Planning | Surveying | Engineering | Environmental

STORMWATER MANAGEMENT AND FLOOD RISK ASSESSMENT

For Riverhead Plan Change Area

Riverhead Landowner Group

Document Information

Client	Riverhead Landowner Group
Site Location	Riverhead
Legal Description	Lot 2 DP 164978, Lot 1 DP 164978, Lot 1 DP 64605, Pt Lot 2 DP 37432, Lot 2 DP 64605Pt, Lot 2 DP 4818, Lot 1 DP 61985, Lot 1 DP 77992, Lot 2 DP 77992, Lot 3 DP 63577, Lot 2 DP 63577, Lot 1 DP 113506, Lot 1 DP 66488, Lot 1 DP 109763, Lot 1 DP 164590, Lot 2 DP 164590, LOT 1 DP 499822, LOT 20 DP 499876
CKL Reference	A20405
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Author	Catherine Liu		
Signed		**Date**	29/03/2022

Reviewed By	Andy Dow		
Signed		**Date**	29/03/2022

Authorised By	Bronwyn Rhynd		
Signed		**Date**	31/03/2022

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Executive summary

This report outlines the development of a stormwater management plan for the Riverhead Future Urban Zone area in support of a Structure Plan and Private Plan Change application, which is anticipated to rezone the land to a mixture of residential and business zones.

A stormwater management strategy has been developed based on the expected discharge rates, volumes, and quality in accordance with the Water Sensitive Design (WSD) principles that are reflected in the Auckland Council Guidelines and the Project team's goals. A flood risk assessment is also prepared to support the stormwater management strategy. This stormwater management strategy demonstrates the overarching principles of how the site's stormwater is to be managed to mitigate any potential detrimental effects of urban development on the receiving environment.

The three receiving environments are, a stream to the south of the site (Southern Stream), east to Riverhead Point Drive and north to Riverhead Forest Stream. A stormwater management options assessment has resulted in a best practicable approach to realise the overall stormwater strategy. A combination of communal/centralized and at-source devices are proposed for the sub-catchments within the site. The best practical option for stormwater management includes the following elements:

- Communal device for each-sub-catchments as summarized in Table 1
- At-source device for some sub-catchments as summarized in Table 1
- Pipe network for primary conveyance
- OLFP and swales for secondary conveyance
- Inert roofing and cladding materials for building
- Permeable paving

Table 1: Summary of Proposed Strategy and SW Management Devices for Each of Three Receiving Environment

Receiving Environment	Sub-catchments	Proposed SW Strategy	Proposed Stormwater Devices
Southern stream	S01_P, S04_P	• WQ treatment (90th percentile) • SMAF 1 retention and detention (95th percentile event)	• Communal bioretention device for each sub-catchment
Riverhead Point Drive drainage	S03_P_1, S03_P_2	• WQ treatment	• Single communal bioretention swale for two sub-catchments
Riverhead Forest Stream	All northern catchment and S02_P	• WQ treatment • SMAF 1 retention and detention	• Communal bioretention device for each sub-catchment

The implementation of the stormwater management plan will ensure that the urban development for the Riverhead Plan Change area will mitigate any potential detrimental effects prior to discharge to the receiving environments.

1 Introduction

CKL has been engaged to support Riverhead Landowner Group[1] with preparation of a structure plan and the submission of an application for a Private Plan Change for the Riverhead Future Urban Zone area (the 'site') located to the west of Riverhead town centre as shown in Figure 1. It is anticipated that the land will be rezoned to a mixture of Residential - Mixed Housing Urban and Residential - Terraced Housing and Apartment Building Zone, Local Centre Zone, Neighbourhood Centre Zone and Mixed Rural Zone.

Figure 1: Site location – General

This report outlines a stormwater management plan (SWMP) for the Structure Plan and Plan Change area, that meets the Auckland Council's policies, plans and guidelines, which aims to protect and enhance the receiving environment as it changes from the current land-use of rural activities to a modern urban form in line with the proposed structure plan.

The SWMP has been developed at a conceptual design level to identify the best practicable stormwater management strategy to manage the potential environmental effects of the stormwater runoff from the

[1] Riverhead Landowner Group is Fletcher Residential Living, Matvin Group and The Neil Group.

land use activity. However, the finalised stormwater management will be confirmed through the future design phases of the development. As such, this SWMP accommodates a level of flexibility through the options proposed. This will allow for adjustments and modifications to align with the final development layout while maintaining the stormwater management objectives, as outlined in this SWMP, which minimise adverse downstream effects.

1.1 Reference Documents

The development of this stormwater management plan is guided by the following key documents, which are referenced throughout this report:

- Auckland Unitary Plan (AUP)– Operative in Part (OiP),
- Auckland Council Stormwater Code of Practice (SWCoP)[2],
- Auckland Council Stormwater Modelling Specification (AC SWMS),
- Auckland Transport Code of Practice (ATCoP),
- Transport Design Manual (Auckland Transport),
- Auckland Council Guideline Document 2017/001 (GD01) Stormwater Management Device Design Guidelines,
- Auckland Council Guideline Document 2015/004 (GD04) Water Sensitive Design Guidelines,
- Auckland Council Guideline Document 2021/007 (GD07) Stormwater Soakage and Groundwater Recharge in the Auckland Region,
- Technical Report: (TR) 2013/018 Hydraulic Energy Management: Inlet and Outlet Design for Treatment Devices,
- Stormwater Runoff Modelling Guidelines (TP108),
- Regionwide Stormwater Network Discharge Consent (the NDC), granted 30th October 2019,
- Auckland Council online GIS information (GeoMaps accessed September 2021),
- Topographical survey provided by Survey Group Ltd, and
- Preliminary Master Plan dated 25th September 2023.

2 Existing Site Appraisal

2.1 General Information

The site comprises of multiple properties with different landowners. The total land area is c. 80.7ha. It is surrounded by the rural area to the west and south, Riverhead Forest to the north and urban development to the east. A stream (Riverhead Forest Stream) forms the northern boundary of the site (Figure 2).

The land use within the site is currently dominated by agriculture/horticulture and some residential area. The current impervious coverage of the entire site is c.10% on average including roof, impervious paving and farm-related canopies based on Aerial Photo view (Figure 2). An overview of existing site features is provided in drawing 001 in Appendix A.

[2] Auckland Council, 2015, Code of Practice for Land Development and Subdivision, Chapter 4 – Stormwater, version 2, November 1, 2015.

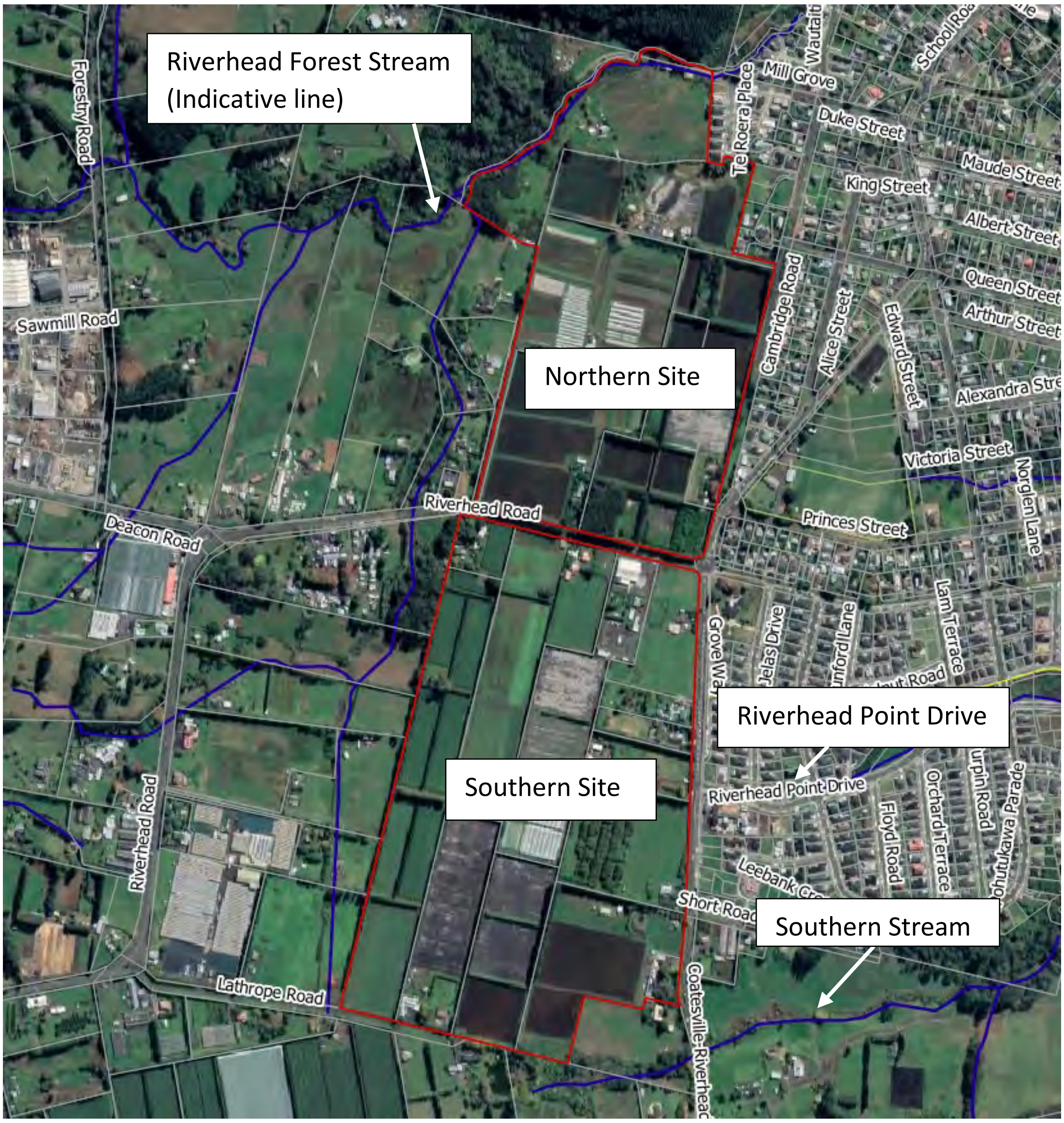


Figure 2: Aerial Photo View (Google Satellite) of Existing Site Vincinity

2.2 Topography

The site generally slopes in a south to north direction, falling from 37 mRL at southwest corner to 13.5 mRL in the north as shown in the topography elevation map (Figure 3).

The proposed development is naturally divided by Riverhead Road, which creates two distinct areas herein referred to as the Northern Site (north of Riverhead Road) and Southern Site (South of Riverhead Road).

The northern site generally falls from south northwards, towards the wetland within one of the properties in the north (22 Duke St). The majority of the southern site slopes from the south to the northwest towards a stream within 280 Riverhead Road. A small area in the southeast sector naturally falls to the south and east, which is detailed in Section 2.4.

As shown in the topography slope map (Figure 4), created from 1m LiDAR DEM, the average slope within the entire site is less than 3%.

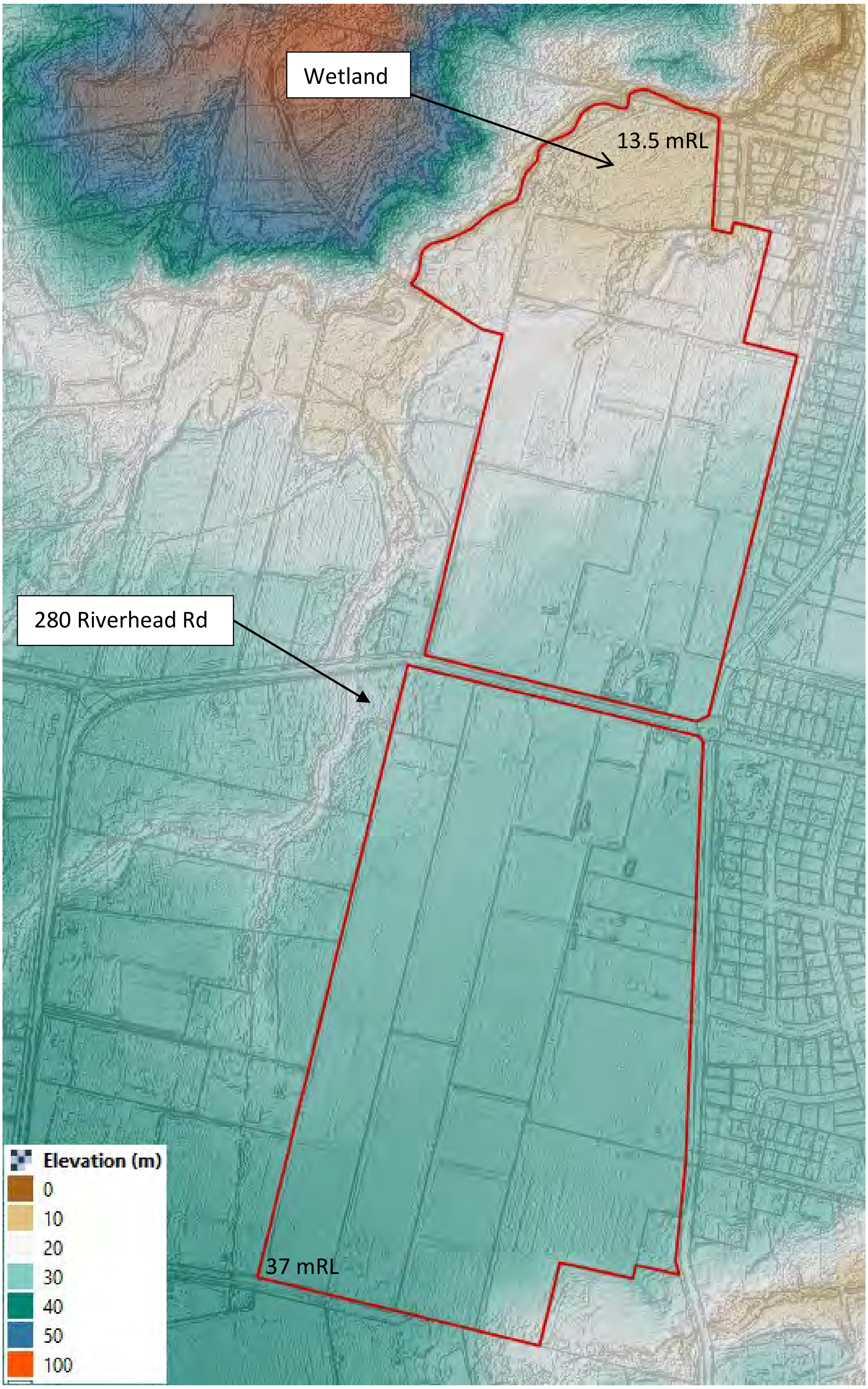


Figure 3: Topography Elevation Map (2016 LiDAR DEM in AVD1946)

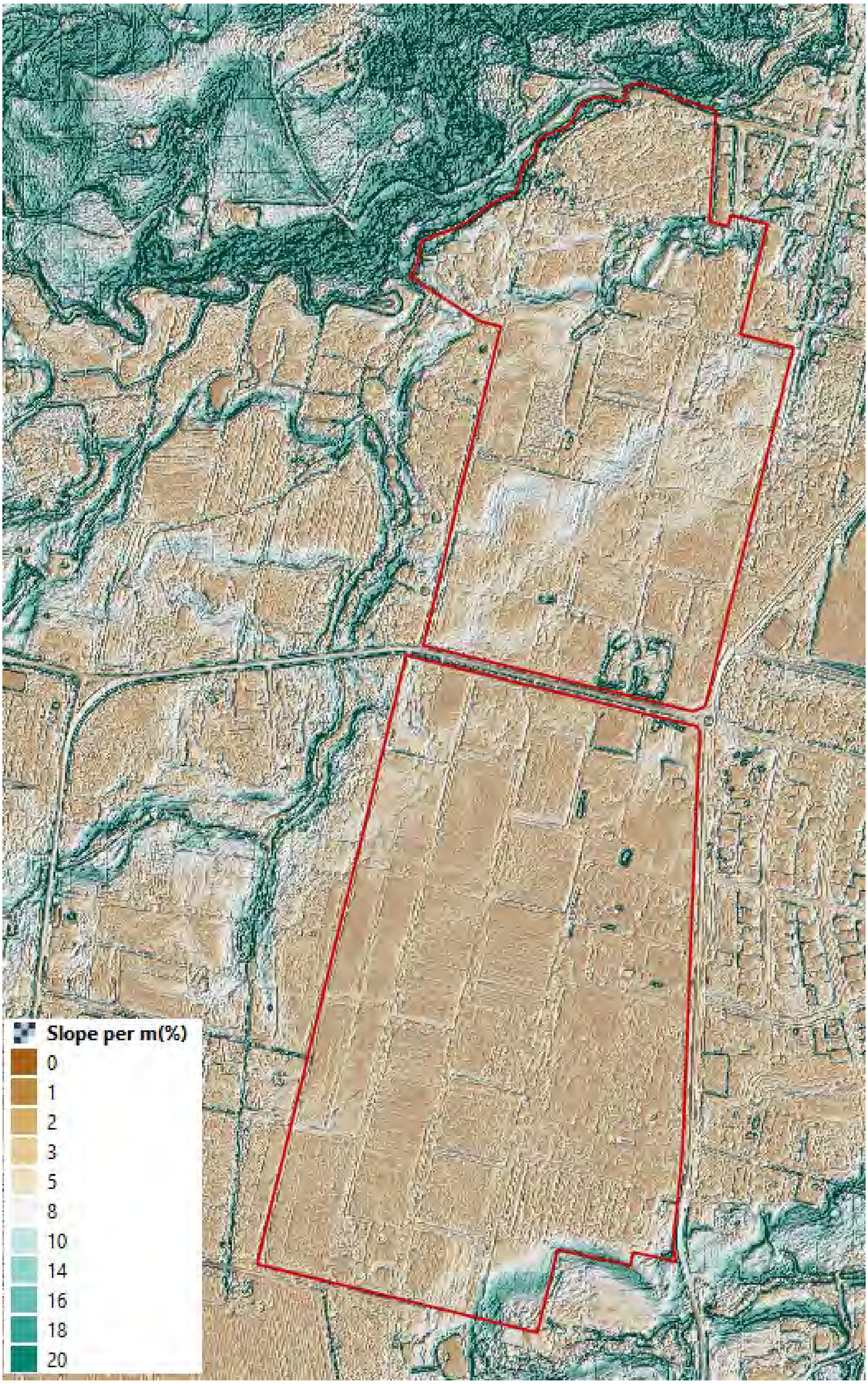


Figure 4: Topography Slope Map (Slope Percentage Every Meter)

2.3 Geotechnical

Geotechnical investigations within the site have been completed through three undertaking for different part of the site respectively by CMW Geosciences in December 2015 and September 2018 and by Soil & Rock Consultants in May 2022. These investigations are summarized in the Soil & Rock report[3]. There are 46 hand auger holes in total drilled crossing the entire site. The locations of the drilled auger holes are shown in Figure 5 (extracted from the S&RC report). No soakage tests were undertaken.

According to the geotechnical report, the Riverhead area is underlain by alluvial deposit of the Puketoka Formation. These alluvial soils generally comprised firm to very stiff silt with varying clay and sand portions.

According to the Soil & Rock geotechnical report, it is suggested that the site is generally suitable for future residential development, subject to detailed geotechnical investigation to address the identified constrains.

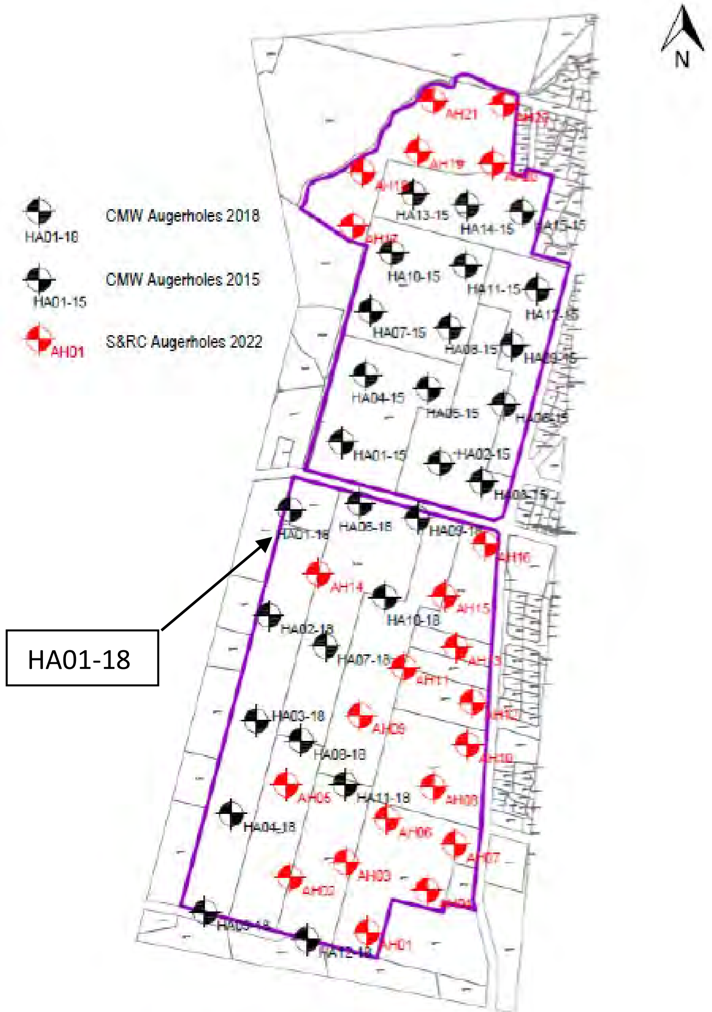


Figure 5: Auger Holes Locations (Extracted from Preliminary Geotechnical Investigation Report)

2.3.1 Groundwater

Groundwater measurements throughout the auger holes generally ranged from 0.8m to 3.3m depth (see the Soil & Rock report for detail). The investigations were carried out across summer, winter, and autumn months. High groundwater levels were measured in both summer and winter. It is noted that the

[3] Preliminary Geotechnical Investigation to Support Plan Change, Coatesville Riverhead Highway, Riverhead (Soil & Rock, 6 May 2022)

groundwater level at borehole HA01-18 (refer to Figure 5 for location) adjacent to the existing receiving environment for the majority of southern site is 2.5m measured in summer by CMW.

The detailed investigation of groundwater levels prior to development is recommended by the Soil & Rock.

2.4 Stormwater Drainage/Network

The existing stormwater pipeline networks and open watercourses around the subject site and surrounding area as identified in AC GeoMaps (accessed in March 2022), is presented in Figure 6. Several major culverts identified through site visit and survey data (Appendix 1) are indicated in Figure 6 with the details provided in the flood risk assessment (refer to Section 0).

There is no public stormwater pipeline identified within the subject site as well as the surrounding rural area to the north, west and south of the site. The developed urban area to the east of the site is served by public reticulated stormwater networks which eventually discharge to the Waitemata Harbour to the east.

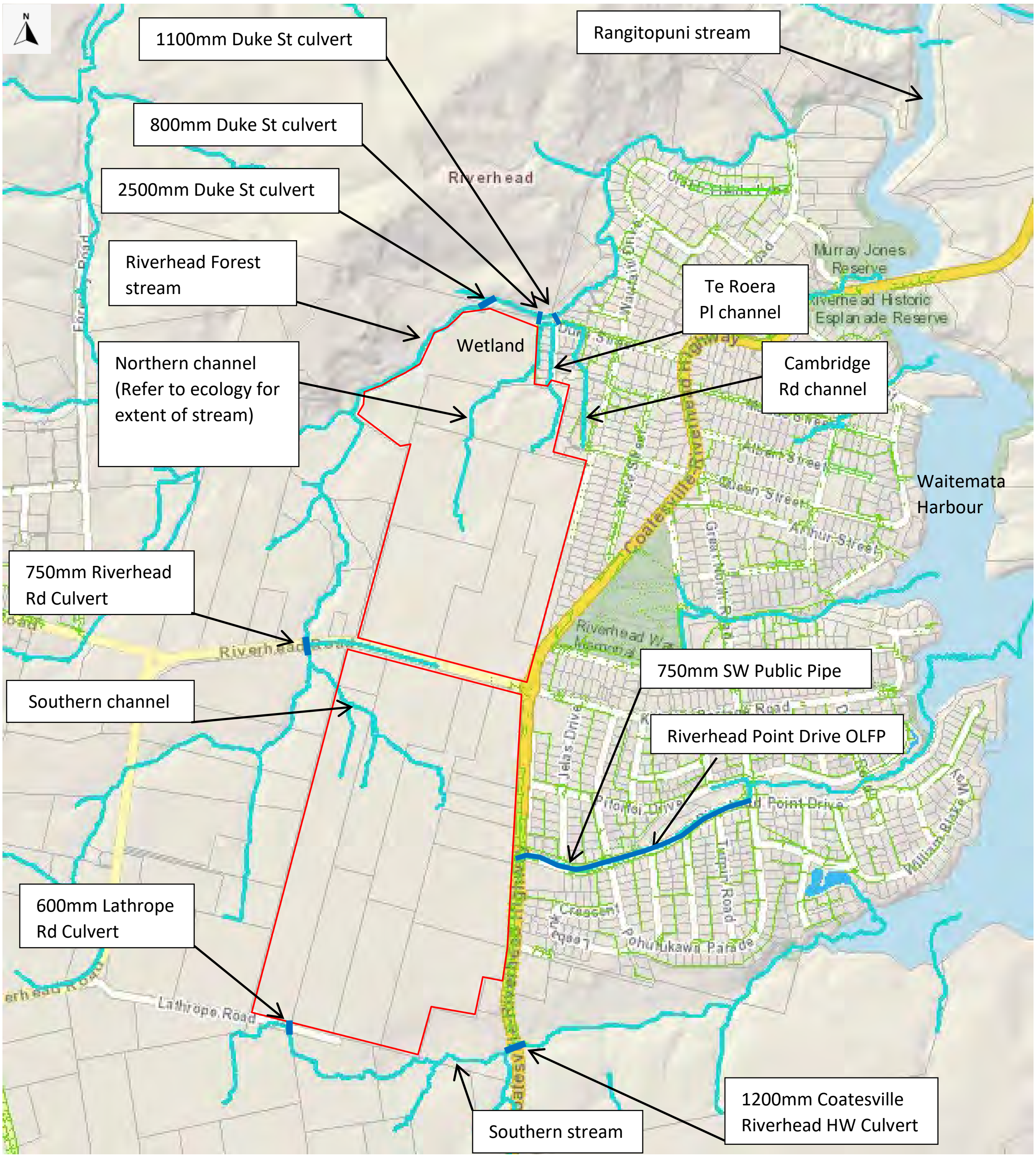


Figure 6 Existing Stormwater Network Drains (GeoMaps)

Riverhead Point Drive drainage

A Ø750mm public stormwater pipe within Riverhead Point Drive was built during the development of this area and provides a connection to the western side of Coatesville-Riverhead Highway where the site is located.

Auckland Council GeoMaps notes there is an open watercourse, as per Figure 6, along Riverhead Point Drive. However, during the Riverhead South development[4] the open channel has been filled and replaced by the road OLFP and piped network.

[4] Resource Consent: RMA 58883A, Riverhead Coatesville Highway, 17 April 2015

2.5 Ecological Features

An ecological assessment has been completed by RMA Ecology Ltd which identified and determined the extents of wetlands and streams within the site as shown in Figure 7. There are no streams or wetlands recorded in the southern site. However, the northern site supports both streams and wetlands which are protected under the National Policy Statement for Freshwater Management (NPS-FM). It is the noted the NPS – FM is pending changes which may affect the definition and extent of the ecological features.

Figure 5. The most northern portion of the PPC site (turquoise boundary, showing Stream I1 (dotted blue line), NPS-FM qualifying natural inland wetlands (red shaded polygons) and constructed drains (purple dotted lines). The constructed pond for horticultural water supply is indicated as a blue polygon.

Figure 7: Northern Catchment Hydrological Features

2.6 Existing Flood Hazards

The existing flood hazards mapped by Auckland Council within and in the vicinity of the site are shown in Figure 8, which includes the following:

- A floodplain identified in the wetland area, northern site,
- A number of flood prone areas/ponding areas identified across the southern and northern sites, and
- Several overland flow paths in align with the open watercourse as shown in Figure 6.

The major flood hazard within the site is the wetland floodplain which leaves significant constraints for the development in this area.

A site-specific flood risk assessment has been undertaken by CKL to assess the potential impact from the proposed development on the flood hazards within and outside the site to support this SWMP design. This flood risk assessment is presented in Section 9.

Figure 8: Overland flow path, flood plain and flood prone areas (GeoMaps)

2.7 Existing Sub-catchment and Receiving Environment

The overall site is divided into smaller sub-catchments that align with the existing contours and subsequent surface flow paths. These sub catchments are presented in Figure 9

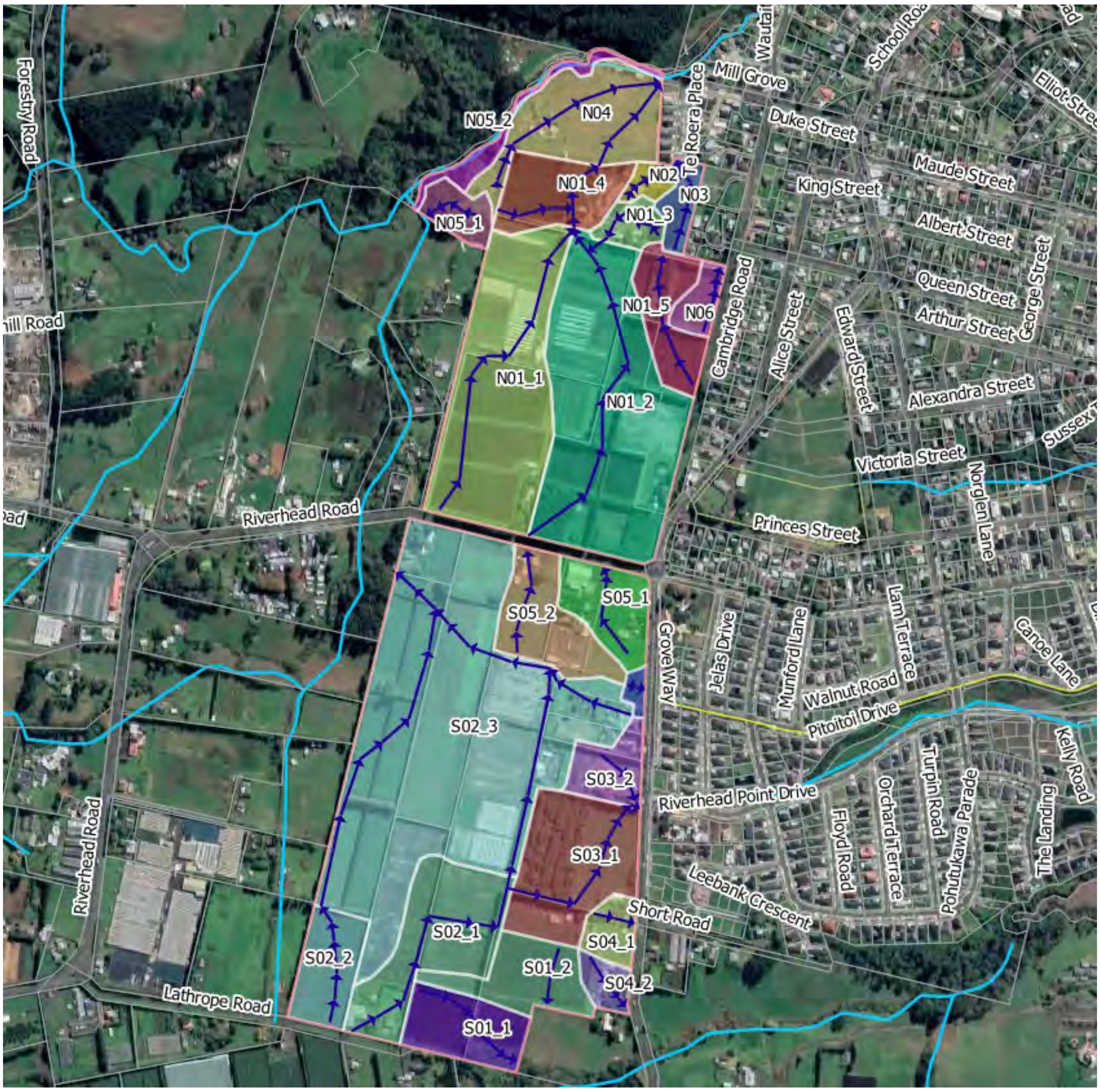


Figure 9 Existing Catchments and Flow Directions

The northern and southern site area are further defined by sub catchments' discharge and receiving environment characteristics, which are summarized as follows.

<u>Northern site sub-catchments:</u>

The entire northern site eventually discharges to the Riverhead Forest stream (a tributary of the Rangitopuni Stream) to the north of the site through open drains and culverts. The Riverhead Forest Stream continues traveling northeast for c1.4 km before discharging to the Rangitopuni Stream estuary at the upper Waitemata Harbour.

The northern channel as shown in Figure 6 is identified as a stream by RMA Ecology's ecological assessment (Section 2.5), and collects the majority of the northern catchment and discharges to the existing wetland (Figure 7) prior to crossing Duke Street through a 800mm culvert and discharging to the Riverhead Forest stream.

A small catchment (N06 in Figure 9) discharges to the Cambridge Rd drain which connects to a drain on the northern side of Duke Street and discharges to the Riverhead Forest stream through a 1100mm culvert.

The rest of the sub-catchments (N01_5 and N03) discharges through Te Roera Place drain to the stream.

<u>Southern site sub-catchments:</u>

Most of the southern site discharges through the southern channel within the site, to a stream to the west. This stream runs northward through a Ø750mm culvert under Riverhead Road prior to merging to the Riverhead Forest stream at the western site boundary.

The rest of the catchment in the southeast discharges respectively to the Riverhead Point Drive drainage (for sub-catchment S03_1 and S03_2) and a stream to the south (for sub-catchment S01_1, S01_2, S04_1 and S04_2) and discharges separately to the estuary of the Waitemata Harbour. The stream to the south with name unknown (referred as 'Southern Stream' in this report) runs through a Ø1200mm culvert under Coatesville-Riverhead Highway.

In summary, the ultimate existing receiving environment for stormwater disposal of the site includes the following, all of which ultimately discharge to the estuary of the Waitemata Harbour:

- Riverhead Forest Stream (discharging to Rangitopuni Stream),
- Riverhead Point Drive drainage, and
- Southern Stream

Table 2 summarises the existing stormwater discharge location and receiving environment with associated sub-catchments.

Table 2: Existing Sub-catchments, Discharge Locations and Receiving Environment

Receiving Environment	Sub-catchments	Total area (ha)	Discharge locations
Riverhead Forest Stream	N01_1, N01_2, N01_3, N01_4	67.5	Northern channel (stream) in site
	N02		Channel in wetland
	N03, N01_5		Te Roera Pl drain
	N05_1, N05_2		Riverhead Forest stream
	N04		Wetland on site
	S02_1, S02_2, S02_3, S05_1, S05_2		Stream to the west
	N06		Cambridge Rd drain
Riverhead Point Drive drainage	S03_1, S03_2, S04_3	6.5	Riverhead Point Drive
Southern Stream	S01_1, S01_2	6.6	Southern Stream
	S04_1, S04_2		Coatesville Riverhead highway

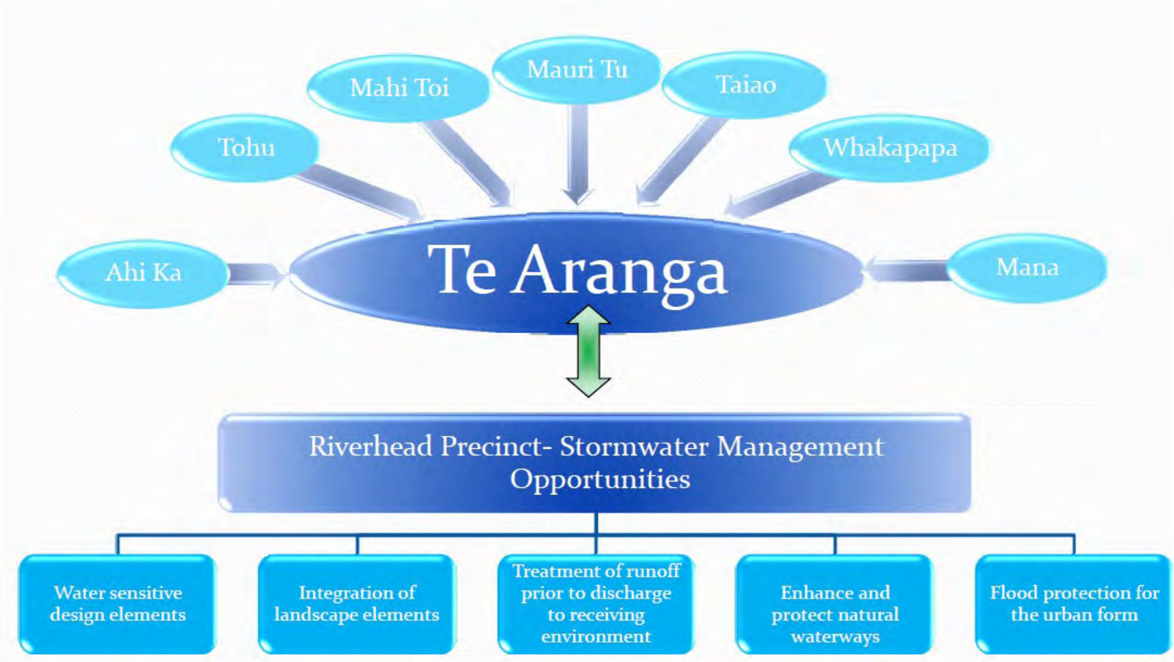
3 Mana whenua: Te ao Māori and mātauranga

CKL's vision for the Riverhead precinct is to have a water sensitive outcome for a progressive urban environment. To achieve this, the following overarching stormwater management principles have been foundational for including and promoting water sensitive design:

- ✓ Promote interdisciplinary planning and design,
- ✓ Protect and enhance the values and function of natural ecosystem,
- ✓ Address stormwater effects as close to source as possible
- ✓ Mimic natural systems and processes for stormwater management, and
- ✓ Integrate Te Aranga Principles.

The seven Te Aranga principles that apply to stormwater management are illustrated below and within the visual diagram:

- Mana (The status of iwi and hapū is recognised and respected)
- Whakapapa (The Māori names are celebrated)
- Taiao (The natural landscape elements)
- Mauri Tu (Environmental health
- Moi Toi (Creative expression)
- Tohu (The wider cultural landscape)
- Ahi Ka (The living presence)



CKL has integrated the Te Aranga Principles into the stormwater strategy for the precinct. These Auckland Council design guideline principles have the key objective to enhance the protection, reinstatement, development, and articulation of mana whenua cultural landscapes enabling all of us (mana whenua, mataawaka, tauiwi and manahiri) to connect to and deepen "our sense of place". Specific examples are presented with respect to Taiao and Mauri Tū.

Taiao – The natural environment

Outcome: the natural environment is protected, restored and/or enhanced.

The stormwater approach protects and enhances the values and functions of natural ecosystems including the integration of green corridors that build on the natural gullies, streams, and lower stream environments. The discharge locations are integrated to ensure the streams and waterways are fed throughout and urban integration is to sustain and enhance the natural environment.

Urban planning and design will work together with the water sensitive design requirements and encourage the clustering of typologies where possible thus land disturbance is minimized.

Stormwater runoff can be utilized as a natural resource to encourage the understanding that the urban form can be optimised and integrated for treatment and conveyance purposes. Often close to source treatment within green spaces can be shared with visual amenity thus getting a "double whammy" outcome: stormwater management within the greenspace environment. These open spaces can be planted with appropriate indigenous flora and provide habitats for all native fauna.

Mauri Tū – Environmental Health

Outcomes: Environmental health is protected, maintained and/or enhanced.

The approach to mimicking nature within the urban form can be undertaken at the lower reaches of the catchment where wetlands and confluences can also be developed into the urban form for treatment and attenuation. This treatment, in combination with the use of inert building materials, enhances and protects the mauri of the wai and protecting the receiving awa.

At source rainwater harvesting is proposed for some of the catchments which encourages the re-use of water and resilience as an alternative water supply source for non-potable uses.

With respect to climate change, stormwater devices are sized considering the future predictions for increase in rainfall intensity, to protect the environmental health.

4 Future Development

4.1 Development Plan

The entire site is currently classified as Future Urban Zone under AUP(OiP). It is proposed to rezone the site to a mixture of mixture of Residential - Mixed Housing Urban and Residential - Terraced Housing and Apartment Building Zone, Local Centre Zone, and Neighbourhood Centre Zone.

The preliminary master plan for the subject site is shown in Figure 10, also Appendix A. The proposed development in terms of land uses includes the following:

- Residential lots
- Retirement village
- Road
- School
- Business area (local centre and neighbourhood centre), and
- Open space including reserve/wetland, riparian margin for streams and stormwater green corridors

The proposed development will be carried out in multiple stages depending on objective of the landowners. The staging plan is not available to date.

Figure 10: Preliminary Master Plan - Version 10 (Source: Urban Acumen)

4.2 Proposed Sub-catchments and Receiving Environment

The proposed sub-catchments within the site have been delineated in alignment with the expected contours, road layout and receiving environments for the fully developed scenario based on the Preliminary Master Plan. The sub-catchment plan is shown in Figure 11 with more detail in Section 5. The discharge locations (yellow arrows) mostly follow the existing discharge patterns except for the sub-catchment N01_P_2. This sub catchment is proposed to discharge to the northern channel (a stream) within the site including the area in the northeast corner originally discharging to the Cambridge Rd drain and Te Roera Pl drain.

Figure 11: Proposed Sub-catchment Plan within the site and Indicative Discharge Locations

Table 3 summarises the stormwater discharge plan with receiving environment and associated sub-catchments.

Table 3: Proposed Sub-catchments, Discharge Locations and Receiving Environment

Receiving Environment	Sub-catchments	Total area (ha)	Discharge locations
Riverhead Forest Stream	N01_P_1, N01_P_2, N01_P_3, N01_P_4	66	Northern channel (stream) in site
	N02_P		Channel in wetland
	N03_P		Te Roera Pl drain
	N05_P_1, N05_P_2		Riverhead Forest stream
	N04_P		Wetland on site
	S02_P		Stream to the west
Riverhead Point Drive drainage	S03_P_1, S03_P_2	6.0	Riverhead Point Drive
Southern Stream	S01_P	8.6	South Stream
	S04_P		Coatesville Riverhead

5 Hydrology Analysis

A hydrological assessment for the internal sub-catchments has been undertaken which estimates the change in peak flows and volumes, resulting from the change in impervious areas, for the fully development scenario in accordance with the preliminary master plan.

A HEC HMS[5] model was produced for the hydrological assessment using the methodology outlined in TP108 for the existing and proposed sub-catchments, as shown in Figure 9 and Figure 11 respectively. The design parameters adopted for the assessment and outcomes are summarised below, with supporting calculations appended for reference, Appendix 2.

5.1 Design Rainfall

Rainfall depths have been derived from TP108 Rainfall depths and adjusted for climate change where necessary using the adjustment factors provided in the SWCoP (Version 3 January 2022). The final rainfall depths used in the analysis are shown in Table 4 below.

Table 4: 24 Hour Duration Design Rainfall Depth

Climate Scenario	90th Percentile	95th Percentile	50% AEP	10% AEP	1% AEP
Existing	25.5 mm	35.5mm	80mm	130mm	210mm
Future (+2.1°C)			87mm	147mm	245mm

[5] Hydrologic Engineering Center (US). The Hydrologic Modelling System (HEC-HMS). US Army Corps of Engineers

5.2 Losses

Based on the existing geology features, as outlined in section 2.3, the underlying soils within the study areas consist primarily of Hydrology Group B as per TP108. The curve numbers and initial losses (initial abstraction) used in the hydrological assessment are shown in Table 5 below.

Table 5: SCS Curve Number and Initial Abstraction

Coverage	CN	Initial Abstractions
Impervious areas	98	0
Pervious areas	74	5

5.3 Coverage

The average impervious coverage for existing sub-catchments is 10%, ranging from 0% to 30%, and estimated from aerial photos.

The impervious coverage for proposed sub-catchments have been estimated based on the preliminary master plan as shown in Figure 10 with the following assumptions:[6]

- 0% for green area
- 10% Mixed Rural area
- 65% for residential area
- 90% for business area

As a result, the entire site has an average impervious coverage of 63% under the proposed development.

The impervious coverage for existing and proposed sub-catchments utilised for this assessment is summarised in Table 6.

It is noted that the impervious assumption of 3% within the sub-catchment N04_P for this stormwater plan reflects the development limitation relating to flood depth and ecological features which restrict the potential yield within this particular sub catchment. This assumption is validated by the ecological assessment and flood extents which are detailed in previous and subsequent sections within this report.

Should future investigations deem greater potential the increase of impervious area would require mitigation of the (potential) increased stormwater discharge with respect to peak flow and volume.

It is to be noted that the flood modelling reflects the structure plan assumption of residential area for sensitivity assessments, as outlined in the subsequent sections of this report.

[6] Impervious coverage percentage reflects the Auckland Unitary Plan zoning and Healthy Waters supplied information

Table 6: Impervious Coverage Assumptions for Existing and Proposed Sub-catchments

Existing Sub-catchments		
Name	Catchment Area (ha)	Impervious for Existing (%)
N01_1	8.90	10%
N01_2	11.20	10%
N01_3	0.84	15%
N01_4	2.63	15%
N01_5	2.14	0%
N02	0.50	15%
N03	0.85	0%
N04	4.49	3%
N05_1	1.01	3%
N05_2	0.94	0%
N06	0.78	0%
S01_1	2.40	0%
S01_2	2.50	0%
S02_1	4.71	0%
S02_2	2.09	0%
S02_3	21.34	10%
S03_1	4.81	20%
S03_2	1.48	20%
S04_1	0.98	30%
S04_2	0.71	30%
S04_3	0.27	10%
S05_1	2.20	30%
S05_2	2.89	30%
Total	**80.7**	**10%**

Proposed Sub-catchments		
Name	Catchment Area (ha)	Impervious for Post (%)
N01_P_1	13.16	65%
N01_P_2	10.04	65%
N01_P_3	1.36	65%
N01_P_4	1.80	65%
N02_P	0.54	65%
N03_P	0.95	65%
N04_P	4.07	3%
N05_P_1	1.61	65%
N05_P_2	0.76	0
S01_P	6.24	65%
S02_P	31.76	70%
S03_P_1	4.35	65%
S03_P_2	1.67	65%
S04_P	2.36	65%
Total	**80.7**	**63%**

5.4 Peak Flow Assessment

The existing and fully developed peak flows for each stormwater receiving environment for 50%, 10% and 1% AEP event with climate change are summarized in Table 7. It shows that there is an 18% -99% increase in the total flows discharging to receiving environments resulting from the full development within the site.

Table 7: Peak Flow Summary for Each Stormwater Discharge Receiving Environment

Receiving Environment	50% AEP		10% AEP		1% AEP	
	Existing (m^3/s)	MPD (m^3/s)	Existing (m^3/s)	MPD (m^3/s)	Existing (m^3/s)	MPD (m^3/s)
Riverhead Forest Stream	4.43	7.02	9.77	13.22	18.89	22.95
Difference	*+2.59 (59%)*		+3.45 (35%)		+4.06 (22%)	
Riverhead Point Drive drainage	0.45	0.67	0.97	1.25	1.87	2.20
Difference	*+0.22 (48%)*		+0.28 (29%)		+0.33 (18%)	
Southern Stream	0.53	1.05	1.17	1.98	2.29	3.46
Difference	*+0.52 (99%)*		+0.81 (69%)		+1.17 (51%)	

6 Stormwater Management Requirements

6.1 Regulation and Design Requirements

This section outlines the overarching regulations and requirements which influence the stormwater management strategy.

6.1.1 Auckland Unitary Plan

Stormwater management principles for the development area are guided by the following sections of the AUP (OiP) and development within the site must meet the relevant objectives and policies unless otherwise covered by other regulatory mechanisms (e.g. Network Discharge Consents).

- E1 – Water Quality and Integrated Management
- E2 – Water quantity allocation and use
- E3 – Lakes, Rivers, Streams, and Wetlands
- E8 – Stormwater – Discharge and diversion
- E9 – Stormwater quality – High contaminant generating car parks and high use roads
- E10 – Stormwater management area – Flow 1 and Flow 2
- E36 – Natural hazards and flooding

It is noted that the site is not within Stormwater Management Area (SMAF 1 or SMAF 2), however the SMAF 1 mitigation is to be applied to the site as required by the NDC.

6.1.2 NDC Requirements

The development site is categorised as a Greenfield and such the following requirements are applied according to the Auckland Regionwide Stormwater Network Discharge Consent (NDC) Schedule 4 (Figure 12).

- **<u>Water quality</u>**: GD01 treatment required for all impervious areas
- **<u>Stream hydrology</u>**: AUP SMAF 1 mitigation requirement is required for area discharging to streams.
    - provide retention (volume reduction) of at least 5mm runoff depth for the impervious area for which hydrology mitigation is required; and
    - provide detention (temporary storage) and a drain down period of 24 hours for the difference between the predevelopment and post-development runoff volumes from the 95th percentile, 24 hour rainfall event minus the 5 mm retention volume or any greater retention volume that is achieved, over the impervious area for which hydrology mitigation is required.
- **<u>Flooding-10% AEP</u>**: peak flow attenuation might be required if downstream network has insufficient capacity depending on downstream network capacity analysis (Section 6.2
- **<u>Flooding-1% AEP</u>:** in accordance with SWCoP, attenuation might be required if downstream buildings are in flooding areas.

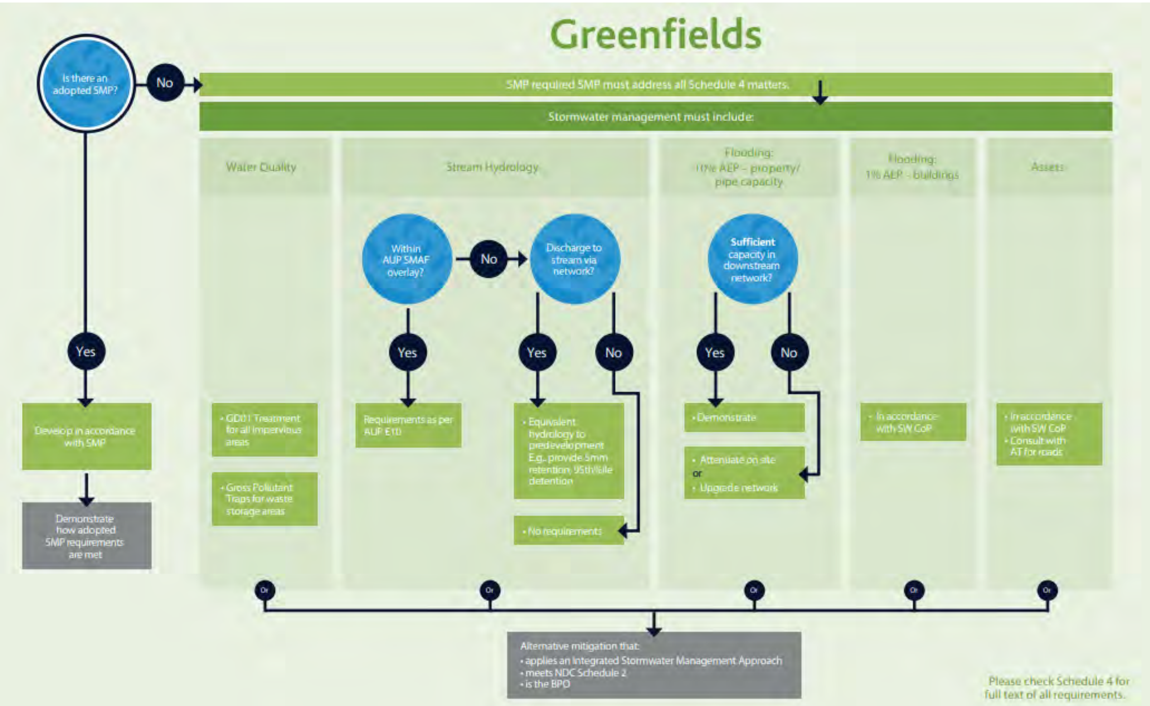


Figure 12: Flowchart of Stormwater Connection Requirement for Greenfields (NDC Schedule 4)

6.1.3 Riverhead South Development SW Connection Requirements

The as-built Riverhead Point Drive drainage (primary pipeline and secondary OLFP) has been constructed during the Riverhead South development. Referring to the stormwater investigation report [7] prepared in 2014 in support of a Special Housing Area (SHA) application at 1186 Coatesville Riverhead HW (within the

[7] Stormwater Investigation Report by Cato Bolam Consultants for Proposed Development at 1186 Coatesville-Riverhead Highway Riverhead, 19th June 2014

site), the trunk pipeline at Riverhead Point Drive was designed to be Ø675mm with a capacity to cater for additional flow at a pre-development level from catchment area of 5.4ha to the western side of Coatesville Riverhead HW. Based on this investigation, the following stormwater strategy had been advised by AC Housing Project Office[8] for the area draining to the Riverhead Point Drive drainage in 2014:

- Onsite attenuation for 50% AEP and 10% AEP storm events would be required, and
- Onsite attenuation for 1% AEP event will not be required if there are adequate overland flow paths and no downstream dwellings affected by flooding.

It is noted that the pipeline has been built as Ø750mm and as such a higher conveyance capacity will be expected. CKL has conducted a detailed pipe capacity assessment to support the stormwater management strategy for the site, refer to Section 0.

6.2 Attenuation Requirements

As per NDC's requirements specified in section 6.1.2, attenuation requirements are subject to the downstream network and/or flooding condition. A specific "attenuation requirements" assessment has been undertaken for each of three receiving environments and presented in the following sections.

6.2.1 Discharging to the Southern Stream

The proposed development area discharging to the Southern Stream will be increased by 2ha which results in peak flow increase of 0.81 m^3/s or 69% for AEP 10% storm and 1.17 m^3/s or 51% for 1% AEP event[9].

This receiving environment features a stream, acting as an OLFP, and a stormwater structure, Ø1200mm culvert under Coatesville-Riverhead Highway, which have been included in the hydraulic flood model developed for the Flood Risk Assessment.

As per the downstream impact assessment in Section 9.4.1, the proposed development discharge will not have an adverse impact on the downstream buildings and the Ø1200mm Coatesville-Riverhead Highway culvert. Therefore, attenuation will **not** be required for the sub-catchments discharging to the Southern Stream, which includes S01_P and S04_P[10].

6.2.2 Discharging to Riverhead Point Drive drainage

The Riverhead Point Drive drainage includes the public stormwater pipeline (for up to 10yr event) and secondary OLFP within the Riverhead Point Drive Road as shown in Figure 6. The attenuation requirements assessment is undertaken against the two systems as following.

Public stormwater pipeline for 10% AEP

A pipe capacity check has been conducted for the two critical pipes of the public pipeline within Riverhead Point Drive for 10% AEP rainfall event with effect of climate change (Figure 13).

[8] Response to Information Requested for Special Housing Area Application, 20th June 2014
[9] Refer to the summary of sub-catchment plans (Table 2 and Table 3) and peak flow assessment (Table 7),
[10] Sub catchments S01_P and S04_P illustrated in Figure 11

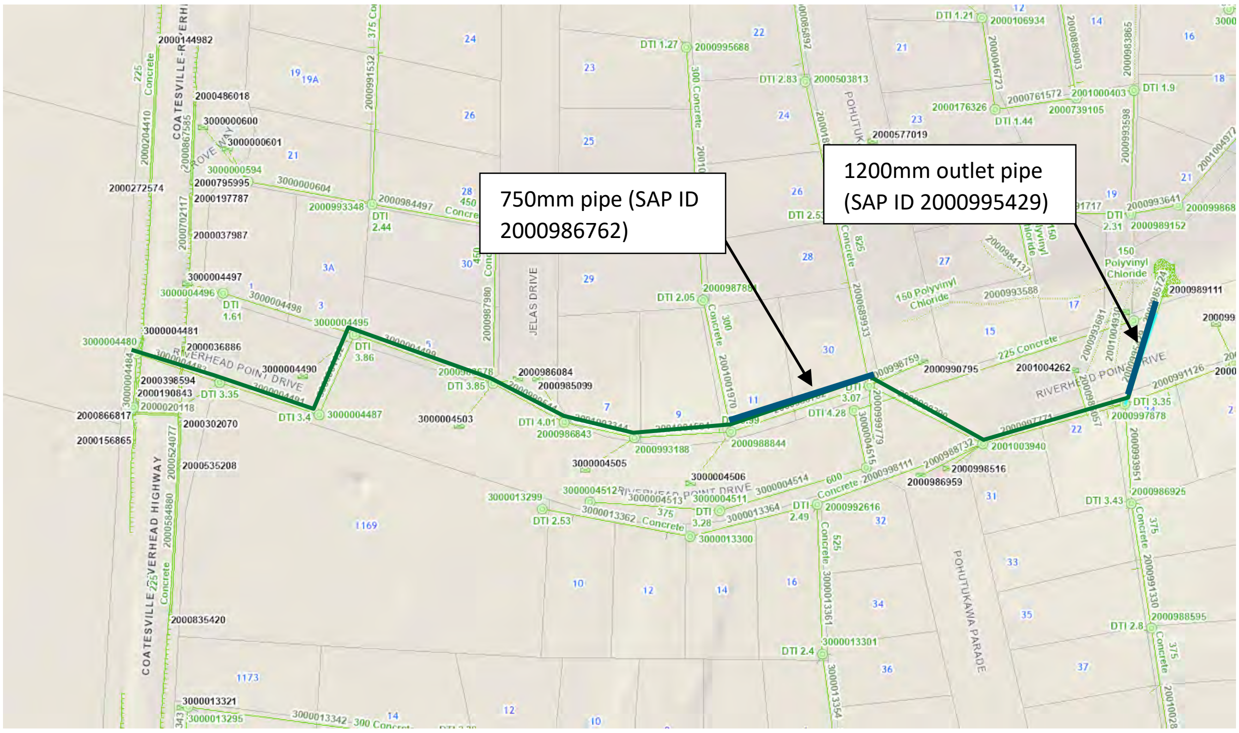


Figure 13: Existing Public Stormwater Pipeline with Connection for the Site within Riverhead Point Drive

A HEC HMS model was built to calculate the peak flow from contributing catchment of the existing network, which excludes the subject site, for MPD development. This establishes the current servicing requirements for the network rather than the proposed (servicing requirements).

The Colebrook-White formula has been used for pipe capacity check with roughness coefficient k=0.6mm based on NZ Standards 4404[11] to consider potential pipe condition. The slope of the pipes were calculated based on upstream and downstream manholes invert levels from AC GeoMaps. The result is summarized in Table 8 with supporting calculations appended (Appendix B Calculations) for reference.

Table 8: Pipe Capacity Check for Existing SW Pipe within Riverhead Point Drive

Pipe (SAP ID)	Size (mm)	Slope	Capacity (m^3/s)	MPD Catchment Discharge (m^3/s)	Remaining Capacity (m^3/s)
2000986762	750	2.6%	2012	0.54	1.48
2000995429	1200	2.5%	6688	2.42	4.27

The results show that the critical 750mm pipe (last section of 750mm pipeline) has remaining capacity (extra capacity) of 1.48 m^3/s while the 1200mm outlet pipe has extra capacity of 4.27 m^3/s. This means that the Riverhead Point Drive pipeline has sufficient remaining capacity to discharge the additional unattenuated peak flow from the site (6.0 ha), which is 1.25 m^3/s (Table 7) under full development condition (MPD).

In this regard, attenuation for 10% AEP event is **not** required for the sub-catchments discharging the Riverhead Point Drive stormwater pipeline, which is 6.0 ha including sub-catchment S03_P_1 and S03_P_2.

[11] NZS 4404:2010 Land Development and Subdivision Infrastructure

Secondary OLFP for 1% AEP

According to the impact assessment in Section 9.4.2, during 1% AEP event, for both blockage and no-blockage scenarios, the flood water on the OLFP is contained within the road corridor and there is no impact on the buildings on both sides of the road.

As above, onsite attenuation for 1% AEP event will ***not*** be required for the sub-catchments within the site (S03_P_1 and S03_P_2) discharging to Riverhead Point Drive OLFP since there are adequate overland flow paths and no downstream dwellings affected by flooding.

6.2.3 Discharging to Riverhead Forest Stream

The Riverhead Forest Stream receiving environment features a conveyance constraint of the culvert under Riverhead Road (as shown in Figure 6) and downstream building flooding issue. The CKL's flood risk assessment has assessed these two issues and provided in Section 9.4.3.

Riverhead Road culvert

The existing Riverhead Road Ø750mm culvert has insufficient capacity for the contributing catchment with 100mm road overtopping occurring during 10% AEP storm under existing condition (ED development and no climate change). The road overtopping depth will be increased by 40mm by the increased flow discharge (and no change to culvert size) from the proposed development within the site during 10% AEP event. The attenuation for 10% AEP will be required for the southern sub-catchment (S02_P) unless the culvert is to be upgraded with sufficient capacity.

Therefore, it is recommended to upgrade this culvert to allow flow full MPD flow for up to 1% AEP event to pass unimpeded downstream. According to the flood model result, the upgrade of the Riverhead Road culvert will have less than minor impact on downstream.

Downstream building flooding

The proposed development (within the site) will increase the flood level on downstream flooded properties, downstream of Duke Street, by less than 30mm during 1% AEP (with no attenuation applied to the discharging flow).

According to the NDC's requirement, stormwater attenuation should be required for 1% AEP due to above issues. However, the flood modelling outcomes demonstrates that onsite attenuation for 1% AEP might worsen the downstream flood risk (further increase of 40mm in flood level -total of 70mm) due to the location of the site within the stream catchment. This is detailed further in Appendix 3.

Therefore, considering the impact on downstream properties is less than minor (less than 30mm increase and existing flood depth greater than 300mm during 1% AEP), CKL has recommended that the attenuation for 1% AEP event is not applied to the sub-catchments within the site discharging to Riverhead Forest Stream. Currently (at the time of writing) AC HW's is reviewing this recommendation.

In summary, it is recommended to upgrade the Riverhead Road culvert to have sufficient capacity for 1% AEP flow and the attenuation is ***not*** recommended for up to 1% AEP for the sub-catchments discharging to Riverhead Forest Stream.

7 Proposed Stormwater Management Strategy

A high-level stormwater management strategy has been developed in accordance with the identified requirements. The stormwater management strategy demonstrates the overarching principles of how the site's stormwater is to be managed. Stormwater management in this area has the objective of minimising or mitigating any detrimental effects of urban development on the receiving environment.

The proposed stormwater strategy is summarized as follows:

- Water Quality
  - Inert roofing and cladding materials for buildings to reduce contaminant generation
  - Water quality treatment (90th percentile storm) for all impervious paving areas to minimise contaminants entering the receiving environment
- Hydrological Mitigation
  - Disposal to soakage wherever feasible
  - Stream protection
    - SMAF 1 Retention (5mm) for all impervious surfaces draining to stream receiving environment to mimic the pre-development hydrology and maintain stream base flows
    - SMAF 1 Detention (95th percentile runoff minus retention volume) for all impervious surfaces draining to stream receiving environment to reduce the erosive velocities of frequent storm events
- Flood Attenuation
  - Attenuation is not recommended for the entire site
- Conveyance
  - Primary network for up to the 10% AEP peak flow conveyance (with climate change), and
  - Secondary flow path for up to the 1% AEP peak flow conveyance (with climate change).
- Discharge Outlet
  - Erosion protection/energy dissipation to be provided at outfalls/discharge points to mitigate scour, and
  - Discharges to be integrated into the stream environments as far as practicable.

The proposed stormwater management strategy based on receiving environment is summarized in Table 9.

Table 9: Summary of Proposed Stormwater Management Strategy Based on Receiving Environment

Receiving Environment	Riverhead Forest Stream		Riverhead Point Drive drainage	Southern Stream
Sub-catchments	All northern site sub-catchments	S02_P	S03_P_1, S03_P_2	S01_P, S04_P
Water quality Treatment	WQ treatment 90th percentile for all impervious paving area	WQ treatment 90th percentile for all impervious paving area	WQ treatment 90th percentile for all impervious paving area	WQ treatment 90th percentile for all impervious paving area
Stream Protection	SMAF 1 retention and detention for all roof and impervious paving area	SMAF 1 retention and detention for all roof and impervious paving area	*Not required*	SMAF 1 retention and detention for all roof and impervious paving area
Attenuation	Not proposed	Not proposed	*Not proposed*	*Not proposed*
Conveyance	Primary for 10% AEP; Secondary for 1% AEP	Primary for 10% AEP; Secondary for 1% AEP	Primary for 10% AEP; Secondary for 1% AEP	Primary for 10% AEP; Secondary for 1% AEP
Discharge Outlet	Erosion protection required	Erosion protection required	*Protection not required*	Erosion protection required

8 Stormwater Management Plan

The stormwater management plan has been developed to implement the stormwater management strategy developed for the site's proposed development to meet the overarching Regional Wide NDC requirements for this large greenfield development.

8.1 Opportunities and constraints for Stormwater management devices

A "Functionality Matrix" of stormwater management devices in GD01 has been summarised in Table 10, which identifies which strategy requirements can be met by each device.

Table 10: Functionality Matrix for Stormwater Treatment device in GD01

Device	Mitigation for Stream Protection			Flood Attenuation	Water Quality
	Retention		Detention		
	Infiltration	Re-use			
Living Roof	✓	×	✓	×	×
Pervious Paving	✓	×	✓	×	×
Rainwater Tank	✓	✓	✓	✓	×
Bioretention Devices	✓	×	✓	×	✓
Swales	×	×	×	×	✓
Infiltration Devices	✓	×	×	×	×
Wetland and Ponds	×	×	✓	✓	✓

This SMP has considered all opportunities and constraints for devices listed in Table 10 to identify the best practical stormwater management devices for this proposed development site.

Table 11 summarises the outcome of this investigation.

Table 11: Stormwater Management Device Advantages and Limitations

Device	Pros	Limitation	Recommendation
Living Roof	• Achieves detention and retention for residential buildings • Amenity • Noise insulation and enhanced air quality and dust interception. • Reduce the impervious area	• It is not possible to direct the runoff from roads and car parks to this device • Higher construction and maintenance costs • Generally, not suitable for volume control • Not suitable for water quality • Where water quality is required, it needs to be incorporated with another SW device	✗ Not recommended for this development
Pervious Paving	• Active system could provide detention and retention. • Reduce the impervious area • Providing amenity	• Not preferred option by Auckland Transport for roads • Noisy on roads when used in high vehicle traffic area • If pervious paving fails, the surface will be considered out of compliance • Generally, not suitable for volume control • Not suitable for traffic areas of high acceleration, deceleration or turning. • Where water quality is required, it needs to be incorporated with another SW device	✓ Permeable paving is recommended where feasible to reduce impervious area
Rainwater Tank	• Able to provide detention and retention • Reduce the use of potable water from the public water supply system for non-potable uses (such as garden irrigation) • Simple to construct with well-understood operation and maintenance	• Not preferred option by Auckland Transport for roads • Not suitable for water quality • Where water quality is required, it needs to be incorporated with another SW device	✓ Recommended for on-lots/at-source SMAF 1 <u>retention</u>, <u>detention</u> and <u>10% AEP attenuation</u> if required

Device	Pros	Limitation	Recommendation
Bioretention Devices	• Provides a full suite of stormwater management with detention, retention, and water quality treatment • Provide enhanced amenity, safety, and aesthetic value through planting and educational opportunities	• Specific construction methods • Specific operation and maintenance • No need to be combined with another SW device to achieve the mitigation requirements	✓ Recommended for at-source and communal treatment and SMAF 1 retention and detention subject to site specific Geotech investigation (device needs to be at least 300mm above seasonal high groundwater table)
Swales	• Only could provide water quality treatment • Simple to construct with well-understood operation and maintenance	• Easily damaged (e.g. compression of soil from vehicles) • Need to be incorporated with another SW device to achieve detention and retention	✓ Recommended for communal treatment and conveyance
Infiltration Devices	• Able to provide the retention • Recharge groundwater	• Not suitable for detention, water quality treatment. • Need to be incorporated with another SW device to achieve detention and water quality treatment	× Not recommended due to potential low infiltration rate based on preliminary Geotech investigation but subject to further specific testing if necessary (minimum required rate >10mm/hr in GD01)
Wetland and Ponds	• Able to provide water quality and detention • Added amenity value for local communities	• Not provide retention • Safety, e.g. potential drowning, and vector source • Improved biodiversity and habitat • Generally used for drainage of more than 2 ha	✓ Recommended for communal treatment and SMAF 1 detention and attenuation if required.

8.2 Stormwater management options

The stormwater management options have been investigated and summarized in the following sections.

8.2.1 Soakage disposal

Soakage disposal has advantages of volume reduction to the receiving environment and ground water recharge. Utilizing soakage devices with pre-treatment for stormwater discharge will eliminate the mitigation requirements. However, based on the preliminary geotechnical investigation as summarized in Section 2.3.1, the ground water level is relatively high (<1m deep) at some locations across the site and *"it is likely that the clay soils onsite will be poorly draining"*. Therefore, the soakage disposal is **not** recommended for the site unless future investigation demonstrate that sufficient soakage is available.

