TE TUPU NGĀTAHI
SUPPORTING GROWTH

VOLUME 4

South Frequent Transit Network Assessment of Flooding Effects

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Version 1.0

WAKA KOTAHI NZ TRANSPORT AGENCY

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Glossary of Defined Terms and Acronyms

We note that 'Takaanini' (with double vowels is used throughout the Report Acknowledging the ongoing kōrero and guidance from Manawhenua on the cultural landscape. 'Takanini' is used where reference is made to a specific and existing named place (e.g., Takanini Road, Takanini Town Centre etc.). Manawhenua is also used throughout the Report as while gifting the programme name as Te Tupu Ngātahi, Manawhenua confirmed this was an appropriate spelling (capital 'M' and one word). Notwithstanding this, the term is spelled as two words in other fora and the proposed designation conditions – Mana Whenua.

Acronym/Term	Description
AEE	Assessment of Effects on the Environment report
AEP	Annual Exceedance Probability
ARI	Average Recurrence Interval
AUP:OP	Auckland Unitary Plan: Operative in Part
AT	Auckland Transport
CEMP	Construction Environmental Management Plan
LID	Low Impact Design
Models	Catchment models
MPD	Maximum Probable Development
NIMT	North Island Main Trunk railway track
NoR	Notice of Requirement
NoR 1	Great South Road FTN Upgrade
NoR 2	Great South Road Upgrade (Drury Section)
NoR 3	Takaanini FTN – Weymouth Road , Alfriston Road and Great South Road Upgrades
NoR 4	Takaanini FTN – Porchester Road and Popes Road Upgrades
NPS:UD	National Policy Statement on Urban Development
PC78	Plan Change 78 to the Auckland Unitary Plan: Operative in Part
The Project	The Four NoRs proposed to authorise transport upgrades along key sections of roads which fall within the South FTN network (subject of this report / application).
RMA	Resource Management Act 1991
SH1	State Highway 1
South FTN	South Frequent Transit Network

Acronym/Term	Description
SWMD	Stormwater Management Devices
Te Tupu Ngātahi	Te Tupu Ngātahi Supporting Growth
Waka Kotahi	Waka Kotahi NZ Transport Agency
WSD	Water Sensitive Design

Executive Summary

This report provides an assessment of flood hazard risks associated with the construction, operation and maintenance of the four Notices of Requirement (**NoR / the Project**) proposed to authorise transport upgrades along key sections of roads which fall within the South Frequent Transit Network (**South FTN**).

Flooding is a natural hazard and as a district planning matter has therefore been considered as part of the 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 as part of the Project works. 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:

1. Desktop assessment to identify potential flooding locations;
2. Modelling of the pre-development terrain with Maximum Probable Development (**MPD**) and future 100-year Average Recurrence Interval (**ARI**) plus climate change rainfall;
3. Modelling of two climate change scenarios, one allowing for 2.1 degrees (RCP4.5 Or SSP2) of temperature increase and one for 3.8 degrees (RCP8.5 Or SSP3) of temperature increase. The higher climate change scenario has been used to undertake a sensitivity analysis; and
4. Inspection and review of flood depths at key locations such as pedestrian crossings, footpaths and where there is more vulnerable development e.g., dwellings.

Existing and Likely Future Environment

The existing environment surrounding most NoRs is established urban, commercial and industrial land uses. The land cover is dominated by houses, yards, roads and community buildings. The stormwater drainage is mostly underground stormwater pipes with some open space channels and modified rivers. The future environment will likely intensify with urban land uses and continue to manage stormwater drainage and flooding in the same way it is presently. It is anticipated that future urban development in the study area will require detention, retention and treatment of stormwater in the form of water sensitive urban design and low impact design principles.

Methodology

This assessment considers whether the proposed road designation area is large enough for a future road upgrade/modification to meet the proposed designation conditions described in the Operational Methodology section below. 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 the hydraulic modelling was used to identify areas of existing flood risk and where the designation may need to be widened to provide room for mitigation. Assessed flood level increases as a result of the proposed road design have not been considered as the future design can be amended to mitigate flood effect without affecting the proposed designation boundary.

The Project traverses six major stormwater catchments: Puhinui Stream, Papakura Stream, Waimahia Creek, Pahurehure Inlet, Slippery Creek and Hingaia Stream. The risk from the existing and likely future MPD development flood models considered development vulnerability and flood risk, refer to the risk matrix below.

Where the risk of flood hazard is identified, a recommendation has been made to achieve the outcomes of the proposed designation conditions. The designation boundary 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			

Other stormwater effects such as stormwater quality and retention/detention are not assessed. However, provision is made for the future mitigation of potential stormwater effects by identifying the space required for stormwater management and treatment devices (**SWMD**), and by incorporating sufficient land in the proposed designation boundaries for this purpose. The assessment considers that flooding effects will be subject to further evaluation in accordance with the designation conditions at a future detailed design stage. 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 the 1 in 100-year ARI rainfall event (with 2.1º CC) 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;
- New 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).

Existing roadside channels and swales will remain unchanged if not affected by the NoR works; and

- Raingardens in the roadside berms to integrate Low Impact Design (**LID**) and Water Sensitive Design (**WSD**) into the built environment. These systems will perform treatment and detention only. If attenuation is required ((10% Annual Exceedance Probability (**AEP**) and 1% AEP)), underground tanks or wetlands will be 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. 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**). It is therefore recommended that flood hazard is 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; and
- 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 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).

Summary of flooding assessment outcomes

NoR	Typical Project works summary	Typical Flood Risk Rating	Recommendations to avoid or mitigate flood effects
NoR 1	Intersection upgrades, road widening, addition of walking and cycling. One bridge upgrade for a major Stream (Otūwairoa / Slippery Creek)	Flooding is generally high through NoRs and in most cases, the road is a conveyance path and a controlling feature on flood levels	• Keep the current vertical alignment with no lifting or lowering of the road crest; • Provide treatment and detention in raingardens, and • Provide additional piped drainage, greater inlet capacity at new kerb locations.

NoR	Typical Project works summary	Typical Flood Risk Rating	Recommendations to avoid or mitigate flood effects
NoR 2	Great South Road vertical alignment and bridge changes between Hingaia Stream Crossing.	The majority of land adjacent to this NoR is a high flood hazard	• Provide treatment and detention in raingardens and avoid attenuation to prevent coincident flow flood effects on downstream land. • Participate in a masterplan discussion to arrive at a target arrangement of all Hingaia Stream crossings to achieve a balance between flood protection to roads, property, public spaces and cost.
NoR 3	Existing Road widening and intersection upgrades along Alfriston Road	Mostly high flood risks in defined overland flowpaths crossing perpendicularly to Alfriston Road	• Keeping the current vertical alignment; • Provide treatment and detention in raingardens for the road runoff, and • Provide additional piped drainage, to suit the changed kerb lines
NoR 4	Road widening of Popes Road and Porchester including an upgrade to the intersection of both roads	Expansive high risk flood areas generated by the Papakura Stream. Additionally, current FUZ land drains into channels along the two roads placing the drainage burden on the road corridor.	• Keep the current vertical alignment; and • Provide treatment, detention and attenuation in swales and wetlands to manage the changes in road runoff • Provide additional piped drainage, to suit changed kerb lines • Keep clean water conveyance channels separate from treatment swales • Co-ordinate with Auckland Council where possible to tie in with a drainage masterplan to unlock developable land.

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

(a) The Project shall be designed to achieve the following flood risk 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 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; and*
- *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 1% AEP rainfall event.*

(b) Compliance with this condition shall be demonstrated in the Outline Plan, which shall include flood modelling of the pre-Project and post-Project 100-year ARI flood levels (for Maximum Probable Development land use and including climate change).

(c) *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 an established and built-up urban environment. In these cases, minimal change to the drainage system is recommended with additional wetlands or raingardens to manage the hydrological effects, the size of which can be determined at a later design stage when resource consents are sought.

Wetlands and swales will provide 10-year and 100-year ARI attenuation and conveyance in the upper catchment and avoid attenuation in the lower catchment unless discharging to the Auckland Council reticulated stormwater network, where 10-year attenuation to pre development flowrates is expected. This will balance the competing needs to hold back peak flowrates in the upper catchment, avoid peak flow coincidence effects in the lower reaches and manage the increases in flow to already under sized stormwater pipes. Bridges are recommended to maintain the same capacity to avoid causing effects upstream or downstream flood effects. 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 report has been prepared to inform the Assessment of Effects on the Environment (**AEE**) for Notices of Requirement (**NoR**) being sought by Auckland Transport (**AT**) for the South FTN under the Resource Management Act 1991 (**RMA**). Four NoRs are proposed to authorise transport upgrades along key sections of roads which fall within the South FTN network. The transport upgrades authorised by the NoRs are referred to in this report as the **Project.**

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

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 the 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 flooding 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.

This report draws a distinction between stormwater effects and flood hazard effects, which are a subset of potential stormwater effects. Flood hazard effects are the focus of this assessment as explained below. Stormwater effects are generally divided into stormwater quantity effects (such as flooding, erosion and changes to hydrology – which may cause effects onstream habitat, baseflow and sediment movement in streams), stormwater discharge quality (including the discharge of contaminants – which may cause effects on aquatic fauna, public health and amenity values) and the effects on streams due to the presence of in-stream structures. These effects are considered through sections 13, 14 and 15 of the RMA and are administered through regional consents by Auckland Council.

A designation is a land use or district planning mechanism. Accordingly, when assessing the actual or potential stormwater effects on the environment of allowing the requirement in terms of section 171 of the RMA, the assessment of effects has been limited to flood hazard matters, being the specific matters that would trigger a District Plan consent requirement under the Auckland Unitary Plan (Operative in Part) (**AUP:OP**). Where Regional Plan consenting requirements are triggered, these will not be authorised by the designation, and will require further regional consents to be obtained prior to construction of the Project.

In presenting information on flood hazard effects, it is acknowledged that there will be a subsequent process for seeking regional council consents. The NoRs also acknowledge that the works required for the Project could lead to risks associated with flooding as a natural hazard and provide an assessment of effects to demonstrate that these risks can be appropriately managed in the future.

1.2 Report Structure

In order to provide a clear assessment of the NoRs, this report follows as appropriate, the structure set out in the main AEE. This report contains an assessment of the actual and potential effects of the

Project as a whole (the four NoRs), the individual NoRs; and (where appropriate) localized areas within the wider extent. Where appropriate, measures to avoid, remedy or mitigate effects are recommended. The sections of this report are arranged as per Table 1 below which provides an overview of the report structure and where the description of effects can be found in this report.

Table 1 - Report Structure

Report Part #	Report Section #	Extent Assessed (Route and/or NoR)
A	4	Whole of Project
B	5.1	NoR 1 – Great South Road FTN Upgrade
	5.2	NoR 2 – Great South Road Upgrade (Drury section)
	5.3	NoR 3 – Weymouth, Alfriston, and Great South Road Upgrades
	5.4	NoR 4 – Porchester Road and Popes Road Upgrades

2 Project Description

2.1 Context – South FTN network

As described further in the AEE, the South FTN is one of the transport works packages proposed for South Auckland between Manukau and Drury as part of Te Tupu Ngātahi Supporting Growth (**Te Tupu Ngātahi**) programme.[1] The South FTN is in turn part of a wider planned multi-modal transport network intended to support growth and enable mode shift in South Auckland.

The South FTN comprises a range of road upgrades including bus priority measures, new and upgraded active mode facilities, and intersection improvements along existing arterial road corridors in South Auckland. In particular, the proposed road upgrades provide for:

- Operation of high-quality FTN[2] bus services along Great South Road between Manukau and Drury (the Great South Road FTN route);
- Operation of high-quality FTN bus services along existing roads between Manurewa, Takaanini, and Papakura (the Takaanini FTN route); and
- Urbanisation of adjoining key connections to FTN routes – Popes Road West, and the Drury section of Great South Road between Waihoehoe Road and State Highway 1 (**SH1**).

The total extent of the South FTN network is shown in Figure 1.

[1] The Programme is a collaboration between Auckland Transport (**AT**) and Waka Kotahi NZ Transport Agency (**Waka Kotahi**) to investigate, plan, and undertake route protection for the strategic transport networks needed to support Auckland's growth over the next 30 years.

[2] FTN services are defined in AT's Regional Public Transport Plan (RPTP) as bus routes operating at least every 15 minutes between 7am-7pm, 7 days-a-week, often supported by priority measures such as bus or transit lanes.

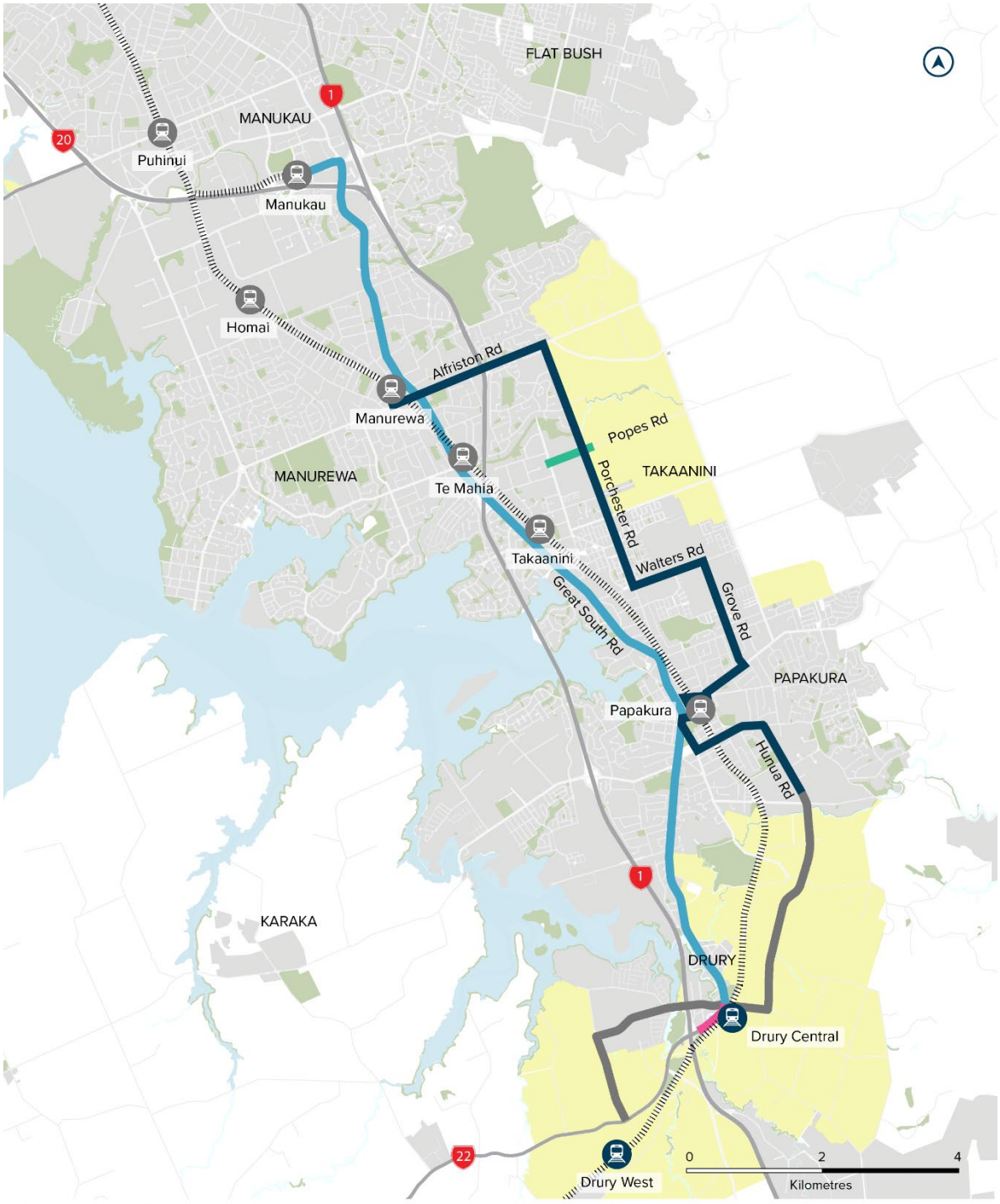

Figure 1 – South FTN – overall Project extent

2.2 The NoRs – proposed spatial extent

Of the full South FTN network extent shown in Figure 1, only a portion falls within the NoRs/Project (see Figure 2). This is because the proposed corridor upgrades do not always require additional land take, can be undertaken within the existing road reserve, and therefore do not require new designations.[3]

Accordingly, this assessment is focussed on the activities proposed to be authorised by the four NoRs. The NoRs seek generally to provide for road widening to accommodate bus priority measures, walking, and cycling facilities, key intersection upgrades, replacement of existing bridges and other associated works. These are described in more detail in Table 2, and the extents are shown in Figure 2. Further detail on the proposed activities and works in each NoR are provided in the AEE.

Table 2 - Summary of the proposed Project

NoR reference	Project component	Description
NoR 1	Great South Road FTN Upgrade	• Road upgrades and transport upgrades providing for the Great South Road FTN route along Great South Road between Manukau and Drury. • NoR comprises eight separate areas along Great South Road (see Figure 2) providing for bus priority measures, walking and cycling facilities, key intersection upgrades, replacement of the existing Otūwairoa / Slippery Creek bridge, and stormwater management devices.
NoR 2	Great South Road Upgrade (Drury section)	• Road upgrades and transport upgrades providing for upgrade of a 520m section of Great South Road in Drury between Waihoehoe Road and the SH1 Drury Interchange. • NoR enables road widening to provide for four lanes, active mode facilities, replacement of the existing Hingaia Stream bridge, and stormwater management devices.
NoR 3	Takaanini FTN – Weymouth, Alfriston, and Great South Road Upgrades	• Road upgrades and transport upgrades providing for the Takaanini FTN route along Weymouth and Alfriston Roads between Selwyn Road and Saralee Drive; and for an adjoining section of the Great South Road FTN route between Halver Road and Myers Road. • NoR enables road widening to accommodate bus priority measures, walking and cycling facilities, key intersection upgrades, replacement of existing bridges along Weymouth Road over the North Island Main Trunk (**NIMT**) and Alfriston Road over SH1, and stormwater management devices.
NoR 4	Takaanini FTN – Porchester Road and Popes Road Upgrades	• Road upgrades and transport upgrades providing for the Takaanini FTN route along Porchester Road generally between Alfriston Road and Walters Road; and for the urbanisation of Popes Road generally between Takanini School Road and Porchester Road. • NoRs provide for urbanisation of both corridors – two traffic lanes, walking and cycling facilities, key intersection upgrades, and stormwater management devices.

