TE TUPU NGĀTAHI
SUPPORTING GROWTH

Pukekohe Transport Network
Assessment of Flood Hazard Effects

12/09/2023

Version 1.0

WAKA KOTAHI NZ TRANSPORT AGENCY

New Zealand Government

Document Status

Responsibility	Name
Author	Justin Kirkman
Reviewer	Roger Seyb

Revision Status

Version	Date	Reason for Issue
1.0	12/09/2023	Final for lodgement

Table of Contents

Appendices

Table of Tables

Table of Figures

Glossary of Defined Terms and Acronyms

AEE	Assessment of Effects on the Environment report
AEP	Annual Exceedance Probability
ARI	Average Recurrence Interval
AT	Auckland Transport
AUP:OP	Auckland Unitary Plan: Operative in Part
CEMP	Construction Environmental Management Plan
FUZ	Future Urban Zone
KiwiRail	KiwiRail Holdings Limited
NIMT	North Island Main Trunk railway track
NoR	Notice of Requirement
RMA	Resource Management Act 1991
SMAF	Stormwater Management Area: Flow
SRP	Sediment Retention Pond
Te Tupu Ngātahi	Te Tupu Ngātahi Supporting Growth Alliance
Waka Kotahi	Waka Kotahi New Zealand Transport Agency

Executive Summary

This report provides an assessment of flood hazard risks associated with the construction, operation and maintenance of the Pukekohe Transport Network (the **Project**).

Flooding is a natural hazard and as a district planning matter has therefore been considered as part of the Notices of Requirement (**NoRs**) for the Project. The works required for the Project have the potential to lead to flooding effects and an assessment is provided to demonstrate that these effects can be appropriately avoided, remedied or mitigated in the future, closer to the construction of the Project. There will be a subsequent process for seeking regional resource consents which will address a wider range of potential stormwater quantity and quality effects.

In the context of this assessment, flood hazard effects may occur during the construction and operation of the Project.

The assessment of flooding effects for the Project has involved the following steps:

- Desktop assessment to identify potential flooding locations;
- Modelling of the pre-development terrain with Maximum Probable Development (**MPD**) and future 100 year Average Recurrence Interval (**ARI**) plus climate change rainfall;
- Modelling of two climate scenarios, one allowing for 2.1 degrees of temperature increase and one for 3.8 degrees of temperature increase. The higher climate change scenario has been used to undertake a sensitivity analysis; and
- Inspection and review of flood depths at key locations such as crossings and where there is more vulnerable development e.g. dwellings.

While stormwater effects apart from flooding are not assessed (as these are part of future consenting processes), provision is made for the future mitigation of potential stormwater effects (stormwater quality and retention/detention) by identifying the space required for stormwater management devices (for example drainage channels and stormwater wetlands) and incorporating sufficient land for that purpose into the proposed designation boundaries. The assessment considers that flooding effects will be subject to further evaluated in accordance with the NoR conditions at a future detailed design stage.

Existing and Likely Future Environment

The existing environment surrounding most NoRs is presently rural with farming activity and rural lifestyle blocks throughout the catchments. The land cover is mostly grass covered grazing areas with sparse tree coverage. The streams, creeks and rivers are largely unmodified with some farm drains in the flatter parts of the catchment to facilitate farming practices. The future environment will likely intensify with urban land uses and maintained natural stream and floodplain areas . Requirements for detention and retention are expected for the future urban developments with water sensitive urban design and low impact design principles leading to more wetlands, swales and raingardens throughout each catchment.

Methodology

This project is an assessment on whether the designation area is large enough for a future road design to meet the proposed conditions. With this target in mind, flood modelling has been limited to using the pre-development state only (2.1º and 3.8 º climate change scenarios). The result of this modelling was used to identify areas where the flood hazard is presently a risk and where the

designation may need widen to consider room for mitigation. Assessment of flood level increases from the road design have not been reviewed as the future design can be changed to include larger span bridges, larger diameter culverts or additional culvert barrels without affecting the designation.

the Project traverses four major stormwater catchments: Ngakoroa Stream, Oira Stream, Whangapouri Stream and Tūtaenui Stream. The results from flood results in each of these models were categorised in to the existing and likely future flood hazard ratings from negligible to low, moderate and high as noted in below. Where the risk of flood hazard is identified a recommendation has been made to achieve the outcomes of the proposed consents, the designation is then checked to test if the recommendations would fit within the proposed designation.

Flood depth / land use	Less Vulnerable e.g. open space, rural land (not in FUZ)	Moderately Vulnerable e.g. commercial and industrial properties	Highly Vulnerable e.g. dwellings, educational facilities
Negligible (flood depth < 0.05 m on land and freeboard >0.5m to buildings)			
Low (flood depth 0.05 m to 0.15 m on land and freeboard <0.5m to buildings)			
Moderate (flood depth 0.15 m to 0.5 m on land and No freeboard to buildings)			
High (flood depth > 0.5m on land and No freeboard to buildings			

While stormwater effects apart from flooding are not assessed (as they will be assessed during a future regional consent process), provision is made for the future management of potential stormwater effects (stormwater quantity and stormwater quality) by identifying the space required for stormwater management devices (SWMDs, i.e. treatment swale and wetlands) and incorporating land for that purpose into the NoRs. In identifying the land required for these devices, preliminary sizing and siting has been undertaken and space allowed for constructing these devices based on the following assumptions:

- Wetlands in the upper half of the catchment are sized to attenuate 100-year peak flows from the transport corridor on a 10% of the total catchment basis.
- Wetlands in the lower half of the catchment would likely produce coincident flood effects and attenuation is not desirable. These are sized on a 3% of the total catchment basis.
- Allowance is made for wetland attenuation storage and hydraulic gradients from corridor inlet to discharge point (typically a minimum of 2.0 to 2.5m vertically).
- Wetland geometry and footprints were modelled to determine the required cut and fill and a 15m buffer added for construction purposes and maintenance access.

- A minimum 6m buffer is provided around the corridor earthworks extents to provide space for construction purposes and allow for works such as drainage channels and culvert inlets/outlets and flexibility in the vertical alignment.
- Diversion channels are identified where they are needed to prevent upstream flooding.
- Roadside swales are sized to take small local catchments only no greater than 4 hectares in size. These swales can provide treatment, detention, retention and attenuation (if required).

Construction Effects

There may be some increases to flood hazards during the construction phase, primarily due to the temporary staging platforms required to construct new bridges and temporary diversions to construct new culverts. However, the details of the construction approach will be confirmed at detailed design. It is expected that the works can be carried out in a way that will appropriately manage the risk, and this can be defined through flood risk mitigation measures captured in the Construction Environmental Management Plan (CEMP). Flood hazard is therefore a matter that is recommended to be addressed in the CEMP and included as a condition of the proposed designations.

Operational Effects

Flood hazard risks from the operation of the Project may result from changes to

- The flood freeboard to existing habitable buildings;
- Overland flow paths and flood prone areas;
- Flood levels on developable land (in the FUZ);
- The ability to access property by residents and emergency vehicles.

Specific upstream properties and terrain features of each NoR alignment identified as having potential flood risk are set out in the table below. Existing buildings and land zoned FUZ are assumed to be highly vulnerable in the future. Moderately vulnerable land uses consider both existing and future commercial / industrial buildings and roads, including the roads proposed by each NoR Project. Less vulnerable land includes both existing non-dwelling occupied land and land zoned rural residential.

Specific measures are recommended for each NoR as set out in the table below. These can be met through flood hazard outcomes that are recommended as conditions for each NoR (set out under the table).

NoR	NoR features	Existing and Likely Future Flood Risk	General Recommendations
NoR1	New transport corridor in greenfield area. Parts of the corridor are within significant floodplains, require stream crossings and cross the North Island Main Railway Line.	Some moderate existing risk to land and negligible future risk at most locations. High existing and future risk in the Ngakoroa floodplain presently zoned as FUZ.	• Size culverts and bridges to meet proposed designation conditions on flood hazard outcomes. • No attenuation in wetlands, attenuation will increase flow coincidence downstream. • Provide diversion channels at the toe of fill embankments to prevent ponding. • Maintain 1200mm freeboard to new bridge soffits using the 100-year ARI flood level with 3.8º Climate change hydrology.

NoR	NoR features	Existing and Likely Future Flood Risk	General Recommendations
NoR2	A new and upgraded transport corridor, located in greenfield area. Parts of the corridor are located in significant floodplains, a number of stream crossings are required , one crossing of the North Island Main Railway Line. The upgrade of Sim Road (south)is located on the existing terrain ridge.	Two locations with a moderate existing and future risk to dwellings with <500mm freeboard and rural land with >0.5m depth. Otherwise negligible existing and future risk	• Size culverts and bridges to meet proposed designation conditions on flood hazard outcomes. • No attenuation in wetlands in the lower half of the Ngakoroa and Oira Streams. • Attenuation for the 10yr and 100yr where wetlands are located in the upper half of the Ngakoroa and Oira Streams • Attenuation in wetlands located within the Whangapouri Stream catchment. • Provide diversion channels at the toe of fill embankments to prevent ponding. • Offset the flood volume displaced by filling in the floodplain with an equivalent volume of excavation within the floodplain. • Maintain 1200mm freeboard to new bridge soffits using the 100-year ARI flood level with 3.8º Climate change hydrology.
NoR3	Two short link roads connecting Paerata Railway Station (Paerata Station connection segment) and SH22 to the NoR2 alignment (Sim to Sim Connection segment). No floodplains or stream crossings.	Negligible risk to FUZ land, no existing buildings in the vicinity of the NoR Negligible existing and future risk.	• The Paerata Station Connection will connect to the station access road. A new culvert will be required at this flowpath crossing and be sized to achieve the designation condition headwater effects. • No flooding recommendations for the Sim to Sim Connection as this follows the terrain crest and has no flood water interaction.
NoR4	New transport corridor in greenfield area. . Parts of the corridor are located within floodplains at the north west extent around the NIMT. Multiple stream crossings are required.	Existing moderate risk to a dwelling, with freeboard <0.5m. Future low to negligible risk to dwellings in FUZ.	• Size culverts and bridges to meet proposed designation conditions on flood hazard outcomes. • Attenuation for the 10yr and 100yr events in the Whangapouri, Ngakoroa and Oira Stream catchments • Provide diversion channels at the toe of fill embankments to prevent ponding. • Offset the flood volume displaced by filling in the floodplain with an equivalent volume of excavation within the floodplain. • Maintain 1200mm freeboard to new bridge soffits using the 100-year ARI flood level with 3.8º Climate change hydrology.
NoR5	Upgrade to Pukekohe East Road and Golding Road. with two culvert extensions. New connection between Golding Road Svendsen Road spanning Station	Mostly moderate risk to FUZ land, moderate risk to rural land. Some high risk vulnerable existing dwellings. Future	• Size culverts and the bridge over the NIMT railway to meet proposed designation conditions on flood hazard outcomes. • Avoid lifting the crown of the road along Golding Road to prevent adverse effects upstream.

NoR	NoR features	Existing and Likely Future Flood Risk	General Recommendations
	Road and the NIMT. Alignment is located in the floodplain at the south west extent around Station Road.	dwellings in the FUZ may have a moderate risk unless built on elevated platforms.	• Attenuation for the 10yr and 100yr in the Whangapouri and Tatuanui Stream catchments • Provide diversion channels at the toe of fill embankments to prevent ponding. • Offset the flood volume displaced by filling in the floodplain with an equivalent volume of excavation within the floodplain. • Maintain 600mm freeboard to the new bridge soffit over the NIMT rail using the 100-year ARI flood level with 3.8º Climate change hydrology.
NoR6	Individual pockets of land subject to NoR to facilitate road widening for active modes. The parcels designated are generally not located in the flood plain.		• Existing designation conditions to apply. Pockets of additional land in this NoR shall not require new conditions.
NoR7	Upgrade to Helvetia Road, Road widening along the existing alignment with one culvert extension. A new section of transport corridor in greenfield area connecting Helvetia Road, Beatty Road, Butcher Road and Paerata Road. Alignment crosses small catchment channels only. Floodplain located towards the southern extent of the corridor at Helvetia Road.	Mostly negligible existing and future risk. One existing dwelling identified as high risk.	• Size culverts and bridges to meet designation conditions on flood hazard outcomes. • Retain culvert sizes at the existing culverts near the Glenbrook Rail Line and Butcher Road to maintain the same flowrate and not cause new or exacerbate upstream flood risk. • Attenuation for the 10yr and 100yr in the Whangapouri Stream catchment
NoR8	Upgrade to Pukekohe East Road for walking and cycling and an upgrade to Mill Road to SH1 for additional vehicles lanes and walking and cycling. .	Negligible risk to FUZ land, negligible risk to rural residential land and moderate risk to highly vulnerable existing dwellings	• Extend culverts at the same diameter and replace culverts at the same diameter. • Avoid lifting the crown of the road along Mill Road to prevent adverse effects upstream. Or lowering the road crown to cause effects downstream • Attenuation for the 10yr and 100yr in the Ngakoroa and Tatuanui Stream catchments

The following flood hazard outcomes (conditions) are recommended for all NoRs:

- No increase in flood levels in a 1% AEP event (3.8º climate change adjusted) for existing authorised habitable floors that are already subject to flooding or have a freeboard less than 500mm;
- No more than a 10% reduction in freeboard in a 1% AEP event (3.8º climate change adjusted) for existing authorised habitable floors with a freeboard of over 500mm;
- No increase in 1% AEP flood levels (3.8º climate change adjusted) for existing authorised community, commercial, industrial and network utility building floors that are already subject to flooding;
- No more than a 10% reduction in freeboard in a 1% AEP event (3.8º climate change adjusted) for existing authorised community, commercial, industrial and network utility building floors;
- No increase of more than 50mm in flood level in a 1% AEP event (3.8º climate change adjusted) on land zoned for urban or future urban development where there is no existing dwelling;
- No new flood prone areas; and
- No more than a 10% average increase of flood hazard (defined as flow depth times velocity) for main access to authorised habitable dwellings existing at time the Outline Plan is submitted. The assessment shall be undertaken for the 50%, 20%, 10% and 1% AEP rainfall events (3.8º climate change adjusted).
- Compliance shall be demonstrated in the Outline Plan, which shall include flood modelling of the pre-Project and post-Project 10% and 1% AEP flood levels (for Maximum Probable Development land use and including 3.8º climate change adjustment).
- Where the above outcomes can be achieved through alternative measures outside of the designation such as flood stop banks, flood walls, raising existing authorised habitable floor level and new overland flow paths or varied through agreement with the relevant landowner, the Outline Plan shall include confirmation that any necessary landowner and statutory approvals have been obtained for that work or alternative outcome.

The assessment concludes that there is unlikely to be significant additional risk of flood effects during construction. Proposed works will be located outside of flood plains and overland flow paths as far as practicable. Where this is not possible, potential flooding effects will be managed through the flood risk mitigation measures set out in the CEMP for existing high flood hazard areas. For those areas where there is an increased flood risk, mitigation measures such as carrying out construction works during dry weather and using diversion drains will be adequate to manage this risk and will be identified through the CEMP.

A number of potential management and mitigation measures have been provided to manage operational effects at the future detailed design stage. In most locations the new alignment will pass through greenfield land and new drainage infrastructure is required. In these cases, a bridge or a culvert is recommended, the size of which can be determined at a later design stage when resource consents are sought. Where the alignment passes along a ridge such as the upgrade of Sim Road or Cape Hill Road, no drainage is required to manage flooding. Where the NoR utilises an existing road with existing drainage, the recommendation is to upgrade culverts to alleviate upstream flood issues while making sure not to cause new or exacerbate existing downstream flood issues.

Wetlands and swales will provide 10-year and 100-year ARI attenuation in the upper half of their larger catchment and avoid attenuation in the lower half. This will maintain the peak flowrates in the upper catchment and avoid peak flow coincidence effects in the lower reaches. Bridges are recommended to maintain 1200mm freeboard to the new bridge soffit using the 100-year ARI flood

level with 3.8º Climate change hydrology. These recommendations have been captured through the series of outcomes that are included as conditions on the NoRs to maintain acceptable flood effects.

1 Introduction

1.1 Purpose and scope of this Report

This flooding assessment has been prepared to inform the Assessment of Effects on the Environment (**AEE**) for nine Notices of Requirement (**NoRs**) being sought by Waka Kotahi NZ Transport Agency (**Waka Kotahi**) and Auckland Transport (**AT**) for the Pukekohe Transport Network under the Resource Management Act 1991 (**RMA**).

This report considers the actual and potential effects associated with the construction and operation of the projects on the existing and likely future environment as it relates to flood effects and recommends measures that may be implemented to avoid, remedy and/or mitigate these effects.

The key matters addressed in this report are as follows:

- Identify and describe the context of the Pukekohe Transport Network area.
- Identify and describe the actual and potential flooding effects of each Project corridor.
- Recommend measures as appropriate to avoid, remedy, or mitigate actual and potential flooding effects (including any conditions/management plan required) for each Project corridor.
- Present an overall conclusion of the level of actual and potential flooding effects for each Project corridor after recommended measures are implemented.

This report should be read alongside the AEE, which contains further details on the history and context of the project. The AEE also contains a detailed description of works to be authorised within each NoR, and the typical construction methodologies that will be used to implement this work. These have been reviewed by the author of this report and have been considered as part of this assessment of flood effects. As such, they are not repeated here. Where a description of an activity is necessary to understand the potential effects, it has been included in this report for clarity.

2 Pukekohe Transport Network Overview

The Pukekohe Project comprises nine NoRs through Pukekohe, Paerata and Drury. A concept design has been undertaken for the NoRs. The design will be further refined through future phases of the Project and will be undertaken within the scope of the designation conditions and future resource consent conditions. The detailed design of the Project will be undertaken prior to construction and reflected in the Outline Plan(s) which will be submitted to Council as set out in s176A of the RMA.

The Pukekohe Transport Network encompasses eight transport projects for the Pukekohe, Paerata and Drury West areas. Auckland Transport has lodged six Notices of Requirement with Auckland Council and Waka Kotahi has lodged two Notices of Requirement with Auckland Council and one with Waikato District Council. The Pukekohe Transport Network includes provision for improved walking and cycling, public transport, and general traffic connections.

For the purposes of this assessment, Mill Road and Pukekohe East Road Upgrade (that includes works within Auckland Council and Waikato District Council) is referred to as one transport project, despite being submitted as two separate NoRs. The matters relevant to each jurisdictional area are addressed through this assessment.

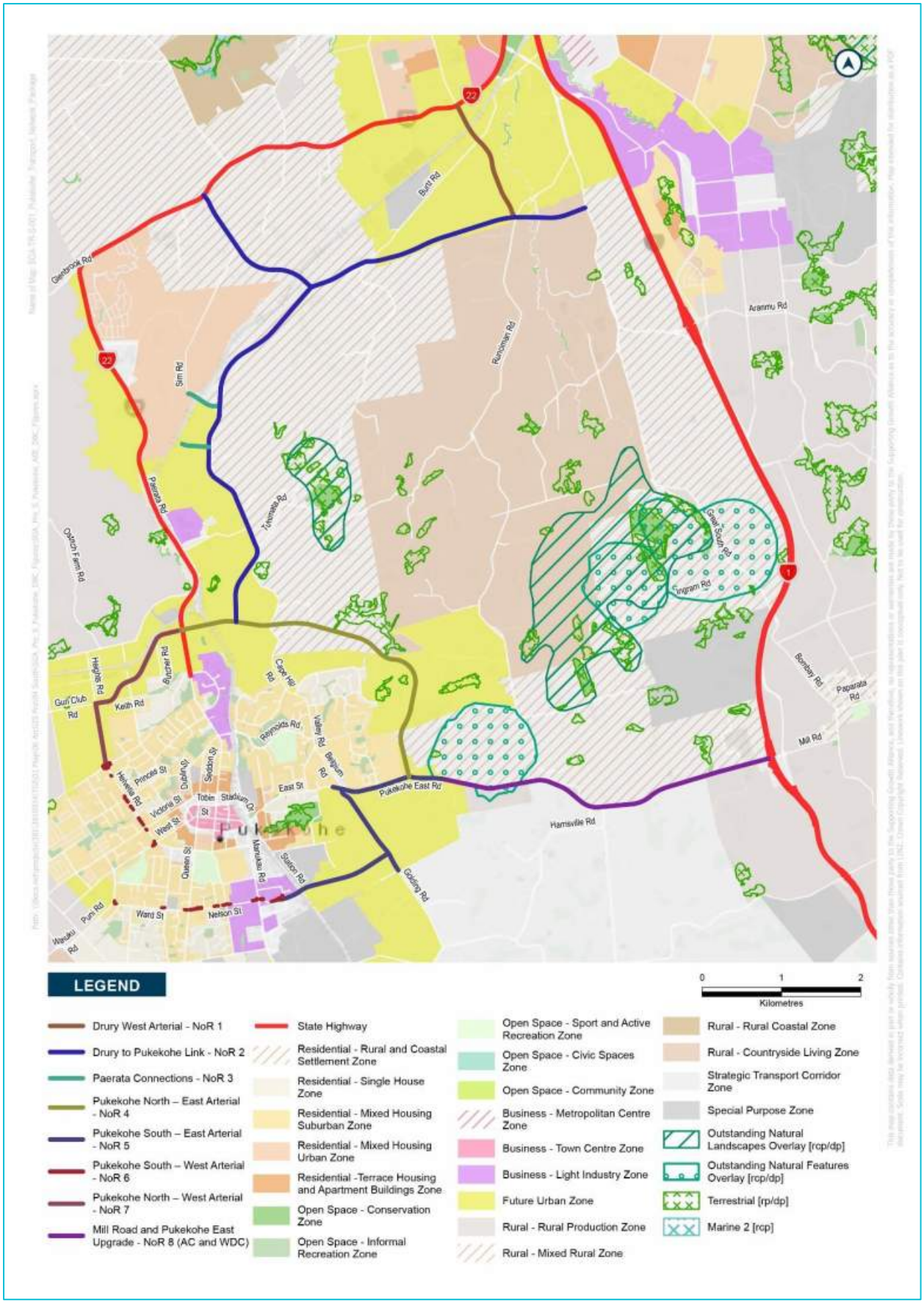


Figure 2-1: Pukekohe Transport Network

Table 1: Pukekohe Transport Network Summary

NoR	Project	Requiring Authority	Description
1	**Drury West Arterial**	AT	• NoR 1 is a 1.6km new transport corridor extending south from the intersection of SH22 and Jesmond Road to the proposed Drury to Pukekohe Link (NoR 2). • It connects Drury West Town Centre, Drury West Rail Station and provides access to the strategic transport network including SH1 and SH22. It connects with Burtt Road and to Runciman Road in the south. • This new transport corridor improves local connectivity in Drury West and the wider area to centres, employment and rail stations. • Between SH22 and Burtt Road, the proposed cross section is a four lane arterial 30m wide. This includes two lanes for PT and walking and cycling facilities on both sides of the corridor. • South of Burtt Road a two lane arterial with a 24m wide cross section is proposed with two lanes for general traffic and walking and cycling facilities on both sides of the corridor. • Three new bridges are proposed over existing NIMT rail line, and two tributaries of the Ngakoroa Stream. • Three new stormwater wetlands are proposed and new culverts and swales.
2	**Drury-Pukekohe Link**	Waka Kotahi	• NoR 2 provides a north south strategic corridor with two general traffic lanes proposed and active transport facilities on one side of the corridor. The total length of the NoR is 10.6km. • NoR 2 is split into the following four segments.
	South Drury Connection segment		• South Drury Connection segment provides a new connection extending from Great South Road in the east at the proposed SH1 Drury South Interchange (a proposed Waka Kotahi SH1 project). The alignment is along the edge of the FUZ to Burtt Road in the west. • It provides a strategic connection improving local access in Drury West, provides resilience in the transport network supporting SH22 and SH1, provides direct connectivity to the proposed Drury South Interchange and supports the proposed strategic active modes corridor. • A 24m wide cross section is proposed with two lanes for general traffic, with walking and cycling on one side of the corridor. • Three new bridges are proposed over tributaries of the Ngakoroa Stream. • Three stormwater wetlands are proposed and new culverts and swales.

NoR	Project	Requiring Authority	Description
	SH22 Connection segment		• Connecting with the South Drury Connection and Drury-Paerata Link segments, this connection provides a strategic connection between State Highway 1 and State Highway 22. • It improves access between Drury West and Paerata, provides resilience in the transport network supporting SH22 and SH1, provides direct connectivity to the proposed Drury South Interchange and supports the proposed strategic active modes corridor. • It includes the new transport corridor and a partial upgrade of Sim Road (north). • A 24m wide cross section is proposed with two lanes for general traffic and walking and cycling on one side of the corridor. • Two new bridges are proposed over the Oria Creek and NIMT. • Two stormwater wetlands are proposed and new culverts and swales.
	Drury-Paerata Link segment		• Drury-Paerata Link segment is a new corridor connecting the segments of South Drury Connection, SH22 Connection and Paerata Arterial. This segment extends from an intersection with Burtt Road in the north, to the Paerata Arterial segment in the south. • It provides connectivity between Drury and Paerata providing a strategic connection between two areas of future urban development. • A 24m wide cross section is proposed with two lanes for general traffic and walking and cycling on one side of the corridor. • Two bridges are proposed over tributaries of the Oira Creek. • Three stormwater wetlands are proposed and new culverts and swales.
	Paerata Arterial segment		• Paerata Arterial segment is located along the eastern edge of Paerata FUZ. It connects with Paerata Connections NoR 3 at the northern extent and to the proposed Pukekohe North East Arterial NoR 4 at its southern extent. • It includes an upgrade of part of Sim Road (south), Tuhimata Road and a new section of transport corridor. • It increases connectivity to Paerata FUZ, Paerata Rail Station and Pukekohe Town Centre. • A 24m wide cross section is proposed with two lanes for general traffic and walking and cycling on one or both sides of the corridor. No bridges are proposed. • Six stormwater wetlands are proposed (one shared with NoR 4 and one shared with NoR 3) and new culverts.
3	**Paerata Connections**	AT	• The Paerata Connections provide two connections from the existing Sim Road (south) proposed to be upgraded by NoR 2 to the Paerata Rail Station and Paerata Rise development. • The connections provide the primary east-west connections for all modes in Paerata.

NoR	Project	Requiring Authority	Description
			• NoR 3 has includes two segments: • The **Sim to Sim Connection segment** provides a new connection of approximately 400m between the two extents of Sim Road over the railway (NIMT). • The **Paerata Rail Station Connection segment** provides a new transport corridor approximately 330m in length between the Paerata Rail Station (KiwiRail designation 6311 currently under construction) and NoR 2. • A 24m wide cross section is proposed with two lanes for general traffic and walking and cycling on both sides of the corridor. • One bridge is proposed over the NIMT to connect the two extents of Sim Road for the Sim to Sim Connection segment. • One new stormwater wetland is proposed (shared with NoR 2) and a new culvert.
4	**Pukekohe North-East Arterial**	AT	• The Pukekohe North-East Arterial is an approximately 4km new transport corridor from SH22 in the northwest connecting to Pukekohe East Road in the south east. • It connects the strategic corridors at SH22 (at the northern extent of the Pukekohe North West Arterial NoR 7), the Drury to Pukekohe Link NoR 2 and Pukekohe East Road proposed to be upgraded by NoR 5 and NoR 8. • Its primary function is for general traffic, freight, an active mode links between future neighbourhoods and alleviating traffic on existing roads at Cape Hill Road and Valley Road. • A 24m wide cross section is proposed with 2 lanes for general traffic and walking and cycling proposed on both or one side of the corridor. • Seven bridges are proposed over the Whangapouri Creek, the NIMT, and other unnamed streams and tributaries. • Six new stormwater wetlands are proposed and new culverts.
5	**Pukekohe South-East Arterial**	AT	• The Pukekohe South-East Arterial upgrades part of Pukekohe East Road, Golding Road and provides a new connection between Golding Road (from north of Royal Doulton Drive) and across Station Road and the NIMT to the existing industrial development on Crosbie Road to Svendsen Road. • It is a primary east-west connection to assist in redirecting general traffic and freight away from the Pukekohe town centre to provide additional resilience to the wider network. • A 24m wide cross section is proposed with two lanes for general traffic with walking and cycling on the southern side of the corridor on Pukekohe East Road and on both sides for the remainder of the corridor. • One bridge is proposed crossing Station Road and the NIMT. • Five new stormwater wetlands are proposed and new and upgraded culverts.

NoR	Project	Requiring Authority	Description
6	**Pukekohe South-West Upgrade**	AT	• Pukekohe South West Arterial involves the re-allocation of road space within the existing road corridor for a bi-directional cycle way and footpath upgrade. The proposed designation is limited to specific intersections and driveways to safely accommodate active mode facilities. The existing road reserve is to be utilised where possible retaining a 20m wide cross section with 2 lane general traffic, walking on both sides and a bi-directional cycleway on one side of the corridor. • No bridges or stormwater wetlands are proposed.
7	**Pukekohe North-West Arterial**	AT	• Pukekohe North-West Arterial provides a connection between Helvetia Road in the southwest and SH22 in the northeast. It upgrades part of Helvetia Road, utilises part of Keith Road (a paper road), and forms a new connection between Beatty Road and Butcher Road to SH22 – connecting to the Pukekohe North East Arterial NoR 4. • It provides an alternative connection for all modes travelling north to south in west Pukekohe assisting in redirection of general traffic away from the town centre and provides additional resilience to the wider network. A 24m wide cross section is proposed with two lanes for general traffic and walking and cycling on both sides of the corridor. • No bridges are proposed. • Two new stormwater wetlands are proposed and new and upgraded culverts.
8 (AC) And 8 (WD)	**Mill Road and Pukekohe East Road Upgrade**	Waka Kotahi	• NoR 8 upgrades Mill Road (Bombay) in the east and Pukekohe East Road in the west. • It provides an important strategic connection between Auckland and Waikato and from SH1 to Pukekohe urban areas for traffic and freight, with a major rural active mode connection. Harrisville Road plays a significant role in distributing traffic from further south into Waikato. • Mill Road is proposed to be upgraded to four lanes (2.1 kms) from SH1 in the east to Harrisville Road in the west. It has a 30m wide cross section with four lanes for general traffic, with walking and cycling on the southern side. • Pukekohe East Road is proposed to be upgraded (3.4 kms) for walking and cycling facilities on the southern side from Harrisville Road in the east to NoR 5 in the west. • One new stormwater wetland is proposed, swales and new and upgraded culverts.

3 Assessment Methodology

3.1 Preparation for this Report

Work undertaken for this report commenced in May 2022. In summary, the preparation for this work has included:

- Input to the options assessment process used to inform the preferred transport corridor alignment.
- Reviews of the project concept designs, Te Tupu Ngātahi GIS viewer and attendance at design review workshops.
- A review of the statutory setting of the Project and surrounding context.
- A review of flood assessment reports, structure plans and Healthy Waters catchment manager plans/expectations for the catchments.
- A review of the other GIS data such as contours and aerial photography.
- A specialists' workshop held in March 2023 to discuss initial findings following the first site visit.
- A more detailed site visit undertaken in March 2023 to further understand the receiving environment.

Alongside the preparation of this assessment, the author has reviewed the following documents:

- Indicative construction methodology
- Revisions and input into the concept design drawings
- Other Technical Assessments
    - Arboricultural Assessment
    - Ecological Assessment
    - Urban Design Assessment

This assessment informs the land requirements 2.1-degree for the NoRs such as they relates to flood matters and effects arising from flood conveyance capacity changes, flood storage displacement and diversion through channels, culverts and bridges. Where other matters or expertise have been relied upon, these have been stated within the assessment.

The AUP:OP was used to identify the existing and likely future environment. Information from the Project Team and flood models for Ngakoroa Stream, Oira Creek, Whangapouri Stream, Pukekohe – Tutaenui Stream catchments were used to assess the flood water levels and extents of the flooding on existing (pre-development) terrain.

3.2 Flooding Assessment

The assessment of flooding effects has involved the following steps:

- Desktop assessment to identify potential flooding locations, namely:
    - Existing buildings that are near/within the existing flood plains.
    - Where the Project involves work near stream crossings, flood plains and major overland flow paths.
    - Flood modelling of the pre-development terrain using the following:
        - the existing terrain using Maximum Probable Development (MPD) development;

  - 100-year average recurrence interval (ARI) plus climate change rainfall (2.1º increase); and
  - 100-year (ARI) plus climate change rainfall (3.8º increase).
- Model results were used to identify flood water levels ≥ 0.05m for the future 100-year flood event (without the proposed project works modelled).
- Inspection of the flood extent maps to identify flooding effects, including:
  - At key cross drainage locations such as culverts and where there are noticeable deep flood levels, consideration was given to flood hazard issues.
  - Properties and buildings with habitable floors showing potential to flooding hazard through flood extent within the existing building footprints.
- A sensitivity analysis to assess the potential impact of climate change on the results.

This assessment is focused on whether the designation area is large enough for a future road design to meet the proposed conditions. With this target in mind, flood modelling has been limited to using the pre-development state only (2.1º and 3.8 º climate change scenarios). The result of this modelling was used to identify areas where the flood hazard is presently a risk and where the designation may need to widen to consider room for mitigation. Assessment of flood level increases from the road design have not been reviewed as the future design can be changed to include larger span bridges, larger diameter culverts or additional culvert barrels without affecting the designation.

1.1.1 Risk Rating for Assessing Operational Effects

A flood risk rating was determined using flood depth from the model outputs to identify where there is an existing flood risk (and hence where the Project works could exacerbate flooding). The flood risk was assessed according to the following criteria:

Flood depth / land use	Less Vulnerable e.g. open space, rural land (not in FUZ)	Moderately Vulnerable e.g. commercial and industrial properties	Highly Vulnerable e.g. dwellings, educational facilities
Negligible (flood depth < 0.05 m on land and freeboard >0.5m to buildings)			
Low (flood depth 0.05 m to 0.15 m on land and freeboard <0.5m to buildings)			
Moderate (flood depth 0.15 m to 0.5 m on land and No freeboard to buildings)			
High (flood depth > 0.5m on land and No freeboard to buildings			

Overall Flood Risk	Negligible		Low		Moderate		High

3.3 Outcomes based approach

The stormwater and flooding considerations are based on an indicative design and proposed designation boundary which incorporate flexibility for design changes to respond to the future environment. The effects assessment recommends flood hazard outcomes to be met in the future design phases that are proposed as designation conditions and provide any required mitigation within the proposed designation boundary.

The majority of the NoRs include new greenfield road areas that will require adequately sized bridges and culverts to maintain an acceptable level of effect to upstream and downstream land. The acceptability of a flood effect has been carefully worded to define flood effect in terms of existing and likely future land uses. Depending on the state of the land areas near the Project when the design is progressed to a more detailed design stage, these conditions may drive a range of culvert sizes and bridge spans. The designation footprint allowed for can manage changes to bridge span, culvert diameter or number of culverts without additional land being required.

There are some portions of NoR 2, 5, 6, 7 and 8 that upgrade existing road alignments. No significant changes to the road alignment has been proposed to prevent causing an increased flood risk to upstream land and dwellings. Therefore, the project geometry is expected to cause limited flood effects.

There are a number of locations where there is existing flood hazard and where the detailed design will need to assess and manage potential flooding effects. In some areas, the corridor passes through existing flood plains and flood volume offset storage areas may be required to prevent exacerbating flood effects. These areas have been designated and calculated to demonstrate that the designation footprint is sufficient to manage these effects. Alternatively, a larger bridge structure / viaduct through floodplain areas may be an option to minimise these types of effect.

Detention and retention of small rainfall events will be provided in wetlands and swales to mitigate the effects of soil infiltration loss. This is a standard approach to hydrologic mitigation and allows for a centralised location for water quality improvement and attenuation of larger storm events also. The changes in impervious areas are small in the context of the overall catchments and are not expected to cause significant effects.

The following conditions are recommended for all NoRs to require the Projects be designed to achieve the following outcomes:

- No increase in flood levels in a 1% AEP event for existing authorised habitable floors that are already subject to flooding or have a freeboard less than 150mm;
- No more than a 10% reduction in freeboard in a 1% AEP event for existing authorised habitable floors with a freeboard of over 150mm;
- No increase in 1% AEP flood levels for existing authorised community, commercial, industrial and network utility building floors that are already subject to flooding;
- No more than a 10% reduction in freeboard in a 1% AEP event for existing authorised community, commercial, industrial and network utility building floors;

- No increase of more than 50mm in flood level in a 1% AEP event on land zoned for urban or future urban development where there is no existing dwelling;
- No new flood prone areas; and
- No more than a 10% average increase of flood hazard (defined as flow depth times velocity) for main access to authorised habitable dwellings existing at time the Outline Plan is submitted. The assessment shall be undertaken for the 50%, 20%, 10% and 1% AEP rainfall events.
- Compliance shall be demonstrated in the Outline Plan, which shall include flood modelling of the pre-Project and post-Project 10% and 1% AEP flood levels (for Maximum Probable Development land use and including climate change).

