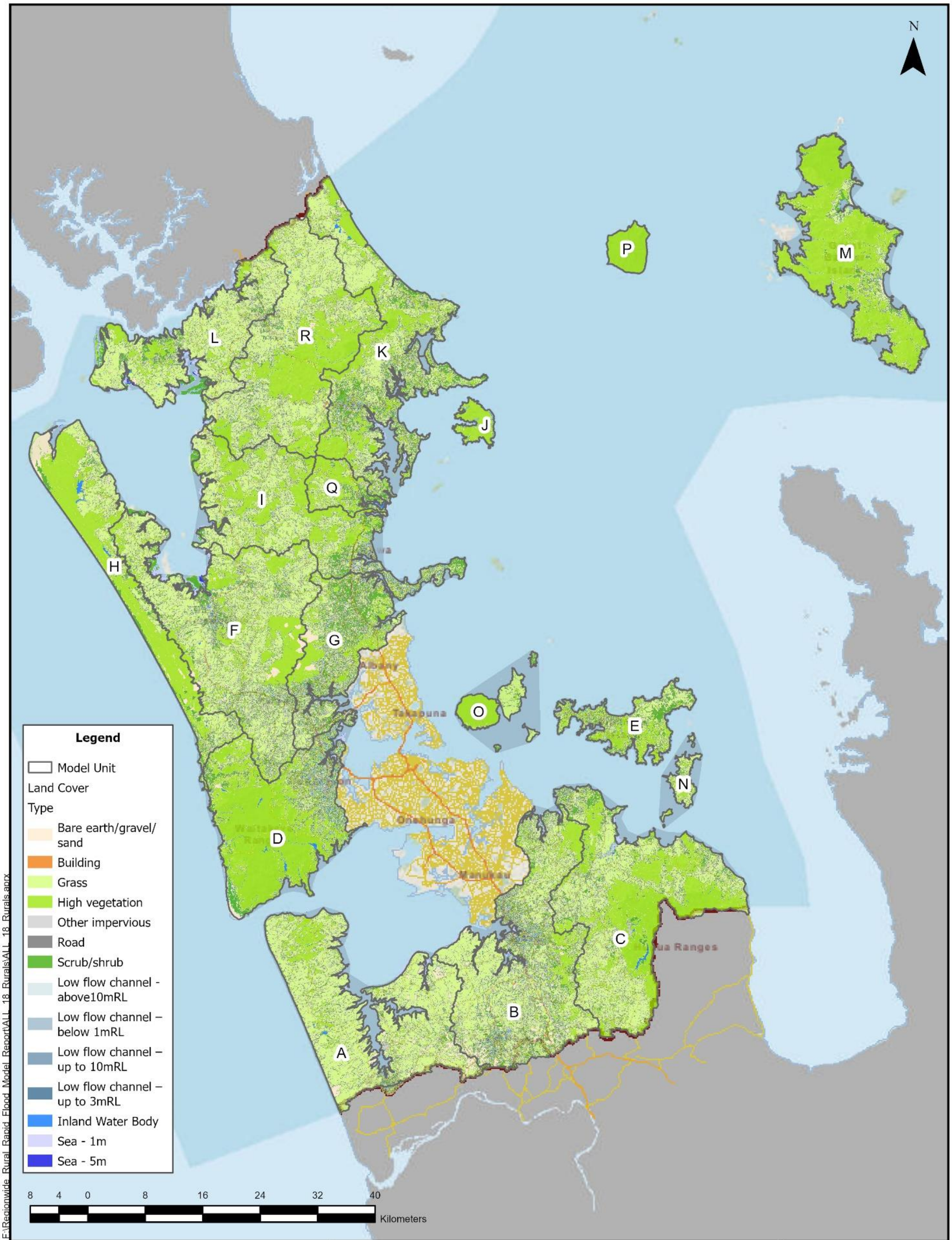

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Map Projection is NZTM 2000.

Figure 04. Existing Land Cover

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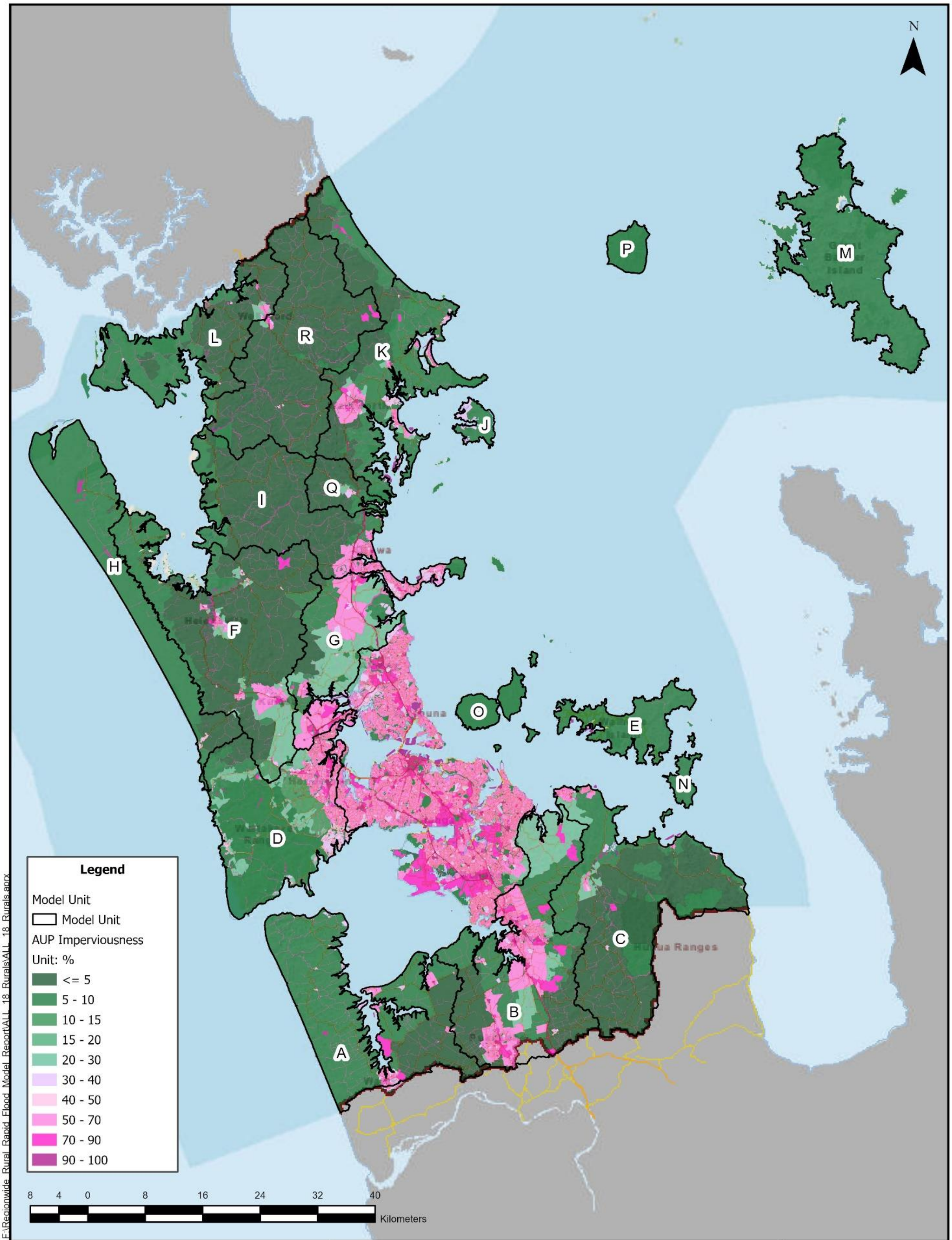
AC Regionwide Rural Rapid Flood Model



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Map Projection is NZTM 2000.

Figure 05. Auckland Unitary Plan Imperviousness

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3. General Methodology

3.1 Modelling Software

The models were constructed using Tuflow (Version: 2020-10-AD). The final deliverables included WaterRIDE and GIS formats.

3.2 Modelling Methodology

This project utilised the rain-on-grid approach for hydraulic modelling, which involves routing overland flow across a topographic surface to generate outputs such as flood extent, depth, velocity, and flood hazard. These outputs can then be used for various purposes, such as planning and emergency response. The resulting model provides a tool for comprehensive assessment of flood risk in the study area, which is essential for identifying potential hazards and developing effective mitigation strategies.

The effective rainfall depth was processed following the guidelines outlined in the TP108 without considering aerial reduction factor (ARF).

Major culverts and bridges were included. All pipe network has been considered fully blocked.

3.3 Mapping Methodology

To assist with flood plain mapping, a geometric network has been generated as part of the model build. The model data is imported into the geometric network objects, which allows for the processing of most of the flood plain mapping exercise using customised GIS tools specifically created for this purpose. This approach enables the efficient and effective mapping of the large areas covered by the modelling work.

Following the mapping exercise, a thorough review was conducted in cooperation with AC to address any exceptions. The resulting flood plain maps required final touch ups, engineering judgments, and manual work to ensure the highest level of quality for the final delivery.

4. Hydraulic Model

4.1 2D Model Surface

The ground surface used for all model units in this project is based on the AC 2016 1m LiDAR DEM, with a modelling grid resolution of 4m x 4m. To ensure the most accurate representation of the ground surface, a number of modifications have been applied. These modifications include:

- Filling the gaps in the estuary channel bathymetry where AC 2016 LiDAR data does not cover.
- Identifying and "burning" onto the DEM to represent the low flow channels under the water surface, which may not be adequately described by the AC 2016 LiDAR data.
- Fixing roads in the DEM that should be closed but appear open or partially open in the AC 2016 LiDAR data.
- Break lines applied for better topographic feature representation, such as roads, depressions, and some dams.

These modifications are crucial for creating an accurate representation of the ground surface and improving the accuracy of the modelling outputs.

4.2 1D Culvert

Culverts were represented by 1D objects in Tuflow, for a better description of the drainage system at critical locations.

The process of identifying culverts for modelling involved considering pipes with a diameter of 1800mm or greater (if diameter information was available). In addition, smaller culverts were also considered, specifically focusing on critical locations with a significant impact on flood risk.

For major crossings where culvert data was not available, estimations were made based on aerial photographs, street view, photograph records or engineering judgement based on catchment size and nearby culverts.

Depressions that were unable to fill during a 100-year storm were considered for culvert inclusion. Moreover, depressions deeper than 3.6m were also considered for inclusion of 1D culverts.

The inlet and outlet losses have been thoroughly considered in the model, incorporating the recommended coefficient values as specified in the Tuflow user manual.

A total of 568 culverts were modelled across all model units.

4.3 Roughness

Friction factor was assigned to the 1D culvert objects as a Manning's “n” value of 0.014.

The hydraulic roughness over the 2D model domain is expected to be different based on various land uses. The 2D roughness values used in the model are listed below.

Table 4.1 - Roughness values over 2D model domain

Land use ID	Description	Manning's n
1	Grass	0.1
2	Other impervious	0.05
3	Road	0.05
4	Scrub / shrub	0.1
5	Bare earth / gravel / sand	0.1
6	High vegetation	0.1
7	Water	0.05
8	Water - 1m	0.05
9	Water - 2m	0.05
10	Water - 5m	0.05
11	Water - 10m	0.05
12	Water - 20m	0.05
13	Water - 50m	0.05
14	Low flow channel – below 1 mRL	0.025
15	Low flow channel – up to 3 mRL	0.04
16	Low flow channel – up to 10 mRL	0.05
17	Low flow channel – above 10 mRL	0.06
18	Building	0.5

5. Hydrological Model

The hydrology of the model has been constructed applying TP108 methodology with considerations of existing and future land use as well as the climate change factor.

Effective rainfall was calculated incorporating rainfall losses; initial losses and applying correction for the continuing losses.

5.1 Curve Number

As detailed in section 2.3, the US SCS soil type coverage in the Auckland Region consists of hydrological soil group A, B and C soils. The following CN values were therefore assigned to the model:

- 98 for all impervious areas.
- 39 for all pervious area in Group A soils.
- 61 for all pervious area in Group B soils.
- 74 for all pervious area in Group C soils.

Initial abstractions (Ia) were set to 5mm for pervious surfaces and 0mm for impervious areas.

5.2 Rain Zones

A great number of rain zones have been created over each model unit to assign effective rainfall series as modelling input. The delineation of the rain zones considers the topographic features such as highways and rural settlements, as well as the unitary plan zoning.

The average size of each rain zone is between 100ha and 900ha, with an average of 225ha. This is considered a suitable resolution to describe the distribution of rain and land use over the rural areas.

Figure.06 shows the rain zone distribution across all model units.

5.3 Rain Data

Each model unit was divided into multiple rain zones, and several hydrological parameters such as imperviousness, curve number have been considered for each rain zone to calculate effective rainfall time series based on TP108 method.

ARF was not considered for this modelling work to avoid ambiguity. Rain zones in all model units were considered to have an ARF of 1.0.

In this project, three scenarios were considered for rainfall input, with their respective 24hr temporal pattern

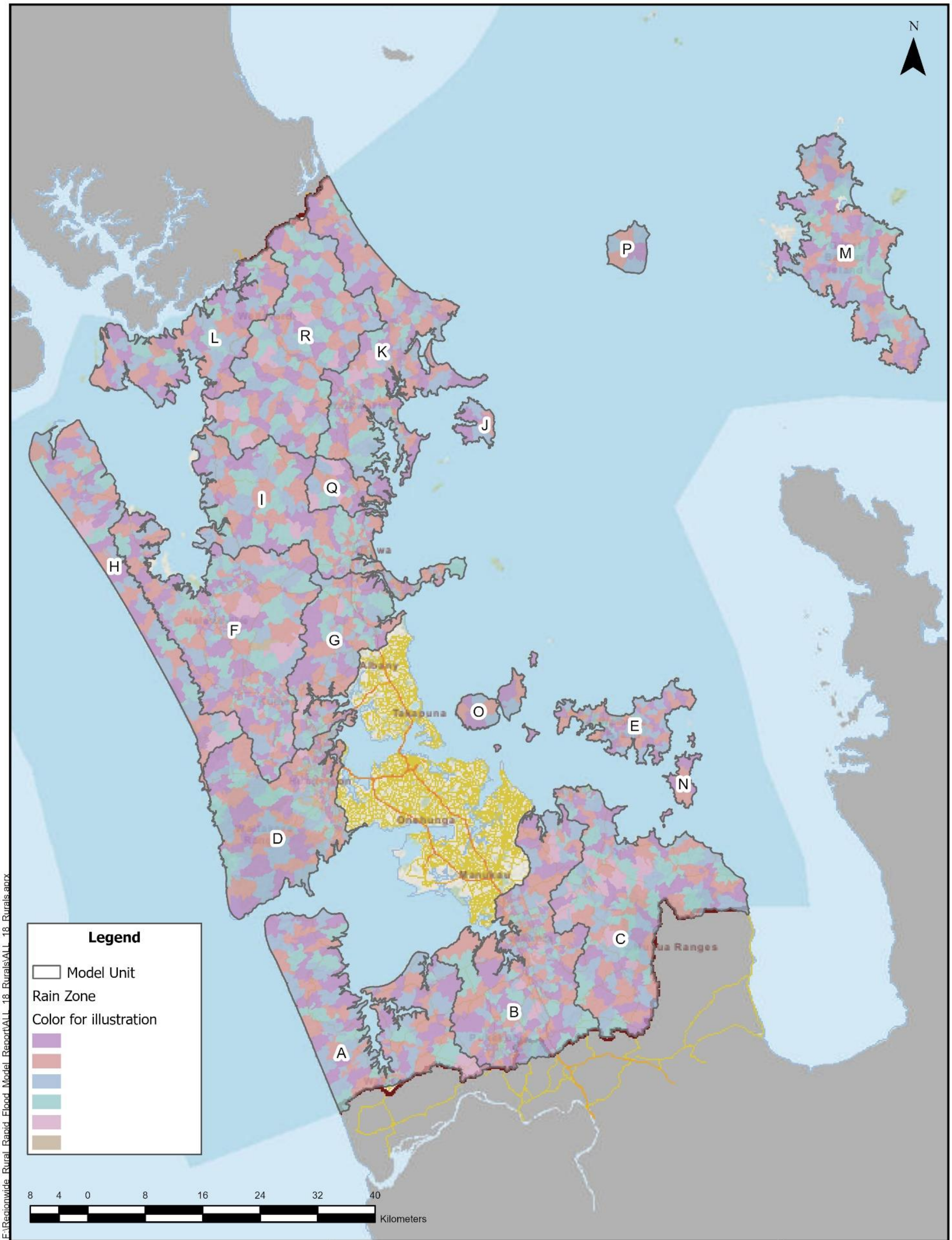
- Existing climate, using rain depths based on TP108 isohyets.
- Future climate with 2.1°C of warming factor on top of TP108 isohyets.
- Future climate with 3.8°C of warming factor on top of TP108 isohyets.

