PROPOSED PLAN CHANGE

STORMWATER MANAGEMENT PLAN

RAYMOND BULL & BLACK SWAMP ROADS, MANGAWHAI

MANGAWHAI EAST

May 2025

REPORT 1838- 2 Rev 1

ASPIRE CONSULTING ENGINEERS

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Revision History

Revision Nº	Prepared By	Description	Date
Rev 0	E Peters	Issued for PC	24/10/2024
Rev 1	H Robins	Peer review update	30/05/2025

Document Acceptance

Action	Name	Signed	Date
Prepared by	E Peters		24/10/2024
Reviewed by	M Bates		24/10/2024
Approved by	P Fairgray		24/10/2024

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Executive Summary

The proposed Stormwater Management Plan outlines the overall potential impacts and management strategy for stormwater generated from the Proposed Plan Change at Black Swamp Road, Mangawhai East.

Stormwater from future developments will be managed through an integrated treatment train approach, in line with best practice using Auckland Council's GD001 document. This is in general accordance with similar developments proposed within the Mangawhai area.

For devices anticipated to be vested to Kaipara District Council, communal devices, such as stormwater wetlands, are preferred to reduce ongoing maintenance requirements. At-source treatment is considered an acceptable solution where communal devices will not be feasible due to staging of the development. At-source treatment will ensure that adequate stormwater management can be achieved irrespective of which areas within the plan change are developed.

The following performance criteria will be used within the Plan Change area:

Performance Criteria	Appropriate for the site?	Catchment and Description	Reason
Water Quality	Y	Entire Plan Change area • Newly formed public roads. • Carparking relating to Neighbourhood and Mixed-Use areas. • All roofs required to be inert building materials.	Impervious areas and potentially contaminating surfaces will be created as part of future developments. Excludes driveways and hardstand surfaces within residential lots.
Stream/Wetland Hydrology			
Groundwater Recharge	Y	Northern Catchment • Only required if peat material is kept in place.	Will be required in the northern catchment and will be required to ensure no long-term drawdown of groundwater level.
Hydraulic Neutrality for wetlands (95% percentile storm)	Y	Northern Catchment Southern Catchment (C & D) • Required to maintain existing hydraulic flows to wetlands and salt marshes. Only required if within a wetland catchment. To be assessed at resource consent stage.	Northern catchment discharges towards tidal salt marshes and wetland adjacent to tidal tributary. Southern Catchment C and D discharges toward tidal tributary with wetland margins.
Flooding			
10% AEP Detention	N	Entire Plan Change area	Not required as no downstream reticulation or properties. Discharge is at the tidal boundary.

1% AEP Detention	N	Entire Plan Change area	Not required due to discharge of development to the tidal boundary.

This report has highlighted critical investigations which will be specifically required for future developments for the Plan Change area, these include:

Actions at Resource Consent Stage for Stormwater Management:

- Undertake geotechnical investigations and soakage tests to confirm soil permeability.
- Complete earthworks design and confirm if peat remains in place.
- Assess overland flow path extents and design conveyance through site.
- Assess overland flow path through site and convey flows from the existing entry and exit points of the future development.
- Future developments to consider staging of stormwater infrastructure to ensure SMP requirements are met.
- Provide operation and maintenance manual for all stormwater devices.
- Further design around platforms within the coastal inundation zone and supporting report from Coastal Engineer

The report demonstrates that stormwater can be properly managed within the site and further details of devices and calculations will be provided to support a Resource Consent Application.

1. Existing Site Appraisal

The proposed Plan Change area is located approximately 1.5km southeast of Mangawhai Village. The area is bound by Mangawhai Harbour to the west, Raymond Bull Road to the north and east, and the southern boundary of a 12-hectare block south from Black Swamp Road (Legal Description – Section 25 Block IV Mangawhai SD).

A tributary of the Mangawhai Harbour bisects the site. Black Swamp Road is located next to the tributary and physically separates the proposed plan change area into two land areas with different topographical characteristics.

The majority of the site is grass with some tree vegetation and several existing dwellings, driveways, farm tracks and legal formed roads. The area is currently used as farmland for grazing cattle, and agriculture purposes. The existing local piped network in the area is very limited. Stormwater runoff flows overland and outlets into the Mangawhai Harbour or Mangawhai Harbour Tributary, typically managed by farm drains and culverts under existing roads

The total proposed plan change area is 93 hectares and is held in several Titles of ownership. The proposal is to rezone these titles to create a residential community including a neighborhood centre, green spaces, an efficient transportation network and diverse housing options.

1.1 Topography

The area is separated into two very unique topographic conditions north and south of the Mangawhai Harbour tributary. The north of Black Swamp Road is generally flat with levels ranging from RL 1.5m to RL 5m over a distance of 700m with an average grade of 0.5% or less.

The northern block has two distinct catchments falling north towards Raymond Bull Road table drains and ultimately through to the Mangawhai Estuary. The second catchment falls south towards the Mangawhai estuary tributary.

The area to the south of Black Swamp Road has an average gradient of 9%, rising in a southern direction from the existing tributary. The Reduced Level at the most southern boundary has an RL of 40m.

Both areas are distinct with different hydrological and environmental considerations around stormwater management.

Fig. 1
Existing aerial of the site

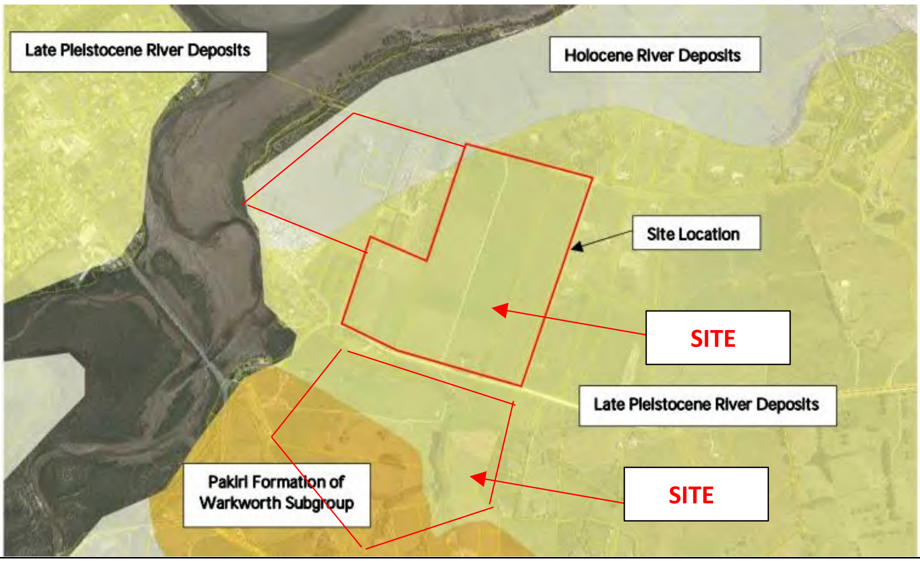
1.2 Geotechnical/Soil Conditions

Initia Geotechnical Specialists undertook site investigations over part of the plan change area in June 2022 and February 2024. Investigations in this area identified a thin layer of topsoil underlain by a layer of organic sandy silt/fibrous Peat between 200mm and 1200mm thick. A strongly cemented hardpan sand underlies the organic silt/fibrous Peat between 100mm to 800mm thick. Tightly packed sand underlies the hardpan layer for significant depth.

Initia undertook a review of the published geological map and have noted the site has been mapped with Holocene river deposits, Late Pleistocene river deposits, and Pakiri formation of Warkworth subgroup.

At this stage the management of earthworks is still subject to further investigation and design but we believe that there could be options to maintain the current peat layer or possibly remove it.

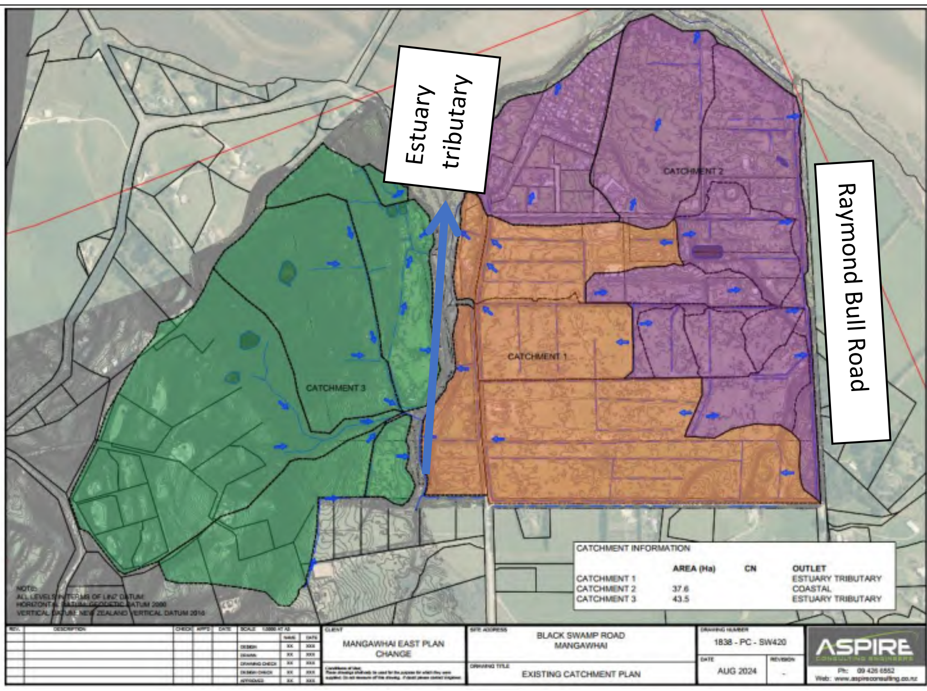
Both options will have an impact on how stormwater is to be managed within the site. If peat deposits are left in place and managed, groundwater recharge will need to be included. If the peat layer is removed and replaced with engineered fill, then no recharge will be necessary. Further discussions around this are outlined in the stormwater management section of this report.

Fig. 2 Mangawhai Geological Map Excerpt	

1.3 Existing Hydrological features and Stormwater Infrastructure

The site has numerous small sub catchments with the northern portion of the site being highly modified through existing farm drainage. Refer to the existing catchment plan within Appendix A. There is a central tidal tributary separating the northern and southern catchments. The project Ecologists have confirmed the extents of tidal influence through to the eastern boundary of the plan change.

The northern catchment is significantly flat with farm drains intersecting stormwater and channelizing approximately half of the area north towards Raymond Bull Road. The remaining southern areas within the northern catchment discharge toward the tidal tributary.

Fig. 3 Existing Catchment Plan	

The southern catchment has reasonable falls through the site and is channelized through established overland flow paths towards the estuary tributary.

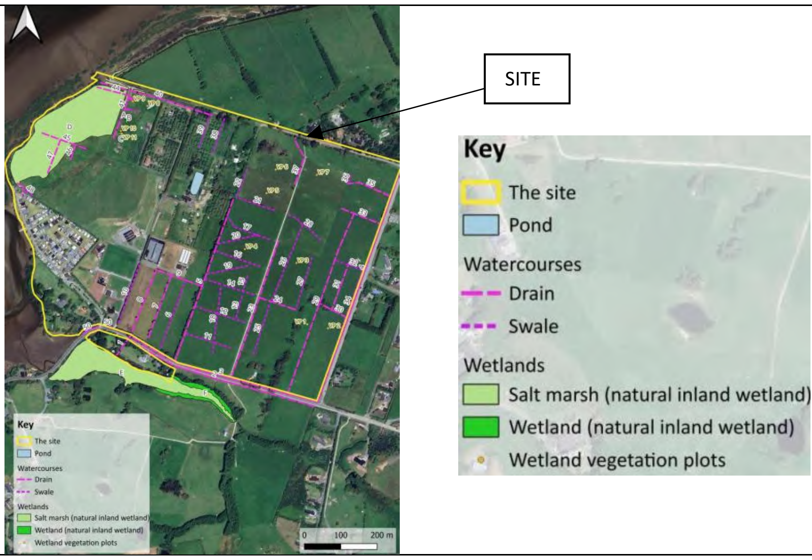
1.4 Receiving Environment

Flows from the proposed plan change area will discharge to the following receiving environments. Refer to the existing catchment plan within Appendix A and excerpt from Virdis Ecology Impact Assessment below in Figure 4. Catchment B drains to the north to Raymond Bull Road and west towards the coastline. The coastline includes areas of mangroves and saltmarsh. Catchment C drains north to the wetland and saltmarsh as it approaches the coastline. Catchment A drains to the south to this wetland and saltmarsh as well.

Further details of the receiving environment with specific locations of discharge points should be provided during the Resource Consent stage, and catchments boundaries should be assessed if any of these change due to earthworks proposals.

Assessment of the tidal extents and saltwater wetlands are covered under the Ecology reports in support of this Plan Change.

Fig. 4
Virdis Ecology Impact Assessment – identified watercourses and wetlands



1.5 Coastal Inundation

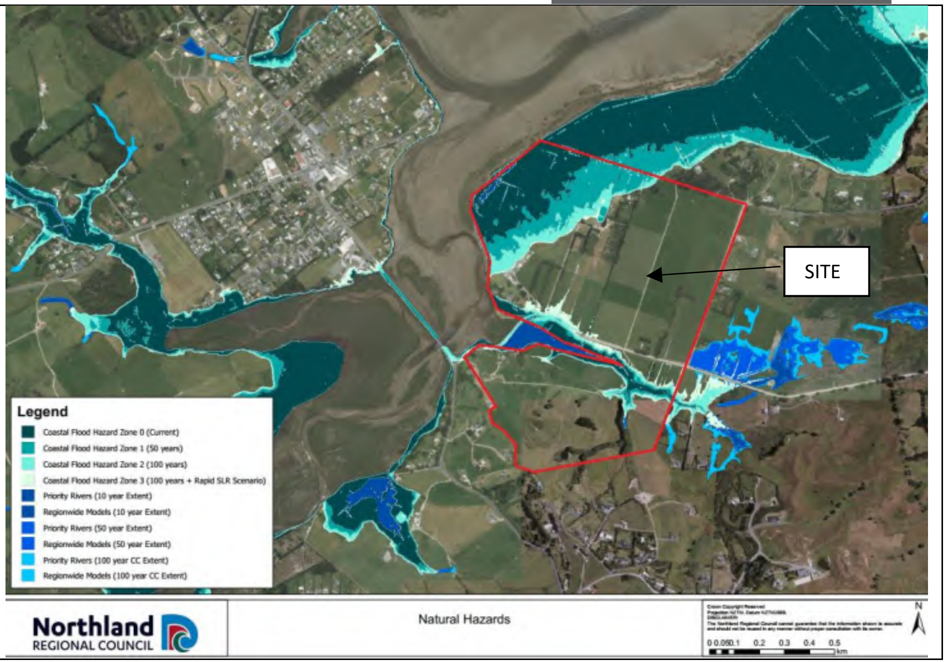
The Northern Regional Council (NRC) has developed a Natural Hazards Plan to address coastal inundation. Coastal inundation occurs when sea water temporarily or permanently inundates land areas along the coast, typically due to storm surges, high tides and sea level rise.

Coastal inundation will be a governing factor in how the development is managed. Refer to Appendix A for the Coastal Inundation and Flooding plan. The Coastal Flood Hazard Zone 2 produced from Northland Regional Council and shown in Figure 5, identifies the area susceptible to coastal inundation in a 1 in 100-year storm event, taking into account projected sea level rise over the next 100 years. The coastal inundation over this area is significant, so this area will need to be evaluated further.

Davis Coastal have undertaken a Coastal Processes and Hazard Assessment, dated October 2024. This report has been supplied as part of the plan change application. In this assessment they have calculated a 100-year future inundation level of 3.7m RL (NZVD).

To mitigate this risk, measures such as raising existing ground levels and defining minimum floor levels for future lots, will need to be implemented to avoid future coastal inundation.

Fig. 5
NRC extract with Coastal inundation extents shown



1.6 Flooding and flow paths

1.6.1 Flooding extents

The Plan Change areas are located within some flood areas noted by the NRC natural hazard maps for flooding. The flood maps are publicly available and are based on the Design Modelling Hakaru Catchment (M08) report, dated May 2021 prepared by Water Technology Pty Limited undertaken on behalf of Northland Regional Council.

The maps indicated that the northern portions of the plan change area near the coastal edge and the tidal tributary are noted as being influenced by the Priority Rivers 100yr CC extent and Region wide models.

The central tributary is also noted as being influenced by these two events.

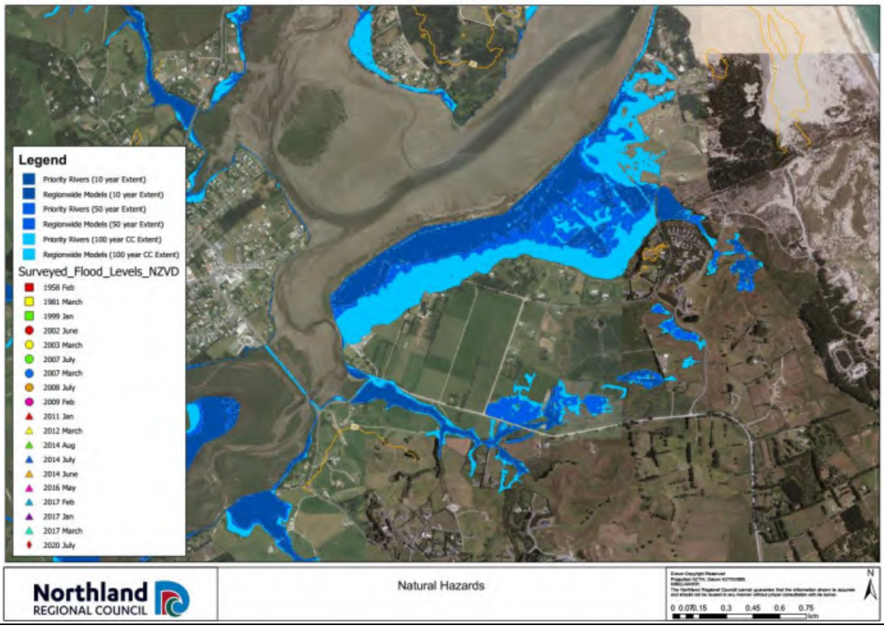
The flood maps align very closely to the coastal inundation extents also published by NRC.

In discussions with the hydraulic modelling team from Water Technology Pty Ltd, the modelling team confirmed that the flood modelling:

> *"The final model was based on NZVD, with the following level adopted:*
>
> *Without climate change: 1.311m RL at Marsden Point:*
>
> - *I believe this is 1396mm OTP*
> - *With climate change: 2.511m RL at Marsden Point.*
>
> *The 1.2m allowance for sea level rise was only included in the climate change scenario."*

On this basis we can conclude that the model is based on the tailwater conditions influenced by the coastal sea level rise rather than flooding impacts within the coastal marine area, as the future coastal inundation level indicated is 3.7m RL and the flood modelling level is 2.511m RL. Refer to Appendix A for the Coastal Inundation and Flooding plan.

Areas of flooding outside of the coastal inundation are not present within the plan change area.

Fig. 6 Flood Extents Map NRC	

1.6.2 Overland Flowpaths

The Northern and Southern Portions of the Plan Change area have two distinct considerations with reference to overland flow paths and management.

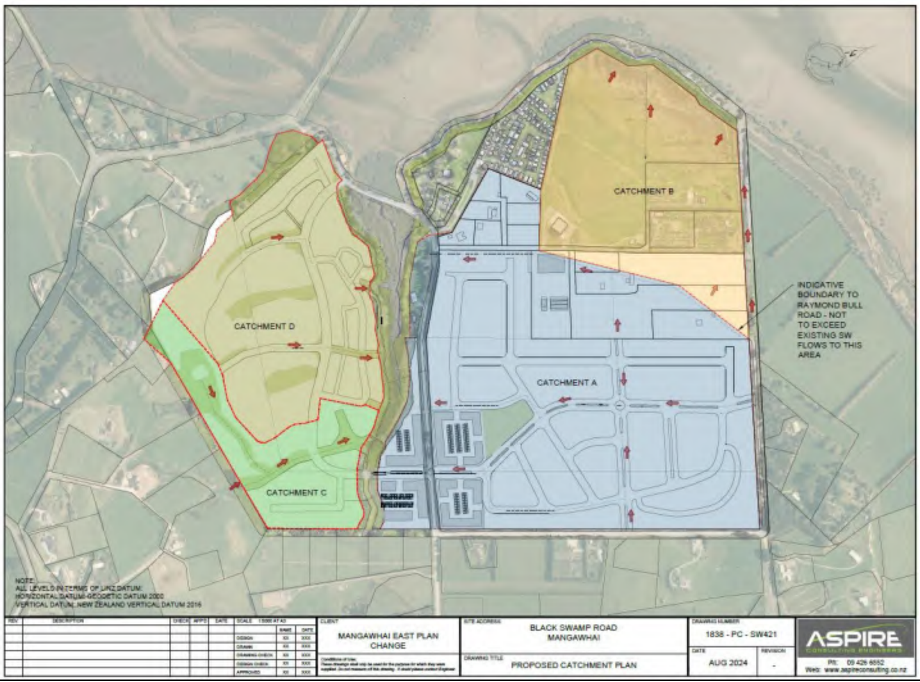
Overland flow paths through the northern section of the Plan Change area will need to be managed either through formal channels or within road corridors acting as overland flow paths for the site.

Conceptually we have considered that a series of larger channel swales which can be incorporated into the road corridor providing conveyance of larger storm events and allowing for reticulation to discharge to these channel swales.

The Southern catchment has some graduated, incised channels which convey flows towards the central tidal tributary.

Hydraulic neutrality to these flow paths should be maintained in future development to provide for a healthy environment.

Flow paths within the southern section should be accounted for within the road corridors with reticulation either discharging to the flow paths or central tidal tributary.

Fig. 7 Proposed Flowpaths	

1.7 Ecology

The site generally is considered agricultural use. A detailed Ecological assessment has been completed by Viridis and Rural Design Limited for the northern and southern catchments respectively.

Both Ecologists have identified the location of Saltwater marsh and wetland perimeter of the central tributary that separates the northern and southern portions of the Plan Change area.

All other water bodies within the site are manmade and are utilized for grazing and farming purposes.

The proposed Stormwater Management will take into account hydraulic flows feeding the wetland areas.

Fig. 8 Wetland identification within Plan Change area South and North	

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1.8 Contaminated Land Hazardous Soils

The presence of acid sulphate in soils can cause corrosion to concrete structures and infrastructure that is in contact with acidic soil and/or groundwater. Stormwater and wastewater pipes can be at risk as these can be exposed to moving groundwater flow and infiltration.

A contamination investigation has not been completed as part of the Plan Change but the area is located within an area noted for Acid Sulfate soils. Further investigations will be undertaken to identify the presence of acid sulphate in this area, and mitigation measures should be implemented depending on the magnitude of the results.

2. Development Summary

At this early stage, the development includes a conceptual masterplan for the Plan Change area. In addition, there will be an underlying structure map included as the Plan Change.

The approximate yield for the plan changes area is around 750 lots with additional mixed use and neighborhood centre activities.

Fig. 9 Concept Development Plan	

The following performance criteria has been developed for stormwater management within the Plan Change area:

2.1 Performance Criteria for Plan Change Area:

Requirement	Design criteria to follow
Water Quality	All roading will require treatment including removal of 75% TSS. Roof areas will require inert building materials as to not generate contaminants. JOALS, parking areas and driveways will not require treatment.
Groundwater Recharge (retention)	Retention is only required on Northern Catchment if Peat remains in place.
Wetland Hydrology (detention)	Review existing catchments going to wetlands and salt marshes. Existing predevelopment flows to wetland should be maintained for the 95th Percentile storm event.
Flooding 10% AEP	Not required due to tidal downstream edge and lower reach of the catchment.
Flooding 1% AEP	Not required due to tidal downstream edge and lower reach of the catchment.

2.2 Earthworks

Generally, there will be earthworks proposed within the site to create roading and platforms to facilitate development of the site.

All earthworks will be designed and completed in accordance with Kaipara District Council Engineering Standards, Northland Regional Council requirements and geotechnical recommendations.

These will be assessed at the time of Resource Consent against the standard assessment criteria of the Kaipara District Council and Northland Regional Council.