Where the above outcomes can be achieved through alternative measures outside of the designation such as flood stop banks, flood walls, raising existing authorised habitable floor level and new overland flow paths varied through agreement with the relevant landowner, the Outline Plan shall include confirmation that any necessary landowner and statutory approvals have been obtained for that work or alternative outcome.

This assessment identifies where existing flood effects occur and may require mitigation. The designation boundary allows for treatment and retention/detention devices which includes areas for storage.

Compliance with the flood hazard outcomes recommended as conditions on all the NoRs will be demonstrated through future detailed stormwater design and further flood modelling of the pre-development and post-development 100-year ARI flood levels (with allowances for MPD and climate change) at the resource consent stage.

3.4 Desktop Assessment

To identify locations considered to be at risk of flooding effects a desktop study was carried out to identify areas where:

- Existing buildings are near / within the existing flood plains
- The project involves carrying out significant work near the stream crossings / major overland flow paths
- The project may alter the existing flood plains, ponding volumes, and natural drainage paths.

The following reference materials were used to inform the desktop study:

- Auckland Unitary Plan Operative in Part
- Auckland Council GIS resources (Auckland GeoMaps)
- Design Drawings
- Flood maps created by the SG modelling team
- SGA Flood Resilience Technical Note
- Indicative Construction Methodologies
- NZTA Stormwater Specification P46
- New Zealand Bridge Manual (SP/M/022) for freeboard allowance
- Pukekohe and Paerata Stormwater Management Plan (SMP)
- Ngakoroa Catchment Watercourse Assessment Report
- Oira Catchment Watercourse Assessment Report

- The Auckland Code of Practice for Land Development and Subdivision Chapter 4: Stormwater, Version 3.0, January 2022
- Auckland Transport Hīkina te Wero: Environment Action Plan, December 2021
- Waka Kotahi Toitū Te Taiao Sustainability Action Plan, April 2020

3.5 Flood Modelling

The purpose of the flood modelling is to identify the extent and scale of existing flooding hazard. This has been used this to consider how the proposed transport corridors of the Pukeohe Transport Network may exacerbate existing flooding and land requirements for potential methods to manage these effects.

3.5.1 Stormwater Catchment Overview

As set out in the figure below, the Project traverses four major stormwater catchments: Ngakoroa Stream, Oira Stream, Whangapouri Stream and Tūtaenui Stream.

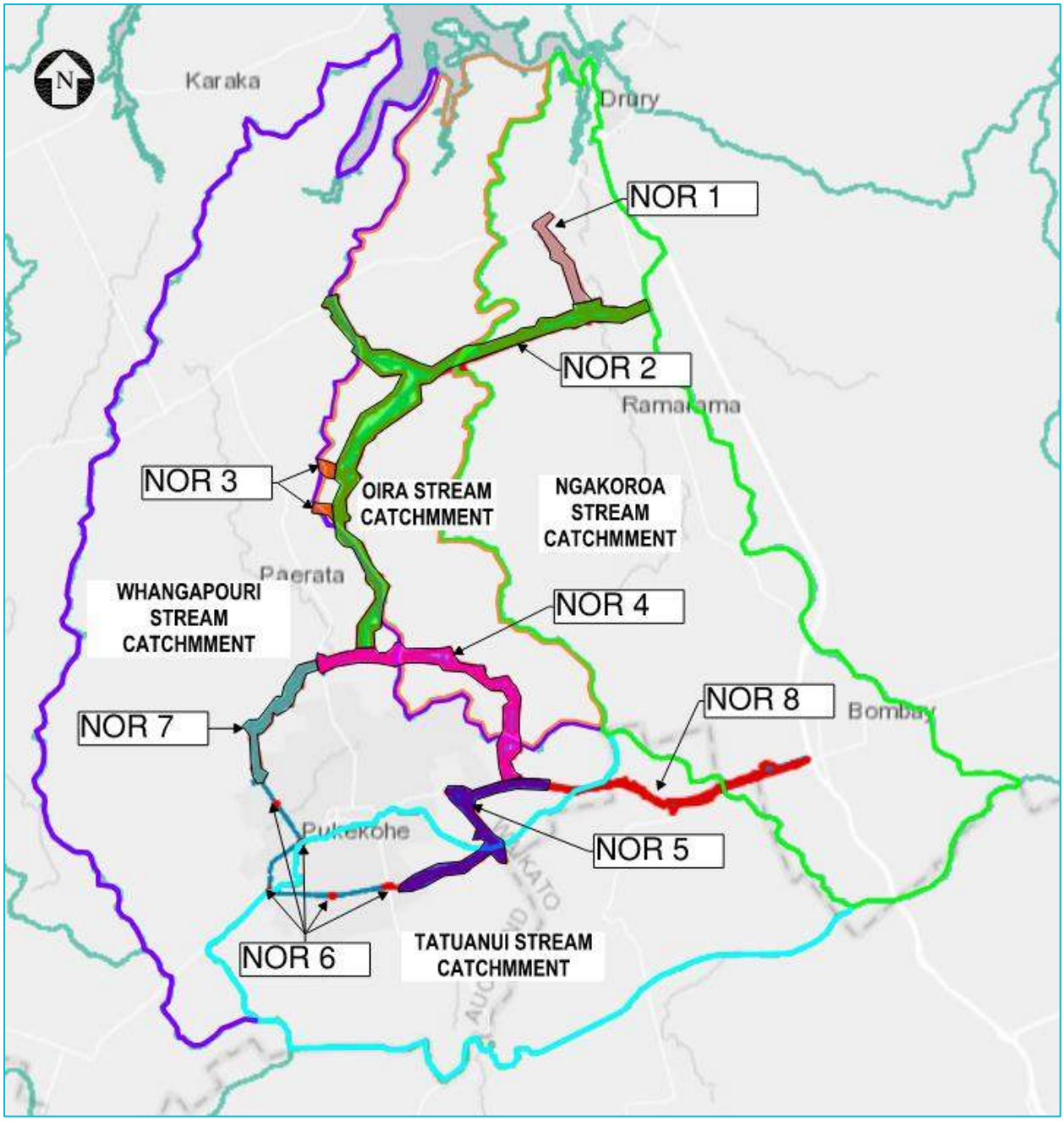


Figure 3-1: Stormwater catchments for the Pukekohe NoRs

Ngakoroa Stream

Ngakoroa Stream catchment includes NoR1, part of NoR2, part of NoR 8 and covers approximately 4,015 ha in total catchment area. The Ngakoroa Stream includes a large tributary which splits from the main branch in the Runciman area and extends south for approximately one-third of the catchment. The catchment is highly modified, with historical vegetation clearance and modified stream channels are evident throughout the catchment including through grower areas. The Ngakoroa Stream catchment drains to Drury Creek before discharging to Manukau Harbour.

The Ngakoroa catchment is also noted as a ‘High Use Stream Management Area’. This means that the value of waterways in this catchment are threatened by high use or take by a number of users. The primary high use is expected to be water extraction for agricultural irrigation.

The catchment is largely composed of agriculture and rural lifestyle blocks. The initial and approved future urban development is in the northern most part and extends to the catchments to the east and west. Subsequent phases of future urban zones are also all located in the northern portion of the catchment.

Oira Creek

Oira Creek catchment includes parts of NoR2, NoR 3, NoR 4 and covers approximately 2,043 ha in total. This catchment extends from the northern side of the Pukekohe East Tuff Crater in the upper catchment and flows north along the eastern side of Paerata. Oira Creek flows into Drury Creek before discharging to Manukau Harbour.

The Oira Creek catchment includes Future Urban zones located at the top of the catchment (Pukekohe-Paerata Future Urban Zone) and at the bottom (Drury-Opaheke Future Urban Zone). Consequently, the Oira Creek catchment is likely to experience a rapid change in land-use within the next 30 years.

Whangapouri Stream

Whangapouri Creek catchment covers all NoRs except NoR 1 and covers an area of approximately 5,270 ha including most of the Pukekohe urban area. The upper catchment includes Future Urban Zone and lower catchment is Rural zone. The Whangapouri Stream catchment includes heavily modified watercourses – both within Pukekohe and modified rural areas e.g. agricultural land.

To the east of the existing Pukekohe urban area, flow is an east to west direction towards the Whangapouri Creek. To the west of Pukekohe town centre Whangapouri Stream drains from south to northeast to the Whangapouri Creek. The area near Helvetia Road area drains from south to east into the Whangapouri Creek.

Pukekohe – Tutaenui Stream

The Pukekohe-Tutaenui catchment includes NoRs, 4, 5, 6, 8, covers an area approximately 2,695 ha and flows north to south into Whakapipi Stream before discharging into the Waikato River. The catchment includes steep, incised channels that have been modified.

3.5.2 Modelling Parameters

Auckland Council have produced catchment models for Ngakoroa Stream, Oira Creek, Whangapouri Stream which were adapted for this assessment (the models). However, the Pukekohe – Tutaenui Stream is not an accepted model and has not been used in this assessment, instead the Auckland Council Geomaps floodplain has been used.

To assess the flooding effects of the Project on the receiving environment the base case scenario was reviewed and areas with the potential for flood risk were identified. To date, only the pre-development scenario has been modelled, this is based on:

- Future 100-year ARI rainfall event + 2.1º climate change considering the maximum probable development (MPD) future land-use without the project in place, and
- Future 100-year ARI rainfall event + 3.8º climate change considering the maximum probable development (MPD) future land-use without the project in place.

The proposed imperviousness for the maximum probable development (MPD) land use was applied i.e. the model assumes the maximum impervious surface limits of the current zone or, if the land is zoned Future Urban in the Auckland Unitary Plan, the probable level of development arising from zone changes.

The models include the existing roads and existing culverts where the culverts are 600 mm or greater. In the models existing culverts < 600 mm diameter are considered to be fully blocked (according to the AC Code of Practice) although larger culverts are considered to be fully working. No additional culverts, land use modifications or surface roughness changes were made to the models received from Council.

3.5.3 Modelling Outputs

The flood depth from the model outputs was compared to the proposed road levels and existing ground levels in the terrain model to identify where there was a potential flood risk. The existing ground level or road level was taken from the terrain model which is broadly based on 2016 LiDAR information. This was confirmed using contour information available from AC Geomaps.

The existing flood risk was assessed according to the criteria set out in Table 2. For those areas identified as having a potential risk of flooding effects, the key mitigation will be to size culverts and bridges to balance flood effects and meet the condition outcomes.

Table 2: Flooding effects risk assessment criteria

Flood depth / land use	Less Vulnerable **e.g. open space, rural land (not in FUZ)**	Moderately Vulnerable **e.g. commercial and industrial properties**	Highly Vulnerable **e.g. dwellings, educational facilities**
Negligible (flood depth < 0.05 m on land and freeboard >0.5m to buildings)			
Low (flood depth 0.05 m to 0.15 m on land and freeboard <0.5m to buildings)			
Moderate (flood depth 0.15 m to 0.5 m on land and No freeboard to buildings)			
High (flood depth > 0.5m on land and No freeboard to buildings			

Overall Flood Risk **Negligible** **Low** **Moderate** **High**

For more vulnerable land uses, including dwellings, if less than 0.5 m freeboard is available there is a greater risk of damage to property. Surveyed floor levels of the existing habitable buildings are not

available and should be checked during the detailed design stage where a potential flood risk is identified.

The required freeboard for bridges and culverts used to assess the suitability of the indicative design is set out in Table 3.

Table 3: Freeboard allowance for the level of serviceability to traffic (NZ Bridge Manual)

Waterway Structure	Situation	Freeboard	
		Measurement Points	Level (m)
Bridge	Normal circumstances	From the predicted peak flood water level to the underside of the superstructure	0.6
	Where the possibility that large trees may be carried down the waterway exists		1.2
Culvert	All situations	From the predicted flood water level to the road surface	0.5

3.5.4 Sensitivity Analysis

Sensitivity is the degree to which a system is affected, adversely or beneficially, by a given exposure.[1] In this instance the sensitivity of the Pukekohe Transport Network to increased rainfall as a result of climate change has been considered.

The flood model has assessed 2.1 degrees of warming and a 16% increase in rainfall based on AC Guidance and MfE. However, given the uncertainty of climate change effects in the future the assessment has also considered a more severe climate change scenario based on RCP 8.5 which allows for 3.8 degrees of warming and a 32.7% increase in rainfall.

The results for RCP 8.5 have been compared to those reported in the flood assessment for RCP 4.5 and areas where higher rainfall may increase flooding have been identified.

In the future it is possible there may be different requirements for assessing climate change, however, at this time the sensitivity analysis has been prepared to understand the risk of climate change on the Pukekohe Transport Network and enable decision makers to respond to this.

3.5.5 Limitations

All of the Pukekohe Transport Network projects have downstream catchments that contain FUZ. The modelled scenarios use imperviousness assumptions associated with the future land use(s) shown in the Auckland Unitary Plan.

Given the area of FUZ and the likely increase in density that is anticipated following the National Policy Statement on Urban Development (NPS:UD) and Medium Density Residential Standards (MDRS), it is possible that significant change in the catchments may take place before or shortly after the corridor is constructed. Therefore, it is anticipated that further modelling will be required during the corridor detailed design phase to take account of catchment characteristics at that time.

[1] Intergovernmental Panel on Climate Change. (2007). Climate Change 2007: Contribution of Working Group II to the Fourth Assessment Report. Cambridge, UK: Cambridge University Press.

Similarly, any new or upgraded culverts will be confirmed at the detailed design stage and will take into account matters such as consent requirements, asset owner requirements, level of service, stream simulation design, fish passage and possible blockage.

The post-development flood models for the Project were not developed or assessed in this report. It is anticipated that these models will be developed during detailed design when a final road alignment is available. Future modelling will be used in conjunction with the proposed NoR conditions and other regulatory requirements to allow flood effects to be adequately mitigated.

3.6 Stormwater features

While stormwater effects apart from flooding are not assessed (as they will be assessed during a future regional consent process), provision is made for the future management of potential stormwater effects (stormwater quantity and stormwater quality) by identifying the space required for stormwater management devices (SWMDs, i.e. treatment swale and wetlands) and incorporating land for that purpose into the NoRs. In identifying the land required for these devices, preliminary sizing and siting has been undertaken and space allowed for constructing these.

Some key assumptions that were used to identify the amount of land sought for stormwater management works within the designations include the following:

- Wetlands are sized to attenuate 100-year peak flows from the transport corridor. Areas for quality and retention/detention requirements has been provided for within the proposed designation footprint.
- Allowance is made for wetland attenuation storage and hydraulic gradients from corridor inlet to discharge point (typically a minimum of 2.0 to 2.5m vertically).
- Wetland geometry and footprints were modelled to determine the required cut and fill and a 15m buffer added for construction purposes and maintenance access.
- A minimum 6m buffer is provided around the corridor earthworks extents to provide space for construction purposes and allow for works such as drainage channels and culvert inlets/outlets and flexibility in the vertical alignment.
- Diversion channels are identified where they are needed to prevent upstream flooding.
- Roadside swales are sized to take small local catchments only no greater than 4 hectares in size. These swales can provide treatment, detention, retention and attenuation (if required).

These allowances are considered appropriate for sizing the devices at this early stage of the design process and also provide opportunity for future refinement. The design of devices is not discussed further in this report as this is considered a matter that will be developed further for the future regional consents and implementation processes.

In general, the approach has been to avoid SWMDs in floodplains where possible. If this is not possible, the design has sought to employ offline systems located in low velocity flood zones where there is minimal risk of scour for resilient and maintainable systems.

The flood model does not account for the flood water storage capacity provided by the proposed SWMDs (wetlands or swales) even though they are designed with attenuation capacity for the additional runoff generated by the increased impervious area from the new road infrastructure.

While the project is not intended to remediate existing flood hazards, it is anticipated the proposed SWMDs will provide improvements in water quality and attenuation where practicable.

Table 4: NoR 1 - Drury West Arterial Concept Stormwater Design Features

Project and Chainage	Stormwater Feature and function	Approximate catchment Area and feature size	Discharge point Location
NoR1 ch.0m to ch.300m	Roadside swales convey 10year flows, WQ, retention and detention	0.96ha catchment 1.5m wide swales on both sides of road	Culvert at NoR1-ch200m inlet end and outlet end.
NoR1 ch.200m	Culvert, convey 100year flows and maintain 500mm freeboard to the road edge	5.36ha catchment. Ø2100mm circular culvert	Channel north of the NIMT railway line then Ngakoroa Stream
NoR1 ch.300m	Bridge over rail and open channels	5.88ha catchment. 75m span bridge	Channel north of the NIMT railway line then Ngakoroa Stream
NoR1 ch.450m	Bridge over stream (tributary to the Ngakoroa Stream)	68.69ha catchment. 33m span bridge	Ngakoroa Stream Tributary
NoR1 ch.600m	Wetland, (WQ, retention and SMAF 1 detention) no attenuation, pass forward approach adopted	2.09ha catchment wetland is 2,015m² in total area (9% of catchment)	Ngakoroa Stream Tributary
NoR1 ch.650m	Culvert, convey 100year flows and maintain 500mm freeboard to the road edge	5.36ha catchment. Ø2100mm circular culvert	Ngakoroa Stream Tributary
NoR1 ch.1150m	Wetland, (WQ, retention and SMAF 1 detention) no attenuation, pass forward approach adopted	1.32ha catchment. wetland is 469m² in total area (3.5% of catchment)	Ngakoroa Stream Tributary
NoR1 ch.1400m	Bridge over stream (tributary to the Ngakoroa Stream)	787ha catchment. 130m span bridge	Ngakoroa Stream Tributary
NoR1 ch.1500	Wetland, (WQ, retention and SMAF 1 detention) no attenuation, pass forward approach adopted	0.99ha catchment. wetland is 1,282m² in total area (13% of catchment)	Ngakoroa Stream Tributary

Table 5: NoR 2 - Paerata Link Concept Stormwater Design Features

Project and Chainage	Stormwater Feature and function	Approximate catchment Area and feature size	Discharge point Location
NoR2 ch.8300	Bridge over stream (tributary to the Ngakoroa Stream)	24.08ha catchment. 90m span bridge	Ngakoroa Stream Tributary

Project and Chainage	Stormwater Feature and function	Approximate catchment Area and feature size	Discharge point Location
NoR2 ch.8100	Wetland, (WQ, retention and SMAF 1 detention) no attenuation, pass forward approach adopted	2.65ha catchment. wetland is 1,746m² in total area (7% of catchment)	Ngakoroa Stream Tributary
NoR2 ch.7850	Bridge over Ngakoroa Stream main branch	2,610ha catchment. 130m span bridge	Ngakoroa Stream
NoR2 ch.7550	Culvert, convey 100year flows and maintain 500mm freeboard to the road edge	4.45ha catchment. Ø2100mm circular culvert	Ngakoroa Stream Tributary
NoR2 ch.7450	Bridge over stream (tributary to the Ngakoroa Stream)	694ha catchment. 90m span bridge	Ngakoroa Stream Tributary
NoR2 ch.7050	Wetland, (WQ, retention and SMAF 1 detention) no attenuation, pass forward approach adopted	6.41ha catchment. wetland is 3,859m² in total area (6% of catchment)	Ngakoroa Stream Tributary
NoR2 ch.6500	Culvert, convey 100year flows and maintain 500mm freeboard to the road edge	12.25ha catchment. Ø2100mm circular culvert	Ngakoroa Stream Tributary
NoR2 ch.6150	Culvert, convey 100year flows and maintain 500mm freeboard to the road edge	17.51ha catchment. Ø2100mm circular culvert	Ngakoroa Stream Tributary
NoR2 ch.5650	Wetland, (WQ, retention and SMAF 1 detention) no attenuation, pass forward approach adopted	1.345ha catchment. wetland is 3,605m² in total area (27% of catchment)	Ngakoroa Stream Tributary
NoR2 ch.5100 to ch.5550	Roadside swales convey 100year flows, WQ, retention and detention	3.11ha catchment 3.0m wide swales on both sides of road	Oira Stream Tributary
NoR2 ch.5000	Wetland, (WQ, retention and SMAF 1 detention) no attenuation, pass forward approach adopted	2.29ha catchment. wetland is 3,143m² in total area (14% of catchment)	Oira Stream Tributary

Project and Chainage	Stormwater Feature and function	Approximate catchment Area and feature size	Discharge point Location
NoR2 ch.1450 (SH22 connection segment)	Bridge over stream (tributary to the Oira Stream)	1,170ha catchment. 180m span bridge	Oira Stream Tributary
NoR2 ch.1000 (SH22 connection segment)	Culvert, convey 100year flows and maintain 500mm freeboard to the road edge	3.37ha catchment. Ø2100mm circular culvert	Oira Stream Tributary
NoR2 ch.900 to ch.1350 (SH22 connection segment)	Roadside swales convey 100year flows, WQ, retention and detention	1.67ha catchment 3.0m wide swales on both sides of road	Oira Stream Tributary
NoR2 ch.300 (SH22 connection segment)	Wetland, (WQ, retention and SMAF 1 detention) no attenuation, pass forward approach adopted	4.67ha catchment. wetland is 1,424m² in total area (3% of catchment)	Oira Stream Tributary
NoR2 ch.4800	Bridge over stream (tributary to the Oira Stream)	213.5ha catchment. 100m span bridge	Oira Stream Tributary
NoR2 ch.4500	Wetland, WQ, retention and SMAF 1 detention attenuation for 10yr and 100yr	8.39ha catchment. wetland is 17,865m² in total area (21% of catchment)	Oira Stream Tributary
NoR2 ch.3900	Bridge over stream (Oira Stream)	823ha catchment. 100m span bridge	Oira Stream
NoR2 ch.4500	Wetland, WQ, retention and SMAF 1 detention attenuation for 10yr and 100yr	8.39ha catchment. wetland is 17,865m² in total area (21% of catchment)	Oira Stream
NoR2 ch.3500	Wetland, WQ, retention and SMAF 1 detention attenuation for 10yr and 100yr	3.27ha catchment. wetland is 4,244m² in total area (13% of catchment)	Oira Stream
NoR2 ch.2400	Wetland, WQ, retention and SMAF 1 detention attenuation for 10yr and 100yr	2.33ha catchment. wetland is 2,656m² in total area (11% of catchment)	Oira Stream
NoR2 ch.2000	Wetland, WQ, retention and SMAF 1 detention attenuation for 10yr and 100yr	1.22ha catchment. wetland is 1,303m² in total area (11% of catchment)	Whangapouri Stream Tributary

Project and Chainage	Stormwater Feature and function	Approximate catchment Area and feature size	Discharge point Location
NoR2 ch.1750	Wetland, WQ, retention and SMAF 1 detention attenuation for 10yr and 100yr	1.28ha catchment. wetland is 1,862m² in total area (14% of catchment)	Oira Stream Tributary
NoR2 ch.1100	Wetland, WQ, retention and SMAF 1 detention attenuation for 10yr and 100yr	3.04ha catchment. wetland is 4,547m² in total area (15% of catchment)	Oira Stream Tributary
NoR2 ch.200	Culvert, convey 100year flows and maintain 500mm freeboard to the road edge	24.95ha catchment. Ø2100mm circular culvert	Whangapouri Stream Farm Drain
NoR2 ch.50	Wetland, WQ, retention and SMAF 1 detention attenuation for 10yr and 100yr	5.32ha catchment. wetland is 4,557m² in total area 9% of catchment)	Whangapouri Stream Farm Drain

Table 6: NoR 3 - Paerata Connections Concept Stormwater Design Features

Project and Chainage	Stormwater Feature and function	Approximate catchment Area and feature size	Discharge point Location
NoR3 ch.150 (Paerata Rail Station Connection)	Culvert (designed by Paerata station designers)	4.76ha catchment. Ø1800mm circular culvert	Whangapouri Stream Tributary
NoR3 ch.300 (Sim Road to Sim Connection)	Wetland, WQ, retention and SMAF 1 detention attenuation for 10yr and 100yr	0.90ha catchment. wetland is 1,998m² in total area 22% of catchment)	Oira Stream Tributary

Table 7: NoR 4 – Pukekohe North-East Arterial Concept Stormwater Design Features

Project and Chainage	Stormwater Feature and function	Approximate catchment Area and feature size	Discharge point Location
NoR4 ch.50	Wetland, WQ, retention and SMAF 1 detention attenuation for 10yr and 100yr	2.88ha catchment. wetland is 2,747m² in total area (10% of catchment)	Whangapouri Stream
NoR4 ch.50	Wetland, WQ, retention and SMAF 1 detention	2.88ha catchment. wetland is 2,747m² in total area (10% of catchment)	Whangapouri Stream

Project and Chainage	Stormwater Feature and function	Approximate catchment Area and feature size	Discharge point Location
	attenuation for 10yr and 100yr		
NoR4 ch.300	Bridge over stream (Whangapouri Stream)	1,488ha catchment. 110m span bridge	Oira Stream
NoR4 ch.500	Culvert, convey 100year flows and maintain 500mm freeboard to the road edge	4.21ha catchment. Ø2100mm circular culvert	Whangapouri Stream Farm Drain
NoR4 ch.1000	Culvert, convey 100year flows and maintain 500mm freeboard to the road edge	2.26ha catchment. Ø1200mm circular culvert	Whangapouri Stream Farm Drain
NoR4 ch.1500	Culvert, convey 100year flows and maintain 500mm freeboard to the road edge	4.33ha catchment. Ø2100mm circular culvert	Oira Stream Tributary
NoR4 ch.1550	Wetland, WQ, retention and SMAF 1 detention attenuation for 10yr and 100yr	1.99ha catchment. wetland is 2,563m² in total area (13% of catchment)	Oira Stream Tributary
NoR4 ch.1650	Bridge over stream (Oira Stream Tributary)	55.11ha catchment. 50m span bridge	Oira Stream Tributary
NoR4 ch.1850	Wetland, WQ, retention and SMAF 1 detention attenuation for 10yr and 100yr	1.51ha catchment. wetland is 1,222m² in total area (8% of catchment)	Oira Stream Tributary
NoR4 ch.1950	Bridge over stream (Oira Stream Tributary)	21.90ha catchment. 65m span bridge	Oira Stream Tributary
NoR4 ch.2650	Culvert (with scruffy dome inlet), convey 100year flows and maintain 500mm freeboard to the road edge	0.97ha catchment. Ø1050mm circular culvert	Oira Stream Tributary
NoR4 ch.2800	Wetland, WQ, retention and SMAF 1 detention attenuation for 10yr and 100yr	4.50ha catchment. wetland is 7,770m² in total area (17% of catchment)	Oira Stream Tributary
NoR4 ch.2900	Bridge over stream (Oira Stream Tributary)	26.40ha catchment. 50m span bridge	Oira Stream Tributary

Project and Chainage	Stormwater Feature and function	Approximate catchment Area and feature size	Discharge point Location
NoR4 ch.3050	Bridge over stream (Oira Stream Tributary)	49.93ha catchment. 55m span bridge	Oira Stream Tributary
NoR4 ch.3600	Bridge over stream (Oira Stream Tributary)	28.02ha catchment. 85m span bridge	Oira Stream Tributary
NoR4 ch.3800	Wetland, WQ, retention and SMAF 1 detention attenuation for 10yr and 100yr	4.71ha catchment. wetland is 11,974m² in total area (25% of catchment)	Whangapouri Stream Tributary
NoR4 ch.4000	Bridge over stream (Oira Stream Tributary)	123.95ha catchment. 83m span bridge	Whangapouri Stream Tributary

Table 8: NoR 5 - Pukekohe South-East Arterial Concept Stormwater Design Features

Project and Chainage	Stormwater Feature and function	Approximate catchment Area and feature size	Discharge point Location
NoR5 ch0 (Pukekohe East Road)	Wetland, WQ, retention and SMAF 1 detention attenuation for 10yr and 100yr	2.55ha catchment. wetland is 5,139m² in total area (20% of catchment)	Whangapouri Stream Tributary
NoR5 ch100	Wetland, WQ, retention and SMAF 1 detention attenuation for 10yr and 100yr	3.00ha catchment. wetland is 3,278m² in total area (11% of catchment)	Whangapouri Stream Tributary
NoR5 ch250	Culvert, convey 100year flows and maintain 500mm freeboard to the road edge	63.10ha catchment. Ø2100mm circular culvert	Whangapouri Stream Tributary
NoR5 ch260	Wetland, WQ, retention and SMAF 1 detention attenuation for 10yr and 100yr	1.54ha catchment. wetland is 3,097m² in total area (20% of catchment)	Whangapouri Stream Tributary
NoR5 ch700	Culvert, convey 100year flows and maintain 500mm freeboard to the road edge	25.55ha catchment. Ø2100mm circular culvert	Whangapouri Stream Tributary
NoR5 ch720	Wetland, WQ, retention and SMAF 1 detention attenuation for 10yr and 100yr	1.58ha catchment. wetland is 3,741m² in total area (24% of catchment)	Whangapouri Stream Tributary

Project and Chainage	Stormwater Feature and function	Approximate catchment Area and feature size	Discharge point Location
NoR5 ch1050 (Pukekohe South-East Arterial)	Wetland, WQ, retention and SMAF 1 detention attenuation for 10yr and 100yr	4.46ha catchment. wetland is 3,256m² in total area (7% of catchment)	Tatuanui Stream Tributary
NoR5 ch.720 (Pukekohe South-East Arterial)	Culvert, convey 100year flows and maintain 500mm freeboard to the road edge	19.59ha catchment. Ø2100mm circular culvert	Tatuanui Stream Tributary
NoR5 ch.300 (Pukekohe South-East Arterial)	Open Channel to replace the infilled open channel	115.5ha catchment. with a channel large enough to convey 29.2m³/s	Tatuanui Stream Tributary
NoR5 ch.200 (Pukekohe South-East Arterial)	Culvert, convey 100year flows and maintain 500mm freeboard to the road edge	115.5ha catchment. Ø2500mm circular pipe (extension of existing pipe)	Tatuanui Stream Tributary

Table 9: NoR 7 - Pukekohe North-West Arterial Concept Stormwater Design Features

Project and Chainage	Stormwater Feature and function	Approximate catchment Area and feature size	Discharge point Location
NoR7 ch.200	Wetland, WQ, retention and SMAF 1 detention attenuation for 10yr and 100yr	2.57ha catchment. wetland is 2,644m² in total area (10% of catchment)	Whangapouri Stream Tributary
NoR7 ch.300	Culvert, extend existing culvert	8.32ha catchment. Ø600mm circular culvert	Whangapouri Stream Tributary
NoR7 ch.1100	Culvert. Convey 100year flows and maintain 500mm freeboard to the road edge	6.11ha catchment. Ø1050mm circular culvert	Whangapouri Stream Tributary
NoR7 ch.1800	Culvert, new culvert downstream of existing railway culvert. Convey 100year flows and maintain 500mm freeboard to the road edge	20.48ha catchment. Ø2100mm circular culvert	Whangapouri Stream Tributary
NoR7 ch.2000	Wetland, WQ, retention and SMAF 1 detention attenuation for 10yr and 100yr	4.31ha catchment. wetland is 3,300m² in total area (8% of catchment)	Whangapouri Stream Tributary

Project and Chainage	Stormwater Feature and function	Approximate catchment Area and feature size	Discharge point Location
NoR7 ch.2050	Culvert, new culvert downstream of existing railway culvert. Convey 100year flows and maintain 500mm freeboard to the road edge	11.67ha catchment. Ø2100mm circular culvert	Whangapouri Stream Tributary

Table 10: NoR 8 – Mill Road and Pukekohe East Road Upgrade Concept Stormwater Design Features

Project and Chainage	Stormwater Feature and function	Approximate catchment Area and feature size	Discharge point Location
NoR8 ch.2600 to ch.3450	Roadside swales convey 100year flows, WQ, retention and detention	1.31ha catchment 6.0m wide swales on southern side of road	Tatuanui Stream Tributary
NoR8 ch.3000	Existing culvert extension (downstream end)	Culvert size to suit existing culvert diameter	Tatuanui Stream Tributary
NoR8 ch.3850 to ch.4600	Roadside swales convey 100year flows, WQ, retention and detention	4.95ha catchment 6.0m wide swales on both sides of road	Tatuanui Stream Tributary
NoR8 ch.4950	New culvert to replace existing culvert at same diameter	Culvert size to suit existing culvert diameter	Ngakoroa Stream Tributary
NoR8 ch.5100	New culvert to replace existing culvert at same diameter	Culvert size to suit existing culvert diameter	Ngakoroa Stream Tributary
NoR8 ch.5250	Wetland, WQ, retention and SMAF 1 detention attenuation for 10yr and 100yr	4.92ha catchment. wetland is 5,512m² in total area (11% of catchment)	Ngakoroa Stream Tributary
NoR8 ch.5500	Existing culvert extension (downstream end)	Culvert size to suit existing culvert diameter	Ngakoroa Stream Tributary
NoR8 ch.5600	Existing culvert extension (upstream end)	Culvert size to suit existing culvert diameter	Ngakoroa Stream Tributary

4 Existing and Future Receiving Environment – Flood Effects

4.1 Existing and Future Environment – relating to all NoRs

The land surrounding most NoRs is presently rural with farming activity and rural lifestyle blocks throughout the catchments. The majority of land cover has sparse tree coverage with grass pasture being the dominant feature. Stream, creeks and rivers are largely unmodified with some farm drains in the flatter parts of the catchment to facilitate farming practices. Lifestyle blocks are sparsely located along the roads with dwellings typically located on the high ground out of floodplains.

The likely future environment will intensify urban land uses with natural stream preservation expected through the planning and consent processes. Requirements for detention and retention are expected for the future urban developments with attenuation in the upper half of the catchment only. This is expected to slightly increase the pre-development peak flood flowrates with a larger volume and longer duration of flooding. The waterways and rivers in the catchment are expected to remain in place with 60m wide blue-green corridors consistent with the structure plans.

4.2 Existing and Future Environment – relating to specific NoRs

The following descriptions discuss the existing and likely future environments for each NoR based on aerial photography from 2022, the current AUP:OP zones, structure plans and plan change applications in progress or granted.

4.2.1 Drury West Arterial - NoR 1

NoR 1 is a new road connection from SH22 in the north, over the North Island Main Tunk (NIMT) Railway line, into a roundabout on Burtt Road and terminating at the Drury to Pukekohe Link NoR 2. The catchment is rural at present with the upstream catchment undeveloped and majority pervious. The new road alignment crosses six (6) overland flowpaths numbered in Figure 4-1 and will include some earthworks filling in floodplain areas. The existing flooding is most prevalent toward the south of the NoR where the new road will cross the main branch of the Ngakoroa Stream.

The future environment is planned to be fully developed as urban under the Future Urban Zone (FUZ) provisions of the AUP:OP. This is expected to avoid development in the stream areas and include green spaces as recreation parks and sporting fields. The impervious percentage of the land will increase as a result of this urbanisation, roads and associated infrastructure. This means less rainwater will infiltrate into the soil and more stormwater runoff will flow at the surface and through the stormwater pipes built to manage runoff. This will likely be managed by the rules of the AUP:OP which will aim to replace the loss of soil storage with stormwater detention and infiltration systems. The future environment will change greatly with regard to stormwater runoff. However, the pressures placed on the downstream infrastructure from the FUZ development are expected to be minimal as a result of the stormwater mitigation that will also be constructed. Figure 4-1 shows the existing aerial and floodplains in the vicinity of NoR 1 along with the AUP:OP zoning indicating the extent of FUZ.