Table below shows the future climate warming factors of different ARI scenarios.

Figure.07 shows the TP108 rain isohyets. 100-year rainfall data from HirdsV4 (NIWA's High Intensity Rainfall Design System, Version 4) was applied for Unit M as the area is not covered by TP108.

Table 5.1 - Climate Change factor over TP108 Rain Isohyets

ARI	2.1°C Climate Change Factor	3.8°C Climate Change Factor
2	+9.0%	+27.4%
5	+11.3%	+29.6%
10	+13.2%	+30.8%
20	+15.1%	+31.2%
50	+16.8%	+31.9%
100	+16.8%	+32.7%



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Map Projection is NZTM 2000.

Figure 06. Rain Zone

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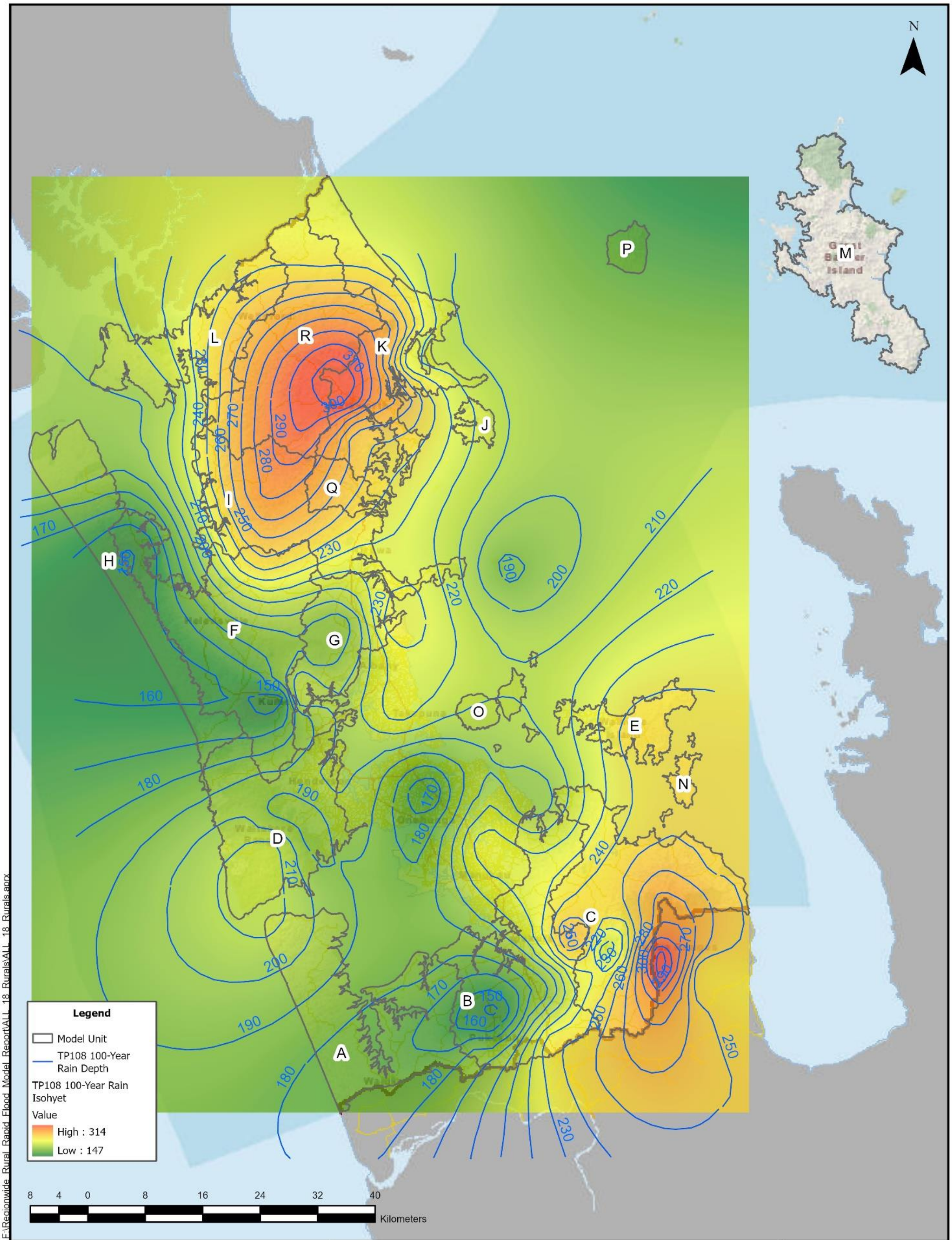

Map Projection is NZTM 2000.

Figure 07. 100-Year TP108 Rain Isohyet

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6. Boundary Condition

6.1 Tidal Data

The tidal border conditions for the modelling work were based on MHWS10 level from NIWA study. The tidal levels across the region vary between 1.0 to 2.3 mRL. To account for potential sea level rise due to climate change, a 1-meter rise has been included, resulting in tidal levels ranging from approximately 2.0mRL to 3.3mRL.

Due to the significant variation in tidal border conditions even within the same model unit, the tidal border line was divided into portions to represent different tidal levels. Tidal zones were separated from each other to ensure that they do not affect the levels of neighbouring areas.

Table below provides a summary of the boundary level for all the model units, specifying the tidal levels or ranges for each unit.

Table 6.1 - Boundary levels summary. MHWS10 + 1m for climate change

Model Unit	Boundary levels (MHWS10) mRL	Boundary levels (MHWS10+1m) mRL	Note
A	1.74 ~ 2.00	2.74 ~ 3.00	1m of sea level rise has been considered to account for climate change.
B	1.58 ~ 2.11	2.58 ~ 3.11	
C	1.58 ~ 1.63	2.58 ~ 2.63	
D	1.70 ~ 1.92	2.70 ~ 2.92	
E	1.46 ~ 1.60	2.46 ~ 2.60	
F	2.19 ~ 2.30	3.19 ~ 3.30	
G	1.43 ~ 1.76	2.43 ~ 2.76	
H	1.71 ~ 2.13	2.71 ~ 3.13	
I	1.42 ~ 2.30	2.42 ~ 3.30	
J	1.35 ~ 1.40	2.35 ~ 2.40	
K	1.25 ~ 1.42	2.25 ~ 2.42	
L	2.00 ~ 2.30	3.00 ~ 3.30	
M	1.12 ~ 1.26	2.12 ~ 2.26	
N	1.60	2.60	
O	1.54	2.54	
P	1.28	2.28	
Q	1.42	2.42	
R	2.12	3.12	

6.2 Initial Conditions

Where no drainage mechanism was modelled, depressions were filled as a part of initial conditions of the model to provide a relatively conservative assessment of flood risk.

A preliminary simulation was run as hotstart to provide appropriate initial conditions prior to the final model simulations.

6.3 Input Data Summary

Table below presents details of the input data used in this modelling study.

Table 6.3 - Modelling Input Data

Data	Description	Note
Model Units	The contributing catchment boundary is defined based the DEM (LiDAR 2016).	
Terrain model	LiDAR 2016, 1m DEM.	DEM modifications applied for large culvert openings and break lines.
Grid Size	4m x 4m.	SGS (Sub-grid sampling) feature applied for 3.8°C CC scenario as flood mapping input.
Rainfall	24-hours design rainfall storm. Climate change of 2.1°C and 3.8°C warming factors applied for future scenarios.	No Areal Reduction factor (ARF) applied.
Hydrology	TP108 method. Effective rain for all rain zones. Curve Number based on different soil types. MPD imperviousness based on the Unitary Plan zones.	10% impervious assumed for the Hauraki Gulf Islands, except Waiheke, with its own unitary plan guidance.
Hydraulic roughness	The Manning's n roughness based on AC landcover layer data.	
Building and Roads	Included as part of model 2D surface.	
Tidal Level Model	The constant MHWS10 levels were applied over time series based on Mean High Water Spring 10%ile estimates around the Auckland Region.	Including 1m sea level rise accounting for climate change scenarios.
Initial conditions	Hotstart run and filled depressions applied.	

7. Model Validation

7.1 TP108 Verification

Table 7.1 presents the results of the verification process conducted on the modelled peak flow rates against the AC TP108 graphical method. The verification was carried out at 21 selected locations across the Auckland Region. The corresponding verification locations can be found in Figure.10.

The peak flow rate errors, which indicate the percentage difference between the modelled and TP108 peak flow rates, predominantly fall below 20%, with an average error of 12.8%. Similarly, the total volumes exhibit mostly less than 5% error, with an average error of 3.4%.

Overall, the verification process demonstrates that the modelled results align well with the TP108 graphical method results, providing greater confidence in the model's performance.

Table 7.1 TP108 verification summary

Location	Catchment Area	TP108 Peak Flow	Modelled Peak Flow	Peak Flow Error	TP108 Volume	Modelled Volume	Volume Error
Unit	ha	m^3/s	m^3/s	%	m^3	m^3	%
P01	171.3	27.9	33.1	18.7	242,478	247,583	2.1
P02	971.2	261.0	175.3	32.8	2,552,063	2,475,153	3.0
P03	509.5	104.2	128.8	23.6	1,017,213	1,011,649	0.5
P04	1202.3	213.1	234.4	10.0	2,231,270	2,272,069	1.8
P05	229.3	86.4	90.1	4.4	603,883	622,214	3.0
P06	29.4	13.8	16.2	17.6	77,869	77,841	0.0
P07	437.5	80.6	85.8	6.4	782,165	803,632	2.7
P08	98.1	34.5	42.6	23.6	241,770	250,617	3.7
P09	131.9	15.1	16.6	9.5	155,122	148,521	4.3
P10	61.6	27.7	30.0	8.2	156,643	162,615	3.8
P11	503.5	185.4	159.1	14.2	1,293,610	1,397,802	8.1
P12	1350.1	327.4	357.1	9.1	3,825,346	4,168,120	9.0
P13	1550.0	255.2	264.9	3.8	3,986,010	4,184,361	5.0
P14	199.1	119.6	126.7	5.9	685,938	697,386	1.7
P15	765.0	115.7	115.3	0.4	1,207,348	1,230,686	1.9
P16	72.9	28.6	34.0	19.1	160,302	177,576	10.8
P17	15613.6	665.3	670.8	0.8	2,6183,029	25,958,938	0.9
P18	6157.5	683.7	782.6	14.5	14,051,990	13,687,440	2.6
P19	8.8	2.6	2.8	10.3	14,376	14,745	2.6
P20	501.8	98.6	106.6	8.1	1,031,011	1,008,030	2.2
P21	409.5	83.2	106.1	27.5	724,690	741,820	2.4
Average				12.8			3.4

7.2 Mass Balance Check

The mass balance error of 100yrsCC simulation is less than 1%, for all completed model unit simulations.

7.3 Model Gauge Validation

The 30th - 31st August 2021 event was used for the validation over the model unit F covering Kaipara River catchment. For the validation process, rain radar data of a 36-hour period from 12:00 on August 30th, 2021, to 00:00 on September 1st, 2021, was used. The recorded rainfall during this period ranged from 21mm to 240mm across all radar cells.

The gauge data of Kaipara River @ Waimauku and Kaukapakapa @ Taylors have been compared against the modelled results to validate the model.

Figure 08 presents the spatial distribution of rainfall, utilizing radar data and gauge locations specifically within Unit F. In Figure 09, a comparison is made between the flood extent estimated by the model and the actual flood extent determined through post-event investigation in Kumeu Township. Charts 7.1 to 7.6 depict the comparisons of simulated and measured water levels, flows, and rating curves.

