

## **Appendix A: Risk identification**

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- **Figure A1 – Target level of detail**
- **Figure A2 – Ground surface elevation**
- **Figure A3 – Geomorphons produced from topographical screening tool**
- **Table A1 – Geomorphic terrain descriptions**
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- **Figure A9 – Distance to nearest CPT within the same geomorphic terrain**





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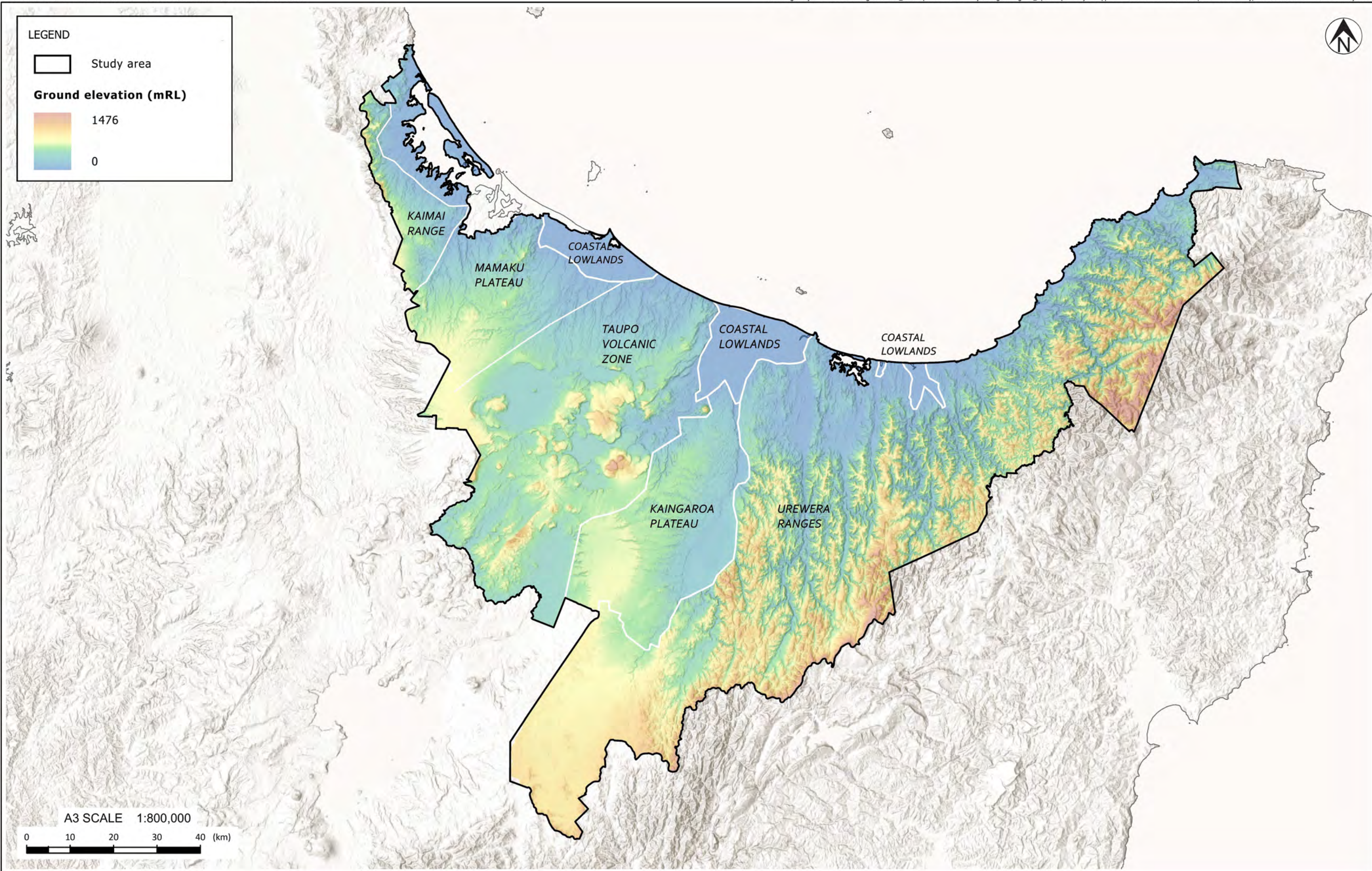
**NOTES:**  
 1. Basemap: sourced from Land Information New Zealand and licensed for re-use under the Creative Commons Attribution 4.0.  
 2. Map indicates the level of detail in the liquefaction assessment that will be targeted. Refer to Table 3.3 of the MBIE Guidelines (2017) for further information about the detail in the liquefaction assessment

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PROJECT No. 1010130.0000		
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CLIENT	BAY OF PLENTY REGIONAL COUNCIL		
PROJECT	REGIONAL LIQUEFACTION HAZARD ASSESSMENT		
TITLE	TARGET LEVEL OF DETAIL IN THE LIQUEFACTION ASSESSMENT		
SCALE (A3)	1:800,000	FIG No.	FIGURE A1
REV	0		0





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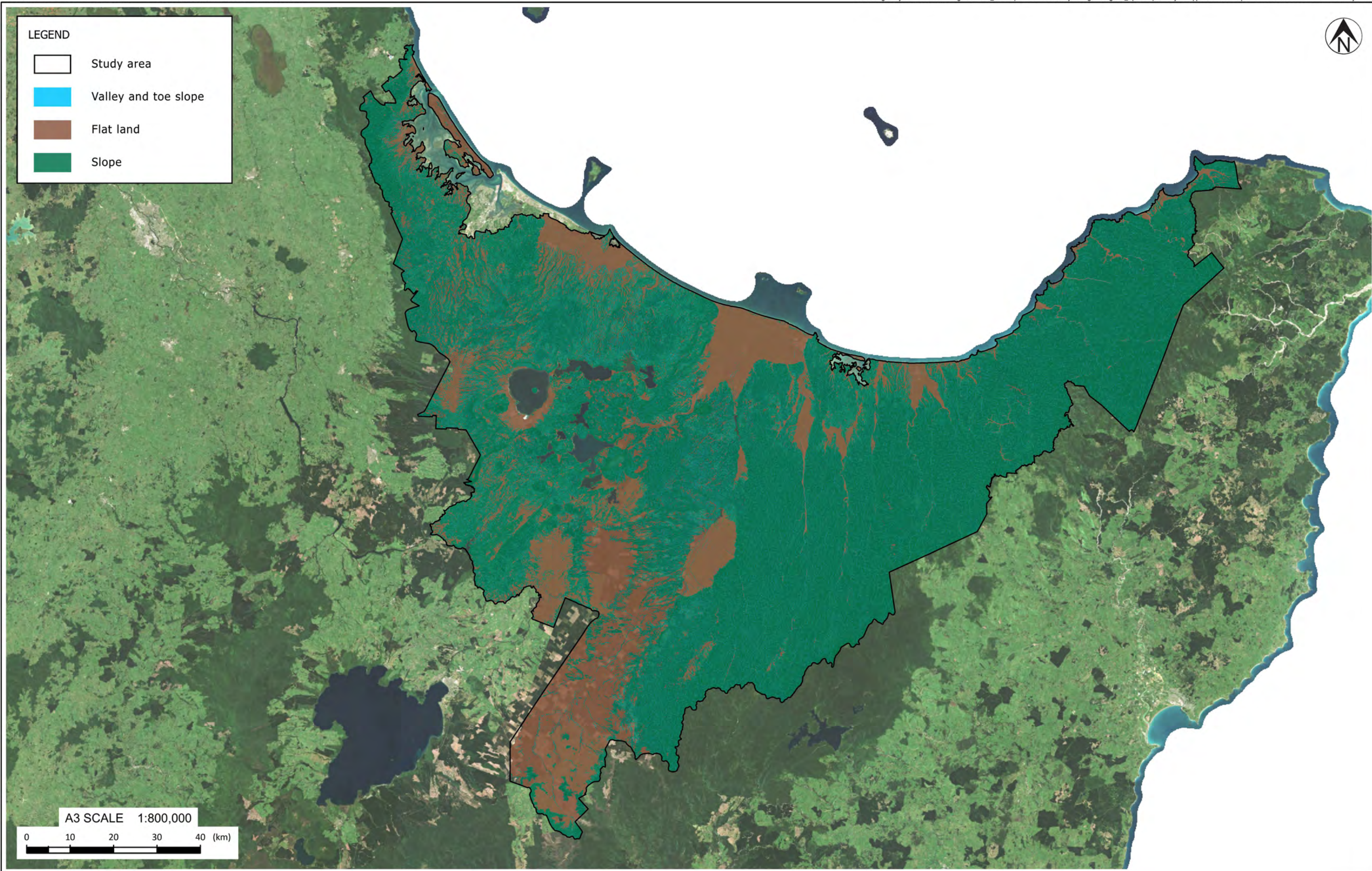
**NOTES:**  
 1. Hillshade: sourced from Land Information New Zealand and licensed for re-use under the Creative Commons Attribution 4.0.  
 2. Elevation data: sourced from BOPLASS Ltd, 2014.

