REPORT

Tonkin+Taylor

Drury East - Waihoehoe Precinct Plan Change Area

Stormwater Management Plan for 116 Waihoehoe Road and surrounds

Prepared for
Oyster Capital
Prepared by
Tonkin & Taylor Ltd
Date
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Document Control

Title: Drury East - Waihoehoe Precinct Plan Change Area					
Date	Version	Description	Prepared by:	Reviewed by:	Authorised by:
Aug 2019	3	Final – Lodged version	Lea Andreae	Tim Fisher	Tim Fisher
June 2020	4	Final – Notification version · General changes to provide clarity and consistency with the Drury East Stormwater Management Plan –Drury Centre and Drury East Plan Change Areas · Update Section 1 – Introduction regarding integration with other developments at Drury East · Description of changes for June 2020 version 4 continued in Section 1.5	Sarah Innes and Charlotte Peyroux	Tim Fisher	Tim Fisher

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Table of contents

Executive summary

Oyster Capital is applying to Auckland Council for a Plan Change under the Auckland Unitary Plan, Operative in Part (AUP), to rezone 48.9 hectares of land in Drury East from Future Urban Zone (FUZ) to Terraced Housing and Apartment Building zone (THAB). Additionally, the Waihoehoe Precinct is proposed to include place-based provisions which create a framework for development. The Plan Change provides capacity for up to 1,054 dwellings.

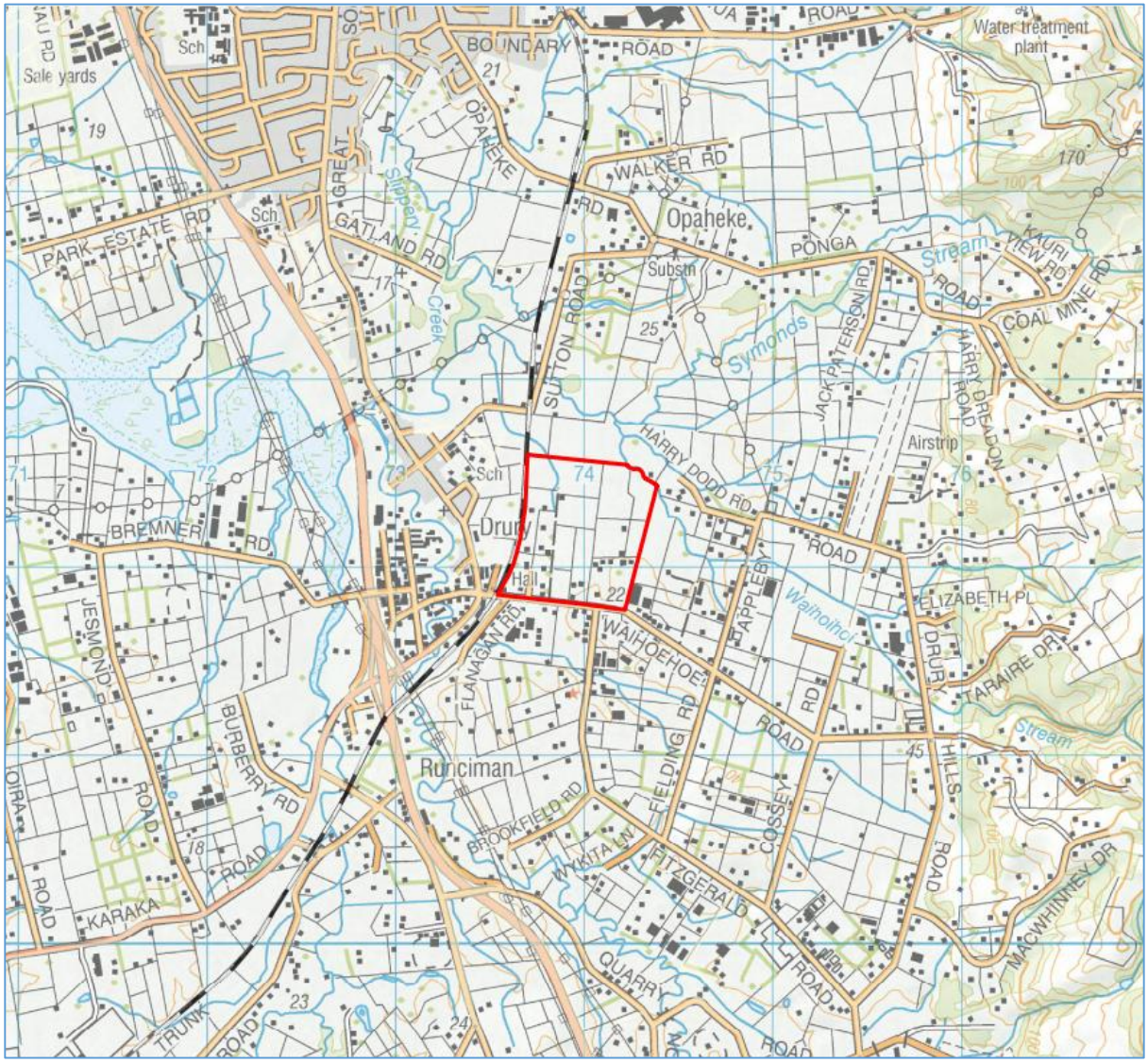

Figure E.1: Waihoehoe Precinct Plan Change Area (outlined in red)

This Stormwater Management Plan (SMP) has been prepared to support the application for the Private Plan Change Area (PCA) made by Oyster Capital. The SMP will support the PCA and the future adoption under the Auckland Council region-wide Network Discharge Consents (NDC). The requirements for stormwater management are based primarily on the AUP provisions with consideration of the Future Urban Land Supply Strategy for the area, the relevant SMPs for the Drury-Opāheke area and the NDC. In addition, an integrated approach has been used for all three Drury East PCAs

The SMP is supported by a flood hazard assessment, which was carried out based on Auckland Council flood modelling of the Slippery Creek. The outcomes are flood hazard information and proposed approaches for flood management for the PCA.

The proposed stormwater management plan follows a water sensitive design approach as required in the AUP. The PCA has been split into two sub-catchments, which have different strategies tailored to their specific flood management requirements.

The flood management strategy for the northern sub-catchment is a "passing flows forward" approach to discharge peak flows to the receiving stream environment. Meanwhile, the flood management strategy for the southern sub-catchment is to attenuate flood flows on site to mitigate flooding in the western parts of the PCA and further downstream.

The following table summarises the main stormwater management proposed for the PCA.

Table E.1: Stormwater management approach for the Waihoehoe Precinct

		North "Passing flows forward"		South "Detention"	
		Roads/car parks	Residential areas	Roads/car parks	Residential areas
Water quality and quantity treatment	Water quality treatment	Raingardens	Rain tanks Detention tanks Permeable paving Inert building materials	Raingardens	Rain tanks Detention tanks Permeable paving Inert building materials
	Hydrological mitigation				
Conveyance and flood management	95% to 10 year flow	Pipe drainage to green outfall		Pipe drainage to attenuation basin	
	10 year to 100 year flow	Overland flow to green outfall		Overland flow to attenuation basin	

1 Introduction

Oyster Capital has worked together with Kiwi Property and Fulton Hogan Land Development (FHLD) who collectively have an interest in land within Drury East. Their areas of interest are shown on Figure 1.1 below. The three private Plan Change requests have been prepared concurrently by Oyster Capital, Kiwi Property and FHLD to allow a wider consideration of the future land use pattern proposed within Drury East and an integrated approach to the planning and delivery of supporting infrastructure. The Drury Centre (Kiwi Property) and Drury East (FHLD) Precincts are located within the Hingaia Stream catchment while the Waihoehoe Precinct (Oyster Capital) is in the Slippery Creek catchment as shown in Figure 1.1.

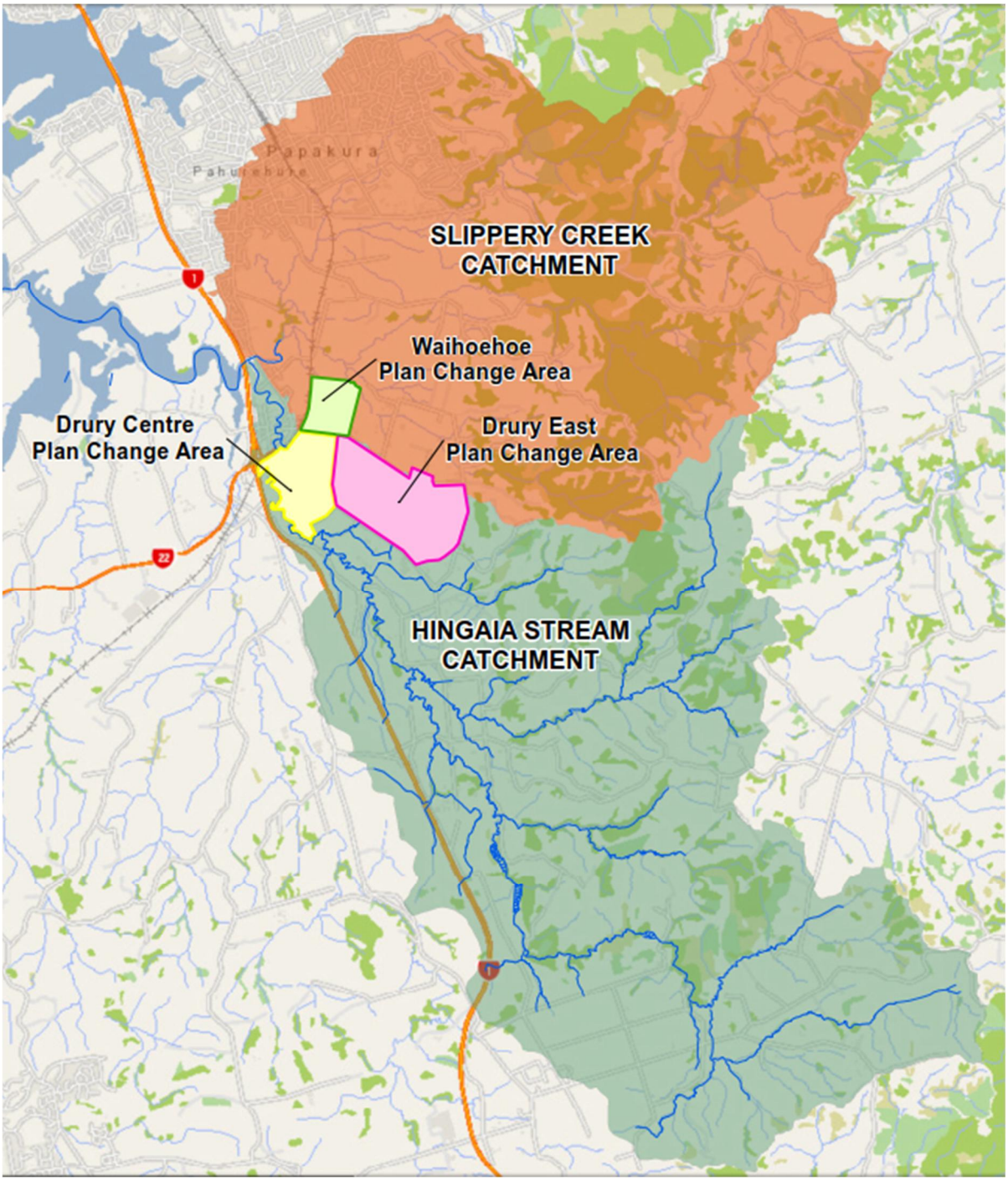

Figure 1.1: Hingaia and Slippery Creek catchment extents and Drury East Plan Change Areas

An integrated stormwater management approach will be implemented across the collective Drury East Plan Change Areas (Drury East PCAs). However different catchment approaches are required for development within the Hingaia Stream catchment when compared with development within the Slippery Creek catchment, to address the unique catchment characteristics, opportunities and constraints (including different flooding issues and the availability of modelling tools for assessment). Accordingly, a Stormwater Management Plan (SMP) for the Drury Centre and Drury East Precincts in the Hingaia Stream catchment is being prepared separately.

Oyster Capital is applying to Auckland Council for a Plan Change under the Auckland Unitary Plan, Operative in Part (AUP) to rezone 48.9 hectares of land in Drury East from Future Urban Zone (FUZ) to Terraced Housing and Apartment Building zone (THAB). Additionally, the Waihoehoe Precinct is proposed to include place-based provisions which create a framework for development. The Plan Change provides capacity for up to 1,054 dwellings.

The Waihoehoe Precinct Plan Change Area (PCA) is bound by Waihoehoe Road in the south, the North Island Main Trunk (NIMT) railway in the west and Waihoihoi Stream in the north-east. It includes all properties at 18-140 Waihoehoe Road and on Kath Henry Lane, Drury.

Oyster Capital has an interest 18.4 hectares of land on the northern side of Waihoehoe Road as shown in Figure 1.2 below. Oyster Capital are experienced residential and land developers in Auckland and are currently undertaking large scale and high-quality housing developments in Whenuapai and Beachlands.

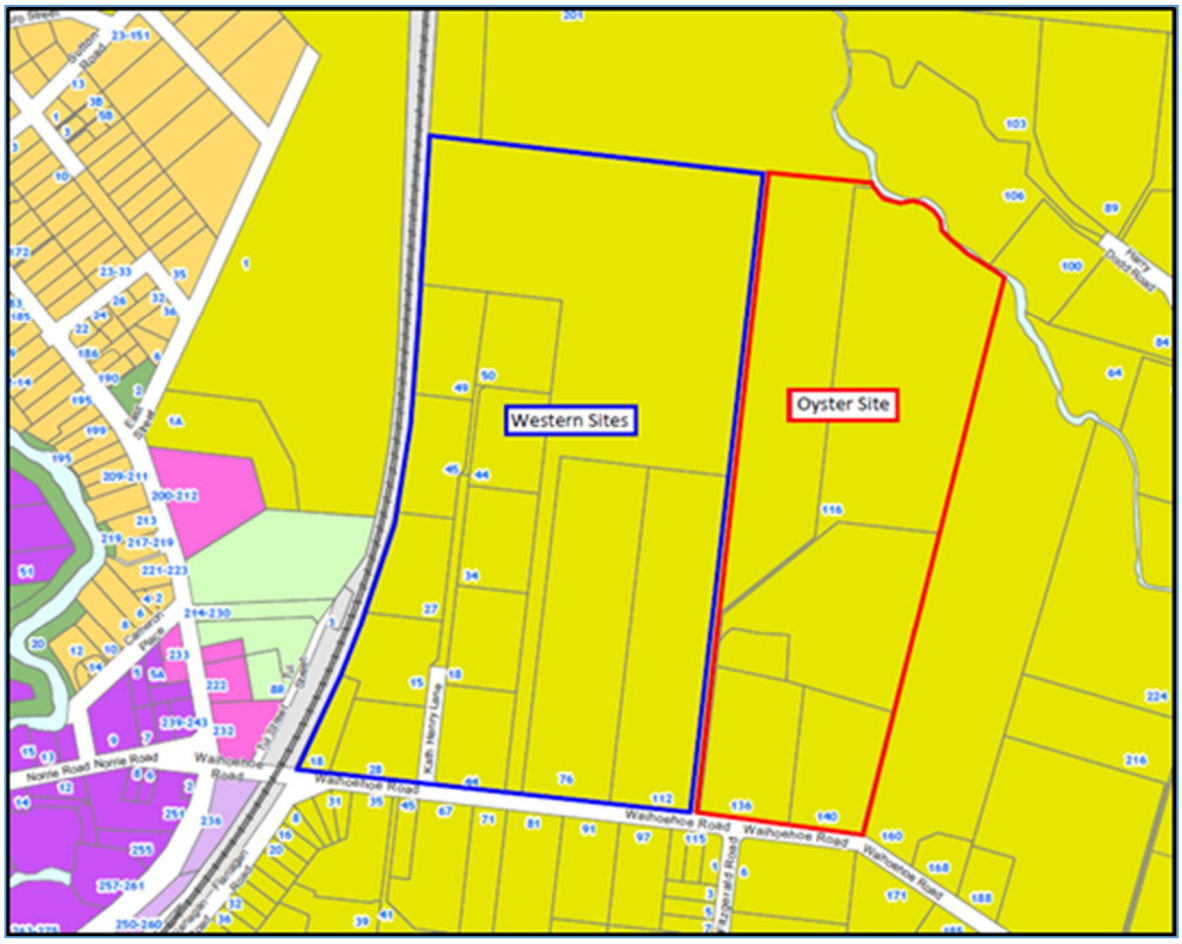

Figure 1.2: Waihoehoe Precinct (outlined in blue and red), including the Oyster Capital land holdings (shown red) and Auckland Unitary Plan Future Urban Zone extent in yellow

1.1 Background

The PCA is currently zoned FUZ under the AUP (refer to Figure 1.2 above and Appendix A, Figure A3 - Unitary Plan Zones). Auckland Council has applied the FUZ to suitable developable land located on the periphery of existing urban areas within the Rural Urban Boundary (RUB). The underlying zoning allows for rural activities to continue until such time as the land is rezoned for urban development.

Auckland Council has prepared a structure plan for the area to inform future plan changes and provide preliminary zoning for housing, centres, industry and open space. Drury-Opāheke is envisioned to be a sustainable, liveable, compact and accessible place with town and local centres, and a mix of residential and commercial buildings that are connected to the wider Auckland region through improved transport networks. Indicative land use statistics show that the area could provide for about 22,000 houses, and a population of about 60,000 over 30 years. The PCA is located to the east of the existing railway and Drury town centre in an area preliminary designated as THAB in the Auckland Council *Drury-Opāheke Structure Plan* (August 2019).

The PCA is currently located within an area that is determined as "1st Half, Decade Two" development within the Future Urban Land Supply Strategy, which sets out a development of the site between 2028 and 2032. This timing is maintained in the Drury-Opāheke Structure Plan. The Plan Change application seeks to rezone the PCA to THAB zone to enable development prior to this time frame.

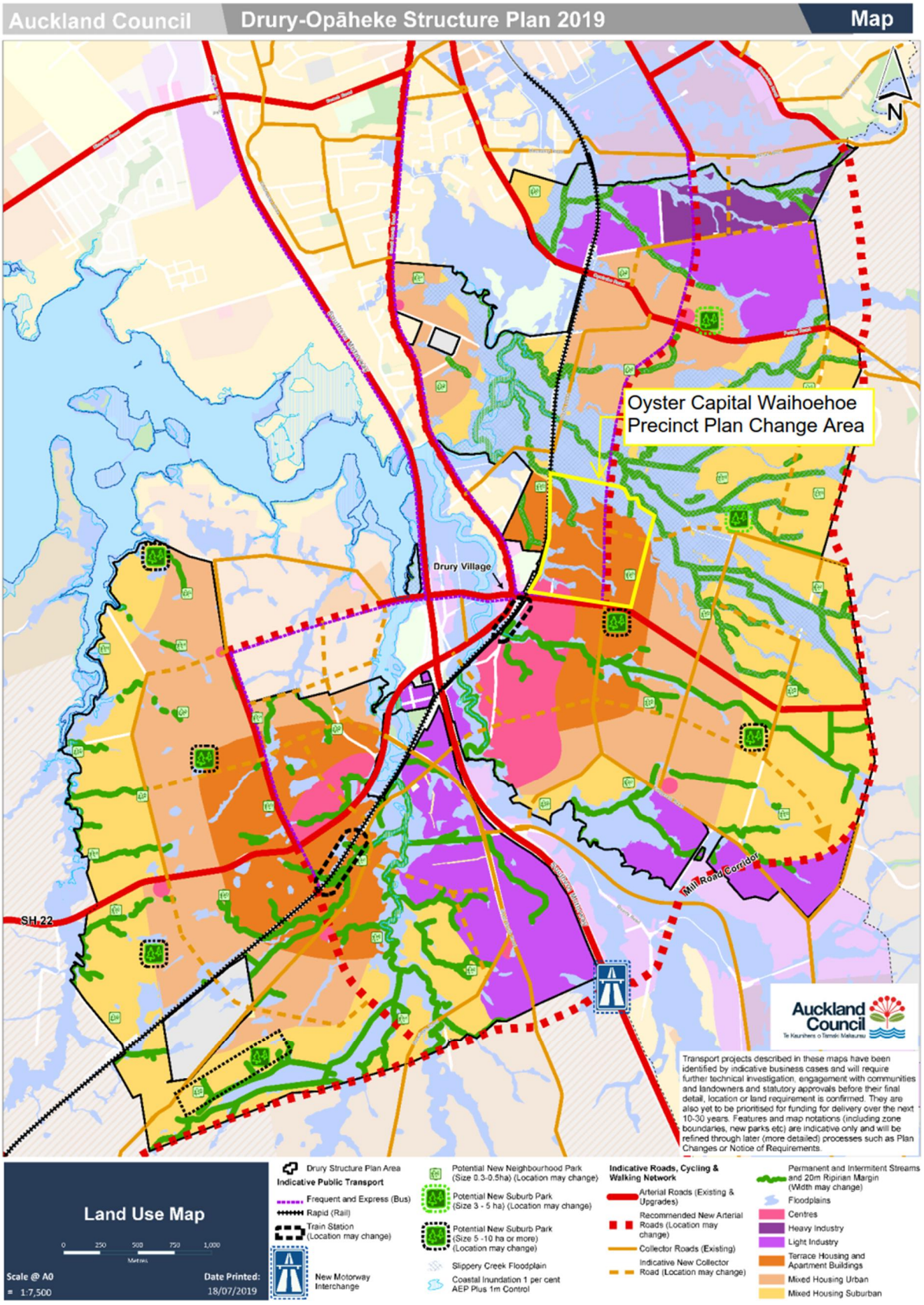

Figure 1.3: The Drury-Opāheke Structure Plan (August 2019) Land Use Map with the Waihoehoe Precinct shown in yellow

1.2 Purpose

The primary purpose of the SMP is to provide guidance to the applicant and Council on how stormwater will be managed within the PCA. It demonstrates that the proposed stormwater management is the Best Practicable Option (BPO), taking into consideration the existing site features and the future land use master plan. This guidance is consistent with Auckland Council policies and plans and based on conventional stormwater management techniques to meet AUP provisions, and to integrate with existing approved and future stormwater systems in the Slippery Creek catchment, as identified in the Drury-Opāheke catchment-wide SMPs.

1.3 Scope

The agreed scope of work includes:

- Discuss with Auckland Council the opportunities and constraints of the site and the Slippery Creek catchment and our proposed stormwater management approach (completed by T+T on 20 December 2018)
- Review the following documents:
  - Relevant Drury-Opāheke master planning reports including:
    - Auckland Council Drury-Opāheke Structure Plan (August 2019)
    - AECOM Opāheke-Drury Stormwater Management Plan - Preliminary (September 2017), prepared for Auckland Council (OD SMP)
    - Mott MacDonald Drury-Opāheke Structure Plan – Future Urban Zone Draft Stormwater Management Plan (April 2019), prepared for Auckland Council (FUZ SMP)
    - Morphum Environmental Ltd Watercourse Assessment Report – Slippery Creek Catchment (2015), prepared for Auckland Council
  - T+T Drury Stormwater Management Summary for the Drury Developers Group (April 2018)
  - Auckland Council Future Urban Land Supply Strategy (July 2017)
  - T+T Stormwater Management Plan – Drury Metropolitan Centre (August 2019), prepared for Kiwi Property Trust Ltd (Job Number: 1003297.v4)
  - Woods Stormwater Management Plan – Drury East (November 2019), prepared for FHLD (Project Number: P16-335)
  - T+T and Woods Drury East Stormwater Management Plan –Drury Centre and Drury East Plan Change Areas (June 2020), prepared for Kiwi Property Trust Ltd and FHLD (Job Number: 1003297.7000)
- Undertake preliminary design of stormwater management devices
- Undertake preliminary design of stormwater/flood attenuation devices
- Assemble, review and assess the Auckland Council flood model results for Slippery Creek
- Summarise from ecology, geotechnical and civil reports the existing environment and existing/proposed infrastructure
- SMP to detail an integrated stormwater management framework

1.4 Outcomes

The outcomes sought by the Waihoehoe Precinct SMP and Drury Centre and Drury East Precinct SMP are:

- An integrated stormwater management approach
- Facilitate urban development and optimise available land
- Recognise the key constraints and opportunities on site and in the Hingaia and Slippery Creek catchments
- Develop a set of Best Practicable Options (BPOs) for stormwater that can be incorporated into the development
- Emphasise a water sensitive design approach that:
  - manages the impact of land use change from rural to urban
  - minimises or mitigates the adverse effects on water quality, freshwater systems, stream health and ecological values of the receiving environment through the implementation of stormwater management devices; this includes tributaries of the Hingaia Stream and Slippery Creek
  - protects and enhances stream systems and riparian margins
- Minimise the generation and discharge of contaminants/sediments into the sensitive receiving environment of the Drury Creek and Manukau Harbour, including changes in water temperature caused by stormwater discharges
- Recognise a Blue-Green network approach with the stormwater management system to integrate "blue" aspects of the PCA (the streams and flood plains) and the "green" aspects of the environment (indigenous biodiversity and ecological significance, and the parks and reserves)
- Protect key infrastructure, people and the environment from significant flooding events. Not worsen downstream flooding

1.5 Post-lodgement revisions

T+T and Woods have previously prepared three separate SMPs in support of the Drury East Plan Change applications, which were lodged in December 2019. Since the plan change lodgement, Healthy Waters has reviewed the application for the Drury East PCAs and have provided feedback and queries in the *Further Information Request – Drury East Plan Changes* including *Healthy Waters Review of Adequacy of Information for a Private Plan Change Request – Drury East -Fulton Hogan and Kiwi Property.* The *Healthy Waters Review of Adequacy of Information for a Private Plan Change (PPC) Request* is included in Appendix J.