Table 7.2 Gauges selected for the validation

Gauge Name	X [m NZTM]	Y [m NZTM]	Catchment Area [km²]
Kaukapakapa @ Taylors	1,735,809	5,945,031	62
Kaipara River @ Waimauku	1,733,345	5,930,348	156

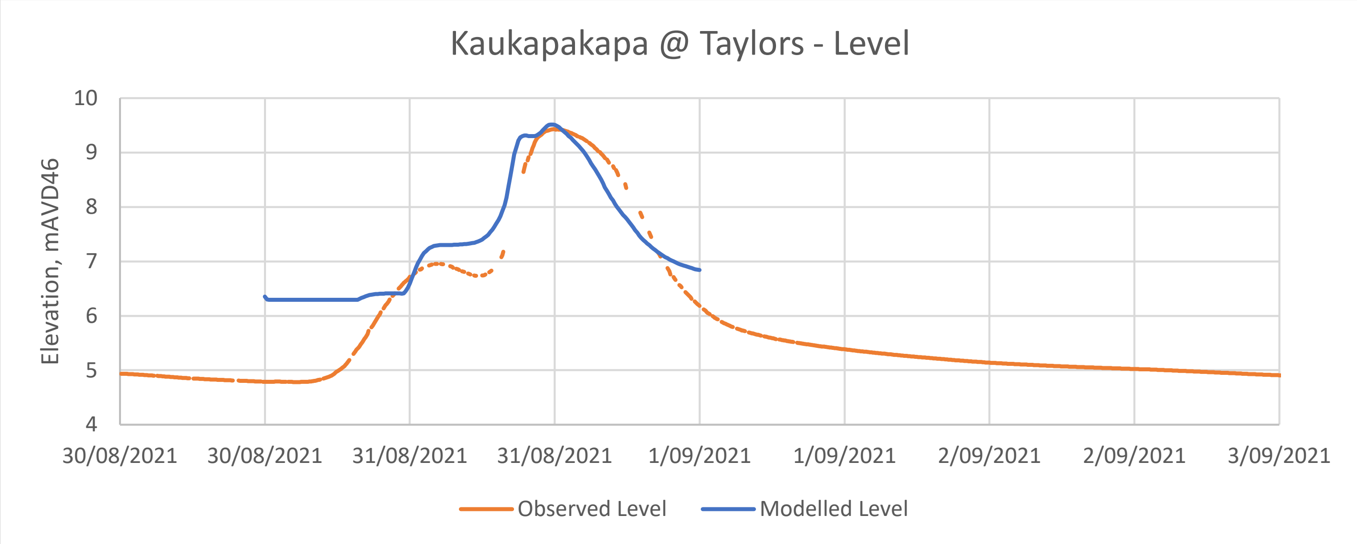

Chart 7.1 Kaukapakapa @ Taylors model results against Level

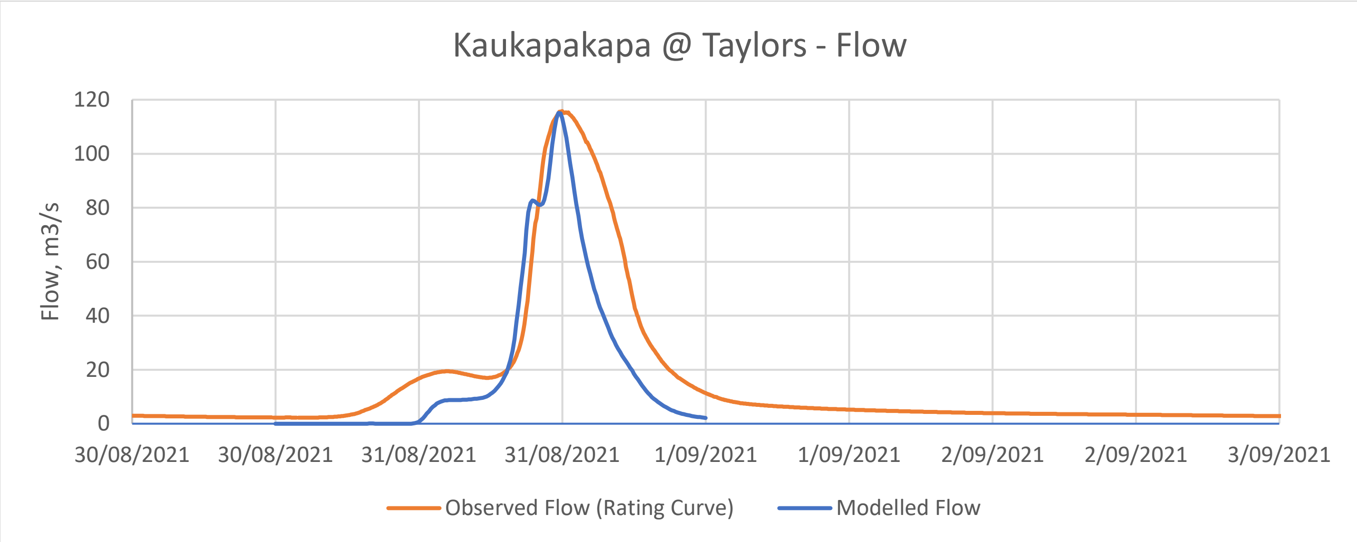

Chart 7.2 Kaukapakapa @ Taylors model results against Flow

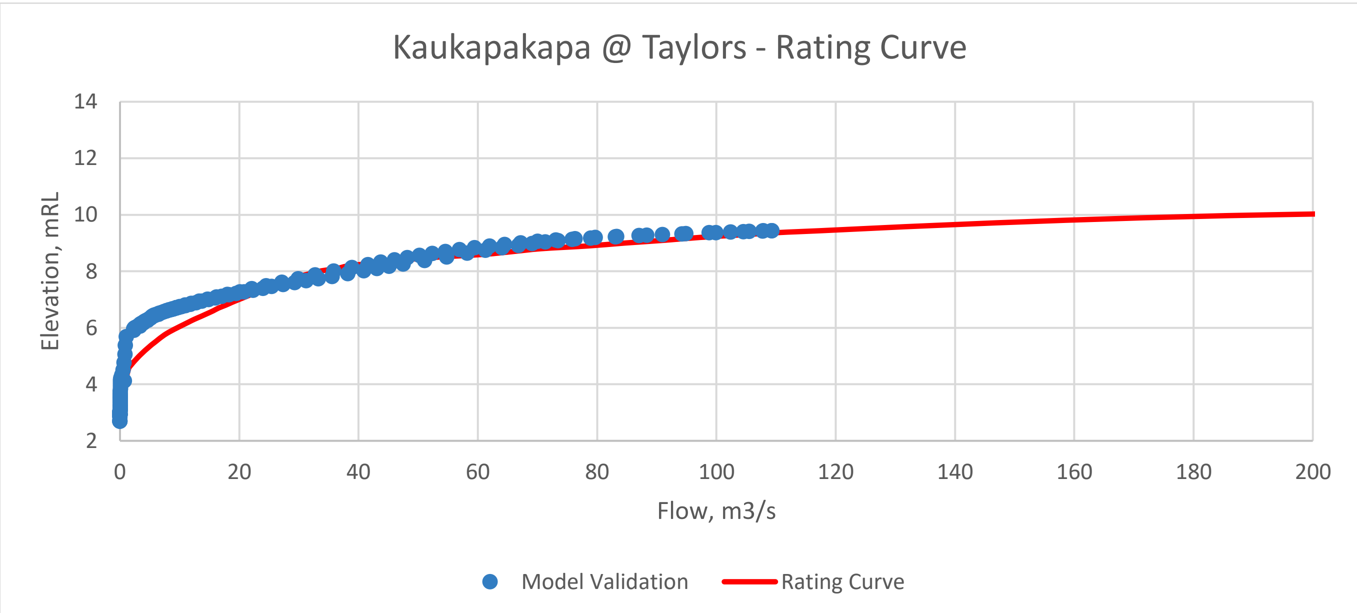

Chart 7.3 Kaukapakapa @ Taylors model results against Rating Curve

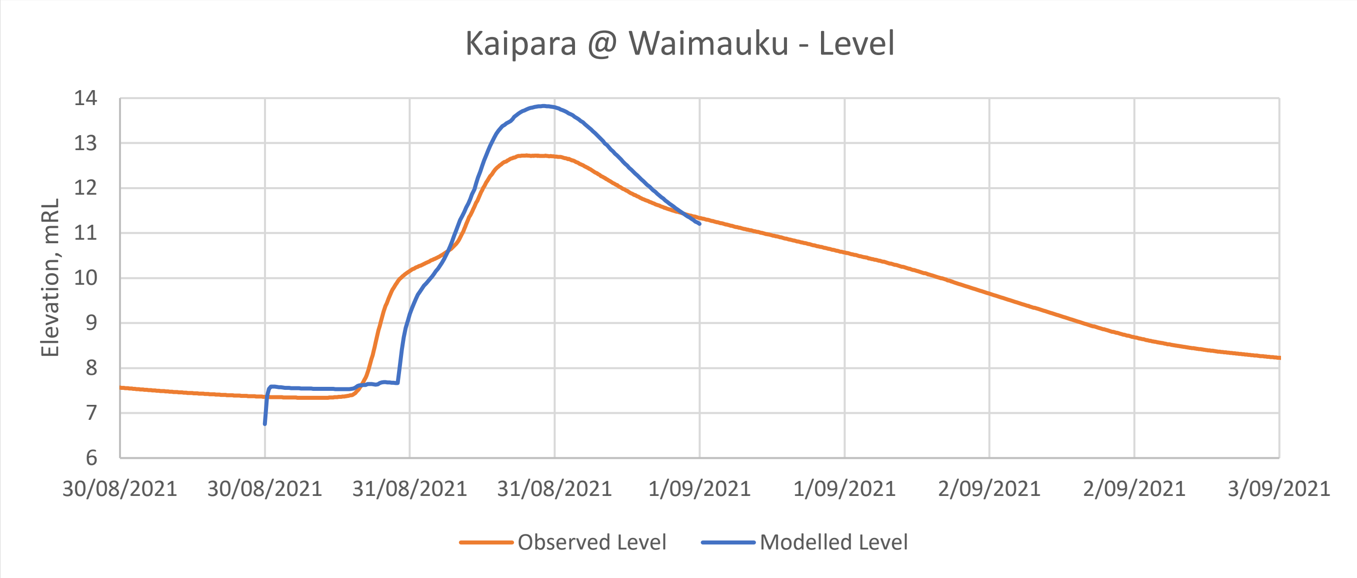

Chart 7.4 Kaipara River @ Waimauku model results against Level

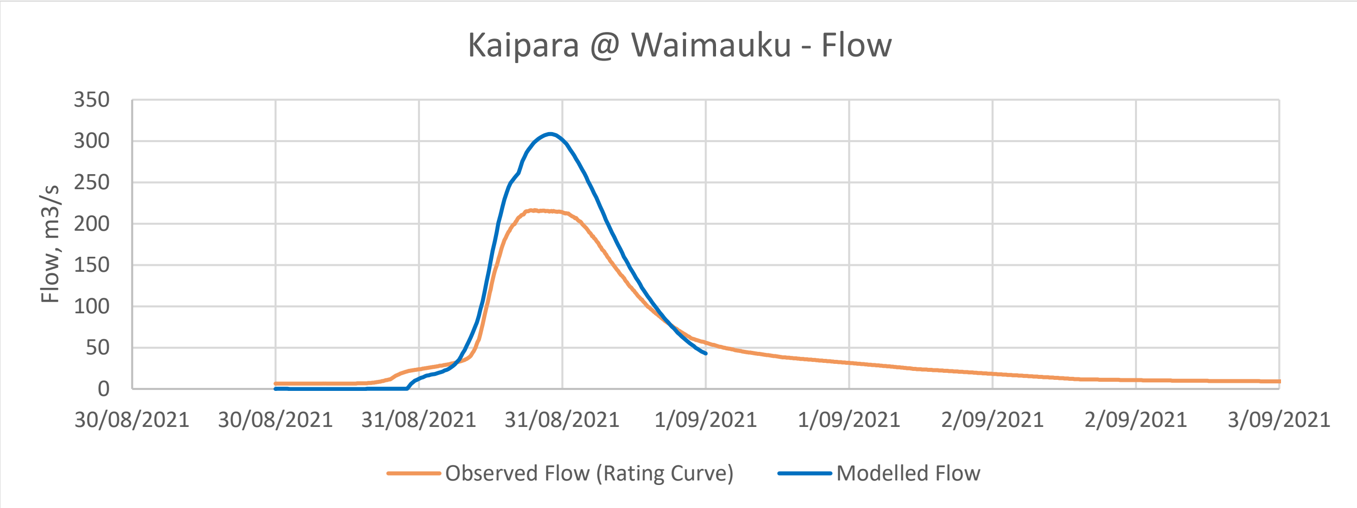

Chart 7.5 Kaipara River @ Waimauku model results against Flow

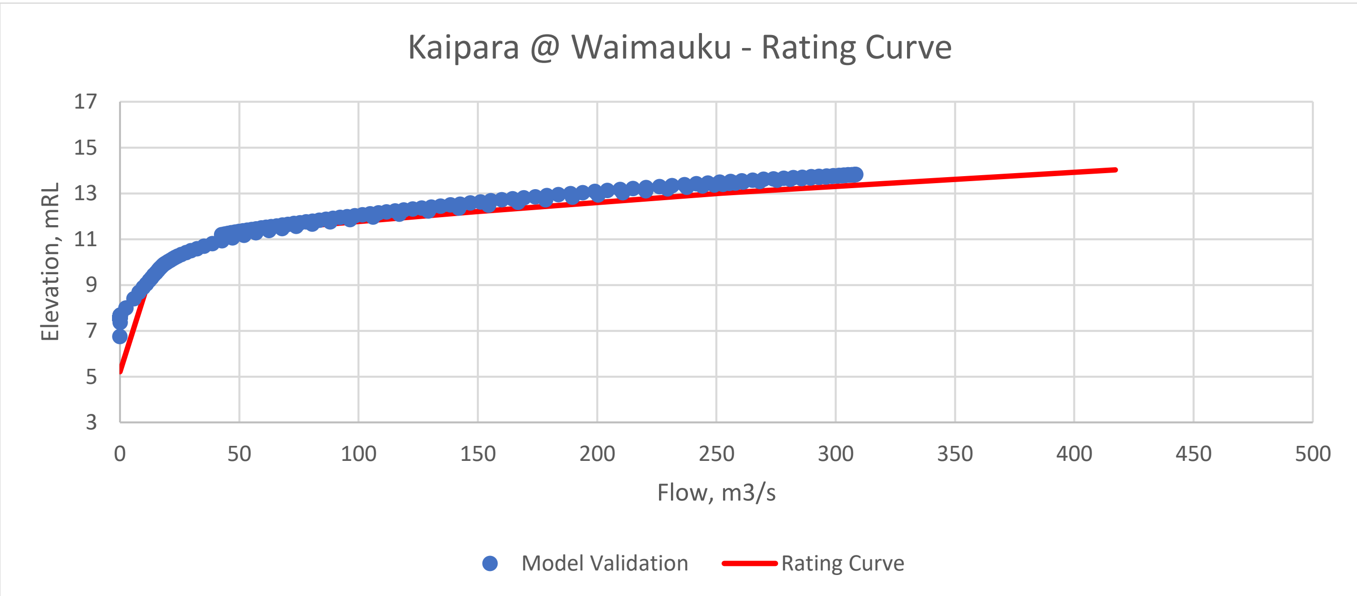

Chart 7.6 Kaipara River @ Waimauku model results against Rating Curve

AC Regionwide Rural Rapid Flood Model

The model validation results at gauges showed that the time to peak in the modelled results matched well with the measured data at both gauges. At the Kaukapakapa River site, the modelled flows and water levels closely followed the gauge's rating curve.

The model however overestimate flood level at the Kaipara River gauge for the validation event. To gain a better understanding of the flow difference, a comparison was made between the volume from each hydrograph and the total rainfall runoff volume, as presented in Table 7.3. The volume for the modelled hydrograph closely matched the rainfall runoff, thereby verifying the model's mass balance. However, flows computed from both rating curves exhibited higher error margins. This discrepancy is likely caused by the hydrological modelling methodology, especially for the discrepancies between the modelled TP108 rainfall loss parameters and the specific August 2021 storm event conditions.

Table 7.3 Volume check (36 hours)

Item	Total volume, million m^3	Percentage, %
Rainfall runoff	13.9	100
Validation model	13.5	97
Flow based on latest rating curve	11.1	80

In general, the model has been validated to show a reasonable level of agreement with the measured gauge data, considering the large scale of the regionwide models. However, there are some differences between the model results and the measured data, which could be attributed to various factors/limitations, such as:

- Limitations of the topographic representation, currently with a 2D model resolution of 4mx4m,
- Missing features that are not accounted for within the model such as pipe network/culverts,
- Consideration of the impact from ground water,
- Rainfall variability over the catchment,
- Land use characteristics during the historical storm events,
- Missing ponding/storage features,
- Accuracy of rating at the flow gauge site.