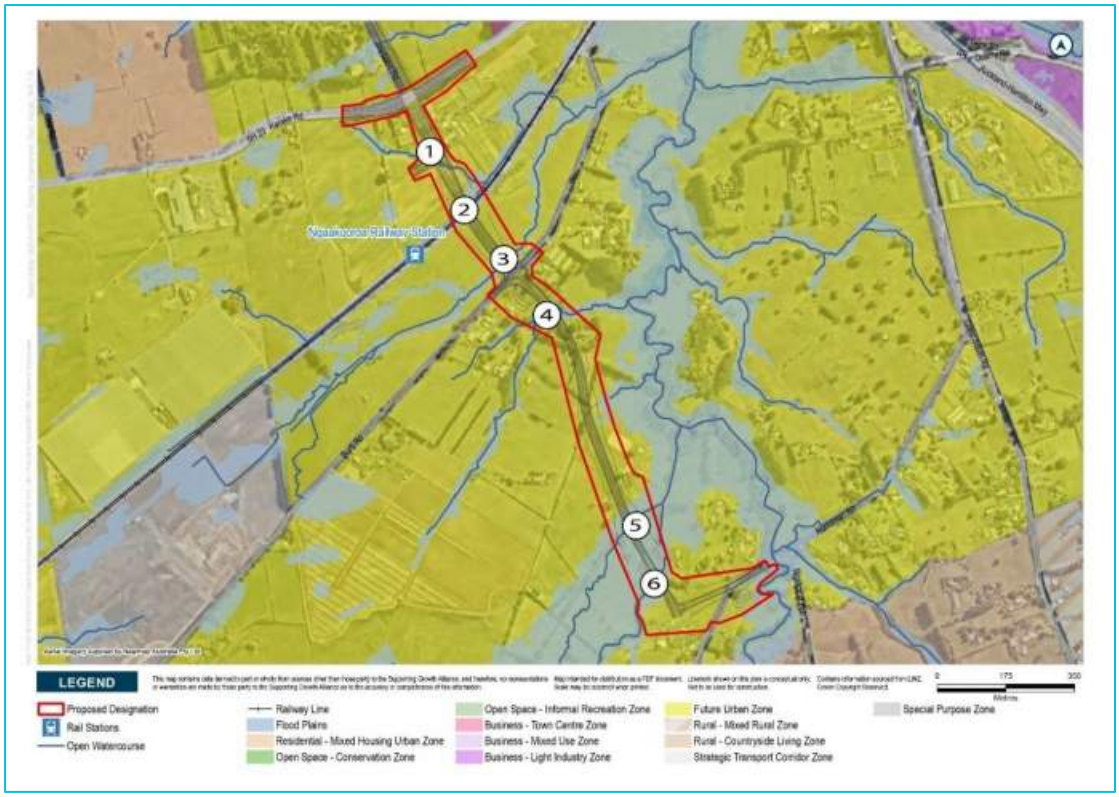


Figure 4-1: NoR 1 Drury West Arterial existing land uses as described using the AUP:OP zones.

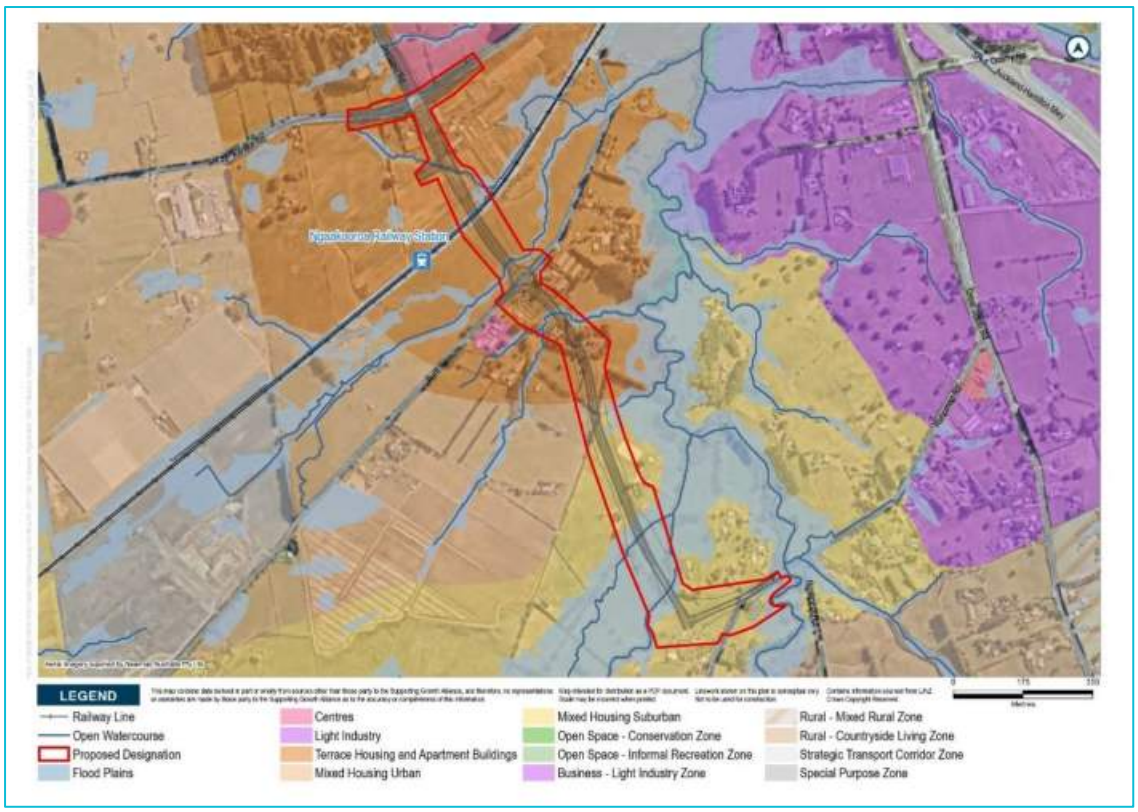


Figure 4-2: NoR 1 Drury West Arterial likely future environment as described using the AUP:OP zones and Drury – Opāheke Structure Plan August 2019 zones.

4.2.2 Drury to Pukekohe Link - NoR 2

NoR 2 is a new connection between Great South Road, Drury in the north, to a new connection north of Pukekohe (NoR 4 – Pukekohe North East Arterial) as shown in Figure 4-3. Figure shows the likely future zoning proximate to NoR 2. For assessment purposes, it has been split into four (4) segments; the South Drury Connection, the State Highway 22 Connection, the Drury Paerata Link and the Paerata Arterial.

NoR 2 is largely rural with the upstream catchment largely undeveloped and pervious. The alignment crosses eight (8) overland flowpaths numbered in Figure 4-3Figure and will include some earthworks filling in floodplain areas. The existing flood prone areas are at the major stream crossings in the South Drury Connection, the State Highway 22 Connection, and the Drury Paerata Link. The Paerata Arterial section follows a terrain ridgeline and therefore has no integration with floodplains and no need for culverts.

The future environment is planned to be FUZ to the north and west of the NoR2 alignment with a gap between the FUZ areas in the middle. The areas outside of the FUZ will remain rural residential and are not expected to be developed in the near future. As discussed in NoR 1, the FUZ development is expected to avoid development in the stream areas and include green spaces as recreation parks and sporting fields. The impervious percentage of the land will increase as a result of this urbanisation, roads and associated infrastructure. The future environment will change greatly with regard to stormwater runoff. However, the pressures placed on the downstream infrastructure from the FUZ development are expected to be minimal as a result of the stormwater mitigation that will be constructed also. Figure 4-3Figure shows the existing aerial and floodplains in the vicinity of NoR 2 along with the AUP:OP zoning indicating the extent of FUZ.

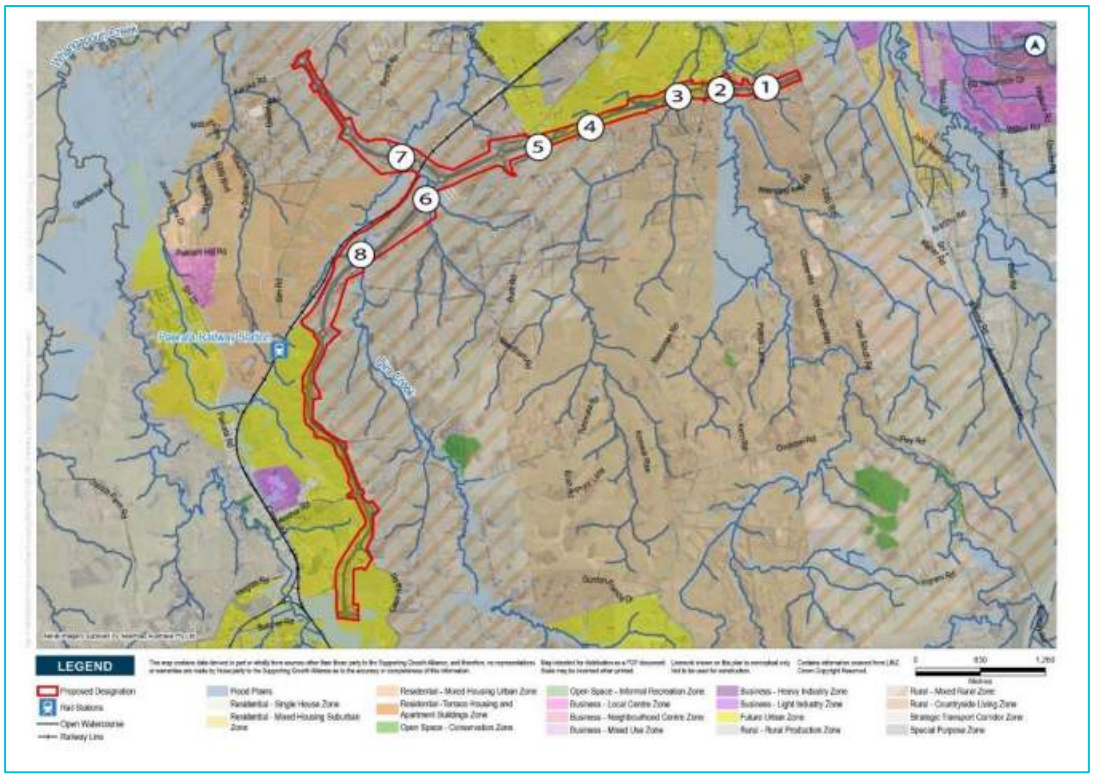


Figure 4-3: NoR 2 Drury – Pukekohe Link existing land uses as described using the AUP:OP zones

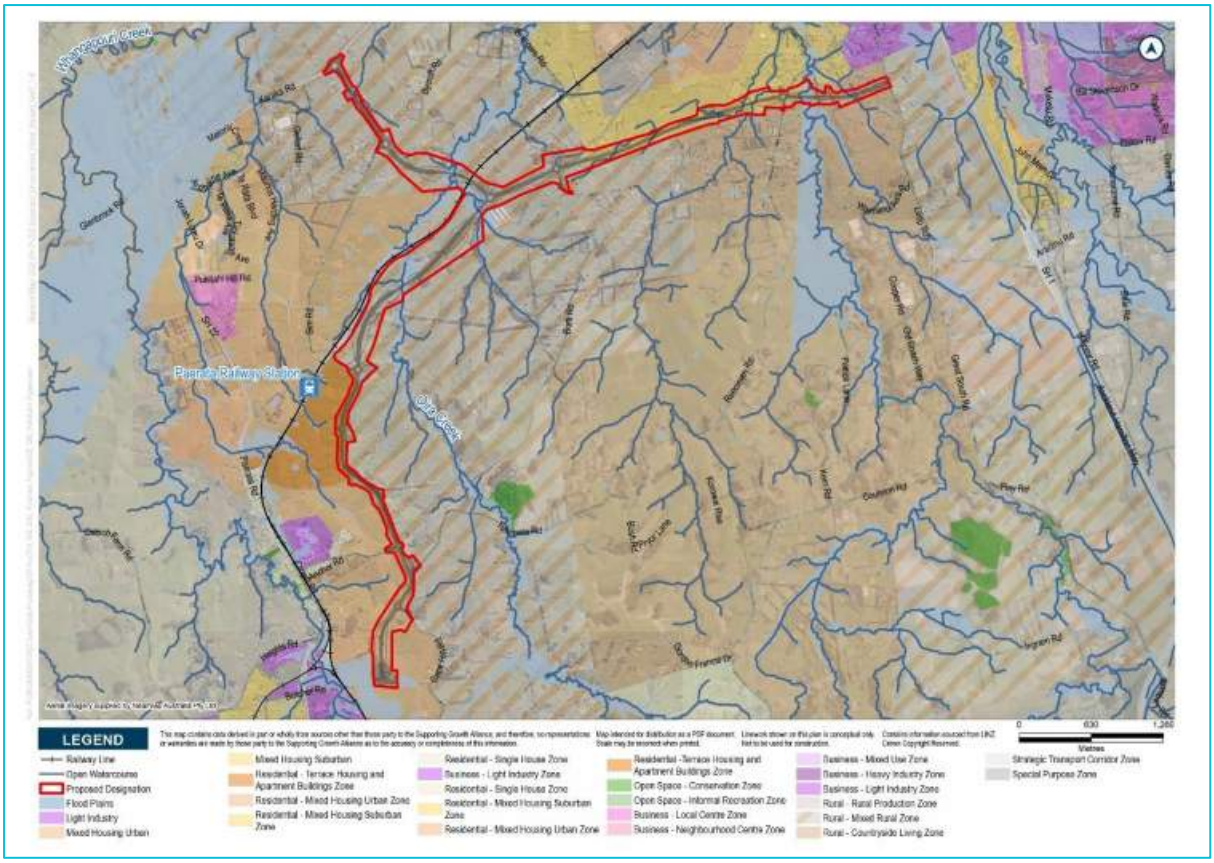


Figure 4-4: NoR 2 Drury likely future environment as described using the AUP:OP zones and Drury – Opāheke Structure Plan August 2019 / Pukekohe-Paerata Structure Plan 2019 zones

4.2.3 Paerata Connections - NoR 3

The Paerata Connections NoR 3 consists of two new road connections. One connection is between Sim Road (south) (the NoR 2 alignment) and the new Paerata Railway Station (southern link) and one connection is between Sim Road (south) (the NoR 2 alignment) across the NIMT connection with the Paerata Rise development (northern link). The catchments for NoR 3 are both small sub-catchments to the Whangapouri Stream. They contain rural land uses and some dwellings along Sim Road.

The northern link (NoR3.1) does not cross any overland flowpaths. NoR3.2 crosses a single flowpath shown as number 1 in Figure . A culvert for this flowpath has been designed and consented as part of the KiwiRail Paerata Station access road. The Paerata Connections (NoR 3) do not include earthworks filling in floodplain areas.

The future environment is planned to be urbanised (as signalled by the FUZ and Auckland Council Pukekohe-Paerata Structure Plan) to the west of Sim Road and remain as rural to the east of Sim Road. As Sim Road follows the ridge line between the Whangapouri and Oira Stream, the whole of the catchment contributing to NoR 3 includes the FUZ areas only. The areas outside of the FUZ will remain rural residential and are not expected to be developed in the near future. As discussed in NoR 1, the FUZ development is expected to avoid development in the stream areas and include green spaces as recreation parks and sporting fields. The impervious area of the land will increase as a result of this urbanisation, roads and associated infrastructure. The future environment will change greatly regarding stormwater runoff. However, the pressures placed on the downstream infrastructure from the FUZ development are expected to be minimal as a result of the stormwater mitigation that

will be constructed also. Figure 4 shows the existing aerial and floodplains in the vicinity of NoR 3 along with the AUP:OP zoning indicating the extent of FUZ.

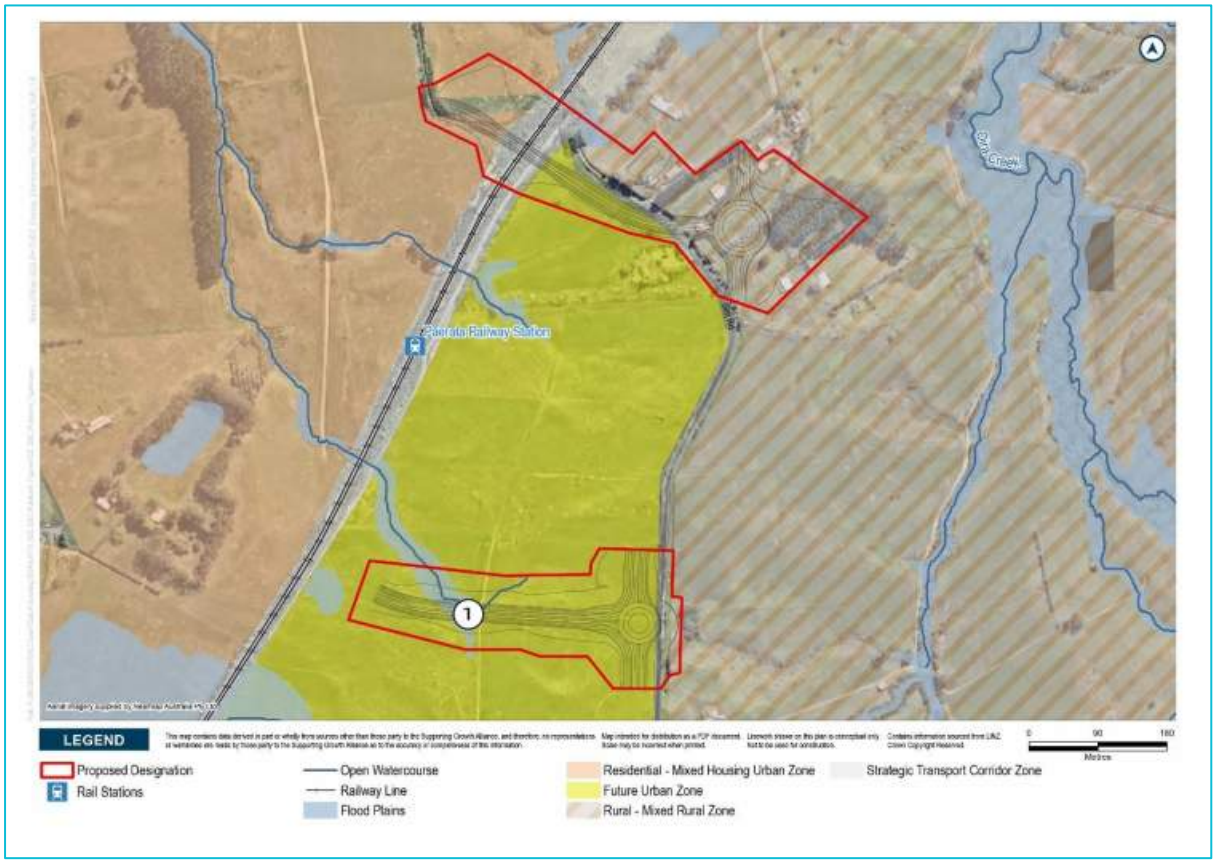


Figure 4-5: Paerata Connections existing land uses as described using the AUP:OP zones

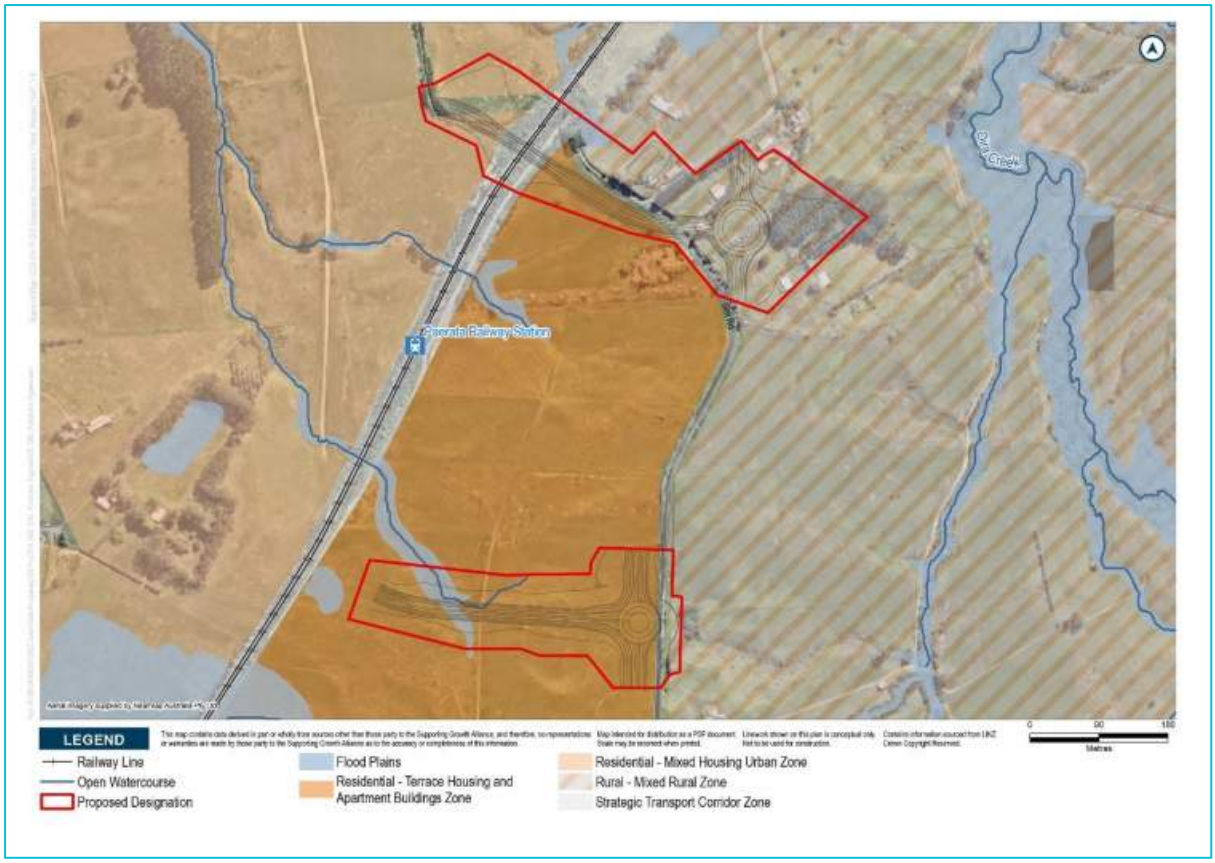


Figure 4-6: NoR 3 Paerata Connections likely future environment as described using the AUP:OP zones and Pukekohe-Paerata Structure Plan 2019 zones

4.2.4 Pukekohe North-East Arterial - NoR 4

NoR 4 connects Paerata Road in the west, to Pukekohe East Road in the south. The catchments for NoR 4 is in the Whangapouri Stream at either end and in the Oira Stream catchment through the mid-section. The route passes through rural land uses located in the FUZ and part is within the rural zone.

The NoR 4 route crosses seven (7) streams as shown in Figure 4-5. These natural streams are located through the low elevation terrain in pastoral farmland. Each stream will need a bridge or a culvert to manage flows through the road crossing earthworks.

The future environment is planned to be FUZ with a section of mixed rural zone in the mid-section. The FUZ development is expected to avoid development in the stream areas and include green spaces as recreation parks and sporting fields. In turn, the future environment will change greatly with regard to stormwater runoff. However, the pressures placed on the downstream infrastructure from the FUZ development are expected to be minimal as a result of the stormwater mitigation that will be constructed also. shows the existing aerial and floodplains in the vicinity of NoR 4 along with the AUP:OP zoning indicating the extent of FUZ.

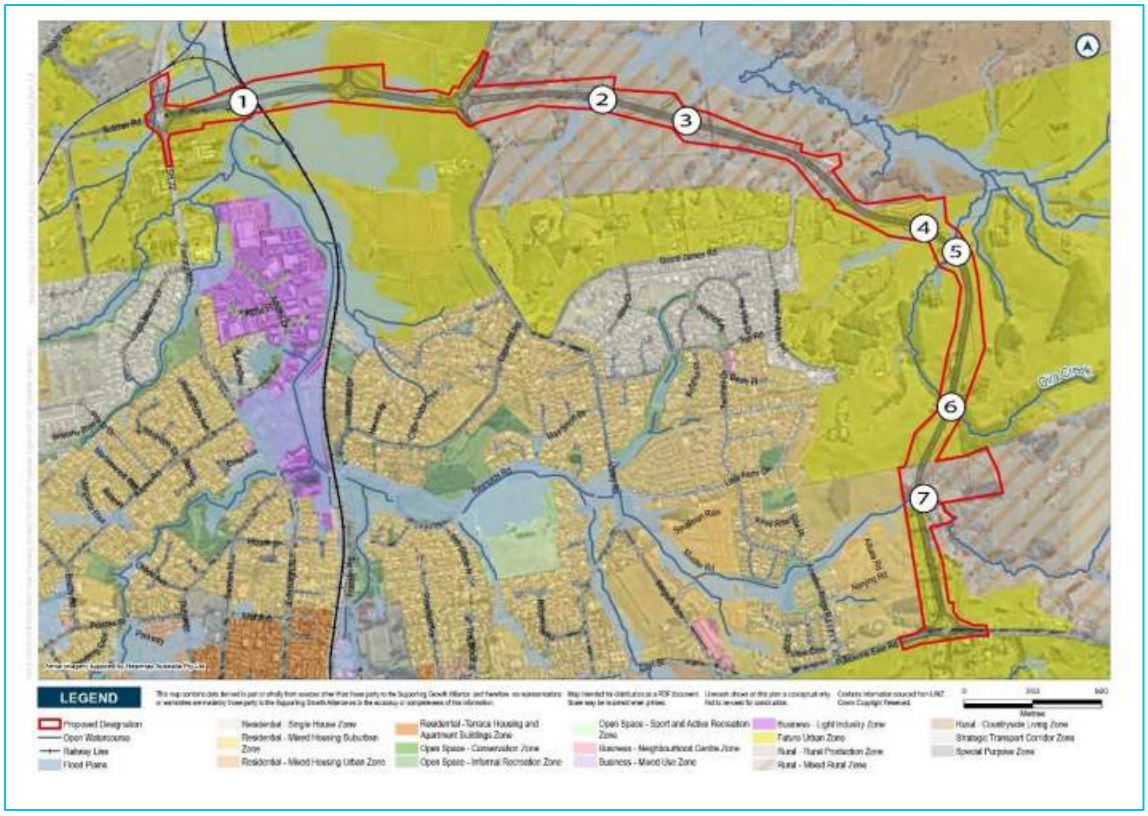


Figure 4-7: NoR 4 Pukekohe North-East Arterial existing land uses as described using the AUP:OP

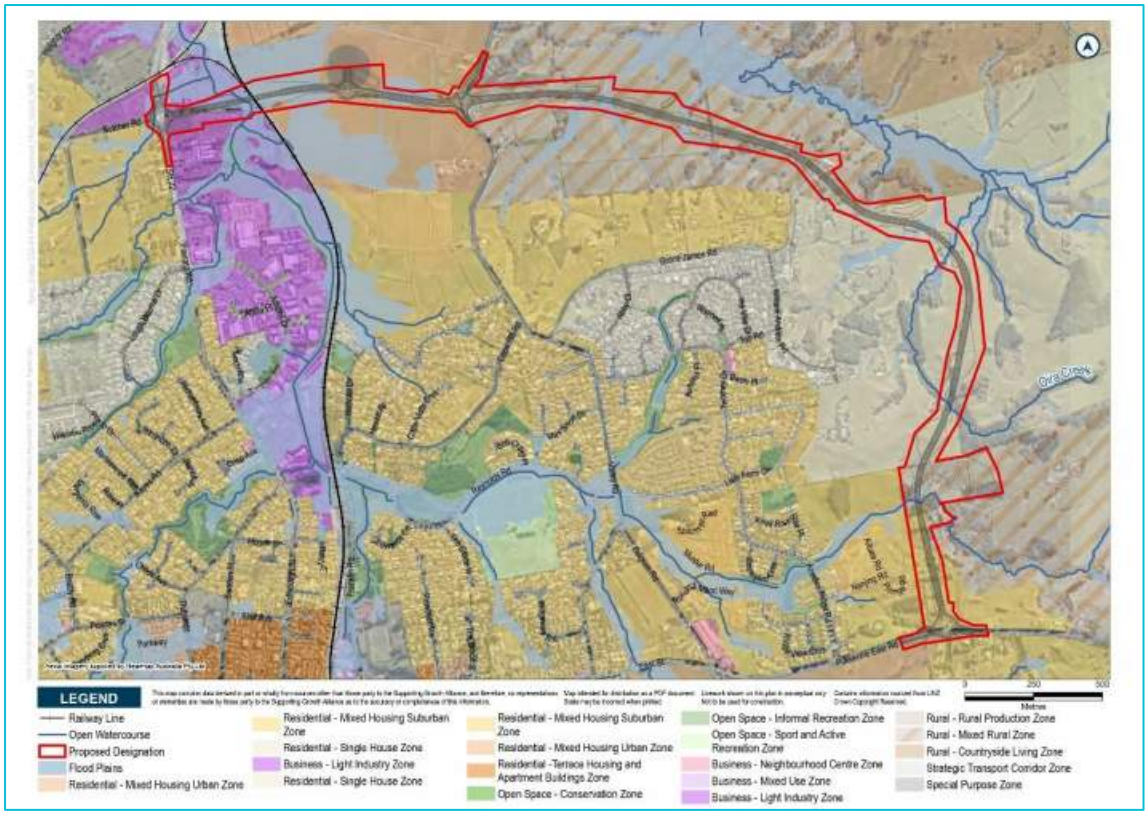


Figure 4-8: NoR 4 Pukekohe North-East Arterial existing land uses (top) and likely future environment (bottom) as described using the AUP:OP zones and Pukekohe-Paerata Structure Plan 2019 zones

4.2.5 Pukekohe South-East Arterial - NoR 5

NoR 5 Pukekohe East Road in the east, to Svendsen Road in the south. The alignment passes through the Whangapouri Stream catchment in the northern half then through the Tatuanui Stream catchment in the southern half. The route is located in the FUZ at Pukekohe East Road, Golding Road and the new section of road between Golding Road and Station Road. The new section of road crosses Station Road and the NIMT to connect at Svendsen and Crosbie Roads in the existing urban area in Pukekohe.

NoR 5 crosses four (4) overland flow paths as shown in Figure . Flow paths at points 1 and 2 pass through the low elevation parts of rural residential land in natural channels and existing culverts under Golding Road. Point number 3 is a small farm drain with a wide and flat floodplain. Points 1 and 2 will require a lengthened culvert to accommodate the widened road and point 3 will need a new bridge or a culvert to manage flows through the proposed works. Crossing 4 is an artificial watercourse that will be filled in by the earth embankment required for the new section of road over the rail. This section of stream will need a diverted open channel of similar or larger capacity on the northern side of the road alignment to maintain drainage and manage flood effects.

The future environment is planned to be urbanised and would likely avoid development in the stream areas and include green spaces as recreation parks and sporting fields. However, it is reasonable to expect the impervious area of the land to increase as a result of this urbanisation, roads and associated infrastructure. Figure shows the existing aerial and floodplains in the vicinity of NoR 5 along with the AUP:OP zoning indicating the extent of FUZ.

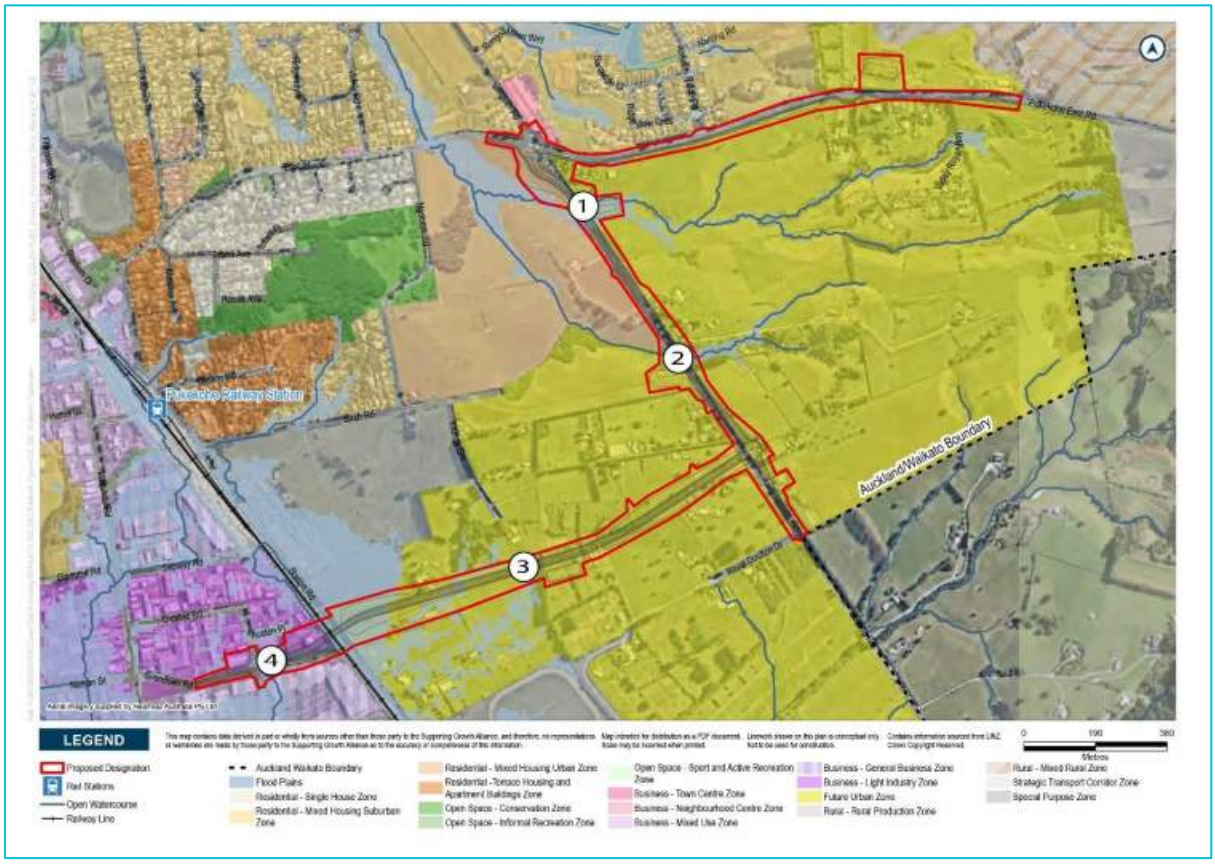


Figure 4-9: NoR 5 Pukekohe South-East Arterial existing land uses as described using the AUP:OP zones

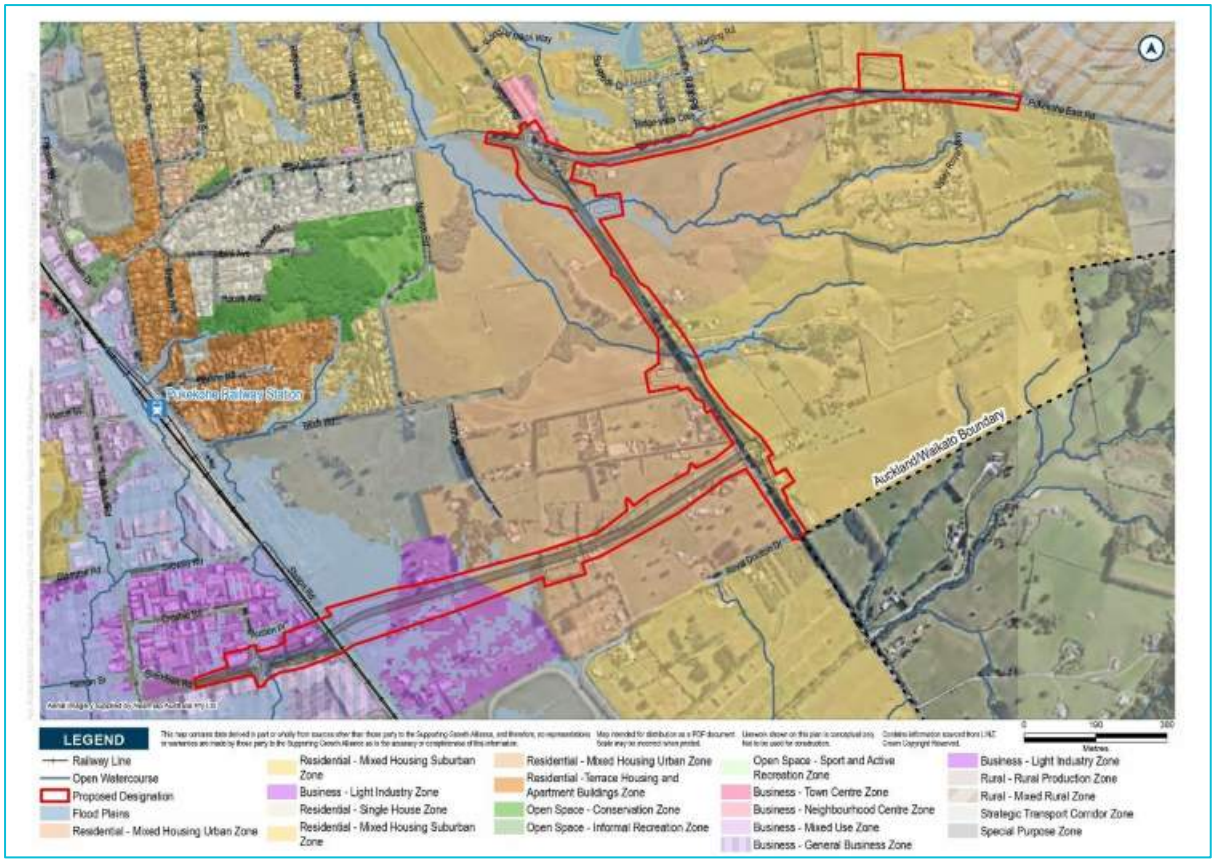


Figure 4-10: NoR 5 Pukekohe South-East Arterial likely future environment as described using the AUP:OP zones and Pukekohe-Paerata Structure Plan 2019 zones

4.2.6 Pukekohe South-West Upgrade - NoR 6

NoR 6 is an active mode upgrade of existing roads in the existing urban area of Pukekohe and includes small, isolated areas of designation. NoR 6 is mostly in the Tatuanui Stream and Whangapouri Stream catchments. The alignment shown in Figure shows the sparse and small parcel nature of land required. This land is needed primarily for localised areas of road widening and has no flood effect component for assessment.