Consultants for Oyster Capital, Kiwi Property and FHLD replied to the Further Information Request with 6 memos covering stormwater management, stream erosion, flooding and ecology. The four memos relevant to the PCA are:

- *Response to Auckland Council Further Information Request on Stormwater Matters for Drury East* memo prepared by T+T and Woods and issued 25 March 2020, which provided an integrated summary of stormwater management for the Drury East developments and flooding for the Hingaia
- *Response to Auckland Council Further Information Request on Stormwater Matters for Drury East - Stream Erosion Risk Assessment for Hingaia Catchment* memo prepared by T+T and

Woods and issued 6 April 2020, which provided an integrated assessment of stream erosion in the Hingaia. The findings of that assessment have been referred to for the PCA

- *Response to Auckland Council Further Information Request on Ecological Matters for Drury East – Drury East Plan Changes – Ecology Response* memo prepared by T+T, The Ecology Company and Freshwater Solutions and issued 24 March 2020
- *Drury East (Oyster Capital) flood modelling – Response to Auckland Council Further Information Request on Stormwater Matters (Version 2)* memo prepared by T+T and issued 6 April 2020

This revision of the SMP has been updated to include information presented in these memos. A description of changes in included in the Document Control table and continued below. All supporting memos are included in full in Appendix K to N

1.5.1 Description of changes for June 2020 version 4 continued

- New Section 1.5 – description of Post-lodgement revisions
- Update to Section 2.3– Ecological assessment to include additional information presented in Response to Auckland Council Further Information Request on Ecological Matters for Drury East – Drury East Plan Changes – Ecology Response memo prepared by T+T, The Ecology Company and Freshwater Solutions and issued 24 March 2020
- Update to Section 2.4– Receiving Environment to include additional information presented in Response to Auckland Council Further Information Request on Ecological Matters for Drury East – Drury East Plan Changes – Ecology Response memo prepared by T+T, The Ecology Company and Freshwater Solutions and issued 24 March 2020 and the Slippery Creek Catchment Watercourse prepared by Morphum Environmental in 2015
- Update to Section 4.1.1– Consideration of AUP objectives and requirements to include additional policy information presented in Response to Auckland Council Further Information Request on Ecological Matters for Drury East – Drury East Plan Changes – Ecology Response memo prepared by T+T, The Ecology Company and Freshwater Solutions and issued 24 March 2020
- Update to Section 4.1.1.2– Hydrological mitigation to include requirements of SMAF 1 framework
- New Section 4.1.2– Network Discharge consent requirements
- Update Section 4.1.3 - The Drury-Opāheke Structure Plan has been issued as final
- New Section 5.2.1.1– Verification of flood management approach to include in section to address additional flood analysis presented in *Drury East (Oyster Capital) flood modelling – Response to Auckland Council Further Information Request on Stormwater Matters (version 2)* memo prepare by T+T and issued on 6 April 2020
- New Section 6.1.3.1– Sensitivity of the receiving environment to include learnings from the *Response to Auckland Council Further Information Request on Stormwater Matters for Drury East - Stream Erosion Risk Assessment for Hingaia Catchment* memo prepared by T+T and Woods and issued 6 April
- Update to Section 6.2– preliminary design of stormwater management devices to include a matrix of stormwater management outcomes and tools for different land use zones for the

Drury East developments as presented in *Response to Auckland Council Further Information Request on Stormwater Matters for Drury East* memo prepared by T+T and Woods and issued 25 March 2020

- New Section 6.2.2.3– Blue-green network to include additional information presented in *Drury East Plan Changes – Ecology Response* memo prepared by T+T, The Ecology Company and Freshwater Solutions and issued 24 March 2020

1.6 Report layout

The SMP is organised into the following sections:

- A description of the PCA is provided in Section 2 and includes heritage features, current land use, natural and physical characteristics, geotechnical, soils and groundwater, ecological survey, receiving environment, existing infrastructure
- Proposed changes, including the proposed development layout, land use changes and infrastructure upgrades, are described in Section 3 of the report
- The stormwater requirements are established based on the AUP, existing SMPs for the Slippery Creek catchment and the Future Urban Land Strategy by Auckland Council. A summary of these reports are provided in Section 4 of the report
- Flood risks and management is described in Section 5 of the report
- The proposed stormwater management solutions are summarised in Section 6

The appendices contain supporting information, namely:

- Appendix A contain key figures in A3 Format
- Appendix B has the drawing set v1-3 of the Concept Masterplan as provided by the client
- Appendix C Mott MacDonald Drury-Opāheke Draft Stormwater Management Plan (April 2019)
- Appendix D AECOM Drury Stormwater Management Plan (September 2017)
- Appendix E T+T Drury Stormwater Management Summary (April 2018)
- Appendix F Lander Geotechnical Preliminary Geotechnical Appraisal Report for Waihoehoe Plan Change Area Drury (4 March 2019)
- Appendix G Focus Environmental Services Ltd Preliminary Site Investigation (March 2019)
- Appendix H Freshwater Solutions Waihoehoe Road Drury Ecological Assessment Draft v1 (March 2019)
- Appendix I Mott MacDonald Drury-Opāheke Draft Future Urban Zone Major Structures Flooding Assessment (December 2018)
- Appendix J – Healthy Waters Review of Adequacy of Information for a Private Plan Change Request (February 2020)
- Appendix K – T+T Response to Auckland Council Further Information Request on Stormwater Matters for Drury East (March 2020)
- Appendix L – T+T Response to Auckland Council Further Information Request on Stormwater Matters for Drury East - Stream Erosion Risk Assessment for Hingaia Catchment (April 2020)
- Appendix M – T+T Drury East Plan Changes - Ecology Response (March 2020)
- Appendix N – T+T Drury East (Oyster Capital) flood modelling - Response to Auckland Council Further Information Request on Stormwater Matters (Version 2) (April 2020)

2 Site description

The PCA comprises 48.9 hectares bounded by Waihoehoe Road to the south and Waihoihoi Stream to the north-east. It is located east of the existing Drury town centre and the NIMT railway (refer to Figure 2.1 and Appendix A, Figure A1 - Property Setting for the full figure) and includes all properties at 18-140 Waihoehoe Road and on Kath Henry Lane, Drury. The land is currently configured as large lots, with the predominant land use being high producing exotic grassland. There is a small built-up area in the south-western corner of the site (refer to Figure 2.2 and Appendix A, Figure A4 - Current Land Use for the full figure).

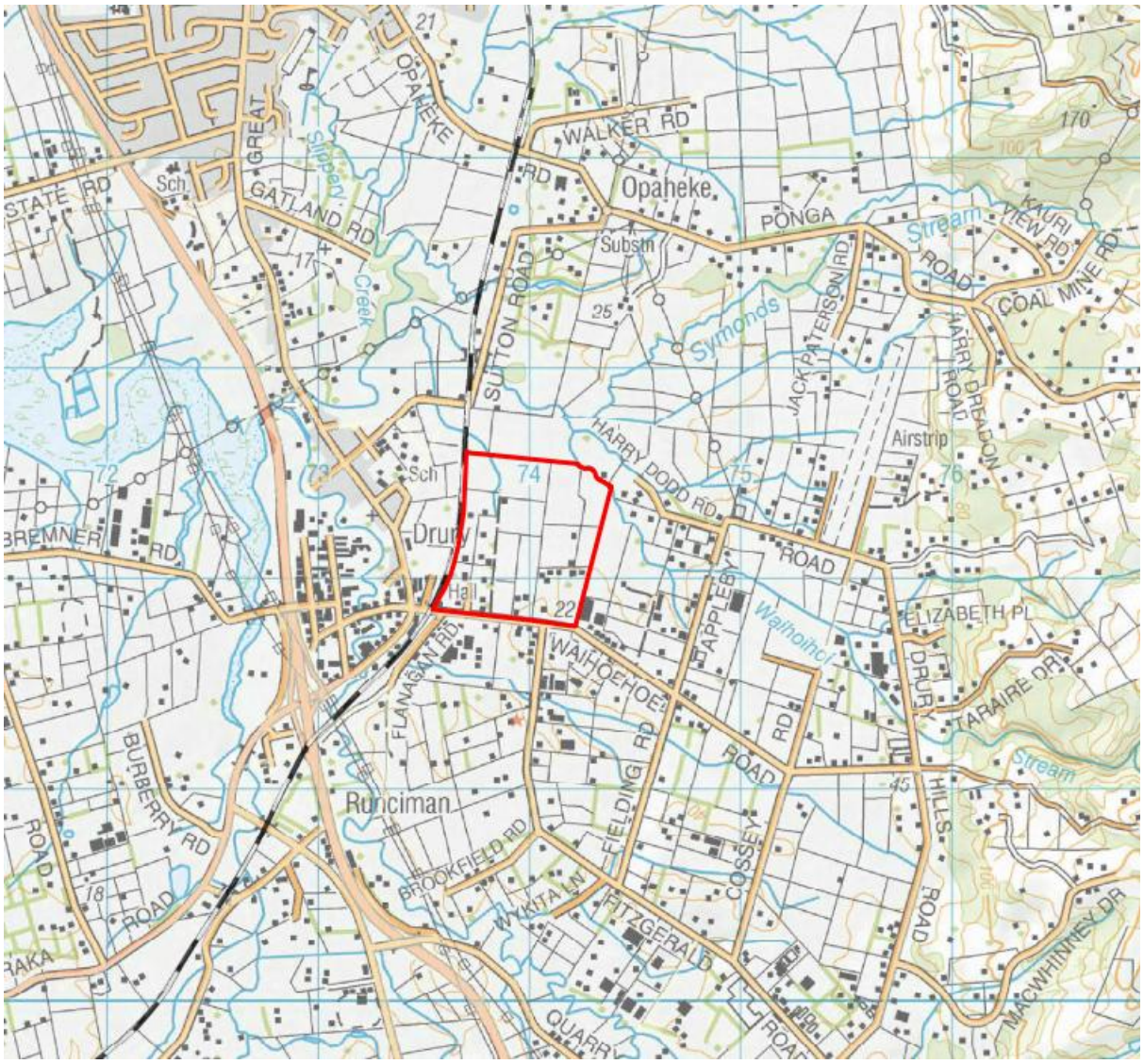

Figure 2.1: Locality plan with the Waihoehoe Precinct shown in red

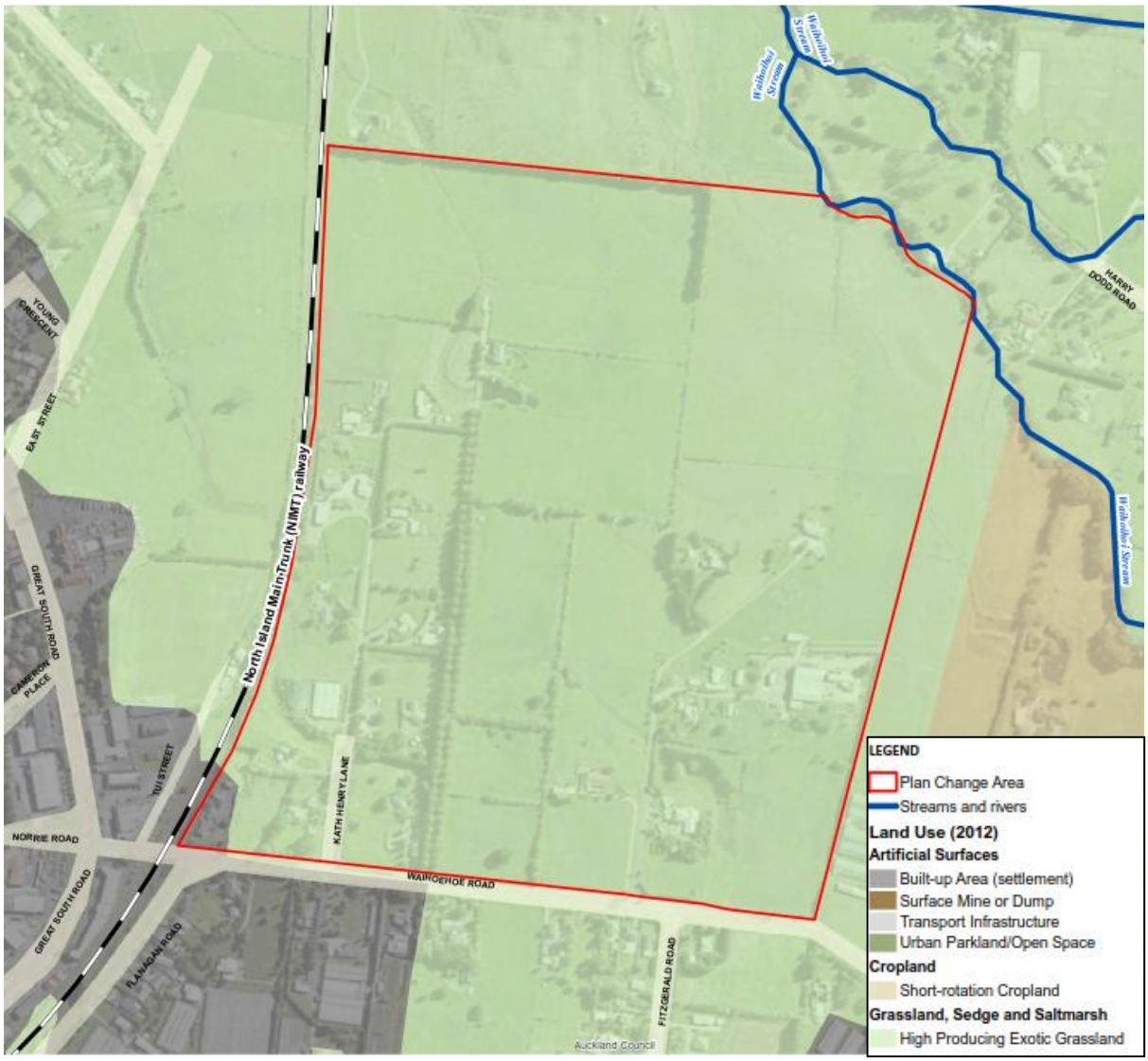

Figure 2.2: Current Land Use of Waihoehoe Precinct

2.1.1 Catchment and topography

The PCA is located at the downstream end of the Slippery Creek catchment and within the Slippery Creek flood plain. The Slippery Creek catchment is approximately 4,630 hectares, and drains to Drury Creek and subsequently to the Pāhurehure Inlet of the Manukau Harbour.

Elevations within the PCA range from approximately 8 m RL at the north western end of the property to 19 m RL in the south western end, with an average slope of 1.2% (refer to Figure 2.3 and Appendix A, Figure A5 - Topography for the full figure). The natural topography within the PCA generally drains in a north westerly direction and forms two sub-catchments.

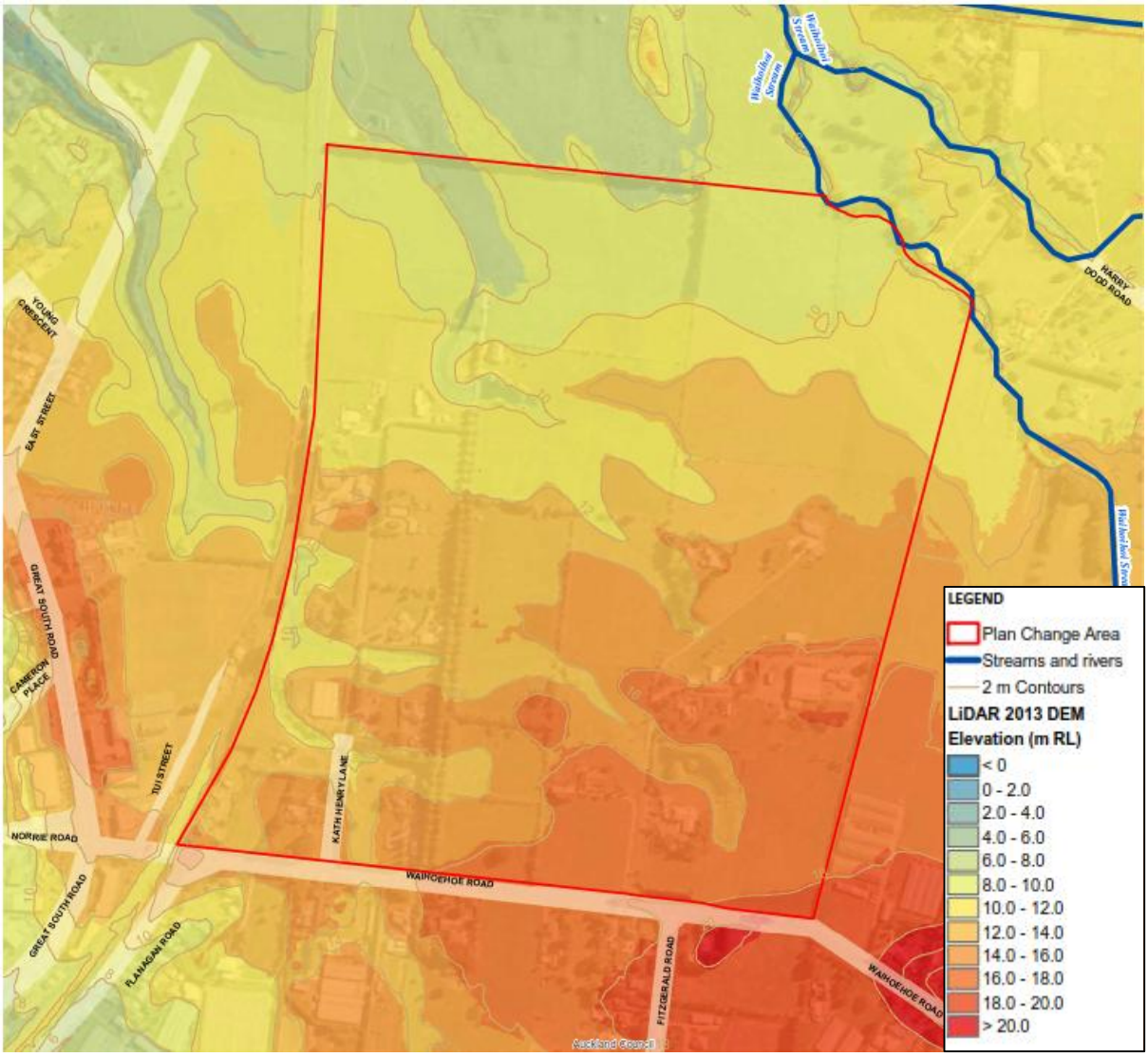

Figure 2.3: Existing Topography of the Waihoehoe Precinct

The southern sub-catchment drains to the railway culvert at the western property boundary, and the northern catchment drains to Waihoihoi Stream as shown in Figure 2.4 (refer to Appendix A, Figure A6 - Existing Flooding for the full figure). Waihoihoi Stream then discharges into Slippery Creek at a point north-west of the PCA.

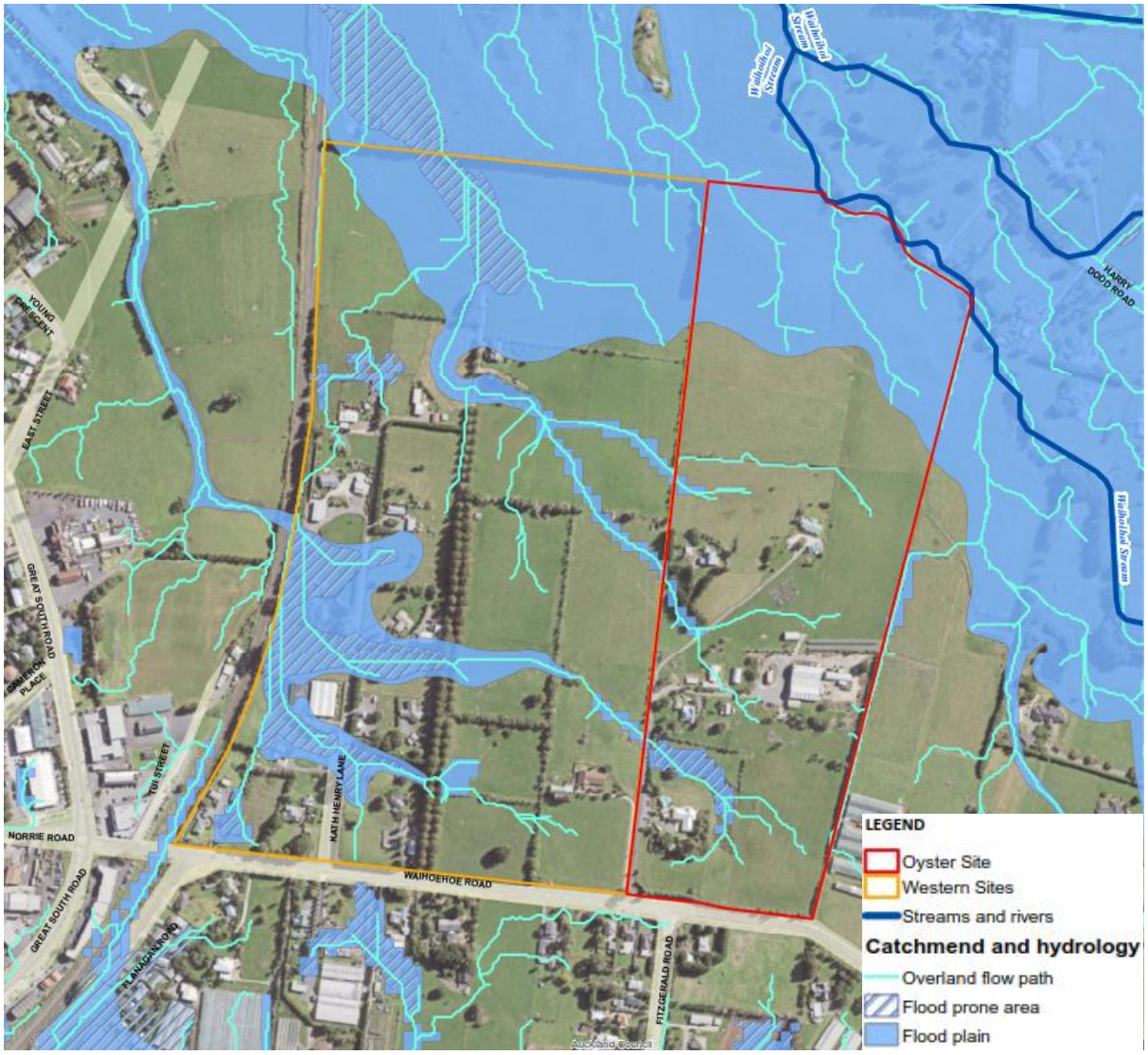

Figure 2.4: Flooding and overland flow paths within the Waihoehoe Precinct

2.1.2 Floodplains and overland flow paths

Flooding is a major issue for the wider Drury-Opāheke catchments. Large runoff volumes, flat terrain, and road and rail crossings within the Slippery Creek catchment, in particular, result in an extensive flooded area. Furthermore, stormwater catchments in the area are interconnected and flood flows from one catchment may influence adjoining catchments due to their common confluence. According to the OD SMP, the floodplain comprises 292 ha of the 735 ha of the Slippery Creek catchment that is within the Drury-Opāheke Structure Plan area. Slippery Creek overflows Great South Road in large storm events.

Northern and southern sub-catchments of the PCA lie within the Slippery Creek (including Waihoihoi Stream) flood plain, which presents is a constraint to development. Flooding in the southern sub-catchment is caused in part by a railway culvert downstream, throttling peak flows and causing ponding during floods (refer to Figure 2.4 and Appendix A, Figure A6 - Existing Flooding for the full figure).

Flood prone areas are defined in the AUP as topographical depressions that may fill with runoff rapidly during a storm event due to a lack of capacity or blockage of the primary network. They can be natural low points or man-made areas where water can pool (e.g. due to an embankment such as

a road). Flood prone areas are mostly limited to the southern and western part of the property. All flood prone areas are contained in the flood plain (refer to Figure 2.4 and Appendix A, Figure A6 - Existing Flooding for the full figure).

Auckland Council GIS flood plain extents for the Opāheke area are based on a 2007 1D model[1] that includes major structures but has no allowance for climate change (OD SMP). The OD SMP classified the modelling confidence for the existing model as low whereas the flooding complexity is classified as high.