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CLIENT	<b>BAY OF PLENTY REGIONAL COUNCIL</b>	
PROJECT	<b>REGIONAL LIQUEFACTION HAZARD ASSESSMENT</b>	
TITLE	GROUND SURFACE ELEVATION (2014 LIDAR SURVEY)	
SCALE (A3)	1:800,000	FIG No. FIGURE A2
REV	0	





**LEGEND**

- Study area
- Valley and toe slope
- Flat land
- Slope

A3 SCALE 1:800,000

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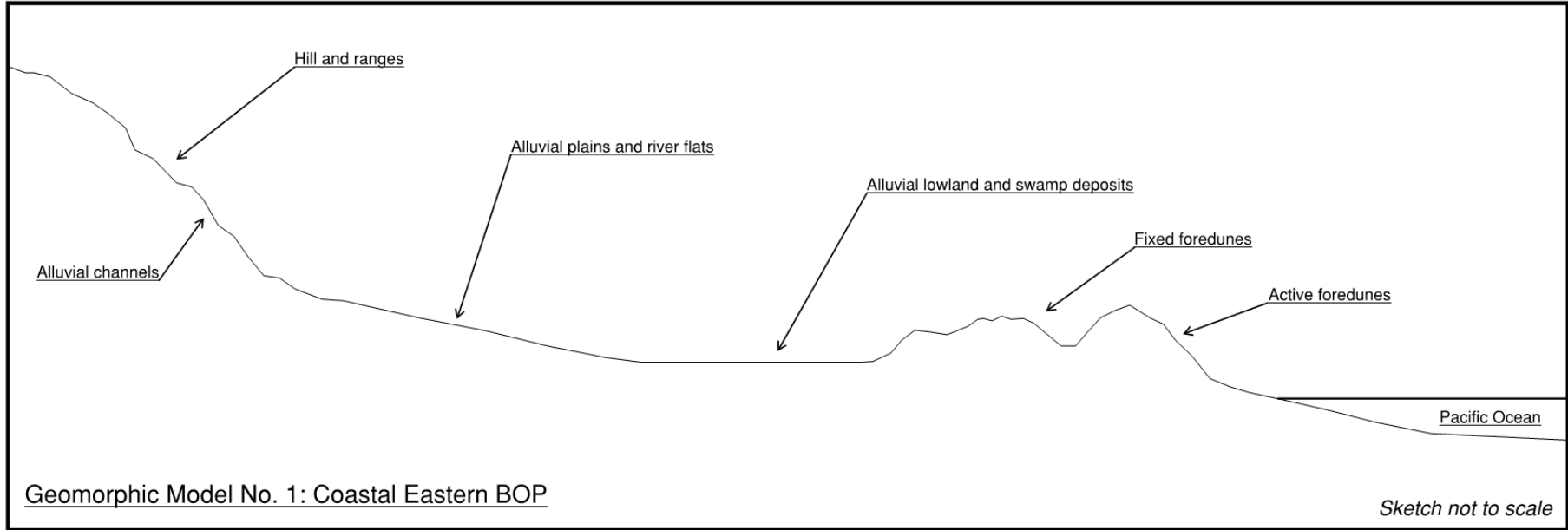
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CLIENT	<b>BAY OF PLENTY REGIONAL COUNCIL</b>		
PROJECT	<b>REGIONAL LIQUEFACTION HAZARD ASSESSMENT</b>		
TITLE	GEOMORPHONS PRODUCED FROM TOPOGRAPHICAL SCREENING TOOL		
SCALE (A3)	1:800,000	FIG No.	FIGURE A3
REV	0		