8.2.2 At source management

This option involves utilizing suitable devices to achieve the required quality and quantity requirements within individual lots. This results in each lot being self-sufficient with respect to stormwater management before discharging to a public conveyance system. Suitable at-source device options for the contributing (runoff) areas include following:

Roof (Inert building materials)

- Rainwater tanks are suitable for retention/detention/attenuation.

Paving within lots

- Bioretention devices (raingarden) for WQ treatment, and SMAF 1 retention and detention, if required,
- Equivalent Landscaping area with 300mm topsoil for retention only, and
- Underground tanks for detention and attenuation if required

Roads

- Bioretention (raingarden or bioretention swale) for WQ treatment, and SMAF 1 retention and detention if required, and
- Underground tanks for detention and attenuation if required.

The main disadvantages for at-source management include the following:

- Number of devices for maintenance and inspection
- Ensuring there is sufficient area for other services can be difficult within lots
- Space constraints for development

A fully at-source management system is **not** recommended for this large development, however a combination with communal management is suitable. (See section below).

8.2.3 Communal management

A communal device, e.g. wetland, basin/pond and bioretention devices, will achieve required quality and/or quantity requirements in several centralized locations. The main advantages include but are not limited to the following:

- Maintenance is simple to complete with minimal disturbance to public, and
- Provides a "green" aesthetic outlook for the community.
- Devices, such as wetlands and bioretention, can provide a very high level of treatment and detention, attenuation in one device.

- Communal devices, such as wetlands, can be integrated into the green infrastructure of the project and support the ecological outcomes (both aquatic and terrestrial)

A concept design level for communal device footprint for each sub-catchment has been estimated based on the following assumptions:

- treatment only: 2% of impervious catchment area
- treatment and SMAF 1 mitigation: 5% of impervious catchment area

The conceptual estimation of communal device areas is given in table below with the footprint and potential location indicated in CKL drawing 005 (Appendix A).

Table 12: Conceptual Estimation of Communal Device Areas for Each Sub-catchment

Catchment	Area (ha)	Impervious Coverage	Impervious area (ha)	High-level Communal Device Area (ha)	
				Treatment only	Treatment +SMAF 1
N01_P_1	13.16	60%	7.90	0.16	0.39
N01_P_2	10.04	75%	7.53	0.15	0.38
N01_P_3	1.36	60%	0.81	0.02	0.04
N01_P_4	1.80	60%	1.08	0.02	0.05
N02_P	0.54	60%	0.32	0.01	0.02
N03_P	0.95	60%	0.57	0.01	0.03
N04_P	4.07	3%	Not required		
N05_P_1	1.61	60%	0.97	0.02	0.05
N05_P_2	0.76	0	Not required		
S01_P	6.24	60%	3.75	0.07	0.19
S02_P	31.76	65%	20.64	0.41	1.03
S03_P_1	4.35	60%	2.61	0.05	0.13
S03_P_2	1.67	60%	1.00	0.02	0.05
S04_P	2.36	60%	1.42	0.03	0.07

8.2.4 Combination of at-source and communal devices

A combination of at source and communal devices will overcome the space constraints that are inherent with at source devices and large footprints for solely communal device approach.

Based on the existing site features, there are areas that are preferable to have a centralised devices to support sub-catchments where practical. This is subject to site specific geotechnical investigation. This approach will simplify the stormwater management of these sub catchments with respect to design, operation, and maintenance.

At-source devices will be utilized to make up the functionality constraints of the communal device, as identified in Table 10, and to reduce the communal device footprint if needed due to available area constraints.

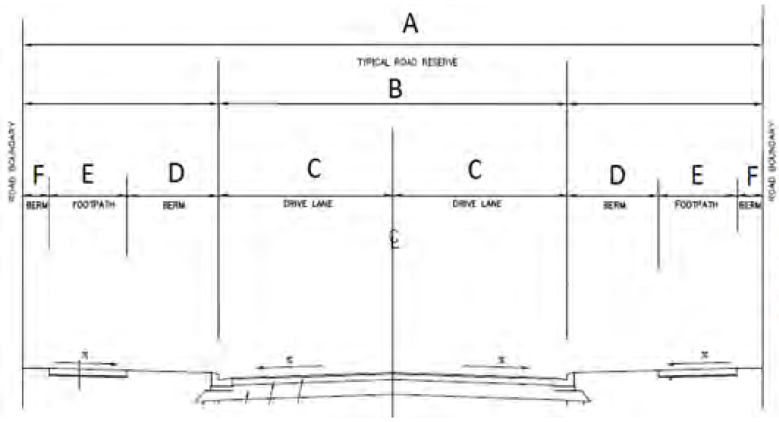
8.3 Best Practicable Stormwater Management Option

The best practicable stormwater management option (BPO) has been proposed respectively for sub-catchments discharging to each of three receiving environments. The BPOs are provided in detail in the following Sections 8.3.2 – 8.3.4, with a summary provided in Section 8.3.5.

With respect to overland flow path conveyance, Section 8.3.1, provides an assessment to cover all sub catchments.

8.3.1 OLFP conveyance - Secondary flow path

All sub-catchments will utilise the road reserve for overland flow path conveyance. A preliminary OLFP assessment using Manning's equation for a typical road reserve, as shown in Figure 14, has been undertaken



Total Road Reserve Width	A	18	m
Total Carriageway Width	B	6	m
Half Carriageway Width	C	3	m
Berm	D	1.5	m
Footpath	E	2	m
Berm	F	5	m
Road crossfall		3%	
Road gradient, m/m		0.010	m/m
Kerb height		125	mm
Height to centreline		0.090	m
Manning's 'n'		0.013	

Figure 14: Typcial Road Cross Section

The outcome of the assessment is summarized in Table 13.

Table 13: Preliminary OLFP Assessment for Typical Road Reserve for 1% AEP with CC

Road	Catchment Area (ha)	Flows (m^3/s)	Road Flood Depth(m)	Road Flood Width
Typical road	1.5	0.6	0.120	6.0m (within carriageway)
Typical road	8.0	3.0	0.220	9.0m (within berm and no flood on footpath)

It shows that the typical road reserve can convey the 1% AEP peak flow from a 1.5 ha catchment (assuming 70% imperviousness) within the carriageway, and there will be no flooding on the footpath for up to 8.0 ha catchment flow. The detailed calculation is provided in Appendix B for reference.

It is recommended that a swale is to be added adjacent to the road where the OLFP catchment area is larger than 8 ha. A conceptual assessment of swale sizing, for 10 ha catchment area, has been undertaken and outcomes presented in Table 14 .

Table 14: Summary of Preliminary Sizing of Conveyance Swale for 1% AEP Runoff for 10 ha Catchment (MPD)

Options	1% AEP Conveyance for 8ha catchment
Total depth (m)	0.42
Side slope	3H:1V
Base width	4.00
Top width (m)	6.5
Longitudinal Slope	1%
Swale capacity (m^3/s)	3.0

8.3.2 Southern Stream sub- catchments- BPO

The development area discharging to the Southern Stream includes two sub-catchments (S01_P and S04_P) which are within the proposed residential zone. The stormwater management requirement for these sub catchments includes WQ treatment and SMAF 1 retention and detention for all impervious area.

A bioretention device (raingarden or bioretention swale) can achieve all above requirements in one location and is suitable for both communal and at-source management. Therefore, a centralized bioretention device for each sub-catchment is the preferred option. Alternatively, when it is not feasible due to site constraints, at-source bioretention option combined with other devices is proposed respectively for lots and roads area.

The proposed primary stormwater disposal system for the residential development is illustrated in Figure 15 with components provided in detail in following sections.

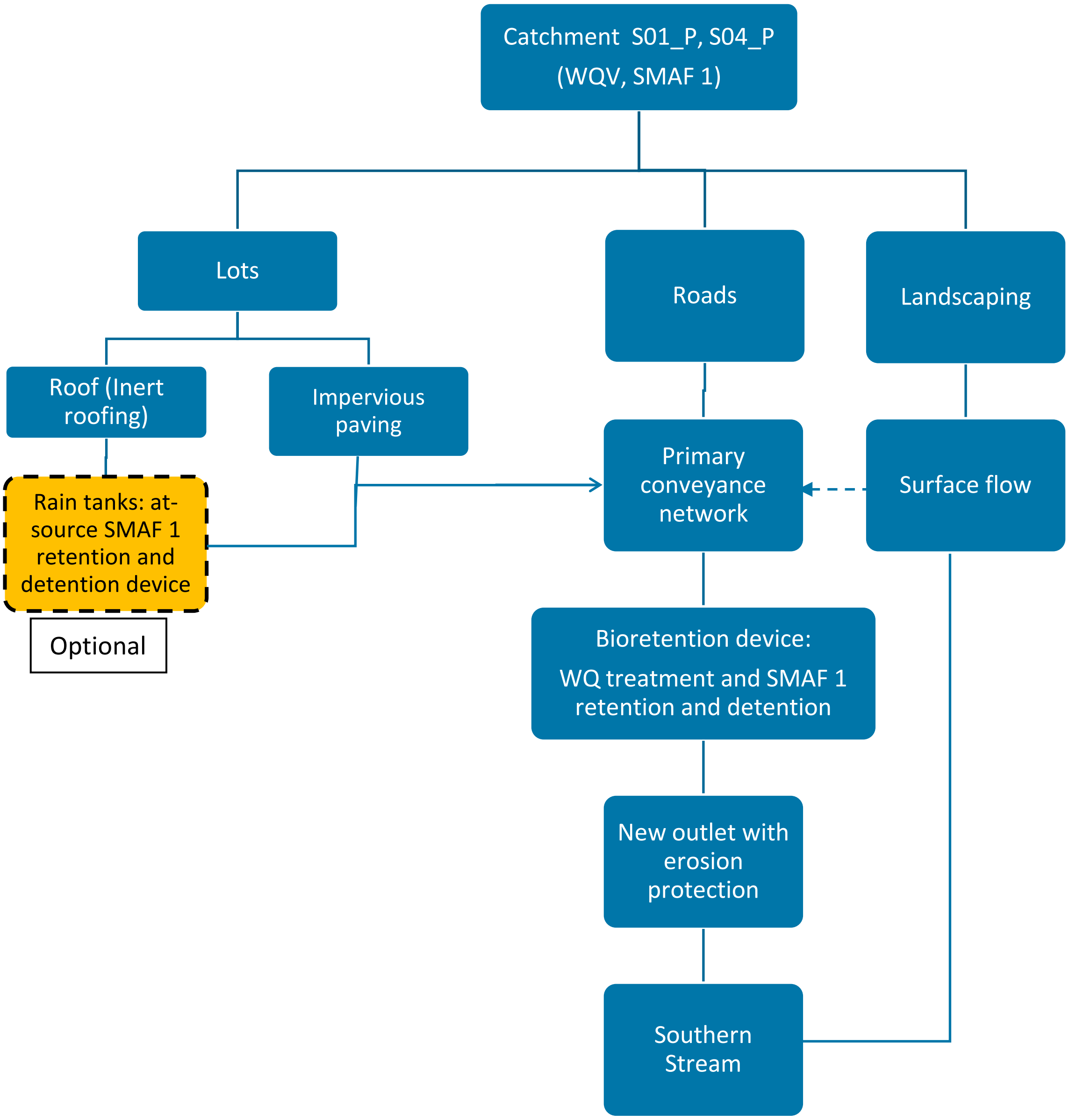


Figure 15: Proposed BPO SMP for Sub-catchments Discharging to Southern Stream

Communal bioretention device

A high-level estimation of the preferred communal bioretention device area is presented below:

- sub-catchment S04_P: = 700 m^2
- sub-catchment S01_P: = 1900 m^2

The potential location of communal device is indicated in CKL's drawing 005 (Appendix A). All the impervious area within the catchment will be connected to the communal device through a new primary conveyance system.

The cross-section of a typical bioretention device, is as shown in Figure 16.

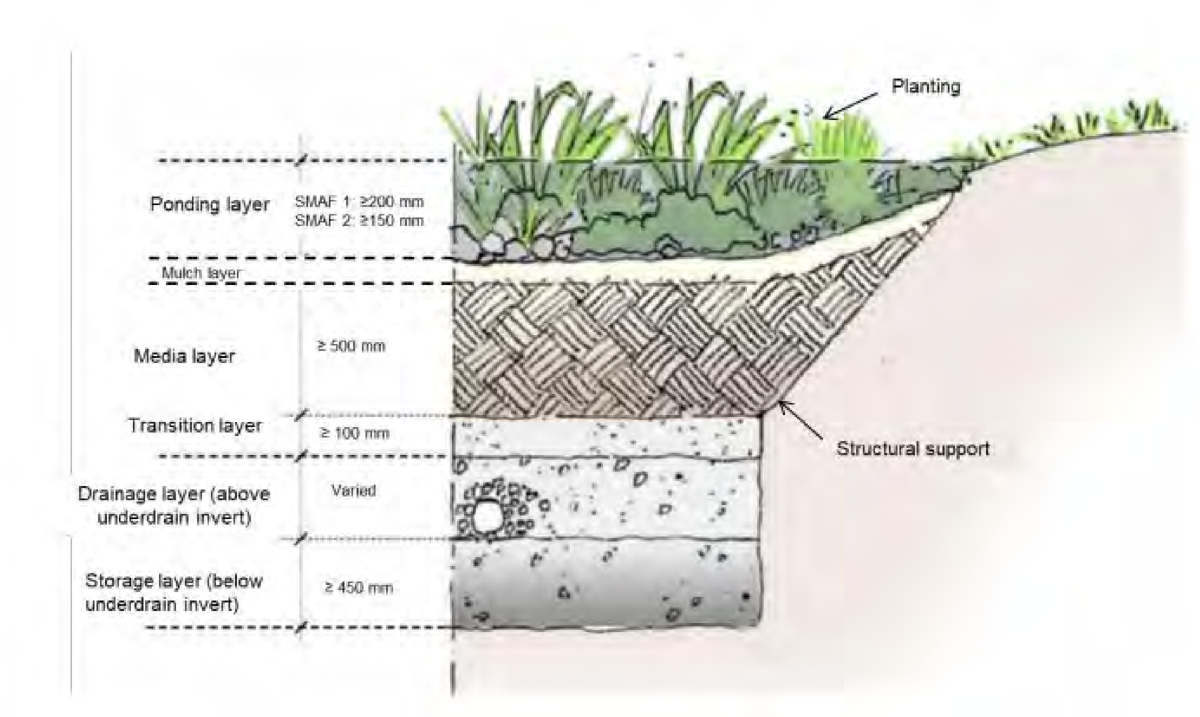


Figure 16: Schematic of Raingarden Device Cross-Section (GD01/2017)

A toolbox approach is provided to calculate the minimum bioretention device size for the required SMAF 1 retention and detention for each 100m^2 impervious contributing area. The typical design parameters, including areas, are given in Table 15.

Table 15: Typical Design of Communal Bioretention Device

Typical Bioretention Device	
Ponding Depth	200 (mm)
Media and Transition Layer Depth	600 (mm)
Media Void Ratio	40%
Drainage Media Depth	250 (mm)
Retention Depth	450 (mm)
Minimum Detention Ponding area	5.0(m^2)/100m^2 impervious Area
Minimum Retention Ponding area	3.5(m^2)/ 100m^2 impervious Area

The integration of the conveyance system to the bioretention device will be through the next stage of design. This will include diversion of treatment flows from the 10% AEP event runoff through the conveyance system. The OLFP will be directed away from the centralized bioretention device to avoid erosion and re-suspension of sediment.

At-source devices

At -source device options will be implemented should the communal bioretention devices not be deemed feasible due to site constraints. The stormwater management for these two sub-catchments can be achieved through following at-source devices:

- Inert cladding
- Rainwater tank for roof area
- Bioretention devices for paving and road

Inert cladding

It is proposed to utilize *inert or low contaminant generating cladding* material for buildings to minimize the pollutant generating surfaces and such water quality treatment will not be required for roof areas.

Rainwater tank for roof area

An above-ground *rainwater tank* is recommended to provide required SMAF 1 retention and detention for the roof area if required. The retention volumes can be used for non-potable reuse (e.g. gardening). An orifice will be installed for 24hr drain down control which will be sized during design stage.

The minimum required retention and detention volume for each 100m^2 roof area is presented in Table 16.

Table 16: Minimum Required Retention and Detention Tank Volume for 100m2 of Roof Area

	Volume per 100m^2 roof area (L)
Retention Volume	500
Detention Volume	1821

Bioretention devices for impervious paving and road

Several *bioretention devices* (raingardens or bioretention swale) can provide treatment and SMAF 1 requirement for the impervious paving within lots and roads. The typical raingarden size for each 100 m^2 impervious area provided within Table 15 above.

As per the AUP, the water quality treatment and hydrology mitigation are not required for permeable paving area. Therefore, it is recommended to utilize permeable paving where possible to reduce the devices sizes.

Conveyance system

- Primary network

A primary piped network will be designed to convey flows up to 10% AEP with climate change for MPD condition. Outlets are to be designed to manage the effects of erosion.

- Secondary flow path

The sub-catchment area of S01_P and S04_P is less than 10 ha. Therefore, it is proposed to utilize the roads OLFPs for conveyance of the overland flow from the road reserve and adjacent lots that flow towards the road reserve for up to 1% AEP event.

The secondary flow path for these sub-catchments will follow the contours to the receiving environment (southern stream). A rock rip rap will be required for erosion protection at the outlets to watercourse. The secondary flow path alignment will be designed to be away from the centralized bioretention device.

8.3.3 Riverhead Point Drive – sub-catchments BPO

The development area discharging to the Riverhead Point Drive includes two sub-catchments (S03_P_1 and S03_P_2) with a total area of 6.0ha falling within proposed residential zone. The stormwater management requirement for this area includes WQ treatment for all impervious area.

The proposed BPO for these two catchments is illustrated in Figure 17 and summarized in the following.

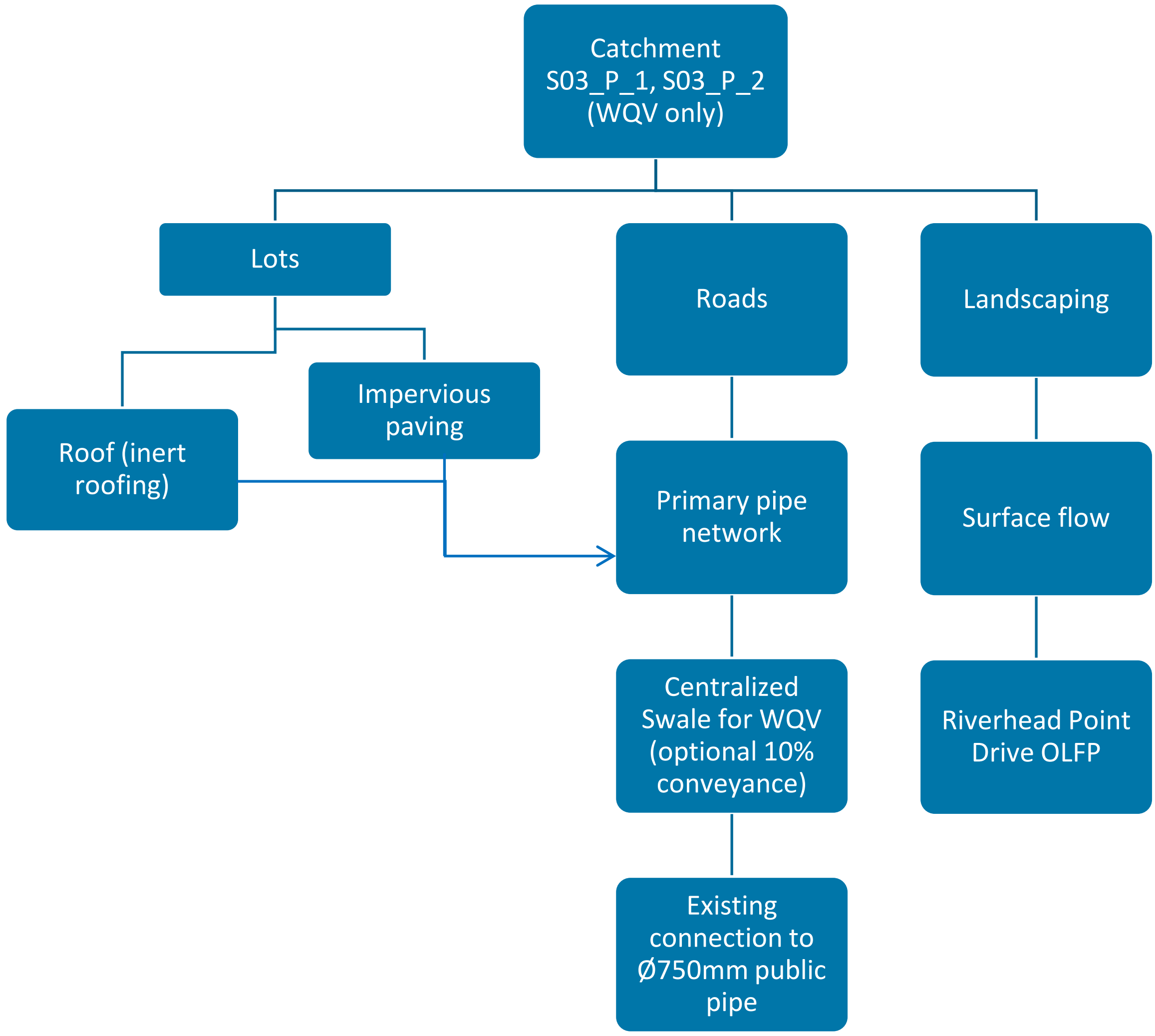


Figure 17: Schematic of Proposed BPO for Sub-catchments Discharging to Riverhead Point Drive

At source

It is recommended to utilize inert roofing and cladding materials for buildings and permeable paving where possible within lots.

No onsite device is required for this BPO.

Centralized Swale

A single centralized vegetated swale is proposed to achieve WQV requirement for all the impervious paving area within two sub-catchments and diversion of catchment flows for up to 10% AEP event.

The best potential location for the proposed communal swale is at the central road which will connect to the intersection of Coatesville-Riverhead Highway and Riverhead Point Drive. A proposed primary pipe system will connect all the impervious area to the centralized swale where required WQV will be provided. An outlet riser (scruffy dome) will be installed at the end of the swale to convey larger connecting to the existing Ø750mm public pipeline.

A preliminary swale sizing has been completed based on WQ flow for 90th percentile event for the two sub-catchments and 10% AEP runoff conveyance and summarized in Table 17.

Table 17: Summary of Preliminary Sizing of Communal Swale for WQV and 10% AEP Conveyance

	WQV+10% AEP Conveyance
Total Depth (m)	0.50
WQ Side slope	5H:1V and 3H:1V
Base width	1.50
Top width (m)	5.7
Longitudinal Slope	2%
Length (m)	103
WQV flow (m^3/s)	0.17
10% AEP peak flow (m^3/s)	1.25

Conveyance System

- Primary network

The primary network includes pipes and centralized swale for 10% AEP storm conveyance for MPD condition.

- Secondary flow path

The secondary OLFP will be within the road reserve. Near the extent of the sub-catchment, the discharging point, the 1% AEP flow from the total catchment area might exceed the carriageway but no footpath flooding. The road network will eventually connect to the Riverhead Point Drive OLFP.

8.3.4 Riverhead Forest Stream – sub-catchments BPO

The stormwater management requirement for the catchment discharging to the Riverhead Forest Stream includes WQ treatment, SMAF 1 retention and detention for all the impervious area.

The proposed BPO for these catchments is illustrated in Figure 18 and detailed in following sections.

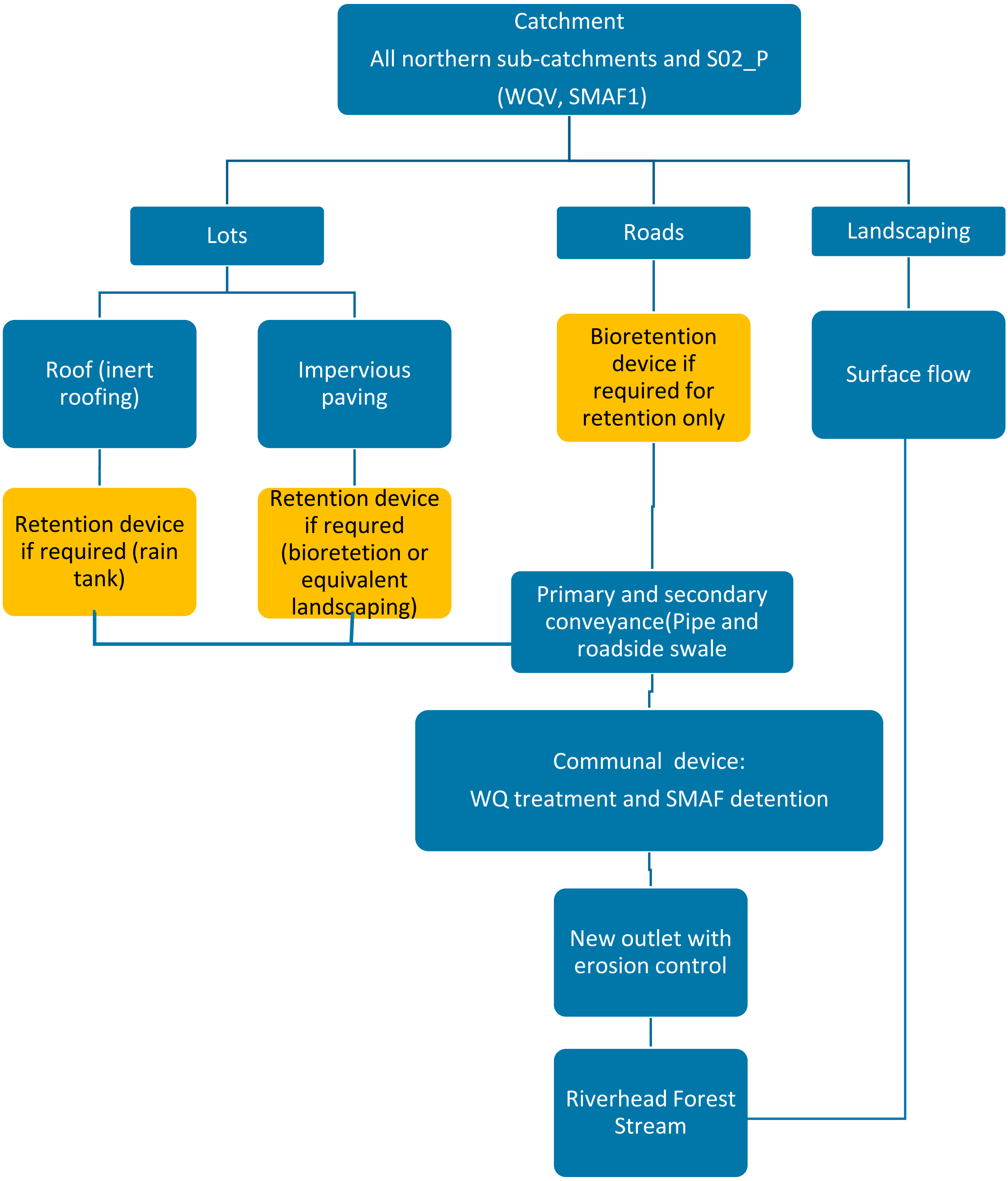


Figure 18: Proposed BPO SMP for Sub-catchments Discharging to Riverhead Forest Stream

Communal device

Communal stormwater management devices are proposed for each sub-catchment to meet the required stormwater management strategy. Based on the functionality of communal devices summarized in Table 10, it is proposed to use communal bioretention or wetland for WQV and SMAF 1 mitigation.

The type of proposed communal device with conceptual device sizing for each sub-catchment is summarized in Table 18 .

Table 18: Proposed Communal Device with High-level Sizing for Each Sub-catchment

Catchment	Area (ha)	WQV and SMAF 1 Device	
		Type of proposed device	Device area (ha)
N01_P_1	13.16	Wetland	0.39
N01_P_2	10.04	Wetland	0.38
N01_P_3	1.36	Bioretention	0.04
N01_P_4	1.80	Bioretention	0.05
N02_P	0.54	Bioretention	0.02
N03_P	0.95	Bioretention	0.03
N05_P_1	1.61	Bioretention	0.05
S02_P	31.76	Wetland	1.03

The conceptual areas presented in the above table relates to the total area required for each sub-catchment. For the larger sub-catchments, e.g. S02_P, these areas can be divided amongst smaller devices to manage site constraints. The potential locations and preliminary footprint areas are illustrated in CKL drawing 005, Appendix A.

At-source retention devices

The following devices are proposed for at-source SMAF 1 retention if the wetland communal device is proposed for the sub-catchment.

- Roof area
  - Rainwater tanks for roof area: 0.5 m^3 required for every 100 m^2 roof area
- Paving on lots
  - Utilize permeable paving where possible
  - Equivalent landscaping area with 300mm topsoil for impervious paving area
  - Bioretention device for retention only with minimum requirement as per Table 15
- Roads
  - Bioretention device for retention only with minimum requirement as per Table 15

The at-source retention will not be required if a communal bioretention device is proposed for the sub-catchment.

Conveyance system

- Primary pipe network

The primary pipe network will be designed to convey 10% AEP storm with effect of climate change. The pipe sizing will be designed during detail design stage.

- Secondary flow path

As per Section 8.3.1, the secondary flow path will utilise the road carriageway for catchment areas up to 8Ha. Thereafter, a swale is required adjacent to the road.

Riverhead Road culvert

The Riverhead Road culvert upgrade is recommended, however subject to AC's approval. The total flows from contributing catchment discharging to the culvert from CKL's flood model result are provided in Table 19.

Table 19: Total Flow at Riverhead Road Culvert for 10% and 1% AEP from HEC RAS Model

AEP	Total flows for MPD (m^3/s)
10% +climate change	12.84
1%+climate change	25.32

Based on a preliminary culvert sizing using the FHWA Culvert Design tool (HY8 7.6), the following culvert has been proposed:

- 4.5m width × 1.5m height box culvert

The analysis result shows that with the proposed culvert in place, the Riverhead Road will overtop by less than 200mm during 1% AEP event with climate change, and there is less than minor impact on downstream. The detailed calculation is provided in Appendix 2 for reference.

8.3.5 Summary of Proposed BPOs

The proposed BPOs for the three receiving environments are summarized in Table 20.

Table 20: Summary of Proposed BPOs Based on Receiving Environment

Receiving Environment	Riverhead Forest Stream	Riverhead Point Drive drainage	Southern Stream
Catchments	All northern sub-catchments and S02_P	S03_P_1, S03_P_2	S01_P, S04_P
Proposed SW Management Devices	• Communal wetland or bioretention device for each sub-catchment (single device or split to smaller ones) • On-site retention device for retention for sub-catchment where communal wetland is proposed	• Single communal swale for two sub-catchments for WQ treatment	• One communal bioretention device for each sub-catchment
Conveyance	• Pipe network for 10% AEP • Road OLFP (for area less than 10ha) and roadside swale (for area larger than 10ha) for 1% AEP • Outlet erosion control required	• Pipe network and swale for 10% AEP • Road OLFP for 1% AEP	• Pipe network for 10% AEP • Road OLFP for 1% AEP • Outlet erosion control required

9 Flood Risk Assessment

A flood risk assessment has been conducted to investigate the potential impact of the proposed development on the neighbouring and downstream properties and the effect of an “on-site flow attenuation option” for up to 1% AEP rainfall event. A HEC HMS and HEC RAS 2D model has been developed which has been reviewed during the development by the Healthy Waters (HW) modelling team in Auckland Council (AC) to support the assessment.

The assessment can be summarized in the following sections with further details in the flood risk assessment report (FRA report Rev02) provided in Appendix 3.

9.1 Data/Resources

The following data/information has been used for the model development:

- TP108 daily rainfall depth contours
- Auckland 2016 1m LiDAR DEM (AVD) provided by Heathy Water Department (AC HWD)
- Existing impervious polygons provided by AC HWD
- Maximum impervious percentage assumption for Zones as per Auckland Unitary Plan Operative in Part (AUP OiP) provided by AC HWD
- Topography survey within the site by Survey Group Ltd
- Survey data for culverts within surrounding area by Survey Group Ltd
- Draft concept plan

9.2 Hydrology Model

A HEC HMS model (version 4.10) has been developed using the TP108 methodology. The TP108 design rainfall depth (without climate change effect) for 50%, 10% and 1% AEP are used for the assessment while 1% AEP rainfall with climate change (3.8°C increase) are used for sensitivity check.

The sub-catchments are delineated respectively within and outside of the site (Refer Figure 2-4 in the FRA report in Appendix 3). It is assumed that the external catchment (outside the site) will remain the existing development (ED) for pre- and post- site development scenarios as recommended by the HW. The maximum probable development (MPD) is assumed for the site post-development with the impervious coverage assumed based on the zone plan and maximum impervious allowance of the AUP zones, e.g. % for green area, 65% for residential and 90% for Local and neighbourhood centre.

In order to assess the potential attenuation effect on the downstream flooding for 10% and 100% AEP event, with the lack of detail attenuation design at this stage, three dummy basins are assumed for three large sub-catchments (discharging to Riverhead Forest Stream) within the site in the HEC HMS model. The dummy basins provide sufficient storage to temporarily store the runoff from the sub-catchments and release the flow through outlet control at pre-development rate (attenuated flow).

The model is run for 24hr with 1 minute interval for all the scenarios. The resultant flow hydrographs for each sub-catchment are used as model inputs for the HEC RAS 2D hydraulic model. The attenuated flow hydrographs are used for the attenuation scenarios.

9.3 Hydraulic Model

9.3.1 Model build

A HEC RAS 2D model (version 6.3) was built to assess the hydraulic features of the catchment flows from the hydrology model. A summary of the model build is provided below with detail in the FRA report in Appendix 3.

- **Model extent**: The 2D model extent is extended to the west of Forest Road (upstream) and the Waitemata Harbour (downstream).
- **Flow boundary condition**: The flow hydrographs from the HEC HMS results for each sub-catchment are loaded as internal boundary condition in the 2D flow area. The loading locations are located within the lower portion of each sub-catchment.
- **Tidal boundary condition**: A constant tidal level (MHWS+1m rise)[12] at the Waitemata Harbour is used as downstream boundary condition.
- **Terrain model**: The terrain model was created from 2016 1m LiDAR DEM (AVD) provided by the HW and the topography survey for the site. It is note that the design surface is not available at the plan change stage.
- **Cell size**: The cell size in the 2D area is 5m x 5m with 2m x 2m refinement along roads, channels, OLFPs and site boundaries.
- **Structures**: A number of culverts with diameter no less than 600mm are modelled in the 2D model. The culvert information (e.g. size and invert level) are based on the survey/site visit and online GIS. The bridges are not modelled but the channels remain open at the bridges locations.
- **Energy loss**: The Manning's roughness 0.05 is assigned for roads and 0.1 for the rest of 2D area.
- **Scenarios**: A total of 14 scenarios, as per list in Table 13 in the FRA report, were modelled in response to the HW's request. It is noted that the pre-development scenarios are based on ED condition within the site and external catchments and rainfall without climate change, while the post-development scenarios are based on the MPD condition within the site, ED condition for external catchment and rainfall without climate change. The climate change scenario has considered the MPD condition for the external catchment and rainfall with climate change. In addition, a validation scenario is modelled for a comparison with the latest flood model result provided by the HW.

9.3.2 Model Validation

A model result comparison between the validation scenario result with AC model result shows that the CKL model is well validated. Referring the Section 4.1 in the FRA report (Appendix 3) for detail.

9.3.3 Model Limitations

The flood modelling limitations includes the accuracy of the LiDAR DEM within the channels and the exclusion of stormwater structures (e.g. bridges and pipes) in the model. In addition, the design surface

[12] Mean High Water Springs (MHWS)+1m sea level rise=2.83m at Waitemata Harbour as per Coastal Marine Area Boundary for the Auckland Region provided by AC

within the site is not available when the flood model is undertaken. The flood extent and OLFP alignment within the site for the post-development scenario is subject to a change at design stage.

The network capacity assessment is not provided in this flood risk assessment for the plan change application. It is recommended by the HW that a further modelling may be necessary to determine the impacts on this infrastructure for more frequent events to confirm the impacts of the plan change development on these assets and roads.

9.3.4 Further Refinement

As per the Section 8 in the FRA report (Appendix 3), the flood model has been reviewed by the HW model team respectively in April and November 2022. In general, the modelling that has been completed is considered appropriate for a plan change application, and it is recommended that as developments proceed within the plan change area the further model refinement may be required to provide updates to the potential impacts of specific developments on flood risk and to ensure that appropriate mitigation is provided if required. The specific model review comments provided on 23rd November 2022 (Table 17 in the FRA report) will be incorporated during the model refinement at the next stage of development as required by the HW.

9.4 Downstream Impact Assessment

The downstream impact assessment investigates the potential impact of the proposed development within the site on the downstream flood risk (without on-site attenuation), as well as the potential benefits or adverse impact of on-site flood mitigation. The assessment based on the flood model results provided in the FRA report, including flood maps and detailed tabular results at key locations as per HW's request, is provided in the Section 5 of the FRA report. The assessment focused on the four downstream areas (as indicated in Figure 10 of the FRA report) which are associated with three receiving environments as per Section 2.7, namely

- Riverhead Forest Stream (associated with Area 3 and 4 in the FRA report)
- Riverhead Point Drive drainage (Area 1 in the FRA report)
- Southern Stream (Area 2 in the FRA report)

Based on the above assessment (see the FRA report for detail) and the additional preliminary structure performance analysis, the downstream impact assessment for three receiving environments can be summarized in the following sections.

9.4.1 Impact on Southern Stream

The flood model result shows that although the flood level at the Southern Stream is increased by 20-50mm in this area (Area 2 in the FRA report Figure 10) for all rainfall events due to the proposed development, the flood water is contained within the existing Southern Stream bounds and no existing dwellings are affected by the stream OLFP.

Coatesville Riverhead Hwy Culvert:

In addition, the model result shows that at the 1200mm culvert at Coatesville Riverhead Hwy (as shown in Figure 6) there is no road overtopping happening for 10% AEP for post-site development condition. During the 1% AEP event, the road will overtop by 150mm depth under the existing condition and further increased by 40mm due to the site development. The culvert outlet velocity and downstream channel velocity will be increased by 0.03 m/s. This impact is considered insignificant.

As above, it is concluded that the site development will have no adverse impact on this receiving environment.

9.4.2 Impact on Riverhead Point Drive

The stormwater discharge to the Riverhead Point Drive under the proposed condition is through a new connection to the 750mm public stormwater pipeline (for up to 10yr event) and secondary OLFP within the Riverhead Point Drive Road as shown in Figure 6. The 750mm pipe is considered for the post-development scenarios in the HEC RAS model. The model result indicates that the overland flow within the Riverhead Point Drive Road (Area 1 in the FRA report Figure 10) for 1% AEP event is reduced due to the diversion through the proposed new connection to 750mm public pipe.

In addition, a blockage scenario for 1% AEP event is undertaken assuming the public stormwater pipeline is fully blocked and the result shows that there is a 10-30mm increase in the flood level within the Riverhead Point Drive. However, for both blockage and no-blockage scenarios, the flood water is contained within the road corridor and there is no impact on the buildings on both sides of the road.

9.4.3 Impact on Riverhead Forest Stream Receiving Environment

The existing flood modelling outcomes has identified flooding downstream of Duke Street in the Riverhead Forest Stream receiving environment (Area 4 in the FRA report Figure 10) with (flood) depth greater than 300mm during 1% AEP event. The proposed site development (to MPD) will increase the existing depth by 30mm during 1% AEP event, with subsequent flood risk factor (V*d) increase by less than 0.1. The impact is considered less than minor given the existing depth is greater than 300mm.

In addition, the attenuation assessment provided in the FRA report Section 5.2 (based on attenuation scenarios result) indicates that the on-site mitigation/attenuation might have an adverse impact on the downstream flood risk, i.e. making the above identified impact worse by further 40mm increase in flood level (total 70mm), due to the location of the site within the lower stream catchment. Therefore, the on-site attenuation is not recommended.

Riverhead Road culvert:

The model result at the Riverhead Road culvert (750mm) as shown in Figure 6 shows that the existing culvert has insufficient capacity with 220 mm road overtopping under the existing condition during 10% AEP rainfall without climate change.

It is recommended to upgrade the Riverhead Road culvert to have sufficient capacity for 1% AEP runoff conveyance. The culvert will be designed to meet the NZ standard. Based on a preliminary assessment, the culvert upgrading will have less than minor impact on the downstream. A further assessment will be required at design stage.

9.5 Conclusion

The proposed development has no downstream impact for the area discharging to Riverhead Point Drive and the Southern Stream. The potential impact downstream of Riverhead Forest Stream is less than minor and it noted that should attenuation be provided the effects are greater (than without attenuation). Therefore, on-site attenuation is not recommended for the entire site development for up to 1% AEP. The Riverhead Road culvert upgrade for up to 1% AEP flood conveyance is recommended.

10 Summary

A stormwater management plan (SWMP) and a flood risk assessment (FRA) has been prepared to support a Plan Change application to change the Riverhead Future Urban Zone to a mixture of residential and business zone. The SWMP and FRA is summarized as following.

10.1 Stormwater Management System

The stormwater management strategy and best practical option has been proposed respectively for sub-catchments discharging to each of three receiving environment and can be summarized in the following:

Sub-catchments discharging to South Stream

- SWM requirements
  - WQ treatment (90^{th} percentile event) for all impervious area
  - SMAF 1 retention and detention for all impervious area
- Proposed BPO
  - Inert roofing and cladding material for buildings
  - Permeable paving where possible
  - Communal/centralized bioretention device (raingardens or bioretention swale) for all impervious area for each sub-catchment (away from secondary OLFP)
  - Pipe network for conveyance of 10% AEP with climate change
  - Road OLFP for conveyance of 1% AEP with climate change

Sub-catchments discharging to Riverhead Point Drive

- SWM requirements
  - WQ treatment (90^{th} percentile event) for all impervious area
- Proposed BPO
  - Inert roofing and cladding material for buildings
  - Permeable paving where possible
  - Single communal bioretention swale for WQ treatment for all impervious area and 10% AEP runoff conveyance within total sub-catchment (6.0ha).
  - Pipe network and communal swale for conveyance of 10% AEP with climate change
  - Road OLFP for conveyance of 1% AEP with climate change

Sub-catchments discharging to Riverhead Forest Stream

- SWM requirements
  - WQ treatment (90^{th} percentile event) for all impervious area
  - SMAF 1 retention and detention for all impervious area
- Proposed BPO
  - Inert roofing and cladding material for buildings
  - Permeable paving where possible
  - Communal device each sub-catchment including
    - Bioretention device (raingardens or bioretention swale) for treatment and SMAF 1 mitigation
    - Wetland for WQ treatment and SMAF detention
  - Pipe network for conveyance of 10% AEP with climate change
  - Road OLFP for conveyance of 1% AEP with climate change for catchment area less than 10ha

- Roadside swale for conveyance of 1% AEP with climate change for catchment area larger than 10ha

10.2 Flood Risk Assessment

The primary objective of the FRA is to assess the potential impact on the downstream and the on-site attenuation benefit/effect to support the SWMP. A hydrology and hydraulic model have been developed for the FRA with methodology agreed by the AC HWD. The flood risk assessment report is prepared and provided separately in Appendix 3. The downstream impact assessment is completed based on the model results for three receiving environments. The on-site attenuation effect assessment is undertaken for the site area discharging to the Riverhead Forest Stream receiving environment. The main outcomes of this FRA is summarized based on receiving environments as following:

<u>Sub-catchments discharging to South Stream</u>

- The Coatesville-Riverhead Highway culvert has capacity for 10% AEP,
- There is no building flooding issued identified in the stream flood plain and the proposed development will not cause any new flooding issue.
- Therefore, <u>no attenuation</u> required for both 10% and 1% AEP event for these sub-catchments.

<u>Sub-catchments discharging to Riverhead Point Drive</u>

- The Riverhead Point Drive stormwater pipeline has sufficient remaining capacity to discharge the additional unattenuated peak flow from the site 10% AEP with effect of climate change,
- There is no building flooding issued identified on both sides of Riverhead Point Drive OLFP, and the proposed development will not cause any new flooding issue.
- Therefore, <u>no attenuation</u> required for both 10% and 1% AEP event for these sub-catchments.

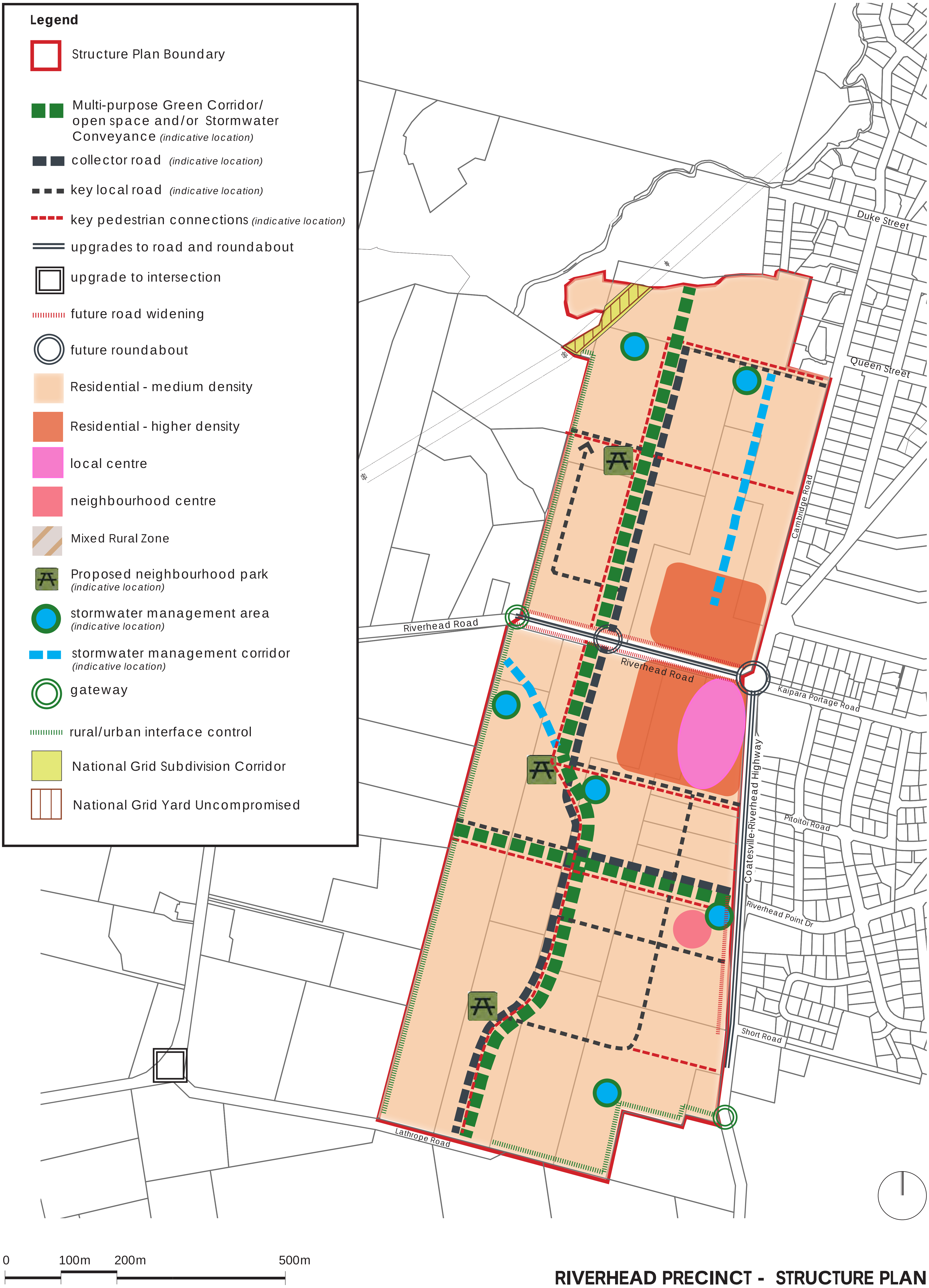
<u>Sub-catchments discharging to Riverhead Forest Stream</u>

- There are existing building flooding issues identified downstream of the site. Therefore, the on-site attenuation should be required as per NDC. However, the proposed development will increase flood level less than 30mm for 1% AEP event which has an effect of less than minor, and on-site attenuation might increase the downstream flood hazard by further 40mm due to the location of the site within the lower part of the entire stream catchment. Therefore, attenuation for 1% AEP is not recommended.
- The existing Riverhead Road culvert has insufficient capacity for 10% AEP under existing condition. The culvert upgrading is recommended. A preliminary assessment shows that upgrading will have no more than minor impact on the downstream.
- Therefore, attenuation requirement for 10% AEP and 1% AEP is <u>not recommended</u> for the site area discharging to this receiving environment, and the Riverhead Road <u>culvert upgrade is proposed</u> for the conveyance of 1% AEP flow.

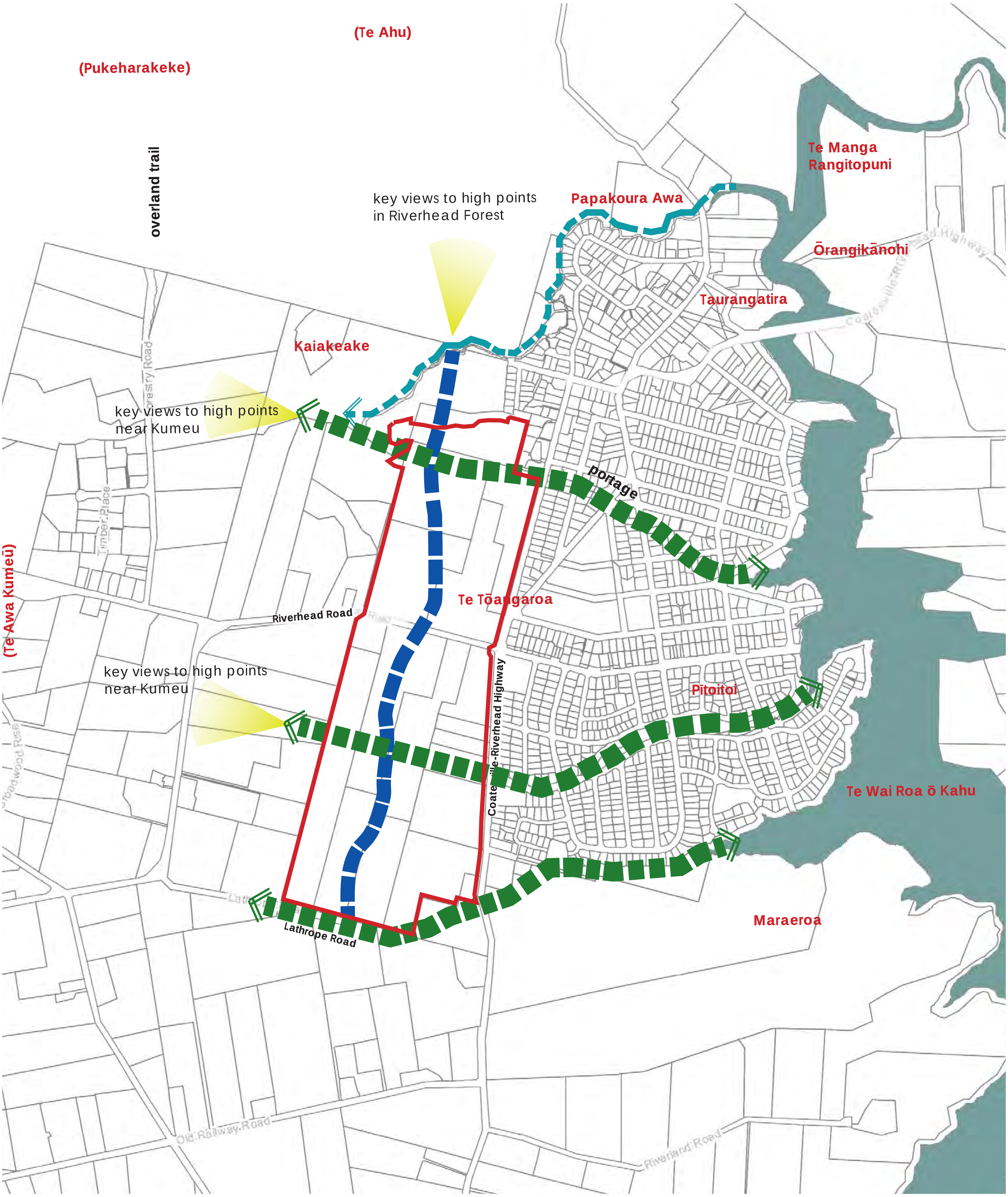
11 Limitations

This report has been prepared solely for the benefit of our client with respect to the particular brief and it may not be relied upon in other contexts for any other purpose without the express approval by CKL. Neither CKL nor any employee or sub-consultant accepts any responsibility with respect to its use, either in full or in part, by any other person or entity. This disclaimer shall apply notwithstanding that the memo/report may be made available to other persons including Council for an application for consent, approval or to fulfil a legal requirement.

Appendix 1 Drawings



RIVERHEAD PRECINCT - STRUCTURE PLAN

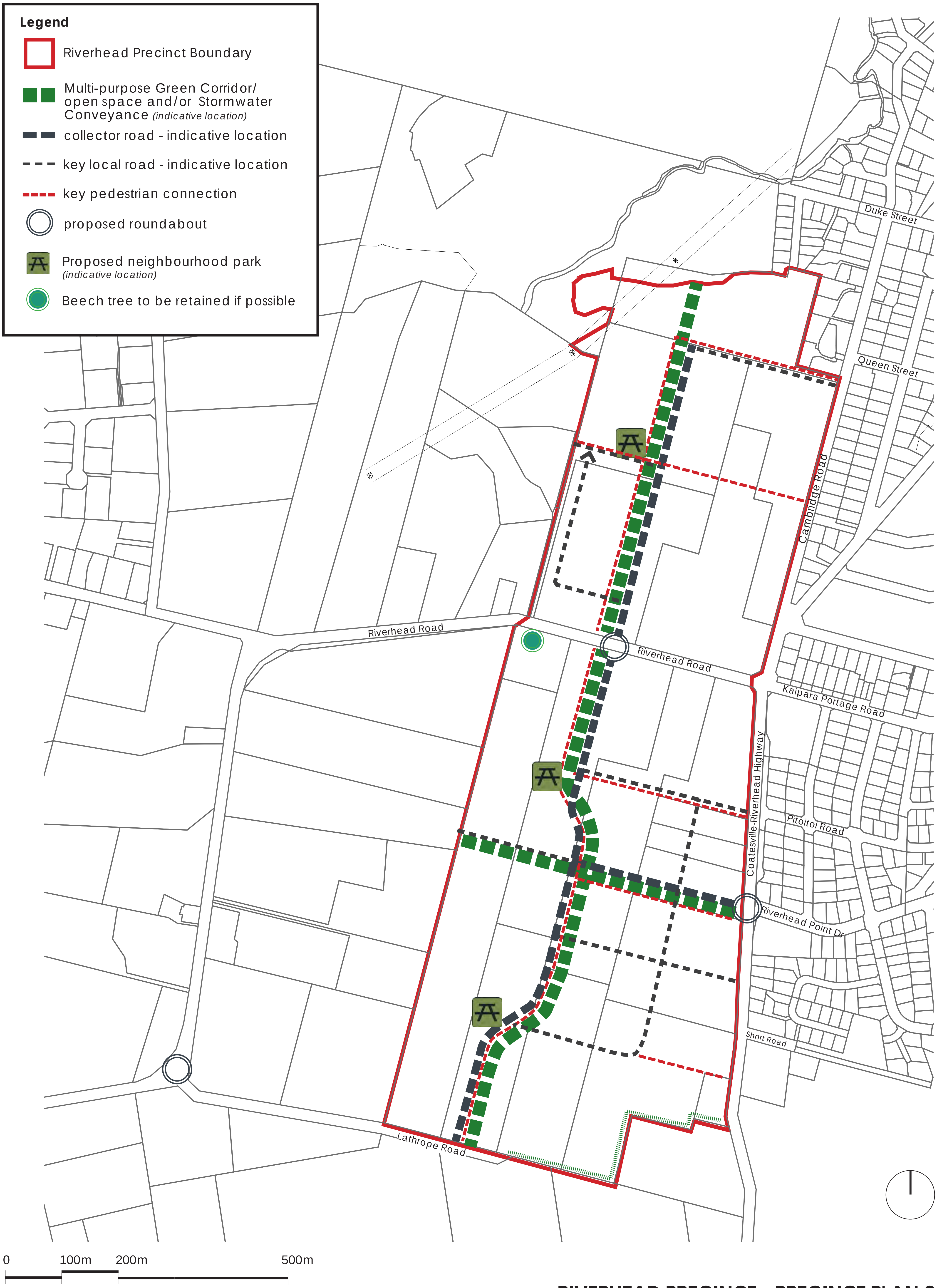


Legend

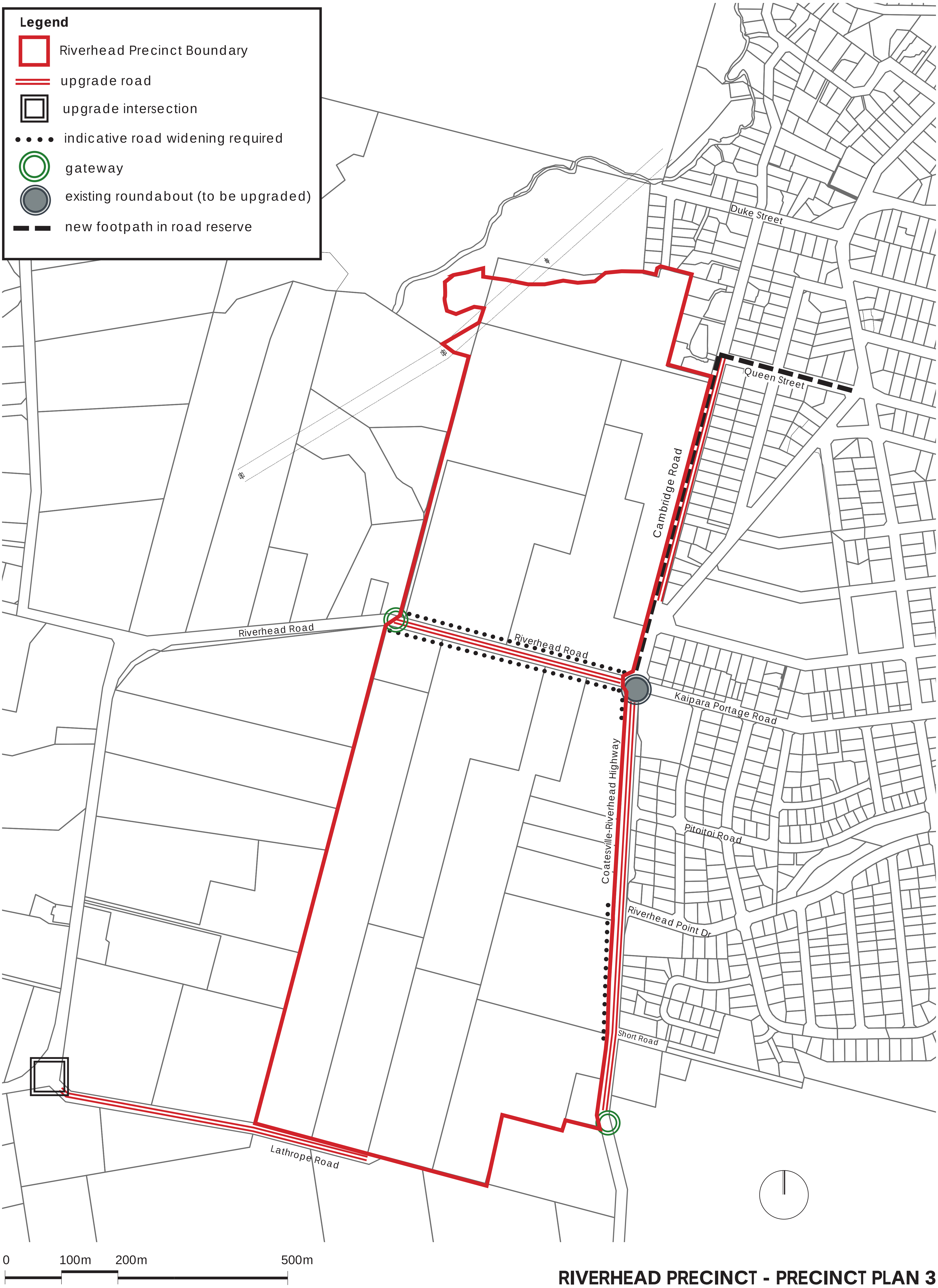
- east - west connections reflecting potential original portage routes, promoting awa ki awa linkage
- existing awa - potential restoration of native vegetation
- potential route for green infrastructure, ecological connections and native habitat and ara hikoi for people's health and well being

0 200m 400m 1km

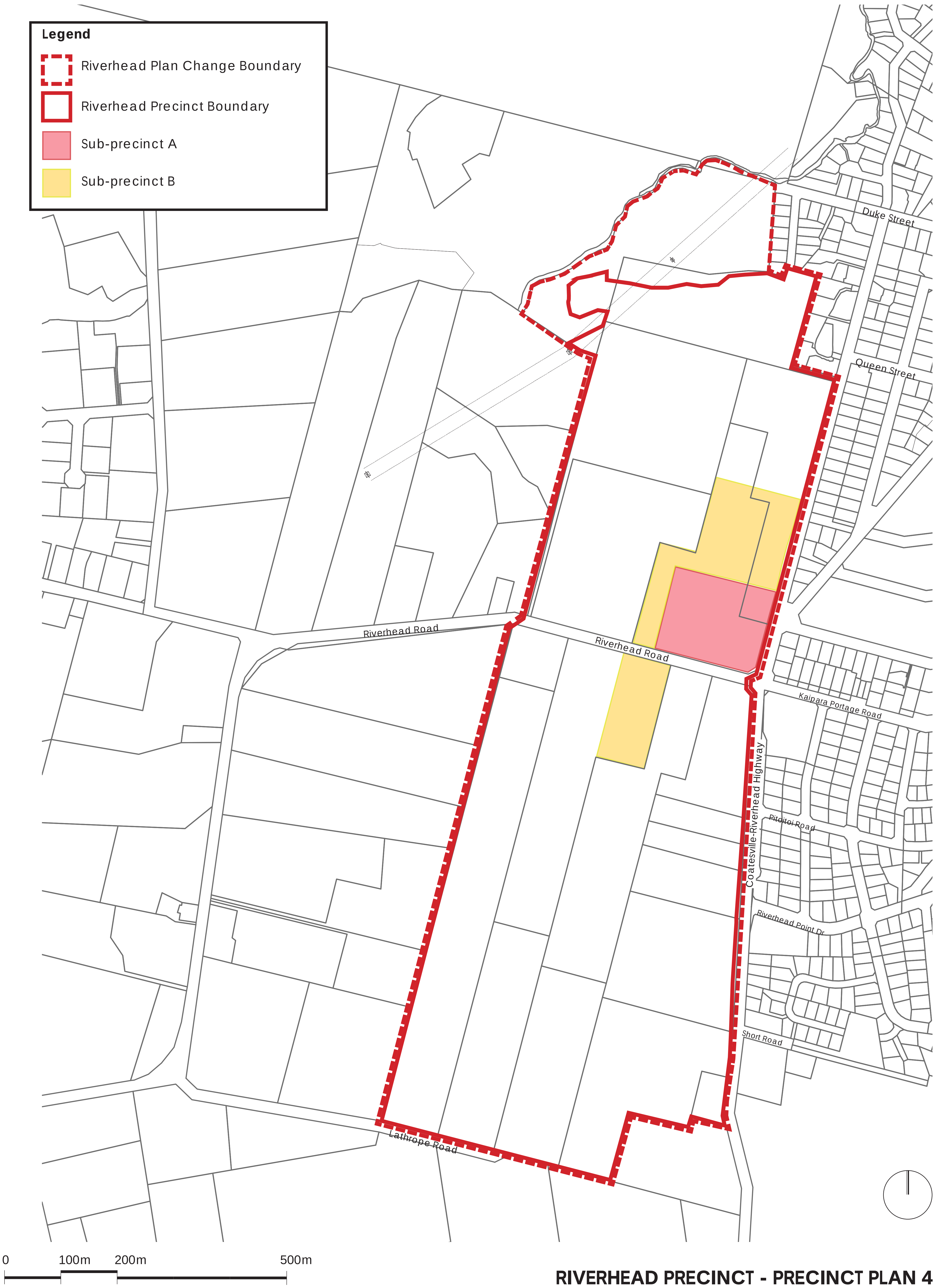
RIVERHEAD PRECINCT - PRECINCT PLAN 1
Mana Whenua Cultural Landscape



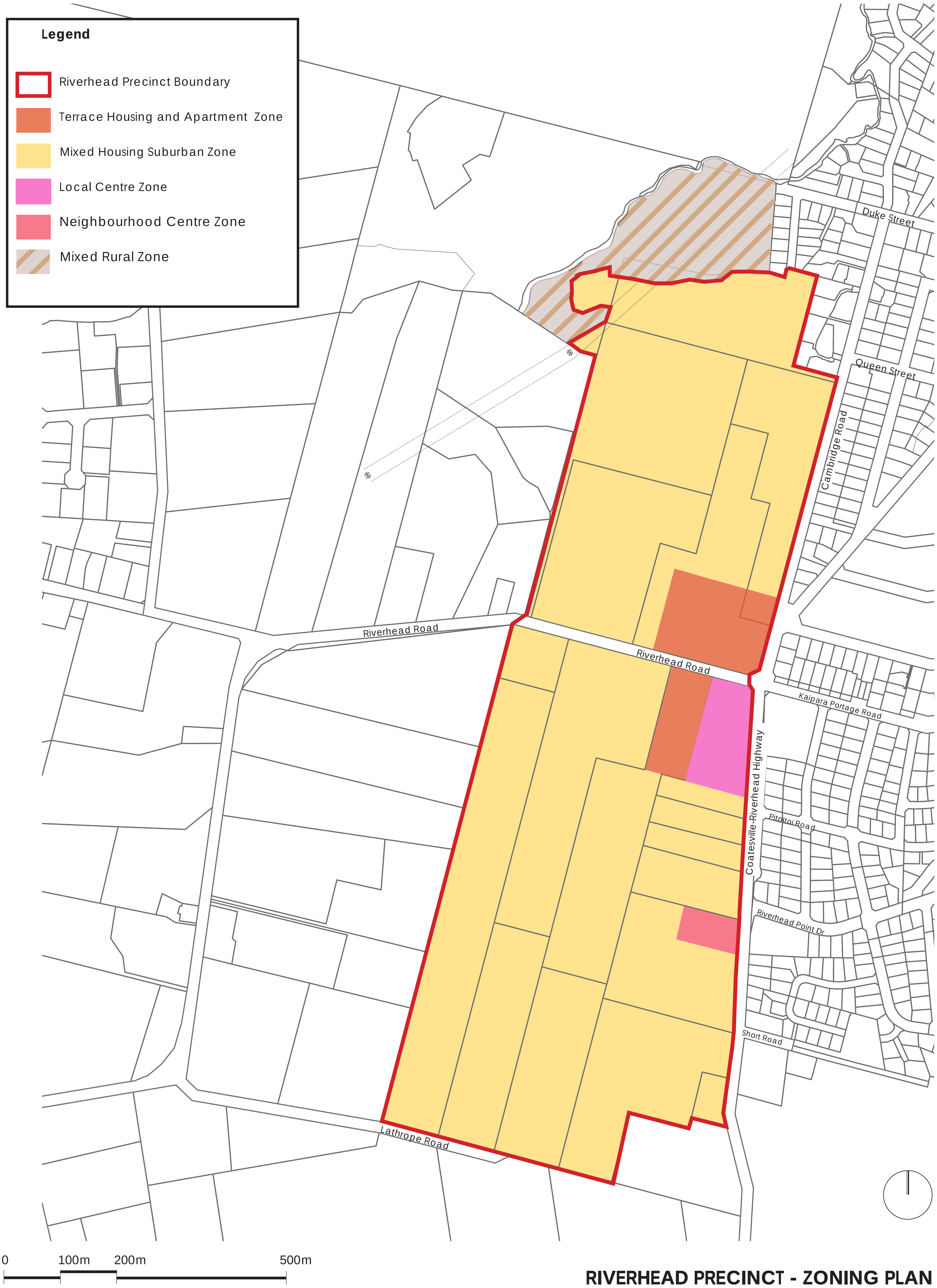
RIVERHEAD PRECINCT - PRECINCT PLAN 2
Structural Elements



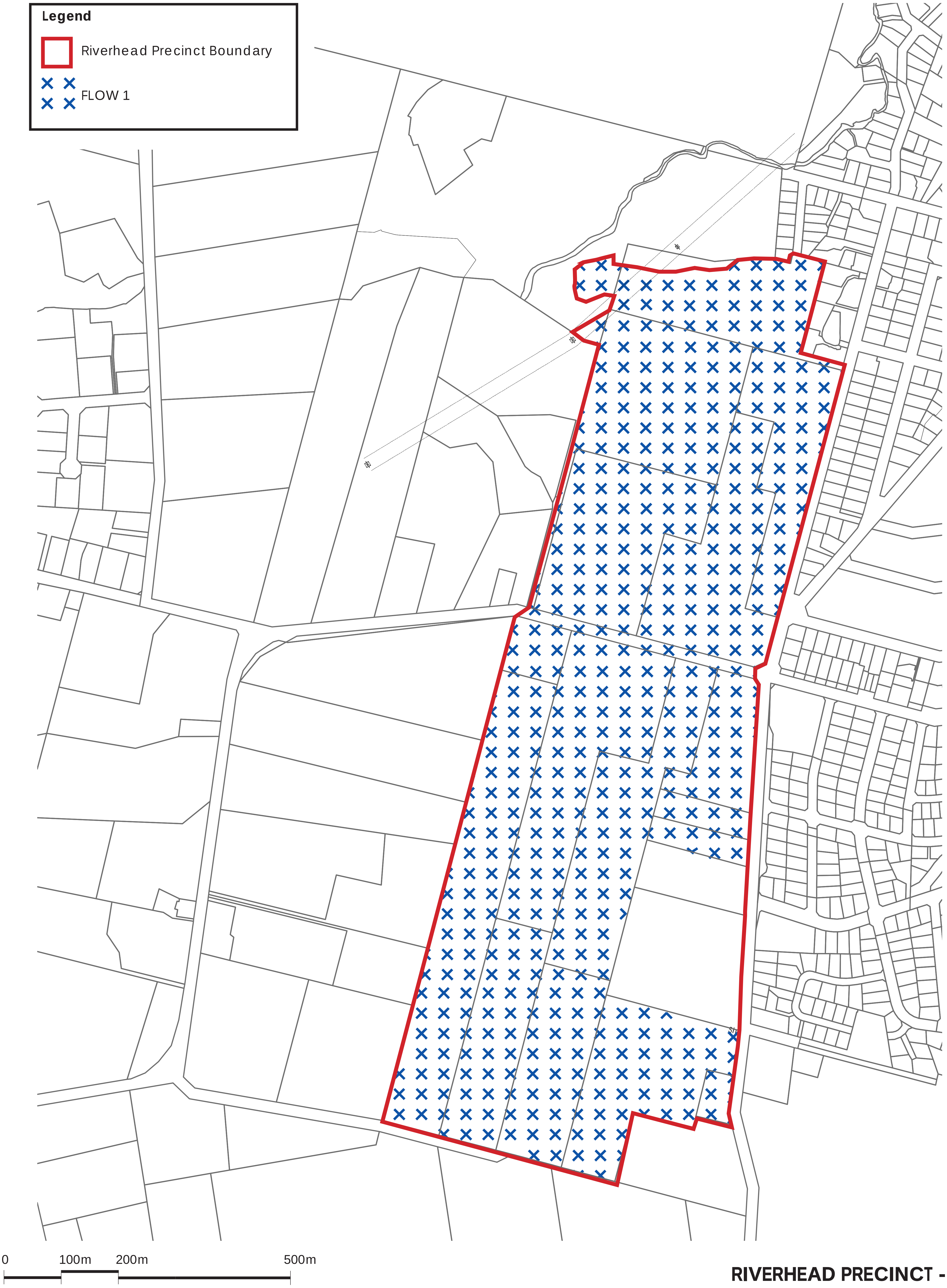
RIVERHEAD PRECINCT - PRECINCT PLAN 3
Transport Upgrades



RIVERHEAD PRECINCT - PRECINCT PLAN 4
Sub-precincts



RIVERHEAD PRECINCT - ZONING PLAN



RIVERHEAD PRECINCT - STORMWATER MANAGEMENT AREA CONTROL

Riverhead

Plan Change

URBAN DESIGN STATEMENT

25 September 2023

FINAL

urban acumen

CLIENT	Riverhead Landowner Group
PROJECT	Riverhead Plan Change
PROJECT NO.	21-028
DOCUMENT	Urban Design Statement
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Prepared by: Lauren White

Urban Acumen Ltd

Suite 2/6, Leek Street

Newmarket

Auckland, 1023

1.0 INTRODUCTION

This document is prepared on behalf of the Riverhead Landowner Group to support the private plan change application for the Riverhead Future Urban Zone. The members of this group own a significant proportion (60%approx) of the future urban zone, and this provides an opportunity for development to occur in an efficient and managed way.