As noted earlier, the Northern Portion of the plan change contains underlying peat material. This peat material may require removal and replacement of certified engineering fill, or alternatively, preloading of the peat material which can remain in place. The reason for recharge is to maintain existing groundwater levels so as to not exacerbate any settlement.

The following stormwater criteria will be used based on the differing scenarios.

Scenario	Stormwater Management
Removal of Peat Material	Not required
Peat Preload	Stormwater shall include groundwater recharge of 5mm storm volume. In accordance with GD001. This can be done through various devices included in the toolbox section.

2.3 Erosion and Sediment Controls

Erosion and sediment controls are to be installed prior to the commencement of any earthworks on the site and maintained for the full duration of the works.

Typical silt control measures will be utilized including silt fences, topsoil bunding, clean water diversion bunds, decanting earth-bunds and sediment retention ponds all designed in accordance with Kaipara District Council and Northland Regional Council. The Kaipara District Council Standards refers to the ARC publication TP90 (Superseded with GD05) as being an acceptable guideline.

These will be assessed at time of Resource Consent against the standard assessment criteria of Kaipara District Council and Northland Regional Council.

3. Mana Whenua Matters

Recognition inclusion and incorporation of Maori values are key to ensuring an ongoing partnership between Tangata Whenua and the development of the land. As such the Core Maori Values have been considered.

The relationship of Māori with their ancestral lands, water, sites, wahi tapu and other taonga is a Matter of National importance as identified in s6 (e) of the Resource Management Act

Te Mana o te Wai

The concept of Te Mana o te Wai recognises the mana and mauri of water. It encompasses the relationship between water, the wider environment and our communities.

Te Mana o te Wai is the fundamental concept of the National Policy Statement for Freshwater Management 2020 (NPS-FM),and has also provided the foundation of this Stormwater Management Plan. The 6 principles are:

- Mana whakahaere: the power, authority, and obligations of tangata whenua to make decisions that maintain, protect, and sustain the health and well-being of, and their relationship with, freshwater
- Kaitiakitanga: the obligations of of tangata whenua to preserve, restore, enhance, and sustainably use freshwater for the benefit of present and future generations.
- Manaakitanga: the process by which tangata whenua show respect, generosity, and care for freshwater and for others.
- Governance: the responsibility of those with authority for making decisions about freshwater to do so in a way that prioritises the health and well-being of freshwater now and into the future.
- Stewardship: the obligations of all New Zealanders to manage freshwater in a way that ensures it sustains present and future generations.
- Care and respect: the responsibility of all New Zealanders to care for freshwater in providing for the health of the nation.

The sole objective of the NPS-FM has recognised the hierarchy of obligations in Te Mana o te Wai that prioritises:

a) First, the health and well being of water bodies and freshwater ecosystems
b) Second, the health needs of people (such as drinking water)
c) Third, the ability of people and communities to provide for their social, economic, and cultural well being, now and in the future.

The six Te Mana o te Wai principles have been used to guide this Stormwater Management Plan and the overall ideologies of this development. Inclusion of devices such as raingardens and/or swales which treat stormwater through filtering contaminants through soil or vegetation should be used to conserve the environment as well as enhance the native ecosystems.

The Mangawhai Spatial Plan (Kaipara District Council December 2020) identifies the Mangawhai Harbour as an area of cultural significance.

Engagement with Mana Whenua is necessary to identify and understand matters of cultural interest or concern.

The Applicants have engaged with Te Uri o Hau by way of a Hui held on the afternoon of 13th June 2024, at the Pro Land office. The Hui included a drive around of the plan change areas, and over parts of the land accessible at the time of the Hui. Shereen Worthington was the representative for Te Uri o Hau at the Hui.

Further engagement will be undertaken with Te Uri o Hau as the plan change progresses and also with any other identified groups as required by Clause 4A of Schedule 1of the Resource Management Act which requires engagement with iwi authorities prior to notification of a proposed plan.

4. Planning Assessment

The following documents are relevant to the development of the Stormwater Management Plan:

- National Policy Statement on Freshwater Management 2020
- National Policy Statement on Urban Development 2020
- Resource Management (National Environmental Standards for Freshwater) Regulations 2020
- Northland Regional Policy Statement
- Kaipara District Plan

These documents are addressed below:

4.1 National Policy Statement for Freshwater Management 2020 (NPS-FM)

The National Policy Statement for Freshwater Management 2020 (NPS-FM) sets out the objectives and policies for freshwater management under the Resource Management Act. It recognises the concept of Te Mana o te Wai when making decisions on any matter relevant to freshwater.

The NPS-FM requires every regional council to make or change its regional policy statement to provide for the integrated management of the effects of:

a) The use and development of land on freshwater, and
b) The use and development of land and freshwater on receiving environments.

4.2 National Policy Statement on Urban Development (NPS UD)

Objective 5 of the NOS UD requires planning decisions relating to urban environment to take account of the principles of the Treaty of Waitangi.

Objective 6 requires that local authority decisions on urban development that affect urban environments are:

integrated with infrastructure planning and funding decisions; and
strategic over the medium term and long term; and
responsive, particularly in relation to proposals that would supply significant development capacity.

Objective 8 requires New Zealand's urban environments to be resilient to the current and future effects of climate change.

Mangawhai is considered to be an urban environment and therefore these provisions are relevant.

4.3 Resource Management (National Environmental Standards for Freshwater) Regulations 2020

The Resource Management (National Environmental Standards for Freshwater) Regulations 2020 (NES-F) provides consistent standards for regional and district councils to target by prescribing minimum technical standards, methods or requirements.

Under the NES-F, earthworks or vegetation clearance within proximity to a wetland or some works within streams e.g. culverts

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A natural inland wetland is defined in Clause 3.21 of the NPS FW as a *wetland that includes permanently or intermittently wet areas, shallow water, land water margins that support a natural ecosystem of plants and animals that are adapted to wet conditions, and are not the following:*

a) in the coastal marine area; or
b) a deliberately constructed wetland, other than a wetland constructed to offset impacts on, or to restore, an existing or former natural inland wetland; or
c) a wetland that has developed in or around a deliberately constructed water body, since the construction of the water body; or
d) a geothermal wetland; or
e) a wetland that:
   i. is within an area of pasture used for grazing; and
   ii. has vegetation cover comprising more than 50% exotic pasture species (as identified in the National List of Exotic Pasture Species using the Pasture Exclusion Assessment Methodology (see clause 1.8)); unless
   iii. the wetland is a location of a habitat of a threatened species identified under clause 3.8 of this National Policy Statement [NPS-FM], in which case the exclusion in (e) does not apply.

4.4 Northland Regional Policy Statement – May 2016

Issues relating to fresh and coastal water are set out in Chapter 2.1.

The following objectives are relevant:

- Objective 3.1 - Integrated catchment management.
- Objective 3.2 – Region-wide water quality
- Objective 3.3 – Ecological flows and water levels.
- Objective 3.8 – Efficient and effective infrastructure.

The following policies are relevant:

- Policy 4.1 – Integrated catchment management.
- Policy 4.2 – Region-wide water quality management.
- Policy 4.3 – Region-wide water quantity management.

Polices and methods relating to natural hazards in Chapter 7 are also relevant as are the provisions in Chapter 8 relating to Tangata Whenua.

4.5 Kaipara District Plan – Operative 1 November 2013

Chapter 2 – District Wide Resource Management Issues identifies water bodies (Lakes, Rivers, Wetlands). Ecology, coasts and harbours, are also identified. 2.3.4 sets out the need to protect and enhance the District's unique natural environments, including the value of their ecosystems. This Chapter also sets out

Chapter 5 of the plan sets out the Tangata Whenua strategy and Chapters 6 relating to Ecological areas and Chapter 7 relating to Natural hazards are also relevant.

4.6 Kaipara Infrastructure Strategy – Revision 6 February 2021

The Kaipara District Council prepared and adopted an Infrastructure and Funding Strategy as part of its long term plan. The following two relevant stormwater issues were identified as posing a high risk in the Infrastructure Strategy:

1. Comprised water quality

Anticipated Response: the Council will improve enforcement of best standards and any requirements to meet resource consents.

2. Climate change and sea level rise can impact existing network and hinder future growth by overwhelming existing capacity and existing flood protections.
   Anticipated Response: Through the creation of robust catchment management plans, we will be better placed to understand the upgrades and infrastructure required to facilitate and plan for growth.

4.7 Kaipara District Council Engineering Standards 2011

The Kaipara District Council Engineering Standards 2011 apply to all land development infrastructure projects within the Kaipara District.

Kaipara District Council acknowledges the benefit that Low Impact Design has and encourages design that follows the principles of NZS4404:2010 and Auckland Regional Council TP124. Auckland Regional Council TP124 has since been superseded by Auckland Council GD04-Water Sensitive Design for Stormwater.

4.8 Auckland Council Water Sensitive Design – Guideline Document 2015/004 (GD04)

GD04 is a guidance document provided by Auckland Council for the design of stormwater management systems, particularly focused on managing the quality of stormwater runoff in urban areas. Water Sensitive Design (WSD) is a best practice stormwater design approach, to balance land development with any environmental impact a development may create.

GD04 outlines the following principles for Water Sensitive Design;

- Promote inter-disciplinary planning and design
- Protect and enhance the values and functions of natural ecosystems
- Address stormwater effects as close to source as possible
- Mimic natural systems and processes for stormwater management.

4.9 NZS4404:2010 Land Development and Subdivision Infrastructure

NZS4404 is the New Zealand standard for land development and subdivision engineering. This standard provides guidelines and specifications for designing and constructing infrastructure associated with land development and subdivision projects. The primary aim is to ensure that new developments are safe, sustainable, and efficiently integrated into the existing environment.

Section 1.4 of the General Requirements and Procedures of NZS4404 describes Low Impact Design solutions that use natural processes and add value to urban environments as being the preferred approach to urban development.

Section 1.5 addresses climate change and the importance of incorporating risk management in the design regarding sea level rise and the increased frequency of extreme weather events.

5. Stakeholder Engagement and Consultation

Extensive Stakeholder engagement has been undertaken, including a public open day being held on 15th June 2024 at the Mangawhai Village Hall.

Letters seeking initial consultation were sent out to landowners and occupiers within the plan change area anticipated at that time, and also to landowners and occupiers of land adjacent to the proposed plan change area. These letters were sent in June 2024.

One on one meetings have been conducted with landowners who have reached out seeking one on one meetings.
Residents of Coast View Lane and Ocean Sounds Place coordinated a meeting held at a residents' home on Friday 24th May.

A meeting was held with Ian Margan a Mangawhai Matters Inc representative on 13th June 2024, ahead of the Hui held with Te Uri o Hau representative Shereen Worthington.

Consultation has been generally positive, and concerns raised by respective parties have been taken into consideration and worked through.

6. **Stormwater Management**

The following section covers the stormwater management requirements for the Proposed Plan Change area:

6.1 Principles of Stormwater Management

The Plan Change area has several stormwater considerations which will be carefully managed for future development options.

These include:

- Water Quality
- Stream/Wetland Hydrology
- Flooding
- Coastal Inundation
- Overland Flow path management

The guiding principle for Water Sensitive Design is to utilise a “treatment train” for stormwater management. GD004 describes the treatment train as the combination of sequential stormwater management responses that collectively deliver stormwater quality and quantity objectives for a site. The treatment train is based on a logical sequence of stormwater flowing through a catchment, beginning with Stormwater runoff controls at source, followed by capture and treatment of overland flows, and finally the enhancement of receiving environments to enhance their stormwater management function.

This treatment train approach is considered the Best Practicable Option (BPO) for future developments. GD004 identifies the Treatment Train in the following stages.

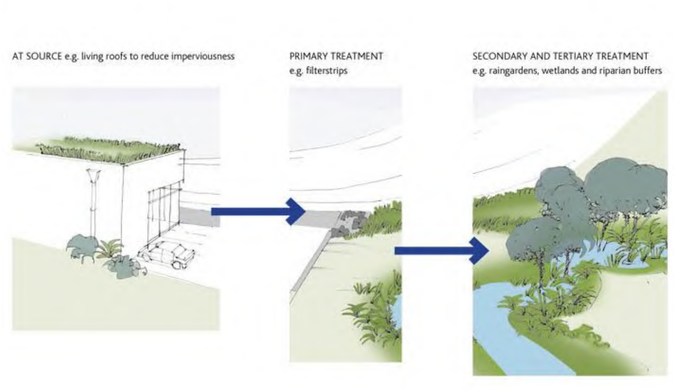


Figure 10 - GD04 – Example Treatment Train Diagram

Further development within the Plan Change Area should look to demonstrate the treatment train approach as part of Best Practicable Option BPO for stormwater management.

6.2 Proposed Stormwater Management

The principles of stormwater management for the site are derived from the underlying existing conditions and the Plan Change proposal.

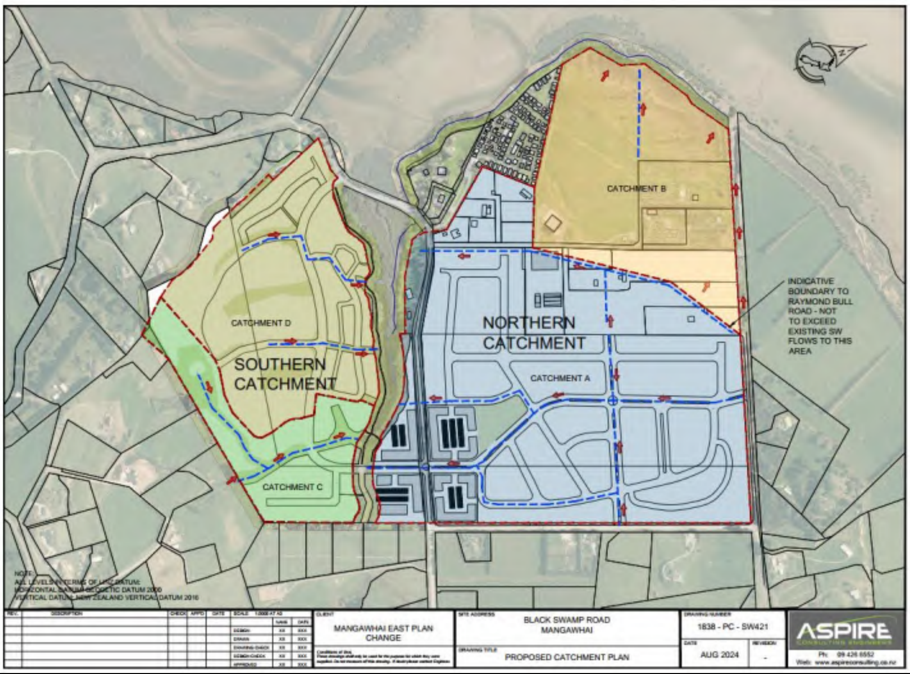
Consideration is required for the following Principles:

- Water Quality – Ensuring contaminants are not discharged to the receiving environment. Typically relating to stormwater generating surfaces (roads etc) which are subjected to contamination.
- Wetland/Stream Hydrology –
    - Retention – The discharge to ground for smaller events with the aim of recharging the groundwater.
    - Detention – Storage and slow release of a 24hr storm event with the aim of alleviating scour and maintaining hydraulic neutrality for the wetland health.
- Flooding frequency and Management 10% and 1% AEP
    - 10% AEP event – More frequent/nuisance flooding. Typically required where sites are reticulated with SW network downstream to alleviate extra flows to the networks.
    - 1% AEP event – Larger storm event and protection of buildings and structures.

The catchments for the proposed plan change are distinctively separated into Northern and Southern Catchments as indicated below.

Both areas have different constraints including geotechnical and topography, which require specific management.

Fig. 11
Proposed Catchment Plan – Plan Change area



The following table outlines the initial Principles of Stormwater Management from the site.

Performance Criteria	Appropriate for the site?	Catchment and Description	Reason
Water Quality	Y	Entire Plan Change area Newly formed public roads. Carparking relating to Neighbourhood and Mixed-Use areas. All roofs required to be inert building materials	Impervious areas and potentially contaminating surfaces will be created as part of future developments. Excludes driveways and hardstand surfaces within residential lots.
Wetland/Stream Hydrology			
Groundwater Recharge (retention)	Y	Northern Catchment Only required if peat material is kept in place.	Will be required in the northern catchment and will be required to ensure no long-term drawdown of groundwater level.
Hydraulic Neutrality for the (95% percentile storm.)	Y	Northern Catchment Southern Catchment (C & D) Required to maintain existing hydraulic flows to wetlands and salt marshes. Only required if within a wetland catchment. To be assessed at resource consent stage.	Northern catchment discharges towards tidal salt marshes and wetland adjacent to tidal tributary. Southern Catchment C and D discharges toward tidal tributary with wetland margins.
Flooding			
10% AEP	N	Entire Plan Change area	Not required as no downstream reticulation or properties. Discharge is at the tidal boundary.
1% AEP	N	Entire Plan Change area	Not required due to discharge of development to the tidal boundary.

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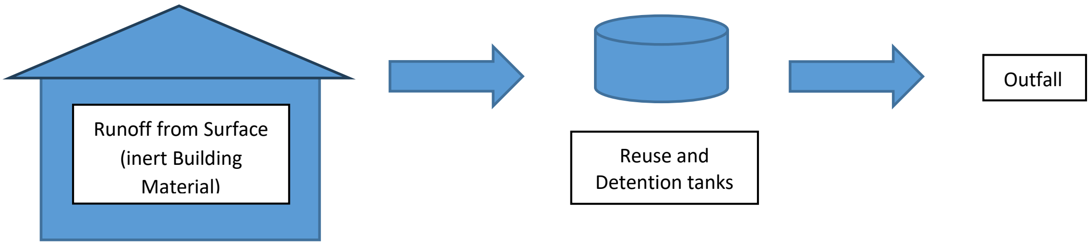
6.3 Treatment Train

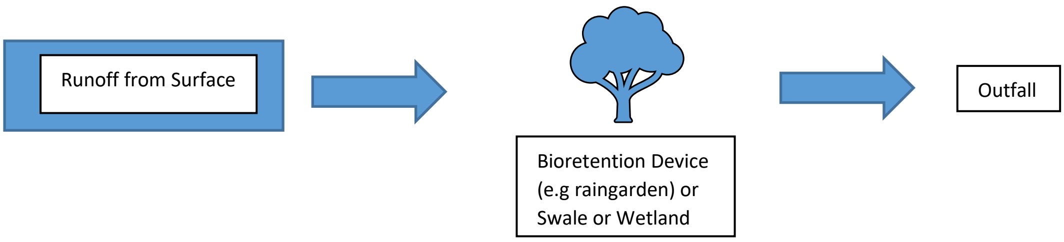
The SW treatment train below has been identified as being appropriate for the development:

Roof areas



- Water Quality – Entire Catchment - Inert Building Materials
- Groundwater Recharge -
  - Northern Catchment (A and B) - Inground recharge pit required in if peat remains in place.
- Hydraulic Neutrality for Wetlands –
  - Southern Catchment (C Only) and Northern Catchment (A and B). Either Detention Tanks or subdivision landform changes to catchments to ensure hydraulic neutrality is maintained if within a catchment of a wetland.

Roading and Carpark Surfaces

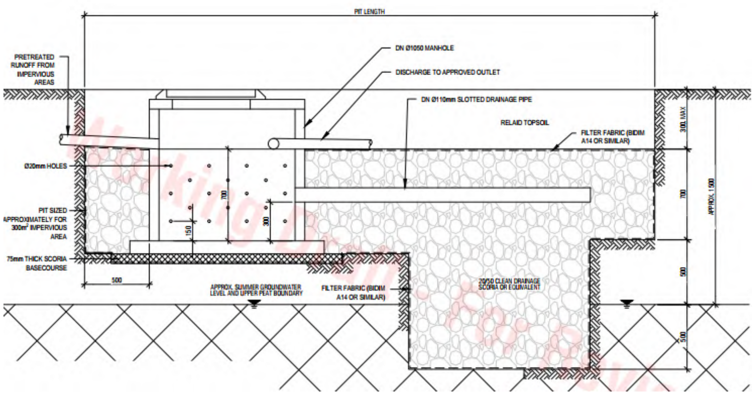


- Water Quality - Entire Catchment – Raingardens, treatment swale, wetland
- Groundwater Recharge – Northern Catchment (if peat remains in place) - Soak pit incorporated into raingardens or wetlands
- Hydraulic Neutrality for Wetlands – Northern Catchment and Southern Catchment (C & D) - Road catchments to discharge to channel areas post treatment. Subdivision catchments to be changed to ensure neutrality of flows.

The treatment train prepared for the Plan Change area is considered the BPO for the site. It provides a level of treatment at source by the way of:

- Re use tanks within the lots
- Tanks can include detention component if required for Wetland/Stream Detention
- Treatment via rain gardens, swales or wetlands.
- Retention using soak pits is required in Northern catchment if peat remains present.
- Detention to provide hydraulic neutrality via bioretention device (e.g. raingarden) or wetlands.

For devices anticipated to be vested to Kaipara District Council, communal devices, such as stormwater wetlands, are preferred to reduce ongoing maintenance requirements. At-source treatment is considered an acceptable solution where communal devices will not be feasible due to staging of the development. At-source treatment will ensure that adequate stormwater management can be achieved irrespective of which areas within the plan change are developed.

Fig. 12 Example communal raingarden	
Fig. 13 Example at-source raingarden	
Fig. 14 Example stormwater wetland	
Fig. 15 Example groundwater recharge pit typical detail	

7. Resource Consent Controls and Actions.

The following is a guideline to ensure compliance with the Principles of the Stormwater Management approach for the Plan Change area.

This provides a Guide for Councils and designers along with specific items which need to be addressed at time of Resource Consent.

7.1 Water Quality

The main source of contaminants from residential development are heavy metals and hydrocarbons from vehicle traffic. These contaminants can have an impact on the receiving environment, including marine life and shellfish.

The highest proportion of contaminants can be removed from the 'first flush' of a rainfall event, so consideration of the 'first flush' should be taken into account when sizing any Water Quality device.

Stormwater quality treatment is required to comply with the NPS-FM. Auckland Councils GD001 guidelines provides detailed design considerations for water quality treatment based on the principles of GD004 *Water Sensitive Design for Stormwater.*

Within the Plan Change area, stormwater generated from High Contaminant Generating Areas (HCGA's), such as high contaminant generating car parks and public roads, are considered to require treatment. Inert building materials should be used to mitigate contaminated runoff from any buildings.

The treatment will be required to be in accordance with Auckland Council's GD001 guidelines and principles from Auckland Councils GD04.

Suggested devices that can achieve the required water quality treatment for this plan change area are:

- Bioretention swale
- Raingarden
- Stormwater tree pit
- Wetlands

The PPC area has been separated into four proposed catchments based on the existing site analysis (subject to change through designed earthworks activities).

All catchments within the PC area will require treatment.

- Action – Development to include Stormwater Treatment for contaminant generating impervious surfaces
    - New Public Roads
    - New large carparks and hardstand areas
- Utilize GD001 requirements for future development.

7.2 Retention/Groundwater Recharge Hydrology Mitigation

Groundwater recharge is only required specifically if the underlying Peat material is to remain in place.

In accordance with GD001 – the 5mm storm event should be specifically discharged to ground for impervious surfaces if groundwater recharge is triggered.

- Action – Designer to confirm earthworks plan with KDC and if required demonstrate groundwater recharge.
    - New Public Roads

- New large carparks and hardstand areas
- Utilize GD001 requirements for future development.

7.3 Catchment Hydrology (24hr slow release 95% percentile SMAF)

Given the nature of the catchments within the Northern and Southern blocks discharging to wetlands, hydraulic neutrality will need to be maintained for the 95th percentile storm.

This can either be done via

- Detention tanks if there is an increase in post development flows to the wetlands or
- Changes to the landform to ensure flows are maintained.

Action – Designer to confirm predevelopment catchments feeding wetlands. Ensure that hydraulic neutrality for the 95th percentile storm is maintained to wetlands at RC stage through catchment calculations and devices if needed.

7.4 Overland Flow/Flooding and Attenuation for 10% and 1% AEP

NRC flood modelling shows that flooding is not a hazard within or downstream of the PPC area. Where flooding is noted, this has been confirmed to be tidally influenced based on tailwater conditions rather than floodwaters.

Therefore, all Catchments within the PC area will be discharged to a tidal tributary and will not require detention.

Overland flowpaths need to be modelled to ensure conveyance of the 1% AEP storm event for all catchments.

