WAKA KOTAHI
NZ TRANSPORT AGENCY

PAPAKURA TO BOMBAY STAGE 2

FLOOD IMPACT ASSESSMENT

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More information

NZ Transport Agency
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Abbreviations

Abbreviation	Term
AC	Auckland Council
AEE	Assessment of Environmental Effects
AEP	Annual Exceedance Probability
AUP: OP	Auckland Unitary Plan (Operative in Part 2016)
CC	Climate Change

Abbreviation	Term
CEMP	Construction Environment Management Plan
CH	Chainage
DSA	Drury South Area
GIS	Geographic Information System
NoR	Notice of Requirement
NoR 1	Alteration to the SH1 Designation 6706
NoR 2	Alternation to SH1 Designation 6700
NoR 3	Alteration to SH1 Designation 6701
NoR 4	Shared User Path between Quarry Road and Bombay Interchange
NoR 5	Drury South Interchange Connections
P2B	SH1 Upgrades Project between Papakura to Bombay
RFHA	Rapid Flood Hazard Assessment
RMA	Resource Management Act 1991
SCI	Southern Corridor Improvements
SH1	State Highway 1 Motorway, the Southern Motorway
SUP	Shared User Path

Glossary of Acronyms / Terms

Acronym/Term	Description
Auckland Council	Means the unitary authority that replaced eight councils in the Auckland Region as of 1 November 2010.
the Project	Stages 2 of the P2B Project between Drury to Bombay
Project Area	Area of land that is within the proposed designation boundary.
NZTA	New Zealand Transport Agency Waka Kotahi

EXECUTIVE SUMMARY

This report provides an Assessment of Flooding Effects to support Stage 2 of the Papakura to Bombay (P2B) Project, referred herein as the 'Project'.

Flooding, being a natural hazard, has been considered as part of the Notices of Requirement (NoRs) for the Project. The proposed works have the potential for causing flooding effects, therefore a flooding impact assessment is provided to demonstrate that measures can be implemented to appropriately prevent or mitigate these effects. A formal process to obtain regional resource consents will be undertaken in the future, which will address a wider range of potential stormwater quantity and quality effects in more detail.

Project Background

P2B is a NZTA led project to improve the transport capacity and functionality of the State Highway network and provide for long-term growth in the South Auckland area. Stage 1 has consent and was divided into sub-sections which are either constructed or construction is underway.

Stage 2 is for route protection and NZTA is seeking five NoRs, three of which alter the existing SH1 designation, one covers the provision of a Shared User Path (SUP) and the remaining NoR is for the connections into the local road network at the new Drury South Interchange.

Stage 2 incorporates the remaining portion of the P2B Project area between south of Quarry Road and the existing Bombay/Mill Road Interchange. The following is a description of the planned works:

- An additional lane in each direction along SH1
- A new interchange constructed at Drury South
- Upgrades to the existing Ramarama and Bombay Interchanges
- Continuation of a Shared User Path (SUP) from Quarry Road near its intersection with Great South Road to Bombay Interchange; and
- Stormwater management devices

Assessment of Flooding Effects

The assessment of flooding effects discusses the flood risks associated with the construction and operation of the Project. Flood risk, which indicates the potential flooding in the area with the consideration of the vulnerability of the location (i.e., whether flooding caused by the Project will affect nearby properties), has been identified in each NoR. In this report, the assessment of construction effects and operational effects have been assessed separately.

During the construction phase, the risk of flooding may increase to some extent. This is primarily because temporary staging platforms may be needed for building the new bridge and temporary diversions may be necessary for constructing new culverts. However, the specific construction methods will be finalised during the detailed design phase. The expectation is that the construction can be carried out in a manner that effectively manages the risk of flooding. This management can be outlined in the Construction Environmental Management Plan (CEMP), which will include measures to mitigate the flood risk, such as performing construction activities outside the flood plains and overland flow paths where possible and/or scheduling construction works during dry periods. Thminis will be developed by the contractor for the various stages and requirements of each of the Projects construction activities. It is recommended to address the issue of flood risk in the CEMP and make it a condition for the proposed designations, to ensure that the adverse flooding effects of the Project are managed during the construction stage. It is worth noting that NZTA has a substantial track record of effectively managing construction works and implementing mitigation strategies, as demonstrated in previous projects like Stage 1A and Southern Corridor Improvements (SCI).

During the operational phase, the flood modelling predicts no adverse impact within the Hingaia Stream upstream and downstream of the proposed bridge across the Hingaia reserve area. The bridge piers are predicted to have minimal impact on the flood plain, given its large extent compared to the piers' cross-section. During extreme flooding events with climate change, peak velocities in the flood plain remain low, suggesting that the flooding characteristics are predominantly controlled by the downstream restrictions rather than the capacity of the Hingaia stream at the bridge location. This explains why the impact of the bridge piers on flooding is considered negligible, as the low velocity results in minimal head losses around the piers.

Minor increases in flood levels upstream and downstream of the proposed Drury South Interchange as well as at the culvert crossings at CH 16660 and CH 17380 were observed. These impacts are primarily attributed to the filling of a portion of the floodplain, resulting in the displacement of flood volume mainly along the existing channels immediately upstream of the culvert crossings. It should be noted that the flood extents of the design scenario remain generally consistent with existing scenario. The impacts consist of flood level increases of up to 200 mm and 120 mm at CH 16660 and CH 17380, respectively, for the 1% AEP event with climate change. However, these impacts are contained within the existing channels, and no new areas are affected. It should also be noted that the affected areas fall within the rural zone, and there is no impact on habitable properties.

A sensitivity assessment was also undertaken to understand the influence of modifying the size of the culvert at CH 16600. The outcome of the sensitivity modelling suggests that upgrading the existing culvert across SH1 at CH 16660 and providing additional flood storage area on the north-western side of the proposed interchange will improve the flooding conditions east and west of the motorway.

The existing motorway alignment crosses some catchment tributaries within the Project extents. In the existing scenario, flows along the tributaries are conveyed through culverts. With the proposed motorway widening, flood storage immediately upstream and downstream of the existing culverts will be displaced along the existing streams, causing a minor increase in flood levels. It is expected that the flood storage displacement will have negligible effect due to the minimal reduction in flood storage capacity.

The table below presents the features of each NoR, the existing and likely future flood risk caused by the Project, general measures recommended for each NoR based on the flood risk assessment, and the residual level of effects once the mitigation is in place.

NoR	Features	Existing and Likely Future Flood Risk	General Recommendations	Residual Level of Effects
NoR 1	▪ Road widening of the existing SH1 corridor from CH 15160 to CH 15500 (State Highway 1 from north of Takanini Interchange to south of Quarry Road, Drury)	▪ Negligible existing risk to agricultural land and residential properties. ▪ Negligible future risk to Light Industry Zone. ▪ Minimal flood volume displacement as existing topography will largely remain unchanged.	▪ Runoff attenuation as discussed in Section 3.2.4.	▪ Negligible flooding effects.
NoR 2	▪ Road widening of the existing SH1 corridor from CH 15550 to CH 22740 (State Highway 1 from south of Quarry Road, Drury to Bombay Road, Bombay) ▪ Drury South Interchange	▪ Mostly negligible and low existing risk to agricultural land and residential properties. One location identified as moderate risk. ▪ Mostly negligible and moderate future risk to Mixed Rural Zone,	▪ Runoff attenuation as discussed in Section 3.2.4. ▪ Maintain the existing streams and stream crossings though culverts for all locations. ▪ Size culvert capacity across SH1 motorway	▪ Negligible flooding effects.

NoR	Features	Existing and Likely Future Flood Risk	General Recommendations	Residual Level of Effects
	▪ Ramarama Interchange	Residential Zone, and Light Industry Zone. ▪ Flood volume displacement due to the filling of flood plains, particularly along the overland flow paths crossing the Project area. ▪ Minor increase in flood level upstream and downstream of the culvert crossings.	where increase in flood risk is identified to accommodate the proposed designation conditions. ▪ Ground shaping in the inlet and outlet of all culvert locations to balance any change in flows upstream and downstream.	
NoR 3	▪ Road widening of the existing SH1 corridor from CH 22740 to CH 24600 (State Highway 1 from Bombay Road to Mill Road, Bombay) ▪ Upgrades to the existing Mill Road/Bombay Interchange ▪ Mill Road over-bridge and abutments ▪ SH1 Great South Road Bridge	▪ Moderate existing risk to School Zone. ▪ Moderate future risk to School Zone. ▪ Flood volume displacement due to the filling of flood plains, particularly along the overland flow paths crossing the Project area. ▪ Minor increase in flood levels downstream of culvert crossings.	▪ Runoff attenuation as discussed in Section 3.2.4. ▪ Maintain the existing streams and stream crossings though culverts for all locations. ▪ Size culvert capacity across SH1 motorway where increase in flood risk is identified to accommodate the proposed designation conditions. ▪ Ground shaping in the inlet and outlet of all culvert locations to balance any change in flows upstream and downstream.	▪ Negligible flooding effects.
NoR 4	▪ 3.0-m wide SUP from CH 15160 to CH 24580 (State Highway 1 from Quarry Road, Drury to Bombay Interchange/ Mill Road)	▪ Low existing risk to agricultural land and residential properties. Moderate existing risk to School Zone. Four locations identified as negligible risk. ▪ Mostly moderate future risk to Mixed Rural Zone, Future Urban Zone, and School Zone. Four locations identified as negligible risk. ▪ Flood volume displacement due to the filling of flood	▪ Runoff attenuation as discussed in Section 3.2.4. ▪ Maintain the existing streams and stream crossings though culverts for all locations. ▪ Size culvert capacity across SH1 motorway where increase in flood risk is identified to accommodate the proposed designation conditions.	▪ Negligible flooding effects.

NoR	Features	Existing and Likely Future Flood Risk	General Recommendations	Residual Level of Effects
		plains, particularly along the overland flow paths crossing the Project area. Minor increase in flood level upstream and downstream of the culvert crossings.	Ground shaping in the inlet and outlet of all culvert locations to balance any change in flows upstream and downstream.	
NoR 5	New link roads to the adjacent network (Maketu Road and Great South Road) to tie-into the proposed Drury South Interchange from CH 300 to CH 1750 Raised viaduct across the Hingaia reserve area	High existing risk to agricultural land, industrial area, and residential properties. High future risk to Future Urban Zone. Flood volume displacement due to the filling of flood plains, particularly along the overland flow paths crossing the Project area. Minor increase in flood levels upstream and downstream of culvert crossings.	Runoff attenuation as discussed in Section 3.2.4. Maintain the existing streams and stream crossings though culverts for all locations. Size culvert capacity across SH1 motorway where increase in flood risk is identified to accommodate the proposed designation conditions. Ground shaping in the inlet and outlet of all culvert locations to balance any change in flows upstream and downstream. If required, provide additional flood storage area by constructing a basin on the north-western side of the proposed interchange.	Negligible flooding effects.

Conclusion

In general, mitigation measures for the flooding effects can be implemented by maintaining the existing streams and stream crossings through culverts. Swales are also proposed alongside the motorway to attenuate runoff from the motorway caused by the increase in impervious surfaces to match pre-Project flows to post-Project peak flows. Upgrading existing culverts can be considered for areas where flood volume displacement was identified based on flood risk assessment. Culverts are proposed within the concept design where appropriate to manage environmental effects. However, the final form of stream crossings with consideration to upstream ponding, erosion protection, and fish passage will be confirmed during the future detailed design and resource consenting phase. Moreover, ground shaping at the inlet and outlet of all culvert locations is recommended to balance any change in flows upstream and downstream, thereby providing mitigation for potential flooding effects.

It is expected that, once the mitigation measures are in place, the residual level of effects would be negligible and the following conditions will be achieved for all NoRs:

- No increase of more than 100mm in flood level on land zoned for urban or future urban development where there is no habitable existing dwelling; and
- No more than a 10% average increase of flood hazard (defined as flow depth times velocity) for main access to authorised habitable dwellings existing at time the Outline Plan is submitted.
- Compliance shall be demonstrated in the Outline Plan, which shall include flood modelling of the pre-Project and post-Project 10% and 1% AEP flood levels (for Maximum Probable Development land use and including climate change).
- Where the above outcomes can be achieved through alternative measures outside of the designation such as flood stop banks, flood walls, raising existing authorised habitable floor level and new overland flow paths or varied through agreement with the relevant landowner, the Outline Plan shall include confirmation that any necessary landowner and statutory approvals have been obtained for that work or alternative outcome.

1 INTRODUCTION

This Assessment of Flooding Effects Report (Report) has been prepared to inform the Assessment of Environmental Effects (AEE) for five Notices of Requirements (NoR) being sought by NZ Transport Agency Waka Kotahi (NZTA) under the Resource Management Act 1991 (RMA).

1.1 Purpose and Scope of this Report

This Report considers the potential flooding effects associated with the construction and operation of the project on the existing and likely future environment, and recommends measures that may be implemented to avoid, remedy, and/or mitigate these effects.

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

1.2 Report Structure

To provide a clear assessment of each NoR, this Report follows the structure set out in the AEE. That is, each notice has been separated out into its own section, and each section contains an assessment of the actual and potential effects for the specific NoR. Where appropriate, measures to avoid, remedy or mitigate effects are recommended.

Table 1-1 describes the extent of each section, and where the description of effects can be found in this Report.

Table 1-1: Summary of the Report Sections

Sections	Section number
Overview of the Project	2
Overview of the methodology used for the assessment, identification of the assessment criteria and any relevant standards or guidelines	3
Description of the Statutory context of the project	4
Overview of stormwater catchment	5
Assessment of specific flooding matters for Stage 2 NoR 1: Alteration to SH1 Designation 6706	6
Assessment of specific flooding matters for Stage 2 NoR 2: Alteration to SH1 Designation 6700	7
Assessment of specific flooding matters for Stage 2 NoR 3: Alteration to SH1 Designation 6701	8
Assessment of specific flooding matters for Stage 2 NoR 4: SUP between Quarry Road and Bombay Interchange	9
Assessment of specific flooding matters for Stage 2 NoR 5: Drury South Interchange Connections	10
Overall conclusion of the level of potential adverse flooding effects of the Stage 2 P2B Project.	11

2 PROJECT DESCRIPTION

2.1 Papakura to Bombay (P2B) Project

P2B is a NZTA led project to improve the transport capacity and functionality of the State Highway network and provide for long term growth in the South of Auckland. An indicative location plan of the P2B area is illustrated in Figure 2-1.

For clarity and by way of summary we note that:

- The previous stages of the P2B, were approved under the Covid 19 Recovery (Fast Track Consenting) Act 2020 (FTA), as part of the Papakura to Drury South project (P2DS), this includes: Stage 1B1 and Stage 1B2; and,
- Stage 1B1 of the P2DS, was approved by the Expert Consenting Panel (EPA) in November 2022, Stage 1B2 was approved by the EPA in July 2023, both applications altered the existing SH1 Designation 6706 (Takanini to Drury Interchange), which is the subject of NoR 1.

Further discussion of the different stages of the P2B Project is contained in the AEE (**Appendix B**), Design Report (**Appendix C**) and legal submissions supporting this application.

2.2 Stage 2

NZTA is seeking five NoRs for Stage 2 of the P2B, which are summarised in Table 2-1. Figure 2-2 shows the location plan of the Project NoR package.

For clarity and by way of summary we note that:

- The Project area, which was formally known as Stages 2 and 3 under the P2B, is now to be referred to as a single stage for route protection only, this is referred herein as ‘Stage 2’ or ‘the Project’,
- Stage 2 incorporates the remaining portion of the P2B Project area south of Quarry Road to the existing Bombay/Mill Road Interchange,
- Stage 2 will protect land required to authorise the future upgrades of the SH1 corridor.

NZTA is seeking to protect land for the following planned works:

- A new interchange constructed at Drury South (one additional lane in both directions of the proposed interchange),
- Upgrades to existing Ramarama Interchange,
- Upgrades to existing Bombay Interchange,
- Continuation of a Shared User Path (SUP) from Quarry Road near its intersection with Great South Road to Bombay Interchange; and,
- Stormwater management devices.