There are several overland flow paths throughout the property, generally draining from south-east to north-west. Overland flow paths are topographical low points that convey stormwater runoff. Major overland flow paths within the PCA (i.e. overland flow paths which drain areas greater than 3 hectares) follow the extent of the floodplain with the exception of one major flow path draining from south to north alongside the railway line and the western property boundary (refer to Figure 2.4 and Appendix A, Figure A6 - Existing Flooding for the full figure). Auckland Council has provided results for a more up-to-date flood hazard model for Slippery Creek which will be further discussed in Section 5.

2.2 Geotechnical, soils, groundwater and contaminated land

2.2.1 Geotechnical

Geotechnical constraints have been identified as a part of the Lander Geotechnical Preliminary Geotechnical Appraisal Report March 2019 for the PCA area. The main findings are summarised below:

- Ground stability: Most of the PCA is observed to have gentle to rolling land with no obvious signs of ground instability. However, it is noted that *"softer ground or lenses of organics can pose constraints to NZS3604 building foundations and residential end use, necessitating remediation during earthworks construction or specifically designed foundation solutions (i.e. "raft" foundations)"* but previous experiences on similar sites indicate that *"only a small proportion of lots may be affected by soft ground or organic soils"*. Liquefaction risks are considered to be moderate and *"it is considered likely the liquefaction induced settlement will occur relatively uncommonly (i.e. in a total fashion) across the landform, and according excessive differential settlements are unlikely to be a cause for concern"*
- Earthworks and infrastructure: Natural deposits encountered across the PCA during the preliminary investigation are typically of high strength and have good engineering characteristics for foundations and earthworks handling. Although not identified to be a specific issue, in the geotechnical investigation undertaken in March 2019, it is noted that natural soils, particularly those with high pumice content will be prone to piping and further investigation at time of subdivision will be required to assess risk if on-site stormwater management systems are proposed

2.2.2 Soils

Geological information provided by GNS show that the primary rock type underlying the PCA is alluvium. Lander Geotechnical confirm that the underlying geological unit is Puketoka Formation sedimentary lithology (alluvial clays, silts and sands, occasional decayed organics and localised peat pads).

Moreover, Landcare Research NZ GIS data show that the northern half of the property is underlain by recent and orthic gley soils (refer to Figure 2.5 and Appendix A, Figure A7 - Geology for the full

[1] Refer to Auckland Council GeoMaps: Municipal Design Ltd/AC, SLIPPERY CREEK ICMP - FHM Publication Final, 2007

figure). Gley soils are strongly affected by waterlogging which mainly occurs in winter and spring with some soils remaining wet all year. The southern half of the property is dominated by orthic granular soils, which are clayey soils formed from material derived by strong weathering of volcanic rocks or ash.

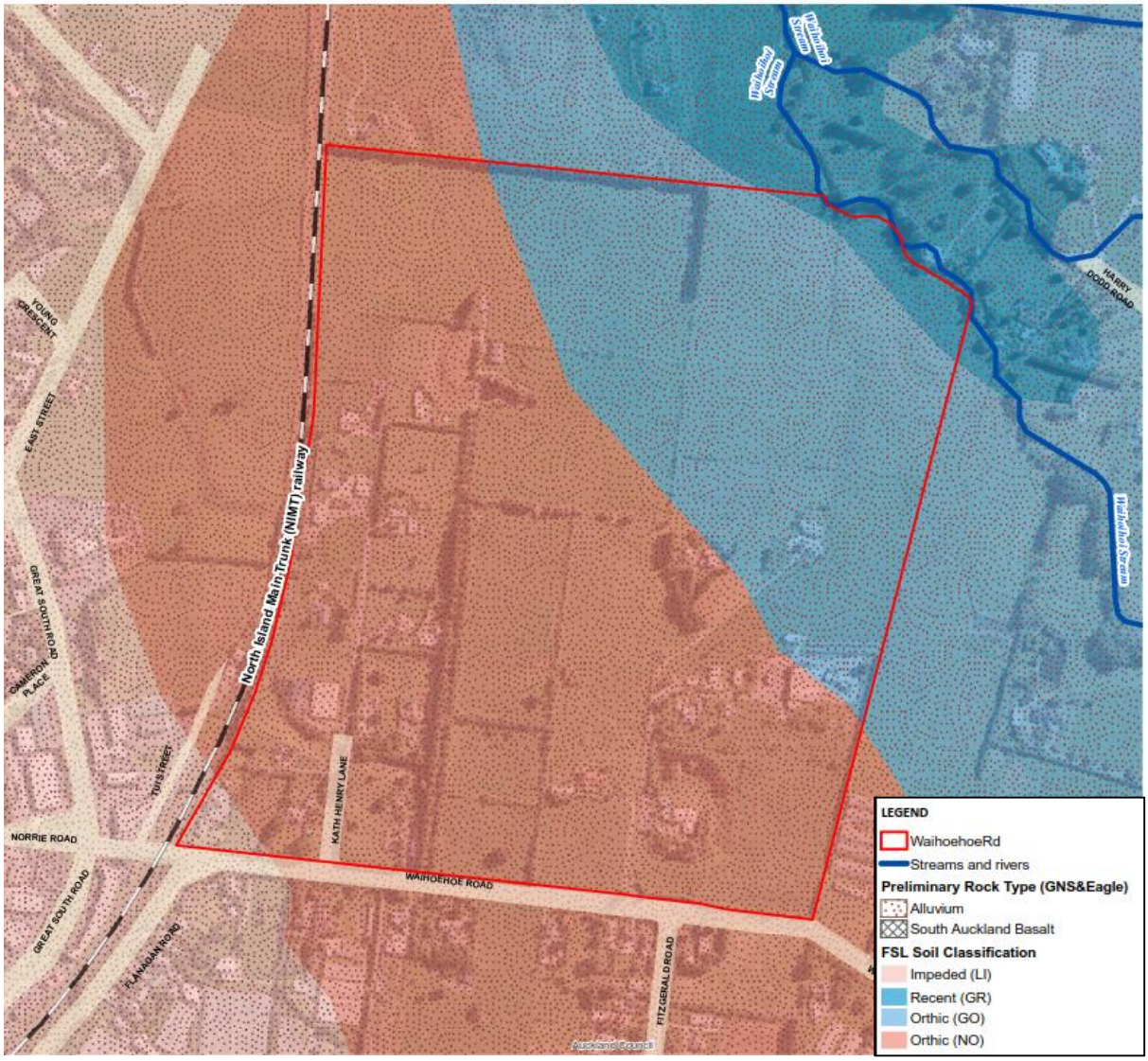

Figure 2.5: Existing geology within the Waihoehoe Precinct

The geotechnical investigations from 12 boreholes around the PCA have indicated that the majority show the top 5 m consisting of inorganic orange, brown, green and grey silts, clays and sands with organic inclusions and staining, with a 100 to 300 mm of topsoil. Further information is provided in the Lander Geotechnical Preliminary Geotechnical Appraisal Report March 2019 for the PCA.

According to Land Environments of New Zealand (LENZ) soil drainage data, soil drainage is poor for the north eastern part of the property. The major part of the property to the south-west shows moderate to good soil drainage (refer to Figure 2.6 and Appendix A, Figure A8 - Soil Drainage and Groundwater Levels for the full figure). Percolation rate tests have not been undertaken as part of the Preliminary Geotechnical Appraisal Report March 2019 and therefore infiltration rates are not yet confirmed.

Site specific testing for infiltration will be required for design of stormwater devices that rely on retention by infiltration.

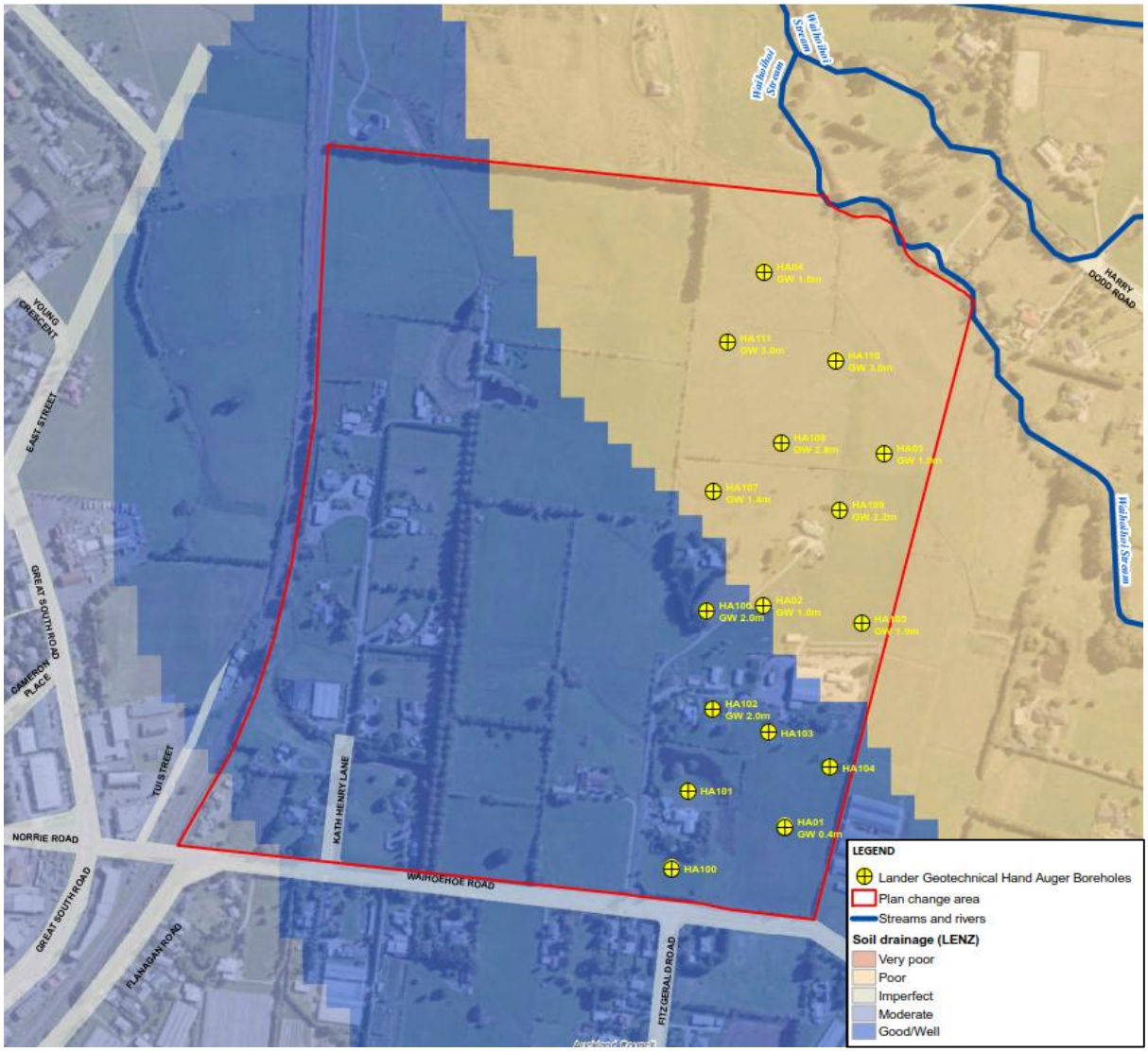

Figure 2.6: Soil drainage within the Oyster Capital Waihoehoe Precinct Plan Change Area

2.2.3 Groundwater

Standing groundwater levels were encountered across the site, ranging between 1.4 and 3.0 metres below ground level. Hand auger samples also show the water table encountered at depths between 0.4 to 1.0 meters below ground level.

The ground water readings are shown against each of the test locations in Figure 2.7 below. Refer to the Lander Geotechnical Preliminary Geotechnical Appraisal Report (March 2019) for more details.

Site specific testing for groundwater levels, including seasonal variation, will be required for design of infrastructure, especially for stormwater devices that rely on infiltration.

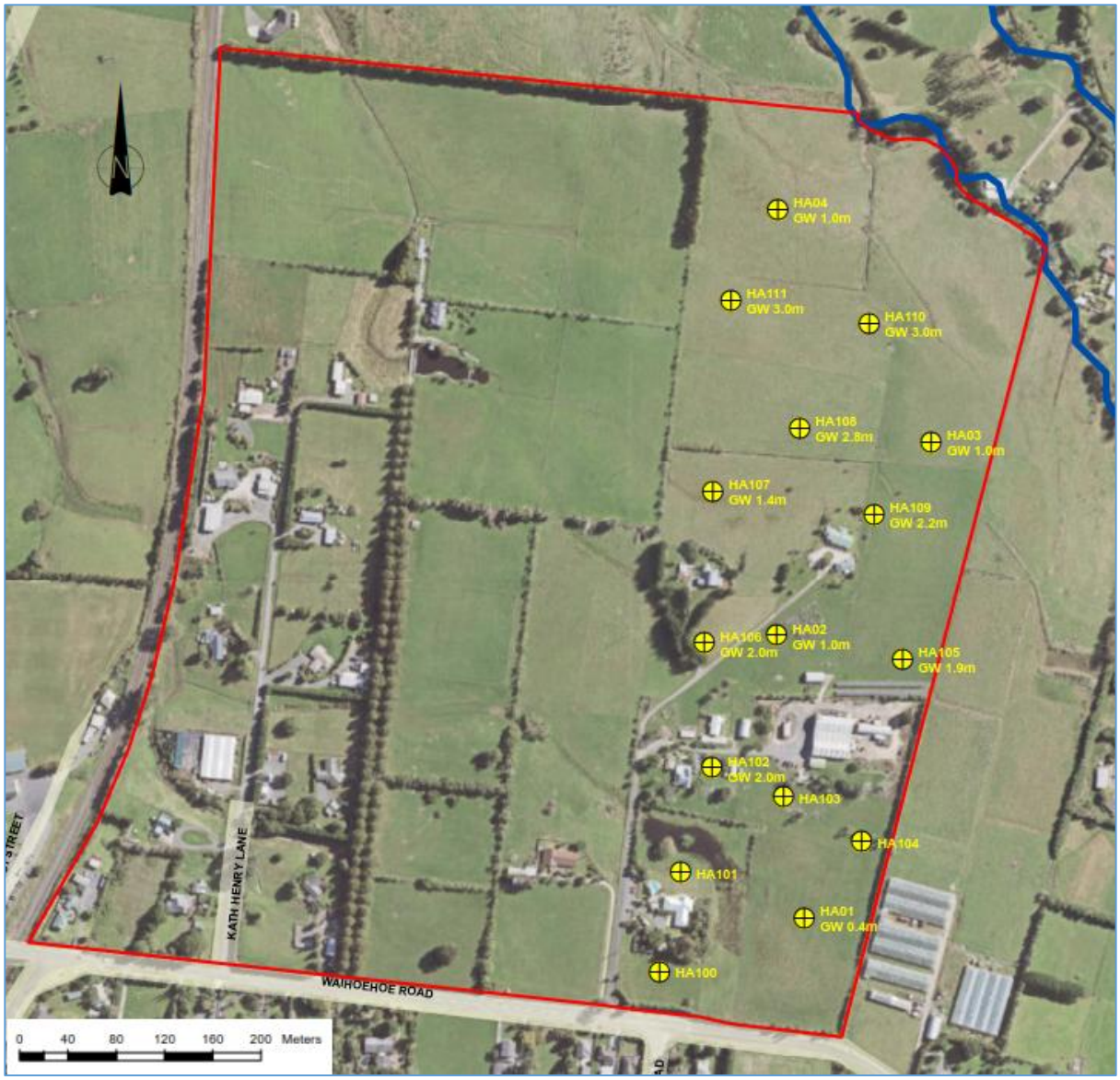

Figure 2.7: Groundwater depth relative to ground level. Groundwater depth data derived from Lander Geotechnical Preliminary Appraisal Report (March 2019)

2.2.4 Contaminated sites

A desktop assessment of the whole PCA and a site inspection of 116, 136 and 140 Waihoehoe Road was undertaken to identify potential contaminated sites within the PCA. The findings of the Focus Environmental Services Ltd *Preliminary Site Investigation* (PSI) (March 2019) are summarised below and the full report is included in Appendix G.

HAIL sites are identified as sites where any potentially hazardous activities listed on the Hazardous Activities and Industries List (HAIL) had occurred (or is currently occurring) on site as a result of past or current land use. A total of ten properties on Waihoehoe Road and Kath Henry Lane, including 116 Waihoehoe Road, are classified as HAIL sites.

The PSI recommends completing a detailed contaminated site investigation (DSI) prior to the developing the PCA. The DSI investigation should include a thorough site walkover and inspection to identify any remaining areas where potentially contaminating land uses or activities may have taken place within the PCA. The DSI will confirm if the identified land uses and/or activities have affected

the site soils and the consenting requirements for these areas within the PCA. This is consistent with the approach of the AUP which requires a DSI where necessary triggers are met.

2.3 Ecological assessment

Ecological values of terrestrial, freshwater and coastal marine areas within the PCA were determined through desktop analysis and field data. The main ecological findings, opportunities and constraints from the Freshwater Solutions' *Waihoehoe Road Drury Ecological Assessment* report (March 2019) and subsequent *Drury East Plan changes - Ecology Response* Memo (24 March 2020) are described below and included in full in Appendix H and Appendix M, respectively.

2.3.1 Terrestrial and freshwater ecology values

- The collective Drury East development area is currently in predominantly agricultural and horticultural land use, including cropping, dairy farming and grazing
- Auckland Council has surveyed streams within the Slippery Creek area[2], however most of the stream length present within the PCA was not mapped. Therefore, we rely on the observations made during field assessments and reported in the *Waihoehoe Road Drury Ecological Assessment* (March 2019) where intermittent watercourses were found to be unfenced with severely damaged streambanks and channels
- The ecological survey which formed the basis of the *Waihoehoe Road Drury Ecological Assessment* (March 2019) was carried out outside the recommended Auckland Council window for classifying intermittent and ephemeral watercourses (i.e. July-October) but during wet conditions. This survey defined the permanent, intermittent and ephemeral streams, which are shown in Figure 2.8. Watercourses and wetlands within the site were also mapped
- All watercourses originate within the PCA and many of the streams within the PCA are highly modified, intermittently flowing headwater systems with minimal natural character and low ecological value in their current state. They commonly have unrestricted stock access to enable grazing when the streams are dry in summer. Photograph 2.1 below provides a representative image of the smaller streams within the PCA
- Riparian vegetation is effectively absent over much of the PCA and most of the stream length is unfenced. Stream banks and channels have been impacted by stock access, with slumping and bank instability prevalent throughout the PCA
- The section of the Waihoihoi Stream flowing adjacent to the PCA was fenced but lined with low stature weed species and occasional mature trees so the streambanks were susceptible to streambank undercutting, slumping (i.e., due to poor root stability) and sedimentation (refer to Photograph 2.2)
- Two wetlands were identified during the site visit shown in Figure 2.8. Wetland W1 is associated with the online Pond P1. Wetland W2 has difficult to determine extents and seems to dry out after prolonged dry periods. Both wetlands are highly modified and degraded, dominated by exotic species, artificially drained in places, are open to stock trampling and have minimal indigenous values and character in their current state
- Three artificial ponds were identified through a combination of reviewing aerial photography and site surveys (refer to Figure 2.8). All ponds are online ponds and most are located in the mid-upper reaches of intermittent tributaries. The ponds provide poor quality still water habitat. The removal of artificial ponds has the potential to improve downstream water quality and fish passage and result in an overall enhancement of aquatic ecological values and natural character within the site

[2] Ingley, R., Rieger, A., Magee, J., Reeves, E., Macintosh, K., Lowe, M., Young, D. (2016) Watercourse Assessment Report: Slippery Creek Catchment. Morphum Environmental for Auckland Council.

- The streams within the PCA were not assessed in the 2016 Slippery Creek Watercourse Assessment Report, however, downstream and in the main stem of the Waihoihoi Stream a sample was taken which indicates 'fair' water and habitat quality (macroinvertebrate community index (MCI) $_{\text{soft-bottomed(sb)}}$ of 99). Freshwater Solutions sampled a section of the Waihoihoi Stream within the PCA and reported an MCI_{sb} indicative of poor stream health (MCI_{sb} of 78). The current state of freshwater ecosystems within the PCA is typically below the bottom line for rural land use (i.e. MCI less than or equal to 94). Under the future urban land use, the national bottom line of 68 is expected to be met, however the proposed stormwater management approach needs to at least maintain, but preferably improve, on the existing condition.
- There is no remnant or secondary regenerating native forest within the PCA and no listed Significant Ecological Areas (SEA), nor does any of the vegetation present meet any of the qualifying criteria for ecological significance
- Indigenous vegetation is very scarce and what is present is largely pasture used to graze sheep and cattle with shelterbelts and amenity gardens
- The Ecological Assessment identifies significant potential to enhance streams and wetlands within the site through weed control, riparian planting, fencing from stock (where applicable), suitable legal protection (i.e. covenant) and through increasing habitat connectivity and restoration of ecological corridors throughout the PCA.

Photograph 2.1: Evidence of unrestricted stock access, lack of riparian margins, upper bank instability

Photograph 2.2: Lack of riparian margins and bank instability along Waihoihoi Stream

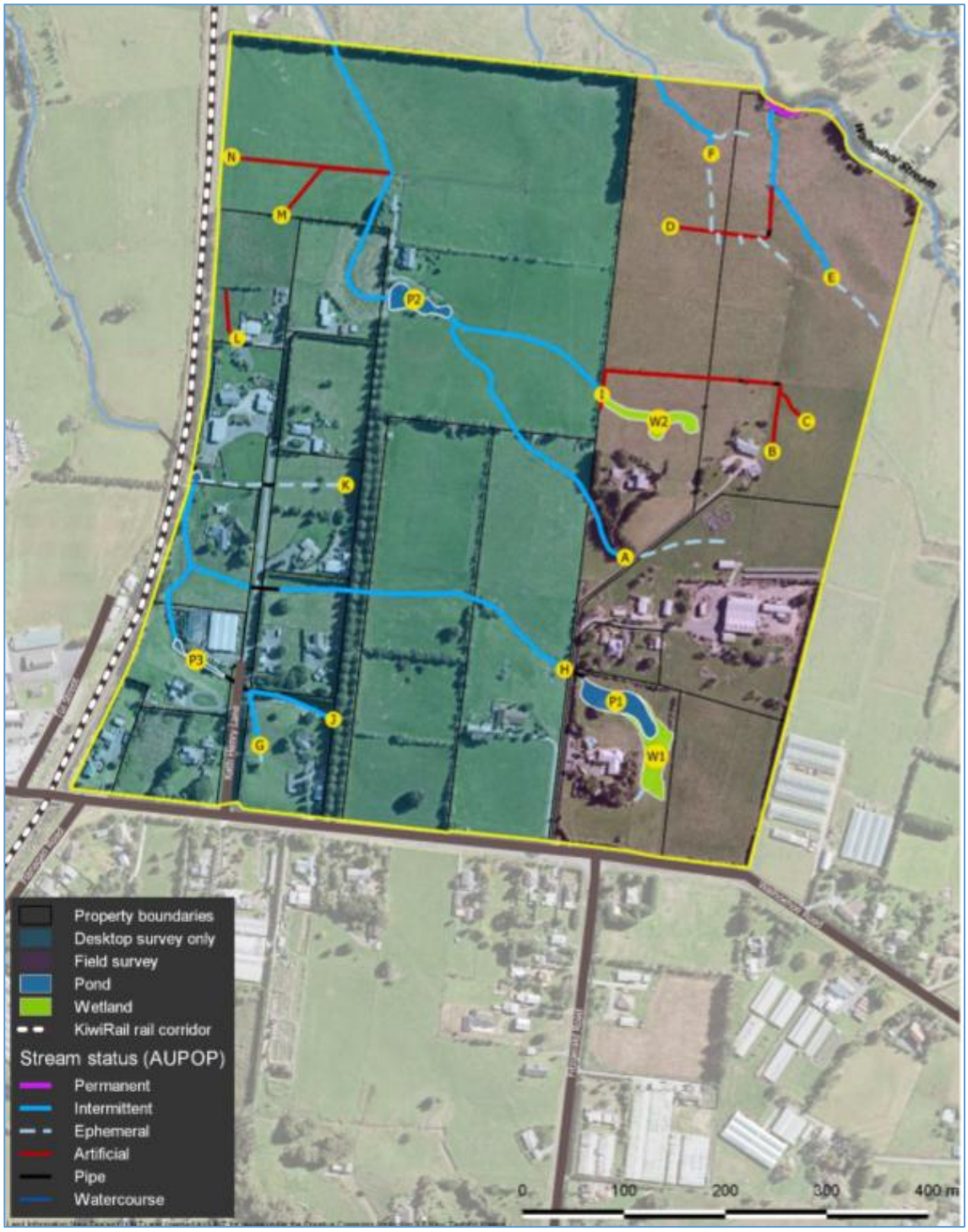

Figure 2.8: Stream status and wetlands within site. Plan sourced from Freshwater Solutions Waihoehoe Road Drury Ecological Assessment (March 2019)

2.4 Receiving environments

2.4.1 Stream, lakes and wetlands

The PCA is bound by Waihoihoi Stream in the North. The stream is one of four main watercourses within the wider Slippery Creek catchment.