All houses to ensure complying freeboard requirements with NZ Building Code E1 requirements.

- Action – Designer to confirm overland flow capacity calculations at time of Resource Consent.
- Action - Designer to confirm freeboard requirements of all dwellings at time of Resource Consent.

7.5 Coastal Inundation

Coastal inundation has been identified above in the existing site appraisal, as a governing factor in how any future development of this area will be managed. Figure 5 and the Coastal Inundation and Flooding plan within Appendix A shows the area susceptible to coastal inundation in a 1 in 100-year storm event, taking into account projected sea level rise over the next 100 years.

Minimum floor levels will need to be established around the inundation level at time of Resource Consent.

- Action - Designer to confirm freeboard requirements of all dwellings at time of Resource Consent.
- Action – Designer to confirm minimum floor levels with supporting report from Coastal Engineer.

7.6 Development Staging

At this stage there are no plans specified for staging of the development. Future developers will need to consider meeting the Stormwater performance criteria for each stage as well as considering the ultimate stormwater solution for the development.

- Action – Future developments to consider staging of stormwater infrastructure to ensure SMP requirements are met.

7.8 Hydraulic Connectivity

Flows conveyed through the site from upstream should be maintained at their current entry points. Connectivity through the Plan Change area is to be maintained.

- Action – Designs should incorporate and maintain hydraulic connections upstream and downstream.

7.9 Asset Ownership

All stormwater devices within public roads and reserves should be vested to Kaipara District Council. Devices which are required to manage site specific requirements such as detention tanks on individual lots will be owned privately.

- Action – Discuss with Kaipara District Council the ownership and amendment of any easements.

7.10 Ongoing Maintenance Requirements

Future stormwater devices shall include an ongoing operation and maintenance regime as part of future development.

- Action – Provide operation and maintenance manual for all stormwater devices.

TABLE 6.2 – STORMWATER MANAGEMENT TOOLBOX FOR DEVELOPMENT

Activity	**Hydrological Requirement**	**Recommended Mitigation**	**Guidelines**
Lots –Buildings (residential and neighbourhood centre zones)	Water Quality	Use of Inert building materials for roof area.	Auckland Council GD01
	Groundwater Recharge (retention 5mm) (subject to Geotech confirmation of stability and infiltration rates)	Propose to use the following devices for retention of the 5mm storm event o Soakage pit in Northern Catchment only if peat remains	Auckland Council GD01 Auckland Council GD04
	Wetland Hydraulic Neutrality (detention 95th percentile)	Mitigation for increases in runoff shall be through either the (95th percentile storm detention and slow release over 24hrs) or through changes to landforms to maintain flows for the 95% percentile storm to the wetland. If detention is required, the following devices can be used. o Combined Reuse/Detention tanks (private ownership within Catchments A, B, C & D)	Auckland Council GD01 Auckland Council GD04
	Attenuation if required by network constraint (10yr)	Not Required	
	Attenuation if required by network constraint (100yr)	Not Required	
Roading and Carparking	Water Quality	Provide treatment through proprietary device such as o Raingarden (public) o Swales (public) o Wetland (public)	Auckland Council GD01 Auckland Council GD04
	Groundwater Recharge (retention 5mm) (subject to Geotech confirmation of stability and infiltration rates)	Allow for 5mm retention for impervious surfaces in the Northern Catchment, only if peat remains. Devices such as • Raingarden with soak pit (public) • Swale with soak pit (public) • Wetland (public)	Auckland Council GD01 Auckland Council GD04

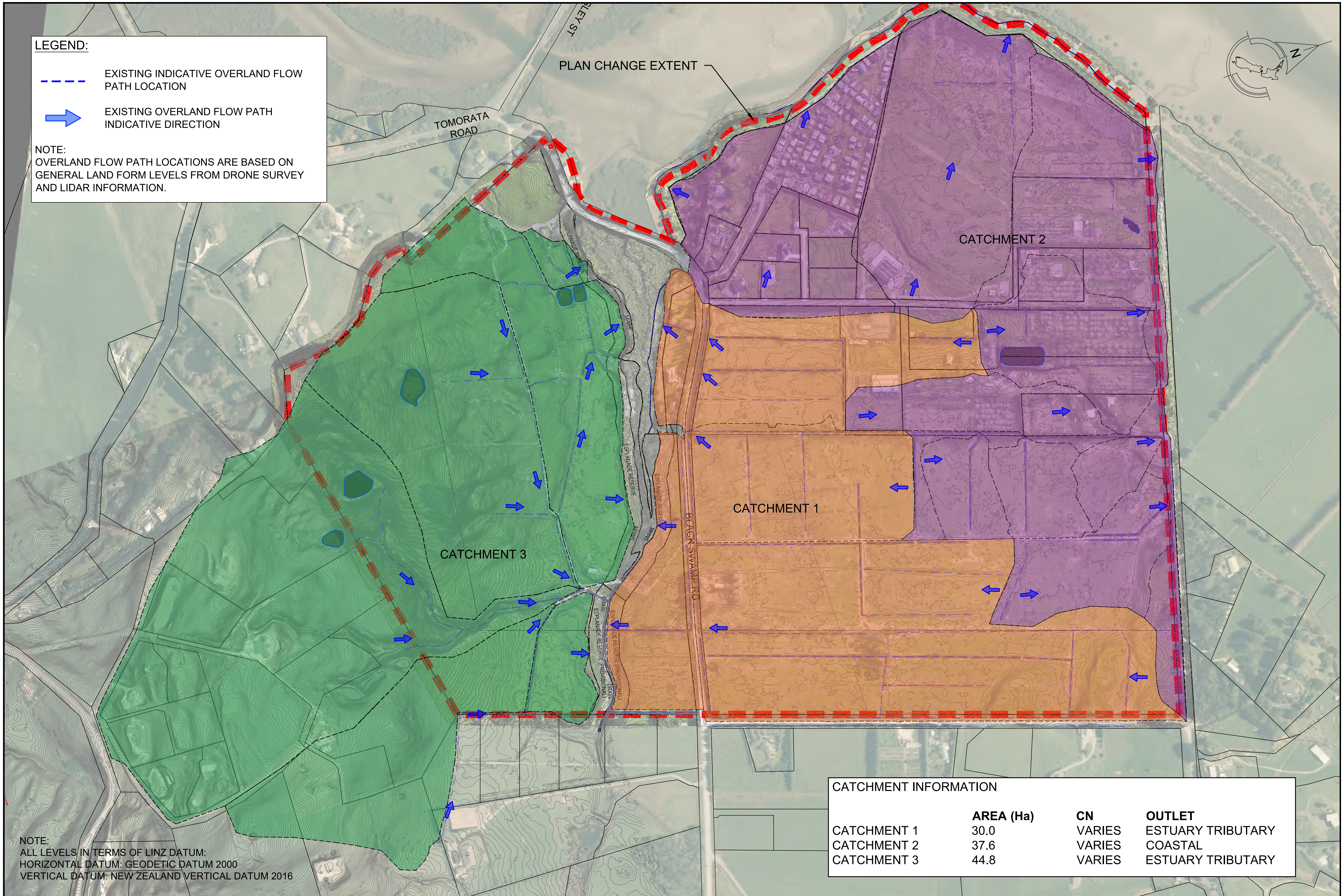
	Wetland Hydraulic Neutrality (detention 95th percentile) Attenuation if required by network constraint (10yr) Attenuation if required by network constraint (100yr)	Mitigation for increases in runoff shall be through either the (95th percentile storm detention and slow release over 24hrs) or through changes to landforms to maintain flows for the 95% percentile storm to the wetland. If detention is required, the following devices can be used. • At source or communal Bioretention device (e.g. raingarden) (public) • Wetland (public) Not Required Not Required	
Open Space	Water Quality	Enhance and improve conveyance channels o Planting	Auckland Council GD01 Auckland Council GD04

8. Conclusion

Having reviewed the existing site considerations including topography, coastal, flood hazards and ecology, we believe this Stormwater Management Plan provides identification of stormwater management practices required within the Plan Change area.

It provides a checklist of actions for future developers, designers and Local Authorities to confirm compliance with the SMP requirements.

Appendix A – Concept Development Plans



LEGEND:

EXISTING INDICATIVE OVERLAND FLOW PATH LOCATION

EXISTING OVERLAND FLOW PATH INDICATIVE DIRECTION

NOTE:
OVERLAND FLOW PATH LOCATIONS ARE BASED ON GENERAL LAND FORM LEVELS FROM DRONE SURVEY AND LIDAR INFORMATION.

NOTE:
ALL LEVELS IN TERMS OF LINZ DATUM:
HORIZONTAL DATUM: GEODETIC DATUM 2000
VERTICAL DATUM: NEW ZEALAND VERTICAL DATUM 2016

CATCHMENT INFORMATION

	AREA (Ha)	CN	OUTLET
CATCHMENT 1	30.0	VARIES	ESTUARY TRIBUTARY
CATCHMENT 2	37.6	VARIES	COASTAL
CATCHMENT 3	44.8	VARIES	ESTUARY TRIBUTARY

REV.	DESCRIPTION	CHECK	APP'D	DATE	SCALE 1:5000 AT A3	
						NAME	DATE
					DESIGN	EP	05/2025
					DRAWN	HR	05/2025
					DRAWING CHECK	MB	05/2025
					DESIGN CHECK	EP	05/2025
					APPROVED	EP	05/2025

CLIENT: MANGAWHAI EAST PLAN CHANGE

Conditions of Use:
These drawings shall only be used for the purpose for which they were supplied. Do not measure off this drawing. If doubt please contact Engineer.

SITE ADDRESS: BLACK SWAMP ROAD MANGAWHAI

DRAWING TITLE: EXISTING CATCHMENT PLAN

DRAWING NUMBER: 1838 - PC - SW420

DATE: MAY 2025

REVISION: -

ASPIRE CONSULTING ENGINEERS
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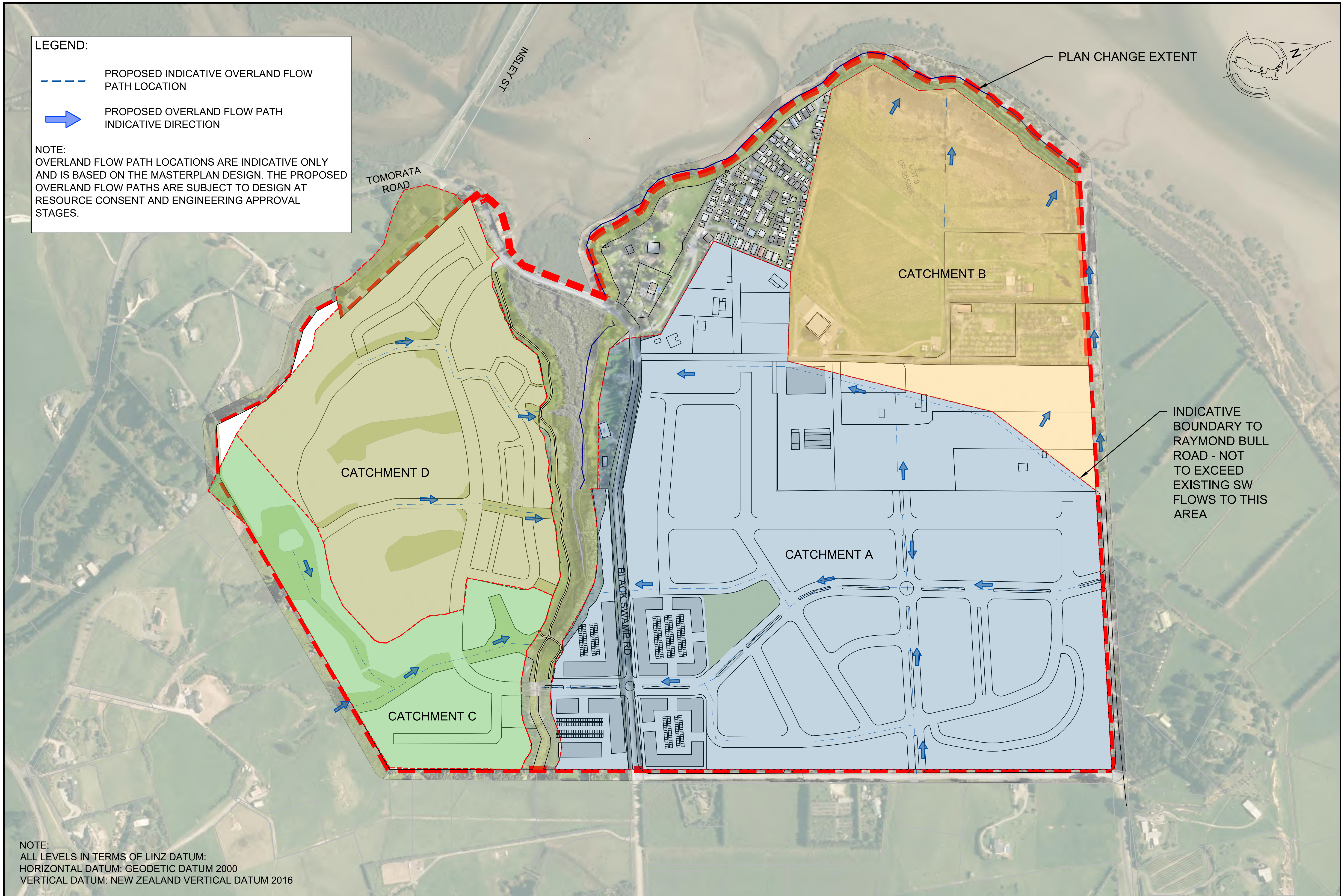
Web: www.aspireconsulting.co.nz



LEGEND:

- PROPOSED INDICATIVE OVERLAND FLOW PATH LOCATION
- PROPOSED OVERLAND FLOW PATH INDICATIVE DIRECTION

NOTE:
OVERLAND FLOW PATH LOCATIONS ARE INDICATIVE ONLY AND IS BASED ON THE MASTERPLAN DESIGN. THE PROPOSED OVERLAND FLOW PATHS ARE SUBJECT TO DESIGN AT RESOURCE CONSENT AND ENGINEERING APPROVAL STAGES.

NOTE:
ALL LEVELS IN TERMS OF LINZ DATUM:
HORIZONTAL DATUM: GEODETIC DATUM 2000
VERTICAL DATUM: NEW ZEALAND VERTICAL DATUM 2016

REV.	DESCRIPTION	CHECK	APP'D	DATE	SCALE 1:5000 AT A3	NAME	DATE
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					DRAWN	HR	05/2025
					DRAWING CHECK	MB	05/2025
					DESIGN CHECK	EP	05/2025
					APPROVED	EP	05/2025

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SITE ADDRESS
BLACK SWAMP ROAD
MANGAWHAI

DRAWING TITLE
PROPOSED CATCHMENT PLAN

DRAWING NUMBER
1838 - PC - SW421

DATE
MAY 2025

REVISION
-

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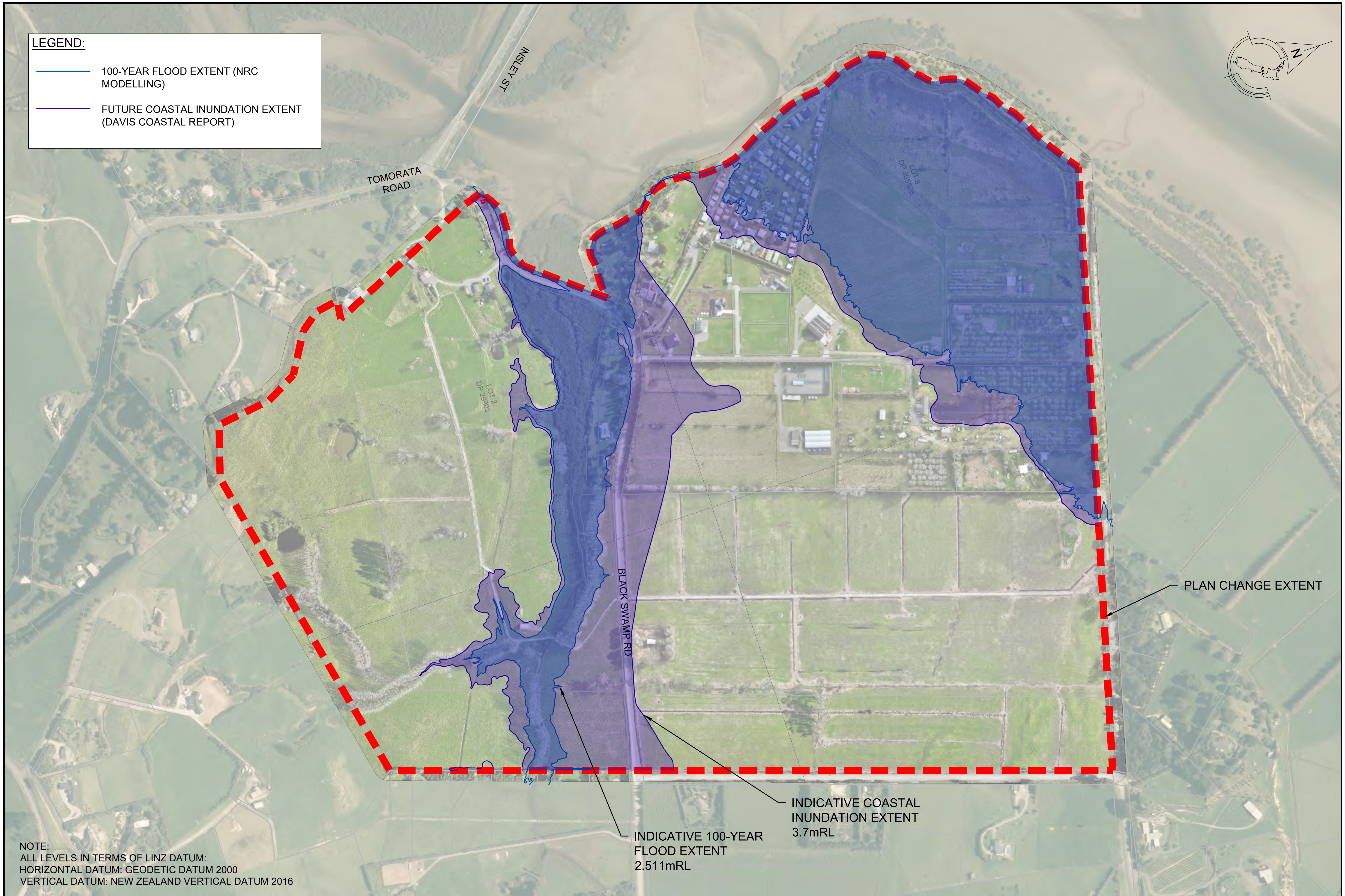

NOTE:
ALL LEVELS IN TERMS OF LINZ DATUM:
HORIZONTAL DATUM: GEODETIC DATUM 2000
VERTICAL DATUM: NEW ZEALAND VERTICAL DATUM 2016

REV.	DESCRIPTION	CHECK	APP'D	DATE	SCALE 1:5000 AT A3	NAME	DATE
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					DRAWN	HR	05/2025
					DRAWING CHECK	MB	05/2025
					DESIGN CHECK	EP	05/2025
					APPROVED	EP	05/2025

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SITE ADDRESS
BLACK SWAMP ROAD
MANGAWHAI

DRAWING TITLE
COASTAL INUNDATION AND FLOODING PLAN

DRAWING NUMBER
1838 - PC - SW430

DATE	REVISION
MAY 2025	-

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Appendix B – Coastal Processes and Hazard Assessment

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Mangawhai East Private Plan Change

Coastal Processes and Hazard Assessment

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October 2024

Job Ref: 24022

Mangawhai East Private Plan Change

for

Cabra Mangawhai Ltd and Pro Land Matters Company Ltd

Coastal Processes and Hazard Assessment

Document Control		
Description	**Revision**	**Date Issued**
Draft for Review	-	14/08/2024
Resource Consent	A	02/10/2024

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Job Reference: 24022

Table of Contents

1.0 Introduction

Application is being made by Cabra Mangawhai Ltd and Pro Land Matters Company Ltd for the rezoning of an area of land on the southern banks of the Mangawhai Estuary, termed for the project purposes as the Mangawhai East Private Plan Change (MEPPC).

Davis Coastal Consultants have been instructed to provide professional services to analyse and advise on the coastal processes and any coastal hazard risk associated with the Proposal.

1.1 Definitions

Within this report terminology for the site is consistent with those defined in the Resource Management Act, the Northland Regional Plan / Kaipara District Plan, or the Collins Dictionary (for Harbour/Estuary):

Coastal **M**arine **A**rea – CMA – *"means the foreshore, seabed, and coastal water, and the air space above the water -*
(a) of which the seaward boundary is the outer limits of the territorial sea:
(b) of which the landward boundary is the line of mean high-water springs…"

Common **M**arine and **C**oastal **A**rea – CMCA – *"means the marine and coastal area other than –*
(a) specified freehold land located in that area; and
(b) any area that is owned by the Crown…"

Estuary – *"an inlet or arm of the sea; the lower portion or wide mouth of a river, where the salty tide meets the freshwater current"*. The terminology 'Mangawhai Estuary' has been used in this report to refer to the entirety of the sheltered waterbody upstream of the mouth.

Mean **H**igh **W**ater **S**prings – MHWS – "*the average of the heights of each pair of successive high waters during that period of about 24 hours in each semi-lunation (approximately every 14 days) when the range of tides is the greatest"*

2.0 Description of Existing Environment

2.1 Location

The MEPPC area is located on the southern shore of the Mangawhai Estuary, and covers an area of approximately 94 hectares. The site is directly east of the Mangawhai Village township, with the MEPPC boundary meeting the southern end of the Insley Street causeway and being generally bisected by Black Swamp Road (Figure 2.1).

Figure 2.1: Location Plan

2.2 Wider Physical Environment

Mangawhai Estuary is an east coast estuarine system located at the northern extent of the Mangawhai-Pakiri embayment. The estuary has a narrow entrance, bounded on the north by a protruding rock headland and on the south by an extensive sand barrier spit. The spit is poorly vegetated and there is evidence of large volume aeolian sand movements.

The estuary has a relatively narrow (300-500m wide) sinuous form which is orientated approximately north-south behind the spit for some 4km, before widening and diverging into two upper arms west of the base of the sandspit. The site is a tributary on the northern, landward arm of the estuary.

The underlying geology of the site is detailed in the reporting by Initia for the northern area and by Wiley Geotechnical Consultants for the land south of Black Swamp Road. and notes the site includes areas of Holocene river deposits, Late Pleistocene river deposits, and Pakiri Formation of the Warkworth Subgroup to the southern portion of the site (Figure 2.2a).

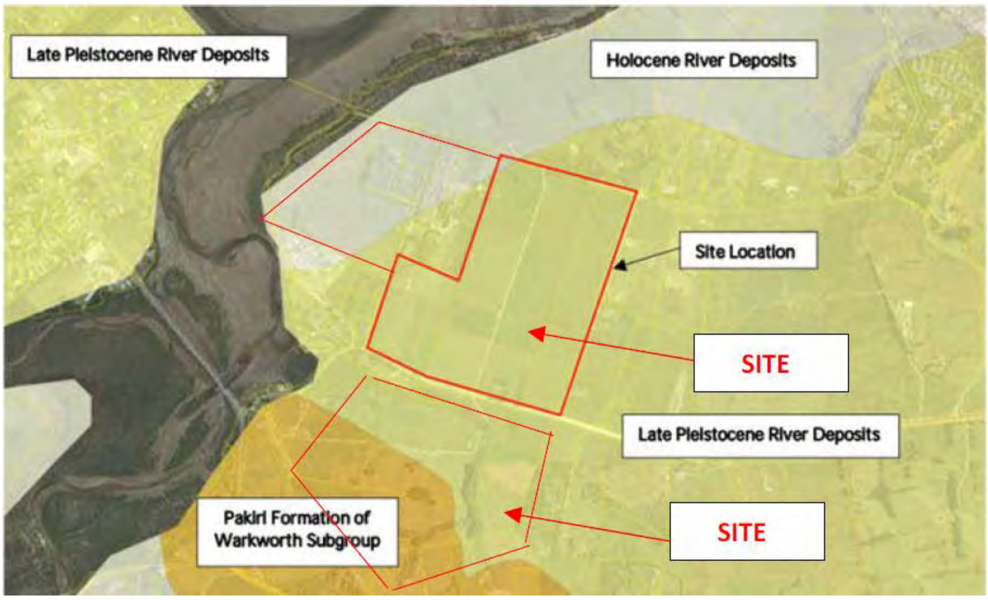


Figure 2.2a: Geology of the site (ex Aspire Reporting)

Hydrographic Chart NZ 522 published by Land Information New Zealand (LINZ) includes the Mangawhai Estuary (Figure 2.2b). The site sits within the upper reaches of the estuary, and, the Chart does not provide depth information for any of the channels. The available bathymetry data is only provided outside the entrance.