This design report includes the urban design input into the development of a structure plan as required by Appendix 1 of the AUP to identity, investigate and address the following:

- **urban growth**
- **natural resources**
- **natural and built heritage**
- **use and activity**
- **urban development**
- **transport networks**
- **infrastructure**
- **feedback from stakeholders**

This design statement forms part of a suite of technical documents prepared to support the development of a structure plan to guide the development of the Riverhead Future Urban Area, and in turn, the proposed plan change. For the purposes of Appendix 1 of the Auckland Unitary Plan, this document constitutes the Neighbourhood Design Statement for the Structure Plan.

The purpose of this document is to outline the contextual issues relating to the potential development of the site which have informed the decision-making process. It identifies opportunities and constraints in response to the site's unique location and environment and establishes design intentions to guide an appropriate development response. It also describes the conceptual masterplan which illustrates and tests potential outcomes, and forms the basis for the proposed structure plan.

By nature, urban design is a multidisciplinary process and relies upon, and is enriched by, collaboration with all built and natural environment professionals. This report relies upon and should be read in conjunction with other specialist reports informing the structure plan and plan change application.

Best practice urban design principles and concepts, along with those established through consultation with stakeholders, have been integral to the design-led process of developing the structure plan.

This process has been informed by national and local urban design policy and guidance including (but not limited to):

- NZ Urban Design Protocol, Ministry for the Environment, 2005
- The Auckland Unitary Plan, Auckland Council, 2016
- Auckland Urban Design Manual, on-line resource, Auckland Council
- National Policy Statement on Urban Development 2020

The methodology for urban design input into this planning process includes the following steps:

- understanding the location of the site and its existing and future context including a "place statement" on Riverhead
- describing and illustrating the site itself with respect to physical characteristics, natural features, and interfaces etc.
- analysing the site and identifying opportunities and constraints to inform the structure planning process
- contributing to the definition of a vision for the site
- consulting and collaborating with the wide project team and stakeholders to develop a shared vision
- developing a masterplan to inform the development of a structure plan and precinct plan to support the plan change and ensure desired urban design outcomes are delivered
- exploring and testing options for structure plan components
- making recommendations and contributing to the development of precinct provisions proposed in the plan change

2.0 SITE LOCATION

"By way of its location, Riverhead forest provides excellent opportunities for recreational users, and has done so for many years. Although the land is state owned, the forest is administered by Carter Holt Harvey Forests, which purchased the cutting rights in 1990. The company encourages recreational use of the forest.

Riverhead forest remains an oasis of land ignored by most but regarded by its regular users as one of Auckland's best recreational outlets. Those users would prefer the forest to stay in the "best kept secret" category. But as the city boundaries shift outwards, this is one playground that is going to see a lot more use."

New Zealand Geographic

https://www.nzgeo.com/stories/riverhead-an-urban-forest/

The site is located immediately adjacent to the west of the existing settlement of Riverhead, a community of approximately 3000 people. Riverhead sits in the upper reaches of the Waitamata Harbour, about 30km/30min drive from Auckland's CBD. It is also accessible by ferry or private boat.

Riverhead is surrounded by rural landscape. It is one of the satellite townships in Auckland's north west, it neighbours including Kumeu/Huapai and Whenuapai, both of which have experienced significant growth over recent years.

The Riverhead-Coatesville Highway (SH28)connects Riverhead to the wider region, including Albany to the north. Massey/Westgate is the nearest metropolitan centre, located approximately 10km to the south, via State Highway 16.

Riverhead sits at the base of Riverhead Forest, one of the northern region state forests, which include Woodhill and Maramarua. Riverhead Forest was part of a nationwide scheme to ensure the supply of timber to future generations of New Zealanders.

At nearly 5000 hectares in area, and with an elevation of up to 109m, this pine forest provides an ever-present green backdrop to the village of Riverhead as well as those of Kumeu and Huapai.

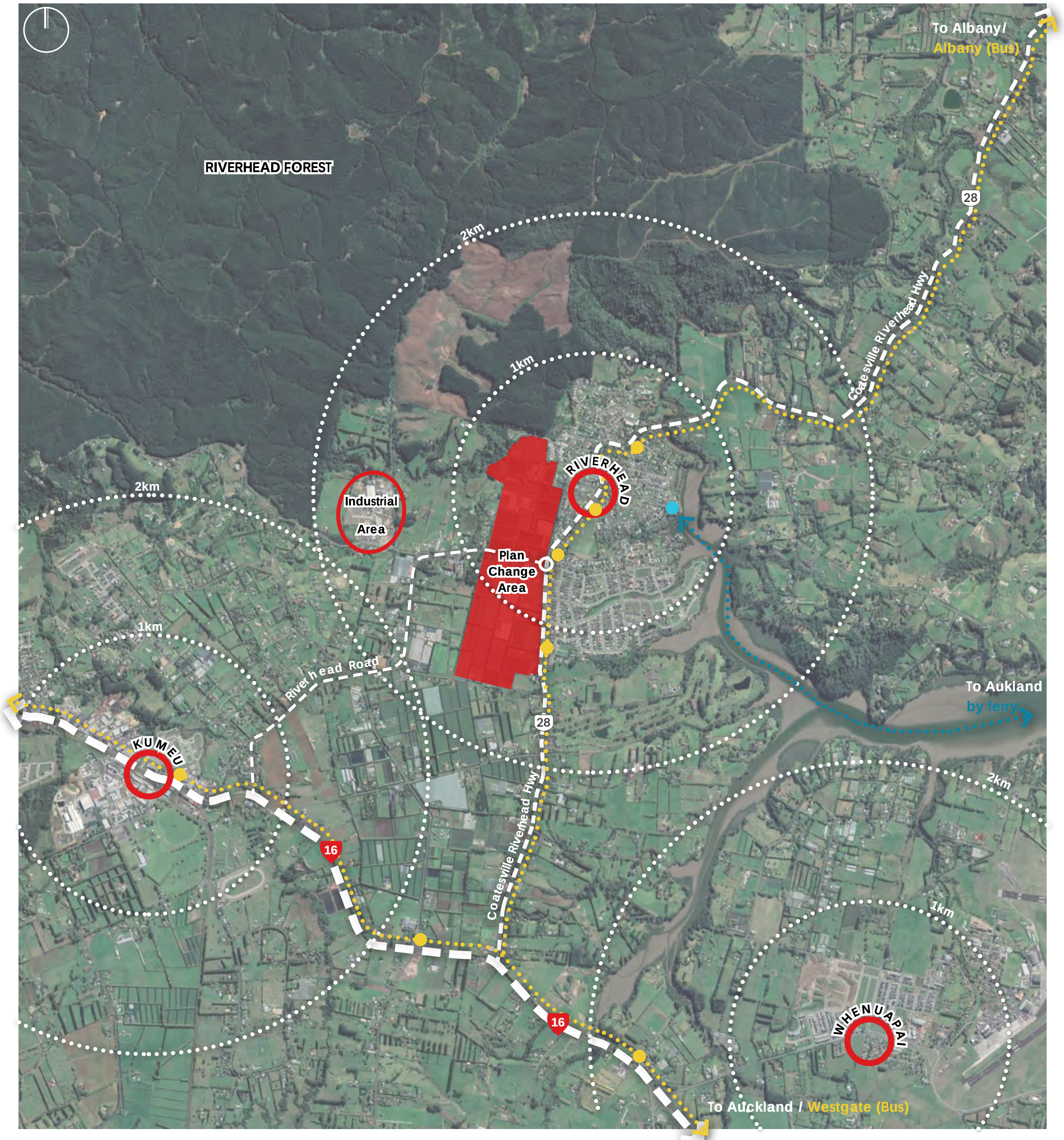


Figure 1 Location - Wider Context

basemap source: Google

Bus Route
Bus Stop
Ferry Service

basemap source: Google

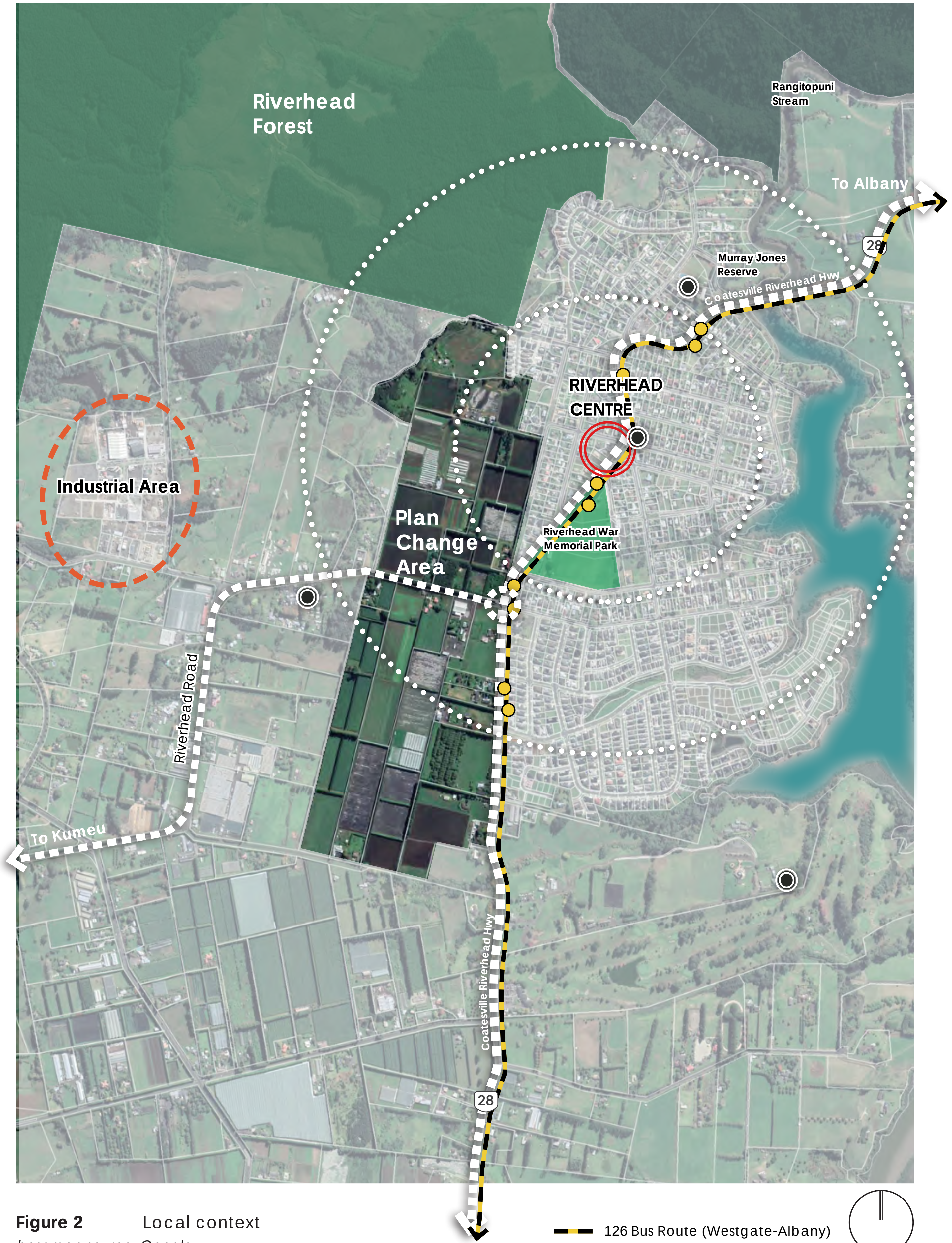


Figure 2 Local context

basemap source: Google

3.0 SITE DESCRIPTION

The plan change site is comprised of 19 different land parcels, across over a dozen different land owneres. In total, it measures approximately 80 hectares.

The site relatively flat rural land, currently used for farming and horticulture. It is regular in shape, with individual land parcels creating a geometric pattern of shelterbelts and other farm boundary definitions.

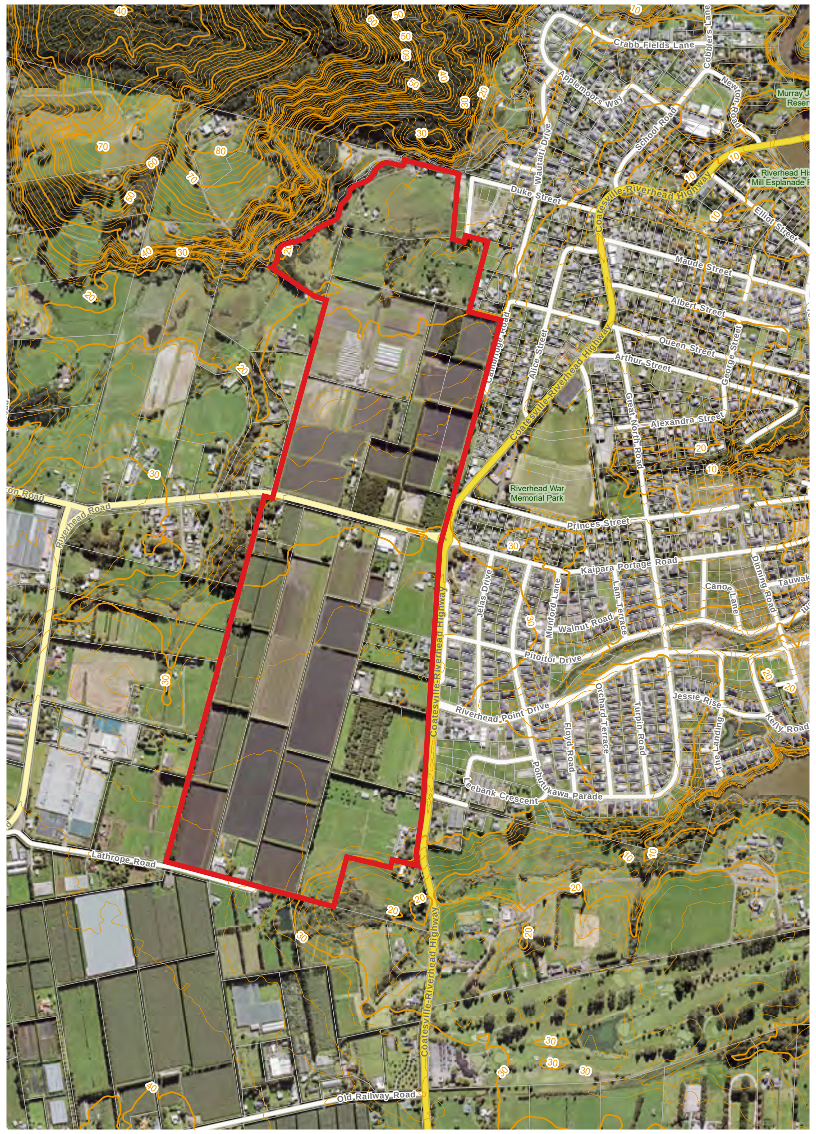


Figure 3 Aerial photo with contour (2m interval)
basemap source: Auckland Council GIS

Figure 4 Aerial photo
basemap source: Google

4.0 SITE ANALYSIS

This report addresses the full future urban zone area, together with live zoned land with the intention of understanding and describing the constraints and opportunities presented by the site itself as well as the potential impact and integration with the existing context.

This section of the document addresses the following aspects of the site and its surrounds:

- Riverhead's sense of place
- cultural values
- access and connectivity
- landform and natural environment
- interfaces
- land uses/activity and social infrastructure
- other infrastructure and land ownership

Residential
- Residential - Large Lot Zone
- Residential - Rural and Coastal Settlement Zone
- Residential - Single House Zone
- Residential - Mixed Housing Suburban Zone
- Residential - Mixed Housing Urban Zone
- Residential - Terrace Housing and Apartment Buildings Zone

Business
- Business - City Centre Zone
- Business - Metropolitan Centre Zone
- Business - Town Centre Zone
- Business - Local Centre Zone
- Business - Neighbourhood Centre Zone
- Business - Mixed Use Zone
- Business - General Business Zone
- Business - Business Park Zone
- Business - Heavy Industry Zone
- Business - Light Industry Zone

Open space
- Open Space - Conservation Zone
- Open Space - Informal Recreation Zone
- Open Space - Sport and Active Recreation Zone
- Open Space - Civic Spaces Zone
- Open Space - Community Zone
- Water [i]

Rural
- Rural - Rural Production Zone
- Rural - Mixed Rural Zone
- Rural - Rural Coastal Zone
- Rural - Rural Conservation Zone
- Rural - Countryside Living Zone
- Rural - Waitakere Foothills Zone
- Rural - Waitakere Ranges Zone

Future Urban
- Future Urban Zone
- Green Infrastructure Corridor (Operative in some Special Housing Areas)

Infrastructure
- Special Purpose Zone - Airports & Airfields, Cemetery, Quarry, Healthcare Facility & Hospital, Tertiary Education, Māori Purpose, Major Recreation Facility, School
- Strategic Transport Corridor Zone

Coastal
- Coastal - General Coastal Marine Zone [rcp]
- Coastal - Marina Zone [rcp/dp]
- Coastal - Mooring Zone [rcp]
- Coastal - Minor Port Zone [rcp/dp]
- Coastal - Ferry Terminal Zone [rcp/dp]
- Coastal - Defence Zone [rcp]
- Coastal - Coastal Transition Zone

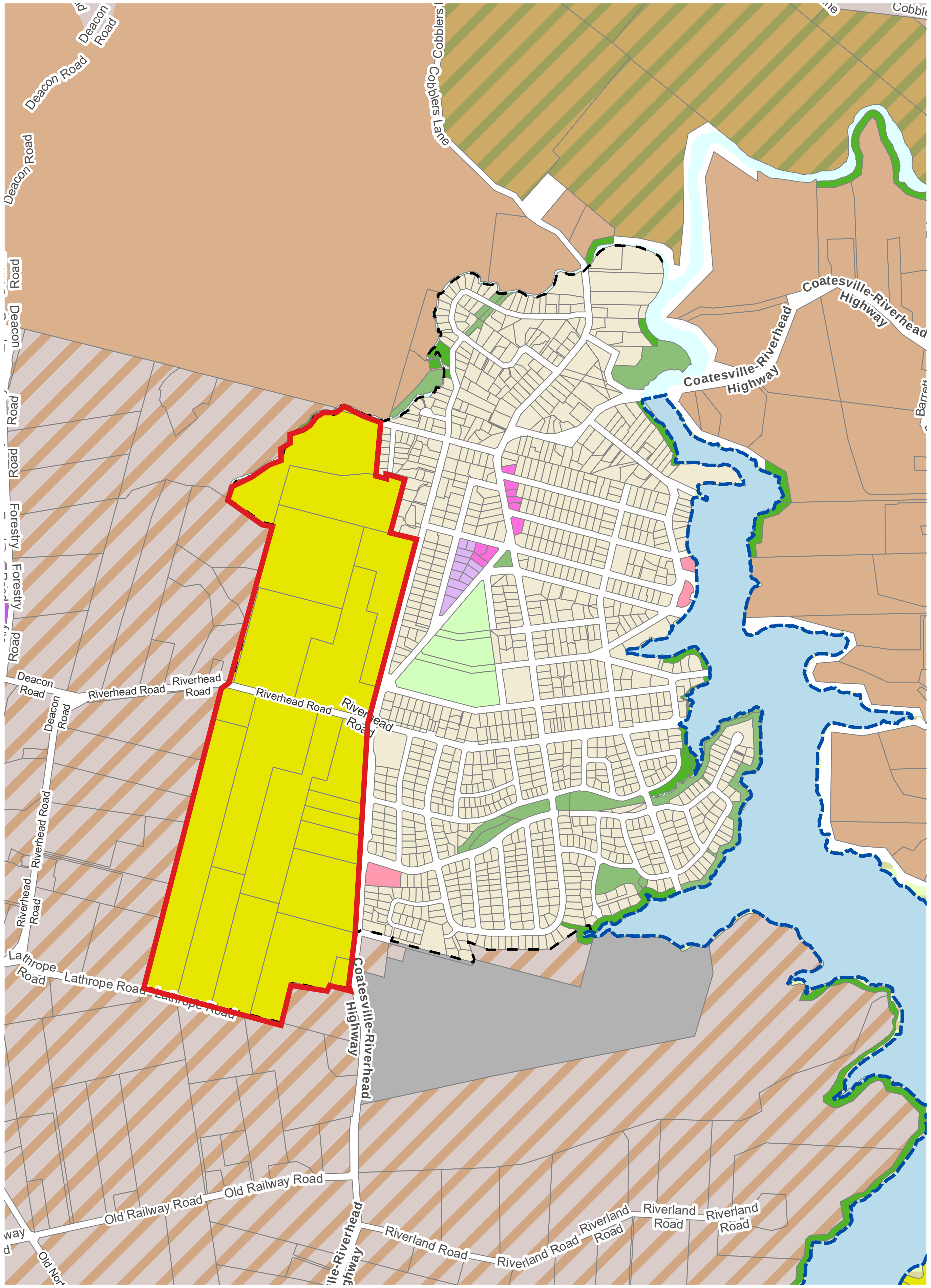


Figure 5 Auckland Unitary Plan Zoning

4.1 RIVERHEAD PLACE STATEMENT

"The traditional name for Riverhead, Rangitopuni, is derived from the presentation of a dog-skin mat (topuni) to the warrior Maki during a peace making ceremony" Graham,1925

Thomas Deacon came to Riverhead in 1843 and, with his sons, ran several hotels in the area. As the population grew commerce began to increase. John Brigham also acquired land near Riverhead in 1855 and established a flour mill there (Mabbett 1981). By 1885 Deacon had shifted his premises to the location of the present Riverhead Hotel.

Matthew Campbell, Jaden Harris and Andrew McAlister, CFG Heritage Ltd.

The current area of the Riverhead township is approximately 172 ha. With an area of approximately 80 ha, the plan change area represents an increase of nearly 50%. Given the size and location of the plan change area, the potential impact of its development on the existing village of Riverhead needs to be understood, anticipated and accommodated.

Typical of most satellite small villages within the Auckland region, Riverhead has a strong sense of place and community.

Much of Riverhead's character is associated with its history which dates back to pre-European times when the area was an iwi canoe portage route between the Waitamata and Kaipara harbours and also an important meeting place. *(Auckland Council North and North West Rural Urban Boundary options: cultural heritage overview, for Auckland Council by Matthew Campbell, GFG Heritage, 19 August 2013).*

The most recent development is Stone Mill, a mixed use, medium density housing development located along Coatesville-Riverhead Highway. Three level buildings provide apartments with ground floor retail units facing onto Coatesville-Riverhead Highway. Two storey townhouses face onto Alice Street or are located around a central shared courtyard area.

This development promotes the proximity to vineyards, harbour and forest as well as easy access to Albany and Westgate shopping. It also champions access to ferry, Albany Park and the Ride bus interchange.

Riverhead Tavern - during the development of early New Zealand, the wharf and hotel was the gateway to lands in the north prior to roads and railway infrastructure.

Primary School

older/more established part of the village - traditional weatherboard single storey detached homes

Memorial Park - playground and team sports

Stone Mill - Coateville-Riverhead Highway - new development of terraces, apartments and ground floor retail

neighbourhood shops, clustered along the highway

recent residential development

rural roads, swales and shelterbelts and views to the forest

food bank, illustrative of a strong community spirit

Like the wider Auckland region, the Riverhead community has experienced significant growth over recent years and is a sought after place to live, with new residential development of various types still ongoing. The recent residential development of Riverhead Point Drive and Deacon Point is evidence of this demand. House builders (e.g. Generation Homes, Golden Homes) are active in the area.

The current settlement exhibits the change of Riverhead over time. The northern area is typically older/more established while new growth has occurred to the south. The Memorial Park and the drainage corridor along the unformed Sussex Terrace form a general boundary between old and new.

Existing sense of place....

The following aspects of the Riverhead environment contribute to its sense of place:

- its Māori history (being defined through iwi narratives and consultation) for example, original portage routes and views towards Kumeu and Riverhead Forest
- its relationship with the coastal environment of the Upper Waitamata harbour - through views to and across it, pedestrian cycle routes along it (albeit limited in the older parts of the village) and coastal esplanade reserves and the scenic ferry trip up through the head of the Waitamata harbour
- its relationship with Riverhead Forest - through visual link to the elevated rural backdrop on the north and east, as well as access for recreation (walking and biking trails)
- its pakeha history as a small working class village and as home to the historic riverside tavern (over 160 years old) and War memorial Park
- surrounding rural land uses, typically associated with food production
- a strong community spirit and active residents association
- Memorial Park and sports and recreation - particularly golf and rugby
- rural type roads with no kerbs, swales and shelterbelts
- wine-making and craft beer (especially Halletau Brewery) make it a destination for food and drink
- a mix of older, established residential area in the north, along with new development, generally in the south
- drainage corridors, connectign to the harbour or Rangitopuni Stream
- exotic street trees which provide autumn colour and change with the seasons

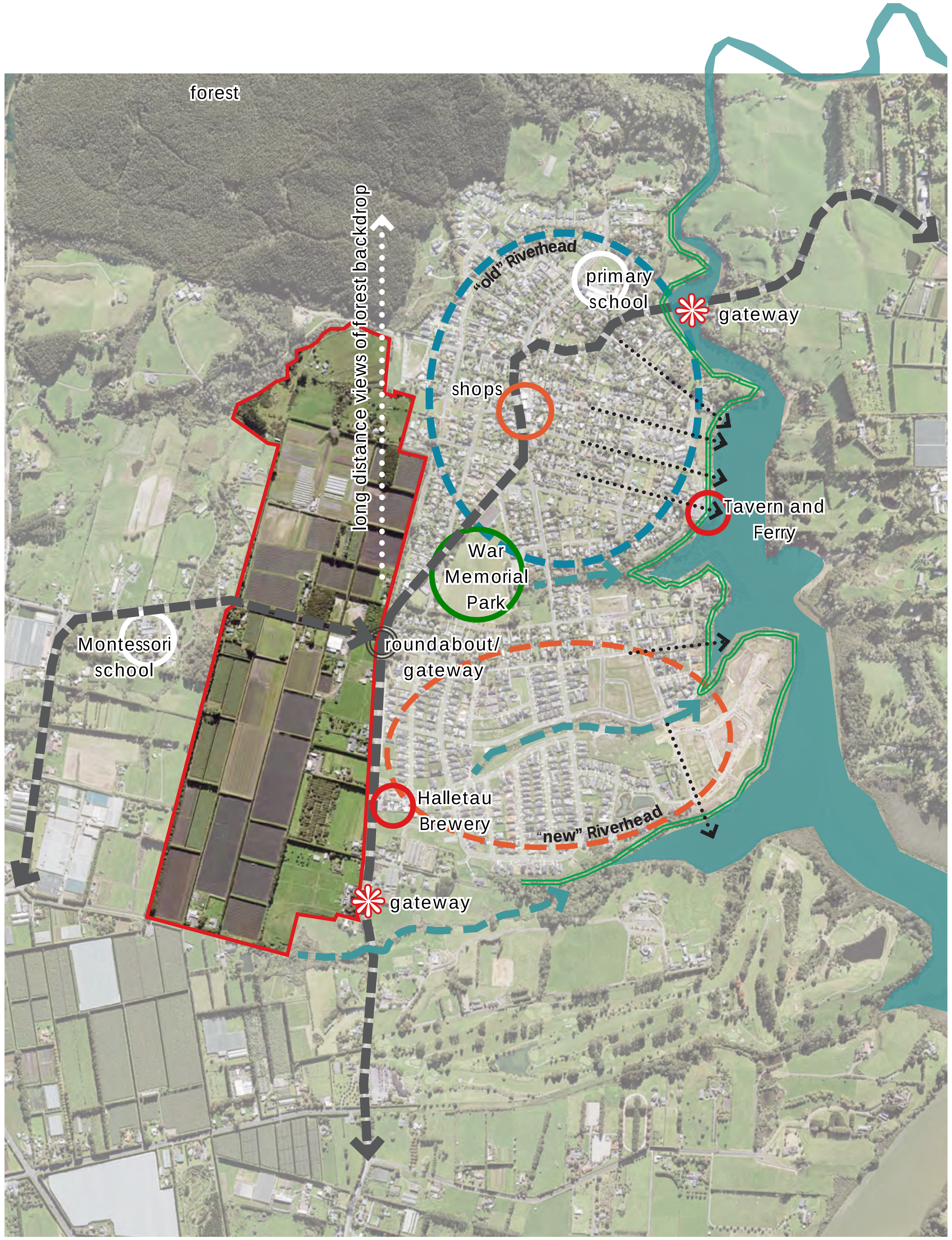


Figure 6 Riverhead Place Analysis

basemap source: AC GIS

4.2 CULTURAL VALUES

Engagement with mana whenua as part of the planning process has been undertaken and through several hui, a preliminary Cultural Overlap Map has been prepared to inform the Structure Plan and precinct plan provisions.

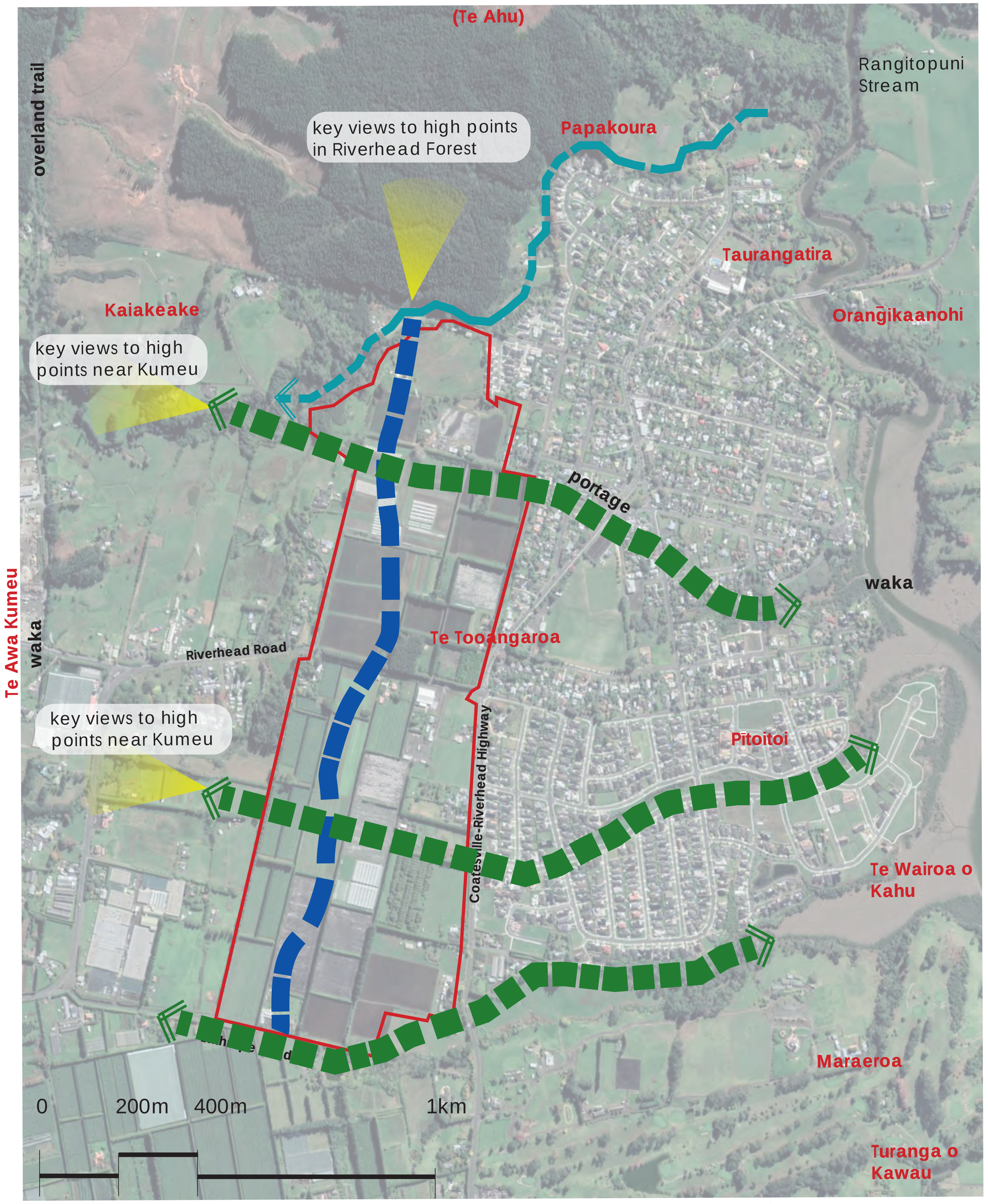
Key feedback comments:

- Mauri of the whenua is most important; notably the two awa, one to the east/coast (with significant wahi tapu) and one to the west;
- there are historic portage routes between the harbours/ headwaters of the meandering Kaipara and Kumeu Rivers
- An important high point in Riverhead Forest (Te Ahu), which used to be used for watching over the portage routes;
- The are no specific sites within the plan change area which warrant scheduling so the focus should be on wider cultural values;
- Stormwater should be regarded as a resource not a problem to be solved, with value for ecology and people;
- Preference is for a treatment train approach (including water reuse), with stormwater and how it sits on the land being an integral part of the design process;
- Other areas of interest include stormwater, biodiversity, energy efficiency and cultural design;
- Opportunities include the wetland to the north and market gardening;
- Support reintroduction of species that formerly existed;
- Important to map cultural values and elements like the portage and views to certain elements;
- Ensure the plan change directs and delivers these ideas (via bespoke precinct provisions); and
- Enable further input at more detailed design stages through workshops and Cultural Values Assessments.

east - west connections reflecting potential original portage routes, promoting awa ki awa linkage

existing awa - potential restoration of native vegetation

potential route for green infrastructure, ecological connections and native habitat and ara hikoi for people's health and well being



Please note: The identified place names are subject to confirmation

Figure 7 Preliminary Cultural Overlay Map

basemap source: AC GIS

4.2 ACCESS AND CONNECTIVITY

Appendix 1.4 of the AUP - matters to identify, investigate and address through structure planning:

Linkages and integration with existing urban-zoned and/or rural-zoned land adjoining the structure plan area through careful edge or boundary treatment.

The plan change area has good access to primary/arterial roads which connect it to the wider area, namely Kumeu/Huapai to the west and Whenuapai/Massey/Auckland to the south east. The Coatesville-Riverhead Highway also provides connection to Albany in the north. The Coatesville-Riverhead Highway supports a bus service between Massey and Albany.

The significant existing and future volume of traffic on these roads does present a potential constraint to accessing development along these frontages. A response to this constraint is evident in the "slip-lane" design of Grove Way and the intersection with Pitoitoi Drive.

The northern portion of the site has some potential for connecting into the suburban fabric of Riverhead through Duke Street, Te Roera Place and Cambridge Road but each of these locations have some limitations, including flood areas. topography and ecological constraints, along with the rural nature of these roads, and limited capacity for both vehicles and pedestrians.

End of Te Roera Place, looking south into PC area

Coatesville-Riverhead Highway (alongside Grove Way)

Central swales in Riverhead Point Drive

Lathrope Road

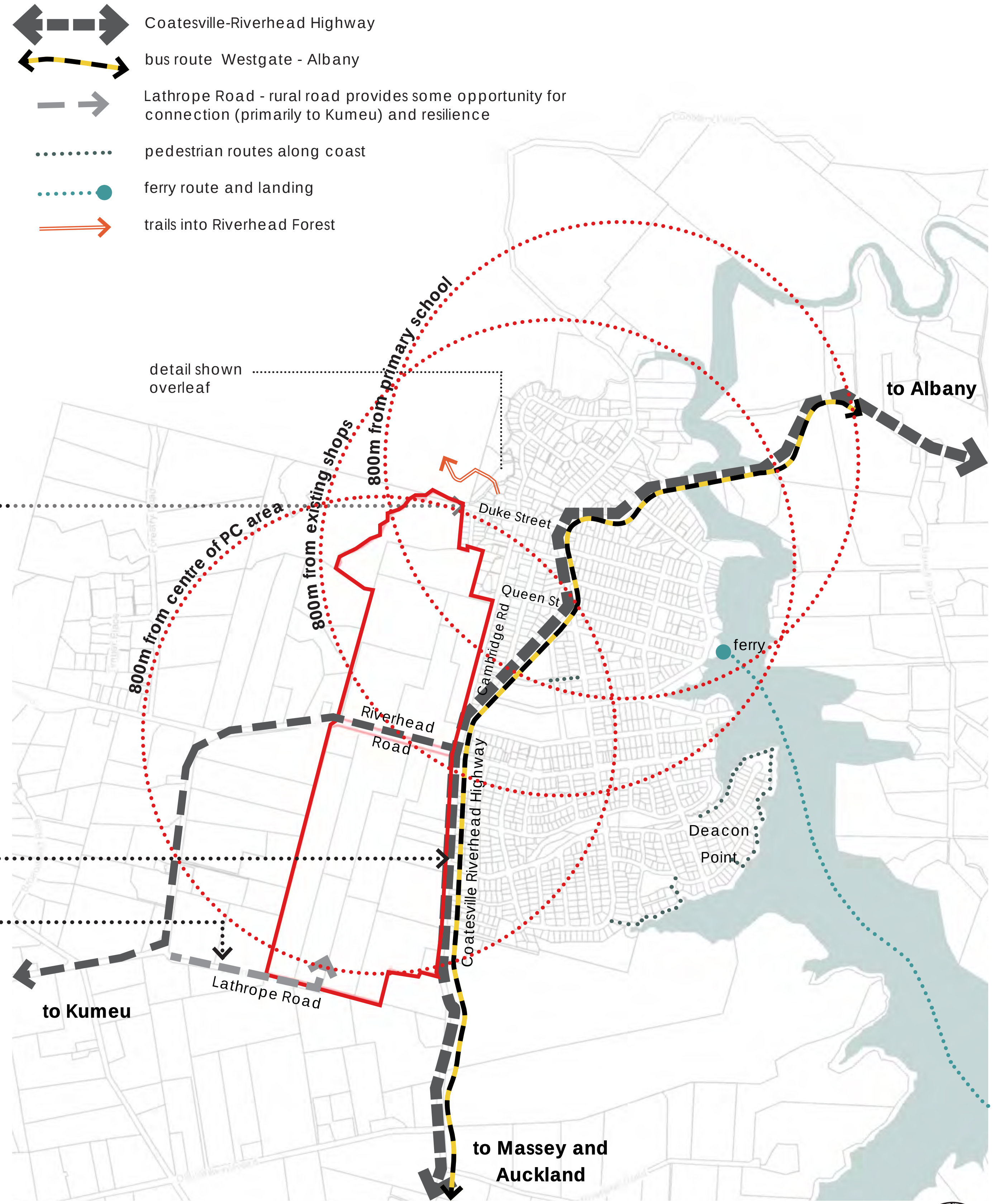


Figure 8 Access Assessment

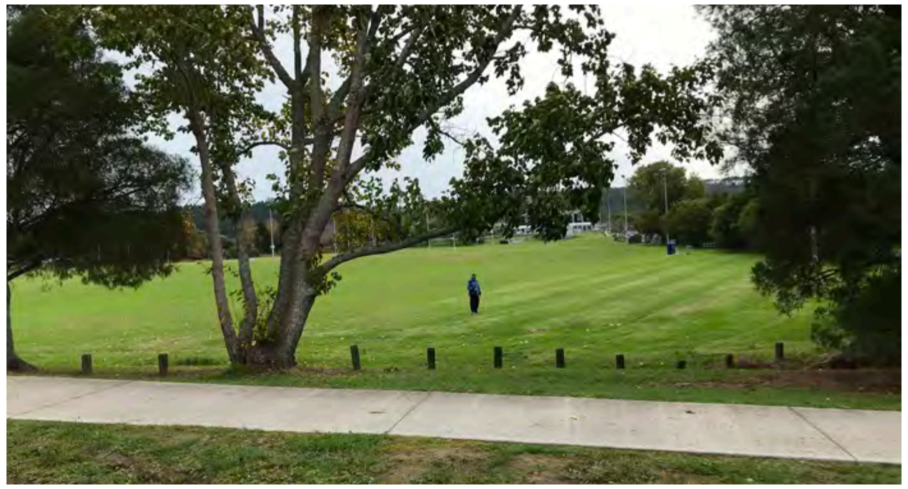
4.3 LANDFORM, VEGETATION AND DRAINAGE

Appendix 1.4 of the AUP - matters to identify, investigate and address in structure planning:

The integration of green networks (such as freshwater and coastal water systems, and ecological corridors) with open space and pedestrian and cycle networks, showing how they reflect the underlying natural character values and provide opportunities for environmental restoration and biodiversity.

The site slopes gently towards the north where it meets a stream which drains to the Upper Waitamata Harbour. On the other side of this stream, the topography rises steeply as part of Riverhead Forest. This landform terminates northerly views and creates a green backdrop to the northerly portion of the PC area. In the northern part of the site, the land form creates a series of north facing "terraces".

The remaining area is relatively flat. The northern portion of the site has wetlands and flooding constraints.



Mature trees around the Memorial Reserve

typical shelterbelt planting along roads/property boundaries

Figure 9 Topography and existing vegetation

AUDM - Te Aranga Design

- *Creating and connecting ecological corridors and webs*
- *Planting of appropriate indigenous flora in public places, strategies to encourage native planting in private spaces*
- *Selection of plant and tree species as seasonal markers , providing habitat for all native fauna as attractors of native bird life*
- *Establishment and management of traditional food and cultural resource areas allowing for active kaitiakitanga*
- *Daylighting, restoration and planting of waterways*

Policy E38.3(14) - AUP *encourages the design of subdivision to incorporate and enhance land forms, natural features and indigenous trees and vegetation.*

As part of a low lying area close to the coastal reaches of the Upper Waitamata Harbour, northern parts of the site are subject to flooding.

There are a number of overland flow paths that traverse the site. A few pockets of mature vegetation remain, along with the occasional specimen tree, notably a beech tree on 298 Riverhead Road.

The vegetation of the site is highly modified due to food production. Properties are often demarcated through shelterbelt planting.

drainage corridor/swale along Riverhead Point Drive

local named drainage corridor

potential tree to retain

land subject to flooding

existing pond

land within catchment but outside FUZ

intermittent stream

contour interval = 1m

Figure 10 Drainage

basemap source: AC GIS

4.4 LAND USE AND SOCIAL INFRASTRUCTURE

Retirement Village

While working alongside Fletchers and Neil Group on the structure plan and plan change process, Matvin are planning to build a retirement village on their land at 1092 Coatesville-Riverhead Highway.

Matvin have consent for their with their specific detailed development project via the COVID-19 Recovery Fast Track Consenting process so they can provide opportunities for retirement village living in Riverhead more quickly.

It is anticipated that construction will begin on the village in the 2024/25 construction season.

RESIDENTIAL DEVELOPMENT

Although there is some recent medium density housing development under construction, Riverhead is essentially a low density residential environment characterised by single storey detached dwellings and lot sizes typically around 800m^2 in both well established and new parts of the village. All residential land in Riverhead is zoned Single House Zone in the Auckland Unitary Plan, the objectives, policies and rules of which discourage densification.

The plan change provides an opportunity to extend the range of residential living in Riverhead, providing more choice and more affordable lifestyle options, and use the land resource and infrastructure networks more efficiently. This includes the potential to deliver attached housing (terraces), hybrid typologies (turn key), low rise apartments and retirement living.

VILLAGE CENTRE/RETAIL/EMPLOYMENT

Small scale neighbourhood shops are scattered through the village, although there is a clearly perceived focus/heart around the Four Square/food market, cafe and kindy. Typically, the local shops have high visibility due to the passing trade along the highway, and convenient parking either in front (parallel or perpendicular) or on side streets.

Future village retail in the plan change area is likely to benefit from good visibility/passing traffic as well as an additional residential catchment. However, given the potential traffic/access restriction along the highway, placing local shops away from this busy road may provide for greater amenity and pedestrian priority.

OPEN SPACE/RECREATION

Current recreation open space provision in Riverhead includes:

- Riverhead Memorial Park (sport fields, facilities and playground)
- Esplanade walkways around the Upper Waitamata harbour

EDUCATION

Education needs in Riverhead are currently met by Riverhead Primary School, which also includes intermediate years (7 and 8). The Ministry of Education (MoE) is adding capacity to Riverhead School and actively investigating the need for a new primary school in the wider area although location and timing of any new primary school is yet to be confirmed. MoE is also investigating options for a new high school in the Kumeu to open between 2026 and 2030.

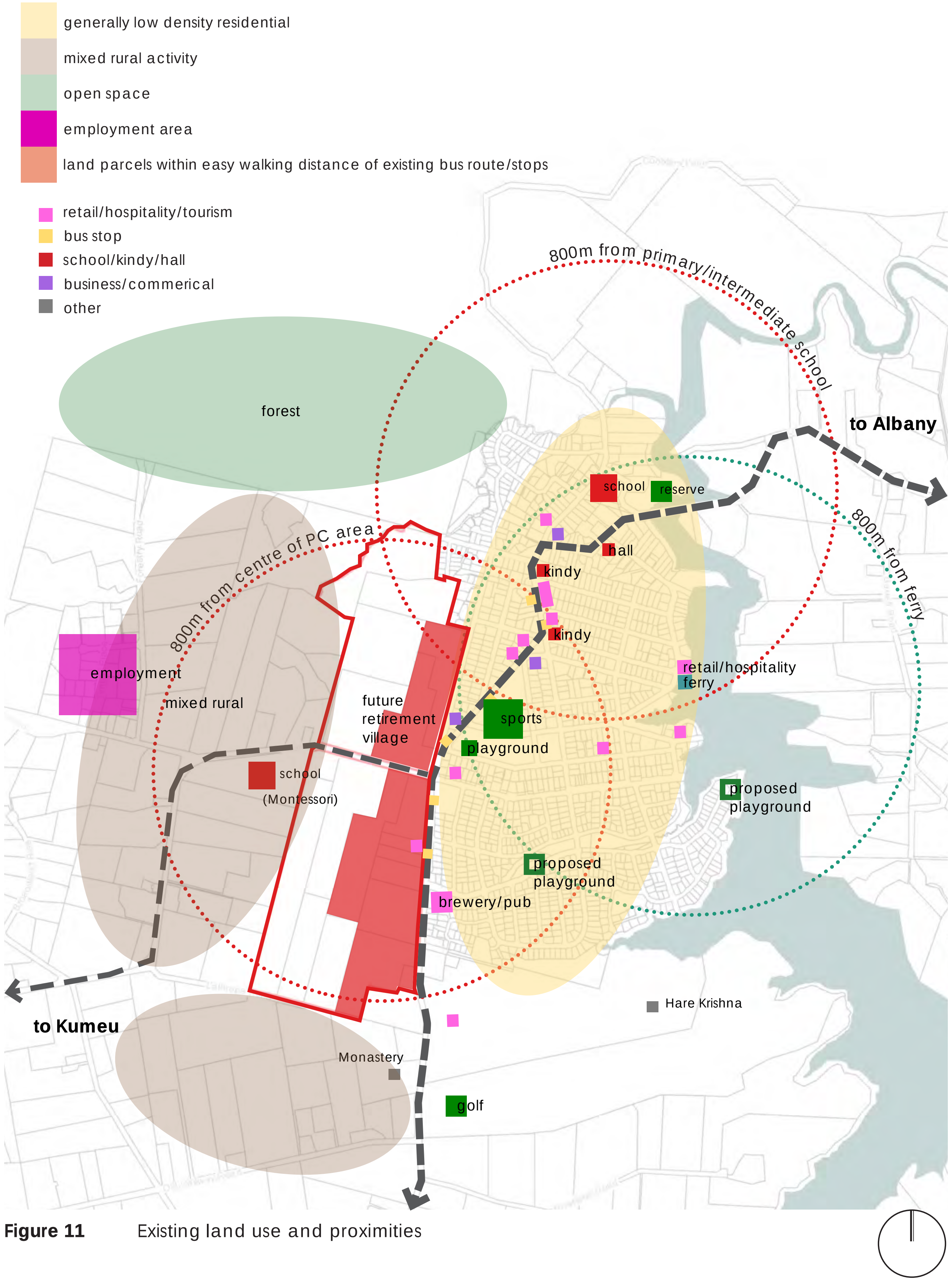


Figure 11 Existing land use and proximities

4.5 CONSTRAINTS

Plan Change Boundary

existing village centre

individual land ownership
influences location of key routes/access and development staging

Arterial routes
traffic speeds, vehicle access restrictions etc. can be a barrier to integration/connectivity

drainage corridor

intermittent stream

flood prone area and/or wetlands

mature beech tree

existing village centre
constrained with respect to growth and not within easy walking distance of all future urban land

steep slope
limits access and/or requires significant earthworks

local road - limited capacity

unformed paper road
limits vehicle connectivity

vehicle access restriction

rural interface

low density village interface

overhead power transmission line

future road widening
from 20 to 24m in line with Supporting Growth Alliance expectations

retirement village
consent granted through COVID 19 Recovery (Fast Track Consenting) Act 2020

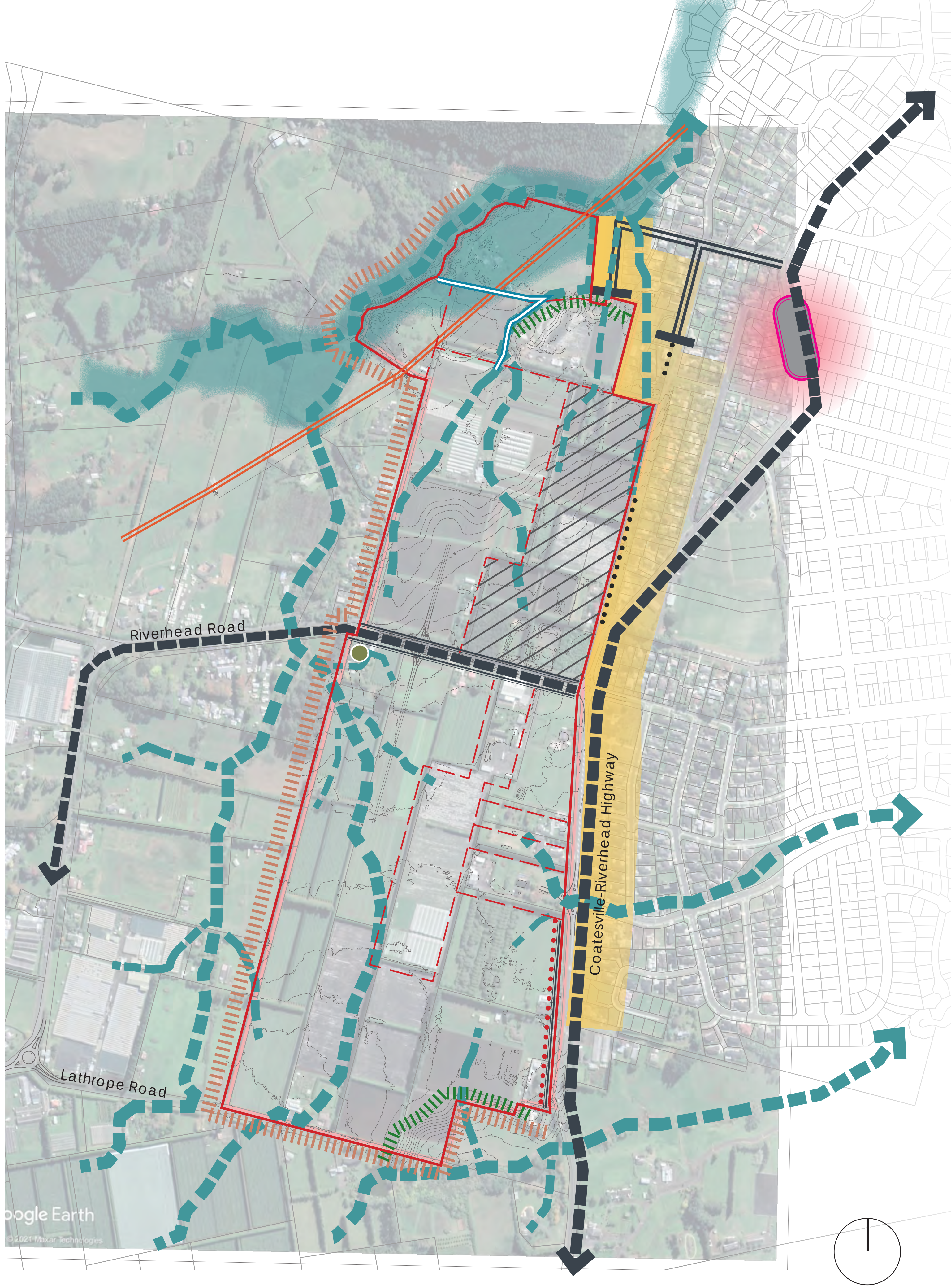


Figure 12 Constraints

4.6 OPPORTUNITIES

- Plan Change Boundary
- existing village centre
- existing arterial routes (upgrades to accommodate pedestrian and cycle facilities)
- key new roading connections
- key active mode infrastructure linking to public transport routes
- celebrate key intersection
- trails into Riverhead Forest
- pedestrian/cycle connection
- response to ecological and flooding constraints
- multi-purpose green corridor/open space and/or stormwater conveyance (indicative location)
- stormwater reserve/device (indicative lcoation)
- intermittent stream
- stream corridor (outside PC area)
- provide strong links to park/sports
- potential centre location and higher density residential (local centre and/or neighbourhood centre)
- potential location of primary school
- gateway feature (natural open space/landcape boundary)
- gateway feature (urban gateway/landscaping/public art)
- benefit from/promote place associated with Halletau
- maintain viewshafts to Riverhead forest
- mix of residential densities/typologies
- appropriate interface with rural activity and stream
- mature beech tree worthy of retention

Figure 13 Opportunities

5.0 DESIGN DRIVERS

5.1 VISION STATEMENT

Informed by a clear understanding of the site's unique opportunities and constraints, a vision can be developed which enables the plan change to:

- contribute to accommodating growth within the area and on land that is well located, accessible and within a logical urban area
- maximise the benefits of location, setting, views and access to attractions and destinations
- promote landscape and ecological value and express the water story with respect to stormwater treatment

....an extension to the existing village, providing greater housing choice, better access to facilities and services and enhancing the natural environment....creating a place where existing residents can welcome new ones and together build a ....

healthy community and a healthy place

5.2 DEVELOPMENT PRINCIPLES

A number of appropriate best practice urban principles have been identified and framed the structure plan to the development of the site.

- **a connected physical environment**

delivering a highly connected new neighbourhood that fosters multi-modal transport choices, including walking and cycling modes with good saftey, convenience and amenity

- **an integrated community**

merging old and new, and responding to village and rural context

- **access to nature**

visual and physical access to a variety of multi-functional connected green spaces, and the wider coastal and rural environment

- **vibrant and local**

a mix of uses that supports a variety of activity and uses building on local identity, such as farmers markets, wine and craft beer to reinforce Riverhead as a destination for local food and drink

- **housing choice and affordability**

with a wide range of housing types and residential densities, a mixed demographic and a local character/point of difference

- **proximity/convenience**

to public transport, education, recreation and jobs

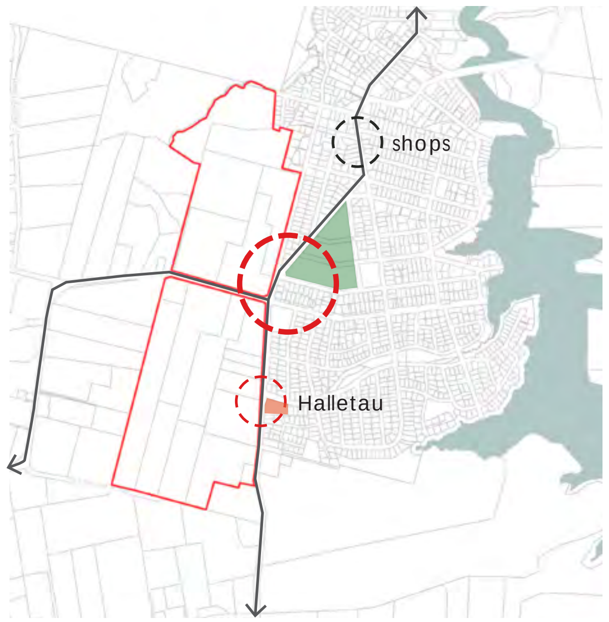
5.3 KEY MOVES

The key design moves illustrated below are informed by the vision and development principles and drive the indicative masterplan which, in turn, informs the spatial arrangement of structure plan components.

1

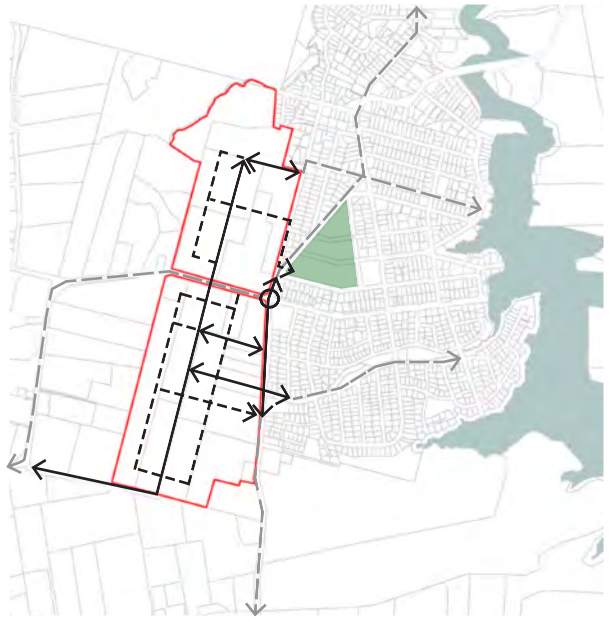
deliver a north-south multi-purpose green corridor which:

- functions as a structural placemaking element
- connects riparian environments and promotes ecological linkages;
- provides opportunities for recreation and co-location of active play spaces and passive areas;
- adds amenity and character to the internal movement network, in particular active modes; and
- restores and protects the mauri and mana of the wai (water) by adopting an exemplar stormwater management approach



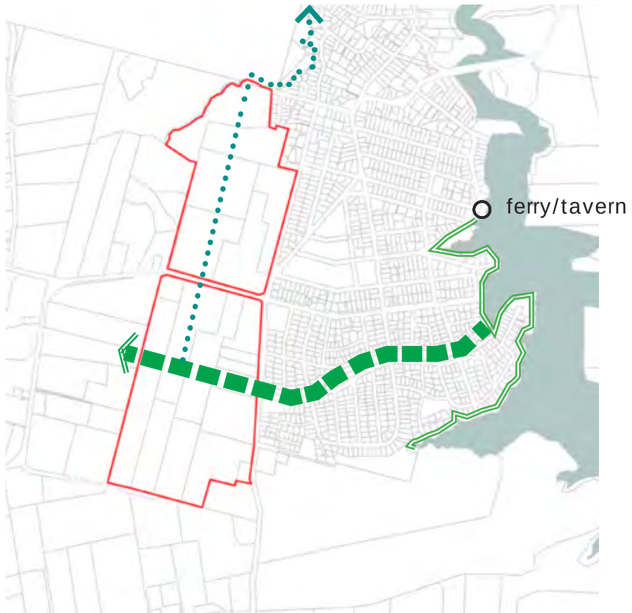
2

provide a new village hub, reinforcing Memorial Park as the heart of the village and supporting this centre with a smaller neighbourhood centre, complementing the existing shops on Coatesville Riverhead Highway



3

ensure a high level of connectivity and safety for walking and cycling, both internally and to the existing village, particularly Memorial Park, and promote good solar orientation though predominant north-south block alignments



4

promote an ecological corridor between the coastal environment of the upper harbour, Rangitopuni Stream and Riverhead Forest which:

- reflects the original portage route;
- adds amenity and character to movement networks;
- incorporates stormwater management areas where practical

5

provide for housing choice and a range of residential densities, with high density reinforcing the centre and medium density transitioning to the surrounding rural environment

5.4 INDICATIVE MASTERPLAN

The indicative masterplan has been an essential design tool for the multi-disciplinary project team during the structure planning process and has been used to explore and communicate ideas with land owners and a wide range of stakeholders. Through a number of design iterations, various design scenarios have been tested to ensure they can be delivered at a detail design/resource consent level.

The opportunities and constraints have informed the ongoing development of the masterplan as well as:

- land ownership and cadastral pattern
- cultural values
- various and uncertain land owner aspirations
- the likely location of intersections on Coatesville-Riverhead Highway and Riverhead Road due to safety/sightlines and necessary separation distances
- other technical reports by the wider project team

Figure 14 Indicative Masterplan

6.0 STRUCTURE PLAN

The key design components and outcomes envisaged by the masterplan have been distilled into the proposed structure plan. The structure plan illustrates the indicative location of key movement corridors, open spaces and land uses. The structure plan will guide future subdivision and development as well as the assessment of subsequent resource consent applications. This section also inlcudes recommendations for precinct plan provisions in order to deliver good urban design outcomes

Note: *Due to significant flood risk, some of the land in the northern portion of the Future Urban Zone has been excluded from the Structure Plan Area and rezoned as Mixed Rural Zone.*

Legend

- Structure Plan Boundary
- Plan Change Area Boundary
- Multi-purpose Green Corridor/ open space and/or Stormwater Conveyance *(indicative location)*
- collector road *(indicative location)*
- key local road *(indicative location)*
- key pedestrian connections *(indicative location)*
- upgrades to road and roundabout
- upgrade to intersection
- future road widening
- future roundabout
- Residential - medium density
- Residential - higher density
- local centre
- neighbourhood centre
- Proposed neighbourhood park *(indicative location)*
- stormwater management area *(indicative location)*
- stormwater management corridor *(indicative location)*
- gateway
- properties with notable ecological and flooding issues to be managed *to be addressed by subsequent design and consenting*
- rural/urban interface control
- National Grid Subdivision Corridor
- National Grid Yard Uncompromised
- intermittent stream
- permanent stream

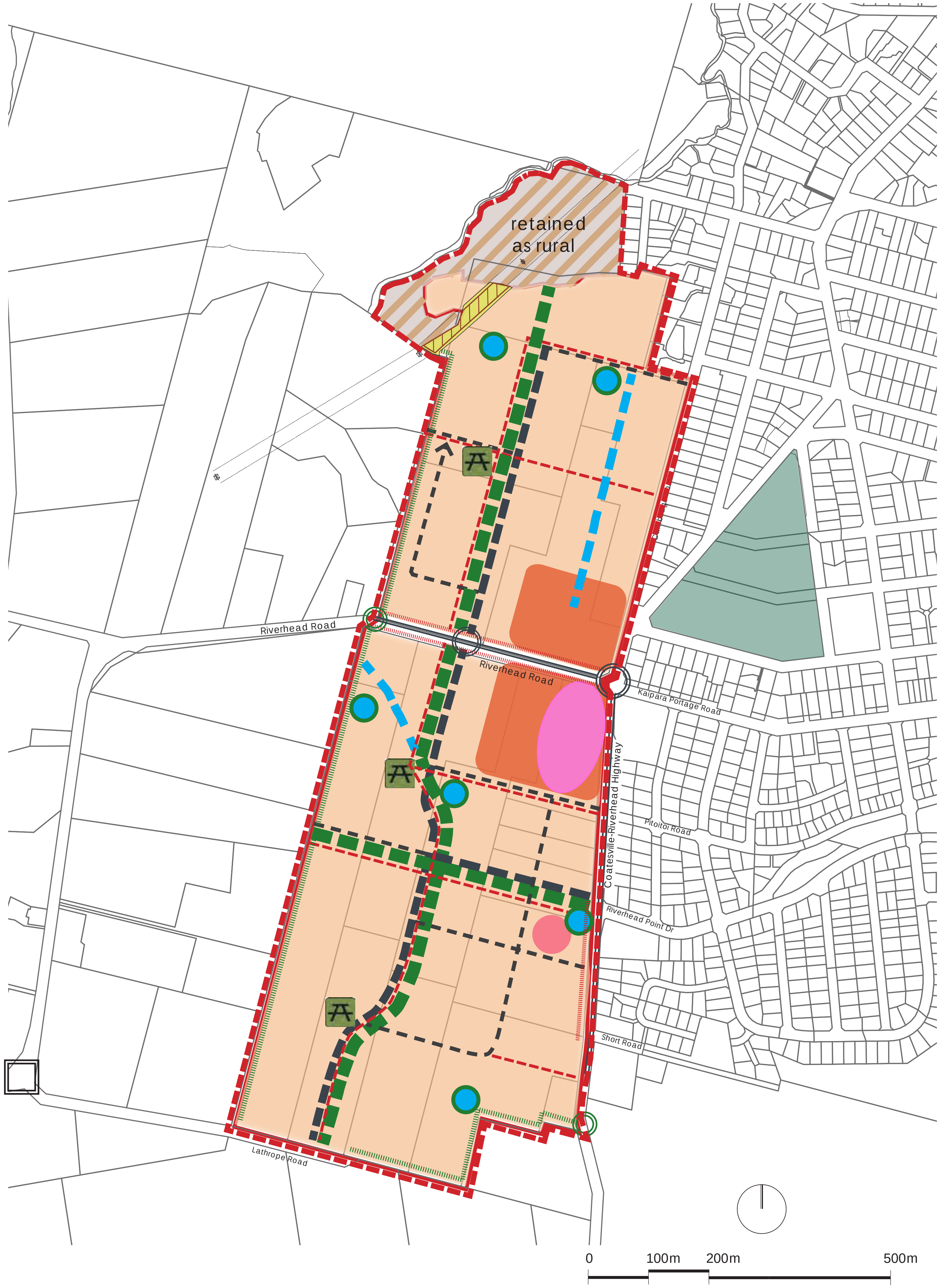


Figure 15 Riverhead Structure Plan

6.1 ACCESS AND CONNECTIONS

The proposed movement network accommodates all travel modes to deliver a connected movement network to support the development of the plan change area. A hierarchy of road typologies are proposed to promote legibility. Along Riverhead Road and Coatesville Riverhead Highway, new roundabouts help to slow traffic and gateways serve to indicate the change from rural to urban and associated need for speed reduction.

