Model Build Report

Milldale Stages 14-17 – Fast-track Approvals Act 2024

Fulton Hogan Land Development Ltd

13/08/2026

Issued for Fasttrack Approval

Document Control

Project Number	P25-609
Project Name	Milldale Stages 14-17 – Fast-track Approvals Act 2024
Client	Fulton Hogan Land Development Ltd
Date	13/08/2026
Version	V1
Issue Status	Issued for Fasttrack Approval
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Reviewer	Boniface Kinnear – Principal Water Engineer Sam Kirk – Associate Engineer
Approval	Tim Rickards – Principal
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Statement of Qualifications and Experience

Originator: Chantelle Potbury – Graduate 3 Waters Engineer

I am a Graduate Water Engineer at Wood and Partners Consultants Ltd ("Woods"). Woods is a multi-disciplinary consultancy specialising in planning, urban design, engineering, water infrastructure, and surveying. I have been employed at Woods since November 2024.

I hold the qualifications of Bachelor of Engineering with Honours from the University of Auckland, which I completed in 2024. I am an Engineering NZ emerging professional member.

I have 1.5 years of professional experience in the water engineering field. My experience includes stormwater management, flood management, and stormwater modelling.

I confirm that, in my capacity as author of this report, I have read and abide by the Environment Court of New Zealand's Code of Conduct for Expert Witnesses Practice Note 2023.

Originator: Juan Alvarez De Lugo – Senior Associate Engineer

I am an Associate Water Engineer in the Water Infrastructure & Planning at Wood and Partners Consultants Limited ("Woods") where I have been employed since May 2019.

I hold a Bachelor of Engineering degree from the University of Auckland. I am a Chartered Professional Engineer (CPEng), member of Engineering New Zealand (CMEngNZ) and Water New Zealand. In addition, I also hold the following qualifications and affiliations:

- International Professional Engineer (IntPE(NZ))
- Water New Zealand Modellling group committee member

I have over 12 years of experience in stormwater modelling (hydrology and hydraulic), stormwater model reviews, technical report writing and review, and flood risk assessments for land development. I have been the lead stormwater engineer responsible for employing different software packages to create/review stormwater models and analyse flood hazards for complex land development and infrastructure projects in the public and private sector. Recent projects include:

- Supporting the infrastructure development in multiple neighbourhoods for Kainga-Ora
- Stormwater models conversion for Auckland Council aimed to aid with stormwater catchment planning and decision-making processes
- Creating and reviewing stormwater models and reports to support resource consent applications for multiple Milldale development stages

I confirm that, in my capacity as the author of this report, I have read and abide by the Environment Court of New Zealand's Code of Conduct for Expert Witnesses Practices Note 2023.

Reviewer: Sam Kirk – Associate Engineer

I, Sam Kirk, am an Associate Engineer at Woods. Woods is a multi-disciplinary consultancy specialising in planning, urban design, engineering, water infrastructure, and surveying. I have been employed at Woods since July 2025, although also previously between January 2019 and September 2022.

I hold the qualifications of a Bachelor of Surveying, which I completed in 2018, and I also hold a Cadastral Surveying License. I am also a Voting Member of S+SNZ.

I have eight years of experience in the Engineering industry. My experience includes the design and construction observation of a range of land development projects, including project management and the procurement of earthworks, roading, services and other infrastructure. I have been involved with the surveying, design and management of previous Milldale projects, dating back to Stage 1A. I have also been involved in managing multiple land development projects in London and Melbourne.

I confirm that, in my capacity as the author of this report, I have read and abide by the Environment Court of New Zealand's Code of Conduct for Expert Witnesses Practices Note 2023.

Reviewer: Boniface Kinnear – Principal Water Engineer

I am a Principal Engineer in the Water Infrastructure & Planning at Wood and Partners Consultants Limited ("Woods") where I have been employed since 2020.