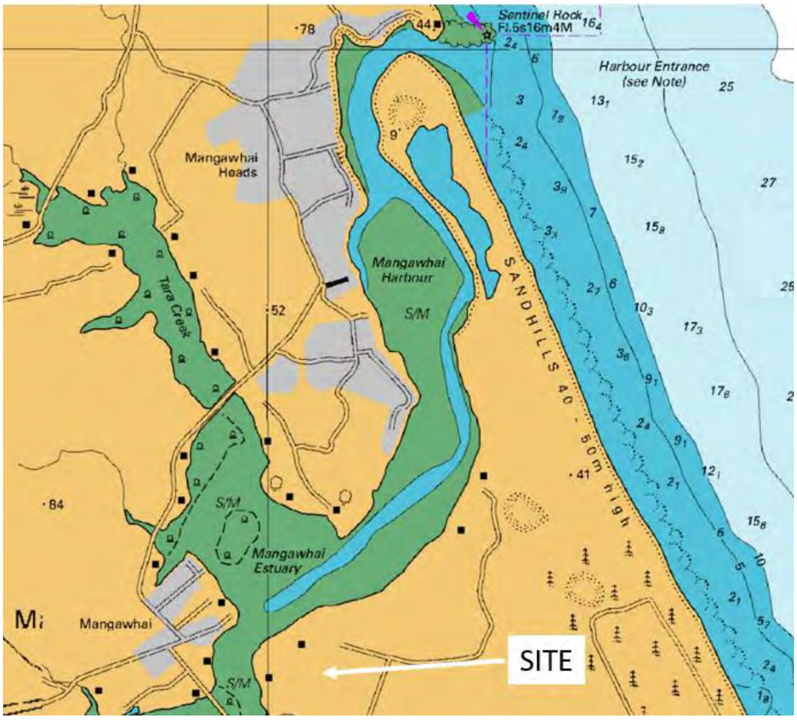


Figure 2.2b: Bathymetry of site ex LINZ Chart NZ522\

2.3 Site Description

The site is bisected by Black Swamp Road, which runs approximately east-south-east from where it meets the coast. The road also marks a dividing point between two quite different geomorphologies through the PPC area. South of the road is primarily sloping hill country and north of the road is generally flatter and more low lying (Figure 2.3).

To the south of the road, raised hillslopes are present to the southern boundary of the PPC area, up to approximately RL 50 (to NZVD2016) at the crest of the southern ridgeline. The hillslope generally falls to the north, at approximately 1:10, where it meets a tributary of the Mangawhai Estuary which extends east, inland from the causeway at Black Swamp Road. With the exception of the causeway this upper estuarine arm appears relatively unmodified for approximately 250m before it has been shaped by surrounding land activities.

Black Swamp Road runs along the northern side of this watercourse. The land north of the road is separated into an elevated plateau, generally at RL 4 and above, and an extensive low-lying area to the north-west of this, typically at and below RL 2. These two areas are separated by a north-east orientated, relatively steep bank, marked on the figure below, which also represents the interface between the Late Pleistocene river deposits at the upper plateau and the more recent Holocene deposits to the lower area.

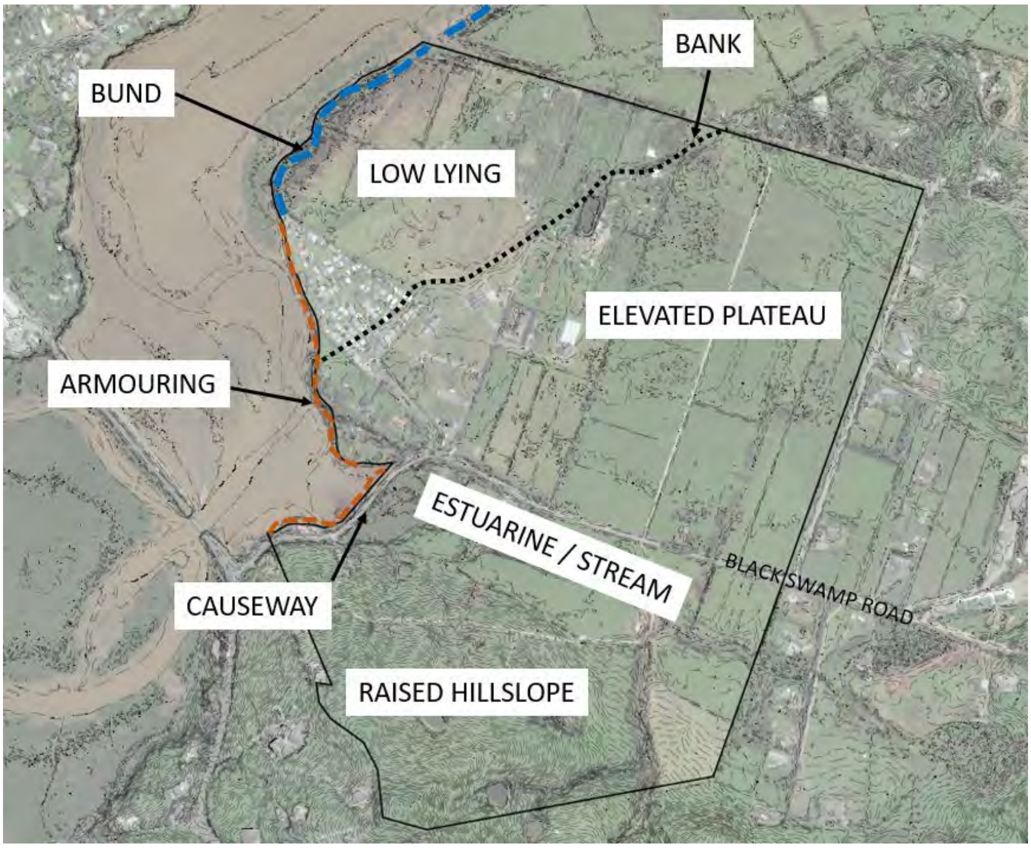


Figure 2.3: Landform through PPC area

A discontinuous raised bund is located at the coastal edge at the northern extent of the PPC area (demarcated by the blue dashed line above), starting approximately at the northern end of the campground and extending north-east. The bund ranges from approximately 1.5-1.8m high and is typically comprised of sandy fill but there are also areas where loose concrete is also present. The bund terminates at the northern boundary of the PPC area, where a beach access point is present, and continues again further north. A drain runs parallel to the bund on the landward side, with this area being still affected by tidal waters. Mangroves and other salt-marsh species are colonising the area immediately behind the bund.

Existing armouring is present to part of the estuary edge, demarcated by the brown dashed line on the figure. At the southern extent, the causeway is armoured by gabion baskets with a rock riprap toe (Photograph 2.3b) to both sides. There is a short extent of rock riprap around the house at 13 Black Swamp Road. Rock riprap continues to the stretch of coastline between the causeway and the campground (Photograph 2.3c), before a timber wall armours the coastal margin at the campground.

Photograph 2.3a: Area behind bund

Photograph 2.2b: Gabion and rock riprap to causeway

Photograph 2.2c: Rock riprap to coastline south of campground

3.0 Coastal Processes

3.1 Wind

Met Ocean Solutions, who are a division of the Meteorological Service of New Zealand, provide a MSL WRF wind model from their 'Met Ocean View' website. No model location is available for the estuary, however data from an output location outside the mouth (3.4km northeast from the site) is reproduced below (Figure 3.1a).

According to this record, prevailing winds are from the southwest and west sectors, with the strongest (10-15m/s) and most frequent winds (5-10m/s) arriving from a south-westerly direction. The coastal edge of the PPC area has a short exposure to the south-westerly wind, acting across the upper estuary from the Insley Street causeway towards the campground area, and an exposure to the north-westerly wind, across the more open estuary basin (Figure 3.1b).

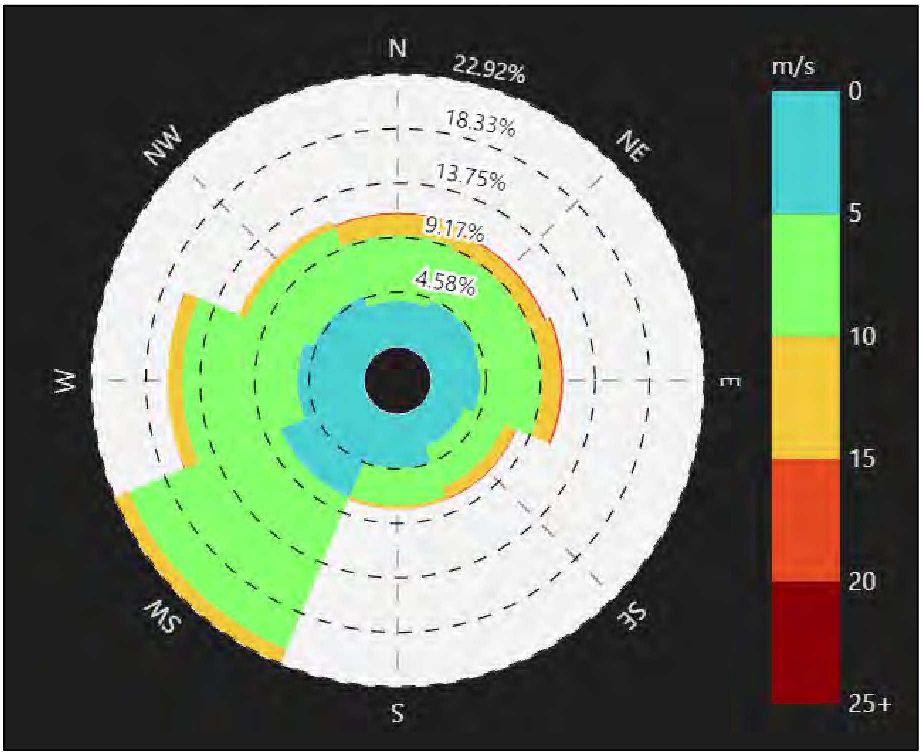


Figure 3.1: Wind rose obtained from app.metoceanview.com (site 36.0841S 174.5991E)

Figure 3.1b: Exposure of coastal parts of PPC area

3.2 Tides

3.2.1 Standard LINZ Data

Tidal data is published by Land Information New Zealand (LINZ) based on a tide gauge at Marsden Point, Whangarei, approximately 30km to the north of Mangawhai. Tidal information has recently been provided for a Secondary Port at Mangawhai Heads, located at the estuary mouth (approximately 4km north from the site). MHWS for the Secondary Port at Mangawhai is 0.3m lower than recorded at Marsden Point. Given its closer proximity, the Secondary Port is considered much more likely to reflect the tidal range at the site, and has been adopted.

Standard LINZ port tidal levels published online by LINZ are in terms of Chart Datum (CD). All levels expressed in this report (denoted 'RL') are in terms of New Zealand Vertical Datum 2016 (NZVD2016), as this is the datum used for the local topographic survey. Relevant tidal data has been expressed in terms of both CD and Relative Level (RL) to NZVD16 below (Table 3.2.1).

Port	HAT*	MHWS	MHWN	MLWN	MLWS	LAT*
Marsden Point CD	3.01	2.7	2.3	0.9	0.5	0.13
Mangawhai Heads CD	2.63*	2.4	2.1	0.8	0.4	-0.13*
Mangawhai Heads RL (NZVD16)	0.9*	0.7	0.3	-1.0	-1.4	-1.6*

Table 3.2.1: LINZ predicted tide levels at Marsden Point & Mangawhai Heads, *= calculated using range ratio method

3.2.2 Storm Tides

During storm events water levels become higher due to lower atmospheric pressure and the effect of onshore wind energy "pushing" water towards the coast and up harbours in an effect called storm surge. Storm tides can be defined as tides that include the effect of storm surge and these represent the highest range of water levels experienced in coastal regions in decadal time scales. There are also other oceanic driven variations in the water level that affect extreme tidal levels that are captured in the tidal record.

In locations with a long tidal record, analysis of past data provides a reliable method of predicting future high-water levels. A report prepared by NIWA (2016) performed an in-depth study using hydrodynamic models calibrated against tide-gauge and wave buoy measurements to calculate storm tides along the Auckland coastline (including at and within the Mangawhai estuary). Joint probability modelling techniques were then applied to calculate the occurrence likelihood of the extreme sea-level elevations. Modelling following a similar approach has also been undertaken by Tonkin & Taylor on behalf of the Northland Regional Council (NRC) for the coastline of the Northland region, which also includes the Mangawhai estuary.

These storm tide predictions incorporate the astronomical tide combined with the joint effects of storm surge and monthly, seasonal and longer timescale oscillations in water level.

The simulated extreme storm tide level calculated in both reports, for within the Mangawhai Estuary, are shown below (Table 3.2.2). Levels provided in the NIWA reporting are relative to Auckland Vertical Datum 1946 (AVD1946). This has been converted to NZVD2016 using the online converter provided by LINZ, including the X and Y co-ordinates of the modelled location.

The model output location for the NIWA work is immediately offshore from the site, in comparison to the model site for the TnT study being further north, closer to the estuary mouth. Accordingly, the NIWA value has been adopted for consideration of the future flood hazard risk to the site.

Storm Tide	AVD1946	NZVD16
1% AEP (1 in 100-year event) per NIWA - adopted	1.81	**1.51**
1% AEP (1 in 100-year event) per TnT		1.6

Table 3.2.2: Maximum storm tide values for site (ex NIWA, 2016), Mangawhai Harbour, Table 3-2

Figure 3.2.2: Comparison in modelling sites

3.3 Wave Climate

Due to the narrow Harbour entrance, the wave environment is sheltered from open ocean swell waves. This is reinforced by research (Santoso et al, 1998) sited in recent work by NIWA (2016), which notes *"the wave setup component that is generated on the open coast is unlikely to propagate far inside the entrance of an estuary"*. Due to the upper estuary location, neither open ocean swell waves nor the associated setup are considered to be relevant to the PPC area.

The area of coastline adjoining the PPC area will be subject to locally generated wind waves. The generally thin and narrow form of the Harbour constrains wave development. The bounding land masses typically restrict fetches to approximately 500 – 1000m, and although slightly larger fetches are available (up to 2.0 – 2.4km), these have a narrow angle along which the wind can generated wave energy.

Wind wave generation within the elongated shape of the Harbour is significantly reduced below that expected over similar fetches over a more open waterbody (e.g. Lake or wide harbour). The Saville method (Saville et al, 1962), in CIRIA C683 (2007) has been used, which was formulated for such conditions, to calculate the effective fetch. The wave climate along this effective fetch was then calculated using the SMB wave prediction formulae for open waters (Equations 4.78 and 4.79) as prescribed by CIRIA. Wind speeds for this hindcast were firstly obtained from the New Zealand Design Actions Standard (AS/NZS 1170:2011), and transformed into 1 hour wind speeds using Formula II-2-1 3(c) of the Coastal Engineering Manual (CEM, USACE, 2008). The 20% AEP (1 in 5 year event) and 1% AEP (1 in 100 year event) wind speeds were adopted for the hindcast.

The results for the 20% and 1% AEP events are shown below (Table 3.3), along with a 'regular wave' hindcasting using a 10m/s wind, to give a comparison to a typical wave to be expected in the Harbour a number of times a year.

Event	Wave Height (m)	Period (s)
'Regular wave'	0.2 – 0.3m	2s
20% AEP (1 in 5 year event)	0.5 – 0.6m	2-3s
1% AEP (1 in 100 year event)	0.6 – 0.7m	3s

Table 3.3: Wave hindcast

The ability of short-period wind waves, generated inside the estuary, to drive significant set-up is considered to be limited. The simple method of Thornton & Guza (1983) takes this as a proportion of the breaking wave height, per Equation 3-3 below. Even with the maximum wave calculated above, this indicates wave set-up with the 1% AEP wind event would be in the order of 0.1m. This event is not necessarily the same event causing the 1% storm tide, and given the very small set-up factor this has been excluded from the maximum coastal flood calculation.

$$\overline{\eta_{max}} = 0.17H_b \qquad (3\text{-}3)$$

3.4 Sea Level Rise

There are two sources of guidance for sea-level rise allowances and the most up-to-date data. The MfE document "Coastal Hazards and Climate Change Guidance" released in 2024 provides precautionary relative sea-level rise allowances recommended for coastal planning and policy, before a Dynamic Adaptive Pathways Planning approach is implemented. For *'coastal subdivision, greenfield developments and major new infrastructure'* a timeframe to 2130 is specified, with the *'medium confidence SSP-8.5H+ based RSLR projection that includes the relevant VLM rate for the local and/or regional area'*. The document notes that the prescribed H+ prediction is the 83rd percentile projections (p83).

In addition to projections of sea-level rise, a relatively recent addition to the future sea-level rise risk scenario is the potential for vertical land movement (VLM). This is where the land at the coast can be slowly changing in elevation (up or down), and in the case of sea-level rise risk, if the ground is sinking lower (due to subsidence) the rising sea-level can reach higher and further inland (Figure 3.4a). With respect to the most recent data, the NZ Sea Rise programme has released location specific sea-level rise projections out to the year 2300 for every 2 kilometres of coastline, which is available in an online tool.

Estimates of local VLM rates (mm/year up or down) for the period of 2003 – 2011 are also available in the online tool. Despite the relatively short period of measurement, the potential for subsidence of the land to increase the effect of sea-level rise in the future needs to be accounted for, especially in planning for greenfield sites, in order to sufficiently identify future hazard risk and allow sufficient planning for this risk.

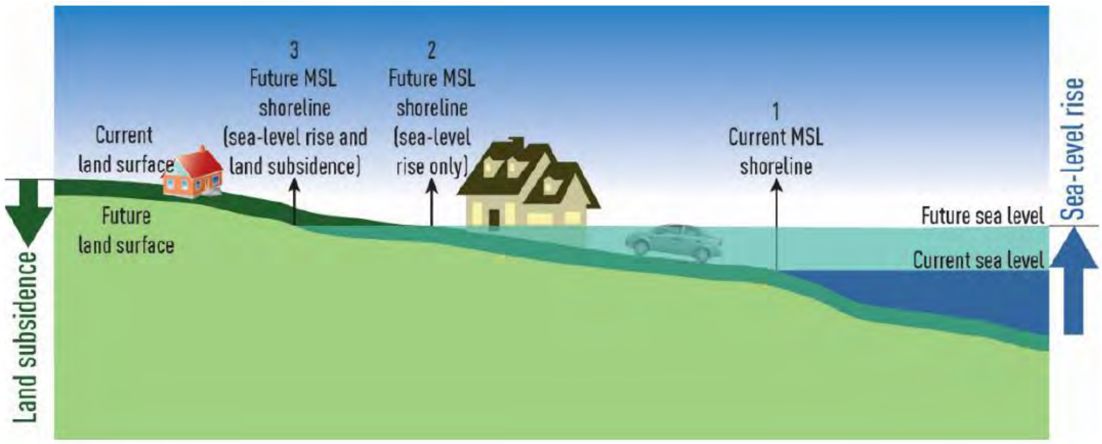


Figure 3.4a: Effect of relative sea-level rise on the shoreline (ex MfE coastal hazards guidance, A Wadhwa, NIWA)

The Intergovernmental Panel on Climate Change (IPCC) previously used Representative Concentration Pathways (RCP) to represent plausible climate futures. These potential future scenarios were focused on a radiative forcing of warming that could be reached by 2100, going from RCP 2.6 – 8.5. The latest assessment reports (published 2021-2022) shifted to a new core set of future representative scenarios, based on Shared Socio-economic Pathways (SSPs). The new SSP's offer five different narratives of how the world may evolve in the future, that also combine the RCP's, related to increases in global mean temperature. The SSP5-8.5 scenario is a worst-case prediction, based on high future emissions.

The closest mapped location on the NZ Sea Rise online tool to the subject site is located within the PPC area, on the Black Swamp Road causeway (Site 897). The predicted effective sea-level rise depends both on the future scenario, and the probability within each scenario. These are summarised in the table below (Table 3.5). The H+ scenario, as prescribed by MfE for coastal subdivision and greenfield developments, is the 83rd percentile (17% chance of occurrence, termed 'p83') scenario. The local sea-level rise prediction with the VLM component is included, and the VLM component is also set out separately. Based on the MfE guidance above, the future hazard assessment must consider a base relative sea-level rise (RSLR) value of 1.7m.

The average VLM rate for the site is -2.3mm/year (+/- 2.6mm), which over the 100 year timeframe would effectively add 0.23m to the RSLR prediction. The p83 prediction for VLM allows for a rate of -5.2mm/yr for the next 100 years. Whilst later work at the site-specific level may consider a summation of these extreme values to be overly conservative, this is considered appropriately conservative for the PPC hazard mapping for a greenfield site and the p83 predicted value has been adopted.

The adopted SLR + VLM value is 2.2m.

Sea Level Rise + Vertical Land Movement (100 years)		
Shared Socio-Economic Pathway	p50	p83 (H+)
SSP5-8.5	1.25m	1.71m
SSP5-8.5 + VLM	1.57m	2.23m
VLM Component	0.32m	0.52m

Table 3.4: Sea-level rise and VLM to 2130 – SSP5 8.5 scenario, Site 897

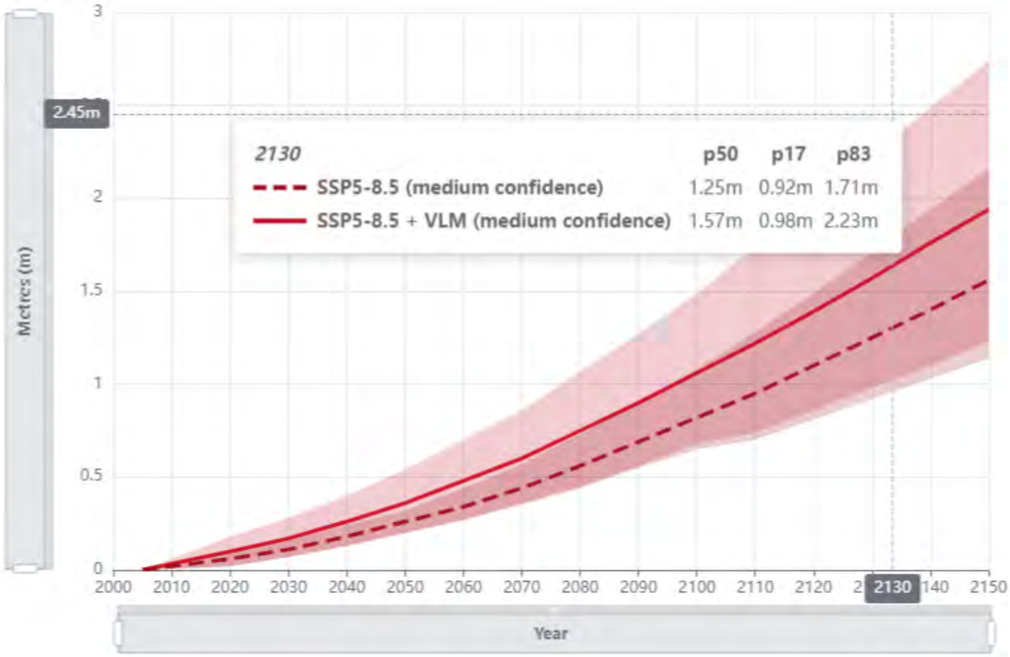


Figure 3.4b: Sea-level rise and VLM to 2130 – SSP5-8.5 scenario, Site 897

3.5 Existing Coastal Flood Hazard Reporting

The Northland Regional Council commissioned a Coastal Flood Hazard Assessment for the entire Northland Region, with that work being undertaken by Tonkin & Taylor (March 2021). That work used a very similar methodology to that applied by NIWA (2016), as referred to in Section 3.2.2 above.