[3] Some limited additional third-party land may be required in the future to provide for intersection upgrades between Takaanini and Opaheke. The relative cost-benefit assessment of these areas did not favour route protection at this time given the projected time scale for future urban growth in this area.

Figure 2 – South FTN – proposed NoRs

3 Assessment methodology

3.1 Preparation for this report

Work undertaken for this report commenced in August 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 – Supporting Growth Alliance (**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 Auckland Council Healthy Waters catchment manager plans/expectations for the catchments;
- A review of the other GIS data such as contours and aerial photography; and
- A more detailed site visit undertaken in August 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; and
  - Urban Design Assessment.

This assessment informs the land requirements for the NoRs as they relate 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 the Puhinui Stream, Papakura Stream, Waimahia Creek, Pahurehure Inlet, Slippery Creek and Hingaia 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 MPD;
  - 100-year ARI plus climate change rainfall (2.1º increase, RCP4.5 or SSP2);

    - 100-year ARI plus climate change rainfall (3.8º increase, SSP3 or RCP8.5); and
    - Model results were used to identify flood water levels increases ≥ 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; and
    - Properties and buildings with habitable floors showing potential of flood risk to the existing building footprints.
- A sensitivity analysis to assess the potential impact of climate change scenarios 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 an existing risk and where the proposed designation may need to widen to consider room for mitigation.

The post-development case was not modelled as it would serve to indicate flood effects related to a single design that will likely not be built in the future when the design is further refined, and resource consents are applied for. Instead, this assessment is focused on the designation of land for future works. The flood effects and designation conditions are related to the sensitivity of the existing and likely future environment that the future Project will have to meet.

3.2.1 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 Table 3.

Table 3 - Overall flood risk rating according to flood depth against land use

Flood depth / land use	Less Vulnerable e.g., open space, rural land	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

Throughout this assessment the considerations for stormwater and flooding were based on a concept design and the proposed designation boundary, which includes sufficient space to respond to the future environment. The effects assessment seeks to confirm that the Project designation is sufficient to meet the outcomes set out below and provide appropriate mitigation measures within the designation boundary.

The Project does not propose substantial changes to the vertical alignment of existing roads within the urban areas. Therefore, the Project geometry is expected to cause limited additional flooding effects, such as loss of flood plain storage or raising the overtopping level. Notwithstanding this, there are a number of locations where there is an existing flood hazard. As such, future detailed design for the Project will need to assess and manage potential flooding effects to meet the outcomes set out below, which are committed to via the designation conditions.

Some increase in road corridor impervious areas within the urban parts of the Project corridor has been identified and is in the order of 10% increase. The retention and detention volumes will be sized for the total impervious area of the Project corridor. The proposed storage volume will mitigate the total stormwater runoff increase as a result of the proposed development, for the retention / detention volume storm event. The changes in impervious areas are minor in the context of the overall catchments and are not expected to result in significant effect. If future detailed modelling for the Project identifies the need for further flood attenuation volume, beyond what is currently provided for, the designation boundary provides sufficient space for this to be incorporated into proposed treatment devices or located adjacent to the corridor.

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

(a) The Project shall be designed to achieve the following flood risk outcomes:

- *(i) 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;*
- *(ii) no more than a 10% reduction in freeboard in a 1% AEP event for existing authorised habitable floors with a freeboard over 150mm;*
- *(iii) no increase in 1% AEP flood levels for existing authorised community, commercial, industrial and network utility building floors that are already subject to flooding;*
- *(iv) no more than a 10% reduction in freeboard in a 1% AEP event for existing authorised community, commercial, industrial and network utility building floors;*
- *(v) 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; and*
- *(vi) no new flood prone areas; and*
- *(vii) 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 1% AEP rainfall event.*

(b) Compliance with this condition shall be demonstrated in the Outline Plan, which shall include flood modelling of the pre-Project and post-Project 100-year ARI flood levels (for Maximum Probable Development land use and including climate change).

(c) *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.*

This assessment identifies where existing flood effects occur and may require mitigation as part of the proposed corridor works. The designation boundary allows for treatment and retention/detention devices which include some storage. However, the final geometric design will be more important in not exacerbating existing flood effects.

Compliance with these flooding outcomes should be demonstrated through a 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 future resource consent stage of the Project.

3.3.1 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 work near the stream crossings / major overland flow paths; and
- The Project may alter the existing flood plains, ponding volumes, and natural drainage paths.

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

- AUP:OP;
- Auckland Council GIS resources (Auckland GeoMaps);
- Design Drawings;
- Flood maps created by the modelling team at Te Tupu Ngātahi;
- SGA Flood Resilience Technical Note;
- Indicative Construction Methodologies;
- NZTA Stormwater Specification P46;
- New Zealand Bridge Manual (SP/M/022) for freeboard allowance;
- Land, Air, Water, Aotearoa;
- Auckland Transport Climate Change Adaptation Policy January 2023
- Auckland Transport Hīkina te Wero: Environment Action Plan, December 2021; and
- Waka Kotahi NZ Transport Agency (**Waka Kotahi**) Toitū Te Taiao Sustainability Action Plan, April 2020.

3.3.2 Flood Modelling

Purpose

The purpose of the flood modelling is to identify the extent and scale of existing flooding effects. We have used this to consider how the proposed Project corridors may exacerbate existing flooding and potential methods to manage these effects.

Stormwater Catchment Overview

The Project traverses six major stormwater catchments: Puhinui Creek catchment, Waimahi Creek catchment, Papakura Stream catchment, Pahurehure Inlet catchment, Slippery Creek Catchment and Hingaia Stream Catchment, refer Figure 3 below. The following descriptions summarise each catchment and pertinent existing features to flooding and drainage.

The Puhinui Creek Catchment covers approximately 2,964 ha. The majority of the catchment is highly developed with large areas of commercial and industrial development. Large sections of both the upper and lower catchment are open space. The main channel of the Puhinui Stream flows north-west towards the Manukau Town Centre and then east to the coast near the Papakura Channel of the Manukau Harbour. Puhinui Creek Catchment discharges by means of two streams namely, Puhinui Creek and Homai Stream and into Manukau Harbour. The NoR 1 Project has a 2.26ha designation area within this catchment and is located along the southern edge of the catchment where a single overland flow path crosses the designation south of the Orams Road and Great South Road intersection.

The Waimahia Creek catchment covers approximately 1,053 ha with the Project (NoR 1 and NoR 3) covering 0.45ha and 0.8ha respectively in the north eastern portion of this catchment. Runoff from the Waimahia Creek catchment drains to the Manukau Harbour. The Waimahia Creek catchment envelops the suburb of Manurewa, which is highly developed, mostly residential land use. The downstream environment includes significant existing flood hazards that will not influence this Project's NoR areas.

The Papakura Stream catchment covers approximately 5,348 ha and is rural in the upper catchment reaches and heavily developed in the lower catchment area. Runoff from the catchment drains to Papakura Stream before discharging to the Pahurehure inlet and onto the Waitemata Harbour. Stormwater runoff from the NoR 1, 3 and 4 Project areas will discharge to existing reticulated stormwater network before discharging to either the Papakura Stream or directly into the Pahurehure inlet. The lower catchment environment includes significant existing flood hazard and subject to climate change induced sea level rise effects and floodplains flooding from the Papakura Stream.

The Pahurehure Inlet catchment is 1,418 ha of highly developed commercial and industrial developments. The catchment's stormwater is almost fully reticulated with some small park areas draining to open channels and wetlands. The catchment drains to the Pahurehure Inlet and into the Manukau Harbour. The Pahurehure Inlet Catchment includes a number of areas with high flood hazard, such as at Walter/Porchester Road and Great South Road where NoR 1 designations will be sought.

The Slippery Creek (Mangapū) catchment is approximately 4,591 ha with three key streams, Waipokapū/Otūwairoa Stream, Mangapū Stream and Waihoehoe Stream. Stormwater runoff from the proposed NoR 1 intersections on Great South Road will discharge to the Waipokapū/Otūwairoa Stream, which discharges to Drury Creek and then into Manukau Harbour. The NoRs within this catchment are largely close to the edge of the catchment (on high land) except for the Great South Road bridge over the Waipokapū/Otūwairoa Stream which the entire catchment discharges through.

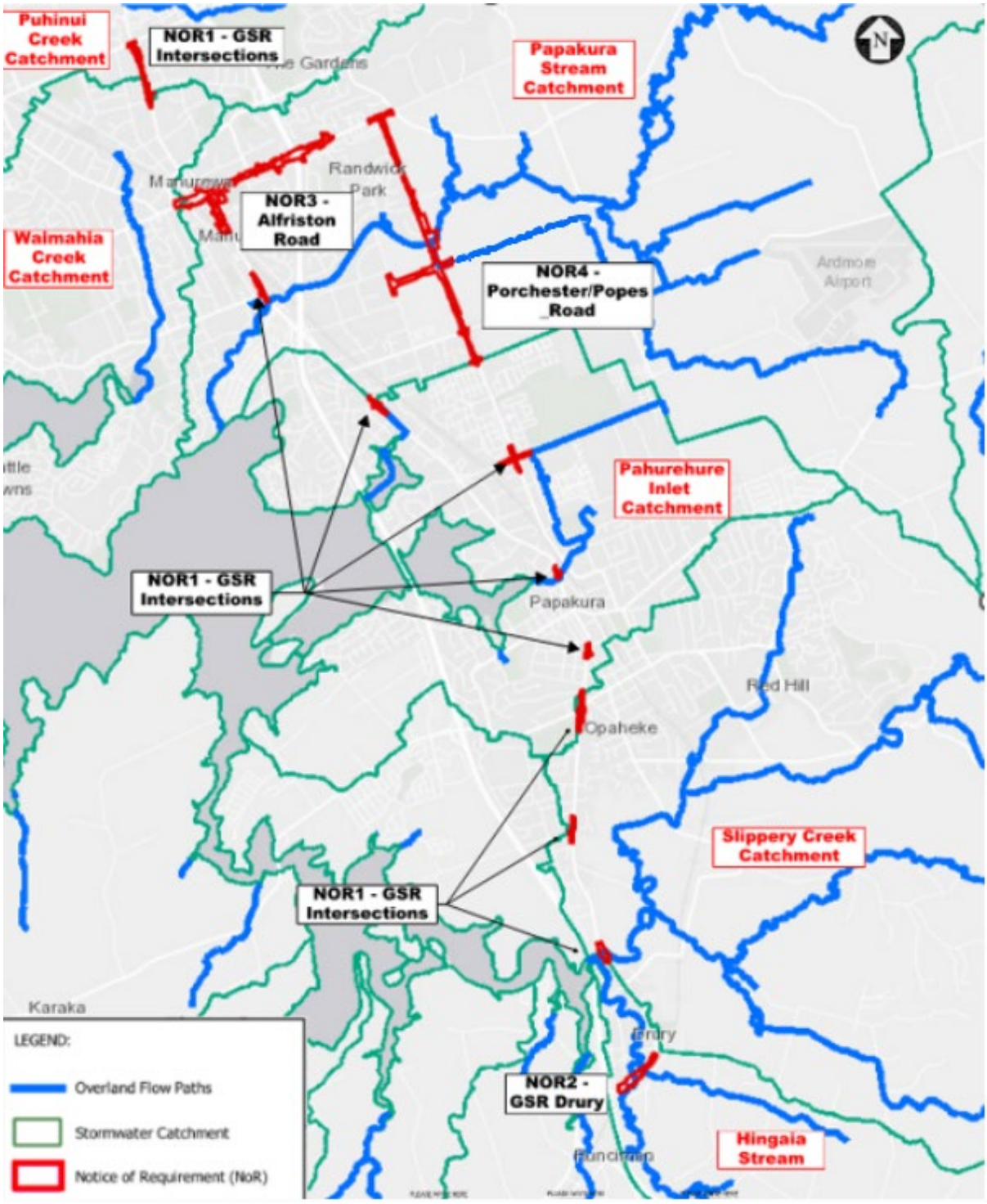

Figure 3 – Stormwater Catchments relative to the NoR Project locations

Modelling Parameters

Auckland Council have produced and supplied catchment models for the Puhinui Creek catchment, Waimahi Creek catchment, Papakura Stream catchment, Pahurehure Inlet catchment, Slippery Creek Catchment and Hingaia Stream Catchment which were adapted for this assessment (**models**).

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 MPD future land-use without the Project in place; and
- Future 100-year ARI rainfall event + 3.8º climate change considering the MPD future land-use without in place.

The proposed development model assumes the MPD impervious surface limits of the land use defined by the AUP or, if the land is zoned Future Urban the most probable land use impervious area is assumed.

The post-development case was not modelled as it would serve to indicate flood effects related to a single design that will likely not be built in the future when the design is further refined, and resource consents are applied for. Instead, this assessment is focused on the designation of land for future works. The flood effects and designation conditions are related to the sensitivity of the existing and likely future environment that the future project will have to meet.

The models include the existing roads and existing culverts which are 600 mm in diameter or greater. The model assumes culverts < 600 mm diameter are fully blocked with larger culverts in good working condition (refer Auckland Council Code of Practice). No additional culverts, land use modifications or surface roughness changes were made to the models received from Council.

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 Auckland Council GeoMaps.

The existing flood risk was assessed according to the criteria set out in Table 3. For those areas identified as having a potential risk of flooding effects, the key mitigation will be to maintain existing road crest levels.

Vulnerable land uses, including dwellings with less than 0.5 m freeboard available were considered at a greater risk of damage to property. Surveyed floor levels of the existing habitable buildings were not available at the time of the assessment and should be reviewed in the future during detailed design. The required freeboard for bridges and culverts used to assess the suitability of the indicative design is set out in Table 4.

Table 4 - 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

3.3.3 Sensitivity Analysis

Sensitivity is the degree to which a system is affected, adversely or beneficially, by a given exposure.[4] In this instance the sensitivity of 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 Council Guidance and Ministry for the Environment. 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. 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 Project and enable decision makers to respond to this in terms of designation conditions and the designation area reserved for future road upgrade works.

3.3.4 Stormwater devices

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 stormwater quantity and quality by identifying the space required for SWMDs, (i.e., treatment swale and wetlands) and providing space 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:

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

- Wetlands are sized to attenuate 10-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 worsening of upstream flooding;
- New 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). Existing roadside channels and swales will remain unchanged if not affected by the NoR works not affected by the NoR works; and
- Raingardens in the roadside berms to integrate Low Impact Design (LID) and WSD into the built environment. These systems will perform treatment and detention only, there attenuation is required (10% AEP and 1% AEP, underground tanks or wetlands will be required.

These allowances are considered appropriate for sizing the devices at concept design and provides 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 design has avoided locating 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, swales or raingardens) 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.

3.3.5 Limitations

Any flood modelling is completed using the information available at the time of writing this report. As this project does not have a commencement date, the modelling scenarios and recommendations detailed in this assessment will need updating at detailed design /Outline Plan stage.

3.4 Existing and future environment

The existing and anticipated future environment is further discussed in the accompanying AEE. In summary, the implementation timeframe for the Project has yet to be confirmed but is likely to be in approximately 10-15 years' time subject to funding availability. The assessment considers the effects of the Project at both the existing environment (as it exists today) and the likely future (planned)

environment which consider potential urban development and intensification sought under Plan Change 78 (**PC78**).

The Project will be constructed and will operate in the existing urban environment or planned environment (i.e., what can be built under the existing Auckland Unitary Plan: Operative in Part (AUP:OP) live zones):

a) **Existing environment:** The corridors are situated primarily within existing urban areas with live zoning including residential, commercial, and open space zones. There is some Future Urban Zone land in the wider area to the northeast/east. The existing activities within the area are generally reflective of the existing underlying zoning; and

b) **Planned environment:** The planned environment is anticipated to remain urban and comprised of similar activities as the existing environment. The density of residential development is however anticipated to change and increase in future. In particular, this includes in the residential zones around Te Mahia and Takaanini stations, in line with the implementation of the National Policy Statement on Urban Development (**NPS:UD**) in the AUP:OP. The remaining residential areas will experience an uplift of density through the implementation of the Medium Density Residential Standards (MDRS) through the Resource Management (Enabling Housing Supply and Other Matters) Amendment Act 2021. PC78 (notified at the time of assessment) seeks to give effect to the NPS:UD and incorporate the MDRS into residential zoning. It is noted that there are some areas of existing residential zoned land (particularly east of the NIMT) that have recently been intensified (i.e., new builds), as such are unlikely to change in the near future.

The likelihood and magnitude of land use change regarding the land use planning context has been identified in Table 3-1 below. This has been used to inform the assumptions made on the likely future environment.

Table 5 - South FTN – existing and future environment

	Current AUP:OP Zoning	Likelihood of Change for the environment[5]	Magnitude of potential change	Likely Receiving Environment[6]
Residential[7]	Residential (Mixed Housing Suburban)	Low - Moderate[8]	Low - Moderate	Residential
	Residential (Mixed Housing Urban)	Low - Moderate[9]	Low - Moderate	Residential
	Residential (Mixed Housing Suburban and Urban) around train stations	Moderate	Moderate - High	Residential and Commercial/Retail[10]
Business	Business (Heavy Industry)	Low	Low	Business (Industrial)
	Business (Light Industry)	Low	Low	Business (Industrial)

[5] Based on AUP:OP zoning/policy direction.

[6] Based on AUP:OP zoning/policy direction.

[7] Based on the NPS:UD and MDRS, these residential areas are likely to experience increased density.

[8] There are areas of existing Residential Zone land that has recently been intensified (i.e., new build developments), as such is unlikely to change in the near future.

[9] There are areas of existing Residential Zone land that has recently been intensified (i.e., new build developments), as such is unlikely to change in the near future.

[10] Note that much of the commercial operations between Manuia Road and Taka Street occur on residentially zoned land.