The future environment will not likely change as this area is already fully developed on both sides of the existing roads. It is reasonable to expect the impervious area of the land to increase slightly as the land intensifies in the future. Figure shows the existing aerial and floodplains in the vicinity of NoR 6 along with the AUP:OP zoning indicating the extent of FUZ.

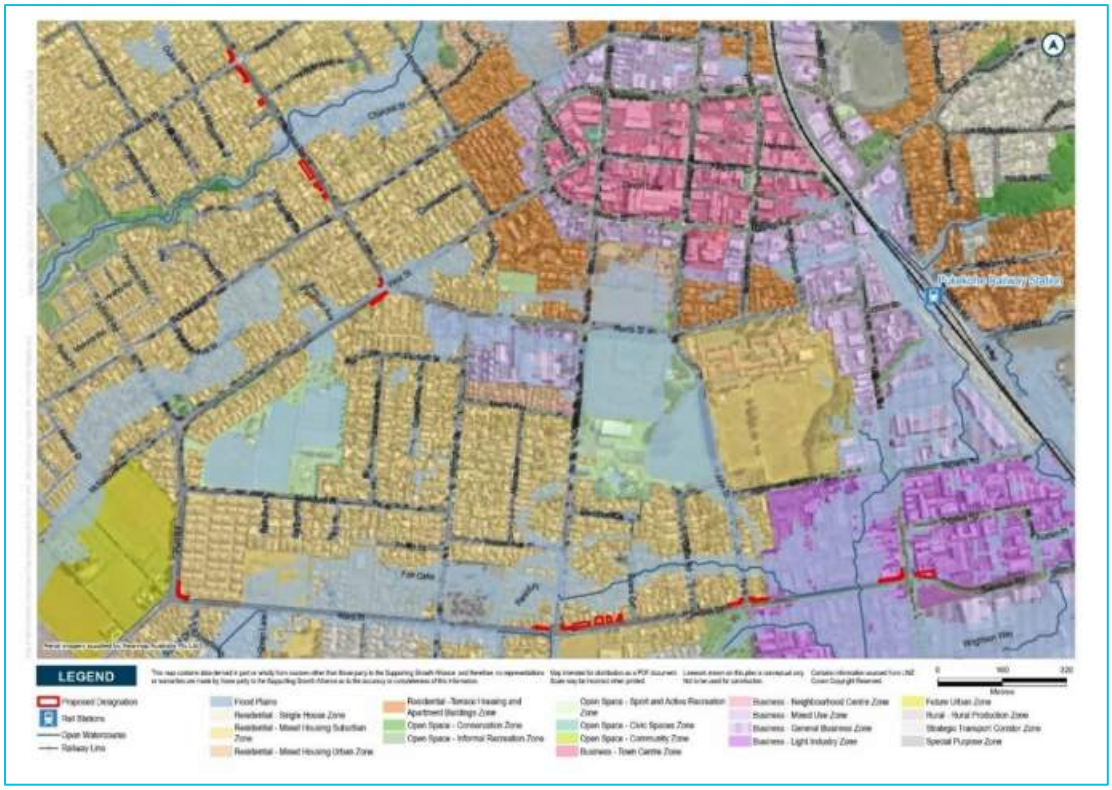


Figure 4-11: NoR 6 Pukekohe South West Upgrade existing land uses as described using the AUP:OP zones and Structure Plan zones

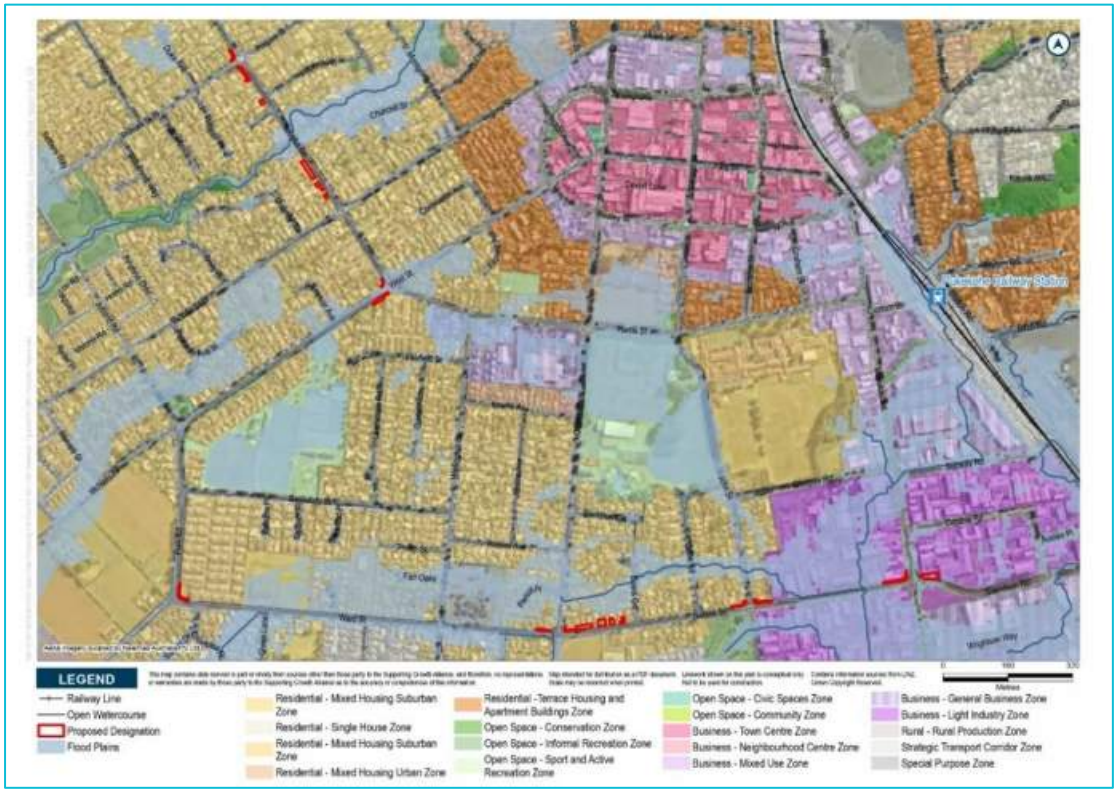


Figure 4-12: NoR 6 Pukekohe South West Upgrade likely future environment as described using the AUP:OP zones and Pukekohe-Paerata Structure Plan 2019 zones

4.2.7 Pukekohe North-West Arterial - NoR 7

NoR 7 upgrades Helvetia Road in the south and provides a new section of road between Helvetia/Gun Club/Heights Roads to Paerata Road in the north-east. NoR 7 is entirely in the Whangapouri Stream catchment and within the FUZ.

The NoR 7 route crosses seven (7) overland flowpaths as shown in Figure . These flowpaths are small headwater catchments to the Whangapouri Stream. Each flowpath, except 6, 5 and 3, have culverts under an existing road. The flowpaths 1, 2, 4 and 7 will require a lengthened or upgraded culvert capacity to manage the larger/wide, higher road embankment.

The future environment will intensify as FUZ is shown on both sides of the NoR 7 alignment. It is reasonable to expect the impervious area of the land to increase as the land intensifies in the future and drainage infrastructure will need to account for this. Figure shows the existing aerial and floodplains in the vicinity of NoR 7 along with the AUP:OP zoning indicating the extent of FUZ.

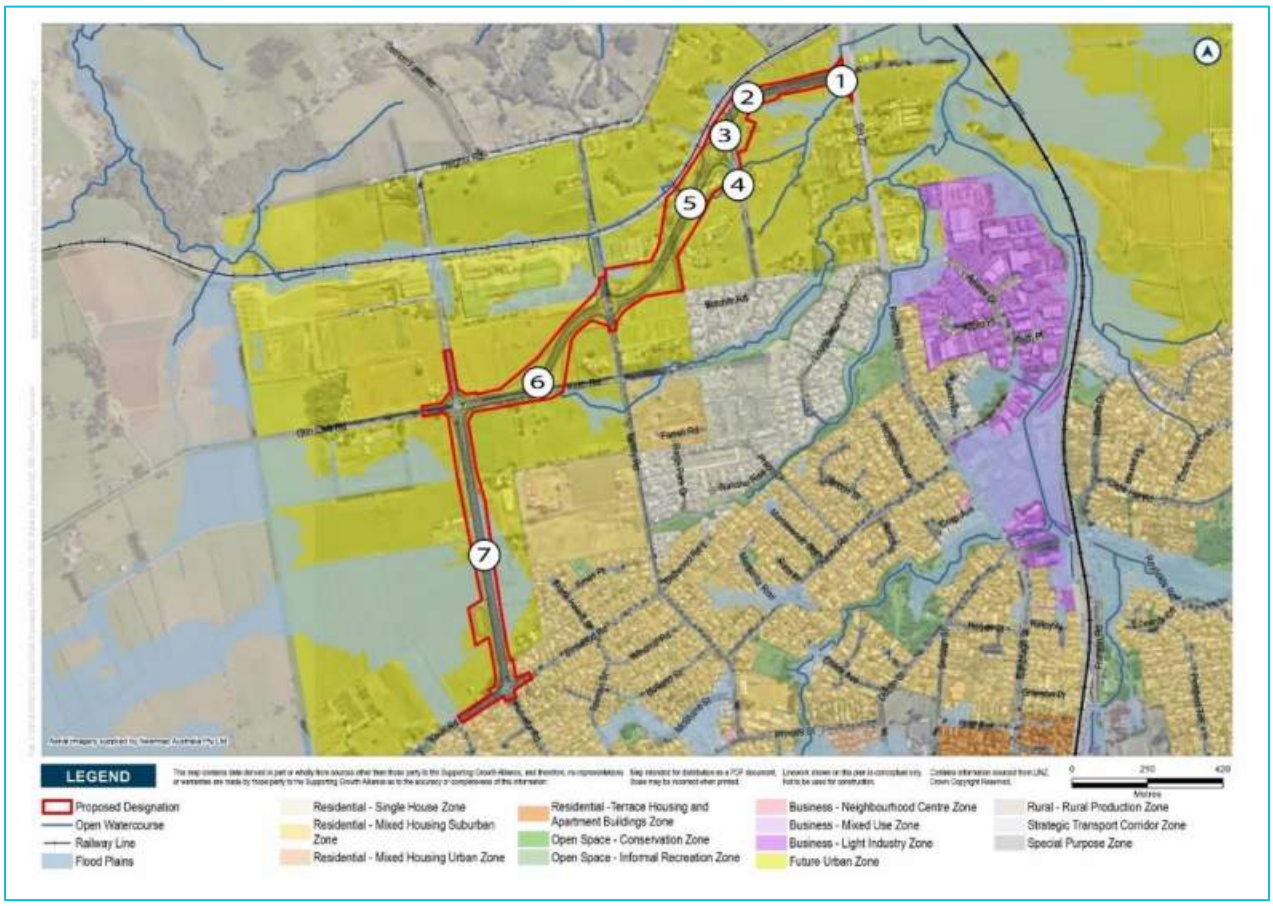


Figure 4-13: NoR 7 Pukekohe North West Arterial existing land uses as described using the AUP:OP zones

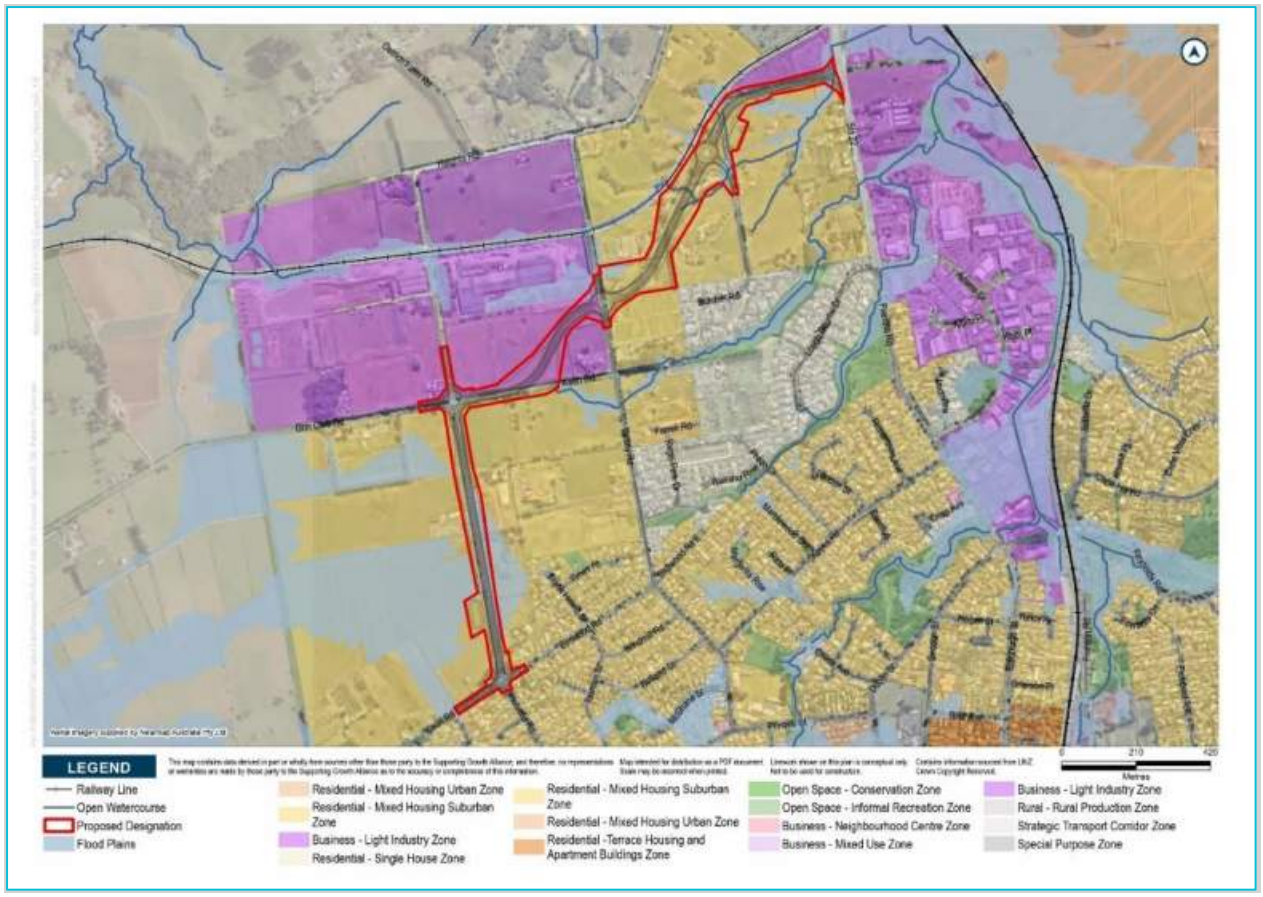


Figure 4-14: NoR 7 Pukekohe North West Arterial likely future environment as described using the AUP:OP zones and Pukekohe-Paerata Structure Plan 2019 zones

4.2.8 Mill Road – Pukekohe East Road Upgrade - NoR 8

NoR 8 is an upgrade of the existing Pukekohe East Road and Mill Road. It includes widening Mill Road for additional vehicles lanes and a shared path from State Highway 1 to Harrisville Road and then a shared path on the southern side of the road from this point into Pukekohe along Pukekohe East Road. NoR 8 passes through the Whangapouri Stream catchment, Tatuanui Stream catchment and the Ngakoroa Stream catchment from west to east. The majority of the alignment is within the rural zone with only the most western part in the Pukekohe FUZ.

NoR 8 crosses two (2) overland flowpaths as shown in Figure . These flowpaths are both branches of the Ngakoroa Stream and already have culverts constructed under the existing road. Both culverts may need to be lengthened or upgraded to accommodate the widened road.

The future environment will largely remain unchanged with the rural zone on the majority of both sides of the alignment. It is reasonable to expect the impervious area of the land to remain the same in the future. Some areas to the west of the NoR 8 is in the future urban zone and therefore, will intensify the impervious surface in this area. As no drainage structures pass under the NoR alignment in this

area, the FUZ will not have an impact on NoR 8 from a stormwater drainage perspective.

shows the existing aerial and floodplains in the vicinity of NoR 8 along with the AUP:OP zoning indicating the extent of FUZ and rural zones.

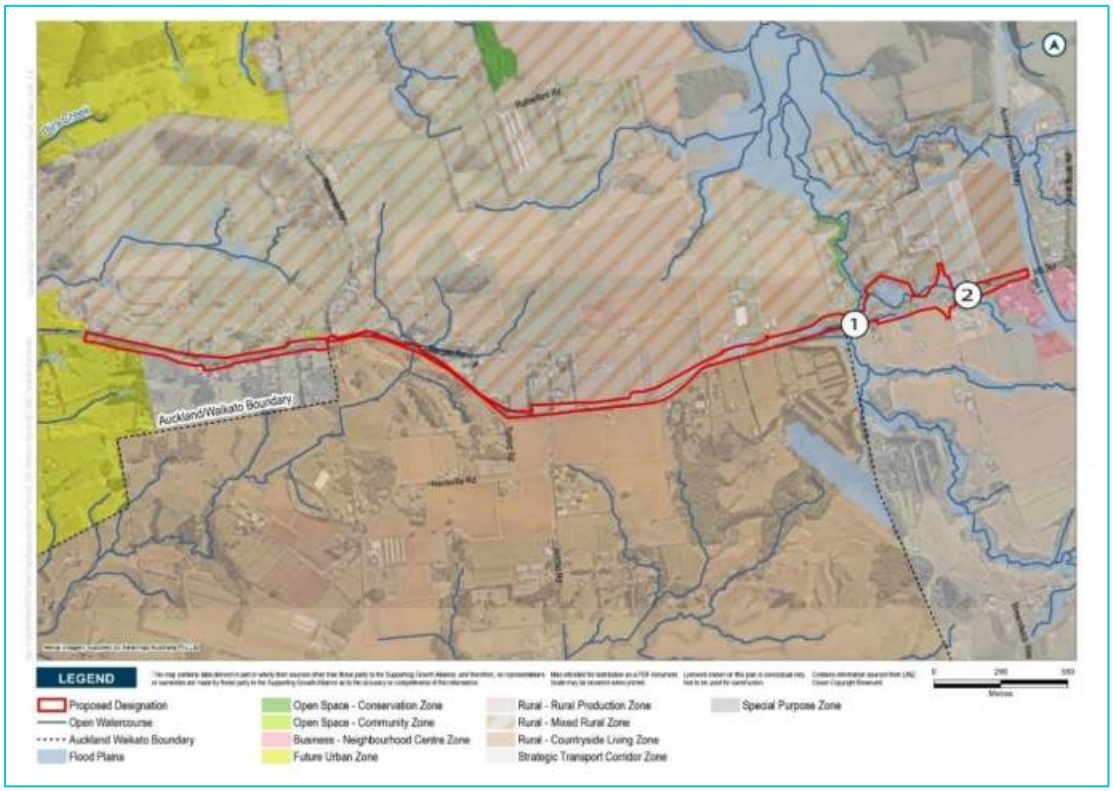


Figure 4-15: NoR 8 (AC) Mill Road and Pukekohe East Road Upgrade existing land uses as described using the AUP:OP zones

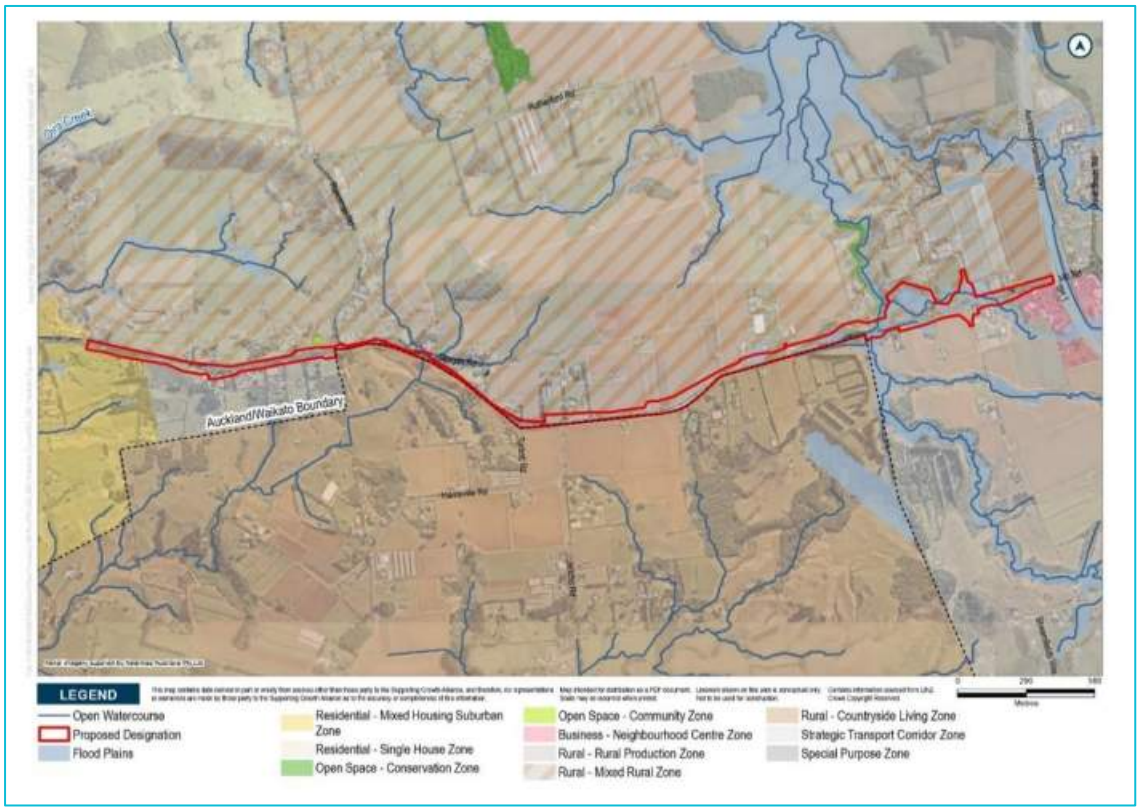


Figure 4-16: NoR 8 (AC) Mill Road and Pukekohe East Road Upgrade likely future environment as described using the AUP:OP zones and Pukekohe-Paerata Structure Plan 2019 zones

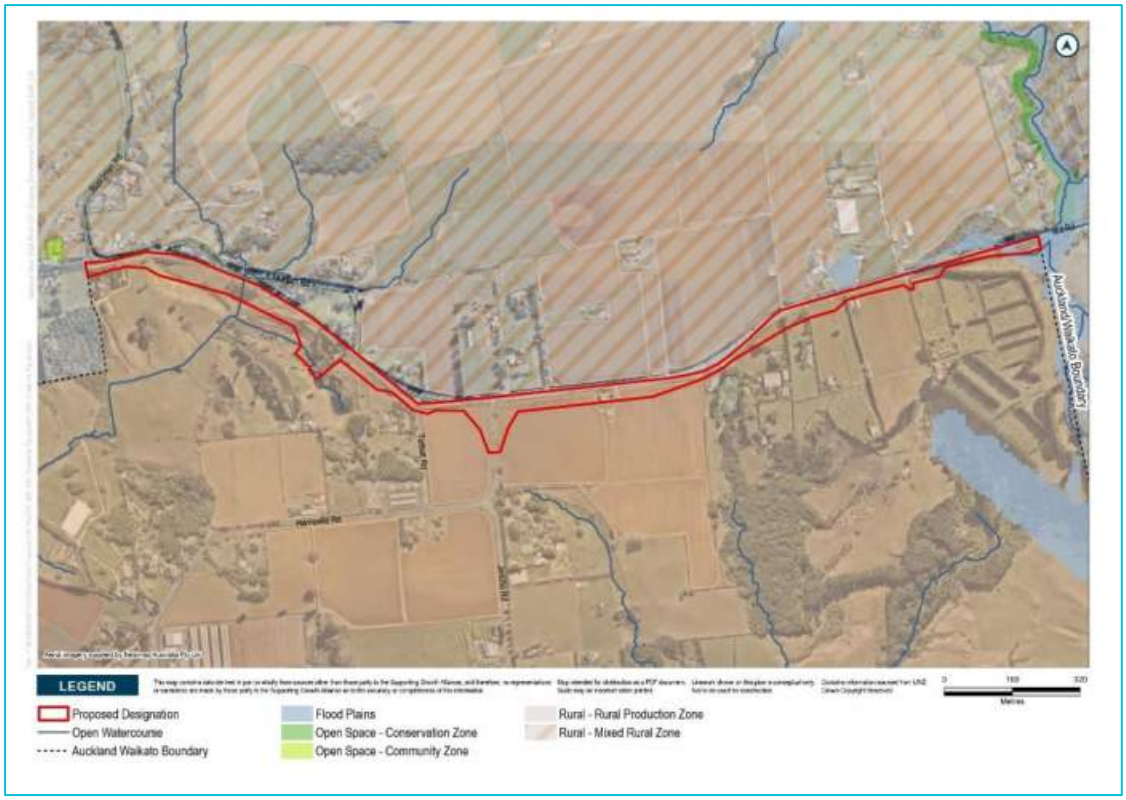


Figure 4-17: NoR 8 (WDC) Mill Road and Pukekohe East Road Upgrade existing and likely future environment as described using the WDP zones.

5 Assessment of Construction Effects

5.1 Construction effects – relating to all NoRs

The construction of a new road can have significant effects on flooding in the surrounding areas if a major rainfall event were to occur during the construction phase. The first phase of construction generally includes the removal of vegetation which can disrupt natural drainage patterns and require temporary diversions.

The second phase of construction is earthworks and it can take a long period of time to complete this work depending on weather, the volume of earth moving and the source and destination of material being transported. The earthmoving process can involve temporary stockpiles, constantly changing barriers to stormwater diversions and new earth works profiles in floodplains. These changes can generate a multitude of effects depending on the timing of the rainfall event and the earthmoving situation at the time.

Construction yards and stockpiles should be located outside of flood plains and major overland flow paths and therefore will not increase flood hazard risks. Construction yard locations will be confirmed during the construction phase and siting them with respect to flooding constraints should be considered further through the Construction Environmental Management Plan (CEMP).

The following phase of construction is structure construction and road sealing. The construction of drainage structures such as culverts and bridges will generally take place offline or during the

presence of a stream diversion. The effects on flooding during this phase will vary depending on the level of completion of the culvert or bridge. Generally, these structures are constructed quickly and the window for a flood event to occur while a culvert is being lain or a bridge abutment is being built is very low. In the event of flood event mid construction, the temporary diversions should manage the risk. Therefore, it is expected that flooding effects can be appropriately managed during the construction phase.

Each NoR will be constructed with similar levels of flood risk during the construction phase, with the exception for NoR 6, where no changes are proposed to drainage infrastructure. Flood risk during construction for each NoR will need to be managed. Typically, resource consent conditions will require a construction program and sequence to be approved prior to construction that considers the likelihood and consequence of flooding during the works period.

5.2 Recommended Measures to Avoid, Remedy or Mitigate Construction Effects

Flood hazard risks for the construction phase should be addressed in a CEMP. The CEMP should be developed prior to construction in conjunction with an experienced Stormwater Engineer and should consider the effects of temporary works, earthworks, storage of materials, temporary diversion and drainage on flow paths, flow levels and velocities. In preparing the CEMP, key issues to consider are:

- Siting construction yards and stockpiles with minimal effects on flood flows
- Methods to reduce the conveyance of materials and plant that is considered necessary to be stored or sited within the flood plain (e.g. actions to take in response to the warning of heavy rainfall events)
- Staging and programming to carry out work when there is less risk of high flow events,
- Diverting overland flow paths away or through areas of work
- Minimizing the physical obstruction to flood flows at the road sag point

Future detailed design will be subject to a separate detailed flood assessment at the outline plan and regional consenting phase, where measures to mitigate effects during construction will be assessed in more detail.

6 Assessment of Operational Effects

6.1 Introduction

Flood hazard risks from the operation of the Project may result from changes to:

- The flood freeboard to existing habitable buildings;
- Overland flow paths and flood prone areas;
- Flood levels on developable land (in the FUZ);
- The ability to access property by residents and emergency vehicles.

Operational effects have been assessed through flood modelling to consider the flooding extents at culvert crossings, bridge structure and areas where the new road embankment significantly encroaches existing flood plains or major overland flow paths. The assessment also considers the extents of flooding on existing properties due to the proposed projects.

The assessment of operational effects for the Project is based on the 100-year flood model results for the pre-development (existing) terrain and considers the flooding extents at the NoR locations without the NoR design included. The following matters have been considered as part of this assessment:

- Existing flooding and freeboard at key points identified from modelling the existing terrain;
- The potential of flooding on existing properties due to the new Project corridor geometry;
- Incremental changes to the corridor impervious area; and
- Potential effects to land as a result of the NoR Project works

The mitigation measures set out in Section 0 are recommended so that flood effects are adequately addressed during the future detailed design stage of the Project and that adverse flood effects are avoided, remedied or mitigated.

Both the 2.1 degree (2.1º) and 3.8 degree (3.8º) climate change scenarios have been assessed to give context and sensitivity of future flood effects that may result from a changing climate.

Future detailed design will be subject to a separate detailed flood assessment at the outline plan and regional consenting phase which will refine the design of transport corridors including the horizontal and vertical alignment, culverts, bridge crossings and location / size of treatment (attenuation, water quality or both).

6.2 Recommended measures to avoid, remedy or mitigate operational effects (all NoRs)

The following general measures are recommended to mitigate flood hazard effects:

- Size culverts and bridges to meet proposed conditions on flood hazard outcomes.
- No attenuation in wetlands in the lower half of the catchment within the Project works are located.
- Attenuation for the 10yr and 100yr where wetlands are located in the upper half of the larger catchment.
- Provide diversion channels at the toe of fill embankments to prevent ponding.
- Offset flood volume displacement effects of filling in the floodplain.

- Maintain 1200mm freeboard to new bridge soffits using the 100 year ARI flood level with 3.8º Climate change hydrology.
- Extend culverts at the same diameter and replace culverts at the same diameter.
- Avoid lifting the crown of the road to prevent adverse effects upstream.
- Avoid lowering the road crown to cause effects downstream.

It is recommended the following condition is included on all NoRs that requires the Projects be designed to achieve the following outcomes:

- No increase in flood levels in a 1% AEP event for existing authorised habitable floors that are already subject to flooding or have a freeboard less than 150mm;
- No more than a 10% reduction in freeboard in a 1% AEP event for existing authorised habitable floors with a freeboard of over 150mm;
- No increase in 1% AEP flood levels for existing authorised community, commercial, industrial and network utility building floors that are already subject to flooding;
- No more than a 10% reduction in freeboard in a 1% AEP event for existing authorised community, commercial, industrial and network utility building floors;
- No increase of more than 50mm in flood level in a 1% AEP event on land zoned for urban or future urban development where there is no existing dwelling;
- No new flood prone areas; and
- No more than a 10% average increase of flood hazard (defined as flow depth times velocity) for main access to authorised habitable dwellings existing at time the Outline Plan is submitted. The assessment shall be undertaken for the 50%, 20%, 10% and 1% AEP rainfall events.
- Compliance shall be demonstrated in the Outline Plan, which shall include flood modelling of the pre-Project and post-Project 10% and 1% AEP flood levels (for Maximum Probable Development land use and including climate change).
- Where the above outcomes can be achieved through alternative measures outside of the designation such as flood stop banks, flood walls, raising existing authorised habitable floor level and new overland flow paths or varied through agreement with the relevant landowner, the Outline Plan shall include confirmation that any necessary landowner and statutory approvals have been obtained for that work or alternative outcome.

6.3 Operational effects – relating to specific NoRs

The following sections provide a NoR specific assessment of operational effects. The figures provide an overview of flood hazard points in relation to the NoRs (highlighted through numbers, which correlate to the following table). Increased detail of each flood hazard is provided in Appendix A – Detailed Flood Hazard Locations of this report. The figures in Appendix A have a letter correlating to a relevant address. These figures (in Appendix A) graphically show a a 2.1º climate change adjustment however also provide the 3.8º and 2.1 º flood levels for the given point in the box at the bottom.

6.3.1 Drury West Arterial – NoR 1

The flood hazards from the 100 year ARI flood with a 2.1º climate change adjustment to rainfall produces a mostly high flood risk in the floodplains surrounding the Ngakoroa Stream. NoR 1 crosses four smaller tributaries to the Ngakoroa Stream before passing over this stream at crossing 5 and 6. Figure shows the results of the modelling with the hazard colours used to indicate the level of hazard to land uses in vicinity of the NoR 1 road alignment.

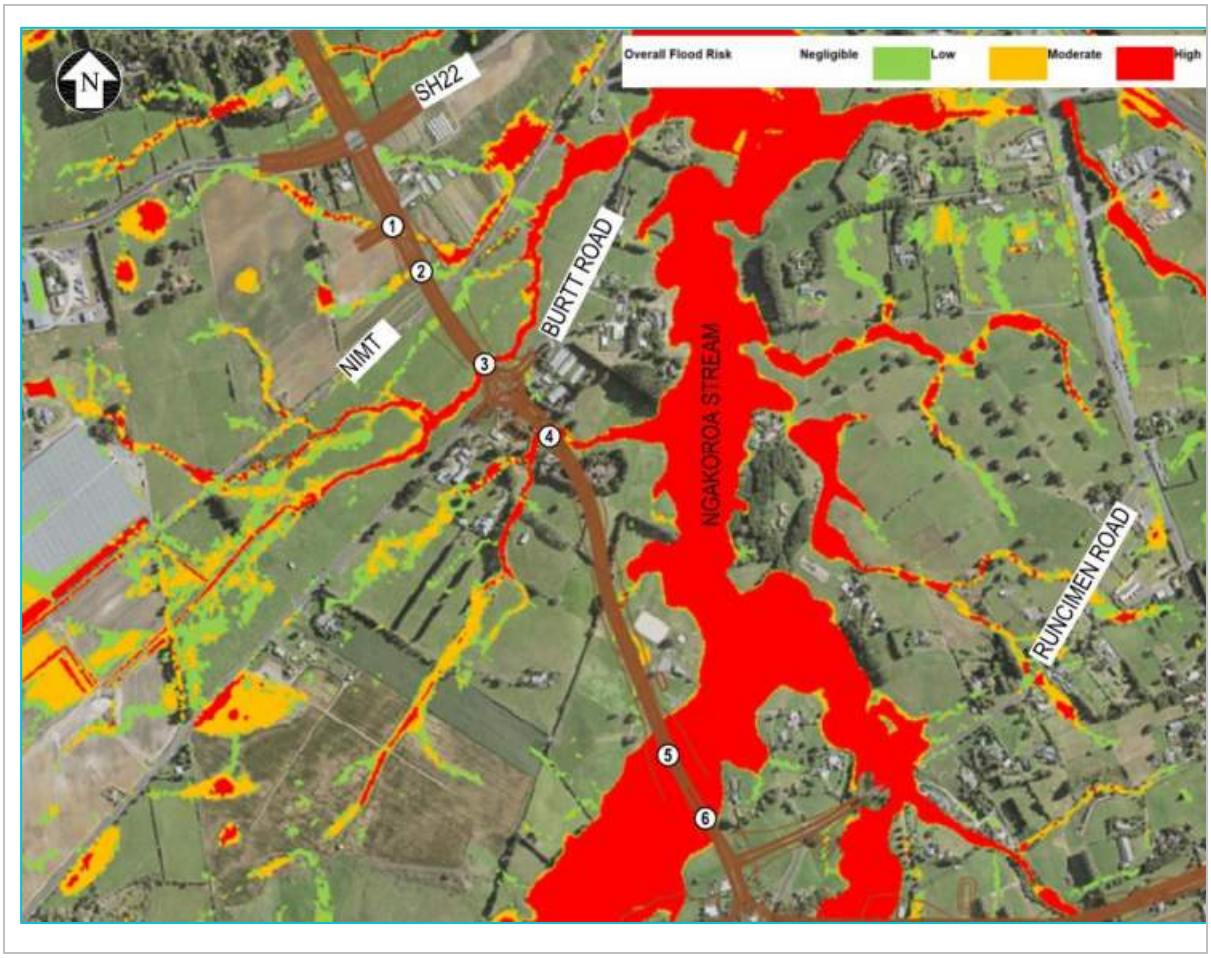


Figure 6-1: 2.1-degree 1% AEP flooding at the Drury West Arterial - NoR 1 designation

The six (6) flowpath crossing flood hazards for the 100 year ARI, 2.1º climate change flood model are described in detail below in Table 11, and numbered within the figure above. Note the future risks defined do not include in-stream areas or likely future riparian buffers. The future risks apply to a reasonable assessment of developable land inside the FUZ areas and include floodplains.