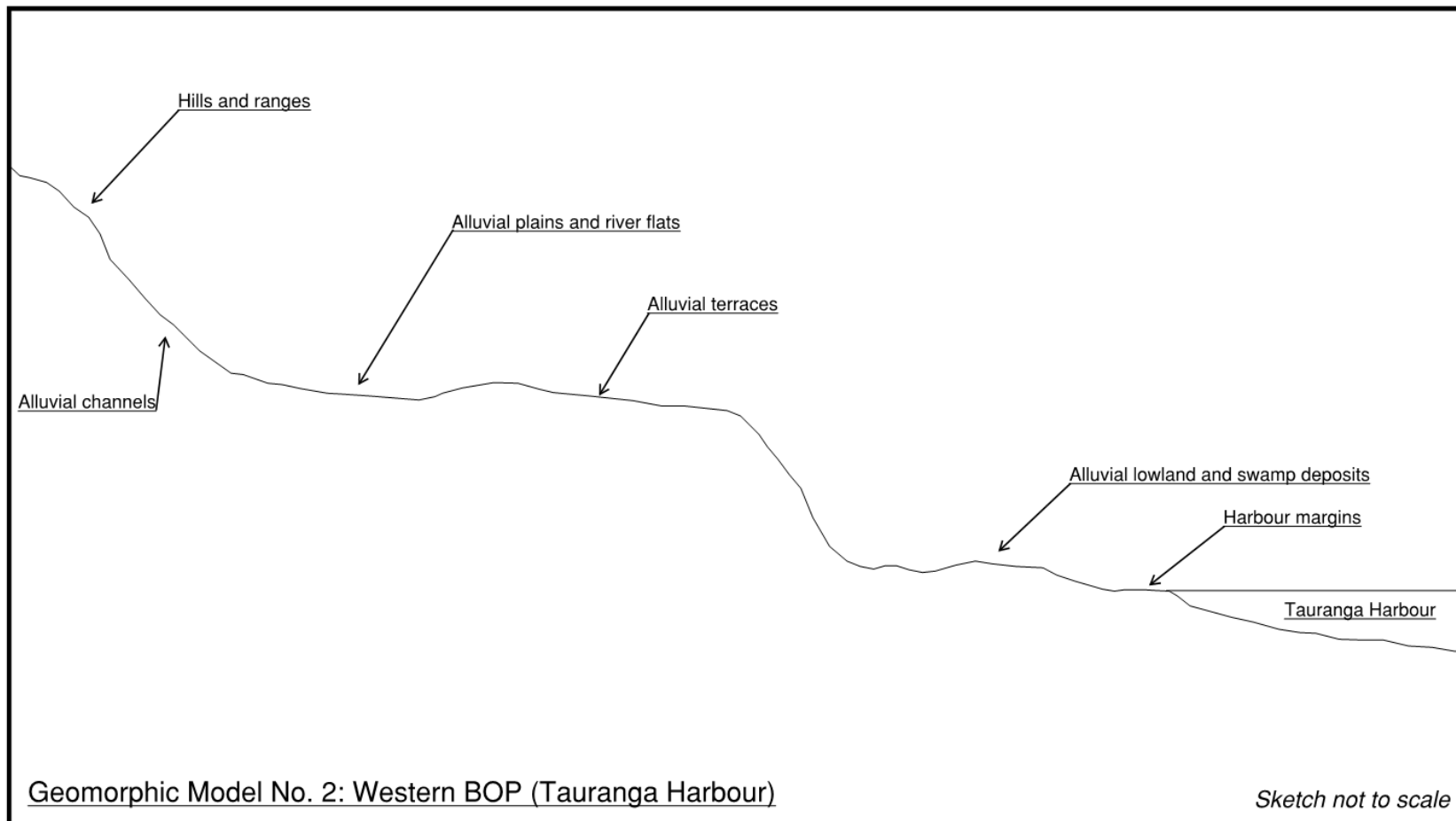


**Appendix A Table A1: Description of geomorphic terrains**

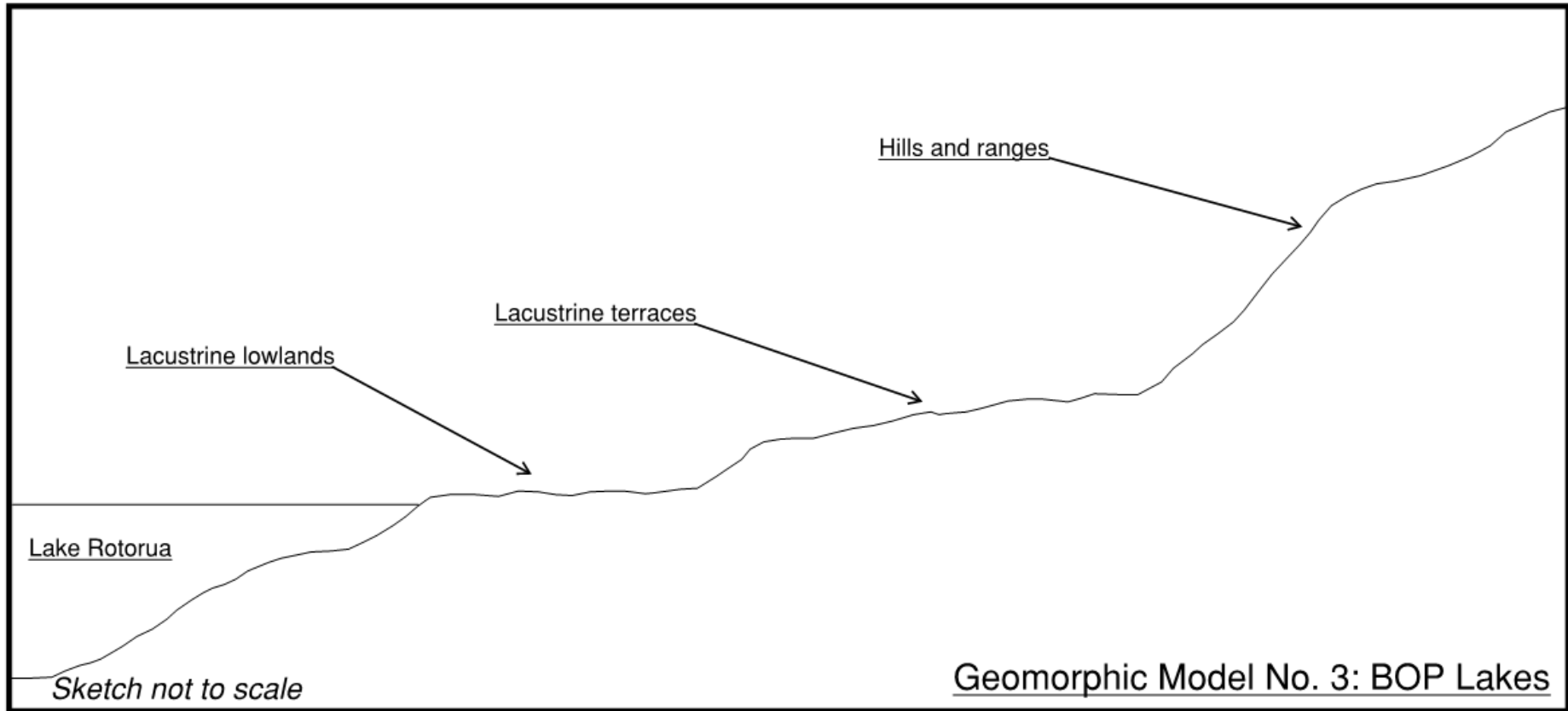
Geomorphic Terrain	Terrain Description	Geological Age	Typical Groundwater Depth	Type Location	Liquefaction Vulnerability Classification
Active Foredunes	Active foredunes comprise the front coastal sand dunes which are, prior to development, actively subject to windblown and coastal processes. These dunes include the current shoreline.	Holocene	< 4 m below ground level	Waihi Beach, Pukehina, Whakatane, Opotiki	Possible
Fixed Foredunes	Fixed foredunes comprise a series crests and troughs, sub-parallel with the coastline. These areas extend inland from the active foredunes and are taken as remnant dune deposits from past coastal regimes which are no longer likely subject to active windblown and coastal process.	Holocene	< 4 m below ground level	Waihi Beach, Pukehina, Whakatane (inland), Opotiki	Possible
Alluvial Lowland and Swamp Deposits	This terrain captures the flat, low lying alluvial land that dominates the coastal areas and low-lying areas of the region. This terrain is typically characterised by low lying, flat topography comprising streams, rivers and swamps. This terrain is one of the youngest in the project area.	Holocene	< 4 m below ground level	Rangataiki Plains, Opotiki	Possible
Alluvial Plains and River Flats	This terrain is very similar to the alluvial lowlands and swamp deposits, however this terrain has a higher topographical elevation. This terrain represents the sediments deposited from the active and historic river systems within the region. The surface of this terrain typically increases in elevation in a landward direction from the coast.	Holocene	< 4 m below ground level	Kawerau, Te Teko, Taneatua, Murupara, Reporoa	Possible
Harbour Margins	Low-lying areas surrounding the present-day shorelines associated with the harbours of the Bay of Plenty region. This terrain is inferred to be primarily formed by estuarine type processes, rather than by alluvial or deltaic processes.	Holocene	< 4 m below ground level	Western Bay of Plenty (Tauranga Harbour), Ohiwa Harbour	Possible
Alluvial Terraces	Generally steep-sided terraces and sea cliffs. The terraces typically comprise Pleistocene-age or older alluvium, with various interbedded ash and tephra deposits. Typically positioned below the hills and ranges terrain.	Early Pleistocene - Middle Pleistocene	> 4 m below ground level	Western Bay of Plenty (Omokoroa, Katikati, Maketu)	Undetermined