Riverhead Road/Coatesville-Riverhead Highway

These arterial roads adjoin the plan change area and will be fully urbanised as part of the development of the site. They accommodate public transport services and also provide the opportunity to provide new walking and cycling facilities. As connections to the wider area, they also have the opportunity to provide gateways and contribute to the overall character of Riverhead.

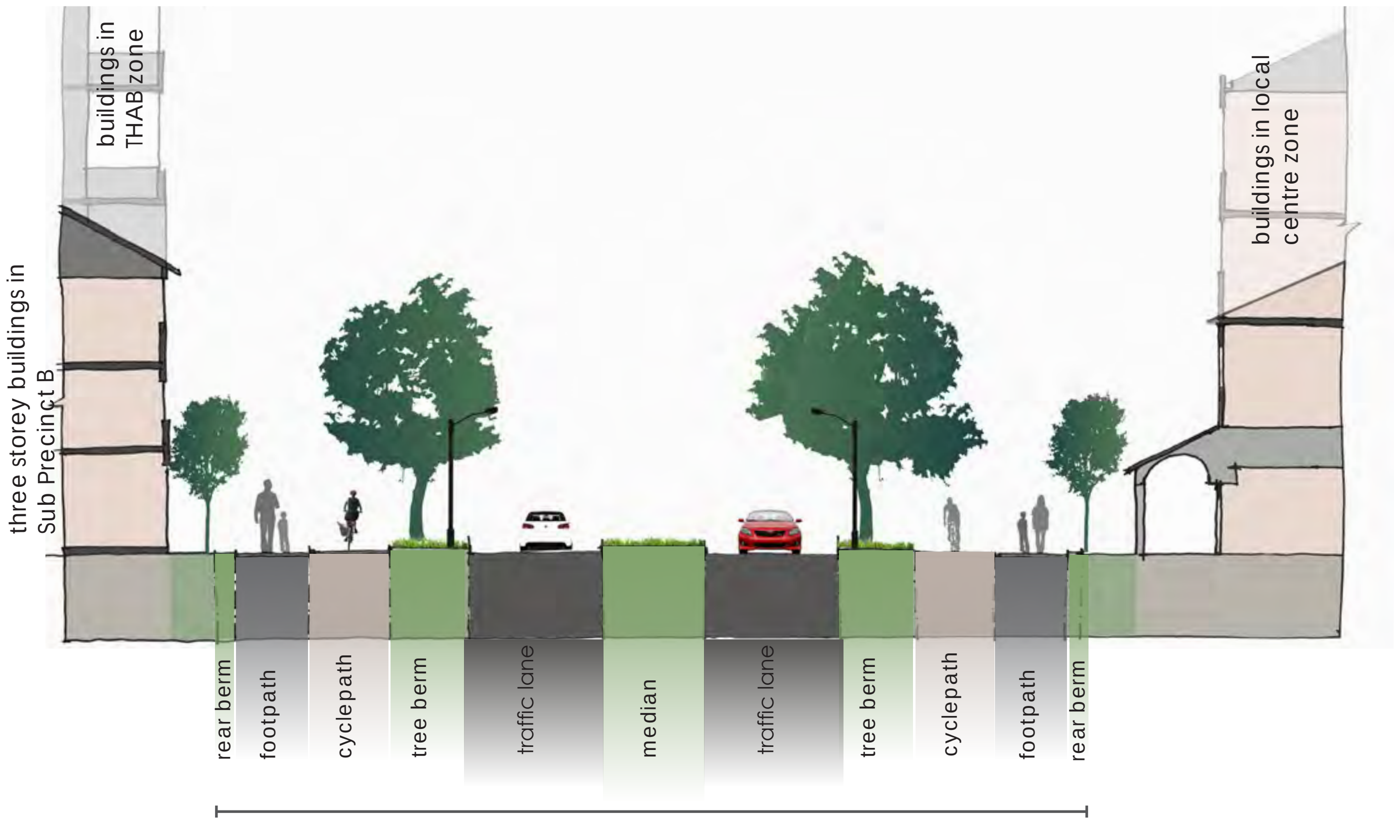


Figure 16 Indicative cross section of Riverhead Road

Collector Road

Collector roads ensure a high level of connectivity across the plan change site and connect the development to the surrounding existing roading infrastructure. They also connect and integrate development on different land parcels (and owners). The "north-south" collector route travels almost the full length of the plan change site, connecting Lathrope Road to the northern portion of the plan change

Figure 17 Roading Connections

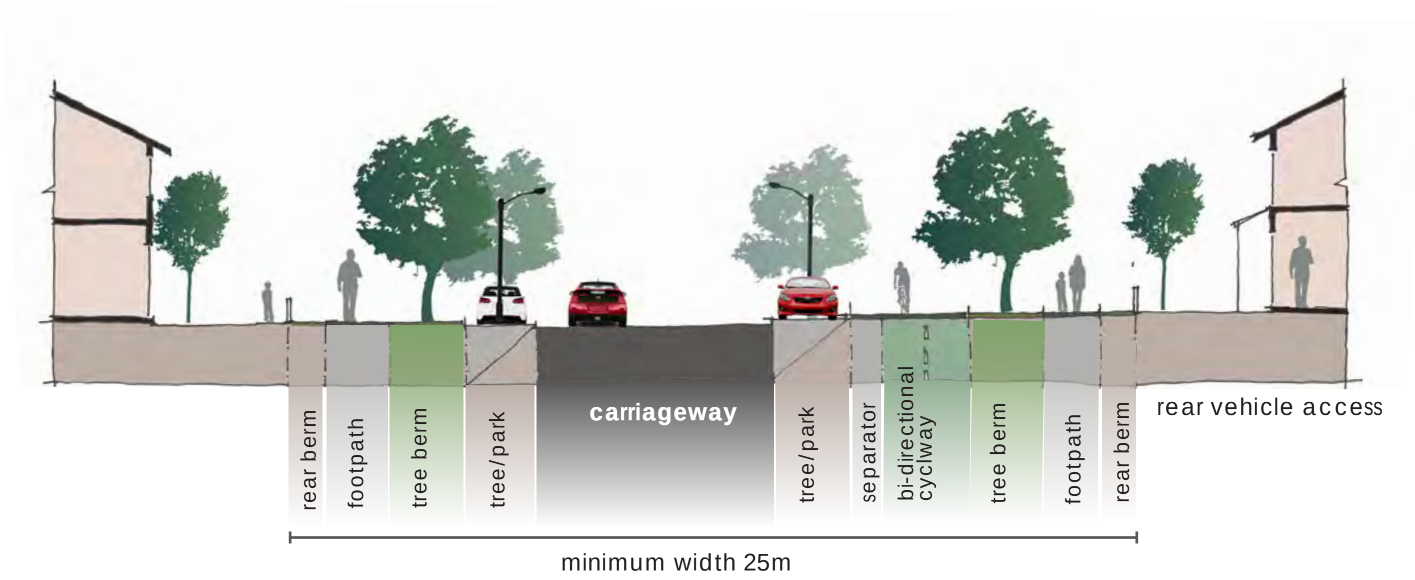


Figure 18 Indicative/potential design of Collector road

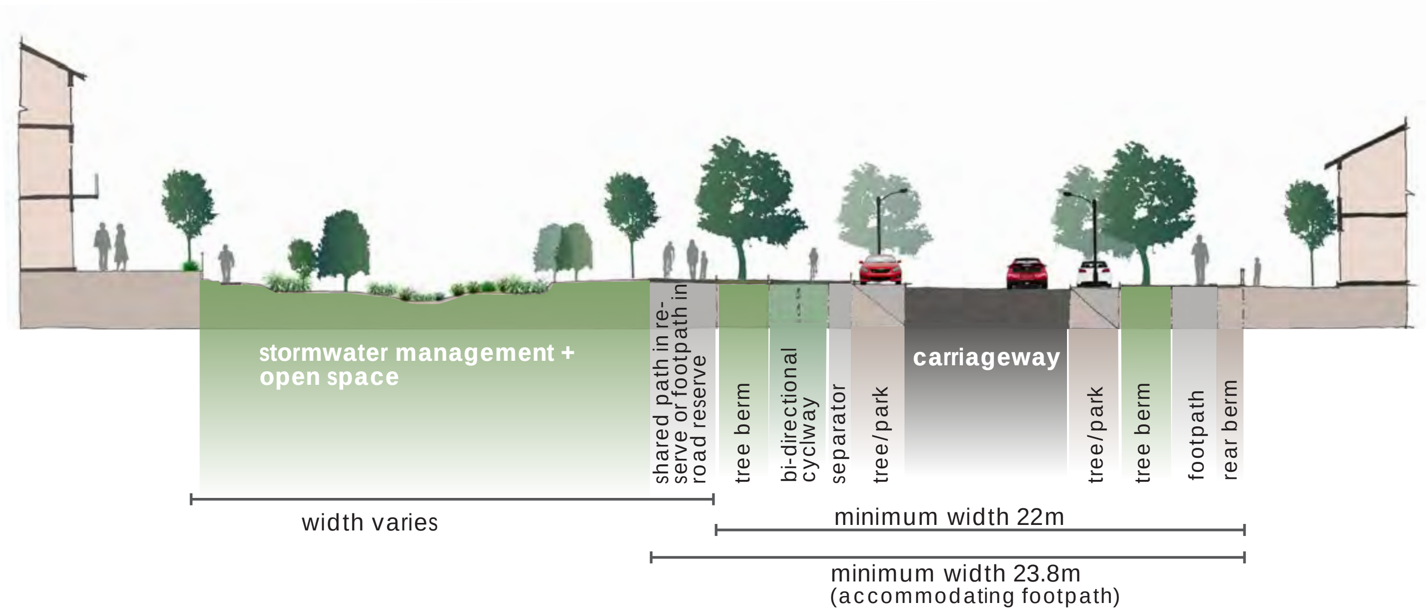


Figure 19 Indicative/potential design for Collector Road adjacent to green corridor

site and promoting views towards Riverhead Forest. It aligns generally with the central multi-purpose open space corridor which enables the open space amenity to be highly accessible and visible and shared by all residents.

The collector road network is not currently proposed to connect to either Duke Street or Cambridge Street. Land in the northern part of the plan change area includes wetlands and is also subject to flooding and these constraints are expected to prevent a collector road from being delivered. Subject to these constraints, future local roads may connect the northern portion of the plan change area to Duke Street. Pedestrian and cycle connectivity to Duke Street is still ensured.

A key east-west collector connects the north-south road to Coatesville Riverhead Highway where a future roundabout is proposed and connection is made to the southern part of the existing village and also to the coastal environment.

Collector roads accommodate pedestrian and cycle paths in both directions to ensure the good provision of safe active travel modes. They also provide good opportunities for street trees which contribute to establishing the green corridors and indicating/reinforcing their collector status.

Key Local Roads

Key local roads connect the north-south collector to the surrounding road network and help to distribute internal traffic towards the surrounding arterial roads. They serve to ensure connections between different land parcels/owners are made thereby ensuring integrated development over time. A key local road also promotes physical and visual connection with the existing village (Pitoitoi Drive).

Two opportunities for local roads to connect to land along the western boundary are proposed, to ensure neighbourhood connectivity should that land be rezoned as urban in the future.

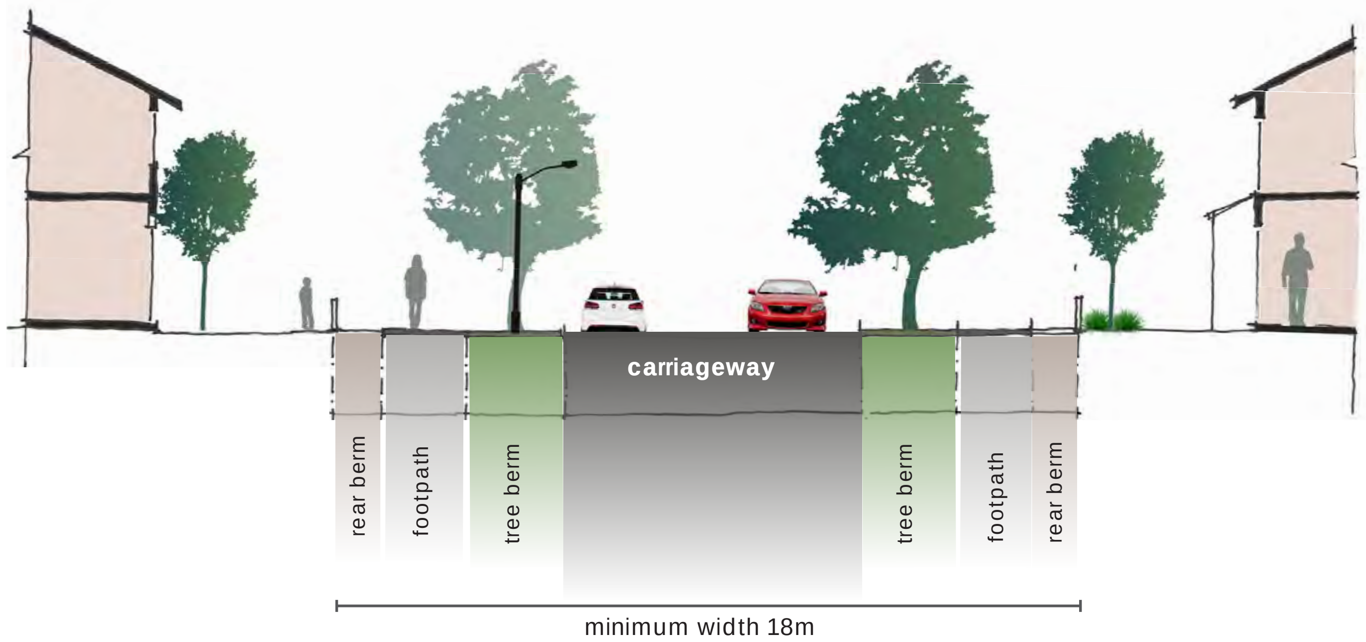


Figure 20 Indicative/potential design for Local Road

Active Mode Provision

Pedestrian connection to Duke Street (and thereafter Riverhead Forest) is indicated on the Structure Plan and the primary north-south open space corridor is also anticipated to accommodate pedestrian and cycle infrastructure.

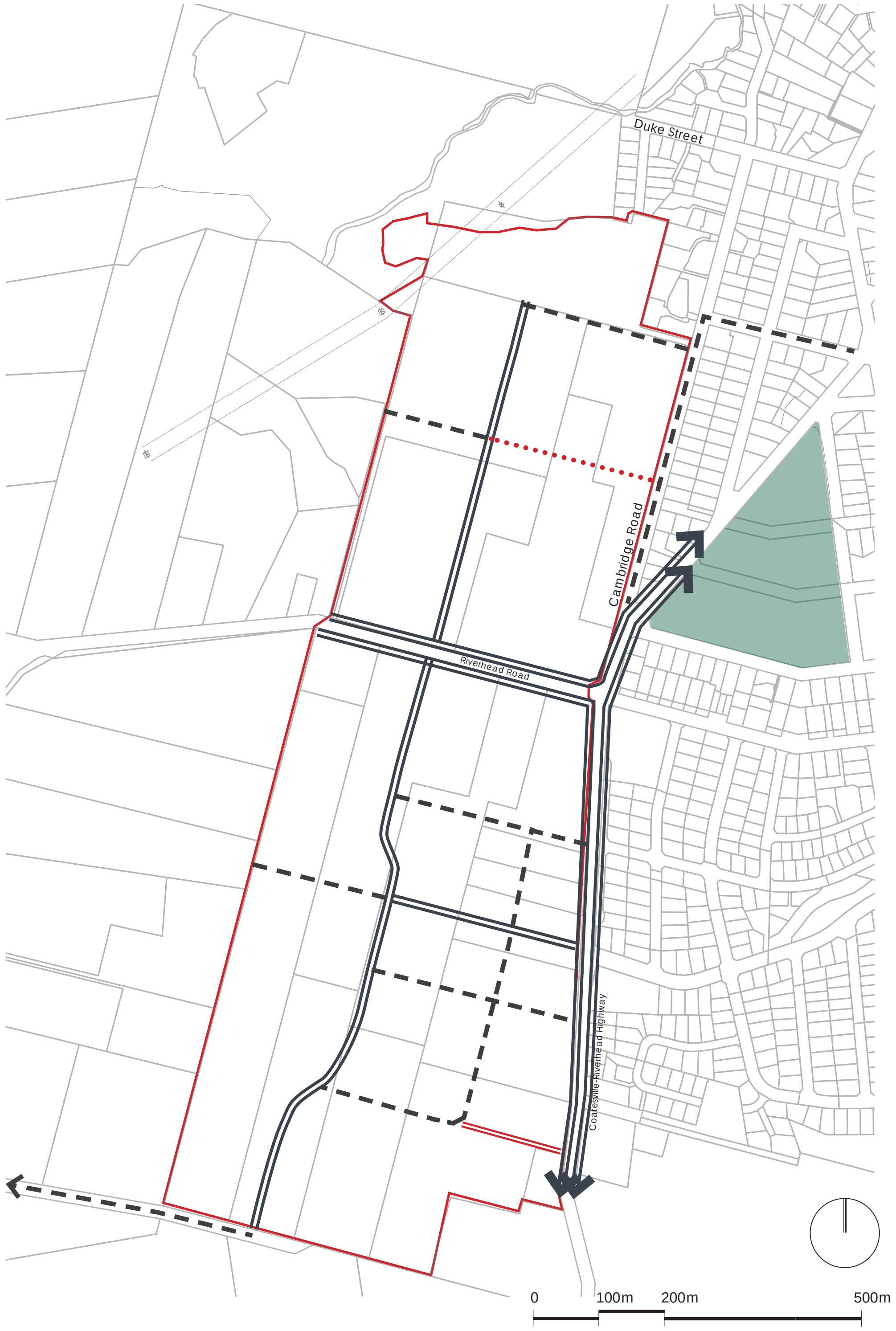
Collector roads are proposed to accommodate pedestrian footpaths and protected cycleways (in both directions). All local roads will include pedestrian footpaths and their low traffic speeds will allow for safe cycling on the carriageway.

Public Transport

Existing buses routes are located on Riverhead Road and Coatesville Riverhead Highway and the pedestrian and cycle infrastructure on collectors and key local roads connects development in the plan change area to these routes. The proposed collector roads can allow accommodate buses if internal routes prove feasible.

Recommendations for provisions:

- In the interests of connectivity, it is recommended that should a road link to Duke Street prove feasible (from both an economic and ecological/flooding perspective), this link is delivered
- subdivision should limit block length in order to promote accessibility, particularly for active modes
- street trees of significant number and scale are provided in collector roads to indicate their function and also reinforce the adjacent open space corridors
- high quality landscaping, including provision for large trees on Riverhead Road and Coatesville-Riverhead Highway to increase amenity for pedestrians and cyclists and contribute to overall Riverhead character
- the north south collector road is encouraged to adopt a curving alignment in order to differentiate it from other routes, promote speed reduction and create some non-rectilinear spaces for stormwater management areas
- adequate pedestrian and cycling connection should be provided from the northern portion of the plan change area to the existing pedestrian network in the village which provides access to the existing primary school and local centre (along Cambridge Road/Queen Street).



Structure Plan Boundary

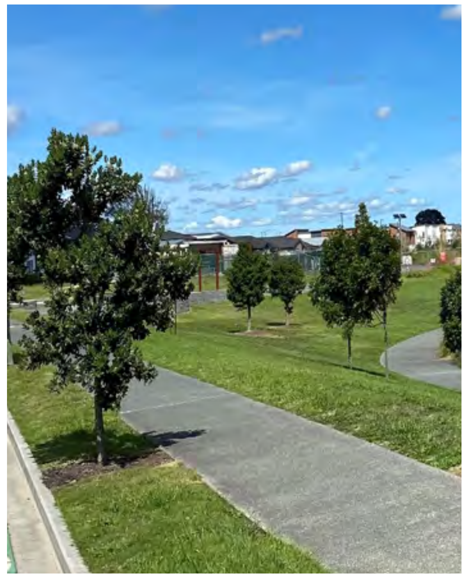
key pedestrian connection

key pedestrian connection

cycle paths on arterial and collector road

key pedestrian and cycling on local road (indicative location)

Figure 21 Active Modes



6.2 CENTRES

Two centres are proposed to serve the plan change area as well as offer the existing village residents greater choice and convenience. Both centres are easily accessed and well connected to proposed walking and cycling infrastructure.

The local centre is situated at the intersection of Riverhead Road and Coatesville-Riverhead Highway as this location has the highest visibility and passing trade. Other benefits to this location include the proximity to Memorial Park (helping to reinforce its role as a community heart) and the future retirement village. It is also within walking distance of a significant area of the existing village. This centre is expected to include a supermarket which, due to its scale and associated car parking, cannot establish in the existing village. A supermarket, in turn, can attract and supports smaller retail services. The size of the local centre (approximately 1.8ha) is sufficient to accommodate a variety of commercial/business activities as well as some residential use.

The better support walkability of the southern portion of the plan change area, a neighbourhood centre (approximately 0.65ha) is proposed along Coatesville-Riverhead Highway, close to the Halletau Brewery and a future key east-west connection. Halletau is a key landmark and contributes to Riverhead sense of place as a destination for food and drink, and a future neighbourhood centre can reinforce this benefit and promote placemaking. Local stormwater management areas can increase the amenity of the local centre.

Recommendations for future design:

- with respect to the local centre, it is recommended that future built form address Riverhead Road (with doors and glazing) as a priority and serve to reinforce this gateway location
- the neighbourhood centre should actively front any open space and future local roads as a priority in order to benefit from landscape amenity and allow convenient short term on-street car parking
- the local centre should provide for employment opportunities and residential use at upper levels
- the neighbourhood centre should prioritise activities that complement the local centre, meet the daily convenience needs of residents and reinforce Riverhead's identity as a destination for food and drink
- the neighbourhood centre should include public open space that can accommodate a variety of activities, including markets
- the architecture of both centres should reflect the village location through building form and materials as well as employ a co-ordinated signage strategy
- car parking for both centres is located away from key public streets and areas

It is anticipated that these outcomes are implemented through the subsequent consenting process for the development of buildings in centres and in line with the applicable AUP zone provisions.

Figure 22 Centres

6.3 HOUSING, BUILT FORM AND YIELD

Housing and Built Form

With the exception of the centres, all land within the plan change area is proposed to be residential. The appropriate residential zoning is determined by a number of factors, including current national policy driving urban development (particularly the need for appropriately located higher densities), residential choice and affordable housing. At the same time, the local context of Riverhead is also a factor informing the ideal nature of future residential development, namely:

- the generally single storey and low density of the existing village, its Single House zoning and limited capacity to intensify;
- its capacity to absorb change and growth while maintaining/reinforcing village identity and character;
- the proposed Retirement Village which includes built form up to five storeys;
- the rural land to the north, west and south;
- the location/proximity of services and recreation space, particularly Memorial Park

From an urban design perspective, the following outcomes are sought for residential density and built form in the plan change area:

- a variety of housing, including smaller and more affordable dwellings in both detached and attached typologies as well as apartments
- flexibility to allow developers to respond/meet the market
- predominantly one and two storey built form but provision for some three storey development in appropriate/logical locations, for example in close proximity of open spaces, centres/services and public transport
- higher density and taller buildings close to Memorial Park and the Riverhead Road/Coatesville-Riverhead Highway intersection to reinforce the future local centre as the heart of the village, and establish a landmark
- opportunity for non-residential activities on the ground floors of buildings in higher density areas adjacent to the local centre in order to reinforce function and place
- a transition between taller buildings around the centre to lower densities and building forms in the remaining areas of the site
- a high quality and vegetated interface for higher density development along the key movement routes and adjacent to existing residential development which contributes to the current landscaped character of streets in Riverhead

Typical existing housing in Riverhead

Examples of the variety of housing form appropriate in Riverhead

The proposed Structure Plan indicates the location of medium density and higher density residential areas.

Including an area for higher residential density (proposed to be zoned as Terrace Housing and Apartment Zone) has the following benefits:

- it increases potential residential density around Memorial Park which is perceived by the community as the heart of Riverhead and encourages its use
- it promotes a higher population in Riverhead which contributes to the creation of a self-sufficient settlement where residents are less likely to need to leave to access facilities and services
- it allows for greater building height at the intersection of Riverhead Road and Coatesville-Riverhead Highway which could create a landmark and reinforce this location as the new heart of the town, incorporating the new local centre and Memorial Park
- it allows for building height which reflects the height of the existing shelterbelt in this location
- it reflects the potential building height in the adjacent proposed local centre
- it allows for a greater diversity and density of housing which is consistent with national policy and extends the lifestyle choice in Riverhead
- it allows additional building height which can take advantage of views to the harbour and Riverhead Forest
- it allows for apartment buildings which do not require numerous accesses and can more easily establish around/build close to and spatially define the roundabout/landmark
- it recognises and accommodates the consented Retirement Village which includes built form up to 5 storeys

The remaining area is identified as appropriate for variety of housing types and styles, including one, two and three storey development and provision for medium density housing delivered through integrated land use and subdivision design and consenting.

Recommendations for provisions:

- promote/frame/reinforce views to Riverhead Forest through the provision of a central north-south green corridor
- promote visual and physical connections to the multi-purpose green corridor and maximise its amenity and safety
- include provision for dwellings in the medium density zone to utilise greater building height to maximise outlook and benefit from amenity associated with open spaces, including neighbourhood parks and the multi-purpose green corridor
- include provisions to allow for the transition of building height from the THAB zone (5 storeys) to the predominantly one and two storey suburban development surrounding it
- include fencing standards to maintain open front boundaries along the open spaces and corridors with low or no fencing

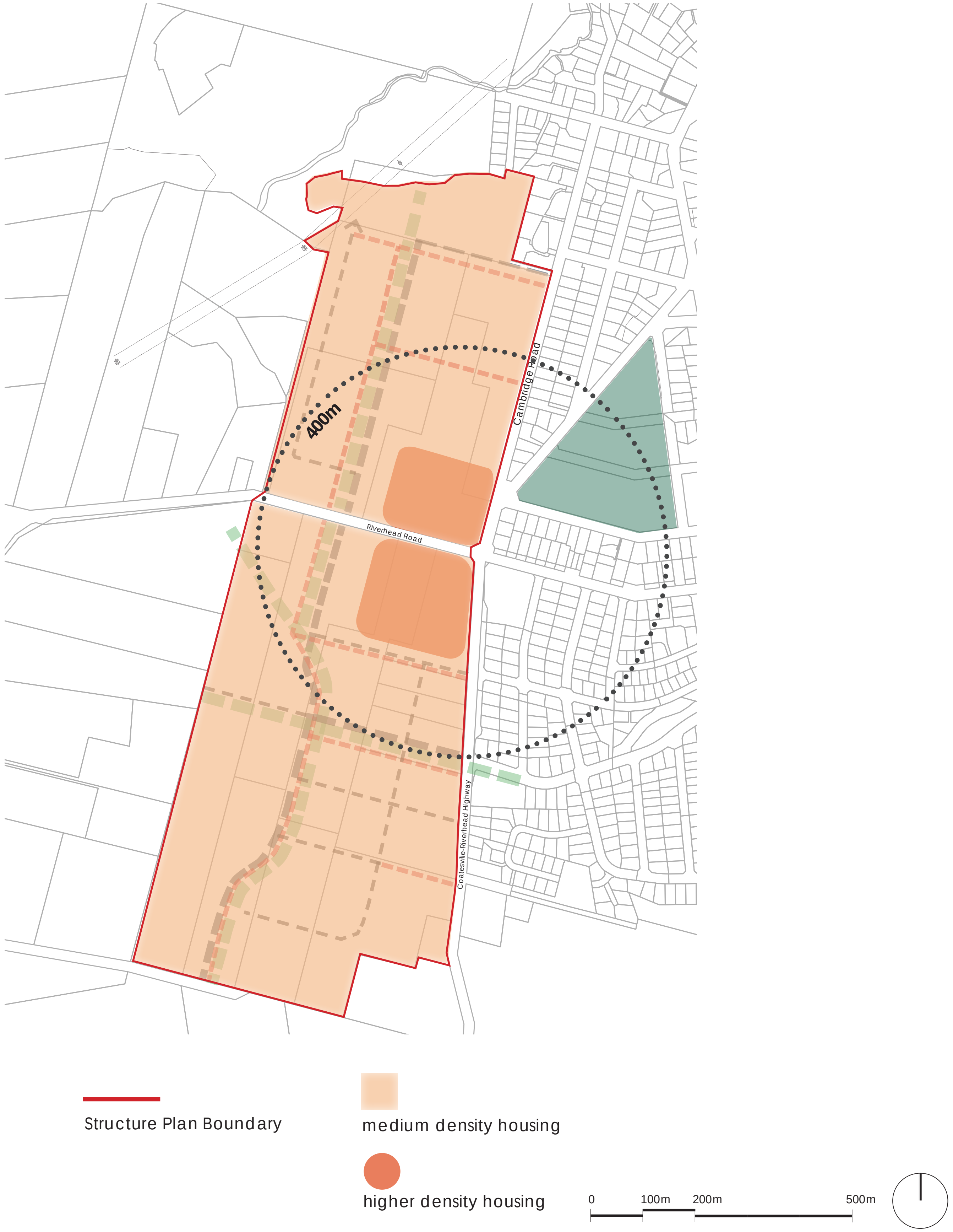


Figure 23 Housing - density distribution

- include criteria to retain notable trees where practical
- include provisions to ensure that the key routes of Riverhead Road and Coatesville-Riverhead Highway have high quality planting/soft landscaping at a scale which adds amenity to the street

Estimating residential yield.....

A number of case studies of the delivered gross density of recent residential developments in comparable locations have informed the potential yield of the plan change area. These are illustrated on the adjacent page and have informed the conclusion to adopt a gross density of 20du/ha in the medium density areas.

Indicative Yield

The estimate of the potential residential yield in the structure plan area is a combination of known developer aspirations (informed by masterplanning and subdivision concept design) and assumptions about the likely yield in the medium density zone and higher density zone. These figures are estimates only as development will occur over a long period of time and adapt to changing market trends.

The approximate extents of the residential zones are:

Higher density (THAB) Zone	4.3ha
Mixed/medium density housing zone	68ha

The estimated yield (rounded figures) is as follows:

Higher density residential area	-	410 dwellings (inc. 310 apartments in retirement village)
Medium density residential area	-	1360 dwellings (inc. 160 villas in retirement village)
Total residential yield	-	**1770** (approx) plus 90 care beds

The following calculations and assumptions have been made:

- the medium density zone is assumed to achieve a gross density of **20du/ha,** comparable to typical yield in a Mixed Housing Suburban Zone and recognises likely open space provision, balanced with clusters of comprehensively developed terraces and duplexes
- yield in the THAB zone south of Riverhead Road (1.5ha approx) is assumed to be **50du/ha**
- estimated yield in the THAB zone north of Riverhead Road is known and provided by Matvin (310 apartments and 90 dementia care beds)
- no allowance has been made for residential development in the local centre zone

1 Kumeu (MHS).. 17du/ha

2 Park Green (MHS).. 14du/ha

3 Whenuapai (MHU).. 23 du/ha

6.4 OPEN SPACE

The proposed open space network is integral to placemaking in the plan change area. Access to nature, and the amenity and identity it provides, is a key part of the vision for a healthy attractive neighbourhood that recognises Riverhead's location and character.

The open space network is comprised of spaces with different functions including stormwater management areas and neighbourhood parks and the conveying and connecting spaces between them. Co-locating open spaces enables a greater visual impact/effect and vegetation of greater stature/ scale.

The spine of the network is therefore the multi-purpose green corridors which:

- at the macro-level, connect the site to the wider open space network – namely to the coast (via Riverhead Point Drive) and to the stream in the north
- promote better ecological values/diversity
- supports the road hierarchy and thereby legibility of the movement network
- at an internal level, creates structuring elements which integrates different land parcels/owner/ developers to deliver a connected neighbourhood
- has the ability to reflect the character of Riverhead which is partly based on swales and street gardens and thereby promote the integration of "old Riverhead" and new development
- provides open space which increases amenity for higher density residential and provides people with access to nature and opportunities for nature play
- provides amenity for key pedestrian and cycle networks
- integrates stormwater spaces, movement and recreation spaces to promote land use and infrastructure efficiency, maximise openness and safety and enable smaller open spaces to benefit from co-location
- enables spaces to have more than one function (or at least future-proofs this possibility) and provides opportunity for reduced maintenance costs in the future

The primary north-south open space connects a number of different development stages/land owners and connects the site visually and physically to Riverhead Forest. The east-west route provides a visual and ecological connection to Riverhead Point Drive and the adjacent drainage corridor, and ultimately the Upper Waitamata Harbour.

Neighbourhood parks are located (indicatively) on the proposed structure plan to co-locate with the central north-south green corridor. Three neighbourhood parks are proposed (one in the north and two in the south) in order to ensure every future dwelling is within a 400m walking distance (300m radial distance). Given the extent of flooding in the north of the PC area and the assumption that little residential development will eventuate there, one park is considered to adequately serve the northern area. The provision of three neighbourhood parks enables each park to have a slightly different function or focus, thereby providing the plan change area with a fuller range of recreational opportunities (e.g. playgrounds catering for different age groups).

Structure Plan/Plan Change Area Boundary

flood attenuation area

stormwater management treatment/attenuation area

stormwater management corridor

neighbourhood park

multi-purpose green corridor

intermittent stream

Figure 24 Open Space

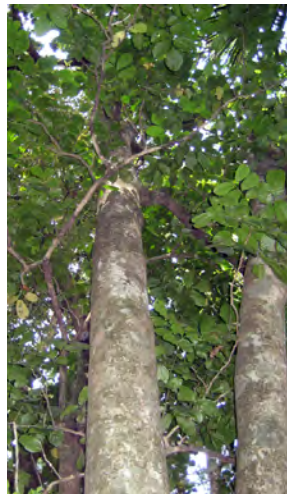
The proposed neighbourhood parks are located to:

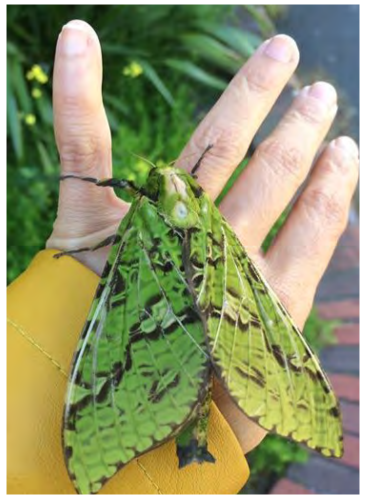
- support the development of medium density housing by providing amenity, recreation and social opportunity for dwellings with little private open space
- support the establishment of greenways/the green corridors and connect to the stream and coastal environment
- integrate with stormwater management areas, key pedestrian and cycle infrastructure
- function as placemakers/focal points for the micro-neighbourhoods in the absence of any significant natural features
- benefit from relatively flat land

Recommendations:

- open spaces with different functions and asset managers (Healthy Waters and Parks) should co-locate to deliver a continuous and connected open space corridor
- open spaces have a strong connection to the collector road network which enables the co-location of open space and active mode infrastructure as well as high profile/visibility and good accessibility
- connective spaces form part of the stormwater management strategy and the conveyance, retention and treatment of stormwater echoes existing swales and natural character
- the design of open spaces reflects mana whenua mātauranga and integrates Te Aranga design principles
- the future school locates adjacent to stormwater management areas and the collector road as a potential component of the open space network
- connective spaces should accommodate pedestrians and cyclists, particularly if their alignment diverges from a collector road
- the north-south open space corridor should include vegetation that includes podocarp species that reference Riverhead Forest
- vegetation in the east-west open space corridor should have a focus on productive vegetation/ market gardens
- each neighbourhood park should have clear identity and cater to a specific age group
- fences adjacent to open spaces should be low and/or visually permeable to ensure passive surveillance

NORTH/SOUTH CONNECTIONS - CATHEDRAL FOREST



PODOCARP SPECIES THAT CREATE A "CATHEDRAL FOREST"

PURIRI MOTH - LIVES ON PURIRI TREES

EAST/WEST CONNECTIONS - MARKET GARDEN



potential planting strategy for green corridors

PRODUCTIVE VEGETATION TO DEVELOP MAHINGA KAI



6.5 RURAL INTERFACES

The long western boundary and the shorter southern boundary of the plan change area adjoins land zoned for and accommodating rural activities, including rural lifestyle properties and productive land. While rezoning of this land is not anticipated in the near future, given its proximity to arterial roads, proposed new centres and open spaces, and current activity/use, it could logically accommodate urban development in the long term (and the proposed structure plan includes connection to it).

Whilst it is likely that future subdivision accommodates a variety of sections along this boundary, the opportunity to restrict residential density along this boundary (e.g. by requiring a larger minimum lot size) is not supported from an urban design perspective. In the future, should the land adjacent to the western boundary be rezoned (possibly to meet the riparian corridor which provides a logical and defendable boundary) there would be an artificial low density zone between neighbourhoods.

Recommendations:

- Given the predominantly north westerly orientation of this boundary, it is likely that dwellings locate private indoor and outdoor space along this boundary. As such, it is recommended that a greater yard/setback (recommend 5m) for buildings along the rural boundary is provided. A yard setback greater than that currently required by the AUP's mixed housing zones (1m) will provide a greater level of separation between future conventional and medium density activity and rural activities.
- an effective landscaping strategy is explored, particularly one which includes specimen trees which will filter views of two storey buildings from the rural environment.

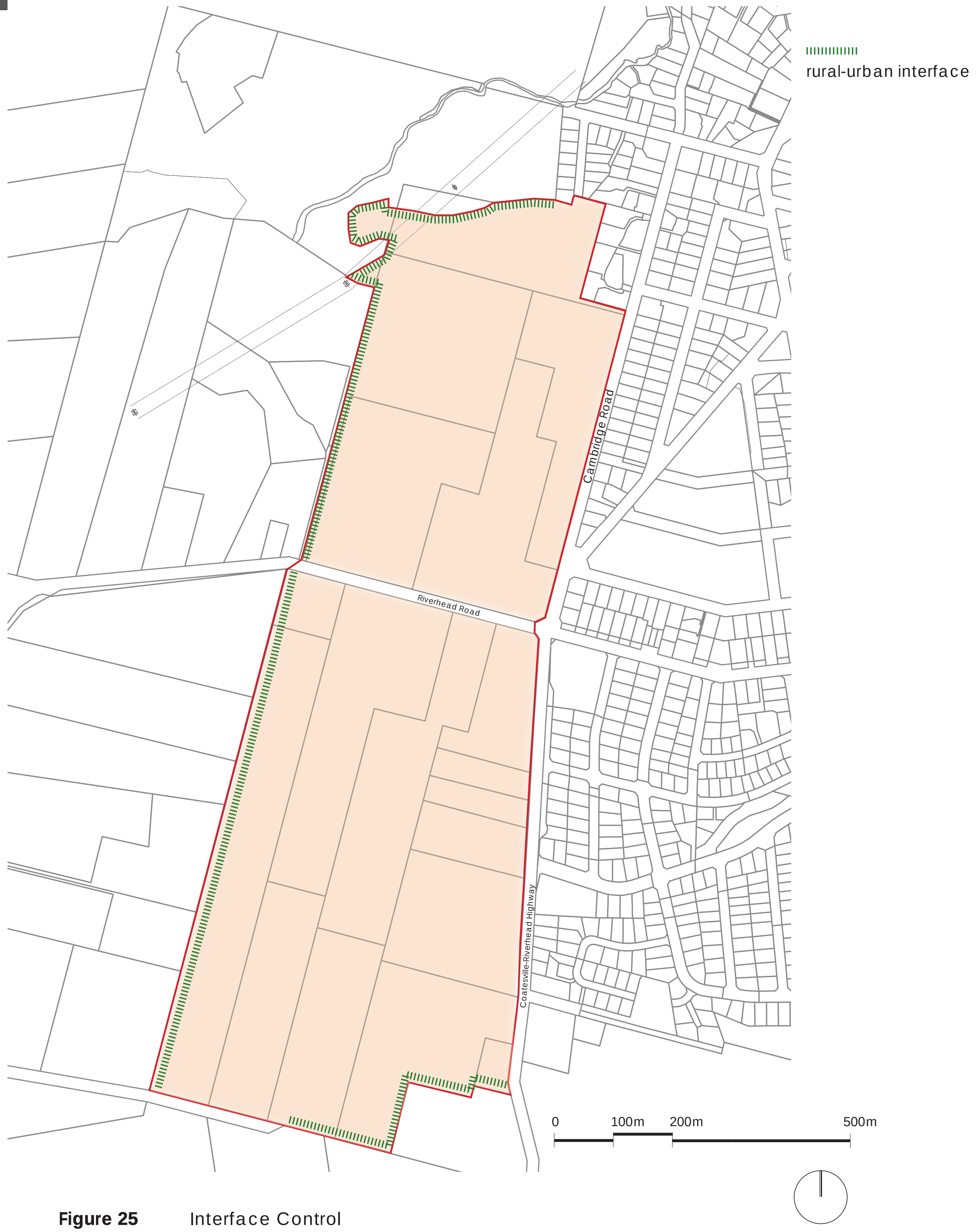


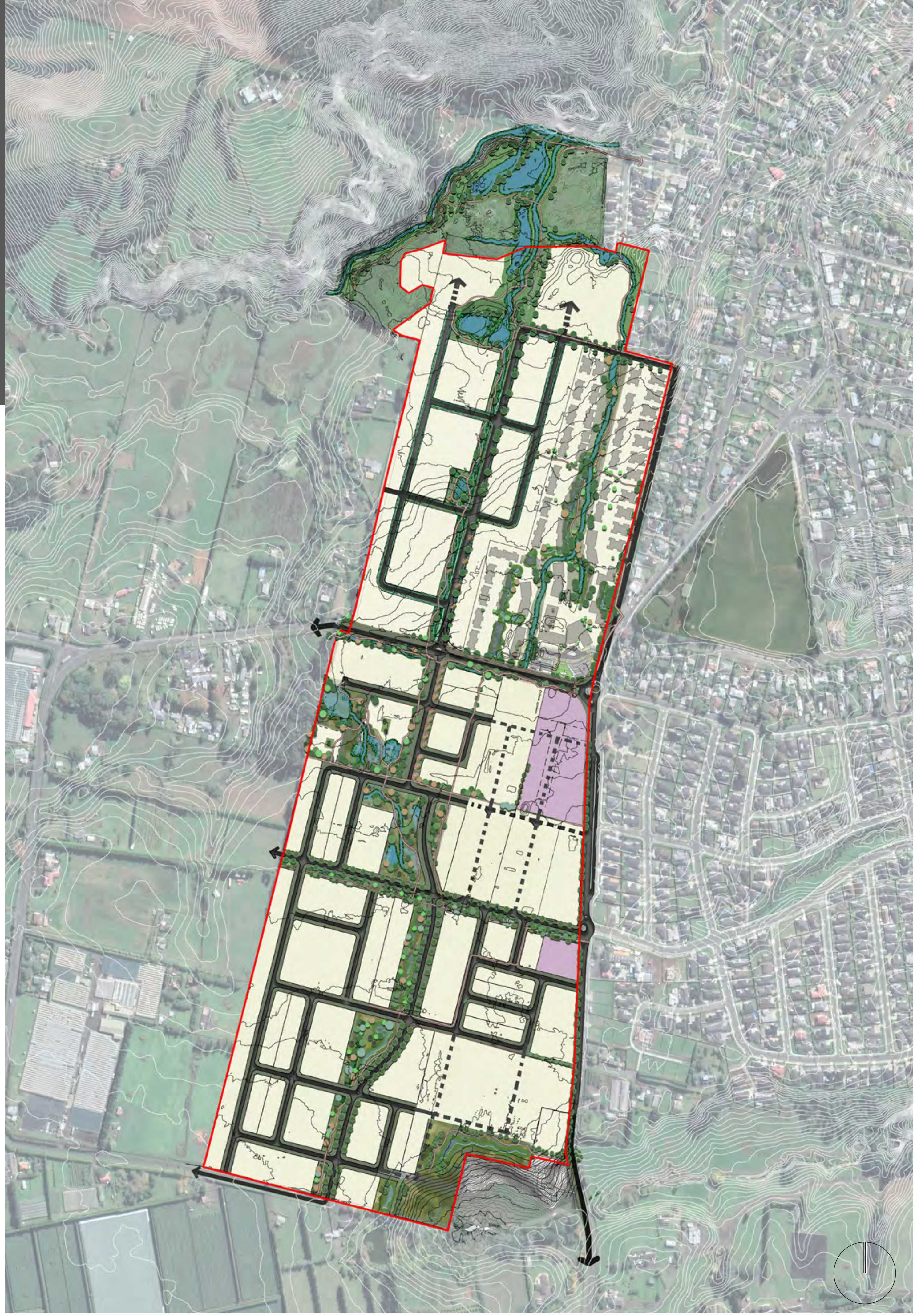
Figure 25 Interface Control

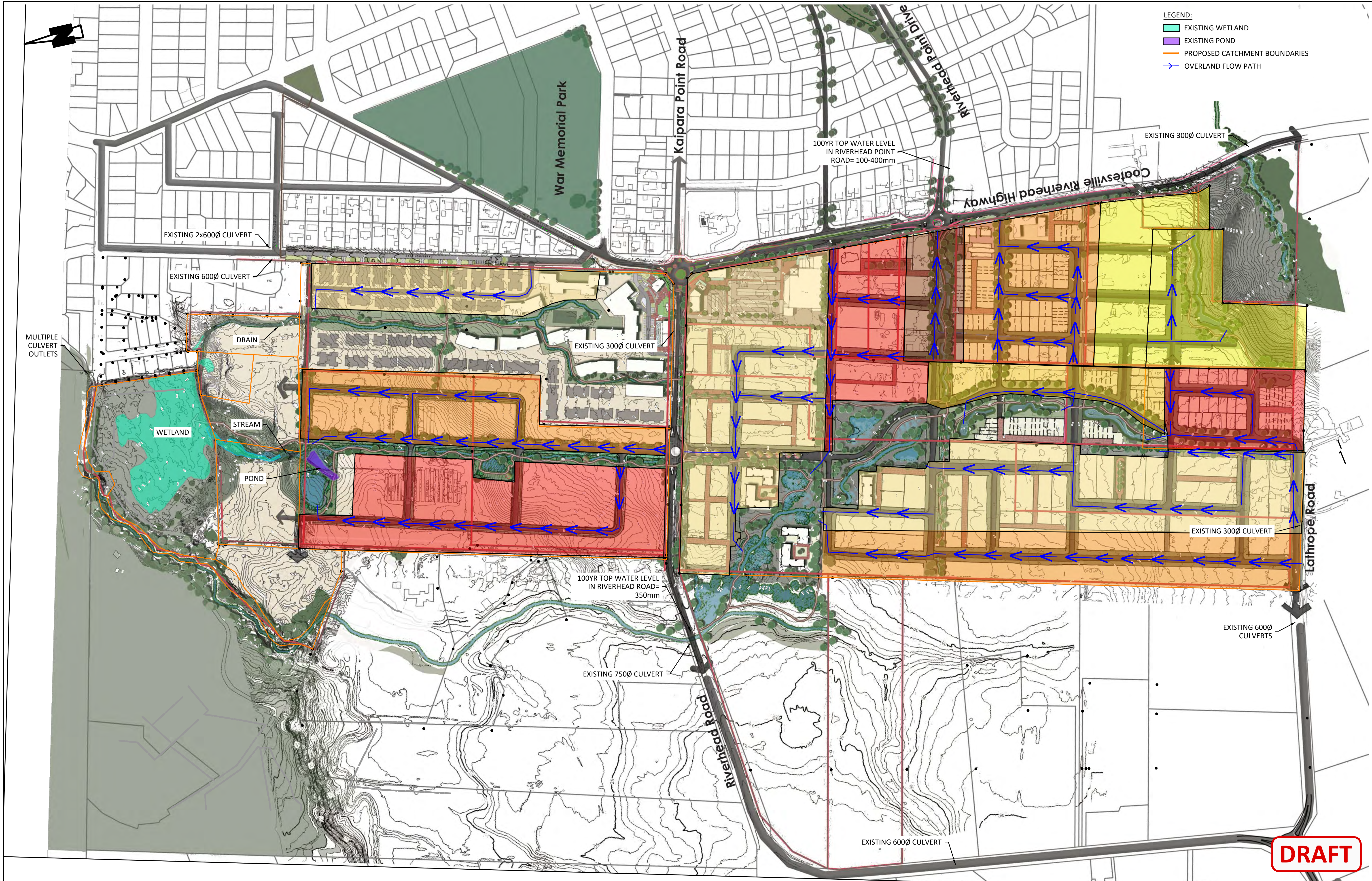
7.0 CONCLUSION

The Plan Change area offers an opportunity for Riverhead to grow in a co-ordinated and efficient way and to provide a wide variety of new housing choice for both existing village residents and those who choose to make Riverhead their new home. It provides for the creation of a new local centre for the village, reinforcing Memorial Park as the heart of the village. Recognising the scale and constraints of the existing retail area, the structure plan provides for a variety of additional retail services and employment opportunities, both of which will increase Riverhead residents' ability to meet their daily convenience needs without leaving the village.

The proposed structure plan will drive a new neighbourhood which integrates with the existing village and promotes visual and physical connections to the upper harbour and Riverhead Forest. It includes features which respond to the unique context of Riverhead and promote placemaking, primarily through a focus on connected multi-purpose open space corridors which connect future residents to both Riverhead Forest and the Upper Waitamata Harbour.

The components of the structure plan ensure connection across multiple land owners, promote the integration of various open spaces and active transport modes and respond appropriately to the adjacent interfaces.





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Auckland Office
A: 25 Broadway, Newmarket
P: 09 524 7029
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Riverhead Plan Change

Riverhead

STORMWATER OLFP MASTER PLAN

Issue	Description	Checked	Date
0			

		Date
Designed:	AM	11.03.22
Drawn:	FDP	11.03.22
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Scale: 1:5000 (A3 Original)

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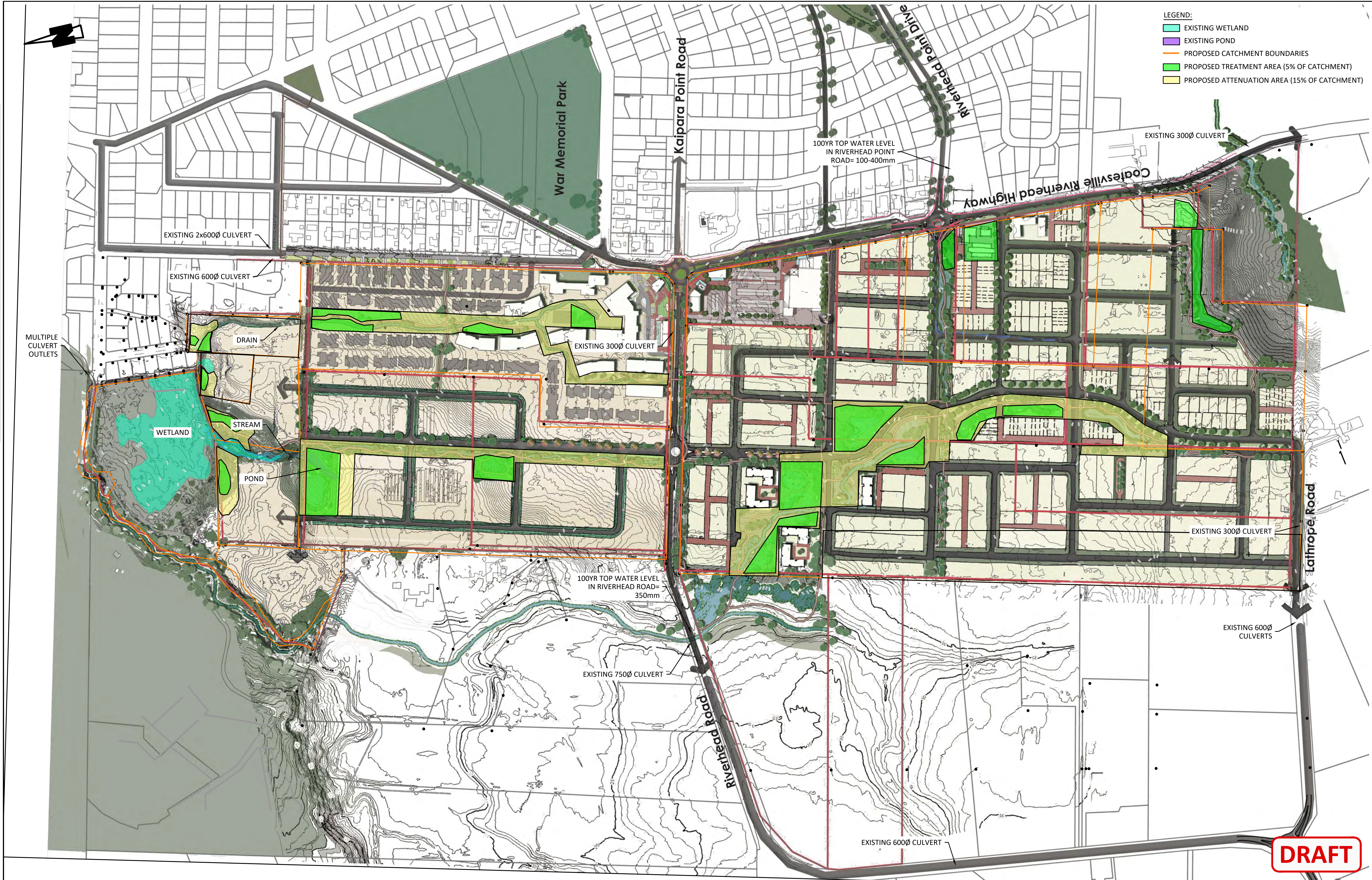

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STORMWATER MANAGEMENT AREAS MASTER PLAN

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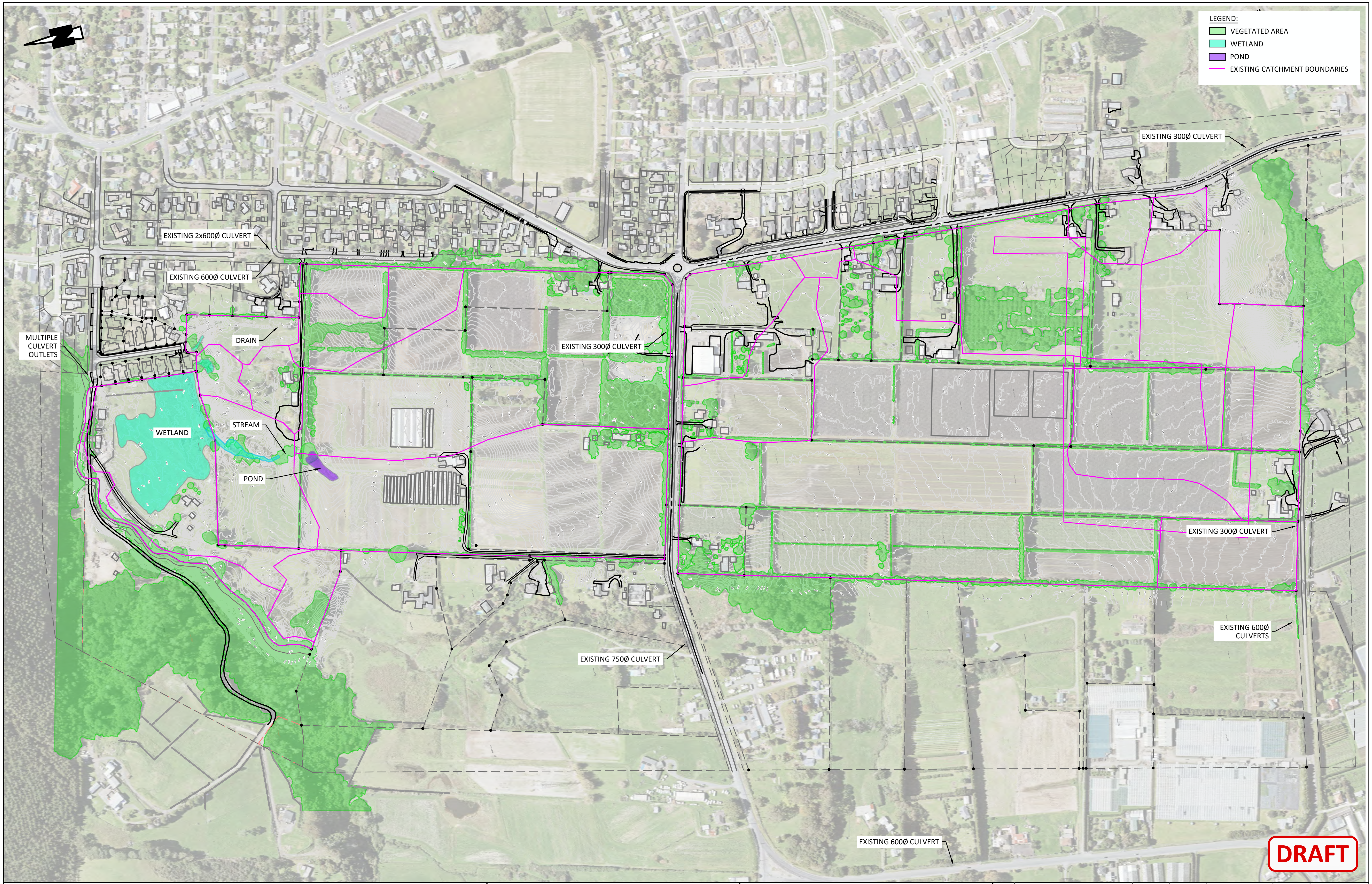

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Existing Site Features

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Proposed Stormwater Master Plan

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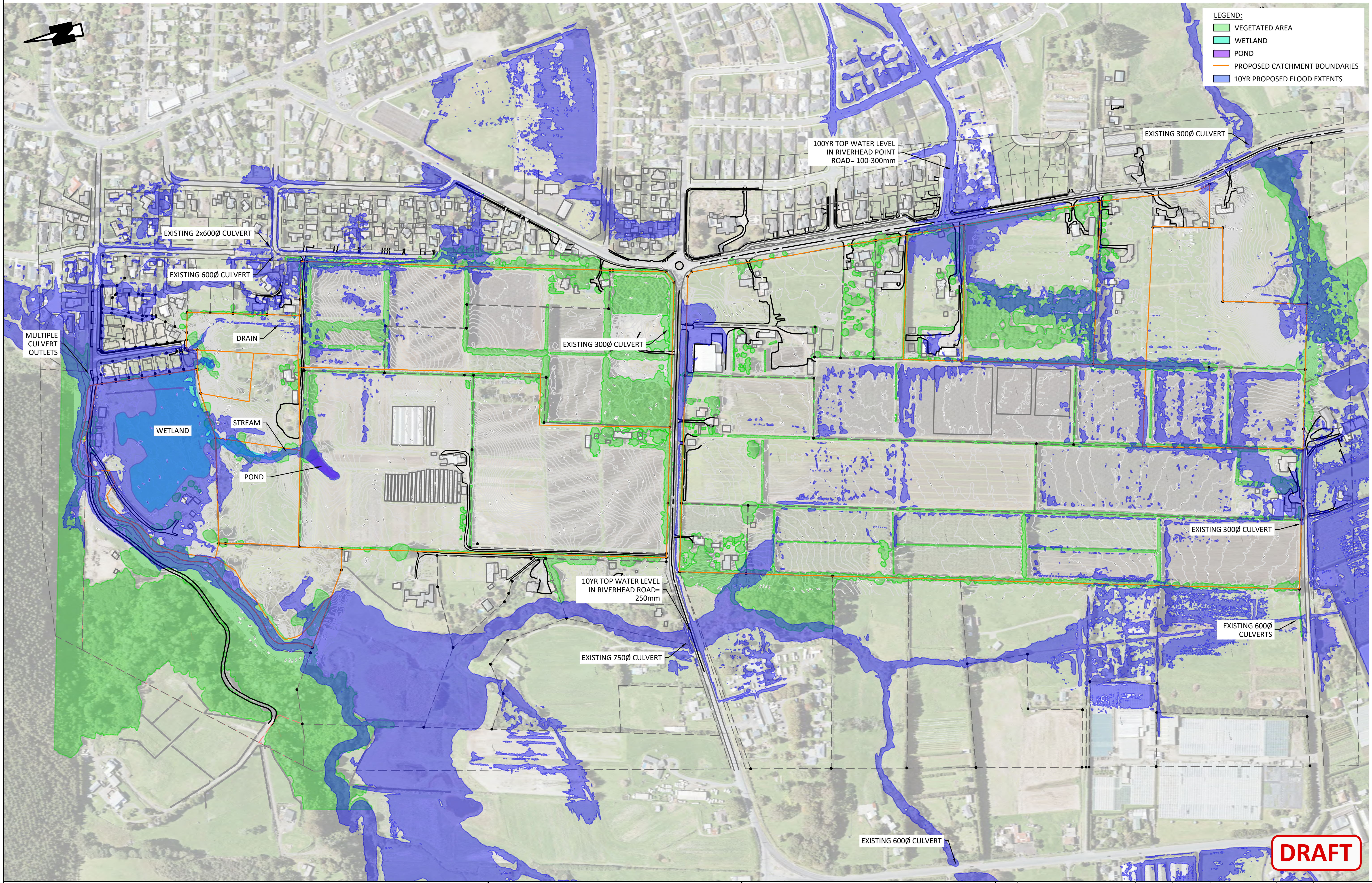

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10 YEAR PROPOSED FLOOD EXTENTS (MPD FOR SITE)

Issue	Description	Checked	Date
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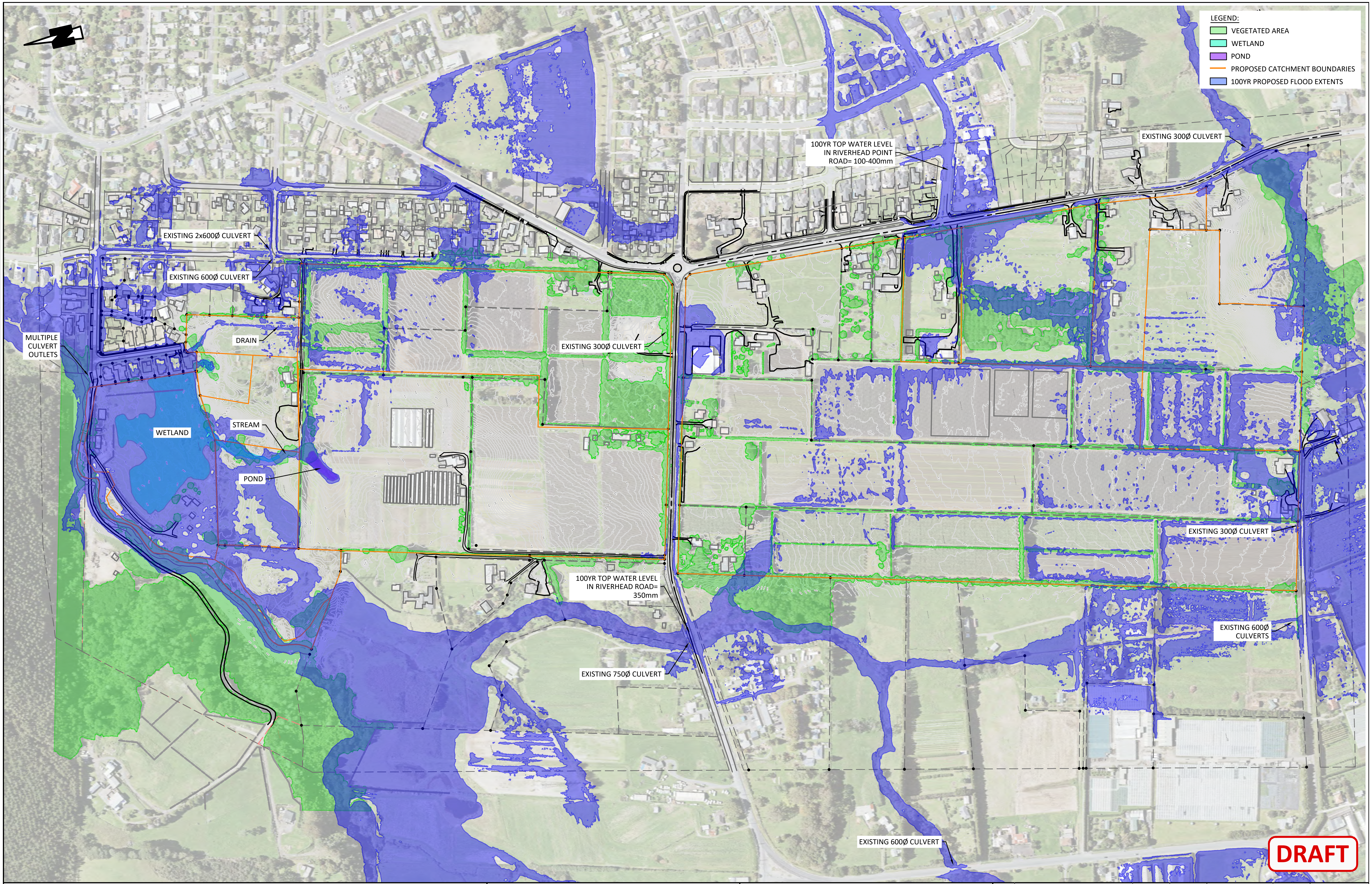

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100 YEAR PROPSOED FLOOD EXTENTS (MPD WHOLE CATCHMENT)

Issue	Description	Checked	Date
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		Date
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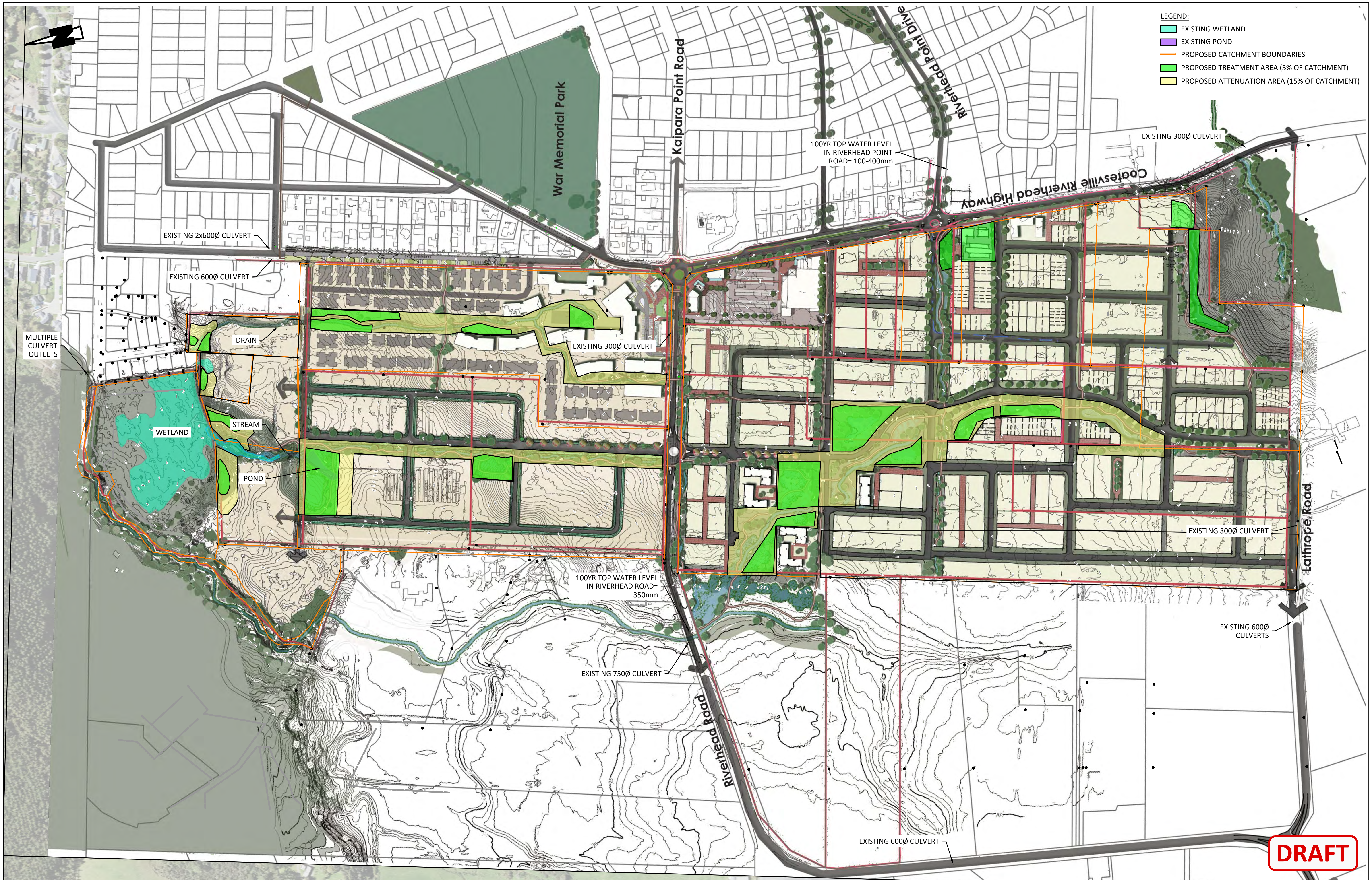

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STORMWATER MANAGEMENT AREAS MASTER PLAN

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		Date
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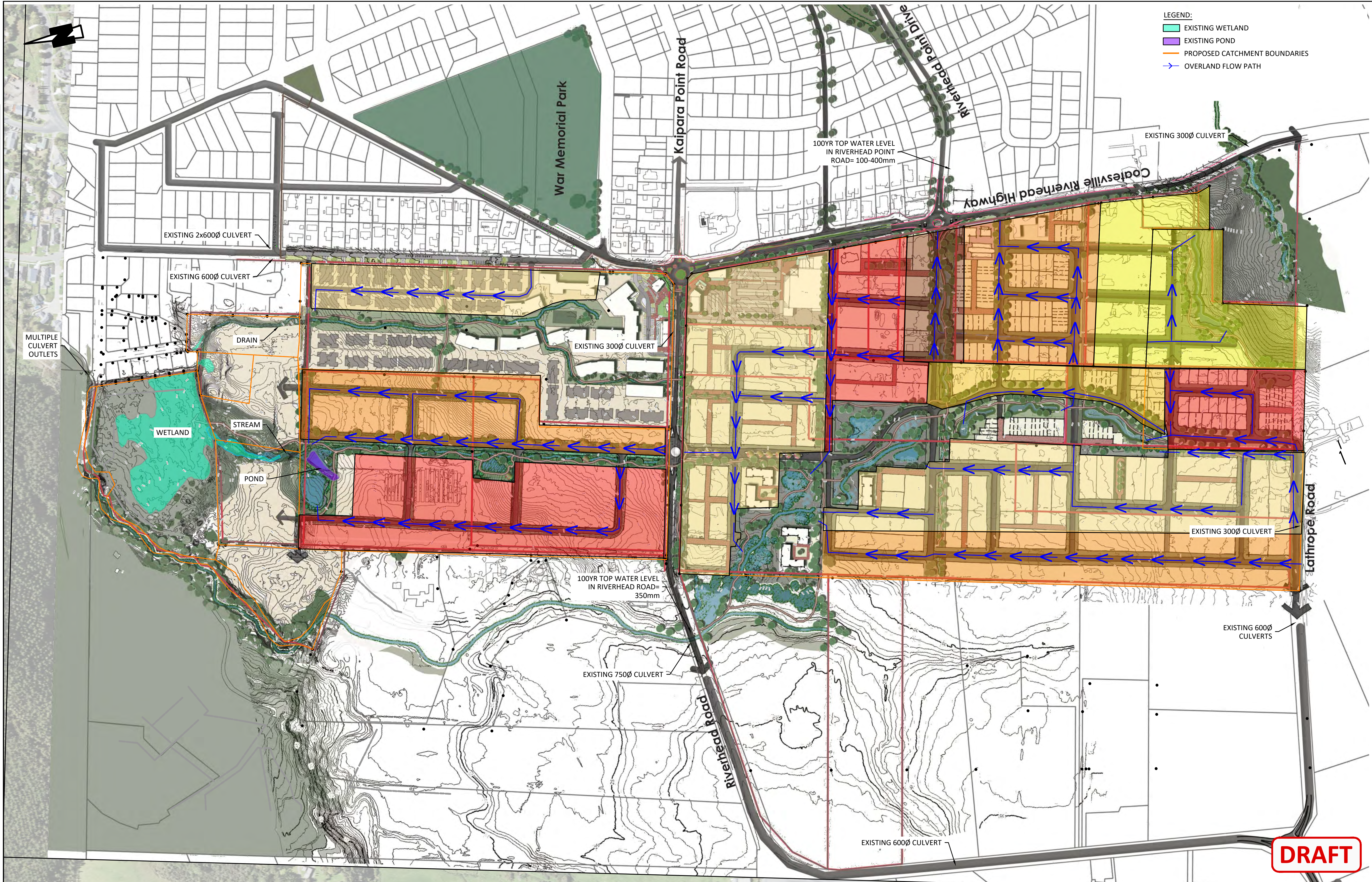

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Riverhead Plan Change

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STORMWATER OLFP MASTER PLAN

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Appendix 2 SWMP Calculation

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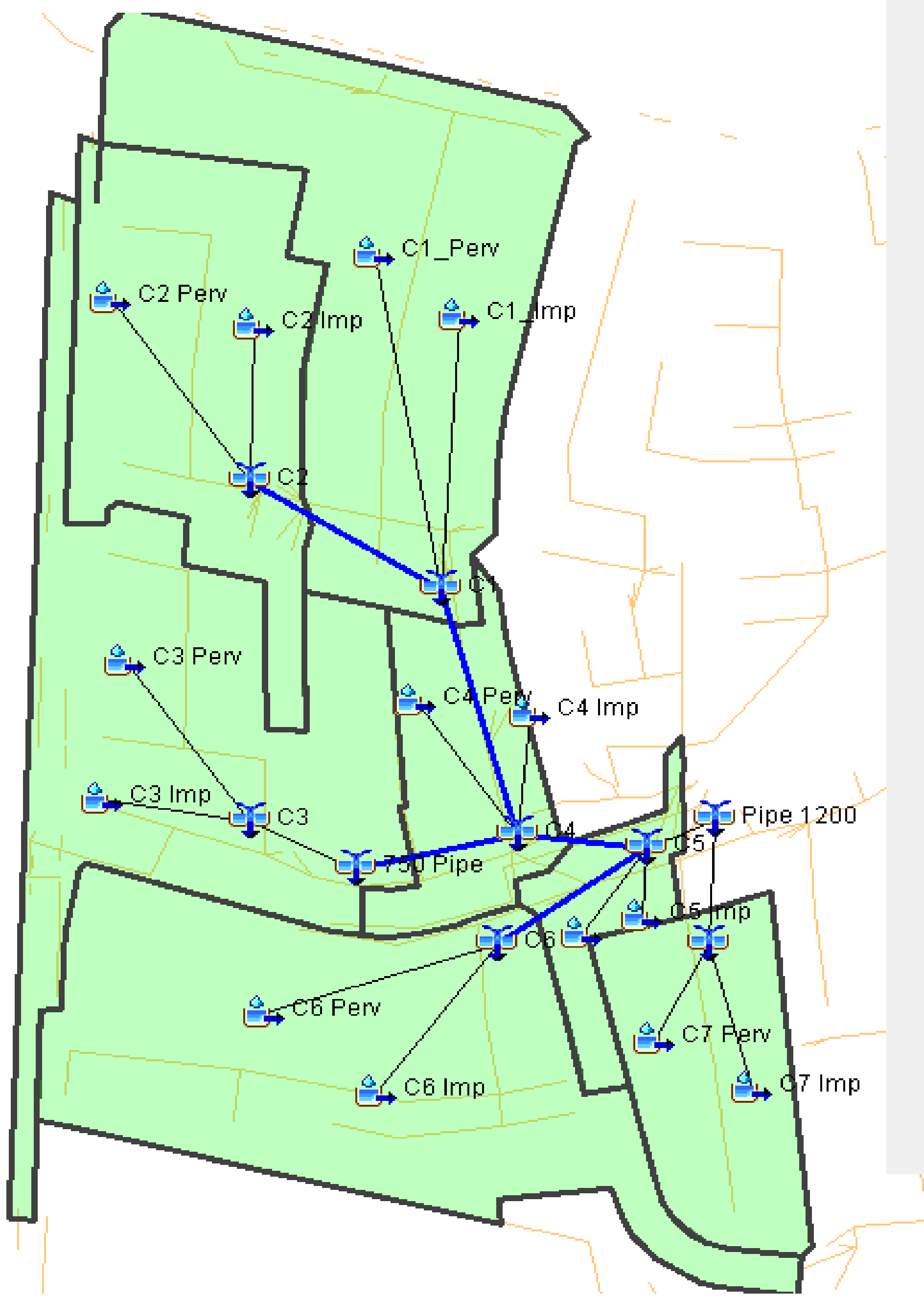
Job No.	A20405	Sheet Name	HEC HMS- Pipe flow
Date	11/2/2022	Path	C:\ProgramData\12DSynergy\data\CKL-HAM-SYN\CI 1 - Environmental_18233\01 Environmental\Modelling and Calculations\SWMA
By	CL	Checked	DM

HEC HMS model

Synergy12d://CKL-HAM-SYN/Projects/A20405/CI 1 - Environmental/01 Environmental/Modelling and Calculations/SWMA/HEC HMS for SW-2022/

Total flow to 750mm pipe for 10yr+CC:	536	L/s
Total flow to 1200mm pipe for 10yr+CC:	2419	L/s



Project: A20405-SW HEC HMS Simulation Run: pipe flow-MPD- 10yCC

Start of Run: 01Jan2000, 00:00 Basin Model: Point Drivey pipe catchment
End of Run: 02Jan2000, 00:00 Meteorologic Model: 10yrCC
Compute Time: DATA CHANGED, RECOMPUTE Control Specifications: Control 1

Show Elements: All Eleme... Volume Units: MM 1000 M3 Sorting: Alphab...