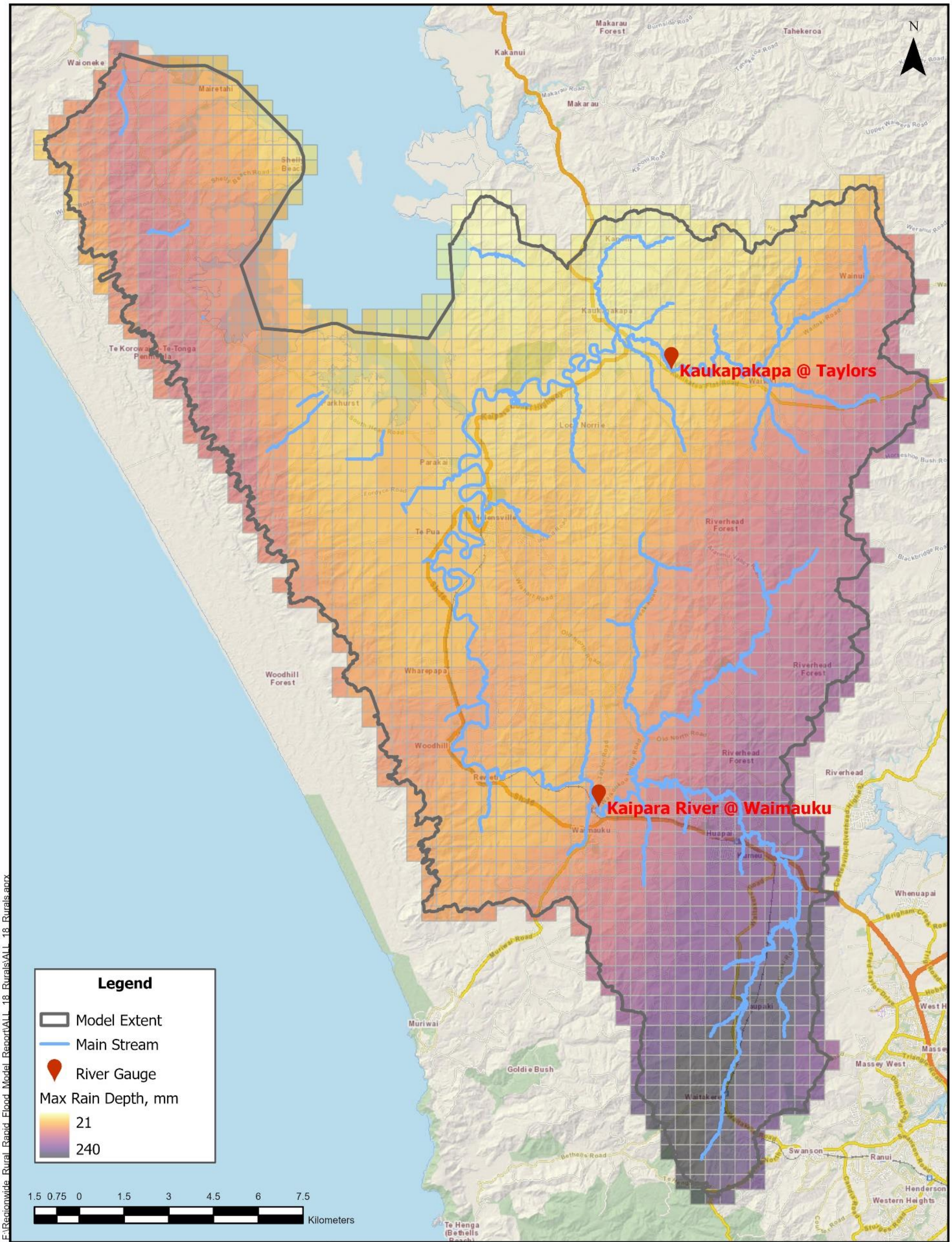

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Figure 08. Rain Radar Data and Gauges for Validation

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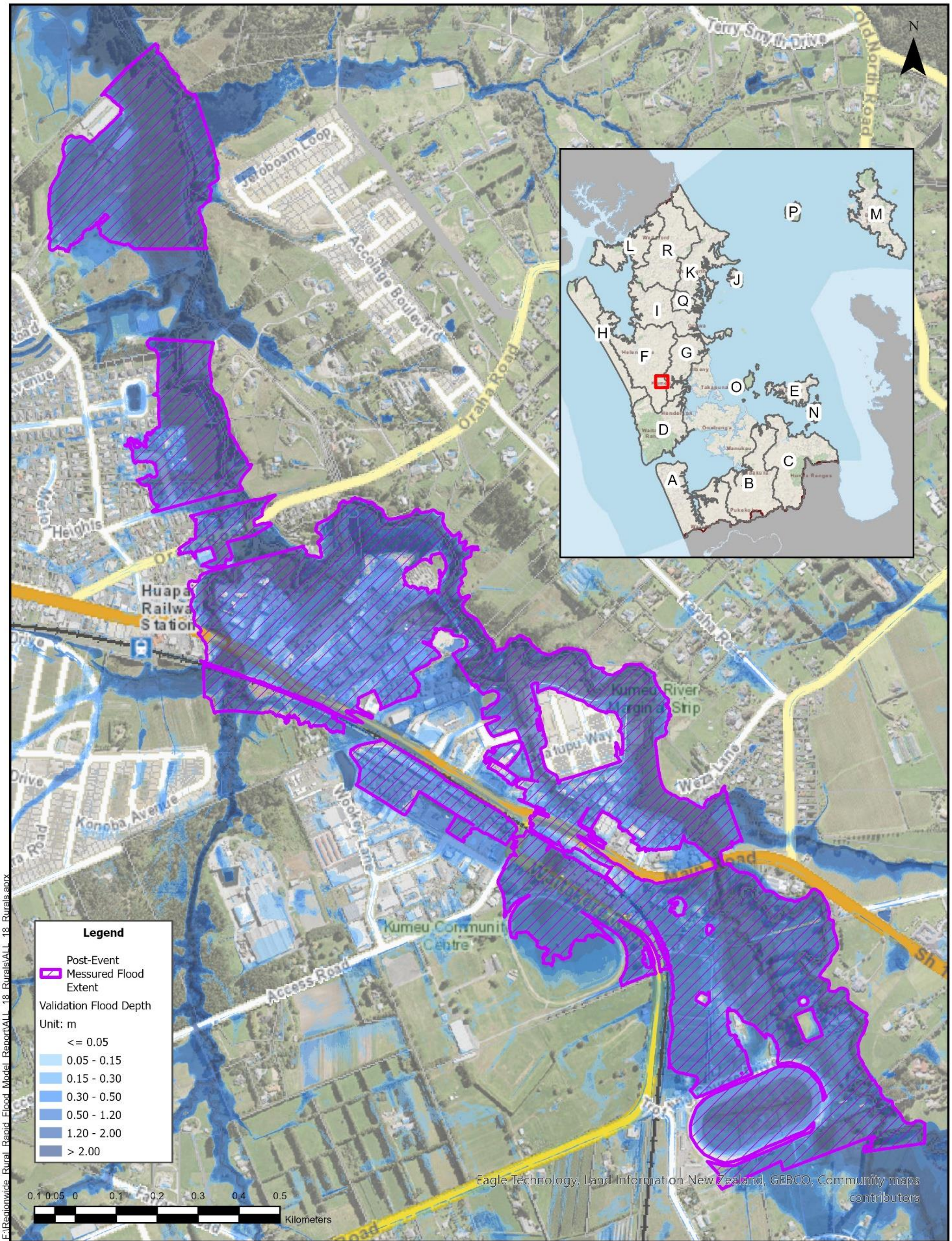

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Map Projection is NZTM 2000.

Figure 09. Flood Extent Comparison in Kumeu Township

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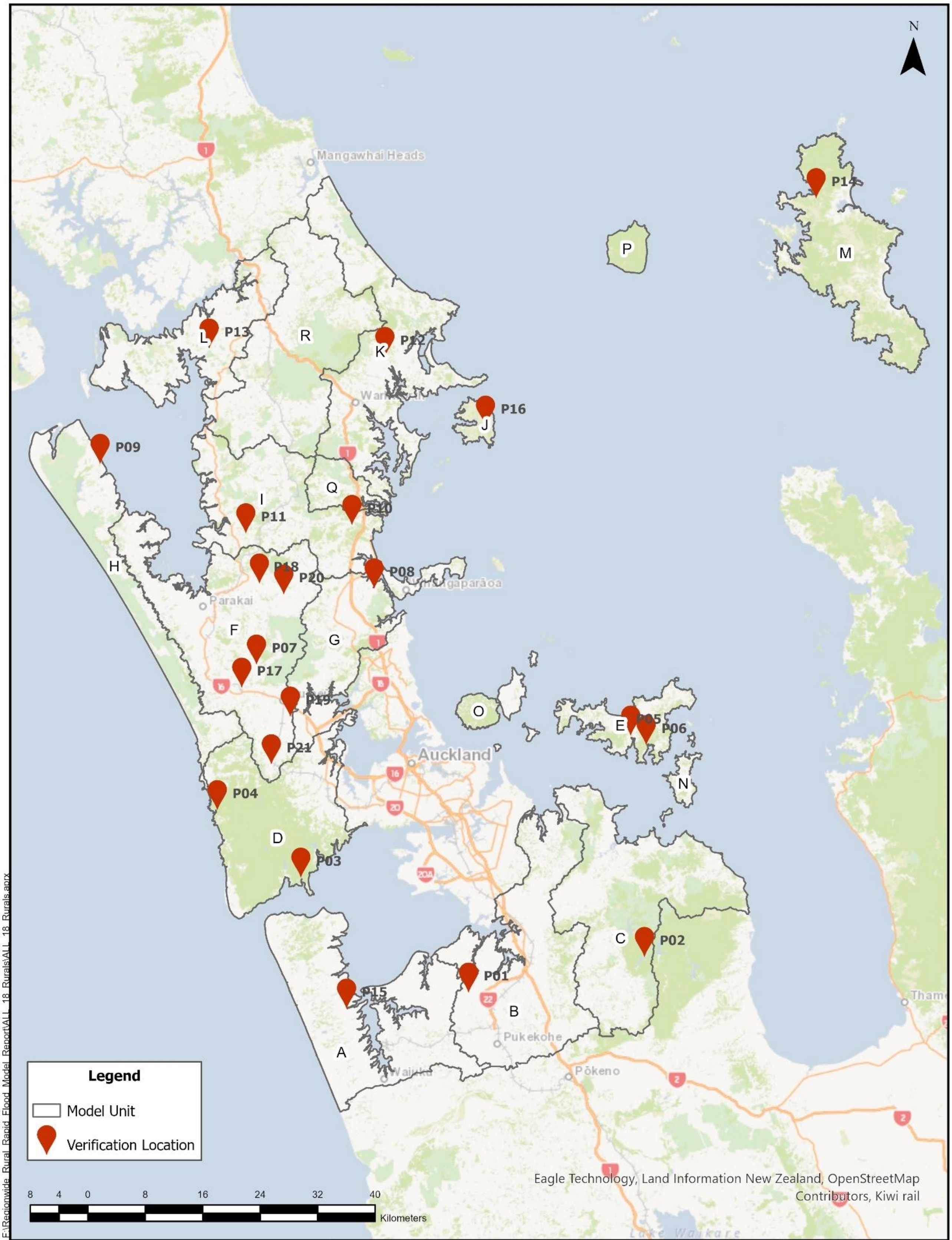

Figure 10. TP108 Verification

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8. Flood Plain Mapping

The flood plain mapping has been conducted in accordance with the AC flood mapping specification, which included the creation of a geometric network and the utilization of customised GIS tools. To ensure accuracy and reliability, the process also included essential manual checks and edits, which were carefully implemented throughout the mapping procedure.

As part of the mapping process, a 1m flood depth raster was generated from the 4x4m + SGS (Sub-grid Sampling) results using the Tuflow flood mapping tool. In addition, 2D cross-section flow lines were created to estimate peak flows approximately every 35m along each overland flow paths and streams, which were then applied with a set of rules for flood plain mapping.

A rigorous and meticulous flood plains review process has been implemented to ensure better accuracy prior to their publication.

9. Conclusions and Limitations

9.1 Conclusions

The methodology employed in this study combines the advanced GIS and modelling technologies with the expertise of highly skilled professionals, involving making several adjustments to the traditional 2D rapid flood modelling methodology, taking into account the unique features of rural areas in the Auckland Region.

A wide range of sensitivity tests were carried out on aspects such as modelling software, hardware, hydraulic and hydrological parameters, modelling performance and data management for pre- and post-processing of the model-related data. The model was also validated over the Kaipara River catchment for the August 2021 storm event.

The project successfully developed flood models, produced various modelling data and generated flood plains covering the entire rural area of 4,428 km² with 18 model units.

Overall, the regionwide rural rapid flood model project provides valuable and updated flood information for improved flood risk management and planning in the rural areas of Auckland, contributing to the council's efforts to address flood risk issues and enhance emergency response capabilities.

9.2 Limitations

This model uses a rain on grid approach and no detailed hydrological modelling has been conducted. As a result, there may be discrepancies in modelled results compared to detailed hydraulic and hydrological models and observed storm events. Therefore, it is recommended to verify the results of this model against manual calculations or a detailed model when assessing flood risks at specific areas of concern.

The stream channel and crossing structures have been represented in 2D in the model bathymetry. However, no detailed survey of the channel cross sections and stream crossing structures has been included in this study, which may lead to the model not accurately representing the true water surface elevations at some locations. Key culverts were represented as 1D objects with some invert levels estimated where data is not available All other smaller structures are considered fully blocked.

The model uses a 4m grid size of the 2D domain, which is a cost-effective approach for quality outputs for large rural areas. However, due to the grid size the approach has limitations at modelling road inverts and head losses at narrow constrictions smaller than 4m, even though the inclusion of break lines provided some improvement on the model representation.

The model uses the AC 2016 LiDAR DEM for the model bathymetry. However, the LiDAR DEM may not describe the stream channels well due to the presence of trees and vegetation, as well as under water bodies, although some adjustments were made to account for these limitations.