Table 11: NoR 1 – 100 year ARI (2.1º CC) flood hazards (Existing Development)

Point	Drainage Channel / Property address	Existing Land Use	Likely Future Land Use	100 Year Flood Level	Existing and likely future flood risk rating
1	110 Karaka Road	Rural Lifestyle Residential building (FUZ) Building floor level 20.50m RL	Future Urban Development in the FUZ	2.1º CC: 18.60m RL 3.8º CC: 18.92m RL	Negligible existing and future risk
2	110 Karaka Road, Drury	Agricultural land in the FUZ invert level 15.00m RL	Ngakoroa Train Station Park and Ride	2.1º CC: 15.20m RL 3.8º CC: 15.35m RL	Some moderate existing risk and negligible future risk
3	647 Burtt Road, Drury	Ephemeral channel invert level RL 10.80m and grazing land	Undeveloped floodplain in the FUZ (St Ignatius of Loyola Catholic College – Future School proposed to open in 2024)	2.1º CC: 11.80m RL 3.8º CC: 12.05m RL	Negligible existing and future risk.
4	584 Burtt Road, 600 Burtt Road, Drury	Rural Lifestyle Residential building (FUZ) Building floor level RL 16.2m RL	Residential buildings in the FUZ	2.1º CC: 11.50m RL 3.8º CC: 12.11m RL	Negligible existing and future risk
5 and 6	Ngakoroa Stream channel level RL 7.1m RL	Ngakoroa Stream Floodplain	Floodplain in the FUZ	2.1º CC: 10.20m RL 3.8º CC: 10.36m RL	High existing and future risk in floodplain, negligible existing and future risk out of floodplain.

The land through which all 6 flowpath crossings intersect with the NoR 1 alignment are rural (within FUZ) with some nearby buildings in vicinity to the natural waterways. Existing and future buildings nearby will need to be considered in future detailed design. The potential afflux at points 1 through to 6 as a result of the project works will depend on the size of culverts or span of bridges constructed. Changes/variation in these dimensions will not affect the designation footprint of the road alignment and therefore can be assessed at a later design stage to meet the flood hazard outcomes that are included as conditions on the proposed designation.

The effects of using a 3.8º climate change adjusted rainfall pattern compared to the 2.1º climate change pattern shows deeper flood depths in all six flowpath crossings for the NoR 1 road alignment. The changes in flood depth are relatively small with the change range of 0.1m to 0.3m measured.

Culvert and bridge designs to manage the flow through these locations can be sized to manage the upstream and downstream flood level changes within the footprint designated at a later design stage.

The general flood effect elimination, minimisation and mitigation recommendations for NoR 1 are:

- Size culverts and bridges to meet proposed designation conditions on flood hazard outcomes.
- No attenuation in wetlands, attenuation will increase flow coincidence downstream.
- Provide diversion channels at the toe of fill embankments to prevent ponding.
- Maintain 1200mm freeboard to new bridge soffits using the 100-year ARI flood level with 3.8º Climate change hydrology.

The flood hazard outcomes in the conditions are appropriate to manage the effects of this NoR considering the existing and likely future land uses. The bridge and culvert solutions will be refined to achieve these conditions and the designation is sufficient to allow for larger structures if required.

6.3.2 Drury – Pukekohe Link – NoR 2

Drury – Pukekohe Link flood hazards from the 100 year ARI flood with a 2.1º climate change adjustment to rainfall will produce a mostly negligible flood risk due to the mostly uninhabited land upstream of flowpath crossings. NoR 2 alignments crosses 8 flowpaths and includes floodplain displacement between points 3 and 4. Figure 6-2Figure shows the results of the modelling with the hazard colours used to indicate the level of hazard to land uses in vicinity of the NoR 2 alignment.

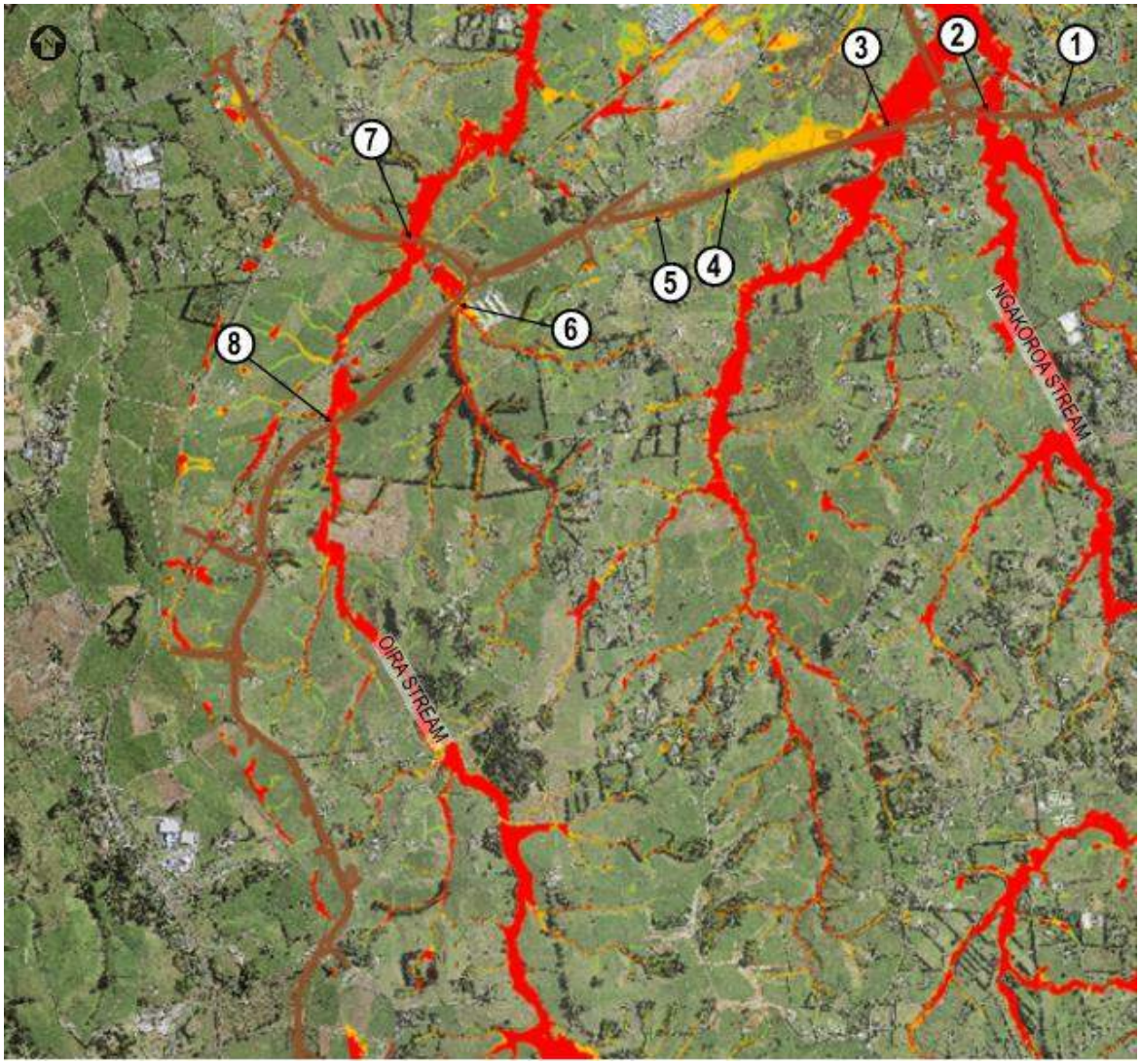


Figure 6-2: 2.1 degree 1% AEP flooding at the Drury – Pukekohe Link - NoR 2 designation.

The eight (8) flowpath crossing flood hazards for the 100 year ARI, 2.1º climate change flood model are described in detail below in Table 12. Note the future risks defined do not include in-stream areas or likely future riparian buffers. The future risks apply to a reasonable assessment of developable land inside the FUZ areas and include floodplains.

Table 12: Drury – Pukekohe Link - NoR 2 – 100 year ARI (2.1º CC) flood hazards (Existing Development)

Point	Drainage Channel / Property address	Existing Land Use	Likely Future land use	100 Year flood level	Existing and likely future flood risk rating
1	Ngakoroa Stream Tributary channel level 14.1m RL	Floodplain/ Agricultural land in the Countryside Living Zone	No change expected, Rural land use	2.1º CC: 19.80m RL 3.8º CC: 20.08m RL	Negligible existing and future risk

Point	Drainage Channel / Property address	Existing Land Use	Likely Future land use	100 Year flood level	Existing and likely future flood risk rating
	(approx.) 17 Ngakoroa Road, Drury				
2	Ngakoroa Stream channel level 9.6m RL 22 Ngakorora Road, Drury	Floodplain/ Agricultural land in the FUZ/Countryside Living Zone	No change expected, Rural land use	2.1º CC: 13.20m RL 3.8º CC: 13.26m RL	Negligible existing and future risk
3	767 Runciman Road, Site level RL 8.92m	Residential dwelling in Rural Zone. Working agricultural and horticultural land uses with >0.5m depth	No change expected, Rural land use	2.1º CC: 9.73m RL 3.8º CC: 9.91m RL	Moderate existing and future risk to dwellings with <500mm freeboard and rural land with >0.5m depth.
3	763B Runciman Road, Site level RL 9.03m	Residential dwelling and lifestyle block in the Rural - Countryside Living Zone.	No change expected, Rural land use	2.1º CC: 9.75m RL 3.8º CC: 9.92m RL	Moderate existing and future risk to dwellings with <500mm freeboard and rural land with >0.5m depth.
4	Ngakoroa Stream Tributary channel level 13.0m RL (approx.) 338 Burtt Road	Floodplain/ Agricultural land in the FUZ/ Countryside Living Zone	No change expected, Rural land use	2.1º CC: RL 13.45m 3.8º CC: 13.65m RL	Negligible existing and future risk
5	Ngakoroa Stream Tributary channel level 22.0m RL 338 Burtt Road	Floodplain/ Agricultural land in the FUZ/ Mixed Rural Zone	No change expected, Rural land use	2.1º CC: RL 22.30m 3.8º CC: 22.35m RL	Negligible existing and future risk
6	357 Burtt Road, Site level RL 18.00m	Commercial buildings in the Rural - Mixed Rural Zone	No change expected, Rural land use	2.1º CC: 17.46m RL 3.8º CC: 17.65m RL	Negligible existing and future risk

Point	Drainage Channel / Property address	Existing Land Use	Likely Future land use	100 Year flood level	Existing and likely future flood risk rating
7	Oira Stream channel level 11.3m RL Bycroft Road, Drury	Floodplain/ Agricultural land in the Rural – Mixed Rural Zone	No change expected, Rural land use	2.1º CC: 14.80m RL 3.8º CC: 15.01m RL	Negligible existing and future risk
8	Oira Stream channel level 14.6m RL 357 Burtt Road, 319E Sim Road	Floodplain/ Agricultural land in the Rural – Mixed Rural Zone	No change expected, Rural land use	2.1º CC: 18.60m RL 3.8º CC: 18.81m RL	Negligible existing and future risk

The land uses upstream of points 1, 2, 4, 5, 7 and 8 is unoccupied farmland and floodplain with no dwellings nearby. Future buildings nearby will need to be considered when deciding on an acceptable level of flood hazard change (afflux).

The commercial and residential buildings at point 3 are already within the floodplain and would likely flood on a regular basis already. The Pinelands Poultry commercial buildings at point 6 were constructed between April 2016 and January of 2017. The land was lifted out of the floodplain to provide adequate freeboard to these buildings and any afflux upstream would begin to erode this afflux and begin placing these buildings at risk.

The amount of filling in the floodplain at point number 3 may generate a displacement effect and increase flood levels locally. The increase can be offset by excavating an equivalate amount of material from the floodplain the southern side or by lengthening the bridge to reduce the amount of fill in the floodplain. The designation contains land available for a combination of these measures to balance the flood effects and achieve the drafted flood effect condition outcomes.

The potential afflux at all points discussed above as a result of the project works will depend in the size of culverts or span of bridges constructed. Sizing of culverts and bridges will need to meet the flood hazard conditions on the NoR. This is best undertaken at future design stages and will, in part, depend on the changes in land use and construction of new buildings at the time the road alignment is developed further for construction.

The effects of using a 3.8º climate change adjusted rainfall pattern compared to the 2.1º climate change pattern shows deeper flood depths in all eight flowpath crossings for the NoR 2 road alignment. The changes in flood depth are relatively small with the change range of 0.09m to 0.32m measured. Culvert and bridge designs to manage the flow through these locations can be sized to manage the upstream and downstream flood level changes within the footprint designated at a later design stage.

The general flood effect elimination, minimisation and mitigation recommendations for NoR 2 are:

- Size culverts and bridges to meet proposed designation conditions on flood hazard outcomes.
- No attenuation in wetlands in the lower half of the Ngakoroa and Oira Streams.
- Attenuation for the 10yr and 100yr where wetlands are located in the upper half of the Ngakoroa and Oira Streams

- Attenuation in wetlands located within the Whangapouri Stream catchment.
- Provide diversion channels at the toe of fill embankments to prevent ponding.
- Offset the flood volume displaced by filling in the floodplain with an equivalent volume of excavation within the floodplain.
- Maintain 1200mm freeboard to new bridge soffits using the 100-year ARI flood level with 3.8º Climate change hydrology.

The flood hazard outcomes in the conditions are appropriate to manage the effects of this NoR considering the existing and likely future land uses. The bridge and culvert solutions will be refined to achieve these conditions and the designation is sufficient to allow for larger structures if required.

6.3.3 Paerata Connections – NoR 3

The NoR 3 flood hazards from the 100 year ARI flood with a 2.1º climate change adjustment to rainfall only crosses a single flowpath. The land uses in proximity of the NoR 3 are rural. Therefore, a negligible flood risk exists to upstream land. Figure 6-3Figure shows the results of the modelling with the hazard colours used to indicate the level of hazard to land uses in vicinity of the NoR 1.

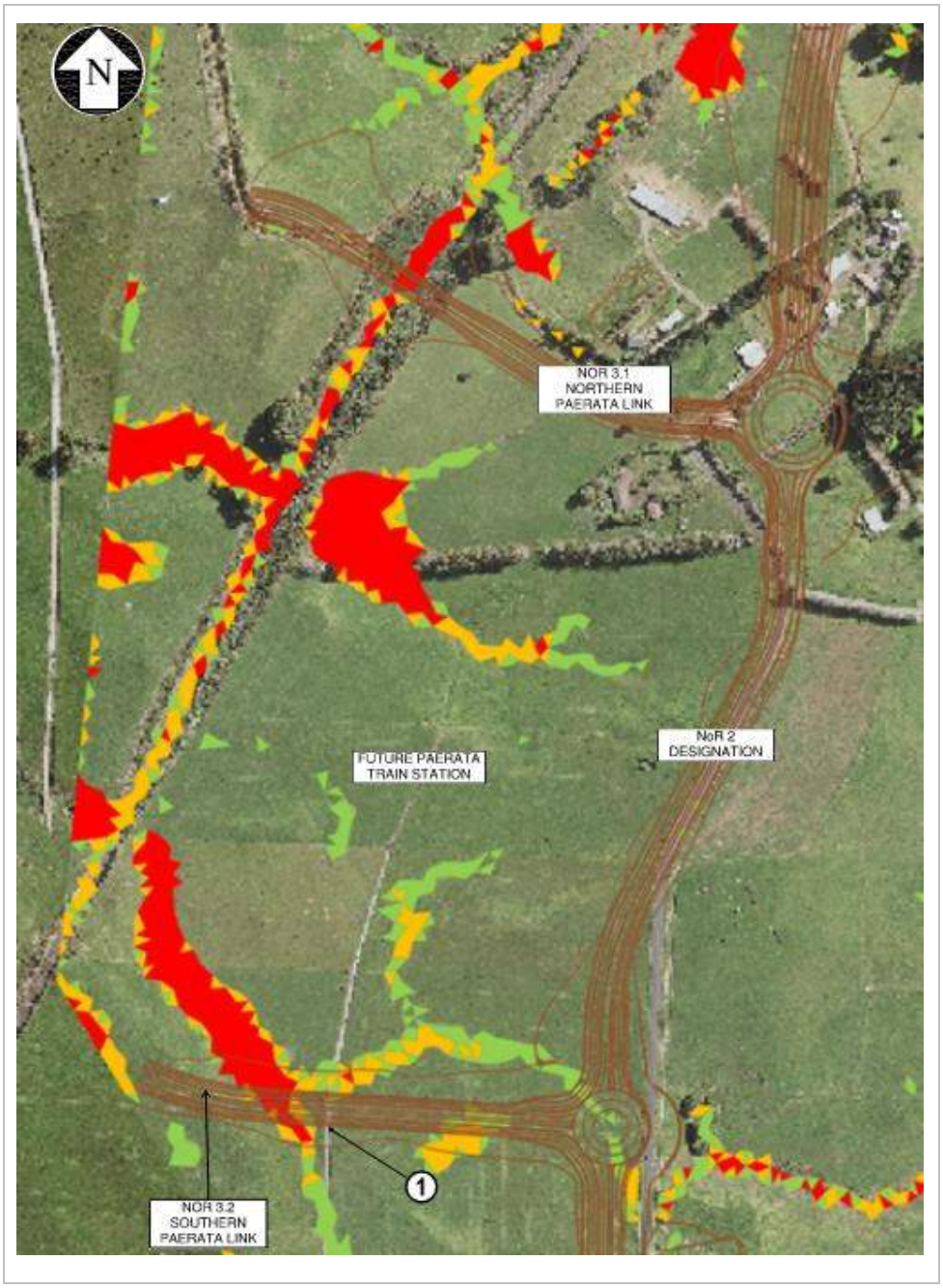


Figure 6-3: 1% AEP flooding 2.1 degree climate change (left) at the Paerata Connections – NoR 3 designation.

The flood hazards for the 100 year ARI, 2.1º and 3.8º climate change scenarios are described in detail below in Table 13. Note the future risks defined do not include in-stream areas or likely future riparian buffers. The future risks apply to a reasonable assessment of developable land inside the FUZ areas.

Table 13: Paerata Connections - NoR 3 – 100 year ARI flood hazards (Existing Development)

Point	Drainage Channel / Property address	Existing Land Use	Likely Future Land use	100 Year flood level	Existing and likely future flood risk rating
1	Whangapouri Stream Tributary Stream level 46.0m RL 412 Sim Road, Drury	Floodplain/ Agricultural land in the FUZ	Future Urban Development in the FUZ	2.1º CC: 44.30m RL 3.8º CC: 45.30m RL	Negligible existing and future risk

The land uses upstream of point 1 is unoccupied farmland and floodplain with no dwellings nearby. Future buildings nearby will be considered in future design stages when demonstrating the project can meet the flood hazard conditions on the proposed designation. This NoR may require a new culvert at this flowpath crossing and discharge in to the Paerata Station wetland. The sizing of a new culvert will be decided through future flood modelling to meet the proposed designation conditions.

The general flood effect elimination, minimisation and mitigation recommendations for NoR 3 are:

- The Paerata Station Connection will connect to the station access road. A new culvert may be required at this flowpath crossing and be sized to achieve the designation condition headwater effects.
- No flooding recommendations for the Sim to Sim Connection as this follows the terrain crest and has no flood water interaction.

The modelled 3.8º climate change scenario produced an overall higher flood level. However, the flood risk rating will remain negligible based on the land use being agricultural and no buildings in the vicinity. The future land use in this area may include dwellings based on the existing FUZ zoning. Future buildings will need to set floor elevations to a suitable height to maintain compliance with the Building Code and the Auckland Design Manual.

6.3.4 Pukekohe North-East Arterial – NoR 4

The NoR 4 flood hazards from the 100 year ARI flood with a 2.1º climate change adjustment to rainfall have only been simulated for the Oira Stream catchment. Flood risk for the Whangapouri catchment (Location 1) has been assessed using flood modelling but only for 3.8º climate change adjustment to rainfall. The NoR 4 crosses 7 flowpaths. Figure Figure shows the results of the modelling with the hazard colours used to indicate the level of hazard to land uses in vicinity of the NoR 4. Note that point 1 is not shown. Refer to Figure for the location of points 1.

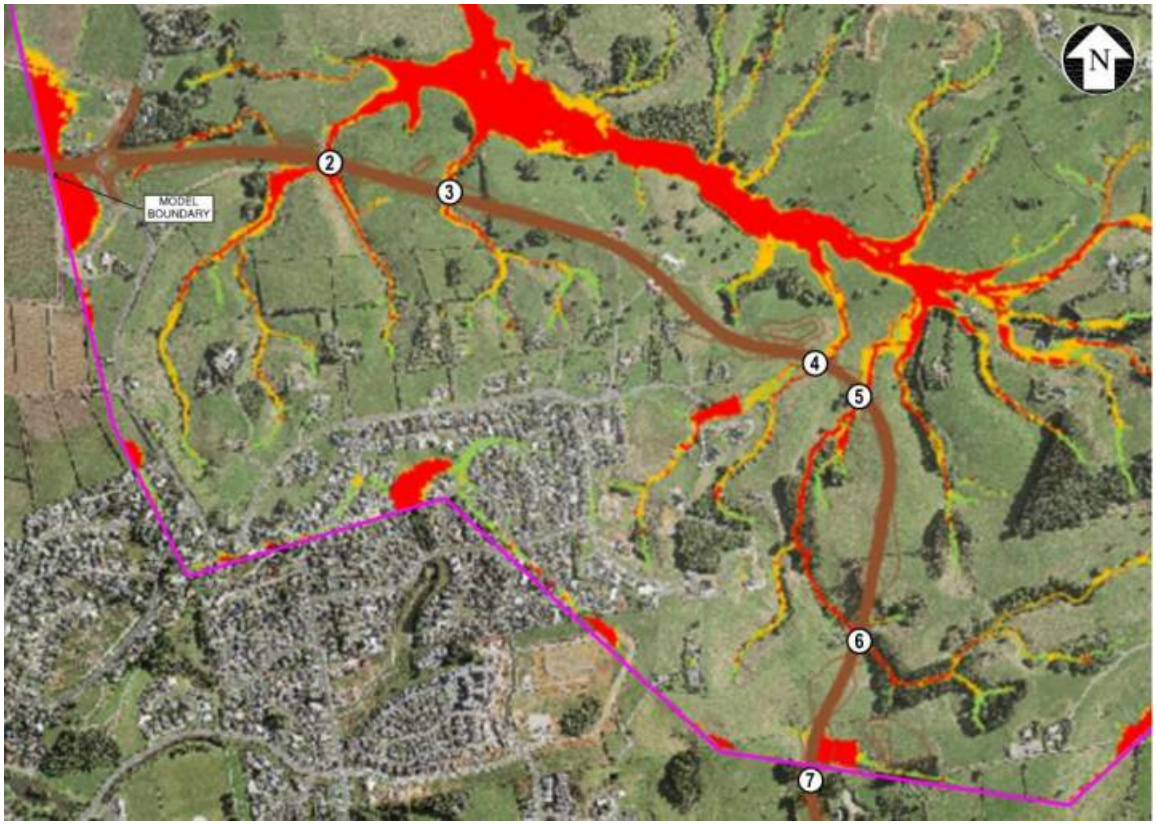


Figure 6-4: 2.1 degree 1% AEP flooding at the Pukekohe North East Arterial NoR 4.

The seven (7) flowpath crossing flood hazards for the 100 year ARI, 2.1º climate change flood model are described in detail below in Table 14. Note the future risks defined do not include in-stream areas or likely future riparian buffers. The future risks apply to a reasonable extent assessment of developable land inside the FUZ areas.

Table 14: Pukekohe North East Arterial NoR 4 – 100 year ARI (2.1º CC) flood hazards (Existing Development)

Point	Drainage Channel / Property address	Existing Land Use	Likely Future Land Use	100 Year flood level	Existing and likely future flood risk rating
1	1219 Paerata Road building floor level: 46.5m RL	Commercial Buildings (storage containers) in the FUZ	Future Urban Development in the FUZ	2.1º CC: 43.5m RL 3.8º CC: 43.72m RL	Negligible existing and future risk
1	1221 Paerata Road building floor level: 43.5m RL	Residential building in the FUZ	Future Urban Development in the FUZ	2.1º CC: 43.5m RL 3.8º CC: 43.72m RL	Existing moderate risk to dwelling, freeboard <0.5m. Future low risk to dwellings in FUZ.
2	Oira Stream Tributary	Floodplain/ Agricultural	Future rural land use	2.1º CC: 34.0m RL 3.8º CC: 34.22m RL	Negligible existing and future risk

Point	Drainage Channel / Property address	Existing Land Use	Likely Future Land Use	100 Year flood level	Existing and likely future flood risk rating
	channel level 31.80m RL 210 Cape Hill Road	land in the Mixed Rural Zone			
3	Oira Stream Tributary channel level 33.00m RL 210 Cape Hill Road	Floodplain/ Agricultural land in the Mixed Rural Zone	Future rural land use	2.1º CC: 33.9m RL 3.8º CC: 34.11m RL	Negligible existing and future risk
4	43 Grace James Road building floor level: 57.20m RL	Residential building in the FUZ.	Future Urban Development in the FUZ	2.1º CC: 45.10m RL 3.8º CC: 45.15m RL	Negligible existing and future risk
4	60 Grace James Road building floor level: 53.20m RL	Residential Building in the FUZ	Future Urban Development in the FUZ	2.1º CC: 45.10m RL 3.8º CC: 45.15m RL	Negligible existing and future risk
5	43 William Andrew Road, building floor level: 59.80m RL	Residential Building in the FUZ.	Future Urban Development in the FUZ	2.1º CC: 44.05m RL 3.8º CC: 44.25m RL	Negligible existing and future risk
6	97C Runciman Road, carport level: 112.0m RL, dwelling level: 113.5m RL	Residential Building in the FUZ	Future Urban Development in the FUZ	2.1º CC: 52.00m RL 3.8º CC: 52.07m RL	Negligible existing and future risk
7	Whangapouri Stream Tributary channel level 55.00m RL 97C Runciman Road	Floodplain/ Agricultural land in the Mixed Rural Zone	Future rural land use	2.1º CC: 57.30m RL 3.8º CC: 58.55m RL	Negligible existing and future risk

The land uses upstream of points 2, 3 and 7 is unoccupied farmland and floodplain with no dwellings nearby. Changes/variation in these dimensions will not affect the designation footprint of the road alignment and therefore can be assessed at a later design stage to meet the flood hazard outcomes that are included as conditions on the proposed designation.

The commercial and residential buildings at point 1 are very close to the floodplain with the access to 1221 Paerata Road showing as flooded despite the building not showing as flooded. If these buildings are still present in the future at detailed design, there should be no increase to existing flood levels and no decrease in freeboard.

The residential buildings at points 4, 5 and 6 are located on terrain well above the adjacent streams, the project works will not likely have any influence on these properties. Afflux from the NoR 4 alignment would cause localised effects to park and floodplain areas only.

The effects of using a 3.8º climate change adjusted rainfall pattern compared to the 2.1º climate change pattern shows deeper flood depths for points 2 through 6. The water depth at point 4 only increased by around 50mm mainly due to the weir present in the channel that controls flows and depths to this location. The changes in flood depth at the other locations are minor and are a negligible flood risk to upstream properties. The 3.8º climate change flood depth at point 1 would begin to flood the residential dwelling at 1221 Paerata Road and the risk rating would then change to from moderate to high.

The general flood effect elimination, minimisation and mitigation recommendations for NoR 4 are:

- Size culverts and bridges to meet proposed designation conditions on flood hazard outcomes.
- Attenuation for the 10yr and 100yr events in the Whangapouri, Ngakoroa and Oira Stream catchments
- Provide diversion channels at the toe of fill embankments to prevent ponding.
- Offset the flood volume displaced by filling in the floodplain with an equivalent volume of excavation within the floodplain.
- Maintain 1200mm freeboard to new bridge soffits using the 100-year ARI flood level with 3.8º Climate change hydrology.

The flood hazard outcomes in the conditions are appropriate to manage the effects of this NoR considering the existing and likely future land uses. The bridge and culvert solutions will be refined to achieve these conditions and the designation is sufficient to allow for larger structures if required.

6.3.5 Pukekohe South-East Arterial – NoR 5

A portion of NoR 5 flood hazards have been modelled as they are in the Whangapouri Stream (3.8º climate change to rainfall only), but the remainder were not as they Tatuanui Stream catchments. The Auckland Council GIS floodplains have been used to assess the flood hazards. The NoR 5 alignments crosses 4 flowpaths as shown.

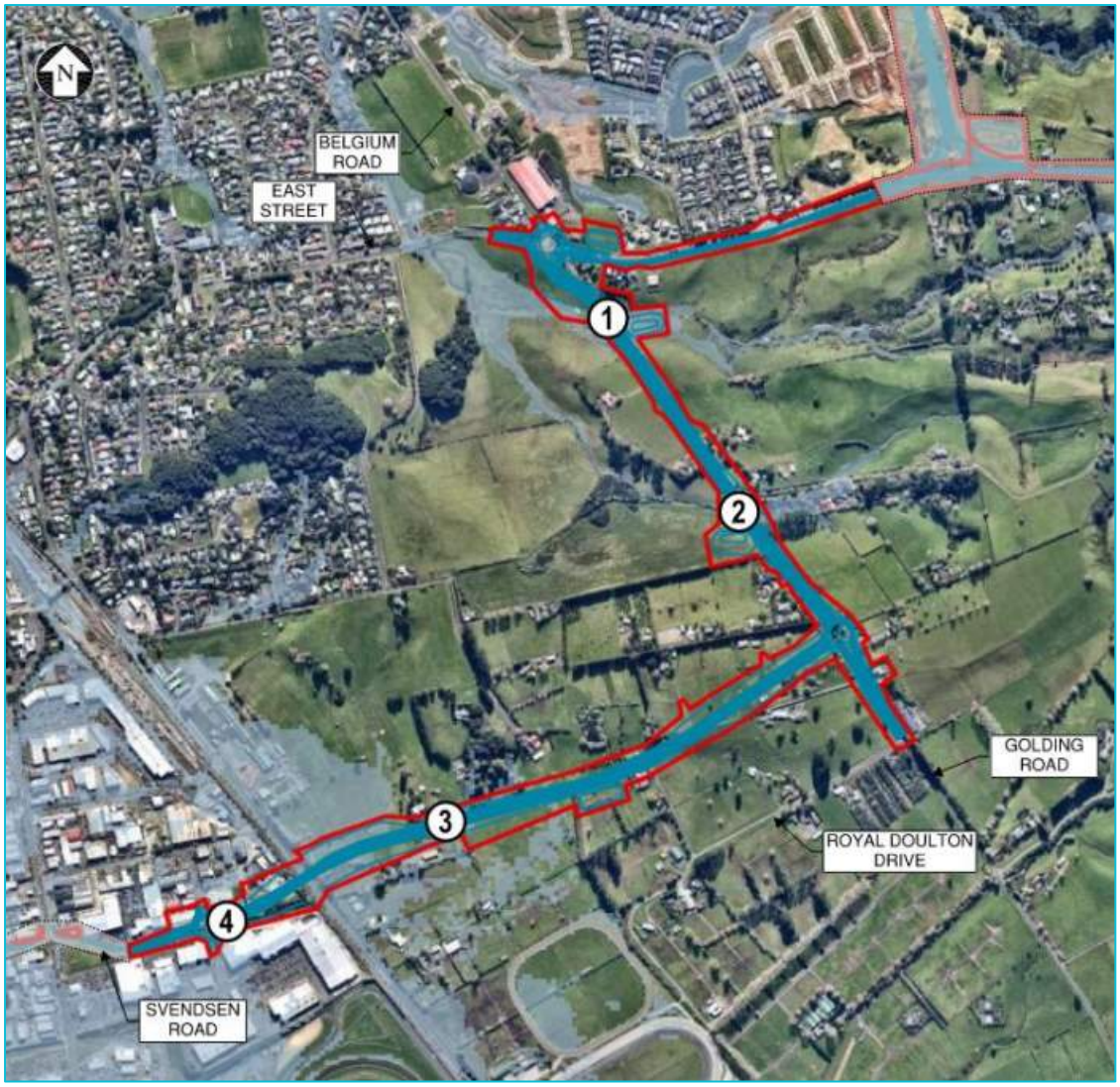


Figure 6-5: 2.1 degree 1% AEP flooding at the Pukekohe South-East Arterial – NoR 5 designation.

The four flowpath crossings flood hazards for the 100 year ARI, 2.1º climate change flood model are described in detail below in Table 15. Note the future risks defined do not include in-stream areas or likely future riparian buffers. The future risks apply to a reasonable assessment of developable land inside the FUZ areas.

Table 15: Pukekohe South-East Arterial - NoR 5 – 100 year ARI (2.1º CC) flood hazards (Existing Development)

Point	Drainage Channel / Property address	Existing land use	Likely future land use	100 Year flood level	Existing flood risk rating
1	12, 16, 18 and 50 Pukekohe East Road building levels 64.2m RL	Residential Buildings in the FUZ	Future Urban Development in the FUZ	2.1º CC: 54.1m RL 3.8º CC: 54.3m RL	Negligible existing and future risk
2	65 Golding Road, building floor level: 59.4m RL	Residential Building in the FUZ	Future Urban Development in the FUZ	2.1º CC: 58.6m RL 3.8º CC: 59.6m RL	Moderate existing and future risk

Point	Drainage Channel / Property address	Existing land use	Likely future land use	100 Year flood level	Existing flood risk rating
2	49 Golding Road, building floor level: 66.6m RL	Residential Building in the FUZ	Future Urban Development in the FUZ	2.1º CC: 58.6m RL 3.8º CC: 59.6m RL	Negligible existing and future risk
3	124 Station Road, building floor levels: 58.0m RL RL	Residential Buildings in the FUZ	Future Urban Development in the FUZ	2.1º CC: 57.8m RL	Moderate existing and future risk
3	150 Station Road, building floor levels: 56.5m RL RL	Residential Buildings in the FUZ	Future Urban Development in the FUZ	2.1º CC: 57.8m RL	High risk existing and future risk
3	170 Station Road, building floor levels: 58.0m RL RL	Residential Buildings in the FUZ	Future Urban Development in the FUZ	2.1º CC: 57.8m RL	Moderate existing and future risk
3	194 Station Road, building floor levels: 58.2m RL RL	Residential Buildings in the FUZ	Future Urban Development in the FUZ	2.1º CC: 57.8m RL	Low risk existing and future risk
4	15 Austen Place, building floor levels: 55.0m RL RL	Industrial Buildings in Business - Light Industry Zone	Future Urban Development in the FUZ	2.1º CC: 55.0m RL	Moderate existing and future risk
4	44-46 Crosbie Road, building floor levels: 55.0m RL RL	Industrial Buildings in Business - Light Industry Zone	Future Urban Development in the FUZ	2.1º CC: 55.0m RL	Moderate existing and future risk

The land uses upstream of points 1, 2 and 3 contain dwellings nearby that may be subject to flood effects if the upstream flood level caused by the NoR 5 alignment is not adequately managed. Future buildings nearby will be considered during future design stages to meet the flood hazard condition proposed on the NoR. The buildings in the floodplain along Station Road at point 3 are flooded due to the constrictive nature of the railway line and the drainage beneath. Additionally, earthworks in this floodplain may exacerbate flooding on these properties. A longer bridge or compensatory earthworks may be needed to avoid worsening flood effects on these properties. The designation extent is sufficient to find a solution to meet the designation conditions being sought.

Flooding at point 4 will likely remain unchanged as a result of the works. If adverse effects are found at this location, the effects can be managed with a channel and pipe network within the designation.

The 3.8º climate change scenario has not been simulated for this catchment and the Auckland Council GIS does not provide information on this event at this location. As noted in previous sections the flood levels will likely increase by 100mm to 400mm as a result. The moderate risk locations would likely become high risk and low risk would become moderate risks.

The general flood effect elimination, minimisation and mitigation recommendations for NoR 5 are:

- Size culverts and the bridge over the NIMT railway to meet proposed designation conditions on flood hazard outcomes.
- Avoid lifting the crown of the road along Golding Road to prevent adverse effects upstream.
- Attenuation for the 10yr and 100yr in the Whangapouri and Tatuanui Stream catchments
- Provide diversion channels at the toe of fill embankments to prevent ponding.
- Offset the flood volume displaced by filling in the floodplain with an equivalent volume of excavation within the floodplain.

6.3.6 South-West Upgrade – NoR 6

Pukekohe Maintain 600mm freeboard to the new bridge soffit over the NIMT rail using the 100-year ARI flood level with 3.8º Climate change hydrology.The flood hazard outcomes in the conditions are appropriate to manage the effects of this NoR considering the existing and likely future land uses. The bridge and culvert solutions will be refined to achieve these conditions and the designation is sufficient to allow for larger structures if required.