The OD SMP describes that waterborne sediment is commonly observed in streams in rural areas within the Slippery Creek catchment. Water quality analyses for the catchment show elevated levels of zinc, lead and copper that might be from existing industry, road runoff and unpainted metal roofs. There is a high risk that this accumulation would continue without any stormwater management as levels typically increase with development. E.coli levels are also elevated, likely as a result of stock within the catchments. This might be decreased through future urban development as available land for grazing stock will decrease and with it the E.coli input into streams.

The northern sub-catchment of the PCA discharges into Waihoihoi Stream and subsequently into Slippery Creek. The Slippery Creek Catchment Watercourse Assessment prepared by Morphum Environmental for Auckland Council (2015) found that erosion of the Waihoihoi Stream banks was typically less than 20 percent and overall upper bank stability was considered to be fair due to evidence of some historical mass wasting, debris jams, and lack of bank stabilising vegetation.

The southern sub-catchment discharges into intermittent streams that flow through railway culverts at the western property boundary and into Slippery Creek. Further downstream, Slippery Creek eventually flows into Drury Creek, which is the receiving watercourse of all streams within the Drury-Opāheke FUZ.

The upper tidal reaches of Drury Creek are classified as a Significant Ecological Area (SEA) – Marine 1 (M1) in the AUP due to the presence of a variety of marshes, grading from mangroves through to extensive areas of jointed rush-dominated saltmarsh, to freshwater vegetation in response to salinity changes. The M1 subtype covers highly significant areas that, due to their physical form, are considered to be the most vulnerable to any adverse effects of inappropriate subdivision, use and development. This same area is a migration path between the marine and freshwater habitats for various native freshwater fish species.

Beyond this, the lower reaches of Drury Creek are classified as SEA – Marine 2 (M2) in the AUP, and comprise various intertidal habitats, ranging from sandy mud intertidal flats, currently exposed rocky reef habitats, and a variety of saline vegetation which provides roost areas of importance to wading birds including pied stilt. The M2 subtype covers similarly significant areas which do not warrant an SEA-M1 identification as they are generally considered to be more robust.

Drury Creek discharges into the Pāhurehure Inlet within the ultimate receiving environment in the upper Manukau Harbour. The Pāhurehure Inlet is also classified as a 'Degraded 1' coastal water area under Section B7 – Natural Resources of the Regional Policy Statement in the AUP.

To understand sediment deposition patterns within the environment, NIWA were engaged by the Ministry for the Environment to develop and apply a new empirical model that estimates mean annual river suspended sediment load and sediment deposition in coastal hydrosystems[3]. The model includes suspended sediment load and inherently includes sediment supply from eroding streambanks as well as upstream hill-slope erosion processes.

Shallow drowned valleys such as the Pāhurehure Inlet have intermediate level deposition rates (median of 0.7 mm/year), where near-bed velocities are low, little resuspension by currents occurs, and a main channel morphology tends to be absent. The trapping efficiency of a shallow drowned valley is typically quite high, and the Pāhurehure Inlet has a predicted trapping efficiency of 0.963. Trapping efficiency is the proportion of incoming sediment load that is retained and settles within the water body measured on a scale of 0 to 1, where 1 means that 'all river-sourced sediment is retained in the coastal hydrosystem'. What this tells us, is that the marine receiving environment is a

[3] Hicks, M., Semadeni-Davies, A., Haddadchi, A., Shankar, U and Plew, D. (2019). Updated Sediment Load Estimator for New Zealand. Prepared by NIWA for the Ministry for the Environment. March 2019. NIWA client report 2018341CH.

natural deposition zone and sediment deposition is expected and required for the environment to continue to function.

Zostera sea grass grows in soft-sediment environments and is present in the wider Pāhurehure Inlet. One of the key functions of seagrass is to trap and stabilise bottom sediments, to protect against sediment erosion in the coastal environment[4]. Seagrasses also depend on sediments for nutrients and anchorage.

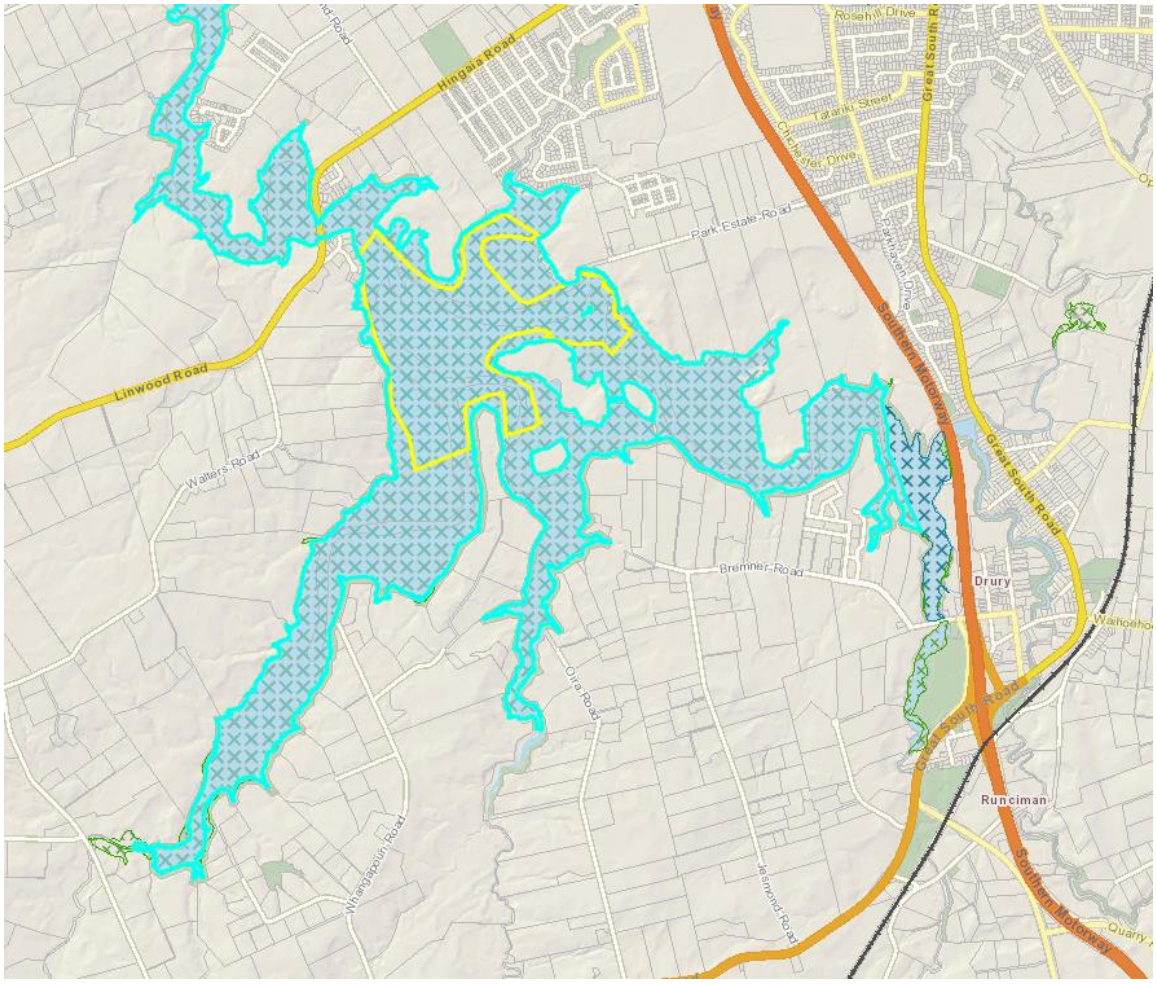

Figure 2.9: Significant Ecological Areas - Marine in the Pāhurehure Inlet and wider Drury Creek estuarine area

2.4.2 Aquifers and soakage

The south-western half of the PCA is located above the Drury Sand Aquifer which is defined both as high-use aquifer and quality sensitive aquifer under the AUP-OP (refer to Figure 2.10 and Appendix A, Figure A11 - Aquifer Management Areas for the full figure). High use aquifers are sensitive to increasing imperviousness, which can result in a reduction in aquifer recharge and infiltration rates. Any stormwater discharge to the aquifer through injection, or otherwise, should be preceded by water quality treatment to ensure there is no cross-contamination of the aquifer.

[4] Turner, S. and Schwarz, A. (2006). Management and conservation of seagrass in New Zealand: an introduction. Science for Conservation 264. Prepared by the Department of Conservation.

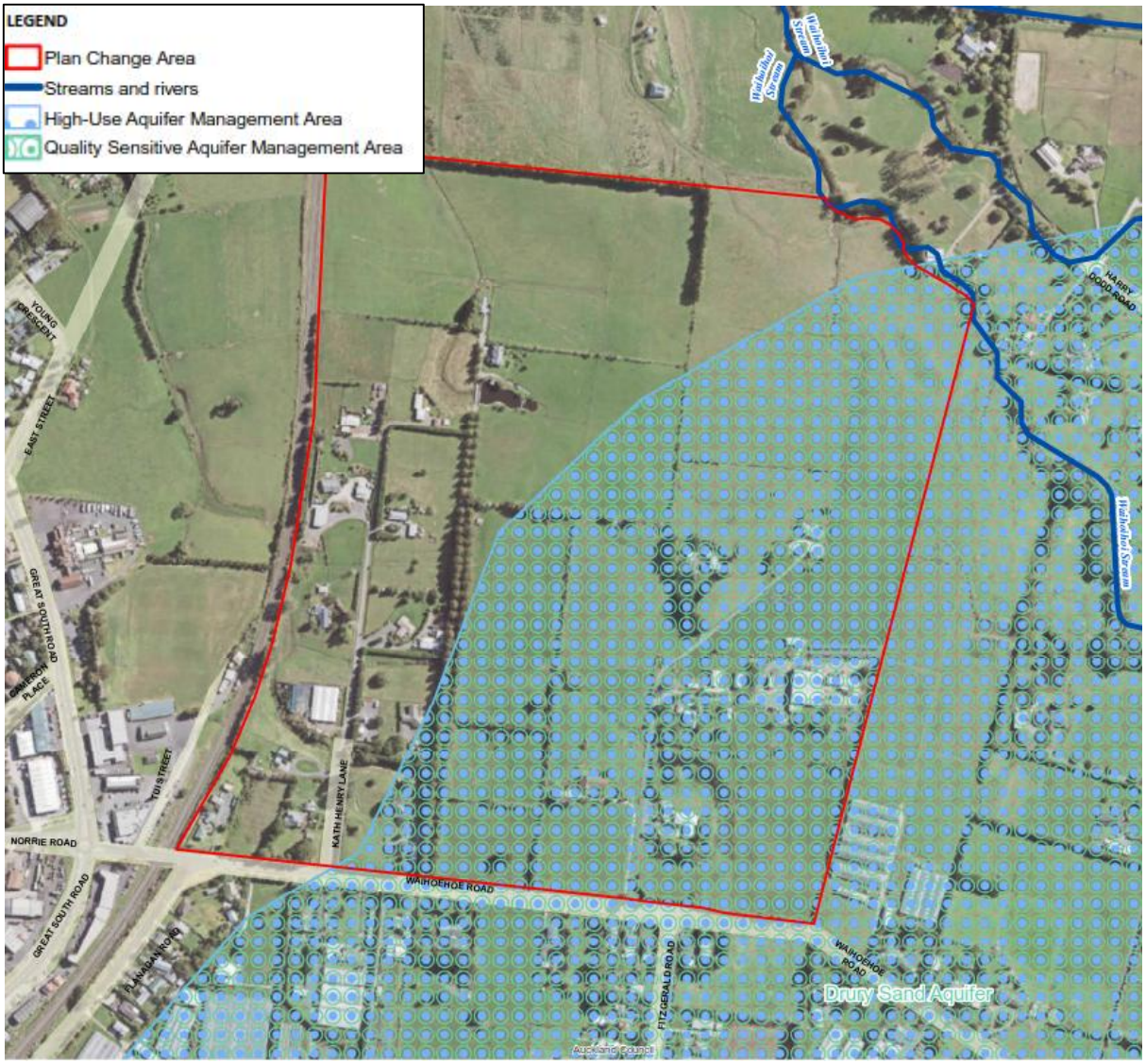

Figure 2.10: Aquifers within the vicinity of the Waihoehoe Precinct

2.5 Existing stormwater network and other infrastructure

2.5.1 On-site

Auckland Council GeoMaps does not show any mapped public stormwater infrastructure within the PCA. Public infrastructure is also limited in the surrounding area with only roadside channels and a 150 mm stormwater main on Waihoehoe Road, with an inlet just across the road from the properties, identified on Auckland Council GeoMaps.

There is no existing public wastewater infrastructure within the PCA.

There is no other relevant infrastructure within the PCA identified by Auckland Council. The closest infrastructure is a Vector Transmission Line that is located approximately 200 m east of the PCA.

2.5.2 Off-site

Auckland Council confirmed that a 900 mm culvert beneath the railway line at the middle of the western boundary of the PCA drains the southern sub-catchment (refer to Figure 2.11 and Appendix A Figure A12 - Existing Stormwater Infrastructure for the full figure). There is another railway culvert

just north of the PCA, and further north is the Sutton Road Bridges (road and rail) on the main branch of the Waihoihoi Stream.

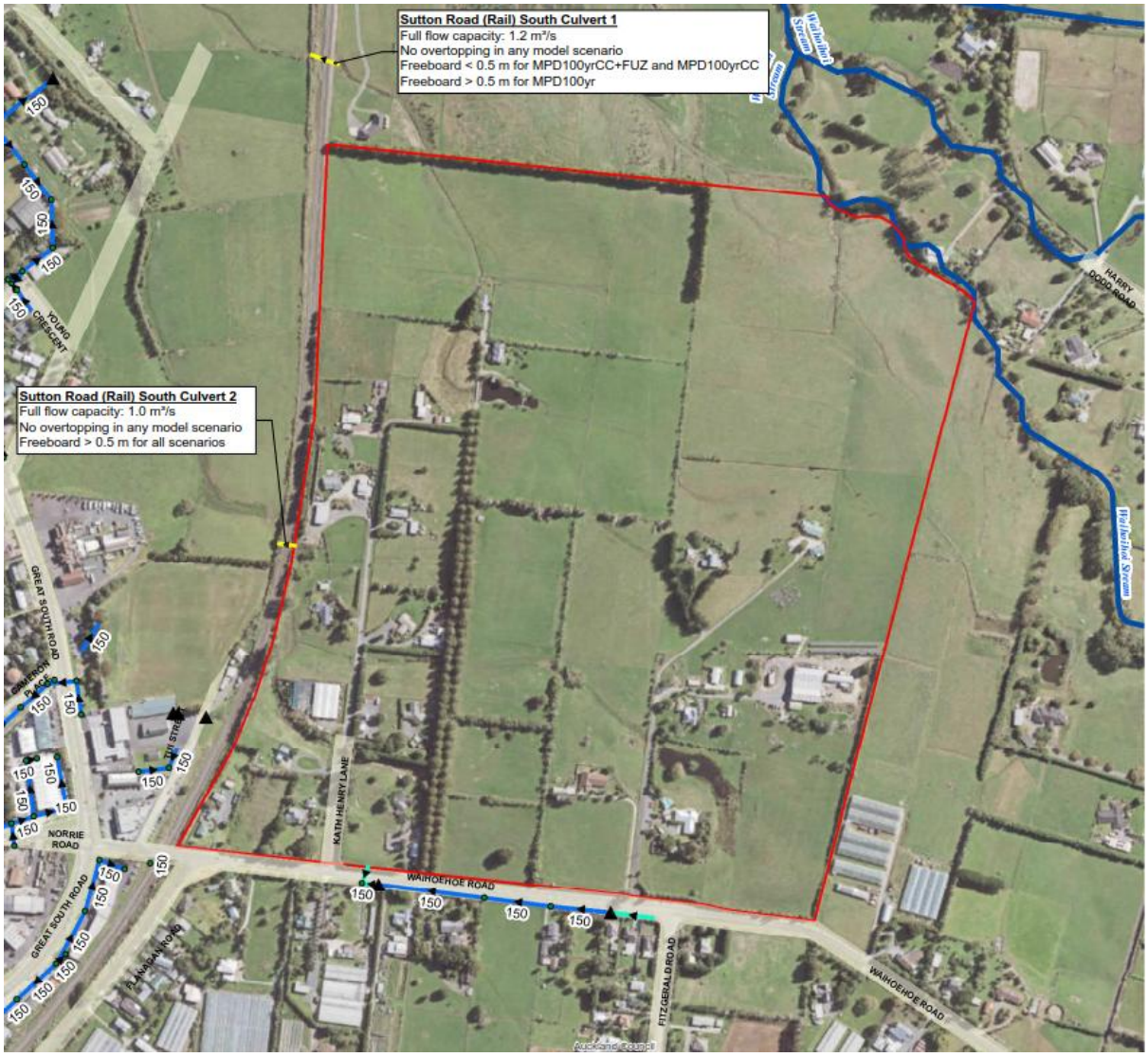

Figure 2.11: Existing Stormwater Infrastructure in the vicinity of the Waihoehoe Precinct

Mott MacDonald assessed both culverts and both bridges as part of the FUZ SMP Major Structures Flooding Assessment (2018). All structures were assessed under three modelling scenarios:

- 100 year Annual recurrence Interval (ARI) Maximum Probable Demand (MPD) with climate change with FUZ (MPD100yrCC+FUZ)
- 100 year ARI MPD with climate change without FUZ (MPD100yrCC)
- 100 year ARI MPD without climate change without FUZ (MPD100yr)

The southern culvert (Sutton Road Rail South Culvert 2) has a full flow capacity of 1.0 m³/s. There is no overtopping of the railway line in any of the three events and freeboards to the railway surface are more than 0.5 m (AT/NZTA freeboard requirement).

The culvert further north (Sutton Road Rail South Culvert 1) has a full flow capacity of 1.2 m³/s. It does not overtop during any of these modelled scenarios, but freeboards are smaller than 0.5 m for both the MPD100yrCC+FUZ and MPD100yrCC scenarios. It is therefore not satisfying the 100 year ARI NZTA Level of Service requirements.

The Sutton Road Bridge and Sutton Road Rail Bridge have a free flow capacity of 32.0 m^3/s and 67.0 m^3/s, respectively. Sutton Road Rail Bridge also does not overtop in any of these modelled scenarios, however, maximum water levels are above the bridge soffit level for all MPD events, making it act as a stop bank and therefore a constraint to the flow. The lack of flow capacity causes a backwater effect to the upstream Sutton Road Bridge which contributes to Sutton Road Bridge overtopping in all three modelled scenarios, and contributes to large upstream floodplain extents.

3 Proposed changes

The Plan Change application proposes rezoning the 48.9 hectare site to THAB zone as shown in Figure 3.1. The masterplan for the PCA is configured so that the residential dwellings are generally located outside of the current Auckland Council 100 year ARI flood plain and includes drainage reserves with 10 m riparian margin around existing intermittent streams. The development land for residential dwellings which falls within the current 100 year ARI flood plain extent (see Figure 3.1) will be raised to exclude it in the future. These minor modifications to the flood plain will be designed to have no offsite effects on adjacent properties and will be addressed at the resource consent stage.

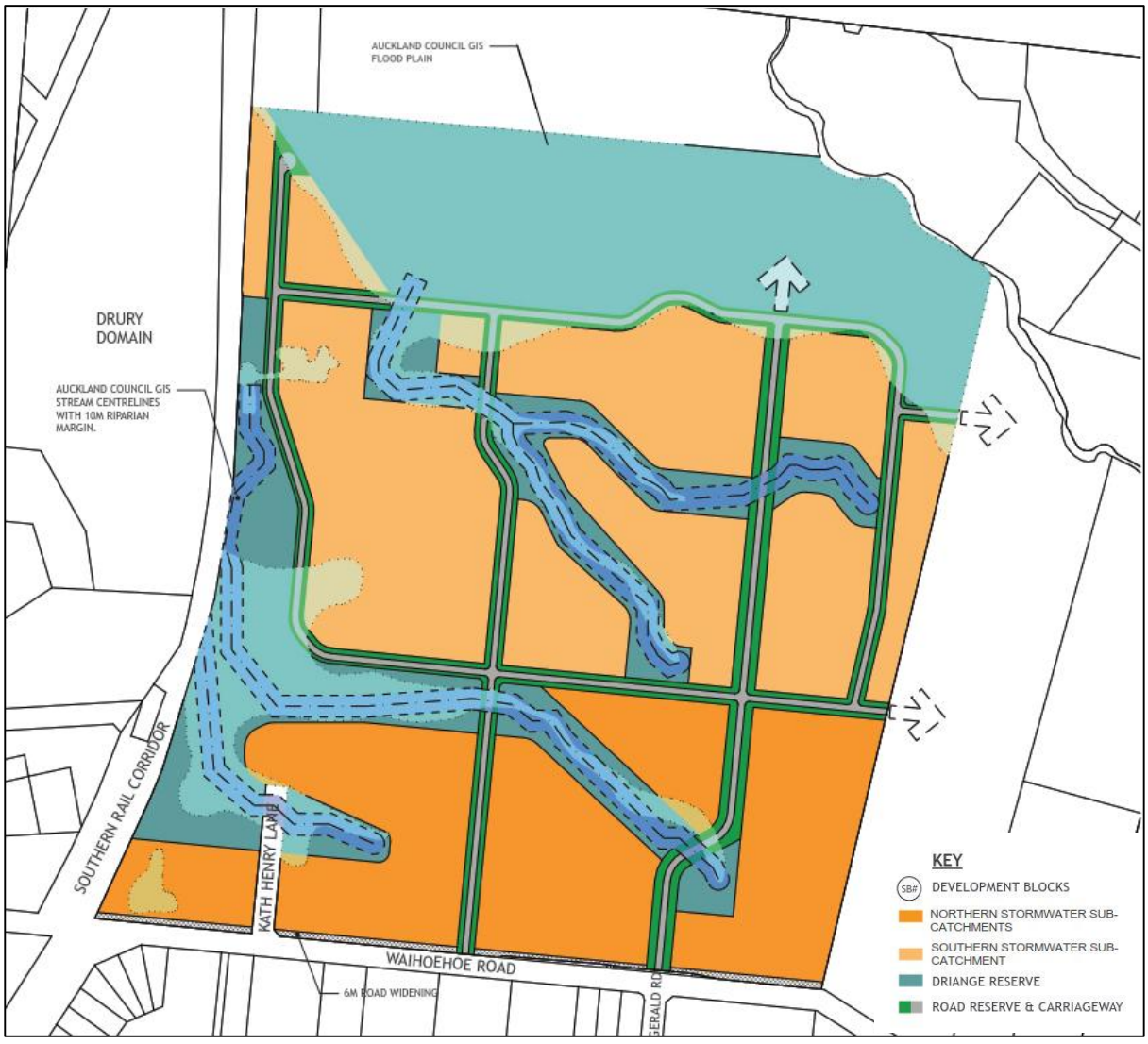

Figure 3.1: Proposed development of Waihoehoe Precinct

4 Stormwater and flood management requirements

This SMP uses the most recent planning and regulatory requirements to develop a stormwater management approach within the PCA. It seeks to demonstrate that the proposed stormwater management is the best practicable option, taking into consideration the existing site features (summarised in Section 2 of this report) and the future land use (summarised in Section 3 of this report). This guidance is consistent with regulatory and stormwater-specific guidelines and based on conventional stormwater management techniques to meet AUP provisions. There are no existing Network Discharge Consents (NDCs) for the area but the OD SMP, FUZ SMP, T+T's Stormwater Management Summary for the Drury Structure Plan Area (DSPA) for the Drury Developers Group (DDG) and T+T and Woods Drury East SMP for the Kiwi Property Drury Centre and FHLD Drury East Precinct have been referred to ensure to the stormwater management approach integrates with existing and future stormwater systems in the Slippery Creek catchment.

4.1.1 Consideration of AUP objectives and requirements

The general AUP policies for management of stormwater, streams and coastal environment are covered in Section E – Auckland Wide rules, namely:

- Chapter E1 – Water quality and integrated management
- Chapter E10 – Stormwater management area, Flow 1 and Flow 2
- Chapter E36 – Natural hazards and flooding

Section D of the AUP-OP sets further policies regarding the management of receiving environments. Relevant stormwater policies are the following:

- Section D2 – Quality-sensitive Aquifer Management Areas Overlay
- Section D9 – Significant Ecological Areas Overlay

4.1.1.1 Water quality and integrated management

Policy 8 in Chapter E1 (Policy E1.3.8) sets out the following policies for management of stormwater runoff from greenfield development:

Avoid as far as practicable, or otherwise minimise or mitigate, adverse effects of stormwater runoff from greenfield development on freshwater systems, freshwater and coastal water by:

- *Taking an integrated stormwater management approach (refer to Policy E1.3.10 below)*
- *Minimising the generation and discharge of contaminants, particularly from high contaminant generating car parks and high use roads and into sensitive receiving environments*
- *Minimising or mitigating changes in hydrology, including loss of infiltration, to:*
  - *minimise erosion and associated effects on stream health and values*
  - *maintain stream base flows*
  - *support groundwater recharge*
- *Where practicable, minimising or mitigating the effects on freshwater systems arising from changes in water temperature caused by stormwater discharges*
- *Providing for the management of gross stormwater pollutants, such as litter, in areas where the generation of these may be an issue*

Chapter E1 of the AUP identifies that where freshwater quality is degraded, that it be improved over time and that the MCI be used as a 'guideline' or indicator of freshwater ecosystem health. Policies

2a, 2band 3 in Section E1 (Policy E1.3.2a and 2b and 3) set out the following policies for management of stormwater runoff:

- Maintain or enhance water quality, flows, stream channels and their margins and other freshwater values where the current condition is above the relevant thresholds OR enhance water quality, flows, stream channels and their margins and other freshwater values where the current condition is below the relevant thresholds

Aquatic macroinvertebrate community structure, abundance and diversity are standard indicators of the long-term health of streams. Different aquatic invertebrate taxa have varying tolerances of pollutants so their presence or absence can provide an indication of stream condition and overall health (i.e. water quality and habitat quality).