Hydrologic Element	Drainage Area (KM2)	Peak Discharge (M3/S)	Time of Peak	Volume (1000 M3)
C1	0.0503077	0.854	01Jan2000, 12:08	6.063
C1_Imp	0.01856	0.400	01Jan2000, 12:06	2.628
C1_Perv	0.0115985	0.133	01Jan2000, 12:15	1.003
C2	0.0201492	0.343	01Jan2000, 12:07	2.432
C2 Imp	0.0124998	0.270	01Jan2000, 12:06	1.770
C2 Perv	0.0076494	0.088	01Jan2000, 12:15	0.662
C3	0.0293429	0.536	01Jan2000, 12:05	3.548
C3 Imp	0.0182634	0.418	01Jan2000, 12:05	2.588
C3 Perv	0.0110795	0.137	01Jan2000, 12:12	0.960
C4	0.0886330	1.499	01Jan2000, 12:08	10.693
C4 Imp	0.0055972	0.140	01Jan2000, 12:02	0.794
C4 Perv	0.0033852	0.057	01Jan2000, 12:03	0.295
C5	0.1252761	2.199	01Jan2000, 12:06	15.204
C5 Imp	0.0030348	0.076	01Jan2000, 12:02	0.430
C5 Perv	0.0017283	0.029	01Jan2000, 12:03	0.150
C6	0.0318800	0.695	01Jan2000, 12:03	3.935
C6 Imp	0.0211754	0.532	01Jan2000, 12:02	3.004
C6 Perv	0.0107046	0.168	01Jan2000, 12:04	0.931
C7	0.0113469	0.248	01Jan2000, 12:02	1.361
C7 Imp	0.0068081	0.171	01Jan2000, 12:02	0.966
C7 Perv	0.0045388	0.077	01Jan2000, 12:03	0.395
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Lag C4	0.0886330	1.499	01Jan2000, 12:09	10.689
Lag C6	0.0318800	0.695	01Jan2000, 12:04	3.933
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750 Pipe	0.0293429	0.536	01Jan2000, 12:05	3.548

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By	CL	Checked	DM

TP108 analysis for pipe catchment-750mm pipe and 1200mm pipe

SUBCATCHMENT		C1		C2		C3		C4		C5		C6		C7	
Total Area	Ha	3.02		2.01		2.93		0.90		0.48		3.19		1.13	
	km^2	0.030158		0.020149		0.029343		0.008982		0.004763		0.031880		0.011347	
Fraction Impervious		62%		62%		62%		62%		64%		66%		60%	
		Perv	*Imperv*	*Perv*	*Imperv*	*Perv*	*Imperv*	*Perv*	*Imperv*	*Perv*	*Imperv*	*Perv*	*Imperv*	*Perv*	*Imperv*
Area	Ha	1.1598	1.8560	0.7649	1.2500	1.1080	1.8263	0.3385	0.5597	0.1728	0.3035	1.0705	2.1175	0.4539	0.6808
	km^2	0.01160	0.01856	0.00765	0.01250	0.01108	0.01826	0.00339	0.00560	0.00173	0.00303	0.01070	0.02118	0.00454	0.00681
SCS Curve Number		74	98	74	98	74	98	74	98	74	98	74	98	74	98
Initial Abstraction, Ia	mm	5	0	5	0	5	0	5	0	5	0	5	0	5	0
Channelisation Factor , C		0.8	0.6	0.8	0.6	0.8	0.6	0.8	0.6	0.8	0.6	0.8	0.6	0.8	0.6
Catchment Length	km	0.420		0.254		0.435		0.115		0.162		0.240		0.154	
Catchment Slope, Sc	m/m	0.003	0.003	0.001	0.001	0.006	0.006	0.059	0.059	0.046	0.046	0.013	0.013	0.019	0.019
Runoff factor (RF)		0.587	0.961	0.587	0.961	0.587	0.961	0.587	0.961	0.587	0.961	0.587	0.961	0.587	0.961
Time of Concentration (tc)	hrs	0.48	0.28	0.48	0.28	0.41	0.23	0.08	0.05	0.11	0.06	0.22	0.12	0.14	0.08
Time of Concentration (tc)	min	29.1	16.6	29.1	16.6	24.4	14.0	10.0	10.0	10.0	10.0	13.1	10.0	10.0	10.0
SCS Lag (tp)	min	19.5	11.2	19.5	11.2	16.4	9.4	6.7	6.7	6.7	6.7	8.8	6.7	6.7	6.7
Catchmemt Storage, S	mm	89.24	5.18	89.24	5.18	89.24	5.18	89.24	5.18	89.24	5.18	89.24	5.18	89.24	5.18

Slope calculation

Name	Pipe/OLFP Length(m)	U/S elevation	D/S elevation	Slope
C1	420	31.75	30.5	0.003
C2	254	31.75	31.5	0.001
C3	435	32	29.5	0.006
C4	115	31.25	24.5	0.059
C5	162	30.5	23	0.046
C6	240	32	29	0.013
C7	154	31	28	0.019

Job name	22 Duke St	File Name	A20405 -Pipe capacity check.xlsx
Job No.	A20405	Sheet Name	Catchment Summary Pipe
Date	11/2/2022	Path	C:\ProgramData\12DSynergy\data\CKL-HAM-SYN\CI 1 - Environmental_182
By	CL	Checked	DM

Catchment analysis for Riverhead Point Drive pipeline

GIS shapefile: Synergy12d://CKL-HAM-SYN/Projects/A20405/CI 1 - Environmental/01 Environmental/Modelling and Calculations/FRA/GIS/SW calculatio

Name	Area (ha)	Single house zone area (ha)	Road area (ha)	Business area (ha)	Average Impervious	Pipe
C1	3.02	2.09	0.9296	0.00	62%	1200
C2	2.01	1.19	0.8206	0.00	62%	120
C3	2.93	1.62	1.3153	0.00	62%	750
C4	0.90	0.48	0.4155	0.00	62%	1200
C5	0.48	0.12	0.3539	0.00	64%	120
C6	3.19	2.09	0.5026	0.5987	66%	1200
C7	1.13	1.13	0	0	60%	1200

Impervious coverage assumption

Single house zone	0.60
Road	0.65
Business	0.90

CI
PO Box 99 463, Au
25 Broadway
Ph:
Fax:

Job name	22 Duke St	File Name	A20405 -Pipe capacity check.xlsx
Job No.	A20405	Sheet Name	Pipe capacity
Date	21/3/2022	Path	C:\ProgramData\12DSynergy\data\CKL-HAM-SYN\CI 1 - Environmental_18233\01 Environmental\Modelling and Calculat
By	CL	Checked	DM

Pipe Capacity Check-Riverhead Point Drive drainage

Roughness factor (k): k = 0.015 mm for PVC stormwater pipes (NZS:4404 2010)
k = 0.15 mm for concrete stormwater pipes (NZS:4404 2010)
k = 0.6 mm is assumed for conservative purpose to take into account potential pipe conditon

750mm Pipe capacity check

Pipe SAP ID	Roughness Factor	Pipe size(mm)	Grade(1 in)	%
2000986762	0.6	750	37.84	2.6
VELOCITY (m/sec)		4.56		
CAPACITY (Q = VA)		2012.4	l/s	
Pipe flow for MPD (HEC HMS model result):		0.54	m3/s	
Remaining capacity		1.48	m3/s	

1200mm Pipe capacity check

Pipe SAP ID	Roughness Factor	Pipe size(mm)	Grade(1 in)	%
2000986762	0.6	1200	40.10	2.5
VELOCITY (m/sec)		5.91		
CAPACITY (Q = VA)		6687.7	l/s	
Pipe flow for MPD (HEC HMS model result):		2.42	m3/s	
Remaining capacity		4.27	m3/s	

Site flow discharging to pipeline: **1.25** L/s
Sufficient? Yes

NZS 4404:2010

Table 4.2 – Guide to roughness coefficients for gravity stormwater pipes concentrically jointed an

Description	Colebrook-White coefficient k (mm)	Man rougl coeff (r
Circular pipes		
PVC	0.003 – 0.015	0.008 -
PE	0.003 – 0.015	0.008 -
Vitreous clay	0.15 – 0.6	0.010 -
Concrete – machine made to AS/NZS 4058	0.03 – 0.15	0.009 -
Corrugated metal	–	0.012 -
GRP (glass reinforced plastic)	0.003 – 0.015	0.008 -
Culverts		
Concrete pre-cast (pipes and boxes)	0.6	0.0
Open channel		
Straight uniform channel in earth and gravel in good condition	–	0.0
Unlined channel in earth and gravel with some bends and in fair condition	–	0.0
Channel with rough stony bed or with weeds on earth bank and natural streams with clean straight banks	–	0.0
Winding natural streams with generally clean bed but with some pools and shoals	–	0.0
Winding natural streams with irregular cross section and some obstruction with vegetation and debris	–	0.0
Irregular natural stream with obstruction from vegetation and debris	–	0.0
Very weedy irregular winding stream obstructed with significant overgrown vegetation and debris	–	0.1

NOTE – Refer to AS 2200 table 2 and notes, and *Metrication: Hydraulic data and formulae* (Lamont).

‹L Limited
ıckland 1149
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ning nness ficient n)
– 0.009
– 0.009
– 0.013
– 0.012
– 0.024
– 0.009
)16
225
)25
)30
)35
)45
)60
)00

Job name	22 Duke St	File Name	A20405-OLFP Riverhead.xlsx
Job No.	A20405	Sheet Name	Q100- 1.5ha
Date	30/03/2022	Path	C:\ProgramData\12DSynergy\data\CKL-HAM-
By	CL	Checked	NV

Catchment flow rates

Typical catchemnt area	15,000	m^2
Imperviousness (assumed)	70%	
TP108 100yr 24 rainfall depth	245	mm
Ratio to convert 24hr depth to rainfall intensity with CC	69.40%	SWCOP(v3)
10min rainfall intensity	170.2	mm/hr

Peak flow-100yr ARI 10 minute +CC

Area (ha)	C No.	Int (mm/hr)	Q = 2.78CiA	
1.05000	0.90	170	447.2	Impervious
0.52500	0.50	170	124.2	Pervious
		Max Flow (L/s)	571.4	
		Max Flow (m^3/s)	0.571	

3. To work out rainfall intensities under different durations, the following ratios can be applied to the 24-hour rainfall depth. As can be seen in the table, the ratios are slightly higher when climate change effects are considered, especially for the shorter durations. This is in-line with the 2008 MfE guidance manual.

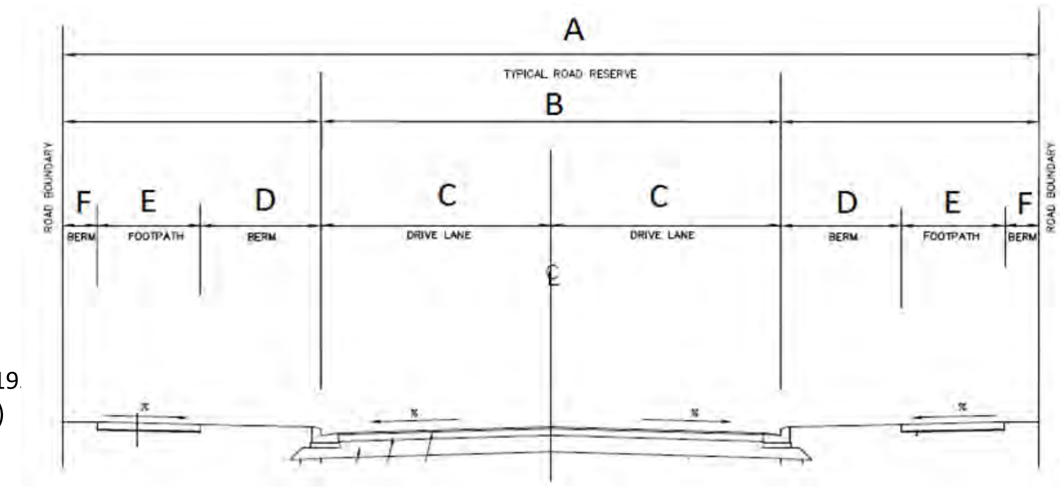
Table 2: Ratio to Convert 24-hour Rainfall Depth to Intensities

Duration	Ratio to convert the existing 24-hour design rainfall depth (in mm) into rainfall intensities (in mm/hr) without Climate Change	Ratio to convert the future 24-hour design rainfall depth (in mm) into rainfall Intensities (in mm/hr) with Climate Change allowances
10 min	67.5%	69.4%
20 min	51.9%	53.2%
30 min	42.8%	43.7%
1 hr	30.3%	30.8%
2 hr	20.5%	20.8%
6 hr	10.5%	10.6%
12 hr	6.8%	6.8%
24 hr	4.2%	4.2%

Job name	22 Duke S	File Name	A20405-OLFP Riverhead.xlsx
Job No.	A20405	Sheet Nar	OLFP Sizing
Date	30/03/202	Path	C:\ProgramData\12DSynergy\data\CKL-HAM-SYN\CI 1 - Environmental_18233\01 Environmental\Modelling and Calculations\SWMA
By	CL	Checked	NV

OLFP within Standard Carriageway Road 1- At Discharge Point

Total Road Reserve Width	A	18	m	
Total Carriageway Width	B	6	m	
Half Carriageway Width	C	3	m	
Berm	D	1.5	m	
Footpath	E	2	m	
Berm	F	5	m	
Road crossfall		3%		
Road gradient, m/m		0.010	m/m	
Kerb height		125	mm	
Height to centreline		0.090	m	
Manning's 'n'		0.013		Manning's n for roadways (Chow, 19
Manning's 'n'		0.03		Manning's n for grass (Chow, 1959)
100yr Q_{24t}-1.5ha		0.571	m^3/s	
100yr Q_{24t}-8ha		3.048	m^3/s	

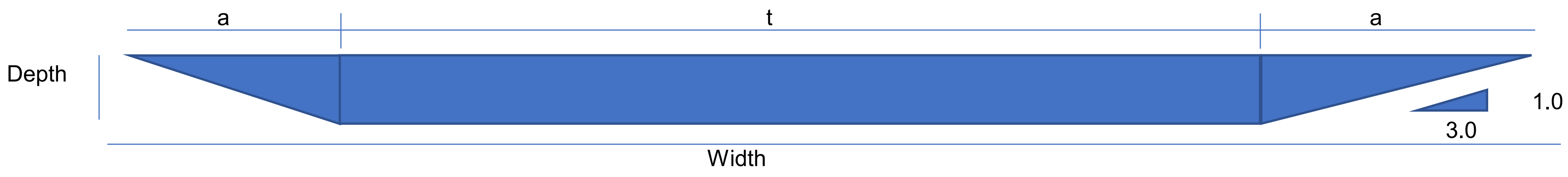


Water Depth	n	Width	Width Within Carriageway (B)	Width Outside Carriageway (Berm D)	Width Outside Carriageway (Footpath E)	Width Outside Carriageway (Berm F)	Area	Wetted Perimeter	Hydraulic Radius	Velocity	Q (m^3/s)
0.00	0.000	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.00	0.00	0.000
0.025	0.013	0.83	0.83	0.00	0.00	0.00	0.010	0.859	0.01	0.40	0.004
0.05	0.013	1.67	1.67	0.00	0.00	0.00	0.042	1.717	0.02	0.64	0.027
0.075	0.013	2.50	2.50	0.00	0.00	0.00	0.094	2.576	0.04	0.84	0.078
0.10	0.013	6.00	6.00	0.00	0.00	0.00	0.330	6.250	0.05	1.07	0.354
0.105	0.013	6.00	6.00	0.00	0.00	0.00	0.360	6.250	0.06	1.14	0.409
0.11	0.013	6.00	6.00	0.00	0.00	0.00	0.390	6.250	0.06	1.20	0.468
0.117	0.013	6.00	6.00	0.00	0.00	0.00	0.432	6.250	0.07	1.28	0.555
0.12	0.013	6.00	6.00	0.00	0.00	0.00	0.450	6.250	0.07	1.32	0.594
0.125	0.013	6.00	6.00	0.00	0.00	0.00	0.480	6.250	0.08	1.38	0.661
0.13	0.013	6.17	6.00	0.17	0.00	0.00	0.523	6.417	0.08	1.39	0.725
0.150	0.015	6.83	6.00	0.83	0.00	0.00	0.730	7.083	0.10	1.45	1.057
0.17	0.016	7.50	6.00	1.50	0.00	0.00	0.990	7.750	0.13	1.54	1.521
0.22	0.019	9.00	6.00	3.00	0.00	0.00	1.770	9.250	0.19	1.77	3.131
0.22	0.019	9.17	6.00	3.00	0.17	0.00	1.873	9.417	0.20	1.83	3.420
0.23	0.018	9.50	6.00	3.00	0.50	0.00	2.090	9.751	0.21	1.94	4.054
0.25	0.018	10.17	6.00	3.00	1.17	0.00	2.563	10.417	0.25	2.17	5.561
0.30	0.017	11.83	6.00	3.00	2.83	0.00	3.980	12.085	0.33	2.74	10.925

Job name 22 Duke S File Name A20405-OLFP Riverhead.xlsx
Job No. A20405 Sheet Nar OLFP Sizing
Date 30/03/202 Path C:\ProgramData\12DSynergy\data\CKL-HAM-SYN\CI 1 - Environmental_18233\01 Environmental\Modelling and Calculations\SWMA
By CL Checked

Grassed Swale OLFP

Manning's 'n'	0.035		Grass
hydrualic gradient, m/m	0.0100	m/m	
100yr Qp	3.05	m^3/s	



Water Depth	n	Width	t	Side Slopes Z	a	Area	Wetted Peri	Hydraulic Radi	Velocity	Q (m^3/s)	% of Total Flow
0.00	0.035	4.00	4.00	3.00	0.00	0.000	4.00	0.00	0.00	0.000	0.00%
0.050	0.035	4.30	4.00	3.00	0.15	0.208	4.32	0.05	0.38	0.079	2.58%
0.100	0.035	4.60	4.00	3.00	0.30	0.430	4.63	0.09	0.59	0.254	8.32%
0.150	0.035	4.90	4.00	3.00	0.45	0.668	4.95	0.13	0.76	0.505	16.59%
0.200	0.035	5.20	4.00	3.00	0.60	0.920	5.26	0.17	0.90	0.829	27.19%
0.250	0.035	5.50	4.00	3.00	0.75	1.188	5.58	0.21	1.03	1.220	40.05%
0.300	0.035	5.80	4.00	3.00	0.90	1.470	5.90	0.25	1.14	1.680	55.12%
0.350	0.035	6.10	4.00	3.00	1.05	1.768	6.21	0.28	1.25	2.207	72.41%
0.400	0.035	6.40	4.00	3.00	1.20	2.080	6.53	0.32	1.35	2.801	91.92%
0.420	0.035	6.52	4.00	3.00	1.26	2.209	6.66	0.33	1.38	3.058	100.35%

Job name	22 Duke St	File Name	A20405-OLFP Riverhead.xlsx
Job No.	A20405	Sheet Name	Q100- 8ha
Date	30/03/2022	Path	C:\ProgramData\12DSynergy\data\CKL-HAM-
By	CL	Checked	NV

Catchment flow rates

Typical catchemnt area	80,000	m^2
Imperviousness (assumed)	70%	
TP108 100yr 24 rainfall depth	245	mm
Ratio to convert 24hr depth to rainfall intensity with CC	69.40%	SWCOP(v3)
10min rainfall intensity	170.2	mm/hr

Peak flow-100yr ARI 10 minute +CC

Area (ha)	C No.	Int (mm/hr)	Q = 2.78CiA	
5.60000	0.90	170	2385.0	Impervious
2.80000	0.50	170	662.5	Pervious
		Max Flow (L/s)	3047.6	
		Max Flow (m^3/s)	3.048	

3. To work out rainfall intensities under different durations, the following ratios can be applied to the 24-hour rainfall depth. As can be seen in the table, the ratios are slightly higher when climate change effects are considered, especially for the shorter durations. This is in-line with the 2008 MfE guidance manual.

Table 2: Ratio to Convert 24-hour Rainfall Depth to Intensities

Duration	Ratio to convert the existing 24-hour design rainfall depth (in mm) into rainfall intensities (in mm/hr) without Climate Change	Ratio to convert the future 24-hour design rainfall depth (in mm) into rainfall Intensities (in mm/hr) with Climate Change allowances
10 min	67.5%	69.4%
20 min	51.9%	53.2%
30 min	42.8%	43.7%
1 hr	30.3%	30.8%
2 hr	20.5%	20.8%
6 hr	10.5%	10.6%
12 hr	6.8%	6.8%
24 hr	4.2%	4.2%

Job name	22 Duke St	File Name	A20405 -SW hydrology analysis-Site.xlsx
Job No.	A20405	Sheet Name	TP108 Rainfall
Date	11/2/2022	Path	C:\ProgramData\12DSynergy\data\CKL-HAM-SYN\CI 1 - Environmental_18233\01 Environmenta
By	CL	Checked	

Design rainfall (24 hr depth)

Climate Scenario	90th Percentile	95th Percentile	50% AEP	10% AEP	1% AEP
Existing	N/A	N/A	80	130	210
Percentage Increase for Climate Change	N/A	N/A	9.0%	13.2%	16.8%
Future (+2.1°C)	25.5	35.5	87	147	245

Inside the site

Development	Sub-Catchment	2yr TP108 Rainfall depth-Ex (mm)	2yr TP108 Rainfall +CC 2.1 (mm)	10yr TP108 Rainfall depth-Ex (mm)	10yr TP108 Rainfall +CC 2.1°C (mm)	100yr TP108 Rainfall depth-Ex (mm)	100yr Rainfall+CC 2.1°C (mm)
Pre-development	N01_1	80	87	130	147.2	205	239
	N01_2	80	87	130	147.2	205	239
	N01_3	80	87	130	147.2	205	239
	N01_4	80	87	130	147.2	205	239
	N01_5	80	87	130	147.2	205	239
	N02	80	87	130	147.2	205	239
	N03	80	87	130	147.2	205	239
	N04	80	87	130	147.2	205	239
	N05_1	80	87	130	147.2	205	239
	N05_2	80	87	130	147.2	205	239
	N06	80	87	130	147.2	205	239
	S01_1	80	87	130	147.2	210	245
	S01_2	80	87	130	147.2	210	245
	S02_1	80	87	130	147.2	210	245
	S02_2	80	87	130	147.2	210	245
	S02_3	80	87	130	147.2	210	245
	S03_1	80	87	130	147.2	210	245
	S03_2	80	87	130	147.2	210	245
	S04_1	80	87	130	147.2	210	245
	S04_2	80	87	130	147.2	210	245
	S04_3	80	87	130	147.2	210	245
	S05_1	80	87	130	147.2	210	245
	S05_2	80	87	130	147.2	210	245
Post-development	N01_P_1	80	87	130	147.2	205	239
	N01_P_2	80	87	130	147.2	205	239
	N01_P_3	80	87	130	147.2	205	239
	N01_P_4	80	87	130	147.2	205	239
	N02_P	80	87	130	147.2	205	239
	N03_P	80	87	130	147.2	205	239
	N04_P	80	87	130	147.2	205	239
	N05_P_1	80	87	130	147.2	205	239
	N05_P_2	80	87	130	147.2	205	239
	S01_P	80	87	130	147.2	210	245
	S02_P	80	87	130	147.2	210	245
	S03_P_1	80	87	130	147.2	210	245
	S03_P_2	80	87	130	147.2	210	245
	S04_P	80	87	130	147.2	210	245

CKL Limited
PO Box 99 463, Auckland 1149
25 Broadway, Newmarket
Ph: 09 524 7029
Fax: 09 524 7032

Job name	22 Duke St	File Name	A20405 -SW hydrology analysis-Site.xlsx
Job No.	A20205	Sheet Name	Site-Catchment
Date	2/3/2022	Path	C:\ProgramData\12DSynergy\data\CKL-HAM-SYN\CI 1 - Environmental_18233\01 Environmental\Modelling and Calculations\SWMA
By	CL	Checked	NV

Site Subcatchment (Existing condition)

see GIS shapefile 'Site Existing SubCatchment-100yr-R01.shp' for detail.

Discharge Locations ID	Discharge Locations	Name	Catchment Area (ha)	100yr Rainfall depth-Ex	100yr Rainfall+CC (3.8°C)	Impervious for Existing (%)	Impervious area (ha)	CN for pervious area	Weighted CN	Weighted Ia	Length (km)	Slope (m/m)	ToC (hr) (C=0.8)	Lag (mins)
N01	Channel to wetland	N01_1	8.90	205	272	10%	0.89	74.0	76.4	4.5	0.611	0.014	0.4	15.0
		N01_2	11.20	205	272	10%	1.12	74.0	76.4	4.5	0.608	0.025	0.3	12.7
		N01_3	0.84	205	272	15%	0.13	74.0	77.6	4.3	0.142	0.005	0.2	7.8
		N01_4	2.63	205	272	15%	0.39	74.0	77.6	4.3	0.242	0.016	0.2	7.7
		N01_5	2.14	205	272	0%	0.00	74.0	74.0	5.0	0.309	0.027	0.2	8.1
N02	Wetland swale	N02	0.50	205	272	15%	0.08	74.0	77.6	4.3	0.091	0.043	0.1	6.7
N03	Te Roera Place	N03	0.85	205	272	0%	0.00	74.0	74.0	5.0	0.186	0.032	0.1	6.7
N04	Wetland	N04	4.49	205	272	3%	0.13	74.0	74.7	4.9	0.428	0.010	0.3	13.6
N05	Stream	N05_1	1.01	205	272	3%	0.03	74.0	74.7	4.9	0.178	0.023	0.1	6.7
		N05_2	0.94	205	272	0%	0.00	74.0	74.0	5.0	0.113	0.045	0.1	6.7
N06	Neighbour	N06	0.78	205	272	0%	0.00	74.0	74.0	5.0	0.139	0.031	0.1	6.7
S01	South channel	S01_1	2.40	210	279	0%	0.00	74.0	74.0	5.0	0.241	0.076	0.1	6.7
		S01_2	2.50	210	279	0%	0.00	74.0	74.0	5.0	0.202	0.029	0.2	6.7
S02	Stream south branch (Riverhead culvert)	S02_1	4.71	210	279	0%	0.00	74.0	74.0	5.0	0.480	0.007	0.4	16.5
		S02_2	2.09	210	279	0%	0.00	74.0	74.0	5.0	0.235	0.008	0.2	9.9
		S02_3	21.34	210	279	10%	2.13	74.0	76.4	4.5	0.656	0.014	0.4	15.8
S03	Riverhead Point Drive	S03_1	4.81	210	279	20%	0.96	74.0	78.8	4.0	0.331	0.003	0.4	15.4
		S03_2	1.48	210	279	20%	0.30	74.0	78.8	4.0	0.162	0.002	0.3	10.7
S04	Coatesville Highway	S04_1	0.98	210	279	30%	0.29	74.0	81.2	3.5	0.120	0.006	0.2	6.7
		S04_2	0.71	210	279	30%	0.21	74.0	81.2	3.5	0.120	0.074	0.1	6.7
	Coatesville Highway	S04_3	0.27	210	279	10%	0.03	74.0	76.4	4.5	0.044	0.004	0.1	6.7
S05	Riverhead Road	S05_1	2.20	210	279	30%	0.66	74.0	81.2	3.5	0.198	0.016	0.2	6.7
		S05_2	2.89	210	279	30%	0.87	74.0	81.2	3.5	0.306	0.009	0.3	10.5
		Total	80.7			10%	8.23							

Site Subcatchment (Proposed condition)

see GIS shapefile 'Site Post SubCatchment-100yr-R03.shp' for detail.

Discharge Locations ID	Discharge Locations	Name	Catchment Area (ha)	100yr Rainfall depth-Ex	100yr Rainfall+CC (3.8°C)	Impervious for Post (%)	Impervious area (ha)	CN for pervious area	Weighted CN	Weighted Ia	Length (km)	Slope (m/m)	ToC (hr) (C=0.6)	Lag (mins)
N01	Channel to Wetland	N01_P_1	13.16	205	272	65%	8.56	74.0	89.6	1.8	0.657	0.024	0.2	8.8
		N01_P_2	10.04	205	272	65%	6.52	74.0	89.6	1.8	0.739	0.018	0.3	10.2
		N01_P_3	1.36	205	272	65%	0.88	74.0	89.6	1.8	0.131	0.006	0.1	6.7
		N01_P_4	1.80	205	272	65%	1.17	74.0	89.6	1.8	0.204	0.008	0.1	6.7
N02	Wetland swale	N02_P	0.54	205	272	65%	0.35	74.0	89.6	1.8	0.091	0.043	0.0	6.7
N03	Te Roera Place	N03_P	0.95	205	272	65%	0.62	74.0	89.6	1.8	0.186	0.032	0.1	6.7
N04	Wetland	N04_P	4.07	205	272	3%	0.12	74.0	74.7	4.9	0.300	0.008	0.2	8.5
N05	Stream	N05_P_1	1.61	205	272	65%	1.05	74	89.6	1.8	0.17	0.010	0.2	6.7
		N05_P_2	0.76	205	272	0	0.00	74	74.0	5	0.09	0.045	0.1	6.7
S01	South Channel	S01_P	6.24	210	279	65%	4.06	74.0	89.6	1.8	0.366	0.058	0.1	6.7
S02	Stream South Branch (R	S02_P	31.76	210	279	70%	22.23	74.0	90.8	1.5	0.872	0.014	0.3	12.3
S03	Riverhead Point Drive	S03_P_1	4.35	210	279	65%	2.82	74.0	89.6	1.8	0.330	0.003	0.3	10.2
		S03_P_2	1.67	210	279	65%	1.08	74.0	89.6	1.8	0.216	0.003	0.2	7.9
S04	Coatesville Highway	S04_P	2.36	210	279	65%	1.54	74.0	89.6	1.8	0.363	0.020	0.2	6.7
		Total	80.7			63%	51.00							

CKL Limited
PO Box 99 463, Auckland 1149
25 Broadway, Newmarket
Ph: 09 524 7029
Fax: 09 524 7032

Jon number	22 Duke St	File Name	A20405 -SW hydrology analysis-Site.xlsx
Job name	A20405	Sheet Name	HEC HMS- Peak flow
Date	25/03/2022	Path	C:\ProgramData\12DSynergy\data\CKL-HAM-SYN\CI 1 - Environmen
Prepared by	CL	Checked	NV

Peak flow result from HEC HMS model

Pre-development

Catchment	2yr-ex	10yr-ex	100yr-ex
N01_1	0.546	1.208	2.303
N01_2	0.736	1.627	3.099
N01_3	0.068	0.148	0.279
N01_4	0.214	0.466	0.877
N01_5	0.153	0.345	0.669
N02	0.042	0.092	0.173
N03	0.064	0.144	0.279
N04	0.271	0.61	1.179
N05_1	0.078	0.174	0.335
N05_2	0.071	0.16	0.309
N06	0.059	0.132	0.256
S01_1	0.181	0.408	0.813
S01_2	0.188	0.425	0.847
S02_1	0.255	0.58	1.164
S02_2	0.139	0.315	0.632
S02_3	1.28	2.833	5.572
S03_1	0.315	0.679	1.308
S03_2	0.113	0.242	0.465
S04_1	0.093	0.194	0.364
S04_2	0.068	0.141	0.264
S04_3	0.022	0.048	0.095
S05_1	0.209	0.436	0.817
S05_2	0.24	0.501	0.942

Post-development

Catchment	2yr-post	10yr-post	100yr-post
N01_P_1	1.498	2.813	4.804
N01_P_2	1.087	2.042	3.488
N01_P_3	0.167	0.312	0.533
N01_P_4	0.221	0.413	0.706
N02_P	0.066	0.124	0.212
N03_P	0.116	0.218	0.372
N04_P	0.293	0.657	1.268
N05_P_1	0.197	0.37	0.631
N05_P_2	0.057	0.129	0.25
S01_P	0.765	1.433	2.512
S02_P	3.317	6.143	10.685
S03_P_1	0.471	0.885	1.552
S03_P_2	0.196	0.368	0.645
S04_P	0.289	0.542	0.95

HEC HMS simulation:

- SW-Site ED-10yrCC
- SW-Site ED-100yrCC
- SW-Site ED-2yrCC
- SW-Site MPDR04-10yrCC
- SW-Site MPDR04-100yrCC
- SW-Site MPDR04-2yrCC
- SW-Site MPDR04-90th Tile
- SW-Site MPDR04-95th Tile

Peak flow sum-up for each receiving enviornment

	Pre-development (m3/s)			Post-development(m3/s)		
Receiving enviornments	2yr	10yr	100yr	2yr	10yr	100yr
Riverhead Forest Stream	4.425	9.771	18.885	7.019	13.221	22.949
Riverhead Point Drive drainage	0.45	0.969	1.868	0.667	1.253	2.197
Southern stream	0.53	1.168	2.288	1.054	1.975	3.462

Peak flow comparison for each receiving enviornment

AEP	50% AEP		10% AEP		1% AEP	
Development	Existing (m^3/s)	MPD (m^3/s)	Existing (m^3/s)	MPD (m^3/s)	Existing (m^3/s)	MPD (m^3/s)
Riverhead Forest Stream	4.43	7.02	9.77	13.22	18.89	22.95
	2.59		3.45		4.06	
	59%		35%		22%	
Riverhead Point Drive drainage	0.45	0.67	0.97	1.25	1.87	2.20
	0.22		0.28		0.33	
	48%		29%		18%	
Southern stream	0.53	1.05	1.17	1.98	2.29	3.46
	0.52		0.81		1.17	
	99%		69%		51%	

Job name	22 Duke St	File Name	A20405 -SW hydrology analysis-Site.xlsx
Job No.	A20205	Sheet Name	Attenuation-Volume
Date	4/3/2022	Path	C:\ProgramData\12DSynergy\data\CKL-HAM-SYN\CI 1 - Environmental_18233\01 Environmental\Modelling and Calculations\SWMA
By	CL	Checked	

Aim: Volume estimation required for 1% AEP attenuation for each post-development sub-catchment
Assumption: high-level attenuation volume = volumeffference between ED and MPD development.

HEC HMS model result
Stormwater Volume result for each sub-catchment for 10% and 1% AEP +CC

Catchment	10% AEP+CC			1% AEP+CC		
	Pre-development	Post-developme	Difference	Pre-development	Post-development	Difference
N01_P_1	12.036	15.85	3.814	22.982	27.668	4.686
N01_P_2	9.172	12.085	2.913	17.516	21.097	3.581
N01_P_3	1.248	1.639	0.391	2.382	2.862	0.48
N01_P_4	1.65	2.17	0.52	3.15	3.787	0.637
N02_P	0.47	0.651	0.181	0.912	1.136	0.224
N03_P	0.827	1.145	0.318	1.604	1.999	0.395
N04_P	3.589	3.594	0.005	6.931	6.94	0.009
N05_P_1	1.423	1.941	0.518	2.747	3.388	0.641
N05_P_2	0.662	0.662	0	1.283	1.283	0
S01_P	5.432	7.522	2.09	10.88	13.499	2.619
S02_P	29.271	39.117	9.846	57.5	69.586	12.086
S03_P_1	4.186	5.236	1.05	8.113	9.397	1.284
S03_P_2	1.61	2.012	0.402	3.119	3.611	0.492
S04_P	2.219	2.845	0.626	4.336	5.105	0.769

SW-PostR04-ED-10yrCC
SW-PostR04-ED-100yrCC
SW-Site MPDR04-10yrCC
SW-Site MPDR04-100yrCC

Proposed Site Subcatchment - ED (assumed for attenuation only)

Name	Catchment Area (ha)	Impervious for ex (%)	Impervious area (ha)	CN for pervious area	Weighted CN	Weighted Ia	Length (km)	Slope (m/m)	ToC (hr) (C=0.8)	Lag (mins)
N01_P_1	13.16	10%	1.32	74.0	76.4	4.5	0.657	0.024	0.3	13.6
N01_P_2	10.04	10%	1.00	74.0	76.4	4.5	0.739	0.018	0.4	15.8
N01_P_3	1.36	10%	0.14	74.0	76.4	4.5	0.131	0.006	0.2	7.2
N01_P_4	1.80	10%	0.18	74.0	76.4	4.5	0.204	0.008	0.2	8.7
N02_P	0.54	0%	0.00	74.0	74.0	5.0	0.091	0.043	0.1	6.7
N03_P	0.95	0%	0.00	74.0	74.0	5.0	0.186	0.032	0.1	6.7
N04_P	4.07	3%	0.12	74.0	74.7	4.9	0.300	0.008	0.3	11.3
N05_P_1	1.61	3%	0.05	74	74.7	4.9	0.17	0.010	0.2	7.3
N05_P_2	0.76	0%	0.00	74	74.0	5	0.09	0.045	0.1	6.7
S01_P	6.24	0%	0.00	74.0	74.0	5.0	0.366	0.058	0.2	7.2
S02_P	31.76	12%	3.81	74.0	76.9	4.4	0.872	0.014	0.5	19.3
S03_P_1	4.35	20%	0.87	74.0	78.8	4.0	0.330	0.003	0.4	15.4
S03_P_2	1.67	20%	0.33	74.0	78.8	4.0	0.216	0.003	0.3	11.9
S04_P	2.36	15%	0.35	74.0	77.6	4.3	0.363	0.020	0.2	9.5
	80.65	10%	8.17							

Proposed Site Subcatchment - MPD

Name	Catchment Area (ha)	Post-impervious	Impervious area (ha)	CN for pervious area	Weighted CN	Weighted Ia	Length (km)	Slope (m/m)	ToC (hr) (C=0.6)	Lag (mins)
N01_P_1	13.16	65%	8.56	74.0	89.6	1.8	0.657	0.024	0.2	8.8
N01_P_2	10.04	65%	6.52	74.0	89.6	1.8	0.739	0.018	0.3	10.2
N01_P_3	1.36	65%	0.88	74.0	89.6	1.8	0.131	0.006	0.1	6.7
N01_P_4	1.80	65%	1.17	74.0	89.6	1.8	0.204	0.008	0.1	6.7
N02_P	0.54	65%	0.35	74.0	89.6	1.8	0.091	0.043	0.0	6.7
N03_P	0.95	65%	0.62	74.0	89.6	1.8	0.186	0.032	0.1	6.7
N04_P	4.07	3%	0.12	74.0	74.7	4.9	0.300	0.008	0.2	8.5
N05_P_1	1.61	65%	1.05	74	89.6	1.8	0.17	0.010	0.2	6.7
N05_P_2	0.76	0	0.00	74	74.0	5	0.09	0.045	0.1	6.7
S01_P	6.24	65%	4.06	74.0	89.6	1.8	0.366	0.058	0.1	6.7
S02_P	31.76	70%	22.23	74.0	90.8	1.5	0.872	0.014	0.3	12.3
S03_P_1	4.35	65%	2.82	74.0	89.6	1.8	0.330	0.003	0.3	10.2
S03_P_2	1.67	65%	1.08	74.0	89.6	1.8	0.216	0.003	0.2	7.9
S04_P	2.36	65%	1.54	74.0	89.6	1.8	0.363	0.020	0.2	6.7
	80.65	63%	51.00							

CKL Limited
PO Box 99 463, Auckland 1149
L2, 25 Broadway, Newmarket
Ph: 09 524 7029
Fax: 09 524 7032

Job Name	22 Duke St	File Name	A20405 -SW hydrology analysis-Site.xlsx
Job No.	A20405	Sheet Name	SMAF 1-RG
Date	25/03/2022		
By	CL	Checked	NV

Aim: Determine Detention and Retention Volumes for SMAF 1-per 100 m^2

SMAF Mitigation Areas

	SMAF Area
Impervious area (m^2)	100.0

TP108 Analysis for Runoff Depth

	Existing	Proposed
Curve Number	74	98
Initial Abstraction, Ia (mm)	5	0
Catchment Storage, S (mm)	89.24	5.18
24hr Rainfall Depth (mm)	35.5	35.5
Runoff Depth, Q24 (mm)	7.77	30.98

Retention Volume Requirement

Retention Depth (mm)	5
Retention Volume(m^3)	0.500

Detention Volume Requirement

Detention Depth (mm)	18.2
Detention Volume (m^3)	1.821

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Fax: 09 524 7032

Job Name	22 Duke St	File Name	A20405 -SW hydrology analysis-Site.xlsx
Job No.	A20405	Sheet Name	SMAF 1-RG
Date	25/03/2022		
By	CL	Checked	NV

Aim: Raingarden Sizing for SMAF 1 for Lot 1 Paving- Straight Sided Device

Impervious Area Catchment (m^2)	100

Retention Volume Requirement

Retention Depth (mm)	5.00
Retention Volume Paving (m^3)	0.50

Detention Volume Requirement

Detention Depth (mm)	18.21
Detention Volume Paving (m^3)	1.82

Raingarden Purpose	SMAF 1
Minimum Retention Area (m^2)	3.50
Minimum Detention Ponding Area (m^2)	5.00

Retention Area Sizing

Soil Infiltration Rate (mm/hr)	2.00
Evapotranspiration Rate (mm/day)	2.00
Drainage Media Void Raito	40%
Retention Drain Down Time (hrs)	72
Minimum Retention Area (m^2)	4
Minimum Retention Depth (mm)	450

Detention Ponding Area Sizing

Bioretention Media Infiltration Rate (m/day)	50-300
Maximum ponding depth (mm)	200
Raingarden Media Void Ratio	35%
Raingarden Media + Transition Layer Depth (mm)	600
Drainage Media Depth (mm)	250
Minimum Detention Ponding Area (m^2)	5.00

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PO Box 99 463, Auckland 1149
25 Broadway, Newmarket
Ph: 09 524 7029
Fax: 09 524 7032

Jon number	22 Duke St	File Name	A20405 -SW hydrology analysis-S
Job name	A20405	Sheet Name	WQV swale
Date	11/2/2022	Path	C:\ProgramData\12DSynergy\da
Preparied by	CL	Checked	NV

Aim: to size swale for water quality treatment and 10yr conveyance for catchment S03_P_1 and S03_P_2

90th Percentaile 24 rainfall depth	26	mm
Ratio to convert 24hr depth to rainfall intensity with CC	69.40%	SWCOP(v3)
10min rainfall intensity	17.7	mm/hr

Peak flow-WQ (90th percentile) 10 minute +CC for impervious area

Area (ha)	C No.	Int (mm/hr)	Q = 2.78CiA	
3.90000	0.90	18	172.7	Impervious
		Max Flow (L/s)	173	
		Max Flow (m^3/s)	0.17	

Bioretention swale

	WQV	10yr
Catchment area (m^2)	6	6
Q (m^3/s)	0.17	1.25
Depth, d (m)	0.3	0.2
Longitudinal Slope	2%	2%
Side Slopes, z	5	3
Base Width, b (m)	1.50	4.50
Top width	4.5	5.7
Area (m^2)	0.90	1.02
Wetted Perimeter (m)	4.56	5.76
Hydraulic Radius (m)	0.20	0.18
n	0.25	0.03
Q swale (m^3/s)	0.172	1.51
Velocity (m/s)	0.19	1.48
Reidence time (mins)	9.00	
Length (m)	103	

Summary

Vegetated depth (m)	0.3
Total depth (m)	0.5
Base width	1.50
Top width (m)	5.7
Longitudinal Slope	2%
Length (m)	103

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PO Box 99 463, Auckland 1149
25 Broadway, Newmarket
Ph: 09 524 7029
Fax: 09 524 7032

Job name	22 Duke St	File Name	A20405 -SW hydrology analysis-Site.xlsx
Job No.	A20205	Sheet Name	Communal device area
Date	23/03/22	Path	C:\ProgramData\12DSynergy\data\CKL-HAM-SYN\CI 1 - Environmental_18233\0
By	CL	Checked	

High Level Estimation of Communal Device Area

Assumption:

- Communal device area for treatment only: 2% of impervious catchment area
- Communal device area for treatment and SMAF 1 mitigation : 5% of impervious catchment area
- Communal device area for attenuation (1% AEP event): 15% of catchment area

Catchment	Area (ha)	Impervious Coverage	Impervious area (ha)	High-level Communal Device Area (ha)		
				Treatment only	Treatment+SM AF 1	1% Attenuation
N01_P_1	13.16	60%	7.898	0.158	0.395	1.975
N01_P_2	10.04	75%	7.527	0.151	0.376	1.505
N01_P_3	1.36	60%	0.814	0.016	0.041	0.203
N01_P_4	1.80	60%	1.079	0.022	0.054	0.270
N02_P	0.54	60%	0.321	0.006	0.016	0.080
N03_P	0.95	60%	0.568	0.011	0.028	0.142
N04_P	4.07	3%	Not required			
N05_P_1	1.61	60%	0.967	0.019	0.048	0.242
N05_P_2	0.76	0	Not required			
S01_P	6.24	60%	3.746	0.075	0.187	0.937
S02_P	31.76	65%	20.645	0.413	1.032	4.764
S03_P_1	4.35	60%	2.608	0.052	0.130	0.652
S03_P_2	1.67	60%	1.000	0.020	0.050	0.250
S04_P	2.36	60%	1.419	0.028	0.071	0.355

Appendix 3 FRA Report

Planning | Surveying | Engineering | Environmental

FLOOD RISK ASSESSMENT REPORT

Riverhead Landowner Group

Document Information

Client	Riverhead Landowner Group
Site Location	Riverhead
Legal Description	Lot 2 DP 164978, Lot 1 DP 164978, Lot 1 DP 64605, Pt Lot 2 DP 37432, Lot 2 DP 64605Pt, Lot 2 DP 4818, Lot 1 DP 61985, Lot 1 DP 77992, Lot 2 DP 77992, Lot 3 DP 63577, Lot 2 DP 63577, Lot 1 DP 113506, Lot 1 DP 66488, Lot 1 DP 109763, Lot 1 DP 164590, Lot 2 DP 164590, LOT 1 DP 499822, LOT 20 DP 499876
CKL Reference	A20405
Office of Origin	Auckland

Author	Catherine Liu		
Signed	Camuelfiu	**Date**	31/10/2022

Reviewed By	Andy Dow		
Signed	ADow	**Date**	31/10/2022

Authorised By	Bronwyn Rhynd		
Signed		**Date**	1/11/2022

Revision	Status	Date	Author	Reviewed By	Authorised By
01	For model review	03/11/2022	CL	AD	BR
02	Final	08/12/2022	CL	BR	BR

Contents

Figures

Tables

Appendices

1 Introduction

CKL have been engaged by Riverhead Landowner Group to prepare a stormwater management plan (SMP) in support of a Private Plan Change (PPC) application for the Riverhead Future Urban Zone area ('the site'). A flood model using HEC HMS and HEC RAS software has been developed by CKL to support the SMP. The primary objective of the flood model is to investigate the potential impact of the proposed development on the neighbouring and downstream properties and the effect of an "on-site flow attenuation option" for up to 1% AEP rainfall event.

CKL has consulted with the Healthy Waters (HW) modelling team in Auckland Council (AC) who has provided guidance on the flood model build and reviewed the model to support the flood risk assessment. The modelling approach used in this flood model has been accepted by HW. In addition, in consultation with HW and in response to further information request, CKL has undertaken modelling of more scenarios than previously presented, in the SMP report dated 23 June 2022, as well as further detailed analysis of the impacts downstream of the Riverhead PPC site.

The flood model has been based on the information from the following resources:

- AC Rapid Flood Hazard Assessment Modelling Specification, August 2012
- AC Stormwater Flood Modelling Specifications, November 2011
- AC Stormwater Code of Practice (version2)
- AC online GIS system GeoMaps (assessed in September 2021)
- Preliminary Rapid Flood Hazard Assessment (RFHA) model results for the area provided by HW (not publicly available at the date of this document issued)
- MHWS-10 Coastal Marine Area Boundary for the Auckland Region

This report outlines the flood model build, model result and conclusions. The outcomes in this report are used to support the best practical stormwater management option (BPO) proposed in the SMP.

2 Catchment Description

The subject site is located at the lower Riverhead Stormwater Catchment, as shown in Figure 1. The receiving environment of the Riverhead Catchment is the Waitemata Harbour. The majority of the site discharges to a stream ('the Stream' in this report) at the northern site boundary. The Stream originates from the Riverhead Forest and, after passing the site, travels to the northeast (for c. 1km) prior to joining the Rangitopuni Stream at the Waitemata Harbour.

Auckland Council's GeoMaps has illustrated the predicted overland flow path (OLFPs) and flood plains in the area for 1% AEP storm event (Figure 1), which indicates the floodplain extent, specifically at the northern site boundary.

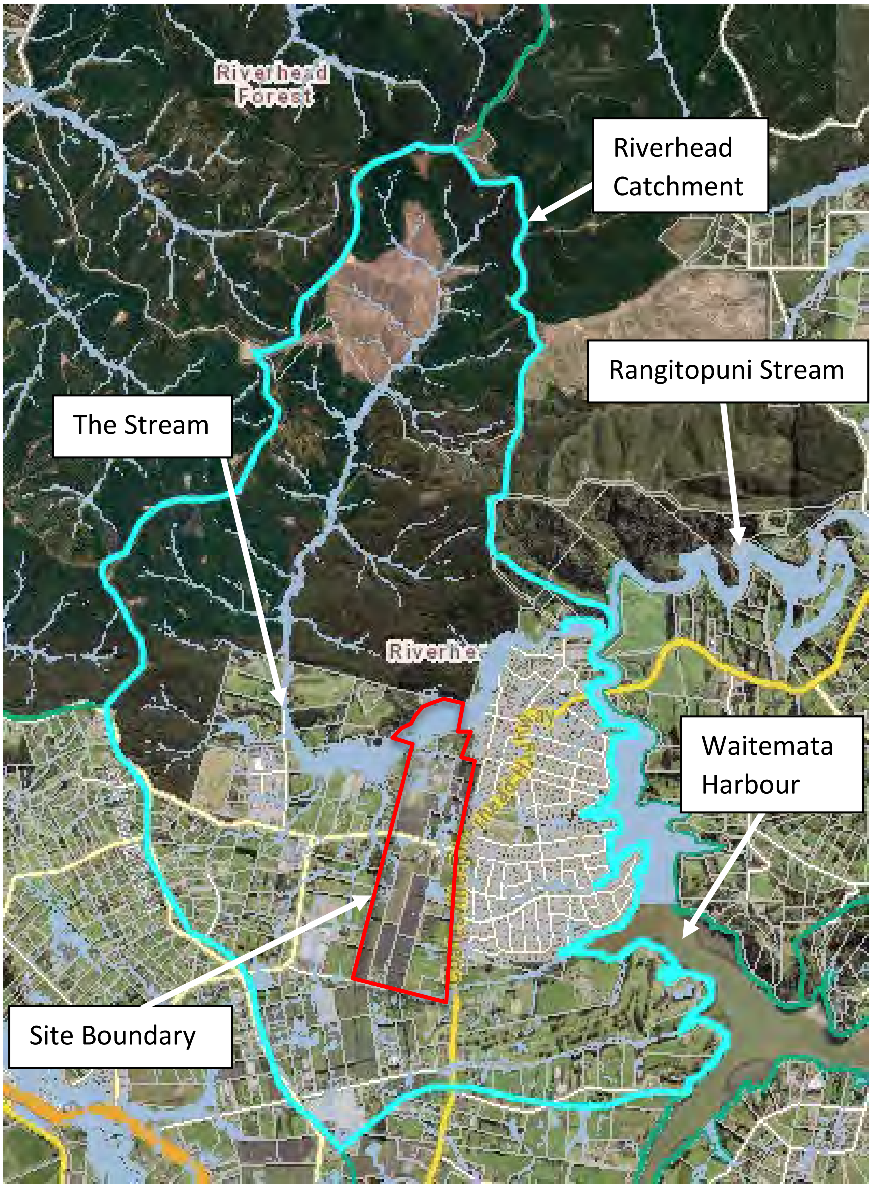


Figure 1: Location of Subject Site and Riverhead Stormwater Catchment and Floodplain Map from GeoMaps (Assessed Oct 2022)

3 Model Build

CKL's flood model includes a HEC HMS hydrological model (version 4.10) and HEC RAS 2D hydraulic model (version 6.3). The flood model build outline is provided in the following sections.

3.1 Modelling Approach

The following modelling approach has been discussed with the AC HW team, who has provided a preliminary RFHA model result for reference:

1) Catchment delineation for the Riverhead catchment area contributing to the flood risk associated with the site
2) Develop a hydrological model using HEC HMS software and TP108 methodology to estimate flow hydrographs for each sub-catchment for the rainfall events 50%, 10% and 1% AEP as per HW's request

3) Develop a 2D hydraulic model using HEC RAS software. The flow hydrographs from 2) are used as boundary conditions. The main parameters are adopted from the preliminary RFHA model provided by HW
4) A validation scenario for 1% AEP with 2.1 °C increase climate change is undertaken and the result at key locations are compared with the AC RFHA model result for model validation purpose
5) Two attenuation scenario respectively for 10% and 1% AEP events are undertaken based on dummy on-site attenuation basins and the results at locations as per HW's request are compared with the post-development without attenuation scenario to assess the potential adverse effect of on-site attenuation.

3.2 Data

The following data has been used for the flood model build:

- TP108[1] 24 hour rainfall depth contours for 100yr;
- There are 16 culverts included in the 2D model with diameters no less than 600mm. The culverts details are based on survey, site visit and GeoMaps:
- The following data provided by the HW for model build:
    - Auckland 1m LiDAR DEM (2016),
    - Existing impervious coverage shapefile,
    - Mean High Water Spring (MHWS)- 10 Coastal Marine Area Boundary for the Auckland Region, and
    - Maximum impervious percentage for AUP Zones.

3.3 Catchments

Catchment delineation

Outside the site - external

The sub-catchment plan for the catchment area excluding the site in Figure 2 was delineated based on the Auckland 1m LiDAR DEM (2016) from LINZ using QGIS Catchment Analysis tools and then manually adjusted to follow the site boundary line and refer to a Rain-on-Grid model result. There are a total of 102 sub-catchments delineated outside of the site (see Appendix 1 for detail). It is noted that most sub-catchment areas are between 2-5 ha except for a few sub-catchment with an area less than 2ha or over 10ha as the following:

- Small catchment (< 2 ha) around the site boundary were delineated in more detail to reflect water exchange at the site boundary:
- C11 (515.9 ha) is the stream catchment within Riverhead Forest area lumped together considering the similarity of the land use and hydrologic response.
- C13 (>10ha) is the lumped sub-catchment discharging to flood ponding area.
- C12_1 and C12_2 (>10ha) are the catchment area upstream of Forest Road discharging to the pond located at the west of Forest Road.
- C21 and C22_1 (>10ha) are the catchments upstream of road and controlled by culverts.
- C42_1 and C42_2 (>10ha): These two sub-catchments located at the downstream of an open channel discharging to the coast and have minor impact on the site and other catchments.

[1] Guideline for Stormwater Runoff Modelling in the Auckland Region (Technical Publication No.108, April 1999)

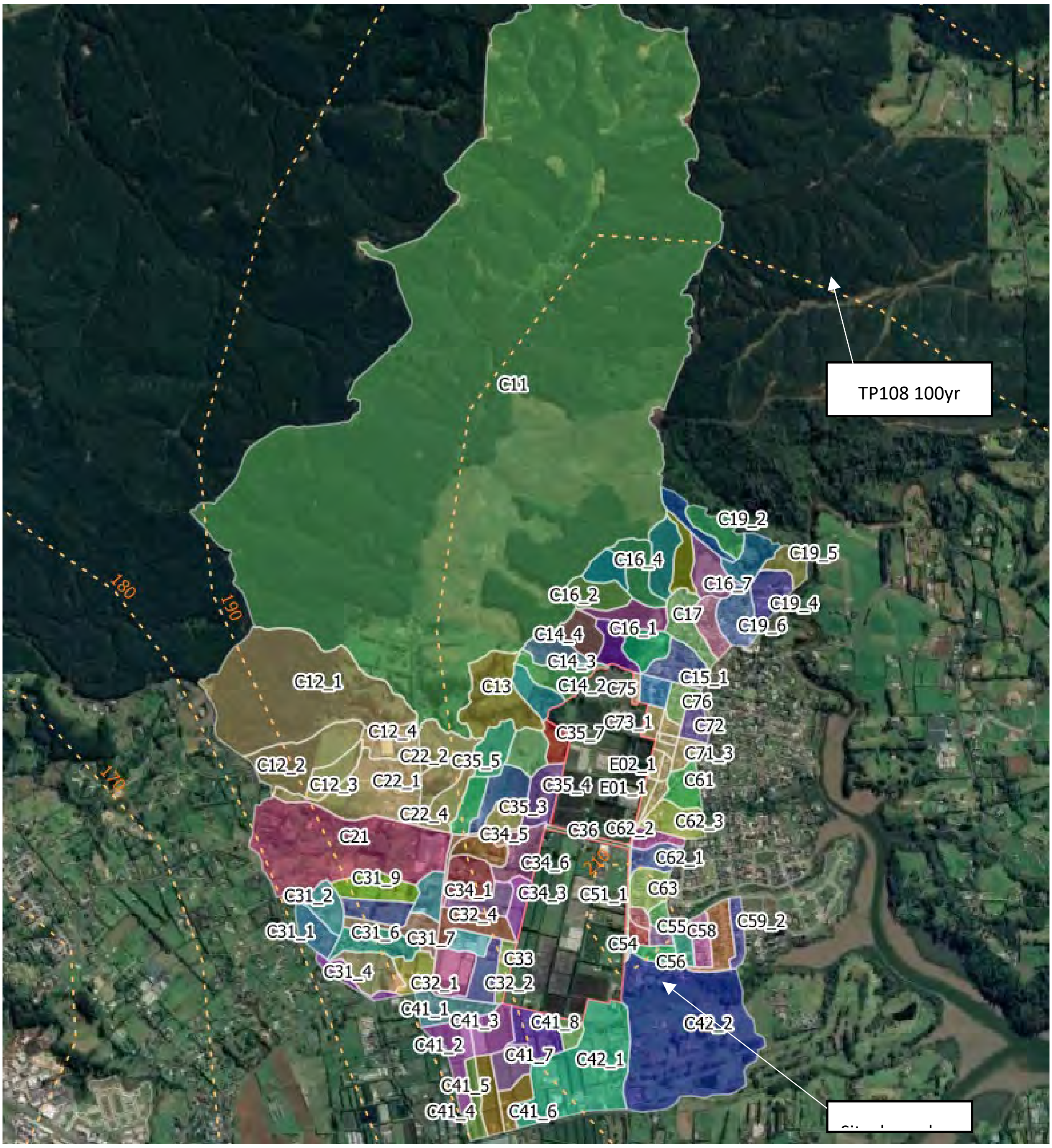


Figure 2: Sub-catchment Plan Excluding the site and TP108 24hr Rainfall Depth Contours (100yr without climate change)

Within the site -internal

The sub-catchment plan within the site boundary was manually delineated for existing condition and post development condition.

- **Existing sub-catchment plan** (Figure 3) was created following the natural contours (from 2016 1m LiDAR) and the current discharge locations which is based on CKL's Rain-on-Grid model result. See Appendix 1 for tabular detail of sub-catchments.

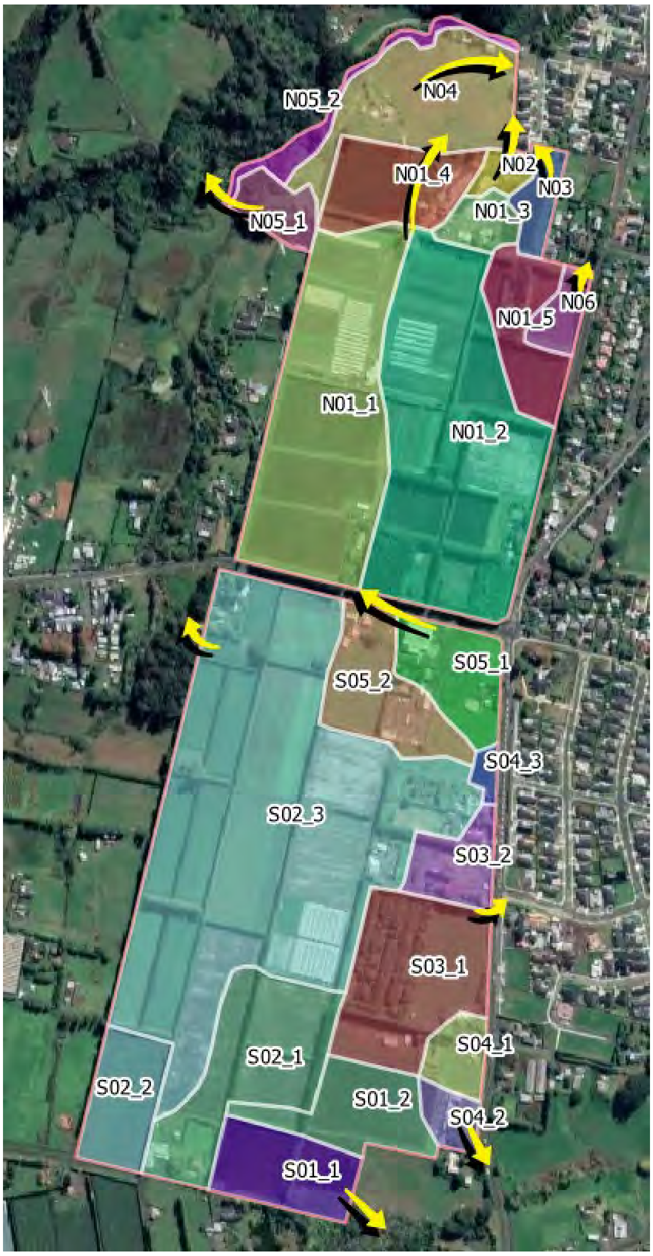


Figure 3: Sub-catchment Plan within the site and Existing Discharge Locations for Pre-development Condition

- **Proposed sub-catchment plan** (Figure 4) was created based on the proposed Master Plan (Appendix 2) and proposed discharge locations for post development, as indicated with the yellow arrows in Figure 4. See Appendix 1 for tabular detail of sub-catchments.