SH1 Papakura to Bombay project

October 2023

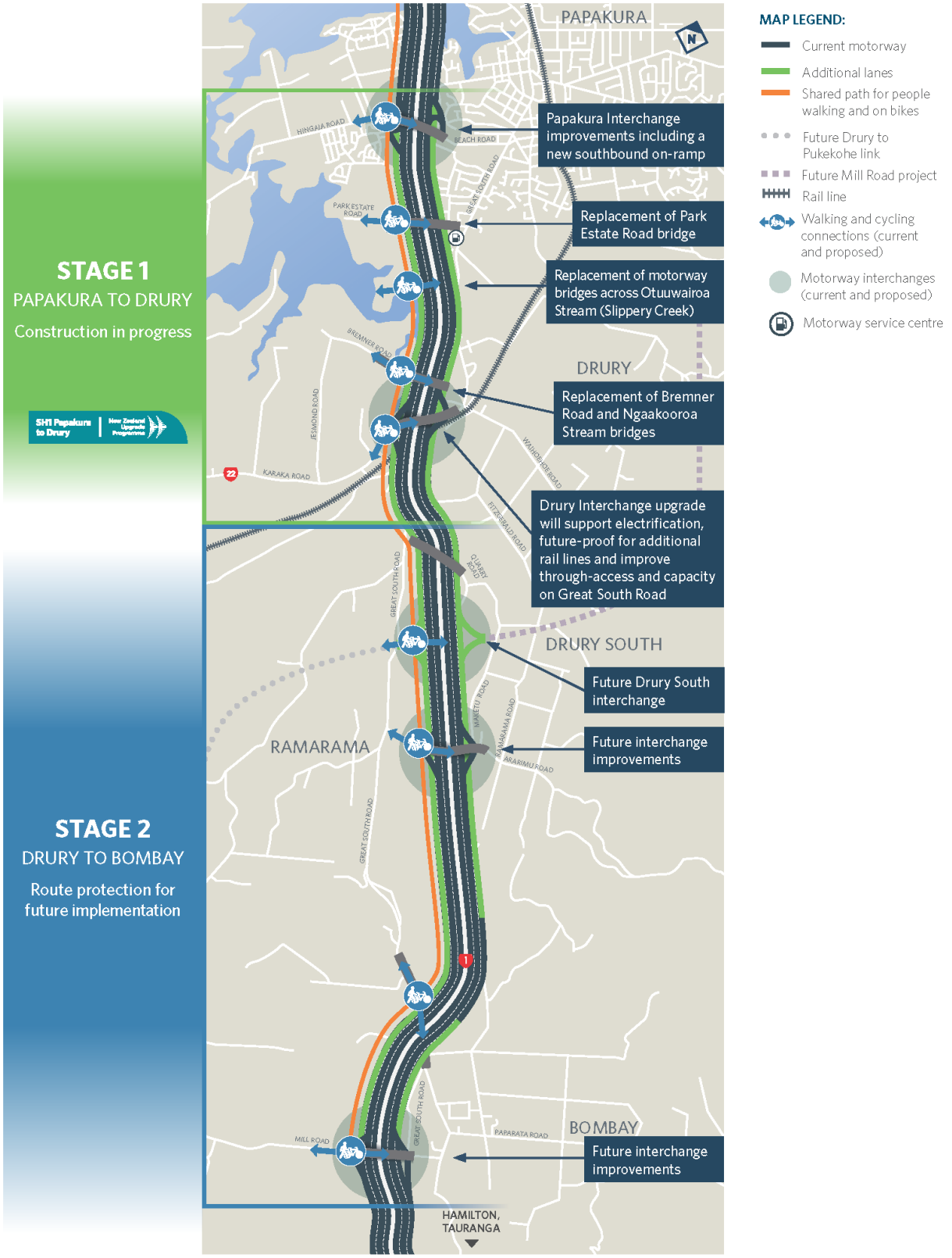

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Figure 2-1 Indicative location plan showing Stage 2 of the NZTA Project

Table 2-1: Summary of the Project NoR Package

Notice	Requiring Authority	Project	Purpose	Extent	Lapse Period
NoR 1	NZTA	Alteration to SH1 Designation 6706	Motorway between Takanini and Hamilton	SH1 CH 15160 to CH 15500 State Highway 1 from north of Takanini Interchange to south of Quarry Road, Drury	Given effect (ie. no lapse date)
NoR 2		Alteration to SH1 Designation 6700	Motorway	SH1 CH 15500 to CH 22740 State Highway 1 from south of Quarry Road, Drury to Bombay Road, Bombay	
NoR 3		Alteration to SH1 Designation 6701	Motorway	SH1 CH 22740 to CH 24600 State Highway 1 from Bombay Road to Mill Road, Bombay	
NoR 4		Shared User Path	Designation for the construction, operation and maintenance of a shared path and associated infrastructure.	SH1 CH 15160 to CH 24580 State Highway 1 from Quarry Road, Drury to Bombay Interchange/Mill Road.	20 years
NoR 5		Drury South Interchange Connections	Designation for the construction, operation and maintenance of a state highway and associated infrastructure.	CH 300 to CH 1750 Adjacent State Highway 1 at Drury South Interchange, linking to Quarry Road to the east, and Great South Road to the west.	20 years

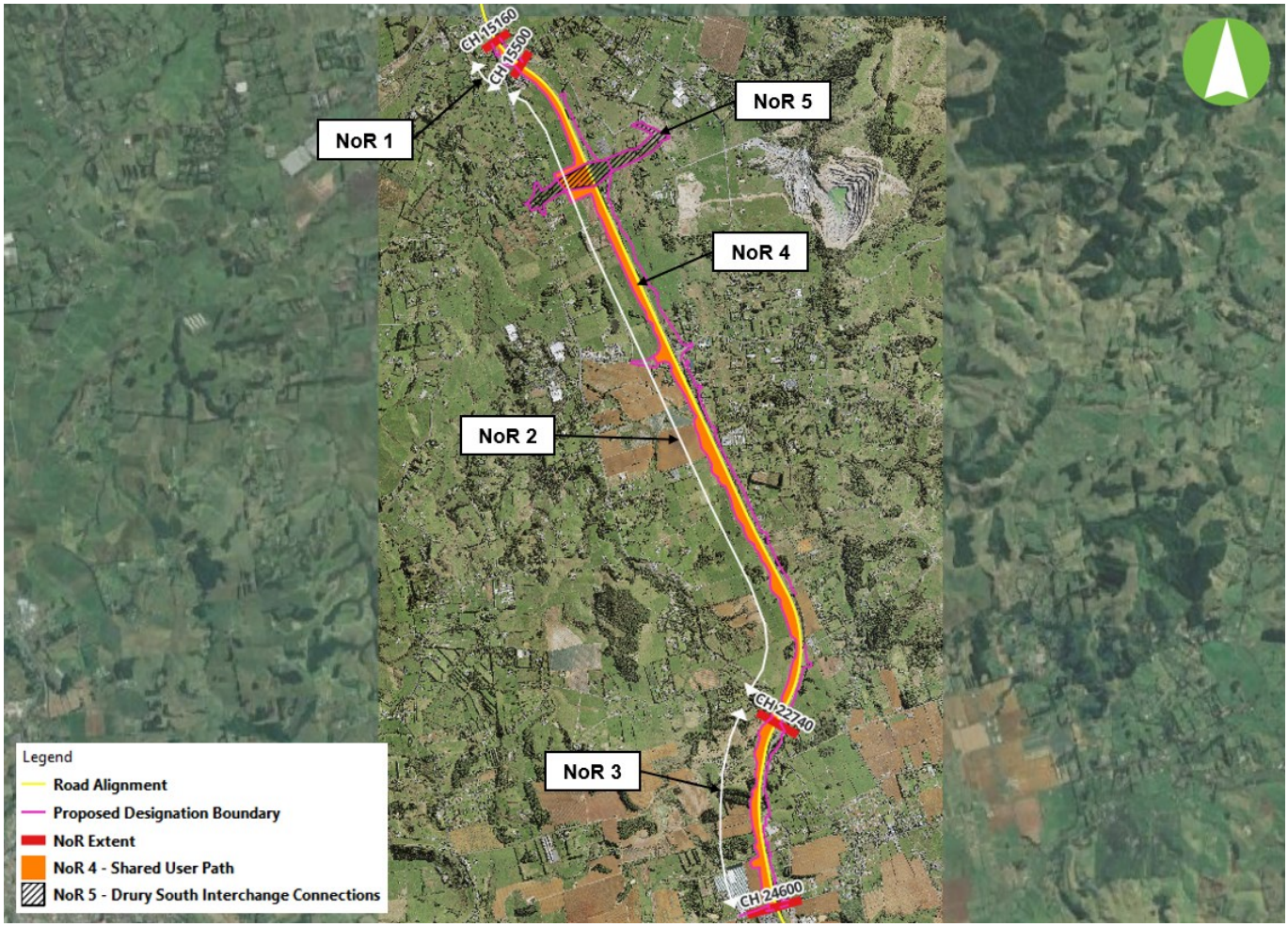


Figure 2-2 Location plan of Project NoR Package

3 ASSESSMENT APPROACH AND METHODOLOGY

3.1 Preparation for this Report

Work undertaken for this Report commenced in September 2023. In summary, the preparation for this work has included:

- Desktop research of the existing flood plains and overland flow paths using on-line resources (e.g., AUP overlays, AC GeoMaps, archived reports, and aerial photography);
- A review of flood assessment reports, structure plans and Healthy Waters catchment manager plans/expectations for the catchments;
- Engagement with Tonkin & Taylor to perform the flood modelling using the existing model used for the Drury South Area (DSA) development project. Details of this project can be found in the Drury South Flood Management Assessment (Tonkin & Taylor, June 2023) which documents compliance with the Drury South Precinct Rules and the relevant Earthworks (BUN60305778) and Network Discharge (DIS60313540, July 2018) Consents for the proposed finalised development and flood plain earthwork design for the Drury South Area (DSA); and,
- Several workshops with NZTA, Tonkin+Taylor, and internal flooding experts to ensure all potential effects on flooding were addressed.

3.2 Methodology

This assessment of flooding effects aims to inform the proposed designation area of the Project. The assessment of construction effects and operational effects have been assessed separately in this report. As regional resource consents are not being sought at this stage, the methodology has focused on identifying areas where flood risk is present in the existing and future environment, and to provide an indicative designation footprint required to mitigate the potential adverse flooding effects resulting from the proposed Project. Flood risk, which indicates the potential flooding in the area with the consideration of the vulnerability of the location (i.e., whether flooding caused by the Project will affect nearby properties), has been identified in each NoR. From this, various mitigation measures (e.g., upgrading culverts, implementing swales, and ground shaping) will be recommended based on the flood risk assessment. The design of specific stormwater and flooding mitigation features will be further developed at the future detailed design stage for each Project, with regional resource consents sought at that time.

Table 3-1 provides a summary of the steps undertaken to assess the flooding effects of the Project.

Table 3-1. Summary of assessment approach

Methodology	Applicable NoR
▪ Desktop assessment to identify areas at risk of flooding	All NoRs
▪ Review of flood depths and potential impacts at key locations such as crossings and areas characterised by high vulnerability to flood risks, such as residential properties	All NoRs
▪ High-level assessment of the potential impact on minor overland flow paths at culvert crossings, utilising the most up-to-date flood information published by Auckland Council	NoR 1, NoR 2, NoR 3, NoR 4
▪ Flood modelling of the pre-development and post-development scenarios with Maximum Probable Development (MPD) and future 1% Annual Exceedance Probability (AEP) plus climate change rainfall	NoR 5
▪ Identify potential mitigation measures, assess their effectiveness, and estimate the required compensatory flood storage to determine the designation boundaries	All NoRs

A Flood Hazard condition is proposed on all Project NoRs which will require the future detailed design of the Project to be designed to achieve specific flood risk outcomes. The following flood hazard outcomes are included on all NoRs. This requires that the Projects be designed to achieve the following:

- No increase of more than 100mm in flood level on land zoned for urban or future urban development where there is no habitable existing dwelling;
- No more than a 10% average increase of flood hazard (defined as flow depth times velocity) for main access to authorised habitable dwellings existing at time the Outline Plan is submitted;
- Compliance shall be demonstrated in the Outline Plan, which shall include flood modelling of the pre-Project and post-Project 10% and 1% AEP flood levels (for Maximum Probable Development land use and including climate change); and,
- Where the above outcomes can be achieved through alternative measures outside of the designation such as flood stop banks, flood walls, raising existing authorised habitable floor level and new overland flow paths or varied through agreement with the relevant landowner, the Outline Plan shall include confirmation that any necessary landowner and statutory approvals have been obtained for that work or alternative outcome.

3.2.1 Desktop Assessment

A desktop assessment was performed to identify areas at risk of flooding, understand the level of risk based on the existing and future land use, and qualitatively assess the potential flooding impact of the proposed works on the surrounding areas. In this assessment, the most up-to-date flood information published by Auckland Council were utilised. The desktop assessment was undertaken to assess the flooding effects for NoRs 1, 2, 3, and 4 where the areas are mainly affected by minor overland flow paths at culvert crossings. The following reference materials were used to inform the desktop study:

- Auckland Council GIS resources (Auckland GeoMaps);
- Regionwide Rural Rapid Flood Model Build Report (AC, 2023);
- Oira Creek and Ngākōroa Stream RFHA Model Build Report (AC, 2017);
- Design Drawings; and
- Indicative Construction Methodologies

The existing and future flood risk was assessed in accordance with a qualitative risk matrix shown in Table 3-2. The risk matrix was developed for this assessment based on the available information. The existing land use was defined based on the available aerial imagery, while the future land use was determined based on the unitary plan zones from AC GeoMaps. Based on the Future Development Strategy, it is assumed that the Future Urban Zone (FUZ) will be live zoned at the time of construction (i.e., 15-20 years), and areas that are currently zoned as 'Rural' are assumed to remain rural over the same timeframe.

Table 3-2: Criteria for flooding effects risk assessment

Flood Volume Displacement		**Land Use**		
		Less Vulnerable (e.g., open space and rural area)	**Moderately Vulnerable** (e.g., commercial area, industrial area, mixed rural)	**Highly Vulnerable** (e.g., future urban, educational facilities)
Negligible	none			
Low	(< 1,000 m^3)			
Moderate	(1,000 – 10,000 m^3)			
High	(> 10000 m^3)			

Overall Flood Risk	Negligible	Low	Moderate	High

Using the design drawings and the flood plain layers downloaded from the AC GeoMaps, the loss of flood storage volume due to the Project works were estimated. The outcome of this assessment was then used to set the designation boundary as well as to identify the potential level of effects and suitable conditions, and to recommend the suitable flood mitigation measures that can be implemented on site.

3.2.2 Flood Modelling

The proposed works within the NoR 5 extent which include the new Drury South Interchange, State Highway 1 (SH1) road widening, and the construction of a bridge connecting Maketu Road to the east and Great South Road to the west is considered a critical location from the flooding perspective since it is located within and along the main tributary of the Hingaia catchment and intersects the main flood plain of the Hingaia Stream. Therefore, in order to evaluate the flooding effects of the Project within NoR 5, flood modelling was undertaken. Tonkin+Taylor was engaged by NZTA to perform the flood modelling and the results formed the basis of the assessment in this Report.

A TUFLOW 1D/2D linked hydraulic model that was developed since 2018 for the DSA project, was utilised for this assessment. This model was derived from the original DHI MIKE FLOOD model of the Hingaia catchment and has been continuously updated in consultation with Auckland Council. The DHI MIKE FLOOD model was originally used for the flood modelling of the DSA. However, in order to provide specific detailed analysis of the Hingaia Stream within the DSA area, a more fit-for-purpose TUFLOW 1D/2D linked model has been developed by Tonkin+Taylor. This model is considered better suited for detailed design purposes as it focuses on a smaller extent but provides a more detailed representation of the hydraulic elements within the study area. This updated TUFLOW model has been verified and has undergone multiple reviews with Auckland Council. In preparing this Report, several workshops between Aurecon and Tonkin+Taylor were held to ensure the model's suitability for this assessment.

As the TUFLOW model is based on an AC catchment model, the hydrological inputs including the design rainfall profile is in accordance with AC specifications and methodology. Moreover, climate change has been accounted for per the AC Code of Practice for Land Development and Subdivision (temperature increase of 2.1 degrees by 2090). Auckland Council (AC) takes guidance from the MfE 2008 study Climate Change Effects and Impacts Assessment: A Guidance Manual for Local Government in New Zealand.

The latest version of the TUFLOW model, which incorporates the latest design configuration including the modified Hingaia flood plain as part of the proposed DSA mitigation works, serves as the baseline scenario for assessing the flooding effects of this Project. This means that the 'existing environment' considered in this assessment is the fully developed environment anticipated by the DSA.