Four Coastal Flood Hazard Zone (CFHZ) scenarios were adopted for that reporting:

- CFHZ0 – Present day 1% AEP
- CFHZ1 – 2% AEP + 0.6m RSLR
- CFHZ2 – 1% AEP + 1.2m RSLR
- CFHZ3 – 1% AEP + 1.5m RSLR

For the Mangawhai Estuary these values are shown below (relative to NZVD2016) (Table 3.5).

Future Inundation Scenario	Level to NZVD2016
CFHZ0	2.0
CFHZ1	2.5
CFHZ2	3.2
CFHZ3	3.5

Table 3.5: Mangawhai Estuary future CFHZ scenarios (NRC, 2021)

The baseline water level, from which sea-level increases were taken from, was the 'static inundation level'. This is the storm tide, with the addition of wave set-up. That reporting states that *"for this regional-scale assessment an allowance for proportional wave set-up within estuaries connected to the open coast have been assumed being 20% of the open coast wave set-up. The proportional wave set-up is added to the wave set-up generated by local breaking waves within the estuaries"*. This explains why the static inundation case for the Mangawhai estuary, for the 1% AEP event, is 0.4m higher than the storm tide (1.6m) at 2.0m (NZVD2016). For the subject site in the upper reaches of the estuary, approximately 6km from the mouth, the potential for wave set-up driven by the open ocean wave environment is considered highly unlikely. This is reinforced by work undertaken by NIWA (2016) where the wave set-up component was removed from their in-estuary model outputs, based on research which indicated that open coast wave setup was unlikely to propagate far inside the entrance of an estuary.

The future sea-level changes were based on the most recent guidance available at the time, which was MfE (2017). The science regarding VLM had not yet been released and accordingly the incorporation of the potential for this to exacerbate any future increase in RSLR had not yet been factored in.

3.6 Coastal Erosion

The erosion drivers in sheltered harbour shorelines, such as at the site, are a combination of weathering of exposed strata from wetting and drying cycles, frittering of weak soils through small locally generated wind waves, and tidal / river currents acting against land, most notably on the outside of bends where these are moving fastest. Two of the locations where existing armouring is present (Figure 3.6a) are where the ebb currents and river flows passing under the Insley Street and Black Swamp Road causeways meander close to the bank. The exposure of these sites to the predominant south-westerly will also be a factor in slow retreat in these locations, which will have motivated the placement of armouring. Armouring is also often required where the coastal margin has been artificially moved seaward, through reclamation, and this appears to be the case at the base of Black Swamp Road where filling has occurred at the edge of the hillslope to form the road and create the building platform for the dwelling on the seaward side of the road.

Figure 3.6a: Tidal currents and presence of armouring

There are two existing regional erosion assessments for the Auckland/Northland Region:

- ACTP 2020/021 – 'Predicting Auckland's Exposure to Coastal Instability and Erosion'
- 1012360.v3 - 'Coastal Erosion Hazard Assessment for Selected Sites 2019-2020' NRC

The Auckland study terminates at the boundary between the Auckland and Northland/Kaipara Council, and does not provide any information for the Mangawhai estuary. The NRC document makes assessment of erosion risk inside the estuary, but only for the residential area of the Mangawhai Heads, from the Molesworth Drive causeway around the promontory and north towards the estuary mouth. No data is provided for the PPC area. However, for the facing coast to the north, which has less effect of tidal currents but is more exposed to the predominant south-westerly, the 100 year future erosion hazard zone is offset approximately 15m from the existing coastal edge. Existing contours through this area are relatively low, at and below RL 3, which means any relaxing of the bank gradient will have a limited effect. This indicates a likely erosion allowance of 0.15m/yr for this area.

Figure 3.6b: Erosion hazard zones – Estuary Drive – north of site

4.0 Future Coastal Hazards

4.1 Future Coastal Flooding Hazard

A long-term combined water level is comprised of the predicted sea-level rise, the potential for Vertical Land Movement, added to the predicted storm tide value. The calculation of the individual components has been set out below (Table 4.1).

	1% AEP
Mangawhai estuary storm-tide – RL	1.5
Relative Sea-Level Rise (2130, SSP5-8.5H+)	1.7
Vertical Land Movement (p83)	0.5
100 year Future Inundation Level	**3.7**

Table 4.1: Future 100 year coastal flooding level

The calculation above uses the 1 in 100 (1% AEP) storm tide as the base still water level. It then includes allowance for the most extreme current predictions for sea-level rise, over the 100 year timeframe. It also conservatively allows for VLM to occur at the highest predicted rates which are significantly above the average measured rate for the site, and also the surrounding area. It has resulted in a future inundation level that is 0.2m above the existing CFHZ3 value, and more appropriately accounts for the current understanding in future hazard risk posed by sea-level rise and VLM. This has been mapped on the attached Plan (**Appendix A**).

4.1.1 Coastal Flooding Mitigation

It is a common requirement that the mitigation measures demonstrate that they will not result in the increase of the hazard elsewhere. This is highly relevant for filling to mitigate the risk of stormwater flooding, as the catchment flood and catchment storage is a specific volume. The placement of fill reduces the storage capacity of the catchment, directly leading to increased effects elsewhere. This is not the case with coastal flooding hazard. The coastal flood is of near infinite volume, in relation to the size of any flooded area. In close proximity to the ocean an area of any extent will be flooded if below inundation level, independent of the level of the balance of the catchment. Accordingly the reduction in size of the flooded area due to filling does not increase the coastal flood risk elsewhere.

The extent of filling that would be required to mitigate the inundation hazard was investigated as part of this reporting, in order to inform the proposed natural hazard provisions for the PPC. As assumed filling to 200mm above the 100 year future inundation level of RL 3.7 would mitigate the inundation risk in that area. The fill requirement for mitigation was plotted and characterised as three scales:

- 0.5m or less
- 0.5 – 1.0m
- 1.0 – 1.5m

These Plans are attached (**Appendix C**). The assessment showed that for the area around Black Swamp Road (Figure 4.1.1a), with the exceptions of right at the margins with the estuarine area, a fill depth of 0.5m or less is required to raise the land level above the 100 year inundation level. Conversely, the exercise highlighted the nature of the low-lying area to the north-west of the PPC area. Even considering filling up to 1.5m only results in a slightly larger area of land being able to be considered flood-proof (Figure 4.1.1b), with regard to the 100 year inundation level, with filling of 1.5 – 2.5m being required for this area.

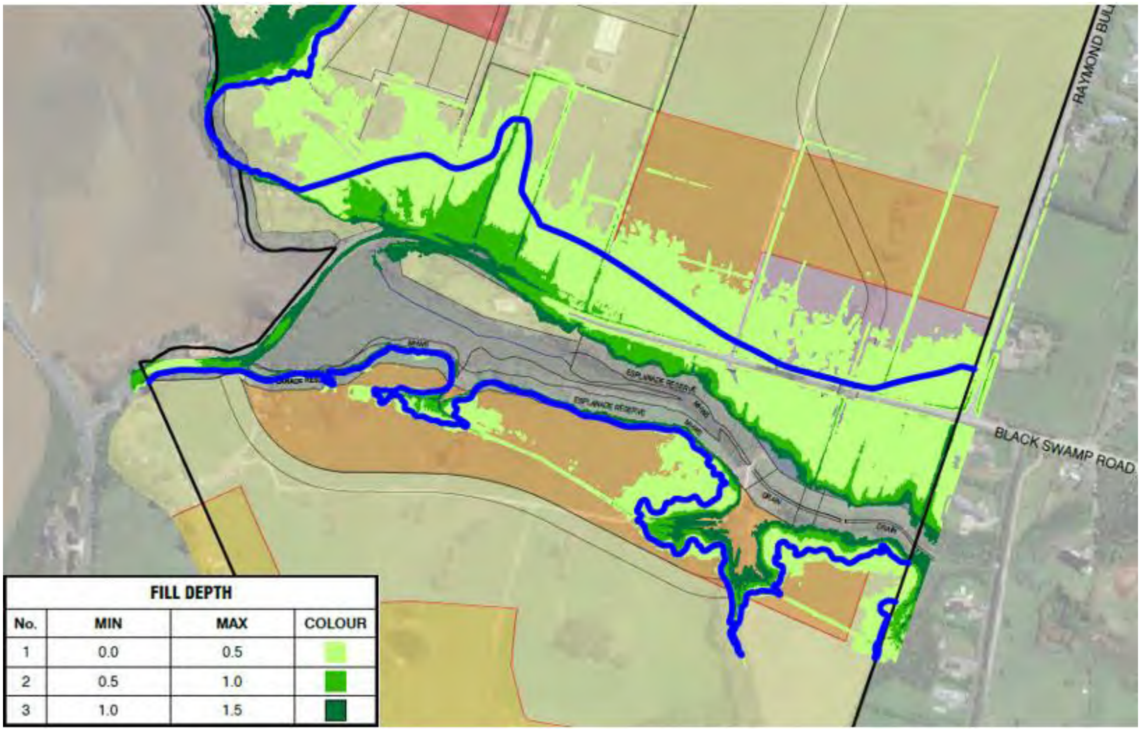


Figure 4.1.1a: Filling around Black Swamp Road

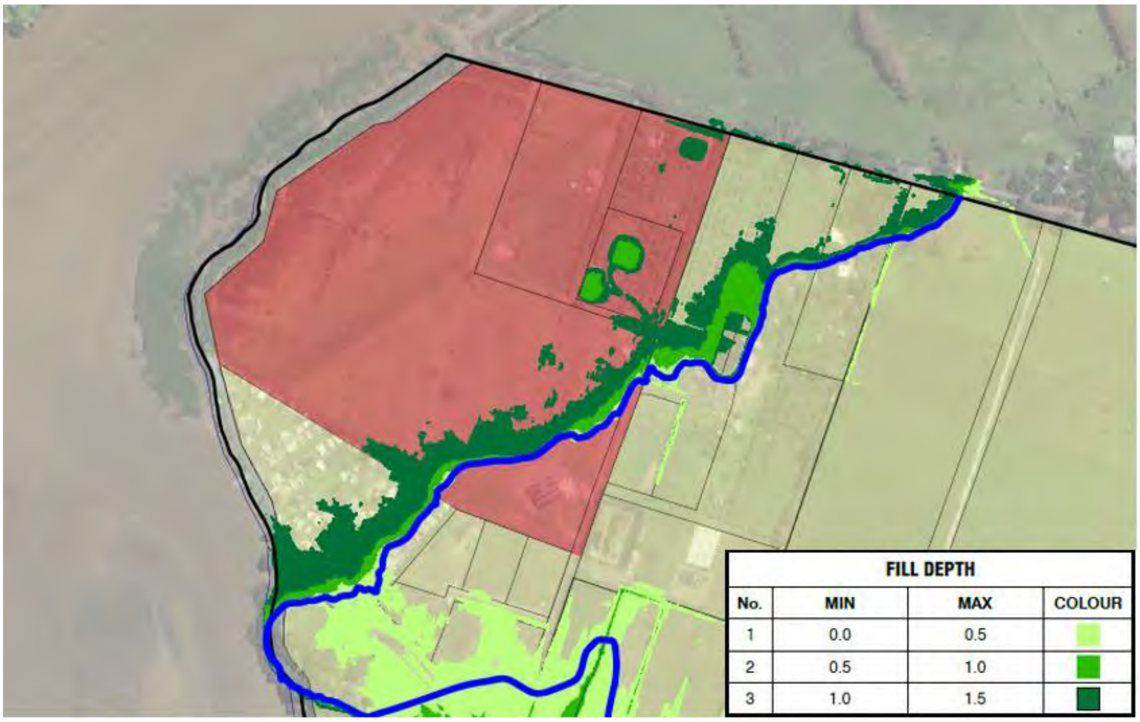


Figure 4.1.1b: Filling to north-west PPC area

4.2 Future Coastal Erosion Hazard

Development at the coastal edge in the future PPC area will also need to be cognisant of the potential for the coastal edge to continue to retreat over time. A 'Coastal Hazard Management' Overlay is proposed, and if development is proposed within this Overlay, site-specific assessment will be required at the time of subdivision to ensure that any development will not exacerbate or be adversely affected by coastal hazards.

The following area has been specified, as an offset from MHWS, for the Future Erosion Hazard Zone:

- 30m offset from MHWS for all coastal land within MEPPC outside Black Swamp Road causeway
- 10m offset from MHWS for all land within MEPPC upstream from Black Swamp Road causeway

5.0 Conclusion

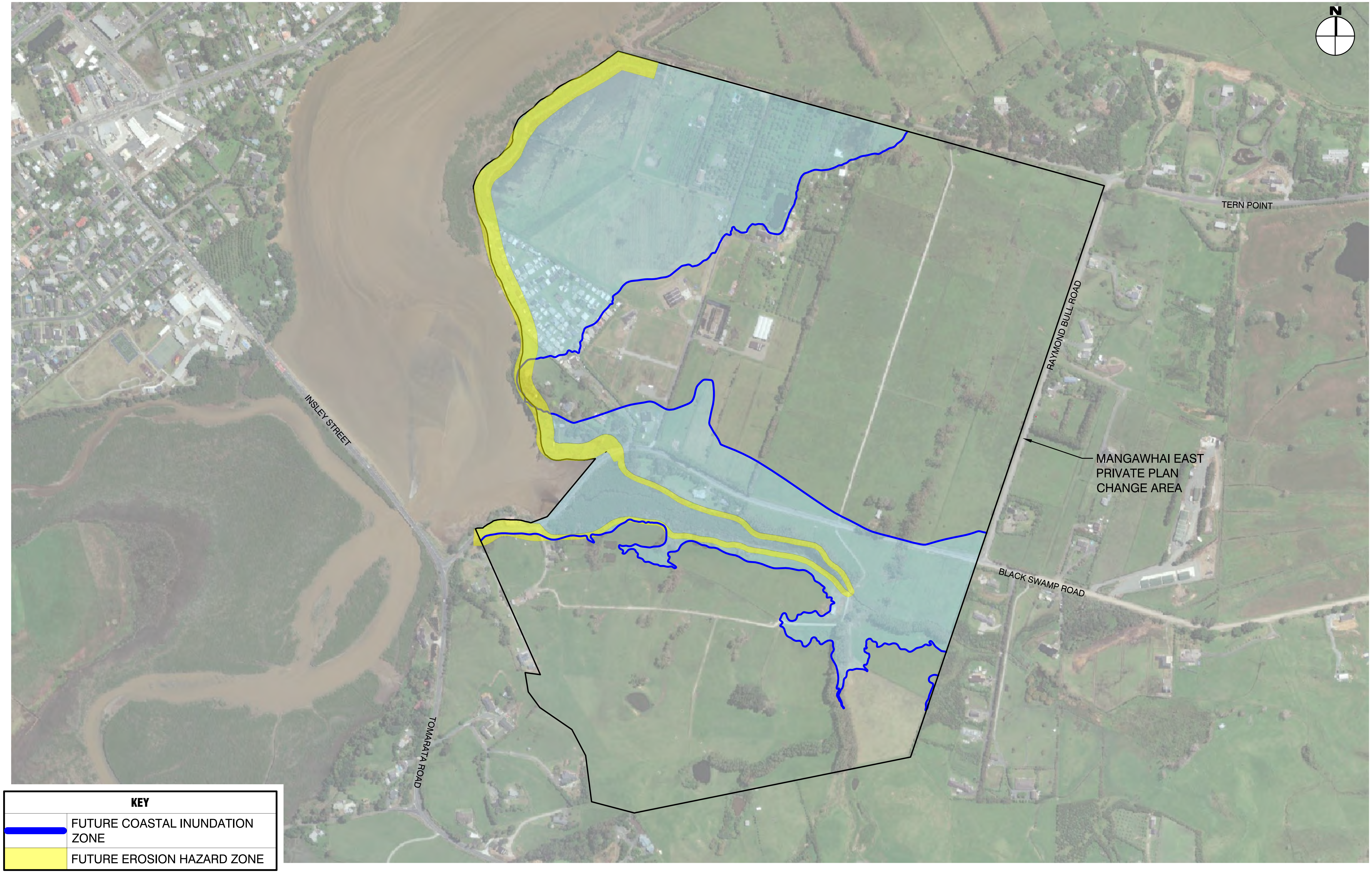
This report has reviewed the existing coastal processes of the site of the MEPPC area, at the southern extent of the Mangawhai estuary. It has considered the existing hazard reporting on both coastal inundation and erosion hazards, and provided an update to this existing work to a suitable level of detail for the PPC process.

Areas where a Coastal Hazard Management Overlay will be specified have been identified through this work, and are set out on the attached Plan, which is to be reflected in the proposed Development area provisions.

The investigation undertaken indicates the lower land area will require significantly greater mitigation in terms of filling to avoid the hazard. Hence an Overlay is proposed, and a Resource Consent will be required for development within the Overlay to enable the effects to be accurately determined at the future development stage.

Subject to the identification of the coastal hazard Overlay and the related planning provisions in the proposed Development Area, coastal hazard effects will not limit the development of land as proposed in the Plan Change.

Appendix A
Future Hazards Plan



KEY	
	FUTURE COASTAL INUNDATION ZONE
	FUTURE EROSION HAZARD ZONE

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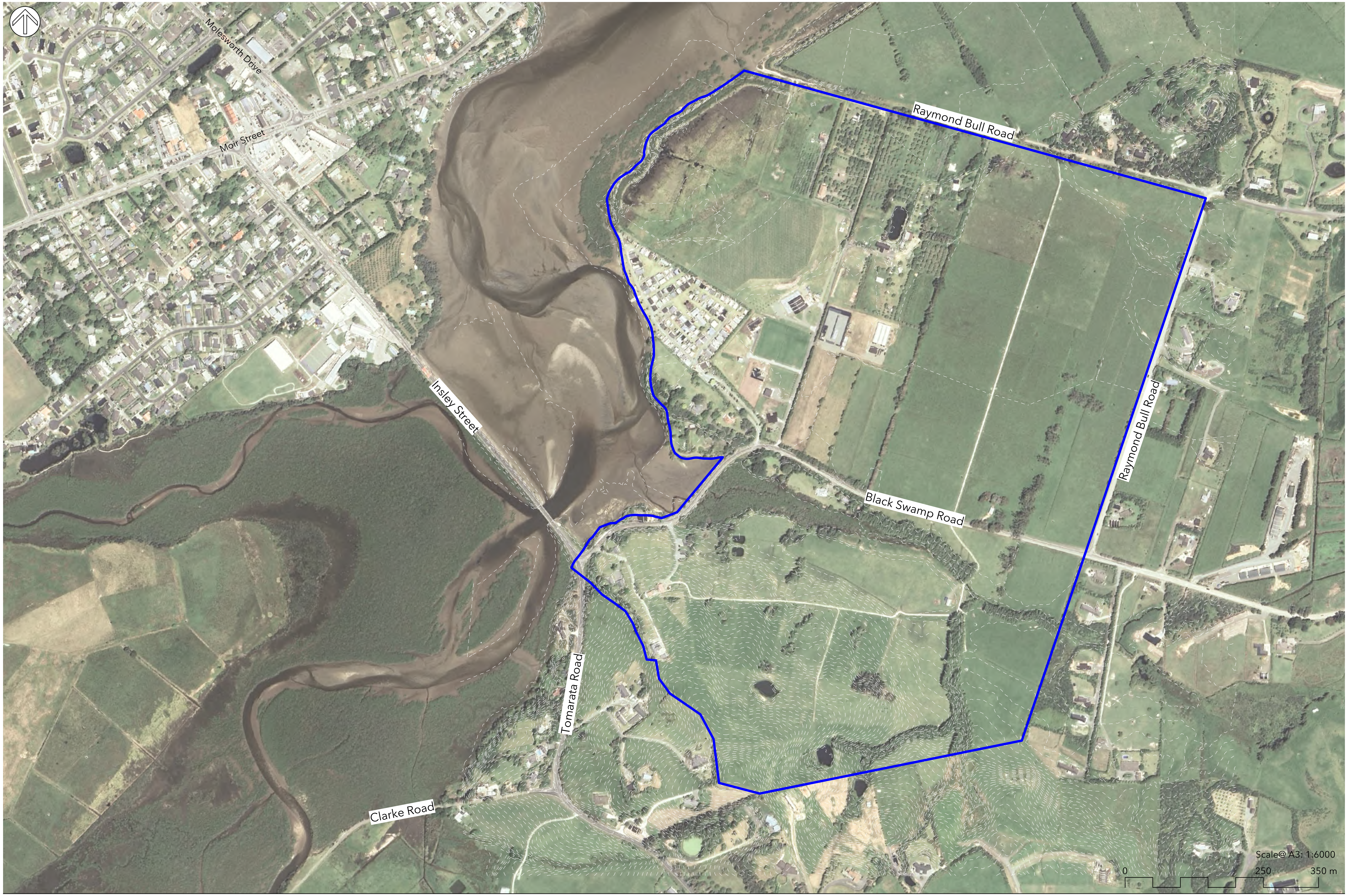
DAVIS COASTAL CONSULTANTS

