TE TUPU NGĀTAHI
SUPPORTING GROWTH

North West Whenuapai Assessment of Flooding Effects

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Version 1.0

WAKA KOTAHI
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Document Status

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Abbreviations

Acronym/Term	Description
AC	Auckland Council
AEE	Assessment of Effects on the Environment
ARI	Average Recurrence Interval
AT	Auckland Transport
AUP:OP	Auckland Unitary Plan Operative in Part
CC	Climate change
CEMP	Construction Environmental Management Plan
FTN	Frequent Transit Network
FUZ	Future Urban Zone
MfE	Ministry of the Environment
MPD	Maximum Probable Development
NoR	Notice of Requirement (under the Resource Management Act 1991)
RCP	Representative Concentration Pathways
RL	Reduced level
RMA	Resource Management Act 1991
SH16	State Highway 16
SH18	State Highway 18
Te Tupu Ngātahi	Te Tupu Ngātahi Supporting Growth
Waka Kotahi	Waka Kotahi NZ Transport Agency

Glossary of Acronyms / Terms

Acronym/Term	Description
AT	Auckland Transport an Auckland Council controlled organisation.
Auckland Council	Means the unitary authority that replaced eight councils in the Auckland Region as of 1 November 2010.
ARI	Average Recurrence Interval
Dry Pond	A permanent pond that is dry between storm events but during rainfall events temporarily stores stormwater runoff to control discharges. Dry ponds provide limited water quality treatment.
Flood difference map	The difference between the pre-development and post-development flood levels as shown on the map
Freeboard	An allowance above the modelled flood level, be it road level or other features (e.g. existing floor level). For buildings freeboard shall be measured from the top water level to the finished floor level. The relevant design manual shall be referred to for the appropriate freeboard and method of calculation.
Lay down areas	An area that has been cleared for the temporary storage of materials and equipment and may include site compounds, stockpiles, sediment retention ponds.
MPD	Maximum Probable Development according to the AUP:OP zonings
Pre-development	Prior to construction of the Project
Post-development	After construction of the Project
Terrain	An elevation model which includes the ground levels based on 2016 LiDAR and the concept design ground levels.
Stormwater Wetland	Constructed wetlands that temporarily store runoff in shallow pools and support conditions suitable for the growth of wetland plants. Stormwater wetlands provide enhanced water quality treatment of stormwater runoff through vegetation uptake, retention and settling.
Wet Pond	A permanent pond that has a standing pool of water and provides water quality treatment, and storage of stormwater runoff to reduce the peak water volume from a rainfall event and provide erosion protection.
Whenuapai Assessment Package	Four Notices of Requirement and one alteration to an existing designation for the Whenuapai Arterial Transport Network for Auckland Transport.

1 Executive Summary

This report provides an assessment of flood effects associated with the construction, operation and maintenance of the Projects that comprise the Whenuapai Assessment Package. The Projects are shown on Figure 1-1 below.

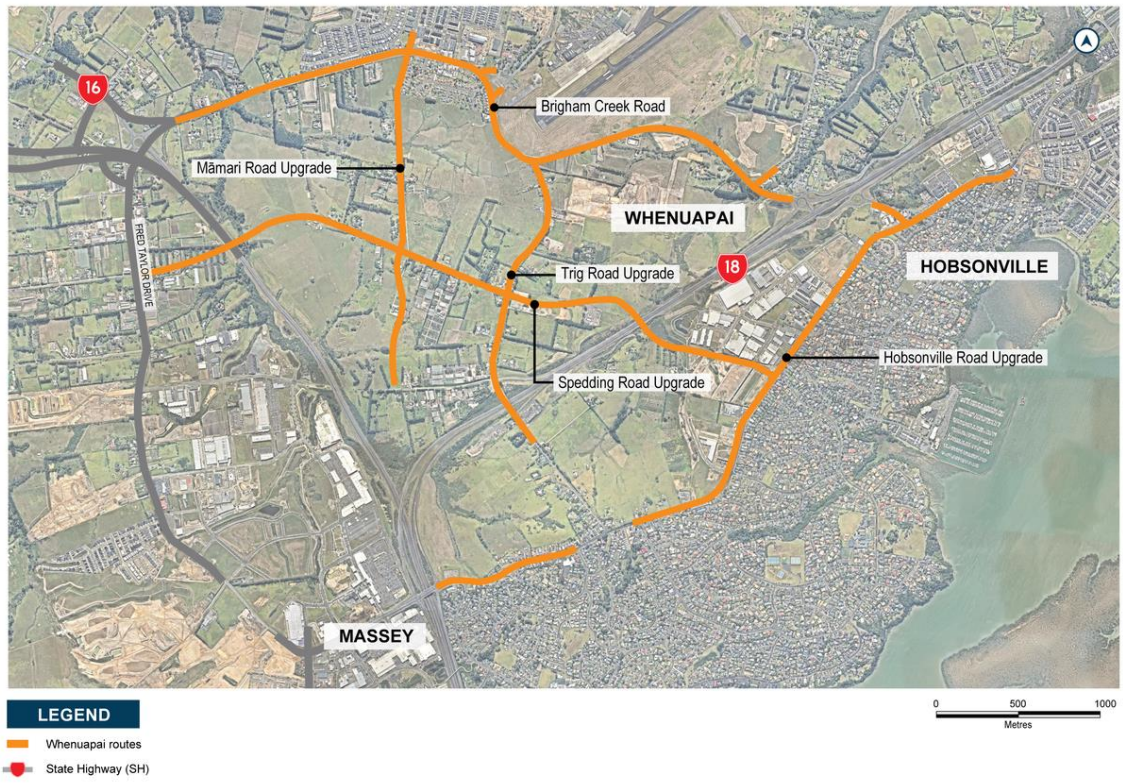

Figure 1-1: Location of the projects in the Whenuapai assessment package

Flooding is a natural hazard and has therefore been considered as part of the Whenuapai Package Notices of Requirement. The works required for the Whenuapai Package have the potential to lead to flooding effects and an assessment of predicted flood effects is provided to demonstrate that these effects can be appropriately mitigated in the future. It is also acknowledged that 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 include changes to:

- the flood freeboard to existing habitable buildings, overland flow paths;
- the ability to access property by residents and emergency vehicles;
- the level of flooding to roads and flooding arising from the blockage of stormwater drainage;
- the effects considered relate to existing habitable buildings / infrastructure and potential future effects on upstream and downstream properties.

Methodology

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

- Desktop assessment to identify potential flooding locations from Auckland Council Geomaps.
- Modelling of the pre-development and post-development terrain with Maximum Probable Development (MPD) and 100year Average Recurrence Interval (ARI) plus climate change rainfall.
- Two climate scenarios were modelled, one allowing for 2.1°C of temperature increase and one for 3.8°C of temperature increase. The higher climate change scenario has been used to undertake a sensitivity analysis to understand the increased risk of greater climate change impacts.
- Producing flood level maps for pre-development and post-development scenarios and flood difference maps to show the change in flood levels and extents (greater than 50mm) as a result of the Project.
- Inspection and review of flood difference maps at key locations such as bridges and where there are noticeable changes in flood extents or flood levels.

While stormwater effects apart from flooding are not assessed, provision is made for the future mitigation of potential stormwater effects (stormwater quantity, stormwater quality and instream structures) by identifying the space required for stormwater management devices (for example drainage channels and ponds) and incorporating land for that purpose into the proposed designation boundaries. These devices have been designed to attenuate the 100year ARI event using 10% of the total roading impervious catchment area (proposed and existing) in accordance with Council and Waka Kotahi guidance[1,2]. Note for existing roads being widened this allows for greater impervious area than the road widening alone.

The assessment considers that flooding effects will be subject to further assessment at a detailed design stage. It is expected that coordination and integration of the corridor design with future urban zone (FUZ) development will be undertaken to confirm and address potential future adverse effects.

Positive Effects

There is the potential for also be a number of positive effects associated with the projects. These include where new bridges are proposed which raise the existing road levels reducing the potential for flood levels to overtop the road and reducing flood hazard.

Additional positive effects can be realised through upgrades to existing culverts or new culvert crossings to improve overland and stream flow under the proposed project corridor. The scale of these effects will be determined at detailed design stage.

Water quality treatment allowances will result in reduced environmental impacts as the total road area, and not just the added road area, for existing roads have been included for treatment.

Construction phase effects

The potential construction flooding effects can be appropriately managed with the measures set out in Section 7.1 and with a Construction Environmental Management Plan (CEMP) addressing flood risk in place, flooding effects are likely to be negligible.

Operational phase effects

NoR W1: Trig Road North Upgrade

[1] Auckland Council's Stormwater Management Devices in the Auckland Region, Guideline Document 2017/001 (December 2017)

[2] Waka Kotahi NZTA's Stormwater Design Philosophy Statement (May 2010)

Flooding risk associated with the operation of the Project is considered negligible. The results for the flood difference map for the 100 year ARI range between -0.05 m and +0.05 m along Trig Road corridor shows little change in the pre and post development predicted flood levels.

NoR W2: Māmari Road Upgrade

The corridor upgrade will obstruct the existing overland flow path at northern section of Māmari Road causing the water to pond upstream. The flood difference map shows an increase in flood level between 0.05 m and 0.5 m which is considered a minor effect. Culvert crossings at northern section of Māmari Road show an increase in flood level both upstream and downstream of the crossings. These effects are considered negligible except for upstream of Chainage 120 which is considered to be a minor effect prior to mitigation. Following mitigation, it is anticipated there would be a negligible effect for all crossings as culverts would be designed to achieve flood neutrality.

NoR W3: Brigham Creek Road Upgrade

The construction and operation of a new bridge across Waiarohia Stream has the potential to increase the freeboard between the road and the flood level resulting in a positive effect for road users by having to raise the road level. This bridge also improves the water flow resulting in decreased flood water levels upstream but there is an increase in flood water levels downstream resulting in a minor effect (>50 mm increase) at one existing property. This can be mitigated by adding an additional culvert alongside the existing culvert to create a balance between the flood level differences upstream and downstream thus aiming for flood neutrality.

There are three proposed crossings in NoR W3. At two of these crossings there is an increase in flood water level between 0.05 m and 0.5 m upstream which is considered a minor effect although this can be mitigated by increasing the culvert size under the proposed road. The third crossing has a light reduction in predicted water levels.

Further modelling at a detailed design stage is proposed to confirm the effectiveness of these mitigation measures, however with mitigation in place it is anticipated flood effects would be minimiseed.

NoR W4: Spedding Road

For Totara Creek there is no effect on nearby properties as there is no difference in predicted flood water levels between the pre and post development scenarios.

At the new culvert crossings there was a minor to moderate effect on flood levels. These effects are able to be minimiseed in the final design by raising the road or upgrading the culverts including upsizing or extending the culverts to optimise their design with the aim of achieving flood neutrality. Further modelling at a detailed design stage is proposed to confirm the effectiveness of these mitigation measures.

NoR W5: Hobsonville Road FTN Upgrade

There are two key stream crossings at Chainage 3060 and Chainage 3800 which have the potential minor and moderate flood effect respectively. These effects are able to be minimised during detailed design which could include upsizing or extending the culverts to optimise the design and achieve flood neutrality.

Sensitivity Analysis

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. However, this increased risk can be addressed through the mitigation measures described in the report.

Conclusion

The assessment found that there was unlikely to be adverse flood risk effects during construction as nearly all proposed lay down areas are outside of the flood plain and overland flow paths. Construction impacts will be mitigated through a CEMP (see Section).

Potential operational effects include increased flood water levels upstream and downstream of crossings and bridges. Effects were assessed as negligible to moderate. Operational impacts will likely be resolved during detailed design by optimising the design of culverts and bridges to minimise flood effects upstream and downstream of crossings.

Further assessment at detailed design stage will be aimed at achieving flood neutrality.

2 Introduction

This flooding assessment has been prepared for the North West Local Arterial Network Notices of Requirement (**NoRs**) for Auckland Transport (**AT**) (the "Whenuapai Assessment Package"). The NoRs are to designate land for future corridors as part of Te Tupu Ngātahi Supporting Growth Programme (**Te Tupu Ngātahi**) to enable the construction, operation and maintenance of transport infrastructure in the North West Whenuapai area of Auckland.

The North West growth area is approximatively 30 kilometres north west of Auckland's central city. It makes a significant contribution to the future growth of Auckland's population by providing for approximately 42,355 new dwellings and employment activities that will contribute 13,000 new jobs across the North West. Whenuapai is one of these growth areas, located between State Highway 16 (**SH16**) and State Highway 18 (**SH18**) and at present is largely rural (but Future Urban Zoned) with an existing community consisting of new and more established residential, business and local centre land uses.

This growth area is expected to be development ready by 2018-2022 with 401 hectares to accommodate 6,000 dwellings. Furthermore, a Whenuapai Structure Plan was adopted by the Council in 2016 and sets out the framework for transforming Whenuapai from a semi-rural environment to an urbanised community over the next 10 to 20 years.

The Whenuapai Assessment Package will provide route protection for the transport corridors, which include walking, cycling and public transport (including the Frequent Transit Network (**FTN**)), needed to support the expected growth in Whenuapai.

This report assesses the flooding effects of the North West Whenuapai Assessment Package identified in Figure 4-1 and Table 2-1 below.

The Whenuapai Assessment Package comprises five separate projects which together form the North West Whenuapai Arterial Network. The network includes provision for general traffic, walking and cycling, and frequent public transport

Refer to the main AEE for a more detailed project description.

Table 2-1: North West Whenuapai Assessment Package – Notices of Requirement and Projects

Notice	Project
NoR W1	Trig Road North
NoR W2	Māmari Road
NoR W3	Brigham Creek Road
NoR W4	Spedding Road
NoR W5	Hobsonville Road (alteration to existing designation 1437)

2.1 Purpose and Scope of this Report

This assessment forms part of a suite of technical reports prepared to support the assessment of effects within the Whenuapai Assessment Package. Its purpose is to inform the AEE that accompanies the four NoRs and one alteration to an existing designation for the Whenuapai Assessment Package sought by AT.

This report considers the actual and potential effects associated with the construction, operation and maintenance of the Whenuapai Assessment Package on the existing and likely future environment as it relates to flooding effects and recommends measures that may be implemented to minimise, remedy and/or mitigate these effects.

The key matters addressed in this report are as follows:

a) Identify and describe the stormwater context of the Whenuapai Assessment Package area,
b) Identify and describe the predicted actual and potential flooding effects of each Project corridor within the Whenuapai Assessment Package,
c) Recommend measures as appropriate to minimise, remedy or mitigate actual and potential flooding effects (including any conditions/management plan required) for each Project corridor within the Whenuapai Assessment Package, and
d) Present an overall conclusion of the level of predicted actual and potential flooding effects for each Project corridor within the Whenuapai Assessment Package after recommended measures are implemented.

This report draws a distinction between stormwater effects and flood hazard effects, which are a subset of potential stormwater effects.

Stormwater effects are broadly divided into:

- Quantity effects (such as flooding, erosion and changes to hydrology - which may cause effects on stream habitat, baseflow and sediment movement in streams),
- 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 RMA section 13, 14 and 15 consents and are administered by regional councils (or, in the case of Auckland, as regional consents by the Auckland Council as a Unitary Authority).

Provision is made for the future management of the stormwater effects (stormwater quantity, stormwater quality and instream structures) by identifying the space required for stormwater management devices (for example drainage channels and wetlands) and incorporating land for that purpose into the NoRs. In identifying the land required for these devices, preliminary sizing and siting has been undertaken and offset allowances made for construction phase works.