	Current AUP:OP Zoning	Likelihood of Change for the environment[5]	Magnitude of potential change	Likely Receiving Environment[6]
	Business (Neighbourhood Centre)	Low	Low	Business (Neighbourhood Centre)
	Business (Town Centre)	Low	Low	Business (Town Centre)
Open Space	Informal Recreation	Low	Low	Informal Recreation
	Community	Low	Low	Community
Greenfield areas	Future Urban	Low - Moderate	High	Urban

4 PART A: PROJECT-WIDE ASSESSMENT

This section assesses common or general flood matters across the entire Project corridor (i.e., all four NoRs). This section also recommends measures to avoid, remedy, or mitigate actual or potential adverse effects.

4.1 Positive effects

Positive flood effects are common for all NoRs and will not be discussed in each NoR section. The positive effects are:

- Culvert capacities have the potential to be improved and/or new stormwater infrastructure provided which will improve any ponding issues and stream flow in the area. This should be balanced against the potential increased effects on downstream land;
- Existing road levels that have been raised to prevent flood flows across the road will have a reduced flood hazard risk. This may lead to upstream flood effects on land or buildings, this is only a positive effect if all effects are fully considered; and
- The Project will provide for stormwater treatment / water quality improvement and retention/detention for existing and proposed impervious areas.

4.2 Assessment of construction effects

The construction effects listed below apply to the entire Project and will not be discussed in each NoR section in Part B. Based on the location of works in terms of overland flows or known flood extents in the vicinity, the proposed construction works which could result in flooding effects include:

- Construction of new culvert crossings or upgrading of existing culvert or bridge crossings;
- Realignment of existing overland flow paths;
- Works, such as regrading and raising levels, within existing floodplains; and
- Storage of materials and use of lay down areas within floodplains.

4.3 Recommended measures to avoid, remedy or mitigate construction effects

The proposed management and mitigation measures for construction effects across the Project are set out below.

4.3.1 General

A CEMP should be prepared to address the flood hazard effects for the construction phase in existing high hazard areas. In preparing the CEMP, key matters to include are (but should not be limited to):

- Siting construction yards, laydown areas and stockpiles outside the predicted flood plains;
- Maintaining overland flow paths around / through areas of work;
- Minimising the physical obstruction to flood flows at the road sag points;
- Staging and programming to provide new drainage prior to raising road design levels and carry out work when there is less risk of extreme flood events;

- Actions to take in response to heavy rain warnings which may include reducing the conveyance of materials and plant that are considered necessary to be stored or sited within the predicted flood plain or significant overland flow path;
- Carrying out earthworks during the summer / dry months to reduce the risk of flooding; and
- Managing the overland flow paths to make sure flows are not diverted toward existing buildings or properties.

4.3.2 Construction of new and existing bridges, culvert crossings and stormwater devices

Some new temporary flooding risks may be posed by the construction of new and existing bridges, culverts and stormwater devices associated with the works required. However, the details of the construction methodology will be confirmed in the future during detailed design and Outline Plan preparation. It is expected that the works can be carried out in a manner that appropriately manages these risks and this can be defined through the flood risk mitigation measures in the CEMP.

4.4 Assessment of operational effects

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

- The available flood freeboard to existing habitable buildings;
- Overland flow paths and flood prone areas;
- Flood levels on developable land; and
- 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 proposed 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.

Mitigation measures within the designation will be developed to manage flood effects during a future design stage of the Project. This approach will assess adverse flood effects and propose solutions to avoid, remedy or mitigate effects as they are identified.

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).

4.5 Recommended measures to avoid, remedy, or mitigate operational effects

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

- Size culverts and bridges to meet proposed conditions on flood hazard outcomes;
- Attenuation of the 10-year rainfall event when the Project works are located in the lower half of the catchment and discharge to a Council pipe network;
- Attenuation for the 10yr and 100yr rainfall events in the upper half of the main catchment to the receiving environment;
- No flow attenuation in wetlands where the Project works are located in the lower half of the main catchment to the receiving environment and discharging to open channels near the coastal marine area. Additionally, where coincident flood peak effects are modelled to be an issue, a pass forward approach would be adopted;
- Provide diversion channels at the toe of fill embankments to reduce ponding;
- Maintain 1200mm freeboard to new bridge soffits using the 100-year ARI flood level with 3.8º Climate change hydrology;
- Extend or replace existing culverts with like for like diameter; and
- Avoid lifting or lowering the crown of the road to prevent adverse effects upstream or downstream, unless agreed with affected landowners.

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

(a) The Project shall be designed to achieve the following flood risk outcomes:

- *(i) 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;*
- *(ii) no more than a 10% reduction in freeboard in a 1% AEP event for existing authorised habitable floors with a freeboard over 150mm;*
- *(iii) no increase in 1% AEP flood levels for existing authorised community, commercial, industrial and network utility building floors that are already subject to flooding;*
- *(iv) no more than a 10% reduction in freeboard in a 1% AEP event for existing authorised community, commercial, industrial and network utility building floors;*
- *(v) 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; and*
- *(vi) no new flood prone areas; and*
- *(vii) 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 1% AEP rainfall event.*

(b) Compliance with this condition shall be demonstrated in the Outline Plan, which shall include flood modelling of the pre-Project and post-Project 100-year ARI flood levels (for Maximum Probable Development land use and including climate change).

(c) *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.*

5 PART B: NOR LEVEL ASSESSMENT

The four NoR projects, shown in Figure 1, have been broken into separate flood plan locations and given a suffix (e.g. NoR1.1, NoR1.2, etc) to reflect the sequential layout of the NoR sections from north to south. Refer to Figure 4 for the flood figure key plan adopted for this assessment.

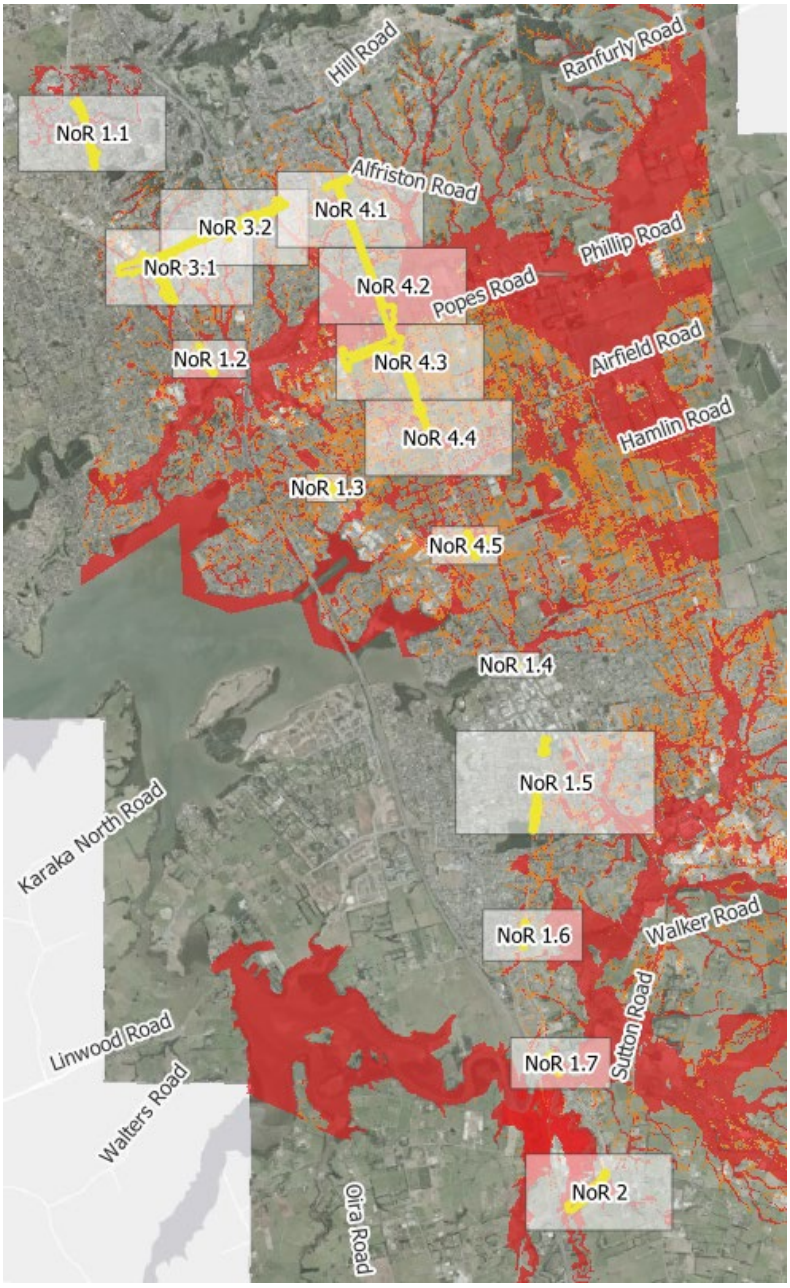

Figure 4 – NoR project locations and flood figure key plan

5.1 NoR 1 – Great South Road FTN Upgrade

NoR 1 comprises of nine interventions along Great South Road between Manukau and Drury. These include eight intersection upgrades, and the replacement of the Otūwairoa / Slippery Creek bridge. The wider corridor will provide for either three or four lanes in the midblock, including bus lanes in one or both directions, and active mode facilities. The changes to the road form may result in new road areas, footpaths and earthworks in flood prone areas leading to flood effects that require mitigation. Each of these locations have been given a suffix (e.g., NoR1.1, NoR1.2, etc) to reflect the sequential layout of the NoR sections from north to south.

5.1.1 NoR 1.1 Intersection Upgrade Overview

The NoR 1.1 corridor is an upgrade of Great South Road between the intersections of Orams Road and Grand Vue Road. Stormwater reticulation is proposed along the perimeter of the corridor and two pipes across Great South Road. Stormwater management will treat and detain stormwater within the road footprint and connect to the existing stormwater network along the length of the road.

Figure 5 – NoR1.1 Project area plan view

5.1.2 NoR1.1 Operational Flood Effects

The 100-year flood model results with 2.1º climate change for the pre-development (existing) terrain has identified two overland flowpaths that affect two properties shown as locations A and B in Figure 6. The upstream catchments to the flooded properties are small, and flooding hazard is classed as high at each property based on the flood depth being > 150mm. Additionally, properties adjacent to the high hazard flood areas will have a freeboard of less than 0.5m to dwellings.

Figure 6 – NoR 1.1 flood hazard map (2.1º CC)

The flood levels at the crossings identified in Figure 6 are overland flows across Great South Road, within the NoR 1 extent. The road crest will control the upstream and downstream flood level and should not be altered as part of future works without compensating for the flood effects to upstream (if raised road) or downstream (if lowered road).

The flood risk rating at the properties within the overland flowpaths are identified in Table 6. No post-development flood simulation has been undertaken. Instead, a set of recommendations are proposed for the design of future works to meet the proposed designation conditions.

Table 6 - Existing flood levels at key locations at NoR 1.1

Point	Drainage Channel / Property address	Existing Land Use	Likely Future Land Use	100 Year flood depth (m)*		Existing and likely future flood risk rating
				2.1º CC	3.8º CC	
1.1A	34 to 39 Great South Road	Residential - Mixed Housing Urban Zone	Residential - Mixed Housing Urban Zone	0.653	0.809	High
1.2B	55 to 59 Great South Road	Residential - Mixed Housing Urban Zone	Residential - Mixed Housing Urban Zone	0.394	0.412	High

*Representative depth across the affected properties.

The effects of using a 3.8º climate change adjusted rainfall pattern compared to the 2.1º climate change pattern shows an increase in depth of 0.156m at location 1.1A and 0.018m at location 1.2B. Overall flood risk is high as the flood depth is greater than 0.15 m and surrounding land use is residential, which involve vulnerable activities.

5.1.3 NoR 1.1 Recommended measures to avoid, remedy, or mitigate operational effects

Where there is an existing high flood risk, proposed mitigation at these locations includes:

- Keeping the current vertical alignment with no lifting or lowering of the road crest. The NoR design upon which the designation has been set does not include any road crown lifting;
- Providing treatment and detention in raingardens for the road runoff; and
- Providing additional piped drainage, greater inlet capacity or creating an overland flow path along the eastern side of the road.

The designation conditions proposed include an outcomes based approach to achieving an acceptable flood change as a result of the future Project design. The above recommendations form the minimum suggested design philosophy to achieve these conditions. The NoR design upon which the designation has been set does not include any road crown lifting, includes space for raingardens and new catchpits, pipes and manholes to suit the new kerb locations.

5.1.4 NoR 1.2 Intersection Upgrade Overview

The NoR 1.2 corridor is an upgrade of the Great South Road and Mahia Road intersection north of the Papakura Stream, as shown in Figure 7. Stormwater pipes are proposed along the perimeter of the corridor with raingardens to treat and detain stormwater within the road footprint and connect to the Papakura Stream directly.

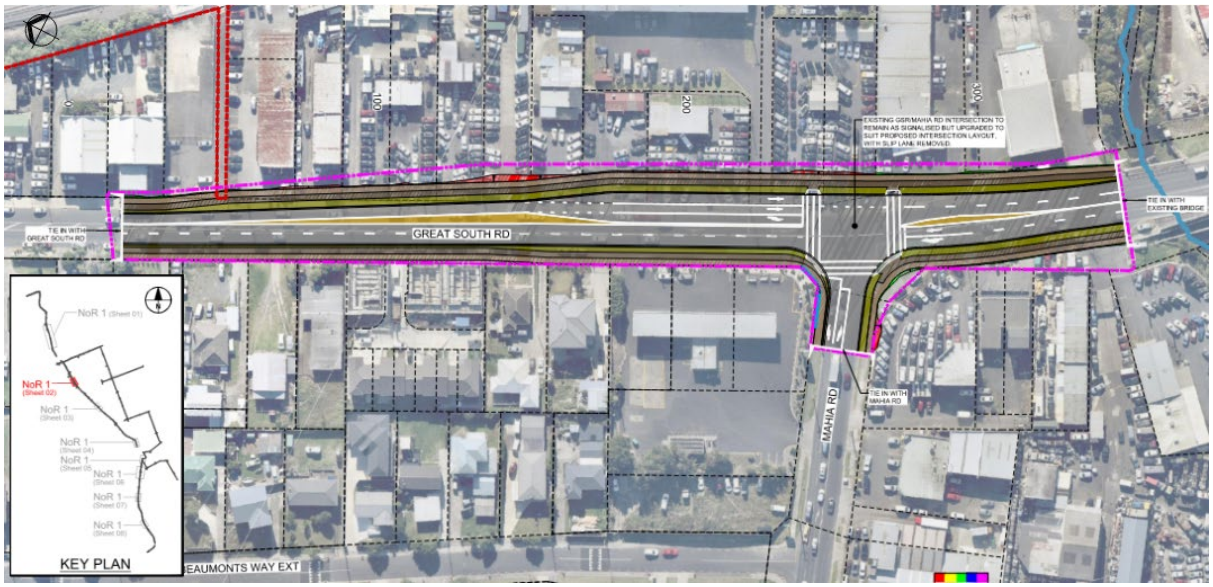

Figure 7 – NoR1.2 Project area plan view

5.1.5 NoR 1.2 Operational Flood Effects

The 100-year flood model results for the pre-development (existing) terrain have identified one overland flowpath that affects 15 properties at location A and a separate set of properties at location B subject to Papakura Stream floodplain effects as shown in Figure 8. The two locations are flooded by separate means, overland flow and riverine. Both flooding modes would result in property flooding, however, the timing and length of inundation would vary. The flooding hazard is classed as medium

and high at each property based on the flood depth being between >150mm. Additionally, properties dwellings adjacent to the high hazard flood areas will have a freeboard of less than 0.5m.

Figure 8 – NoR1.2 flood hazard map (2.1º CC)

The flood levels at the crossings identified at location A, in Figure 8, are subject to overland flow flooding that will flow over and along Great South Road, within the NoR 1 extent. The road height will control the flooding level upstream and downstream and should not be altered as part of future works without compensating for the flood effects to upstream (if raised road) or downstream (if lowered road) that would result.

The properties at location B are subject to Papakura Stream flooding. The NoR 1 road design will not have a significant effect on flooding at this location as this is in the floodplain and largely driven by upstream catchment and the capacity of the Papakura Bridge on Great South Road (not in scope).

The flood risk rating at the properties within the overland flowpaths are identified in Table 7. No post-development flood simulation has been undertaken. Instead, a set of recommendations are proposed for the design of future works to meet the proposed designation conditions.

Table 7 - Existing flood levels at key locations

Point	Drainage Channel / Property address	Existing Land Use	Likely Future Land Use	100 Year flood levels (m)*		Existing and likely future flood risk rating
				2.1º CC	3.8º CC	
1.2A	282 to 304 Great South Road	Business - Light Industry Zone	Business - Light Industry Zone	0.135	0.164	Moderate to high
1.2B	318, 324, 321 to 327 Great South Road	Business - Light Industry Zone	Business - Light Industry Zone	1.245	1.611	High

*Representative depth across the affected properties.

The point 1.2B has a high risk of flooding by virtue of being next to Papakura Stream, at a max of 1.611 m (3.8º CC). Point 1.2A has a moderate risk of flooding at a max of 0.164m.

5.1.6 NoR1.2 Recommended measures to avoid, remedy, or mitigate operational effects

Where there is an existing moderate and high flood risk, proposed mitigation at these locations includes:

- Keeping the current vertical alignment with no lifting or lowering of the road crest;
- Providing treatment and detention in raingardens for the road runoff; and
- Providing additional piped drainage, greater inlet capacity or creating an overland flow path along the eastern and western side of the road.

The designation conditions proposed include an outcomes based approach to achieving an acceptable flood change as a result of the future project design. The above recommendations form the minimum suggested design philosophy to achieve these conditions. The NoR design upon which the designation has been set does not include any road crown lifting, includes space for raingardens and new catchpits, pipes and manholes to suit the new kerb locations.

5.1.7 NoR 1.3 Intersection Upgrade Overview

The NoR 1.3 corridor is an upgrade of Great South Road at the intersection of Taka Street and Walter Stevens Drive. A combination of new and existing stormwater network is proposed along Great South Road with raingardens to treat and detain stormwater within the road footprint and connect to the existing stormwater network.