The TUFLOW flood model has been updated accordingly for this Project by incorporating the following elements to form the post-development scenario:

- Design surface of the proposed new Drury South Interchange;
- Bridge configuration of the proposed link between Quarry Road and Great South Road; and
- Culvert modification at CH 16600 and CH 17380 west of Drury Transpower Substation.

The bridge concept design which has been developed for this NoR application, has gone through numerous iterations, including adjustments to the abutments and pier alignments to minimise its impact on the flooding regime of the Hingaia Stream.

A technical memorandum detailing the inputs, methodology and assumptions used in the flood modelling for this assessment was prepared by Tonkin+Taylor and included in **Appendix A**. For flood mapping, a threshold value of ±50 mm has been adopted as negligible since it falls within the flood model's margin of error. This aligns with the threshold used in the P2B Stage 1 project.

3.2.3 Sensitivity Assessment

Sensitivity assessments were conducted using the TUFLOW model to understand the influence of the culvert at CH 16660 on flood levels. The objective was to explore the feasibility of improving the flooding conditions downstream of the culvert at CH16660, thereby addressing concerns affecting the eastern portion of the motorway (i.e., the downstream stream and adjacent areas). A few mitigation options were identified and evaluated within the flood model to determine their effectiveness. These included modifying the size of culvert at CH16660 and providing additional flood storage area on the north-western side of the proposed Drury South Interchange. The details of the modelling are included in **Appendix A**.

3.2.4 Stormwater Hydrological Assessment

A hydrological assessment has been conducted to determine the effects of increased impervious surfaces within the Project boundary on stormwater runoff. Swales have been proposed alongside the motorway to attenuate the additional runoff caused by the Project and to match the pre-Project flows to post-Project peak flows. This ensures that any potential flooding impacts contributed by the increased imperviousness are sufficiently mitigated.

4 STATUTORY CONTEXT

4.1 Notice of Requirement – District Plan Requirements

This assessment has been prepared to support the AEE and NoR process. If confirmed, the designations will authorise the District Plan land use components of the Project. Accordingly, when assessing the actual or potential effects on the environment of allowing the requirement in terms of Section 171 of the RMA, this assessment has been limited to matters that would trigger a District Plan consent requirement. Where regional consenting requirements are triggered, these will not be authorised by the designation, and will require further regional consents at a later date.

4.2 Future Regional Resource Consents

No regional resource consents are currently being sought for the Project. These will be sought at a later date, before construction commences. Although regional consents are not being sought at this time, flooding effects arising in respect of activities that require regional consents have been considered as part of this assessment to inform design, and the proposed designation footprint. While flooding effects in respect of regional consent matters have been considered for these limited purposes, a detailed assessment of Regional Plan matters is not proposed to be undertaken at this NoR phase.

5 OVERVIEW OF STORMWATER CATCHMENT

5.1 Catchment Description

The Project interfaces with two catchments: Hingaia Stream catchment to the east and Ngākōroa Stream catchment to the west of SH1 motorway. The majority of the Project Area lies within the boundaries of the Hingaia catchment as shown in Figure 5-1. Although the Project Area is primarily within the Hingaia catchment, its southern and northern ends cross into the Ngākōroa catchment.

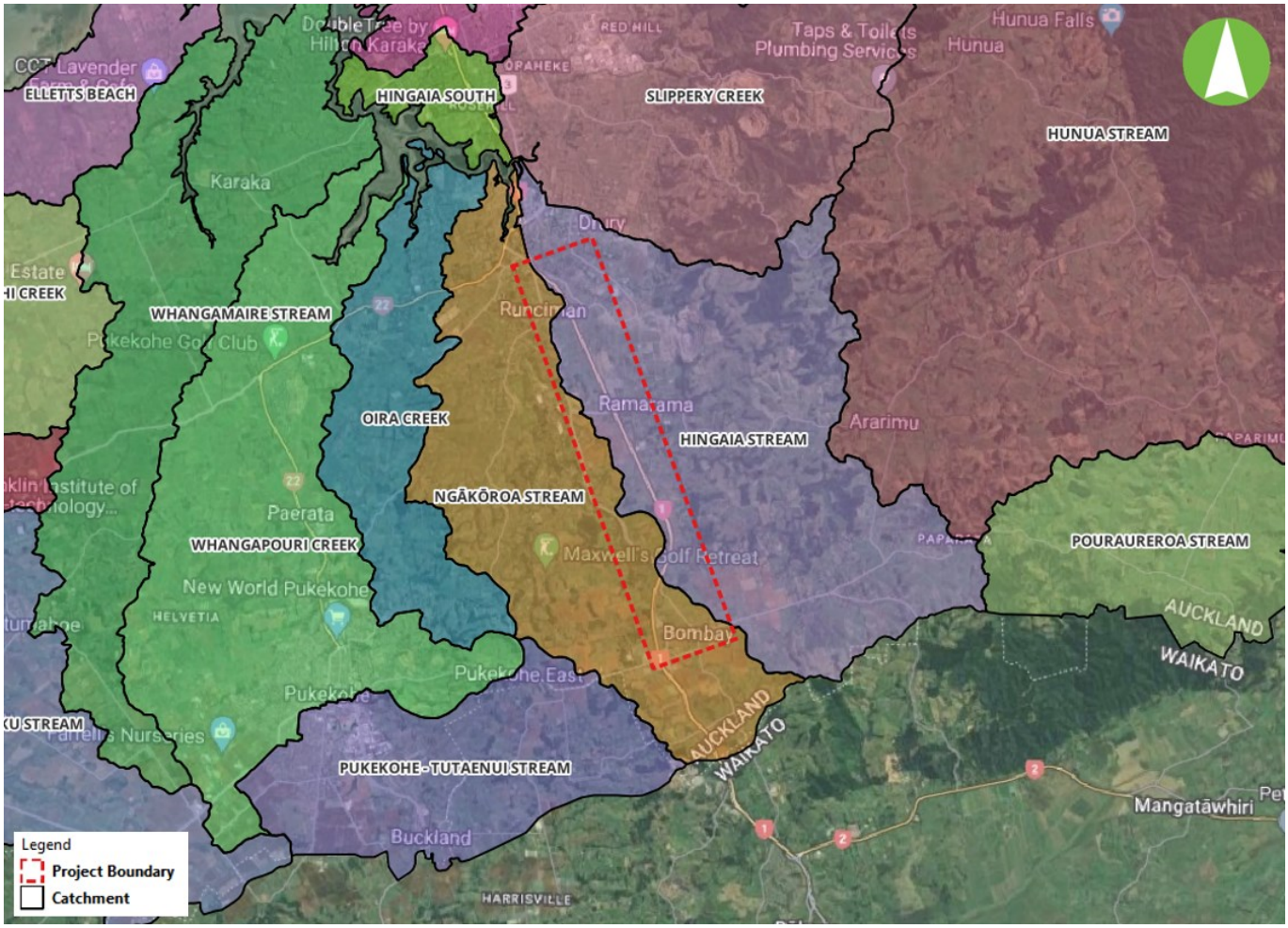


Figure 5-1 Wider catchments interfacing with the Project

5.2 Flood Plain and Overland Flow Paths

Minor overland flow paths from the tributaries of the Hingaia Stream and Ngākōroa Stream intersect the motorway, as illustrated in Figure 5-2. As can be observed in the figure, these overland flow paths that intersect the Project Area are located close to the upstream end of the catchment and therefore convey flows from a relatively small contributing sub-catchment areas.

However, the northern portion of the Project Area is where most of the catchment flows converge as it is situated at the downstream part of the Hingaia catchment. As can be seen in Figure 5-2, the area east of the SH1 at the northern end of the Project extent is inundated during the 1% AEP event plus climate change, rendering it high-risk in terms of flooding due to the presence of a large flood plain. Additionally, this area also falls within the Future Urban Zone (FUZ) as outlined in the Auckland Unitary Plan (AUP), therefore the risk to human safety needs to be considered carefully.

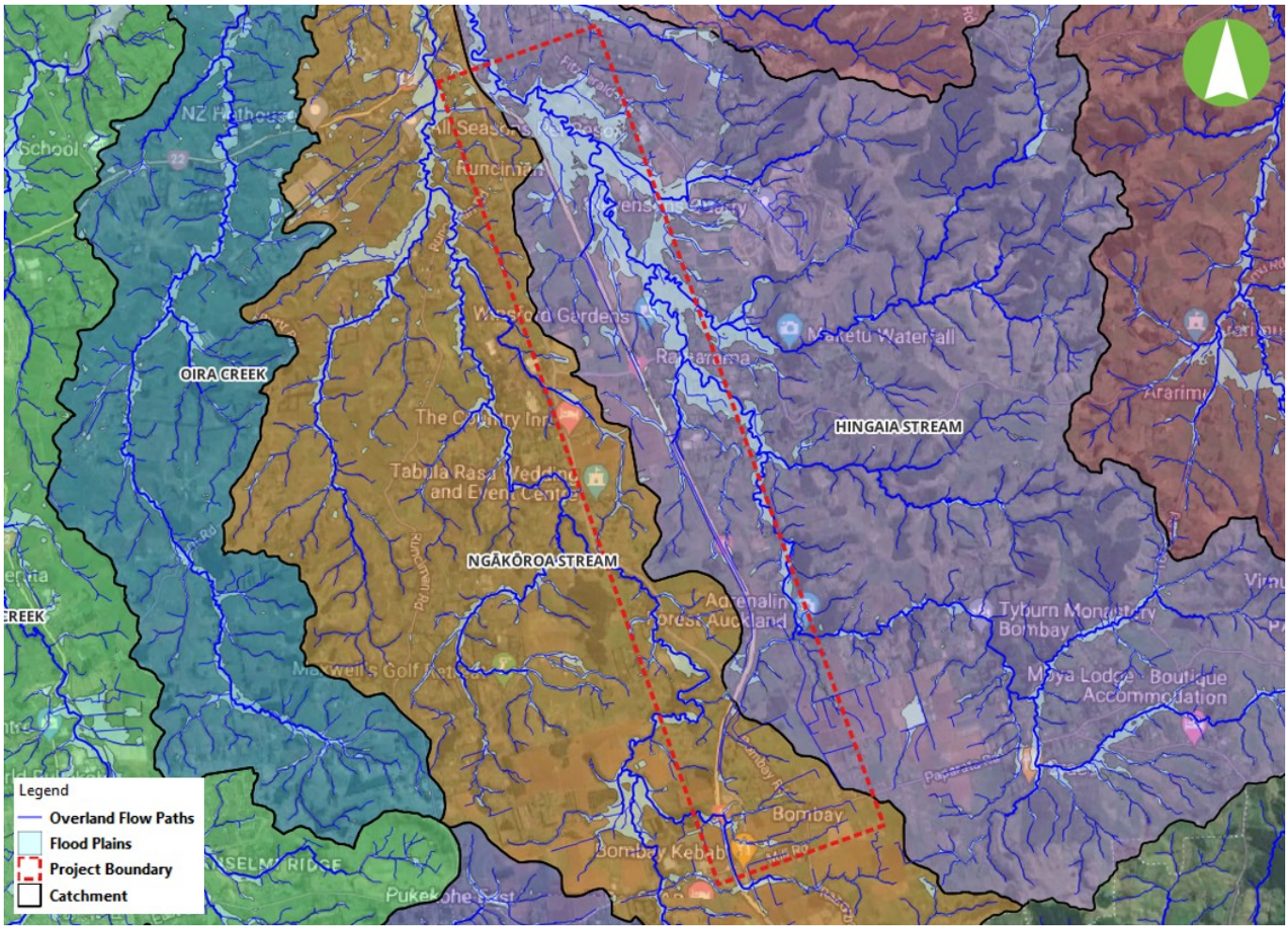


Figure 5-2 Overland Flow Paths Intersecting the Project Boundary (Source: AC GeoMaps)

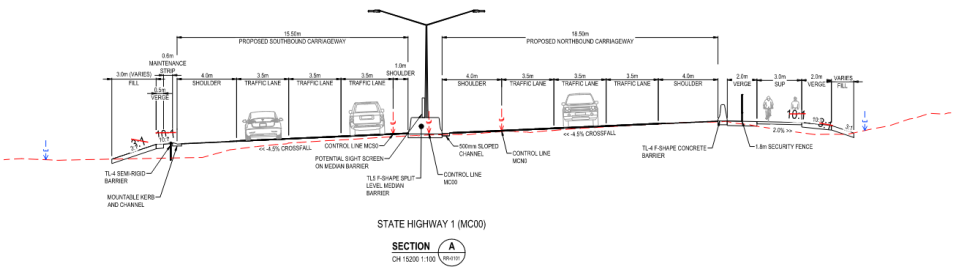
6 NOR 1: ALTERATION TO SH1 DESIGNATION 6706

This section assesses the specific flooding matters in relation to NoR 1: Alterations to the existing SH1 Designation 6706.

6.1 Overview and Description of Works

Table 6-1 sets out the proposed alterations to the existing SH1 Designation 6706 to provide widening of the existing SH1 corridor and accommodate the future upgrades to the SH1 network.

Table 6-1: Overview of the alteration to SH1 Designation 6706

NoR 1 – Alteration to SH1 Designation 6706	
Overview	▪ Six general traffic lanes (4.3m shoulders) on State Highway 1. ▪ Safety improvements include upgrading interchanges, wider shoulders, new barriers, and improved lighting along the full extent of the Project.
Structures	▪ N/A
Extent	▪ CH 15160 to CH 15500 - State Highway 1 from north of Takanini Interchange to south of Quarry Road, Drury (refer to Figure 6-1).
Access Lanes	▪ Designed to accommodate special vehicle lane within the 4m shoulder.
Intersections	▪ N/A
Stormwater Infrastructure	▪ Vegetated treatment swales to provide water quality treatment of all runoffs from impervious carriageway surfaces (existing and proposed) and water quantity treatment for the increase in impervious surfaces. ▪ In instances where constraints do not allow for the formation of vegetated treatment swales, runoff will be collected by piped reticulation and conveyed to constructed wetlands to provide stormwater quality and quantity treatment.
Typical cross sections	

6.2 Existing and Future Environment

Figure 6-1 shows the overland flow paths and floodplains within the project boundary for NoR 1. The existing land use on both sides of the motorway is a combination of agricultural land and residential properties. Based on the available information, there are no culvert crossings within the area however, there is an existing overland flow path beneath the existing Quarry Road overbridge which flows towards the eastern side of the motorway to the Hingaia Stream. During the 1% AEP event with climate change, flooding within the Hingaia Stream reaches a level of up to around 15 m, resulting in flood water backing up towards the sag section of the motorway at CH 15500 as shown in Figure 6-1.

Figure 6-1 Overland flow paths and floodplains within NoR 1 project boundary

Figure 6-2 shows the likely future environment within the vicinity of NoR 1 project extent. Based on the unitary plan zones from AC GeoMaps, the future condition in the western side of the motorway is expected to be fully developed under the Future Urban Zone, while the eastern side of the motorway is to be developed under the Light Industry Zone. In general, this area will be moderately to highly vulnerable in the future.

Figure 6-2 Likely future environment within the vicinity of NoR 1 project boundary

6.3 Assessment of Construction Effects

During the construction phase, localised flooding impacts may arise due to temporary diversions during the installation of new culverts and/or modifications to existing ones. However, due to the relatively short construction duration in combination with the low probability of an extreme flood event, it is unlikely that there will be any construction flooding effects. The details of the construction approach will be refined by the contractor prior to construction. It is expected that the construction activities can be carried out in a manner that minimises or mitigates flood risks. It is worth noting that NZTA has a substantial track record of effectively managing construction works and implementing mitigation strategies, as demonstrated in previous projects like Stage 1A and Southern Corridor Improvements (SCI). The flood management strategies will be further developed throughout the project delivery phase and will undergo additional assessment during detailed construction planning. It is important that the future Construction Environmental Management Plan (CEMP) remains cognisant of the potential adverse effects on flooding during construction activities.

6.4 Assessment of Operational Effects

The operation of NoR 1, which include the road widening as well as a new SUP (authorised by NoR 4) is not expected to significantly alter the flooding regime within and outside the project boundary because the existing topography will largely remain unchanged. Additionally, the proposed works are located at the fringe of the flood plain which acts as flood storage only and not a major flow path. Furthermore, the affected area is relatively small compared to the wider flood plain along the Hingaia Stream. Therefore, any impact on flooding caused by the proposed works is likely to be negligible. The flood extent is expected to remain generally consistent with the existing flooding conditions (refer to Figure 6-1) such that flooding will only be contained within the existing streams, hence no other properties are expected to be adversely affected.