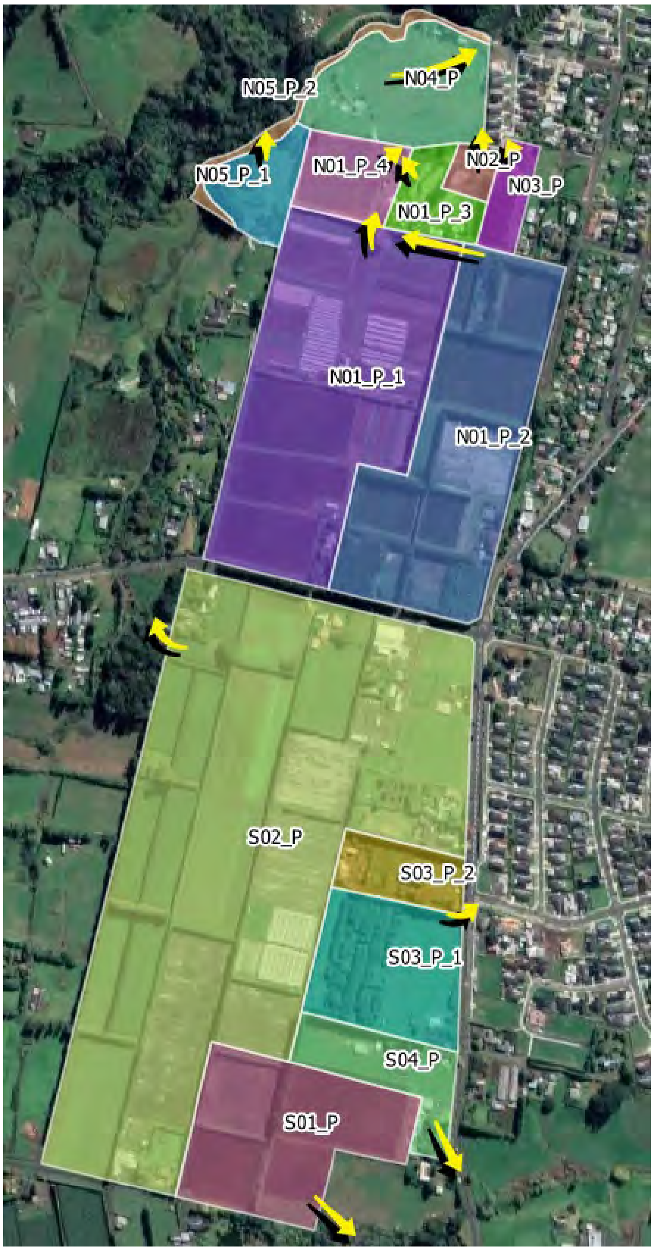


Figure 4: Sub-catchment Plan within the site and Proposed Discharge Locations for Post-development

Impervious Coverage

- **<u>Outside the site (ED)</u>**: the impervious coverage of sub-catchments outside the site was estimated based on the impervious surface GIS data provided by AC for existing development condition. See Appendix 1 for detail of the imperviousness for each sub-catchment.

  It is noted that the estimated imperviousness for outside-site sub-catchments has been used for both pre and post development modelling scenarios. This is because that the purpose of the flood modelling is to assess the potential flood risk effect from the proposed development within the site rather than outside the site, which is not within the control of this Riverhead PPC.

- **<u>Within the site:</u>**
  - **<u>For pre-development condition</u>**, the impervious coverage for the site is estimated based on the Aerial view resulting in an average 10% for the whole site, ranging from 0% to 30% (see Appendix 1 for estimated imperviousness for each sub-catchment).

- **For post-development condition**, based on the preliminary, the following assumption has been used to estimate average impervious coverage for each sub-catchment within the site (for this flood risk assessment only) resulting in an average 63% imperviousness for the whole site (see Appendix 1 for detail):
    - 0% for green area
    - 65% for residential zone
    - 90% for business zone

3.4 Hydrology Model (HEC HMS)

HEC HMS model (version 4.10) was used to calculate catchment flows for each sub-catchment. The model parameters were prepared according to TP108 methodology and summarized in the following sections.

3.4.1 Design Rainfall

The design rainfall data is generated from the standard TP108 24-hour temporal pattern and the 24-hour rainfall depth from TP108 24hr rainfall depth contours and summarized in table below (See Appendix 1 Calculation for detailed rainfall depth for each sub-catchment).

As discussed with AC HW, rainfall with no climate change is used for flood assessment modelling while another scenarios for 1% AEP with climate change (3.8°C increase) will be modelled for sensitivity check.

It is noted that 1% AEP with climate change (2.1°C increase) is used for model validation in consistence with the AC RFHA model.

Table 1: Design Rainfall

AEP	TP108 24hr rainfall depth (mm)	Percentage increase in rainfall depth for climate change (2.1°C increase)	Percentage increase in rainfall depth for climate change (3.8°C increase)
50%	80	N/A	N/A
10%	130	N/A	N/A
1%	190-210	16.8%	32.7%

3.4.2 SCS Curve Number and Ia

Based on Auckland Geology map, dominated soil type for all the sub-catchment is mudstone and sandstone, which is considered as SCS Hydrological Group C as per TP108 Table 3-2.

The following CN number and Initial Abstraction (Ia) has been assumed for all the sub-catchments:

- CN=74 and Ia=5 for pervious area;
- CN=98 and Ia=0 for impervious area.

A weighted CN and Ia was calculated based on above assumptions and impervious percentage for each sub-catchment (See Appendix 1 Calculation for detail).

3.4.3 Time of Concentration

- TP108 equation (4.3) has been used to calculate time of concentration (tc) for each sub-catchment.
- Equal Area method has been used to estimate catchment slope using QGIS tools.
- Channelization factor (C):

- C=0.8 for pre-development condition within the site,
- C=0.6 for post-development condition within the site, and
- C=0.8 for outside the site

- SCS lag time (tp) for HEC HMS model input (see Table 1-3) is tp=2/3* tc

3.4.4 Dummy attenuation basins

In order to assess the potential attenuation effect on the downstream flooding for 10% and 100% AEP event, with the lack of attenuation design at this stage, three dummy basins with assumed outlet structures are added in the HEC HMS model for three large sub-catchments within the site (N01_P_1, N01_P_2 and S02_P). See Appendix 1 for detailed parameters for the three sub-catchments for attenuation model.

The dummy basins provide sufficient storage to temporarily store the runoff from the contributing catchment and release the flow through outlet control at pre-development rate (ED condition).

The dummy basins are modelled as 'Reservoir' element with 'Spillway' outlet structures. The assumed basin geometry is summarized in Table 2. The indicative location of dummy basins are shown in Figure 5.

Table 2: Dummy Basins Geometry Assumptions

Dummy Basins	Contributing Catchment	Maximum Volume (1000 m3)	Maximum Depth (m)	Spillway length (m)
Dummy Basin S02	S02_P	10	1.5	2.5
Dummy Basin N01_1	N01_P_1	4	1.5	1.1
Dummy Basin N01_2	N01_P_2	4	1.5	1

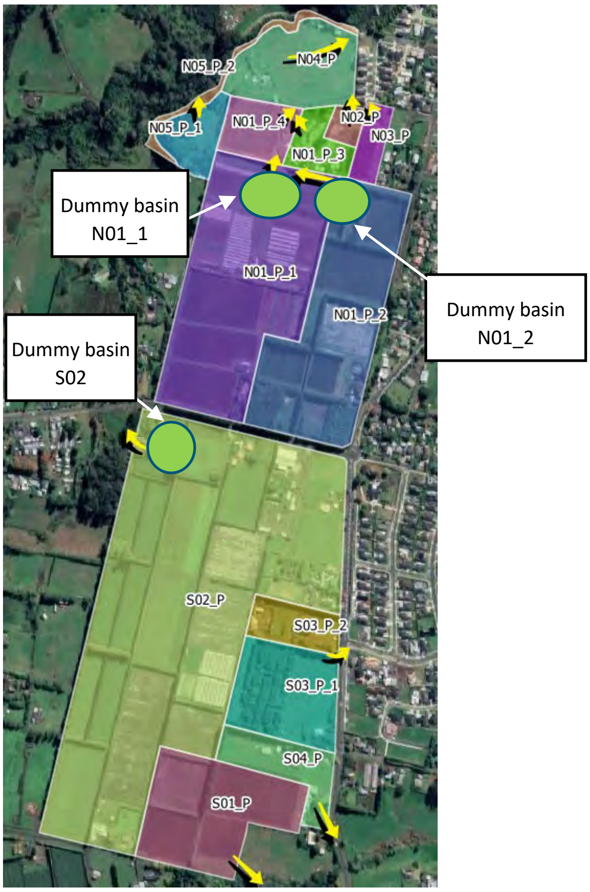


Figure 5: Indicative Location of Dummy Basins

3.4.5 Simulation and result

Outside Sub-catchment

HEC-HMS model simulations for outside of the site with ED and MPD condition are summarized in Table 3.

Table 3: HEC HMS Model Simulation and Model Files for Outside Sub-catchment

Simulation Runs	Basin model	Meteorologic model	Description
OutsideED-R04-2yr	Outside-Catch-ED-R04	2yr	ED imperviousness. 50% AEP without climate change
OutsideED-R04-10yr	Outside-Catch-ED-R04	10yr	ED imperviousness. 10% AEP without climate change
OutsideED-R04-100yr	Outside-Catch-ED-R04	100yr	ED imperviousness. 1% AEP without climate change
OutsideMPD-R04-100yrCC	Outside-Catch-MPD-R04	100yrCC-2.1°C	MPD imperviousness. 1% AEP with climate change (2.1°C increase)
OutsideMPD-R04-100yrCC3.8	Outside-Catch-MPD-R04	100yrCC-3.8°C	MPD imperviousness. 1% AEP with climate change (3.8°C increase)

See Appendix 1 (Calculation) for the detail of HEC HMS model result (peak flow) for each sub-catchment for all the scenarios as per Table 3.

Within the Site

HEC HMS model simulations for the site with ED and MPD condition (without attenuation) are summarized in Table 4 and Table 5 and the model results (peak flow) are provided in Table 6 and Table 7.

Table 4: HEC HMS Model Simulation and Model Files for Site Sub-catchment for ED Condition

Simulation Runs	Basin model	Meteorologic model	Description
Site Sub-ED-R01-2yr	Site-Sub-ED-R01-0.8	2yr	ED imperviousness. 50% AEP without climate change
Site Sub-ED-R01-10yr	Site-Sub-ED-R01-0.8	10yr	ED imperviousness. 10% AEP without climate change
Site Sub-ED-R01-100yr	Site-Sub-ED-R01-0.8	100yr	ED imperviousness. 1% AEP without climate change
Site Sub-ED-R01-100yrCC3.8	Site-Sub-ED-R01-0.8	100yrcc-3.8°C	ED imperviousness. 1% AEP with climate change (3.8°C increase)

Table 5: HEC HMS Model Simulation and Model Files for Site Sub-catchment for MPD Condition

Simulation Runs	Basin model	Meteorologic model	Description
Site Sub-MPD-R03-100yr	Site-Sub-MPD-R01-0.6	100yr	MPD imperviousness. 1% AEP without climate change
Site Sub-MPD-R03-100yrCC	Site-Sub-MPD-R01-0.6	100yrcc-2.1°C	MPD imperviousness. 1% AEP with climate change (2.1°C increase)
Site Sub-MPD-R03-100yrCC3.8	Site-Sub-MPD-R01-0.6	100yrcc-3.8°C	MPD imperviousness. 1% AEP with climate change (3.8°C increase)

Table 6: HEC HMS Model Result- Peak Flows of Each Sub-catchment within the Site for ED Condition

Sub-catchment	50%AEP-ED-NoCC	10% AEP-ED-NoCC	1% AEP-ED-NoCC
N01_1	0.487	1.022	1.894
N01_2	0.657	1.377	2.549
N01_3	0.058	0.121	0.224
N01_4	0.183	0.381	0.704
N01_5	0.129	0.280	0.533
N02	0.036	0.075	0.139
N03	0.054	0.117	0.222
N04	0.230	0.497	0.942
N05_1	0.066	0.142	0.267
N05_2	0.060	0.129	0.246
N06	0.050	0.107	0.204
S01_1	0.153	0.331	0.648
S01_2	0.159	0.344	0.675
S02_1	0.250	0.524	1.002
S02_2	0.136	0.284	0.542
S02_3	1.143	2.397	4.581
S03_1	0.283	0.578	1.081
S03_2	0.101	0.206	0.384
S04_1	0.087	0.169	0.304
S04_2	0.063	0.122	0.220
S04_3	0.019	0.041	0.077
S05_1	0.195	0.379	0.683
S05_2	0.226	0.440	0.796

Table 7: HEC HMS Model Result- Peak Flows of Each Sub-catchment within the Site for MPD Condition

Sub-catchment	1% AEP-MPD-NoCC	1% AEP-MPD+CC2.1°C	1% AEP-MPD+CC3.8°C
N01_P_1	4.143	4.883	5.596
N01_P_2	2.923	3.534	4.050
N01_P_3	0.434	0.528	0.607
N01_P_4	0.575	0.699	0.803
N02_P	0.172	0.210	0.241
N03_P	0.310	0.376	0.431
N04_P	1.011	1.268	1.492
N05_P_1	0.514	0.625	0.719
N05_P_2	0.199	0.250	0.294
S01_P	2.093	2.533	2.828
S02_P	8.841	10.685	11.930
S03_P_1	1.300	1.572	1.802
S03_P_2	0.540	0.653	0.749
S04_P	0.791	0.958	1.098

3.4.6 Dummy attenuation (10% and 1% AEP)

HEC HMS model simulations for the attenuation scenarios are summarized in Table 8.

Table 8: HEC HMS Model Simulation and Model Files for Dummy Attenuation (10% and 1% AEP)

Simulation Runs	Basin model	Description
Dummy attenu-R0310yrNoCC	Dummy attenuation - 10yr	ED imperviousness for pre-development and MPD imperviousness for post-development. 10% AEP without climate change
Dummy attenuation-R03-0.6	Dummy attenuation-R03-0.6	ED imperviousness for pre-development and MPD imperviousness for post-development. 1% AEP without climate change

Attenuation results for three sub-catchments are summarized in Table 9 (10% AEP) and Table 10 (1% AEP).The result shows that after attenuation, not only the peak flow is reduced but also the peak time is delayed compared to ED condition. This effect might have an impact on downstream flooding (see Hydraulic model result for details).

Table 9: Attenuation result-10% AEP

Sub-catchment	Peak flow -Existing (m3/s)	Peak time-Existing	Peak flow -Post (m3/s)	Peak time-Post	Attenuated flow out of basins (m3/s)	Peak time-attenuated
N01_P_1	1.57	12:09	2.44	12:04	1.47	12:14
N01_P_2	1.13	12:11	1.77	12:05	1.05	12:17
S02_P	3.27	12:14	5.20	12:07	3.12	12:21

Table 10: Attenuation result-1% AEP

Sub-catchment	Peak flow - Existing (m3/s)	Peak time-Existing	Peak flow -Post (m3/s)	Peak time-Post	Attenuated flow out of basins (m3/s)	Peak time-attenuated
N01_P_1	3.62	12:09	4.88	12:04	3.61	12:11
N01_P_2	2.60	12:11	3.53	12:05	2.54	12:14
S02_P	7.77	12:14	10.68	12:07	7.68	12:17

The model result (1% AEP) at the three dummy attenuation basin are given in Table 11.

Table 11: Model Result at Three Dummy Attenuation Basin for 1% AEP

Dummy basins	Peak Depth (m)	Peak storage (1000 m3)
Dummy Basin S02	1.29	7.9
Dummy Basin N01_1	1.27	3.3
Dummy Basin N01_2	1.11	2.8

3.5 Hydraulic Model (HEC RAS)

HEC RAS model (version 6.3) was used to assess the hydraulic features of the catchment flows. The model build is summarized in the following sections.

3.5.1 Geometry

As shown in Figure 6, the geometry (post-development for example) includes following components:

- **2D flow area** is the 2D model extent (blue line in Figure 6). Cell size for 2D flow area is 2m x 2m (along break lines) and 5m x 5m for the rest area.
- **Break lines:** for finer cell size (2m x 2m) refinement along roads, channels, OLFPs and site boundaries.
- **Flow boundary condition line**: external ('C11') and internal (all other flow boundary condition lines) lines where flow hydrographs are loaded to 2D flow area (see section 3.5.3 for detail).

  It is noted that boundary condition lines are located lower catchment. For the subject site, due to the lack of design surface, the flow boundary condition lines are located at the discharge outlet, i.e. channel and basin for each sub-catchment within the site.
- **Downstream boundary condition line**: where water leaves 2D flow area through downstream boundary conditions (see section 3.5.3 for detail).
- **Culverts:** modelled as 2D connection in the model (see section 3.5.4 for detail of culverts in the model).
- **Terrain model** : see section 3.5.2 for detail.

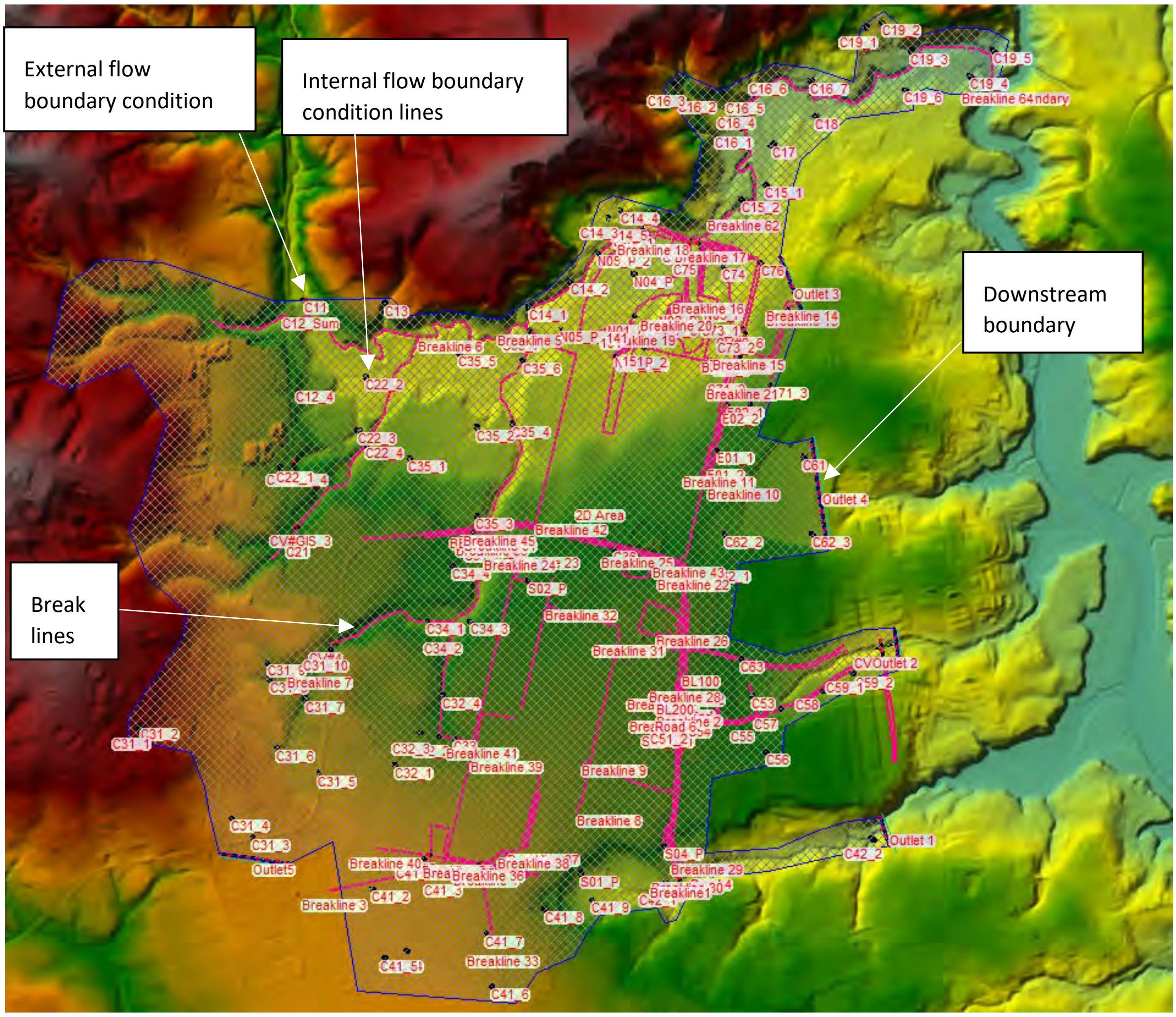


Figure 6: HEC RAS 2D Model Geometry with Terrain (Post-development)

3.5.2 Terrain model

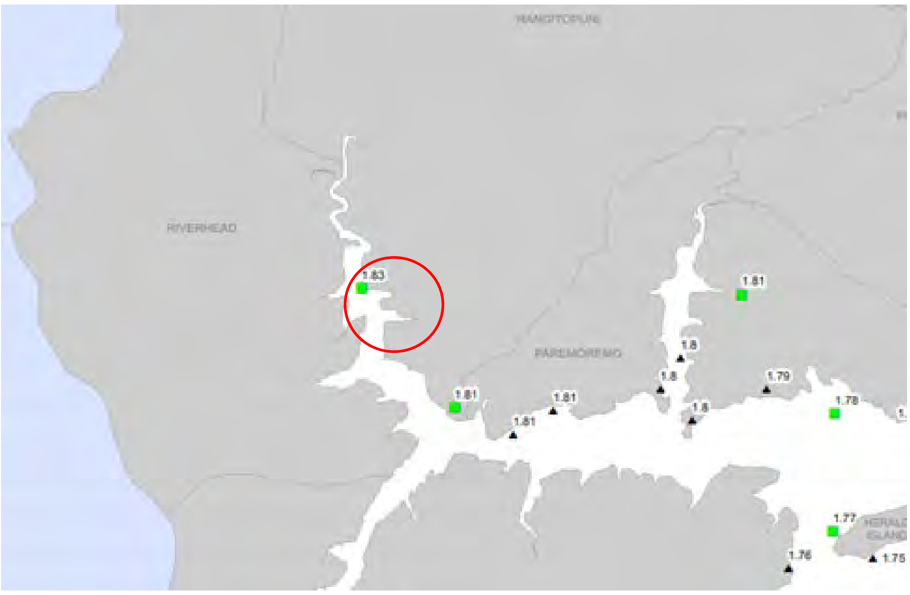
Terrain model was formed by merging the following resources:

- 2016 1m LiDAR DEM (AVD) provided by HW, and
- Topography survey TIN converted to AVD

It is noted that design surface is not available at this stage so same terrain model has been used for both pre- and post-development scenarios. This is reasonable considering the modelling focus is on the downstream impact rather than the site.

3.5.3 Boundary condition

- Flow boundary conditions: flow hydrographs from the HEC HMS model result for each sub-catchment (see Hydrology analysis summary for detail)
- Downstream boundary conditions:
    - *Coastal boundary*: the following coastal boundary condition obtained from the Coastal Marine Area Boundary for the Auckland Region provided by AC was set at the catchment outlet at the estuary:
        - MHWS+1m rise=1.83 +1=2.83 m



    - *Other outlets*: normal depth boundary condition (friction slope = 0.005) was set for all the other boundary lines where water will leave the 2D flow area.

3.5.4 Structures

Culverts

The culverts modelled in the 2D model are as shown in Figure 7 and Table 12. The culvert information is based on survey and online GIS (GeoMaps) information.

Table 12: Information of Existing Culverts in the Model

Culverts	Size(mm)	Sources
CV#1_1	800	Survey
CV#1_2	600	Survey
CV#1_3	1100	Survey
CV#1_4	600	Survey
CV#2_1	600	Survey
CV#2_2	Double 600	Survey
CV#3	1200	GeoMaps
CV#4	600	Survey
CV#5	600	Survey
CV#6_1	600	Survey
CV#9_6	600	Aerial photo

Culverts	Size(mm)	Sources
CV#_1	2500	Site visit
CV#GIS_1	Double 1200	GIS Geomaps
CV#GIS_2	900	GIS Geomaps
CV#GIS_3	900	GIS Geomaps
CV#GIS_4	600	GIS Geomaps

Figure 7: Indicative Location of Culverts in the Model

<u>Bridges</u>

There are a couple of bridge structures downstream of the site. In the flood model, the channels at the bridge locations remain open in the terrain and the bridge decks are not added . Consideration of whether or not the bridge decks are included in the model has been discussed with HW. It was concluded that including these bridge structures will not affect the flood assessment outcomes in this report due to the following:

- Bridges are located downstream and the decks obstruction impact on the flood plain within the subject site is considered negligible.
- The bridges are located where the flood level is dominated by the tidal boundary condition.
- Downstream impact assessment outcomes will not be affected as they are based on flood model result comparisons (difference) between pre- and post-development .

3.5.5 Energy loss

As discussed with AC HW, the following Manning's roughness values have been assigned according to Auckland Council Rapid Flood Hazard Assessment Modelling Specification (2012)

- 0.05 for roads
- 0.1 for rest of area

3.5.6 Computation

- Adjustable time step varying from 1 secs to 32 secs
- Simulation periods:24 hrs

3.6 Model Scenarios

The modelled scenarios and description and their model files are given in Table 13 and summarized as following:

- Validation scenario

AC HWD has provided flood information associated with the site from the latest 2D flood model. The AC model result was based on MPD condition and rainfall with climate change for 2.1 °C increase. CKL's flood model has run a scenario with above condition for validation and the result is provided in section 4.

- Impact assessment scenarios

The model scenarios proposed by the HW for impact assessment in Table 13 include 50%, 10% and 1% AEP scenarios without climate change and the scenario for localised impact testing (combination of 50% and 1% AEP).

In addition, two attenuation scenarios have been modelled in order to assess the potential on-site attenuation effect on the downstream flooding during 10% and 1% AEP event. At this stage of design, three dummy attenuation basins have been assumed for three large sub-catchments within the site (N01_P_1, N01_P_2 and S02_P) and attenuation analysis has been conducted in HEC HMS model (refer to section 3.4 for dummy attenuation calculation). The attenuated flow hydrographs from the HEC HMS model result have been loaded where the dummy basins are located in the HEC RAS 2D model.

The model result for all the effect assessment scenarios are provided in section 4.

Table 13: HEC RAS Model Scenarios and Model Files

Rainfall event	Development	Model Files	Description
50% AEP	**Pre-development**	**Plan/result:** *Pre-SiteEDR01+OutEDR04-2yrNoCC* **Geometry:** *Geo-Pre-V7* **Flow file:** *SiteEDR01+OutEDR04-ED-2yrNoCC*	50% AEP flood assessment scenario for pre-development. No climate change. ED imperviousness within the site and outside of the site.
	Post-development	**Plan/result:** *Post-SitePostR03+OutEDR04-2yrNoCC* **Geometry:** *Geo-Post-V7* **Flow file:** *SitePostR03+OutEDR04-ED-2yrNoCC*	50% AEP flood assessment scenario for post-development. No climate change. MPD imperviousness within the site and ED imperviousness outside of the site.

Rainfall event	Development	Model Files	Description
10% AEP	Pre-development	**Plan/result:** *Pre-SiteEDR01+OutEDR04-10yrNoCC* **Geometry:** *Geo-Pre-V7* **Flow file:** *SiteEDR01+OutEDR04-ED-10yrNoCC*	10% AEP flood assessment scenario for pre-development. No climate change. ED imperviousness within the site and outside of the site.
	Post-development	**Plan/result:** *Post-SitePostR03+OutEDR04-10yrNoCC* **Geometry:** *Geo-Post-V7* **Flow file:** *SitePostR03+OutEDR04-ED-10yrNoCC*	10% AEP flood assessment scenario for post-development. No climate change. MPD imperviousness within the site and ED imperviousness outside of the site.
1% AEP	Pre-development	**Plan/result:** *Pre-SiteEDR01+OutEDR04-100yrNoCC-V3* **Geometry:** *Geo-Pre-V7* **Flow file:** *SiteEDR01+OutEDR04-ED-100yrNoCC*	1% AEP flood assessment scenario for pre-development. No climate change. ED imperviousness within the site and outside of the site.
	Post-development	**Plan/result:** *ProstSitePostR03+OutEDR04-100yr* **Geometry:** *Geo-Post-V7* **Flow file:** *SitePostR03+OutEDR04-100yrNoCC*	1% AEP flood assessment scenario for post-development. No climate change. MPD imperviousness within the site and ED imperviousness outside of the site.
50% AEP for upstream and 1% for the rest	Pre-development	**Plan/result:** *Pre-SiteEDR01+OutEDR04-100yrNoCC+US2yr* **Geometry:** *Geo-Pre-V7* **Flow file:** US2yr+*SiteEDR01+OutEDR04-ED-100yrNoCC*	Scenario to test localised impact for pre-development. No climate change. 50% AEP for upstream of 50 Forestry Road (C11,C12_4 and C12_sum) and 1% AEP for the rest of catchment. ED imperviousness within the site and outside of the site.
	Post-development	**Plan/result:** *Post-SitePostR03+OutEDR04-100yr+US2yr* **Geometry:** *Geo-Post-V7* **Flow file:** US2yr+*SitePostR03+OutEDR04-100yrNoCC*	Scenario to test localised impact for post-development. No climate change. 50% AEP for upstream of 50 Forestry Road (C11,C12_4 and C12_sum) and 1%AEP for the rest of catchment. MPD imperviousness within the site and ED imperviousness outside of the site.
1% AEP - Attenuation	Post-development	**Plan/result:** Attenuation-*SitePostR03+OutEDR04-100yr* **Geometry:** *Geo-Post-V7* **Flow file:** *SitePostR03+OutEDR04-100yrNoCC-attenu*	Attenuation scenario to test potential attenuation effect No climate change. MPD imperviousness within the site and ED imperviousness outside of the site. Dummy attenuated flow for three large sub-catchments within the site.
10% AEP - Attenuation	Post-development	**Plan/result:** Attenuation-*SitePostR03+OutEDR04-10yr* **Geometry:** *Geo-Post-V7* **Flow file:** *SitePostR03+OutEDR04-10yrNoCC-attenu*	Attenuation scenario to test potential attenuation effect No climate change. MPD imperviousness within the site and ED imperviousness outside of the site. Dummy attenuated flow for three large sub-catchments within the site.

Rainfall event	Development	Model Files	Description
1% AEP + Climate Change 2.1°C	Pre-development	**Plan/result:** *Pre-SiteEDR01+OutMPD R04-100yrCC* **Geometry:** *Geo-Pre-V7* **Flow file:** *SiteEDR01+OutMPDR04-100yrCC*	Scenario for 2.1 °C climate change. Climate change for 2.1°C increase. ED imperviousness within the site and MPD outside the site.
	Post-development	**Plan/result:** *Post-SitePostR01+OutMPD R04-100yr* **Geometry:** *Geo-Post-V7* **Flow file:** *SitePostR03+OutMPDR04-100yrCC*	Scenario for 2.1 °C climate change (validation scenario) Climate change for 2.1°C increase. MPD imperviousness within the site and MPD outside the site.
1% AEP + Climate Change 3.8°C	Pre-development	**Plan/result:** *Pre-SiteEDR01+OutMPD R04-100yrCC3.8* **Geometry:** *Geo-Pre-V7* **Flow file:** *SiteEDR01+OutMPDR04-100yr3.8CC*	Climate change for 3.8°C increase. . ED imperviousness within the site and MPD outside the site.
	Post-development	**Plan/result:** *Post-SiteMPDR03+OutMPD R04-100yrCC* **Geometry:** *Geo-Post-V7* **Flow file:** *SitePostR03+OutMPDR04-100yr3.8CC*	Climate change for 3.8°C increase. . MPD imperviousness within the site and MPD outside the site.

All above scenarios use same terrain model and land use file as following:

- **Terrain model:** 2016LiDAR+SurveyCut-AVD MtEden-1mResmb
- **Land use:**Manning-MPD-0.1 and 0.05

4 Model Results

4.1 Validation result

A comparison of the validation scenario (Scenario for 2.1 °C climate change for post-development) result with AC model result at the locations around the site (Figure 8) is given in Table 14 which shows well validated.

Table 14: Comparison of Validation Model Result with AC Model Result

	AC Model	CKL model	AC Model	CKL model	AC Model	CKL model
Locations	Qp (m^3/s)	Qp (m3/s)	Peak time	Peak time	TWL	TWL(m)
Centre	125	122	12:50	12:44	15.09	15.07
Western boundary	--	--	--	--	19.6	19.5
Eastern boundary	--	--	--	--	14.8	14.88

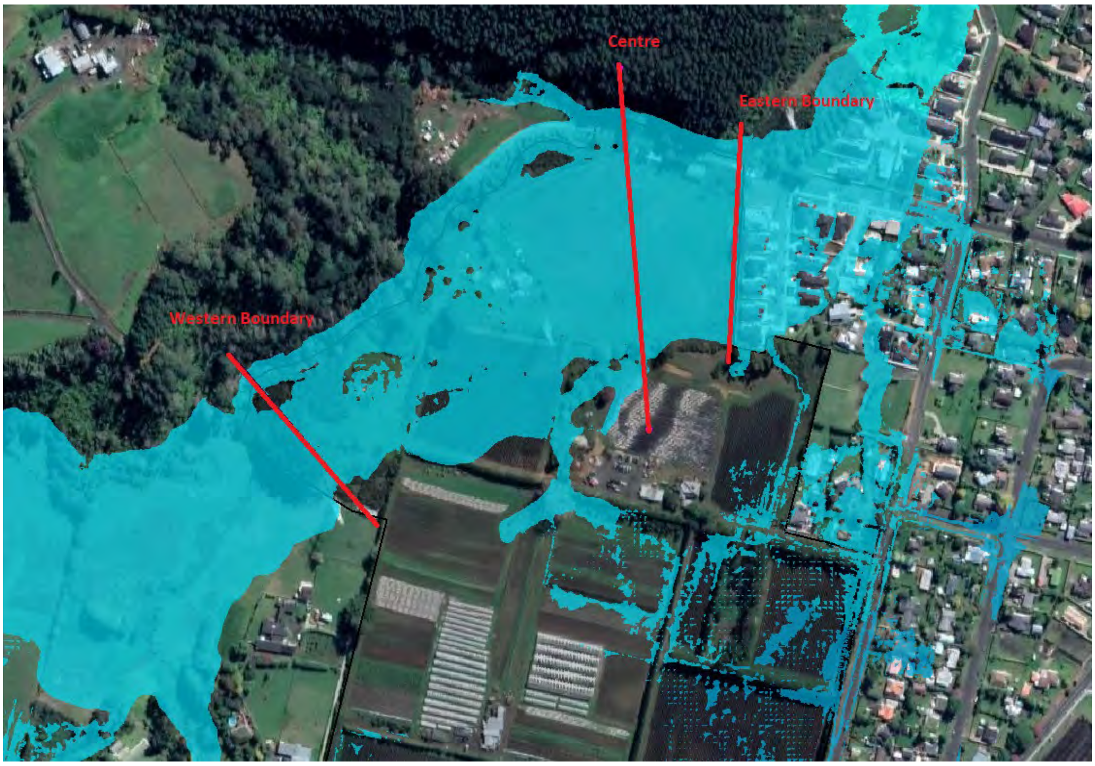


Figure 8: Indicative Location for Model Result Comparison for Validation

The model result extracted from HEC RAS model is provided in Appendix 5.

4.2 Impact assessment scenarios result

- Flood maps

The model result maps for entire model extent for all the scenarios are provided in Appendix 3, including maximum flood depth maps (pre- and post-development) and flood level difference map between post-development and pre-development condition. In addition, the difference map for post-development without and with on-site attenuation are also provided for 10% and 1% AEP events.

- Tabular result at key locations

A detailed model result has been provided at key locations (as shown in Figure 9) as per HW's request. The tabular results for each location are provided in Appendix 4.

Figure 9: Key Locations for Detailed Flood Model Result Comparison

5 Impact Assessment

The effect assessment investigates the potential impact of the proposed development within the site on the downstream flood risk (without on-site attenuation), as well as the potential benefits or adverse impact of on-site flood mitigation.

5.1 Impact assessment without on-site attenuation

The key locations as shown in Figure 9 fall within four downstream areas (associated with the site discharge) as indicated in Figure 10.

Figure 10: Downstream Locations of Interest

According to the flood level difference maps in Appendix 3 and the detailed tabular results at key locations in Appendix 4, a flood risk classification and development impact assessment is undertaken and summarized in Table 15. The flood risk classification is based on the hazard classification criteria as per the AC Modelling Specification (Figure 11).

Table 15: Flood Risk and Impact Assessment for Downstream Areas of Interest

Areas of interest in Figure 10	Associated discharging location for the site	Key Locations in Figure 9	Flood Risk Classification*	Impact Assessment
Area 1	Discharging to the Hallertau development (to Waitemata Harbour) through the OLFP within Riverhead Point Drive	K	Minor (Depth <0.2m Velocity<1.0 m/s)	No impact- (Overland flow discharged from the site at this OLFP is reduced due to the proposed new connection to 750mm public pipe under the Riverhead Point Drive (See SMP for detail)
Area 2	Discharging directly to a separate stream (to Waitemata Harbour) or through Coatesville Riverhead Hwy	L, M	Significant (Depth>0.3m Velocity<2m/s)	No impact on existing buildings (Although the flood level is increased by 20-50mm in this area for all rainfall events, the OLFP is contained within the existing Stream and no existing dwelling is affected by the OLFP.)
Area 3	Discharging to a tributary of the Stream (downstream of 280 Riverhead Road)	C,D,J	Significant (Depth>0.3m Velocity<2m/s)	No impact on existing buildings (Although the flood level is increased by over 100mm, the OLFP is contained within the Stream and the existing dwellings are outside the modelled floodplain.)
Area 4	Direct discharging to the Stream (downstream of 22 Duke Street)	All the rest locations	Significant** (Depth>0.3m))	Affected • The flood level increase is 10-50mm for all rainfall events. • The hazard level (V*D) is increased less than 0.1.

Notes:

*: Flood risk classification is according to the hazard classification criteria in Figure 11 as per the AC Modelling Specification.

**: Existing flood depth is greater than 300mm, the effect of the discharge without attenuation is an increase of 10-50mm.

For Area 4, the existing flood depth is greater than 300mm therefore the existing flood risk classification is Significant. The increase in flood depth due to the site development is in the order of 10mm – 50mm depending on rainfall event (30mm for 1% AEP). This increase is considered as less than minor given the existing flood depth.

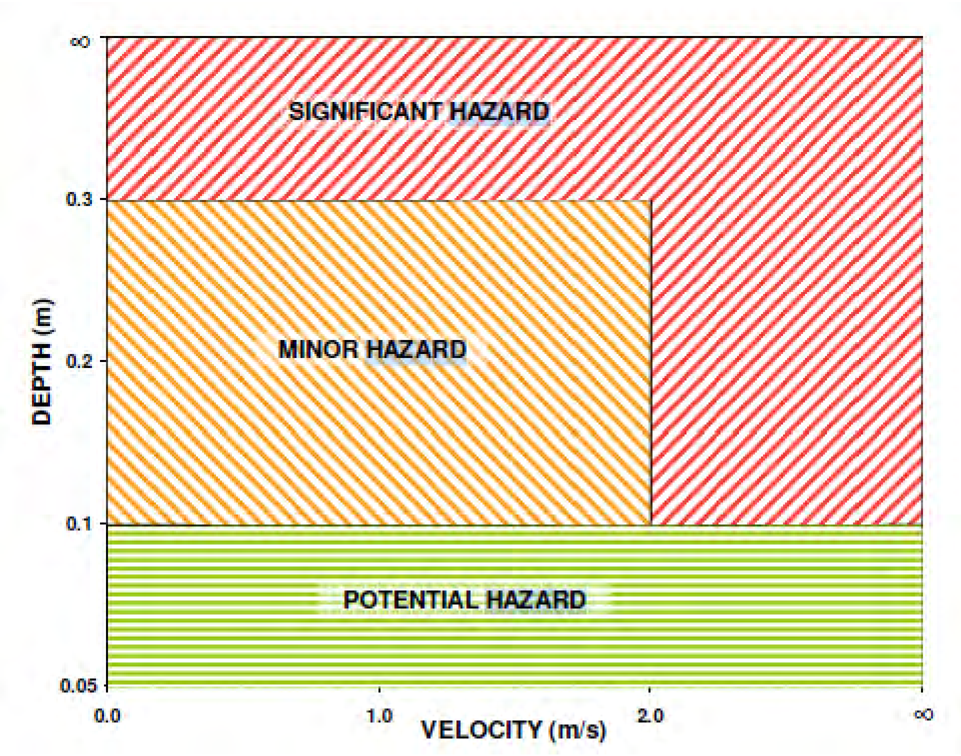


Figure 11: Depth-Velocity Criteria for Hazard Classification (AC Modelling Specification)

The summary of the flood risk assessment is as follows,

- In the Area 1 (Location K at Riverhead Point Drive OLFP in Figure 9), the flood risk is classified as Minor and there is no impact from the site development. The flood risk on the OLFP is reduced due to the proposed new connection to the public pipe. Therefore, on-site attenuation is not required for the site catchment contributing to the Area 1.
- In the Area 2 (Location L and M at Coatesville Riverhead Hwy stream in Figure 9), the flood risk classification is Significant with flood depth greater than 0.3m. The velocity is less than 1.3m/s and the flood hazard factor (V*D) is less than 1.0 for all the AEP rainfall events. The flood levels for the post-development scenarios are increased by up to 50mm (1%AEP) due to the increased discharge from the site development (without attenuation), however, there are no existing building within the flood extent. The increased flood level will not affect the buildings within these areas. Therefore, on-site attenuation is not required for the site catchment contributing to the Area 2.
- For the Area 3 (Location J, C and D downstream of 280 Riverhead Road in Figure 9), the flood level is increased by more than 100mm but no impact on the existing buildings in the area. The attenuation might not be required for the site catchment contributing to the Area 3. However, ultimate discharge location for the Area 3 is the Area 4(downstream of 22 Duke Street, so the attenuation requirement is subject to the flood risk assessment outcomes for the Area 4 (see following).
- In the Area 4, the building flooding issue is identified. The flood level is increased by 10-50mm and flood hazard factor (V*D) is increased by less than 0.1 at all locations in this area for all the AEP rainfall events.
    - 30mm for 1% AEP event
    - With respect to NDC requirements this may need attenuation due to the flooding occurring downstream
    - However, considering the site location within the wider catchment, the benefit of the on-site attenuation is to be investigated, refer to the following section

5.2 On-site attenuation benefits assessment

A further assessment has been undertaken to assess the potential effect/ benefit of on-site flow attenuation mitigation (e.g. attenuation basins) on downstream flooding in the Area 4 (shown in Figure 10) during AEP 10% and 1% AEP rainfall events.

The model result of two attenuation scenarios (10% and 1% AEP) are compared with the post-development without attenuation scenarios. In addition to the detailed tabular result comparison at the key locations in Appendix 4, the flood level difference maps between post-development without and with attenuation for 10% and 1% AEP are generated (Figure 25 and Figure 26 in Appendix 4) to assist the attenuation impact assessment.

The difference maps show that the increase in flood level at the downstream Area 4 (downstream of 22 Duke Street) due to proposed development could be further increased by up to 30mm for 10% AEP event and 40mm for 1% AEP event <u>due to on-site attenuation</u>.

In addition, the detailed results at the key locations downstream of 22 Duke Street (Location E, A, B, P, O, G, H, I, N) in Appendix 4 show that the flood flow and flood hazard factor (V*D) for attenuation scenario are also further increased for both 10% and 1% AEP events. This means that the on-site mitigation/ attenuation for the subject site might have an adverse impact on the downstream flood risk and therefore is not recommended.

This result is likely due to the location of the proposed site, which is a small sub-catchment discharging to the lower (wider) stream catchment. The flood flow at the downstream of 22 Duke Street is dominated by the wider stream catchment (Riverhead Forest stream) flow which is much bigger than the flow from the site catchment and the peak time arrives (c.40 minutes) later than the site flow. As indicated in flow hydrographs in Figure 12, the attenuated peak flow from the site catchment is no greater than the pre-development flow, but the attenuated flow hydrograph is flattened and delayed which results in the site flow to merge with the stream peak flow might be increased. This means that due to the site flow delay (due to on-site attenuation), the stream catchment flow might collide with a higher flow from the site catchment, and result in an increased flood level at the downstream locations compared to no-attenuation scenario.

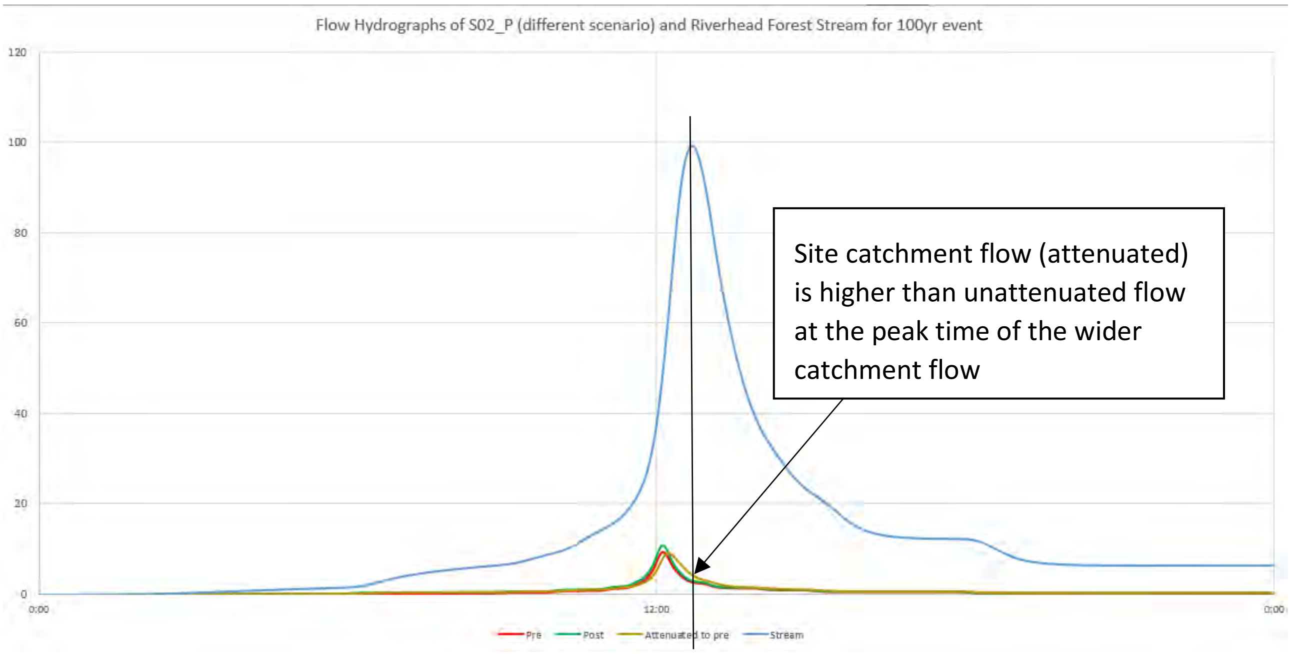


Figure 12: Flow Hydrographs of Riverhead Stream versus Sub-catchment S02_P within the site before and after attenuation

5.3 Conclusions

Based on above assessment, it is concluded that the on-site attenuation is not required for the site catchment discharging to the downstream Area 1 (Riverhead point Drive) and Area 2 (Coatesville Riverhead Hwy stream) as per Figure 10, and not recommended for the site catchment discharging to the Area 4 (downstream of 22 Duke Street) and the Area 3 (downstream of 280 Riverhead Road) which ultimately discharge to the Area 4 in Figure 10 considering the potential adverse impact from the on-site attenuation due to the location of the site within the wider catchment.

6 Model Limitations

It is noted that the flood modelling provided in this report are subject to the modelling limitations including the accuracy of the LiDAR DEM within the channels and the exclusion of stormwater structures (e.g. bridges and pipes) in the model.

The design surface within the site is not available when the flood model is undertaken. The flood extent and OLFP alignment within the site for the post-development scenario is subject to a change at design stage.

The network capacity assessment is not provided in this flood risk assessment for the plan change application. There are both public and private infrastructure located downstream of the plan change area. It is recommended by the HW that a further modelling may be necessary to determine the impacts on this infrastructure from a usability perspective, to include depth of flooding, duration of flooding and extent of flooding for more frequent events to confirm the impacts of the plan change development on these assets and roads.

7 Further Refinement

It is noted that the flood model refinement might be required at next stage when the design surface and detailed stormwater development plan becomes available. The model refinement will incorporate the specific model review comments provided by the HW on 23rd November 2022 as per Section 8.2 (Table 17).

8 Model Review and Response

8.1 Model Review in April 2022

CKL submitted the first flood model in March 2022 and received the model review from HW through an email dated 14 April 2022. The model review comments cover the RFI request received in July regarding the flood risk assessment for the Plan Change application. A response to the main HW comments and RFI requests are summarized in Table 16.

Table 16: Response to HW Comments (in April) and RFI Request(in July)

HW Comments/Requests	CKL Response
1. Flood assessment - model review item. Please provide results for those are not currently available, please refer to the attached excel for detail.	See Table 13 for all the model scenario as per HW request
2. Flood assessment - the current flow assessment was not complete. It is necessary to provide results on flood level, flow, velocity, depth and flood extent on key locations.	See section 4.2 and Appendix 4
3. Attenuation assumption Provide more information to assist HW to understand attenuation scenarios better	See Section 3.4.4 for detail
4. C for outside of the development site need to be 0.8-1 rather than 0.6	Updated. C=0.8 used for external catchment ED condition
5. Please add in Model Limitation to the report.	Added. See section 6**.**

8.2 Model Review in November 2022

In response to the HW model review and RFI request as above, an updated model was submitted to the HW in early November for the second review. The second model review comments were provided by the in an email dated 23rd November, 2022 (Appendix 6). It was commended that *'in general, the modelling that has been completed is considered appropriate for a plan change application to determine the potential effects of the land use change*.' There is no further update required at this stage until the next stage of development that a further model refinement may be necessary to incorporate the specific modelling comments listed in Table 17.

Table 17: HW's Model Comments in November 2022 and CKL's response

HW Comments in November 2022	CKL Response
<u>Comments on report:</u>	
1. In general, the modelling that has been completed is considered appropriate for a plan change application to determine the potential effects of the land use change. It is recommended that as developments proceed within the plan change area that this high-level model is refined to provide updates to the potential impacts of specific developments on flood risk and to ensure that appropriate mitigation is provided if required.	No action required.
2. The model review undertaken by Healthy Waters has been a high-level assessment on the approach that was made to the modelling along with reviewing the assumptions and available model build data. It has not looked specifically at the impacts of the recommended flood management approach.	No action required.

HW Comments in November 2022	CKL Response
3. From a review of the model report, Areas of Interest 1, 2 and 3 appear to increase the water level downstream; however, this elevation is contained within the bounds of the watercourse and appears to have limited increase on flood risk to property, or reduction in developable potential in downstream lot areas. Increases range between 20mm to 100mm in general.	No action required.
4. For Area of Interest 4, the flood model shows that flood level increase 10-50mm during all rainfall events, impacting some existing buildings and roads. There is a localised increases in the flood elevation of over 100mm, this increase is resulting in very localised increased flood risk to existing buildings, potentially this increase in flood level may be related to the loading of sub-catchment hydrographs, but there is no explanation provide for this very isolated increase in the reporting, discussion around this isolated increase is recommended.	Action required during model refinement stage: • Further discussion on the localized impact to be added.
5. As mentioned above, there are existing properties that are indicated within the local elevation increase in the modelling. Because there is an increase in flood risk to existing buildings, the decision on whether this is significant will need to be made by the Regulatory team processing the plan change application, not Healthy Waters. 3.	No action required.
6. The Difference maps need to specify in detail what the Pre and Post condition is that is being assessed (i.e. it is not clear if Pre-development means Plan Change Area(PCA) and outside PCA are both ED? Post-development means PCA proposed development, outside PCA - ED or MPD?).	The flood maps in this report are updated with information of ED or MPD condition.
7. Please ensure that the flood change legend is available on each of the difference plans in the report (Especially for Figure 10 within the report).	Legend is added.
Specific comments on modelling: 1. Tidal boundary in the existing scenario (ED) should be using MHWS without Sea Level Rise (Please added in sensitivity check to the report if possible); 2. Roughness values are considered in the high range for Roads(Used 0.05, recommending 0.03) and open fields(used 0.1, recommending 0.05); 3. Roughness value low for AMRCO pipe (used 0.013, recommending 0.02); 4. No separate roughness zone for stream/low flow channel; buildings are not represented in the model; 5. Downstream of Duke St has assumed no obstruction as no foot bridge, no bridges were modelled; 6. There are a number of relatively large sub-catchments that include two or more overland flowpaths. This method of assessment may be resulting in over-estimating flood impacts locally as the resulting loading will be a relatively large	These comments to be incorporated during model refinement at next stage of development as recommended.

HW Comments in November 2022	CKL Response
hydrograph point loaded onto the terrain. The result may be concentrated flows influenced by the terrain. It is recommended that these sub-catchments be refined through the design process.	
Model limitation to add to report: 1. This assessment is lacking on culvert and network capacity assessment. There are both public and private infrastructure located downstream of the plan change area. It may be necessary to undertake further modelling to determine the impacts on this infrastructure from a usability perspective, to include depth of flooding, duration of flooding and extent of flooding for more frequent events to confirm the impacts of the plan change development on these assets and roads.	• Model limitation added in Section 6 in this report. • Further structure impact assessment will be added during model refinement.
Further Refinement Section to add to report: It is recommended to list the above Specific comments on modelling in the Flood Risk Assessment Report and the SMP as a new section "Further Refinement", and be clear that during the next stage of model refinement the above modelling comments should be incorporated into, so that it is consistent and clear for people involves in the next stage of development.	Further Refinement section is added in this report as required (Section 7).

9 Summary

A flood model has been built to support the stormwater management plan (the SMP) prepared by CKL using the modelling approach accepted by the AC HW. The primary objective of the flood model is to assess the potential impact and on-site attenuation benefits.

There are 14 scenarios modelled as per HW's request. The flood level difference maps and detailed tabular result at key locations have been generated to assist the impact assessment on the four downstream Areas of interest depending on the discharge locations of the subject site.

The conclusions are that the proposed development has no impact on the existing buildings for the Area 1(Riverhead point Drive OLFP) and Area 2 (Coatesville Riverhead Hwy stream) and such the on-site attenuation is not required for the site area contributing to these areas.

Although the Area 4 will be affected by the site development, the on-site attenuation is not recommended for the site area contributing to the Area 3 and 4 (downstream of 280 Riverhead Road and downstream of 22 Duke Street) for 10% and 1% AEP event due to the adverse impact according to the attenuation effect assessment result.

10 Limitations

This report has been prepared solely for the benefit of our client with respect to the particular brief and it may not be relied upon in other contexts for any other purpose without the express approval by CKL.

Neither CKL nor any employee or sub-consultant accepts any responsibility with respect to its use, either in full or in part, by any other person or entity. This disclaimer shall apply notwithstanding that the memo/report may be made available to other persons including Council for an application for consent, approval or to fulfil a legal requirement.

Appendix 1 Hydrology Calculation

CKL Limited
PO Box 99 463, Auckland 1149
25 Broadway, Newmarket
Ph: 09 524 7029
Fax: 09 524 7032

Job name	22 Duke St	File Name	A20405 -Hydrology analysis.xlsx
Job No.	A20405	Sheet Name	TP108 Rainfall
Date	11/2/2022	Path	C:\ProgramData\12DSynergy\data\CKL-AZU-SYN-1\CI 1 - Environmental_18233\01 Environmental\Modelling and Calculations\FRA
By	CL	Checked	NV

Design rainfall (24 hr depth)

Outside the site

Sub-Catchment	2yr TP108 Rainfall depth-Ex (mm)	10yr TP108 Rainfall depth-Ex (mm)	100yr TP108 Rainfall depth-Ex (mm)	100yr Rainfall+CC 2.1°C (mm)	100yr Rainfall+CC 3.8°C (mm)
C11	80	130	200	234	265
C12_1	80	130	195	228	259
C12_2	80	130	195	228	259
C12_3	80	130	195	228	259
C12_4	80	130	195	228	259
C13	80	130	200	234	265
C14_1	80	130	205	239	272
C14_2	80	130	205	239	272
C14_3	80	130	205	239	272
C14_4	80	130	205	239	272
C14_5	80	130	205	239	272
C15_1	80	130	205	239	272
C15_2	80	130	205	239	272
C16_1	80	130	205	239	272
C16_2	80	130	205	239	272
C16_3	80	130	205	239	272
C16_4	80	130	205	239	272
C16_5	80	130	205	239	272
C16_6	80	130	205	239	272
C16_7	80	130	205	239	272
C17	80	130	205	239	272
C18	80	130	205	239	272
C19_1	80	130	205	239	272
C19_2	80	130	190	222	252
C19_3	80	130	190	222	252
C19_4	80	130	190	222	252
C19_5	80	130	190	222	252
C19_6	80	130	190	222	252
C21	80	130	190	222	252
C22_1	80	130	195	228	259
C22_2	80	130	200	234	265
C22_3	80	130	200	234	265
C22_4	80	130	200	234	265
C31_1	80	130	190	222	252
C31_10	80	130	190	222	252
C31_2	80	130	190	222	252
C31_3	80	130	190	222	252
C31_4	80	130	190	222	252
C31_5	80	130	190	222	252
C31_6	80	130	190	222	252
C31_7	80	130	190	222	252
C31_8	80	130	190	222	252
C31_9	80	130	200	234	265
C32_1	80	130	200	234	265
C32_2	80	130	200	234	265
C32_3	80	130	200	234	265
C32_4	80	130	200	234	265
C33	80	130	200	234	265
C34_1	80	130	200	234	265
C34_2	80	130	200	234	265
C34_3	80	130	200	234	265
C34_4	80	130	200	234	265
C34_5	80	130	200	234	265
C34_6	80	130	200	234	265
C35_1	80	130	200	234	265
C35_2	80	130	200	234	265
C35_3	80	130	200	234	265
C35_4	80	130	200	234	265
C35_5	80	130	200	234	265
C35_6	80	130	200	234	265
C35_7	80	130	210	245	279
C36	80	130	195	228	259
C41_1	80	130	195	228	259
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C41_9	80	130	200	234	265
C42_1	80	130	205	239	272
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C51_1	80	130	210	245	279
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C58	80	130	210	245	279
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C73_1	80	130	205	239	272
C73_2	80	130	205	239	272
C74	80	130	205	239	272
C75	80	130	205	239	272
C76	80	130	205	239	272
E01_1	80	130	210	245	279
E01_2	80	130	210	245	279
E02_1	80	130	210	245	279
E02_2	80	130	210	245	279

Inside the site

Development	Sub-Catchment	2yr TP108 Rainfall depth-Ex (mm)	10yr TP108 Rainfall depth-Ex (mm)	100yr TP108 Rainfall depth-Ex (mm)	100yr Rainfall+CC 2.1°C (mm)	100yr Rainfall+CC 3.8°C (mm)
Pre-development	N01_1	80	130	205	239	272
	N01_2	80	130	205	239	272
	N01_3	80	130	205	239	272
	N01_4	80	130	205	239	272
	N01_5	80	130	205	239	272
	N02	80	130	205	239	272
	N03	80	130	205	239	272
	N04	80	130	205	239	272
	N05_1	80	130	205	239	272
	N05_2	80	130	205	239	272
	N06	80	130	205	239	272
	S01_1	80	130	210	245	279
	S01_2	80	130	210	245	279
	S02_1	80	130	210	245	279
	S02_2	80	130	210	245	279
	S02_3	80	130	210	245	279
	S03_1	80	130	210	245	279
	S03_2	80	130	210	245	279
	S04_1	80	130	210	245	279
	S04_2	80	130	210	245	279
	S04_3	80	130	210	245	279
	S05_1	80	130	210	245	279
	S05_2	80	130	210	245	279
Post-development	N01_P_1	80	130	205	239	272
	N01_P_2	80	130	205	239	272
	N01_P_3	80	130	205	239	272
	N01_P_4	80	130	205	239	272
	N02_P	80	130	205	239	272
	N03_P	80	130	205	239	272
	N04_P	80	130	205	239	272
	N05_P_1	80	130	205	239	272
	N05_P_2	80	130	205	239	272
	S01_P	80	130	210	245	279
	S02_P	80	130	210	245	279
	S03_P_1	80	130	210	245	279
	S03_P_2	80	130	210	245	279
	S04_P	80	130	210	245	279

CKL Limited
PO Box 99 463, Auckland 1149
25 Broadway, Newmarket
Ph: 09 524 7029
Fax: 09 524 7032

Job name	22 Duke St	File Name	A20405 -Hydrology analysis.xlsx
Job No.	A20405	Sheet Name	Outside subcatch-R04
Date	9/6/2021	Path	C:\ProgramData\12DSynergy\data\CKL-AZU-SYN-1\CI 1 - Environmental_18233\01 Environmental\Modelling and Calculations\FRA
By	CL	Checked	NV 02/03/2022

Sub-catchments outside the site (ED and MPD condition)-R04

Note: This version is for combined catchment-flow model input. The catchment flow for the sub-catchment 'ROG ' will not be used in HEC RAS model but extracted from CKL's RainOnGrid model result which is well matched with AC's model result. This methodology has been approved by AC.