Policy E1.3.2 identifies some 'national bottom lines' for stream health using the MCI and directs that where the current condition is lower than the bottom line that these systems be enhanced. If the bottom line is met, then the current condition should be maintained or enhanced. The bottom-line MCIs of 94 and 68 for rural and urban environments respectively are relevant to this assessment. An MCI score of 94 is indicative of 'fair' stream health (i.e. MCI range between 80 and 99) whilst anything lower than 80 is deemed 'poor' and representative of a degraded aquatic system.

The other relevant policies from Section E1 are summarised briefly below:

- Discharges must avoid contamination that will have an adverse effect on the life supporting capacity of freshwater (Policy E1.3.4)
- Discharges must avoid contamination that will have an adverse effect on health of people and communities (Policy E1.3.5)
- An integrated stormwater management approach (Policy E1.3.10) must have regard to all of the following:
  - The nature and scale of the development and practical and cost considerations
  - The location and design of site and infrastructure to protect significant site features and minimise effects on receiving environments
  - The nature and sensitivity of receiving environments
  - Reducing stormwater flows and contaminants at source
  - The use and enhancement of natural hydrological features and green infrastructure where practicable
- Avoid, minimise or mitigate adverse effects of stormwater diversions and discharges (Policy E1.3.11)
- Manage contaminants in stormwater runoff from High Contaminant Generating Carparks (more than 30 cars) and High Use Roads (more than 5000 vehicles per day) to minimise adverse effects on water and sediment quality (Policy E1.3.12)
- Require stormwater quality or flow management to be achieved on-site unless there is a downstream communal device (Policy E1.3.13)
- Adopt the best practicable option to minimise the adverse effects of stormwater discharges (Policy E1.3.14)
- Utilise stormwater discharge to ground soakage where it is possible to do so in a safe and effective manner (Policy E1.3.15)

4.1.1.2 Hydrological mitigation

Hydrological mitigation seeks to minimise the change in hydrology, namely runoff volumes and flow rate, as a result of development. Chapter E10 of the AUP sets out a hydrological mitigation

framework for brownfield sites which discharge to sensitive or high-value stream environments that have been identified as particularly susceptible to the effects of development. This framework must be applied to developments within the AUP management Stormwater Management Area Control – Flow 1 and Flow 2 (SMAF) overlay.

The general approach of this SMP is to provide a minimum of the SMAF 1 framework to provide hydrological mitigation for all impervious surfaces within the PCA. The SMAF 1 hydrological mitigation requirements in the AUP are:

- Retention (volume reduction) of at least 5 mm of runoff depth from impervious surfaces where possible with limitations set out in Table E10.6.3.1.1
- Detention (temporary storage) and a drain down period of 24 hours for the difference between the pre-development and post-development runoff volumes from a 95th percentile, 24 hour rainfall event minus the achieved retention volume, over the impervious area for which hydrology mitigation is required

The retention volume may be taken up by detention if:

- a suitably qualified person has confirmed that soil infiltration rates are less than 2 mm/hr or there is no area within the PCA of sufficient size to accommodate all required infiltration that is free of geotechnical limitations (including slope, setback from infrastructure, building structures or boundaries and water table depth)
- rainwater reuse is not available because:
  - the quality of the stormwater runoff is not suitable for on-site reuse (i.e. for non-potable water supply, garden/crop irrigation or toilet flushing)
  - there are no activities occurring within the PCA that can re-use the full 5 mm retention volume of water

4.1.1.3 Natural hazards and flooding

Chapter E36 sets out the policies relating to management of natural hazards and flooding. The relevant policies are summarised briefly below:

- Identify land subject to natural hazards, taking into account the likely effects of climate change (Policy E36.3.1)
- Avoid development in greenfield areas which would result in an increased risk of adverse effects from coastal hazards, taking account of a longer-term rise in sea level in areas subject to coastal hazard (Policy E36.3.5)
- Avoid locating buildings in the 100 year ARI floodplain (Policy E36.3.17)
- Earthworks within the 100 year ARI floodplain should not permanently reduce floodplain conveyance or exacerbate flooding experienced by other sites upstream or downstream (Policy E36.3.20)
- Ensure all development in the 100 year floodplain does not increase adverse effects or increased flood depths or velocities to other properties upstream or downstream of the PCA (Policy E36.3.21)
- Maintain the function and capacity of overland flow paths to convey stormwater runoff safely and without damage to the receiving environment (Policy E36.3.29) and Policy E36.3.30)

4.1.1.4 Quality-sensitive aquifer management areas overlay

Policies 3 in Chapter D2 sets out the following policies for management of water quality for Quality-sensitive Aquifer Management Areas:

- Recognise the sensitivity of the following aquifers to groundwater contamination and minimise the discharge of contaminants in quality-sensitive aquifer management areas: rural aquifers - Kaipara Sand, Franklin Volcanic, Drury Sand and Āwhitu Sand (Policy D2.3.1)
- Discourage the discharge of contaminants where they are likely to have significant adverse effects on groundwater quality within quality-sensitive aquifer management areas (Policy D2.3.2)

4.1.1.5 Significant ecological areas overlay

Policy 2 in Chapter D9 of the AUP set out the following policy for management of stormwater runoff to Significant Ecological Areas:

- Adverse effects on indigenous biodiversity values in significant ecological areas that are required to be avoided, remedied, mitigated or offset may include, but are not limited to, any of the following: downstream effects on wetlands, rivers, streams, and lakes from hydrological changes further up the catchment (Policy D9.3.2)

4.1.2 Network Discharge Consent

The Auckland region-wide NDC came into effect in October 2019. The NDC allows for the stormwater diversion and discharges from developments to be incorporated under Auckland Council's consent, and for assets to be vested to Auckland Council, provided they comply with the NDC conditions.

The revised requirements and template for an SMP under the NDC are quite different to previous SMP formats and identify either a compliant approach or a BPO approach. The NDC requirements for greenfield developments, relevant to the PCA, and as stipulated in the NDC Schedule 4, are:

- Treatment of 100% of impervious areas by a water quality device designed in accordance with GD01/TP10 for the relevant contaminants
- Achieve equivalent hydrology (infiltration, runoff volume, peak flow) to pre-development (grassed state) levels. A method of achieving equivalent hydrology to pre-development (grassed state) is to provide retention (volume reduction) and detention (temporary storage) for all impervious areas equivalent to SMAF 1
- Ensure that there is sufficient capacity within the pipe network downstream of the connection point to cater for the stormwater associated with the development in the 10 year ARI event, including incorporating flows from contributing catchment at MPD
- Buildings must not be flooded in the 100 year ARI event
- All new assets that are intended to become part of the public stormwater network are to be designed and constructed to be durable and perform to the required level of service for the life of the asset, subject to reasonable asset maintenance
- Stormwater management assets in the road corridor require approval from Auckland Transport prior to vesting

The requirement to provide water quality and hydrological mitigation to all impervious surfaces is more stringent than the regulations outlined in AUP, which only require treatment for high contaminant generating car parks and high use roads. It is common practice on greenfield developments with sensitive receiving environments to have treatment for all impervious areas (at least those generating contaminants, so if inert building materials are adopted it is expected that roofs can be excluded)

The intention is for this SMP to eventually be adopted into Auckland Council's region-wide Network Discharge Consent.

4.1.3 Drury-Opāheke Structure Plan

The Drury-Opāheke Structure Plan (August 2019) sets out key stormwater opportunities and constraints relating to development of the structure plan area, including:

- Flooding
  - There is existing flooding of parts of the structure plan area, and it is particularly extensive in the Slippery Creek catchment
  - The flood plain extent is primarily determined by the large catchment upstream of the FUZ area rather than the effect of additional impervious area created by anticipated urban development
  - The best way to manage flooding in the future urban areas is to pass flows forward or get the water to the Manukau Harbour as quickly as possible
  - There is opportunity to provide flood mitigation to reduce hazards and unlock development
- Water sensitive design
  - A decrease in water quality, aquifer recharge and instream ecological values has been identified as a result of changes in land-use and land development
  - Increased erosion (and associated sedimentation) due to increased impervious areas is of particular concern due to the highly sensitive, low energy receiving environment of the Pāhurehure Inlet
  - There is opportunity to:
    - restore and enhance existing watercourses
    - retain existing and increasing where appropriate the vegetation buffering to natural watercourses to improve water quality and increase numbers and diversity of instream biota
    - improve the water quality of stormwater reaching the Pāhurehure Inlet through reduced contaminant loads (sediment, metals and nutrients)
    - improve ecological functionality in currently degraded areas, along with the ability to set aside areas for public amenity value and stormwater attenuation

These stormwater opportunities and constraints are discussed further in the FUZ SMP.

4.1.4 Opāheke-Drury Stormwater Management Plan

AECOM prepared a first revision of a SMP (OD SMP, September 2017) to support the structure planning for the Drury-Opāheke area. Stormwater management requirements listed in the SMP correspond with the AUP requirements described above. Furthermore, the following hydrology outcomes are to be achieved in accordance with the OD SMP:

- All development must ensure pre-development hydrology for the wider catchment area is maintained
- Pre-development hydrology must be matched in terms of flows, levels, volumes and frequency of runoff
- Hydrology mitigation volumes (retention and detention) could be tailored to more closely match the pre-development hydrology. In the interim the application of SMAF 1 (designed for clay soils) will achieve good stormwater outcomes should zoning occur before more detailed information is available. (Section 4.1.2 of the OD SMP)

4.1.5 T+T Drury Stormwater Management Summary

In addition to the requirements set out by OD SMP, T+T was engaged in 2018 to prepare a Stormwater Management Summary for the DSPA for the DDG. The PCA is located within the Drury-East development area that includes land to be developed by FHLD. The DDG Stormwater Management Summary sets out its response to the requirements of the AUP and the OD SMP. It emphasises a Water Sensitive Design (WSD) approach to protect and enhance stream systems and natural hydrology, while mitigating for hydrological changes and managing flooding effects.

The DDG Stormwater Management Summary also suggests that AUP rules are not only focused on targeting high contaminant generating surfaces such as high use roads and large carparks, but also on a wider application of water quality treatment for impervious surfaces. It thereby recognises the sensitive nature of the downstream receiving environment.

4.1.6 Drury-Opāheke Future Urban Zone Stormwater Management Plan (Draft)

Mott McDonald have produced a more recent draft SMP for the Drury-Opāheke Structure Plan Future Urban Zone (FUZ SMP, April 2019) to support Auckland Council's structure plan for the area. The FUZ SMP recognises the key constraints and opportunities in the catchments and reflects the requirements of the AUP. The FUZ SMP seeks to achieve the following outcomes:

- Protecting and enhancing the environment and to connect communities to water
- Ecological values are maintained or enhanced
- Stream health is maintained or enhanced through improved baseflow
- Urban development is facilitated, key infrastructure is protected, and people and the environment protected from significant flooding events
- Stormwater is integrated with land uses and other values (e.g. landscape) so that the amount of land available for development is optimised
- Sediment into sensitive receiving environments is minimised
- Contaminants input into the sensitive receiving environments of the Drury Sands aquifer and the Manukau Harbour are minimised

To achieve these outcomes the FUZ SMP identifies a number of requirements for management of stormwater within the FUZ. The key requirements for the Slippery Creek Catchment are summarised below.

General

- Development to be carried out using an integrated stormwater management approach (in accordance with E1.3.8 and E1.3.10 of the AUP)

Water quality

- Treatment of all impervious areas (excluding non-contaminant generating areas) to be provided at or near source using devices such as swales, rain gardens and tree pits
- Use inert building materials
- Exemplary sediment and erosion control measures are to be provided during earthworks and construction
- Integrated green outfalls to be used when discharging to streams

Flooding

- Due to the significant flood plain within Slippery Creek, development should be limited to land outside the flood plain. The flooding issues within this catchment require development of a comprehensive solution to avoid effects of cumulative development
- Hydrological and hydraulic modelling is still ongoing to confirm flood mitigation options. The draft outputs indicate that for the 100 year ARI MPD CC scenario the "pass forward" option for each of the four sub-catchments (i.e. Hingaia Stream, Slippery Creek, Ngakoroa Stream and Oira Creek) provides the best solution for releasing land for development
- All buildings to be outside the 100 year ARI floodplain in accordance with E36.3.17 of the AUP Avoid locating infrastructure in the 100 year ARI floodplain unless it can be designed to be resilient to flood damage
- Avoid increasing flood risk and flood extent upstream and downstream for all flood events up to the 100 year ARI
- Identify overland flow paths and ensure that they remain unobstructed and able to safely convey runoff
- Use capacity available in riparian margins as part of the water conveyance system and enhance intermittent streams to provide capacity and conveyance as a means to manage flood waters

Hydrological mitigation

- Changes in hydrology are avoided as far as practicable and any changes in hydrology are minimised or mitigated (in accordance with E1.3.8 of the AUP)
- The minimum requirement when hydrological mitigation is necessary is in accordance with Table E10.6.3.1.1 of the AUP. An erosion assessment is to be carried out by Auckland Council[5] to determine if additional measures (such as additional detention requirements) are required to mitigate the hydrological impacts of development

Streams

- Protect and enhance all permanent and intermittent streams as directed in the AUP
- Outfalls should be pulled back from the streams where possible to allow for dispersal of flows and to disconnect impervious surfaces from the receiving environment
- Provide distributed stormwater outlets into watercourses where possible, rather than single discharge points
- For essential stream crossings, bank-to-bank bridges with minimal riparian and stream bed disturbance are preferred
- Address erosion issues, both erosion hotspots and culvert erosion before and/or as urban development occurs. Details for each watercourse is provided in the Watercourse Assessment Report (refer Section 2.3.1)

The FUZ SMP addresses the Slippery Creek catchment in totality and states that development must be located outside of floodplains. T+T has been in discussions with Council's Healthy Waters department regarding the potential development of the PCA. T+T understand that Healthy Waters generally support development of the PCA and outside of identified floodplains given the minor predicted effects that they have identified from imperviousness increases in the FUZ and the wider need to encourage intensification close to the primary centre in Drury East and public transport. This

[5] Drury-Opāheke Structure Plan report (August 2019) "A Bank Stability and Toe Erosion Model assessment of streams is planned for the future. This assessment will inform hydrology mitigation requirements and works needed to avoid, remedy or mitigate the effects of changes to the hydrological regime due to increases in impervious area."

approach preserves the ability for integrated Council-led improvements to flood storage/conveyance within the flood plain extent at a later time.

4.2 Technical guidance

The technical guidance presented in Table 4.1 is used to support the SMP.

Table 4.1: Technical guidance supporting the Stormwater Management Plan

Technical guidance	Application
Morphum Environmental Ltd Watercourse Assessment Report – Slippery Creek Catchment prepared for Auckland Council (2015)	Considered for PCA
Auckland Council Future Urban Land Supply Strategy (July 2017)	Key considerations for the development area
AECOM Drury Stormwater Management Plan for Auckland Council (September 2017)	Considered for PCA
T+T Stormwater Management Summary for the Drury Structure Plan Area for the Drury Developers Group (April 2018)	Considered for PCA
Mott MacDonald Drury-Opāheke Draft Stormwater Management Plan for Auckland Council (April 2019)	Considered for PCA
T+T Drury Metropolitan Centre Stormwater Management Plan for Kiwi Property (August 2019)	Considered for PCA
Auckland Council Draft Drury-Opāheke Structure Plan (August 2019)	Considered for PCA
Woods Stormwater Management Plan – Drury East) prepared for FHLD (November 2019)	Considered for PCA
T+T and Woods Drury East Stormwater Management Plan – Kiwi Property Drury Metropolitan Centre and Fulton Hogan Drury East Precinct Plan Change Areas prepared for Kiwi Property Trust Ltd and FHLD (June 2020)	Considered for PCA
Auckland Council Technical Publication 108 - Guidelines for stormwater runoff modelling in the Auckland Region (April 1999)	Hydrological method for flood modelling
Auckland Council Technical Publication 124 – Low Impact Design Manual for the Auckland Region (2000)	Design of low impact stormwater treatment devices. Superseded by GD04
Auckland Council, Technical Publication 10 - Stormwater management devices in the Auckland Region: Design guidelines manual (December 2003)	Design of approved stormwater quality devices. Superseded by GD01 unless referenced directly
Auckland Council Stormwater Rapid Flood Hazard Assessment Modelling Specifications (August 2012)	2D flood hazard model specification
Auckland Council Technical Report 035 - Auckland Unitary Plan stormwater management provisions: Technical basis of contaminant and volume management requirements (May 2013)	95th percentile 24 hour rainfall depth for hydrological mitigation devices
Auckland Council, Guidance Document 04 - Water Sensitive Design for Stormwater (March 2015)	Consideration of Water Sensitive Design approaches. Supersedes TP124
Auckland Council Code of Practice for Land Development and Subdivision: Chapter 4 - Stormwater (November 2015)	Design of stormwater assets

Auckland Council Guidance Document 01 - Stormwater Management Devices in the Auckland Region (December 2017)	Design of stormwater devices. Supersedes TP10

4.3 Stormwater requirements

The requirements for stormwater management that will be adopted for the PCA and subsequent development are based primarily on the existing AUP stormwater and flooding provisions, Schedule 4 of the NDC and previous SMPs for Drury prepared by AECOM, T+T and Mott MacDonald.

Table 4.2: 116 Waihoehoe Rd and surrounds – Recommended requirements for stormwater management

Aspect	Applicability	Requirements	Reference
Flooding	All areas	New residential buildings are required to be outside the 100 Year ARI floodplain (including the effects of climate change over a 100 year timeframe and a 1 m sea level rise).	AUP Chapter E36.4 Activity Table E36.4.1 Activities in the 100 year ARI floodplain and overland flow paths, permitted activity A24 surface parking areas to comply with E36.6.1.7. Activities A34 to A38 relate to new structures or buildings in the floodplain and A42 to new structures or building in an overland flow path. Schedule 4 of the NDC. Mott MacDonald Draft SMP (April 2019)
Stormwater quality	High use roads (>5,000 vehicles per day)	Stormwater runoff from high use road are to be treated by an approved stormwater quality device. Approved stormwater quality devices … is sized and designed in accordance with TP10 or achieves … for high use roads and carparks, stormwater quality devices that are more effective at removal of sediment and metals should be used (refer to full definition in the AUP).	AUP Chapter E.9 – Stormwater quality – High contaminant generating car parks and high use roads. Standards E9.6.1.4 (permitted activities) and E9.6.2.2. (Controlled activities)
	High contaminant car park such as for shopping areas (>30 vehicles, refer to full definition in reference material)	Stormwater runoff from high contaminant car parks are to be treated by an approved stormwater quality device. Approved stormwater quality devices … is sized and designed in accordance with TP10 or achieves … for high use roads and carparks, stormwater quality devices that are more effective at removal of sediment and metals should be used (refer to full definition in reference material).	AUP Chapter E.9 – Stormwater quality – High contaminant generating car parks and high use roads. Standards E9.6.1.3 (permitted activities) and E9.6.2.1 (controlled activities)

Aspect	Applicability	Requirements	Reference
	Other areas that are not high contaminant generating activities e.g. Minor roads Residential, commercial	Water sensitive design approach subject to practicality and BPO. Schedule 4 of the NDC stipulates treatment of 100% of impervious areas by a water quality device designed in accordance with GD01/TP10 for the relevant contaminants	Schedule 4 of the NDC and AUP E.1.3.8 and E.1.3.10
	All areas	Wider application of AUP rules for water quality treatment for all impervious surfaces	Stormwater Management Summary for the Drury Structure Plan Area (DSPA) for the Drury Developers Group (DDG), T+T, 2018
Stormwater quantity	All areas	All development must ensure pre-development hydrology for the wider catchment area is maintained. Pre-development hydrology must be matched in terms of flows, levels, volumes and frequency of runoff. Hydrology mitigation volumes (retention and detention) could be tailored to more closely match the pre-development hydrology. In the interim the application of SMAF 1 (designed for clay soils) will achieve good stormwater outcomes should zoning occur before more detailed information is available.	Section 4.1.2, Opāheke-Drury Stormwater Management Plan, AECOM, 2017 and Schedule 4 of the NDC
	Downstream	Ensure that there is sufficient capacity within the pipe network downstream of the connection point to cater for the stormwater associated with the development in the 10 year ARI event, including incorporating flows from contributing catchment at MPD	Schedule 4 of the NDC

5 Flood risk management

The FUZ SMP identifies existing extensive flooding downstream in the Slippery Creek catchment. This attributes the large flood plain extent primarily to the large catchment upstream of the FUZ area, rather than the effect of existing and additional impervious area created by anticipated urban development. The FUZ SMP identifies that urbanisation of the FUZ is expected to have minimal effects on existing flood hazards. A flood hazard assessment has been undertaken to assess the flood risk and effects attributed to future development of the PCA.

5.1 Flood hazard assessment

The flood hazard assessment has been undertaken using the Auckland Council Slippery creek rapid flood hazard assessment model, which includes effective rainfall and major inflows from Slippery Creek, Hingaia Creek, Waihoihoi Stream, Symonds Creek, Whangapouri Creek, Ngakoroa Creek and Oira Creek, and associated tributaries (refer to Figure 5.1 and Appendix A, Figure A13 - Slippery Creek Model – Flood Level Diff. ED+FUZ to ED (Whole catchment) for the full figure). The model was built for the purpose of producing a floodplain map for the Slippery Creek catchment. The model uses a 1m Digital Terrain Model (DTM) from 2013. The model was compiled using Infoworks ICM v 7.5.6. A full methodology is provided in the Slippery Creek catchment – Rapid Flood Hazard Assessment report (AECOM, April 2018).

The flood hazard assessment was undertaken for the following scenarios:

1 100 year ARI with Existing Development (ED) conditions (no future development modelled within the upstream FUZ, no climate change) as a baseline scenario

2 100 year ARI with ED conditions and with future development modelled within the FUZ (no climate change) to assess the effects of the proposed plan change

3 100 year ARI plus climate change, with MPD and development of the FUZ to assess and plan for the future probable flood hazard

From discussions with Auckland Council, it was established that the FUZ scenarios assume an impervious coverage assumption of 60% within the FUZ and the MPD scenario assumes an additional 20% impervious coverage in the rural areas to the east of the catchment (i.e. the imperviousness of the catchment is higher for the MPD for both the FUZ and outside the FUZ). Therefore, the direct impact of the development of just the FUZ is shown through the comparison of the two ED scenarios with and without FUZ. The MPD scenario doesn't represent the impact of the development of just the FUZ, as it includes development changes upstream of the FUZ. However, the MPD scenario with FUZ and climate change should still be used to assess and plan for the future probable flood hazard for the future development.

In scenario 3 (MPD 100 year ARI with CC and FUZ) effective rainfall and eastern inflows include an allowance for climate change in accordance with the Auckland Council Stormwater Flood Modelling Specifications (November 2011) with a 16.8% increase in the 100 year 24-hour design rainfall. The southern inflows to the model (downstream of the study site) do not include allowances for climate change in any of the three scenarios.

Figure 5.1 shows the flood level differences between the ED 100 year ARI with development of the FUZ and the ED 100 year without development of the FUZ, as well as the 2D model extents, and the Future Urban Zone. The flood depth difference shows that changes due to the development of the Future Urban Zone are minor and less than 0.05 m for most of the catchment. There are only two areas with higher differences of up to 0.15 m upstream of the railway line around Sutton Road and in the western part of the PCA area.