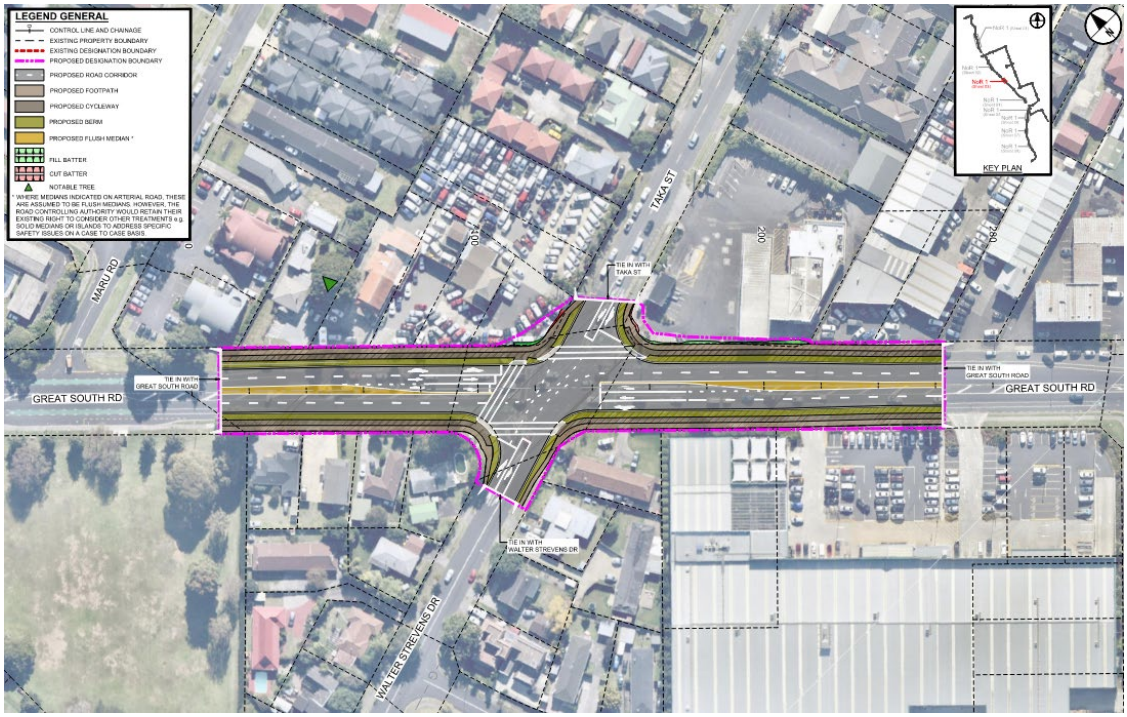

Figure 9 – NoR1.3 Project area plan view

5.1.8 NoR 1.3 Operational Flood Effects

The 100-year flood model results for the pre-development (existing) terrain have identified one overland flowpath that affects five properties at location A, four locations at location B and one property at location C as shown in Figure 10. The catchments flooding the properties is large and connected to the Papakura Stream floodplain. The flood hazard is classed as moderate and high at each property based on the flood depth being on each property varying with depths greater than 150mm in some locations. Additionally, properties adjacent to the high hazard flood areas will have a freeboard of less than 0.5m placing these buildings in a moderate risk also.

Figure 10 – NoR1.3 flood hazard map (2.1º CC)

Locations A and B are flood prone and the flood level is governed by the Great South Road crest level. The road crest level should not be altered as part of future works without compensating for the flood effects to upstream (if raised road) or downstream (if lowered road) that would result.

The flood risk rating at the properties within the overland flowpaths are detailed in Table 8. No post-development flood simulation has been undertaken, instead, a set of recommendations are proposed for the design of future works to meet the proposed designation conditions.

Table 8 - Existing flood levels at key locations at NoR 1.3

Point	Drainage Channel / Property address	Existing Land Use	Likely Future Land Use	100 Year flood depths (m)*		Existing and likely future flood risk rating
				2.1º CC	3.8º CC	
1.3A	154 to 162 Great South Road, Conifer Grove, Takanini	Residential - Mixed Housing Urban Zone	Residential - Mixed Housing Urban Zone	0.445	0.464	High

Point	Drainage Channel / Property address	Existing Land Use	Likely Future Land Use	100 Year flood depths (m)*		Existing and likely future flood risk rating
				2.1º CC	3.8º CC	
1.3B	166 to 174 Great South Road, Conifer Grove, Takanini	Business – Light Industry Zone	Business – Light Industry Zone	0.5	0.52	High
1.3C	2 Walter Strevens Drive, Conifer Grove, Takanini	Residential - Mixed Housing Suburban Zone	Residential - Mixed Housing Suburban Zone	0.094	0.122	Moderate

*Representative depth across the affected properties

The properties subject to flooding in this area are residential and commercial with large flood depths expected to cause damage to property in the event of a 100-year storm event, including climate change. The 3.8º Climate change scenario sensitivity scenario shows this depth would worsen and damage to property would be more severe. The flooding could be relieved with a lowering of the Great South Road alignment. However, the increase volume of floodwater flowing over the road would need to be managed to manage risk to road safety and downstream properties.

5.1.9 NoR 1.3 Recommended measures to avoid, remedy, or mitigate operational effects

Where there is an existing moderate and high flood risk, proposed mitigation includes:

- Keeping the current vertical alignment of the road crests;
- Providing treatment and detention in raingardens for road runoff;
- Providing additional piped drainage, greater inlet capacity or creating a flood storage area in the flood prone areas to prevent property damage; and
- Create a drainage diversion on the southern side of the intersection to divert flows away from location C properties.

Opportunities to improve/reduce the flood hazard to properties at locations A, B and C were not considered as part of the scope of the Project and would require land not justifiable as functional need to the NoR. The designation conditions proposed include an outcomes-based approach to achieving an acceptable flood change as a result of the future Project design, not an improvement. The above recommendations form the minimum suggested design philosophy to achieve these conditions. The NoR design upon which the designation has been set does not include any road crown lifting, includes space for raingardens and new catchpits, pipes and manholes to suit the new kerb locations.

5.1.10 NoR 1.4 Intersection Upgrade Overview

The NoR 1.4 corridor is an upgrade of the Great South Road and Subway Road intersection. Stormwater pipes are proposed along Great South Road with raingardens to treat and detain stormwater within the road footprint and connect to the existing stormwater network.

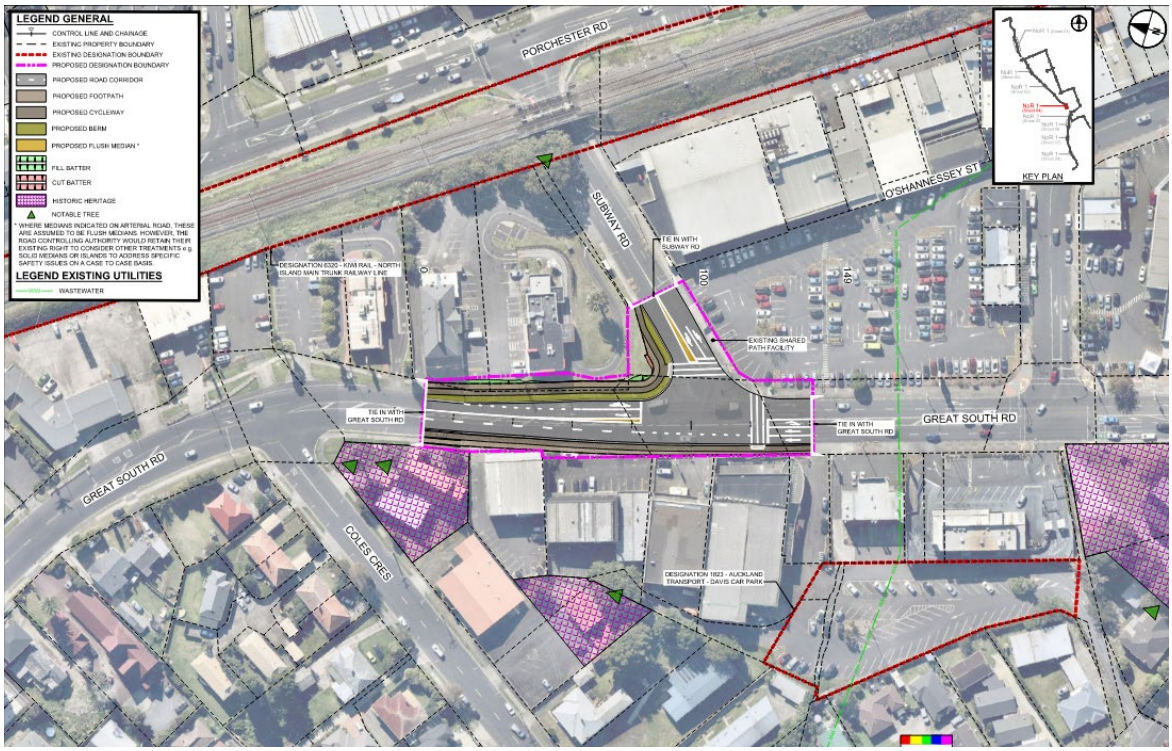

Figure 11 – NoR1.1 Project area plan view

5.1.11 NoR 1.4 Operational Flood Effects

The 100-year flood model results for the pre-development (existing) terrain have identified a single large overland flowpath that passes under the North Island Main Trunk (**NIMT**) railway line, along Subway Road. Flooding from Subway Road spreads out and affects two properties (locations B and C on Figure 12) before it overtops Great South Road and inundates properties to the south west (location A on Figure 12). The flood hazard at all three locations is classed as high at each of the properties identified based on the flood depth being between greater than 0.15m on land with a freeboard of less than 0.5m to flooded and adjacent dwellings.

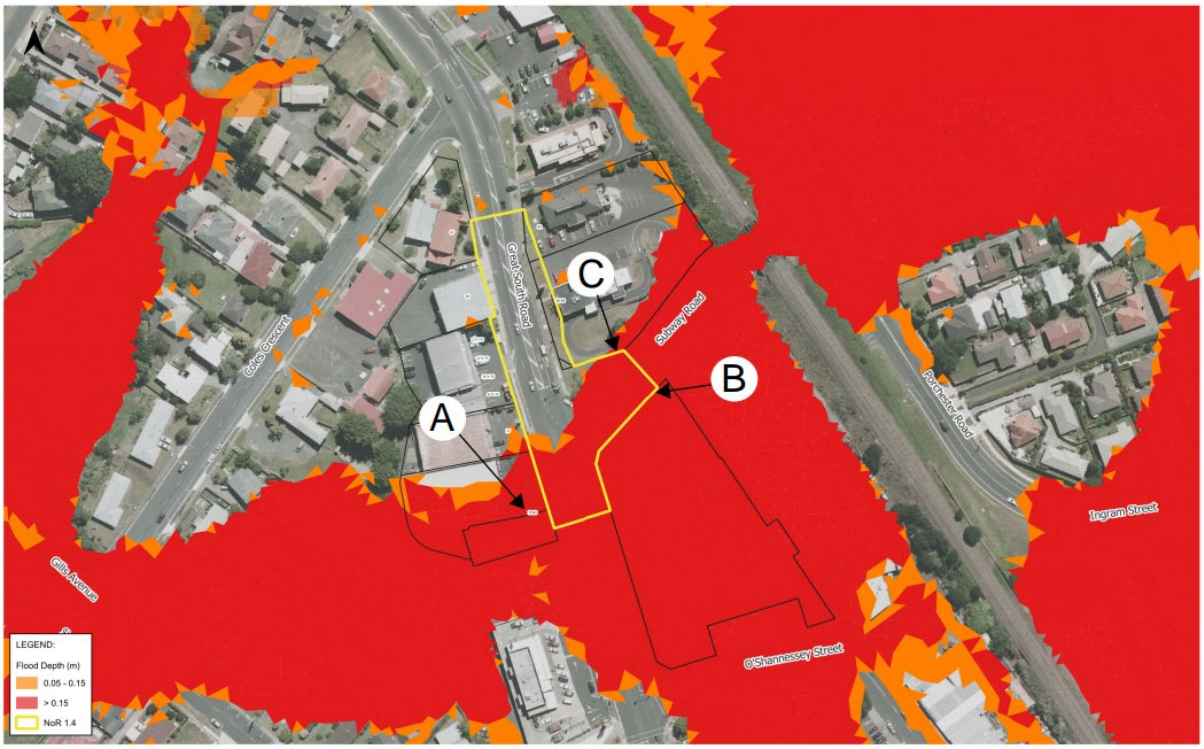

Figure 12 – NoR1.4 flood hazard map (2.1º CC)

The flood levels at the crossings identified in Figure 12 are overland flows that will flow over Great South Road, within the NoR1 extent. The road crest will therefore control the amount of flooding upstream and downstream and should not be altered as part of future works without compensating for the flood effects to upstream (if raised road) or downstream (if lowered road) properties.

The flood risk rating at the properties within the overland flowpaths are detailed in Table 9. No post-development flood simulation has been undertaken. Instead, a set of recommendations are proposed for the design of future works to meet the proposed designation conditions.

Table 9 - Existing flood levels at key locations at NoR 1.4

Point	Drainage Channel / Property address	Existing Land Use	Likely Future Land Use	100 Year flood depths*		Existing and likely future flood risk rating
				2.1º CC	3.8º CC	
1.4A	79-83 Great South Road, Papakura	Commercial	Commercial	0.867	1.06	High
1.4B	90 Great South Road, Papakura	Commercial	Commercial	1.229	1.399	High
1.4C	86-88 Great South Road, Papakura	Commercial	Commercial	0.718	0.894	High

*Representative depth across the affected properties

The flood depths at all three locations are high and will continue regardless of the proposed works within this NoR designation. The future design should be undertaken with measures to mitigate, remedy or avoid effects considered; some measures are suggested in the next section.

5.1.12 NoR 1.4 Recommended measures to avoid, remedy, or mitigate operational effects

The high flood risk identified at all three locations adjacent to the NoR 1.4 designation are likely to remain high risk into the future. The following measures are proposed as they relate to the works and mitigations inside the NoR designation:

- Keeping the current vertical alignment with no lifting or lowering of the road crest;
- Providing treatment and detention in raingardens for the road runoff; and
- Providing additional piped drainage, greater inlet capacity or creating a flood storage area in the flood prone areas to prevent property damage.

Opportunities to improve/reduce the flood hazard to properties at locations A, B and C were not considered as part of the scope of the Project and would require land not justifiable as functional need to the NoR. The designation conditions proposed include an outcomes based approach to achieving an acceptable flood change as a result of the future Project design, not an improvement. The above recommendations form the minimum suggested design philosophy to achieve these conditions. The NoR design upon which the designation has been set does not include any road crown lifting, includes space for raingardens and new catchpits, pipes and manholes to suit the new kerb locations.

5.1.13 NoR 1.5 Intersection Upgrade Overview

The NoR 1.5 corridor comprises of the upgrade of two sections of Great South Road:

- Great South Road upgrade where it meets Opaheke Road, and
- Upgrade of Great South Road where it intersects with Settlement Road.

New stormwater pipes are proposed within the NoR corridor at both locations with raingardens to treat and detain stormwater within the road footprint and connect to the existing stormwater network.

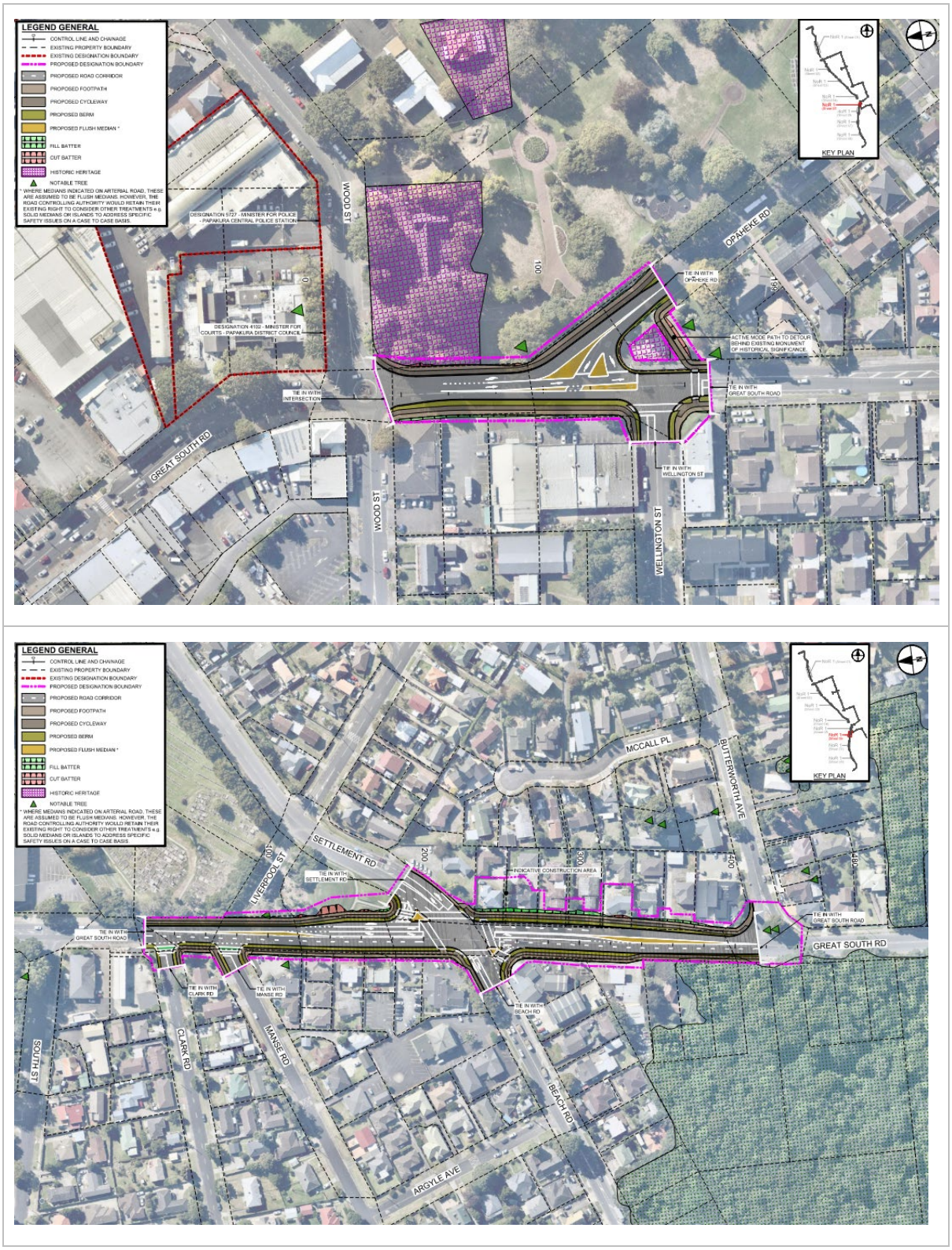

Figure 13 – NoR1.5 Project area plan view

5.1.14 NoR 1.5 Operational Flood Effects

The 100-year flood model results for the pre-development (existing) terrain have identified an overland flowpath along Wood Street that overtops Great South Road to continue west. This flowpath affects six properties at location A, two properties at location B, two properties at location C and four properties at location D. The catchments to each property showing flood hazard risk are small and isolated generally with “pockets of ponding” observed along the NoR boundaries. Flooding hazard is classed as moderate to high at each property based on most flood depth being between 0.05m to 0.15m, some small areas with greater than 0.15m. Additionally, adjacent buildings to flood prone areas may have a freeboard of less than 0.5m (depending on finished flood elevation).