The designation is a land use or district planning mechanism. Hence, the assessment of effects has been limited to flood hazard matters as they are the only matters that would trigger a District Plan consent requirement under the AUPOIP. In presenting information on flood hazard effects, it is therefore acknowledged that there will be a subsequent process for seeking regional council consents.

Flood hazard effects include changes to; the flood freeboard to buildings, the depth of flooding on property, the creation of new overland flow paths, the ability to access property by residents and emergency vehicles and potential flood prone areas caused by blockage of culverts.

2.2 Report Structure

The report is structured as follows:

a) Overview of the methodology used to undertake the assessment and identification of the assessment criteria and any relevant standards or guidelines,
b) Description of each Project corridor and project features within the Whenuapai Assessment Package as it relates to stormwater,
c) Identification and description of the existing and likely future flooding environment,
d) Description of the actual and potential positive flooding effects of the Project,
e) Description of the actual and potential adverse flooding effects of construction of the Project,
f) Description of the actual and potential adverse flooding effects of operation of the Project,
g) Recommended measures to minimise, remedy or mitigate potential adverse flooding effects, and
h) Overall conclusion of the level of potential adverse flooding effects of the Project after recommended measures are implemented.

This report should be read alongside the AEE, which contains further details on the history and context of the Project. The AEE also contains a detailed description of works to be authorised for the Project, likely staging 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, unless a description of an activity is necessary to understand the potential effects, then it has been included in this report for clarity.

2.3 Preparation for this Report

In preparation of this report several resources were used to support the assessment. These included technical specialist inputs, previous reports, catchment flood models and team workshops.

The Whenuapai Structure Plan and AUPOP were used to identify the existing and likely future environment. Information from the Project Team and SGA Whenuapai model were used to assess the relative changes to predicted flood water levels and extents between the existing (pre-development) and future (post-development) terrain.

It should be noted the existing terrain (based on AC 2016 LiDAR) has been used for flood modelling of the pre-development and post-development scenarios as there is no information about what future landforms will take.

3 Assessment Methodology

3.1 Chapter Summary

The assessment of flooding effects has involved the following steps using the AC and SG GIS to identify where:

- Desktop assessment to identify potential flooding locations, namely:

– Existing buildings appear to be near/within the existing flood plains.
– Where the Projects involve work near stream crossings and major overland flow paths.

- Flood modelling of the pre-development (without SGA) and post-development (with SGA) terrain, including:

– Flood modelling of the proposed future land use using Maximum Probable Development (MPD) development with the 100year ARI plus climate change rainfall
– Model results were used to identify changes in the flood water levels to create flood difference maps.

- Inspection of the flood difference maps to identify flooding effects, including:

– At key cross drainage locations such as culverts and where there are noticeable deep flood levels, consideration was given to flood hazard issues.
– Properties and buildings with habitable floors showing potential to flooding hazard through flood extent within the existing building footprints.

- A sensitivity analysis to assess the potential risk of extreme climate change (3.8°) compared to the existing projected climate change temperature increase (2.1°).

3.2 Outcomes based approach

The stormwater and flooding considerations are based on an indicative design and proposed designation boundary which incorporate flexibility for design changes to respond to the future environment. The effects assessment is based on the Project being able to meet the requirements of the proposed designation condition and provide any required mitigation within the designation boundary.

The proposed condition requires the Project be designed to achieve the following outcomes:

- No increase in flood levels for existing authorised habitable floors that are already subject to flooding (that is, no increase in flood level where the flood level using the pre project model scenario is above the habitable floor level)
- No more than a 10% reduction in freeboard for existing authorised habitable floors (that is, if existing freeboard was 500mm, an acceptable change would be to reduce freeboard to 450mm)
- No increase of more than 50mm in flood level on land zoned for urban or future urban development where there is no existing habitable dwelling

- No new flood prone areas (with a flood prone area defined as a potential ponding area that relies on a single culvert for drainage and does not have an overland flow path)
- No more than a 10% average increase of flood hazard (defined as flow depth times velocity) for main access to authorised habitable dwellings.

Compliance with the recommended flooding outcomes, secured by the proposed condition, will ensure that potential flooding effects will be negligible up to minor and appropriately managed.

Where the above outcomes can be achieved through alternative measures outside of the designation such as flood stop banks, flood walls and overland flow paths, this may be agreed with the affected property owner and Auckland Council.

This assessment identifies where flood effects require consideration and the types of mitigation measures that could be implemented to address the effect. The designation boundary has been confirmed to provide sufficient land to accommodate those potential mitigation measures identified.

Compliance with these flooding outcomes would be demonstrated through a detailed stormwater design and further flood modelling of the pre-development and post-development 100year ARI flood levels (with allowances for full development according to the AUP:OP zonings with associated imperviousness and climate change) at the resource consent stage.

3.3 Desktop Assessment

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

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

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

- Whenuapai Structure Plan
- Auckland Unitary Plan Operative in Part
- Auckland Council GIS resources (Auckland GeoMaps)
- Design Drawings
- Flood maps created by the SGA modelling team
- Indicative Construction Methodologies
- NZTA Stormwater Specification P46
- New Zealand Bridge Manual (SP/M/022) for freeboard allowance.

A full list of references is provided in Section 13.

3.4 Flood Modelling

3.4.1 Stormwater Catchment Overview

The projects are situated within the Whenuapai stormwater catchment. The catchment size is 1,931Ha and is drained by numerous creeks and streams, including Brigham Creek that forms the area's north-western boundary and Waiarohia Inlet which forms the area's north-eastern boundary. The catchment has two primary stream catchments, namely Totara Creek flowing to Brigham Creek and Waiarohia Stream flowing to the Waiarohia Inlet.

Other major streams in the northern part, namely Riverlea Stream, Ratara Stream and Orchard Stream and in the southern part namely, Waiarohia Stream which feed into the Upper Waitematā Harbour via Brigham Creek and Totara Creek and other tidal inlets.

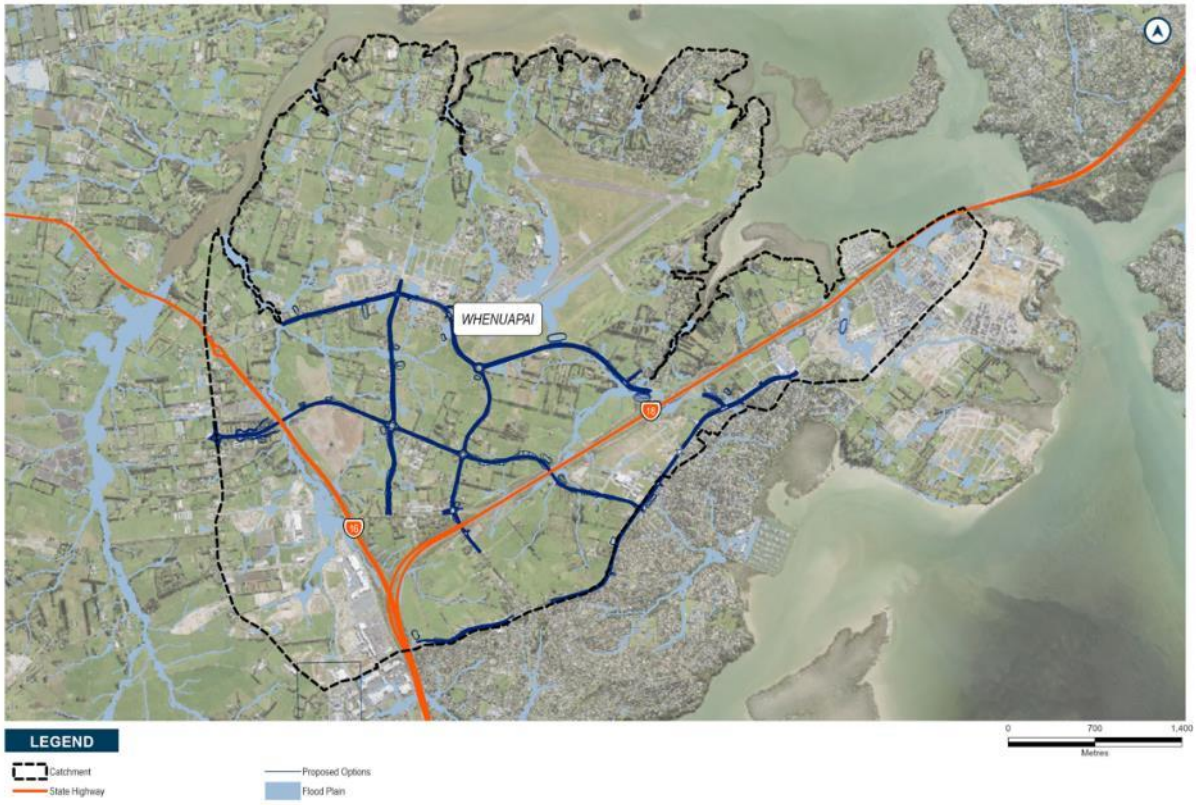

Figure 3-1: Existing 100year ARI flood plain for Whenuapai Catchment (Auckland Council GIS)

3.4.2 Modelling Parameters

Auckland Council had produced a Whenuapai Rapid Flood Hazard Assessment catchment model which was adapted for this assessment. To assess the flooding effects of the Projects on the Whenuapai catchment two scenarios were considered for each NoR.

The two scenarios modelled for the assessment of effects are:

Scenario 1: pre-development

- Future 100year ARI rainfall event with 2.1°C of warming and future land-use without the project in place

Scenario 2: post-development

- Future 100year ARI rainfall event with 2.1°C of warming and future land-use with the project in place

For the sensitivity analysis a further two scenarios were modelled:

Scenario 3: pre-development increased climate change

- Future 100year ARI rainfall event with 3.8°C of warming and future land-use without the project in place

Scenario 4: post-development increased climate change

- Future 100year ARI rainfall event with 3.8°C of warming and future land-use with the project in place
- The proposed imperviousness for the maximum probable development (MPD) land use was applied i.e. the model assumes the maximum impervious surface limits of the current zone or, if the land is zoned Future Urban in the Auckland Unitary Plan, the probable level of development arising from zone changes.

The modelling used an indicative design for the road which is not the final design. The type and size of cross drainage structures are not fixed and will be assessed further for subsequent regional consenting and design phases. Changes to these structures will alter the model outputs and upsizing the crossings may be required to reduce upstream and downstream flood risk.

The models include the existing roads and existing culverts where the culverts are 600mm or greater and details could be located. In the models existing culverts < 600 mm diameter are considered to be fully blocked although larger culverts are considered to be fully working. This approach is a refinement of the AC rapid flood hazard modelling approach where pipes smaller than 1,200mm are excluded from the model. The reason for selecting 600mm is that the risk of blockage is much greater.

New culverts have been added to convey flows at existing overland flow paths that are crossed by new road alignments and some existing culverts have been extended to allow for the proposed road widening. To extend the culverts the existing grade has been extrapolated and the inlet and outlet invert levels have been established.

New bridges are incorporated into the model by leaving a gap in the terrain to replicate the bridge opening. Piers are not modelled specifically.

3.4.3 Climate Change

Climate change is accounted for in the model runs as per the revised Auckland Council (AC) Code of Practise (CoP) version 3 dated January 2022, which allows for 2.1°C of warming and a 16.8% increase on rainfall. A sensitivity analysis to understand the risk of climate change by comparing the results of 2.1°C of warming to 3.8°C of warming see Section 3.5.

The modelling outputs were used to identify changes in predicted flood water levels and flooding extents. Increased flood hazard is associated with higher risk effects, for example a change in flood water level on land can result in the loss of use of the land or a reduction in the performance of drainage systems.

The assessment criteria for the flooding assessment are shown in Table 3-1.

Table 3-1: Flooding effects assessment criteria

Effect	Change in flood water level on neighbouring property	Change in flood water level at habitable buildings
Positive	A reduction in flood level	A reduction in flood level
Negligible	Less than 0.05 m	Less than 0.05 m
Minor	0.05m to 0.5 m	0.05m to 0.15 m
Moderate	Greater than 0.5 m	Greater than 0.15 m

For more vulnerable land uses, including dwellings, if less than 0.5m freeboard is available there is a greater risk of damage to property. The effects of properties identified as potentially at risk of flooding considers the flood water level only. Surveyed floor levels of the existing habitable buildings are not available and should be done during the detailed design stage.

The required freeboard for bridges and culverts used to assess the suitability of the indicative design is set out in Table 3-2.

Table 3-2 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

3.4.4 Future Urban Zone

Development within the FUZ areas will change catchment hydrology, the terrain, building and property types that are potentially exposed to flooding. The assessment has therefore considered specific effects on existing properties and more generally considered effects on potential future development. It is anticipated that future developments will take account of flood risk and manage that risk within their development.

The model does not include the additional runoff generated by the increased impervious area from the new road as stormwater devices have been designed to adequately capture this additional runoff (see

Section 3.6). However, the model does account for the increased impervious area as a result of development within the FUZ area.

Hence, the model output incorporates a high degree of conservatism around future flood effects as it is anticipated that future developments outside the designation will need to design, construct and operate their own stormwater devices to ensure they can mitigate the stormwater generated by additional impervious areas to the pre-development scenario.

It is expected that coordination and integration of the corridor design with FUZ development will be required to confirm and address potential future effects. Mitigation measures in the future detailed design will reflect the actual development in the FUZ areas. See Section 3.4.4.1 for more detail of the limitations of this assessment.

3.4.4.1 Model Limitations

All of the corridors have upstream and/or downstream catchments in the FUZ area. The modelled scenarios use imperviousness assumptions associated with the future land use(s) shown in the Auckland Plan, Whenuapai Structure Plan and relevant Precinct Plans. However, it is probable that significant change in the catchments will take place before or shortly after the corridor is constructed. Therefore, it is expected that further modelling will be required during the corridor detailed design phase to take account of catchment characteristics at that time.

Rapid Flood Hazard Assessment models have a relatively coarse terrain grid and do not include stormwater drainage pipes smaller than 600mm diameter. Culverts have been added at selected crossings of the project corridors. However, the results from the models are considered appropriate to assess the relative or overall flooding effects due to the project corridors for the current stage of design.

The SGA design model is based on a preliminary design. The new culverts and bridges are indicative they may not be the final solution as this will be determined by the detailed design. Future modelling will be used to ensure flood effects will be adequately mitigated and flood neutrality can be achieved.

The culvert sizes are an initial estimate used to assess the relative effects of flooding outside the corridors. Larger culverts can be constructed if required to mitigate effects with the size or levels of service. New or upgraded culverts will be confirmed at the detailed design stage and will consider matters such as consent requirements, asset owner requirements, level of service, stream simulation design, fish passage, blockage.

3.5 Sensitivity Analysis

Sensitivity is the degree to which a system is affected, adversely or beneficially, by a given exposure[3]. In this instance the sensitivity of the designation to increased rainfall as a result of climate change has been considered.

As set out in Section 3.4.3 the flood model has allowed for 2.1°C of warming and a 16.8% increase on rainfall based on the AC CoP. However, given the uncertainty of climate change effects in the future

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

the assessment has also considered a more severe climate change scenario based on 3.8°C of warming and a 32.7% increase on rainfall.

The results for 3.8°C of warming have been compared to those reported in the flood assessment for 2.1°C of warming and areas where higher rainfall may increase flooding risk have been identified. Further mitigation at these locations has been included where necessary to encourage flood resilience.

In the future it is possible there may be different requirements for climate change, however, at this time a pragmatic approach has been taken and the sensitivity analysis has been prepared to better understand the risk of climate change and enable decision makers to respond to this.