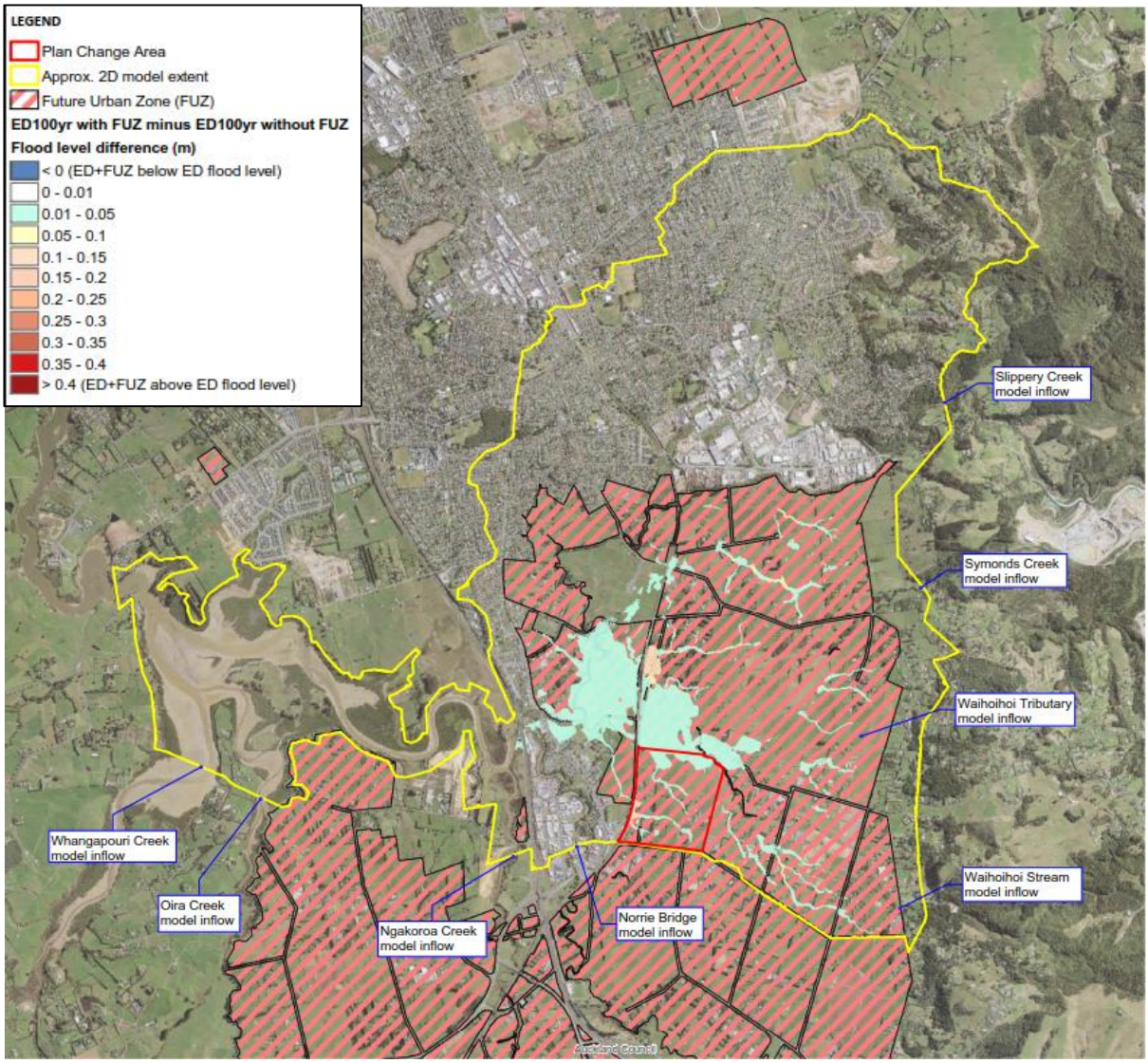

Figure 5.1: Slippery Creek Model – Flood level differences between the Existing Development 100 year ARI <u>with</u> development of the Future Urban Zone and the Existing Development 100 year <u>without</u> development of the Future Urban Zone

Figure 5.2 shows the flood level differences between the MPD 100 year ARI plus climate change and FUZ (scenario 3) and the ED 100 year ARI scenario (scenario 1), as well as the 2D model extents, and the Future Urban Zone. The changes in flood depth for those scenarios are strongly influenced by the model inflows from the upper catchments and the MPD assumption of 20% imperviousness for rural areas.

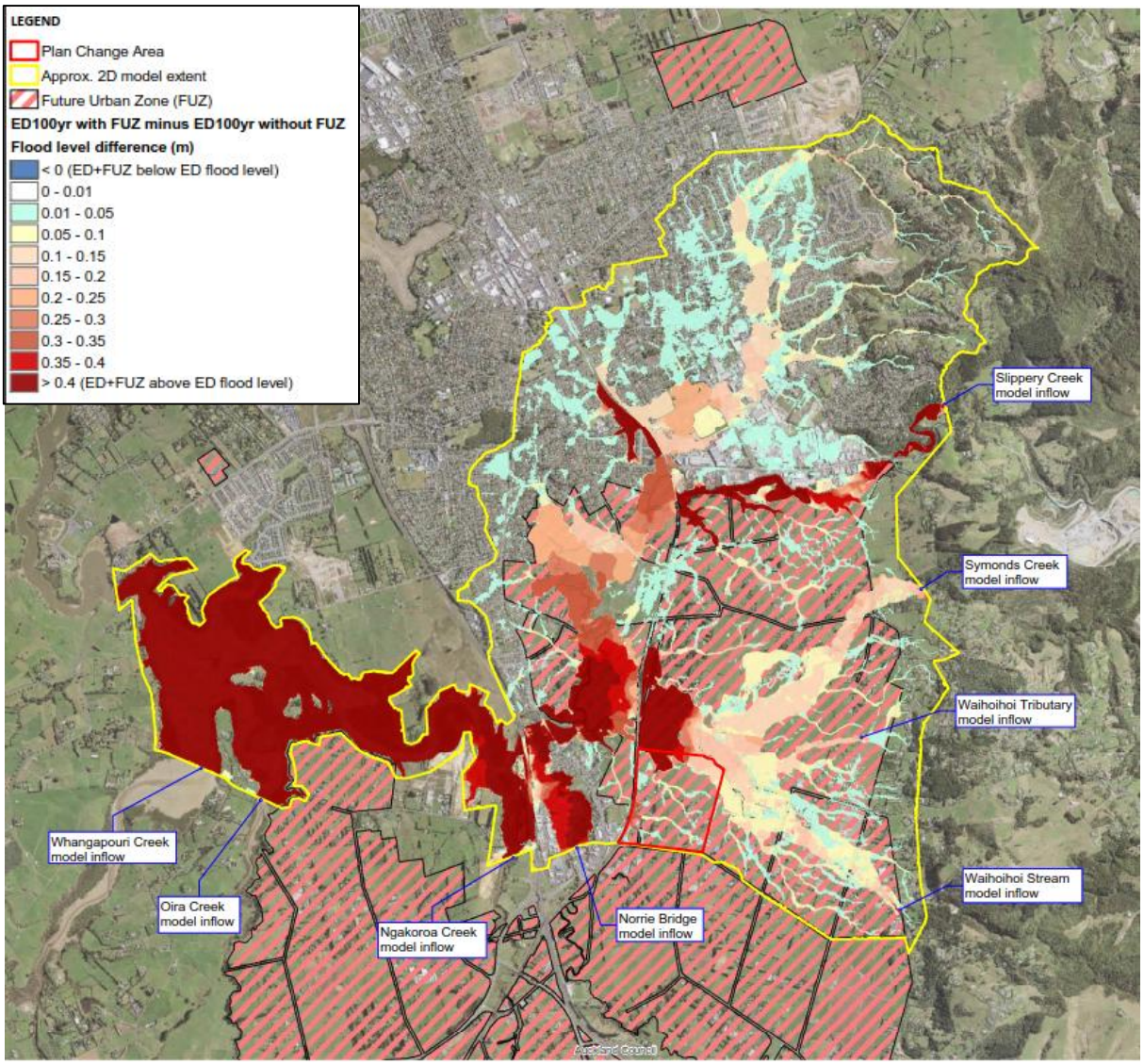

Figure 5.2: Slippery Creek Model – Flood level differences between the Maximum Probable Development 100 year ARI plus climate change and Future Urban Zone and the Existing Development 100 year ARI without development of the Future Urban Zone

Upgrades to the model for resource consents and design purposes should refine the assumptions for the probable impervious coverage for the rural areas and account for climate change in the southern inflows.

5.1.1 Existing flood risk

The existing flood hazard is available from Auckland Council's GIS database, and is discussed in Section 2.1.2 of this SMP. Figures indicating the existing flood risk extent are provided in Appendix A, Figure A6 - Existing Flooding.

5.1.2 Proposed flood risk

The flood extents in the three proposed scenarios are shown in Figure 5.3 (refer to Appendix A, Figure A15 - Slippery Creek Model – Flood Extents Comparison (PCA area) for full figures). The peak water level results adjacent to the PCA for the MPD scenario are as follows:

- The flood depths for a 1 in 100 year ARI storm event with MPD scenario range from 0.06 metres to 2.2 metres within the PCA area (refer to Figure 5.4 and Appendix A, Figure A18 - Slippery Creek Model – MPD100yrCC+FUZ Flood Depths (PCA area) for full figure)
- There is an increase in flood levels within the PCA of up to 0.5 meters compared to the ED 100yr (no CC and no FUZ) scenario (refer to Figure 5.5 and Appendix A, Figure A19 - Slippery Creek Model – Flood Level Diff. MPD+FUZ+CC to ED (PCA area) for full figure). Noting that the MPD includes increases to imperviousness within the FUZ and upstream of the FUZ as well as climate change factors (refer to Section 5.1 for details)
- A comparison of the MPD 100 year ARI plus climate change flood extents (excluding depths below 0.05 m) with the previously modelled Auckland Council GIS 100 year ARI flood plain (refer to Figure 5.6 and Appendix A, Figure A20 - Flood Extent Comparison – AC floodplain to MPD scenario (PCA area) for full figure) indicates:
  - Flooding is predicted be less than described in Section 2.1.2 for the lower parts of the PCA area) i.e. recent flood modelling shows less flooding into the development than previously predicted.
  - Flooding is predicted by the MPD 100 year ARI model for upper areas within the PCA, but these are overland flow paths that can be managed and redirected within roads as part of the stormwater management approach

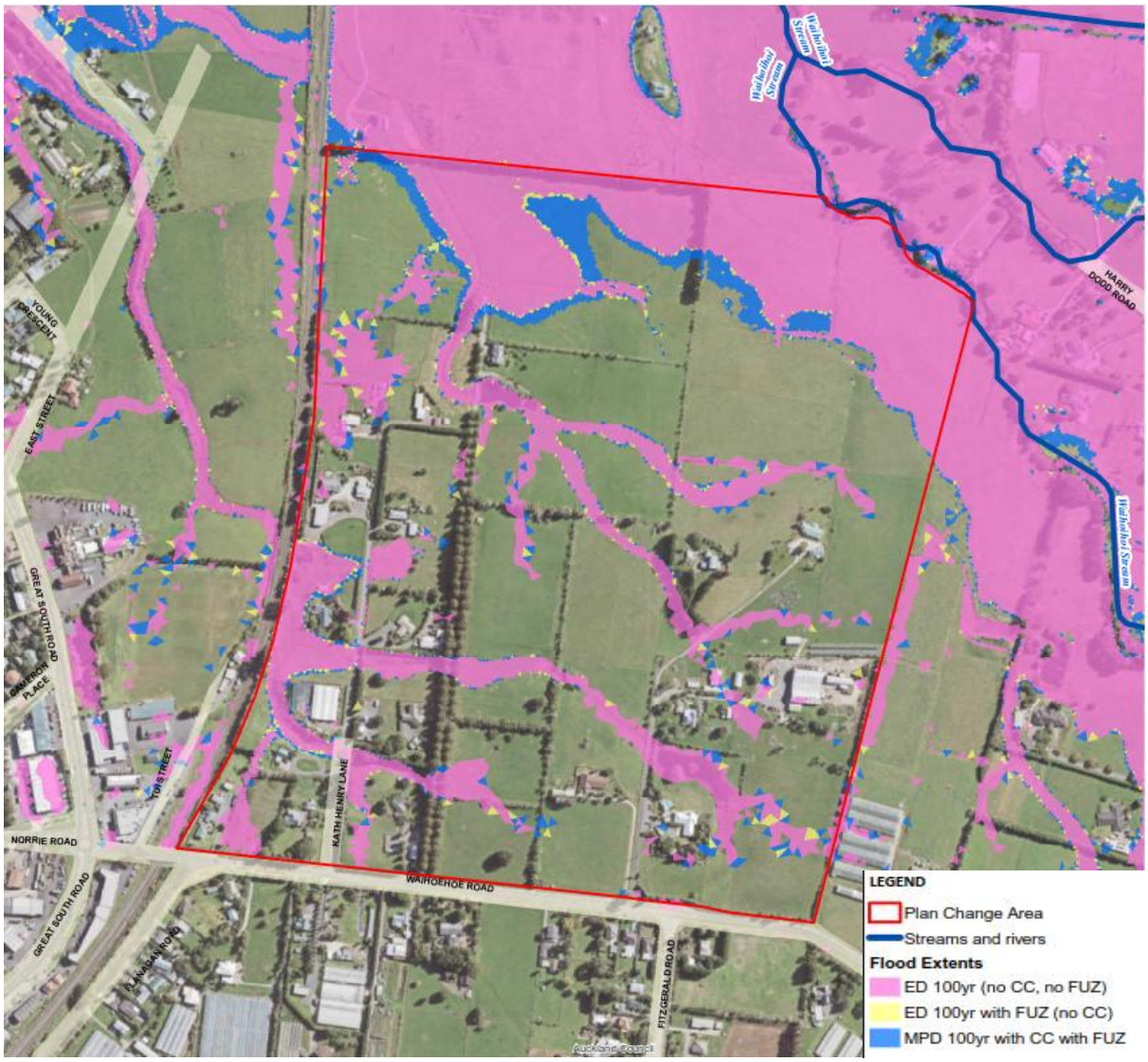

Figure 5.3: Slippery Creek Model – Flood extent comparison: Maximum Probable Development 100 year ARI plus climate change and Future Urban Zone to Existing Development 100 year ARI <u>with</u> development of the Future Urban Zone to Existing Development 100 year ARI <u>without</u> development of the Future Urban Zone

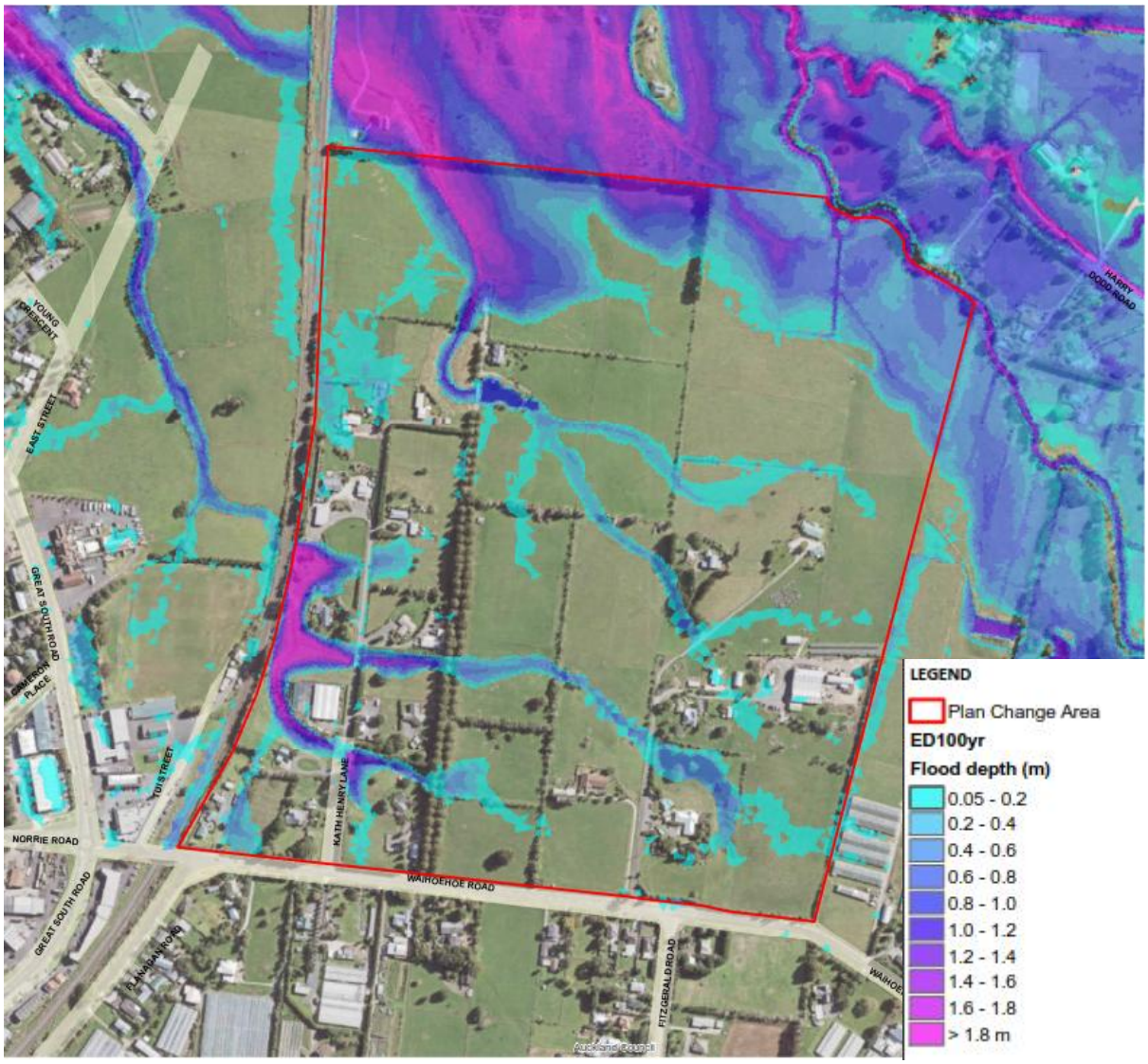

Figure 5.4: Slippery Creek Model – Flood depth: Maximum Probable Development 100 year ARI plus climate change and Future Urban Zone

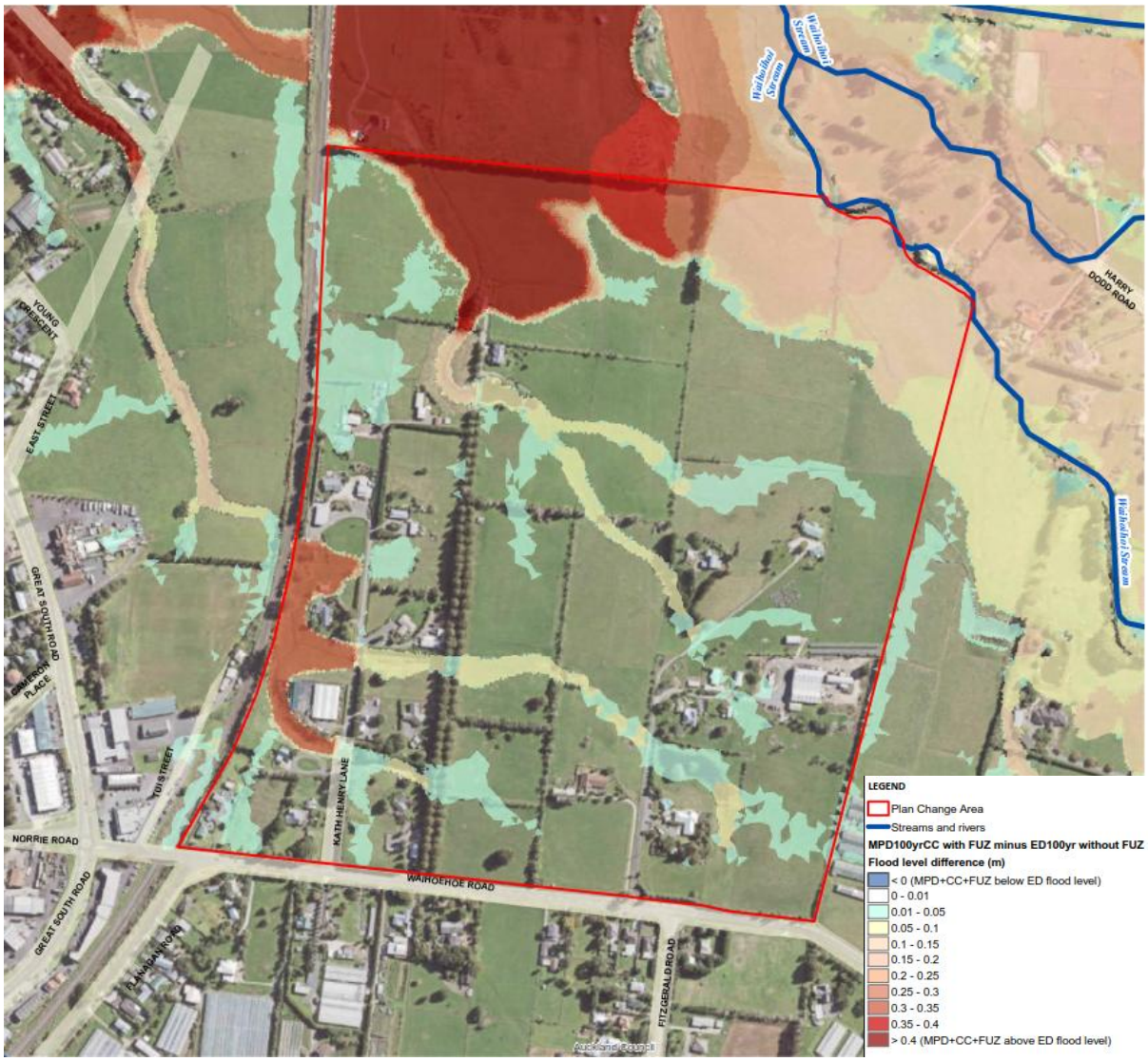

Figure 5.5: Slippery Creek Model – Flood level difference: Maximum Probable Development 100 year ARI plus climate change and Future Urban Zone minus Existing Development 100 year ARI <u>without</u> development of the Future Urban Zone

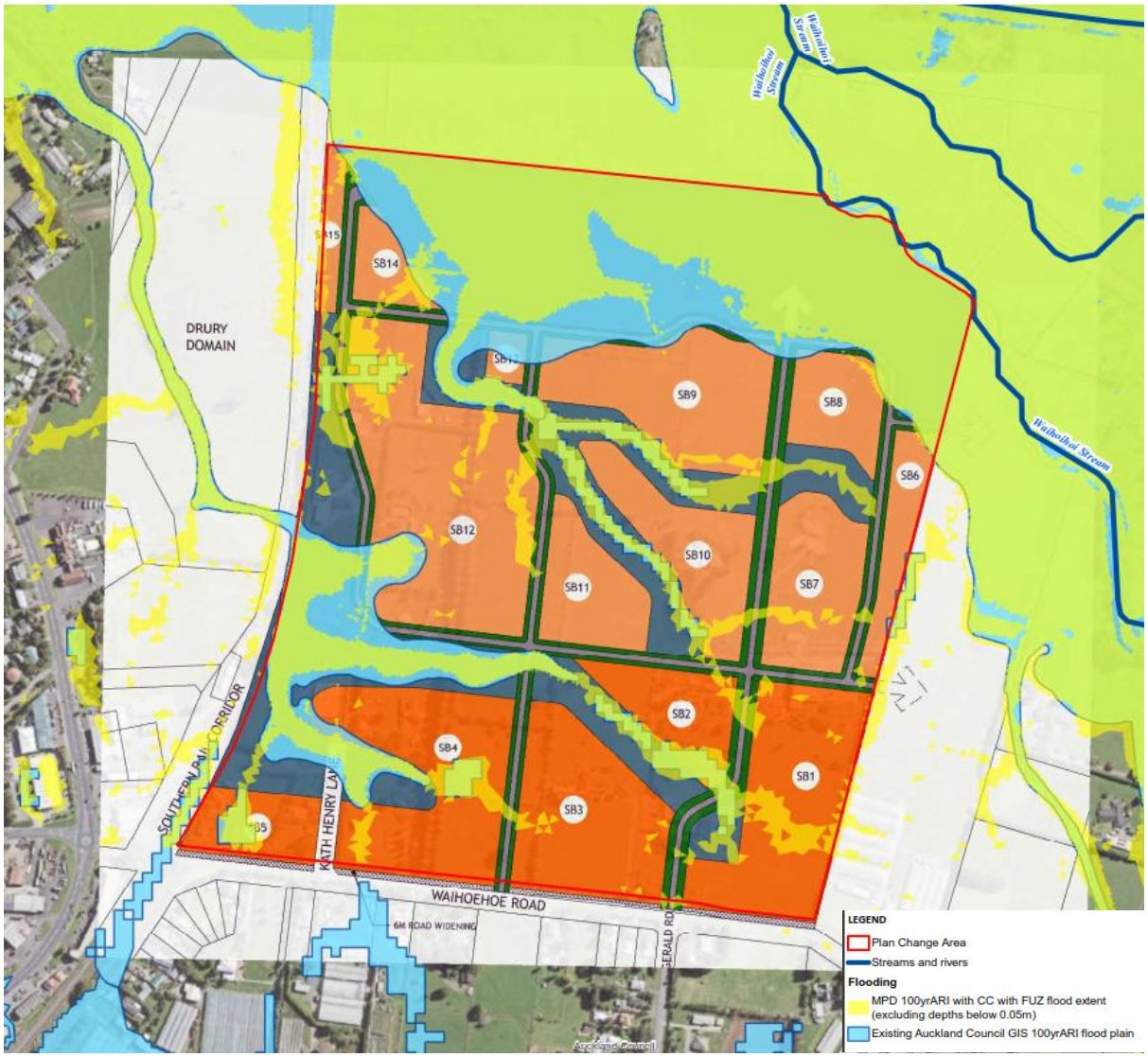

Figure 5.6: Slippery Creek Model – Flood extent comparison: Maximum Probable Development 100 year ARI plus climate change and Future Urban Zone to Auckland Council GIS 100 year ARI flood plain

5.1.3 Changes to flood risk

The development of the FUZ results in minor increased peak flows and depth of flooding within the PCA and wider Slippery Creek flood plain, while peak flows and depths increase significantly due to MPD development upstream of the FUZ and catchment and climate change factors (refer to Section 5.1 for details). Peak flows and flood depths extracted from the Slippery Creek flood model for the scenarios described in Section 5.1 are provided in Table 5.1. The location of the cross-sections from which the peak flows were extracted is provided in Figure 5.7.