6.5 Recommended Measures to Avoid, Remedy or Mitigate Flooding Effects

As discussed in Section 6.4, the flooding impact within the NoR 1 extent is expected to be minimal. Nonetheless, any potential flood effects can be mitigated through ground shaping in the inlet and outlet of the culvert locations to balance any change in flows upstream and downstream. For proposed mitigation measures for the increase in impervious surfaces (for road widening and formation of shared user path), refer to Section 3.2.4. With these measures, it is expected that the residual level of effects would be negligible, and the conditions set out in Section 3.2 will be achieved.

Figure 6-3 Proposed swale within NoR 1 project boundary

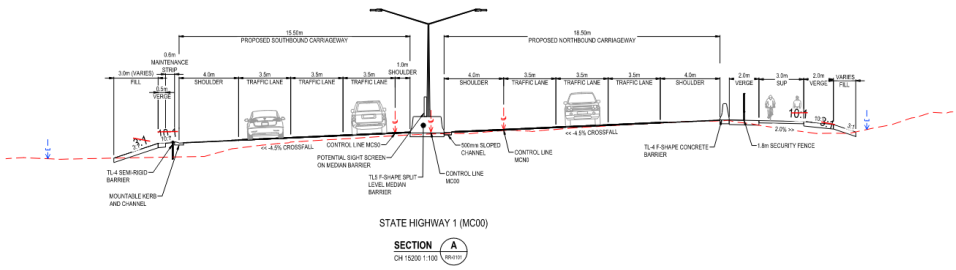
7 NOR 2: ALTERATION TO SH1 DESIGNATION 6700

This section assesses the specific flooding matters in relation to NoR 2: Alterations to the existing SH1 Designation 6700.

7.1 Overview and Description of Works

Table 7-1 sets out the proposed alterations to the existing SH1 Designation 6700 to provide widening of the existing SH1 corridor and accommodate the future upgrades to the SH1 network.

Table 7-1: Overview of the alteration to SH1 Designation 6700

NoR 2 – Alteration to SH1 Designation 6700	
Overview	▪ Six general traffic lanes (4.3m shoulders) on State Highway 1. ▪ Safety improvements include upgrading interchanges, wider shoulders, new barriers, and improved lighting along the full extent of the Project.
Structures	▪ Drury South Interchange ▪ Ramarama Interchange
Extent	▪ CH 15550 to CH 22740 - State Highway 1 from south of Quarry Road, Drury to Bombay Road, Bombay (refer to Figure 7-1).
Access Lanes	▪ Designed to accommodate special vehicle lane within the 4m shoulder.
Intersections	▪ Drury South Interchange – new over-pass with roundabouts ▪ Ramarama Interchange – modified Stevensons roundabout with ramp signals and off-line bridge
Stormwater Infrastructure	▪ Vegetated treatment swales to provide water quality treatment of all runoffs from impervious carriageway surfaces (existing and proposed) and water quantity treatment for the increase in impervious surfaces. ▪ In instances where constraints do not allow for the formation of vegetated treatment swales, runoff will be collected by piped reticulation and conveyed to constructed wetlands to provide stormwater quality and quantity treatment.
Typical cross sections	

7.2 Existing and Future Environment

Figure 7-1 shows the overland flow paths and floodplains within the project boundary for NoR 2. The existing land use on both sides of the motorway is mainly agricultural land with a few pockets of residential properties. There are several culvert crossings in the area located at the following chainages: CH 16000, CH 16660, CH 17380, CH 18240, CH 18520, CH 18580, CH 19580, CH 19660, CH 20820, and CH 22060. The overland flow paths at these locations generally flow towards the eastern side of the motorway to the tributaries of Hingaia Stream.

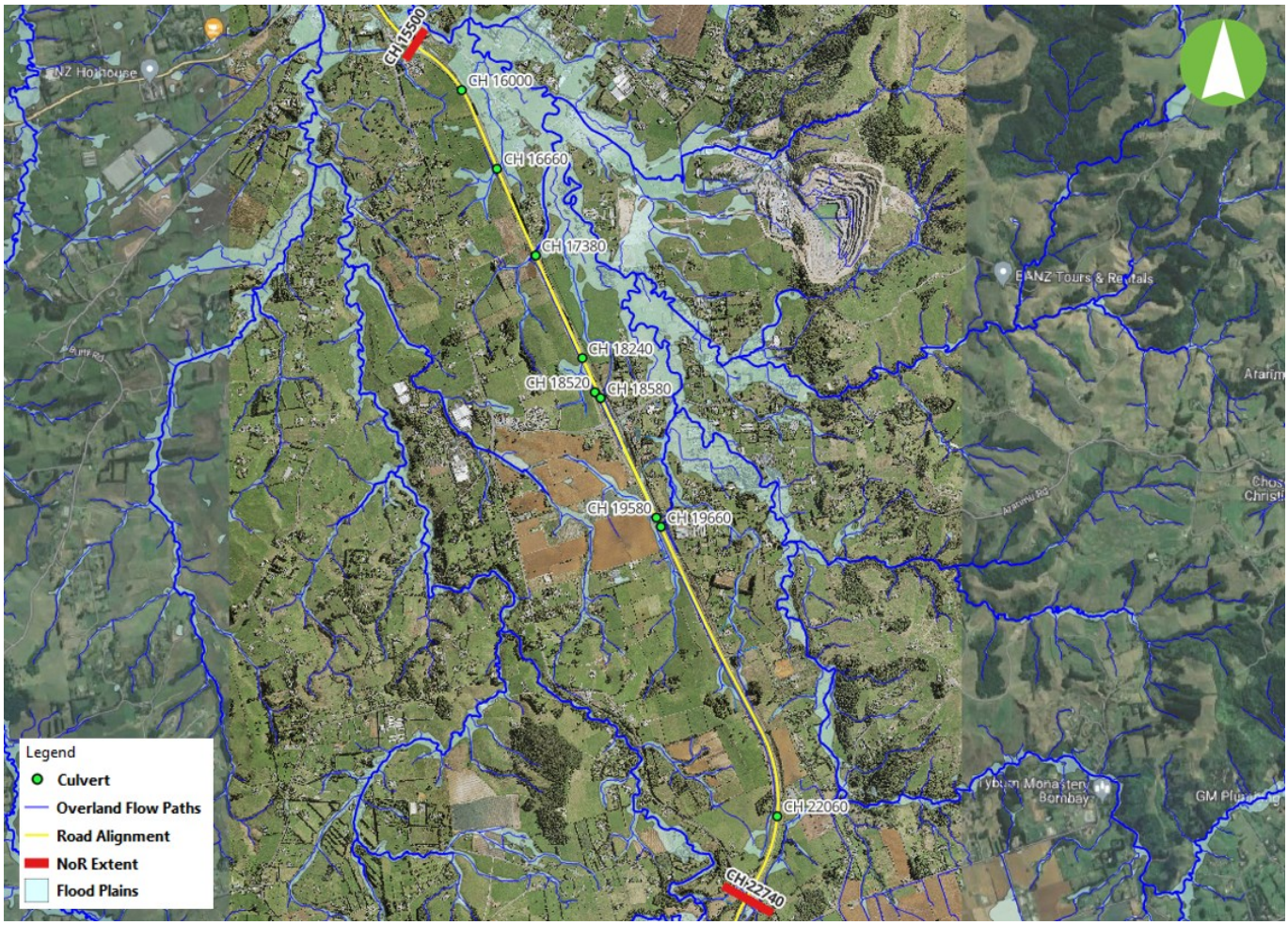


Figure 7-1 Overland flow paths and floodplains within NoR 2 project boundary

Figure 7-2 shows the likely future environment within the vicinity of NoR 2 project extent. Based on the unitary plan zones from AC GeoMaps, the future condition on the western side of the motorway is expected to be fully developed under the Future Urban Zone from CH 15500 to CH 16600 and will remain as Mixed Rural Zone from CH 16660 to CH 22740. The eastern side of the motorway is planned to be developed under the Light Industry Zone from CH 15500 to CH 16600 and Residential Zone from CH 16600 to CH 18580, while the rest is expected to remain as Rural Production Zone. In general, this area will be moderately to highly vulnerable in the future.

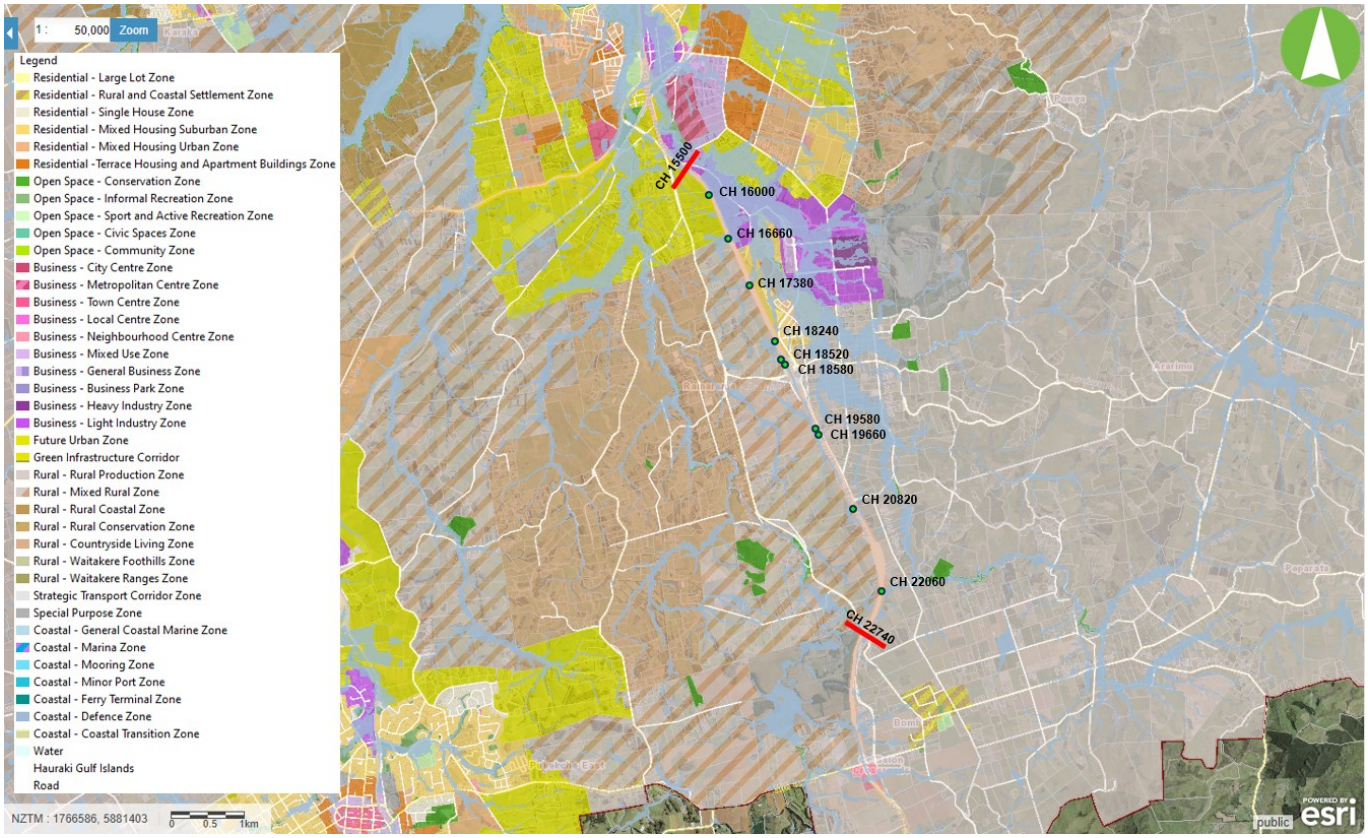


Figure 7-2 Likely future environment within the vicinity of NoR 2 project boundary

7.3 Assessment of Construction Effects

The construction effects for NoR 2 are expected to be similar with what was discussed in Section 6.3.

7.4 Assessment of Operational Effects

The risk assessment of flooding effects for NoR 2 is set out in Section 3.2.10. Table 7-2 presents the flood risk for all the culvert crossings within the NoR 2 extent based on 1% AEP event with climate change. The flood risk assessment for the culverts located at CH 16660 and CH 17380 is discussed in Section 10.4, as these were included in the flood modelling.

Table 7-2: NoR 2 – Flood risk for 1% AEP with climate change

Culvert Crossing	Land Use		Flood Volume Displacement 1% AEP with CC (m^3)		Area Increase of Flood Extent 1% AEP with CC (ha)		Existing and Likely Future Flood Risk Rating
	Existing	Future	Upstream	Downstream	Upstream	Downstream	
CH 16000	Agricultural land on both sides of the motorway	Future urban zone on the western side of motorway, light industry zone on the eastern side of the motorway	860	-	0.24	-	Low existing and moderate future risk

Culvert Crossing	Land Use		Flood Volume Displacement 1% AEP with CC (m^3)		Area Increase of Flood Extent 1% AEP with CC (ha)		Existing and Likely Future Flood Risk Rating
	Existing	Future	Upstream	Downstream	Upstream	Downstream	
CH 18240	Agricultural land on both sides of the motorway	Mixed rural zone on the western side of motorway, mixed housing suburban zone on the eastern side of motorway	20,746	265	0.45	negligible	Moderate existing and future risk
CH 18520	Agricultural land on both sides of the motorway	Mixed rural zone on the western side of motorway, mixed housing suburban zone on the eastern side of motorway	-	-	-	-	Negligible existing and future risk
CH 18580	Agricultural land on both sides of the motorway	Mixed rural zone on the western side of motorway, mixed housing suburban zone on the eastern side of motorway	-	-	-	-	Negligible existing and future risk
CH 19580	Agricultural land on the western side of the motorway, residential properties and agricultural land on the eastern side of the motorway	Mixed rural zone on the western side of motorway, rural production zone on the eastern side of motorway	-	-	-	-	Negligible existing and future risk
CH 19660	Agricultural land on the western side of the motorway, residential properties and agricultural land on the eastern side of the motorway	Mixed rural zone on the western side of motorway, rural production zone on the eastern side of motorway	-	-	-	-	Negligible existing and future risk

Culvert Crossing	Land Use		Flood Volume Displacement 1% AEP with CC (m^3)		Area Increase of Flood Extent 1% AEP with CC (ha)		Existing and Likely Future Flood Risk Rating
	Existing	Future	Upstream	Downstream	Upstream	Downstream	
CH 20820	Agricultural land on both sides of the motorway	Mixed rural zone on the western side of motorway, rural production zone on the eastern side of motorway	4,010	-	0.16	-	Low existing and moderate future risk
CH 22060	Agricultural land on the western side of the motorway, residential properties and agricultural land on the eastern side of the motorway	Mixed rural zone on the western side of motorway, rural production zone on the eastern side of motorway	1,242	87	0.16	negligible	Low existing and moderate future risk

The proposed works within the NoR 2 extent which include the road widening as well as a new SUP (authorised by NoR 4) are not expected to significantly alter the flooding regime within and outside the project boundary because the existing topography will largely remain unchanged. There will be a minor increase in flood level upstream and downstream of the culvert crossings due to flood volume displacement, however the flood extent is expected to remain generally consistent with existing flooding conditions (refer to Figure 7-1) such that flooding will only be contained within the existing streams. This is because the stream channels have sufficient capacity to contain the increased water volume without overflowing their banks. Therefore, minor increases in flood level will not cause water to significantly spread laterally. With this, no other properties are expected to be adversely affected. Therefore, any potential adverse flooding impact resulting from the proposed works is expected to be mitigated sufficiently.

7.5 Recommended Measures to Avoid, Remedy or Mitigate Flooding Effects

Flooding effects within the NoR 2 extent can be minimised by maintaining the existing streams and stream crossings through culverts. For locations where flood volume displacement is identified (refer to Table 7-2), any adverse flooding impacts can be mitigated by upgrading the existing culverts across the motorway. Moreover, ground shaping in the inlet and outlet of all culvert locations is recommended to balance any change in flows upstream and downstream, thereby providing mitigation for potential flooding effects. For proposed mitigation measures for the increase in impervious surfaces (for road widening and formation of shared user path), refer to Section 3.2.4. Figure 7-3 shows the proposed swale locations within NoR 2 project extent.

With the mitigation measures in place, it is expected that the residual level of effects would be negligible, and the conditions set out in Section 3.2 will be achieved.