Figure 14 – NoR1.5 flood hazard map (2.1º CC)

The flood levels at the crossings identified in Figure 14 are overland flows that will flow over Great South Road at location A, within the NoR 1 extent. The road crest will therefore control the amount of flooding upstream and downstream and should not be altered as part of future works without compensating for the flood effects to upstream (if raised road) or downstream (if lowered road) that would result. Flooding at locations B, C and D is mostly due to flood prone areas and the Great South Road crest level, which will not likely lead to a change in flood effects.

The flood risk rating at the properties within the overland flowpaths are detailed in Table 10. No post-development flood simulation has been undertaken, instead, a set of recommendations are proposed for the design of future works to meet the proposed designation conditions.

Table 10 - Existing flood levels at key locations at NoR1.5

Point	Drainage Channel / Property address	Existing Land Use	Likely Future Land Use	100 Year flood levels (m)*		Existing and likely future flood risk rating
				2.1º CC	3.8º CC	
1.5A	250-260, 293-299 Great South Road, Papakura	Business - Metropolitan Centre Zone	Likely same as baseline	0.204	0.234	High
1.5B	338-340 Great South Road and 1 Butterworth Avenue, Opaheke, Papakura	Residential - Mixed Housing Suburban Zone	Likely same as baseline	0.141	0.374	Moderate
1.5C	322A and 2/326 Great South Road, Opaheke, Papakura	Residential - Mixed Housing Suburban Zone	Likely same as baseline	0.099	0.109	High
1.5D	365-367 Great South Road, Opaheke, Papakura	Residential - Mixed Housing Urban Zone	Likely same as baseline	0.044	0.051	Low

*Representative depth across the affected properties

While the NoR 1.5 corridor doesn't cross any major flowpaths, the flood prone areas of potential flood hazards alongside the road give an overall moderate flood risk to adjacent properties. Flooding at location B is trapped within the flood affected properties and does not overlap with the proposed NoR boundary or interact with the road within the boundary.

5.1.15 NoR 1.5 Recommended measures to avoid, remedy, or mitigate operational effects

The high and moderate flood risks identified at location A adjacent to the NoR 1.5 designation are caused by Wood Street behaving as the conveyance path for flood waters from the local area This location should consider the following measures when entering a future design stage:

- Keeping the current vertical alignment with no lifting or lowering of the road crest;
- Provide treatment and detention in raingardens for the road runoff; and
- Provide additional piped drainage, greater inlet capacity to suit the changed kerb lines.

The other three locations (B, C and D) are not subject to the same constraints as that discussed at location A and future road designs should provide hydrologic mitigation with less of a focus on maintaining the road vertical alignment. The designation conditions proposed include an outcomes-based approach and the above recommendations form the minimum suggested design philosophy to achieve these conditions. The NoR design upon which the designation has been set does not include any road crown lifting, includes space for raingardens and new catchpits, pipes and manholes to suit the new kerb locations.

5.1.16 NoR 1.6 Intersection Upgrade Overview

The NoR 1.6 corridor is an upgrade of the Great South Road and Park Estate Road intersection.

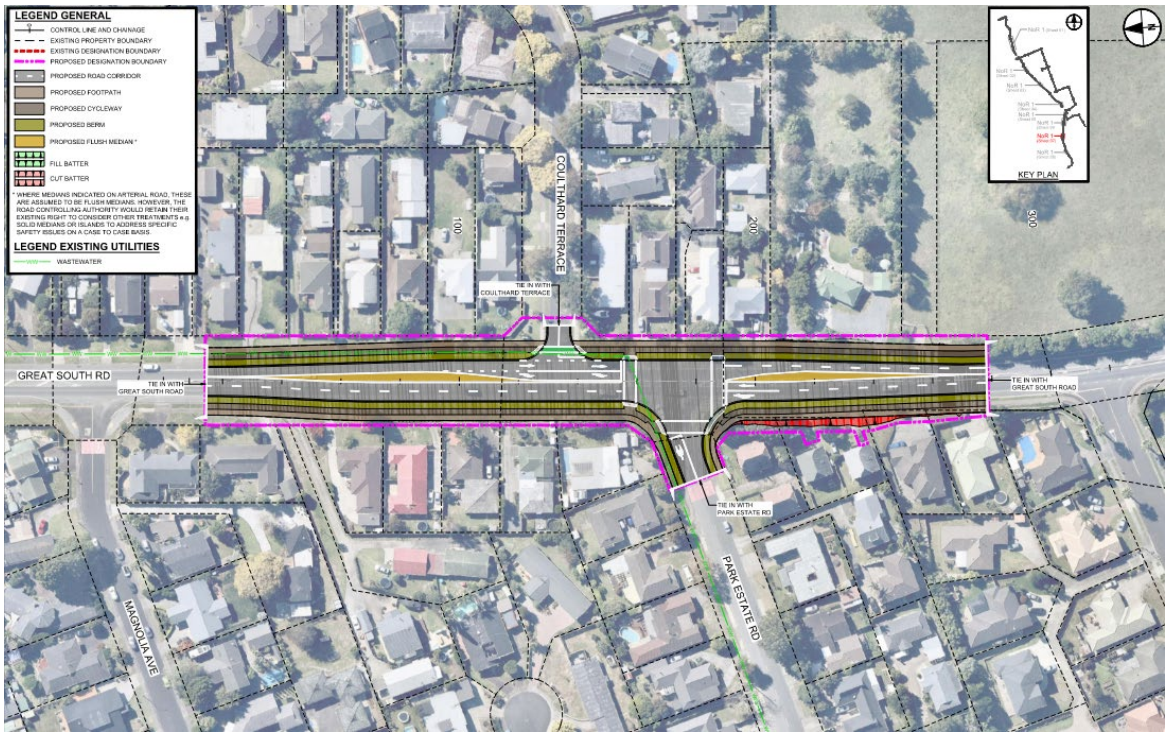

Figure 15 – NoR1.6 Project area plan view

5.1.17 NoR 1.6 Operational Flood Effects

The pre-development (existing) terrain 100-year flood model results identified no overland flowpaths in the vicinity of the NoR. The overland flows to the west of Great South Road will spill over Great South Road at a location other than at the subject site designation. The flood depths at locations A and B in Figure 16 are outside the designation and the works inside the designation will not likely result in changes to these flood levels.

Figure 16 – NoR1.6 flood hazard map (2.1º CC)

Flood depths shown in Figure 16 show a minimal interaction with the NoR designation. Flows at location B generally accumulate on the western side of Great South Road and will spill to the east at locations outside of this NoR. The road crest will therefore have no influence on flooding upstream or downstream.

The flood risk rating at the properties within the overland flowpaths are detailed in Table 11. No post-development flood simulation has been undertaken, instead, a set of recommendations are proposed for the design of future works to meet the proposed designation conditions.

Table 11 - Existing flood levels at key locations at NoR1.6

Point	Drainage Channel / Property address	Existing Land Use	Likely Future Land Use	100 Year flood levels (m)*		Existing and likely future flood risk rating
				2.1º CC	3.8º CC	
1.6A	446-456 Great South Road, Opaheke, Papakura	Residential - Mixed Housing Suburban Zone	Likely same as baseline	0.338	0.376	High
1.6B	461-465 Great South Road, Opaheke, Papakura	Residential - Mixed Housing Suburban Zone	Likely same as baseline	0.047	0.083	Low

*Representative depth across the affected properties

NoR 1.6 doesn't cross any overland flow path, but there are some areas of along the corridor that have chance of localised flooding. Point 1.6A has the highest maximum depth modelled at 0.195 m at a 3.8º CC scenario, with a High overall flood risk.

5.1.18 NoR1.6 Recommended measures to avoid, remedy, or mitigate operational effects

The flood risks identified at location A and B do not affect the designation boundary and flood effects are not likely. To manage any possible effect, the future design at this location should consider the following measures:

- Provide treatment and detention in raingardens for the road runoff; and
- Provide additional piped drainage, greater inlet capacity to suit the changed kerb lines.

The designation conditions proposed include an outcomes-based approach and the above recommendations form the minimum suggested design philosophy to achieve these conditions. The NoR design upon which the designation includes space for raingardens and new catchpits, pipes and manholes to suit the new kerb locations.

5.1.19 NoR 1.7 Bridge Upgrade Overview

The NoR 1.7 corridor is an upgrade of Great South Road and a replacement of the bridge crossing Slippery Creek.

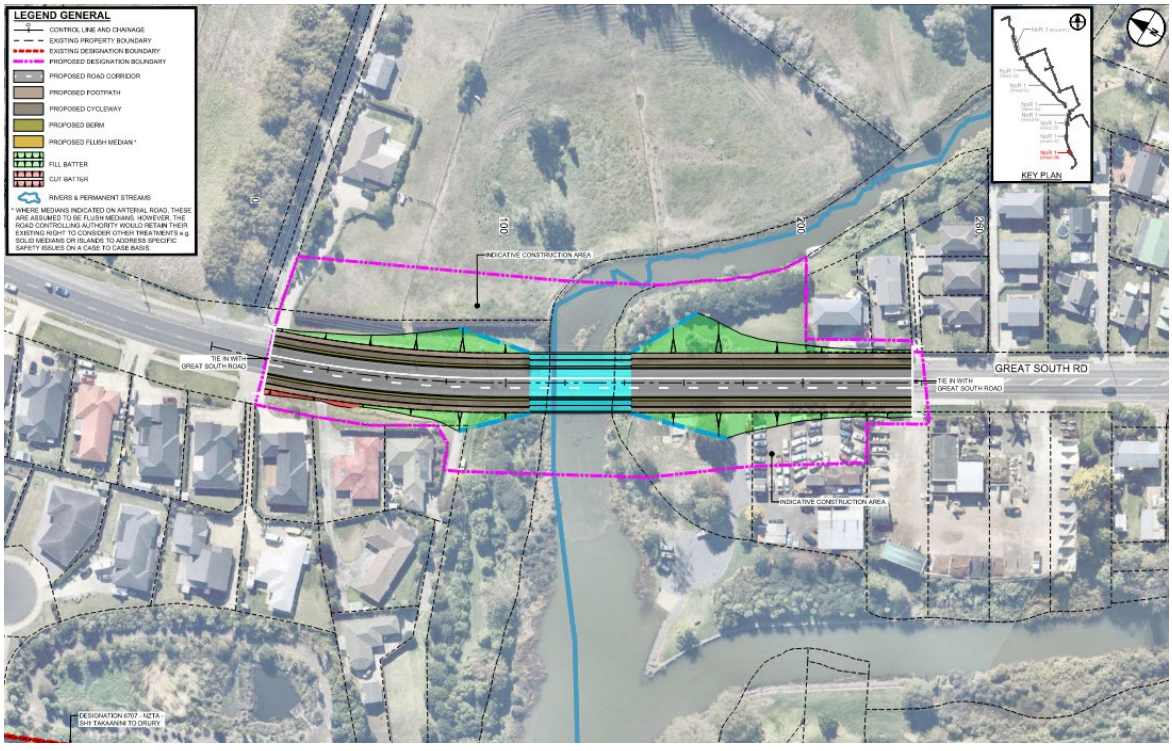

Figure 17 – NoR1.1 Project area plan view

5.1.20 NoR 1.7 Operational Flood Effects

The 100-year flood model results for the pre-development (existing) terrain shows the stream under the bridge floods the neighbouring properties and is a high flood hazard due to the flood depth being between greater than 0.15m with a freeboard of less than 0.5m to buildings where flooding is showing and for the adjacent buildings.

Figure 18 – NoR 1.7 flood hazard map (2.1º CC)

The flood levels at the crossings identified in Figure 18 are Slippery Creek flows that will flow under, over and around the side of Great South Road at the bridge. The road crest and bridge structure will therefore control the amount of flooding upstream and downstream. The raising of the road and increasing the capacity for stream flows to pass under the bridge should be carefully consider the following factors:

- Sea level rise effects on tailwater;
- The constrictive effect of the bridge under SH1 immediately downstream;
- The increase in flooding on properties at location C;
- The decrease in flooding at location A and B including more upstream land and the future development potential of this land;
- The location and level of the bottom bridge chord; and
- The location of the bridge abutments.

The flood risk ratings at the properties within the Slippery Creek floodplain are identified in Table 12. No post-development flood simulation has been undertaken. Instead, a set of recommendations are proposed for the design of future works to meet the proposed designation conditions.

Table 12 - Existing flood levels at key locations at NoR1.7

Point	Drainage Channel / Property address	Existing Land Use	Likely Future Land Use	100 Year flood depths (m)*		Existing and likely future flood risk rating
				2.1º CC	3.8º CC	
1.7A	600 Great South Road, Rosehill, Papakura	Future Urban Zone	Likely to be Residential Buildings	3.427	4.306	High
1.7B	134-136 Great South Road, Drury	Residential - Mixed Housing Suburban Zone	Residential - Mixed Housing Suburban Zone	0.572	1.585	High
1.7C	135-139 Great South Road, Drury	Residential - Mixed Housing Suburban Zone	Residential - Mixed Housing Suburban Zone	0.881	2.183	High

*Representative depth across the affected properties

5.1.21 NoR1.7 Recommended measures to avoid, remedy, or mitigate operational effects

The flood risks identified at location will be adversely affected by lifting road but improved by increasing the capacity of the bridge. Additionally, the tailwater constraints from SH1 and sea-level rise will influence the amount of benefit that can be achieved with works at this location. To manage effects, the future design at this location should consider the following measures:

- Co-operative approach with Waka Kotahi to review both bridge capacities together to achieve a best for all parties approach;
- Provide treatment and detention in raingardens for the road runoff; and
- Provide additional piped drainage, to suit the changed kerb lines.

The designation conditions proposed include an outcomes-based approach and the above recommendations form the minimum suggested design philosophy to achieve these conditions. The NoR design upon which the designation includes space for raingardens and new catchpits, pipes and manholes to suit the new kerb locations.

5.2 NoR 2 – Great South Road Upgrade (Drury section)

As outlined in the Project description (see Section 2), NoR 2 comprises a range of interventions providing for the upgrade of Great South Road in Drury between Waihoehoe Road and the SH1 Drury Interchange. These include road widening to provide four lanes, active mode facilities, and the replacement of the Hingaia Stream bridge.

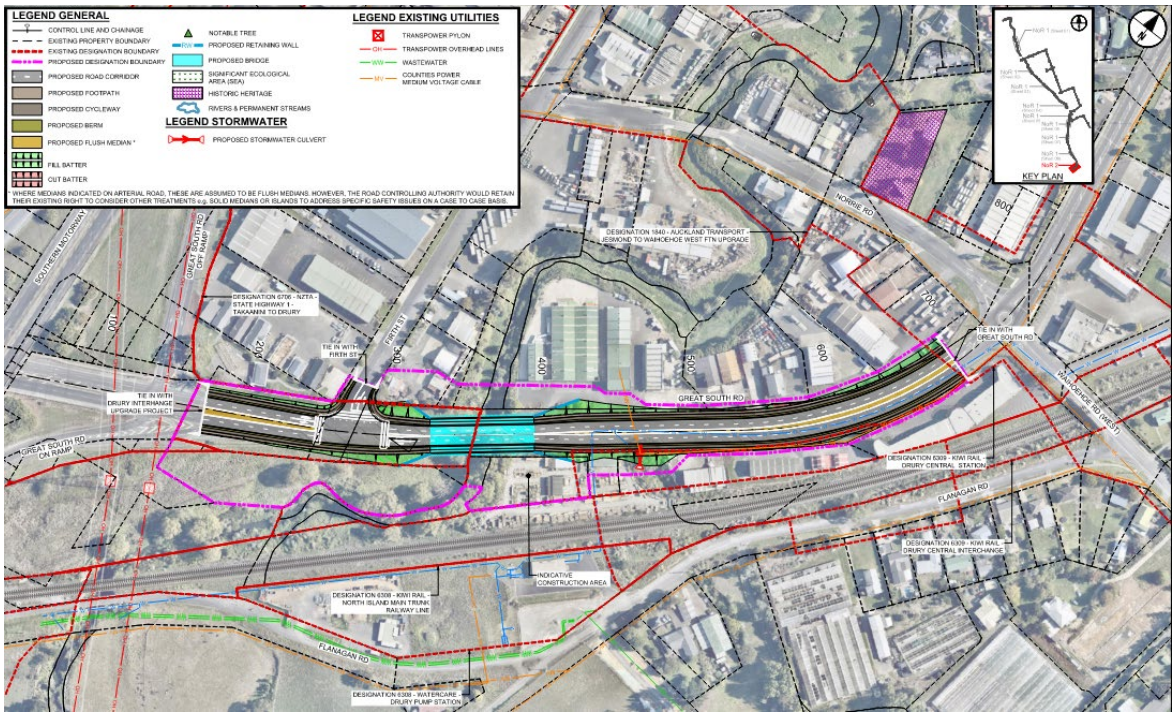

Figure 19 – NoR2 Project area plan view

5.2.1 NoR 2 Operational Flood Effects

The 100-year flood model results for the pre-development (existing) terrain have identified the Hingaia Steam as the primary source of flooding and properties at location A may be affected by works in this area. The catchments which affect the flooded properties is large, and flooding hazard is classed as high at each property, based on the flood depth being >0.15m with a freeboard of less than 0.5m to buildings.