3.6 Stormwater devices

While stormwater effects apart from flooding are not assessed, provision is made for the future management of potential stormwater effects (stormwater quantity and stormwater quality) by identifying the space required for stormwater management devices (SWMDs, i.e. treatment swale and wetlands) and incorporating land for that purpose into the NORs. In identifying the land required for these devices, preliminary sizing and siting has been undertaken and extra space allowed for constructing the works.

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

- Wetlands are sized to attenuate 100 year peak flows from the corridor (as of the required stormwater wetland sizing criteria this gives the largest footprint). Quality and retention/detention requirements are able to fit within the footprint
- Allowance is made for wetland attenuation storage and hydraulic gradients from corridor inlet to discharge point (typically a minimum of 2.0 to 2.5m vertically)
- Wetland geometry and footprints were modelled to determine the required cut and fill and a 15m buffer added for construction purposes and maintenance access
- A minimum 6m buffer is provided around the corridor earthworks extents to provide space for construction purposes and allow for works such as drainage channels and culvert inlets/outlets and flexibility in the vertical alignment
- Diversion channels are identified where they are needed to prevent upstream flooding.

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

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

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

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

4 Projects Overview

An overview of the Whenuapai Assessment Package is provided in Figure 4-1 below, with a brief summary of the projects provided in Table 4-1 below.

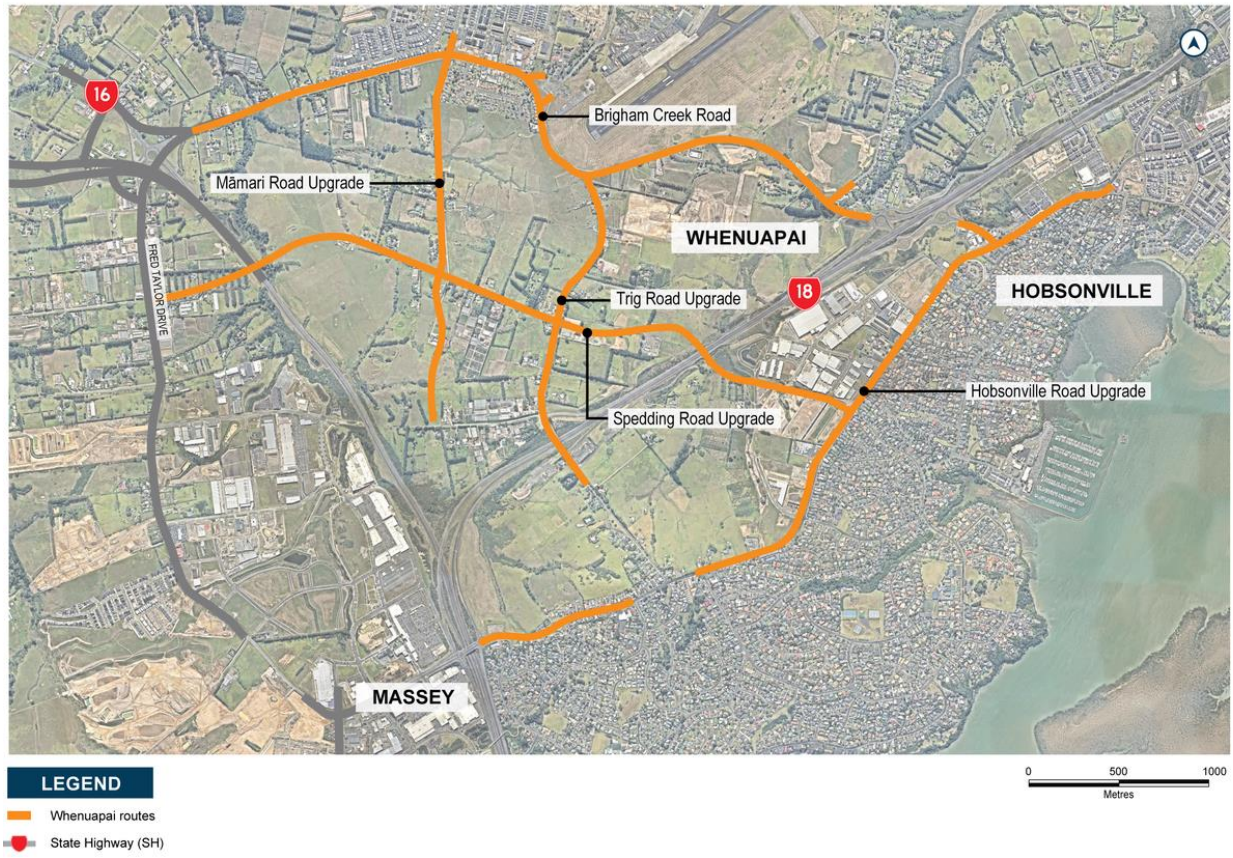

Figure 4-1: North West Projects – Overview of NoRs for Assessment

Table 4-1: Projects Project Summary

Corridor	NOR	Description	Requiring Authority
Trig Road North	NoR W1	Upgrade of Trig Road corridor to a 24m wide 2 lane local arterial cross-section with separated cycle lanes and footpaths on both sides of the corridor	Auckland Transport
Māmari Road	NoR W2	Upgrade of Māmari Road corridor to a 30m urban arterial cross-section Frequent Transit Network (FTN) with separated cycle lanes and footpaths on both sides of the corridor	Auckland Transport
Brigham Creek Road	NoR W3	Upgrade of Brigham Creek Road to a 30m wide four-lane arterial cross-section with walking and cycling facilities on both sides	Auckland Transport

Corridor	NOR	Description	Requiring Authority
Spedding Road	NoR W4	Spedding Road West: the upgrade of the existing Spedding Road and new extension of Spedding Road to a 24m wide two-lane arterial with separated active modes. Spedding Road East: A new extension of Spedding Road to a two-lane arterial with separated active modes. Note the NoR extends the length of Spedding Road East and West.	Auckland Transport
Hobsonville Road (alteration to existing designation 1437)	NoR W5	To alter the existing Hobsonville Road designation 1437 to allow for the proposed widening of the Hobsonville Road corridor: Upgrade of sections of Hobsonville Road to accommodate a 30m wide four-lane cross section with separated cycle lanes and footpaths on both sides of the corridor, and Upgrade of sections of Hobsonville Road to accommodate a 24m wide two-lane cross section with separated cycle lanes and footpaths on both sides of the corridor.	Auckland Transport

Please refer to the AEE for further information on these projects, including a project description, key project features and the planning context.

5 Summary of Modelling Results

A summary of the operational effects for each of the corridors is set out in Table 5-1 below and discussed in more detail in Section 8.

Indicative mitigation measures have been provided in in Section 8 which will minimise flooding effects and help enable the outcomes set out in Section 3.2 to be met. The outcomes generally reflect a negligible up to minor flood effect i.e. <0.05m increase in flood depth.

The outcomes set out in Section 3.2 will form part of the designation conditions and compliance with those conditions will ensure the residual flood effects for all NoRs will be negligible up to minor.

Table 5-1: Summary of flood modelling results

Corridor name	Location	Potential effect without mitigation	Potential effect with implementation of the recommended flooding outcomes
NoR W1	n/a	n/a	No more than 0.05 m increase in flood level, Negligible up to minor effect
NoR W2	41-43 Brigham Creek Road (Chainage 340, Point 42 in Figure 10-1) Existing overland flow path	+0.17 m increase in flood level Minor effect	No more than 0.05 m increase in flood level, Negligible up to minor effect
	Adjacent to 9 Spedding Road (Chainage 120 Māmari South, Points 9 and 10 in Figure 10-2)	+0.28 m upstream, +0.40 m downstream, Minor effect upstream and downstream Design road level is outside of flood plain	No more than 0.05 m increase in flood level, Negligible up to minor effect
	Adjacent to 7 Spedding Road (Chainage 380 Māmari South, Points 11 and 12 in Figure 10-2)	+0.71 m upstream, +0.03 m downstream, Moderate effect upstream, negligible effect downstream Design road level is outside of flood plain	No more than 0.05 m increase in flood level, Negligible up to minor effect
NoR W3	Adjacent to 36 Brigham Creek Road (Chainage 1260, Points 1 and 2 in Figure 11-1)	+0.03 m upstream, -0.02 m downstream, Negligible effect upstream and positive effect downstream Design road level is outside of flood plain	No more than 0.05 m increase in flood level, Negligible up to minor effect
	Adjacent to 141 Brigham Creek Road (Chainage 2700, Points 36 and 37 in Figure 11-1)	+0.24 m upstream, -0.18 m downstream, Minor effect upstream, positive effect downstream Design road level is outside of flood plain	No more than 0.05 m increase in flood level, Negligible up to minor effect

Corridor name	Location	Potential effect without mitigation	Potential effect with implementation of the recommended flooding outcomes
	Adjacent to 150-152 Brigham Creek Road (Chainage 3620, Points 3 and 4 in Figure 11-2)	-0.02m upstream, +0.16m downstream Positive effect upstream and minor effect downstream Design road level is outside of flood plain	No more than 0.05 m increase in flood level, Negligible up to minor effect
	162 Brigham Creek Road (Chainage 3980, Points 27 and 29 in Figure 11-3)	-1.1m upstream, +0.15m downstream Positive effect upstream and minor effect downstream Design road level is outside of flood plain	No more than 0.05 m increase in flood level, Negligible up to minor effect
	Point BR3 (Figure 11-3) Building/ house/ driveway	+0.14 m Minor effect	No more than 0.05 m increase in flood level, Negligible up to minor effect
NoR W4	Adjacent to 27 Trig Road (Chainage 800, Spedding Rd East, Points 21 and 22 in Figure 12-2)	0.00m upstream, 0.00m downstream No effect upstream and downstream	No more than 0.05 m increase in flood level, Negligible up to minor effect
	Adjacent to 14 Spedding Road (Chainage 1080, Spedding Rd West, Points 38 and 39 in Figure 12-3)	+0.17m upstream, -0.57m downstream Minor effect upstream, positive effect downstream Design road level is outside of flood plain	No more than 0.05 m increase in flood level, Negligible up to minor effect
	Point SW1 (Figure 12-3) Building / house, driveway	+0.06 m Minor effect	No more than 0.05 m increase in flood level, Negligible up to minor effect
	Adjacent to 6 Rawiri Place (Chainage 1040, Spedding Rd East, Points 23 and 24 in in Figure 12-2)	+0.01m upstream, +0.03m downstream Negligible effect both upstream and downstream	No more than 0.05 m increase in flood level, Negligible up to minor effect
	Adjacent to 49 Trig Road (Chainage 300 Spedding Rd East, Points 15 and 16 in Figure 12-4)	+0.93m upstream, +0.15m downstream Moderate effect upstream, minor effect downstream Design road level is outside of flood plain	No more than 0.05 m increase in flood level, Negligible up to minor effect
	Westpoint Drive (Chainage 1180, Spedding Rd East, Points 25 and 26 in Figure 12-2)	+0.20m upstream, +0.09m downstream Minor effect upstream and downstream Design road level is outside of flood plain	No more than 0.05 m increase in flood level, Negligible up to minor effect

Corridor name	Location	Potential effect without mitigation	Potential effect with implementation of the recommended flooding outcomes
NoR W5	283 Hobsonville Road (Chainage 3060, Point 32 and 33 in Figure 13-1)	+0.16m upstream, -0.08m downstream Minor effect upstream and positive effect downstream Design road level has the potential to overtop	No more than 0.05 m increase in flood level, Negligible up to minor effect
	Intersection of Hobsonville Road and Brigham Creek Road (Chainage 3800, Point 30 and 31 in Figure 13-1)	+0.47m upstream, -0.02m downstream Minor effect upstream, positive effect downstream Design road level is outside of flood plain	No more than 0.05 m increase in flood level, Negligible up to minor effect
	Point HR6 (Figure 13-2) Building / house	+0.23 m Moderate effect	No more than 0.05 m increase in flood level, Negligible up to minor effect

6 Positive Effects

The positive effects for projects are those where the predicted 100year ARI flood level difference map shows a decrease in water levels and an increase in freeboard for bridges, culverts and habitable buildings using the criteria set out in Table 3-1 and Table 3-2. There are positive flooding effects for NoR W2 – NoR W5. NoR W1 does not have any identified positive flooding effects.

Positive flooding effects for the projects include raising the existing road levels which will have a positive effect for road users by preventing flood flows across the road and reducing flood hazard.

Where new bridges are proposed, the maximum freeboard requirement has been adopted to provide flood resilience. The positive effects from the proposed new bridges identified by the model include:

- All proposed new bridges have a freeboard of 1.2 m, including over Sinton Stream, Waiarohia Stream, Trig Stream, Rawiri Stream and Totara Creek.
- New bridges over Sinton Stream, Waiarohia Stream, Trig Stream which have been confirmed to increase the freeboard for the road and decrease water levels upstream and downstream of the bridge crossing for the 100year ARI flood level.
- The new bridge over Totara Creek will increase the freeboard for the road but will not affect water levels upstream and downstream of the bridge crossing the 100year ARI flood level.

The projects create the opportunity to improve existing culvert capacities and/or propose new culvert crossings to improve overland and stream flow in the area. For example, following the Hobsonville Road upgrade and the extension of the culvert crossing and new inlet the flood levels at surrounding properties zoned for future urban land are lower compared to the pre-development flood levels.

It is noted that the proposed culverts and bridges form part of the indicative design and the final design may include different crossings. The final design will be subject to further flood modelling at

the detailed design stage. The final design will ensure that adequately mitigated and flood neutrality can be achieved.

7 Construction Effects

Construction effects apply to the entire project, however, are more likely at locations within or adjacent to overland flows or flood prone areas, the proposed construction works which could result in flooding effects include:

- Construction of new culvert crossings or upgrading of existing culvert crossings
- Construction of new bridges over streams or overland flow paths
- Installation of diversion drains / realignment of existing overland flow paths
- Construction of new dry ponds or wetlands / upgrading of existing dry ponds or wetlands
- Temporary use of lay down areas.

These effects are particularly for NoR W1, NoR W3 and NoR W5 where there is an increased flood risk for the proposed construction works. The potential effects of these are:

- Bulk earthworks to complete the contouring for new landscape features e.g., dry ponds or stormwater wetlands and new or upgraded culverts require a dry works area and can alter overland flow paths or generate erosion and sediment effects
- The construction of new bridges over streams will require temporary staging platforms for piling rigs and cranes to be constructed on the banks and possibly over the stream bed and potentially causing a constriction to flood flows and raising upstream flood levels
- The siting of dry ponds or stormwater wetlands within an existing overland flow path can obstruct runoff and result in flows being diverted towards existing properties.

Section 7.1 below describes methods for minimising/mitigating these potential effects.

7.1 Recommended Measures to Minimise, Remedy or Mitigate Construction Effects

The management and mitigation measures for construction effects are:

General:

- Carrying out earthworks during the summer / dry months to reduce the risk of flooding
- Locating lay down areas outside of existing overland flow paths
- Managing the overland flow paths to make sure flows are not diverted toward existing buildings or properties
- Construction Environmental Management Plan (CEMP) be developed prior to construction by an experienced Stormwater Engineer and shall consider the effects of temporary works, earthworks, storage of materials and temporary diversion and drainage on flow paths, flow level and velocity. Including:
  - Siting construction yards and stockpiles outside the flood plain
  - Diverting overland flow paths away from area of work
  - Minimizing 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 high flow events

- Methods to reduce the conveyance of materials and plant that is considered necessary to be stored or sited within the flood plain (e.g., actions to take in response to the warning of heavy rainfall events).