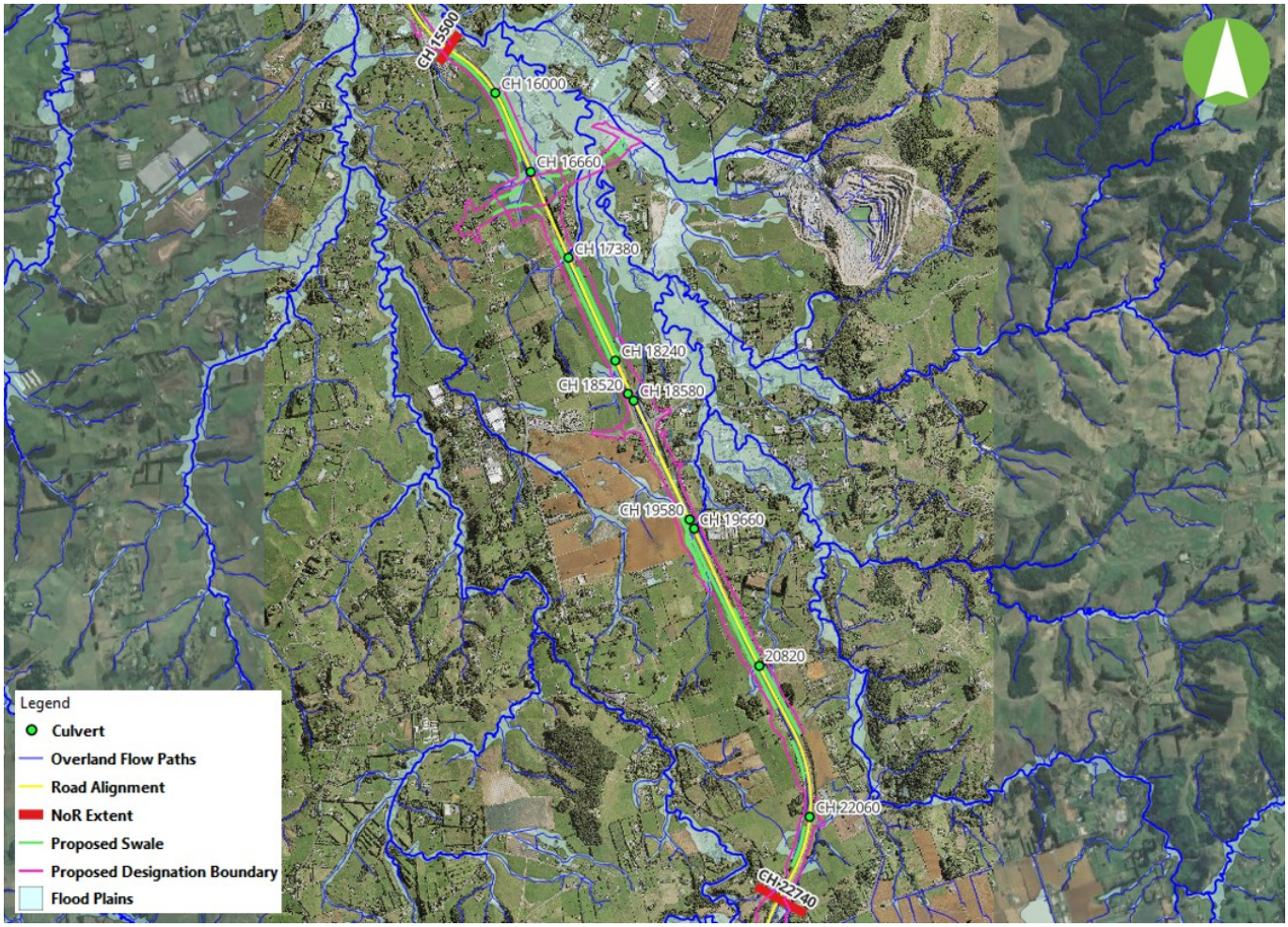


Figure 7-3 Proposed swale locations within NoR 2 project boundary

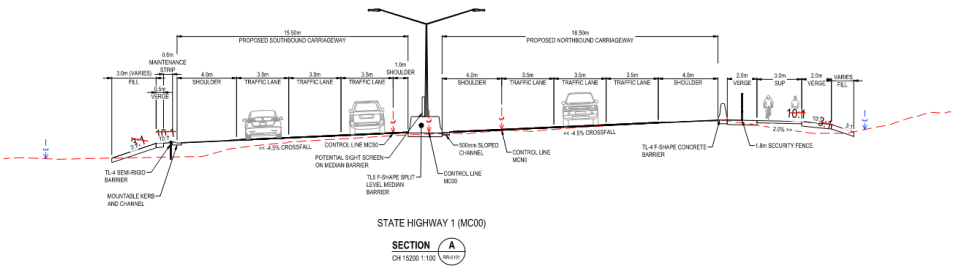
8 NOR 3: ALTERATION TO SH1 DESIGNATION 6701

This section assesses the specific flooding matters in relation to NoR 3: Alterations to the existing SH1 Designation 6701.

8.1 Overview and Description of Works

Table 8-1 sets out the proposed alterations to the existing SH1 Designation 6701 to provide widening of the existing SH1 corridor and accommodate the future upgrades to the SH1 network.

Table 8-1: Overview of the alteration to SH1 Designation 6701

NoR 3 – Alteration to SH1 Designation 6701	
Overview	▪ Six general traffic lanes (4.3m shoulders) on State Highway 1. ▪ Safety improvements include upgrading interchanges, wider shoulders, new barriers, and improved lighting along the full extent of the Project.
Structures	▪ Upgrades to the existing Mill Road/Bombay Interchange ▪ Mill Road over-bridge and abutments ▪ SH1 Great South Road Bridge
Extent	▪ CH 22740 to CH 24600 - State Highway 1 from Bombay Road to Mill Road, Bombay (refer to Figure 8-1).
Access Lanes	▪ Designed to accommodate special vehicle lane within the 4m shoulder.
Intersections	▪ Bombay Interchange – northbound signals ▪ Mill Road Bridge – altering both abutments to allow realignment of the road beneath Bombay Interchange
Stormwater Infrastructure	▪ Vegetated treatment swales to provide water quality treatment of all runoffs from impervious carriageway surfaces (existing and proposed) and water quantity treatment for the increase in impervious surfaces. ▪ In instances where constraints do not allow for the formation of vegetated treatment swales, runoff will be collected by piped reticulation and conveyed to constructed wetlands to provide stormwater quality and quantity treatment.
Typical cross sections	

8.2 Existing and Future Environment

Figure 8-1 shows the overland flow paths and floodplains within the project boundary for NoR 3. The existing land use on both sides of the motorway is mainly agricultural land with some residential properties. There is an existing school zone west of the motorway around CH 23080 and CH 23560. Several culvert crossings can also be found in the area, particularly at the following chainages: 23080, 23560, and 24000. The overland flow paths at these locations generally flow towards the western side of the motorway to the Ngākōroa Stream. Based on Oira Creek and Ngākōroa Stream RFHA Report (Auckland Council, 2017), the culverts at chainage 23560 and 24000 both have a single barrel with a diameter of 1.2 m and 2.1 m, respectively, taken from AC-provided SH1 culvert spreadsheets.

Figure 8-1 Overland flow paths and floodplains within NoR 3 project boundary

Figure 8-2 shows the likely future environment within the vicinity of NoR 3 project extent. Based on the unitary plan zones from AC GeoMaps, the future condition on the western side of the motorway is expected to remain as a Special Purpose Zone (i.e., School Zone) and Mixed Rural Zone. The eastern side of the motorway is expected to remain under the Rural Production Zone. In general, this area will be less vulnerable, with the exception of the School Zone, which is highly vulnerable in the future.

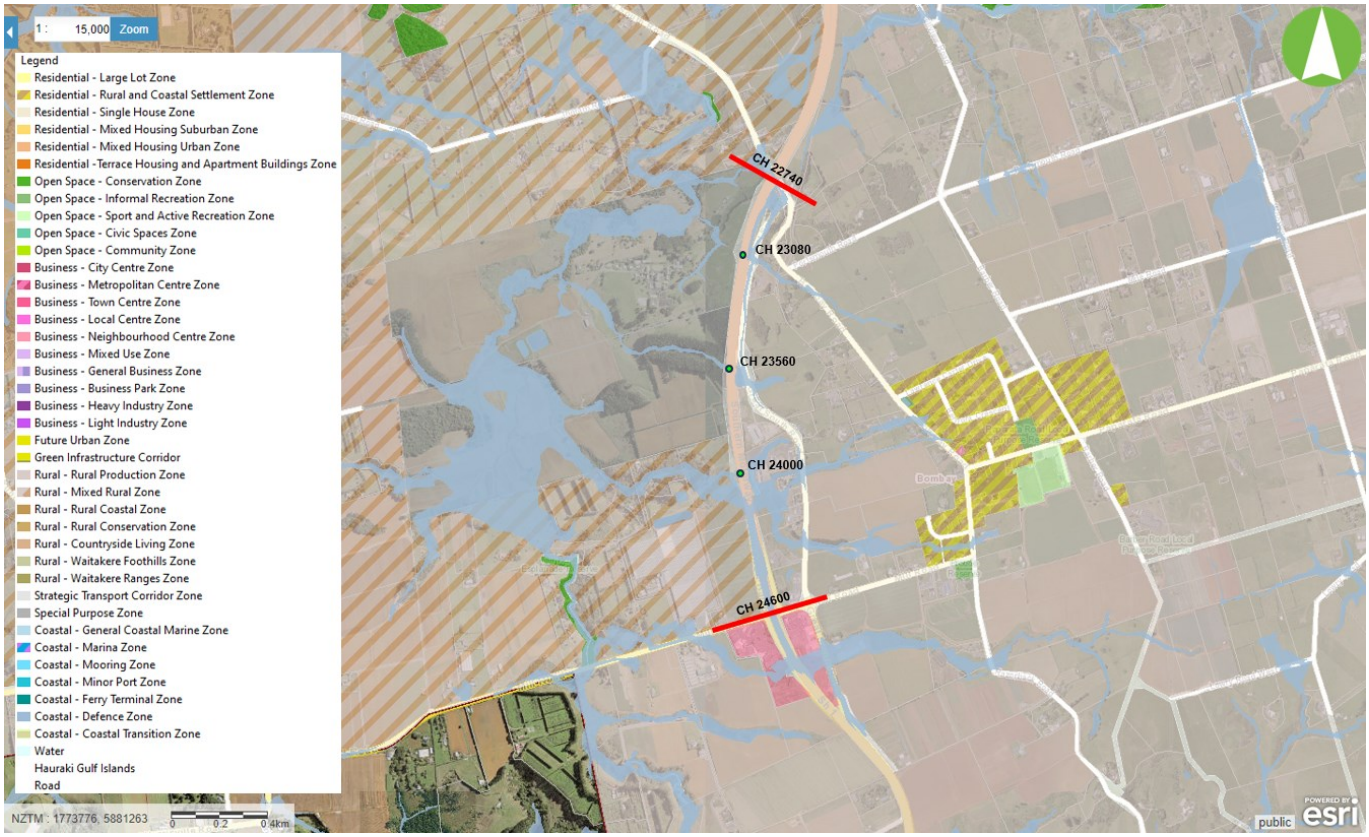


Figure 8-2 Likely future environment within the vicinity of NoR 3 project boundary

8.3 Assessment of Construction Effects

The construction effects for NoR 3 are expected to be similar with what was discussed in Section 6.3.

8.4 Assessment of Operational Effects

The risk assessment of flooding effects for NoR 3 is set out in Section 0. Table 8-2 presents the flood risk for all the culvert crossings within the NoR 3 extent based on the 1% AEP event with climate change.

Table 8-2: NoR 3 – Flood risk for 1% AEP with climate change

Culvert Crossing	Land Use		Flood Volume Displacement 1% AEP with CC (m^3)		Area Increase of Flood Extent 1% AEP with CC (ha)		Existing and Likely Future Flood Risk Rating
	Existing	Future	Upstream	Downstream	Upstream	Downstream	
CH 23080	Agricultural land and school on the western side of the motorway, residential properties and agricultural land on the eastern side of the motorway	School zone on the western side of motorway, rural production zone on the eastern side of motorway	-	20	-	negligible	Moderate existing and future risk

Culvert Crossing	Land Use		Flood Volume Displacement 1% AEP with CC (m^3)		Area Increase of Flood Extent 1% AEP with CC (ha)		Existing and Likely Future Flood Risk Rating
	Existing	Future	Upstream	Downstream	Upstream	Downstream	
CH 23560	Agricultural land and school on the western side of the motorway, residential properties and agricultural land on the eastern side of the motorway	School zone on the western side of motorway, rural production zone on the eastern side of motorway	-	788	-	0.02 ha	Moderate existing and future risk
CH 24000	Agricultural land and residential properties on both sides of the motorway	Mixed rural zone on the western side of motorway, rural production zone on the eastern side of motorway	-	1,472	-	0.03 ha	Moderate existing and future risk

The proposed works within the NoR 3 extent which include the road widening as well as a new SUP (authorised by NoR 4) are not expected to significantly alter the flooding regime within and outside the project boundary because the existing topography will largely remain unchanged. There will be negligible to minimal flood volume displacement upstream of the culvert crossings, hence it is anticipated that flood level will not significantly increase in these areas. However, there will be a minor increase in flood level downstream of the culvert crossings, but it is expected that the flood extent will remain generally consistent with existing flooding conditions (refer to Figure 8-1) such that flooding will only be contained within the existing streams. This is because the stream channels have sufficient capacity to contain the increased water volume without overflowing their banks. Therefore, minor increases in flood level will not cause water to significantly spread laterally. With this, no other properties are expected to be adversely affected. Therefore, any potential adverse flooding impact resulting from the proposed works is expected to be mitigated sufficiently.

8.5 Recommended Measures to Avoid, Remedy or Mitigate Flooding Effects

Flooding effects within the NoR 3 extent can be minimised by maintaining the existing streams and stream crossings though culverts. For locations where flood volume displacement is identified (refer to Table 8-2), any adverse flooding impacts can be mitigated by upgrading the existing culverts across the motorway, if required. Moreover, ground shaping in the inlet and outlet of all culvert locations is recommended to balance any change in flows upstream and downstream, thereby providing mitigation for potential flooding effects. For proposed mitigation measures for the increase in impervious surfaces (for road widening and formation of shared user path), refer to Section 3.2.4. Figure 8-3 shows the proposed swale and wetland locations within NoR 3 project extent.

With the mitigation measures in place, it is expected that the residual level of effects would be negligible, and the conditions set out in Section 3.2 will be achieved.