Alluvial Channels	Active fluvial systems eroding older hills and ranges forming steep sided typically narrow channels or small gullies. Characterised by colluvial/alluvial deposition typically at the base of gullies or within the upper reaches of stream valleys. Also includes the deposits of side slope processes and fans.	Holocene	< 4 m below ground level	Small rivers and streams in hills and ranges terrain	Possible
Debris Flows and Landslide Deposits	Represents large mass flow/colluvium deposits that can be observed at 1:25,000 scale. Minor unit across region are not identified on the geomorphic map.	Holocene	> 4 m below ground level	Matata	Undetermined
Lacustrine Lowlands	Low-lying, flat land located alongside several lakes within the region. Represents recent lake sediments that were deposited by recent, historic shorelines.	Holocene	< 4 m below ground level	Rotorua CBD, Ngongotaha, Tarawera	Possible
Lacustrine Terraces	This terrain sits above the lacustrine lowlands and represents historic shorelines of several lakes within the region. Typically sub horizontal to gently sloping surfaces that are elevated above the current lake levels/lacustrine lowlands.	Late Pleistocene	> 4 m below ground level	Owhata (Rotorua), Western Heights	Undetermined
Hills and Ranges	Terrain characterised by elevated topography which is often capped with tephra and residual soils. This terrain typically sits above the alluvial terraces and covers the majority of the project area. Represents the oldest terrain in the project area.	Older than Pliocene	> 8 m below ground level	Kaimai Ranges, Te Uruwera Ranges, Raukumara Ranges	Undetermined or Unlikely
Volcanic Plateaus	This terrain comprises extensive areas of continuous flat to gently sloping land that is positioned at high elevations. This terrain is derived from volcanic material, predominantly comprising mass flow deposits (pyroclastic flows and airfall tephra).	Early Pleistocene - Middle Pleistocene	> 8 m below ground level	Mamaku Plateau, Kaingaroa Plateau	Undetermined or Unlikely
Reclamation Fill	Uncontrolled and engineered fill, reworked natural soils or construction waste, inferred to be > 3m thick.	Holocene	< 4 m below ground level	Whakatane CBD	Possible