Figure 20 – NoR 2 flood hazard map (2.1º CC)

The flood levels identified in Figure 20 are a result of stream/river flows that flow over Great South Road, within the NoR 1 extent. The road crest will influence the depth of flooding upstream but not necessarily control it. Flood behaviour in this area is complex with multiple downstream and upstream structures controlling the flood levels and flowrates at this location. Lifting the road and increasing the bridge capacity will need to be carefully balanced and consider the other Hingaia Stream structures when developing the design in the future.

The flood hazard for the 100-year ARI, 2.1º and 3.8º climate change flood models are described 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 on the developed or reasonably developable land areas, including floodplains.

Table 13 - Existing flood levels at key locations at NoR 2

Point	Drainage Channel / Property address	Existing Land Use	Likely Future Land Use	100 Year flood depths (m)*		Existing and likely future flood risk rating
				2.1º CC	3.8º CC	
2A	263-279 Great South Road	Business - Mixed Use Zone	Likely same as baseline	2.184	2.443	High

*Representative depth across the affected properties

The land upstream of Hingaia stream is a mixture of Business and Residential Zones. The buildings within the vicinity of point A are on existing flood plains. The replacement Hingaia Bridge can be designed in a large number of ways to achieve a balance between flood protection to the road, maintaining flood level changes and the capacity of flow under the bridge all within the proposed

designation. The changes to the nearby bridges will have a large influence on the solution and level of effect change at this NoR.

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 the NoR 2 road alignment. The changes in flood depth are relatively small of about 0.3m. For recommended measures to avoid, minimise or mitigate flood effects see Section 4.5.

5.2.2 NoR 2 Recommended measures to avoid, remedy, or mitigate operational effects

Where there is an existing moderate flood risk, proposed mitigation at these locations includes:

- Providing treatment and detention in raingardens and avoid attenuation to prevent coincident flow flood effects on downstream land; and
- Participate in a masterplan with Auckland Transport, Auckland Council Healthy Waters and KiwiRail to arrive at an arrangement of all Hingaia Stream crossings to achieve a balance between effect to property, flood protection to roads and achieving an overall best for catchment outcome.
- The designation conditions proposed include an outcomes-based approach and the above recommendations form the minimum suggested design philosophy to achieve these conditions. The NoR design upon which the designation includes space for raingardens. Discussions with other stakeholders has occurred with no catchment scale strategy yet decided.

5.3 NoR 3 – Weymouth, Alfriston, and Great South Road Upgrades

NoR 3 comprises a range of interventions providing for the route along Weymouth and Alfriston Roads generally between Selwyn Road and Alfriston Park; as well as for the Great South Road FTN route between Alfriston Road and Myers Road. These interventions include road widening to provide for four lanes (general traffic and bus lanes in both directions), active mode facilities, eight intersection upgrades, stormwater treatment wetlands, and replacements of bridges over the NIMT and SH1. This NoR has been split in to two parts NoR 3.1 (west of Claude Road intersection) and NoR 3.2 (east of Claude Road intersection).

5.3.1 NoR 3.1 Upgrade Overview

The NoR 3.1 corridor is the east end of NoR 3, and is the upgrade of Weymouth Road leading into Alfriston Road, and extends down to Great South Road at the intersection, refer Figure 21 below. Stormwater treatment/attenuation ponds are proposed at the very west end, and southeast of the intersection with Great South Road. These ponds will be used to manage runoff from the new impervious surfaces generated in this NoR designation and discharge to the existing piped network.

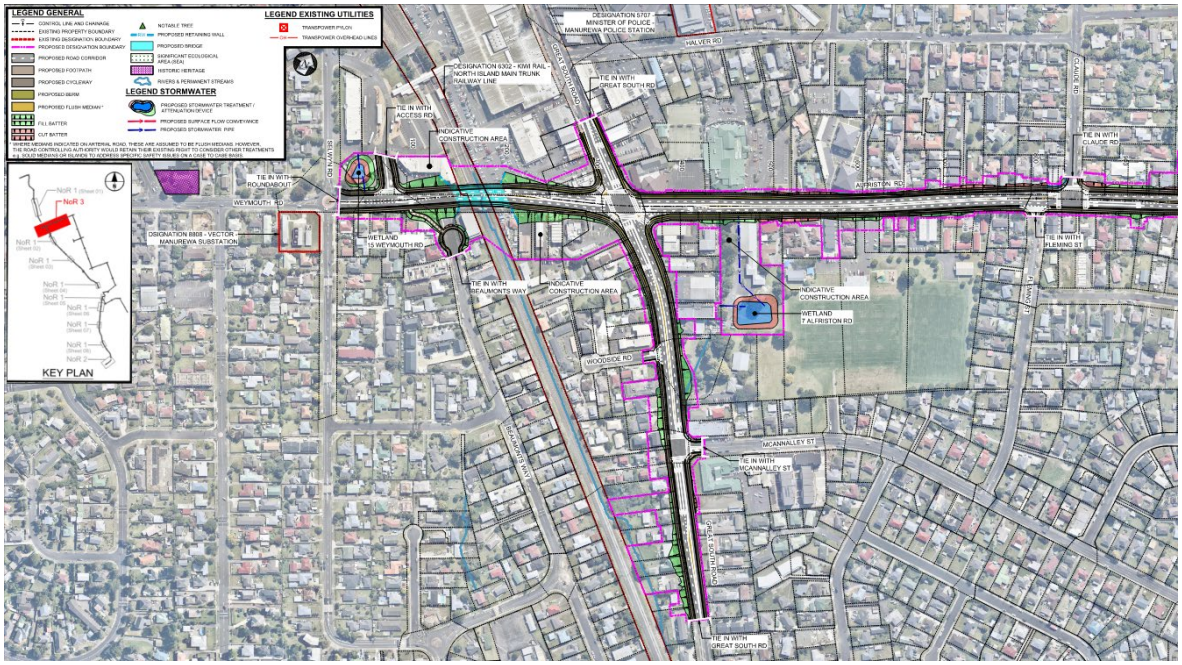

Figure 21 – NoR3.1 Project area plan view (west)

5.3.2 NoR 3.1 Operational Flood Effects

The 100-year flood model results for the pre-development (existing) terrain have identified five overland flowpaths along NoR 3.1, Figure 22. The catchments to the flooded properties are small, and flooding hazard is classed as moderate and high at each property based on the flood depth being between 0.05m to >0.15m in some areas.

A freeboard of less than 0.5m to buildings adjacent to the flooded properties also creates a moderate to low risk.

Figure 22 – NoR3.1 flood hazard map (2.1º CC)

The NoR 3 flood hazards from the 100-year ARI flood with a 2.1º climate change adjustment to rainfall crosses several overland flowpaths. The land use at NoR 3 is a mixture between Residential and Business. Figure 22 and Table 14 show the results of the modelling with the hazard colours used to indicate the flood depth to land uses in the vicinity of the NoR 3.

Table 14 - Existing flood levels at key locations at NoR 3.1

Point	Drainage Channel / Property address	Existing Land Use	Likely Future Land Use	100 Year flood levels (m)*		Existing and likely future flood risk rating
				2.1º CC	3.8º CC	
3.1A	12-16, 11-15 Weymouth Road, Manurewa, Auckland	Business - Light Industry Zone	Likely same as baseline	0.449	0.582	High
3.1B	233-243 Great South Road	Residential - Mixed Housing Urban Zone	Likely same as baseline	0.75	0.896	High
3.1C	253-261 Great South Road	Residential - Mixed Housing Urban Zone	Likely same as baseline	3.14	3.216	High
3.1D	5-7 Alfriston Road, Manurewa East,	Business - Town Centre Zone	Likely same as baseline	0.339	0.394	Moderate
3.1E	27-30 Alfriston Road	Open Space - Sport and Active Recreation Zone	Likely same as baseline	0.063	0.094	Low

*Representative depth across the affected properties

Point 3.1A, where Weymouth Road crosses an overland flow path, and points 3.1B and 3.1C on Great South Road have overall high risks of flooding. The modelled 3.8º climate change scenario produced an overall higher flood, but not by a great amount, with an increase in the range of 0.08 to 0.13m.

The land use upstream of all points includes residential dwellings and vulnerable land uses with potentially unacceptable flood effects from the Project works. The presence of stormwater treatment wetlands can help with flooding/attenuation, but only to mitigate the effects of the new hardstand areas. Improving/lowering flood hazard to properties in this area is not in the scope of this NoR and would require a larger land designation to perform flood storage.

5.3.3 NoR 3.1 Recommended measures to avoid, remedy, or mitigate operational effects

The high flood risk identified at all five locations adjacent to the designation are likely to remain high risk in the future. The following measures are proposed as they relate to the works and mitigations inside the NoR designation:

- Keeping the current vertical alignment with no lifting or lowering of the road crest;
- Providing treatment, detention and attenuation in wetlands and raingardens for the road runoff; and
- Providing additional piped drainage, greater inlet capacity and new catchpit drainage where kerbs have been moved.

There are opportunities to improve/reduce the flood hazard to properties at locations B, C, D and E. However, this would be outside the scope of the Project and would require land not justifiable as functional need to the NoR. The designation conditions proposed include an outcomes-based approach to achieving an acceptable flood change as a result of the future Project design, not an improvement. The above recommendations form the minimum suggested design philosophy to achieve these conditions. The NoR design upon which the designation includes space for wetlands, raingardens, new catchpits, pipes and manholes to suit the altered road geometry.

5.3.4 NoR 3.2 Upgrade Overview

The NoR 3.2 corridor is an upgrade of the east end of NoR 3, Alfriston Road. Stormwater treatment/attenuation ponds are proposed at 75 Alfriston Road and at 26R Saralee Drive to mitigate the effects of the increased hardstand areas proposed within the design of this NoR.

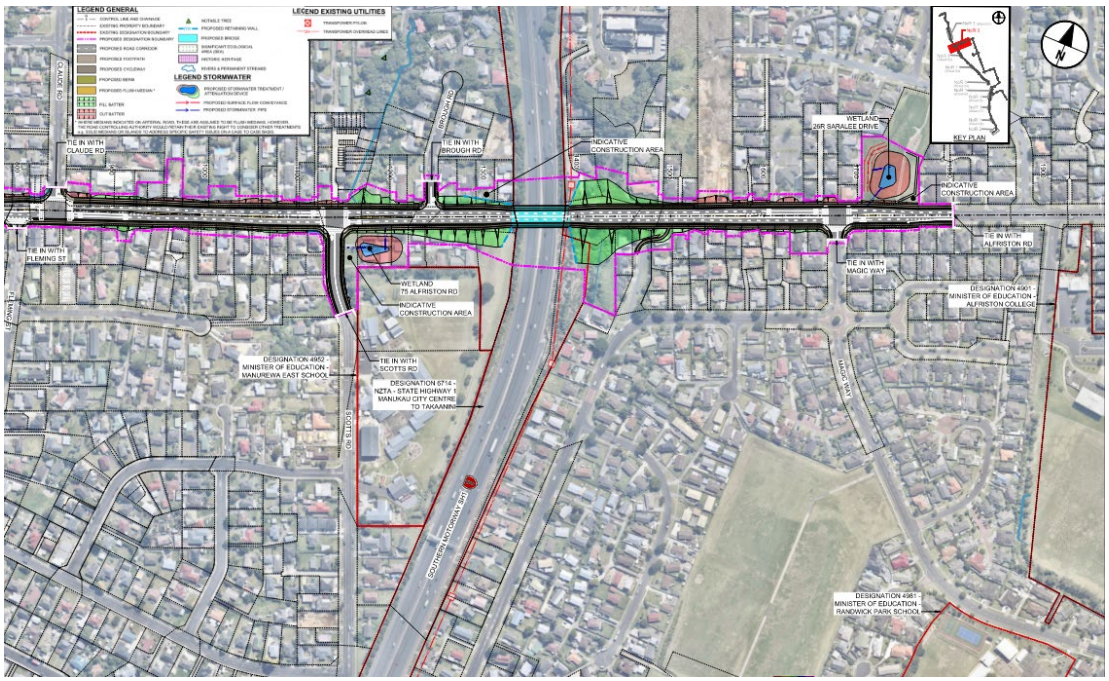

Figure 23 – NoR 3.2 Project area plan view

5.3.5 NoR 3.2 Operational Flood Effects

The 100-year flood model results for the pre-development (existing) terrain have identified four overland flowpaths along Alfriston Road. Flooding hazard is classed as high at each property based on the flood depth being >0.15m.

Figure 24 – NoR3.2 flood hazard map (2.1º CC)

The flood levels at the crossings identified in Figure 24 are overland flows that will flow over Great South Road, within the NoR 3 extent. The road crest will therefore control the amount of flooding upstream and downstream and should not be altered as part of future works without compensating for the flood effects to upstream (if raised road) or downstream (if lowered road) that would result.

The flood risk rating at the properties within the overland flowpaths are detailed in Table 15. No post-development flood simulation has been undertaken, instead, a set of recommendations are proposed for the design of future works to meet the proposed designation conditions.

Table 15 - Existing flood levels at key locations at NoR 3.2

Point	Drainage Channel / Property address	Existing Land Use	Likely Future Land Use	100 Year flood levels(m)*		Existing and likely future flood risk rating
				2.1º CC	3.8º CC	
3.2A	51, 52 Alfriston Road, Manurewa East	Residential - Mixed Housing Urban Zone	Likely same as baseline	0.518	0.576	High
3.2B	72-76 Alfriston Road	Residential - Mixed Housing Suburban Zone	Likely same as baseline	3.838	3.905	High
3.2C	92-92R,125 Alfriston Road	Residential - Mixed Housing Suburban Zone	Likely same as baseline	1.356	1.396	High
3.2D	124, 141A-B Alfriston Road	Residential - Mixed Housing Suburban Zone	Likely same as baseline	0.398	0.446	High

*Representative depth across the affected properties

Residential dwellings are highly vulnerable, and the risk of flooding at NoR 3.2 flowpaths is high. Overall, the 3.8º climate change model gives a slightly higher level of flooding by about 0.05m. The proposed stormwater ponds shown in Figure 23 align with the points 3.2B and 3.2D in Figure 24. These ponds will be protected from inundation in the 1% AEP and may require diversion channels to divert the overland flow paths around them. This diversion channel has been considered in the designation and wetland sizing exercise for this NoR.

5.3.6 NoR 3.2 Recommended measures to avoid, remedy, or mitigate operational effects

Where there is an existing high flood risk, the following mitigation should be considered to achieve the designation conditions:

- Keeping the current vertical alignment;
- Provide treatment, detention and attenuation in raingardens and wetlands for the road runoff; and
- Provide additional piped drainage, to suit the changed kerb lines.

The designation conditions proposed include an outcomes-based approach and the above recommendations form the minimum suggested design philosophy to achieve these conditions. The NoR design upon which the designation includes space for wetlands, raingardens, new catchpits, pipes and manholes to suit the altered road geometry.

5.4 NoR 4 – Porchester Road and Popes Road Upgrades

NoR 4 comprises a range of interventions providing for the route along Porchester Road generally between Alfriston Road and Walters Road; and for the urbanisation of Popes Road generally between Takanini School Road and Mill Road. These interventions provide for the urbanisation of both corridors, with two traffic lanes, widening for active mode facilities, seven intersection upgrades, and stormwater treatment wetlands.

This NoR has been split in to six parts:

- NoR 4.1, 4.2, 4.3 and 4.4 showing the Porchester Road NoR;
- NoR 4.5 showing Popes Road; and
- NoR 4.6 showing the Waters and Porchester Road intersection upgrade.

5.4.1 NoR 4.1 Upgrade Overview

The NoR 4.1 corridor is an upgrade of 1000m of Porchester Road south of the Alfriston Road intersection, refer to Figure 25.

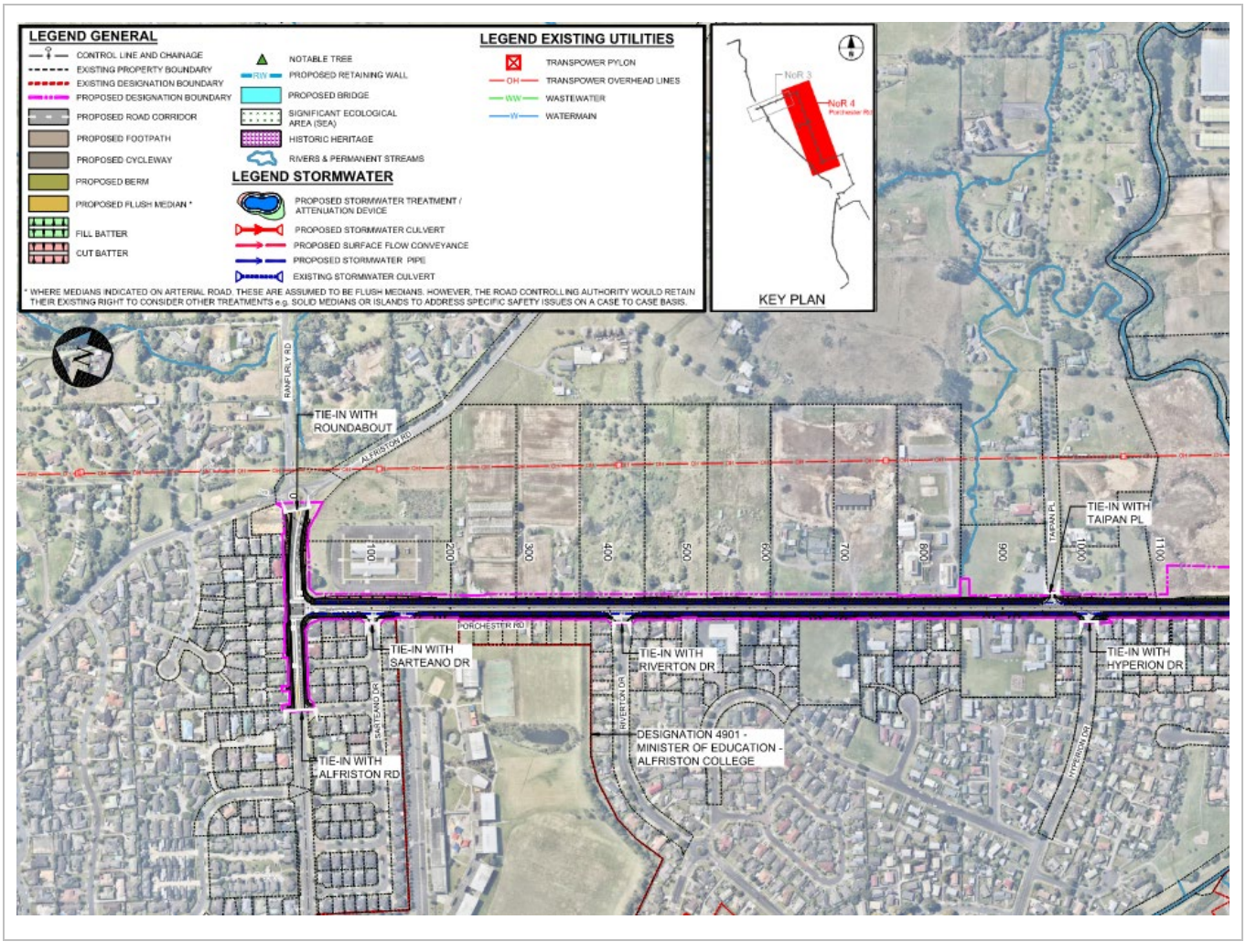

Figure 25 – NoR 4.1 Project area plan view

5.4.2 NoR 4.1 Operational Flood Effects

The 100-year flood model results for the pre-development (existing) terrain have identified two overland flowpaths shown as locations A and B on Figure 26. Relative to the total Papakura Stream catchment the catchments which affect the flooded properties are small, and flooding hazard is classed as moderate with some high hazard areas at each property based on the flood depth being between 0.05m to 0.2m on land with a freeboard of less than 0.5m to buildings nearby.