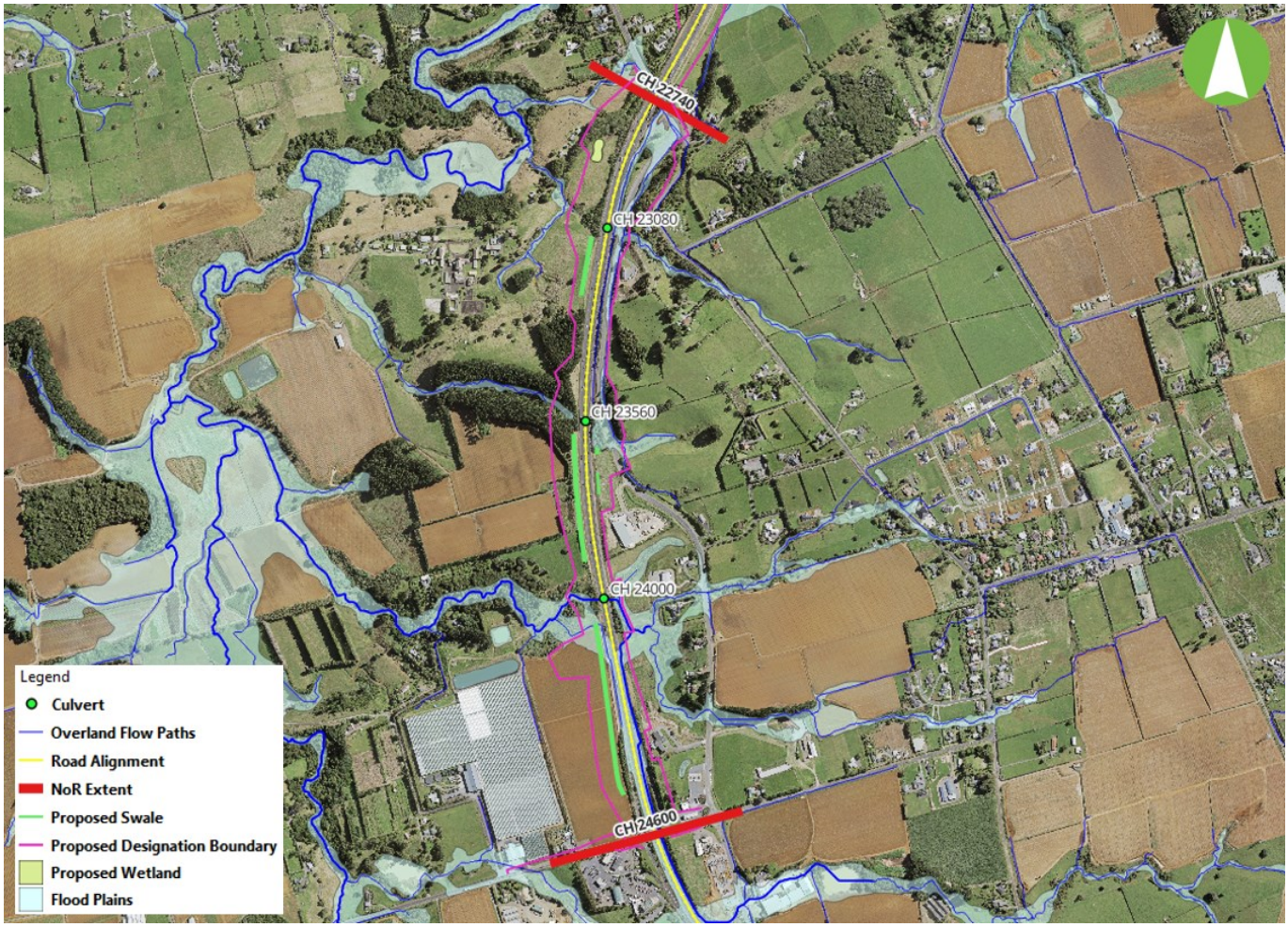


Figure 8-3 Proposed swale locations within NoR 3 project boundary

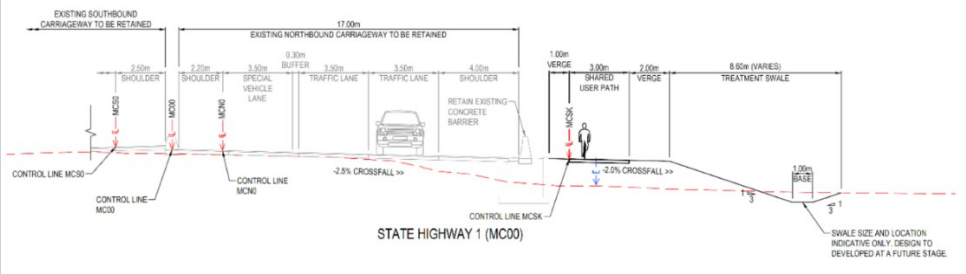
9 NOR 4: SHARED USER PATH

This section assesses the specific flooding matters in relation to NoR 4: Shared User Path.

9.1 Overview and Description of Works

Table 9-1 sets out the proposal for the SUP between Quarry Road and Bombay Interchange.

Table 9-1: Overview of the SUP

NoR 4 – Construction, operation and maintenance of a new SUP	
Overview	▪ Requires a new designation between 200m north of Quarry Road to 600m south of the existing Mill Road/Bombay Interchanges, with some locations overlapping the existing SH1 Designations 6706, 6700 and 6701. ▪ 3.0m wide SUP continuing from 200m north Quarry Road to 600m south of the existing Bombay/Mill Road Interchange. ▪ Located on the western side of the motorway.
Structures	▪ Tie-ins to all new and upgraded motorway interchange (ie. Drury South, Ramarama and Bombay) ▪ New bridge at Great South Road
Extent	▪ SH1 CH 15160 to CH 24580 - State Highway 1 from Quarry Road, Drury to Bombay Interchange/Mill Road (refer to Figure 9-1)
Intersections	▪ Grade separated tie-in at all interchanges
Stormwater Infrastructure	▪ Vegetated treatment swales to provide water quality treatment of all runoffs from impervious carriageway surfaces (existing and proposed) and water quantity treatment for the increase in impervious surfaces. ▪ In instances where constraints do not allow for the formation of vegetated treatment swales, runoff will be collected by piped reticulation and conveyed to constructed wetlands to provide stormwater quality and quantity treatment.
Typical cross sections	

9.2 Existing and Future Environment

Figure 9-1 shows the overland flow paths and floodplains within the Project Area for NoR 4. As it overlaps with the existing SH1 Designations 6706, 6700 and 6701 corresponding to NoR 1, NoR 2, and NoR 3, respectively, the existing flooding conditions and land use from these NoRs can be referred to in the following sections: Section 6.2, Section 7.2, and Section 8.2.

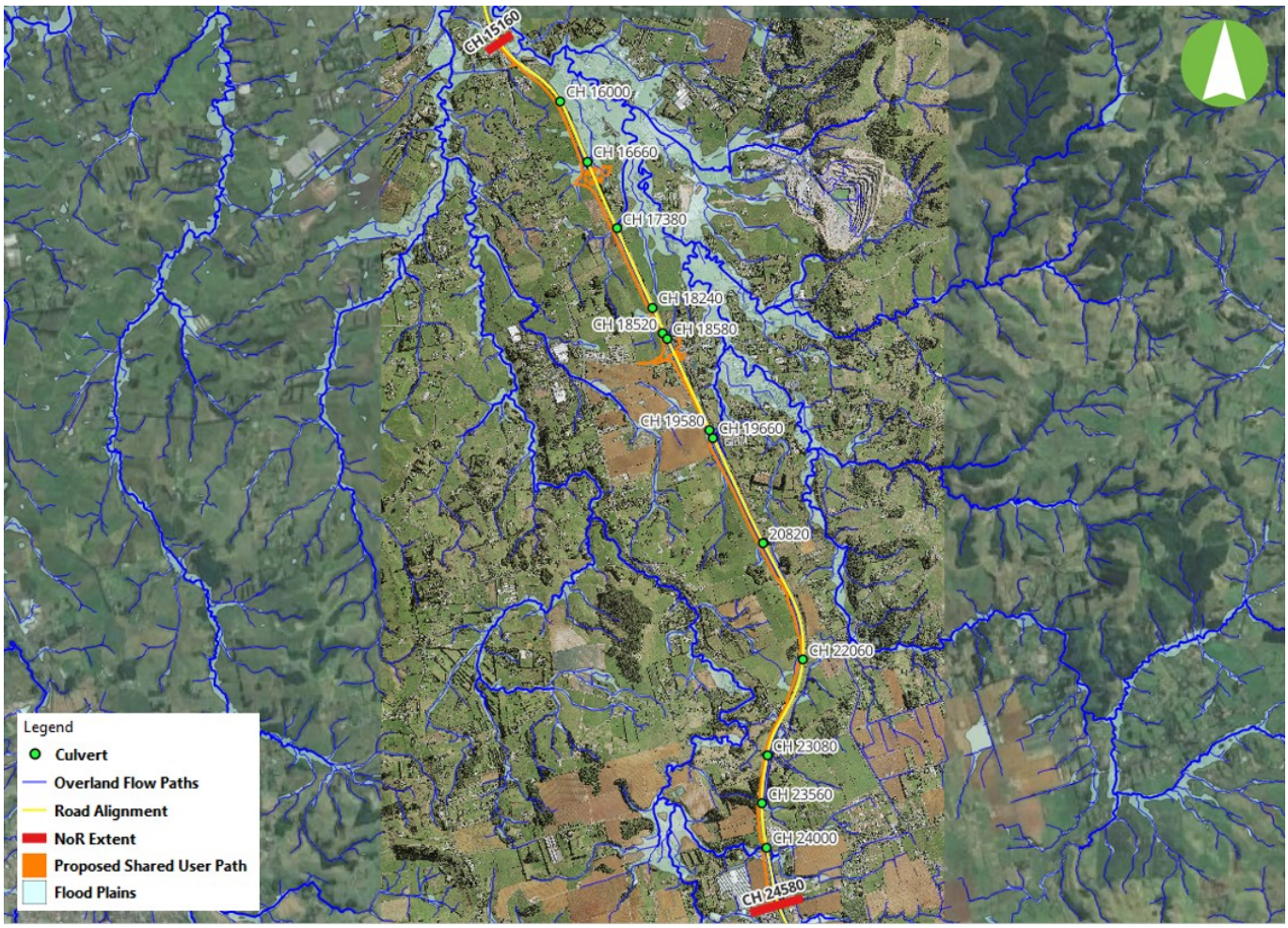


Figure 9-1 Overland flow paths and floodplains within NoR 4 project boundary

Figure 9-2 shows the likely future environment within the vicinity of NoR 4 project extent. Based on the unitary plan zones from AC Geomaps, the future condition on the western side of the motorway is expected to be developed under the Future Urban Zone, with some areas remaining as Mixed Rural Zone and School Zone, while the eastern side of the motorway is planned to be developed under the Future Urban Zone, Light Industry Zone, and Residential Zone, with some areas remaining as Rural Production Zone. The location of the likely future environment for NoR 4 extent is discussed in the sections pertaining to NoR 1 to 3. In general, this area will be moderately to highly vulnerable in the future.

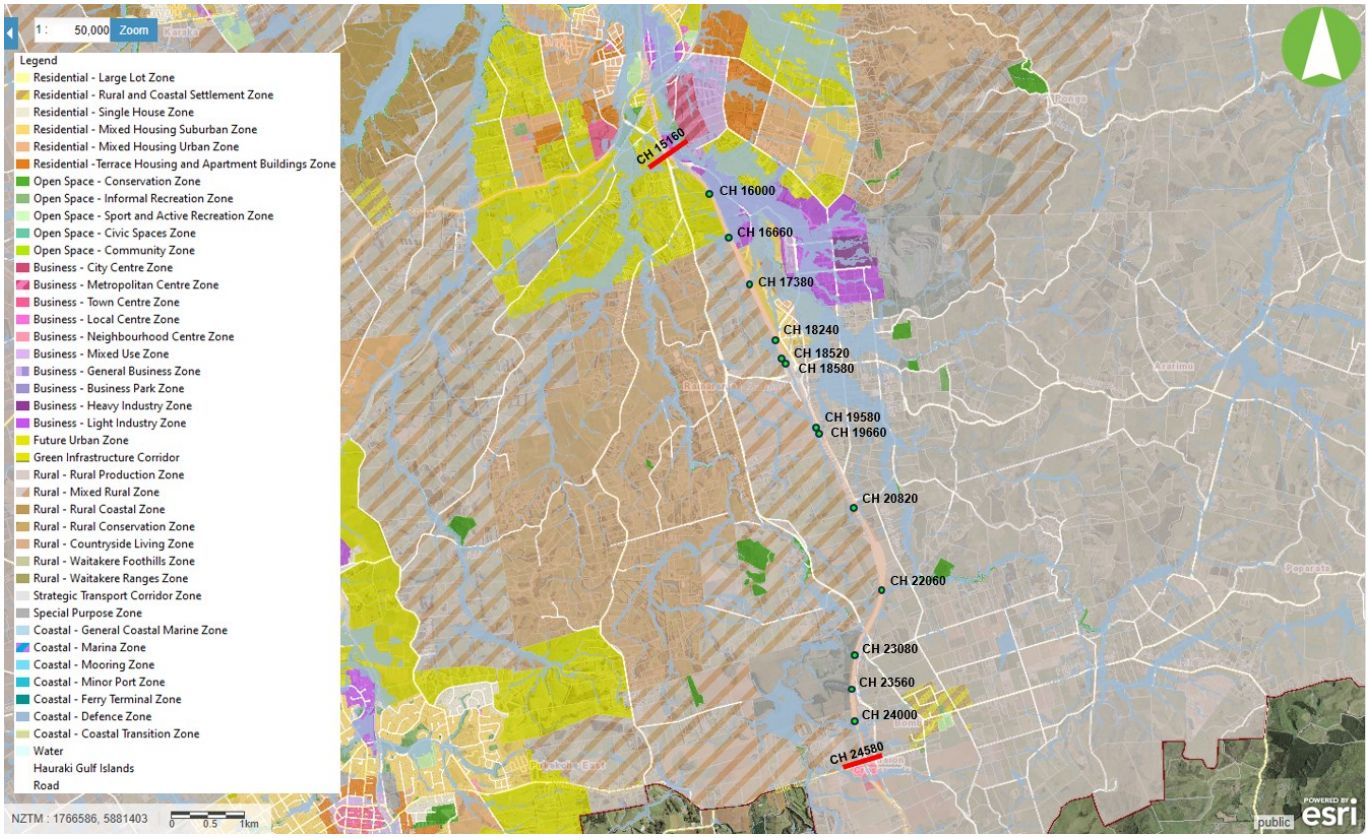


Figure 9-2 Likely future environment within the vicinity of NoR 4 project boundary

9.3 Assessment of Construction Effects

The construction effects for NoR 4 are expected to be similar with what was discussed in Section 6.3. In addition, it should be noted that the Project works is primarily for SUP, hence it is expected to be of a small magnitude and can be effectively managed.

9.4 Assessment of Operational Effects

As discussed in Section 9.2, the extent of NoR 4 overlaps with NoR 1, NoR 2, and NoR 3, hence the assessment of flooding effects can be referred to Section 6.4, Section 7.4, and Section 8.4, respectively. The proposed works within the NoR 4 extent which include a new SUP are generally located along the western side of the motorway are not expected to significantly alter the flooding regime within and outside the project boundary because the existing topography will largely remain unchanged. Therefore, any potential adverse flooding impact resulting from the proposed works is expected to be mitigated sufficiently.

9.5 Recommended Measures to Avoid, Remedy or Mitigate Flooding Effects

Flooding effects within the NoR 4 extent can be minimised by maintaining the existing streams and stream crossings though culverts. For locations where flood volume displacement is identified (refer to Table 7-2 and Table 8-2), any adverse flooding impacts can be mitigated by upgrading the existing culverts across the motorway. Moreover, ground shaping in the inlet and outlet of all culvert locations is recommended to balance any change in flows upstream and downstream, thereby providing mitigation for potential flooding effects. For proposed mitigation measures for the increase in impervious surfaces (for road widening and formation of shared user path), refer to Section 3.2.4. Figure 9-3 shows the proposed swale locations within NoR 4 project extent.

With the mitigation measures in place, it is expected that the residual level of effects would be negligible, and the conditions set out in Section 3.2 will be achieved.