Construction of new and existing culvert crossings, stormwater wetlands and dry ponds:

- Existing culvert extensions should be done prior to commencement of bulk earthworks to allow for the passage of clean water across the site
- Installing temporary diversions or to allow flows to be maintained while new culverts, stormwater wetlands and dry ponds are constructed
- For larger embankments requiring a longer duration of works or for overland flow paths with more regular and higher flow rates diversions should be installed prior to works commencing
- Where no diversion is required a 6m working clearance between any earthworks and designation boundary should be adopted to accommodate access and materials
- For larger diameter pipes a working clearance of ± 20m from the upstream extent and ± 15m from the downstream extents should be provided.

Construction of new bridges:

- Temporary platforms should generally be set back as far as practicable from the stream banks and main channel to minimise the risk of flooding
- Staging of earthworks for the abutments and stockpiling of materials outside the flood plain to mitigate the potential for blocking flow paths and flood plains.

8 Operational Effects

There are a range of operational effects particularly from proposed new bridges and crossings. The model is based on an indicative design which will respond to the future environment, and it may be that some of these structures are modified in the future. Future detailed design will be subject to a separate flooding assessment at the resource consent stage. For the project the assessment of operational flooding effects considered:

- New culvert crossings (≥ 600 mm diameter)
- New bridge structures at Sinton Stream, Waiarohia Stream, Trig Stream, Rawiri Stream and Totara Creek
- Significant areas where the new road embankment encroaches existing flood prone areas
- The extent of flooding on existing properties due to the new project corridor

The effects of these are:

- Increasing impervious areas resulting in increased runoff and potentially increased flood levels
- Altering existing overland flow paths resulting in flows being redirected towards existing properties
- Obstructing an existing overland flow path resulting in ponding at existing low Points or newly created depressions along the corridor
- Improving flows under the road reducing upstream flood levels and increasing flood levels at properties further downstream.

The new bridge structures resulted in positive effects (see Section 6). For the culverts the effects were considered to be negligible to moderate prior to mitigation. This includes NoR W2, NoR W3, NoR W4 and NoR W5 (see Table 5-1).

The mitigation measures set out in Section 8.1 have been designed to assist in minimising flood effects. There are a range of potential mitigation measures that can be applied and additional modelling during detailed design will consider which measures are most appropriate to ensure adverse flood effects are minimised, remedied or mitigated. The detailed design would then need to demonstrate compliance with outcomes set out in Section 3.2 as required by an appropriate condition of consent.

8.1 Recommended Measures to Minimise, Remedy or Mitigate Operational Effects

It is recommended that during detailed design additional flood modelling is carried out and mitigation measures implemented as required to achieve the outcomes set out in Section 3.2. Compliance with these outcomes will be required as a condition of consent. Based on the interim design potential mitigation measures have been identified in order to show that the feasibility to meet these outcomes has been considered.

Mitigation measures which may be implemented include:

- Creating new overland flow path diversions to discharge to nearby overland flow paths or streams to mitigate ponding and decrease flood levels at affected properties
- Increasing culvert sizes so that the upstream and downstream water level differences do not increase by more than 0.05m on land zoned for urban and future urban development
- Upgrading culverts by adding smaller culverts to create a balance between the flood level differences upstream and downstream
- Installing drains at the toe of embankment sloping towards the culverts can also allow for additional storage to decrease the velocity and peak flow through the culvert crossings
- Optimising the proposed bridge span and freeboard during detailed design
- Integrating development design requirements for FUZ upstream and downstream of the proposed corridor.

9 NoR W1: Trig Road North Upgrade

9.1 Project Corridor Features

9.1.1 Catchment Characteristics

The project corridor lies on a ridge with several overland flow paths draining west of the corridor towards Sinton Stream and east of the corridor towards Waiarohia Stream. Existing minor culvert crossings drain the low-lying areas located next to the road.

Existing flood prone areas have been identified from Auckland GeoMaps at Chainage 20 and further downstream of the catchment on the western and eastern side of Trig Road.

The existing cross drainage for this project corridor consists of two culvert crossings. The interim design is based on the existing culverts being upgraded either by upsizing or extending the culverts. The cross-drainage structures for this corridor are smaller than 600 mm and therefore not assessed.

9.2 Existing and Likely Future Environment

9.2.1 Planning Context

The Trig Road corridor runs through an existing rural environment, with the land either side of the Trig Road corridor currently zoned FUZ under the AUPOP. The Whenuapai Structure Plan indicates that the FUZ area land will be re-zoned for Business use.

Table 9-1 below provides a summary of the North West existing and likely future environment

Table 9-1: Trig Road Upgrade Existing and Likely Future Environment

Environment today	Zoning	Likelihood of Change for the environment[4]	Likely Future Environment[5]
Undeveloped greenfield areas	Future Urban Zone	High	Urban
New Zealand Defence Force Air Base	Special Purpose - Airports and Airfields Zone	Low	Urban

Please refer to the AEE for further information on the planning context.

[4] Based on AUPOP zoning/policy direction
[5] Based on AUPOP zoning/policy direction

9.3 Proposed works

Along NoR RW1 it is proposed to upgrade Trig Road from an existing rural two-lane road to a lower-speed urban two-lane arterial. The proposed design includes two general traffic lanes and new facilities for walking and cycling on both sides.

Two stormwater catchments are created along the transport corridor and runoff from the catchment flows into two proposed stormwater wetlands, as shown in the Indicative Design Drawings, for treatment and attenuation.

9.4 Assessment of Flooding Effects and Measures to Minimise, Remedy or Mitigate Actual or Potential Adverse Effects

9.4.1 Positive Effects

There are no positive effects associated with NoR W1.

9.4.2 Assessment of Construction Effects

Potential construction effects have been described in Section 7 above.

9.4.3 Recommended Measures to Minimise, Remedy or Mitigate Construction Effects

Resource consents for diversion and discharge of stormwater and stream works will be sought as part of future resource consent processes.

The potential flooding effects during construction will be considered by, and managed through, flood risk mitigation measures to be set out in the Construction Environmental Management Plan (CEMP).

All other mitigation measures as set out in Section 7.1 apply.

9.4.4 Assessment of Operational Effects

The results for the flood difference map for the 100year ARI range between -0.05m and +0.05m along the Trig Road corridor. Flooding risk associated with the Project is therefore negligible.

9.4.5 Recommended Measures to Minimise, Remedy or Mitigate Operational Effects

No specific measures have been identified as there is only a small risk of flooding from culvert blockages. All other mitigation measures as set out in in Section 8.1 apply. The detailed design will still need to demonstrate compliance with the outcomes set out in Section 3.2 as required by the conditions of consent.

9.5 Conclusions

The potential construction flooding effects can be appropriately managed with the measures set out in Section 7.1 and with a CEMP addressing flood risk in place, flooding effects will continue to be negligible.

Based on the results of the flood modelling the Trig Road upgrade will have a negligible effect on flooding. To mitigate operational flood effects recommended mitigation measures set out in Section 8.1 should be adopted.

10 NoR W2: Māmari Road Upgrade

10.1 Project Corridor Features

10.1.1 Catchment Characteristics

The corridor crosses two streams, Sinton Stream and Pikau Stream, and an existing pond west of Māmari Road South that discharges in Pikau Stream.

The 100year ARI flood maps from the model with MPD and existing terrain show existing flooding issues at the proposed culvert crossings, Sinton Stream bridge crossing and flooding of properties upstream of Ngahue Crescent, Whenuapai.

10.2 Existing and Likely Future Environment

10.2.1 Planning Context

The northern section of Māmari Road to Spedding Road is an existing road corridor (although a section of the road is a ‘paper road’). The eastern side of this section is predominantly zoned under the AUPOP as FUZ, with a portion of Residential – Single House Zone. The western side of this section is also predominantly FUZ. The Whenuapai Structure Plan indicates that the FUZ land will be re-zoned medium residential to the north (east side of Māmari only) and business to the south.

Table 10-1 below provides a summary of the North West existing and likely future environment.

Table 10-1: Māmari Road Existing and Likely Future Environment

Environment today	Zoning	Likelihood of Change for the environment[6]	Likely Future Environment[7]
Residential	Residential	Low	Residential
Undeveloped greenfield areas	Future Urban	High	Urban
Timatanga Community School	Special Purpose - School Zone	Low	Urban

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

[7] Based on AUP:OP zoning/policy direction

Please refer to the AEE for further information on the planning context.

10.3 Proposed works

The project proposes that the function of Māmari Road will change from an existing rural two-lane road to an urban four-lane arterial. The proposed design includes the same number of general traffic lanes (two), with two bus lanes, and new facilities for walking and cycling.

Other proposed works in NoR W2 which can result in flooding effects include:

- Construction of a new bridge over Sinton Stream
- Construction of a new culvert crossings at Chainages 120, 380 and 560 (Māmari South)
- Construction of a diversion drains / realignment of existing overland flow paths
- Construction of three new dry ponds

Additional flood storage using attenuation ponds is required for NoR W2 to attenuate and discharge the 100year ARI pre-development peak flow. Stormwater catchments and features are shown in the Indicative Design Drawings.

10.4 Assessment of Flooding Effects and Measures to Minimise, Remedy or Mitigate Actual or Potential Adverse Effects

10.4.1 Positive Effects

10.4.1.1 Sinton Stream Bridge

The proposed 95m Sinton Stream bridge spans across a 60m wide 100year ARI flood plain with bridge piers set outside the main channel.

The results show a reduction in the predicted water level of RL 17.52m (-0.16m) upstream and to RL 16.77m (-0.04m) downstream (refer to Points 19 and 20 in Figure 8-1). The structure has a freeboard of ± 1.44m between the 100year ARI flood level and bridge soffit. There are no flood effects on any nearby buildings under the post-development scenario. Overall, the effects of the bridge on flood hazards are considered positive.

It should be noted that the overland flow, impeded by the proposed corridor upgraded between Chainage 660 and 820, is not able to discharge into Sinton Stream and can create ponding. Despite this, as noted above, the freeboard between the soffit level and 100year ARI flood level is adequate.

10.4.2 Assessment of Construction Effects

Potential construction effects have been described in Section 7 above.

Stream crossings are key sites for potential flooding effects during construction, this includes:

- Sinton Stream
- Existing overland flow path at Chainage 340 Māmari North

10.4.3 Recommended Measures to Minimise, Remedy or Mitigate Construction Effects

Resource consents for diversion and discharge of stormwater and stream works will be sought as part of future resource consent processes. Various culverts need to be installed or upgraded. There could be increased flood levels or new flow paths created during construction if adequate flow diversions are not provided.

The potential flooding effects during construction will be considered by, and managed through, flood risk mitigation measures to be set out in the Construction Environmental Management Plan (CEMP).

All other mitigation measures as set out in Section 7.1 apply.

10.4.4 Assessment of Operational Effects

10.4.4.1 Māmari Road North

An existing overland flow path adjacent to 41-43 Brigham Creek Road (Chainage 340, Point 42 in Figure 10-1) is obstructed by the corridor upgrade causing water to pond upstream. The flood difference map shows an increase in flood level between 0.05m and 0.5m which is considered a minor effect. However, the difference between the proposed road RL and the 100year flood level is 0.67m providing adequate freeboard > 0.5m. The effect could potentially be minimised by refining the size of the culvert during detailed design.

Figure 10-1: 100year flood difference map for Māmari Road (North) and Sinton Stream bridge crossing

10.4.4.2 Māmari Road South

The new proposed culvert crossing near 9 Spedding Road, Whenuapai (Chainage 120, Māmari Road South) shows an increase in the 100year ARI flood level upstream and downstream of the crossing. The level between the road level centre line and the flood level is ± 2.72m freeboard which is above the ± 0.5m freeboard required over a culvert. The flood difference map shows an increase between

0.05m and 0.5m upstream and downstream which is considered a minor effect (Point 9 and Point 10 in Figure 10-2).

The new proposed culvert crossings near 7 Spedding Road (Chainage 380 Māmari South) and 80 Trig Road, Whenuapai (Chainage 560 Māmari South) show an increase in the 100year ARI flood levels upstream and downstream of the crossings. The flood difference map shows an increase greater than 0.5m upstream which is considered a moderate effect and less than 0.5 and 0.05 downstream which is considered minor and negligible effect (Point 11 and Point 12 in Figure 10-2). However, the level between the road level centre lines and the flood levels are 2.4m and 1.85m respectively, resulting in adequate freeboard.

These effects can potentially be minimised by designing the culverts to achieve flood neutrality during the detailed design phase. This is possible within the current designation boundary and a final solution can be addressed at a future stage of design.

Figure 10-2: 100year flood difference map for Māmari Road (South)

10.4.5 Recommended Measures to Minimise, Remedy or Mitigate Operational Effects

The potential mitigation measures could be adopted as set out in Section 8.1. Specifically, the following has been considered:

- Diverting the existing overland flow path at the northern section of Māmari Road to discharge to Sinton Stream.
- Upsizing culverts in the southern section of Māmari Road so that the upstream and downstream water level differences do not increase by more than 0.05m on land zoned for urban and future urban development.

While the potential operational effects were assessed as moderate these are likely to be significantly reduced with the mitigation measures above. Further assessment at the detailed design stage can be used to confirm the potential effects following mitigation.

Compliance with the recommended flooding outcomes set out in Section 3.2 to be included in the designation conditions, will ensure that potential flooding effects will be negligible up to minor and appropriately managed.

10.5 Conclusions

No increased risk from flooding was identified during the assessment of construction effects and flood effects will be managed as set out Section 7.1.

The assessment of operational effects found negligible to moderate flood effects during the operational phase of the corridor.

Effects could be mitigated by providing new channels or drains next to corridor to increase attenuation and lower the peak flow and diverting flows to discharge to new inlet/pipe. Mitigation will be confirmed at detailed design stage.

Potential flooding effects can be appropriately managed and will be negligible up to minor effect subject to the recommended design outcomes and conditions outlined in set out in Section 3.2 of this report being met.

11 NoR W3: Brigham Creek Road Upgrade

11.1 Project Corridor Features

11.1.1 Catchment Characteristics

The corridor crosses several overland flow paths and the Waiarohia Stream. Existing flood prone areas from Auckland GeoMaps are evident where overland flow paths and streams traverse the road. The 100year ARI flood maps from the model show existing flooding issues at the proposed culvert crossings and flooding of properties at: 36, 41-43, 44-48, 45, 115, 117, 119, 121 and 141 Brigham Creek Rd. The existing culvert crossing over Waiarohia Stream shows overtopping of the road.

11.2 Existing and Likely Future Environment

11.2.1 Planning Context

The land adjacent to the majority of Brigham Creek Road is zoned under the AUP:OP as FUZ, except within the Whenuapai urban area (which is zoned under the AUP:OP as a range of residential and business zones) and the Whenuapai New Zealand Defence Force (NZDF) airbase. The Whenuapai Structure Plan indicates that the FUZ land will be re-zoned mostly medium density residential with an area of high density residential near SH16.

Table 11-1 below provides a summary of the North West existing and likely future environment.

Table 11-1: Brigham Creek Road Upgrade Existing and Likely Future Environment

Environment today	Zoning	Likelihood of Change for the environment[8]	Likely Future Environment[9]
Business	Business (Light Industrial)	Low	Business (Light Industrial)
	Business (Local centre)	Low	Business (Local centre)
Residential	Residential	Low	Residential
Open Space	Open Space –Informal Recreation Zone	Low	Open Space
Undeveloped greenfield areas (Future Urban Zone)	Future Urban	High	Urban
New Zealand Defence Force Air Base	Special Purpose - Airports and Airfields Zone	Low	Special Purpose – Airports and Airfields Zone

Please refer to the AEE for further information on the planning context.