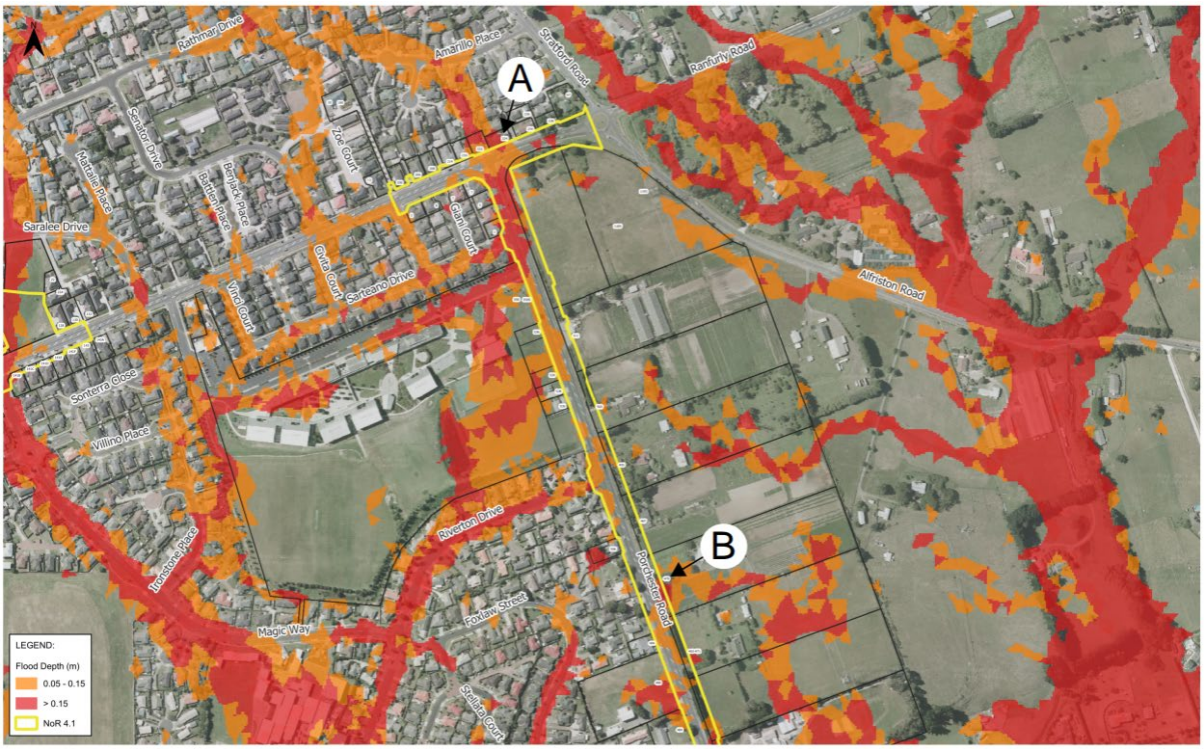

Figure 26 – NoR 4.1 flood hazard map (2.1º CC)

The flood hazards for the 100-year ARI, 2.1º and 3.8º climate change scenarios are described two points in Table 16. Note the future risks defined do not include in-stream areas or likely future riparian buffers. The future risks apply to the reasonable fulfilment of developable land when this NoR is progressed.

Table 16 - Existing flood levels at key locations at NoR 4.1

Point	Drainage Channel / Property address	Existing Land Use	Likely Future Land Use	100 Year flood levels (m) *		Existing and likely future flood risk rating
				2.1º CC	3.8º CC	
4.1A	216-224 Alfriston Road, 1-7 Porchester Road	Residential - Mixed Housing Suburban Zone	Likely same as baseline	0.162	0.189	High
4.1B	479, 463-471 Porchester Road	Future Urban Zone	Likely to remain rural based on existing flood hazard	0.179	0.193	Moderate existing, high future flood risk

*Representative depth across the affected properties

Both Point 4.1A and 4.1B are representative of a higher level of flood depth at their flowpaths which presents as land with a generally high flood risk where it is flooding existing buildings. Future development surrounding the study area will not be considered as this land will likely be rezoned to avoid developing houses in the floodplain.

5.4.3 NoR 4.1 Recommended measures to avoid, remedy, or mitigate operational effects

Where there is an existing moderate or high flood risk, the following mitigation should be considered to achieve the designation conditions:

- Keeping the current vertical alignment;
- Provide treatment and detention in swales to manage the changes in road runoff; and
- Provide additional piped drainage, to suit the changed kerb lines that discharge to swales or a terminal wetland.

The designation conditions proposed include an outcomes-based approach and the above recommendations form the minimum suggested design philosophy to achieve these conditions. The NoR design upon which the designation includes space for new swales, a wetland, new catchpits, pipes and manholes to suit the altered road geometry.

5.4.4 NoR 4.2 Upgrade Overview

The NoR 4.2 corridor is a 600m long upgrade of Porchester Road, including where it crosses Papakura Stream. Stormwater treatment/attenuation ponds are proposed on either side of Papakura Stream to receive, treat and attenuate the proposed road corridor's impervious surface.

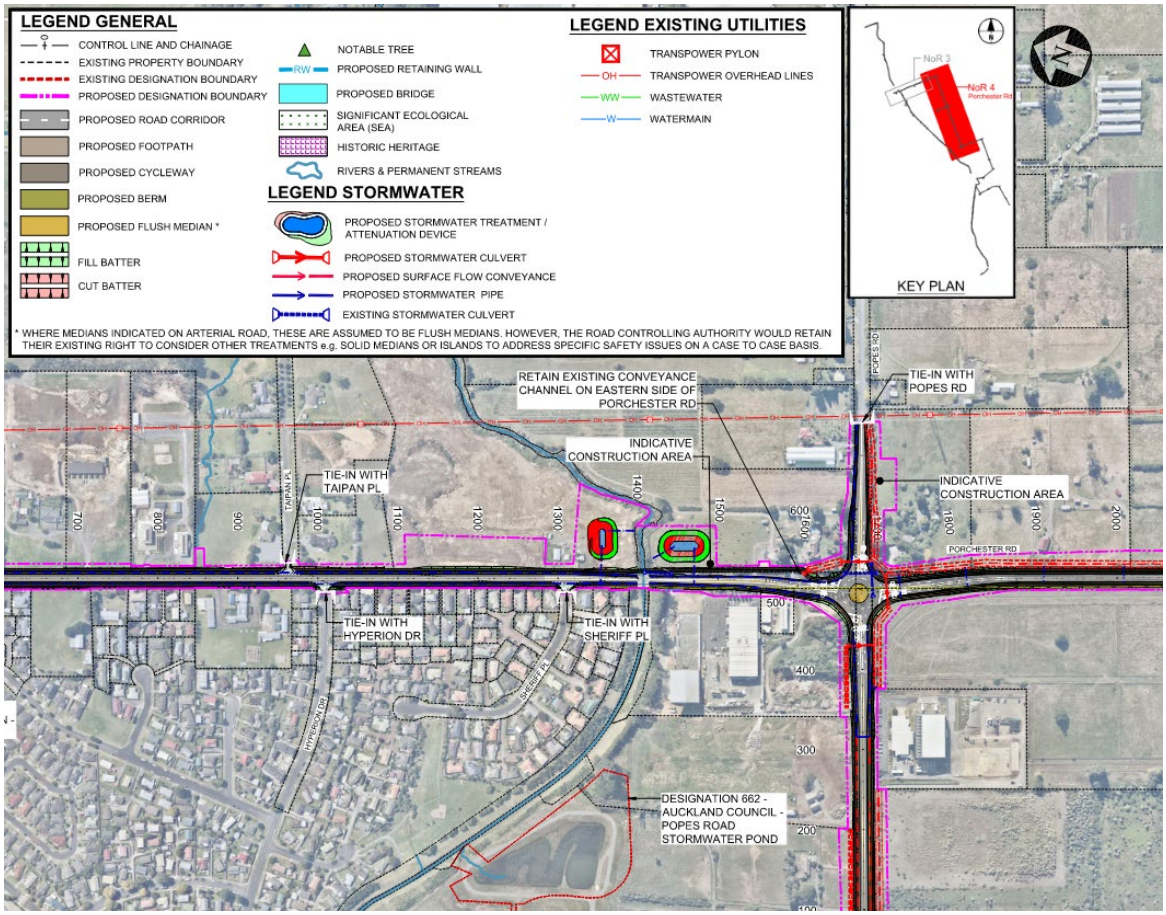

Figure 27 – NoR 4.2 Project area plan view

5.4.5 NoR 4.2 Operational Flood Effects

The 100-year flood model results for the pre-development (existing) terrain have identified two overland flowpaths, with points A and B chosen as representatives. Flooding hazard is classed as moderate where flood depth is between 0.05m to 0.15m and high where flood depth is >0.15m.

Figure 28 – NoR4.2 flood hazard map (2.1º CC)

The flood hazards for the 100-year ARI, 2.1º and 3.8º climate change scenarios are described in Table 17. Note the future risks defined do not include in-stream areas or likely future riparian buffers.

Table 17 - Existing flood levels at key locations at NoR 4.2

Point	Drainage Channel / Property address	Existing Land Use	Likely Future Land Use	100 Year flood levels(m)*		Existing and likely future flood risk rating
				2.1º CC	3.8º CC	
4.2A	455 Porchester Rd	Future Urban Zone	Likely to remain rural based on existing flood hazard	0.344	0.382	Moderate existing, high future
4.2B	11-17 Sheriff Place, 391 Porchester Road, Randwick Park, Auckland	Residential and Future Urban Zone	Likely to remain rural residential based on existing flood hazard	4.724	4.936	High

*Representative depth across the affected properties

Points 4.2A and 4.2B are both currently in the FUZ. Future development surrounding the study area will not be considered as this land will likely be rezoned to avoid developing houses in the floodplain. Point 4.2B is where the NoR crosses the Papakura Stream and has possible flood levels of more than 4m. Earthworks in this area may exacerbate flooding on surrounding properties.

The 3.8 modelling shows deeper levels of flood of a maximum increase of about 0.2m compared to the 2.1 modelling.

5.4.6 NoR 4.2 Recommended measures to avoid, remedy, or mitigate operational effects

Where there is an existing moderate or high flood risk, the following mitigation should be considered to achieve the designation conditions:

- Keeping the current vertical alignment;
- Provide treatment, detention and attenuation in swales and wetlands to manage the changes in road runoff; and
- Provide additional piped drainage, to suit the changed kerb lines.

The designation conditions proposed include an outcomes-based approach and the above recommendations form the minimum suggested design philosophy to achieve these conditions. The NoR design upon which the designation includes space for two new wetlands, new catchpits, pipes and manholes to suit the altered road geometry.

5.4.7 NoR 4.3 Upgrade Overview

The NoR 4.3 corridor is an upgrade of the Porchester Road and Popes Road intersection, extending to Takanini School Road.

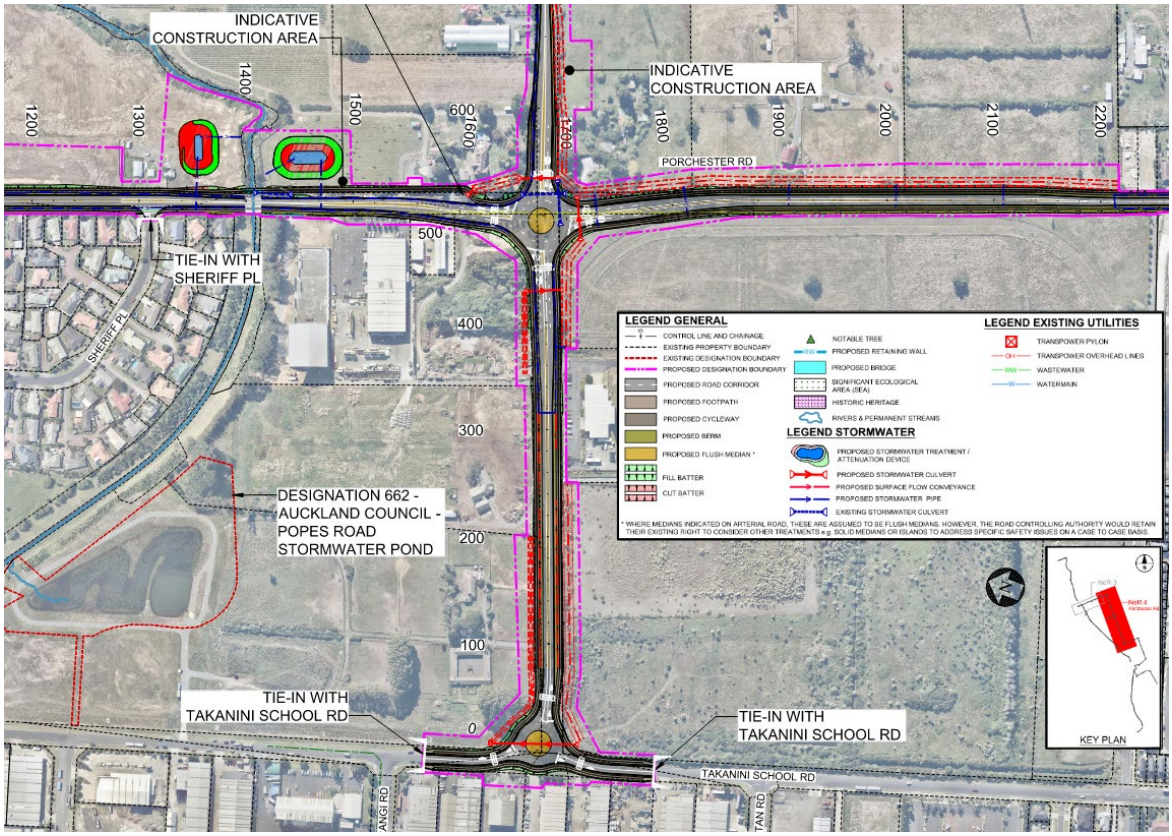

Figure 29 – NoR 4.3 Project area plan view

5.4.8 NoR 4.3 Operational Flood Effects

The 100-year flood model results for the pre-development (existing) terrain have identified that the extension of the Papakura Stream catchment onto Popes Road, and almost all of the properties adjacent to the NoR have a moderate to high flood hazard as a result of development in the expansive Papakura Stream floodplain. Point A in Figure 30 is chosen as a representative location of the flooding risk at Takanini School Road.

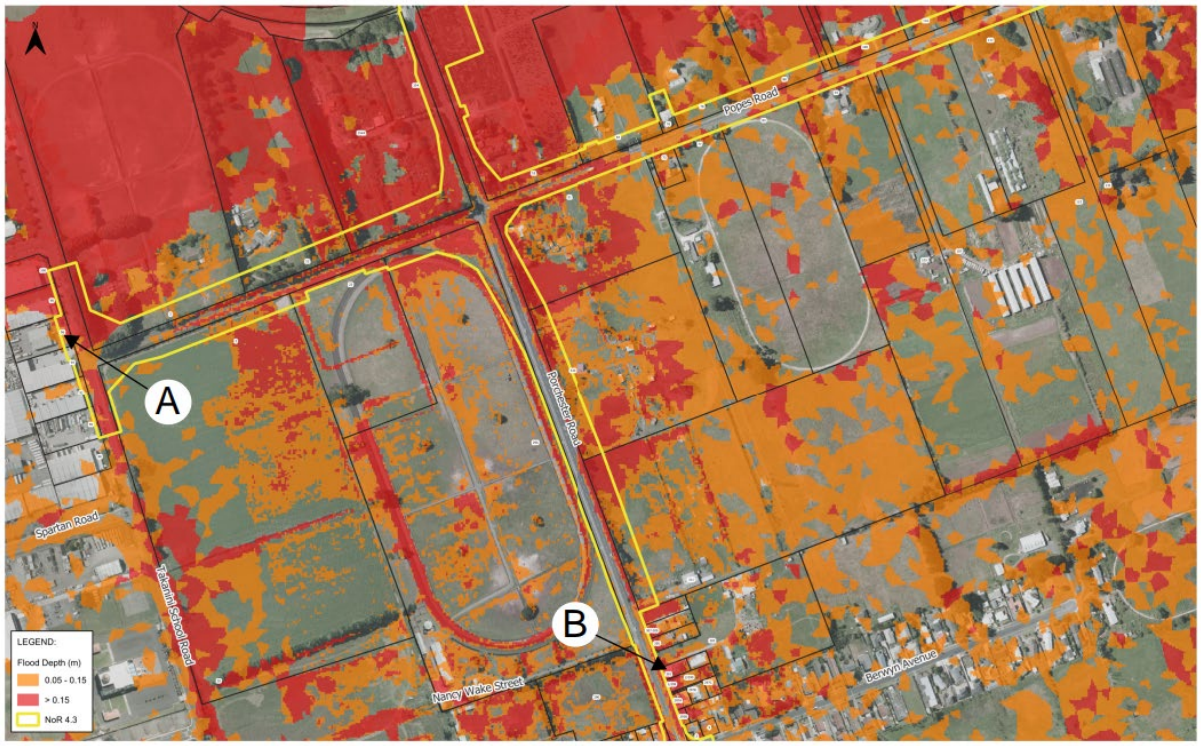

Figure 30 – NoR4.3 flood hazard map (2.1º CC)

The flood hazards for the 100-year ARI, 2.1º and 3.8º climate change scenarios are described in Table 18.