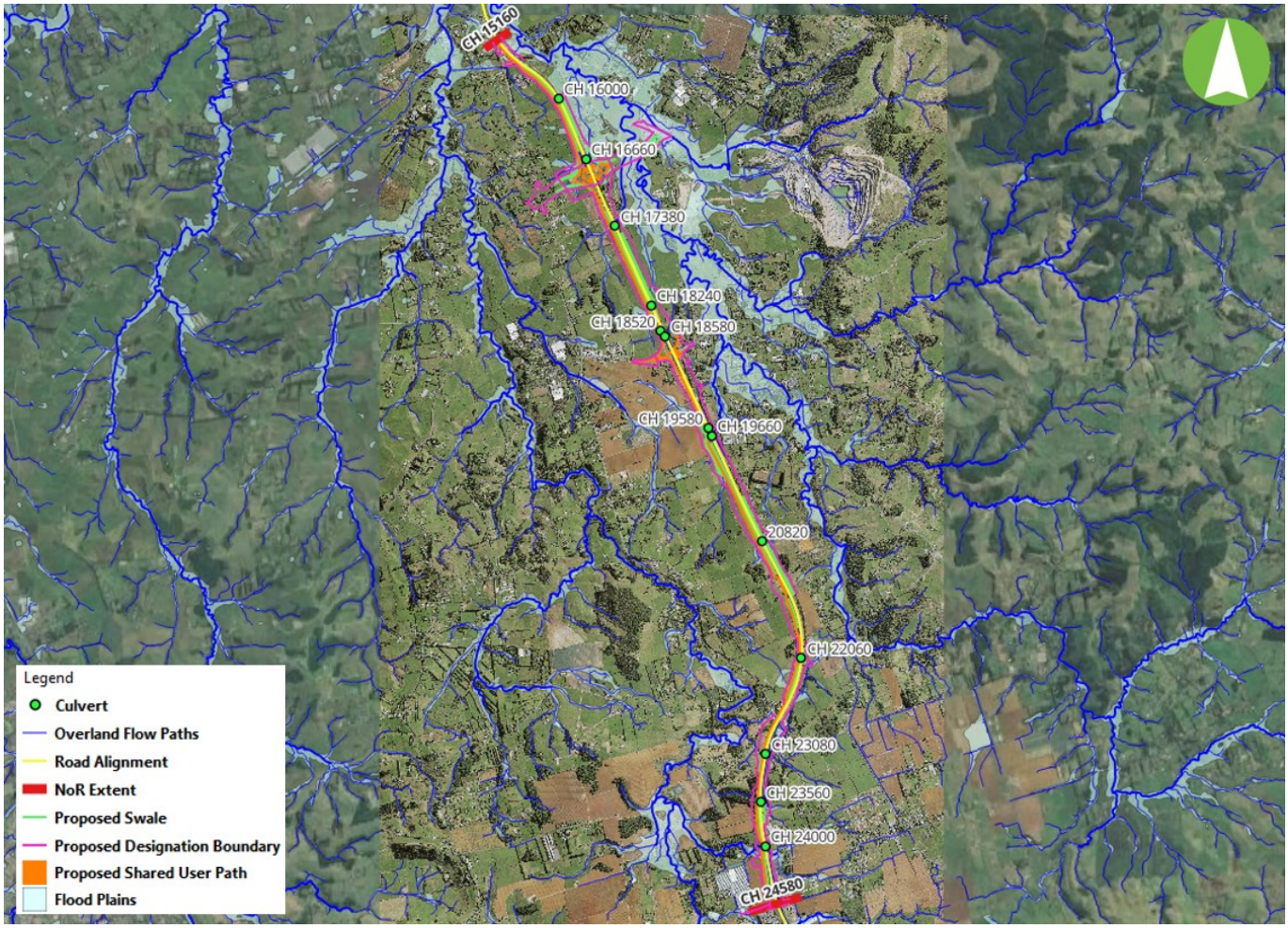


Figure 9-3 Proposed swale locations within NoR 4 project boundary

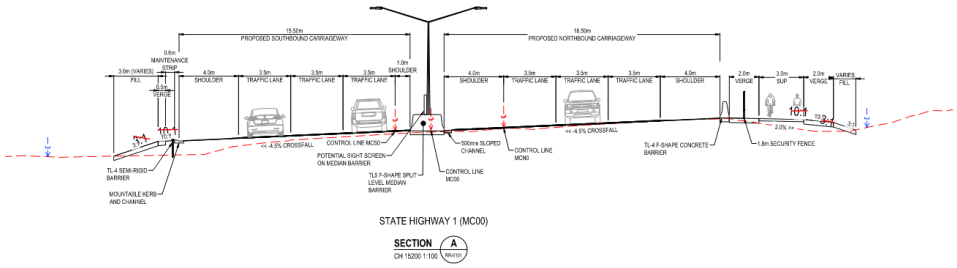
10 NOR 5: DRURY SOUTH INTERCHANGE CONNECTIONS

This section assesses the specific flooding matters in relation to NoR 5: Drury South Interchange Connections.

10.1 Overview and Description of Works

Table 10-1 sets out the proposed designation to accommodate the construction, operation, and maintenances of a new link road between Maketu Road and Great South Road.

Table 10-1: Overview of the Drury South Interchange Connections

NoR 5 – Drury South Interchange Connections	
Overview	▪ New link roads to the adjacent network (Maketu Road and Great South Road) to tie-into the proposed Drury South Interchange. ▪ Four traffic lanes, cycle lanes and footpaths on either side.
Structures	▪ Raised viaduct across the Hingaia reserve area.
Extent	▪ CH 300 to CH 1750 - Adjacent State Highway 1 at Drury South Interchange, linking to Quarry Road to the east, and Great South Road to the west (refer to Figure 10-1).
Access Lanes	▪ Accommodation for a special vehicle lane or bus lane within the 4m shoulder.
Intersections	▪ Signalised intersection at Maketu Road ▪ Round-about intersection tie-in to Great South Road
Stormwater Infrastructure	▪ Vegetated treatment swales to provide water quality treatment of all runoffs from impervious carriageway surfaces (existing and proposed) and water quantity treatment for the increase in impervious surfaces. ▪ In instances where constraints do not allow for the formation of vegetated treatment swales, runoff will be collected by piped reticulation and conveyed to constructed wetlands to provide stormwater quality and quantity treatment.
Typical cross sections	

10.2 Existing and Future Environment

Figure 10-1 shows the overland flow paths and floodplains within the project boundary for NoR 5. The existing land use within the vicinity is a combination of agricultural land, residential settlements, and industrial area (e.g., Transpower Substation). There are two culverts near the project area: CH 16660 and CH 17380 (authorised by NoR 2). The overland flow paths at these locations generally flow towards the eastern side of the motorway to the tributaries of Hingaia Stream, and then discharges towards the north. Figure 10-2 shows the flood depth and extent for the 1% AEP event including climate change for the baseline scenario. This result is based on the TUFLOW 1D/2D linked hydraulic model that was updated by Tonkin+Taylor specifically for this assessment. As mentioned in Section 3.2.2, the baseline scenario considered for the purpose of this assessment includes the proposed works to the Hingaia flood plain as part of the DSA project.

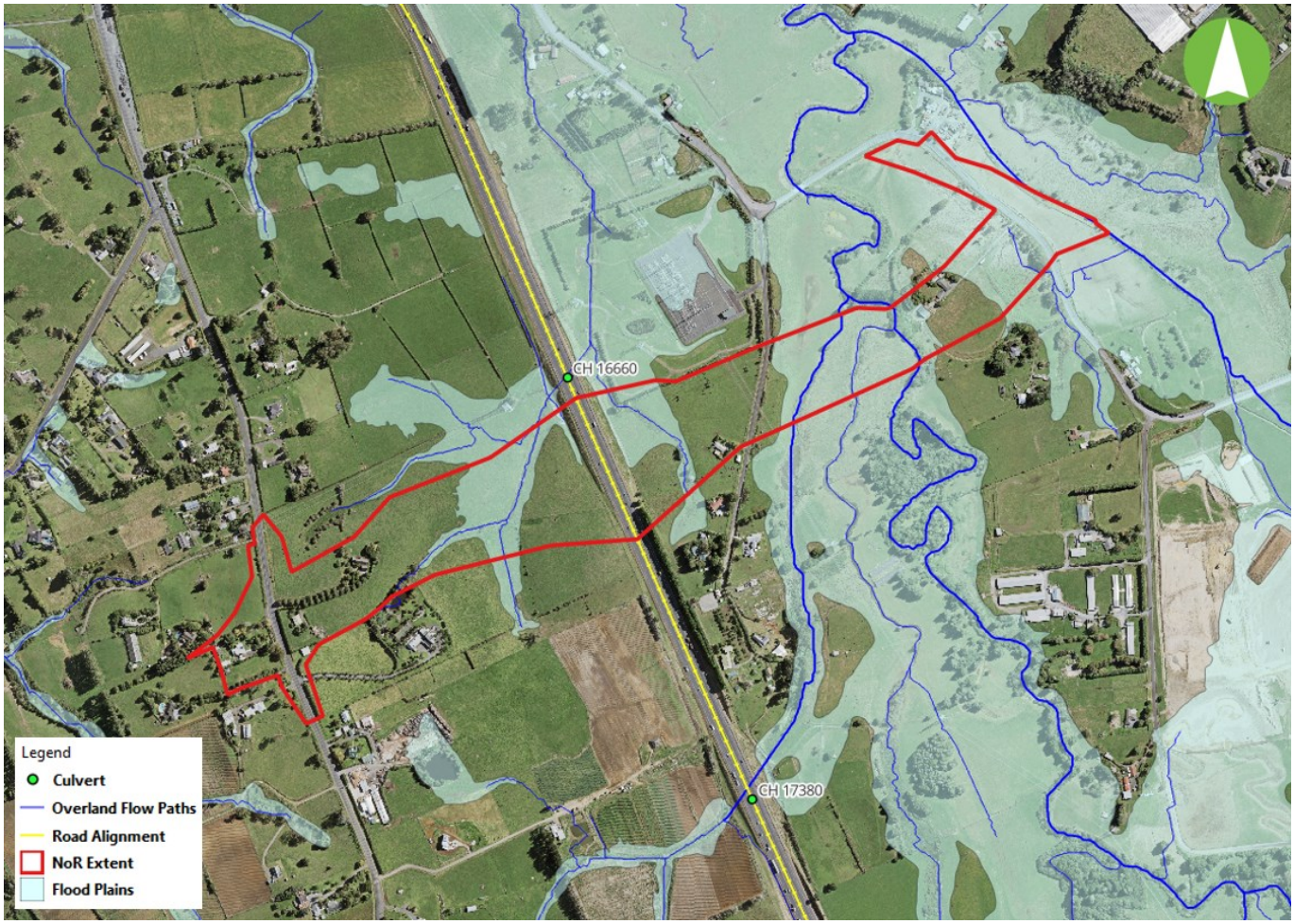


Figure 10-1 Overland flow paths and floodplains within NoR 5 project boundary

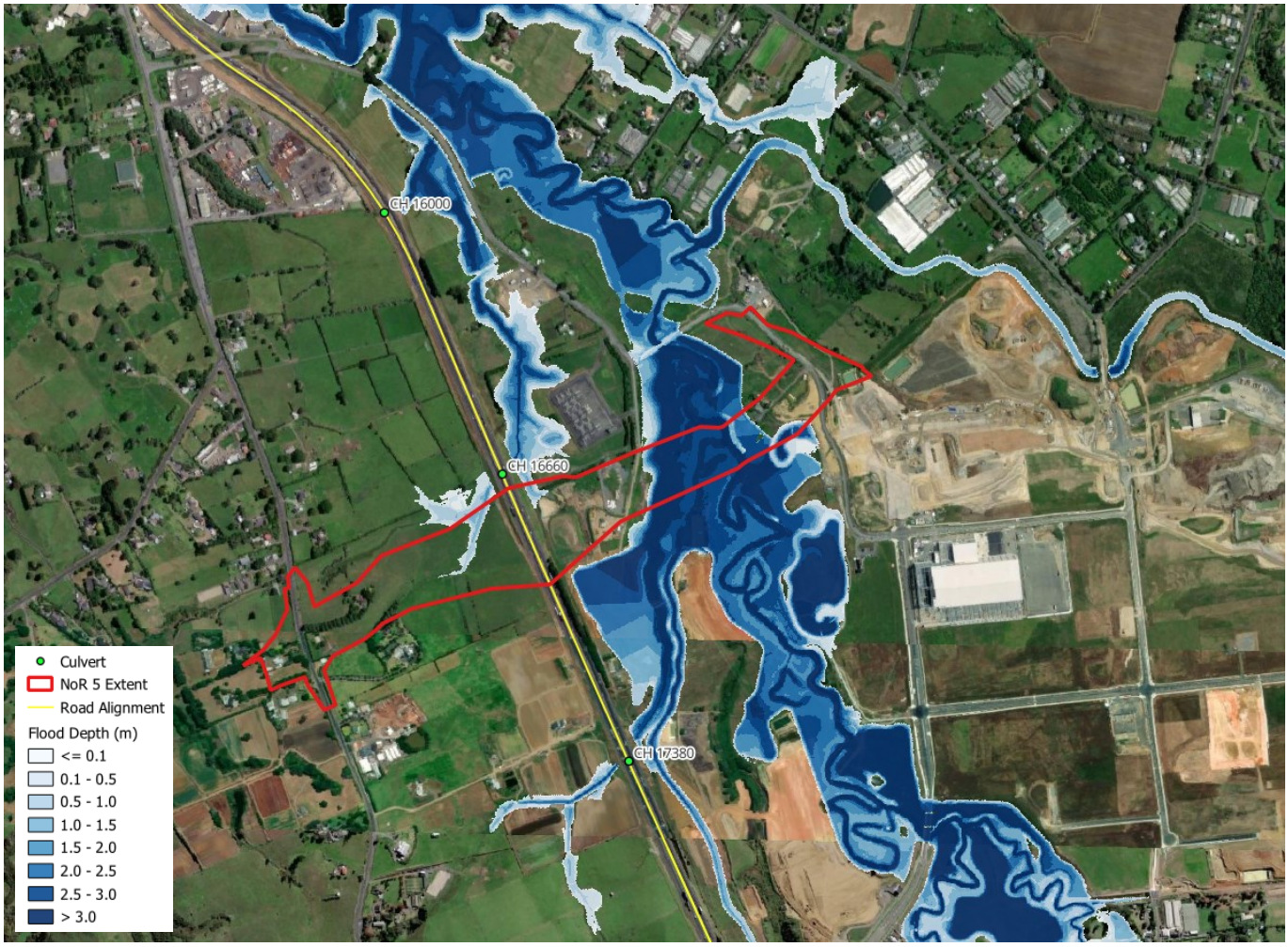


Figure 10-2 Flood extent 1% AEP event with climate change – Baseline scenario

Figure 10-3 shows the likely future environment within the vicinity of NoR 5 project extent. Based on the unitary plan zones from AC GeoMaps, the future condition on the western side of the motorway is expected to remain as Mixed Rural and Rural Production Zone, while the eastern side of the motorway is planned to be developed under the Light Industry Zone and Mixed Housing Suburban Zone. In general, this area will be moderately to highly vulnerable in the future.

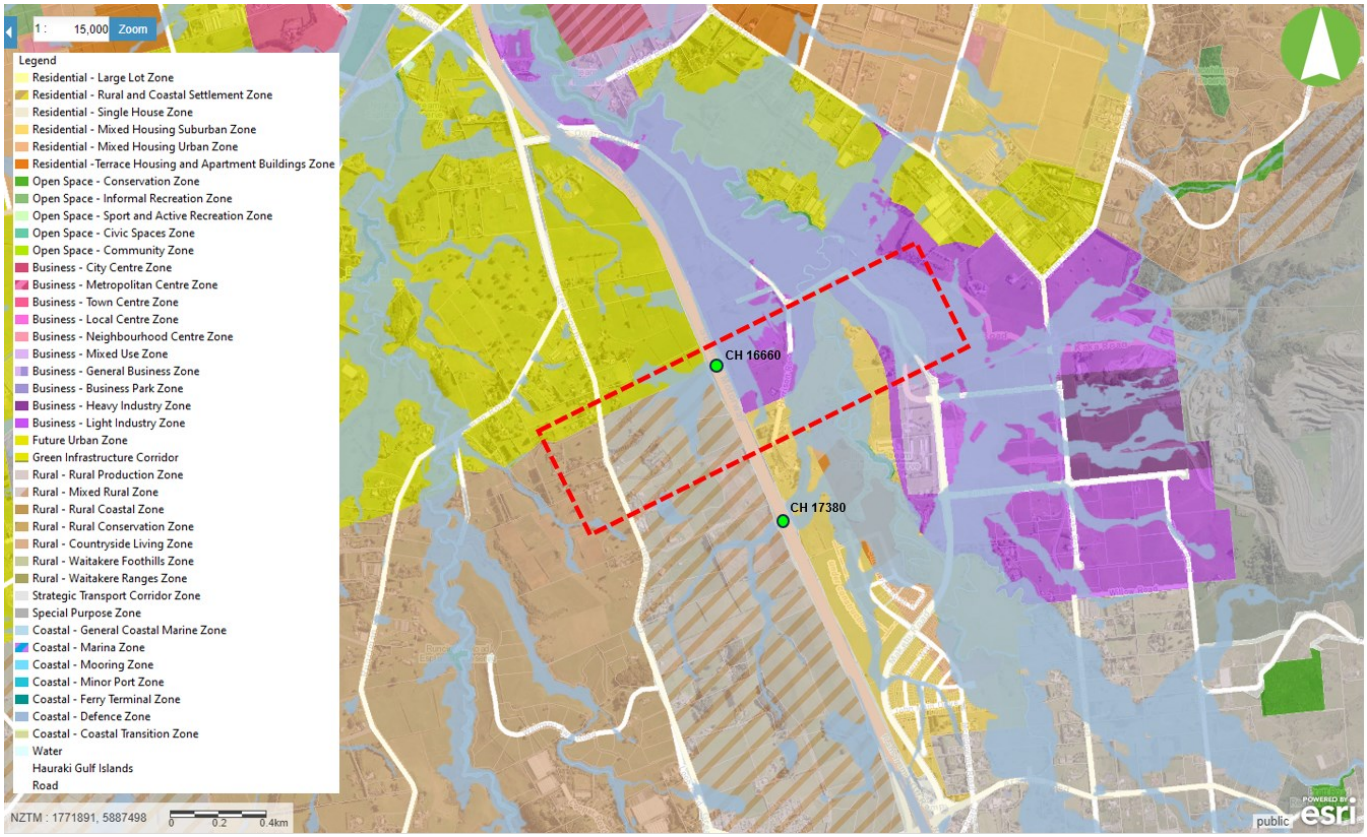


Figure 10-3 Likely future environment within the vicinity of NoR 5 project boundary

10.3 Assessment of Construction Effects

During the construction phase, localised flooding impacts may arise due to temporary staging platforms that may be needed for building the new bridge as well as temporary diversions during the installation of new culverts and/or modifications to existing ones. The details of the construction approach will be refined at detailed design. It is expected that the construction activities can be carried out in a manner that minimises or mitigates flood risks. It is worth noting that NZTA has a substantial track record of effectively managing construction works and implementing mitigation strategies, as demonstrated in previous projects like Stage 1A and Southern Corridor Improvements (SCI). The flood management strategies will be further developed throughout the project delivery phase and will undergo additional assessment during detailed construction planning. It is important to note that these details should align with the principles outlined in the Construction Environmental Management Plan (CEMP). Through the use of the CEMP, the construction effects are expected to be appropriately mitigated.