								ED condition (C=0.8)					MPD condition (C=0.6)				
Name	Catchment Area (ha)	100yr Rainfall depth-Ex	100yr Rainfall+CC (2.1°C)	100yr Rainfall+CC (3.8°C)	CN for pervious area	Length (km)	Slope (m/m)	Impervious for ED	Weighted CN for ED	Weighted Ia for ED	ToC (hr)	Lag (mins)	Impervious for MPD	Weighted CN for MPD	Weighted Ia for MPD	ToC (hr)	Lag (mins)
C11	515.9	200	234	265	74	3.140	0.0162	0%	74.1	5.0	1.1	43.9	15%	77.7	4.2	0.8	31.6
C12_1	42.8	195	228	259	74	1.071	0.0425	1%	74.1	5.0	0.4	16.2	22%	79.3	3.9	0.3	11.4
C12_2	11.1	195	228	259	74	0.326	0.1053	2%	74.5	4.9	0.1	6.7	21%	79.1	3.9	0.1	6.7
C12_3	3.6	195	228	259	74	0.395	0.0533	1%	74.2	5.0	0.2	7.8	15%	77.5	4.3	0.1	6.7
C12_4	4.7	195	228	259	74	0.298	0.0490	27%	80.5	3.6	0.2	6.7	90%	95.5	0.5	0.1	6.7
C13	10.9	200	234	265	74	0.452	0.1613	1%	74.2	5.0	0.2	6.7	10%	76.4	4.5	0.1	6.7
C14_1	3.4	205	239	272	74	0.271	0.2866	0%	74.0	5.0	0.1	6.7	13%	77.2	4.3	0.1	6.7
C14_2	4.7	205	239	272	74	0.337	0.2365	1%	74.2	5.0	0.1	6.7	13%	77.2	4.3	0.1	6.7
C14_3	3.8	205	239	272	74	0.364	0.1399	0%	74.0	5.0	0.1	6.7	18%	78.4	4.1	0.1	6.7
C14_4	3.8	205	239	272	74	0.271	0.2325	0%	74.0	5.0	0.1	6.7	25%	80.0	3.8	0.1	6.7
C14_5	3.0	205	239	272	74	0.336	0.1120	0%	74.0	5.0	0.1	6.7	27%	80.5	3.6	0.1	6.7
C15_1	4.7	205	239	272	74	0.294	0.0444	40%	83.5	3.0	0.2	6.7	64%	89.5	1.8	0.1	6.7
C15_2	3.7	205	239	272	74	0.256	0.0942	1%	74.3	4.9	0.1	6.7	27%	80.6	3.6	0.1	6.7
C16_1	4.3	205	239	272	74	0.404	0.1757	1%	74.3	4.9	0.1	6.7	27%	80.5	3.7	0.1	6.7
C16_2	4.0	205	239	272	74	0.342	0.1661	0%	74.0	5.0	0.1	6.7	25%	80.0	3.8	0.1	6.7
C16_3	2.9	205	239	272	74	0.256	0.1962	0%	74.0	5.0	0.1	6.7	25%	80.0	3.8	0.1	6.7
C16_4	4.9	205	239	272	74	0.457	0.1283	0%	74.0	5.0	0.2	6.7	25%	80.1	3.7	0.1	6.7
C16_5	4.8	205	239	272	74	0.343	0.2252	0%	74.0	5.0	0.1	6.7	26%	80.2	3.7	0.1	6.7
C16_6	3.2	205	239	272	74	0.393	0.2578	1%	74.2	5.0	0.1	6.7	29%	81.0	3.5	0.1	6.7
C16_7	4.5	205	239	272	74	0.253	0.1147	0%	74.0	5.0	0.1	6.7	29%	80.9	3.6	0.1	6.7
C17	4.9	205	239	272	74.0	0.401	0.0262	43%	84.3	2.8	0.2	8.7	61%	88.7	1.9	0.2	6.7
C18	3.3	205	239	272	74.0	0.360	0.0367	38%	83.2	3.1	0.2	7.4	63%	89.1	1.8	0.1	6.7
C19_1	2.7	205	239	272	74.0	0.541	0.1563	39%	83.4	3.0	0.2	6.7	43%	84.3	2.8	0.1	6.7
C19_2	3.8	190	222	252	74.0	0.368	0.1540	20%	78.9	4.0	0.1	6.7	28%	80.8	3.6	0.1	6.7
C19_3	4.0	190	222	252	74.0	0.270	0.1128	11%	76.7	4.4	0.1	6.7	25%	80.1	3.7	0.1	6.7
C19_4	4.1	190	222	252	74.0	0.296	0.0486	13%	77.0	4.4	0.2	6.7	61%	88.6	2.0	0.1	6.7
C19_5	2.8	190	222	252	74.0	0.202	0.0464	23%	79.6	3.8	0.1	6.7	41%	83.9	2.9	0.1	6.7
C19_6	5.0	190	222	252	74.0	0.408	0.0429	42%	84.2	2.9	0.2	7.6	68%	90.2	1.6	0.1	6.7
C21	33.3	190	222	252	74.0	0.744	0.0552	14%	77.3	4.3	0.3	11.3	26%	80.2	3.7	0.2	8.2
C22_1	14.2	195	228	259	74.0	0.740	0.0616	15%	77.6	4.3	0.3	10.9	81%	93.4	1.0	0.2	6.8
C22_2	4.6	200	234	265	74.0	0.381	0.0165	7%	75.6	4.7	0.3	10.7	14%	77.3	4.3	0.2	7.8
C22_3	3.8	200	234	265	74.0	0.399	0.0292	8%	75.9	4.6	0.2	9.2	15%	77.6	4.2	0.2	6.8
C22_4	4.0	200	234	265	74.0	0.481	0.0195	5%	75.2	4.8	0.3	11.9	14%	77.3	4.3	0.2	8.7
C31_1	3.4	190	222	252	74.0	0.409	0.0634	10%	76.4	4.5	0.2	7.4	29%	81.0	3.5	0.1	6.7
C31_10	2.9	190	222	252	74.0	0.183	0.0184	11%	76.7	4.4	0.2	6.7	16%	77.9	4.2	0.1	6.7
C31_2	3.5	190	222	252	74.0	0.375	0.0607	18%	78.3	4.1	0.2	6.9	35%	82.3	3.3	0.1	6.7
C31_3	1.9	190	222	252	74.0	0.503	0.0285	31%	81.4	3.5	0.3	10.2	43%	84.2	2.9	0.2	7.4
C31_4	5.2	190	222	252	74.0	0.424	0.0325	3%	74.6	4.9	0.2	9.4	14%	77.3	4.3	0.2	6.9
C31_5	3.4	190	222	252	74.0	0.394	0.0127	20%	78.8	4.0	0.3	11.4	21%	79.1	3.9	0.2	8.5
C31_6	4.9	190	222	252	74.0	0.572	0.0322	4%	75.0	4.8	0.3	11.5	17%	78.1	4.1	0.2	8.3
C31_7	3.9	190	222	252	74.0	0.465	0.0406	21%	79.1	3.9	0.2	8.9	17%	78.1	4.2	0.2	6.8
C31_8	3.8	190	222	252	74.0	0.413	0.0479	4%	74.9	4.8	0.2	8.2	17%	78.1	4.1	0.1	6.7
C31_9	5.0	200	234	265	74.0	0.473	0.0523	2%	74.5	4.9	0.2	8.8	19%	78.6	4.0	0.2	6.7
C32_1	4.7	200	234	265	74.0	0.370	0.0103	58%	87.9	2.1	0.3	10.5	16%	77.8	4.2	0.2	8.8
C32_2	3.7	200	234	265	74.0	0.360	0.0235	6%	75.5	4.7	0.2	9.3	14%	77.3	4.3	0.2	6.8
C32_3	2.1	200	234	265	74.0	0.250	0.0123	61%	88.6	2.0	0.2	7.6	10%	76.4	4.5	0.2	6.7
C32_4	4.5	200	234	265	74.0	0.524	0.0159	8%	75.9	4.6	0.3	13.3	14%	77.3	4.3	0.2	9.8
C33	2.0	200	234	265	74.0	0.372	0.0190	4%	75.0	4.8	0.3	10.2	11%	76.7	4.4	0.2	7.5
C34_1	5.1	200	234	265	74.0	0.363	0.0167	5%	75.1	4.8	0.3	10.4	12%	76.9	4.4	0.2	7.6
C34_2	3.1	200	234	265	74.0	0.392	0.0333	2%	74.5	4.9	0.2	8.9	10%	76.4	4.5	0.2	6.7
C34_3	2.3	200	234	265	74.0	0.334	0.0263	1%	74.2	5.0	0.2	8.7	10%	76.4	4.5	0.2	6.7
C34_4	2.9	200	234	265	74.0	0.310	0.0142	7%	75.7	4.6	0.2	9.7	11%	76.5	4.5	0.2	7.2
C34_5	1.5	200	234	265	74.0	0.624	0.0226	68%	90.4	1.6	0.3	11.4	58%	88.0	2.1	0.2	8.8
C34_6	4.7	200	234	265	74.0	0.3553	0.0010	6%	75.5	4.7	0.6	23.7	13%	77.2	4.3	0.4	17.4
C35_1	3.0	200	234	265	74.0	0.31752	0.0266	4%	75.0	4.8	0.2	8.3	12%	76.9	4.4	0.2	6.7
C35_2	4.7	200	234	265	74.0	0.43646	0.0225	4%	75.1	4.8	0.3	10.7	11%	76.6	4.5	0.2	7.9
C35_3	2.4	200	234	265	74.0	0.28347	0.0273	9%	76.2	4.5	0.2	7.5	14%	77.4	4.3	0.1	6.7
C35_4	4.5	200	234	265	74.0	0.33823	0.0132	5%	75.1	4.8	0.3	10.6	11%	76.6	4.5	0.2	7.8
C35_5	4.2	200	234	265	74.0	0.35041	0.0203	0%	74.0	5.0	0.2	9.7	10%	76.4	4.5	0.2	7.1
C35_6	3.8	200	234	265	74.0	0.29453	0.0104	0%	74.1	5.0	0.3	10.5	10%	76.4	4.5	0.2	7.7
C35_7	2.2	210	245	279	74.0	0.29527	0.0267	4%	75.0	4.8	0.2	7.9	10%	76.4	4.5	0.1	6.7
C36	1.1	195	228	259	74.0	0.59825	0.0093	99%	97.8	0.1	0.3	13.3	90%	95.5	0.5	0.3	10.2
C41_1	4.7	195	228	259	74.0	0.53835	0.0024	26%	80.3	3.7	0.6	22.6	18%	78.4	4.1	0.4	17.3
C41_2	5.4	195	228	259	74.0	0.48823	0.0023	0%	74.0	5.0	0.6	23.1	10%	76.4	4.5	0.4	16.9
C41_3	4.4	195	228	259	74.0	0.36971	0.0040	3%	74.7	4.9	0.4	16.2	12%	77.0	4.4	0.3	11.9
C41_4	2.7	195	228	259	74.0	0.41877	0.0047	0%	74.1	5.0	0.4	16.9	11%	76.5	4.5	0.3	12.3
C41_5	3.6	195	228	259	74.0	0.42085	0.0061	2%	74.5	4.9	0.4	15.6	10%	76.4	4.5	0.3	11.4
C41_6	2.6	195	228	259	74.0	0.33095	0.0109	3%	74.6	4.9	0.3	11.2	10%	76.4	4.5	0.2	8.2
C41_7	3.5	200	234	265	74.0	0.33779	0.0082	0%	74.0	5.0	0.3	12.4	10%	76.4	4.5	0.2	9.0
C41_8	5.1	200	234	265	74.0	0.38527	0.0207	7%	75.6	4.7	0.3	10.0	15%	77.7	4.2	0.2	7.4
C41_9	1.5	200	234	265	74.0	0.1647	0.0726	0%	74.0	5.0	0.1	6.7	10%	76.4	4.5	0.1	6.7
C42_1	22.3	205	239	272	74.0	0.94608	0.0262	7%	75.7	4.6	0.4	16.9	12%	76.9	4.4	0.3	12.5
C42_2	43.2	210	245	279	74.0	0.94783	0.0273	7%	75.6	4.7	0.4	16.7	46%	85.0	2.7	0.3	11.3
C51_1	0.3	210	245	279	74.0	0.24068	0.0017	100%	97.9	0.0	0.3	12.1	90%	95.6	0.5	0.2	9.3
C51_2	0.2	210	245	279	74.0	0.15963	0.0020	98%	97.6	0.1	0.2	8.8	90%	95.5	0.5	0.2	6.8
C52	0.9	210	245	279	74.0	0.13188	0.0064	47%	85.3	2.6	0.2	6.7	68%	90.3	1.6	0.1	6.7
C53	1.2	210	245	279	74.0	0.14063	0.0234	47%	85.2	2.7	0.1	6.7	68%	90.2	1.6	0.1	6.7
C54	1.2	210	245	279	74.0	0.23439	0.0094	61%	88.6	2.0	0.2	7.9	91%	95.8	0.5	0.1	6.7
C55	1.1	210	245	279	74.0	0.12836	0.0338	44%	84.6	2.8	0.1	6.7	69%	90.5	1.6	0.1	6.7
C56	1.8	210	245	279	74.0	0.23906	0.0072	19%	78.6	4.0	0.2	9.7	66%	89.8	1.7	0.2	6.7
C57	2.0	210	245	279	74.0	0.24466	0.0326	59%	88.1	2.1	0.1	6.7	69%	90.6	1.6	0.1	6.7
C58	2.4	210	245	279	74.0	0.3376	0.0295	53%	86.6	2.4	0.2	7.3	69%	90.6	1.5	0.1	6.7
C59_1	4.1	210	245	279	74.0	0.52029	0.0233	59%	88.1	2.1	0.3	10.3	69%	90.6	1.6	0.2	7.5
C59_2	2.1	210	245	279	74.0	0.37044	0.0228	61%	88.5	2.0	0.2	8.2	72%	91.2	1.4	0.1	6.7
C61	3.3	210	245	279	74.0	0.25776	0.0225	34%	82.1	3.3	0.2	7.0	55%	87.2	2.2	0.1	6.7
C62_1	3.0	210	245	279	74.0	0.24097	0.0059	48%	85.6	2.6	0.2	9.6	69%	90.5	1.6	0.2	6.8
C62_2	1.9	210	245	279	74.0	0.19466	0.0156	50%	86.0	2.5	0.2	6.7	68%	90.2	1.6	0.1	6.7
C62_3	4.4	210	245	279	74.0	0.35693	0.0137	22%	79.2	3.9	0.3	10.4	47%	85.4	2.6	0.2	7.2
C63	3.7	210	245	279	74.0	0.26276	0.0152	55%	87.3	2.2	0.2	7.5	70%	90.8	1.5	0.1	6.7
C71_1	0.4	205	239	272	74.0	0.28313	0.0376	45%	84.7	2.8	0.2	6.7	80%	93.1	1.0	0.1	6.7
C71_2	0.6	205	239	272	74.0			45%	84.7	2.8		6.7	80%	93.1	1.0		6.7
C71_3	1.7	205	239	272	74.0			45%	84.7	2.8		6.7	80%	93.1	1.0		6.7
C72	2.1	205	239	272	74.0	0.31562	0.0156	51%	86.3	2.4	0.2	8.5	68%	90.4	1.6	0.2	6.7
C73_1	1.4	205	239	272	74.0	0.2408	0.0327	32%	81.6	3.4	0.1	6.7	65%	89.7	1.7	0.1	6.7
C73_2	0.8	205	239	272	74.0			32%	81.6	3.4		6.7	65%	89.7	1.7		6.7
C74	2.1	205	239	272	74.0	0.14384	0.0189	35%	82.5	3.2	0.1	6.7	67%	90.0	1.7	0.1	6.7
C75	0.6	205	239	272	74.0	0.12785	0.0185	26%	80.3	3.7	0.1	6.7	68%	90.3	1.6	0.1	6.7
C76	2.6	205	239	272	74.0	0.24062	0.0276	42%	84.1	2.9	0.2	6.7	69%	90.5	1.6	0.1	6.7
E01_1	1.0	210	245	279	74.0	0.41842	0.0075	58%	87.9	2.1	0.3	6.7	72%	91.3	1.4	0.2	6.7
E01_2	1.2	210	245	279	74.0			58%	87.9	2.1		6.7	72%	91.3	1.4		6.7
E02_1	0.8	210	245	279	74.0	0.17598	0.0430	52%	86.4	2.4	0.1	6.7	67%	90.2	1.6	0.1	6.7
E02_2	0.7	210	245	279	74.0			52%	86.4	2.4		6.7	67%	90.2	1.6		6.7

CKL Limited
PO Box 99 463, Auckland 1149
25 Broadway, Newmarket
Ph: 09 524 7029
Fax: 09 524 7032

Job name	22 Duke St	File Name	A20405 -Hydrology analysis.xlsx
Job No.	A20205	Sheet Name	Site-Pre R01+PostR03
Date	7/29/2021	Path	C:\ProgramData\12DSynergy\data\CKL-AZU-SYN-1\CI 1 - Environmental_18233\01 Environmental\Modelling and Calculations\FRA
By	CL	Checked	NV 02/03/2022

Site Subcatchment (Existing condition)

see GIS shapefile 'Site Existing SubCatchment-100yr-R01.shp' for detail.

Discharge Locations ID	Discharge Locations	Name	Catchment Area (ha)	100yr Rainfall depth-Ex	100yr Rainfall+CC (3.8°C)	Impervious for Existing (%)	Impervious area (ha)	CN for pervious area	Weighted CN	Weighted Ia	Length (km)	Slope (m/m)	ToC (hr) (C=0.8)	Lag (mins)
N01	Channel to wetland	N01_1	8.90	205	272	10%	0.89	74.0	76.4	4.5	0.611	0.014	0.4	15.0
		N01_2	11.20	205	272	10%	1.12	74.0	76.4	4.5	0.608	0.025	0.3	12.7
		N01_3	0.84	205	272	15%	0.13	74.0	77.6	4.3	0.142	0.005	0.2	7.8
		N01_4	2.63	205	272	15%	0.39	74.0	77.6	4.3	0.242	0.016	0.2	7.7
		N01_5	2.14	205	272	0%	0.00	74.0	74.0	5.0	0.309	0.027	0.2	8.1
N02	Wetland swale	N02	0.50	205	272	15%	0.08	74.0	77.6	4.3	0.091	0.043	0.1	6.7
N03	Te Roera Place	N03	0.85	205	272	0%	0.00	74.0	74.0	5.0	0.186	0.032	0.1	6.7
N04	Wetland	N04	4.49	205	272	3%	0.13	74.0	74.7	4.9	0.428	0.010	0.3	13.6
N05	Stream	N05_1	1.01	205	272	0%	0.00	74.0	74.0	5.0	0.178	0.023	0.1	6.7
		N05_2	0.94	205	272	0%	0.00	74.0	74.0	5.0	0.113	0.045	0.1	6.7
N06	Neighbour	N06	0.78	205	272	0%	0.00	74.0	74.0	5.0	0.139	0.031	0.1	6.7
S01	South channel	S01_1	2.40	210	279	0%	0.00	74.0	74.0	5.0	0.241	0.076	0.1	6.7
		S01_2	2.50	210	279	0%	0.00	74.0	74.0	5.0	0.202	0.029	0.2	6.7
S02	Stream south branch (Riverhead culvert)	S02_1	4.71	210	279	0%	0.00	74.0	74.0	5.0	0.480	0.007	0.4	16.5
		S02_2	2.09	210	279	0%	0.00	74.0	74.0	5.0	0.235	0.008	0.2	9.9
		S02_3	21.34	210	279	10%	2.13	74.0	76.4	4.5	0.656	0.014	0.4	15.8
S03	Riverhead Point Drive	S03_1	4.81	210	279	20%	0.96	74.0	78.8	4.0	0.331	0.003	0.4	15.4
		S03_2	1.48	210	279	20%	0.30	74.0	78.8	4.0	0.162	0.002	0.3	10.7
S04	Coatesville Highway	S04_1	0.98	210	279	30%	0.29	74.0	81.2	3.5	0.120	0.006	0.2	6.7
		S04_2	0.71	210	279	30%	0.21	74.0	81.2	3.5	0.120	0.074	0.1	6.7
	Coatesville Highway	S04_3	0.27	210	279	10%	0.03	74.0	76.4	4.5	0.044	0.004	0.1	6.7
S05	Riverhead Road	S05_1	2.20	210	279	30%	0.66	74.0	81.2	3.5	0.198	0.016	0.2	6.7
		S05_2	2.89	210	279	30%	0.87	74.0	81.2	3.5	0.306	0.009	0.3	10.5
		Total	80.7			10%	8.20							

Site Subcatchment (Proposed condition)

see GIS shapefile 'Site Post SubCatchment-100yr-R03.shp' for detail.

Discharge Locations ID	Discharge Locations	Name	Catchment Area (ha)	100yr Rainfall depth-Ex	100yr Rainfall+CC (3.8°C)	Impervious for Post (%)	Impervious area (ha)	CN for pervious area	Weighted CN	Weighted Ia	Length (km)	Slope (m/m)	ToC (hr) (C=0.6)	Lag (mins)
N01	Channel to Wetland	N01_P_1	13.16	205	272	65%	8.56	74.0	89.6	1.8	0.657	0.024	0.2	8.8
		N01_P_2	10.04	205	272	65%	6.52	74.0	89.6	1.8	0.739	0.018	0.3	10.2
		N01_P_3	1.36	205	272	65%	0.88	74.0	89.6	1.8	0.131	0.006	0.1	6.7
		N01_P_4	1.80	205	272	65%	1.17	74.0	89.6	1.8	0.204	0.008	0.1	6.7
N02	Wetland swale	N02_P	0.54	205	272	65%	0.35	74.0	89.6	1.8	0.091	0.043	0.0	6.7
N03	Te Roera Place	N03_P	0.95	205	272	65%	0.62	74.0	89.6	1.8	0.186	0.032	0.1	6.7
N04	Wetland	N04_P	4.07	205	272	65%	2.64	74.0	89.6	1.8	0.300	0.008	0.2	7.2
N05	Stream	N05_P_1	1.61	205	272	65%	1.05	74	89.6	1.8	0.17	0.010	0.2	6.7
		N05_P_2	0.76	205	272	0	0.00	74	74.0	5	0.09	0.045	0.1	6.7
S01	South Channel	S01_P	6.24	210	279	65%	4.06	74.0	89.6	1.8	0.366	0.058	0.1	6.7
S02	Stream South Branch (R	S02_P	31.76	210	279	70%	22.23	74.0	90.8	1.5	0.872	0.014	0.3	12.3
S03	Riverhead Point Drive	S03_P_1	4.35	210	279	65%	2.82	74.0	89.6	1.8	0.330	0.003	0.3	10.2
		S03_P_2	1.67	210	279	65%	1.08	74.0	89.6	1.8	0.216	0.003	0.2	7.9
S04	Coatesville Highway	S04_P	2.36	210	279	65%	1.54	74.0	89.6	1.8	0.363	0.020	0.2	6.7
		Total	80.7			66%	53.52							

CKL Limited
PO Box 99 463, Auckland 1149
25 Broadway, Newmarket
Ph: 09 524 7029
Fax: 09 524 7032

Job name	22 Duke St	File Name	A20405 -Hydrology analysis.xlsx
Job No.	A20205	Sheet Name	Site SubCatch -dummy attenu
Date	11/2/2022	Path	C:\ProgramData\12DSynergy\data\CKL-AZU-SYN-1\CI 1 - Environmental_18233\01 Environmental\Modelling and Calculations\F
By	CL	Checked	NV 02/03/2022

Site Subcatchment (Proposed condition)

Catchment	Catchment Area (ha)	Rainfall depth-Ex	Impervious for Post (%)	Impervious area (ha)	CN for pervious area	Weighted CN	Weighted Ia	Length (km)	Slope (m/m)	ToC (hr) (C=0.6)	Lag (mins)
N01_P_1	13.16	205	70%	9.21	74.0	90.8	1.5	0.657	0.024	0.2	8.6
N01_P_2	10.04	205	70%	7.03	74.0	90.8	1.5	0.739	0.018	0.3	10.1
S02_P	31.76	210	70%	22.23	74.0	90.8	1.5	0.872	0.014	0.3	12.3
		Total									

Site Subcatchment (ED condition)

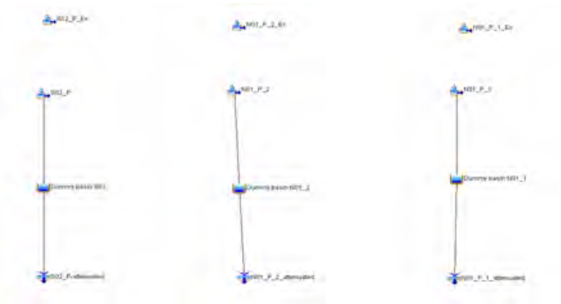
Catchment	Catchment Area (ha)	Rainfall depth-Ex	Impervious for Post (%)	Impervious area (ha)	CN for pervious area	Weighted CN	Weighted Ia	Length (km)	Slope (m/m)	ToC (hr) (C=0.8)	Lag (mins)
N01_P_1	13.16	205	15%	1.97	74.0	77.6	4.3	0.657	0.024	0.3	13.4
N01_P_2	10.04	205	15%	1.51	74.0	77.6	4.3	0.739	0.018	0.4	15.6
S02_P	31.76	210	15%	4.76	74.0	77.6	4.3	0.872	0.014	0.5	19.1

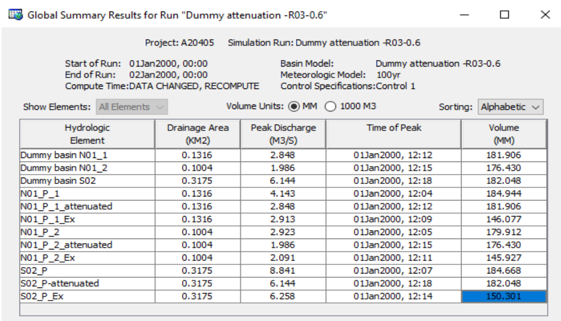
Attenuation model result -peak flows

Sub-catchment	Peak flow -ED (m3/s)	Peak time-ED	Peak flow -MPD (m3/s)	Peak time-MPD	Attenuated flow out of basins (m3/s)
N01_P_1	2.913	12:09	4.143	12:04	2.848
N01_P_2	2.091	12:11	2.923	12:05	1.986
S02_P	6.258	12:14	8.841	12:07	6.144

Attenuation model result -dummy basins

Dummy basins	Peak Depth (m)	Peak storage (1000 m3)	Spillway length (m)
Dummy Basin S02	1.23	7.3	2.5
Dummy Basin N01_1	1.27	3.3	1.1
Dummy Basin N01_2	1.07	2.7	1




Global Summary Results for Run "Dummy attenuation -R03-0.6"

Project: A20405 Simulation Run: Dummy attenuation -R03-0.6

Start of Run: 01Jan2000, 00:00
End of Run: 02Jan2000, 00:00
Compute Time:DATA CHANGED, RECOMPUTE
Basin Model: Dummy attenuation -R03-0.6
Meteorologic Model: 100yr
Control Specifications:Control 1

Show Elements: All Elements Volume Units: MM 1000 M3 Sorting: Alphabetic

Hydrologic Element	Drainage Area (KM2)	Peak Discharge (M3/S)	Time of Peak	Volume (MM)
Dummy basin N01_1	0.1316	2.848	01Jan2000, 12:12	181.906
Dummy basin N01_2	0.1004	1.986	01Jan2000, 12:15	176.430
Dummy basin S02	0.3175	6.144	01Jan2000, 12:18	182.048
N01_P_1	0.1316	4.143	01Jan2000, 12:04	184.944
N01_P_1_attenuated	0.1316	2.848	01Jan2000, 12:12	181.906
N01_P_1_Ex	0.1316	2.913	01Jan2000, 12:09	146.077
N01_P_2	0.1004	2.923	01Jan2000, 12:05	179.912
N01_P_2_attenuated	0.1004	1.986	01Jan2000, 12:15	176.430
N01_P_2_Ex	0.1004	2.091	01Jan2000, 12:11	145.927
S02_P	0.3175	8.841	01Jan2000, 12:07	184.668
S02_P-attenuated	0.3175	6.144	01Jan2000, 12:18	182.048
S02_P_Ex	0.3175	6.258	01Jan2000, 12:14	150.301

CKL Limited
PO Box 99 463, Auckland 1149
25 Broadway, Newmarket
Ph: 09 524 7029
Fax: 09 524 7032

Job name	22 Duke St	File Name	A20405 -Hydrology analysis.xlsx
Job No.	A20205	Sheet Name	Site SubCatch -dummy attenu10yr
Date	11/2/2022	Path	C:\ProgramData\12DSynergy\data\CKL-AZU-SYN-1\CI 1 - Environmental_18233\01 Environmental\Modelling and Calculations\F
By	CL	Checked	NV 02/03/2022

Site Subcatchment (Proposed condition)

Catchment	Catchment Area (ha)	Rainfall depth-Ex	Impervious for Post (%)	Impervious area (ha)	CN for pervious area	Weighted CN	Weighted Ia	Length (km)	Slope (m/m)	ToC (hr) (C=0.6)	Lag (mins)
N01_P_1	13.16	130	70%	9.21	74.0	90.8	1.5	0.657	0.024	0.2	8.6
N01_P_2	10.04	130	70%	7.03	74.0	90.8	1.5	0.739	0.018	0.3	10.1
S02_P	31.76	130	70%	22.23	74.0	90.8	1.5	0.872	0.014	0.3	12.3
		Total									

Site Subcatchment (ED condition)

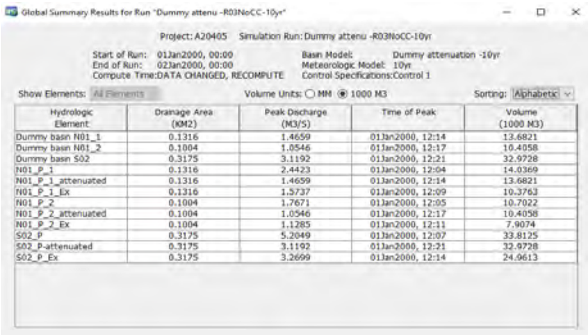
Catchment	Catchment Area (ha)	Rainfall depth-Ex	Impervious for Post (%)	Impervious area (ha)	CN for pervious area	Weighted CN	Weighted Ia	Length (km)	Slope (m/m)	ToC (hr) (C=0.8)	Lag (mins)
N01_P_1	13.16	130	15%	1.97	74.0	77.6	4.3	0.657	0.024	0.3	13.4
N01_P_2	10.04	130	15%	1.51	74.0	77.6	4.3	0.739	0.018	0.4	15.6
S02_P	31.76	130	15%	4.76	74.0	77.6	4.3	0.872	0.014	0.5	19.1

Attenuation model result -peak flows

Sub-catchment	Peak flow -ED (m3/s)	Peak time-ED	Peak flow -MPD (m3/s)	Peak time-MPD	Attenuated flow out of basins (m3/s)
N01_P_1	1.573	12:09	2.442	12:04	1.465
N01_P_2	1.128	12:11	1.767	12:05	1.054
S02_P	3.269	12:14	5.204	12:07	3.119

Attenuation model result -dummy basins

Dummy basins	Peak Depth (m)	Peak storage (1000 m3)	Spillway length (m)
Dummy Basin S02	1.1	6	1.5
Dummy Basin N01_1	1.01	2.53	0.8
Dummy Basin N01_2	0.81	3.03	0.8


Global Summary Results for Run "Dummy attenu -R03NoCC-10yr"

Project: A20405 Simulation Run: Dummy attenu -R03NoCC-10yr

Start of Run: 01Jan2000, 00:00 Basin Model: Dummy attenuation -10yr
End of Run: 02Jan2000, 00:00 Meteorologic Model: 10yr
Compute Time: DATA CHANGED, RECOMPUTE Control Specifications: Control 1

Show Elements: All Elements Volume Units: MM 1000 M3 Sorting: Alphabetic

Hydrologic Element	Drainage Area (KM2)	Peak Discharge (M3/S)	Time of Peak	Volume (1000 M3)
Dummy basin N01_1	0.1316	1.4659	01Jan2000, 12:14	13.6821
Dummy basin N01_2	0.1004	1.0546	01Jan2000, 12:17	10.4058
Dummy basin S02	0.3175	3.1192	01Jan2000, 12:21	32.9728
N01_P_1	0.1316	2.4423	01Jan2000, 12:04	14.0369
N01_P_1_attenuated	0.1316	1.4659	01Jan2000, 12:14	13.6821
N01_P_1_Ex	0.1316	1.5737	01Jan2000, 12:09	10.3763
N01_P_2	0.1004	1.7671	01Jan2000, 12:05	10.7022
N01_P_2_attenuated	0.1004	1.0546	01Jan2000, 12:17	10.4058
N01_P_2_Ex	0.1004	1.1285	01Jan2000, 12:11	7.9074
S02_P	0.3175	5.2049	01Jan2000, 12:07	33.8125
S02_P-attenuated	0.3175	3.1192	01Jan2000, 12:21	32.9728
S02_P_Ex	0.3175	3.2699	01Jan2000, 12:14	24.9613

CKL Limited
PO Box 99 463, Auckland 1149
25 Broadway, Newmarket
Ph: 09 524 7029
Fax: 09 524 7032

Job name	22 Duke St	File Name	A20405 -Hydrology analysis.xlsx
Job No.	A20205	Sheet Name	CN
Date	7/29/2021	Path	C:\ProgramData\12DSynergy\data\CKL-AZU-SYN-1\CI 1 - Environmental_18233
By	CL	Checked	NV

SCS Curver Number

SCS soil group	Land use	CN for pervoius area
C	lawn/pasture	74

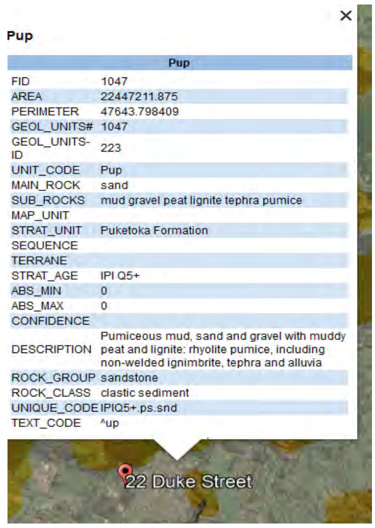


Table 3.2 - Hydrological Soil Classifications for prevalent Auckland Soils

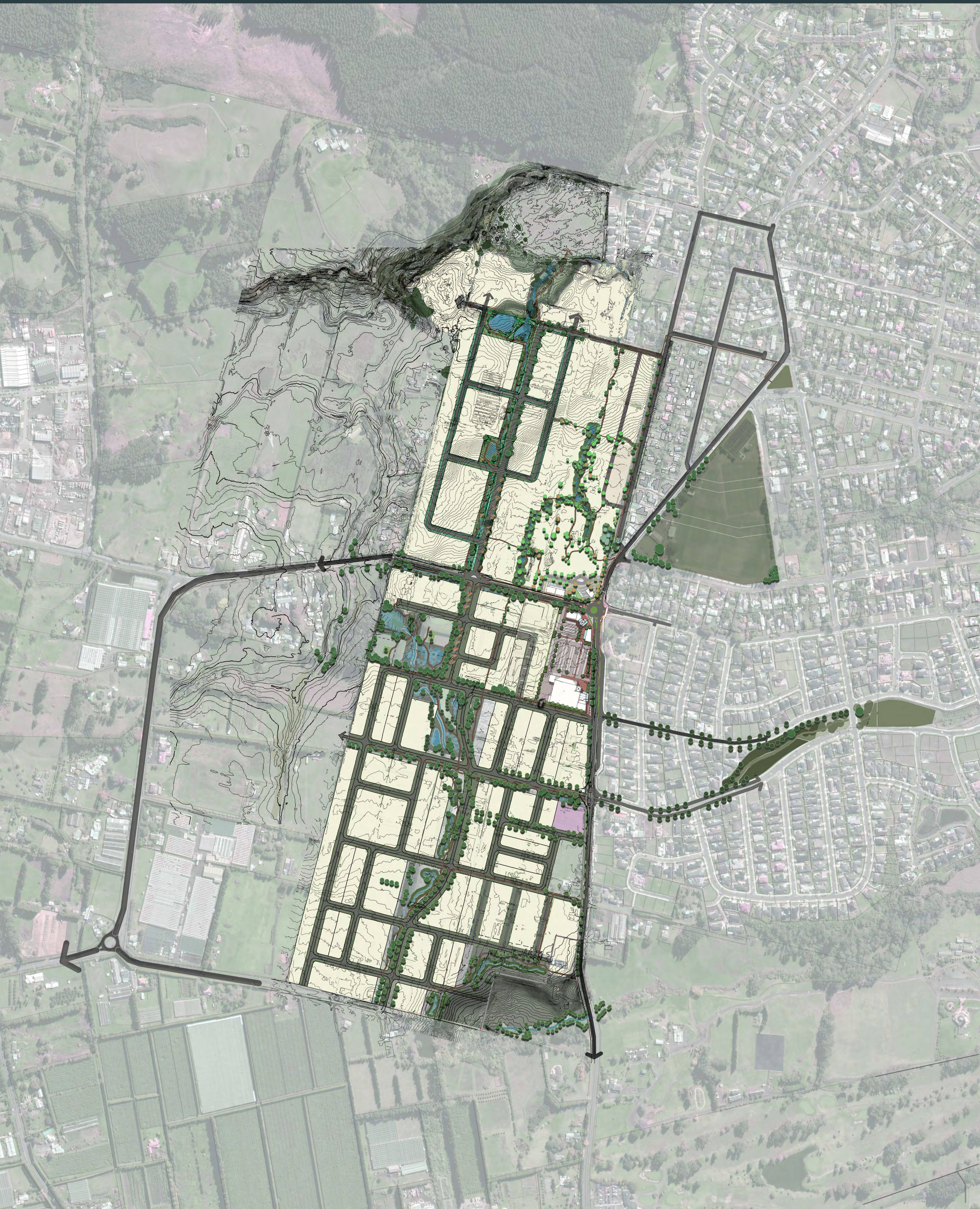
Auckland Soil	SCS Hydrological Soil Group
Weathered mudstone and sandstone (Waitemata and Onerahi Series)	Group C
Alluvial sediments	Group B
Granular volcanic loam (ash, tuff, scoria)	Group A
Granular volcanic loam underlain by free-draining basalt	use CN = 17 for all pervious areas

Table 3.3 - Curve numbers for typical Auckland conditions

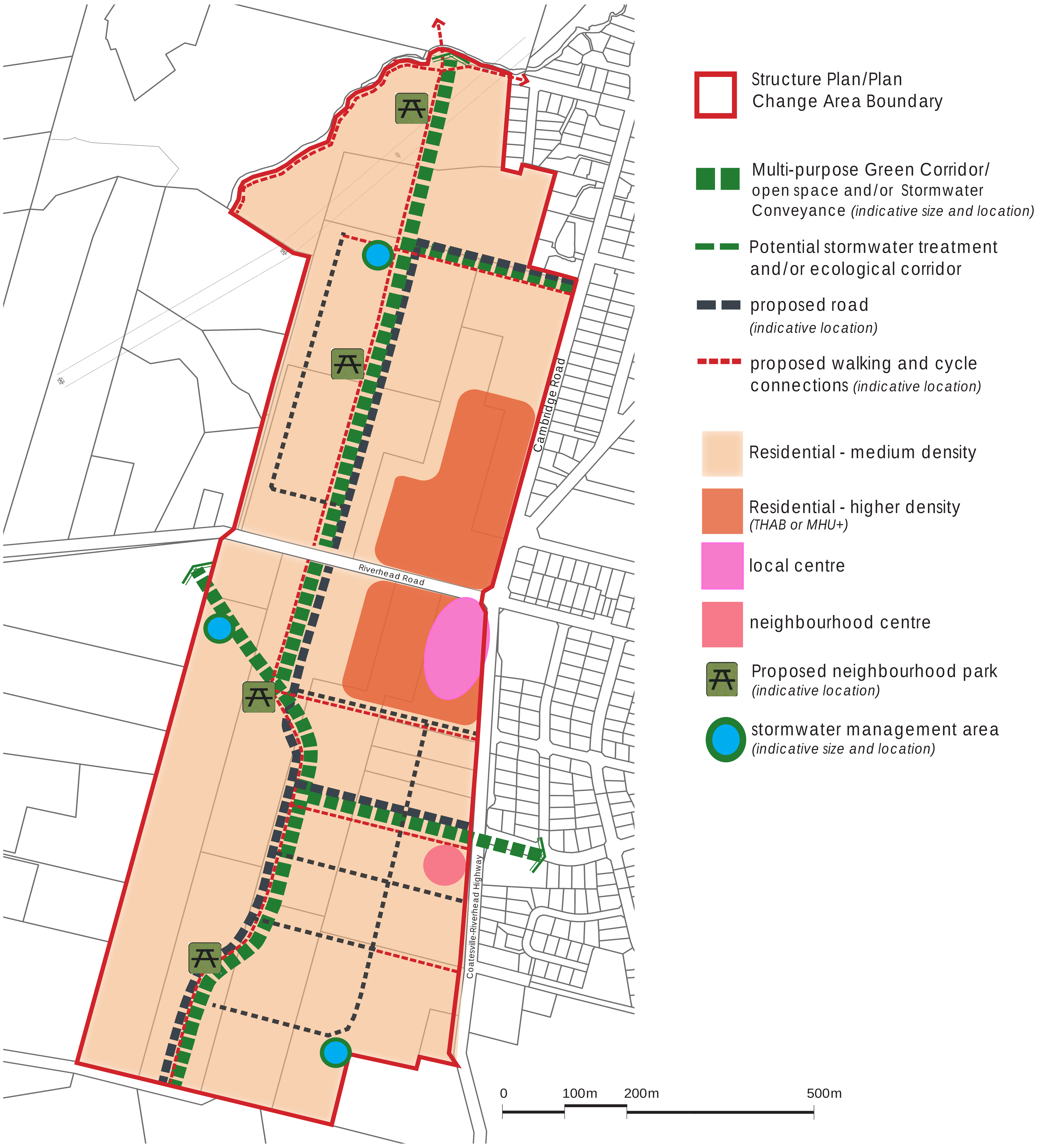
Land use	Group A Soil (volcanic granular loam)	Group B Soil (alluvial)	Group C Soil (mudstone/sandstone)
Bush, humid-climate, not-grazed	30	55	70
Pasture, lightly grazed, good grass cover	39	61	74
Urban lawns	39	61	74
Crops, straight rows, minimal vegetative cover	72	81	88
Sealed roads, roofs	98	98	98

Appendix 2 Master Plan

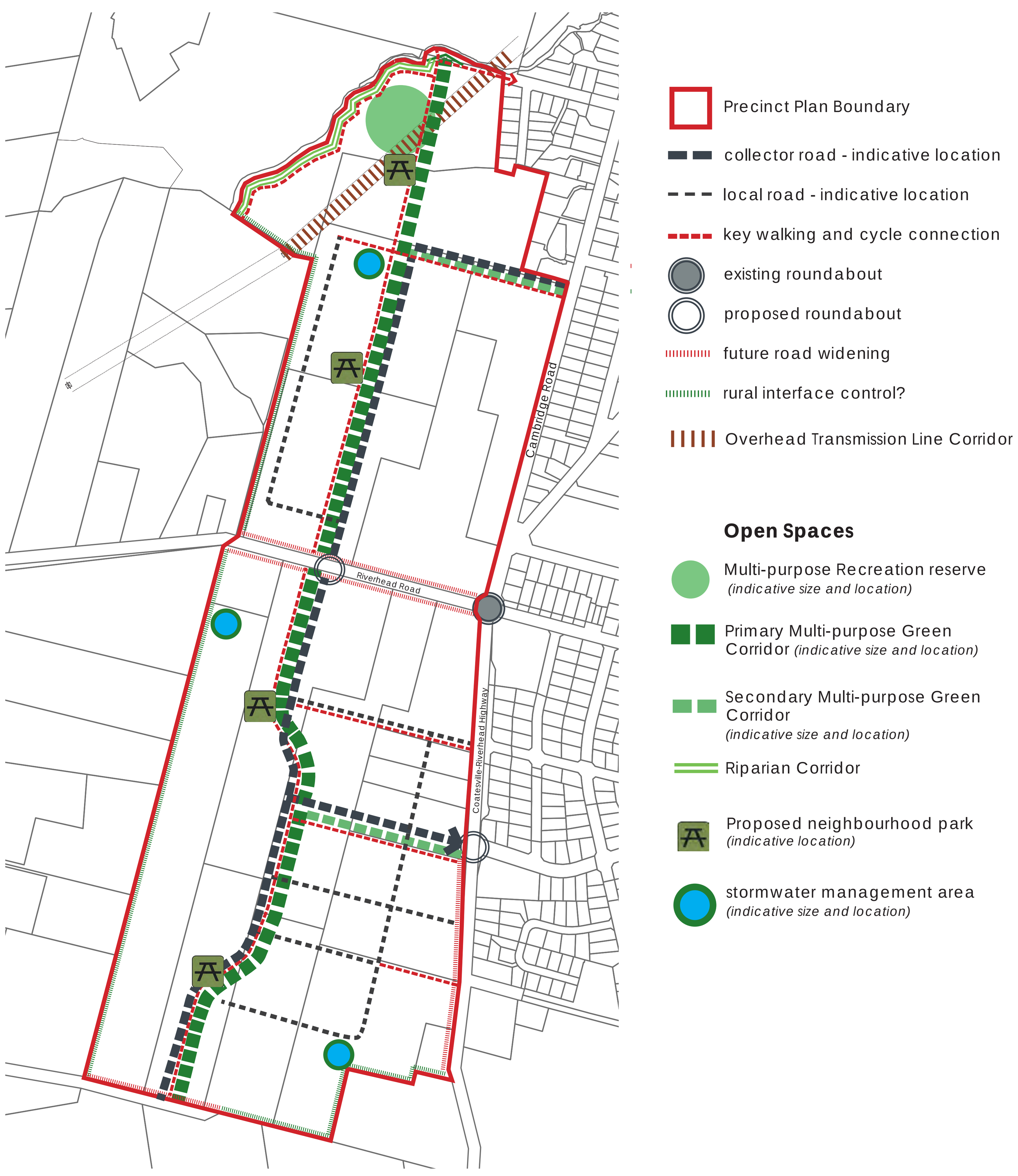
10 the **indicative** development concept...

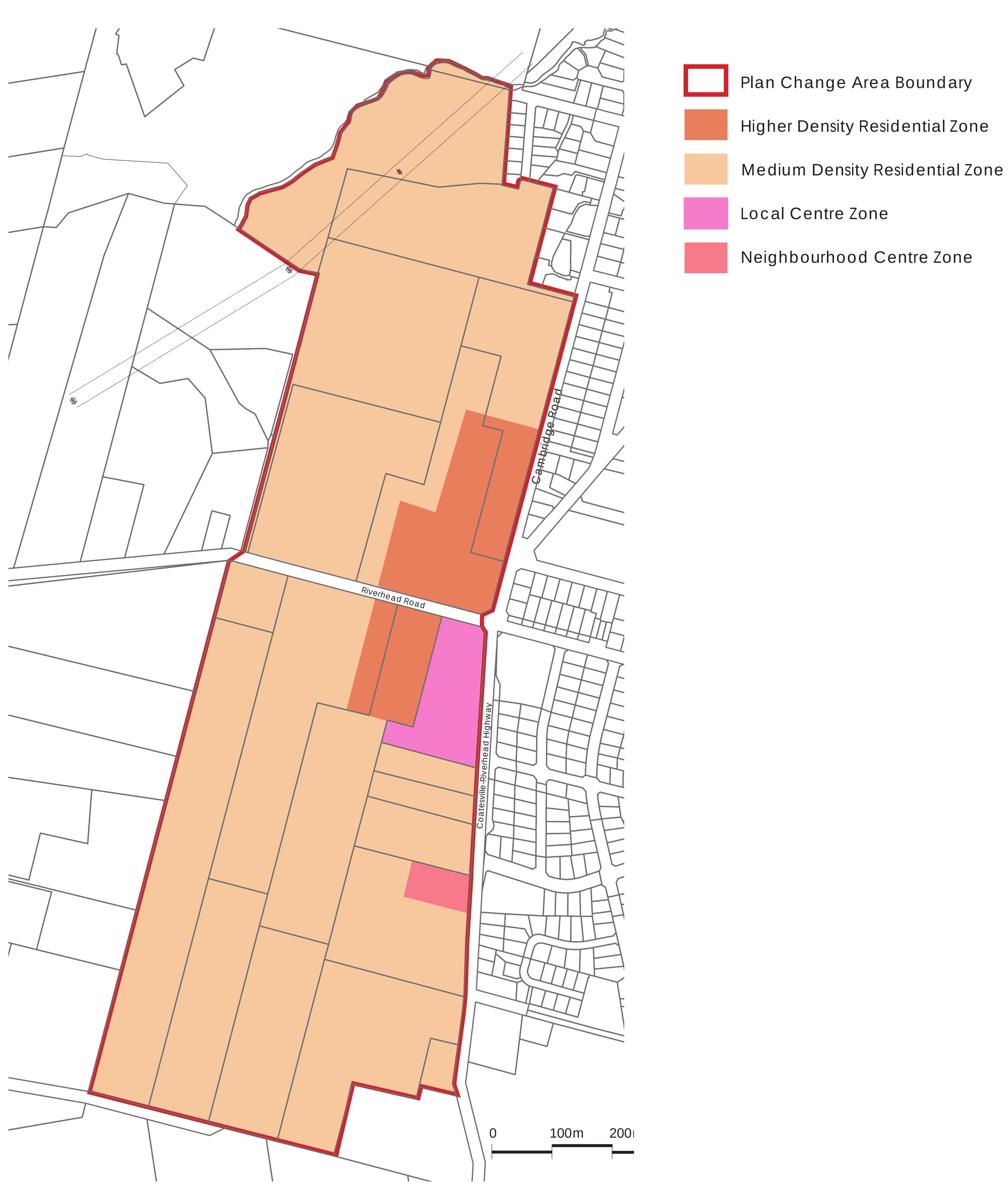


11 the draft structure plan and zoning map



Once agreed, these drawings will be included in the Auckland Unitary Plan and ensure all parts of the plan change area develop in an integrated and efficient way.





Appendix 3 Hydraulic Model Result- Flood Maps

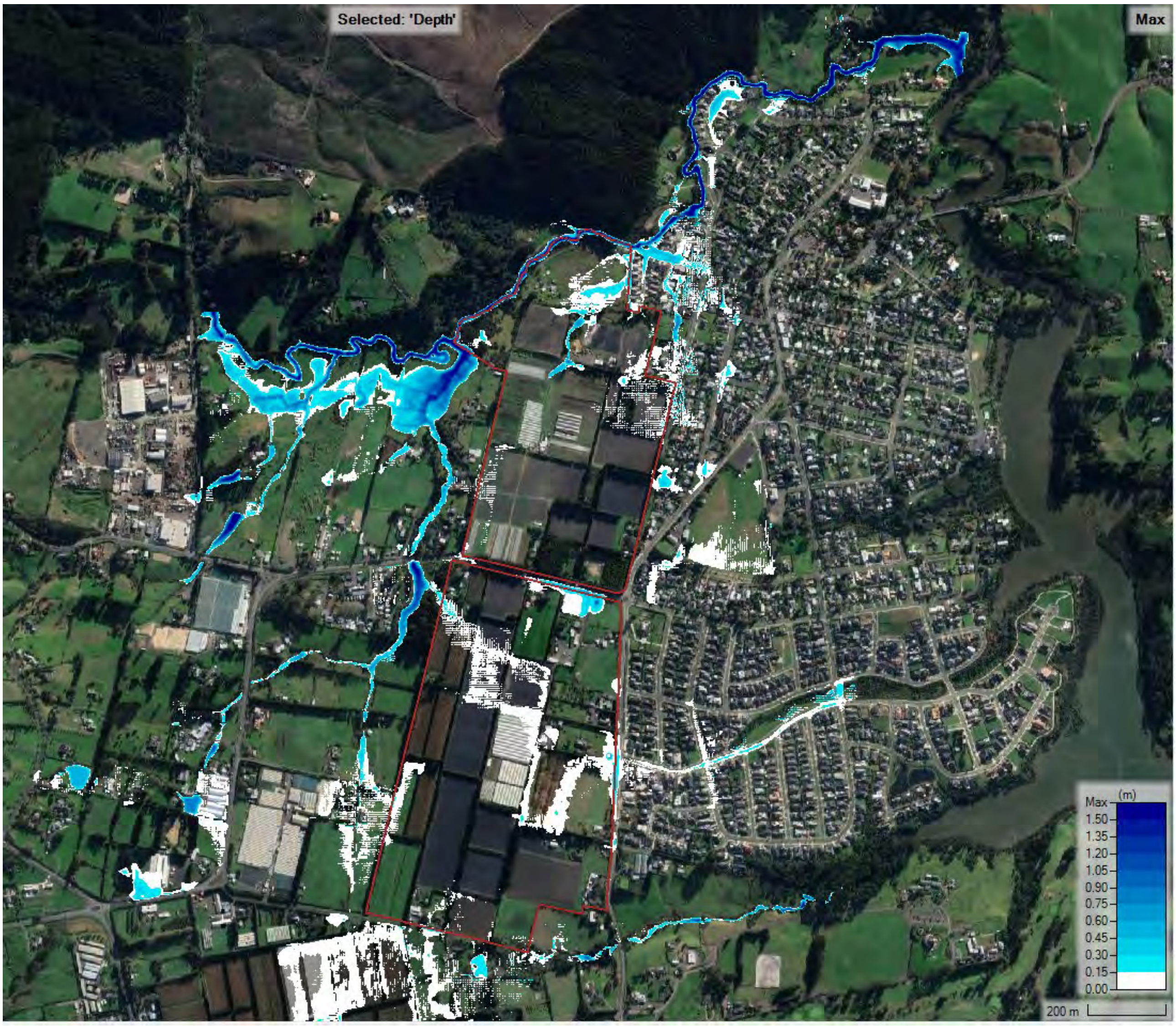


Figure 13: Maximum Flood Depth Map for Pre-development (Site and External ED) for 2yr without CC

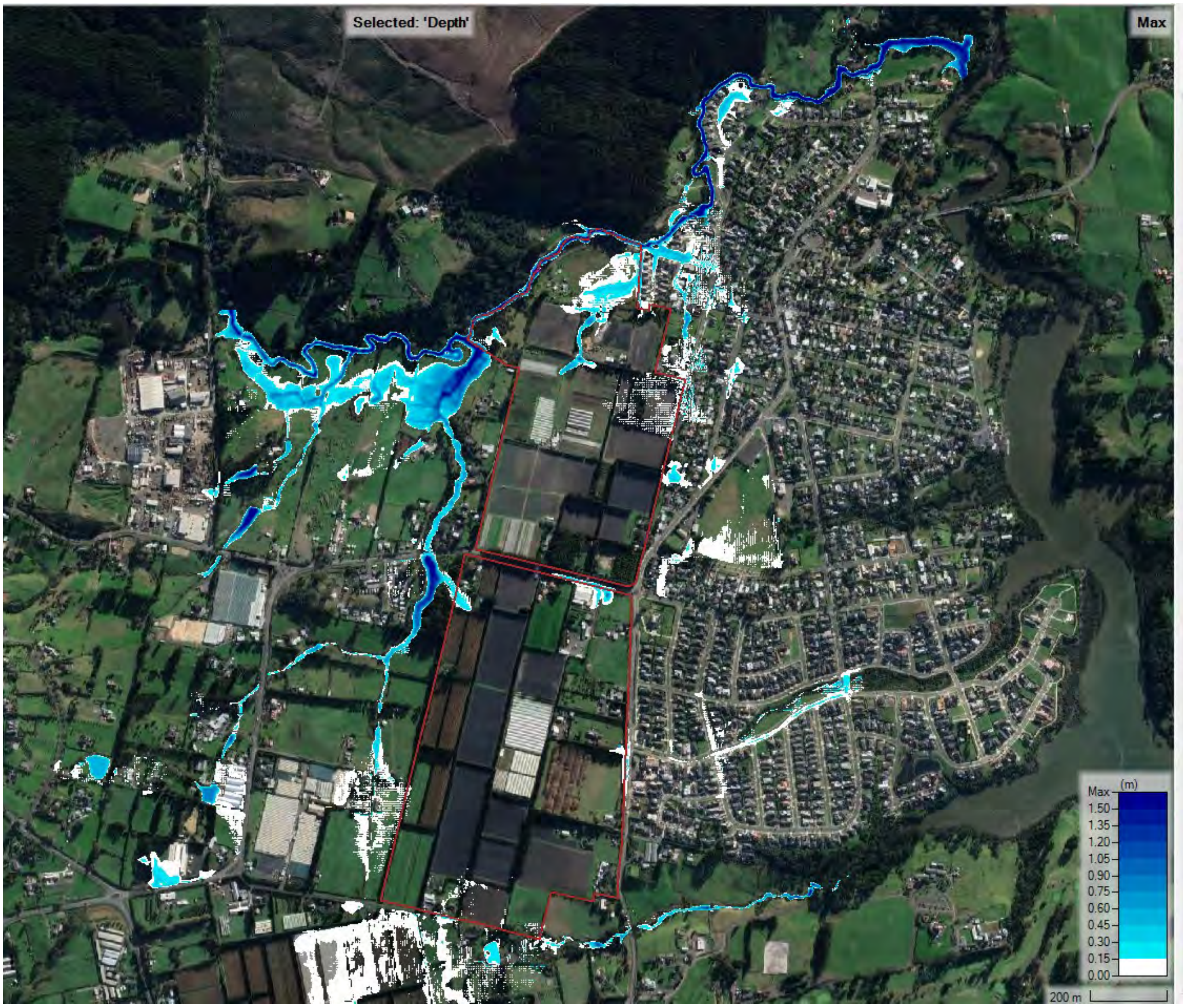


Figure 14: Maximum Flood Depth Map for Post-development (Site MPD+ External ED) for 2yr without CC

Figure 15: WSE Difference Map between Post-(SiteMPD+External ED) and Pre-development (Site ED+External ED) scenarios for 2yr without CC

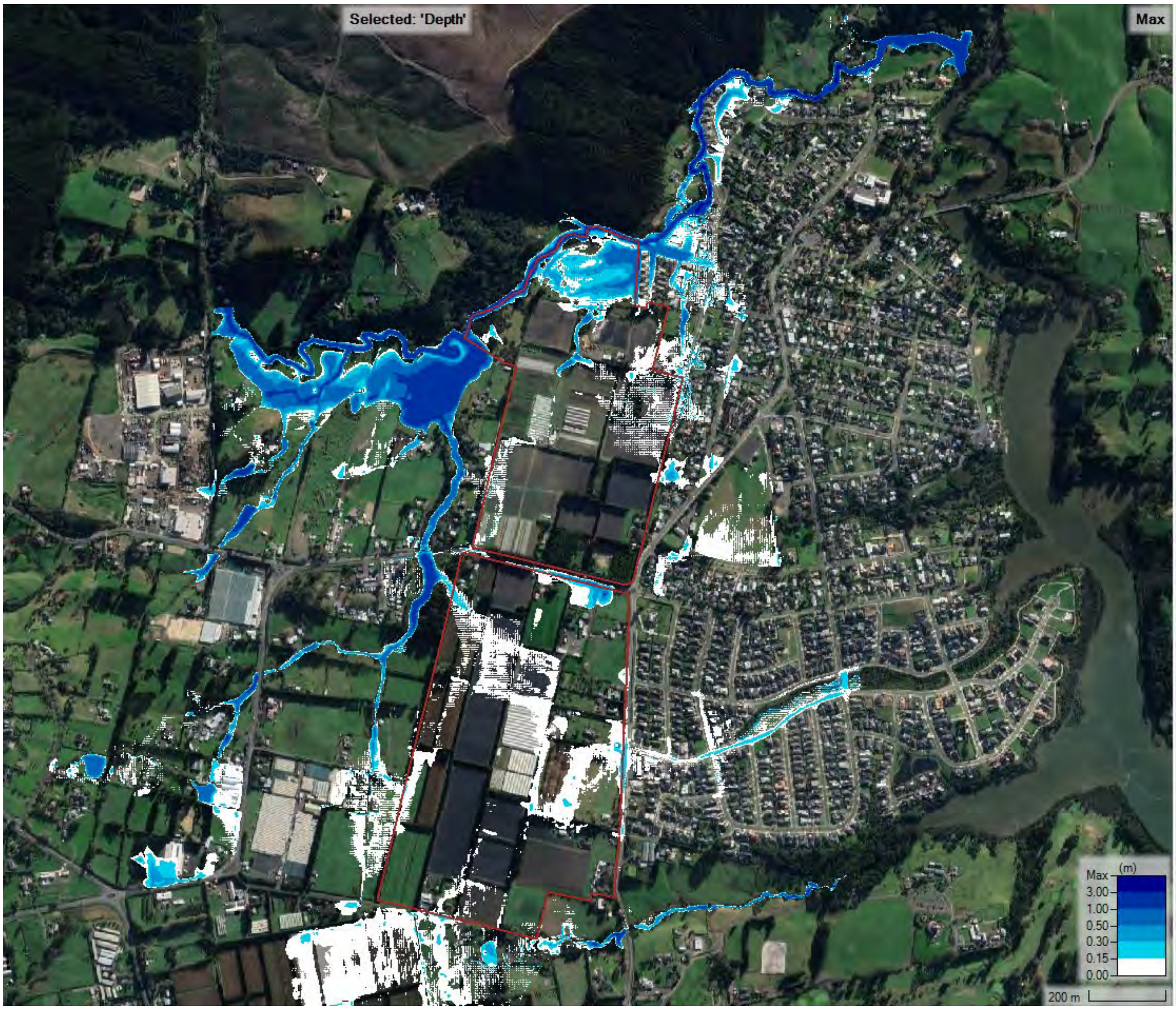


Figure 16: Maximum Flood Depth Map for Pre-development(Site ED+External ED) for 10yr without CC

Figure 17: Maximum Flood Depth Map for Post-development (SiteMPD+External ED) for 10yr without CC

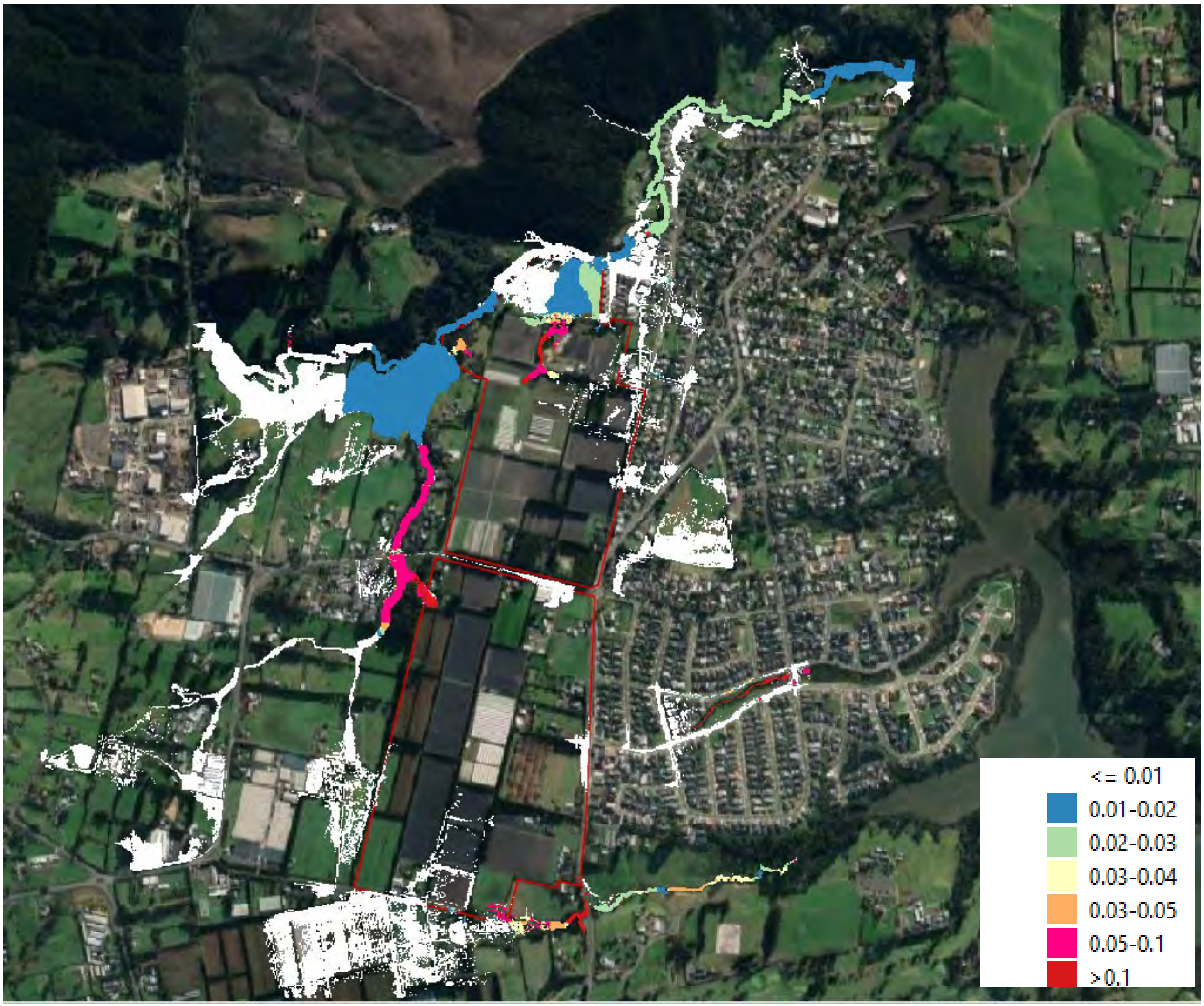


Figure 18: WSE Difference Map between Post-and Pre-development (Site ED+External ED) scenarios for 10yr without CC

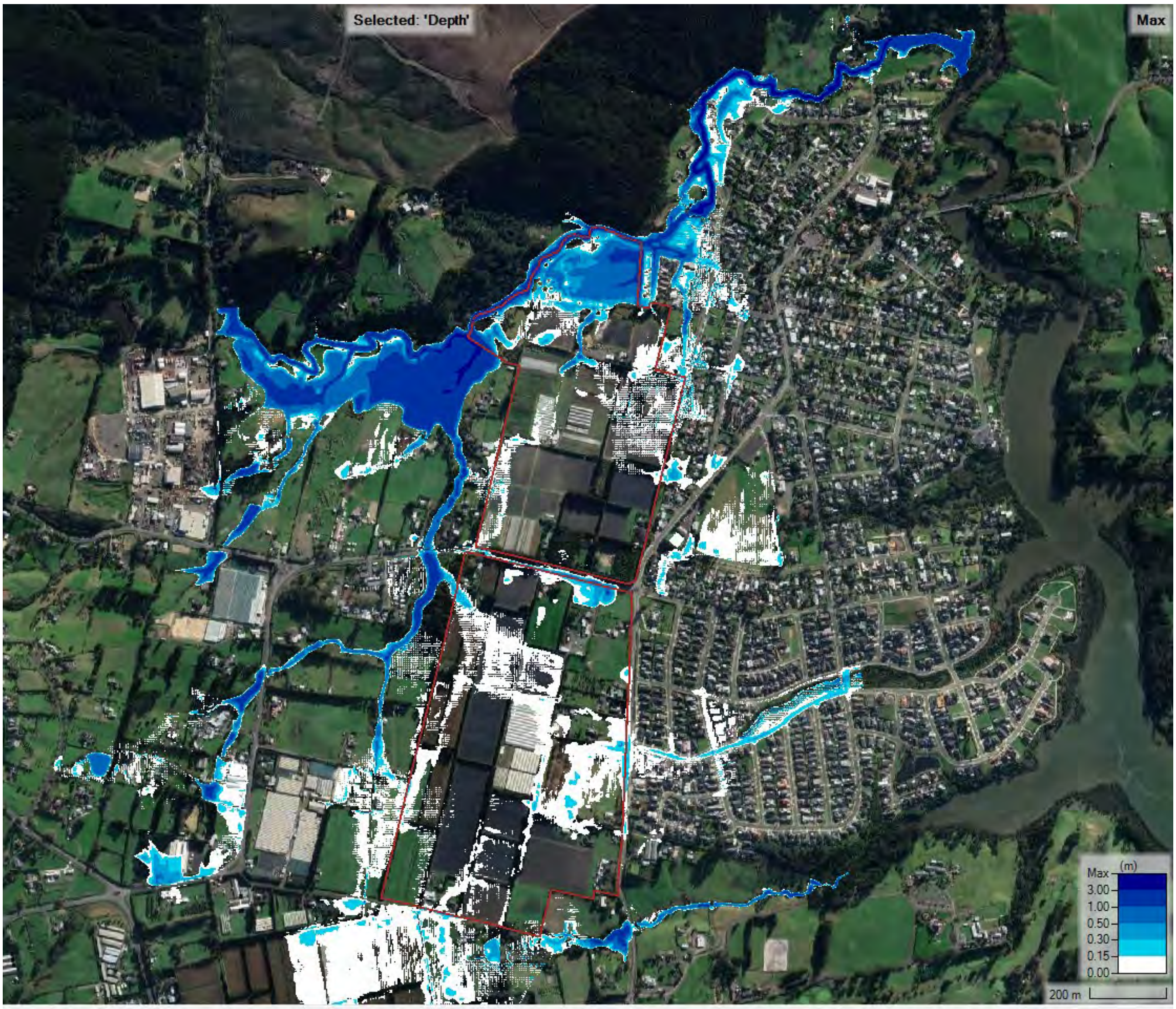


Figure 19: Maximum Flood Depth Map for Pre-development(Site ED+External ED) for 100yr without CC

Figure 20: Maximum Flood Depth Map for Post-development (SiteMPD+External ED) for 100yr without CC

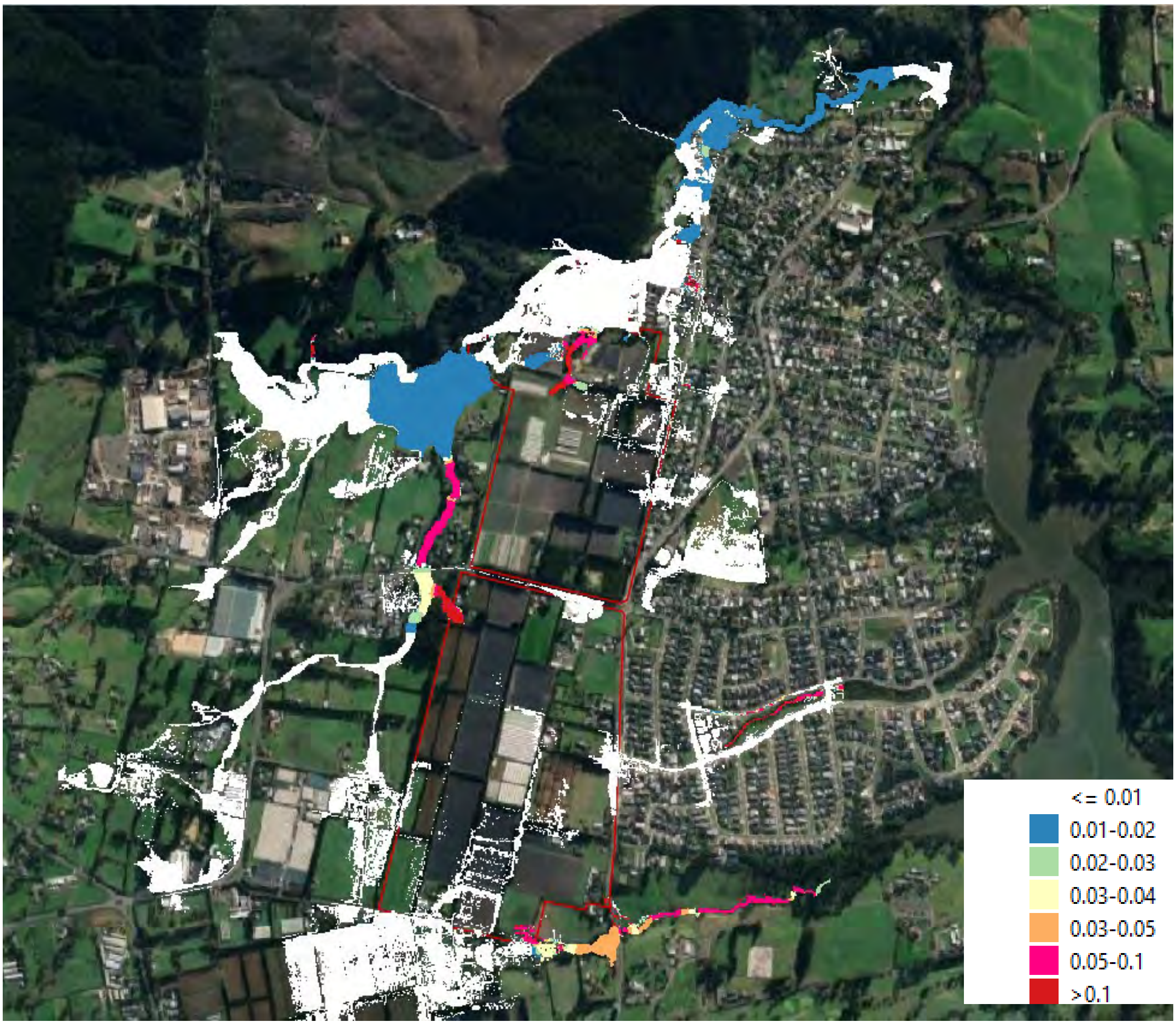


Figure 21: WSE Difference Map between Post-and Pre-development scenarios for 100yr without CC

Figure 22: Maximum Flood Depth Map for Pre-development(SiteED+External ED) for combination of 2yr+100yr without CC

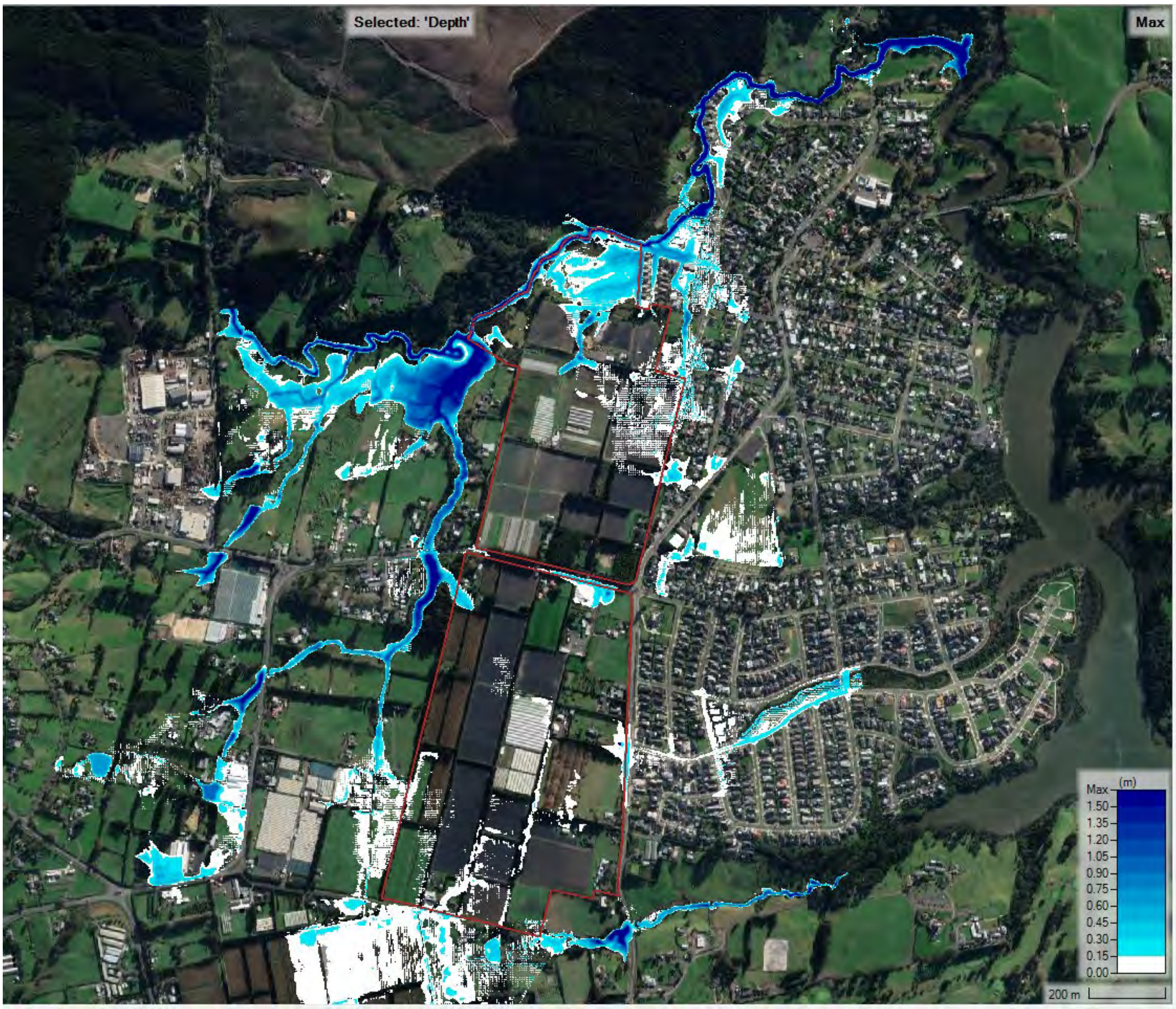


Figure 23: Maximum Flood Depth Map for Post-development (SiteMPD+External ED) for combination of 2yr+100yr without CC