Table 5.1: Comparison of peak flows in the ED and MPD flood model scenarios

Location	100 year ARI with ED scenario (no CC, no FUZ)		100 year ARI with ED with FUZ scenario (no CC)		100 year ARI with MPD with FUZ with CC scenario	
	Peak flows (m^3/s)	Flood depths (m)	Peak flows (m^3/s)	Flood depths (m)	Peak flows (m^3/s)	Flood depths (m)
Location 1 – Culvert crossing (south) under railway line	1.50	2.50	1.65	2.64	1.83	2.84
Location 2 – Culvert crossing (north) under railway line	2.41	2.52	2.44	2.55	2.73	3.00
Location 3 – Sutton Road bridge	84.87	4.27	86.92	4.31	103.36	4.82
Location 4 – Waihoihoi Stream railway bridge	94.47	4.15	96.59	4.19	123.83	4.78
Location 5 – Northern railway culvert	5.60	2.38	5.91	2.49	8.32	3.14

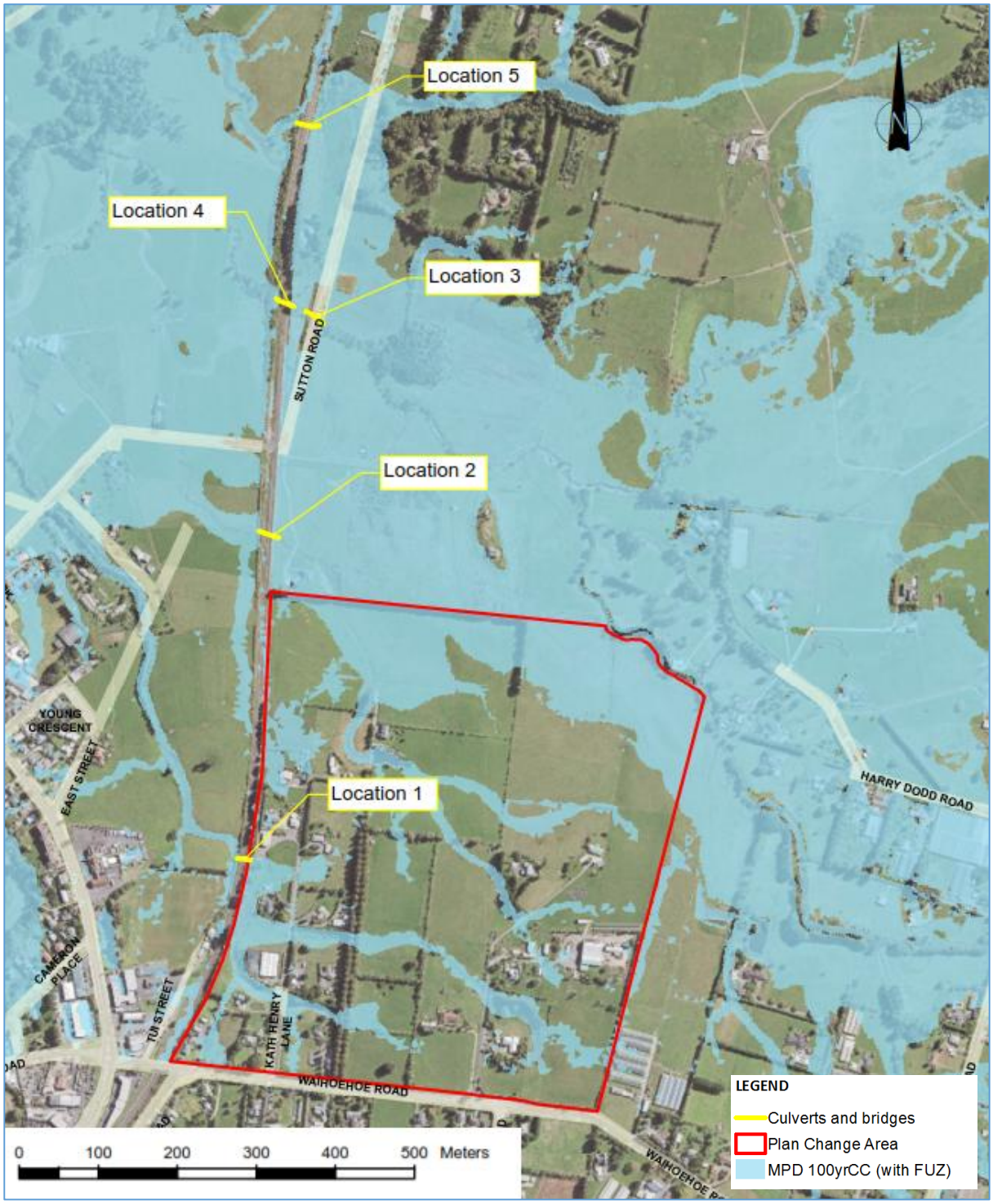

Figure 5.7: Location of model cross-sections as referred to in Table 5.1.

The flood level changes due to development of the FUZ in the vicinity of the PCA area are shown in Figure 5.8. It shows:

- A minor increase of flood levels of less than 0.05 m in the northern part of the PCA area flowing to the northern railway culvert and Waihoihoi Stream due to the development of the Future Urban Zone
- A moderate increase of flood levels of up to 0.14 m upstream of the southern railway culvert in the south-western part of the PCA area due to the development of the Future Urban Zone associated with the PCA area

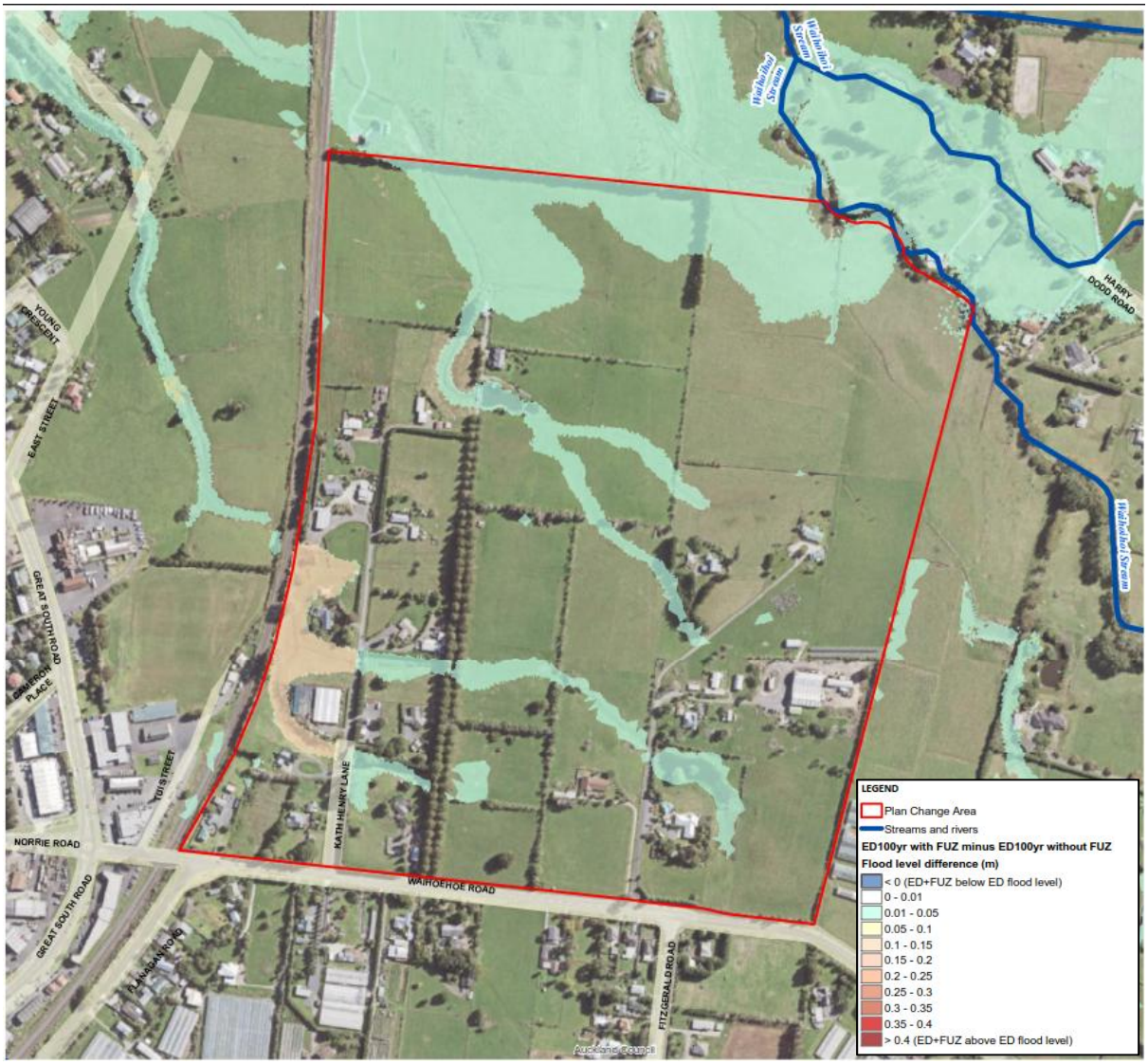

Figure 5.8: Slippery Creek Model – Flood Level Difference: Existing Development 100 year ARI with development of the Future Urban Zone to Existing Development 100 year ARI without development of the Future Urban Zone

5.2 Flood management approaches

As mentioned in Section 4.1.6, the FUZ SMP states that development in the Slippery Creek catchment must be located outside of floodplains and that the "pass forward" flood management approach provides the best solution for releasing land for development.

There are two sub-catchments within the PCA and they both have different catchment opportunities and constraints and therefore require separate stormwater and flood hazard management approaches:

5.2.1 Northern sub-catchment

The northern sub-catchment of the PCA is in close proximity to Waihoihoi Stream. The Waihoihoi Stream is a main branch of the Slippery Creek floodplain that is fed by significant flows from approximately 17 km² of upstream catchment. The flood hazard assessment shows that flooding from the Waihoihoi Stream impacts the northern part of the property and therefore peak flows generated as a result of development within the PCA can discharges to the stream without encountering flow constraint e.g. culvert. Additionally, attenuation of flows has the potential to worsen the flooding as it could synchronise the delayed discharge of the PCA with peaks flows in the stream from the upper reaches of the Slippery Creek catchment.

In accordance with the FUZ SMP and confirmed in discussions with the Auckland Council catchment manager, the lower parts of the catchment should follow a "passing flows forward" approach. After stormwater treatment, the northern sub-catchment will allow for quick conveyance of flows into the Waihoihoi Stream without further attenuation in order to pass them through before the peak flows from the upper catchment reach the area.

5.2.1.1 Verification of the flood management approach for the northern sub-catchment

Further assessment for the potential flooding caused by the proposed flood management approaches during a 'development only flood scenario' was undertaken to address the Healthy Waters *Further Information Request – Drury East Plan Changes.* The purpose of this assessment is to ascertain whether the development with its additional runoff causes a new flooding mechanism and effects, and to confirm the suitability of the flood management approaches. The findings of the assessment are summarised below but reference should be made for to the *Drury East (Oyster Capital) flood modelling – Response to Auckland Council Further Information Request on Stormwater Matters* memo (April 2020) in Appendix N for the proposed methodology and detailed results.

The Auckland Council Slippery Creek rapid flood hazard 100 year ARI with ED conditions (no future development modelled within the upstream FUZ, no climate change) model results were used as the pre-development description of catchment flooding.

The "Post-development" flow was based on the "extra flow" from the Oyster Capital Waihoehoe Precinct PCA northern sub-catchment development (represented by the post-development less the pre-development flows from the PCA). Only "extra flow" from the development is added because the "Pre-development" case already accounts for the greenfield runoff from the PCA.

Figure 5.9 presents a combined hydrograph of flows through three railway structures at Locations 2, 4 and 5 (shown previously in Figure 5.7) for the "pre-development" scenario, "extra flow" and "post-development" scenario.

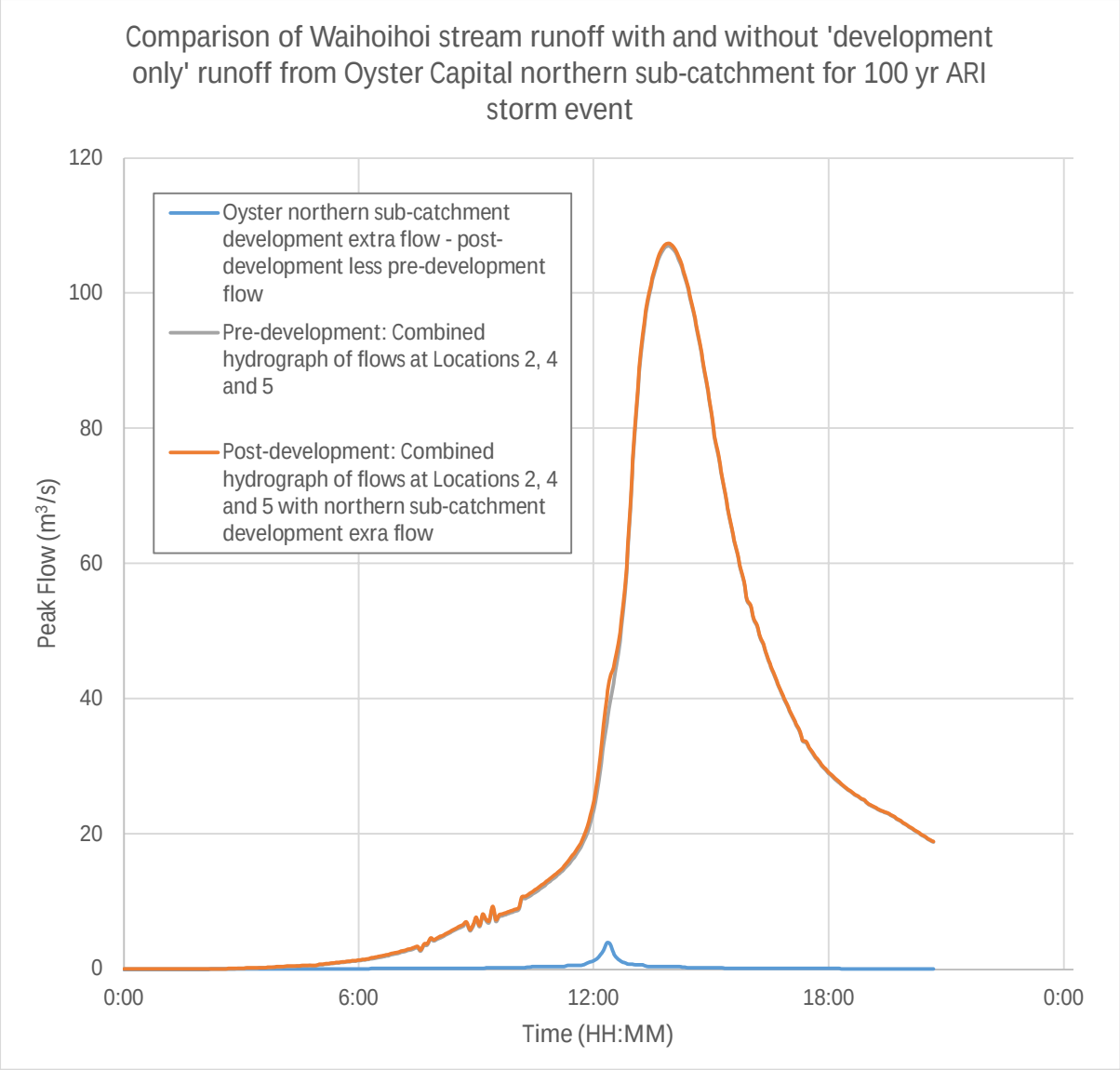

Figure 5.9: Waihoihoi stream hydrographs with and without 'development only' flows.

The "Pre-development" and "Post-development" hydrographs almost look identical, except for a very negligible change in flow at approximately 12:20pm, which corresponds with the development's peak flows. This change occurs prior to the catchment peak flow at 1:50pm.

The minimal change shown on the hydrographs in Figure 5.9 confirms that the northern sub-catchment development "extra flows" are negligible and occur earlier in comparison to the peak flows generated by the upstream catchment. This confirms that the development should adopt a "passing flows forward" approach for the northern sub-catchment. Flows from the northern sub-catchment will be discharged directly into Waihoihoi Stream and Slippery Creek as quickly as possible in order to pass them through before the peak flows from the upper reaches of the catchment reach the area.

5.2.2 Southern sub-catchment

The southern sub-catchment drains in western direction to a culvert crossing the railway line and further downstream to the Slippery Creek floodplain. This branch of the floodplain is reasonably isolated, with the culvert creating a throttle which results in flooding upstream of the culvert.

Changes to peak flows due to development have the potential to increase flood levels upstream of the culvert impacting on properties within the PCA, but that are yet to be developed.

Upon discussion with the Auckland Council catchment manager, it was agreed that the southern sub-catchment should follow an “attenuation” approach where peak flows generated by development of the PCA are attenuated within the site and as close to the source as possible. The southern sub-catchment of the site will detain flows of up to the 100 year ARI storms within the sub-catchment to mitigate flooding within the western part of the PCA and further downstream.

5.3 Flood risk management

To ensure that there are no adverse flooding impacts to properties downstream of the PCA attributed to the proposed development, the following approaches are proposed to manage the impact of flood risk to downstream properties:

- Avoid development within the 100 year ARI floodplain where possible
- Manage the floodplain with riparian buffers and green corridors to provide erosion protection and increase ecological amenity
- Ensure that all building platforms are set above the 100 year ARI MPD flood levels, with a suitable allowance for freeboard
- Maintain sub-catchments within the site to mimic pre-development conditions where possible. This ensures that flows entering downstream receptors are maintained in the same magnitude under post-development conditions
- Maintain overland flow path capacity within the PCA area. If required, easements and flow channels should be provided for 100 year ARI peak flows. Where obstruction of an overland flow path cannot be avoided, provide alternative routes through the PCA
- Follow designated flood management approach for the northern and southern sub-catchment, respectively:
    - Northern sub-catchment: Allow for quick conveyance of flows into Waihoihoi Stream to pass flows forward before peak flows from upper catchments reach the area.
    - Southern sub-catchment: Detain flows of up to 100-year ARI storms within the sub-catchment to mitigate flooding within the western part of the plan change area and further downstream

6 Integrated stormwater management approach

This section presents the integrated approach to post-development stormwater management across all three Drury East PCAs. The approaches are consistent with regulatory, Slippery Creek catchment management plans and stormwater-specific guidelines. The approaches incorporate feedback from the Mana Whenua. The stormwater management plan provides the framework consents and development.

The stormwater management principles for the Drury East PCAs are described below and have been conceptualised to be in line with site specific constraints and opportunities identified and presented in Section 2, the AUP policies on integrated stormwater management and relevant SMPs, as presented in Section 4.

6.1 Stormwater management approach

The stormwater management approach seeks to implement an integrated stormwater management approach for all three Drury East PCAs, which includes:

- Facilitate urban development and optimise available land
- Recognise the key constraints and opportunities on site and in the Hingaia and Slippery Creek catchments
- Develop a set of Best Practicable Options (BPOs) for stormwater that can be incorporated into the development
- Emphasise a water sensitive design approach that:
  - manages the impact of land use change from rural to urban
  - minimises or mitigates the adverse effects on water quality, freshwater systems, stream health and ecological values of the receiving environment through the implementation of stormwater management devices; this includes tributaries of the Hingaia Stream and Slippery Creek
  - protects and enhances stream systems and riparian margins
- Minimise the generation and discharge of contaminants/sediments into the sensitive receiving environment of the Drury Creek and Manukau Harbour, including changes in water temperature caused by stormwater discharges
- Recognise a Blue-Green network approach with the stormwater management system to integrate “blue” aspects of the PCA (the streams and flood plains) and the “green” aspects of the environment (indigenous biodiversity and ecological significance, and the parks and reserves
- Protect key infrastructure, people and the environment from significant flooding events. Not worsen downstream flooding

6.1.1 Application of Water Sensitive Design

Water sensitive design is a philosophy that is integral to achieving integrated stormwater management as required by Policy 8 (E1.3.8) of the AUP. Water sensitive design is defined as:

“An approach to freshwater management, it is applied to land use planning and development at complementary scales including region, catchment, development and site. Water sensitive design seeks to protect and enhance natural freshwater systems, sustainably manage water resources, and mimic natural processes to achieve enhanced outcomes for ecosystems and our communities.”

Water Sensitive Design for Stormwater (GD04) is a guideline document produced by Auckland Council to set out principles and objects for water sensitive design (WSD) in the Auckland region. A summary of WSD principles and how they have been applied the PCA is summarised below:

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

The detailed design will also need to consider local issues and constraints such as physical constraints, ground conditions and receiving environments. Section 6.2 provides further information about design requirements and preliminary sizing of stormwater management devices for the PCA.

6.1.2 Water quality

The development of the PCA into THAB zoning could result in increased contamination of stormwater runoff due to the land-use changes and increased impervious area. The stormwater quality will therefore change and may negatively impact the sensitive receiving environments if unmitigated.

The water quality management approach seeks to minimise the generation of contaminants as much as possible. Where contaminants are generated, the preferred approach is to use green infrastructure to treat contaminants at-source, or as close to the source as practicable. Specifically, this approach seeks to:

- Eliminate or minimise the generation and discharge of contaminants
- Treat all contaminant generating impervious areas at or near source by a water quality device designed in accordance with GD01/TP10 to target sediment, metals and gross pollutants

6.1.3 Water quantity

The general approach to water quantity management for small storm events is to provide a minimum of SMAF 1 hydrological mitigation for all impervious surfaces within the PCA. The SMAF 1 hydrological mitigation objectives outlined in the AUP are:

- Retention of at least 5 mm of runoff depth from impervious surfaces where possible
- Detention and a drain-down period of 24 hours for the difference between the pre-development and post-development runoff volumes from a 95th percentile, 24-hour rainfall event less the achieved retention volume, over the impervious area for which hydrological mitigation is required

Retention is the process of storing and using stormwater runoff onsite, reducing the volume of stormwater discharged to the receiving environment. Detention is the temporary storage and slower release of runoff, which effectively reduces peak flows.

The approach for flood management (i.e. for larger storm events) is included in Section 5.3.

6.1.3.1 Sensitivity of the receiving environment

The PCA is currently predominantly in rural land and, unless carefully managed, urbanisation may have the following effects on the receiving environment (i.e. Waihoihoi Stream and Slippery Creek):

- Deterioration of stream banks at the discharge point caused by increased stormwater flows and volumes, which may result in ongoing bank instability due to increased stream erosion potential

- Change in stream morphology caused by changes to overland flow paths and increased peak flows within streams
- Change in stream ecology due to erosion and also protection at stormwater outfalls

As outlined above, the general approach to offset urbanisation effects is to provide a minimum of SMAF 1 hydrological mitigation for all impervious surfaces within the PCA. In addition to SMAF 1 hydrological mitigation, the following measures may be appropriate as stream erosion mitigation methods, as recommended by ecology and stormwater experts for the three Drury East PCAs:

- Removal of stock from the site and therefore avoiding active bank de-stabilisation through stock access and pugging
- Incorporation of green spaces adjacent to stream networks to provide for planting of riparian margins to improve bank stability and reduce erosion potential
- Modification of hydrograph mitigated through stormwater retention/detention (SMAF 1 hydrological mitigation) measures which will slow flows
- Remediation or removal of existing in-stream structures (culverts, inlets/outlets) which are currently identified as having erosion issues
- Realignment of streams which have been channelised to a more natural alignment
- Incorporation of erosion and scour protection measures at all outfalls to minimise erosion at new structures
- Targeted in-stream erosion protection measures may be required within larger streams
- Restoration of streams including restoring sinuosity, removal of inline ponds, adding retreats and armouring where appropriate is also expected to improve stream habitat quality
- Proposed riparian planting along stream corridors to develop the Blue-Green network will result in a demonstrable improvement in instream habitat (i.e., increased stability, woody debris) and water temperature control that will enhance conditions for aquatic fauna

Erosion potential has been assessed for the other Drury East developments (within the Hingaia Catchment) using a modified version of the Erosion Stream Risk Tool provided by Auckland Council. The tool's application was limited to assessing the change in erosion risk due to development. (i.e. it did not quantify how much extra erosion would occur, nor the change in sediment load that would be to the receiving environment so it cannot be used to directly assess effects). The stream erosion risk assessment for Hingaia catchment found very minor increase to erosion potential during the two, 10 and 100 year ARI storm events and predicted that the application of SMAF 1 hydrological mitigation would result in an even smaller increase to the erosion risk. The benefit from SMAF 1 hydrological mitigation would also increase for smaller events. For details of assessment methodology and results, refer to the *Response to Auckland Council Further Information Request on Stormwater Matters for Drury East – Stream Erosion Risk Assessment for Hingaia Catchment* memo (April 2020) included in Appendix L.