**Appendix A Figure 4.1: Geomorphic model No. 1**

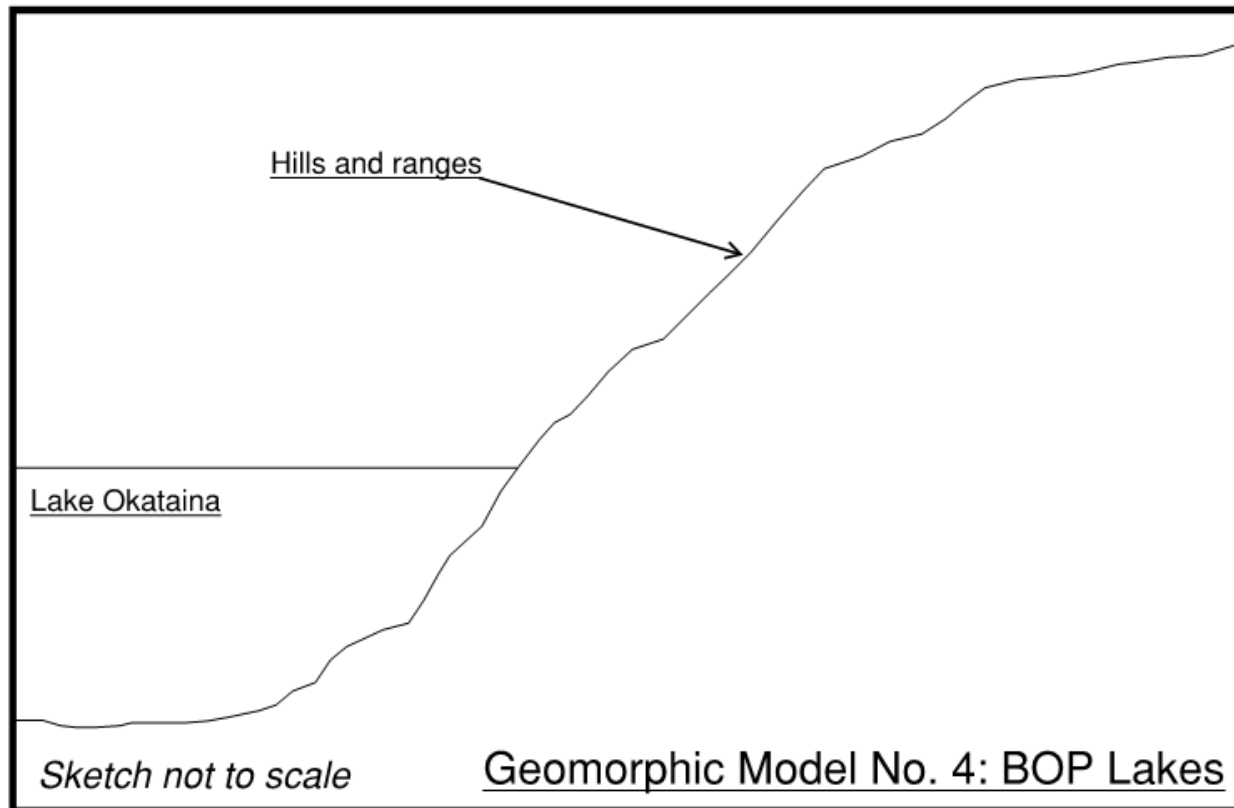


Appendix A Figure 4.2: Geomorphic model No. 2



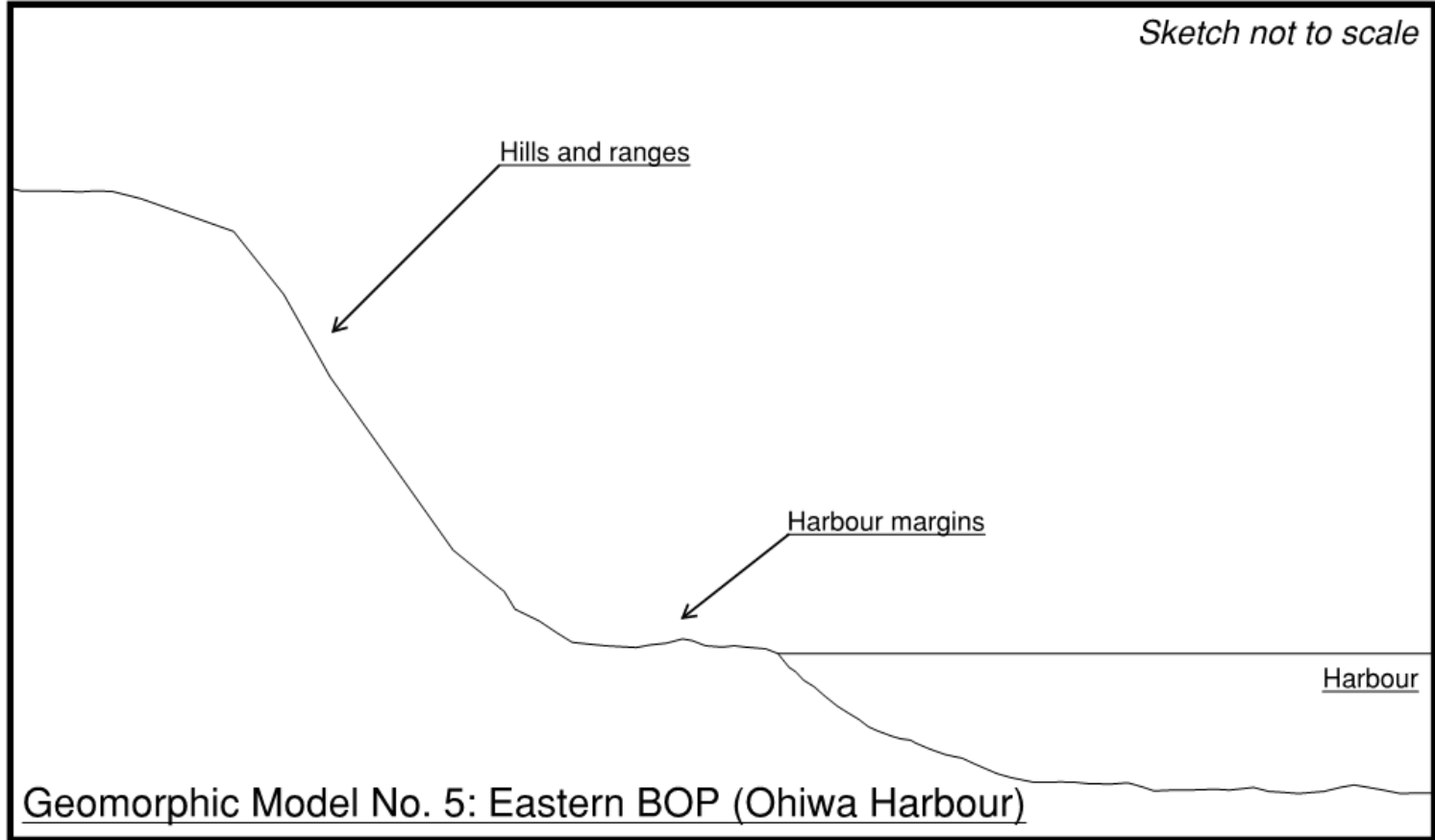
Appendix A Figure 4.3: Geomorphic model No. 3





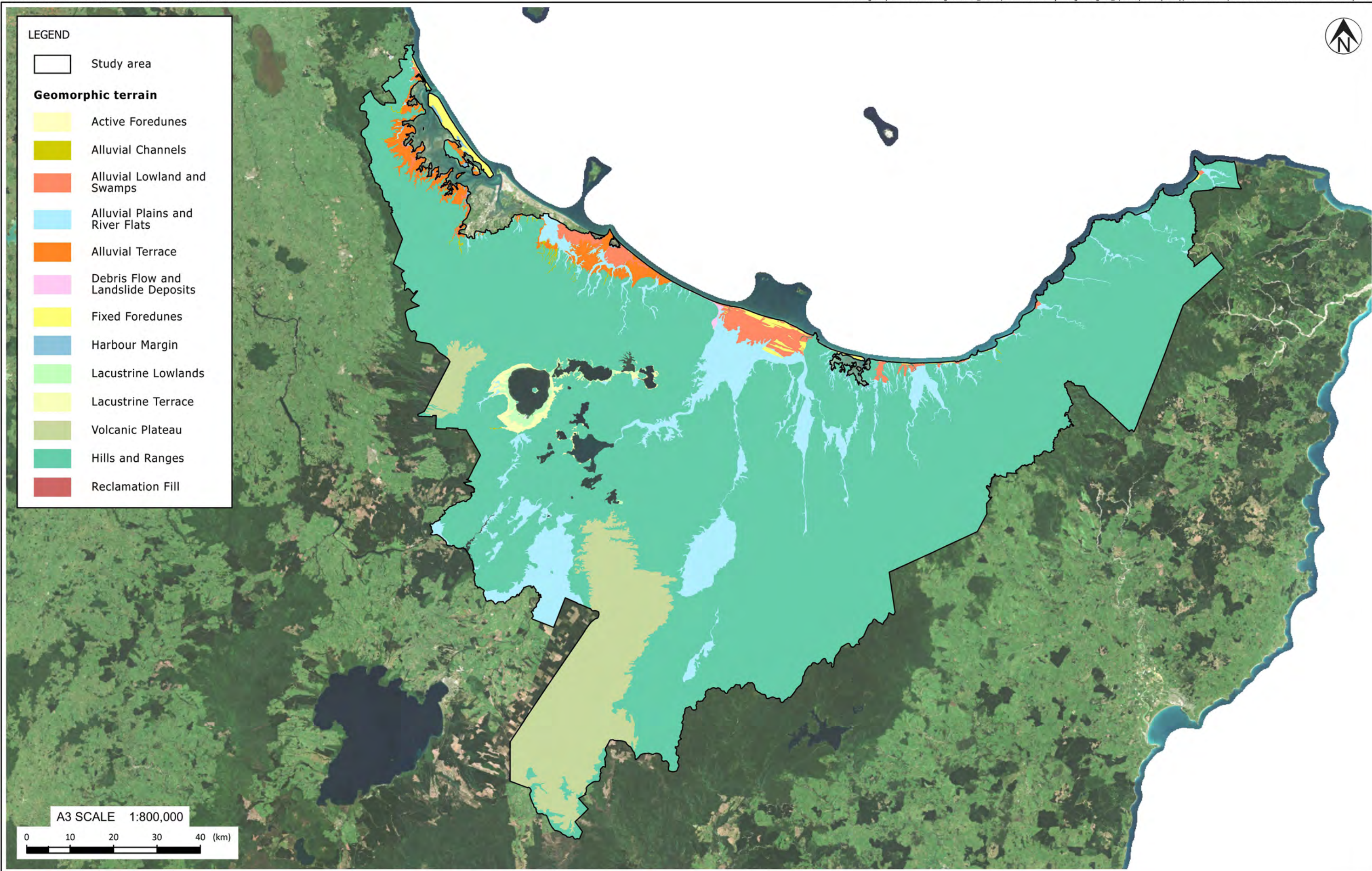
Appendix A Figure 4.4: Geomorphic model No. 4