[8] Based on AUP:OP zoning/policy direction
[9] Based on AUP:OP zoning/policy direction

11.3 Proposed works

The project proposes that the function of Brigham Creek Road will change from an existing rural two-lane road to an urban four-lane arterial. The proposed design includes four traffic lanes and new facilities for walking and cycling. The cross section will change along the length of the Brigham Creek Road corridor, reallocating the 30m corridor to best accommodate vehicles, PT, active modes and freight in relation to the adjacent land use.

Other proposed works in NoR W3 which can result in flooding effects include:

- Construction of a new bridge over Waiarohia Stream
- Upgrade of an existing culvert crossing at Chainage 3230
- Construction of new culvert crossings at Chainages 1260, 3620 and 3800
- Construction of diversion drains / realignment of existing overland flow paths
- Construction of a new wetland and two new dry ponds, upgrade of two existing attenuation ponds

Additional flood storage using attenuation ponds is required for NoR W3 to attenuate and discharge the 100year ARI pre-development peak flow. Stormwater catchments and features are shown in the Indicative Design Drawings.

11.4 Assessment of Flooding Effects and Measures to Minimise, Remedy or Mitigate Actual or Potential Adverse Effects

11.4.1 Positive Effects

The proposed new bridge over Waiarohia Stream provides a significant improvement to flood conveyance upstream of the bridge and a decrease in flood levels has been identified through modelling. Upstream of the proposed new bridge shows a reduction of 0.58m in the 100year ARI flood levels post-development and an associated increase in freeboard between the habitable building floor level and the 100year ARI flood level see Section 11.4.4.3.

The 100year ARI flood difference map for the upgraded culvert crossing adjacent to 153 Brigham Creek Road (Point 5 and 6 in Figure 11-2) show a decrease in water levels of -1.97m upstream and -0.22m downstream due to the upsizing of culverts at this location. This will result in positive effects through increasing the freeboard of the road.

11.4.2 Assessment of Construction Effects

Potential construction effects have been described in Section 7 above.

Stream crossings are key sites for potential flooding effects during construction, this includes:

- Waiarohia Stream
- Overland flow path at Brigham Creek Road Chainage 2700

The proposed upgraded Brigham Creek Wetland 1 and Dry Pond 2 are partially encroaching into the existing 100year flood plain

11.4.3 Recommended Measures to Minimise, Remedy or Mitigate Construction Effects

Resource consents for diversion and discharge of stormwater and stream works will be sought as part of future resource consent processes.

The potential flooding effects during construction will be considered by, and managed through, flood risk mitigation measures to be set out in the Construction Environmental Management Plan (CEMP).

All other mitigation measures as set out in Section 7.1 apply.

11.4.4 Assessment of Operational Effects

11.4.4.1 Brigham Creek Road West of Trig Road

The new proposed culvert crossing adjacent to 36 Brigham Creek Road (Chainage 1260) has a negligible effect in terms of increased flood level (see Points 1 and 2 in Figure 11-1). Moreover, there is adequate freeboard (0.67 m).

11.4.4.2 Brigham Creek Road East of Trig Road

Existing overland flow paths on both sides of the corridor adjacent to 141 Brigham Creek Road (Chainage 2700, Points 36 and 37 in Figure 11-1) are impeded by the proposed corridor upgrade, causing the water to pond and flood levels to increase. The increase in flood levels upstream is considered a minor effect (+0.24 m) and the flood level decreases downstream. The detailed design could consider installing new diversion drains on both sides of the corridor to discharge to nearby overland flow paths or streams and a final solution can be addressed at a future stage of design.

Figure 11-1: 100year flood difference map for Brigham Creek Road East of Trig Road

Adjacent to 150-152 Brigham Creek Road (Chainage 3620, Points 3 and 4 in Figure 11-2 flood levels show a decrease in the 100year ARI flood level upstream of the crossing and an increase

downstream which is considered minor (+0.16 m). The road level centre line has a freeboard which is adequate (0.8 m).

Figure 11-2: 100year flood difference map for Brigham Creek Road East of Trig Road

11.4.4.3Waiarohia Stream bridge

The proposed 10m bridge over Waiarohia Stream spans across a ±10m wide 100year ARI flood plain with bridge piers set outside the main river channel. The results for the 100year ARI pre-project development scenario show that the water level at the location of the proposed bridge structure is RL 10.56m upstream and RL 9.03m downstream (refer to Points 27 and 29 in Figure 11-3) with the water overtopping the existing road.

The results for the post-development scenario have the water level decreasing to RL 9.46m (-1.10 m) upstream and increase to RL 9.18m (+0.15 m) downstream (refer to Points 27 and 29 in Figure 11-3). The improved stream flow allows more water to pass through resulting in an increase of water levels of properties further downstream at 162 Brigham Creek Road (refer to Point BR3 in Figure 11-3).

The proposed road design level of RL 13.26m allows for a 1.2m freeboard between the bridge soffit and the 100year ARI flood level. The detailed design should consider optimizing the flood levels upstream and downstream of the cross drainage structure by either revising the proposed bridge span or adding an additional culvert to the existing. This is possible within the current designation boundary.

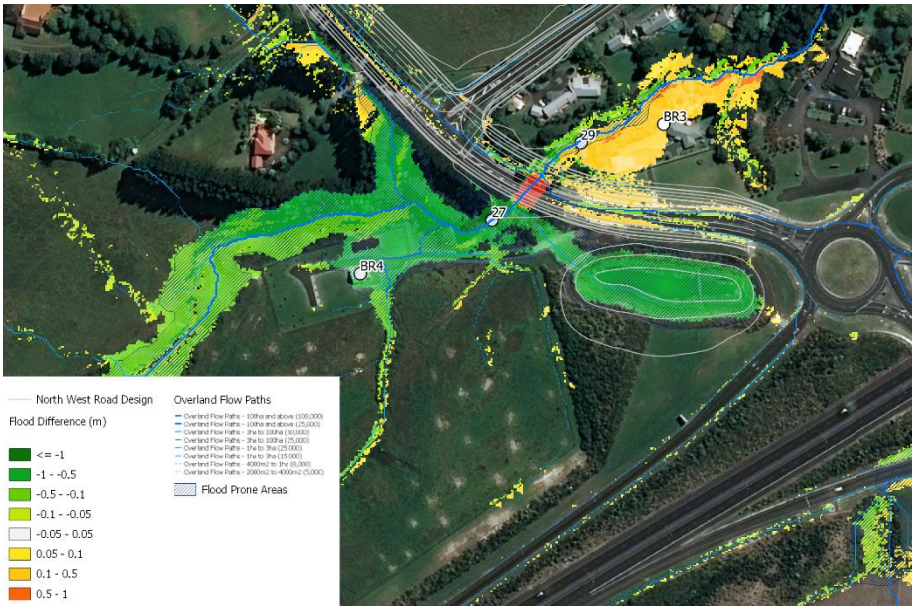

Figure 11-3: 100year flood difference map for Brigham Creek Road and Waiarohia Stream bridge crossing

11.4.5 Recommended Measures to Minimise, Remedy or Mitigate Operational Effects

The potential mitigation measures could be adopted as set out in Section 8.1. Specifically, the following has been considered:

- Creating new overland flow path diversions on both sides of the corridor to discharge to nearby overland flow paths or streams to mitigate ponding and decrease flood levels at affected properties
- Sizing the culvert at 150-152 Brigham Creek Road (Chainage 3620) so that the upstream and downstream water level differences do not increase by more than 0.05m on land zoned for urban and future urban development
- Design check dams in the proposed diversion drain between Chainage 3100 and 3620 to decrease the peak flow towards the culvert inlet adjacent to 150-152 Brigham Creek Road (Chainage 3620)
- Upgrading the culvert at Waiarohia Stream by adding smaller culverts to create a balance between the flood level differences upstream and downstream or optimizing the proposed bridge span and freeboard.

While the potential operational effects were assessed as moderate these are likely to be significantly reduced with the mitigation measures above. Further assessment at the detailed design stage can be used to confirm the preferred mitigation.

Compliance with the recommended flooding outcomes set out in Section 3.2, to be included in the designation conditions, will ensure that potential flooding effects will be negligible up to minor and appropriately managed.

11.5 Conclusions

No increased risk from flooding was identified during the assessment of construction effects and flood effects will be managed as set out Section 7.1.

During operation model results found Brigham Creek Road upgrade will have a minor effect on flooding prior to mitigation measures being applied. The proposed bridge improves the stream flow so that it decreases flood levels upstream, however, by allowing water to travel more easily under the road it is likely to increase the flood levels downstream. Flood effects can be addressed at detailed design stage of the development to require the crossing to minimise flood level differences upstream and downstream.

For other crossings, the increase in flood levels could be mitigated through the measures set out in Section 8.1 including diversion drains, culvert sizes and integrating corridor and upstream development design requirements e.g., requiring buildings to be built with sufficient freeboard. Mitigation will be confirmed at detailed design stage.

Potential flooding effects can be appropriately managed and will be negligible up to minor effect subject to the recommended design outcomes and conditions outlined in set out in Section 3.2 of this report being met.

12 NoR W4: Spedding Road

12.1 Project Corridor Features

12.1.1 Catchment Characteristics

The corridor crosses a number of overland flow paths and three streams, namely Totara Creek, Trig Stream and Rawiri Stream.

Existing flood prone areas from Auckland GeoMaps are evident where overland flow paths and streams traverse the road. The 100year ARI flood maps from the latest Auckland Whenuapai catchment model with MPD and existing terrain show flooding at the proposed Trig Stream bridge crossing, the new culvert crossing at Chainage 1180 and potential flooding of property at 121 Fred Taylor Drive.

12.2 Existing and Likely Future Environment

12.2.1 Planning Context

The land on either side of Spedding Road is zoned under the AUPOP as FUZ, with Business – Light Industry Zone land at the eastern end of the proposed Spedding Road corridor. Proposed Plan Change 5 (PPC5) proposes to rezone the surrounding FUZ land to Business – Light Industry Zone in the north and Residential - Mixed Housing Urban Zone and Open Space – Informal Recreation zone in the south.

Table 12-1 below provides a summary of the North West existing and likely future environment.

Table 12-1: Spedding Road Existing and Likely Future Environment

Environment today	Zoning	Likelihood of Change for the environment[10]	Likely Future Environment[11]
Business	Business (Light Industrial)	Low	Business (Light Industrial)
Residential	Residential	Low	Residential
Undeveloped greenfield areas (Future Urban Zone)	Future Urban	High	Urban

Please refer to the AEE for further information on the planning context.

12.3 Proposed works

[10] Based on AUP:OP zoning/policy direction
[11] Based on AUP:OP zoning/policy direction

The project proposes that the function of Spedding Road will change from an existing rural two-lane road to an urban two-lane arterial. The proposed design includes two general traffic lanes and new facilities for walking and cycling.

Other proposed works in NoR W4 which can result in flooding effects include:

- Construction of new bridges over Totara Creek, Trig Stream and Rawiri Stream
- Construction of new culvert crossing at Chainage 1080, Spedding Road West, and Chainages 80, 300 and 1180, Spedding Road East
- Construction of diversion drains / realignment of existing overland flow paths
- Construction of six new wetlands and upgrading of one existing stormwater pond; Spedding Road East Wetland 3 (shared in NoR W4 and NoR W5)

Additional flood storage using attenuation ponds is required for NoR W3 to attenuate and discharge the 100year ARI pre-development peak flow. Stormwater catchments and features are shown in the Indicative Design Drawings.

12.4 Assessment of Flooding Effects and Measures to Minimise, Remedy or Mitigate Actual or Potential Adverse Effects

12.4.1 Positive Effects

12.4.1.1 Totara Creek bridge

The proposed 255m Totara Creek bridge spans across a 60m wide 100year ARI flood plain with bridge piers set outside the main river channel.

The results for the 100year ARI pre-project development scenario show that the flood level at the location of the proposed bridge structure is RL 14.18m upstream and RL 14.06m downstream (refer to Points 43 and 44 in Figure 12-1). The structure has a freeboard of 7.69m between the 100year ARI flood level and bridge soffit which is above the 1.2m required freeboard. There are no effects on any nearby buildings.

12.4.1.2Trig Stream bridge

The proposed 155m Trig Stream bridge spans across a 60m wide 100year ARI flood plain with bridge abutments / piers set outside the main river channel.

The results for the 100year ARI pre-development scenario show that the flood level at the location of the proposed bridge structure is RL 19.91m upstream and RL 19.82m downstream. Post-development the flood level remains unchanged upstream and downstream (refer to Points 21 and 22 in Figure 12-2).

The structure has a freeboard of 7.26m between the 100year ARI flood level and bridge soffit which is above the 1.2m required freeboard and also crosses over Upper Harbour Motorway. There are no effects on any nearby buildings.

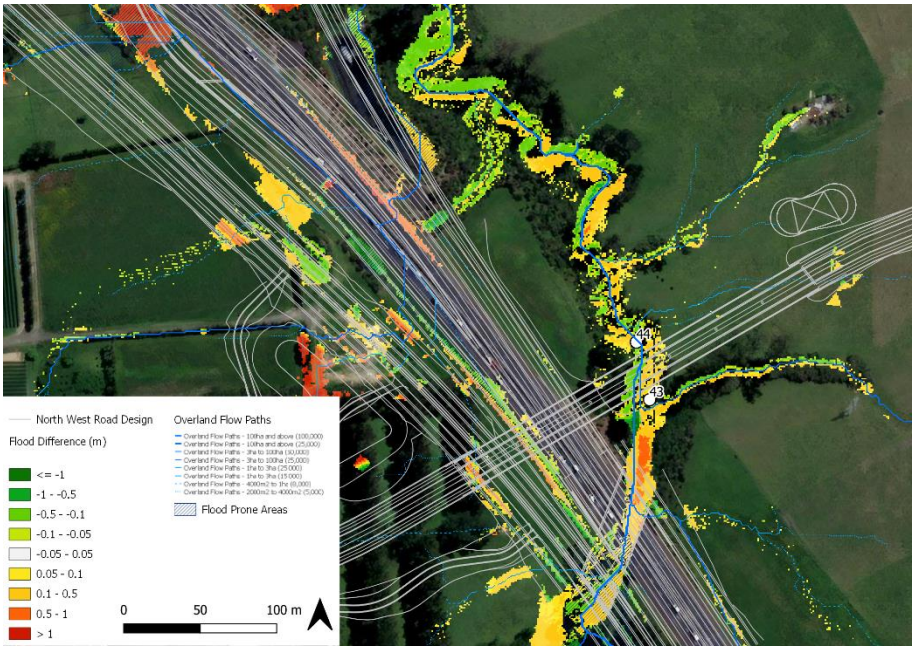

Figure 12-1: 100year flood difference map for Totara Creek Bridge

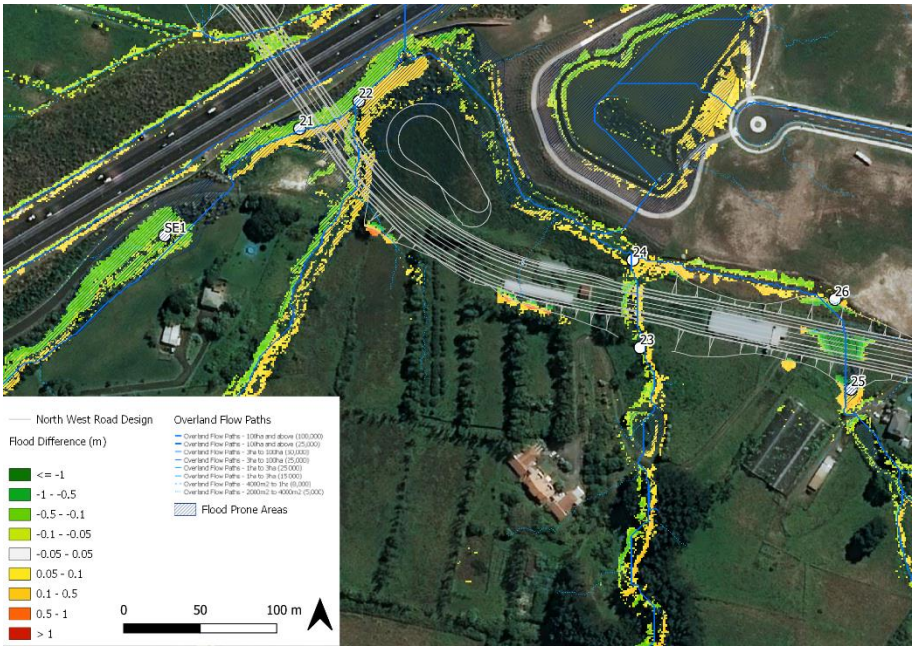

Figure 12-2: 100year flood difference map for Spedding Road East, Trig Stream and Rawiri Stream crossings

12.4.2 Assessment of Construction Effects

Potential construction effects have been described in Section 7 above.