P04 FUTURE EROSION HAZARD ZONE
24022-01.1 CABRA MANGAWHAI PLAN CHANGE
SCALE 1:6000
DATE: 12.08.24
REV: -

Appendix B

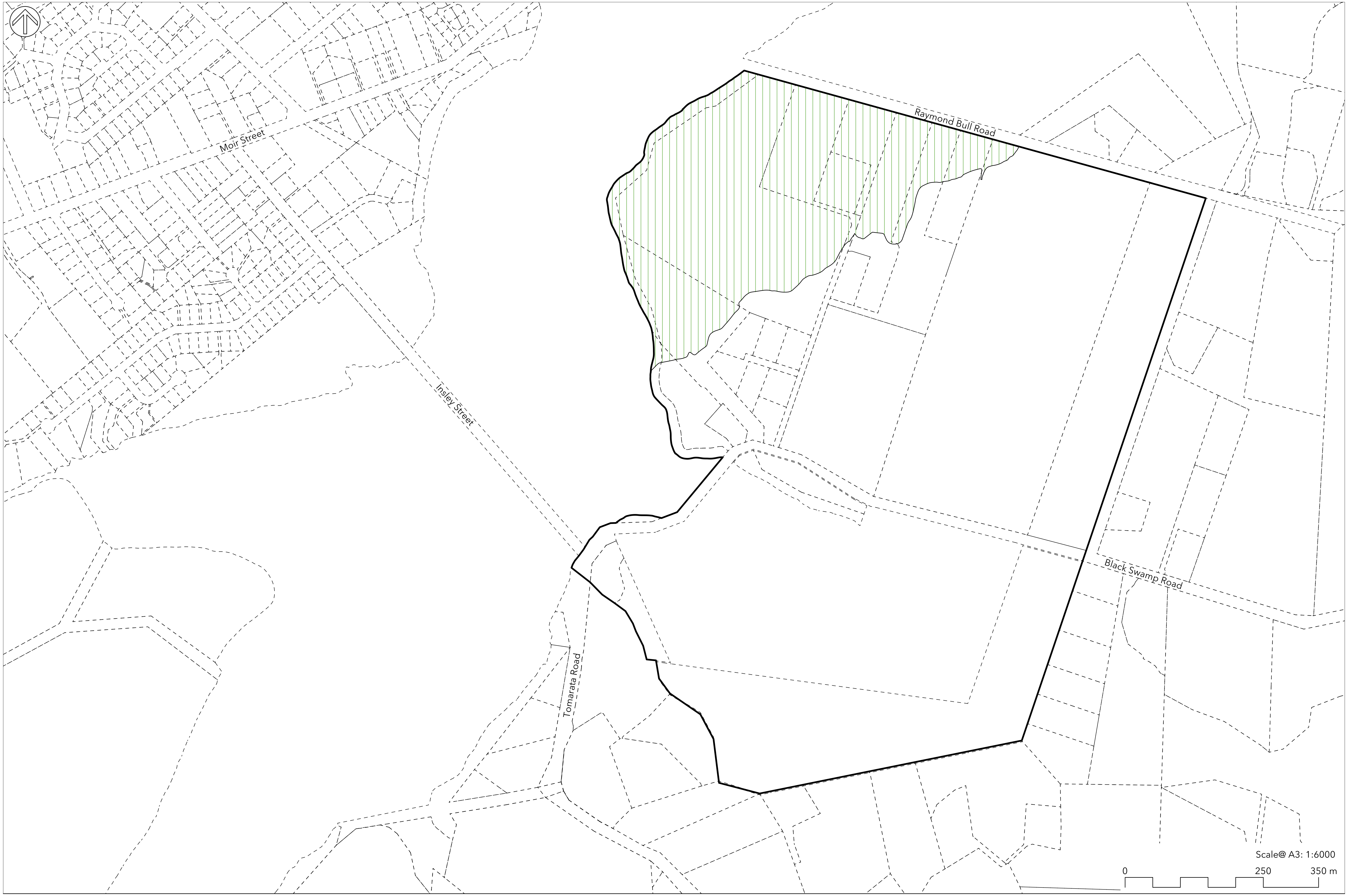
Proposed Planning Maps



Develpment Area - Mangawhai East

DEVELOPMENT
AREA

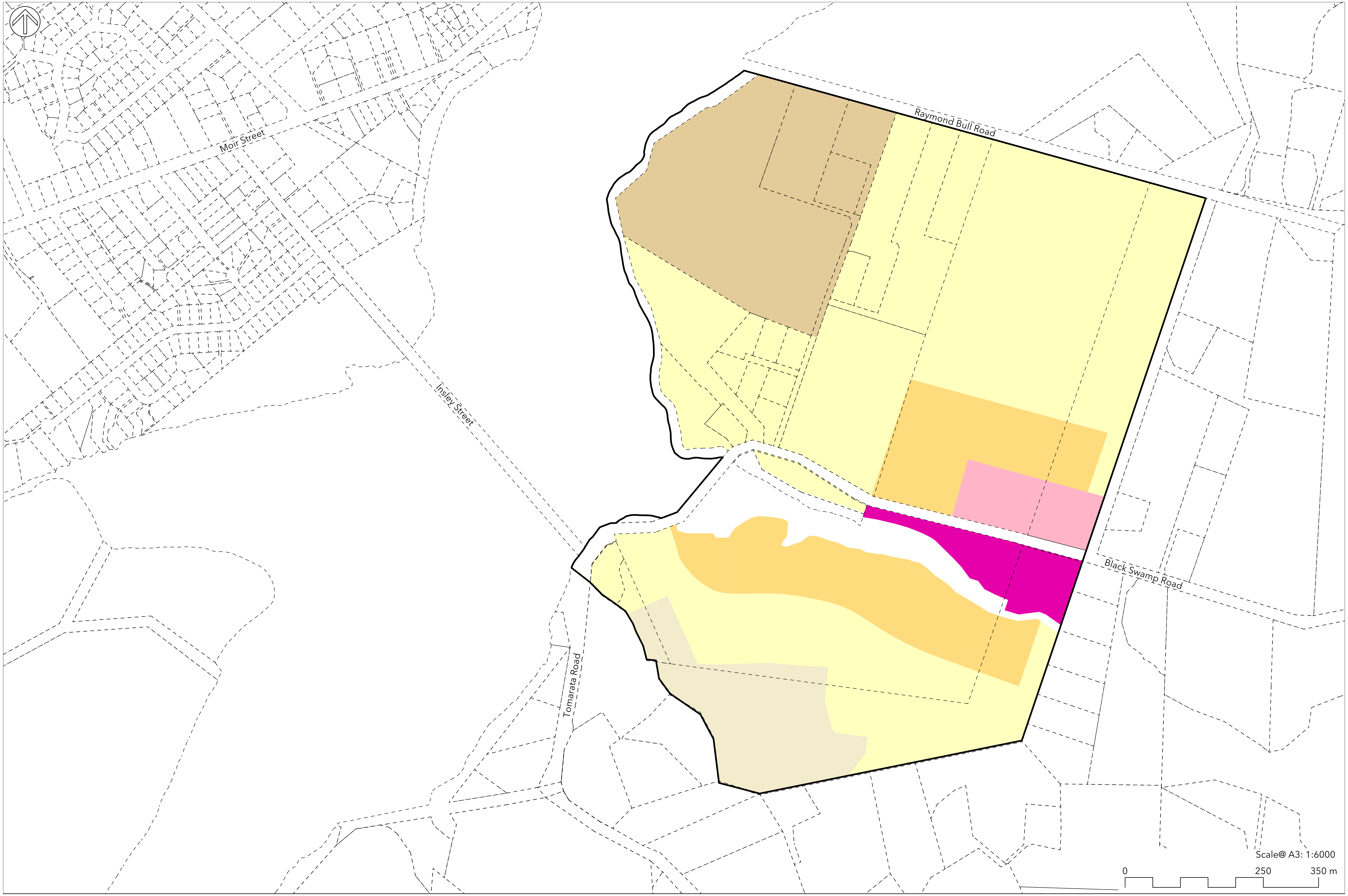
13-Sep-24
ISSUE DATE / REF # - A



Coastal Inundation Overlay

PROPOSED COASTAL INUNDATION OVERLAY MAP

13-Sep-24
ISSUE DATE / REF # - A



Neighbourhood Centre Zone
Mixed Use Zone
Large Lot Residential
Low Density Residential
Medium Density Residentiall
Rural Lifestyle Zone

PROPOSED ZONING MAP
MANGAWHAI EAST

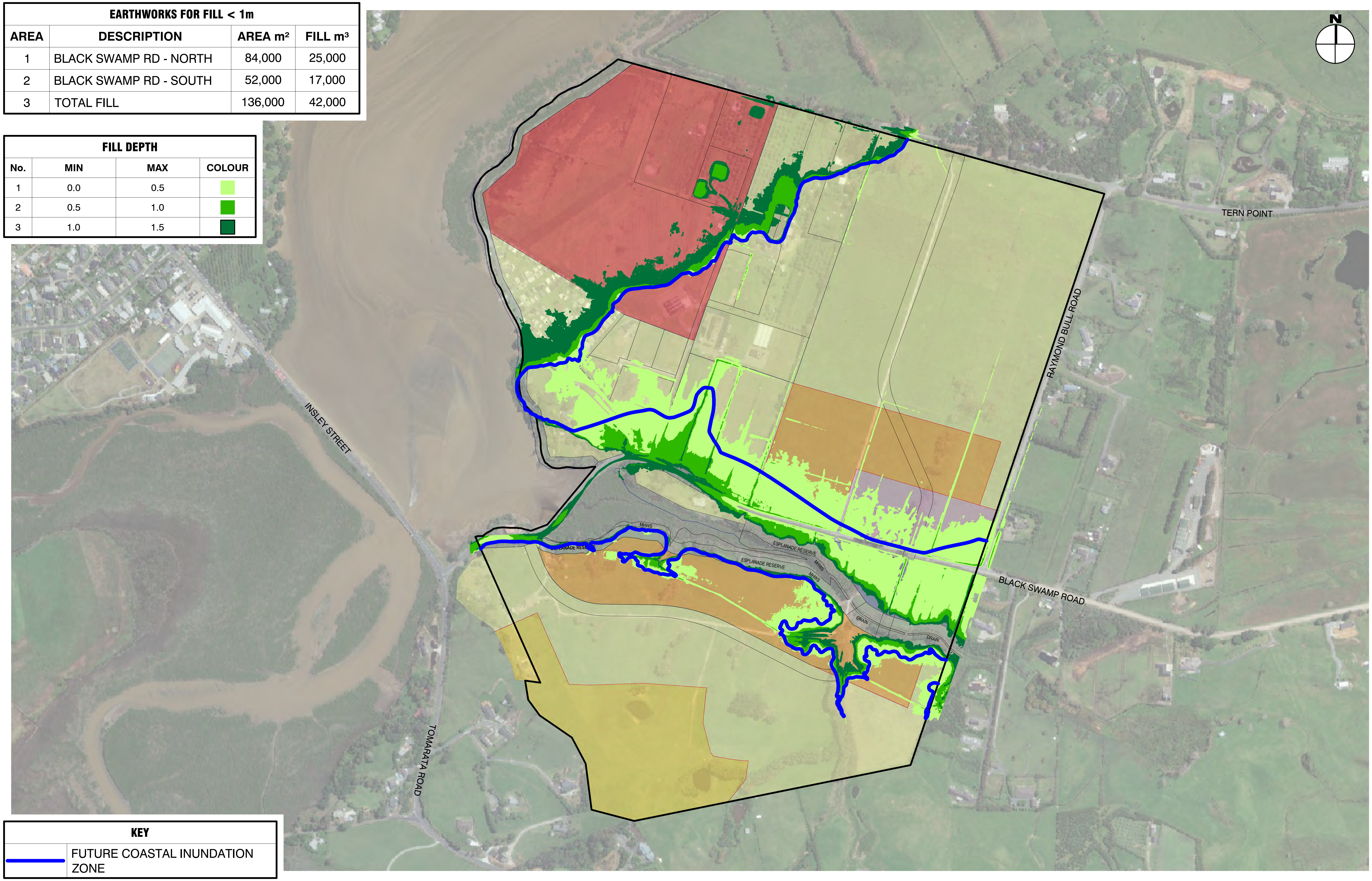
13-Sep-24
ISSUE DATE / REF # - A

Appendix C

Fill Assessment – Not Proposed

EARTHWORKS FOR FILL < 1m			
AREA	DESCRIPTION	AREA m²	FILL m³
1	BLACK SWAMP RD - NORTH	84,000	25,000
2	BLACK SWAMP RD - SOUTH	52,000	17,000
3	TOTAL FILL	136,000	42,000

FILL DEPTH			
No.	MIN	MAX	COLOUR
1	0.0	0.5	
2	0.5	1.0	
3	1.0	1.5	



KEY	
	FUTURE COASTAL INUNDATION ZONE

P01 OVERALL PLAN

24022-01 CABRA MANGAWHAI PLAN CHANGE

SCALE 1:6000

DATE: 27.09.24

REV: B

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Appendix C – Design Modelling Hakaru Catchment Report

Design Modelling

Hakaru Catchment (M08)

Northland Regional Council

5 May 2021

Document Status

Version	Doc type	Reviewed by	Approved by	Date issued
01	Draft	Lachlan Inglis	Ben Hughes	05/05/2021

Project Details

Project Name	Hakaru Catchment (M08)
Client	Northland Regional Council
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Document Number	M08_20010434_R02V01_Validation_Report.docx

Cover Photo: Helen Beech (https://www.rnz.co.nz/news/national/350285/flooding-in-northland-forces-school-and-road-closures)

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Environment ISO 14001 SAI GLOBAL
Health & Safety AS 4801 SAI GLOBAL

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1 PROJECT OVERVIEW

Overview

Water Technology was commissioned by Northland Regional Council (NRC) to undertake a region-wide flood modelling study. The study area encompassed the entire Northland Regional Council area which covers an area of over 12,500 km^2, with the exclusion offshore islands. The aim of this project was to map riverine flood hazard zones across the entire Northland region and update existing flood intelligence.

Modelling approach

This project used a 2D Direct Rainfall (also known as Rain on Grid) approach for hydraulic modelling and has provided flood extents for a defined range of design storms. The hydraulic modelling software TUFLOW was used. TUFLOW is a widely used software package suitable for the analysis of flooding. TUFLOW routes overland flow across a topographic surface (2D domain) to create flood extent, depth, velocity and flood hazard outputs that can be used for planning, intelligence and emergency response. The latest release of TUFLOW offers several recent advanced modelling techniques to improve modelling accuracy which where practical, were tested and adopted in this project.

This study delineated and modelled 19 catchments, shown in Figure 1-1. To validate the adopted methodology and model parameters used in the design modelling, 9 catchments were calibrated against recent (and historic) flood events. The calibration/validation methodology is documented in a standalone report *NRC Riverine Flood Mapping - Calibration Report – R01* and is referred to throughout this document as the *Calibration Report*.

This report documents the calibration results and design modelling methodology for Hakaru Catchment (M08), noting that this catchment was calibrated to the December 2014 flood event.

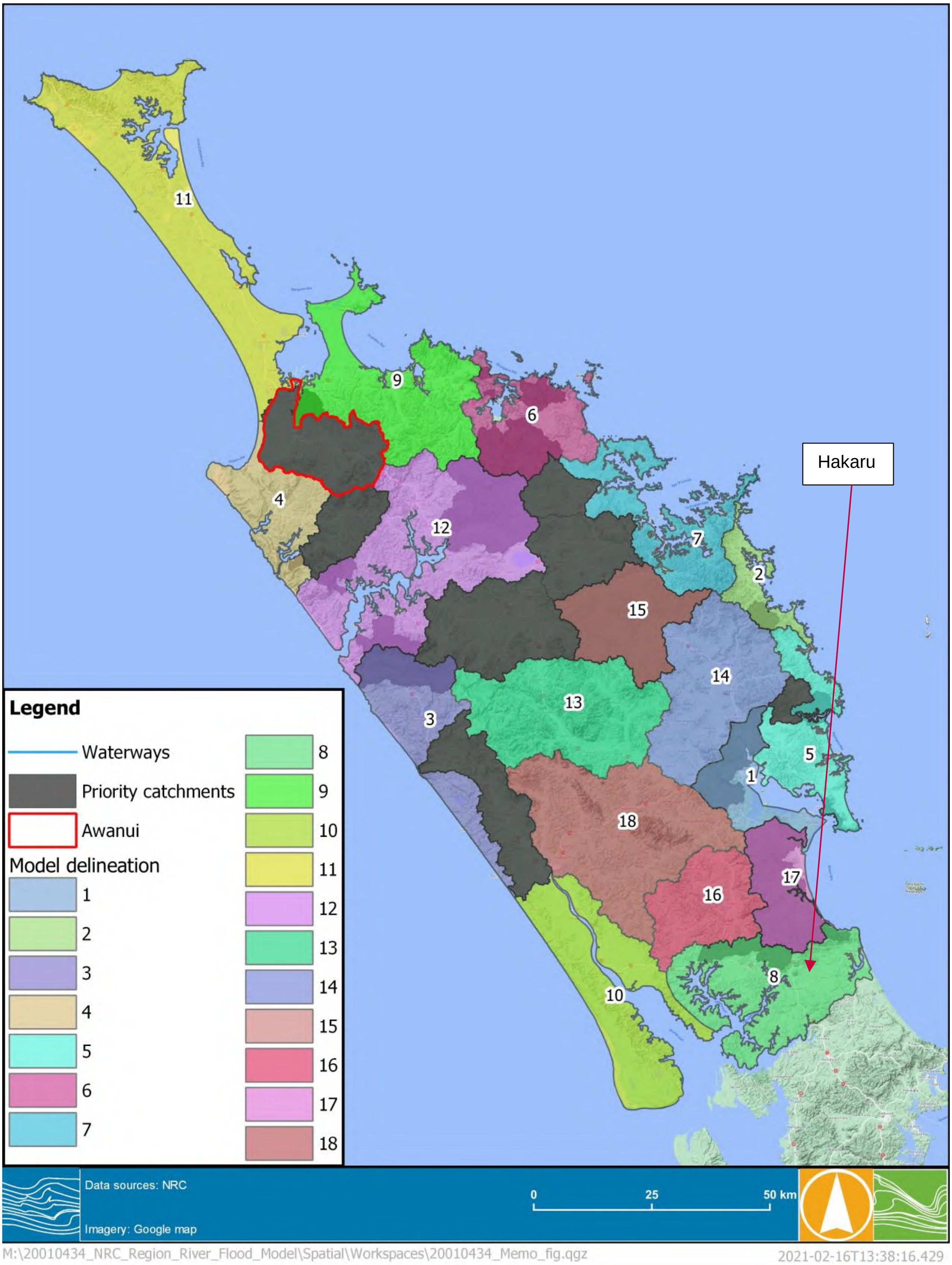

FIGURE 1-1 MODEL DELINEATION

2 STUDY AREA

The Model 08 catchment is coastal catchment, covering a total area of approximately 739 km^2 with Mangawhai its largest township. The Arapaoa River and Otamatea River are the two major waterways within the catchment with numerous tributaries that join them upstream before discharging into the sea to the west of the catchment. Several small waterways also merge at Mangawhai Harbour before leaving from the east coast of the catchment. Figure 2-1 displays the study area of the catchment Model 08.

FIGURE 2-1 STUDY AREA

3 CALIBRATION RESULTS

The detail methodology of model calibration should refer to the *Calibration Report*. This section documents the final model calibration results and its performance.

Hakaru at Topuni Creek Farm gauge is the only streamflow gauge found available within the catchment. This gauge has both flow and water level records. There is no gauge zero and the model could not be calibrated against recorded flood levels. However, an arbitrary gauge zero was used to compare the shape of the water level plot. This model calibration therefore relied on matching the modelled flows to the gauged flows.

The calibration focused on calibrating the model to the rainfall event between 13th to 18th December in 2014 which is the largest event in the 9 years of available data in this gauge. Table 3-1 summarises the comparison between the observed and modelled values and Table 3-2 shows the quantitative assessment of the calibration performance. Figure 3-1 and Figure 3-2 show the modelled plots compared to the gauged records.

The modelled hydrograph has a good match to the gauged hydrograph in terms of its peak value, shape and timing. The modelled peak flow is close to the gauged record with around 8% difference and the time to peak is only 1 hours earlier than that observed. However, the modelled flood volume is much smaller than the total volume recorded during the event.

With the gauge zero not available, the modelled peak water level could not be compared to the gauged level. However, with using an arbitrary gauge zero, the modelled level plot shows a good match to the gauged one in terms of its shape as shown in Figure 3-2.

Based on the calibration result, the model calibration for the catchment appears suitable and fit for purpose.

TABLE 3-1 SUMMARY OF CALIBRATION RESULTS FOR CATCHMENT MODEL 03

Location	Peak flow (m^3/s)			Time to peak diff. (hour)	Volume (ML)			Peak WSE (m OTP)		
	Modelled	Gauged	Diff.		Modelled	Gauged	Diff.	Modelled	Gauged	Diff. (mm)
Hakaru at Topuni Creek Farm gauge	132	122	8.22%	-1.0	4736	10055	-52.90%	5.21	N/A	N/A

TABLE 3-2 QUANTITATIVE ASSESSMENT OF JANURARY 2011 CALIBRATION FOR CATCHMENT MODEL 03

Location	Peak flow within 15% of recorded (Y/N)	Volume within 15% of recorded (Y/N)	Peak WSE within 300mm of recorded (Y/N)	Timing to peak within +/- 1 hour	Model flow within 10% of recorded flow at the same stage (Y/N)
Hakaru at Topuni Creek Farm gauge	Y	N	N/A	Y	N/A

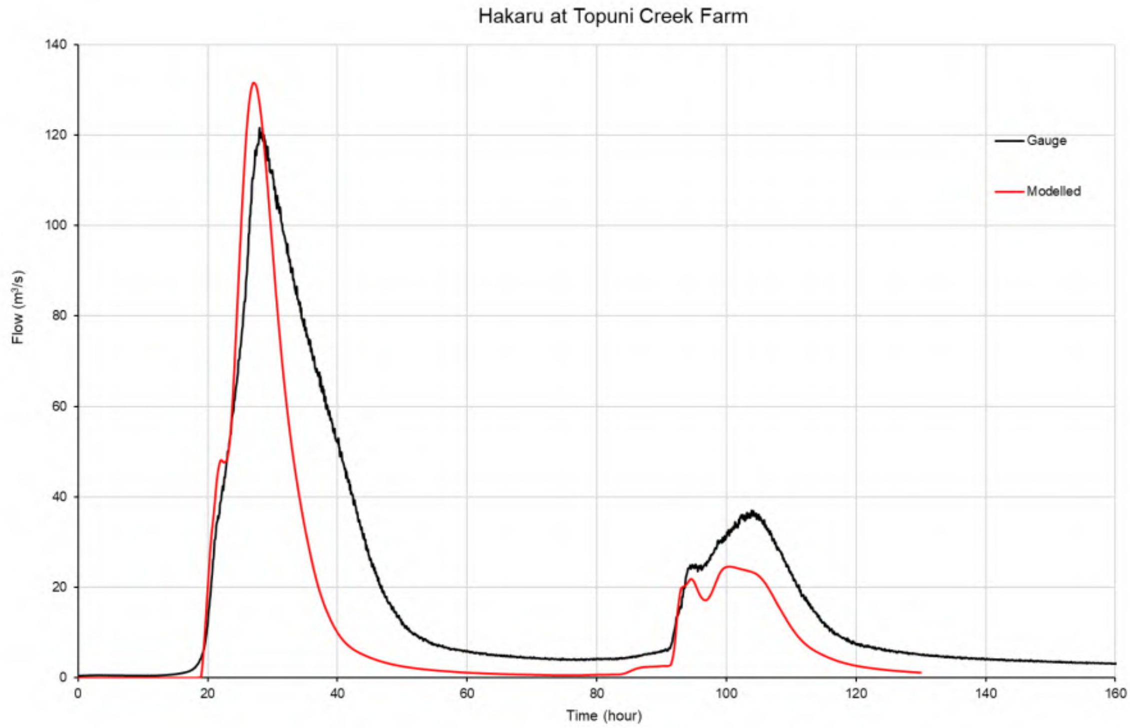

FIGURE 3-1 MODELLED AND GAUGED HYDROGRAPH AT HAKARU AT TOPUNI GAUGE

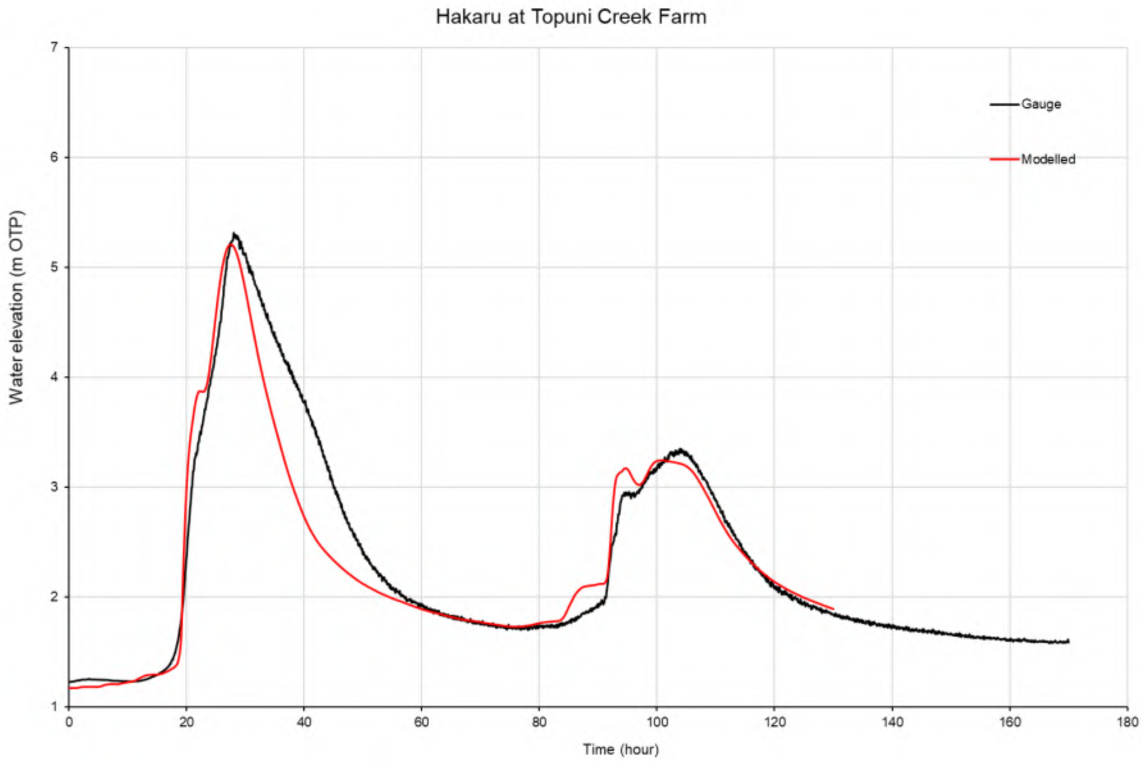

FIGURE 3-2 MODELLED AND GAUGED WATER LEVEL AT HAKARU AT TOPUNI GAUGE (*ARBITRARY GAUGE ZERO)

4 DESIGN MODELLING

4.1 Overview

A hydraulic model (TUFLOW) of the Hakaru catchment (M08) was constructed to model overland flooding. A range of storm durations were run and results for each Annual Exceedance Probability (AEP) event were enveloped to ensure the critical duration was well represented across each part of the study area. The merged results captured the maximum flood level and depth of the range of design event durations modelled.

Table 4-1 and the following sections detail the key modelling information used in the development of the hydraulic model.