Table 18 - Existing flood levels at key locations at NoR4.3

Point	Drainage Channel / Property address	Existing Land Use	Likely Future Land Use	100 Year flood levels*		Existing and likely future flood risk rating
				2.1º CC	3.8º CC	
4.3A	94-100 Takanini School Road, Takanini	Business - Heavy Industry Zone	Likely same as baseline	0.641	0.907	High
4.3B	295-309 Porchester Road, Takanini	Residential - Mixed Housing Suburban Zone	Likely same as baseline	0.28	0.294	High

*Representative depth across the affected properties

The land use immediate upstream of Papakura Stream is Future Urban Zone, with further upstream being Mixed Rural Zone. Point 4.3A is within the catchment of Papakura Stream, with an overall high flood risk of a depth level of >0.15m both in a 2.1 and 3.8 degree climate change, and in a business zone.

5.4.9 NoR 4.3 Recommended measures to avoid, remedy, or mitigate operational effects

Where there is an existing moderate or high flood risk, the following mitigation should be considered to achieve the designation conditions:

- Keeping the current vertical alignment;

- Provide treatment, detention and attenuation in swales and wetlands to manage the changes in road runoff;
- Provide additional piped drainage, to suit the changed kerb lines;
- Keep clean water conveyance channels separate from treatment swales; and
- Maintain all channels and avoid replacing with piped drainage. The open channels are important maintain groundwater levels, manage secondary flow paths where overtopping roads and to carry flow where piped networks are blocked/ under capacity.

Auckland Council Healthy Waters will likely produce a catchment scale solution for the developable land that will change the flood behaviour in this area. Maintaining the current system of flow conveyance at this stage is highly recommended until such time as a more comprehensive masterplan is developed. The designation conditions proposed include an outcomes-based approach and the above recommendations form the minimum suggested design philosophy to achieve these conditions. The NoR design upon which the designation includes space for new swales, a wetland, new catchpits, pipes and manholes to suit the altered road geometry.

5.4.10 NoR 4.4 Upgrade Overview

The NoR 4.4 corridor is an upgrade of the very south end of Porchester Road until where it meets Airfield Road. The works are largely minor widening works to accommodate walking and cycling facilities. Stormwater drainage will need to adjust to the new kerb lines and small treatment swales/raingardens are proposed in the road berm areas.

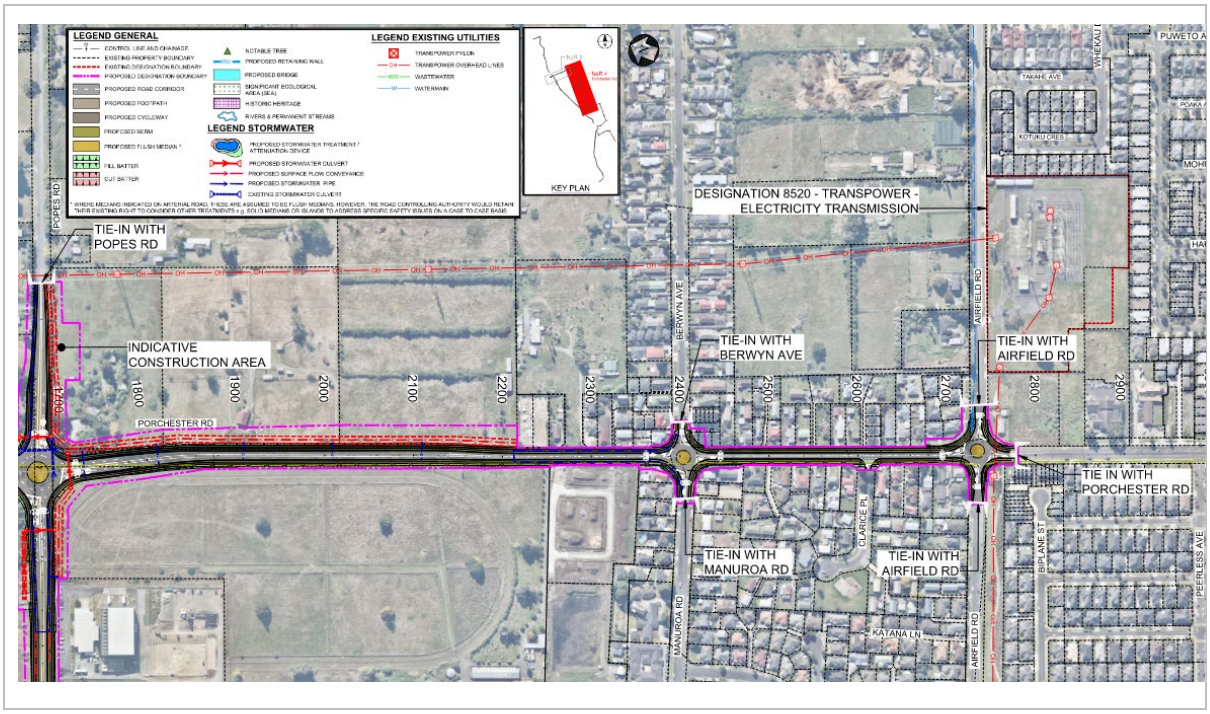

Figure 31 – NoR 4.4 Project area plan view

5.4.11 NoR 4.4 Operational Flood Effects

The 100-year flood model results for the pre-development (existing) terrain have identified widespread flooding over the whole of the NoR alignment show below as location A. The catchments are to the flooded properties generate a mix of moderate and high hazards areas at each property based on the

flood depth being between 0.05m to 0.23m, with a freeboard of less than 0.5m to buildings in the vicinity of the flooded areas.

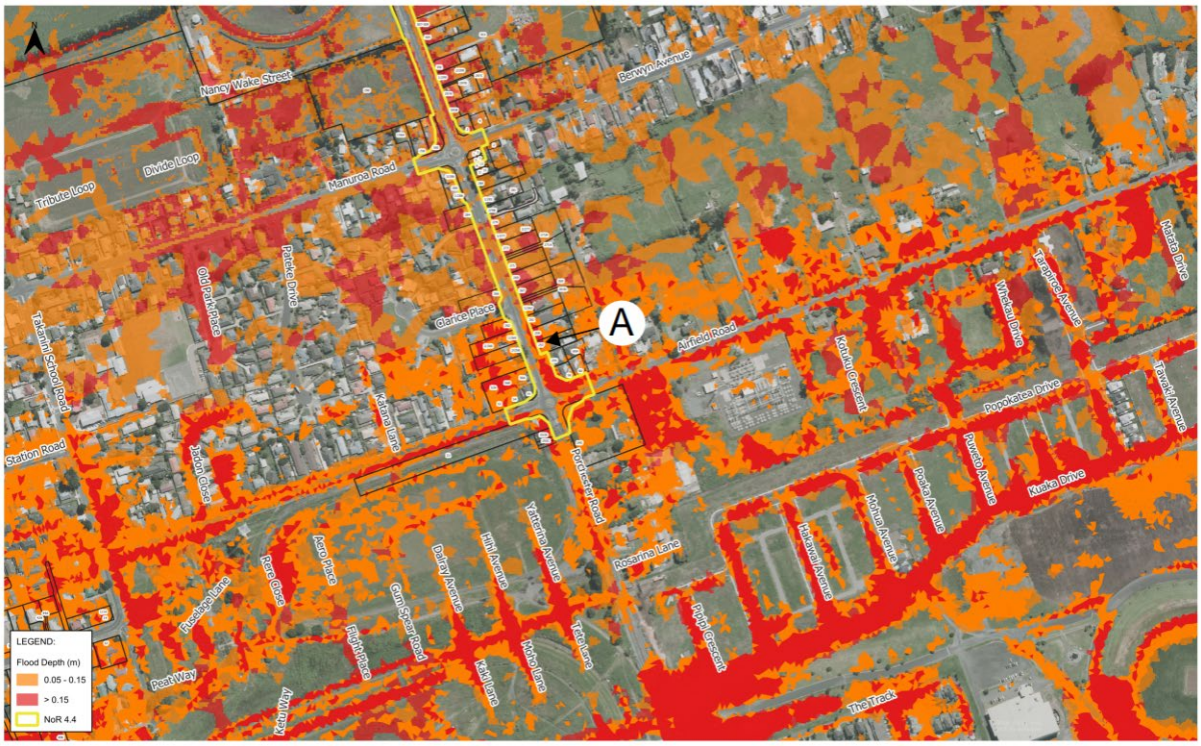

Figure 32 – NoR 4.4 flood hazard map (2.1º CC)

The flood hazards for the 100-year ARI, 2.1º and 3.8º climate change scenarios are described for one representative point in Table 19.

Table 19 - Existing flood levels at key locations at NoR4.4

Point	Drainage Channel / Property address	Existing Land Use	Likely Future Land Use	100 Year flood depths (m)*		Existing and likely future flood risk rating
				2.1º CC	3.8º CC	
4.4A	255-469, 258-262 Porchester Road, Takanini	Residential - Mixed Housing Suburban Zone	Likely same as baseline	0.216	0.229	High

*Representative depth across the affected properties

There is an overall high flood risk of a flood depth >0.2 m in the residential zone.

5.4.12 NoR 4.4 Recommended measures to avoid, remedy, or mitigate operational effects

Where there is an existing moderate or high flood risk, the following mitigation should be considered to achieve the designation conditions:

- Keeping the current vertical alignment;
- Provide treatment and detention in swales to manage the changes in road runoff;
- Provide additional piped drainage, to suit the changed kerb lines; and
- Keep clean water conveyance channels separate from treatment swales.

The designation conditions proposed include an outcomes-based approach and the above recommendations form the minimum suggested design philosophy to achieve these conditions. The NoR design upon which the designation includes space for new swales, new catchpits, pipes and manholes to suit the altered road geometry.

5.4.13 NoR 4.5 Upgrade Overview

The NoR 4.5 corridor is an upgrade to the intersection of Porchester Road and Walters Road. The works are largely minor widening woks to accommodate walking and cycling facilities. Stormwater drainage will need to adjust to the new kerb lines and small treatment swales/raingardens are proposed in the road berm areas.

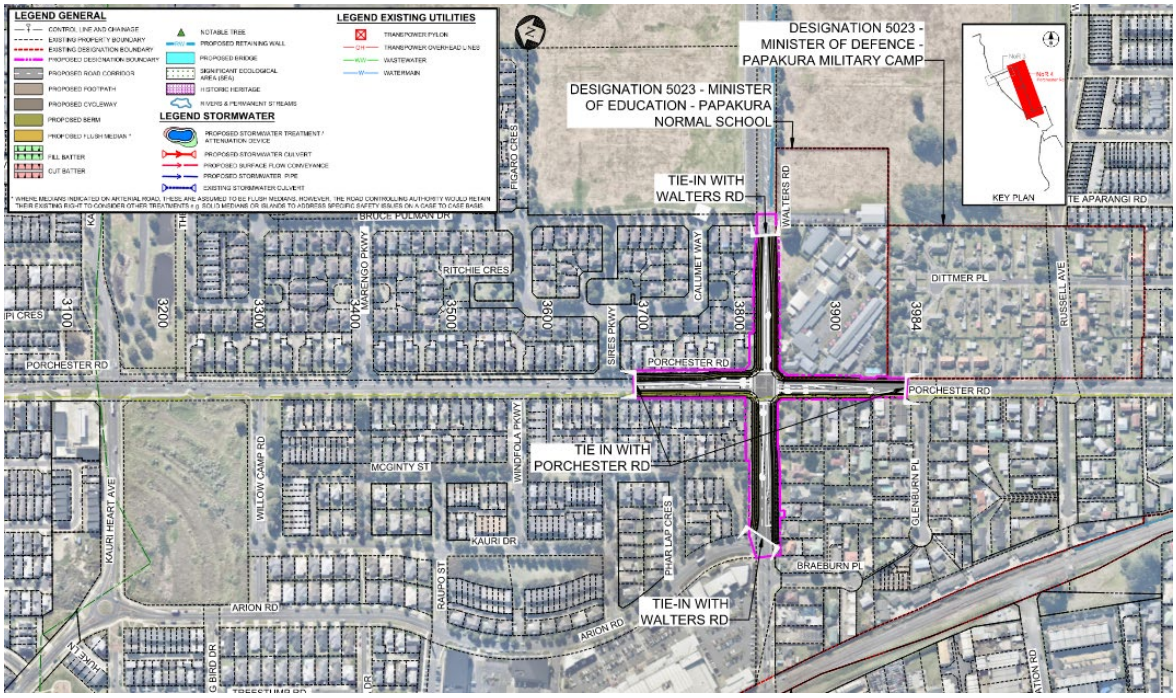

Figure 33 – NoR4.5 Project area plan view

5.4.14 NoR 4.5 Operational Flood Effects

The 100-year flood model results for the pre-development (existing) terrain have identified an overland flowpath that overtops the middle of the intersection. This affects properties on the east, north and south of the intersection referred to as locations A, B and C respectively. Flooding hazard is classed as moderate at locations B and C generally, except at location A where the flood depth is deep enough to trigger a high hazard rating. The freeboard to buildings adjacent flooded areas is less than 0.5m, placing these buildings at risk of effect also.

Figure 34 – NoR4.5 flood hazard map (2.1º CC)

The flood hazards for the 100-year ARI, 2.1º and 3.8º climate change scenarios are described for the representative point A in Table 20.

Table 20 - Existing flood levels at key locations at NoR 4.5

Point	Drainage Channel / Property address	Existing Land Use	Likely Future Land Use	100 Year flood levels (m)*		Existing and likely future flood risk rating
				2.1º CC	3.8º CC	
4.6A	31-39 Walters Road; 145 – 159 Porchester Road	Residential - Mixed Housing Urban Zone	Likely same as baseline	0.415	0.456	High
4.6B	157-159, 184-186 Porchester Road, Papakura	Residential - Mixed Housing Suburban Zone	Likely same as baseline	0.202	0.22	High
4.6C	35-41 Walters Road; 156-166 Porchester Road, Papakura	Residential - Mixed Housing Urban Zone	Likely same as baseline	0.191	0.216	High

*Representative depth across the affected properties

5.4.15 NoR 4.5 Recommended measures to avoid, remedy, or mitigate operational effects

The flood risk identified at all three locations adjacent to the designation are likely to remain at their respective risk ratings into the future. The following measures are proposed as they relate to the works and mitigations inside the NoR designation:

- Keeping the current vertical alignment with no lifting or lowering of the road crest;
- Providing treatment and detention in raingardens for the road runoff; and
- Providing additional piped drainage, greater inlet capacity and new catchpit drainage where kerbs have been moved.

There are opportunities to improve/reduce the flood hazard to properties at locations A, B and C. However, this would be outside the scope of the Project and would require land not justifiable as functional need to the NoR. The designation conditions proposed include an outcomes based approach to achieving an acceptable flood change as a result of the future project design, not an improvement. The above recommendations form the minimum suggested design philosophy to achieve these conditions. The NoR design upon which the designation includes space for new raingardens, catchpits, pipes and manholes to suit the altered road geometry.

6 Conclusion

This assessment has used a number of methods to analyse, interpret and assess the potential flood effects associated with the Project. A flood risk rating was used in this assessment to identify areas where existing flood effects are likely and makes recommendations to mitigate any effects during the future detailed design stage of the Project.

The assessment found 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.

There are potential risks of increased flood levels upstream and downstream of overland flow path crossings and where the vertical alignment of the road is subject to change. Some of the effects were assessed as moderate risk due to the flood depth being greater than 0.05m but less than 0.15m for more vulnerable uses (e.g., habitable buildings), and 0.5m for less vulnerable uses (e.g., open space).

A number of potential management and mitigation measures have been proposed to manage operational effects at the future detailed design stage. A series of outcomes are identified to be included as conditions on the NoRs and maintain effects at a level that is no more than minor.

A sensitivity analysis has been undertaken to consider the effects of additional rainfall under a more severe climate change scenario. The sensitivity analysis identified an increased risk of flooding at some locations which can be addressed through the proposed mitigation that is described in the report. In general, the following approaches should be considered to achieve the designation conditions:

- Keeping the current vertical alignment;
- Provide treatment, detention, retention and attenuation to manage the increase in road stormwater runoff;
- Prioritise the use of water sensitive urban design where practicable to achieve this outcome;
- Provide additional reticulated drainage, to suit the changed kerb lines;
- Keep clean water conveyance channels separate from treatment swales; and
- Maintain existing open channels / table drains and avoid replacing with piped drainage. The open channels are important maintain groundwater levels, manage secondary flow paths where overtopping roads and to carry flow where piped networks are blocked/ under capacity.

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

(a) The Project shall be designed to achieve the following flood risk outcomes:

(i) 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;

(ii) no more than a 10% reduction in freeboard in a 1% AEP event for existing authorised habitable floors with a freeboard over 150mm;

(iii) no increase in 1% AEP flood levels for existing authorised community, commercial, industrial and network utility building floors that are already subject to flooding;

(iv) no more than a 10% reduction in freeboard in a 1% AEP event for existing authorised community, commercial, industrial and network utility building floors;

(v) 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; and

(vi) no new flood prone areas; and

(vii) 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 1% AEP rainfall event.

(b) Compliance with this condition shall be demonstrated in the Outline Plan, which shall include flood modelling of the pre-Project and post-Project 100-year ARI flood levels (for Maximum Probable Development land use and including climate change).

(c) *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.*

Compliance shall be demonstrated in the Outline Plan, which shall include flood modelling of the pre-Project and post-Project 100-year ARI 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 levels 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.