Stream crossings are key sites for potential flooding effects during construction, this includes:

- Rawiri Stream
- Totara Creek

12.4.3 Recommended Measures to Minimise, Remedy or Mitigate Construction Effects

Resource consents for diversion and discharge of stormwater and stream works will be sought as part of future resource consent processes.

The potential flooding effects during construction will be considered by, and managed through, flood risk mitigation measures to be set out in the Construction Environmental Management Plan (CEMP).

All other mitigation measures as set out in Section 7.1 apply.

12.4.4 Assessment of Operational Effects

Spedding Road West culvert crossing

The new proposed culvert crossings adjacent to 14 Spedding Road (Chainage 1080) show an increase of +0.15m in the 100year ARI flood levels upstream of the crossing and a decrease of -0.79m downstream. The 100year flood difference map shows an increase between 0.05m and 0.5m upstream which is considered a minor effect (see Points 38 and 39 in Figure 12-3). The edge of road is the same as the flood level of RL 27.53 m. There is also insufficient freeboard.

There is an existing flooding issue in this area. Despite this not being a designated flood plain or flood prone area depths of flooding in the pre-development scenario are approximately 1.2 m. The installation of additional stormwater infrastructure including a culvert or other cross-drainage will alleviate this flooding. This is possible within the current designation boundary.

Flood levels at 14 Spedding Road (Point SW1 in Figure 12-3) shows an increase in flood level between 50 mm and 150 mm which is a minor effect. Mitigation could include creating a new diversion for an existing overland flow path to connect to the culvert at Points 38 and 39.

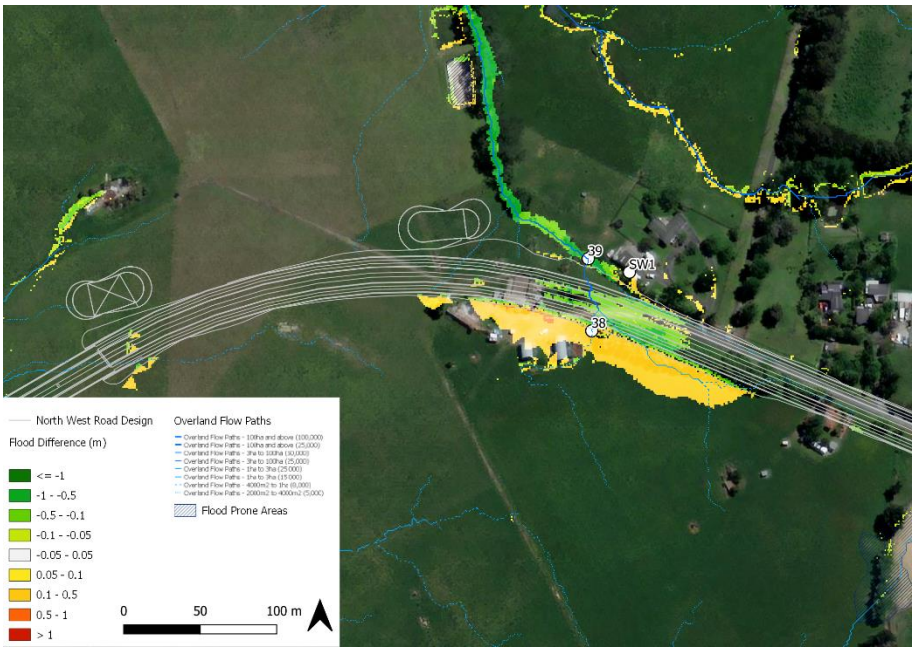

Figure 12-3: 100year flood difference map for Spedding Road West

12.4.4.1 Rawiri Stream bridge

The proposed 35m Rawiri Stream bridge spans across a 15m wide 100year ARI flood plain with bridge abutments / piers set outside the main river channel.

The results for the 100year ARI pre-development scenario show that the flood level at the location of the proposed bridge structure is RL 24.17m upstream and RL 22.68m downstream. Post-development the flood level increases to RL 24.18m (+0.01 m) upstream and to RL 22.71m (+0.03 m) downstream (refer to Points 23 and 24 in Figure 12-2).

The structure has a freeboard of 5.78m between the 100year ARI flood level and bridge soffit which is above the ± 1.2m required freeboard. There are no effects on any nearby buildings. The potential effects of the bridge on flood hazards are considered negligible.

12.4.4.2 Spedding Road East culvert crossings

The new proposed culvert crossings adjacent to 49 Trig Road show:

- At Chainage 80 an increase of +0.80m in the 100year ARI flood levels upstream of the crossing and a decrease of -0.05m downstream (see Points 13 and 14 in Figure 12-4). However, the road centre line is 1m above the flood level, resulting in adequate freeboard. The flood level increase is between 0.05m and 0.5m upstream which is considered a minor effect.
- At Chainage 300 show an increase of +0.93m in the 100year ARI flood levels upstream of the crossing and +0.14m downstream (see Points 15 and 16 in Figure 12-4). The road centre line is 4.27m above the flood level, resulting in adequate freeboard. The flood difference map shows an increase greater than 0.5m upstream which is considered a moderate effect.

These effects are likely due to the culverts being undersized restricting flow. During detailed design upsizing the culverts and increasing the flow through the culverts could reduce flood levels upstream.

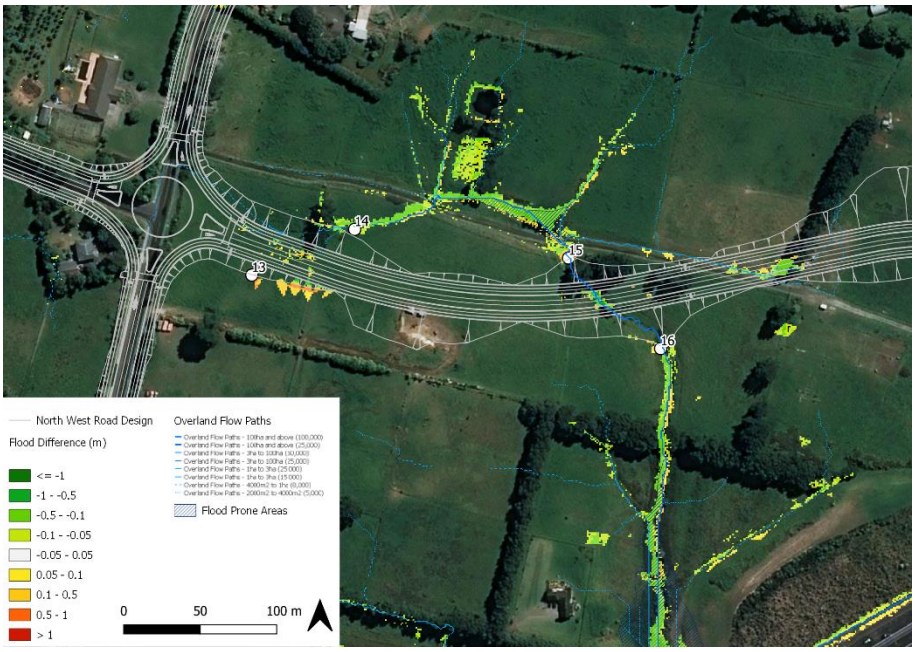

Figure 12-4: 100year flood difference map for Spedding Road East at Chainage 80 and 300

The new proposed culvert crossing adjacent to 43 Westpoint Drive (Chainage 1180, Points 25 and 26 in Figure 12-2) shows an increase of +0.20m in the 100year ARI flood levels upstream of the crossing and +0.09m downstream. The increased flooding is considered a minor effect upstream and downstream. The vertical alignment between Chainage 1060 and 1573 is proposed to change to allow for a developer to connect the new proposed West Point Drive road to Spedding Road. An existing temporary overland flow path north of the culvert outlet, discharges to the existing pond by means of an 1800 mm diameter pipe. The corridor intercepts this overland flow path and there is the potential for this overland flow path to be made permanent.

12.4.5 Recommended Measures to Minimise, Remedy or Mitigate Operational Effects

- The potential mitigation measures could be adopted as set out in Section 8.1. Specifically the following has been considered: Designing the proposed culvert crossings adjacent to 6 Rawiri Place (Chainage 1040, Spedding Rd East) and adjacent to 49 Trig Road (Chainage 80 and Chainage 300, Spedding Rd East) to achieve flood neutrality
- Realign overland flow path north of corridor and optimize culvert design at Chainage 1180 (Spedding East) to discharge into overland flow path
- Lift the vertical alignment of the road to increase freeboard adjacent to 43 Westpoint Drive (Chainage 1180, Spedding Rd East) and realign an overland flow path to discharge into culvert to reduce flood risk
- Creating a new diversion for an existing overland flow path to discharge into the stream and decrease flood levels at the property on 14 Spedding Road

While the potential operational effects were assessed as moderate these are likely to be significantly reduced with the mitigation measures above. Further assessment at the detailed design stage can be used to confirm the preferred mitigation.

Compliance with the recommended flooding outcomes set out in Section 3.2, to be included in the designation conditions, will ensure that potential flooding effects will be negligible up to minor and appropriately managed.

12.5 Conclusions

Based on the results of the flood modelling the Spedding Road upgrade will have a positive to moderate effect on flooding.

No increased risk from flooding was identified during the assessment of construction effects and flood effects will be managed as set out Section 7.1.

The assessment of operational effects found positive to moderate flood effects during the operational phase of the corridor. A range of proposed mitigation measures are set out in Section 8.1 and the mitigation measures will be confirmed at detailed design stage.

Potential flooding effects can be appropriately managed and will be negligible up to minor effect subject to the recommended design outcomes and conditions outlined in set out in Section 3.2 of this report being met.

13 NoR W5: Hobsonville Road FTN Upgrade

13.1 Project Corridor Features

13.1.1 Catchment Characteristics

The project corridor lies mostly on a ridge, crossing a few overland flow paths and an existing pond outlet upstream of the road that discharges towards Waiarohia Stream.

Existing flood prone areas from Auckland GeoMaps are evident where overland flow paths traverse the road. The 100year ARI flood maps from the latest Auckland Whenuapai catchment model with MPD and existing terrain show flooding at the existing pond at Chainage 3800 and flooding of properties at, 281, 283 and 285 Hobsonville Road, 11 and 15 Starlight Cove.

13.2 Existing and Likely Future Environment

13.2.1 Planning Context

The Hobsonville Road corridor runs through an existing rural environment, with the land either side of the Trig Road corridor currently zoned FUZ under the AUPOP.

Table 13-1 below provides a summary of the North West existing and likely future environment.

Table 13-1: Hobsonville Road FTN Upgrade Existing and Likely Future Environment

Environment today	Zoning	Likelihood of Change for the environment[12]	Likely Future Environment[13]
Business	Business (Light Industrial)	Low	Business (Light Industrial)
	Business (Local centre)	Low	Business (Local centre)
Residential	Residential	Low	Residential
Undeveloped greenfield areas (Future Urban Zone)	Future Urban	High	Urban

Please refer to the AEE for further information on the planning context.

[12] Based on AUP:OP zoning/policy direction
[13] Based on AUP:OP zoning/policy direction

13.3 Proposed works

The Project proposes that the function of Hobsonville Road will change from an existing two lane road to an urban two to four lane arterial with mixed components for vehicles, public transport, active modes, and freight. The proposed design includes three types of cross sections specifically:

- A generally 30m corridor that provides two vehicle lanes, two public transport lanes, and improved walking and cycling facilities.
- A generally 24m corridor that provides two vehicle lanes and new facilities for walking and cycling.
- A generally 30m corridor that provides four vehicle lanes, as well as new facilities for walking and cycling.

Other proposed construction works in NoR W5 which can result in flooding effects include:

- Realign the existing culvert crossing at Chainage 3800
- Construction of an inlet structure connecting to existing drainage network
- Construction of diversion drains / realignment of existing overland flow paths
- Upgrade of one existing stormwater pond; Hobsonville Rd Wetland 5
- Construction of five new wetlands

Additional flood storage using attenuation ponds is required for NoR W3 to attenuate and discharge the 100year ARI pre-development peak flow. Stormwater catchments and features are shown in the Indicative Design Drawings.

13.4 Assessment of Flooding Effects and Measures to Minimise, Remedy or Mitigate Actual or Potential Adverse Effects

13.4.1 Positive Effects

Following the Hobsonville Road upgrade the flood levels at surrounding properties zoned for future urban land are lower compared to the pre-development flood levels (refer to Section 13.4.4).

13.4.2 Assessment of Construction Effects

Potential construction effects have been described in Section 7 above.

Wetland 4A is on top of an existing overland flow path and an existing culvert crossing at Chainage 3800 that drains the existing pond located south of the corridor. This may obstruct and divert flow elsewhere. The upgrade of the existing wetland also lies within a flood prone area and the existing 100year flood plain.

13.4.3 Recommended Measures to Minimise, Remedy or Mitigate Construction Effects

Resource consents for diversion and discharge of stormwater and stream works will be sought as part of future resource consent processes.

The potential flooding effects during construction will be considered by, and managed through, flood risk mitigation measures to be set out in the Construction Environmental Management Plan (CEMP).

All other mitigation measures as set out in Section 7.1 apply.

13.4.4 Assessment of Operational Effects

13.4.4.1 Hobsonville Road south of Suncrest Drive

The proposed drainage for NoR W5 Hobsonville Road is an inlet structure on property 283 Hobsonville Road, with a new pipe connecting to the existing underground pipe network. The area has been identified as a flood prone area as it relies on a single culvert for drainage and does not have an overland flow path.

The proposed road centre line level will increase from RL 40.32m to RL 40.72m (+0.3 m). The 100year flood difference map shows an increase in upstream flood levels of +0.16m which is considered a minor effect, however the proposed new road will still flood. Refer to Points 32 and 33 in Figure 13-1 for the flood difference map.