Appendix A Figure 4.5: Geomorphic model No. 5





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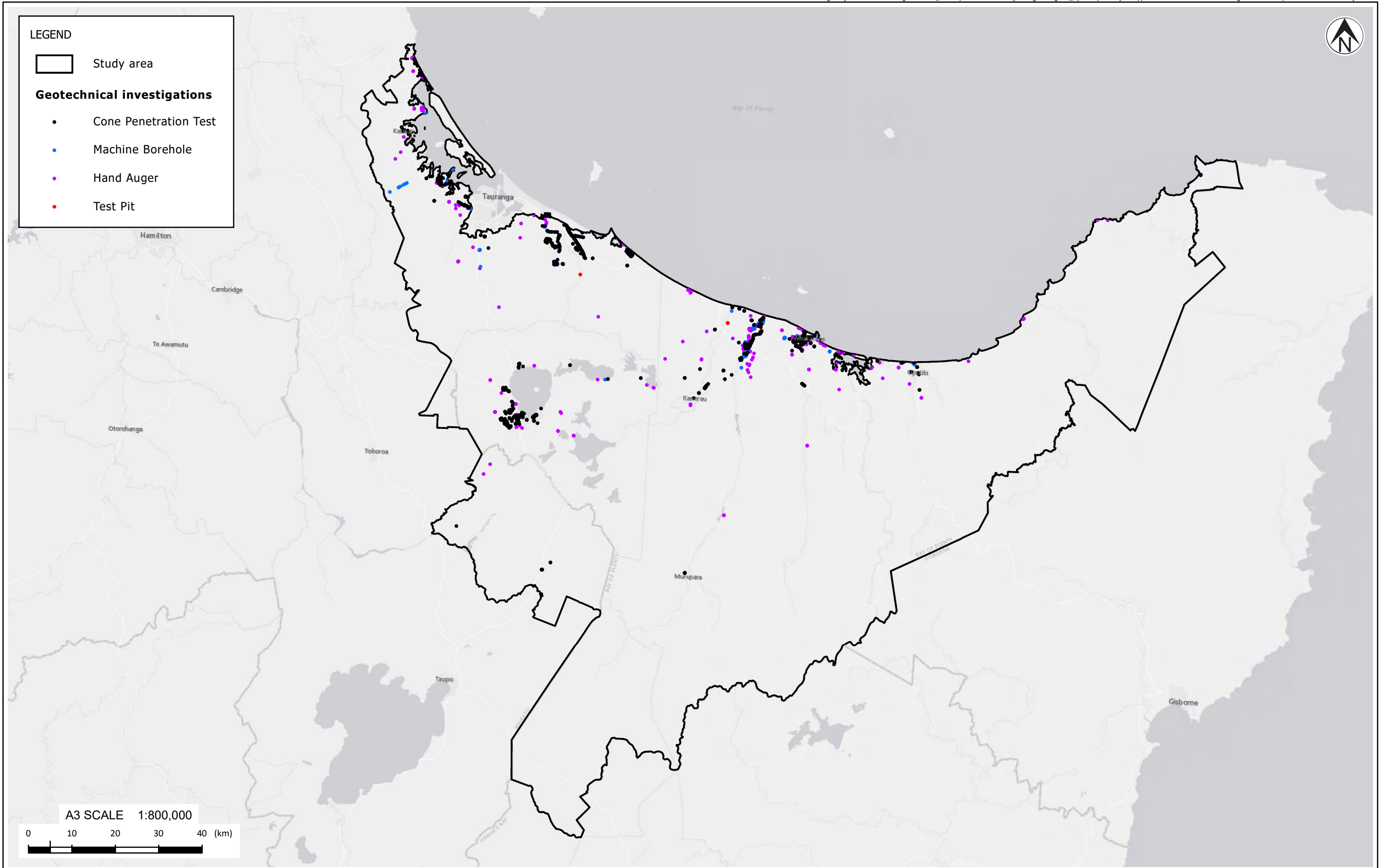
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PROJECT	REGIONAL LIQUEFACTION HAZARD ASSESSMENT		
TITLE	GEOMORPHIC MAP OF STUDY AREA		
SCALE (A3)	1:800,000	FIG No.	FIGURE A5
REV			0





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 2. Geotechnical investigations: sourced from the New Zealand Geotechnical Database (NZGD).

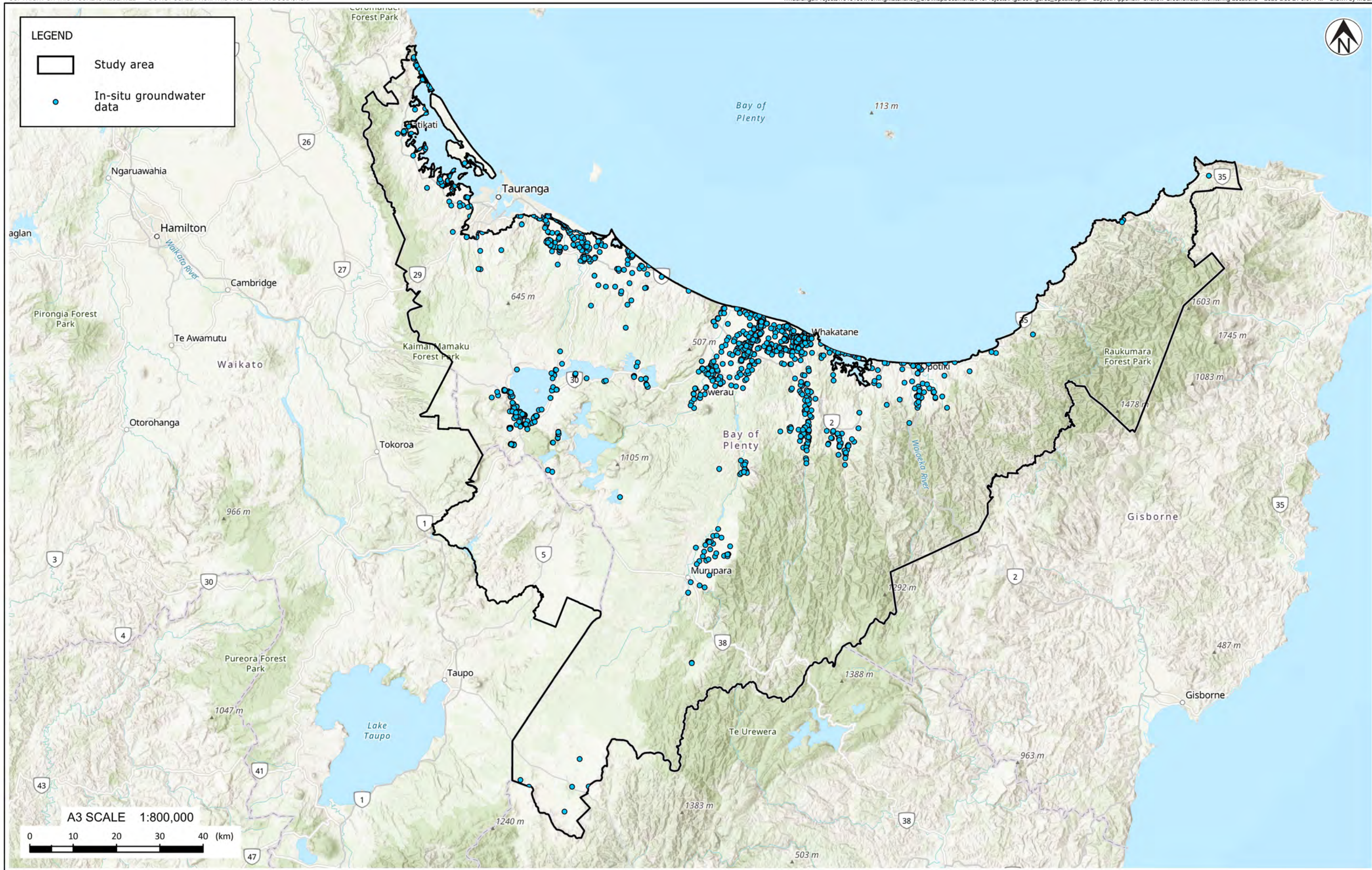
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PROJECT	REGIONAL LIQUEFACTION HAZARD ASSESSMENT		
TITLE	GEOTECHNICAL INVESTIGATIONS AVAILABLE ON NZGD WITHIN STUDY AREA		
SCALE (A3)	1:800,000	FIG No.	FIGURE A6
REV			0