NoR 6 includes designated areas for an active mode upgrade and driveway regrading. No changes to flooding are expected. The future design stages will need to meet the flood hazard outcomes included on the existing designation.

6.3.7 Pukekohe North-West Arterial – NoR 7

The NoR 7 flood hazards have been modelled in the Whangapouri Stream catchment for the 3.8º climate change scenario and the Auckland Council GIS floodplains have been used to assess the flood hazards for 2.1º climate change scenario. The NoR 7 alignments crosses 7 flowpaths as shown in **Error! Reference source not found.**Figure 6-6.

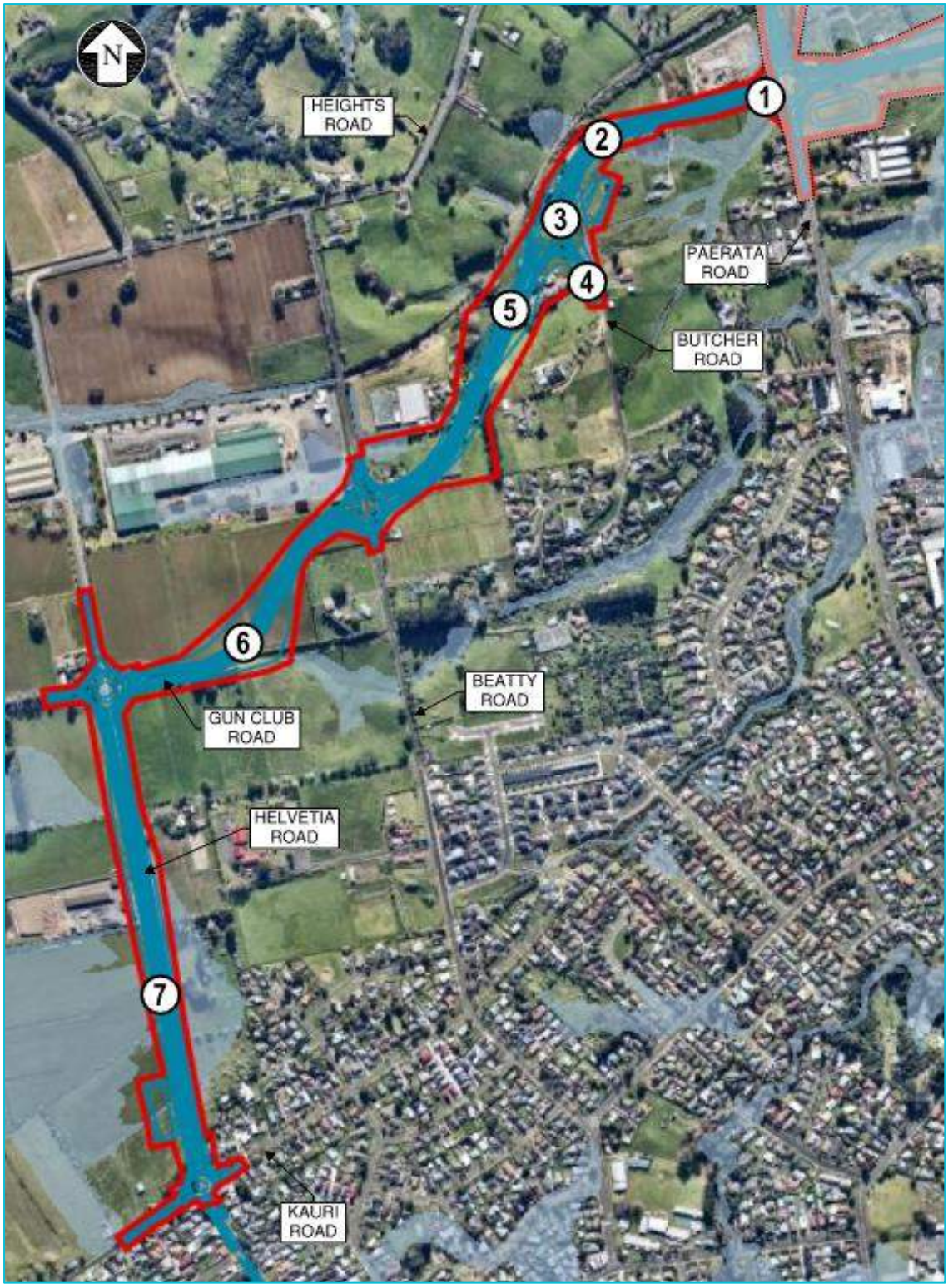


Figure 6-6: 2.1 degree 1% AEP flooding at the Pukekohe North-West Arterial – NoR 7 designation.

The seven flowpaths crossings by the NoR 7 alignments may generate flood hazards for the 100 year ARI, 2.1º climate change flood model are described in detail below in Table 15. Note the future risks defined do not include in-stream areas or likely future riparian buffers. The future risks apply to a reasonable assessment of developable land inside the FUZ areas.

Table 16: Pukekohe North-West Arterial -NoR 7 – 100 year ARI (2.1º CC) flood hazards (Existing Development)

Point	Drainage Channel / Property address	Existing land use	Likely future land use	100 Year flood level	Existing flood risk rating
1	1210 Paerata Road, building levels 45.50m RL	Residential Buildings - FUZ	Future Urban Development in the FUZ	2.1º CC: 43.2m RL 3.8º CC: 44.4m RL	Negligible existing and future risk
1	1214 Paerata Road, building floor level: 47.3m RL	Residential building - FUZ	Future Urban Development in the FUZ	2.1º CC: 43.2m RL 3.8º CC: 44.4m RL	Negligible existing and future risk
2	62 Heights Road, building floor level: 73.0m RL	agricultural use - Rural - Rural Production Zone	Future Urban Development in the FUZ	2.1º CC: 54.5m RL 3.8º CC: 54.6m RL	Negligible existing and future risk
3	107 Heights Road, building floor levels: 75.0m RL RL	Residential building - FUZ	Future Urban Development in the FUZ	2.1º CC: 57.2m RL 3.8º CC: 60.3m RL	Negligible existing and future risk
4	36 Butcher Road, building floor levels: 50.0m RL RL	Commercial building - FUZ	Future Urban Development in the FUZ	2.1º CC: 46.2m RL 3.8º CC: 48.1m RL	Negligible existing and future risk
5	107 Heights Road, building floor levels: 75.0m RL RL	Residential Buildings	Future Urban Development in the FUZ	2.1º CC: 57.2m RL 3.8º CC: 60.4m RL	Negligible existing and future risk
6	185 Heights Road, no buildings	Agricultural Land - FUZ	Future Urban Development in the FUZ	Sheet flow for both 2.1º and 3.8º	Negligible existing and future risk
7	222 Helvetia Road, building floor levels: 71.2m RL RL	Residential building - FUZ	Future Urban Development in the FUZ	2.1º CC: 67.7m RL 3.8º CC: 67.7m RL	Negligible existing and future risk
7	248 Helvetia Road, building floor levels: 67.2m RL	Residential building – FUZ within the existing floodplain	Future Urban Development in the FUZ	2.1º CC: 67.7m RL 3.8º CC: 67.7m RL	High existing and future risk
7	256 Helvetia Road, building floor levels: 71.0m RL RL	Residential building - FUZ	Future Urban Development in the FUZ	2.1º CC: 67.7m RL 3.8º CC: 67.7m RL	Negligible existing and future risk

Point	Drainage Channel / Property address	Existing land use	Likely future land use	100 Year flood level	Existing flood risk rating
7	270 Helvetia Road, building floor levels: 74.2m RL RL	Residential building - FUZ	Future Urban Development in the FUZ	2.1º CC: 67.7m RL 3.8º CC: 67.7m RL	Negligible existing and future risk

At points 2, 3 and 5, the upstream railway line culverts controls the headwater and therefore the flood risk to the upstream properties. The design proposed at these locations would include new culverts with the same diameter. This would maintain the same flowrate and not cause new or exacerbate upstream flood risk.

Land uses upstream of points 1, 4, 6 and 7 contain dwellings nearby that may be subject to flood effects if the upstream flood level caused by the NoR 7 alignment is not adequately managed. Sizing of culverts and bridges will need to meet the flood hazard conditions on the NoR. This is best undertaken at future design stages and will, in part, depend on the changes in land use and construction of new buildings at the time the road alignment is developed further for construction.

There is flooding at 248 Helvetia Road which is caused by an undersized culvert beneath Helvetia Road. There is an opportunity to improve flooding for this dwelling at the expense of causing downstream flood effects. This betterment should be investigated further at future design stages. Effects can be managed to a neutral or improved flood conditions on the upstream land.

The 3.8º climate change scenario has not been simulated for this catchment and the Auckland Council GIS does not provide information on this event at this location. As noted in previous sections the flood levels will likely increase by 100mm to 400mm as a result. The negligible risk locations would likely remain negligible and high risk location would remain high risk with a worsened flood depth.

The general flood effect elimination, minimisation and mitigation recommendations for NoR 7 are:

- Size culverts and bridges to meet designation conditions on flood hazard outcomes.
- Retain culvert sizes at the existing culverts near the Glenbrook Rail Line and Butcher Road to maintain the same flowrate and not cause new or exacerbate upstream flood risk.
- Attenuation for the 10yr and 100yr in the Whangapouri Stream catchment

The flood hazard outcomes in the conditions are appropriate to manage the effects of this NoR considering the existing and likely future land uses. The bridge and culvert solutions will be refined to achieve these conditions and the designation is sufficient to allow for larger structures if required.

6.3.8 Mill Road and Pukekohe East Road Upgrade – NoR 8

The NoR 8 flood hazards from the 100 year ARI flood with a 2.1º and 3.8º climate change adjustment to rainfall have been modelled and shown in

. The NoR alignment follows the existing Mill Road section and crosses two flowpaths, both serviced by existing culverts. The road widening may not require any culvert lengthening or include any floodplain filling with the NoR design. However, future designs might require culvert lengthening. No adverse flood effects are expected from this NoR. Any future designs that may include culvert modification can meet the designation conditions by modelling the effect of the works and oversizing the culvert extension if unacceptable flood effects are found.

Figure 6-7: 1% AEP flooding 2.1 degree climate change at the NoR 8 designation.

The flood hazards for the 100 year ARI, 2.1º and 3.8º climate change scenarios are described in detail below in Table 13. Note the future risks defined do not include in-stream areas or likely future riparian buffers. The future risks apply to a reasonable assessment of developable land inside the rural and FUZ areas.

Table 17: Mill Road and Pukekohe East Road Upgrade - NoR 8 – 100 year ARI flood hazards (Existing Development)

Point	Drainage Channel / Property address	Existing land use	Likely Future Landuse	100 Year flood level	Existing flood risk rating
1	144 Mill Road, building floor level: 155m RL	Rural lifestyle block - Rural - Rural Production Zone	Remain rural lifestyle block	2.1º Climate change: 145.1m RL	Negligible existing and future risk
				3.8º Climate change: RL 145.6m RL	Negligible existing and future risk
1	155 Mill Road, building floor level: 145m RL	Rural lifestyle block - Rural - Mixed Rural Zone	Remain rural lifestyle block	2.1º Climate change: 144.8m RL	Moderate existing and future risk
				3.8º Climate change: RL 145.2m RL	High risk existing and future risk

Point	Drainage Channel / Property address	Existing land use	Likely Future Landuse	100 Year flood level	Existing flood risk rating
2	182 Mill Road, building floor level: 162.6m RL	Residential building - Rural - Rural Production Zone	Remain rural lifestyle block	2.1º Climate change: 161.5m RL	Negligible existing and future risk
				3.8º Climate change: RL 161.95m RL	Negligible existing and future risk
2	188 Mill Road, building floor level: 163.1m RL	Working agricultural and horticultural land uses - Rural - Rural Production Zone	Remain rural lifestyle block	2.1º Climate change: 161.5m RL	Negligible existing and future risk
				3.8º Climate change: RL 161.95m RL	Negligible existing and future risk

The land uses upstream of point 1 is farmland and floodplain with some dwellings nearby. Future buildings nearby will need to be considered when deciding on an acceptable level of flood hazard change. The downstream building at 155 Mill Road is located at a low elevation and may become flood prone as a result of the NoR 8 project works or as a result of climate change. This culvert crossing will likely not be altered and therefore the effects of lifting or lowering the road crest would have the most significant effect on flood levels. Lifting the road would reduce the freeboard to 144 Mill Road and lowering the road would exacerbate flooding to 155 Mill Road. No change in road crest elevation is therefore recommended to minimise flood effects.

The buildings upstream of point 2 are not presently vulnerable to flooding and Mill Road would overtop before these properties experienced flooding. As noted at location 2, the upstream properties will be vulnerable to flooding if the road crest height were elevated, preventing flow to overtop the road and escape without flooding the dwellings. No change in road crest elevation is therefore recommended to minimise flood effects.

The modelled 3.8º climate change scenario produced an overall higher flood level. However, the flood risk rating will remain negligible based on the road crest height allowing flow to overtop the road before causing adverse effects on the upstream land. The only exception being 155 Mill Road where the more severe climate change impact would change this properties flood hazard rating from medium to high.

The general flood effect elimination, minimisation and mitigation recommendations for NoR 8 are:

- Extend culverts at the same diameter and replace culverts at the same diameter.
- Avoid lifting the crown of the road along Mill Road to prevent adverse effects upstream. Or lowering the road crown to cause effects downstream
- Attenuation for the 10yr and 100yr in the Ngakoroa and Tatuanui Stream catchments

The flood hazard outcomes in the conditions are appropriate to manage the effects of this NoR considering the existing and likely future land uses. The bridge and culvert solutions will be refined to achieve these conditions and the designation is sufficient to allow for larger structures if required.

6.4 Recommended Measures to Avoid, Remedy or Mitigate Operational Effects

It is recommended that during detailed design, additional flood modelling is carried out and mitigation measures are implemented (as required) to achieve the following outcomes:

- No increase in flood levels in a 1% AEP event for existing authorised habitable floors that are already subject to flooding or have a freeboard less than 150mm (that is, no increase in flood level where the flood level using the pre project model scenario is above the habitable floor level);
- No more than a 10% reduction in freeboard in a 1% AEP event for existing authorised habitable floors with a freeboard of over 150mm (that is, if existing freeboard was 500mm, an acceptable change would be to reduce freeboard to 450mm);
- No increase in 1% AEP flood levels for existing authorised community, commercial, industrial and network utility building floors that are already subject to flooding;
- No more than a 10% reduction in freeboard in a 1% AEP event for existing authorised community, commercial, industrial and network utility building floors;
- No increase of more than 50mm in flood level in a 1% AEP event on land zoned for urban or future urban development where there is no existing habitable dwelling;
- No new flood prone areas (with a flood prone area defined as a potential ponding area that relies on a single culvert for drainage and does not have an overland flow path); and
- No more than a 10% average increase of flood hazard (defined as flow depth times velocity) for the main access to authorised habitable dwellings at the time the Outline Plan is submitted. The assessment shall be undertaken for the 50%, 20%, 10% and 1% AEP rainfall events.

Mitigation measures which may be implemented include:

- Maintaining existing road levels within the corridor at overland flow paths and floodplains;
- Creating new overland flow path diversions to discharge to nearby overland flow paths or streams to mitigate ponding and decrease flood levels at affected properties. This is where existing predicted overland flow paths run parallel to the proposed Project corridor and do not cross under the road;
- Increasing culvert sizes or pipe systems to manage changes to flood levels;
- Using storage within linear treatment devices, raingardens, wetlands or separate attenuation devices to reduce the peak flow increase due to changes in impervious area within the corridor; and
- Integrating development stormwater design requirements with adjacent development or wider upgrades to public infrastructure upstream and downstream of the proposed corridor.

7 Conclusion

This assessment has considered the potential flood effects of the Pukekohe Transport Network. The assessment uses a flood risk rating to identify those areas where existing flood effects are likely and makes recommendations to mitigate any effects during the future detailed design stage of the Project.

The flood hazard risks can be adequately managed during construction. Proposed works will be located outside of flood plains and overland flow paths as far as practicable. Where this is not possible, potential flooding effects will be managed through the flood risk mitigation measures set out in the CEMP for existing high flood hazard areas. For those areas where there is an increased flood risk, mitigation measures such as carrying out construction works during dry weather and using diversion drains will be adequate to manage this risk and will be identified through the CEMP.

There are potential operational effects risks of increased flood levels upstream and downstream of crossings and where the vertical alignment of the road is elevated. Some of the effects were assessed as moderate based on a flood depth of greater than 0.15 m for more vulnerable uses (e.g. habitable buildings) and 0.5 m for less vulnerable uses (e.g. open space).

A number of potential management and mitigation measures have been provided to manage operational effects at the future detailed design stage. In some locations the recommendation is to maintain the current vertical alignment, this means the road will overtop however flood effects will not increase. Flood hazard outcomes are identified to be included as conditions on all of the NoRs so that flood hazard effects can be appropriately managed.

TE TUPU NGĀTAHI
SUPPORTING GROWTH

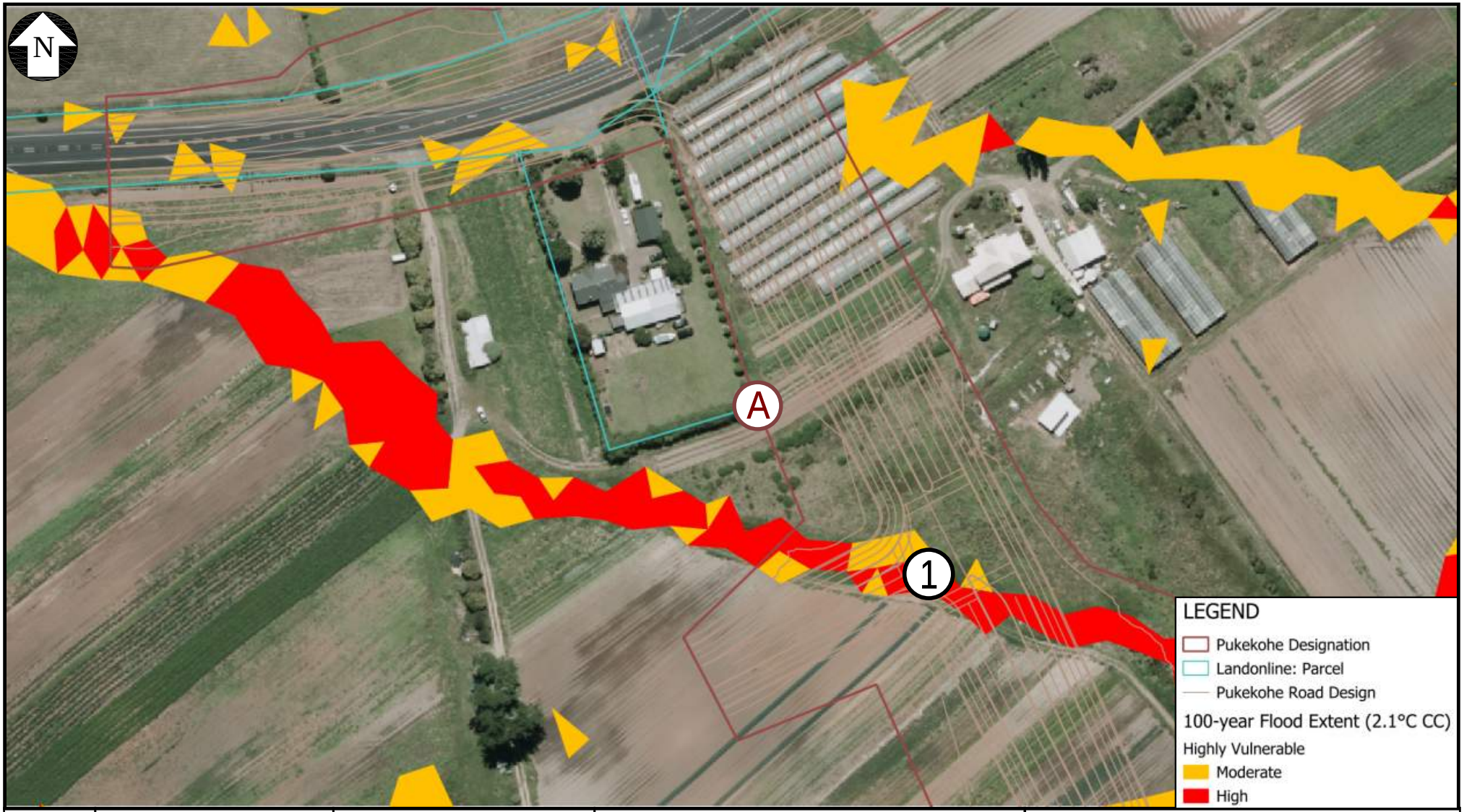
Appendix A

Detailed Flood Hazard Locations

WAKA KOTAHI
NZ TRANSPORT AGENCY

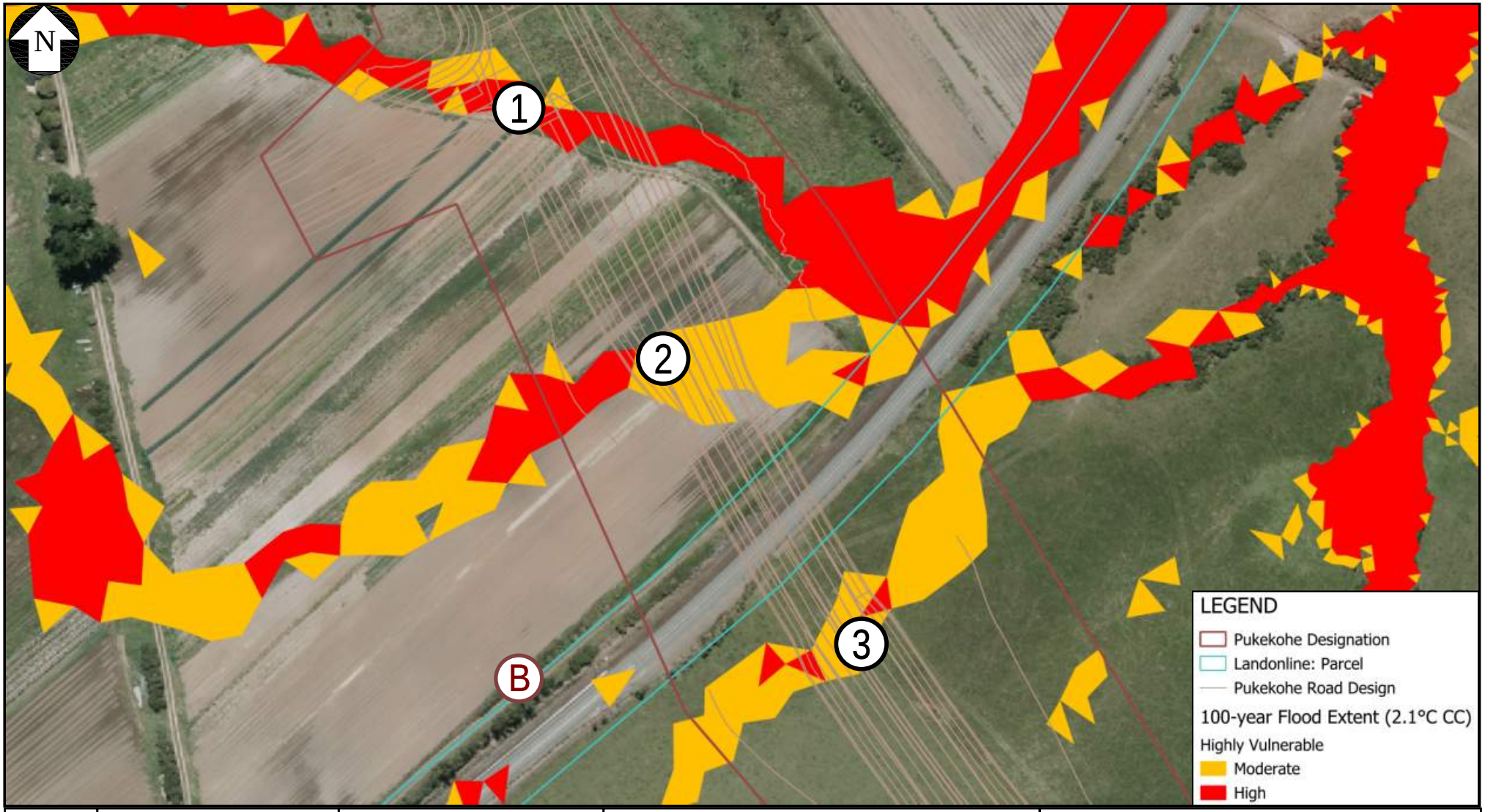
New Zealand Government

NOR 1 Location 1 - 100-year Flood Map



Location	Address	Land invert level (AUK1946)	2.1°C climate change 100-year flood level AUK1946)	3.8°C climate change 100-year flood level (AUK1946)
A	110 Karaka Road Drury	18.49m	18.63m	18.64m

NOR 1 Location 2 - 100-year Flood Map



Location	Address	Land invert level (AUK1946)	2.1°C climate change 100-year flood level AUK1946)	3.8°C climate change 100-year flood level (AUK1946)
B	110 Karaka Road Drury	13.67m	13.90m	13.92m

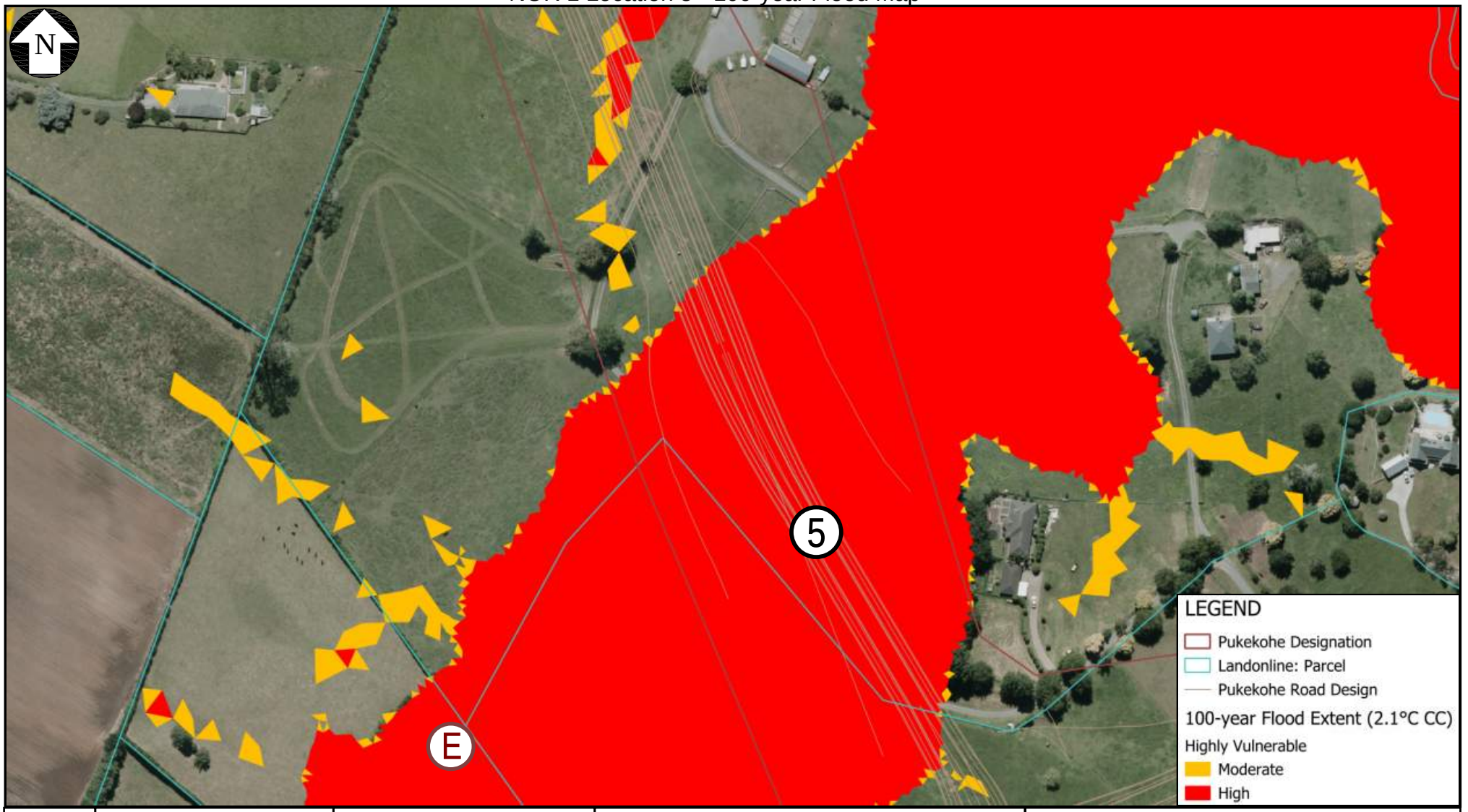
NOR 1 Location 3 - 100-year Flood Map

Location	Address	Land invert level (AUK1946)	2.1°C climate change 100-year flood level AUK1946)	3.8°C climate change 100-year flood level (AUK1946)
C	647 Burtt Road Drury	12.36m	12.42m	12.43m

NOR 1 Location 4 - 100-year Flood Map

Location	Address	Land invert level (AUK1946)	2.1°C climate change 100-year flood level AUK1946)	3.8°C climate change 100-year flood level (AUK1946)
D	576 Burtt Road Drury	11.46m	11.84m	11.94m

NOR 1 Location 5 - 100-year Flood Map



Location	Address	Land invert level (AUK1946)	2.1°C climate change 100-year flood level AUK1946)	3.8°C climate change 100-year flood level (AUK1946)
E	801 Runciman Road Drury	7.10m	9.72m	10.04m

NOR 1 Location 6 - 100-year Flood Map

Location	Address	Land invert level (AUK1946)	2.1°C climate change 100-year flood level AUK1946)	3.8°C climate change 100-year flood level (AUK1946)
E	801 Runciman Road Drury	7.87m	9.72m	10.04m

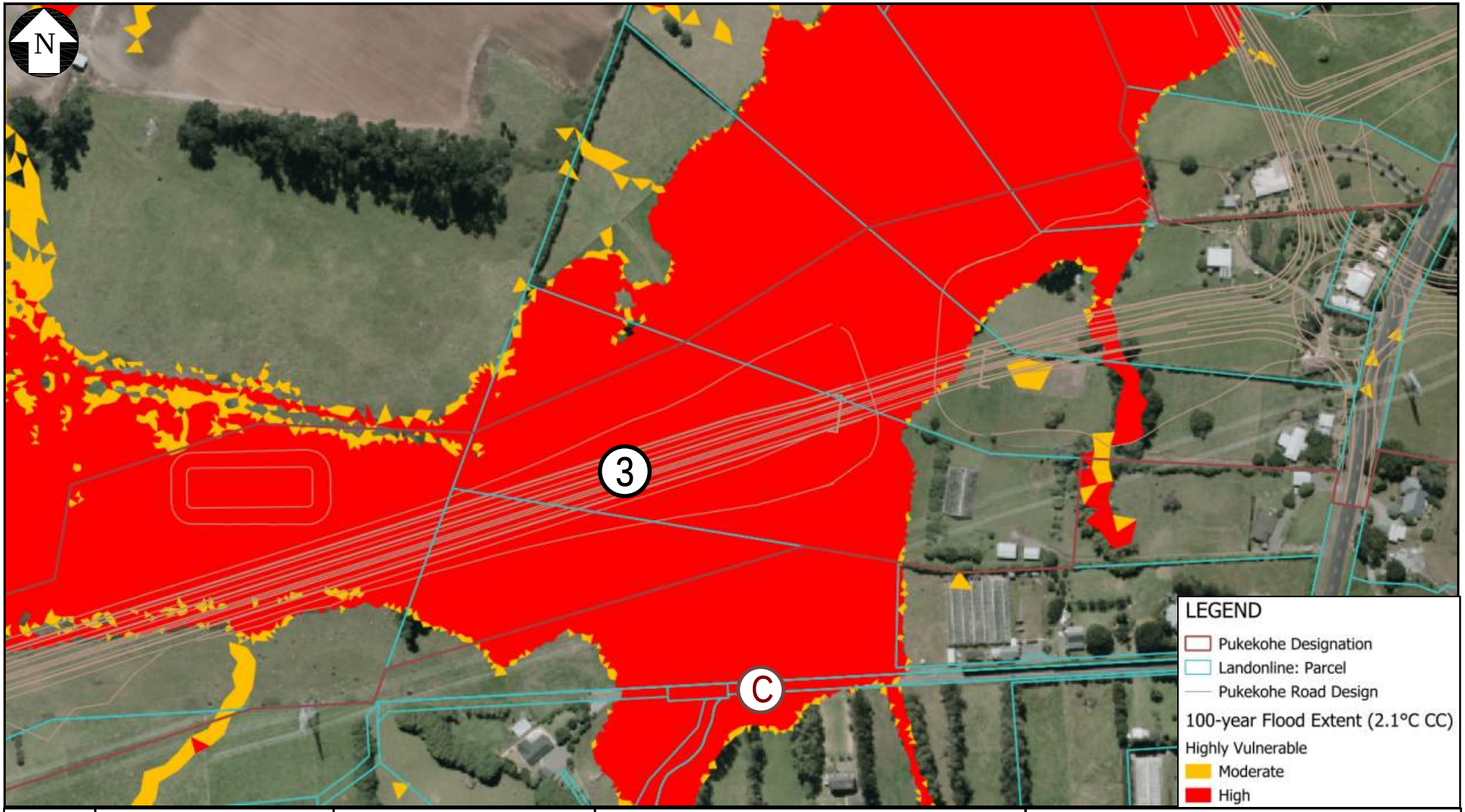
NOR 2 Location 1 - 100-year Flood Map

Location	Address	Land invert level (AUK1946)	2.1°C climate change 100-year flood level AUK1946)	3.8°C climate change 100-year flood level (AUK1946)
A	17 Ngakoroa Road Drury	14.72m	15.48m	15.57m

NOR 2 Location 2 - 100-year Flood Map

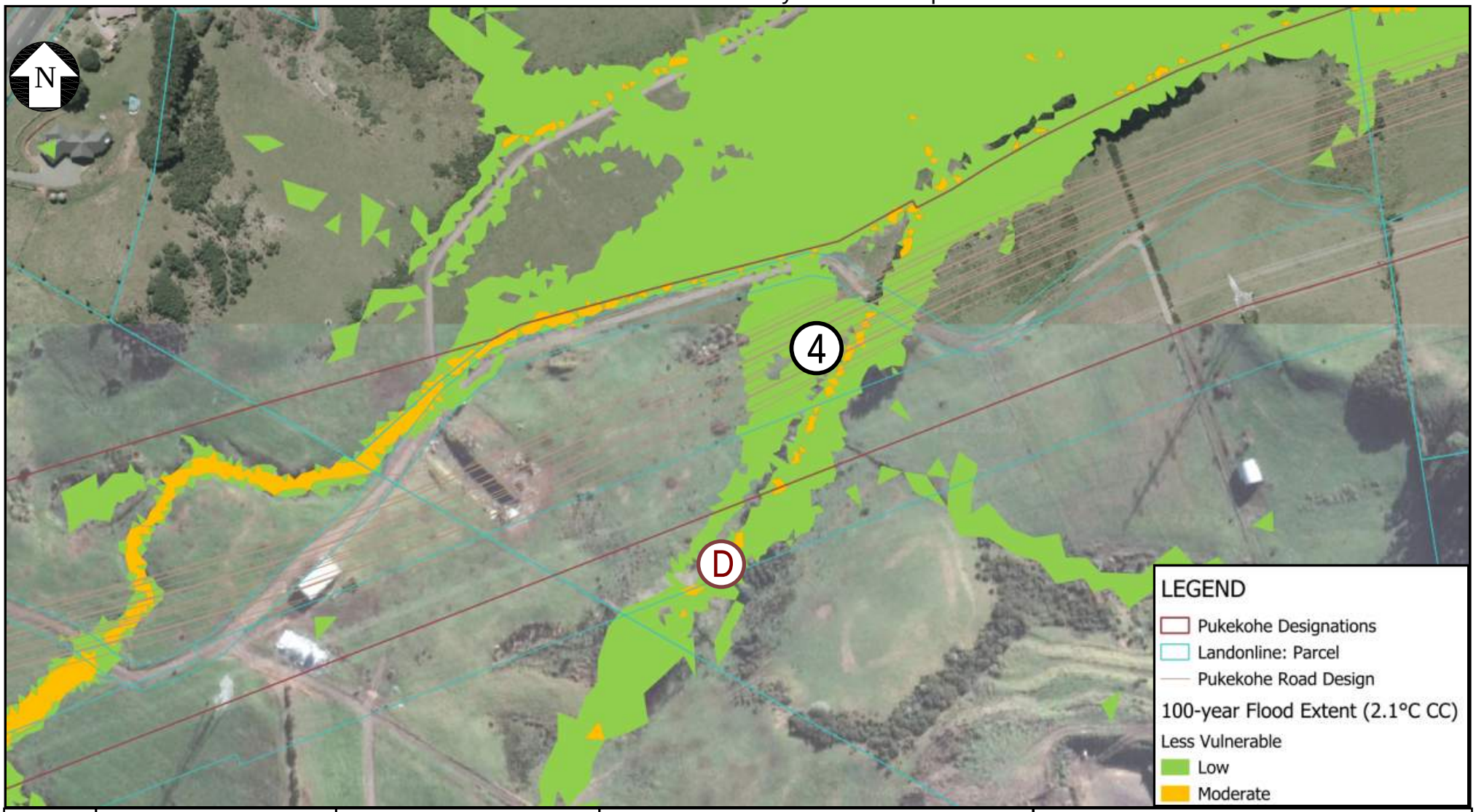
Location	Address	Land invert level (AUK1946)	2.1°C climate change 100-year flood level AUK1946)	3.8°C climate change 100-year flood level (AUK1946)
B	22 Ngakoroa Road Drury	9.49m	11.74m	12.11m