10. Reference

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Appendix A: Model Output

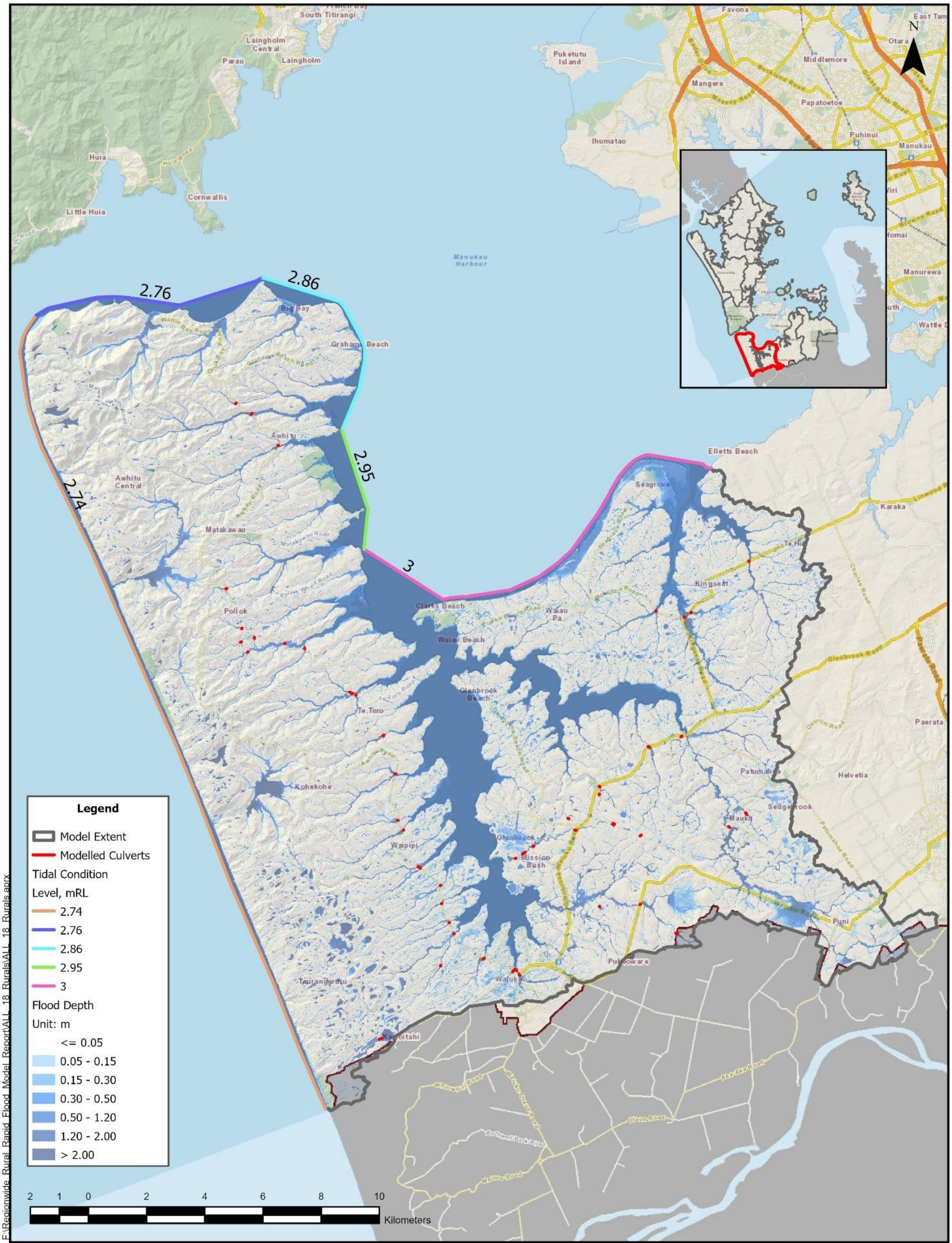

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Figure A01. Flood Depth - Unit A - 100-Year MPD 3.8D CC

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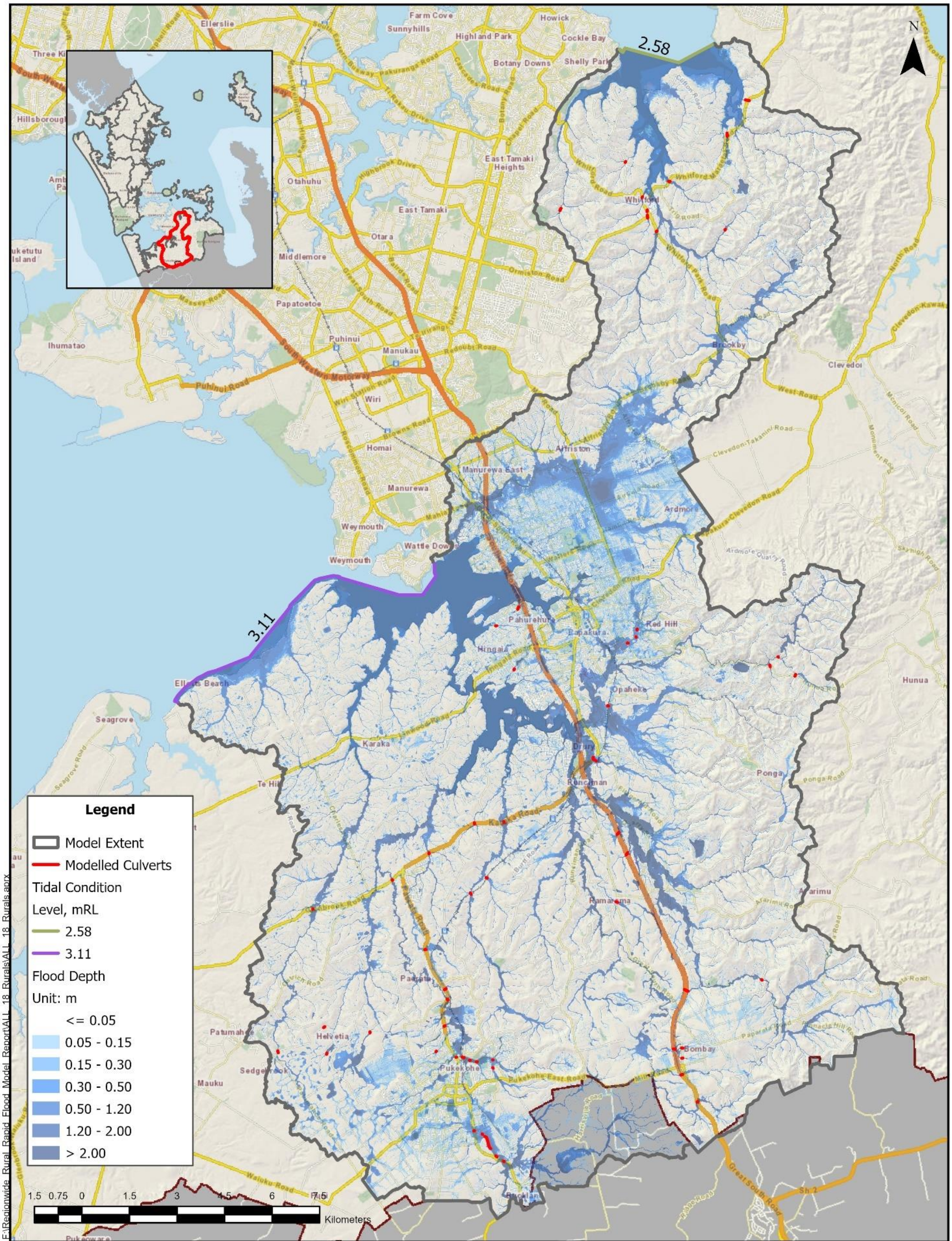

Figure A02. Flood Depth - Unit B - 100-Year MPD 3.8D CC

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AC Regionwide Rural Rapid Flood Model

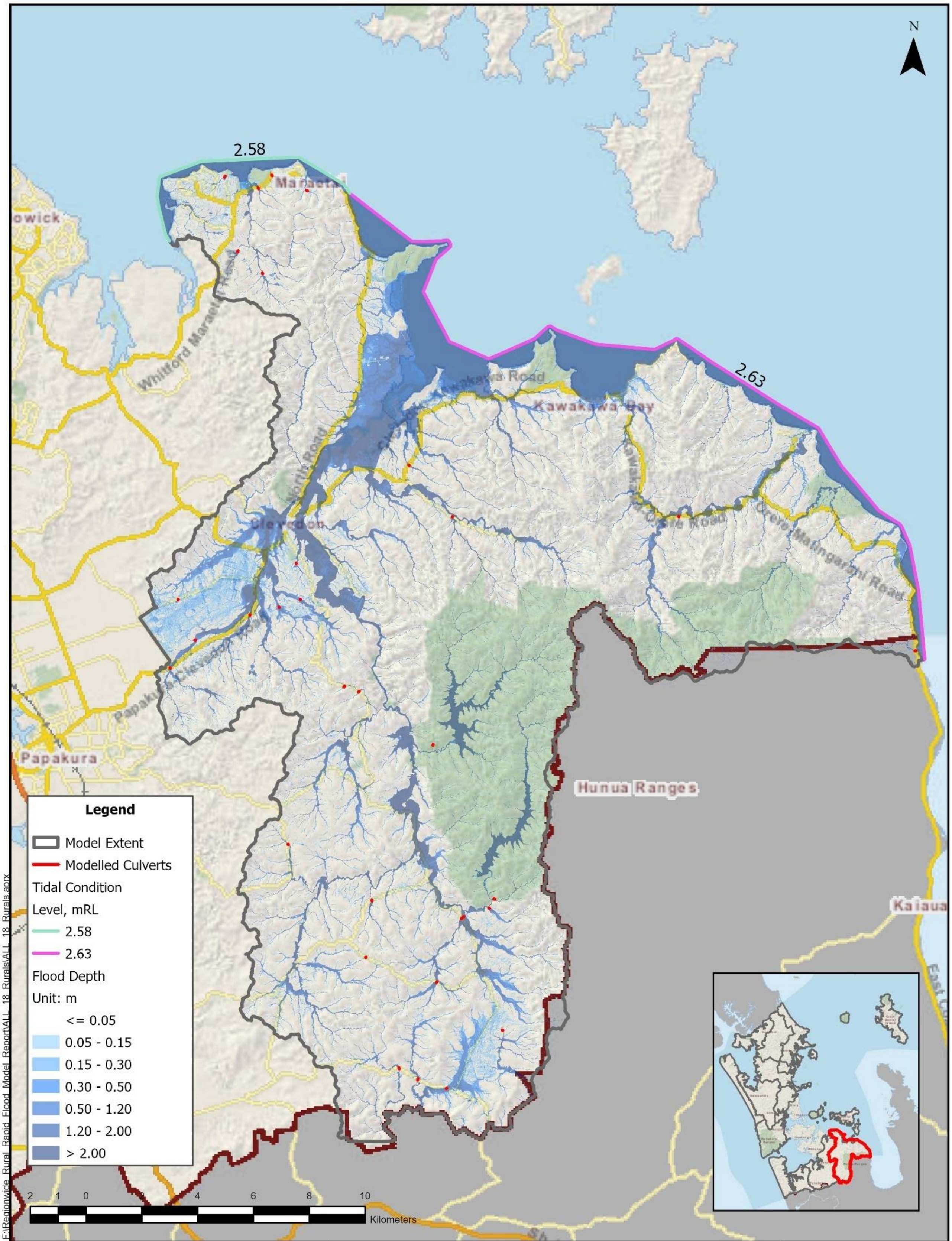

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Figure A03. Flood Depth - Unit C - 100-Year MPD 3.8D CC

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Map Projection is NZTM 2000.

Figure A04. Flood Depth - Unit D - 100-Year MPD 3.8D CC

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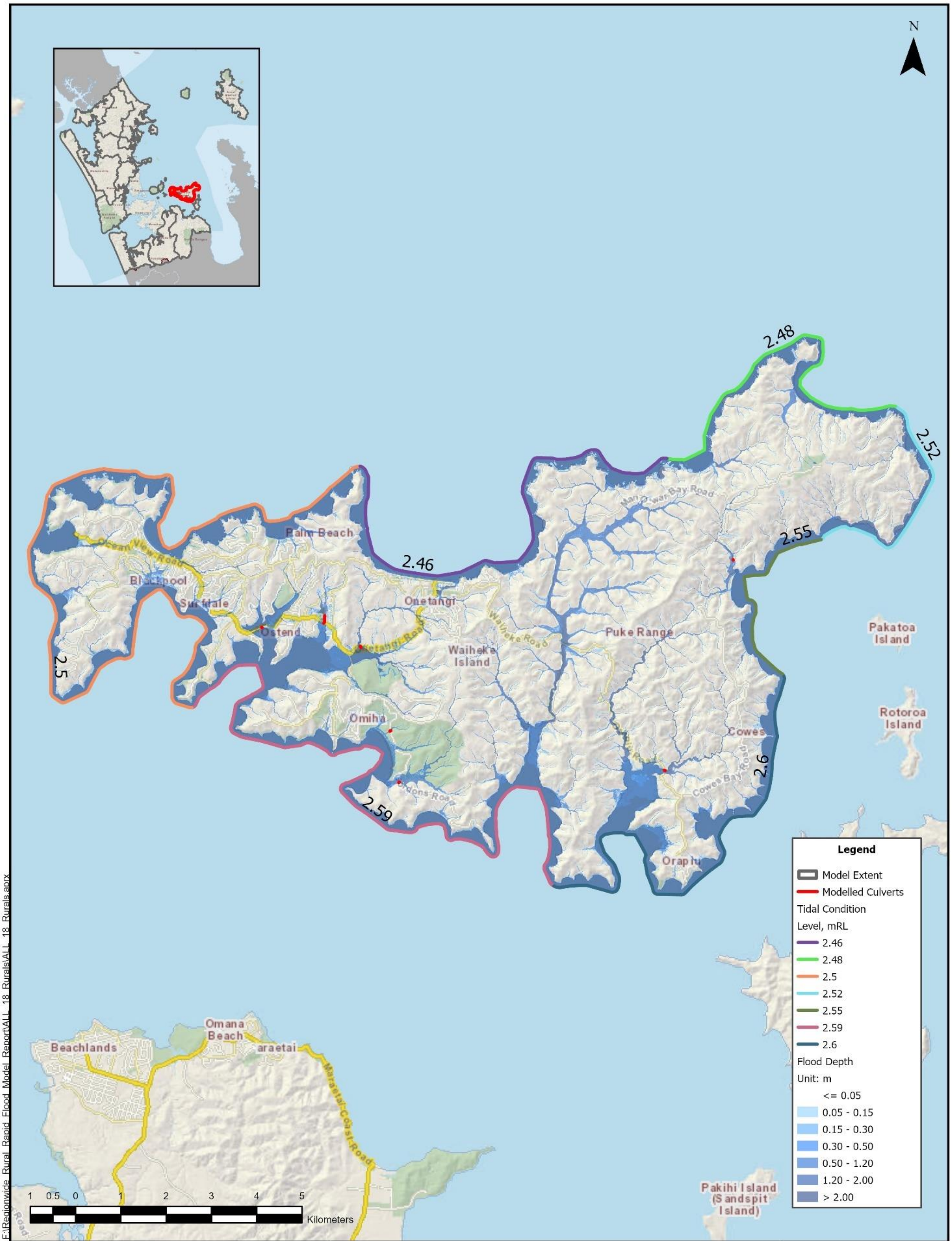

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Figure A05. Flood Depth - Unit E - 100-Year MPD 3.8D CC