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 2. Groundwater measurement locations: sourced from Bay of Plenty Regional Council and the New Zealand Geotechnical Database.

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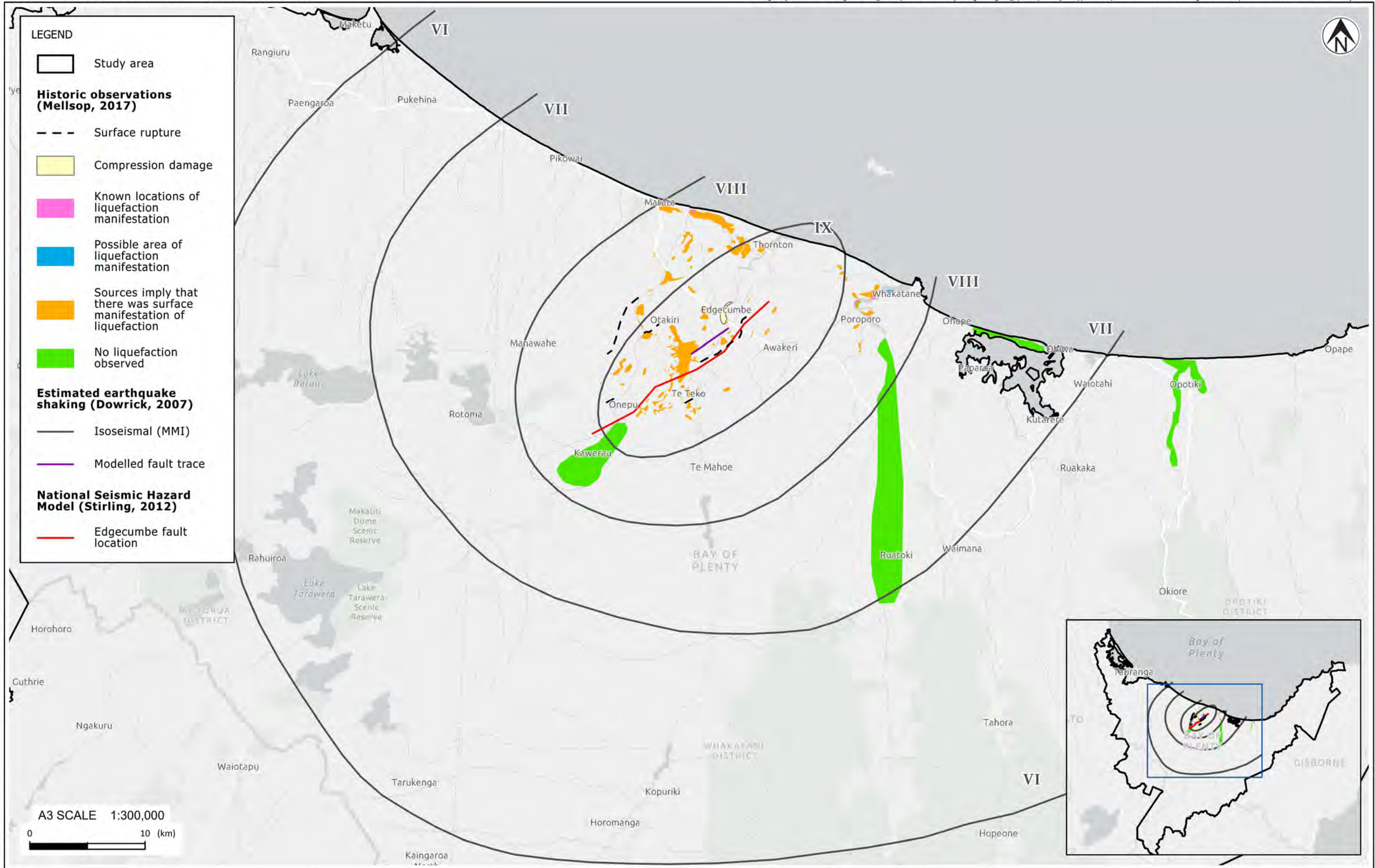
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PROJECT	REGIONAL LIQUEFACTION HAZARD ASSESSMENT		
TITLE	SHALLOW GROUNDWATER MONITORING LOCATIONS		
SCALE (A3)	1:800,000	FIG No.	FIGURE A7
REV	0		



Appendix A Table A2. Estimated Peak Ground Accelerations (PGA) and Magnitude ( $M_{eff}$ ) for various return period earthquakes for towns within the Bay of Plenty region based on the NZTA Bridge Manual methodology (NZTA, 2018)