Properties at 277 Hobsonville Road and 285 Hobsonville Road, Hobsonville was identified as having an increase in flood level greater than 150 mm which would be a moderate effect. This could be mitigated by upgrading the underground pipe network to allow more inflow which will reduce water levels upstream. This is possible within the current designation boundary and a final solution can be addressed at a future stage of design.

Figure 13-1: 100year flood difference map for Hobsonville Road FTN at Chainage 3060

13.4.4.2 Intersection of Hobsonville Road and Brigham Creek Road

The existing culvert crossing at the intersection of Hobsonville Road and Brigham Creek Road (Chainage 3800) is an outlet pipe for the existing pond upstream of Hobsonville Road. It is proposed to retain the size and realign the culvert to minimise impeding on Wetland 4A.

The 100year flood level difference map shows an increase of +0.47m upstream which is considered a moderate effect (Point 30 in Figure 13-1).The new road centre line level has increased from RL 30.50m to RL 31.60m however, the freeboard between edge of corridor and flood level is 0.43m which is less than the 0.5m required freeboard.

Flood effects at 18 Williams Road (Point HR6 in Figure 13-1) show an increase in flood level greater than 150 mm which is a moderate effect. This is likely due to the culvert being undersized / modelled as blocked. Upsizing the culvert during detailed design should minimise this effect, which is possible within the current designation boundary.

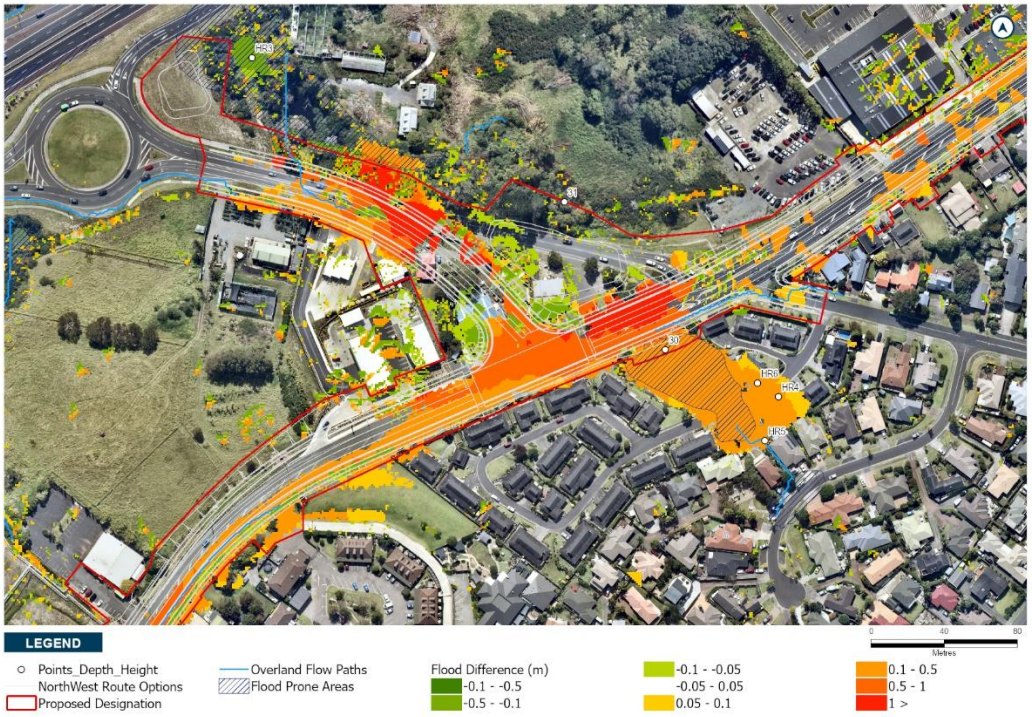

Figure 13-2: 100year flood difference map for Hobsonville Road at the intersection of Brigham Creek Road

At 397 Hobsonville Road, Hobsonville (Point HR7, Figure 13-3) flood difference maps show an increase in flood level between 50 mm and 150 mm which is a minor effect. The effects is due to the road widening interfering with the overland flow path. Realigning the overland flow path to discharge into existing pipe network downstream could minimise this effect. This is possible within the current designation boundary and a final solution can be addressed at a future stage of design.

At 1 Wiseley Road, Hobsonville (Point HR8, Figure 13-3) flood difference maps show an increase in flood level greater than 150 mm. The majority of the flooding is located in the carparking area however a building in the south west of the site may be affected so the effect is considered moderate. Upgrading the drainage for carpark area is considered likely to minimise this effect. This is possible within the current designation boundary and a final solution can be addressed at a future stage of design.

Figure 13-3: 100year ARI level difference map for Hobsonville Road FTN

13.4.5 Recommended Measures to Minimise, Remedy or Mitigate Operational Effects

The potential mitigation measures could be adopted as set out in Section 8.1. Specifically, the following has been considered:

- Upgrading the proposed inlet and pipe capacities at 283 Hobsonville Road (Chainage 3060) to discharge to the existing underground drainage network to reduce the flood levels off-site.
- Increasing the pond outlet capacity at the intersection of Hobsonville Road and Brigham Creek Road (Chainage 3800) to allow more flow to discharge downstream

While the potential operational effects were assessed as moderate these are likely to be significantly reduced with the mitigation measures above. Further assessment at the detailed design stage can be used to confirm the potential effects following mitigation.

Compliance with the recommended flooding outcomes set out in Section 0, to be included in the designation conditions, will ensure that potential flooding effects will be negligible up to minor and appropriately managed.

13.5 Conclusions

No increased risk from flooding was identified during the assessment of construction effects and flood effects will be managed as set out Section 7.1.

The assessment of operational effects found positive to moderate flood effects during the operational phase of the corridor. The increased flood levels at 283 Hobsonville Road (Chainage 3060) can be mitigated by upgrading the proposed inlet and pipe capacities and discharging into the existing underground drainage network. The increase in flood levels at intersection of Hobsonville Road and Brigham Creek Road (Chainage 3800) could be mitigated by upsizing the culvert crossing or

increasing the existing pond attenuation capability. The proposed mitigation has the potential to reduce the flood levels of properties upstream. Mitigation will be confirmed at detailed design stage.

Potential flooding effects can be appropriately managed and will be negligible up to minor subject to the recommended design outcomes and conditions outlined in set out in Section 3.2 of this report being met.

14 Sensitivity Analysis

The sensitivity analysis identified those locations where a flood risk under a more sever climate change scenario (3.8 degree temperature change) would increase the flood risk. These results have been used to justify the designation and it is expected that revised modelling at the detail design stage will consider the appropriate RCP, or any additional climate change requirements for the final design to achieve the appropriate outcome(s).

1.1 NoR W2: Māmari Road Upgrade

For Māmari Road Upgrade (NoR W2) there was no change to flood risk for the southern section of this road (Table 14-1). No further mitigation is proposed beyond that already recommended.

The northern section of the road was likely to be influenced by the Alternative State Highway which is being considered under a separate package so sensitivity results are not reported here.

Table 14-1: Flood levels at key crossings NoR W2: Māmari Road Upgrade

Chainage	**2.1 degree temperature change**	**3.8 degree temperature change**	**Flood level change**	**Change in potential effect without mitigation**
	100year flood level (RL) post development	**100year flood level (RL) post development**		
Chainage 120, Māmari South (Points 9 and 10)	32.73m upstream 31.77m downstream	32.94m upstream 31.81m downstream	+0.21m upstream +0.04m downstream	No change – minor effect
Chainage 380, Māmari South (Points 11 and 12	36.96 upstream 35.90m downstream	37.11m upstream 35.94m downstream	+0.15m upstream +0.04m downstream	Upstream no change – moderate effect Downstream no change – minor effect
Chainage 560, Māmari South (Points 7 and 8)	40.10m upstream 36.32m downstream	40.48m upstream 36.34m downstream	+0.38m upstream +0.02m downstream	Upstream no change – moderate effect Downstream no change – minor effect

1.2 NoR W3: Brigham Creek Road

There was a flood level change of +0.09m upstream of Chainage 1260 (Point 2) and +0.10m upstream of Chainage 3620 (Point 3) for the upgrade of Brigham Creek Road (NoR W3) resulting in a minor effect. No specific measures have been identified as flooding can be managed through mitigation measures as set out in in Section 8.1 including sizing of culverts to achieve flood neutrality. For all other crossings there was no increase in flood risk (Table 14-2).

Table 14-2: Flood levels at key crossings NoR W3: Brigham Creek Road

Chainage	2.1 degree temperature change	3.8 degree temperature change	Flood level change	Change in potential effect without mitigation
	100year flood level (RL) post development	100year flood level (RL) post development		
Chainage 1260, Points 1 and 2	26.48m upstream 26.26m downstream	26.57m upstream 26.26m downstream	+0.09m upstream No change downstream	Upstream negligible changes to minor effect Downstream no change – negligible effect
Chainage 2700, Points 36 and 37	32.34m 31.45m	32.34m 31.45 m	No change	Upstream no change – minor effect Downstream no change – positive effect
Chainage 3230, Points 5 and 6	25.08m upstream 22.53m downstream	25.16m upstream 22.69m downstream	+0.08m upstream +0.16m downstream	No change – positive effect
Chainage 3620, Points 3 and 4	17.60m upstream 15.60m downstream	17.70m upstream 15.79m upstream	+0.10m upstream +0.19m downstream	Upstream positive changes to minor effect Downstream no change – minor effect
Chainage 3980, Points 27 and 29	9.46m upstream 9.18m downstream	9.84m upstream 9.40m downstream	+0.38m upstream +0.22m downstream	Upstream no change – positive effect Downstream no change – minor effect

For properties assessed there was no change to flood risk (Table 14-3). No further mitigation is proposed beyond that already recommended.

Table 14-3: Consideration of flooding at key locations identified NoR W3: Brigham Creek Road

Point on flood difference map	2.1 degree temperature change		3.8 degree temperature change		Flood depth change (m)
	Water Level (m)	Potential Effect	Water Level (m)	Potential Effect	
Point BR3	9.07	Minor	9.27	Minor	+0.2
Point BR4	10.11	Positive effect	10.50	Positive effect	+0.4

1.3 NoR W4: Spedding Road

There was an increased risk of flooding upstream of Chainage 800 and upstream of Chainage 1040 in Spedding Rd East. The model output for 3.8 degree temperature change resulted in a minor effect at both locations. No specific measures have been identified as flooding can be managed through mitigation measures as set out in in Section 8.1 including sizing of culverts to achieve flood neutrality. For all other crossings there was no increase in flood risk (Table 14-4).

Table 14-4: Flood levels at key crossings NoR W4: Spedding Road

Chainage	2.1 degree temperature change	3.8 degree temperature change	Flood level change	Change in potential effect without mitigation
	100year flood level (RL) post development	100year flood level (RL) post development		
Chainage 80, Spedding Rd East (Points 13 and 14)	47.22m upstream 41.96m downstream	47.34m upstream 41.98m downstream	+0.12m upstream +0.02m downstream	Upstream no change – moderate effect Downstream no change – positive effect
Chainage 300 (Spedding Rd East (Points 15 and 16)	38.43m upstream 35.33m downstream	38.62m upstream 35.47m downstream	+0.19m upstream +0.14m downstream	Upstream no change – moderate effect Downstream no change – minor effect
Chainage 800, Spedding Rd East (Points 21 and 22)	19.91m upstream 19.82m downstream	20.43m upstream 20.516m downstream	+0.12m upstream +0.02m downstream	Upstream negligible changes to minor effect Downstream no change – negligible effect
Chainage 1040, Spedding Rd East (Points 23 and 24)	24.18m upstream 22.71m downstream	24.32m upstream 22.85m downstream	+0.12m upstream +0.02m downstream	Upstream negligible changes to minor effect Downstream no change – negligible effect
Chainage 1180, Spedding Rd East (Points 25 and 26)	29.22m upstream	29.419m upstream	+0.12m upstream +0.02m downstream	Upstream no change – minor effect Downstream no change – minor effect

For properties assessed there was no change to flood risk (Table 14-5). No further mitigation is proposed beyond that already recommended.

Table 14-5: Consideration of flooding at key locations identified NoR W4: Spedding Road

Point on flood difference map	2.1 degree temperature change		3.8 degree temperature change		Flood depth change (m)
	Water Level (m)	Potential Effect	Water Level (m)	Potential Effect	
Point SE1	21.43	Positive effect	22.09	Positive effect	+0.66

1.4 NoR W5: Hobsonville Road

Upstream of Chainage 3800 (Point 30) flood depth increased by 0.29m resulting in an increased effect for the model output for 3.8 degree temperature change. The moderate effect can be mitigated by upsizing the proposed culvert crossings to increase flow. In addition to this all other mitigation measures as set out in Section 8.1 apply. Downstream of Chainage 3800 and at Chainage 3060 there was no increase in flood risk (Table 14-6).

Table 14-6: Flood levels at key crossings NoR W5: Hobsonville Road

Chainage	Proposed cross drainage	2.1 degree temperature change	3.8 degree temperature change	Flood level change	Change in potential effect without mitigation
		100year flood level (RL) post development	100year flood level (RL) post development		
Chainage 3060, (Point 32 and 33)	450 mm diameter underground pipe network crossing the road	40.83m upstream 39.83m downstream	40.85m upstream 39.85m downstream	+0.02m upstream +0.02m downstream	Upstream no change – minor effect Downstream no change – positive effect
Chainage 3800 (Point 30 and 31)	600 mm diameter culvert crossing	31.20m upstream 27.12m downstream	31.49m upstream 27.15m downstream	+0.29m upstream +0.03m downstream	Upstream minor changes to moderate effect Downstream positive changes to negligible effect

For properties assessed there was at increased flood risk identified at Point HR3, Point HR4, Point HR5 and Point HR6 (Table 14-7). Future development within the open space at HR3 should take notice of the potential increase of 0.58m in flood level to achieve the required freeboard for habitable floor levels. No further mitigation is proposed beyond that already recommended.

Table 14-7: Consideration of flooding at key locations identified NoR W5: Hobsonville Road

Point on flood difference map	2.1 degree temperature change		3.8 degree temperature change		Flood depth change (m)
	Water Level (m)	Potential Effect	Water Level (m)	Potential Effect	
Point HR1	40.83	Moderate effect	40.85	Moderate effect	+0.02
Point HR2	40.83	Moderate effect	40.84	Moderate effect	+0.01
Point HR3	17.82	Positive effect	18.40	Moderate effect	+0.58
Point HR4	31.20	Moderate effect	31.49	Moderate effect	+0.29
Point HR5	31.20	Negligible effect	31.49	Moderate effect	+0.29
Point HR6	31.20	Moderate effect	31.49	Moderate effect	+0.29
Point HR7	34.41	Moderate effect	34.45	Moderate effect	+0.04
Point HR8	33.53	Minor effect	33.57	Minor effect	+0.04

15 Conclusions

The assessment of the potential flood effects for the Projects was based on an indicative design of the new road.

There will be a number of positive effects associated with the development particularly where new bridges are proposed which raise the existing road levels reducing the potential for flood levels to overtop the road and reducing flood hazard. Additional positive effects can be realised through upgrades to existing culverts or new culvert crossings to improve overland and stream flow under the roads.

The assessment found that there was unlikely to be additional risk of flood effects during construction as nearly all proposed lay down areas are outside of the flood plain and overland flow paths. For those areas where there is an increased risk mitigation measures such as carrying out construction works during dry weather and using diversion drains will be adequate to manage this risk.