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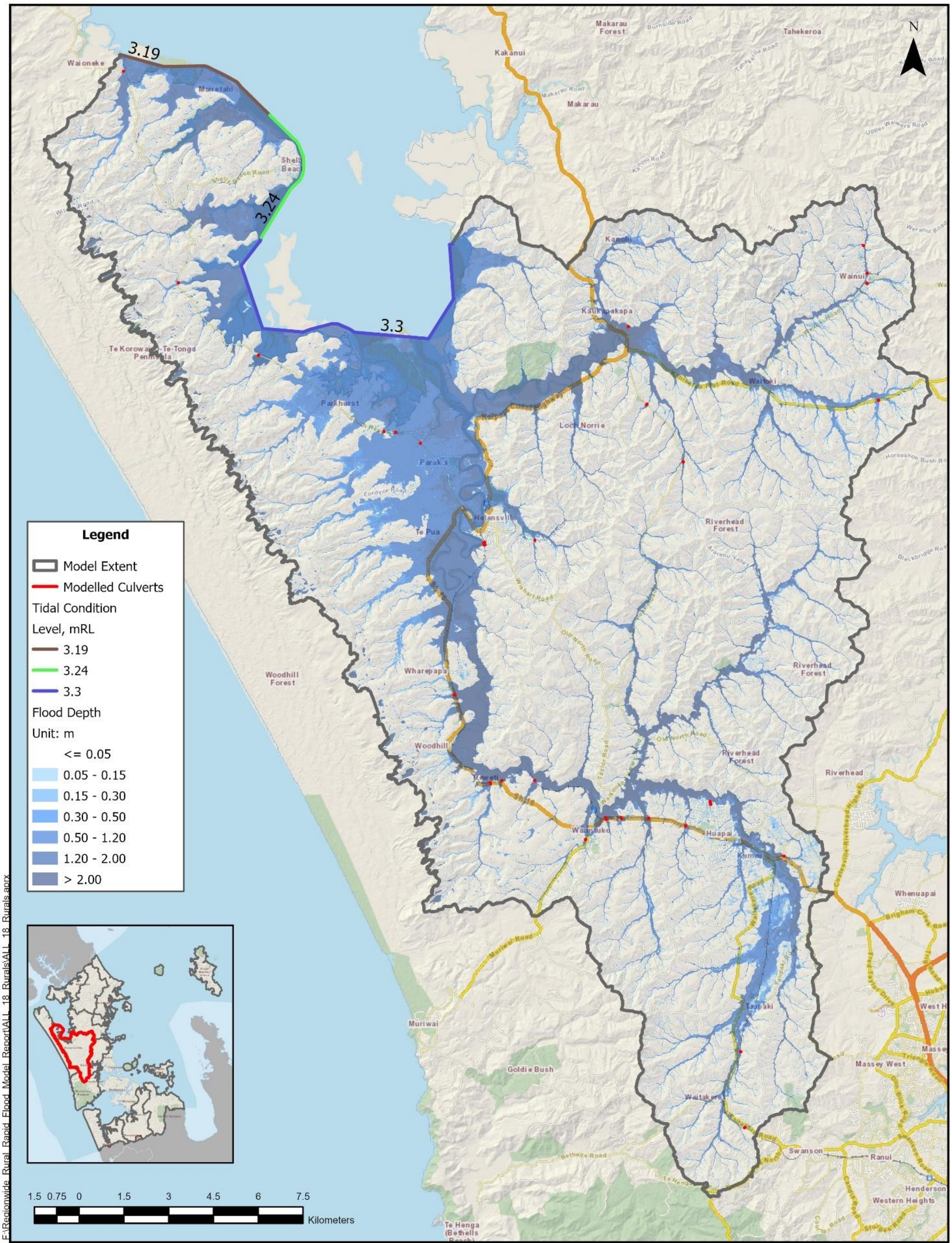

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Map Projection is NZTM 2000.

Figure A06. Flood Depth - Unit F - 100-Year MPD 3.8D CC

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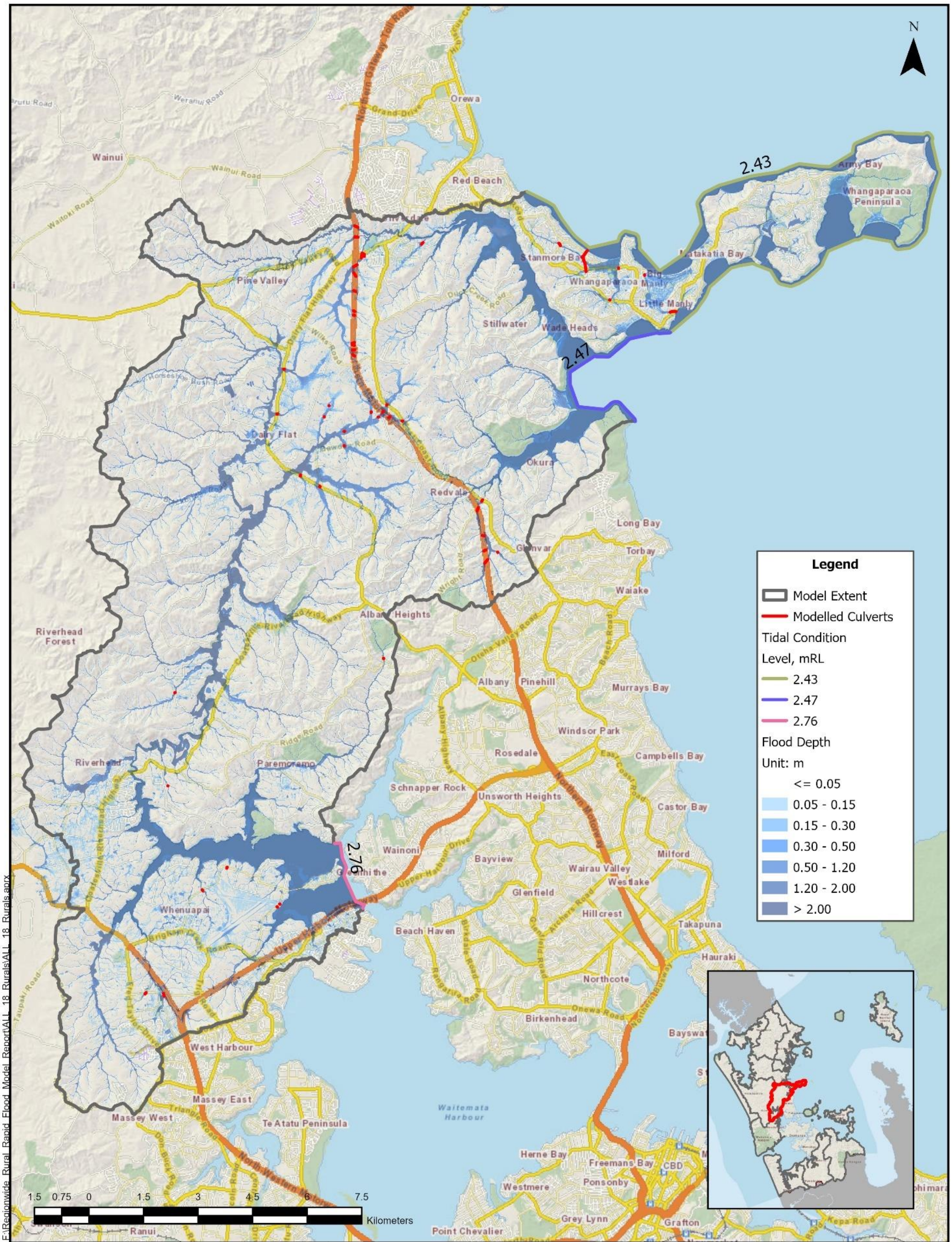

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Map Projection is NZTM 2000.

Figure A07. Flood Depth - Unit G - 100-Year MPD 3.8D CC

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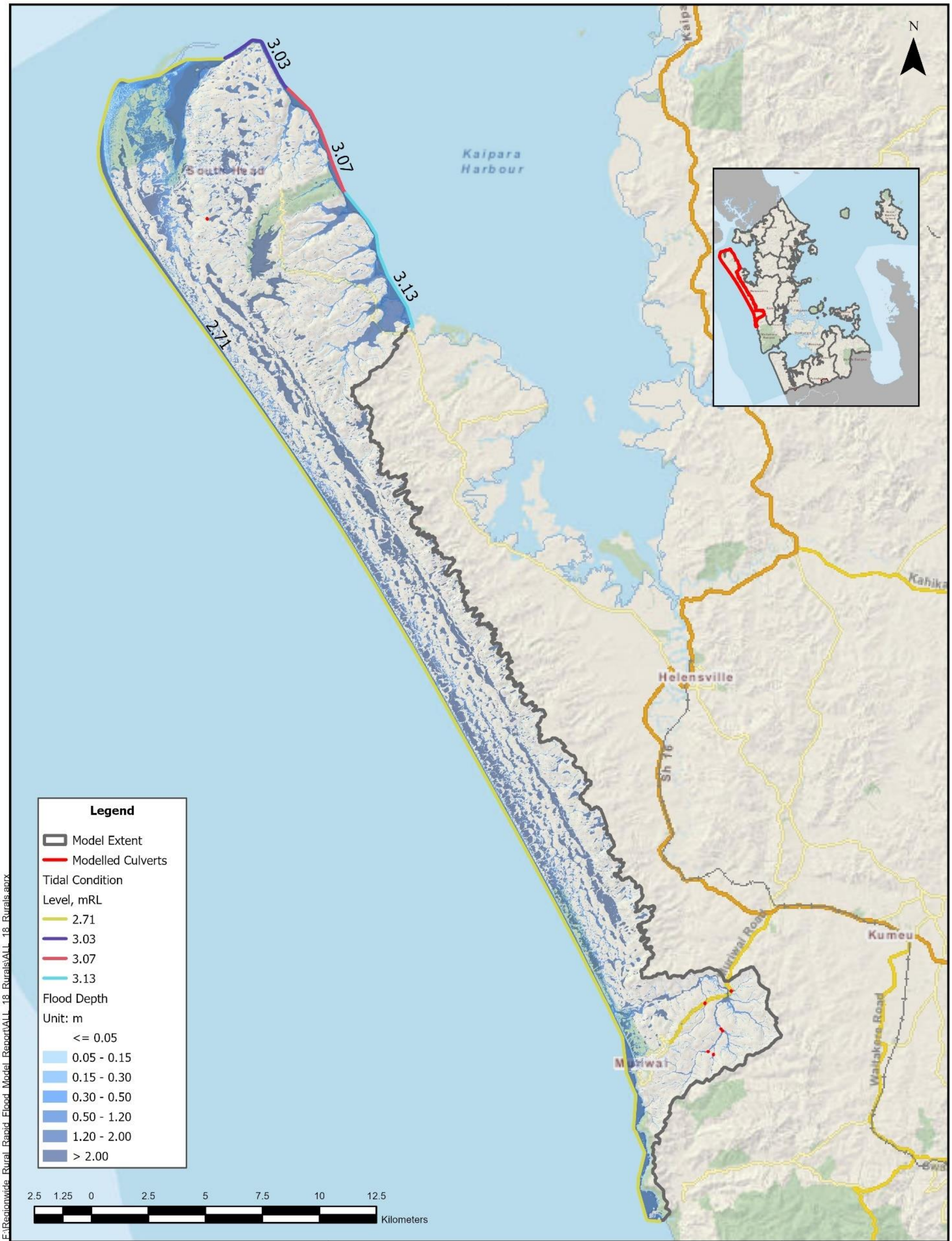

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Map Projection is NZTM 2000.

Figure A08. Flood Depth - Unit H - 100-Year MPD 3.8D CC

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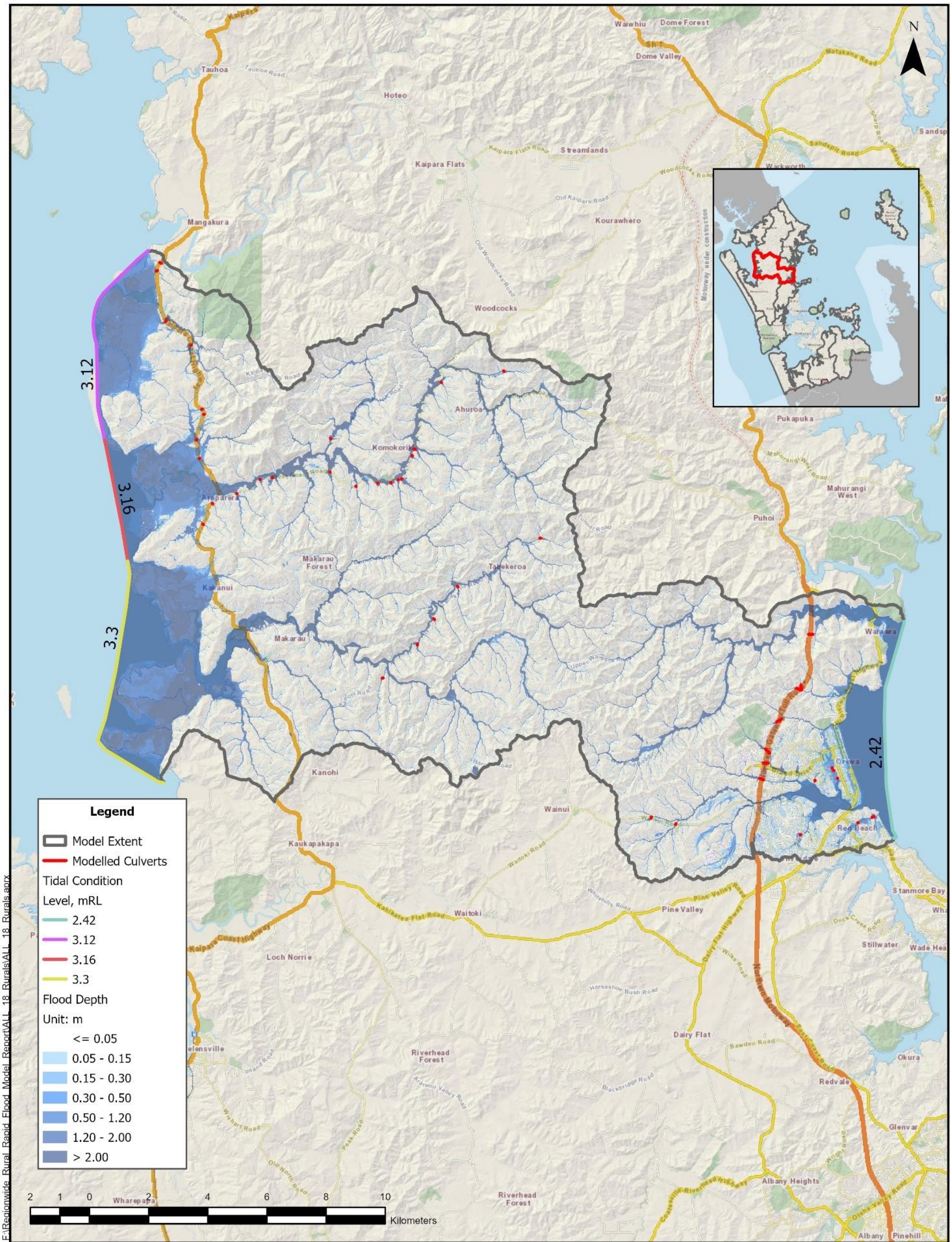

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Figure A09. Flood Depth - Unit I - 100-Year MPD 3.8D CC