The Erosion Stream Risk Tool requires an understanding of the stream cross section, bed slope and critical shear stress, inter alia, as inputs to the assessment. The Auckland Council Infoworks model for Slippery Creek uses a bathymetric surface (3D terrain model based on LiDAR) with structures. It does not include a channel survey and therefore we do not have stream cross sections from the model to use in a site-specific erosion assessment.

Furthermore, the stream erosion risk assessment for Hingaia catchment concluded that there was a poor correlation between the predicted erosion locations and observed erosion which puts doubt in the predictive ability of the Stream Erosion Risk Assessment to identify erosion risk areas. It could therefore be useful for analysing the effects of the erosion change due to development but there is some uncertainty in predicting erosion potential. For these reasons, the learnings from the stream

erosion risk assessment for the Hingaia catchment are considered to be transferrable to the PCA i.e. the application of SMAF 1 hydrological mitigation would lessen any increase to the erosion risk attributed to development of the PCA. Any additional mitigation for stream erosion can be developed as the SMP progresses based on site observations of erosion and/or improved erosion modelling when the data is available, and the methodology is improved.

It was also worth mentioning that many of the stream systems are expected to be nutrient enriched at present based on the observed prevalence of macrophytes, unrestricted access by livestock and the adjacent agricultural and horticultural land use. The increase in streambank sediment entering the receiving environment will be balanced in part by the effective removal of contributing sediment loads from agricultural land use and the future potential benefits associated with stream enhancement and restoration measures.

Furthermore, the PCA comprises only a very small portion of the 37,637 hectares Pāhurehure Inlet catchment. Even at the more local scale of the upper Drury Creek, the PCA comprises a small proportion of the overall contributing catchment. On that basis, any changes within the PCA on sediment levels in Slippery Creek would be very difficult to distinguish from changes elsewhere within the catchment.

Also, until further assessment is undertaken, a robust ecological assessment of the potential effects of sedimentation in the marine SEA cannot be completed. Further assessment of the change in sediment contribution to the wider environment will be undertaken prior to a plan change hearing, although this may be risk based. This will provide more assessment of the anticipated changes in sediment risk and will incorporate mitigation measures which will reduce the potential stream bank erosion and therefore sediment generation.

Combined with the condition of the Waihoihoi Stream discussed in Section 2.4.1 (i.e. fair bank stability and low evidence of erosion scarring), the proposed stream erosion mitigation measures will ultimately minimise and mitigate the erosion risks in the receiving environment attributed to development of the PCA.

6.2 Preliminary design of stormwater management devices

A matrix of stormwater management outcomes (as described in Section 6.1 above) and corresponding tools for different land use zones are presented in Table 6.1. This toolbox has been developed to show alignment of stormwater quality, hydrological mitigation and flood attenuation approaches across all three Drury East PCAs. In addition, a broad range of BPOs for mitigating effects and/or achieving these outcomes are listed for the corresponding land-use. This toolbox will be used to develop an integrated stormwater management approach for the Drury East PCAs, though different devices and/or combinations may be adopted across the three Drury East PCAs to achieve the same outcomes. This creates performance standards as consistent as possible across the three Drury East PCAs, and provides a stormwater management toolbox as broad as possible to allow for flexibility of implementation.

Table 6.1: Stormwater Management Toolbox

Zone	Land Use	Performance Outcomes				Best Practicable Options	Notes
		Water Quality	Hydrological Mitigation	Flood Attenuation	Water Sensitive Design [1]		[1] The proposed stormwater management options adopt a Blue-Green network approach that includes other devices or measures which are not listed in this table i.e. filter strips, green outfalls (where practicable), streams protected and enhanced with riparian buffer and re-vegetation planting. The need for bank stabilisation/instream works to be determined by stream erosion assessments. [2] Stormwater Management Devices in the Auckland Region –Guideline Document 20017/001 (GD01). (December 2017). Auckland Council Eliminate or minimise the generation and discharge of contaminants. Treat all contaminant generating impervious areas at or near source by a water quality device designed in accordance with GD01 to target sediment, metals and gross pollutants. Elimination of contamination generation is considered the BPO option so if inert roofing materials are used, these impervious surfaces will not generate contaminants and therefore will not require water quality treatment. [3] Auckland Unitary Plan –Operative in Part (AUP). Auckland Council The PCA does not fall within a Stormwater Management Area - Flow 1 (SMAF 1) overlay but this will be adopted as the minimum requirement. The minimum hydrological mitigation requirements proposed are as follows: · Retention (volume reduction) of at least 5mm of runoff depth from impervious surfaces · Detention of the 95th percentile event for the difference between the pre-development and post-development runoff volumes from a 95th percentile, 24 hour rainfall event minus the achieved retention volume. Exceptions for providing retention can be made in cases where soil infiltration rates preclude disposal to ground and rainwater reuse is not possible. It is noted that if retention cannot be met, devices are to be lined with the retention volume being treated as a detention through bioretention devices. [4] No increase in peak flood level effects to properties upstream and downstream of the Plan Change Area. [5] Flood attenuation for the Waihoehoe Precinct Southern Zone. [6] Hydrology mitigation will be provided for impervious areas; Water quality treatment will be provided where contaminants are generated e.g. Water quality treatment won't be provided for roofs with inert building material or footpaths. Bio-retention devices generally have the added benefit of providing WQ treatment too.
Performance standard		GD01[2]	AUP: OP SMAF 1[3]	100 year ARI: not worsen downstream flooding [4]			
Mixed Housing – Urban Mixed Housing – Suburban Terraced Housing Apartment Buildings	Roads and associated carparks	✓	✓	✗✓[5]	✓	Bio-retention devices including: · Raingardens[4] · Tree pits · Vegetated swales	
	Roofs, driveways, gardens and landscaping	✗✓[6]	✓[6]	✓	✓	Inert Building materials Rainwater tanks for re-use of roof runoff Permeable pavements for driveways or laneways Bio-retention devices including: · Communal detention devices · Living Roofs · Raingardens · Vegetated swales	

The design of stormwater management devices to achieve the stormwater management objectives (as above) will be in accordance to all relevant technical guidance listed in Section 4.2. The following sections give a general overview of proposed management options and design requirements. Further details of the stormwater system will be addressed as part of a more comprehensive preliminary design once a site layout has been finalised.

6.2.1 Water quality and quantity

6.2.1.1 Road areas

As mentioned in Section 4, it is suggested that AUP and NDC requirements are not only focused on targeting high contaminant generating surfaces, but also on a wider application of water quality treatment for impervious surfaces. Accordingly, all roads within the PCA will be treated using vegetated bio-retention devices comprising of a combination of raingardens and potentially swales and tree pits. Raingardens will be used for treatment within roads and car parks to capture contaminant-laden runoff close to the source. Vegetated swales can also be used on roads as they provide an alternative conveyance route and visual amenity, when compared to a piped network. Swales also provide treatment close to the source. Vegetated bio-retention devices also have the advantage of providing a secondary function of hydrological mitigation, and may also be able to be integrated with landscaping areas. These devices generally provide multiple functions: retention/detention, visual amenity and water quality treatment close to the source.

In addition, grated catchpits may be used at inlets to the stormwater network to capture gross contaminants, solids, sediment, and gravels and pre-treatment devices, (i.e. gross pollutant traps) will be adopted to capture runoff from communal waste storage areas in apartments or multi-unit developments prior to discharging to bio-retention devices or other green infrastructure.

Proposed layouts provided by the client show that all road types have incorporated landscaping space adjoining the roads that has potential to be developed into vegetated bio-retention devices. All proposed road types provide 2.3 to 2.4 m wide sections of landscaping space to each side of the road breaking up the parking lanes (see Figure 6.1).

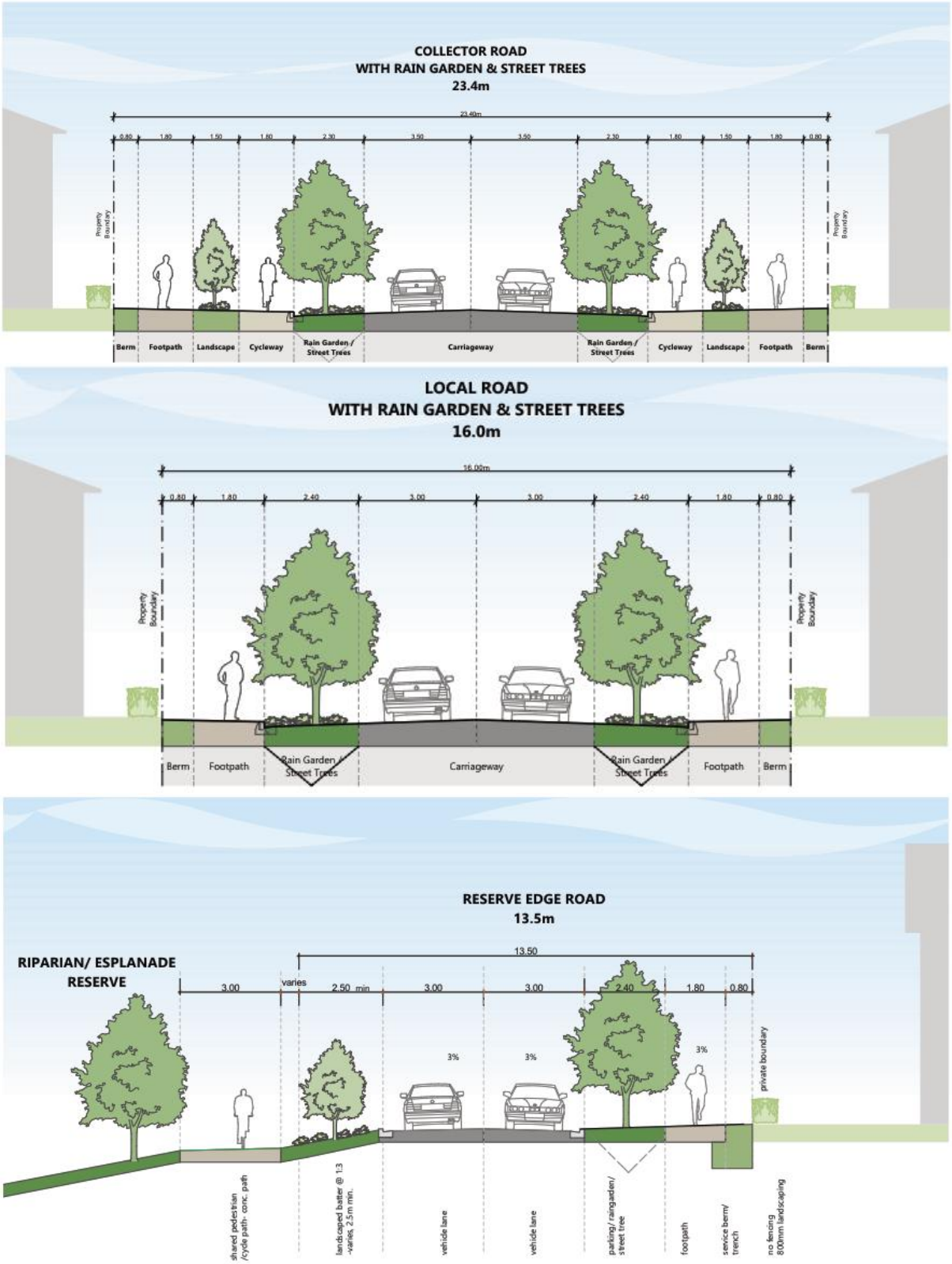

Figure 6.1: Proposed Road Cross sections provided by Oyster Capital (August 2019)

6.2.1.2 Private lots

The concept design of the PCA allows for THAB Zoning that allow for a maximum of 70% impervious area for each property.

The water quality objectives in Section 6.1.2 could be met on private lots through the following measures and stormwater management devices:

- Use of inert building materials to prevent generation of contaminant-laden runoff within residential lots, i.e. avoid use of high contaminant yielding building roofing, spouting, external wall cladding and architectural features using materials with an:
  - Exposed surface or surface coating of metallic zinc of any alloy containing greater than 10% zinc
  - Exposed surface or surface coating of metallic copper or any alloy containing greater than 10% copper
  - Exposed treated timber surface or any roof material with a copper-containing or zinc-containing algaecide

It is noted that the region-wide NDC is not only focused on targeting those high contaminant generating surfaces, but also has a preference for wider applications of water quality treatment for all impervious surfaces. However, if inert roofing materials are used, these impervious surfaces will not generate contaminants and therefore will not require quality treatment. Elimination of contamination generation is considered the BPO option.

If building materials that generate contaminants are used, site-specific water quality treatment will be required.

To meet the hydrological mitigation objectives, the following management options are proposed:

- For retention
  - By infiltration, where feasible and possible in a safe, and effective manner. This may be provided through appropriately designed bio-retention devices. Pervious pavements or porous concrete may be included as part of private or shared driveways / access to the dwellings within the PCA
  - At source collection of roof runoff from residential dwellings and buildings, through the use of rainwater tank
- For detention
  - Raingardens, planter boxes, swales and tree pits are bio-retention devices which can be designed to provide also detention within private residential property or along road corridors and within public impervious spaces, while adding to the landscape value of the PCA
  - Above-ground rainwater storage tanks or underground detention tanks will be provided within residential lots to provide storage volumes for reuse, and a separate detention volumes with a controlled discharge rate, with the latter devices minimising land take

The hydrological mitigation outcome is not fully achieved unless both retention and detention can be provided. However, the viability of water retention is contingent on land use activity (i.e. water re-use demand) and geological conditions. As mentioned in Section 2.2.2, soil drainage is anticipated to be poor for the north-eastern part of the PCA and moderate to poor for the south-western part major part of the PCA. Exceptions for providing retention are acceptable in cases where soil infiltration rates preclude disposal to ground and the demand for rainwater re-use is limited, in which case the retention volume can be replaced by detention as the BPO.

6.2.1.3 Flood attenuation– southern sub-catchment

Peak flows within the southern sub-catchment of the PCA will be mitigated by providing multiple attenuation basins to ensure post-development flow match pre-development flows for the 1 in 100 year ARI storm event, as well as for more frequent events such as the 1 in 2 and 1 in 10 year ARI storms. The controlled release of stormwater discharge will match pre-development conditions for the 10 year and 100 year ARI rainfall events, thereby ensuring no worsening of flood risk on the downstream environments due to development within the PCA. Other benefits of attenuation basins include provision of amenity value from open spaces and planting of native species to improve ecological value. The attenuation devices will be designed at Resource Consent.

A preliminary TP108 storage calculation for a 100 year ARI storm based on maximum impervious area assumptions for the designated zones (see Figure 6.2) was carried out to prove feasibility. The calculation results in a required volume of approximately 2,200 m³ just for the southern part of 116 Waihoehoe Rd and a total required storage volume of 8,450 m³ for the whole southern sub-catchment. It is proposed that the detention basins are formed within the drainage reserves using culverted road crossings and other throttles in the streams to hold back water. The proposed available drainage reserve area can comfortably accommodate the calculated necessary storage volumes.

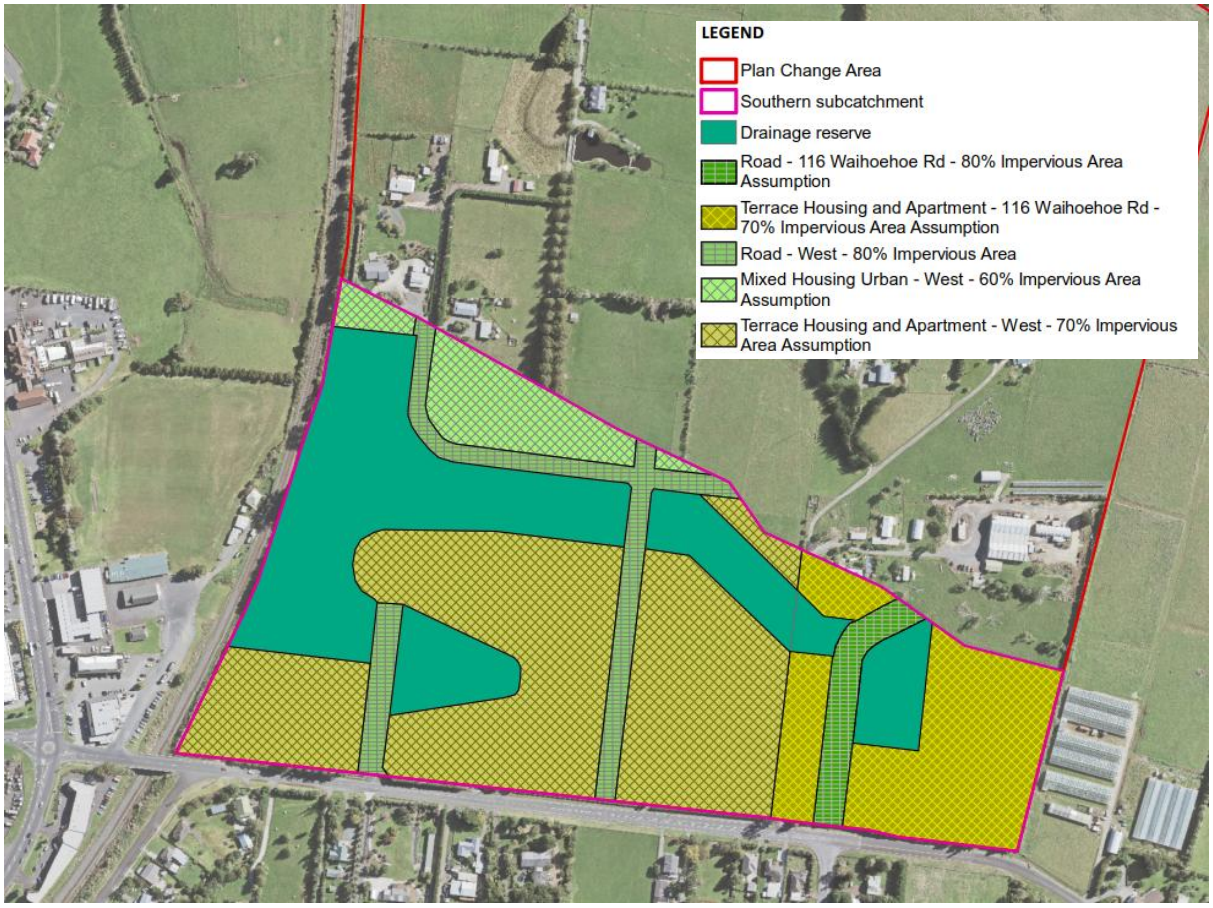

Figure 6.2: Overview of impervious area assumptions for attenuation basins within the southern sub-catchment

Figure 6.3: Proposed location of attenuation basin for the southern sub-catchment

Early engagement with Auckland Council will be undertaken to ensure that the proposed basin design is validated in line with the intended stormwater management outcomes and maintenance requirements.

6.2.2 Stormwater conveyance

6.2.2.1 Stormwater network

Primary flows generated by a 10 year ARI storm event will be conveyed by a piped stormwater network to the downstream receiving environment. Stormwater infrastructure will be designed as per the Auckland Council Stormwater Code of Practice (November 2015). It is proposed to be located in the road corridor to provide easy access for maintenance.

6.2.2.2 Overland flow paths

For events greater than a 10 year ARI storm event and up to a 100 year ARI storm, the excess flow or secondary flows will be conveyed by using roads and drainage reserves as overland flow routes, where they are to be maintained) or through dedicated flow channels, integrated within the PCA layout plan. All secondary flow paths will be located within public areas (roads and parks) and not on private properties.

All roads are proposed to be a minimum of 600 mm lower than adjacent properties. Therefore, overland flow paths are proposed to follow the roads. All flow paths are proposed to be located within public areas (roads and parks) and not private properties. A maximum allowable depth of flow within the road corridor will be agreed with Auckland Council prior to detailed design of roads, to ensure safety within the road corridor.

6.2.2.3 Blue-Green network

The Blue-Green Network envisaged under the Structure Plan, overlain with the riparian corridors as proposed in the Plan Change is shown in the *Drury East Plan Changes – Ecology Response* memo (March 2020) included in Appendix M. There are some parts of the PCA where stream alignment does not correspond between the two datasets. We consider that for the most part this relates to a lack of spatial resolution. The plan is conceptual and provides sufficient information at this time to identify that the Blue-Green Network, including the important connectivity with SEA to the west of Drury Hills Road, is integral to the Plan Change.

6.2.3 Discharge to receiving environment

6.2.3.1 Northern sub-catchment

The northern sub-catchment discharges directly into stream in order to pass flows forward. The downstream receiving environment will also be protected from erosion through the use of green outfalls and vegetated channels to dissipate energy prior to discharge to the receiving environment.

6.2.3.2 Southern sub-catchment

The southern sub-catchment uses a different approach where flows up to a 100 year storm event are intended to be attenuated on-site. Conveyance systems will discharge into attenuation basins through green outfalls. Figure 6.3 shows the proposed location of an attenuation basin within the drainage reserve of 116 Waihoehoe Road. It is proposed that outfalls from the basins are set to mimic the existing flow regime out of the PCA, and the outflow rates are restricted to mimic the flow rates from the existing development conditions. Restrictions to control discharge rates will be formed at road crossing by culverts and at other locations by structures and/or terrain shaping. Early engagement with Auckland Council will be necessary to determine a suitable outflow rate and discharge location along the existing flow route

7 Applicability

This report has been prepared for the exclusive use of our client Oyster Capital, with respect to the particular brief given to us. We understand and agree that they will submit this report as part of an application for Plan Change and that Auckland Council, as the consenting authority, will use the report for the purpose of assessing that application.

Tonkin & Taylor Ltd

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Appendix A: Report Figures

A1 - Property Setting

A2 - Plan Change Area within Drury-Opāheke Draft Land Use Plan

A3 - Unitary Plan Zones

A4 - Current Land Use

A5 - Topography

A6 - Existing Flooding

A7 - Geology

A8 - Soil Drainage and Groundwater Levels

A9 - Stream Classification from Ecological Assessment

A10 - Significant Ecological Areas

A11 - Aquifer Management Areas

A12 - Existing Stormwater Infrastructure

A13 - Slippery Creek Model – Flood Level Diff. ED+FUZ to ED (Whole catchment)

A14 - Slippery Creek Model – Flood Level Diff. MPD+FUZ+CC to ED (Whole catchment)

A15 - Slippery Creek Model – Flood Extents Comparison (PCA area)

A16 - Slippery Creek Model – ED100yr (no FUZ) Flood Depths (PCA area)

A17 - Slippery Creek Model – ED100yr+FUZ Flood Depths (PCA area)

A18 - Slippery Creek Model – MPD100yrCC+FUZ Flood Depths (PCA area)

A19 - Slippery Creek Model – Flood Level Diff. MPD+FUZ+CC to ED (PCA area)

A20 - Flood Extent Comparison – AC floodplain to MPD scenario (PCA area)

A21 - Slippery Creek Model – Flood Level Difference ED+FUZ to ED (PCA area)

A22 - Proposed Stormwater Management Areas

Appendix B: Concept Masterplan Drawings v1-v3

Appendix C: Mott MacDonald Drury-Opāheke Draft Stormwater Management Plan (2019)

Appendix D: AECOM Drury Stormwater Management Plan (2017)

Appendix E: T+T Drury Stormwater Management Summary (2018)

Appendix F: Lander Geotechnical– Preliminary Geotechnical Appraisal Report for Waihoehoe Plan Change Area Drury

Appendix G: Focus Environmental Services Ltd – Preliminary Site Investigation

Appendix H: Freshwater Solutions – Waihoehoe Road Drury Ecological Assessment Draft v1

Appendix I: Mott MacDonald Drury-Opāheke Draft Future Urban Zone Major Structures Flooding Assessment (December 2018)

Appendix J: Healthy Waters Review of Adequacy of Information for a Private Plan Change Request (February 2020)

Appendix K: Response to Auckland Council Further Information Request on Stormwater Matters for Drury East (March 2020)

Appendix L: Response to Auckland Council Further Information Request on Stormwater Matters for Drury East - Stream Erosion Risk Assessment for Hingaia Catchment (April 2020)

Appendix M: Drury East Plan Changes - Ecology Response (March 2020)

Appendix N: Drury East (Oyster Capital) flood modelling – Response to Auckland Council Further Information Request on Stormwater Matters (Version 2) (April 2020)

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