NOR 2 Location 3 - 100-year Flood Map



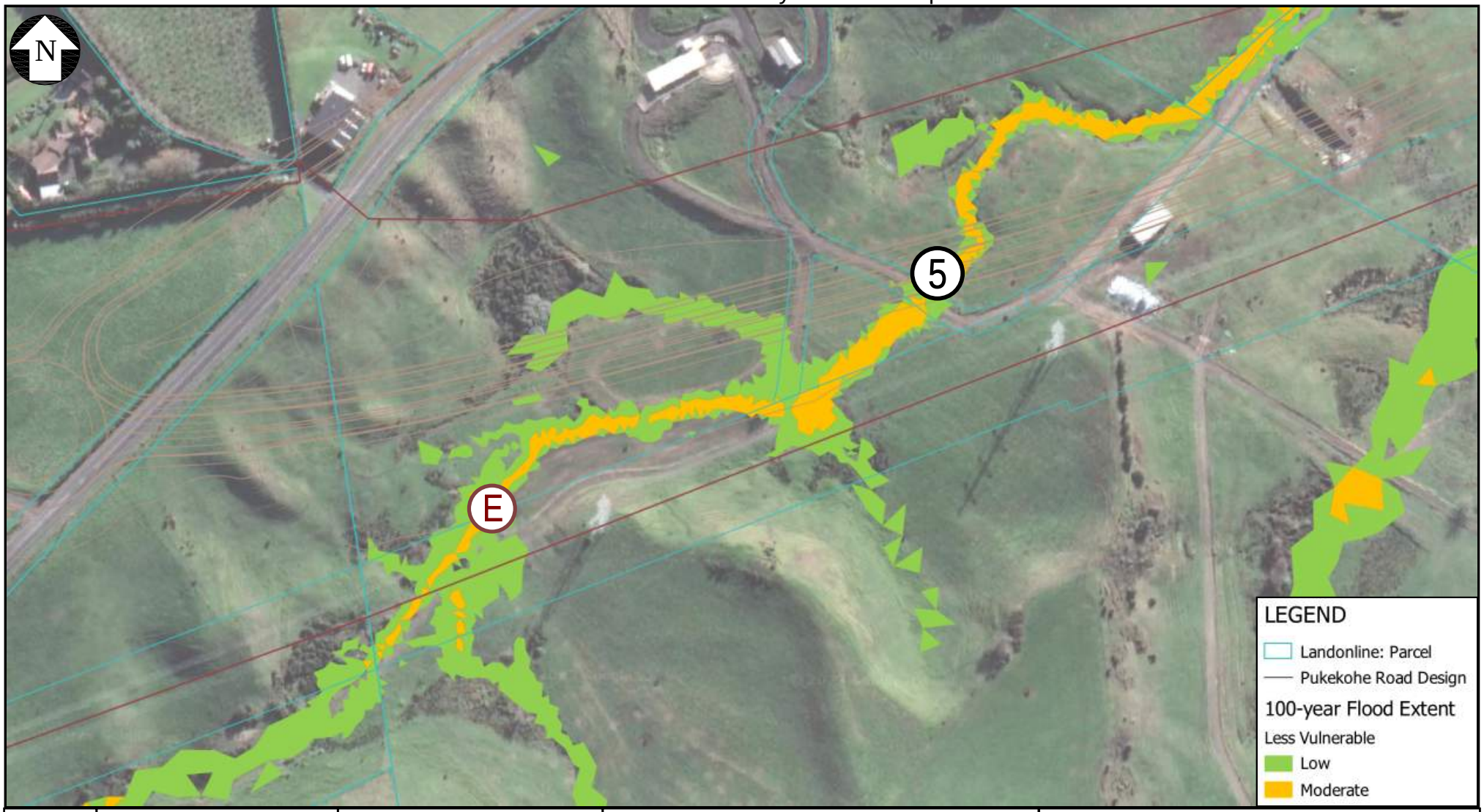
Location	Address	Land invert level (AUK1946)	2.1°C climate change 100-year flood level AUK1946)	3.8°C climate change 100-year flood level (AUK1946)
C	767 Runciman Road Drury	9.05m	9.74m	10.06m

NOR 2 Location 4 - 100-year Flood Map



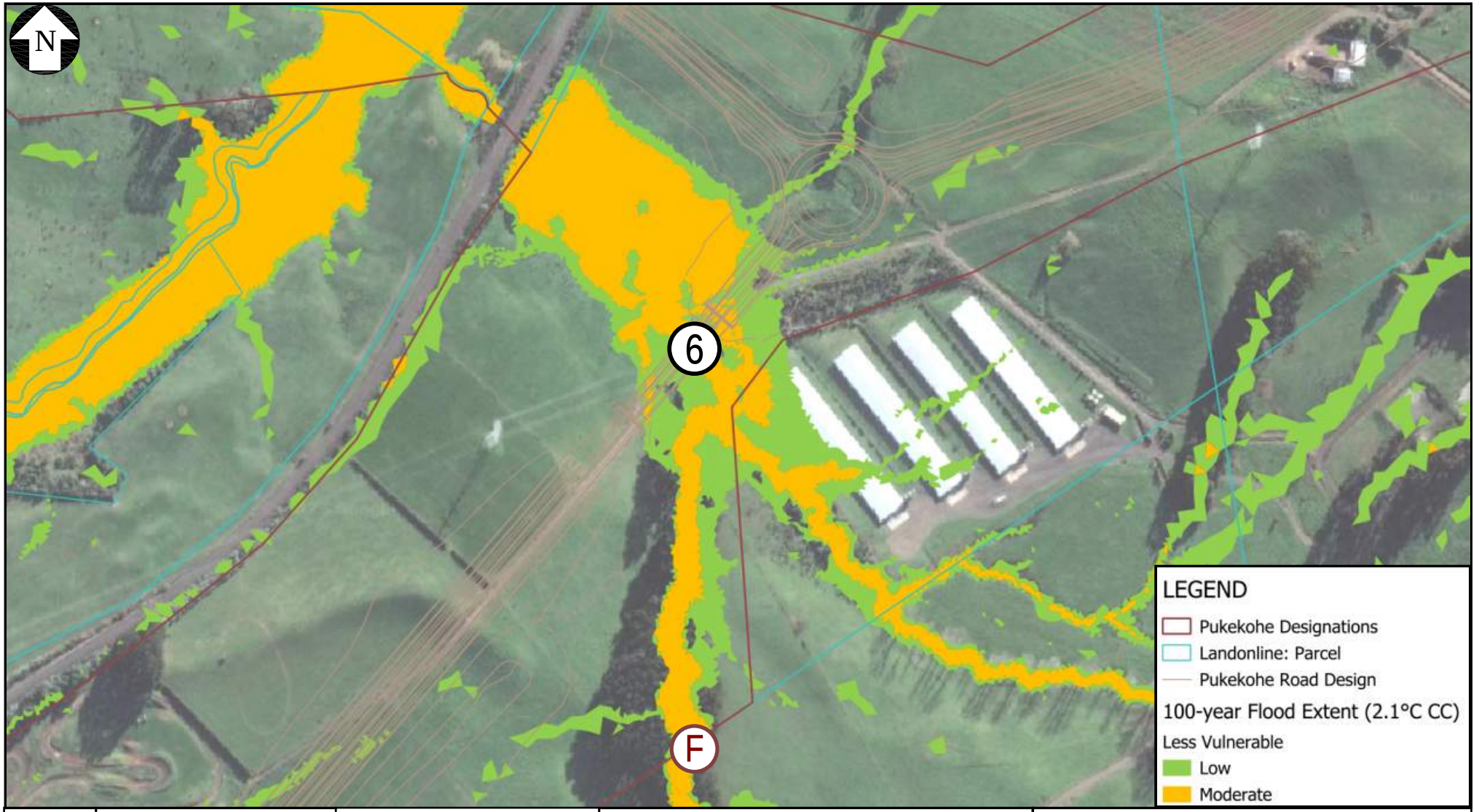
Location	Address	Land invert level (AUK1946)	2.1°C climate change 100-year flood level AUK1946)	3.8°C climate change 100-year flood level (AUK1946)
D	338 Burtt Road Drury	14.68m	14.821m	14.86m

NOR 2 Location 5 - 100-year Flood Map



Location	Address	Land invert level (AUK1946)	2.1°C climate change 100-year flood level AUK1946)	3.8°C climate change 100-year flood level (AUK1946)
E	338 Burtt Road Drury	25.21m	25.49m	25.50m

NOR 2 Location 6 - 100-year Flood Map

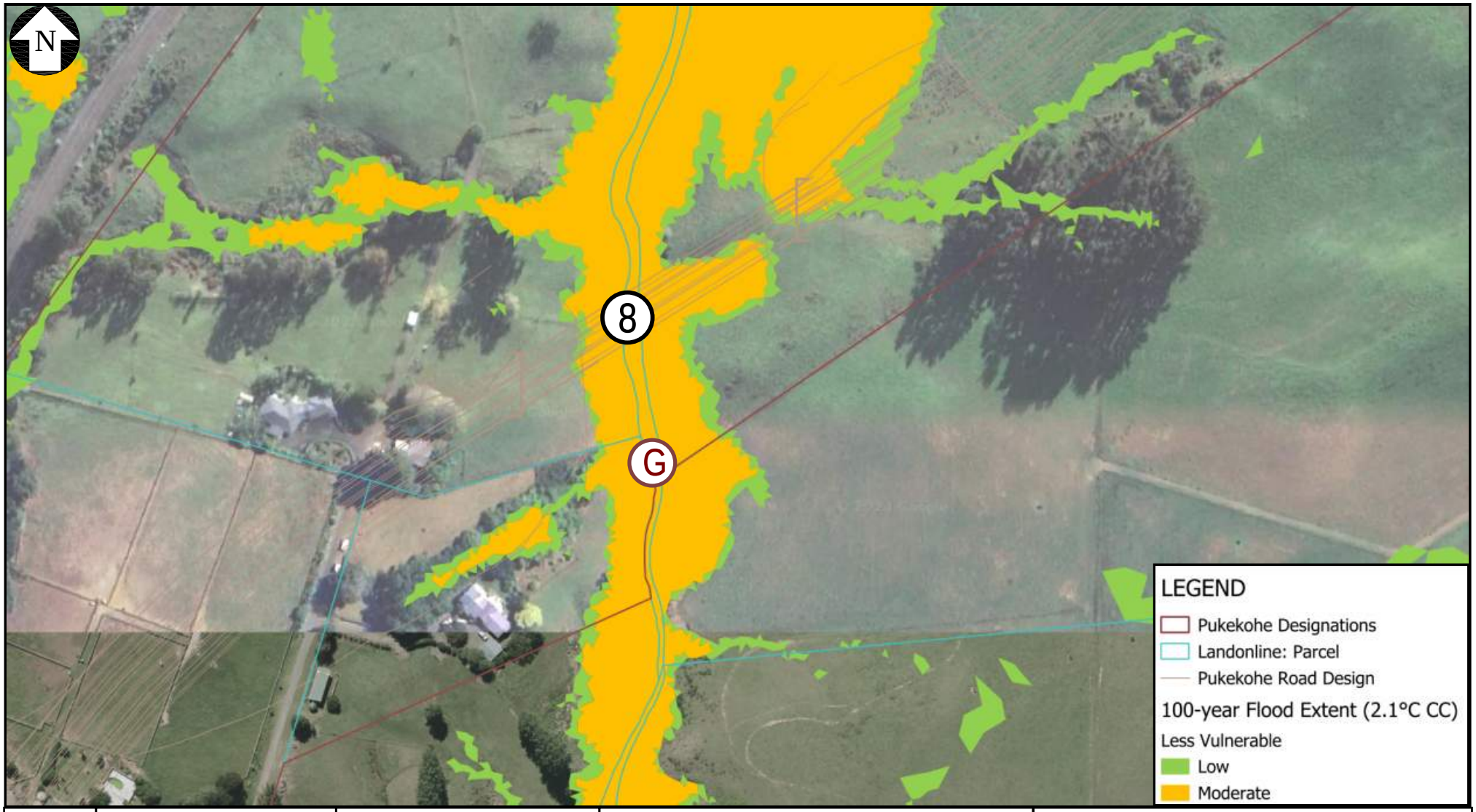


Location	Address	Land invert level (AUK1946)	2.1°C climate change 100-year flood level AUK1946)	3.8°C climate change 100-year flood level (AUK1946)
F	357 Burtt Road, Drury	19.06 m	18.77m	19.10m

NOR 2 Location 7 - 100-year Flood Map

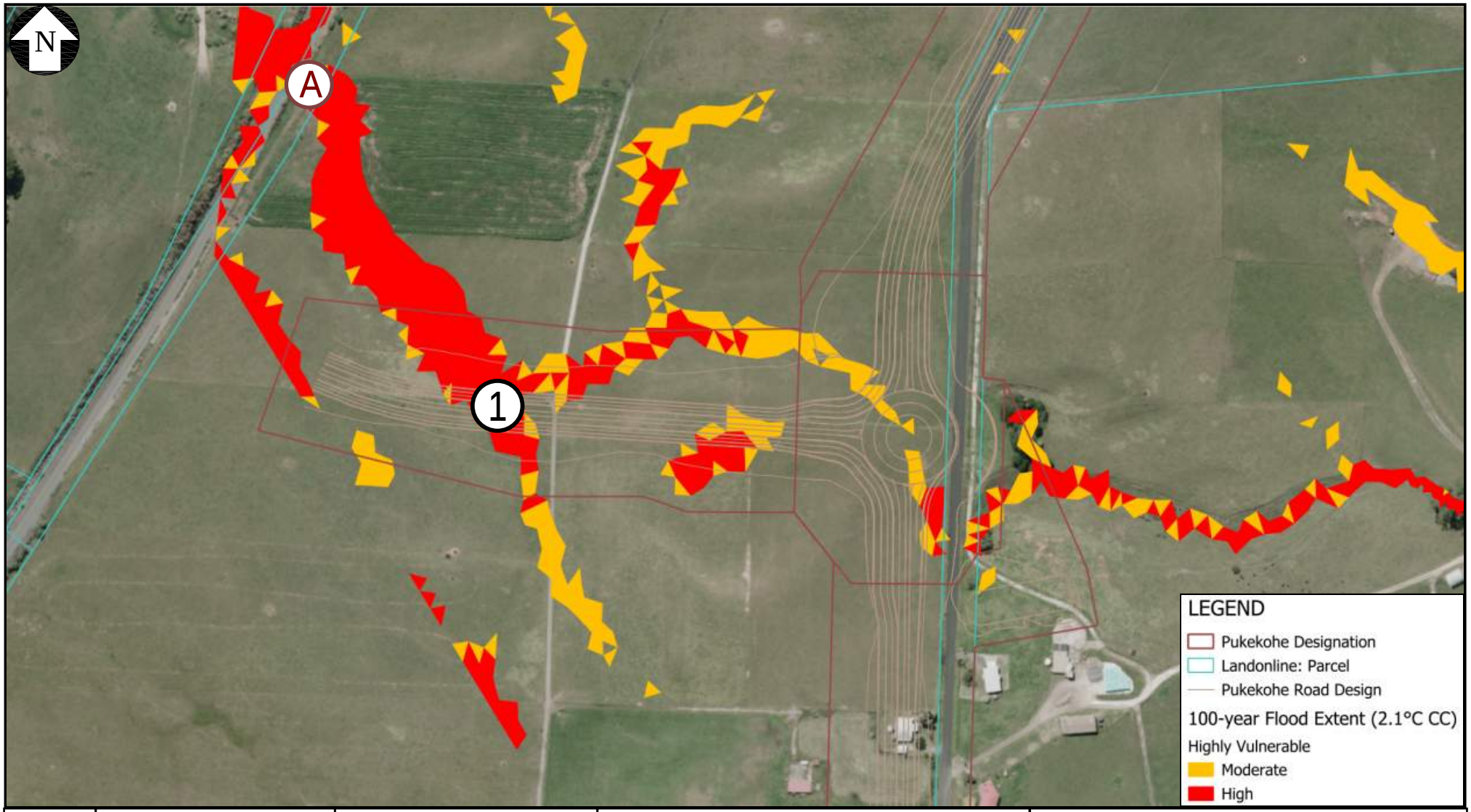
Location	Address	Land invert level (AUK1946)	2.1°C climate change 100-year flood level AUK1946)	3.8°C climate change 100-year flood level (AUK1946)
F	Bycroft Road Drury	12.52m	13.98m	14.19m

NOR 2 Location 8 - 100-year Flood Map



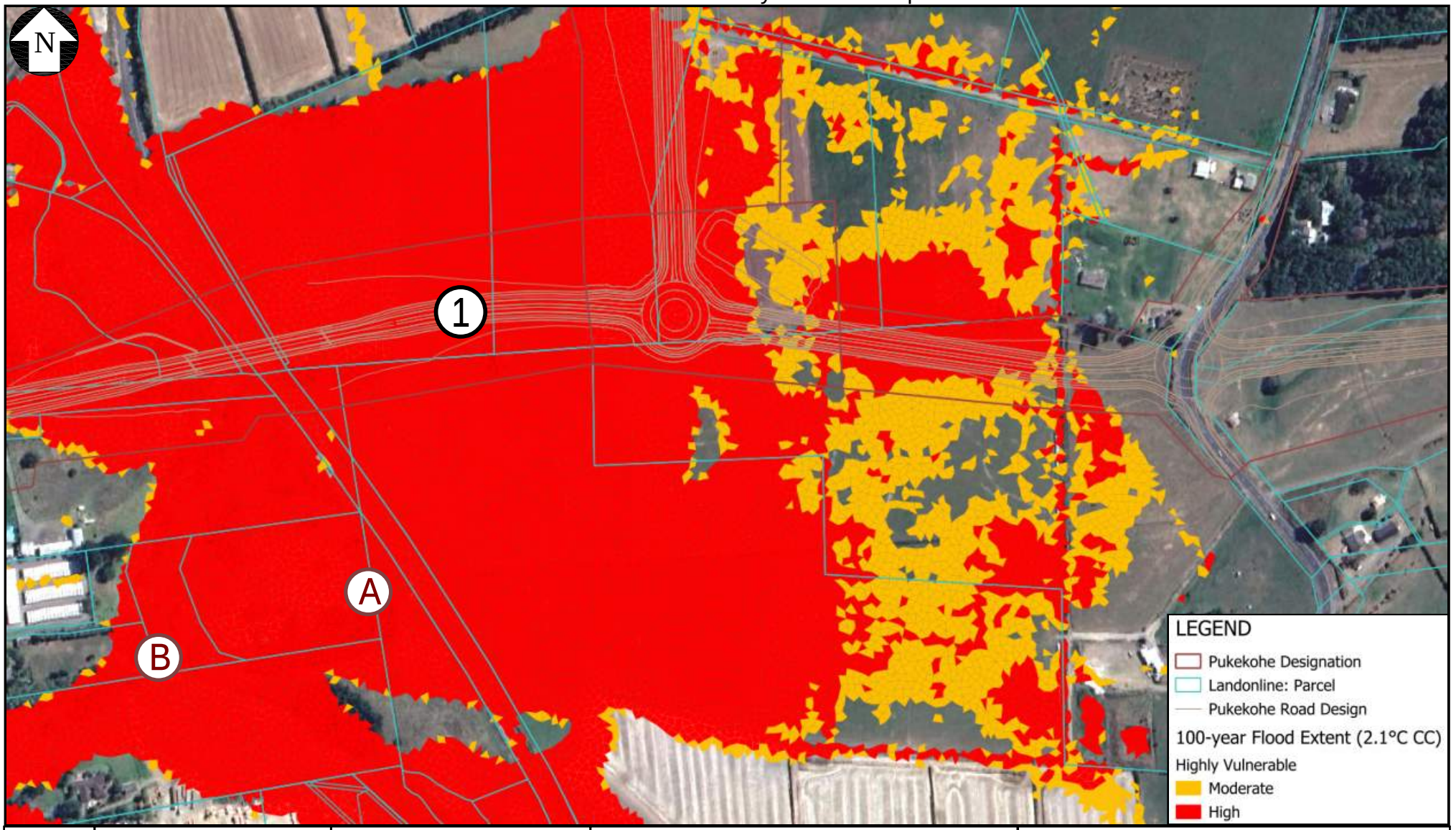
Location	Address	Land invert level (AUK1946)	2.1°C climate change 100-year flood level AUK1946)	3.8°C climate change 100-year flood level (AUK1946)
G	357 Burtt Road 319E Sim Road	14.75m	18.35m	18.88m

NOR 3 Location 1 - 100-year Flood Map



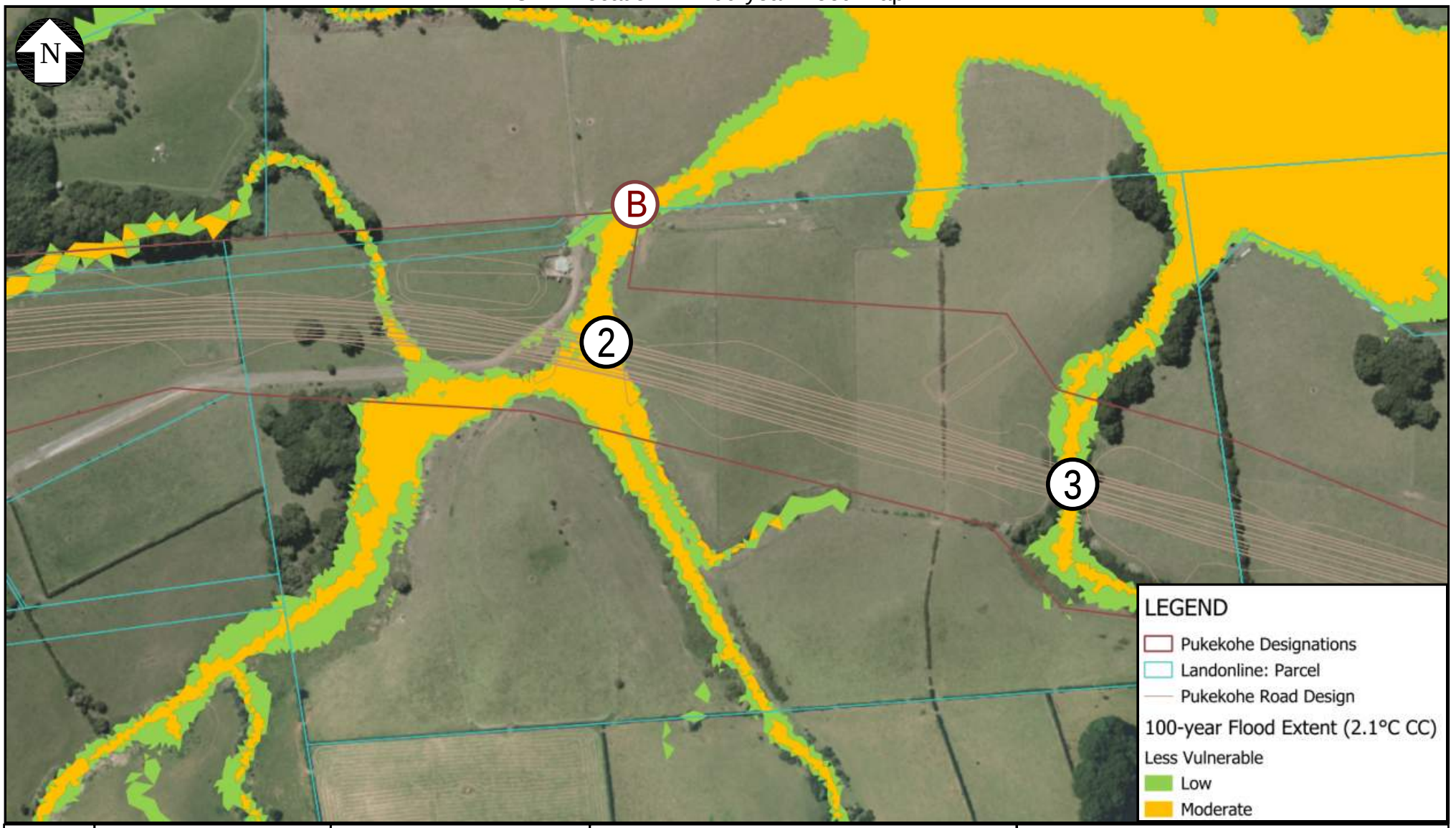
Location	Address	Land invert level (AUK1946)	2.1°C climate change 100-year flood level AUK1946)	3.8°C climate change 100-year flood level (AUK1946)
A	412 Sim Road Drury	44.43m	44.56m	44.74m

NOR 4 Location 1 - 100-year Flood Map



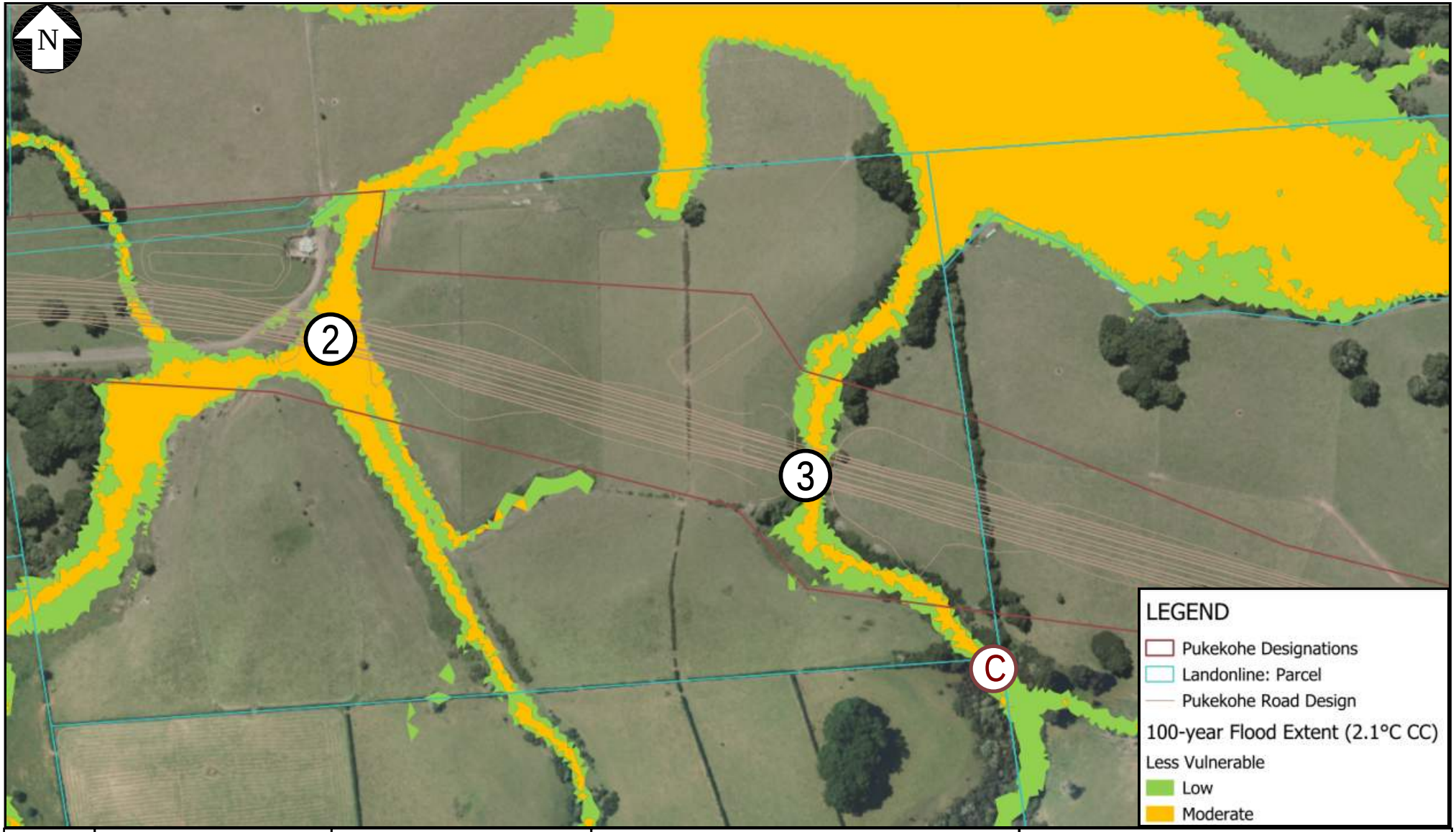
Location	Address	Land invert level (AUK1946)	2.1°C climate change 100-year flood level AUK1946)	3.8°C climate change 100-year flood level (AUK1946)
A	1219 Paerata Road	42.42m	NA	44.45m
B	1221 Paerata Road	40.82m	NA	44.47m

NOR 4 Location 2 - 100-year Flood Map



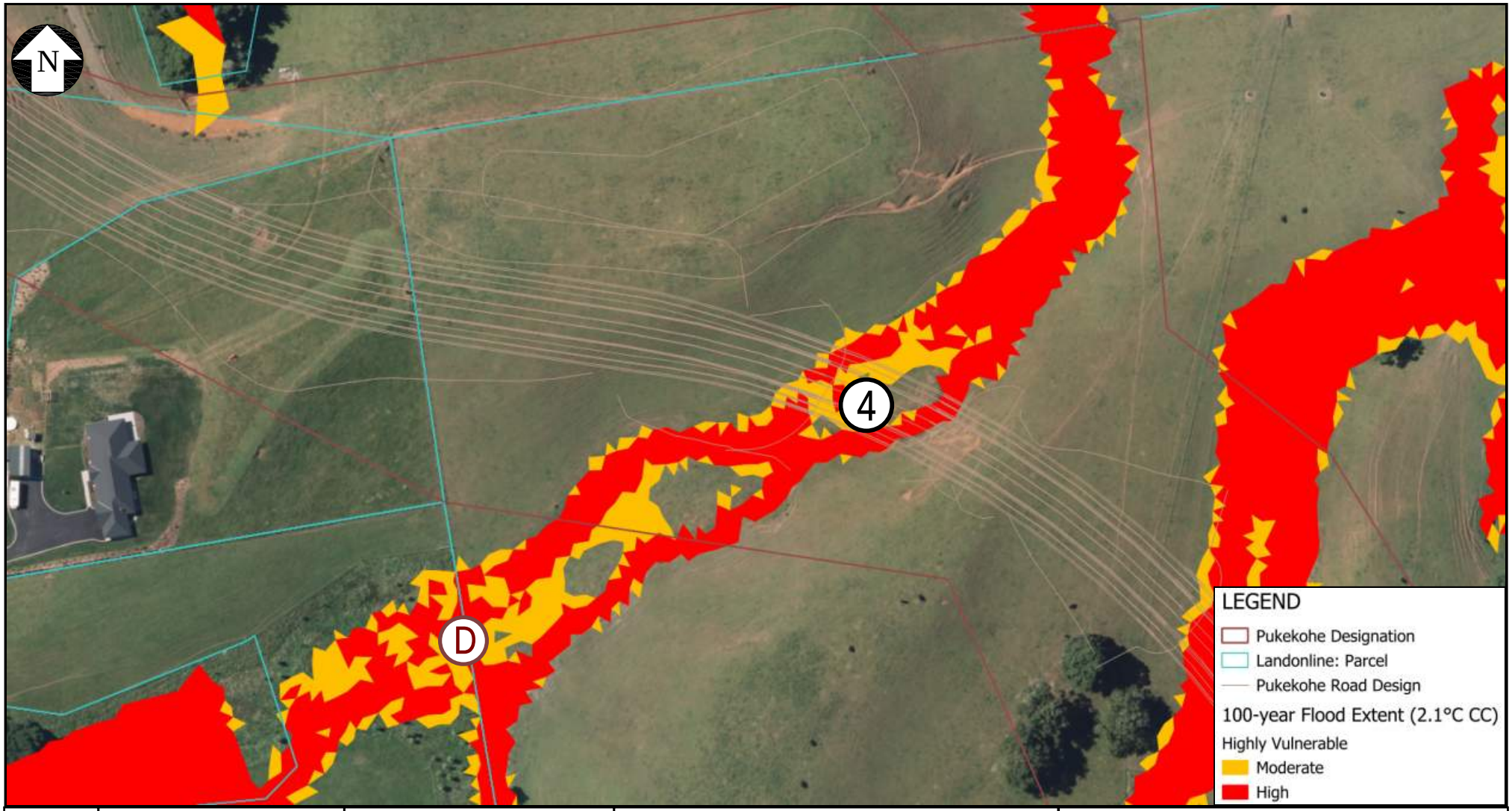
Location	Address	Land invert level (AUK1946)	2.1°C climate change 100-year flood level AUK1946)	3.8°C climate change 100-year flood level (AUK1946)
B	240 Cape Hill Road Pukekohe	33.04m	33.37m	33.53m

NOR 4 Location 3 - 100-year Flood Map



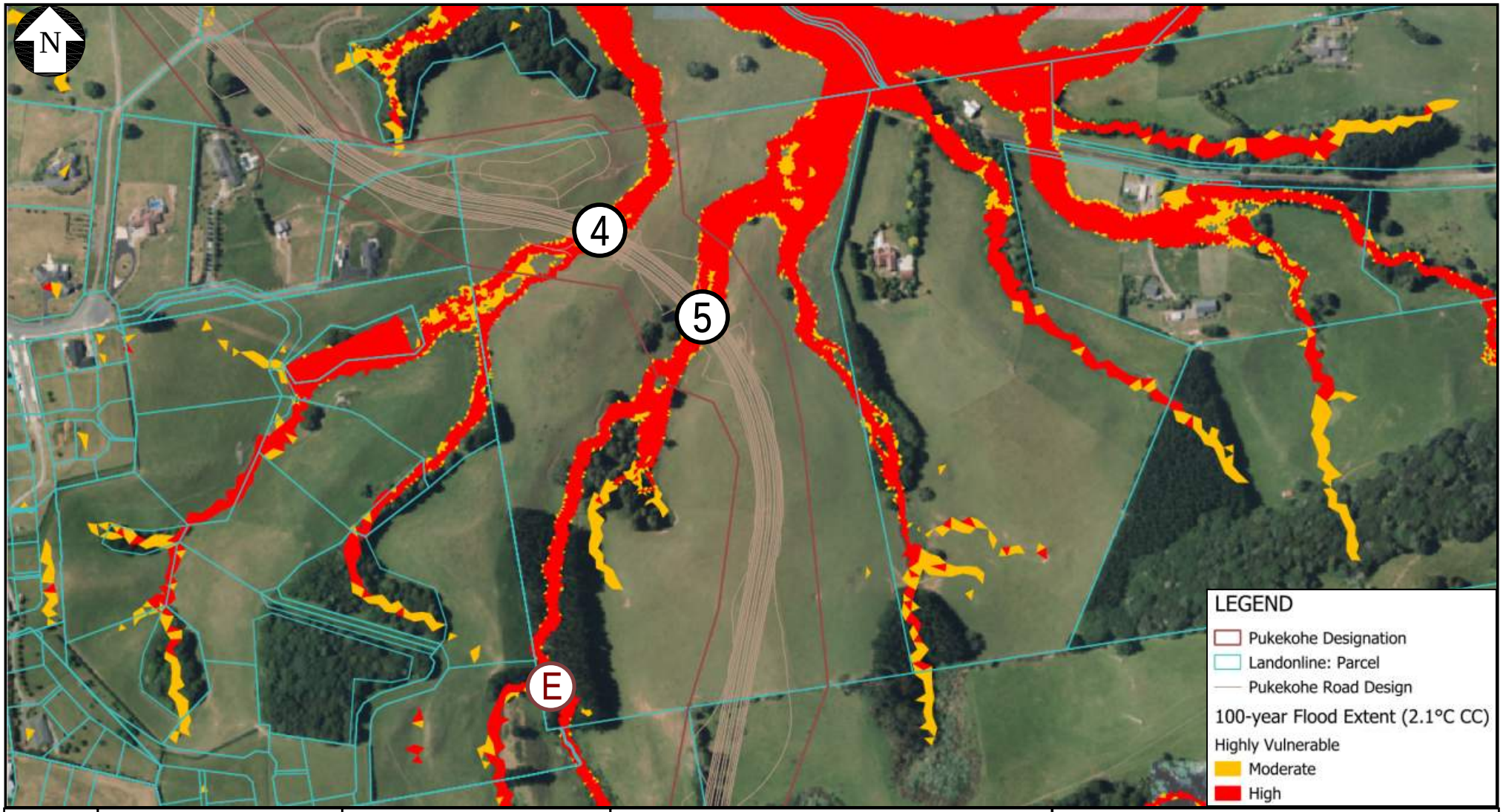
Location	Address	Land invert level (AUK1946)	2.1°C climate change 100-year flood level AUK1946)	3.8°C climate change 100-year flood level (AUK1946)
C	210 Cape Hill Road Pukekohe	34.34m	35.07m	33.19m