TABLE 4-1 KEY MODELLING INFORMATION

Terrain data	NRC 1m LiDAR without filling of sinks but includes the "burning of creek alignments' through embankments
Model type	Direct rainfall model
Model build	Build: 2020-10-AA-iSP-w64
Rainfall	See Sections 4.2.1 and 4.2.4
Losses	See Section 4.2.3
Boundaries	See Section 4.2.4
Modelling solution scheme	TUFLOW HPC (adaptive timestep)
Modelling hardware	GPU
Modelling technique	Sub-grid-sampling (SGS)
Model grid size	10m with 1m SGS

4.2 Model Parameters

A range of model parameters were adopted based on the calibration of the December 2014 event for the Hakaru Catchment. Details of these are outlined below.

4.2.1 Rainfall Intensity-Duration-Frequency

Intensity-Duration-Frequency (IDF) tables were developed by NIWA through the High Intensity Rainfall Design System (HIRDSV4)[1]. Design rainfall totals for durations from 10 minute up to 120 hours were developed for design modelling and were developed at 179 rainfall gauge sites across the wider study area. The IDF tables cover a range of magnitude events from 1 in 1.58 ARI through to 1 in 250 ARI along with climate change predictions (Representative Concentration Pathway 4.6, 6 & 8.5) up to the year 2100. For this catchment, ten rainfall gauges were used with a spatially weighted grid of rainfall totals created for design modelling. Figure 4-1 shows the 12-hour cumulative rainfall grid for the 1% AEP event along with the rainfall gauge locations used to create the grid.

[1] Accessed via https://hirds.niwa.co.nz/

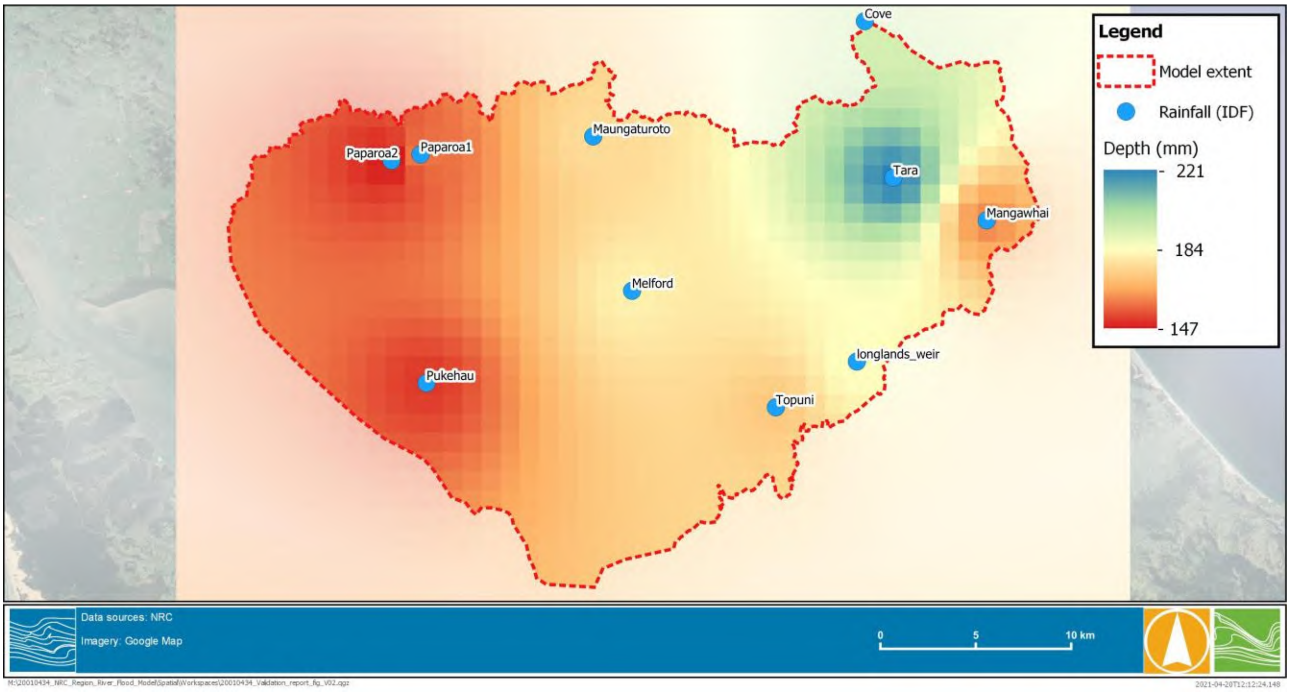

FIGURE 4-1 EXAMPLE OF DESIGN RAINFALL GRID (12-HOUR, 1% AEP RAINFALL) FOR M08

4.2.2 Design Rainfall Temporal Patterns

Design temporal patterns (rainfall hyetographs) were provided by NRC for design modelling. These were developed by HIRDS and subsequently reviewed as part of a as part of project undertaken by Macky & Shamseldin (2020)[2]. The project aimed to provide multiple design hyetographs and a better representation of rainfall variability across the Northland region, replacing the single set of design hyetographs previously developed.

The HIRDS design temporal pattern is recommended for design modelling of Northland catchments[2]. Hence, the design hyetographs for the rainfall gauges were developed using the rainfall IDF data at available rainfall gauges for the catchment. Although a 12-hour hyetograph is suitable for design modelling for most Northland catchments as suggested[2], a range of durations were selected; including 1-hour, 6-hour, 12-hour and 24-hour for each of the following AEPs:10%, 2% and 1% AEP to ensure that the event critical duration was identified across the catchment. The shorter durations were critical in the upper parts of the catchment, while the longer 24-hour durations were critical in the lower catchment, where flood volumes are generally the predominant factor in generating peak flood levels.

Table 4-2 summarises the 1% AEP rainfall depth (based on IDF from HIRDSV4) for different event durations at each rainfall gauge and Figure 4-2 shows the design cumulative rainfall across the different gauges for the 12-hour duration event. Considering a single temporal pattern is assigned (i.e. HIRDS hyetograph), the proportional amount of rainfall applied through time for a given duration (e.g., 6-hour) is generally consistent (as shown in Figure 4-2) across the catchment area.

[2] Macky & Shamseldin (2020) - Northland Region-wide Hyetograph review

TABLE 4-2 1% AEP DESIGN RAINFALL DEPTH

Gauge location	1% AEP (mm)			
	1-hour	6-hour	12-hour	24-hour
Hakaru at Tara_641512	70	167	221	278
Mangawhai_A64151	63	128	161	199
Maungaturoto Melford_A64132	59	137	181	234
Paparoa 2_A64123	55	115	146	181
Paparoa 1_A64121	58	124	160	199
Paparoa at Maungaturoto_641213	61	138	176	218
Pukehau_A64221	54	118	151	189
Topuni_A64241	64	135	172	211
Waikoukou at Longlands Weir_647512	67	146	185	225
Waipu Cove_A64051	68	152	193	238

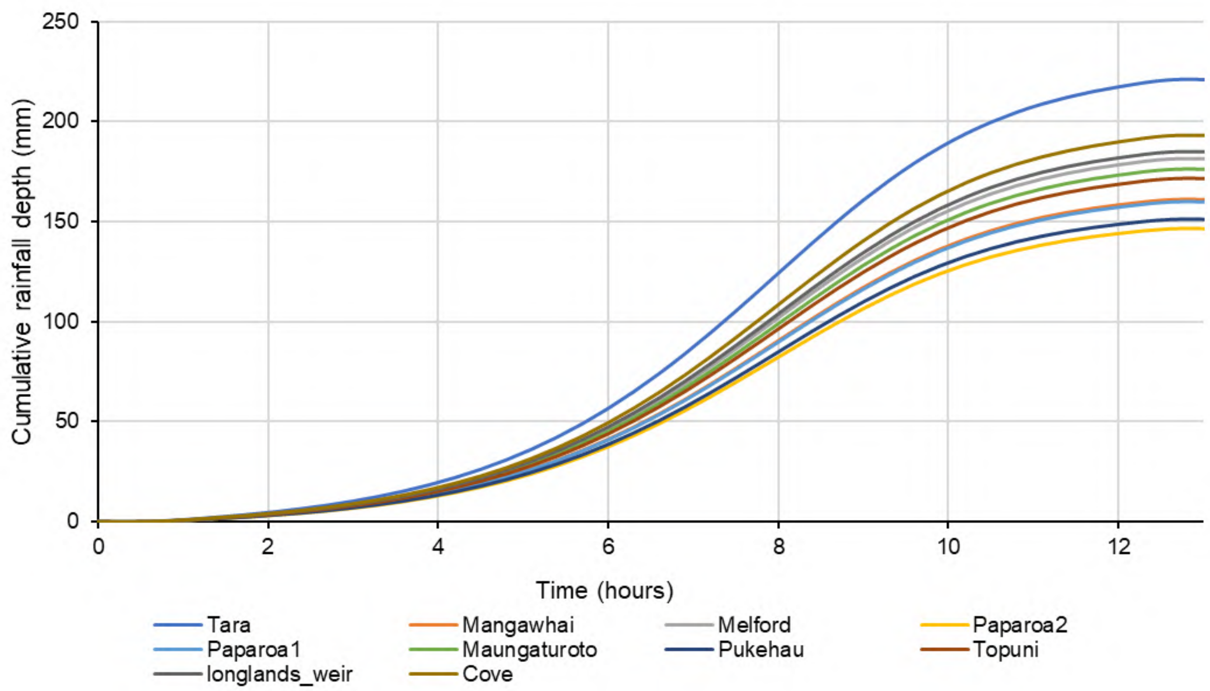

FIGURE 4-2 TEMPORAL PATTERN FOR DESIGN RAINFALL OF 12-HOUR, 1% AEP EVENT

A climate change scenario (for the 1% AEP events) was modelled for the 2081-2100 timeframe, for the RCP 8.5. This is based on the increases in rainfall intensity of 35%, 30%, 26% and 22% respectively for 1-hour, 6-hour, 12-hour and 24-hour duration events.

4.2.3 Losses

Each model cell was assigned a Manning's "*n*" (surface roughness), initial loss and a continuing loss based on the land use types and hydrologically important characteristics. Table 4-3 summarises the adopted roughness and loss parameters. It should be noted these parameters were calibrated to a historic event where streamflow gauges were present within the catchment. Figure 4-3 displays the roughness layer based on the land use type, showing most land use is forest and grassland.

TABLE 4-3 DESIGN MODEL PARAMETERS

Hydrological areas	Land use types	Manning's n	Initial loss (IL) – mm	Continuing loss (CL) – mm/hr
Entire M08 catchment	Forest	0.18	42	1.5
	Grassland	0.15	42	1.5
	Cropland – perennial	0.06	20	1
	Cropland – annual	0.06	20	1
	Wetland – open water	0.04	0	0
	Wetland – vegetated	0.05	10	1
	Urban areas	0.10	5	1.5
	Waterways	0.08	0	0
	Other	0.06	15	1.5

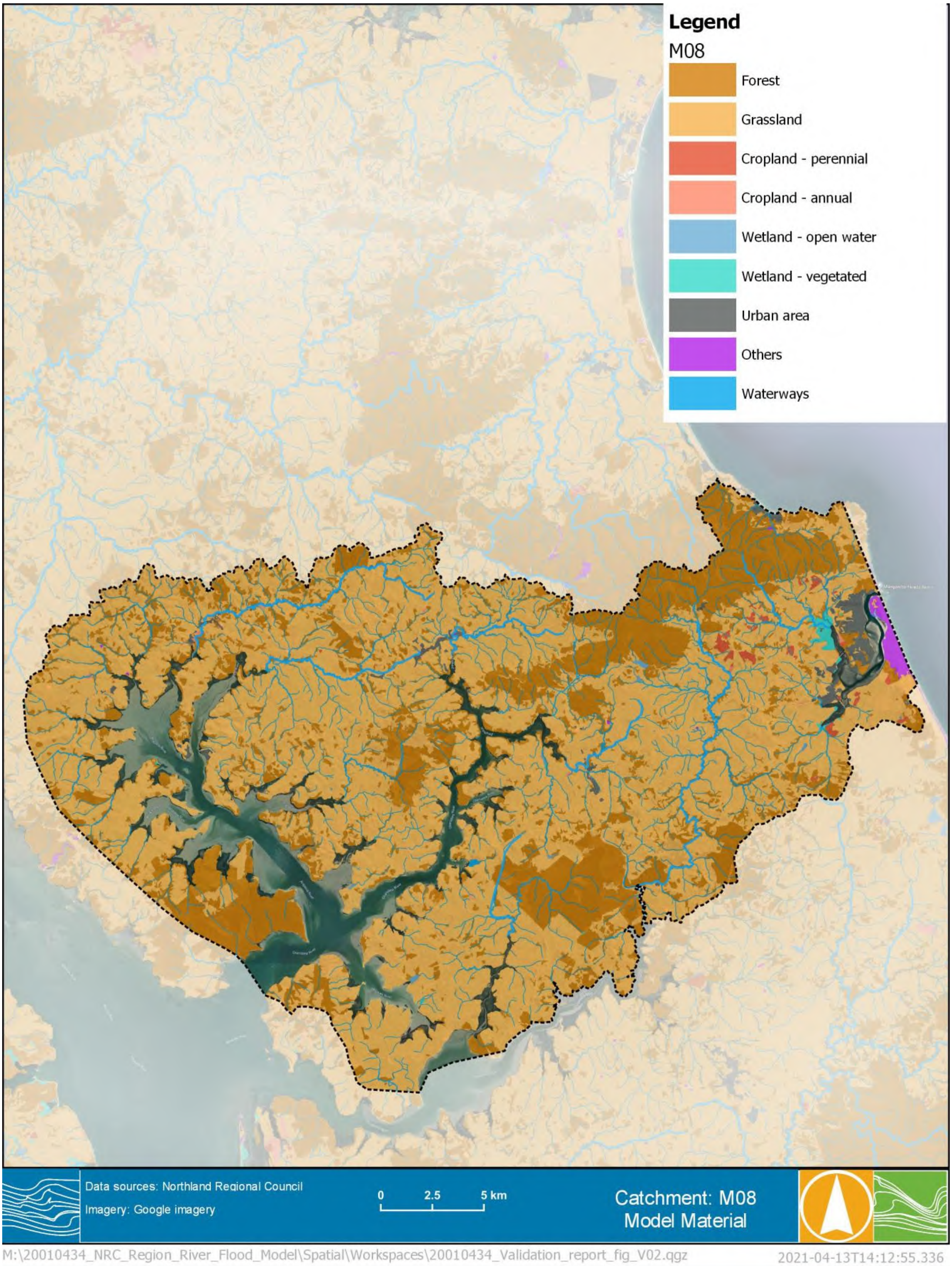

FIGURE 4-3 HYDRAULIC MODEL MATERIAL LAYER

4.2.4 Boundaries

As the Hakaru catchment is a coastal catchment, a static tail-water (i.e. 2161 mm OTP) outflow boundary based on the 2 year ARI tide level[3] at Pouto Point was applied at the western downstream boundary and a static tail-water (i.e. 1396 mm OTP) outflow boundary based on the 2 year ARI tide level at Marsden Point was applied at the eastern downstream boundary for the design modelling. A 1.2 m sea level rise was adopted for climate change runs based on the project brief. In the calibration modelling, both of these boundaries were stage-discharge boundary (i.e. type HQ).

There is no upstream inflow coming from upstream catchments applied in this catchment model.

[3] MWH, 2010 *Priority Rivers – Flow Assessment, Sea Level Rise and Storm Surge*, prepared for Norhland Regional Council

5 MODELLING RESULTS

5.1 Modelled Result Processing/Filtering

Design modelling consisted of running the model for four storm durations (1-hour, 6-hour, 12-hour and 24-hour) with the results enveloped for each design event (i.e. 1%, 2% and 10% AEP) to ensure the critical duration was well represented across each part of the catchment. Each model run produced gridded results, including depth, water surface elevation (WSE), flood hazard (Z0) and velocity. Several post-processing steps were required to produce the final design modelling outputs. These are described as follows:

Step 1:

- The modelling results are firstly merged to produce a single data set for each AEP from the storm durations modelled. For example, the flood depth output is produced by merging the depth results of the four different durations within each AEP. This allows for the critical storm duration across each part of the catchment to be represented (i.e. the short intense storms in upper reaches and longer duration storms in the lower parts of the catchment).

Step 2:

- The maximum gridded results are then remapped to a finer DEM grid using LiDAR data resampled to a 5-m grid resolution. This allows the flood extent to be more accurately displayed on the map and the higher resolution gridded results (i.e. same resolution as the 5-m DEM) to be produced.

Step 3:

- Finally, the remapped results are post-processed by filtering out depths below 100mm and puddle areas less than 2000m^2 as agreed with NRC.

Figure 5-1, Figure 5-2 and Figure 5-3 respectively show the final post-processed flood depths, velocity and hazard of the 1% AEP design event modelled for M08. Figure 5-4 shows the flood depth map zoomed in at a township (Kaiwaka) as an example. It is noted that the hazard classification is based on the following criteria:

TABLE 5-1 FLOOD HAZARD CLASSIFICATION

Hazard classification	Hazard – VxD (m^2/s)
Low	< 0.2
Low to Moderate	0.2 to 0.4
Moderate	0.4 to 0.6
Moderate to High	0.6 to 0.84
High	> 0.84