10.4 Assessment of Operational Effects

The outcome of the flood modelling indicates that the Project results to a potential minor flood impacts upstream of the culvert crossings at CH 16600 and CH 17380 but negligible impact within the Hingaia Stream and flood plain area. The affected areas upstream of CH 16600 and CH 17380 are zoned Mixed Rural and Rural Production. In the post-development scenario, the flood extents remain generally consistent with that of the existing condition, as shown in Figure 10-4, and no new areas are flooded or affected by the Project.

The bridge piers are expected to have a minimal effect on the flood plain due to the relatively large expanse of the flood plain in comparison to the small cross section of the piers. It should be noted, however, that the peak velocities through the flood plain during the 1% AEP event with climate change in the vicinity of the bridges are less than 0.5 m/s. This indicates that the flooding is primarily controlled by restrictions downstream, rather than the capacity of the Hingaia Stream at the location of the bridge piers. Due to the low velocity, the head losses around the piers are expected to be small. There are small increases in flood levels around the bridge piers and abutments, typically

around 5mm, with one localised area showing up to 35mm. This magnitude of flood impact caused by the bridge piers falls within the model's margin of error (± 50 mm) and therefore is considered negligible.

The required length of the proposed bridge structure is dictated by the extents of the Hingaia Stream flood plain. Resilience of the bridge to flooding is achieved by making sure that the bridge deck is above the 1% AEP flood level and providing freeboard in accordance with the NZTA Bridge Manual. This also ensures that the bridge superstructure does not cause an obstruction for flood flows during extreme flood events which may result in adverse impacts on areas upstream of the bridge.

As mentioned in Section 10.2, there are two culverts across the motorway, CH 16600 and CH 17380 (authorised by NoR 2), which are affected by the project works within NoR 5. A minor increase in flood level, up to 120 mm, is noticeable in the overland flow path upstream of the culvert at CH 17380. It should be noted that the flood extent remains generally consistent with existing conditions (as shown in Figure 10-2) such that flooding is also contained within the existing streams. Upstream of the culvert at CH 16660, there is an observed increase in flood level of up to 200 mm. This increase is primarily attributed to the filling of a portion of the floodplain intersecting the proposed interchange. This area of the floodplain was previously wet but is now dry, as illustrated in Figure 10-4. The loss of flood storage and the displacement of flood volume has led to increased flood levels on the adjacent land, which is primarily rural properties and open pasture for production purposes. A similar effect is observed at the immediate downstream to the east of the motorway (shown as red in Figure 10-4), however, this can be adequately mitigated within the bounds of the proposed designation. Further downstream of CH 16660, flood levels are predicted to increase by up to 40 mm, which falls within the model's margin of error and is therefore considered negligible, as illustrated in Figure 10-4.

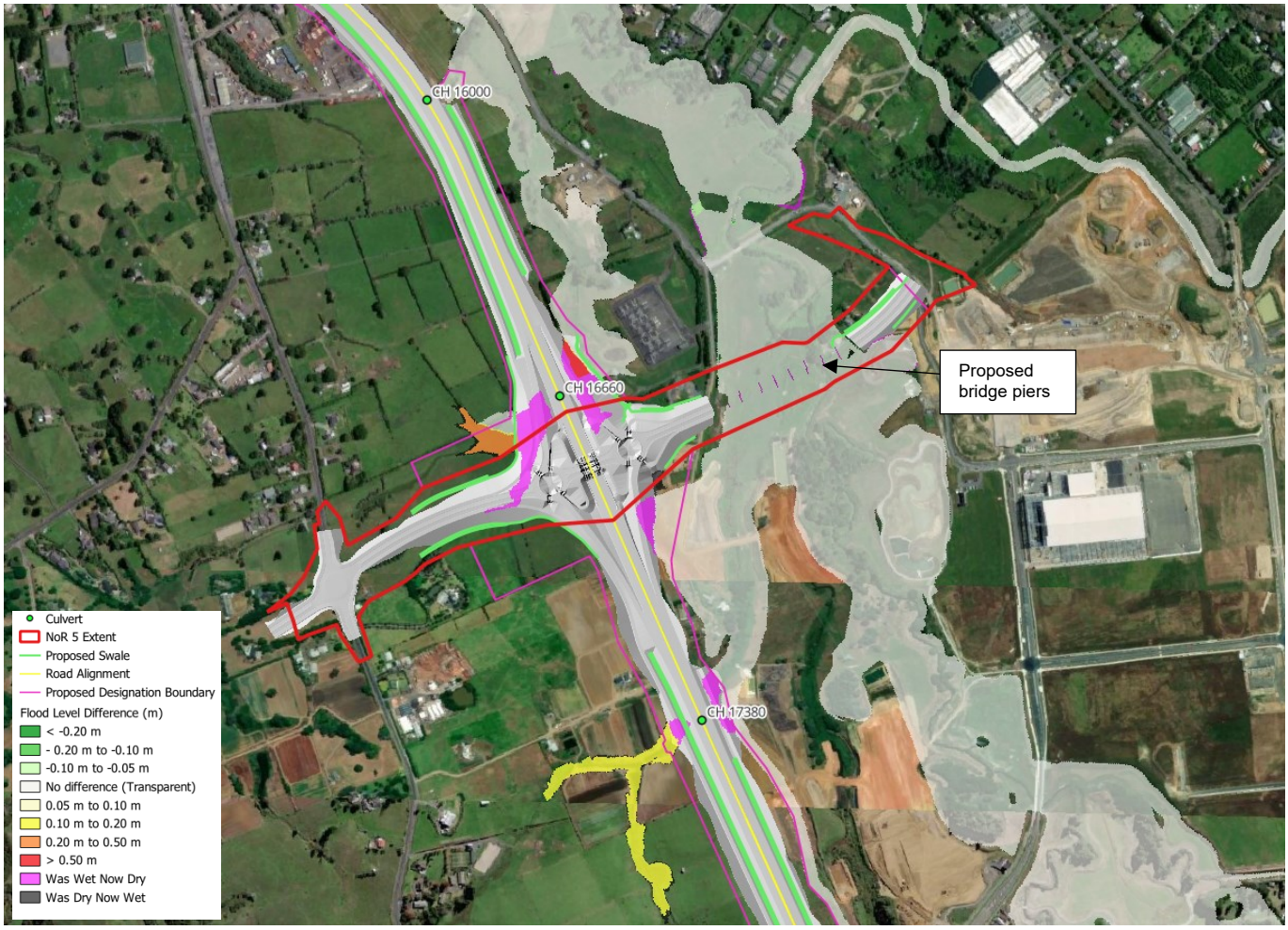


Figure 10-4 Flood impact (post-development vs pre-development) for the 1% AEP event with climate change – NoR 5

10.5 Recommended Measures to Avoid, Remedy or Mitigate Flooding Effects

As mentioned in the preceding section, the results of the flood modelling of the wider Hingaia catchment indicate that there is negligible impact within the Hingaia Stream and flood plain area. There are potential minor flooding impacts upstream of CH 16600 and CH 17380, but they are contained within the existing channels and no land zoned for urban or future urban development are affected. It should also be noted that the flood extents remain generally consistent with that of the existing condition and that no new flooded areas are introduced by the Project.

A sensitivity assessment was undertaken to understand the influence of modifying the size of the culvert at CH 16600. The outcome of the sensitivity modelling suggests that upgrading the existing culvert across SH1 at CH 16660 and providing additional flood storage area on the north-western side of the proposed interchange will result in a reduction of flood levels on both the eastern and western side of the motorway. The reduction in flood levels on the downstream side (east of motorway) is around -5 mm and is mapped as 'no change' in Figure 10-5 since it falls within the ± 50 mm threshold. On the upstream side (west of motorway), the previous flood level increase of 200 mm without mitigation is now indicating a reduction of -10 mm with the mitigation in place. A provision for a flood mitigation basin is incorporated in the proposed designation boundary as shown in Figure 10-5.

Moreover, ground shaping in the inlet and outlet of the culvert at CH 17380 is recommended to balance any change in flows upstream and downstream, if required. For proposed mitigation measures for the increase in impervious surfaces (for road widening and formation of shared user path), refer to Section 3.2.4. With the mitigation measures in place, it is expected that the residual level of effects would be negligible and within the NoR boundary, and the conditions set out in Section 3.2 will be achieved.

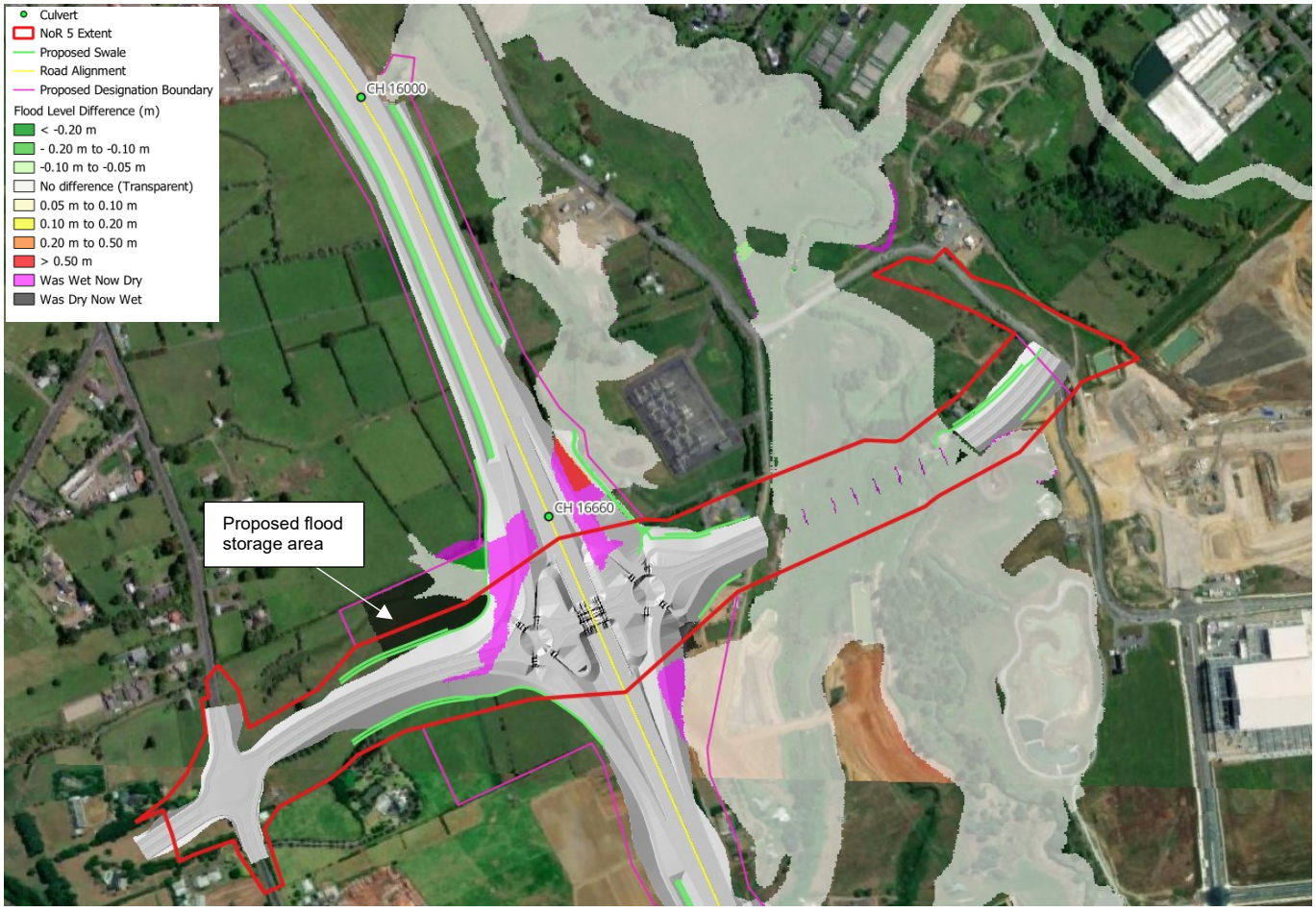


Figure 10-5 Result of sensitivity test for the 1% AEP event with climate change

11 CONCLUSION

This assessment has examined the potential impact of flooding associated with the Stage 2 of the Papakura to Bombay Project. Flood modelling and desktop assessment were employed to identify areas where existing flood effects are likely, and recommendations have been made to address and minimise these effects during the subsequent detailed design phase of the Project. The flooding effects have been assessed separately for the construction effects and operational effects.

The construction phase is expected to effectively manage flood risks, with proposed activities strategically positioned outside flood plains and overland flow paths whenever feasible. In instances where this is not achievable, flood risk mitigation measures outlined in the Construction Environmental Management Plan (CEMP) will be implemented for existing high flood risk areas. To address increased flood risk in specific areas, mitigation measures such as scheduling construction during dry weather and utilising diversion drains will be identified in the CEMP to adequately manage the risk.

Various management and mitigation measures have been proposed for addressing operational effects during the future detailed design stage. Conditions related to flood risk outcomes will be incorporated into the Project NoRs to ensure proper management of flood risk effects. During the operational phase, the flood modelling predicts no adverse impact within the Hingaia Stream upstream and downstream of the proposed bridge. Minor increases in flood levels upstream and downstream of the proposed interchange were observed primarily due to the filling of a portion of the floodplain, however, it should be noted that the flood extent will be contained within the existing channels. For the minor overland flow paths at culvert crossings, similar flooding condition is expected, hence no other properties will be adversely affected.

In general, mitigation measures for the flooding effects can be implemented by maintaining the existing streams and stream crossings through culverts. Swales are proposed alongside the motorway to attenuate runoff from the motorway caused by the increase in impervious surfaces to match pre-Project flows to post-Project peak flows. Upgrading existing culverts is a mitigation measure that can be considered for areas where flood volume displacement was identified based on flood risk assessment. Moreover, ground shaping in the inlet and outlet of all culvert locations is recommended to balance any change in flows upstream and downstream, thereby providing mitigation for potential flooding effects.

It is expected that, once the mitigation measures are in place, the residual level of effects would be negligible. and the following conditions will be achieved for all NoRs:

- No increase in flood levels for existing authorised habitable floors that are already subject to flooding;
- No more than a 10% reduction in freeboard for existing authorised habitable floors;
- No increase of more than 50 mm in flood level on land zoned for urban or future urban development where there is no habitable existing dwelling;
- No new flood prone areas;
- Compliance shall be demonstrated in the Outline Plan, which shall include flood modelling of the pre-Project and post-Project 1% AEP flood levels (for Maximum Probable Development land use and including climate change); and,
- Where the above outcomes can be achieved through alternative measures outside of the designation such as flood stop banks, flood walls, raising existing authorised habitable floor level, and new overland flow paths or varied through agreement with the relevant landowner, the Outline Plan shall include confirmation that any necessary landowner and statutory approvals have been obtained for that work or alternative outcome.

APPENDICES

Appendix A:

Flood Modelling Technical Memorandum

New Zealand Government

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