Town/ City	C0,1000		Effective magnitude for design return period (years)		PGA (g) 1/25			PGA (g) 1/50			PGA (g) 1/100			PGA (g) 1/250			PGA (g) 1/500			PGA (g) 1/1000			PGA (g) 1/2500		
	Subsoil Class A/B	Subsoil Class D&E	500 - 2500	50 - 100	Class A & Class B	Class C	Class D & Class E	Class A & Class B	Class C	Class D & Class E	Class A & Class B	Class C	Class D & Class E	Class A & Class B	Class C	Class D & Class E	Class A & Class B	Class C	Class D & Class E	Class A & Class B	Class C	Class D & Class E	Class A & Class B	Class C	Class D & Class E
Whakatane	0.43	0.46	6.1	6.1	0.08	0.11	0.09	0.12	0.15	0.12	0.17	0.22	0.18	0.25	0.33	0.27	0.33	0.44	0.35	0.43	0.57	0.46	0.60	0.79	0.64
Opotiki	0.40	0.44	6.1	6.1	0.08	0.10	0.08	0.11	0.14	0.12	0.15	0.20	0.17	0.23	0.31	0.25	0.31	0.41	0.34	0.40	0.53	0.44	0.55	0.74	0.61
Kawerau	0.41	0.43	6.2	6.2	0.08	0.10	0.08	0.11	0.15	0.12	0.16	0.21	0.17	0.24	0.31	0.25	0.32	0.42	0.33	0.41	0.55	0.43	0.57	0.76	0.60
Murupara	0.42	0.41	6.3	6.3	0.08	0.11	0.08	0.11	0.15	0.11	0.16	0.21	0.16	0.24	0.32	0.24	0.32	0.43	0.32	0.42	0.56	0.41	0.58	0.77	0.57
Rotorua	0.35	0.39	6.0	6.0	0.07	0.09	0.08	0.09	0.13	0.11	0.13	0.18	0.15	0.20	0.27	0.23	0.27	0.36	0.30	0.35	0.47	0.39	0.48	0.64	0.54
Ruatoria	0.34	0.41	6.1	6.1	0.07	0.09	0.08	0.09	0.12	0.11	0.13	0.17	0.16	0.20	0.26	0.24	0.26	0.35	0.32	0.34	0.45	0.41	0.47	0.63	0.57
Te Puke	0.30	0.35	6.0	6.0	0.06	0.08	0.07	0.08	0.11	0.09	0.23	0.31	0.27	0.12	0.15	0.13	0.30	0.40	0.35	0.17	0.23	0.20	0.42	0.55	0.48
Tauranga	0.29	0.34	5.9	5.9	0.06	0.07	0.07	0.08	0.10	0.09	0.11	0.15	0.13	0.17	0.22	0.20	0.22	0.30	0.26	0.29	0.39	0.34	0.40	0.53	0.47
Waihi	0.29	0.34	5.9	5.9	0.06	0.07	0.07	0.08	0.10	0.09	0.22	0.30	0.26	0.11	0.15	0.13	0.29	0.39	0.34	0.17	0.22	0.20	0.40	0.53	0.47
Mount Maunganui	0.29	0.34	5.9	5.9	0.06	0.07	0.07	0.08	0.10	0.09	0.11	0.15	0.13	0.17	0.22	0.20	0.22	0.30	0.26	0.29	0.39	0.34	0.40	0.53	0.47



**LEGEND**

- Study area
- Historic observations (Mellsop, 2017)**
- Surface rupture
- Compression damage
- Known locations of liquefaction manifestation
- Possible area of liquefaction manifestation
- Sources imply that there was surface manifestation of liquefaction
- No liquefaction observed
- Estimated earthquake shaking (Dowrick, 2007)**
- Isoseismal (MMI)
- Modelled fault trace
- National Seismic Hazard Model (Stirling, 2012)**
- Edgecumbe fault location

A3 SCALE 1:300,000  
 0 10 (km)

**NOTES:**

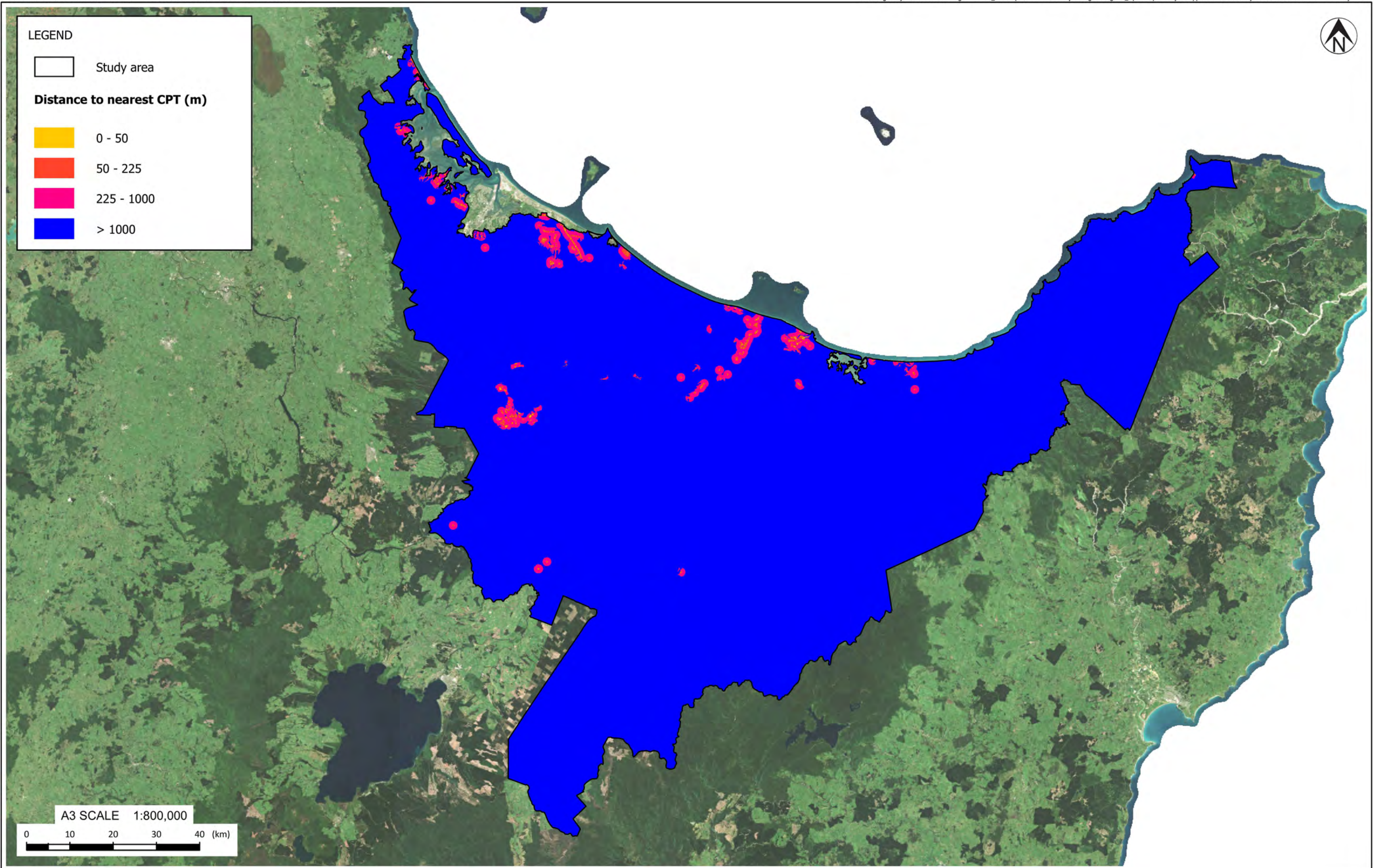
1. Basemap: sourced from Land Information New Zealand and licensed for re-use under the Creative Commons Attribution 4.0.
2. Historic observations: sourced from QuakeCore and Mellsop, 2017.
3. Estimated earthquake shaking: sourced from Dowrick, 2007.
4. National Seismic Hazard Model faults: sourced from Stirling, 2012.

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PROJECT	REGIONAL LIQUEFACTION HAZARD ASSESSMENT		
TITLE	LIQUEFACTION OBSERVATIONS FROM 1987 EDGECCUMBE EARTHQUAKE		
SCALE (A3)	1:300,000	FIG No.	FIGURE A8
REV	0		





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TITLE	DISTANCE TO THE NEAREST CPT WITHIN THE SAME GEOMORPHIC TERRAIN
SCALE (A3)	1:800,000
FIG No.	FIGURE A9
REV	0