I hold a Bachelor of Science in Environmental Engineering from the University of Southern California, Los Angeles, California which I obtained 2004. I also hold a Master of Engineering Studies Degree and a Master of Engineering in Environmental Engineering both from the University of Auckland completed in 2007 and 2008 respectively. I am a Chartered Professional Engineer (CPEng), a chartered member of Engineering New Zealand (CMEngNZ) and an International Professional Engineer (IntPE)/APEC Engineer. Additionally, I am a member of the Environment Institute of Australia and New Zealand (EIANZ) as well as a member of the Rivers Group NZ.

I have over 18 years of experience in environmental management, contaminated land, impact assessments, stormwater design and modelling, flood risk assessments, stream assessments, water infrastructure and stormwater management. I have authored several stormwater management plans, flood modelling reports, infrastructure assessment/design reports, earthworks reports and detailed site investigation reports to support numerous projects.

I confirm that, in my capacity as the author of this report, I have read and abide by the Environment Court of New Zealand's Code of Conduct for Expert Witnesses Practices Note 2023.

Approval: Timothy Rickards – Principal Civil Engineer

I am a Principal Civil Engineer at Wood and Partners Consultants Ltd ("Woods"). Woods is a multi-disciplinary consultancy specialising in planning, urban design, engineering, water infrastructure, and surveying. I have been employed at Woods since Feb 2013.

I hold the qualifications of Bachelor of Engineering (Technology), which I completed in 2008. I am a Chartered Professional Engineer of Engineering New Zealand.

I have 20 years of professional experience in the Engineering industry. My experience includes the design and construction observation of a range of land development projects, including the design of large-scale stormwater systems, stormwater management devices and overland flowpaths as well as undertaking flood risk assessments and flooding effects assessments.

I have lead the design of the stormwater systems throughout the previous stages of Milldale and have an extensive knowledge of development.

I confirm that, in my capacity as the reviewer/ approver of this report, I have read and abide by the Environment Court of New Zealand's Code of Conduct for Expert Witnesses Practice Note 2023.

Contents

Appendices

Appendix A – [Impervious catchment calculations]

Appendix B – [Model results: flood depth and afflux plans (Milldale Stage 14-17)]

1. Introduction

1.1. General Proposal

This flood modelling report has been prepared by Woods on behalf of Fulton Hogan Land Development Limited (FHLD) (the Applicant) in support of the substantive application for the Milldale Stages 14–17 (Milldale North) Project under the Fast-track Approvals Act 2024 (FTAA). The report provides additional commentary to the proposed Stormwater Assessment Report and should be read alongside the Infrastructure Report and the Planning Report.

The Project relates to approximately 231 ha of land centred around Wainui Road in Wainui, Auckland. The proposal provides for a comprehensively planned urban development comprising residential neighbourhoods, a supporting commercial area, transport and servicing infrastructure, open space, ecological restoration and associated enabling works.

1.2. Purpose and Scope of this Report

The purpose of this report is to document the flood assessment undertaken for the proposed Milldale Stages 14–17 Project and present results to be assessed within the Stormwater Assessment Report.

This report mainly:

- Describes the existing flood environment and the basis of the hydrological and hydraulic modelling;
- Presents and summarises the results of the flood modelling exercise
- Identifies changes in flood levels, depths and extents within, upstream and downstream of the Development Area;

The model build has been prepared having regard to the Milldale Stages 14–17 Stormwater Management Plan, the Auckland Unitary Plan, the applicable Auckland Council Stormwater Code of Practice and the TP108 rainfall-runoff methodology.

1.3. Site Description

The Project site comprises approximately 231 ha of land located north of the existing Milldale development and consists of two distinct areas:

- The Development Area – approximately 97 ha containing the proposed Stages 14–17 residential development and the principal earthworks, transport and stormwater infrastructure; and
- Te Korowai o Maraeariki – approximately 134 ha north of the Orewa Awa, containing ecological restoration works, recreational tracks and localised private water-supply and wastewater infrastructure.

This Flood modelling focuses principally on the Development Area, seen in Figure 1. Te Korowai o Maraeariki is considered where its catchments, proposed works or infrastructure interfaces are relevant to the flood assessment. A more detailed description of the site relative to this flood model and its relationship with the wider catchment is provided in Section 4, including the relevant upstream and downstream watercourses, catchments and infrastructure.