Potential operational effects included increased flood levels upstream and downstream of crossings and bridges. Some of the effects were assessed as moderate based on an increase in flood level of greater than 0.15m for habitable buildings and 0.5m for general property. These effects are a result of the changing terrain, based on the spatial land take for the new infrastructure, which obstructs existing overland flows and flood plains. These effects are likely overstated as they can be addressed through detailed design of the bridges, culverts and crossings to manage flows upstream and downstream to minimise flooding effects.

A number of management and mitigation measures have been considered to minimise flood effects during detailed design. Further assessment at the detailed design stage can be used to confirm the potential effects following mitigation.

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. However, this increased risk can be addressed through the mitigation measures described in the report.

16 References

Auckland Council (Nov 2011) Auckland Council Stormwater Modelling Specification

Auckland Council GeoMaps (accessed 2021)

Te Tupu Ngātahi flood models, as follows:

Available Models	**North West Whenuapai Package projects within the catchment models**
Whenuapai Rapid Flood Hazard Assessment	Trig Road North Upgrade (NoR W1), Māmari Road Upgrade (NoR W2), Brigham Creek Road Upgrade (NoR W3), Spedding Road (NoR W4) and Hobsonville Rd FTN Upgrade (NoR W5)

New Zealand Transport Agency (April 2016) NZTA P46 Stormwater Specification

New Zealand Transport Agency (2013) Bridge Manual SP/M/022 third edition

1 Appendix 1 – Flood model results

1.1 NoR W2: Māmari Road Upgrade

Table 16-1: Māmari Road Upgrade existing and future flood levels at key crossings

Chainage	Existing cross drainage	Modelled cross drainage	Pre-development 100year ARI flood level	Post development 100year ARI flood level	Level difference for 100year post minus pre-development	Potential effect without mitigation	Recommended mitigation
Adjacent to 41-43 Brigham Creek Road (Chainage 340 Māmari North, Point 42 in Figure 8-1)	n/a Existing overland flow path	n/a	22.51m upstream Existing ground level 22.32 m	22.68m upstream Design road level 23.35 m	+0.17m	Minor effect	Diverting the existing overland flow path to Sinton Stream
Adjacent to 7 Māmari Road (Chainage 500 Māmari North, Points 19 and 20 in Figure 8-1)	n/a	Sinton Stream Bridge, 95m long	17.53m upstream, 16.78m downstream Existing ground level 16.2 m	17.52m upstream, 16.77m downstream Modelled bridge soffit level 19.17 m	-0.01m upstream, -0.01m downstream	Positive effect upstream and downstream	
Adjacent to 9 Spedding Road (Chainage 120 Māmari South, Points 9 and 10 in Figure 8-2)	n/a	3500 mm x 1000 mm box culvert	32.45m upstream, 31.37m downstream Existing ground level 31.59 m	32.73m upstream, 31.77m downstream Design road level 35.45 m	+0.28m upstream, +0.40m downstream	Minor effect upstream and downstream	Upsizing the proposed culvert crossings to increase flow

Chainage	Existing cross drainage	Modelled cross drainage	Pre-development 100year ARI flood level	Post development 100year ARI flood level	Level difference for 100year post minus pre-development	Potential effect without mitigation	Recommended mitigation
Adjacent to 7 Spedding Road (Chainage 380 Māmari South, Points 11 and 12 in Figure 8-2)	n/a	3500 mm x 1000 mm box culvert	36.25m upstream, 35.87m downstream Existing ground level 24.22 m	36.96 upstream, 35.90m downstream Design road level 39.36 m	+0.71m upstream, +0.03m downstream	Moderate effect upstream, negligible effect downstream	Upsizing the proposed culvert crossings to increase flow
Adjacent to 80 Trig Road (Chainage 560 Māmari South, Points 7 and 8 in Figure 8-2)	n/a	750 mm diameter culvert	38.70m upstream, 36.26m downstream Existing ground level 37.35 m	40.10m upstream, 36.32m downstream Design road level 41.95 m	+1.40m upstream, +0.06m downstream	Moderate effect upstream, minor effect downstream	Upsizing the proposed culvert crossings to increase flow

1.2 NoR W3: Brigham Creek Road Upgrade

Table 1-2: Brigham Creek Road Upgrade existing and future flood levels at key crossings

Chainage	Existing Cross Drainage / Property address	Modelled Cross Drainage / Affected area	Pre-development 100year ARI flood level	Post development 100year ARI flood level	Level difference for 100year post minus pre-development	Potential effect without mitigation	Recommended mitigation
Adjacent to 36 Brigham Creek Road (Chainage 1260, Points 1 and 2 in Figure 11-1)	n/a	600 mm diameter culvert	26.45m upstream, 26.26m downstream Existing road level 26.47 m	26.48m upstream, 26.24m downstream Design road level 27.15 m	+0.03m upstream, -0.02m downstream	Negligible effect upstream and positive effect downstream	n/a
Adjacent to 141 Brigham Creek Road (Chainage 2700, Points 36 and 37 in Figure 11-1)	n/a Existing overland flow path both sides of the road	n/a Existing overland flow path both sides of the road	32.10m (upstream), 31.63m (downstream) Existing road level 31.88 m	32.34m (upstream), 31.45m (downstream) Design road level 32.89 m	+0.24m upstream, -0.18m downstream	Minor effect upstream, positive effect downstream	New diversion drains for the overland flow path alongside the corridor
Adjacent to 153 Brigham Creek Road (Chainage 3230, Points 5 and 6 in Figure 11-2)	600 mm diameter culvert	1050 mm diameter culvert	27.04m upstream, 22.75m downstream Existing road level (Chainage 3220) 23.50 m	25.08m upstream, 22.53m downstream Design road level (Chainage 3220) 25.80 m	-1.96m upstream, -0.22m downstream	Positive effects both upstream and downstream	n/a

Chainage	Existing Cross Drainage / Property address	Modelled Cross Drainage / Affected area	Pre-development 100year ARI flood level	Post development 100year ARI flood level	Level difference for 100year post minus pre-development	Potential effect without mitigation	Recommended mitigation
Adjacent to 150-152 Brigham Creek Road (Chainage 3620, Points 3 and 4 in Figure 11-2)	n/a	(x3) 750 mm diameter culverts	17.62m upstream, 15.44m downstream Existing road level 16.17 m	17.60m upstream, 15.60m downstream Design road level 18.409 m	-0.02m upstream, +0.16m downstream	Positive effect upstream and minor effect downstream	Upsizing the proposed culvert crossings to increase flow
162 Brigham Creek Road (Chainage 3980, Points 27 and 29 in Figure 11-3)	4000 mm x 3600 mm box culvert	Waiarohia Stream Bridge, 10m wide opening	10.56m upstream, 9.03m downstream Existing road level 10.16 m	9.46m upstream, 9.18m downstream Design road level 13.26 m, bridge soffit level 11.46 m	-1.1m upstream, +0.15m downstream	Positive effect upstream and minor effect downstream	Optimize proposed bridge span or retain existing box culvert and include additional culverts
Point BR3 (Figure 11-3)	162 Brigham Creek Road, Hobsonville	Building / house, site level RL9.26 m	8.93 m	9.07m	+0.14 m	Increase in flood level between 50 mm and 150 mm, minor effect	Optimize proposed bridge span or retain existing box culvert and include additional culverts
Point BR4 (Figure 11-3)	Brigham Creek Road, Hobsonville	Building, FUZ, site level RL10.41 m	10.78 m	10.11 m	-0.67 m	Reduction in flood level, Positive effect	n/a

1.3 NoR W4: Spedding Road

Table 1-3: Spedding Road existing and future flood levels at key crossings

Chainage	Existing Cross Drainage / Property address	Modelled Cross Drainage / Affected area	Pre-development 100year ARI flood level	Post development 100year ARI flood level	Level difference for 100year post minus pre-development	Potential effect without mitigation	Recommended mitigation
Adjacent to 15-19 Spedding Road (Chainage 600, Spedding Rd West, Points 43 and 44 in Figure 12-1)	n/a	Totara Creek bridge, 255m long	14.18m upstream, 14.06m downstream Existing ground level 12.04 m	14.19m upstream, 14.09m downstream Bridge soffit level 21.88 m	+0.01m upstream, +0.03m downstream	Negligible effect upstream and downstream	n/a
Adjacent to 14 Spedding Road (Chainage 1080, Spedding Rd West, Points 38 and 39 in Figure 12-3)	n/a	450 mm diameter culvert (modelled as blocked)	27.33m upstream, 24.83m downstream Existing ground level 25.95 m	27.50m upstream, 24.26m downstream Design road CL level 27.42 m	+0.17m upstream, -0.57m downstream	Minor effect upstream, positive effect downstream	Lift the vertical alignment of the road to increase freeboard and optimize culvert design to allow more inflow
Adjacent to 49 Trig Road (Chainage 80, Spedding Rd East, Points 13 and 14 in Figure 12-4)	n/a	750 mm diameter culvert	46.42m upstream, 42.01m downstream Existing ground level 44.58 m	47.22m upstream, 41.96m downstream Design road CL level 48.40 m	+0.20m upstream, -0.05m downstream	Minor effect upstream, positive effect downstream	Upsizing the proposed culvert crossings to increase flow

Chainage	Existing Cross Drainage / Property address	Modelled Cross Drainage / Affected area	Pre-development 100year ARI flood level	Post development 100year ARI flood level	Level difference for 100year post minus pre-development	Potential effect without mitigation	Recommended mitigation
Adjacent to 49 Trig Road (Chainage 300 Spedding Rd East, Points 15 and 16 in Figure 12-4)	n/a	2500 mmx 1000 mm box culvert	37.50m upstream, 35.18m downstream Existing ground level 36.33 m	38.43m upstream, 35.33m downstream Design road CL level 42.70 m	+0.93m upstream, +0.15m downstream	Moderate effect upstream, minor effect downstream	Upsizing the proposed culvert crossings to increase flow
Adjacent to 27 Trig Road (Chainage 800, Spedding Rd East, Points 21 and 22 in Figure 12-2)	n/a	Trig Stream Bridge, 155m long	19.91m upstream, 19.82m downstream Existing ground level 18.70 m	19.91m upstream, 19.82m downstream Bridge soffit level 27.17 m	0.00m upstream, 0.00m downstream	No effect upstream and downstream	n/a
Adjacent to 6 Rawiri Place (Chainage 1040, Spedding Rd East, Points 23 and 24 in in Figure 12-2)	n/a	Rawiri Stream Bridge, 35m long	24.17m upstream, 22.68m downstream Existing ground level 22.35 m	24.18m upstream, 22.71m downstream Bridge soffit level 29.96 m	+0.01m upstream, +0.03m downstream	Negligible effect both upstream and downstream	Upsizing the proposed culvert crossings to increase flow
Adjacent to 43 Westpoint Drive (Chainage 1180, Spedding Rd East, Points 25 and 26 in in Figure 12-2)	n/a	3000 mmx 1000 mm box culvert	29.02m upstream, 29.02m downstream Existing ground level 26.88 m	29.22m upstream, 29.11m downstream Modelled Road level 32.30 m	+0.20m upstream, +0.09m downstream	Minor effect upstream and downstream	Optimizing culvert design and realigned overland flow path

Chainage	Existing Cross Drainage / Property address	Modelled Cross Drainage / Affected area	Pre-development 100year ARI flood level	Post development 100year ARI flood level	Level difference for 100year post minus pre-development	Potential effect without mitigation	Recommended mitigation
Point SE1 (in Figure 12-2)	25 Trig Road, Whenuapai	Open Space, FUZ	21.59 m	21.44 m	-0.15 m	Reduction in flood level, Positive effect	n/a
Point SW1 (Figure 12-3)	14 Spedding Road, Whenuapai	Building / house, driveway site level RL26.23 m	25.91 m	25.97 m	+0.06 m	Increase in flood level between 50 mm and 150 mm, minor effect	Further assessment during detailed design

1.4 NoR W5: Hobsonville Road FTN Upgrade

Table 1-4: Hobsonville Road FTN Upgrade existing and future flood levels at key crossings

Chainage	Existing Cross Drainage / Property address	Modelled Cross Drainage / Affected area	Pre-development 100year ARI flood level	Post development 100year ARI flood level	Level difference for 100year post minus pre-development	Potential effect without mitigation	Recommended mitigation
283 Hobsonville Road (Chainage 3060, Point 32 and 33 in Figure 13-1)	450 mm diameter underground pipe network crossing the road	No culvert crossing modelled.	40.67m upstream, 39.91m downstream Existing road CL level 40.32 m	40.83m upstream, 39.83m downstream Design road CL level 40.72 m	+0.16m upstream, -0.08m downstream	Minor effect upstream and positive effect downstream	Upgrade pipe network to allow more inflow
Intersection of Hobsonville Road and Brigham Creek Road (Chainage 3800, Point 30 and 31 in Figure 13-1)	600 mm diameter culvert crossing	600 mm diameter culvert crossing	30.73m upstream, 27.14m downstream Existing road CL level 30.50 m	31.20m upstream, 27.12m downstream Design road CL level 31.60 m	+0.47m upstream, -0.02m downstream	Minor effect upstream, positive effect downstream	Upgrade existing culvert size
Point HR1 (Figure 13-1)	277 Hobsonville Road, Hobsonville	Building / house, site level RL40.77 m	40.67 m	40.83 m	+0.16 m	Increase in flood level greater than 150 mm, moderate effect	Upgrade pipe network to allow more inflow
Point HR2 (Figure 13-1)	285 Hobsonville Road, Hobsonville	Building / house, driveway, site level RL40.32 m	40.67 m	40.83 m	+0.16 m	Increase in flood level greater than	Upgrade pipe network to allow more inflow

Chainage	Existing Cross Drainage / Property address	Modelled Cross Drainage / Affected area	Pre-development 100year ARI flood level	Post development 100year ARI flood level	Level difference for 100year post minus pre-development	Potential effect without mitigation	Recommended mitigation
						150 mm, moderate effect	
Point HR3 (Figure 13-2)	174 Brigham Creek Road, Hobsonville	Open space, Business	18.15 m	17.82 m	-0.33 m	Reduction in flood level, positive effect	n/a
Point HR4 (Figure 13-2)	11 Starlight Cove, Hobsonville	Building / house, site level RL31.60 m	31.06 m	31.20 m	+0.14 m	Increase in flood level greater than 150 mm, moderate effect	Upsize existing culvert
Point HR5 (Figure 13-2)	15 Starlight Cove, Hobsonville	Building / house, site level RL31.62 m	30.96 m	31.20 m	+0.24 m	Increase in flood level greater than 150 mm, moderate effect	Upsize existing culvert
Point HR6 (Figure 13-2)	18 Williams Road, Hobsonville	Building / house, site level RL30.98 m	30.97 m	31.20 m	+0.23 m	Increase in flood level greater than 150 mm, moderate effect	Upsize existing culvert
Point HR7 (Figure 13-3)	397 Hobsonville Road, Hobsonville	Building/carpark, site level RL	34.21 m	34.41 m	+0.20 m	Increase in flood level greater than 150 mm, moderate effect	Upgrade drainage for carpark area

Chainage	Existing Cross Drainage / Property address	Modelled Cross Drainage / Affected area	Pre-development 100year ARI flood level	Post development 100year ARI flood level	Level difference for 100year post minus pre-development	Potential effect without mitigation	Recommended mitigation
Point HR8 (Figure 13-3)	1 Wiseley Road, Hobsonville	Building/carpark, site level RL	33.46 m	33.53 m	+0.07 m	Increase in flood level between 50 mm and 150 mm, minor effect	Realign overland flow path to discharge into existing pipe