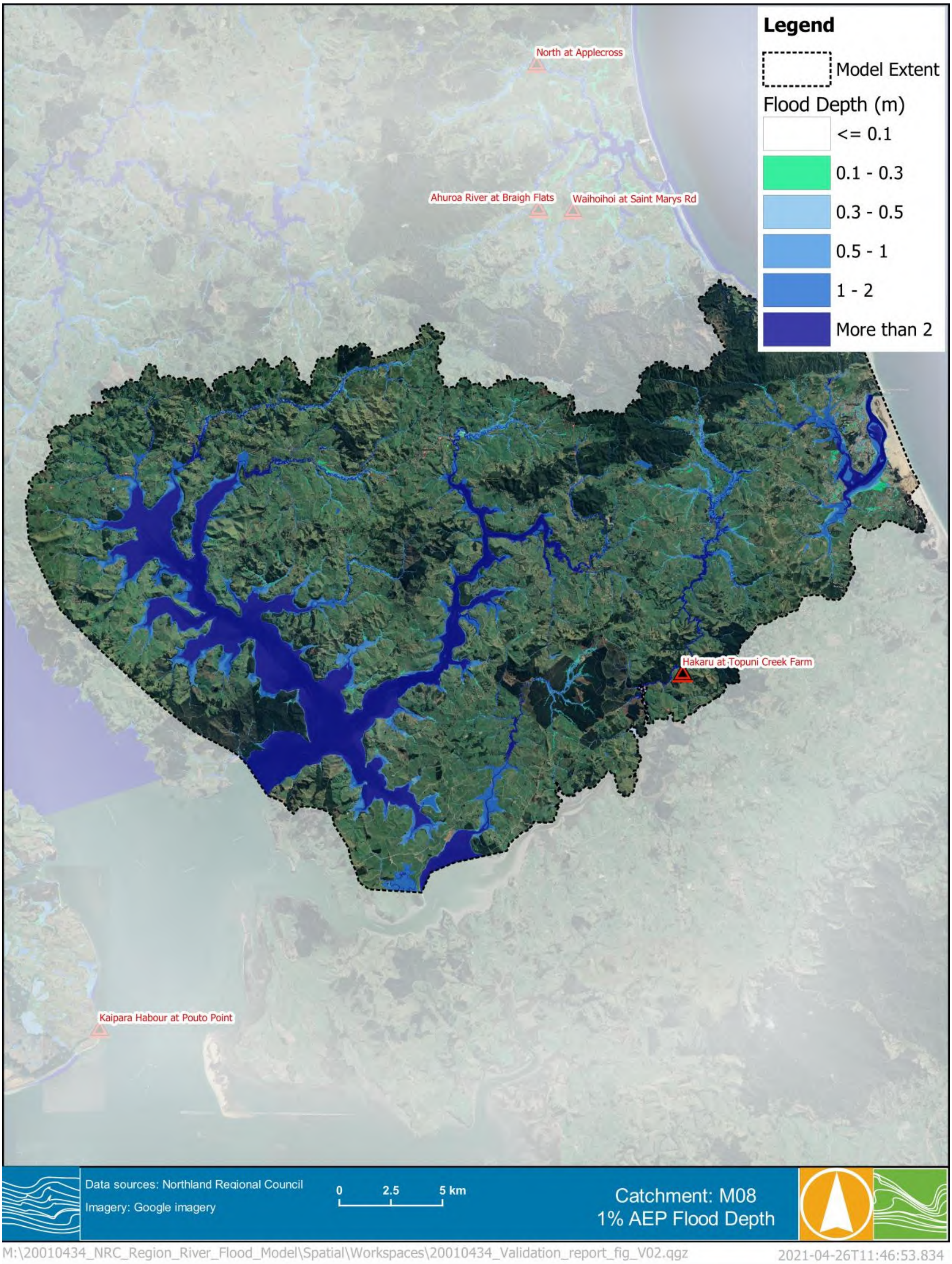

FIGURE 5-1 DESIGN MODELLING OF 1% FLOOD DEPTH

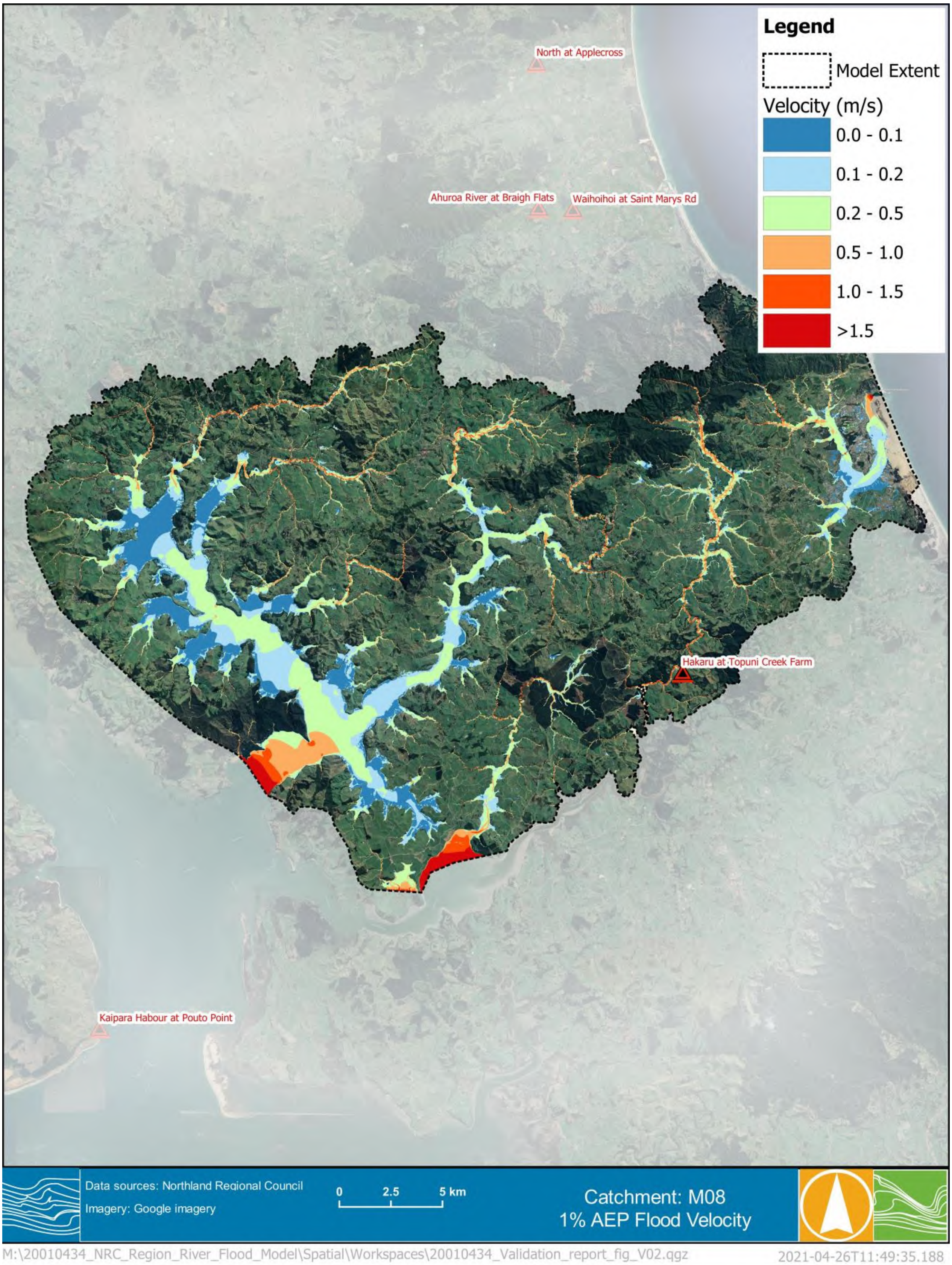

FIGURE 5-2 DESIGN MODELLING OF 1% AEP FLOOD VELOCITY

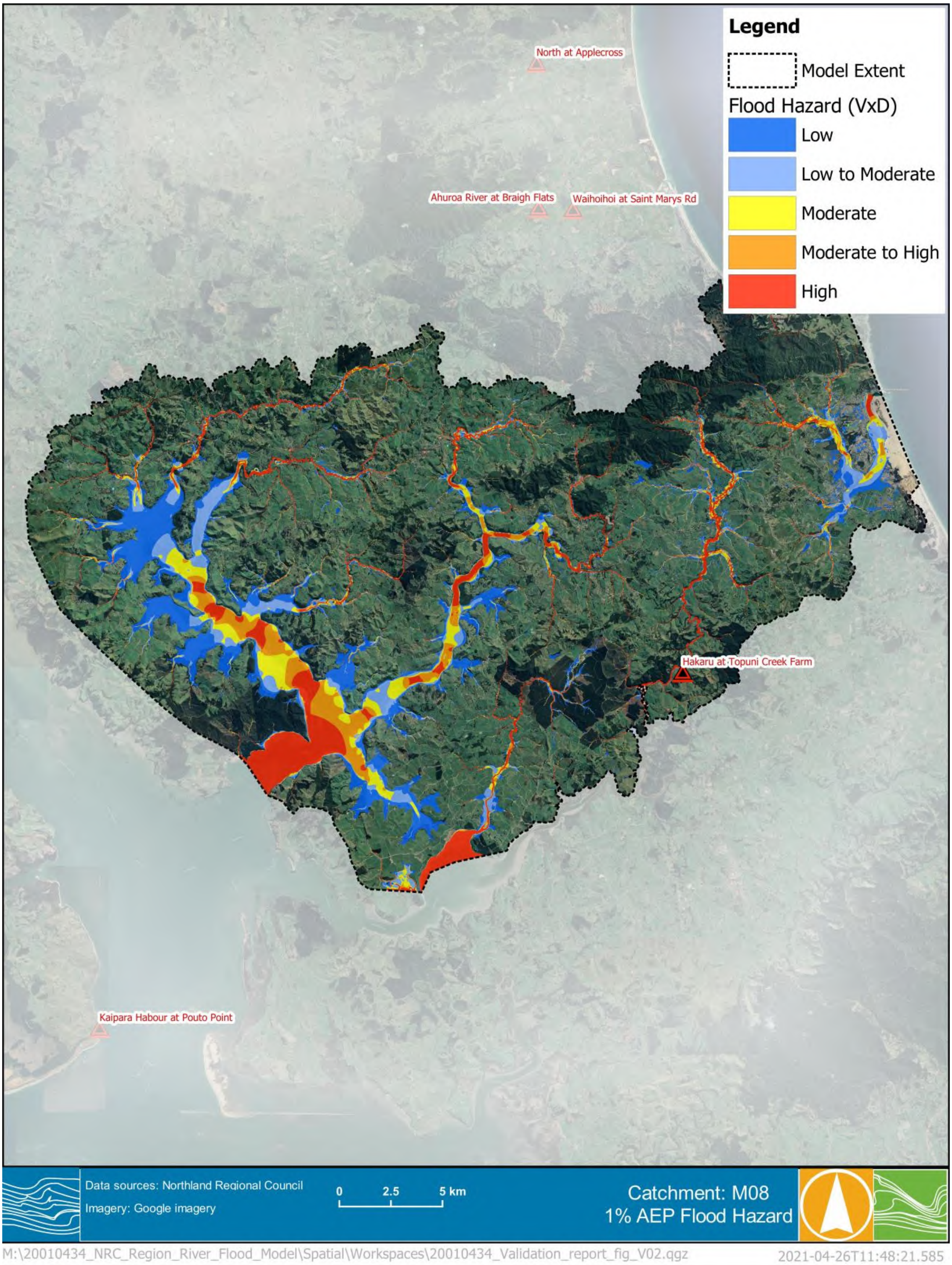

FIGURE 5-3 DESIGN MODELLING OF 1% AEP FLOOD HAZARD

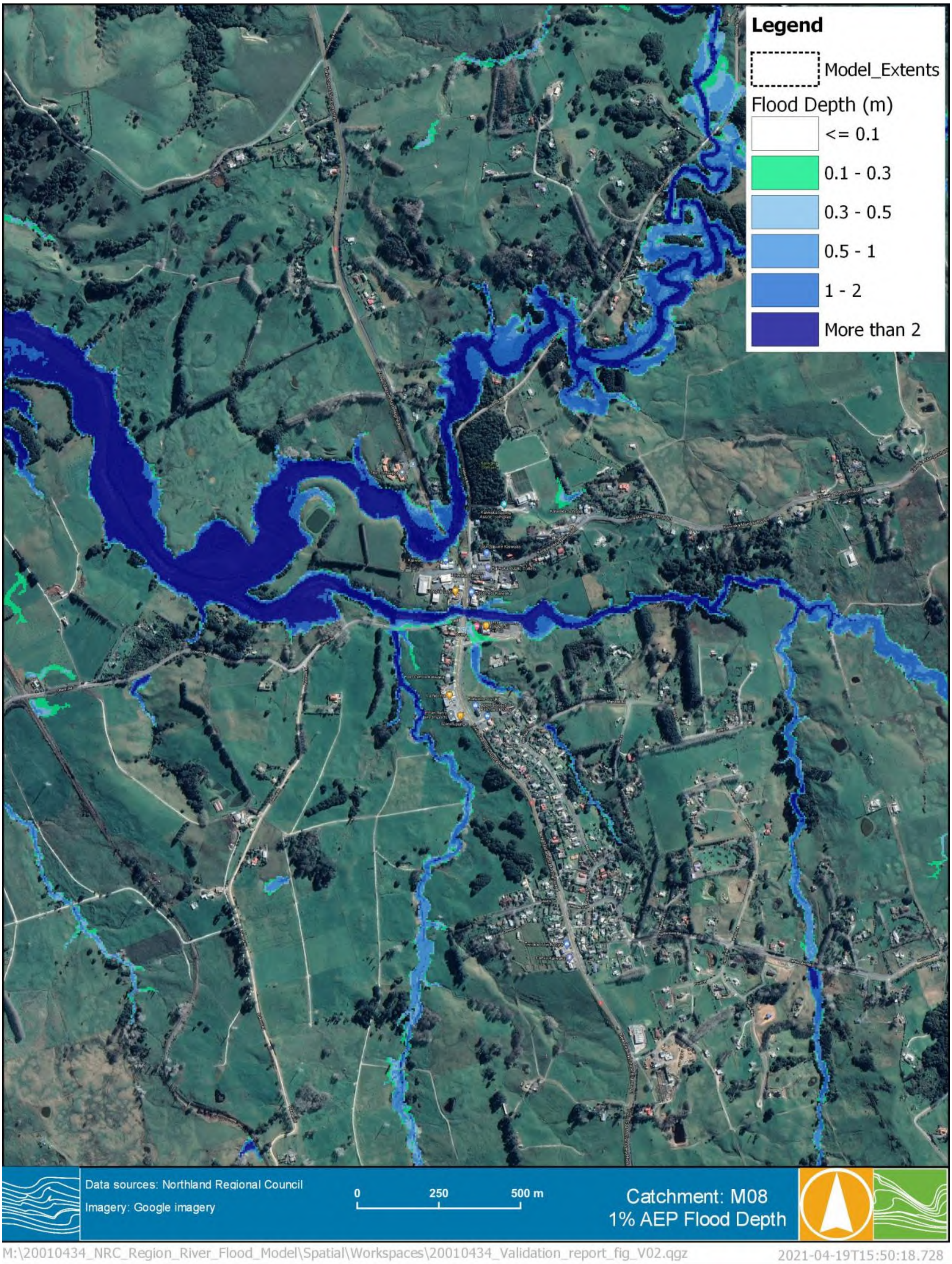

FIGURE 5-4 DESIGN MODELLING OF 1% AEP FLOOD DEPTH ZOOMED AT KAIWAKA

6 VERIFICATION OF DESIGN FLOWS

Flow lines were included at gauge locations in the hydraulic model as 2D Plot Outputs (2D PO) for calibration and design events. This allows flow hydrographs and peak flows to be extracted at these locations. Figure 6-1 displays the location of the Hakaru at Topuni Creek Farm gauge which is the only gauge found in the Hakaru catchment.

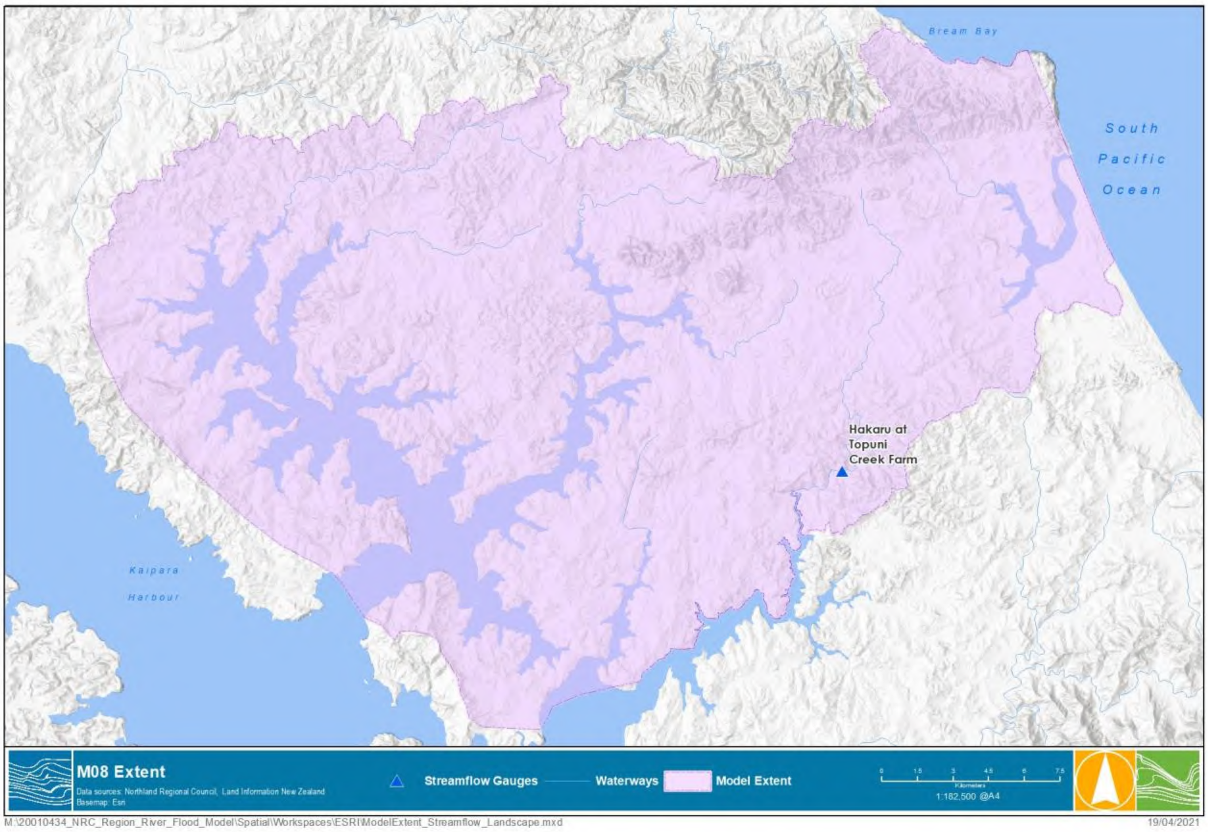

FIGURE 6-1 AVAILABLE STREAMFLOW GAUGES WITHIN HAKARU CATCHMENT

The modelled peak flow for the 1% AEP design flood was compared with hydrological estimates, including the Rational Method and SCS Method, as well as the historic maxima from streamflow gauge records.

6.1 Regional Estimation Methods

For catchments where a suitable streamflow gauge record was not available, additional estimation methods were used to provide design flow verification. These methods are based on empirical estimations using catchment area and design rainfall totals to estimate peak design flows. These methods were checked for each streamflow gauge location within the study area and are described below.

6.1.1 NIWA New Zealand River Flood Statistics Portal

The New Zealand River Flood Statistics portal[4] provides peak flood estimation at streamflow gauging stations and the entire river system in New Zealand completed in 2018. The design estimates can be extracted from the portal are:

- Flood Frequency estimates (at flow gauge).
- Flood Frequency estimates, noted as Henderson & Collins 2018 (at river reach).
- Rational Method HIRDS V3 (at river reach).

The flood frequency estimates given by the portal are determined using the Mean Annual Flow method developed by Henderson & Collins (2018)[5].

6.1.2 SCS method

The Soil Conservation Service (SCS) method, first developed by the U.S. Department of Agriculture's Soil Conservation Service, calculates peak flood flow based on rainfall and land-cover-related parameters. It is the recommended method for stormwater design in the Auckland region, providing a useful comparison. The peak flow equation is:

$Q = (P - Ia)^2 / (P - Ia + S)$

where:

- Q is run-off depth (millimetres).
- P is rainfall depth (millimetres)
- S is the potential maximum retention after run-off begins (millimetres).
- Ia is initial abstraction (millimetres), which is 5 millimetres for permeable areas and zero otherwise.

The retention parameter S (measured in millimetres) is related to catchment characteristics through:

$S = (1000/CN - 10)\ 25.4$.

The value of the curve number (CN) represents the run-off from 0 (no run-off) to 100 (full run-off) and it is influenced by soil group and land use. A CN value of 50 was used for the SCS estimation of this catchment.

The run-off depth (Q) is then converted to a peak flow rate using the SCS unit hydrograph.

---

[4] NIWA Flood Frequency tool, accessed via: https://niwa.co.nz/natural-hazards/hazards/floods
[5] Henderson, R.D., Collins, D.B.G., Doyle, M., Watson, J. (2018) *Regional Flood Estimation Tool for New Zealand Final Report Part 2*. NIWA Client Report

6.1.3 Rational Method

The Rational Method is widely used across both New Zealand and Australia. The equation is based on catchment area and design rainfall. The equation is:

$Q = C\ i\ A\ /3.6$

where:

- Q is the estimate of the peak design discharge in cubic metres per second
- C is the run-off coefficient
- i is rainfall intensity in mm/hr hour, for the time of concentration
- A is the catchment area in km^2.

6.2 Verification Results

Table 6-1 summarises the comparison of 1% AEP peak flow estimates with the modelled values at Hakaru at Topuni Creek Farm gauge in the Hakaru catchment and the differences between the estimation methods and modelled results can be visualised in Figure 6-2.

The Rational Method and the SCS method are only applicable for relatively small catchments, with the SCS method limited to 12 km².The catchment size for Hakaru at Topuni Creek Farm gauge is 82 km². These equations are therefore subject to great uncertainty in summarising the catchment characteristics.

At the Hakaru at Topuni Creek Farm gauge, the modelled design flow has a good match to the Henderson&Collins estimate from NIWA. Overall, the modelled peak flow at this gauge tends to sit within a reasonable range of the design flow estimates.

The use of empirical method estimations provides an additional degree of verification for streamflow gauges with less than 25 years of record. It is also noted that the calibration process identified uncertainty with the streamflow records for high flows. The uncertainty of high flow extrapolation at these gauges could result in further uncertainty of flow estimate methods that rely solely on streamflow gauge data.

TABLE 6-1 SUMMARY OF 1% AEP PEAK FLOW COMPARISON

Gauge location	Hydraulic model (m^3/s)		Records at gauge (m^3/s)		Empirical estimates (m^3/s)		NIWA Flood Frequency Tool 2018 (m^3/s)
	Critical duration	Modelled peak	Dec 2014 peak	Highest on record	SCS	Rational method	NIWA – H&C 2018
Hakaru at Topuni Creek Farm	24 hr	210.3	121.5	121.5	109.6	64.3	178

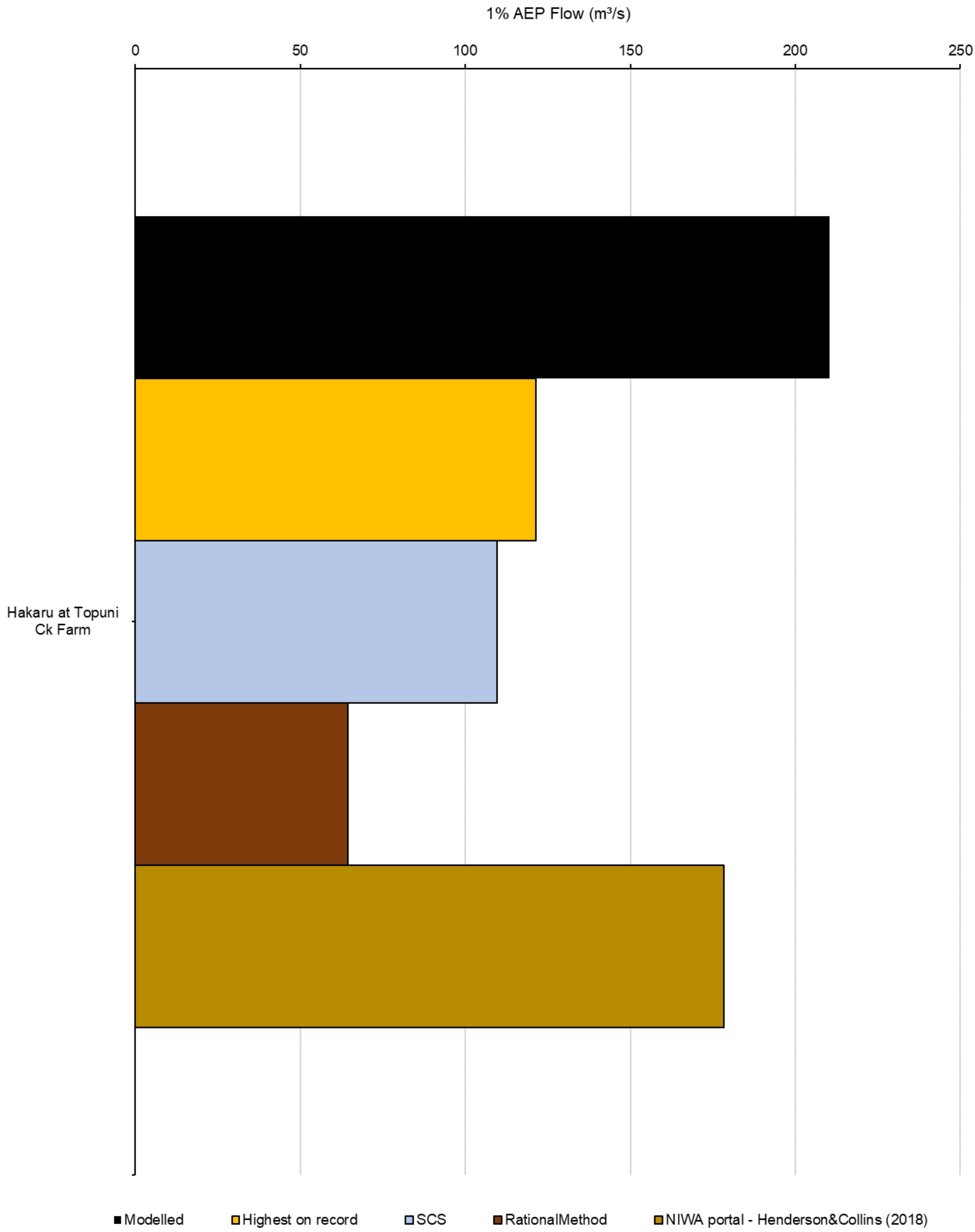

FIGURE 6-2 VERIFICATION OF DESIGN MODELLING RESULTS AGAINST HYDROLOGICAL ESTIMATES

7 SUMMARY

The Hakaru catchment model (M08) was calibrated to the December 2014 flood event. The design modelling of this catchment consisted of four storm durations (1-hour, 6-hour, 12-hour and 24-hour) for each design AEP (i.e. 1%, 2% and 10% AEP). Design flood extents and gridded results, including depth, water surface elevation, velocity and hazard were produced and delivered to NRC.

The modelled 1% AEP design flow at Hakaru at Topuni Creek Farm gauge was verified against several design flood estimation methods. The comparison of design flow provides a general validation check of the modelled results given the accuracy of these estimation methods can be constrained by the reliability of gauged flow records (where used) and general limitations with empirical design estimates. Overall, the modelled design flow at this streamflow gauge assessed within the study area provided a reasonable fit to design flow estimates.

When considering the scope and the scale of this project, the current modelling results are considered fit for use. Modelling outputs can be used to identify flood hazard and potential flood risk. It can also inform planning decisions, infill flood mapping between detailed flood studies and provide a basis for broad emergency management exercises.

Appendix D – Flood Modelling Correspondence

From:	Evan Peters
Sent:	Monday, 29 July 2024 1:30 pm
To:	Bertrand F. Salmi
Cc:	Phil Fairgray; Mike Bates
Subject:	Re: Mangawhai East plan change - Stormwater catchment boundary conditions.
Follow Up Flag:	Follow up
Flag Status:	Flagged

Very helpful. Thank you!

Evan Peters
CPEng (civil), CMEngNZ
DIRECTOR / ENGINEER

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From: Bertrand F. Salmi <Bertrand.Salmi@watertechnology.co.nz>
Sent: Monday, 29 July 2024 1:29 pm
To: Evan Peters <evan@aspireconsulting.co.nz>
Cc: Phil Fairgray <phil@aspireconsulting.co.nz>; Mike Bates <mike@aspireconsulting.co.nz>
Subject: RE: Mangawhai East plan change - Stormwater catchment boundary conditions.

Hi Evan,

The final model was based on NZVD, with the following level adopted:

- Without climate change: 1.311m RL at Marsden Point:
  - I believe this is 1396mm OTP
- With climate change: 2.511m RL at Marsden Point.

The 1.2m allowance for sea level rise was only included in the climate change scenario.

I trust this helps.

Ngaa mihi

Bertrand F. Salmi
Principal Stormwater Specialist
(Mātanga mātāmua wai āwha (in te reo))

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From: Evan Peters <evan@aspireconsulting.co.nz>
Sent: Monday, July 29, 2024 12:55 PM
To: Bertrand F. Salmi <Bertrand.Salmi@watertechnology.co.nz>
Cc: Phil Fairgray <phil@aspireconsulting.co.nz>; Mike Bates <mike@aspireconsulting.co.nz>
Subject: Mangawhai East plan change - Stormwater catchment boundary conditions.

Hi Bertrand

Thank you for your time on the phone earlier. As discussed, we are preparing a Stormwater management plan for a large site which will be heading to Plan Change in the near future.

Initially what I would need clarified is that the boundary conditions proposed in your Hydraulic Modelling Report (M08), dated May 2021 includes an additional 1.2m for sea level rise at the coastal boundary of the Mangawhai Estuary.

Therefore the outlet boundary condition would be 1396mm + 1200mm = 2596mm.

4.2.4 Boundaries

As the Hakaru catchment is a coastal catchment, a static tail-water (i.e. 2161 mm OTP) outflow boundary based on the 2 year ARI tide level[3] at Pouto Point was applied at the western downstream boundary and a static tail-water (i.e. 1396 mm OTP) outflow boundary based on the 2 year ARI tide level at Marsden Point was applied at the eastern downstream boundary for the design modelling. A 1.2 m sea level rise was adopted for climate change runs based on the project brief. In the calibration modelling, both of these boundaries were stage-discharge boundary (i.e. type HQ).

There is no upstream inflow coming from upstream catchments applied in this catchment model.

As discussed, I will send another email around other items which we may need guidance/assistance on.

Evan Peters
CPEng (civil), CMEngNZ
DIRECTOR / ENGINEER

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