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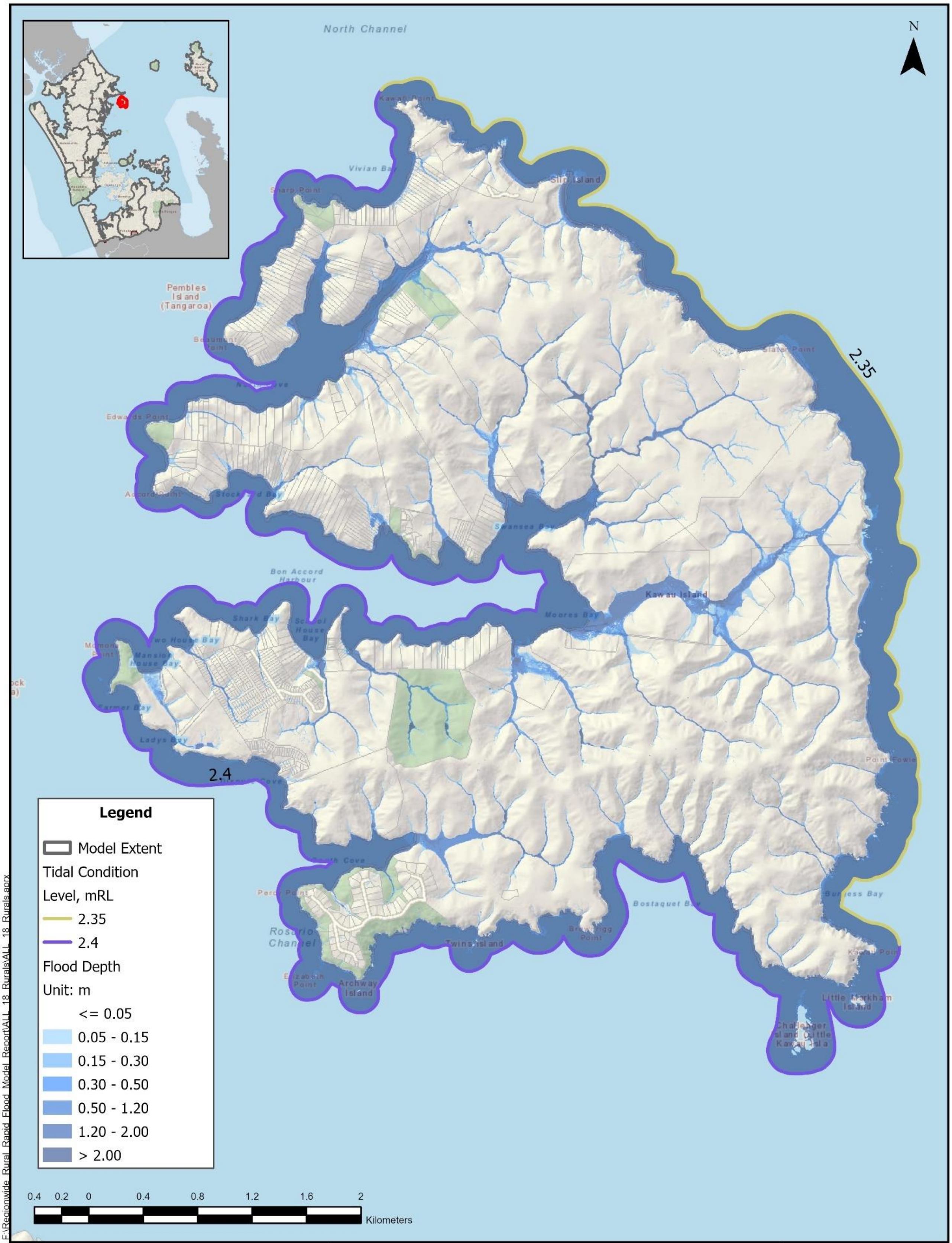

Figure A10. Flood Depth - Unit J - 100-Year MPD 3.8D CC

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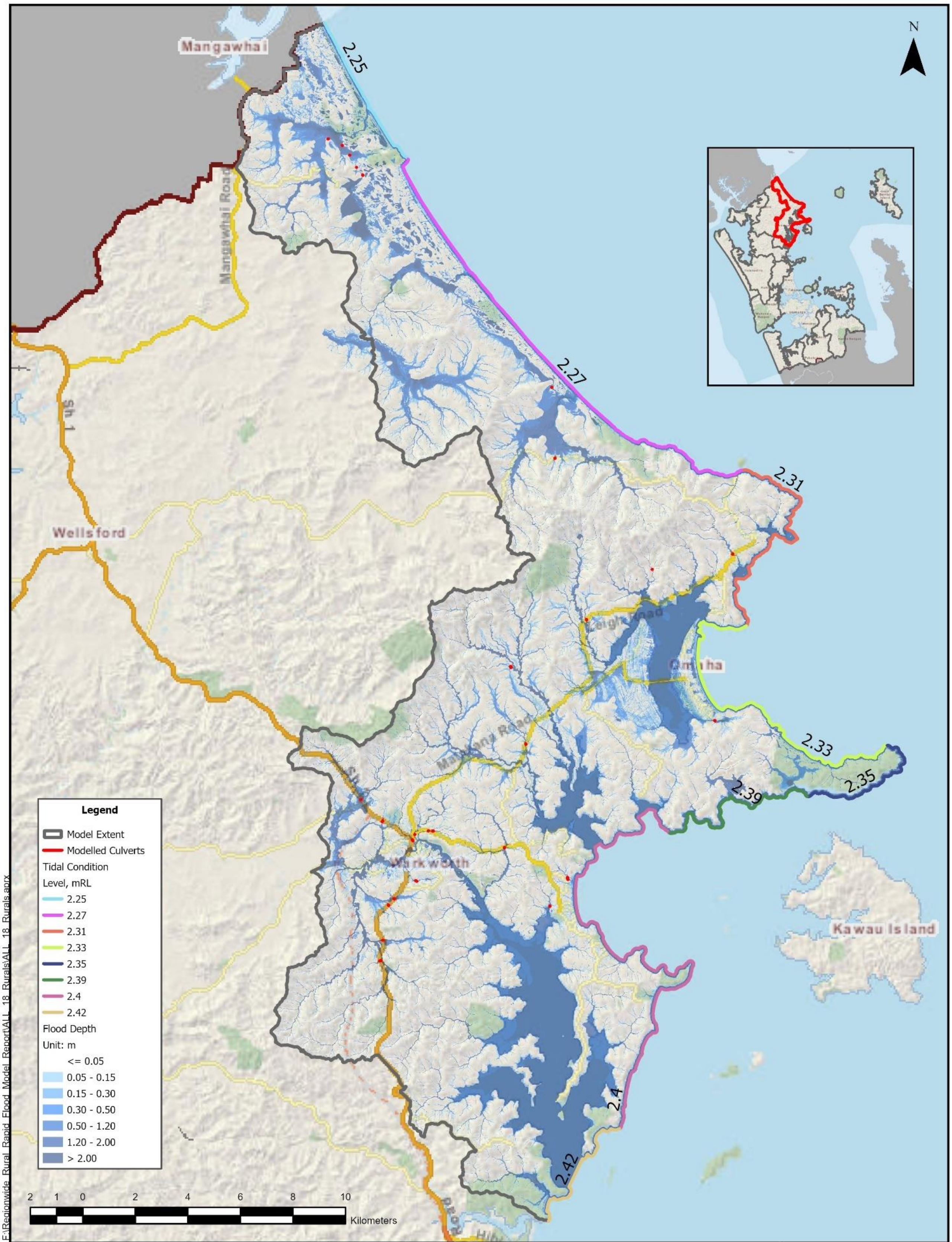

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Map Projection is NZTM 2000.

Figure A11. Flood Depth - Unit K - 100-Year MPD 3.8D CC

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Figure A12. Flood Depth - Unit L - 100-Year MPD 3.8D CC

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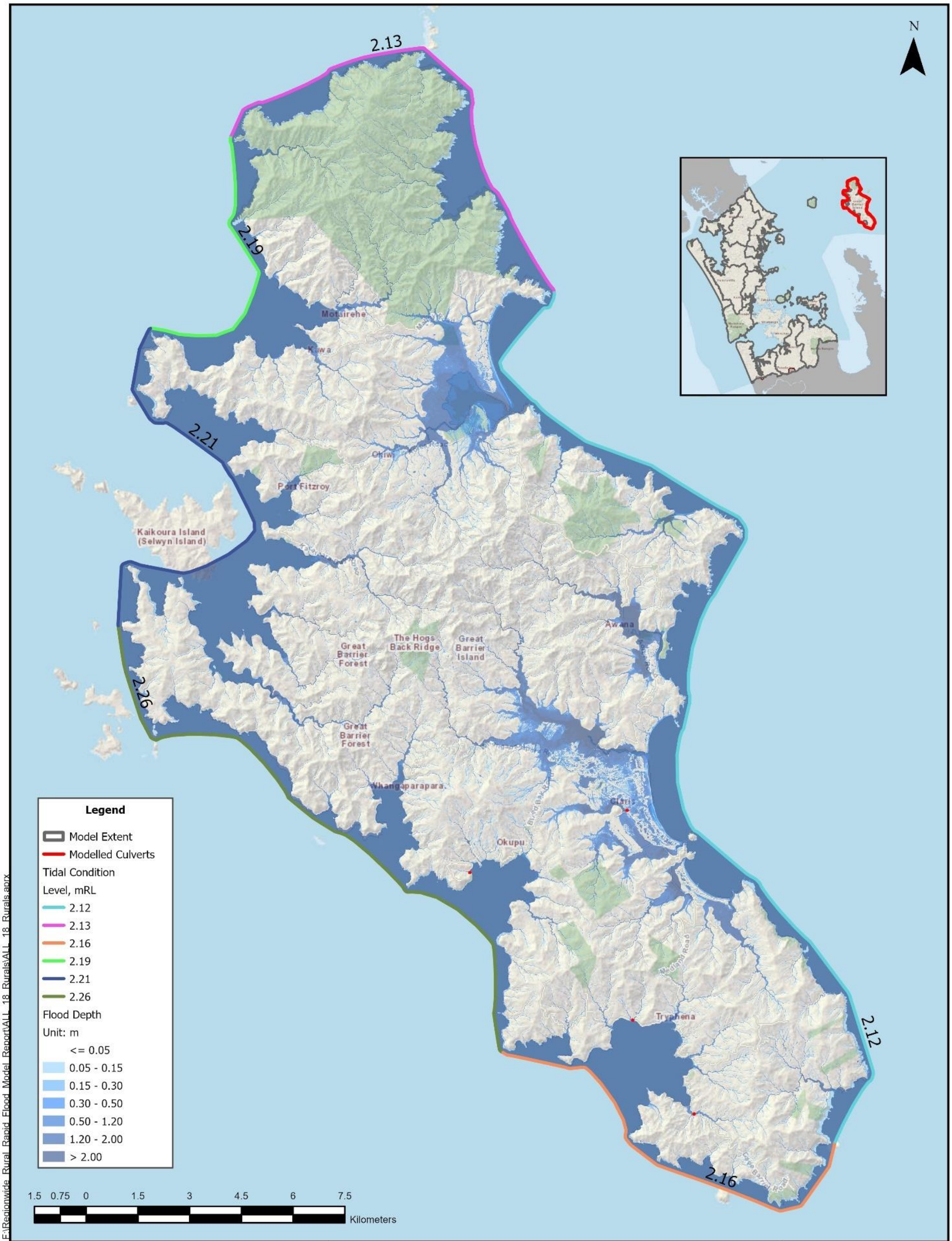

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Figure A13. Flood Depth - Unit M - 100-Year MPD 3.8D CC

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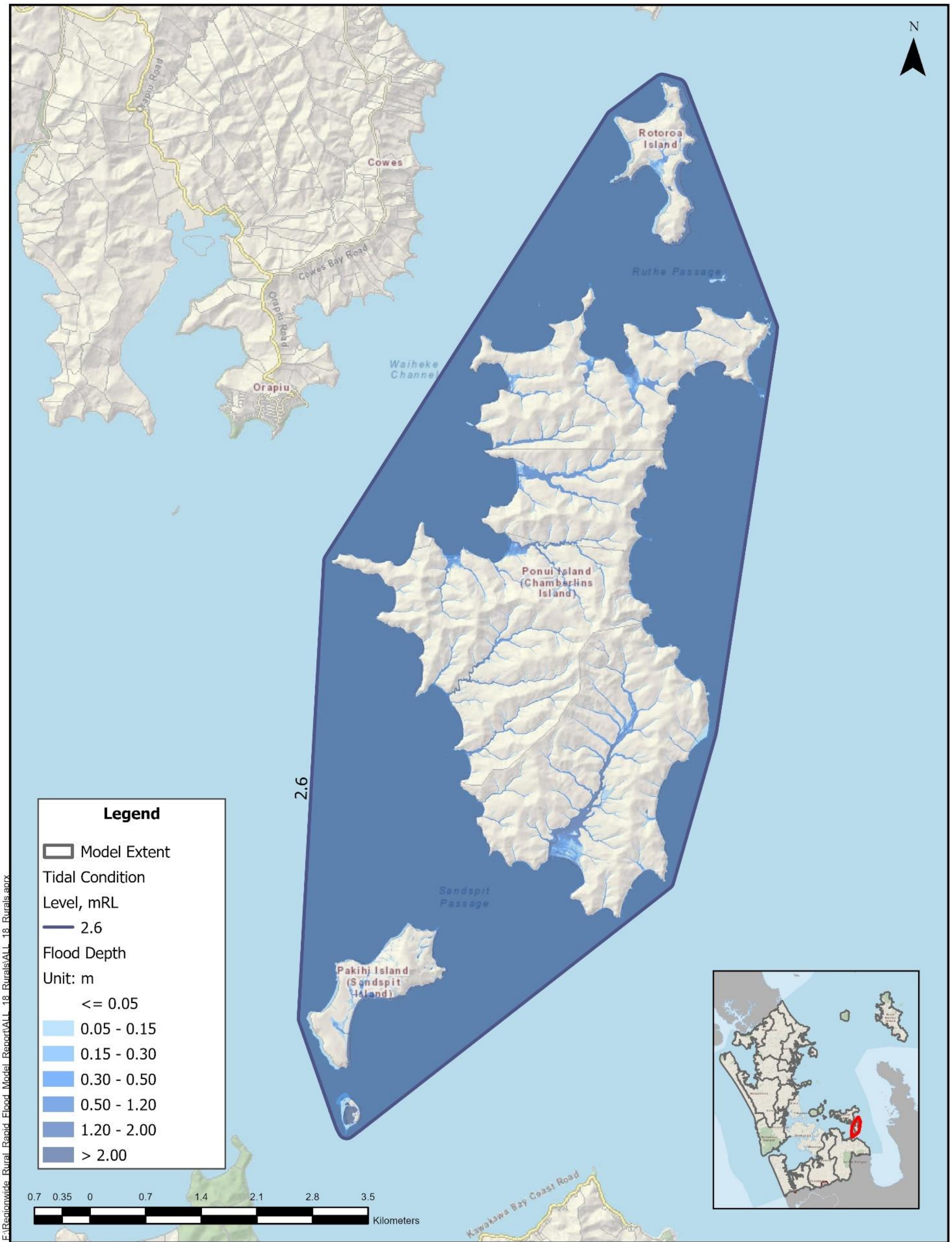

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Map Projection is NZTM 2000.