NOR 4 Location 4 - 100-year Flood Map



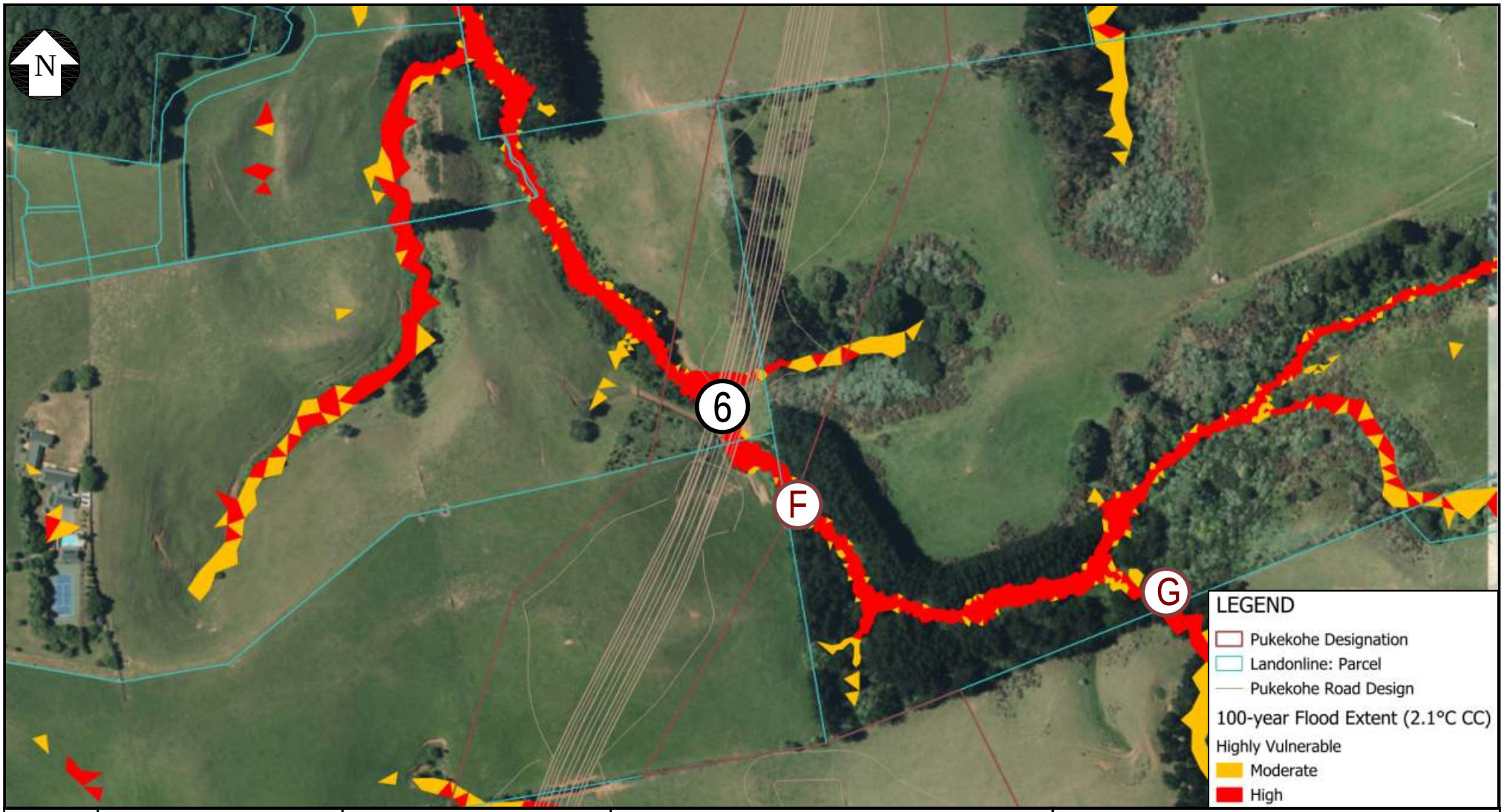
Location	Address	Land invert level (AUK1946)	2.1°C climate change 100-year flood level AUK1946)	3.8°C climate change 100-year flood level (AUK1946)
D	43 Grace James Road	40.60m	40.74m	40.80m

NOR 4 Location 5 - 100-year Flood Map



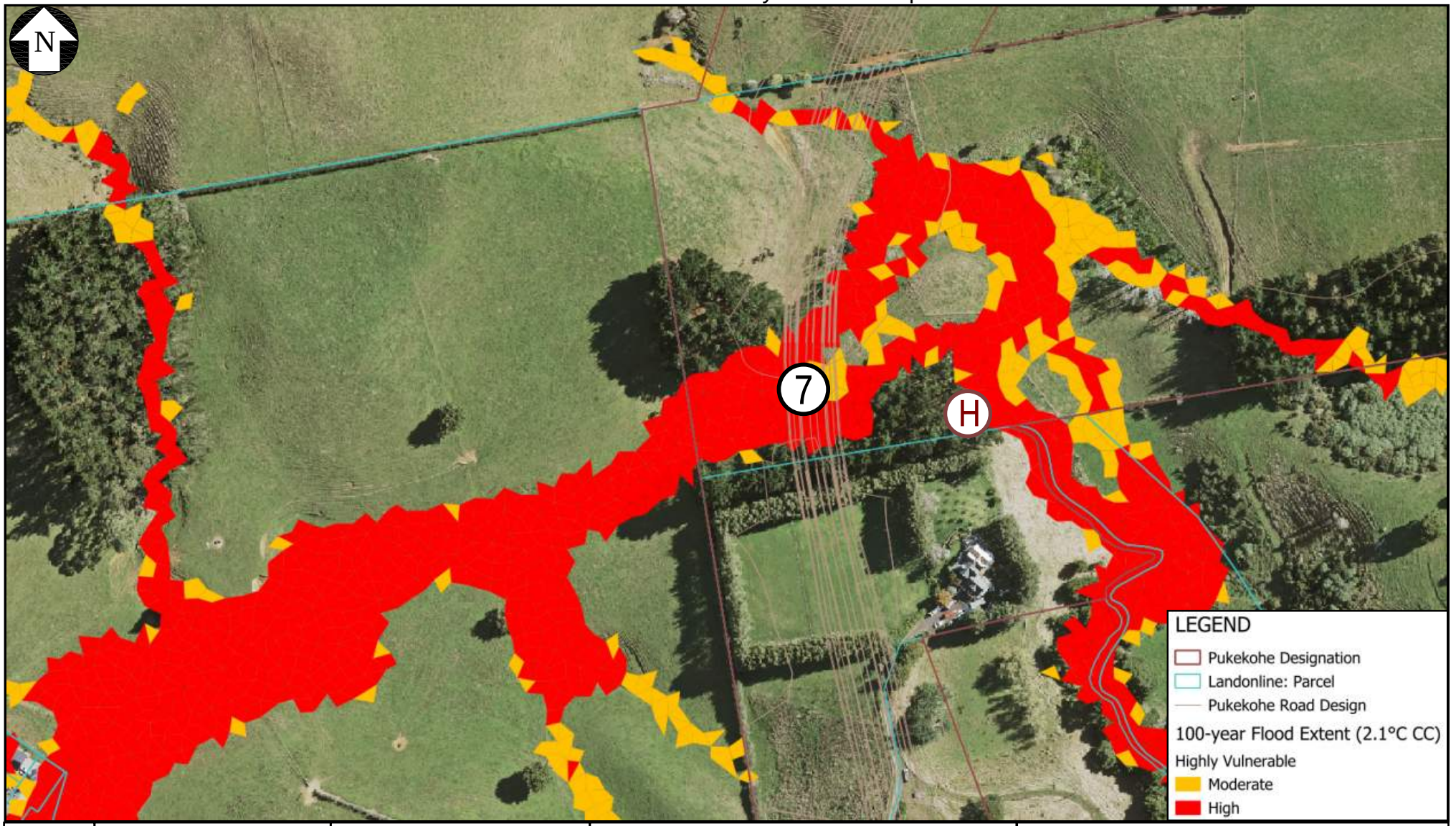
Location	Address	Land invert level (AUK1946)	2.1°C climate change 100-year flood level AUK1946)	3.8°C climate change 100-year flood level (AUK1946)
E	45 William Andrew Road	45.41m	45.43m	45.70m

NOR 4 Location 6 - 100-year Flood Map



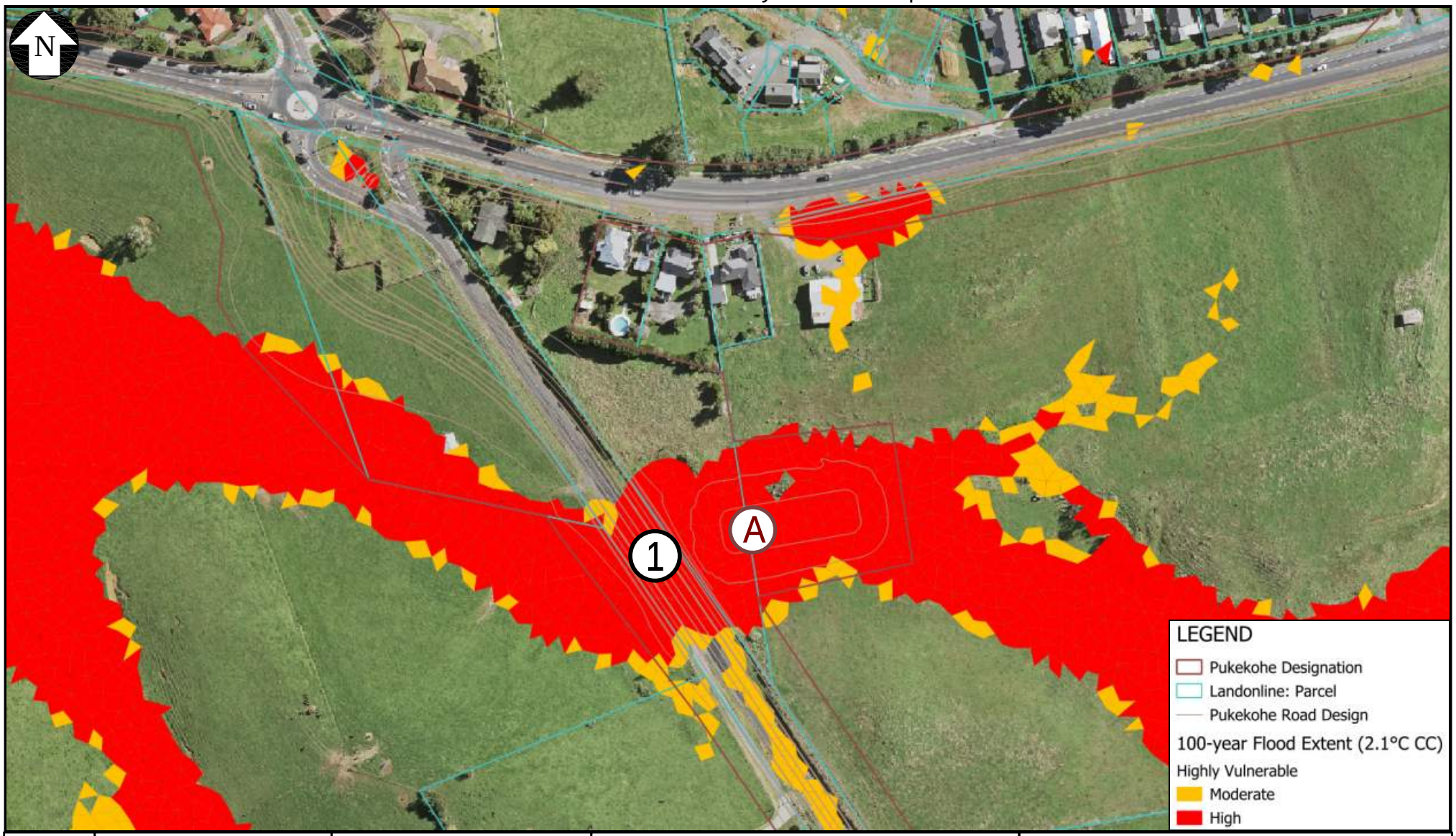
Location	Address	Land invert level (AUK1946)	2.1°C climate change 100-year flood level AUK1946)	3.8°C climate change 100-year flood level (AUK1946)
F	109 Runciman Road	50.68m	50.95m	51.79m
G	97C Runciman Road	67.29m	67.50m	67.54m

NOR 4 Location 7 - 100-year Flood Map



Location	Address	Land invert level (AUK1946)	2.1°C climate change 100-year flood level AUK1946)	3.8°C climate change 100-year flood level (AUK1946)
H	97C Runciman Road	55.64m	NA	58.57m

NOR 5 Location 1 - 100-year Flood Map



Location	Address	Land invert level (AUK1946)	2.1°C climate change 100-year flood level AUK1946)	3.8°C climate change 100-year flood level (AUK1946)
A	50 Pukekohe East Road	53.40m	NA	55.08m

NOR 5 Location 2 - 100-year Flood Map

Location	Address	Land invert level (AUK1946)	2.1°C climate change 100-year flood level AUK1946)	3.8°C climate change 100-year flood level (AUK1946)
B	49 Golding Road	57.28m	NA	59.58m
C	54 Golding Road	57.52m	NA	59.61m

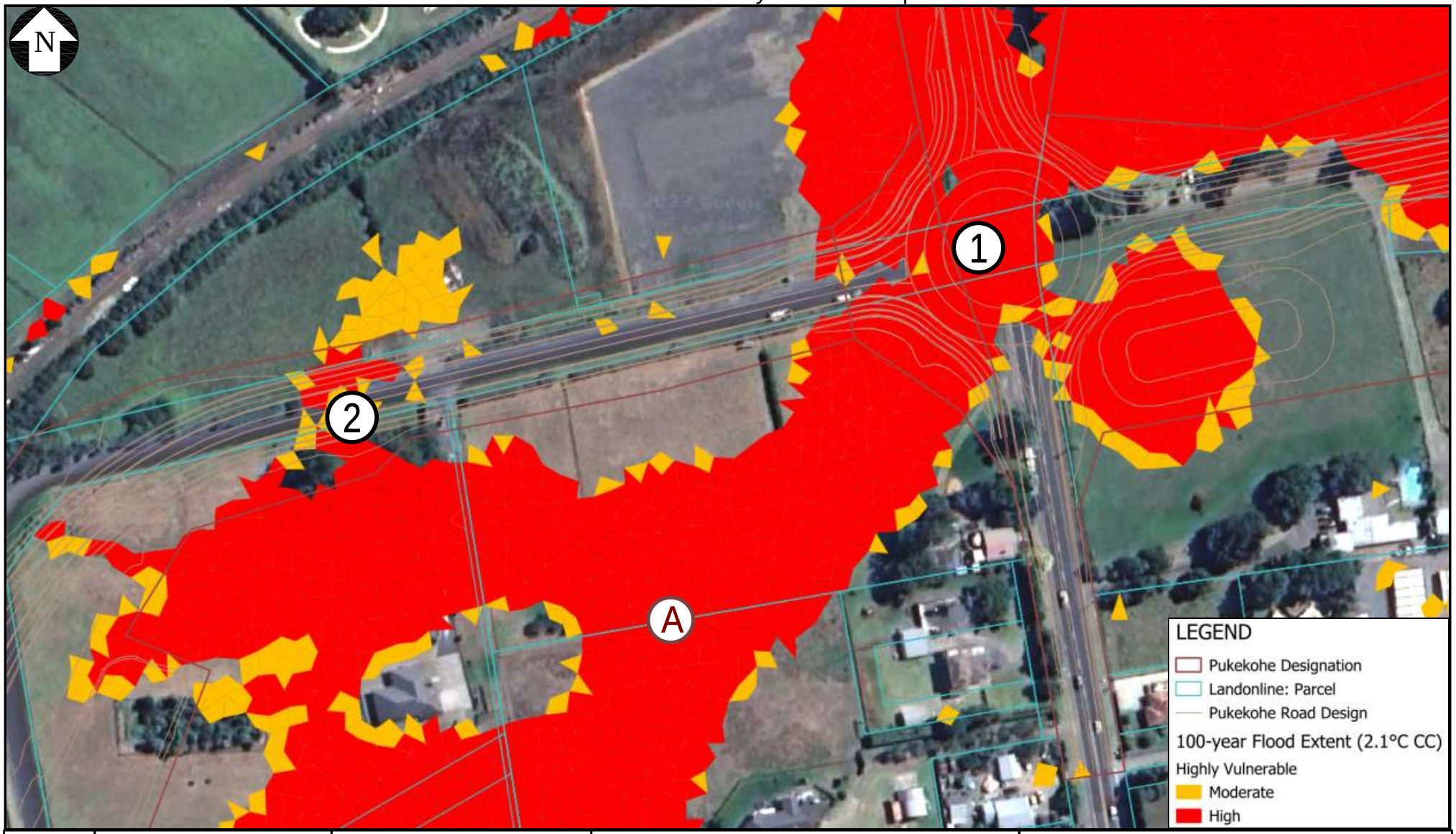
NOR 5 Location 3 - 100-year Flood Map

Location	Address	Land invert level (AUK1946)	2.1°C climate change 100-year flood level AUK1946)	3.8°C climate change 100-year flood level (AUK1946)
D	43A Youngs Grove 124, 150, 170, 194 Station Road	58.0m	NA	59.0m

NOR 5 Location 4 - 100-year Flood Map

Location	Address	Land invert level (AUK1946)	2.1°C climate change 100-year flood level AUK1946)	3.8°C climate change 100-year flood level (AUK1946)
E	44-46 Crosbie Road 15 Austen Place	55.0m	NA	55.0m

NOR 7 Location 1 - 100-year Flood Map



Location	Address	Land invert level (AUK1946)	2.1°C climate change 100-year flood level AUK1946)	3.8°C climate change 100-year flood level (AUK1946)
A	1216 Paerata Road	42.20m	NA	44.42m

NOR 7 Location 2 - 100-year Flood Map

Location	Address	Land invert level (AUK1946)	2.1°C climate change 100-year flood level AUK1946)	3.8°C climate change 100-year flood level (AUK1946)
B	22 Butcher Road	44.84m	NA	45.56m

NOR 7 Location 3 - 100-year Flood Map

Location	Address	Land invert level (AUK1946)	2.1°C climate change 100-year flood level AUK1946)	3.8°C climate change 100-year flood level (AUK1946)
C	62 Heights Road	50.25m	NA	54.64m

NOR 7 Location 4 - 100-year Flood Map

Location	Address	Land invert level (AUK1946)	2.1°C climate change 100-year flood level AUK1946)	3.8°C climate change 100-year flood level (AUK1946)
C	62 Butcher Road	46.30m	NA	46.44m

NOR 7 Location 5 - 100-year Flood Map

Location	Address	Land invert level (AUK1946)	2.1°C climate change 100-year flood level AUK1946)	3.8°C climate change 100-year flood level (AUK1946)
D	107 Heights Road	56.35m	NA	60.36m
E	157A Beatty Road	52.84m		52.95m

NOR 7 Location 6 - 100-year Flood Map

Location	Address	Land invert level (AUK1946)	2.1°C climate change 100-year flood level AUK1946)	3.8°C climate change 100-year flood level (AUK1946)
F	165 Heights Road	65.41m	NA	65.48m

NOR 8 Location 1 - 100-year Flood Map

Location	Address	Land invert level (AUK1946)	2.1°C climate change 100-year flood level AUK1946)	3.8°C climate change 100-year flood level (AUK1946)
A	144 Mill Road	143.19m	NA	143.93m

NOR 8 Location 2 - 100-year Flood Map

Location	Address	Land invert level (AUK1946)	2.1°C climate change 100-year flood level AUK1946)	3.8°C climate change 100-year flood level (AUK1946)
B	216 Mill Road	161.82m	NA	162.27m

TE TUPU NGĀTAHI
SUPPORTING GROWTH

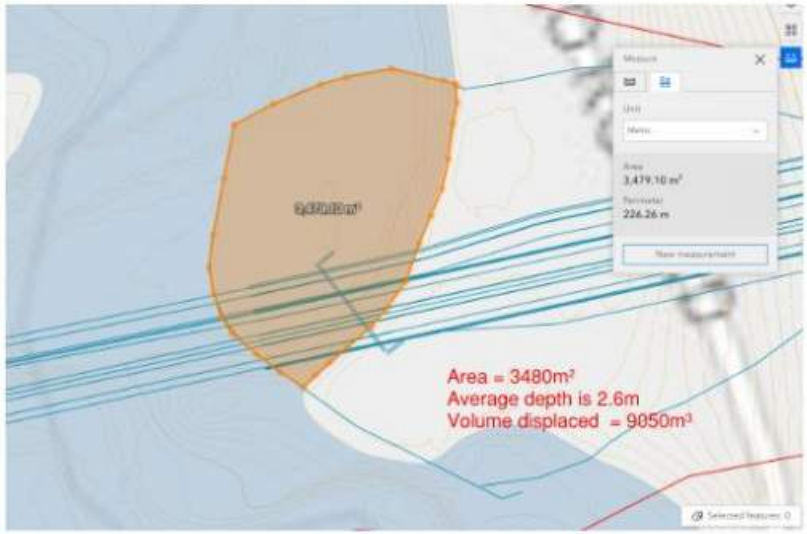
Appendix B

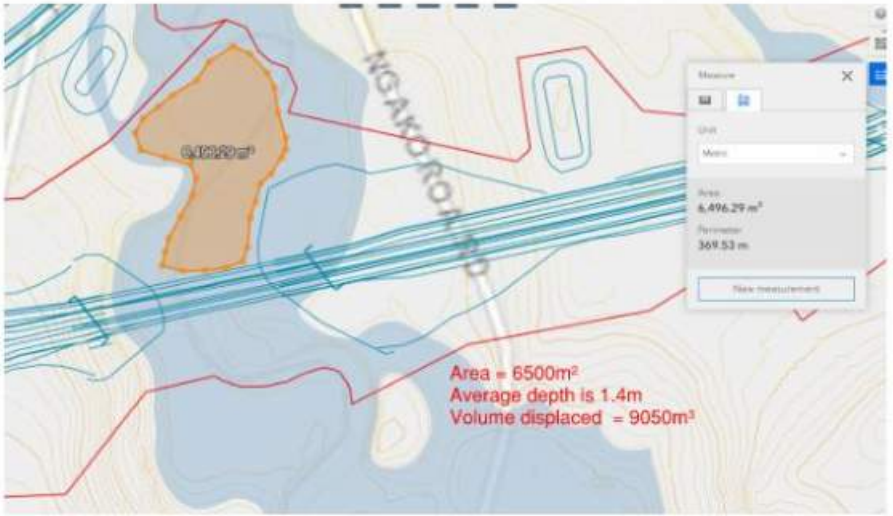
Flood storage loss and offset calculations

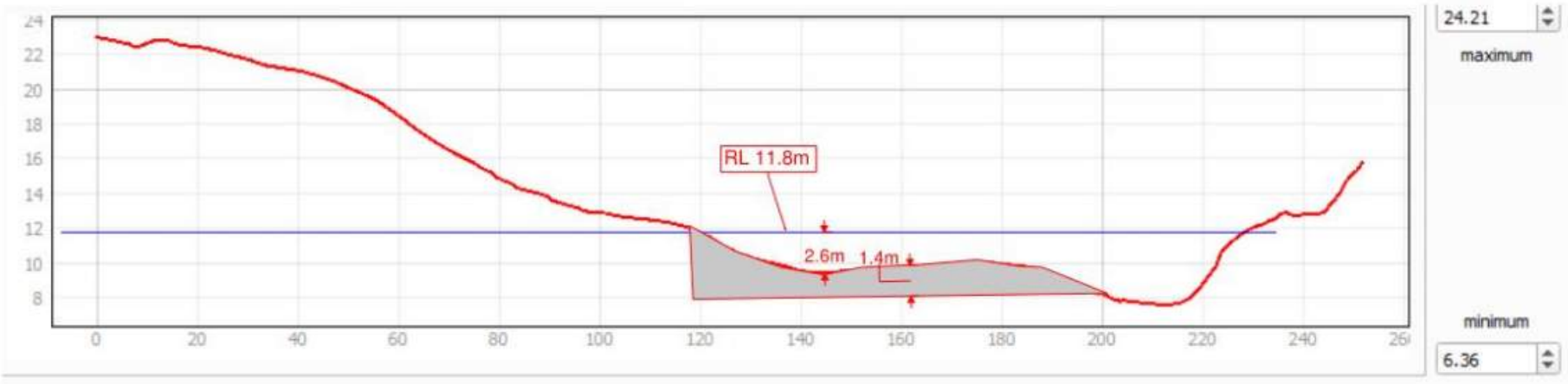
WAKA KOTAHI
NZ TRANSPORT AGENCY

New Zealand Government

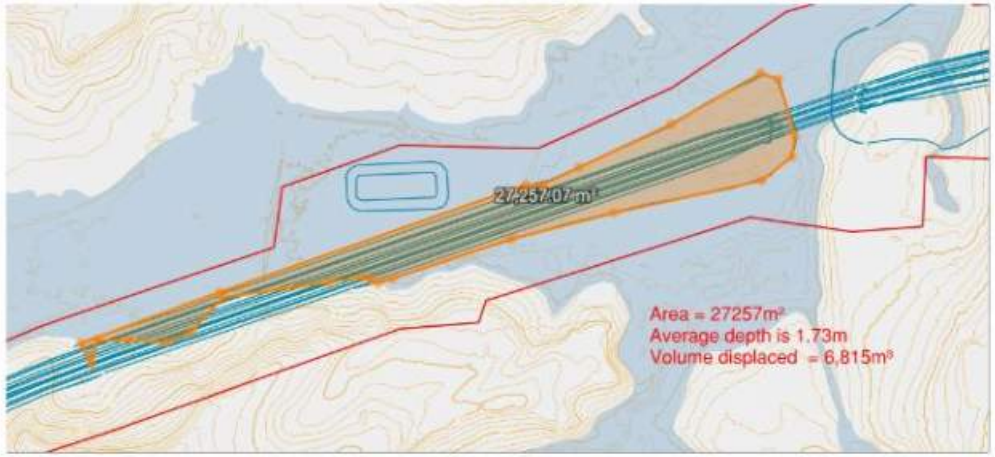
NOR 2 - Location 2

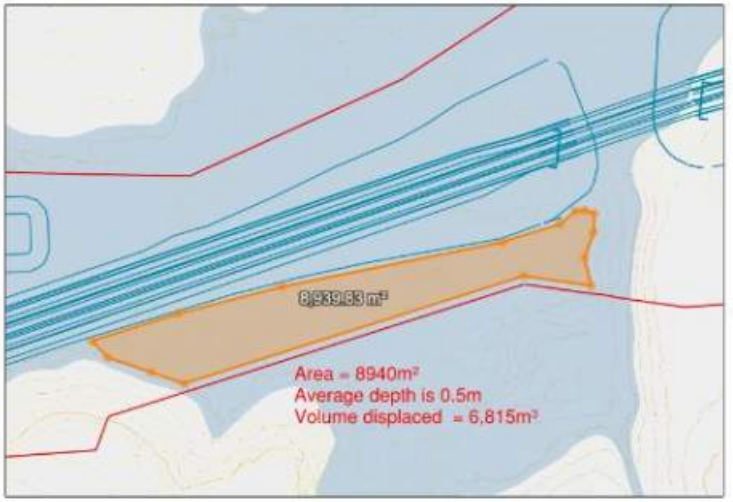


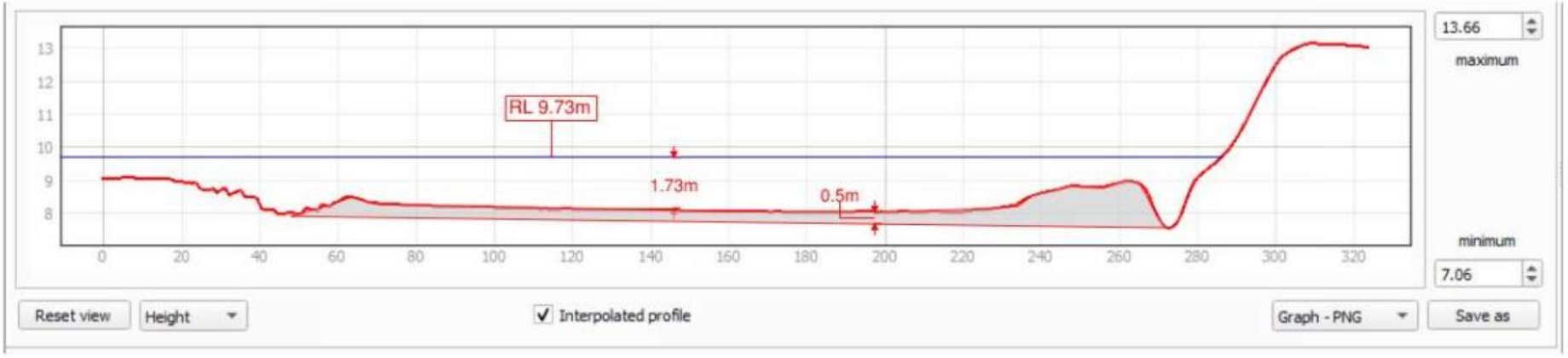




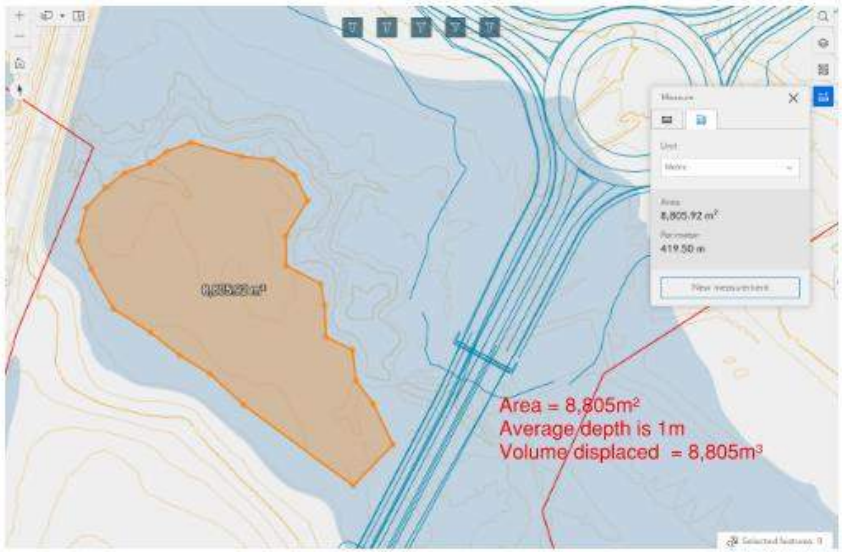
NOR 2 - Location 3

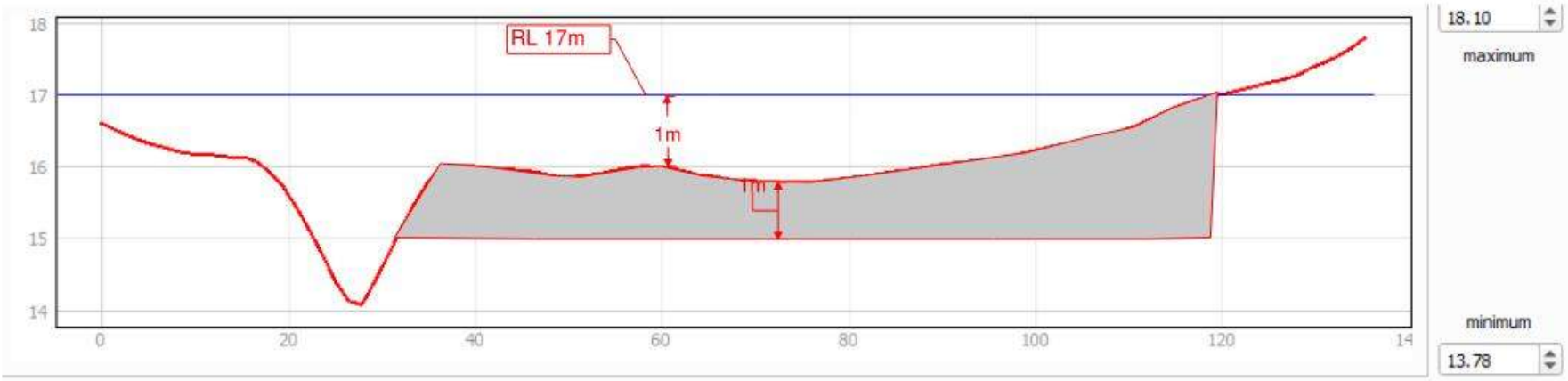




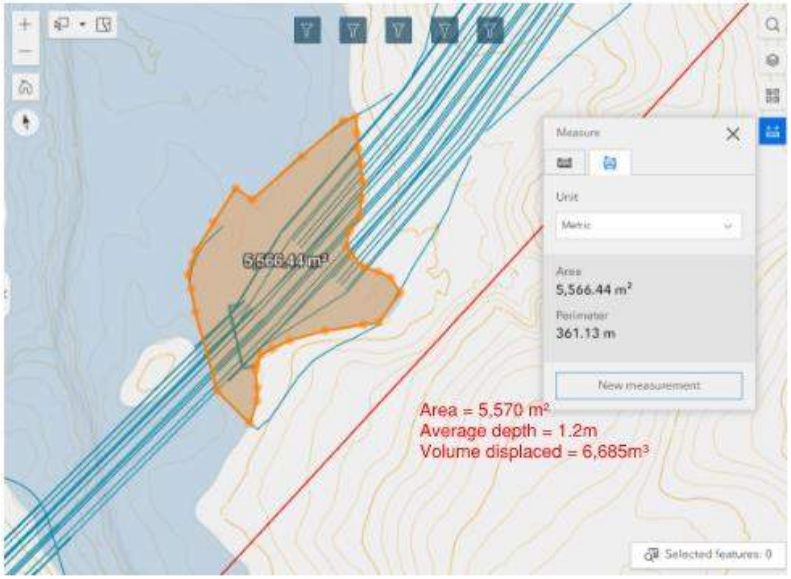


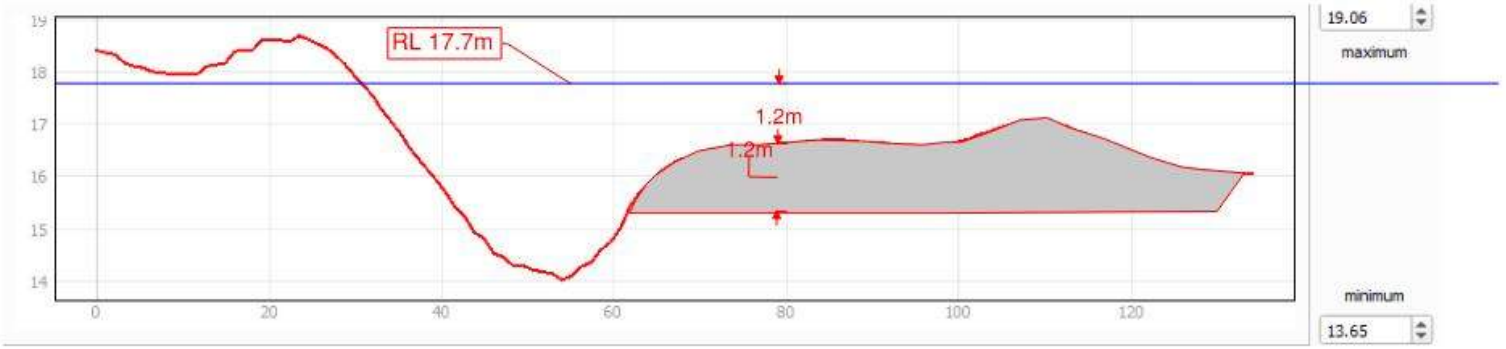
NOR 2 - Location 6





NOR 2 - Location 8





NOR 4 Location 1