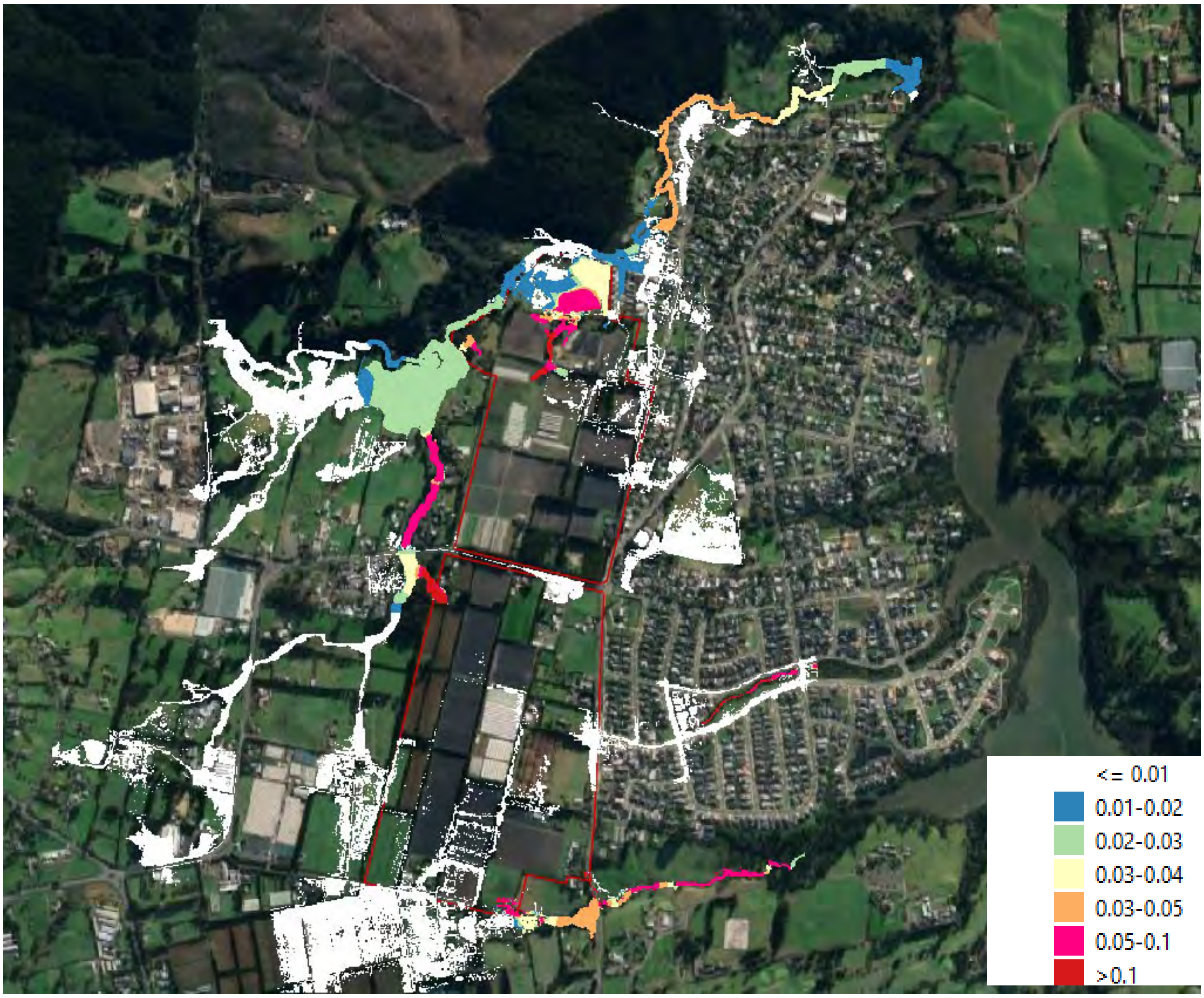


Figure 24: WSE Difference Map BETWEEN POST-development and Pre-development for Localized Impact Scenario (Combination of 2yr and 100yr without CC)

Figure 25: WSE Difference Map Between Attenuation Scenario and Post-development((SiteMPD+External ED) scenarios for 100yr without CC

Figure 26: WSE Difference Map Between Post-development (SiteMPD+ExternalED) without Attenuation and With Attenuation On Site For 10yr without CC

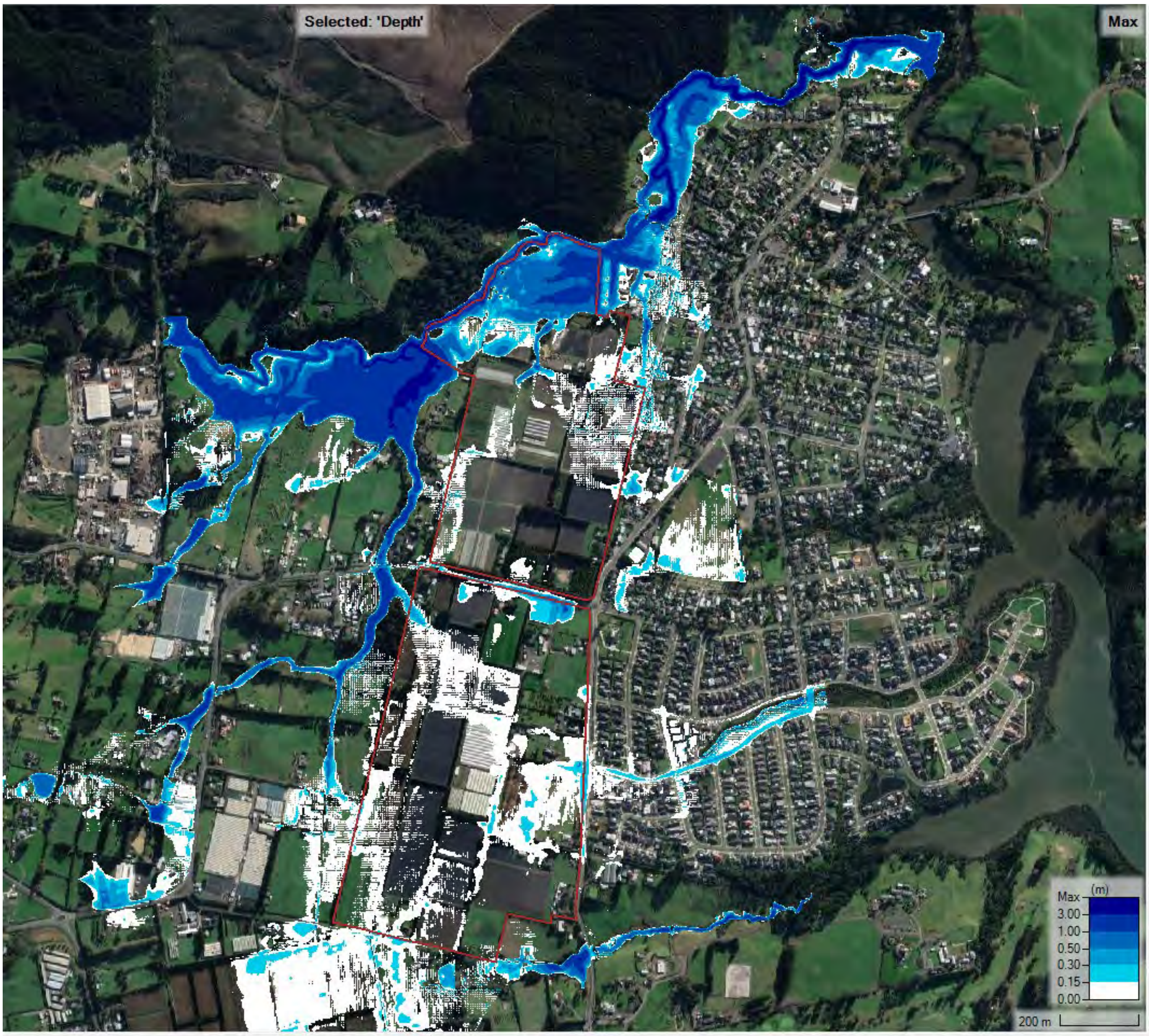


Figure 27: Maximum Flood Depth Map for Pre-development (SiteED+External MPD) for 100yr + Climate Change 2.1°C

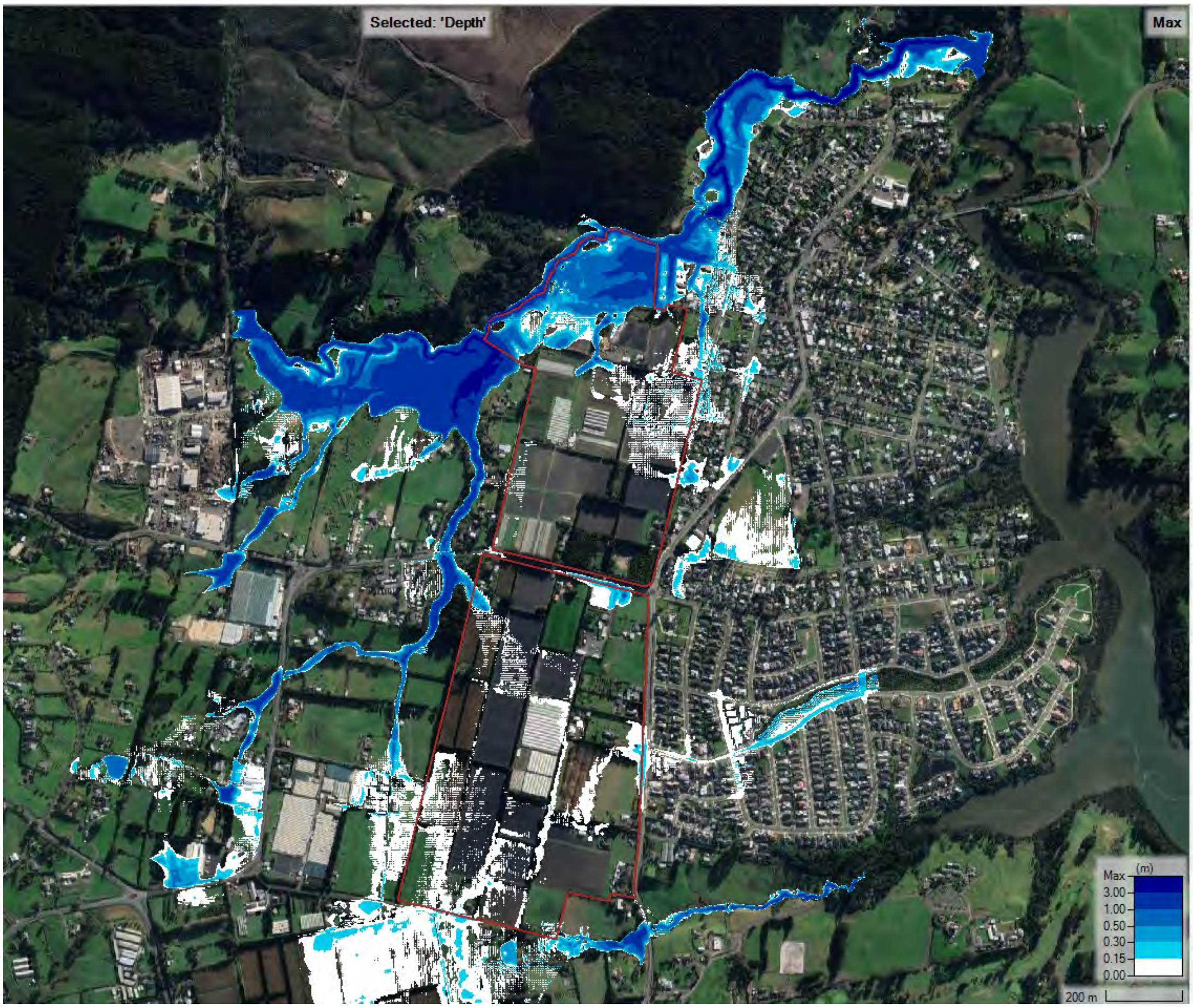


Figure 28: Maximum Flood Depth Map for Post-development (SiteMPD+External MPD) for 100yr + Climate Change 2.1°C

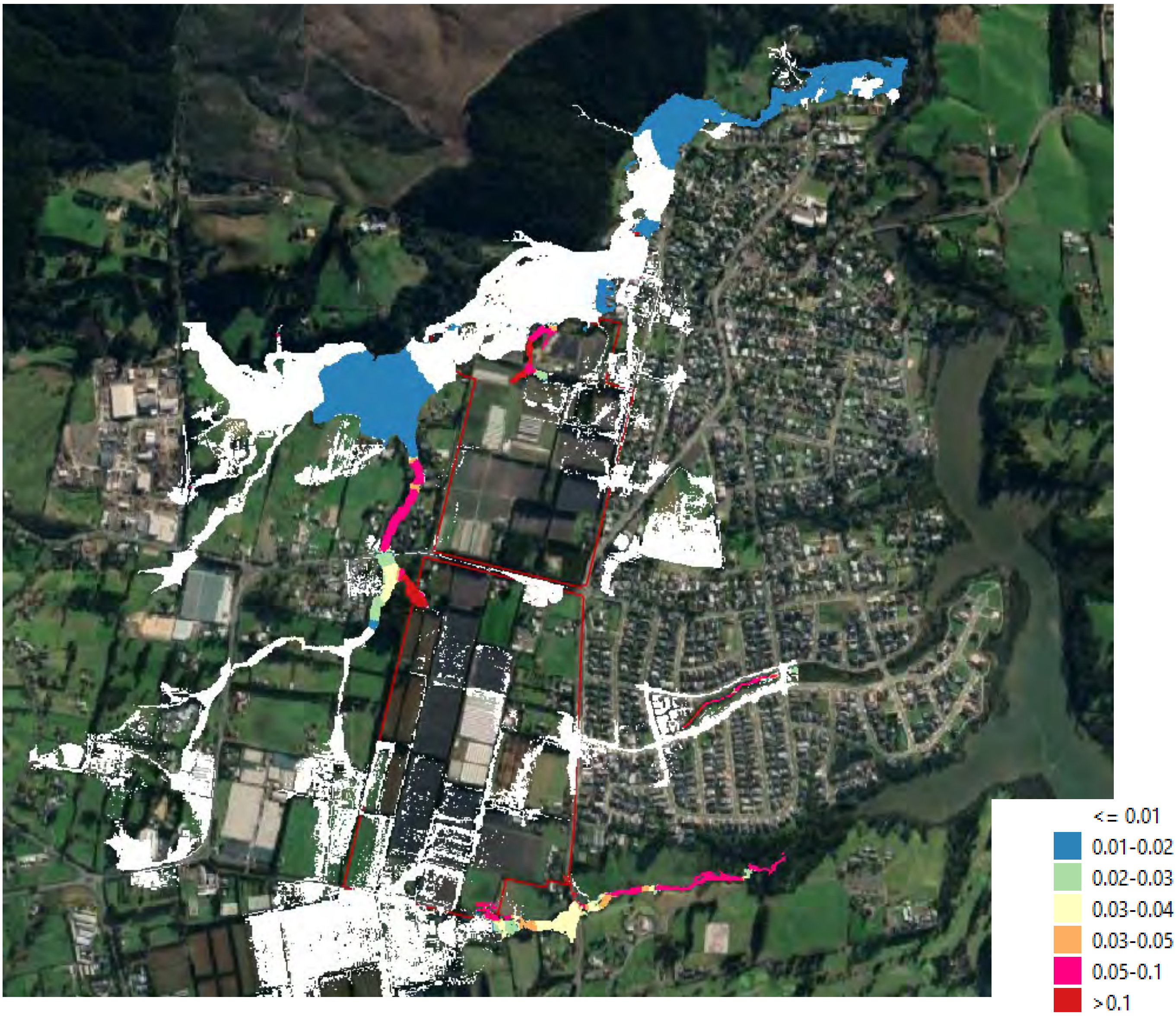


Figure 29: WSE Difference Map between Post-(SiteMPD+ExternalMPD) and Pre-development(SiteED+ExternalMPD)scenarios for 100yr + Climate Change 2.1°C

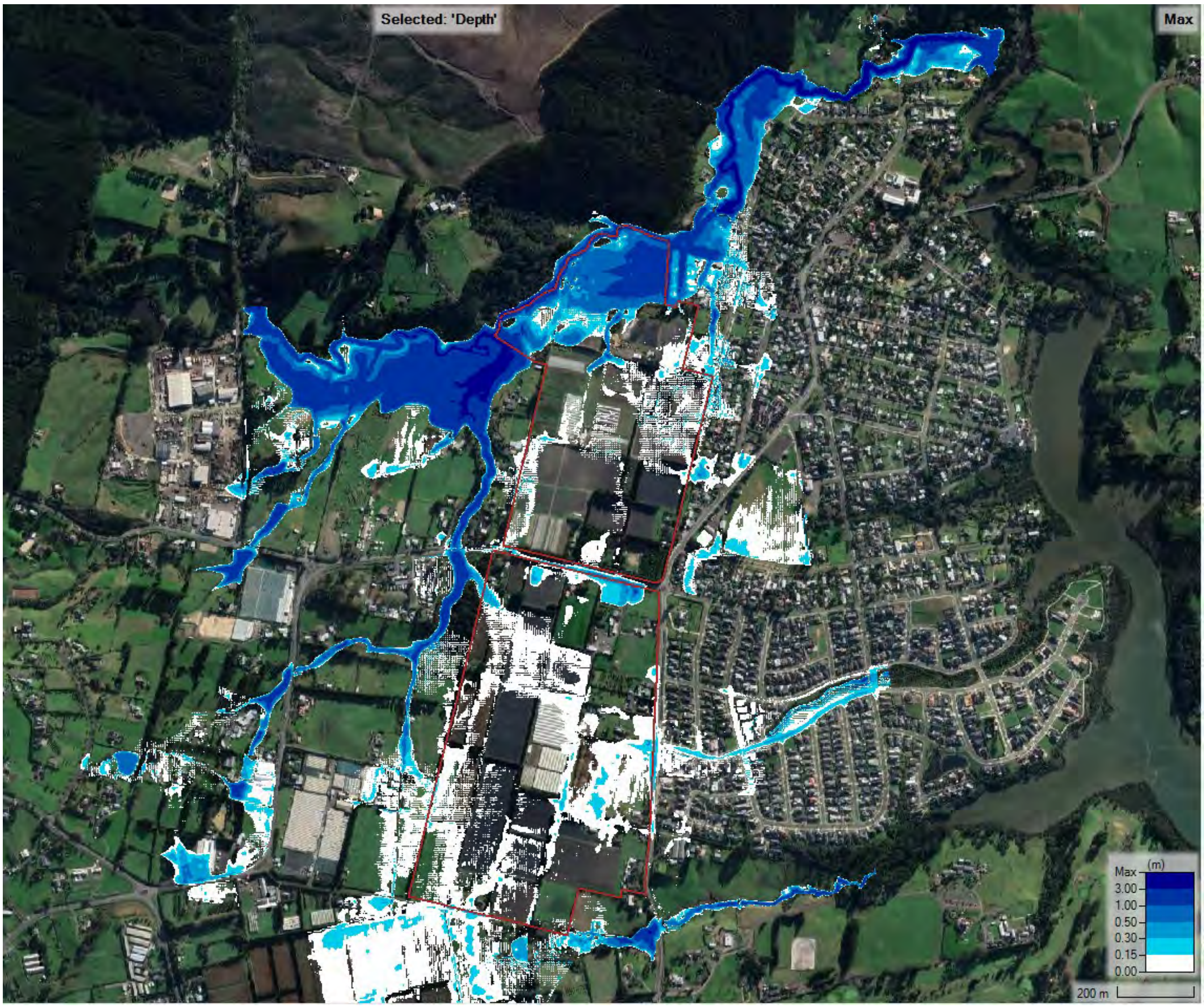


Figure 30: Maximum Flood Depth Map for Pre-development (SiteED+External MPD) for 100yr + Climate Change 3.8°C

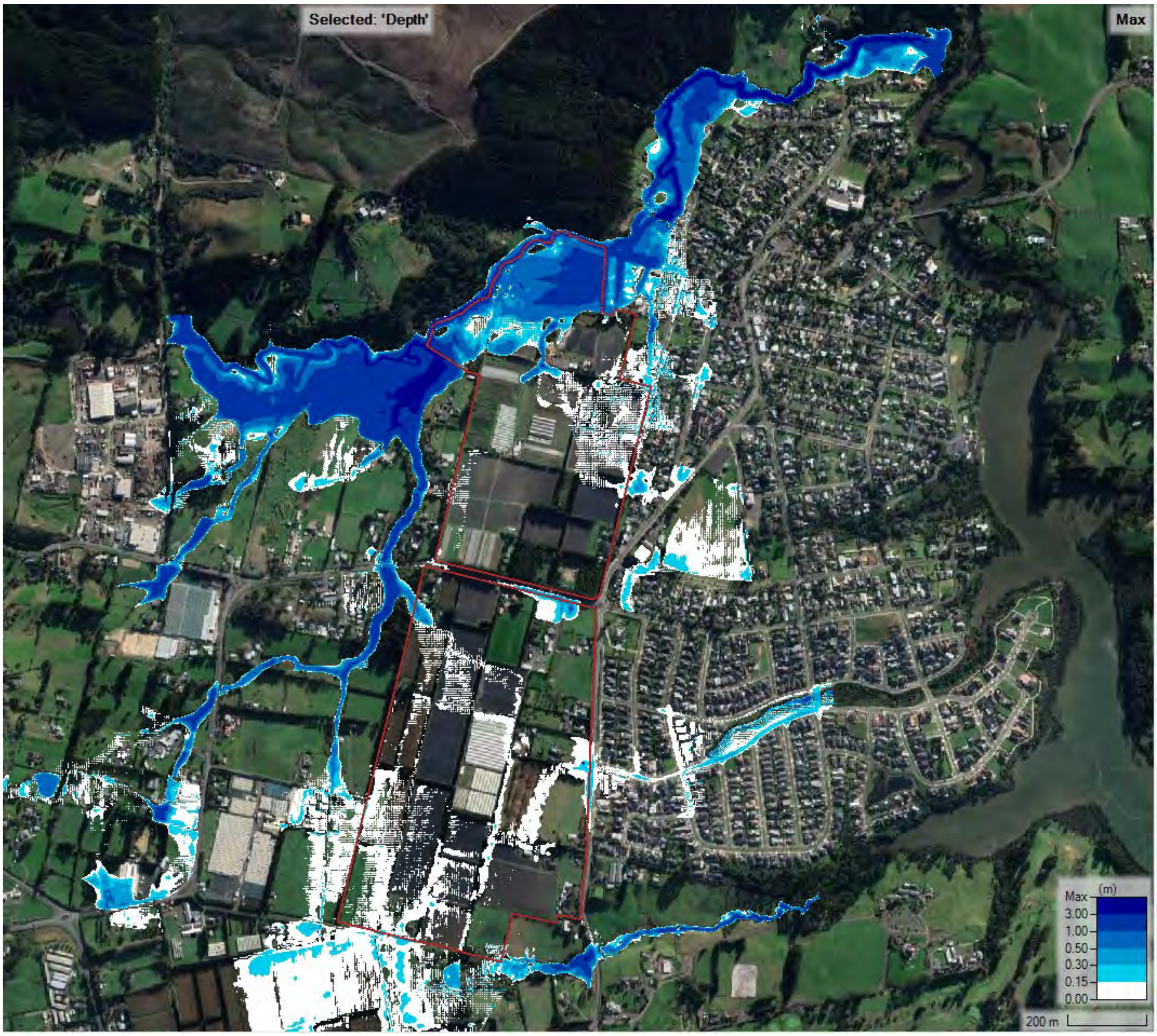


Figure 31: Maximum Flood Depth Map for Post-development (Site MPD+External MPD) for 100yr + Climate Change 3.8°C

Figure 32: WSE Difference Map between Post-(SiteMPD+ExternalMPD) and Pre-development(SiteED+ExternalMPD) scenarios for 100yr + Climate Change 3.8°C

Appendix 4 Hydraulic Model Result-Tabular Result at Key Locations

Table 18: MODEL RESULT AT LOCATION A

Rainfall	Development	Flow rate (m3/s)	Flood Level (m)	Flood Velocity (m/s)	Flood hazard (V*D)	Duration, hr (depth>0.2m)
50% AEP	Pre	16.97	13.68	1.52	3.12	>24
	Post	17.58	13.71	1.51	3.19	>24
10% AEP	Pre	25.81	14.06	1.81	4.16	>24
	Post	25.86	14.07	1.75	4.15	>24
1% AEP	Pre	35.12	14.42	2.3	4.77	>24
	Post	35.32	14.43	2.71	4.78	>24
50% AEP and 1% AEP	Pre	25.09	14.01	1.71	4.08	>24
	Post	25.19	14.02	3.04	4.08	>24
1% AEP Attenuation	Post	35.6	14.44	4.69	4.81	>24
10% AEP Attenuation	Post	25.9	14.08	5.3	4.14	>24
1% AEP + Climate Change 2.1°C	Pre	44.5	14.66	1.79	5.08	>24
	Post	44.73	14.67	2.23	5.09	>24
1% AEP + Climate Change 3.8°C	Pre	49.21	14.77	1.79	5.72	>24
	Post	49.36	14.78	1.81	5.73	>24

Table 19: MODEL RESULT AT LOCATION B

Rainfall	Development	Flow rate (m3/s)	Flood Level (m)	Flood Velocity (m/s)	Flood hazard (V*D)	Duration, hr (depth>0.2m)
50% AEP	Pre	2.62	13.3	0.8	0.31	4
	Post	2.89	13.32	0.47	0.34	4
10% AEP	Pre	12.93	13.68	1.15	1	4
	Post	13.35	13.69	1.15	1.03	4
1% AEP	Pre	27.92	14.07	1.73	2.34	9.5
	Post	28.07	14.07	1.84	2.36	9.5
50% AEP and 1% AEP	Pre	10.11	13.62	1.03	0.81	3.5
	Post	10.72	13.63	1.03	0.91	3.5
1% AEP Attenuation	Post	28.56	14.17	2.05	2.37	7
10% AEP Attenuation	Post	13.69	14.08	1.15	1.13	4
1% AEP + Climate Change 2.1°C	Pre	35.55	14.29	2.02	2.98	11
	Post	35.58	14.30	2.11	2.98	11
1% AEP + Climate Change 3.8°C	Pre	39.04	14.42	2.16	3.32	9.5
	Post	39.06	14.43	2.18	3.60	9.5

Table 20: MODEL RESULT AT LOCATION C

Rainfall	Development	Flow rate (m3/s)	Flood Level (m)	Flood Velocity (m/s)	Flood hazard (V*D)	Duration, hr (depth>0.2m)
50% AEP	Pre	1.86	17.61	0.75	0.65	>24
	Post	3.20	17.69	0.94	0.97	>24
10% AEP	Pre	8.66	18.28	1.39	1.91	>24
	Post	10.78	18.3	1.50	2.21	>24
1% AEP	Pre	16.21	19.08	1.59	2.75	>24
	Post	19.2	19.09	1.49	3.13	>24
50% AEP and 1% AEP	Pre	16.29	18.42	1.75	2.93	>24
	Post	19.21	18.47	1.86	3.27	>24
1% AEP Attenuation	Post	17.25	19.09	1.58	2.74	>24
10% AEP Attenuation	Post	8.97	18.39	1.4	1.95	>24
1% AEP + Climate Change 2.1°C	Pre	23.46	19.55	1.34	2.83	>24
	Post	26.29	19.56	1.51	3.18	>24
1% AEP + Climate Change 3.8°C	Pre	28.39	19.73	1.27	3.06	>24
	Post	31.71	19.74	1.42	3.4	>24

Table 21: MODEL RESULT AT LOCATION D

Rainfall	Development	Flow rate (m3/s)	Flood Level (m)	Flood Velocity (m/s)	Flood hazard (V*D)	Duration, hr (depth>0.2m)
50% AEP	Pre	16.90	17.51	0.59	1.51	>24
	Post	17.45	17.54	0.60	1.49	>24
10% AEP	Pre	38.65	18.23	0.61	1.66	>24
	Post	39.24	18.25	0.63	1.59	>24
1% AEP	Pre	74.29	19.03	0.58	1.66	>24
	Post	74.87	19.04	0.59	1.61	>24
50% AEP and 1% AEP	Pre	31.53	18.03	0.44	1.32	>24
	Post	32.33	18.05	0.48	1.31	>24
1% AEP Attenuation	Post	75.85	19.06	0.63	1.65	>24
10% AEP Attenuation	Post	39.55	18.26	0.58	1.65	>24
1% AEP + Climate Change 2.1°C	Pre	117.38	19.52	0.57	1.95	>24
	Post	118.59	19.53	0.57	1.97	>24
1% AEP + Climate Change 3.8°C	Pre	141.12	19.7	0.57	2.21	>24
	Post	142.19	19.7	0.57	2.22	>24

Table 22: MODEL RESULT AT LOCATION E

Rainfall	Development	Flow rate (m3/s)	Flood Level (m)	Flood Velocity (m/s)	Flood hazard (V*D)	Duration, hr (depth>0.2m)
50% AEP	Pre	16.88	14.98	2.3	3.01	>24
	Post	17.44	15.01	1.55	3.09	>24
10% AEP	Pre	28.37	15.39	1.85	4.47	>24
	Post	28.50	15.40	1.45	4.49	>24
1% AEP	Pre	34.89	15.55	1.86	5.2	>24
	Post	34.95	15.55	3.61	5.2	>24
50% AEP and 1% AEP	Pre	26.31	15.34	1.79	4.23	>24
	Post	26.58	15.35	2.61	4.25	>24
1% AEP Attenuation	Post	35.03	15.55	1.67	5.21	>24
10% AEP Attenuation	Post	28.58	15.40	1.5	4.50	>24
1% AEP + Climate Change 2.1°C	Pre	39.15	15.64	1.66	5.6	>24
	Post	39.25	15.64	2.31	5.6	>24
1% AEP + Climate Change 3.8°C	Pre	40.66	15.68	1.78	5.75	>24
	Post	40.78	15.68	2.06	5.76	>24

Table 23: MODEL RESULT AT LOCATION F

Rainfall	Development	Flow rate (m3/s)	Flood Level (m)	Flood Velocity (m/s)	Flood hazard (V*D)	Duration, hr (depth>0.2m)
50% AEP	Pre	17.60	12.29	1.39	2.44	>24
	Post	18.33	12.32	1.44	2.52	>24
10% AEP	Pre	37.73	12.98	1.86	4.27	>24
	Post	38.39	12.99	1.88	4.32	>24
1% AEP	Pre	67.38	13.49	2.24	6.18	>24
	Post	67.90	13.50	2.30	6.21	>24
50% AEP and 1% AEP	Pre	33.46	12.82	1.78	3.94	>24
	Post	34.42	12.85	1.80	4.01	>24
1% AEP Attenuation	Post	68.88	13.51	1.88	6.27	>24
10% AEP Attenuation	Post	39.01	13.21	2.30	4.36	>24
1% AEP + Climate Change 2.1°C	Pre	96.07	13.77	2.53	7.8	>24
	Post	96.77	13.78	2.54	7.84	>24
1% AEP + Climate Change 3.8°C	Pre	110.41	13.90	2.66	8.56	>24
	Post	110.86	13.91	2.66	8.59	>24

Table 24: MODEL RESULT AT LOCATION G

Rainfall	Development	Flow rate (m3/s)	Flood Level (m)	Flood Velocity (m/s)	Flood hazard (V*D)	Duration, hr (depth>0.2m)
50% AEP	Pre	17.54	7.39	1.07	3.55	>24
	Post	18.36	7.44	1.10	3.66	>24
10% AEP	Pre	37.61	8.45	1.41	6.11	>24
	Post	38.27	8.48	1.42	6.18	>24
1% AEP	Pre	69.85	9.33	1.83	9.54	>24
	Post	70.34	9.34	1.84	9.59	>24
50% AEP and 1% AEP	Pre	33.51	8.30	1.36	5.63	>24
	Post	34.46	8.33	1.7	5.74	>24
1% AEP Attenuation	Post	71.63	9.36	1.86	9.74	>24
10% AEP Attenuation	Post	38.9	8.50	1.43	6.25	>24
1% AEP + Climate Change 2.1°C	Pre	109.56	9.85	2.35	13.75	>24
	Post	110.55	9.86	2.36	13.84	>24
1% AEP + Climate Change 3.8°C	Pre	131.90	1.01	2.56	14.97	>24
	Post	132.64	10.02	2.57	15.02	>24

Table 25: MODEL RESULT AT LOCATION H

Rainfall	Development	Flow rate (m3/s)	Flood Level (m)	Flood Velocity (m/s)	Flood hazard (V*D)	Duration, hr (depth>0.2m)
50% AEP	Pre	17.53	6.7	0.99	3.06	>24
	Post	18.18	6.74	1	3.11	>24
10% AEP	Pre	39.70	7.78	1.32	5.52	>24
	Post	40.46	7.80	1.33	5.59	>24
1% AEP	Pre	73.33	8.81	1.57	8.13	>24
	Post	73.72	8.82	1.57	8.15	>24
50% AEP and 1% AEP	Pre	35.02	7.71	1.25	5.05	>24
	Post	36.12	7.72	1.27	5.16	>24
1% AEP Attenuation	Post	74.39	8.84	1.58	8.20	>24
10% AEP Attenuation	Post	41.16	7.83	1.34	5.66	>24
1% AEP + Climate Change 2.1°C	Pre	95.87	9.22	1.71	9.62	>24
	Post	96.34	9.23	1.71	9.65	>24
1% AEP + Climate Change 3.8°C	Pre	105.83	9.39	1.77	10.23	>24
	Post	106.1	9.39	1.77	10.25	>24

Table 26: MODEL RESULT AT LOCATION I

Rainfall	Development	Flow rate (m3/s)	Flood Level (m)	Flood Velocity (m/s)	Flood hazard (V*D)	Duration, hr (depth>0.2m)
50% AEP	Pre	17.68	6.15	1.06	3.45	>24
	Post	18.33	6.19	1.08	3.55	>24
10% AEP	Pre	39.97	7.17	1.54	6.58	>24
	Post	40.74	7.20	1.55	6.67	>24
1% AEP	Pre	75.23	8.17	1.82	9.27	>24
	Post	75.64	8.18	1.82	9.36	>24
50% AEP and 1% AEP	Pre	35.57	7.02	1.46	6	>24
	Post	36.70	7.06	1.47	6.14	>24
1% AEP Attenuation	Post	76.40	8.20	1.82	9.39	>24
10% AEP Attenuation	Post	41.45	7.23	1.56	6.75	>24
1% AEP + Climate Change 2.1°C	Pre	88.41	8.58	1.80	9.64	>24
	Post	88.55	8.59	1.82	9.61	>24
1% AEP + Climate Change 3.8°C	Pre	92.46	8.77	1.77	9.68	>24
	Post	92.53	8.88	1.78	9.51	>24

Table 27: MODEL RESULT AT LOCATION J

Rainfall	Development	Flow rate (m3/s)	Flood Level (m)	Flood Velocity (m/s)	Flood hazard (V*D)	Duration, hr (depth>0.2m)
50% AEP	Pre	2.05	24.05	0.31	0.12	4.5
	Post	3.03	24.23	0.4	0.2	4.5
10% AEP	Pre	7.69	24.37	0.32	0.31	6.5
	Post	9.97	24.50	0.4	0.39	6.5
1% AEP	Pre	13.64	24.51	0.32	0.52	11
	Post	16.91	24.59	0.36	0.6	11
50% AEP and 1% AEP	Pre	13.68	24.51	0.31	0.5	10.5
	Post	16.91	24.59	0.32	0.63	10.5
1% AEP Attenuation	Post	15.64	24.54	0.34	0.57	>24
10% AEP Attenuation	Post	8.66	24.37	0.3	0.33	9
1% AEP + Climate Change 2.1°C	Pre	20.36	24.79	0.4	0.79	>24
	Post	24.02	24.80	0.45	0.87	>24
1% AEP + Climate Change 3.8°C	Pre	24.82	24.82	0.47	0.95	>24
	Post	29.1	24.84	0.50	1.01	>24

Table 28: MODEL RESULT AT LOCATION K

Rainfall	Development	Flow rate (m3/s)	Flood Level (m)	Flood Velocity (m/s)	Flood hazard (V*D)	Duration, hr (depth>0.2m)
50% AEP	Pre	0.35	31.8	0.29	0.01	1
	Post	0	0	0	0	0
10% AEP	Pre	0.74	31.82	0.37	0.02	2
	Post	0	0	0	0	0
1% AEP	Pre	0.29	31.85	0.5	0.03	2
	Post	1.54	31.79	0.28	0.01	0
50% AEP and 1% AEP	Pre	1.53	31.85	0.5	0.03	1.5
	Post	0.3	31.79	0.28	0.01	0
1% AEP Attenuation	Post	0.3	31.79	0.28	0.01	0.5
10% AEP Attenuation	Post	0	0	0	0	0
1% AEP + Climate Change 2.1°C	Pre	1.93	31.86	0.54	0.05	3
	Post	0.65	31.81	0.36	0.02	0.5
1% AEP + Climate Change 3.8°C	Pre	2.27	31.87	0.58	0.05	4
	Post	0.97	31.82	0.41	0.03	0.5

Table 29: MODEL RESULT AT LOCATION L

Rainfall	Development	Flow rate (m3/s)	Flood Level (m)	Flood Velocity (m/s)	Flood hazard (V*D)	Duration, hr (depth>0.2m)
50% AEP	Pre	0.56	20.13	0.67	0.25	6
	Post	0.82	20.20	0.73	0.4	6
10% AEP	Pre	1.49	20.35	0.81	0.45	>24
	Post	2.05	20.40	0.86	0.65	>24
1% AEP	Pre	3.37	20.56	0.9	0.65	>24
	Post	4.07	20.59	0.94	0.71	>24
50% AEP and 1% AEP	Pre	3.37	20.56	0.9	0.78	>24
	Post	4.07	20.59	0.94	0.84	>24
1% AEP Attenuation	Post	4.07	20.59	0.94	0.71	>24
10% AEP Attenuation	Post	2.05	20.4	0.86	0.65	>24
1% AEP + Climate Change 2.1°C	Pre	4.89	20.69	0.93	0.87	>24
	Post	5.7	20.73	0.96	0.92	>24
1% AEP + Climate Change 3.8°C	Pre	5.89	20.76	0.93	0.89	>24
	Post	6.74	20.81	0.95	0.96	>24

Table 30: MODEL RESULT AT LOCATION M

Rainfall	Development	Flow rate (m3/s)	Flood Level (m)	Flood Velocity (m/s)	Flood hazard (V*D)	Duration, hr (depth>0.2m)
50% AEP	Pre	1.63	17.12	0.59	0.21	4
	Post	2.01	17.16	0.64	0.25	4
10% AEP	Pre	3.39	17.42	0.77	0.38	5
	Post	3.74	17.43	0.79	0.41	5
1% AEP	Pre	6.24	17.44	0.95	0.67	7.5
	Post	7.23	17.47	0.99	0.61	7.5
50% AEP and 1% AEP	Pre	6.24	17.41	0.95	0.61	>24
	Post	7.24	17.44	0.99	0.67	>24
1% AEP Attenuation	Post	7.23	17.47	0.99	0.67	8.5
10% AEP Attenuation	Post	3.74	17.43	0.79	0.41	4.5
1% AEP + Climate Change 2.1°C	Pre	10.34	17.53	1.11	0.85	9
	Post	11.62	17.56	1.15	0.92	9
1% AEP + Climate Change 3.8°C	Pre	12.93	17.58	1.19	0.98	>24
	Post	14.28	17.61	1.22	1.05	>24

Table 31: MODEL RESULT AT LOCATION N

Rainfall	Development	Flow rate (m3/s)	Flood Level (m)	Flood Velocity (m/s)	Flood hazard (V*D)	Duration, hr (depth>0.2m)
50% AEP	Pre	0.09	7.41	0.05	0.01	0
	Post	0.09	7.41	0.05	0.01	0
10% AEP	Pre	0.25	7.47	0.08	0.03	0.75
	Post	0.25	7.47	0.08	0.03	0.75
1% AEP	Pre	1.07	7.63	0.19	0.09	2.5
	Post	1.19	7.65	0.20	0.1	2.5
50% AEP and 1% AEP	Pre	0.47	7.53	0.11	0.04	2
	Post	0.47	7.53	0.11	0.04	2
1% AEP Attenuation	Post	1.46	7.68	0.43	0.12	2
10% AEP Attenuation	Post	0.25	7.47	0.08	0.03	0.5
1% AEP + Climate Change 2.1°C	Pre	14.07	8.24	0.71	0.76	3
	Post	14.39	8.26	0.71	0.78	3
1% AEP + Climate Change 3.8°C	Pre	20.16	8.51	0.8	1.05	3
	Post	20.35	8.52	0.8	1.06	3

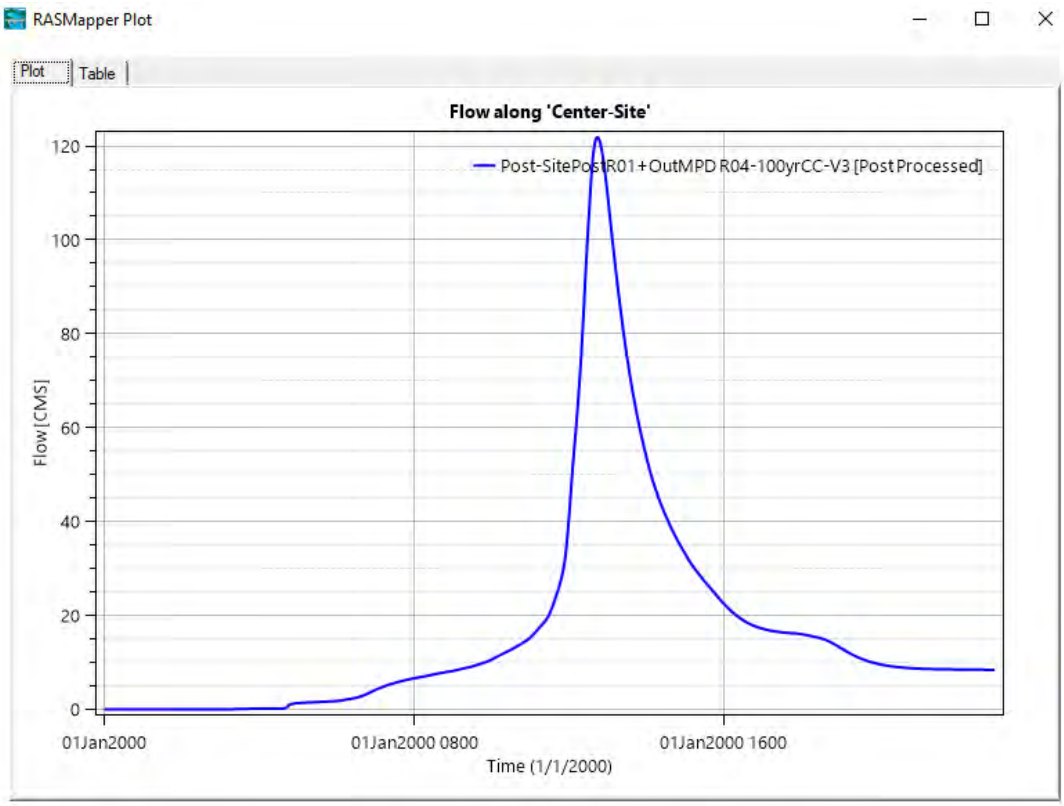
Table 32: MODEL RESULT AT LOCATION O

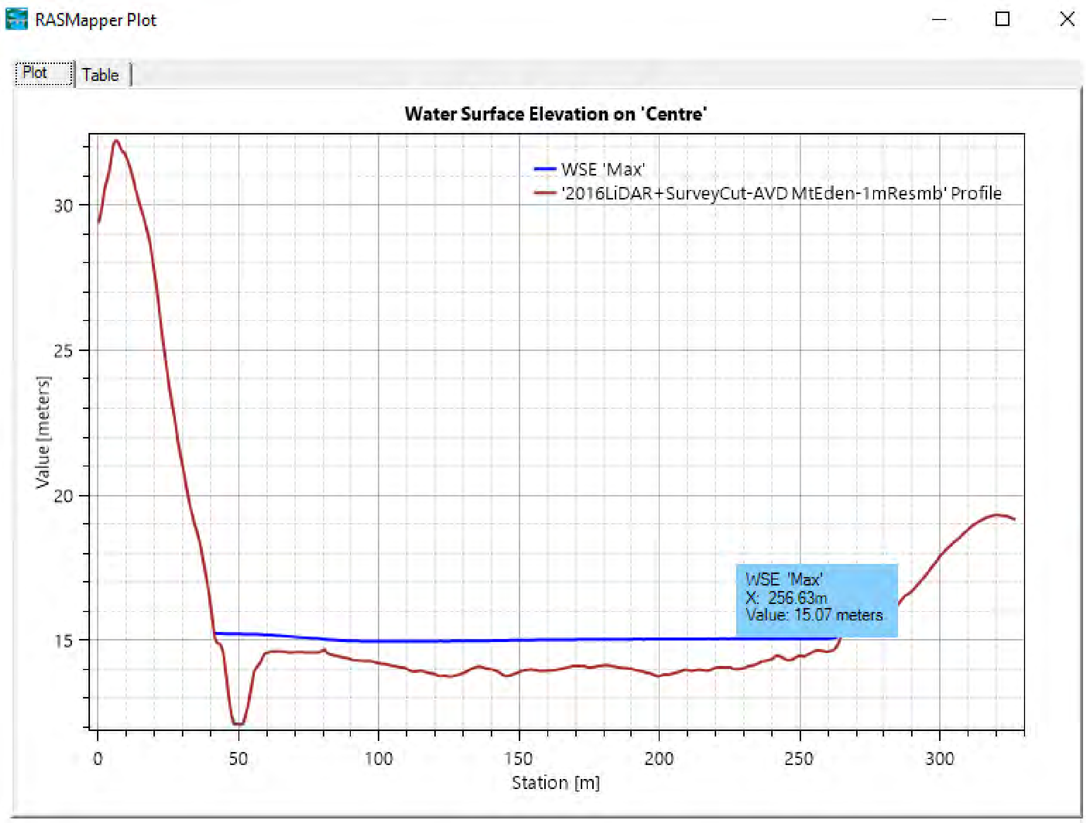
Rainfall	Development	Flow rate (m3/s)	Flood Level (m)	Flood Velocity (m/s)	Flood hazard (V*D)	Duration, hr (depth>0.2m)
50% AEP	Pre	0.03	13.26	0.06	0.0	1
	Post	0.04	13.28	0.06	0.0	1
10% AEP	Pre	1.54	13.6	0.16	0.1	3.5
	Post	1.59	13.6	0.17	0.1	3.5
1% AEP	Pre	4.73	13.84	0.33	0.28	5
	Post	4.79	13.84	0.34	0.29	5
50% AEP and 1% AEP	Pre	1.21	13.56	0.14	0.07	3.0
	Post	1.28	13.57	0.14	0.08	3
1% AEP Attenuation	Post	4.93	13.85	0.34	0.29	5.5
10% AEP Attenuation	Post	1.65	13.61	0.17	0.1	3.5
1% AEP + Climate Change 2.1°C	Pre	9.65	14.06	0.52	0.55	7
	Post	9.76	14.06	0.53	0.56	7
1% AEP + Climate Change 3.8°C	Pre	12.63	14.17	0.61	0.71	8.5
	Post	12.71	14.17	0.62	0.72	8.5

Table 33: MODEL RESULT AT LOCATION P

Rainfall	Development	Flow rate (m3/s)	Flood Level (m)	Flood Velocity (m/s)	Flood hazard (V*D)	Duration, hr (depth>0.2m)
50% AEP	Pre	0.32	13.29	0.51	0.07	1
	Post	0.37	13.31	0.56	0.08	1
10% AEP	Pre	3	13.65	0.6	0.42	3.5
	Post	3.08	13.66	0.7	0.42	3.5
1% AEP	Pre	6.81	13.97	1.02	1.05	6.5
	Post	6.91	13.98	1.04	1.06	6.5
50% AEP and 1% AEP	Pre	2.49	13.6	1.03	0.32	3
	Post	2.59	13.61	1.06	0.35	3
1% AEP Attenuation	Post	7.03	13.99	1.14	1.07	6
10% AEP Attenuation	Post	3.09	13.67	0.84	0.45	4
1% AEP + Climate Change 2.1°C	Pre	11.40	14.3	1.66	1.97	8
	Post	11.54	14.3	1.7	2.02	8
1% AEP + Climate Change 3.8°C	Pre	14.31	14.44	14.48	2.52	9
	Post	14.5	14.44	14.48	2.53	9

Appendix 5 Hydraulic Model Result-Cross Section for Validation




RASMapper Plot
Plot
Table
Water Surface Elevation on 'Centre'
WSE 'Max'
'2016LiDAR+SurveyCut-AVD MtEden-1mResmb' Profile
WSE 'Max'
X: 256.63m
Value: 15.07 meters
Value [meters]
Station [m]
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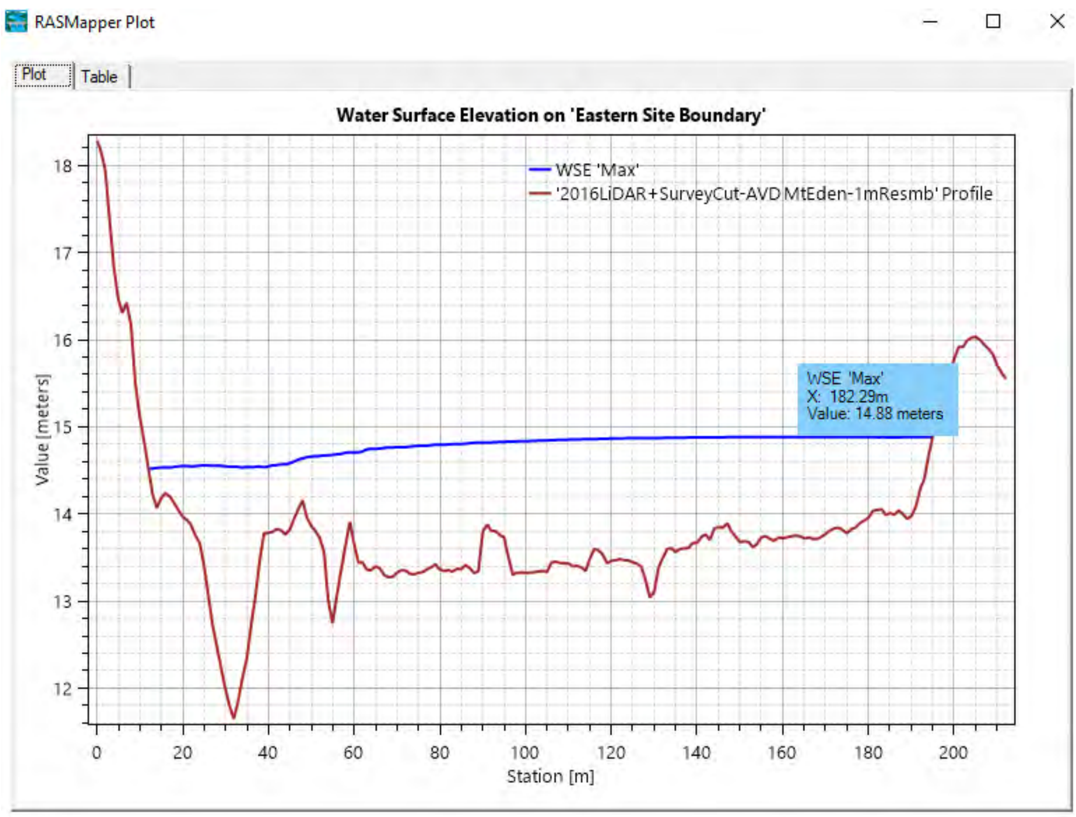
25
20
15
0
50
100
150
200
250
300


RASMapper Plot
Plot
Table
Water Surface Elevation on 'Eastern Site Boundary'
WSE 'Max'
'2016LiDAR+SurveyCut-AVD MtEden-1mResmb' Profile
WSE 'Max'
X: 182.29m
Value: 14.88 meters
Value [meters]
Station [m]
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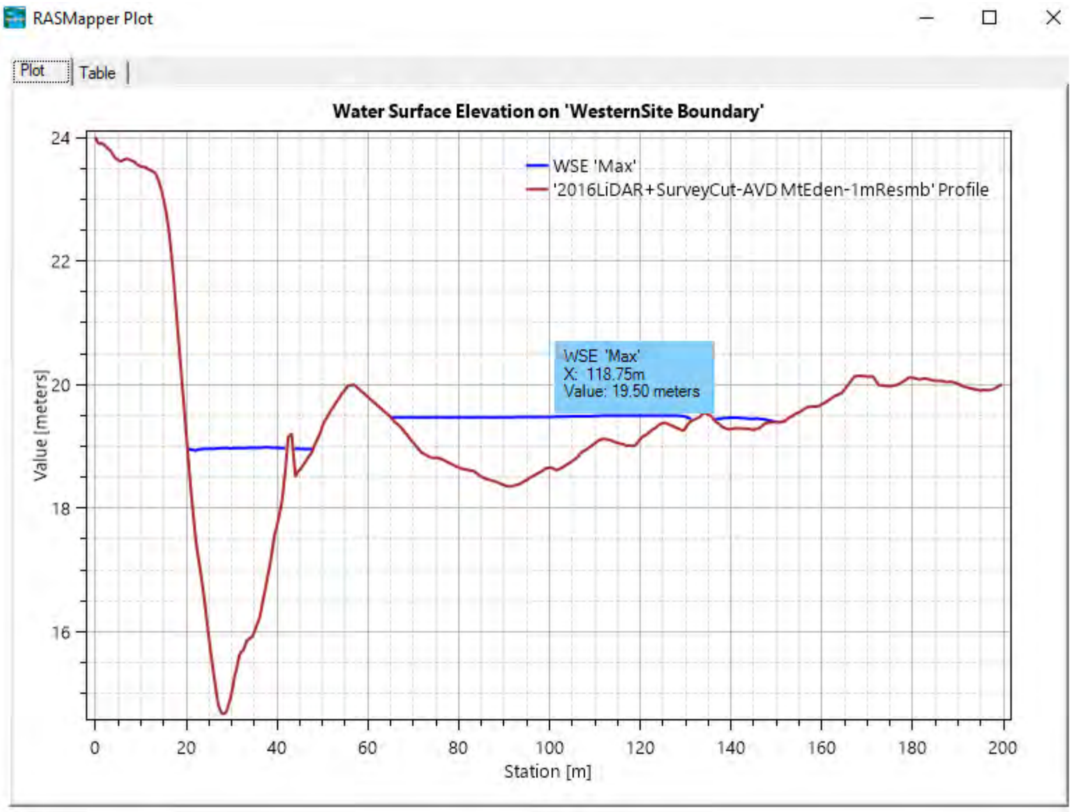
17
16
15
14
13
12
0
20
40
60
80
100
120
140
160
180
200


RASMapper Plot
Plot
Table
Water Surface Elevation on 'WesternSite Boundary'
WSE 'Max'
'2016LiDAR+SurveyCut-AVD MtEden-1mResmb' Profile
WSE 'Max'
X: 118.75m
Value: 19.50 meters
Value [meters]
24
22
20
18
16
0
20
40
60
80
100
120
140
160
180
200
Station [m]

Appendix 6 Auckland Council Flood Model Review (November 2022)

From:	Kedan Li
To:	Bronwyn Rhynd; Catherine Liu
Cc:	Andrew Dow; Mostafa Baghersad; Susan Andrews
Subject:	RE: [#CKL A20405] [#CKL] Files Issued- A20405 Riverhead Plan Change flood model
Date:	Wednesday, November 23, 2022 11:21:16 AM
Attachments:	image001.png image002.png image003.png image004.png

Hi Bronwyn and Catherine,

Please find my model review comments below.

Summary of Riverhead -Flood Risk Assessment Report and Model Review:

Document Reviewed: A20405-EV- Flood Risk Assessment Report Rev01-issued.pdf Date 03/11/2022.
Model Reviewed: A20405- HEC HMS Model; A20405-HEC RAS Model

Comments on report:

1. In general, the modelling that has been completed is considered appropriate for a plan change application to determine the potential effects of the land use change. It is recommended that as developments proceed within the plan change area that this high-level model is refined to provide updates to the potential impacts of specific developments on flood risk and to ensure that appropriate mitigation is provided if required.
2. The model review undertaken by Healthy Waters has been a high-level assessment on the approach that was made to the modelling along with reviewing the assumptions and available model build data. It has not looked specifically at the impacts of the recommended flood management approach.
3. From a review of the model report, Areas of Interest 1, 2 and 3 appear to increase the water level downstream; however, this elevation is contained within the bounds of the watercourse and appears to have limited increase on flood risk to property, or reduction in developable potential in downstream lot areas. Increases range between 20mm to 100mm in general.
4. For Area of Interest 4, the flood model shows that flood level increase 10-50mm during all rainfall events, impacting some existing buildings and roads. There is a localised increases in the flood elevation of over 100mm, this increase is resulting in very localised increased flood risk to existing buildings, potentially this increase in flood level may be related to the loading of sub-catchment hydrographs, but there is no explanation provide for this very isolated increase in the reporting, discussion around this isolated increase is recommended.

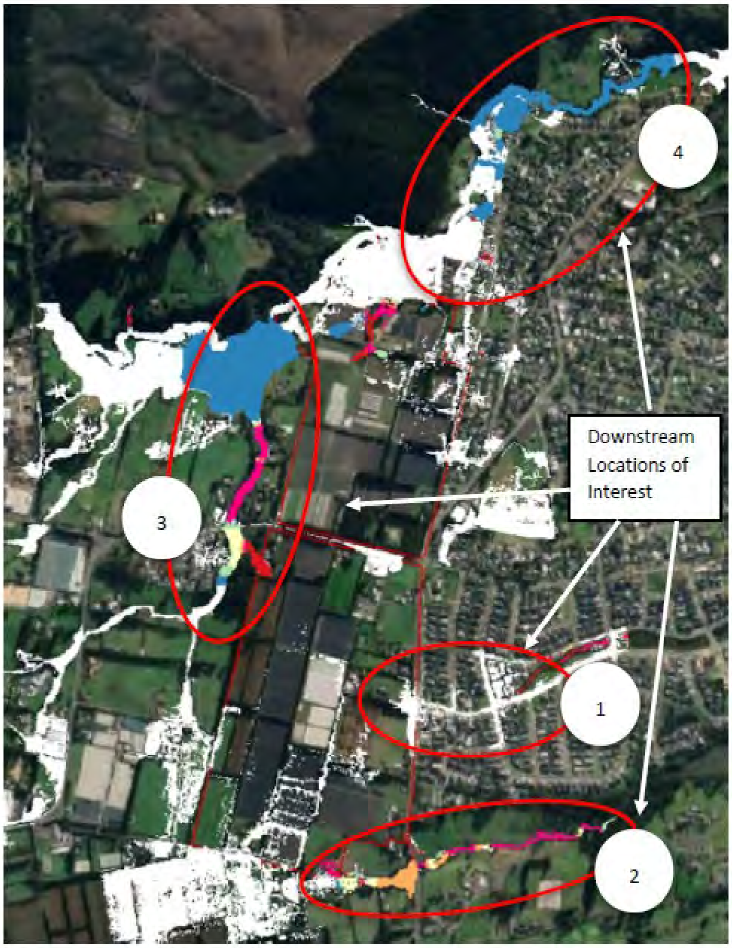


Figure 10: Downstream Locations of Interest

5. As mentioned above, there are existing properties that are indicated within the local elevation increase in the modelling. Because there is an increase in flood risk to existing buildings, the decision on whether this is significant will need to be made by the Regulatory team processing the plan change application, not Healthy Waters.
6. The Difference maps need to specify in detail what the “Pre” and “Post” condition is that is being assessed (i.e. it is not clear if Pre-development means Plan Change Area(PCA) and outside PCA are both ED? Post-development means PCA proposed development, outside PCA -ED or MPD?).
7. Please ensure that the flood change legend is available on each of the difference plans in the report (Especially for Figure 10 within the report).

Specific comments on modelling:

1. Tidal boundary in the existing scenario (**ED**) should be using MHWS without Sea Level Rise (Please added in sensitivity check to the report if possible);
2. Roughness values are considered in the high range for Roads(Used 0.05, recommending 0.03) and open fields(used 0.1, recommending 0.05);
3. Roughness value low for AMRCO pipe (used 0.013, recommending 0.02);
4. No separate roughness zone for stream/low flow channel; buildings are not represented in the model;

5. Downstream of Duke St has assumed no obstruction as no foot bridge, no bridges were modelled;
6. There are a number of relatively large sub-catchments that include two or more overland flowpaths. This method of assessment may be resulting in over-estimating flood impacts locally as the resulting loading will be a relatively large hydrograph point loaded onto the terrain. The result may be concentrated flows influenced by the terrain. It is recommended that these sub-catchments be refined through the design process.

Model limitation to add to report:
This assessment is lacking on culvert and network capacity assessment. There are both public and private infrastructure located downstream of the plan change area. It may be necessary to undertake further modelling to determine the impacts on this infrastructure from a usability perspective, to include depth of flooding, duration of flooding and extent of flooding for more frequent events to confirm the impacts of the plan change development on these assets and roads.

Further Refinement Section to add to report:
It is recommended to list the above **Specific comments on modelling** in the Flood Risk Assessment Report and the SMP as a new section "Further Refinement", and be clear that during the next stage of model refinement the above modelling comments should be incorporated into, so that it is consistent and clear for people involves in the next stage of development.

Thank you.

Kind Regards,
Kedan

Kedan Li | Senior Healthy Waters Specialist
Healthy Waters | Infrastructure & Environmental Services
Auckland Council, Level 17, Auckland House, 135 Albert Street, Auckland
Visit our website: www.aucklandcouncil.govt.nz

From: Bronwyn Rhynd <Bronwyn.Rhynd@ckl.co.nz>
Sent: Thursday, 3 November 2022 4:12 pm
To: Kedan Li <kedan.li@aucklandcouncil.govt.nz>; Catherine Liu <Catherine.Liu@ckl.co.nz>
Cc: Andrew Dow <andrew.dow@ckl.co.nz>; Mostafa Baghersad <mostafa.baghersad@ckl.co.nz>; Susan Andrews <susan.andrews@aucklandcouncil.govt.nz>
Subject: RE: [#CKL A20405] [#CKL] Files Issued- A20405 Riverhead Plan Change flood model

Hi Kedan
Thanks for the explanation, I had misinterpreted the start of the review process for you
IF there is anything that we can assist you please let us know.
Regards

Bronwyn Rhynd
Director-Environmental Engineer-FEngNZ CPEng IntPE(NZ)
DDI 09 220 5930 | P 09 524 7029 | M 027 454 5533 | Bronwyn.Rhynd@ckl.co.nz | Level 2, 25 Broadway, PO Box 99463, Newmarket, Auckland, 1149 | www.ckl.co.nz

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From: Kedan Li <kedan.li@aucklandcouncil.govt.nz>
Sent: Thursday, 3 November 2022 3:49 PM
To: Bronwyn Rhynd <Bronwyn.Rhynd@ckl.co.nz>; Catherine Liu <Catherine.Liu@ckl.co.nz>
Cc: Andrew Dow <andrew.dow@ckl.co.nz>; Mostafa Baghersad <mostafa.baghersad@ckl.co.nz>; Susan Andrews <susan.andrews@aucklandcouncil.govt.nz>
Subject: RE: [#CKL A20405] [#CKL] Files Issued- A20405 Riverhead Plan Change flood model

Hi Bronwyn,

During our meeting, quote that you said:

1. "The model would be ready very soon."
2. "I would not quote you for anything, just an understanding of the likely timeframe."

With regards to Item 1, I was assuming the model would be ready in around a week time as you said VERY SOON, so that was assumed model ready by 24th October. I have allowed myself three weeks of review while my other work. That three weeks from the 24th hence gives the 12th November.

2, now that I have not yet received the model for review, however it has been almost three weeks from our original conversation, plus only one week till the 12th Nov, and you are quoting me on top of the original email. I am disappointed too.

Hence, I will keep my original rational, three weeks from model been received although I will be out of office mostly next week.

Kedan

From: Bronwyn Rhynd <Bronwyn.Rhynd@ckl.co.nz>
Sent: Thursday, 3 November 2022 3:12 pm
To: Kedan Li <kedan.li@aucklandcouncil.govt.nz>; Catherine Liu <Catherine.Liu@ckl.co.nz>
Cc: Andrew Dow <andrew.dow@ckl.co.nz>; Mostafa Baghersad <mostafa.baghersad@ckl.co.nz>; Susan Andrews <susan.andrews@aucklandcouncil.govt.nz>
Subject: RE: [#CKL A20405] [#CKL] Files Issued- A20405 Riverhead Plan Change flood model
Importance: High

Hi Kedan,

Thank you for updating us on timeframes, it is a little disappointing that the timeframe is now extended, as we discussed this with you previously and you had kept the time to review and get back to us by 12th November (see attached email trail).

I understand that you are busy that is the reason for us discussing the project timeframes with you on 18th October.

Can you please provide us the background to the extended timeframes so that we can provide our client with the reasons for the updated timeframes?

Regards

Bronwyn Rhynd
Director-Environmental Engineer-FEngNZ CPEng IntPE(NZ)
DDI 09 220 5930 | P 09 524 7029 | M 027 454 5533 | Bronwyn.Rhynd@ckl.co.nz | Level 2, 25 Broadway, PO Box 99463, Newmarket, Auckland, 1149 | www.ckl.co.nz
CKL Planning | Surveying | Engineering | Environmental

From: Kedan Li <kedan.li@aucklandcouncil.govt.nz>
Sent: Thursday, 3 November 2022 3:00 PM
To: Catherine Liu <Catherine.Liu@ckl.co.nz>
Cc: Bronwyn Rhynd <Bronwyn.Rhynd@ckl.co.nz>; Andrew Dow <andrew.dow@ckl.co.nz>; Mostafa Baghersad <mostafa.baghersad@ckl.co.nz>; Susan Andrews <susan.andrews@aucklandcouncil.govt.nz>
Subject: RE: [#CKL] Files Issued- A20405 Riverhead Plan Change flood model

Hi Catherine,

Thank you for letting me know.

Just a note on the reviewing timeframe, as we are progressing on the time, my availability changes as well. I will still try to review and come back to you within 3 weeks from the date that I receive the model.

Thank you.

Kind Regards,
Kedan

From: Catherine Liu <Catherine.Liu@ckl.co.nz>
Sent: Thursday, 3 November 2022 2:47 pm
To: Kedan Li <kedan.li@aucklandcouncil.govt.nz>
Cc: Bronwyn Rhynd <bronwyn.rhynd@ckl.co.nz>; Andrew Dow <andrew.dow@ckl.co.nz>; Mostafa Baghersad <mostafa.baghersad@ckl.co.nz>
Subject: [#CKL] Files Issued- A20405 Riverhead Plan Change flood model

Hi Kedan,
Please see the link below for the Riverhead flood model report. The flood model is posted to you through courier this afternoon. Please keep an eye on its arrival.
Click here

The modelled have been updated to the latest version, which is HEC HMS 4.10 and HEC RAS 6.3. Hope you will get them open with no issue. But do not hesitate to give me a call or email if any issue.

Thank you very much for your time in reviewing. Looking forward to your feedback.

Kind regards,

Catherine

Catherine Liu
Senior Environmental Engineer-MEng (Hydrology&Water Resource)
DDI 09 220 5932 | P 09 524 7029 | M 027 700 9402 | Catherine.Liu@ckl.co.nz
L2, 25 Broadway, PO Box 99463, Newmarket, Auckland, 1149 | www.ckl.co.nz

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