Figure A14. Flood Depth - Unit N - 100-Year MPD 3.8D CC

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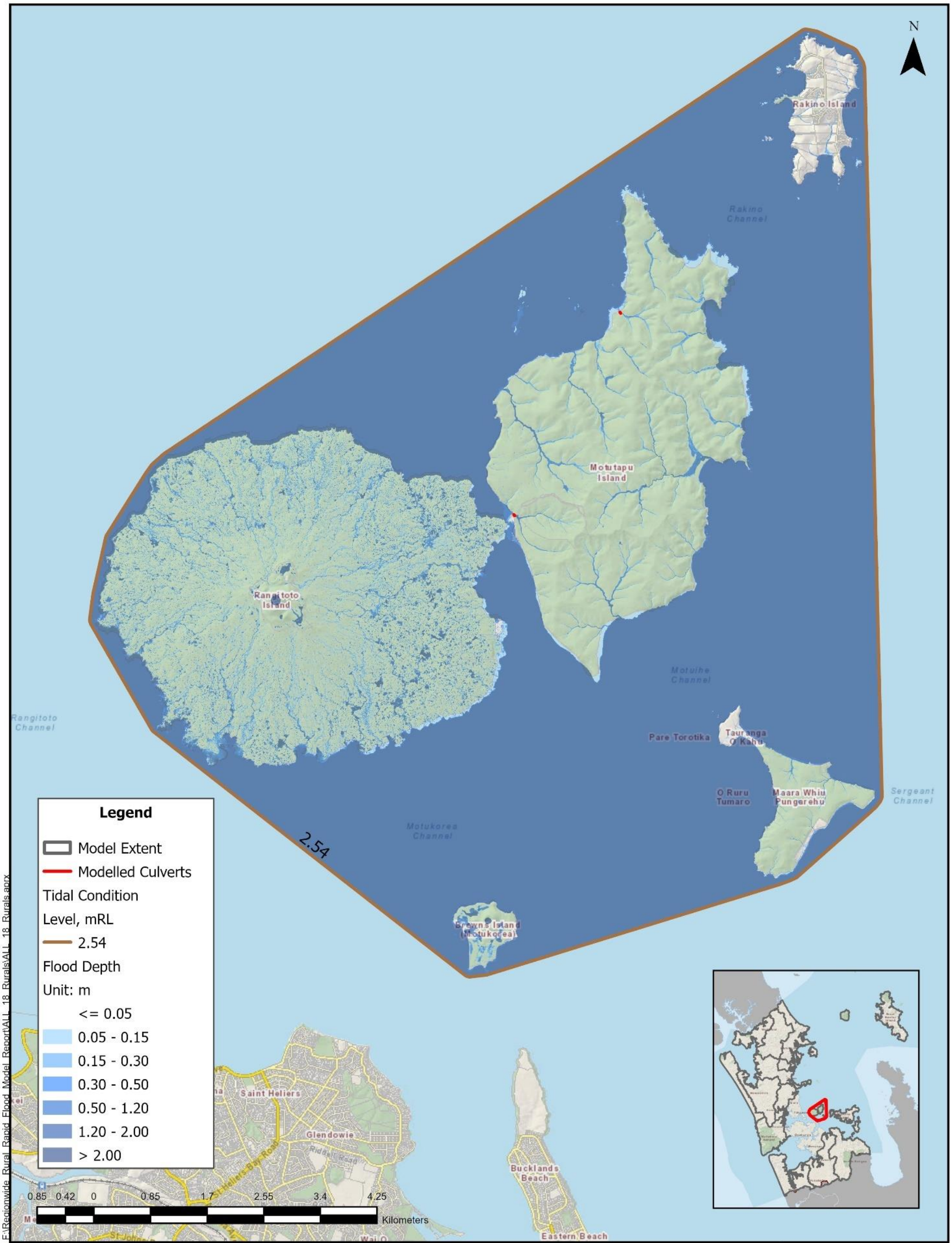

Figure A15. Flood Depth - Unit O - 100-Year MPD 3.8D CC

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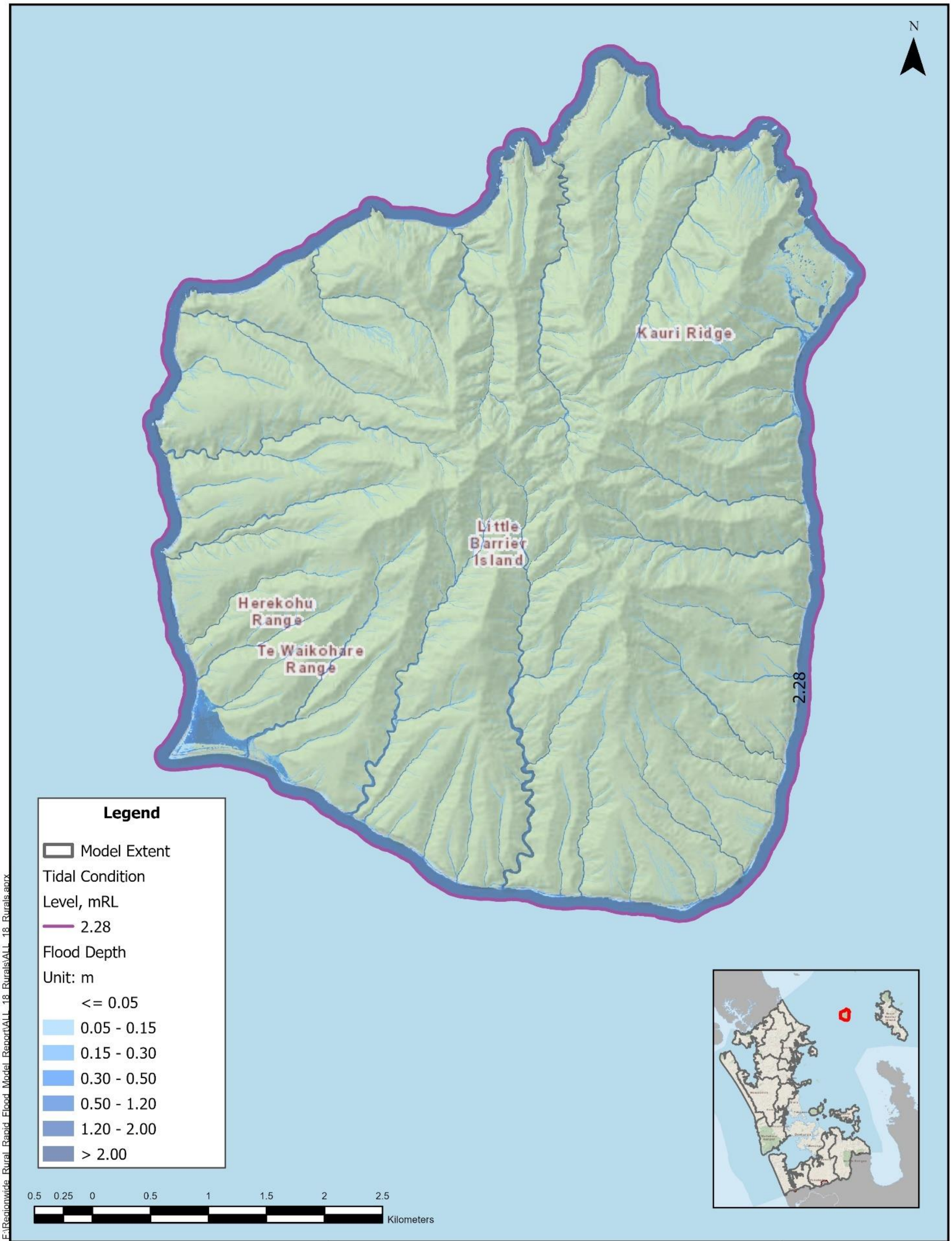

Map Projection is NZTM 2000.

Figure A16. Flood Depth - Unit P - 100-Year MPD 3.8D CC

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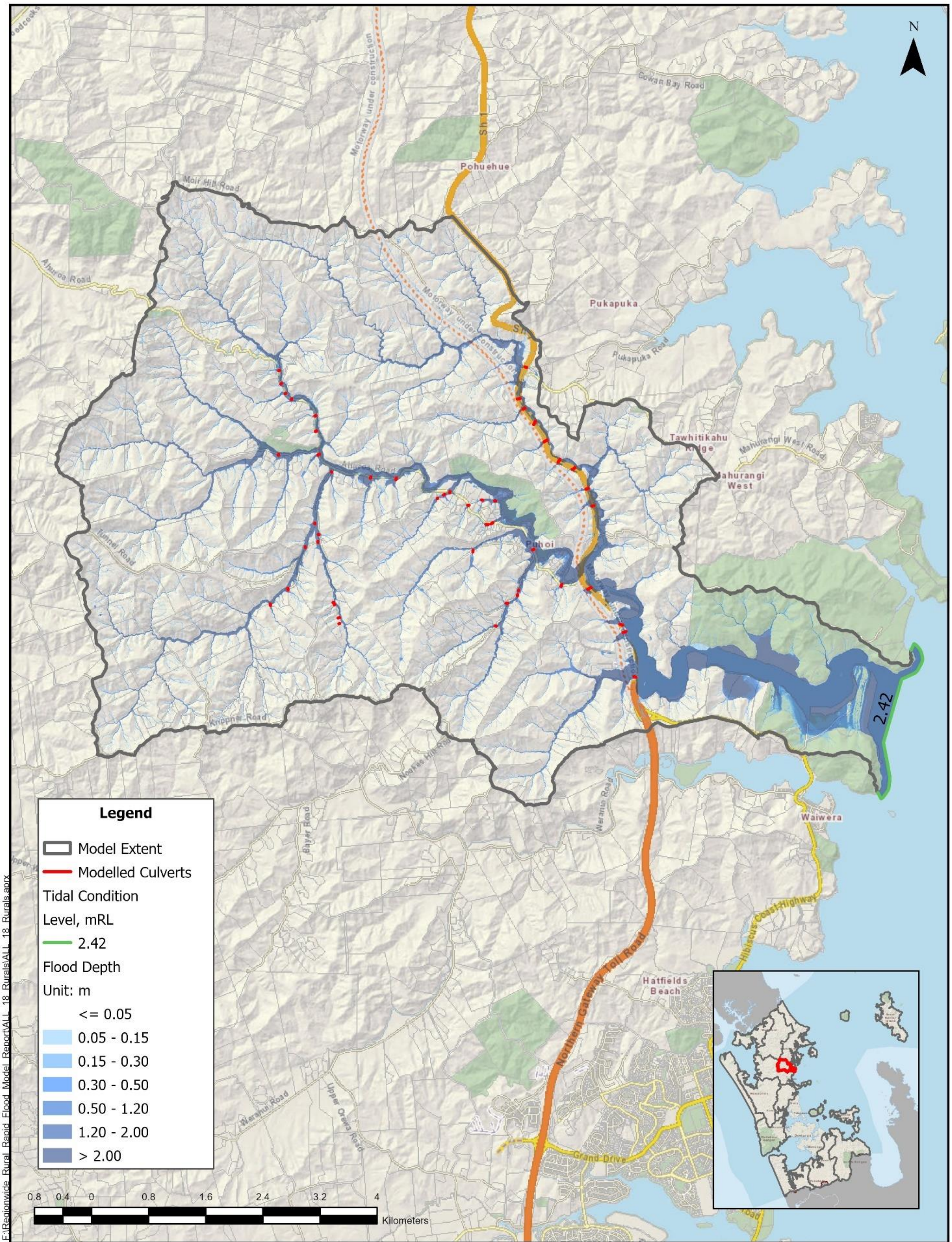

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Map Projection is NZTM 2000.

Figure A17. Flood Depth - Unit Q - 100-Year MPD 3.8D CC

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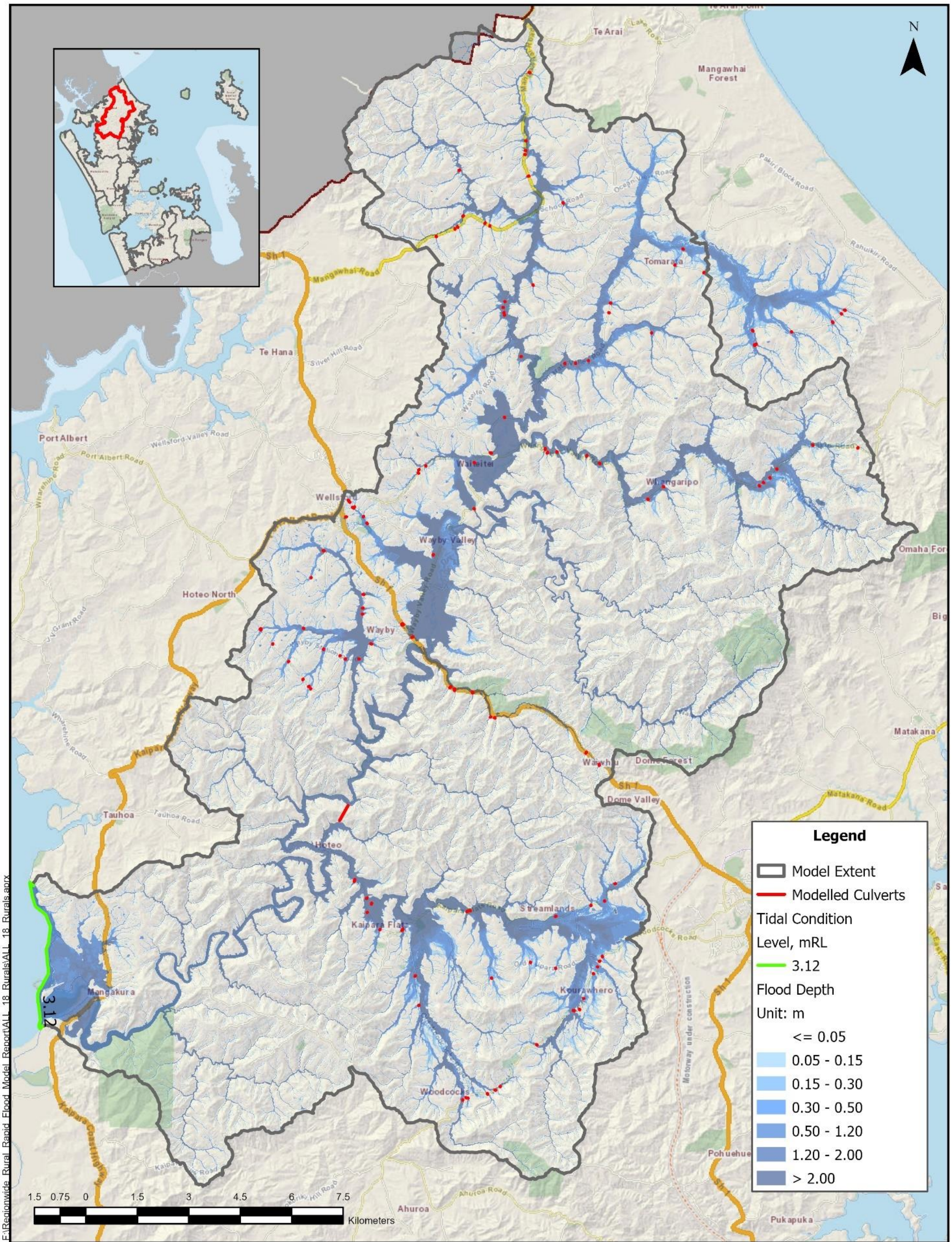

Figure A18. Flood Depth - Unit R - 100-Year MPD 3.8D CC

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