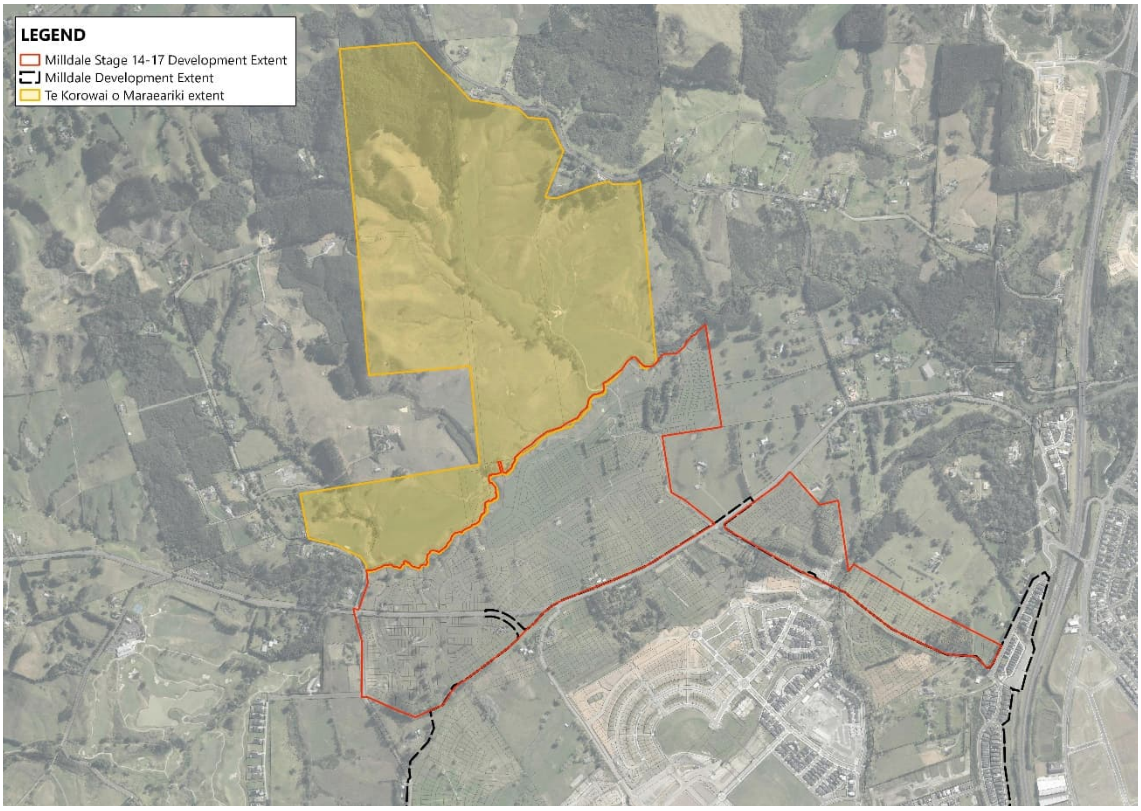

Figure 1: Project site development areas

2. Background

The Wainui East Stormwater Management Plan, Version 4, dated 2016 and prepared by Woods (the Wainui East SMP V4), was developed for the wider Wainui East Future Urban Zone. However, it has been adopted by Auckland Council Healthy Waters only for the live-zoned Wainui Precinct, comprising the existing Milldale development. Within that area, stormwater management is guided by the Wainui East SMP V4 under Auckland Council's regional Network Discharge Consent (NDC).

The approximately 97 ha Development Area associated with Milldale Stages 14–17 remains Future Urban Zone. It is therefore outside the area for which the Wainui East SMP V4 has been adopted and is not presently covered by the existing regional NDC stormwater-discharge framework. The development area and adopted SMP area are shown in Figure 2. A detailed description of this background is provided in the Stormwater Assessment Report.

This flood modelling builds upon the model originally developed for the Wainui East SMP V4 and the subsequent modelling undertaken for the consented Milldale Stages 10–13 Fast-track application. The model has been updated to represent the proposed Stages 14–17 landform, catchments and relevant stormwater infrastructure. The model development, assumptions and results are described in the following sections of this report.

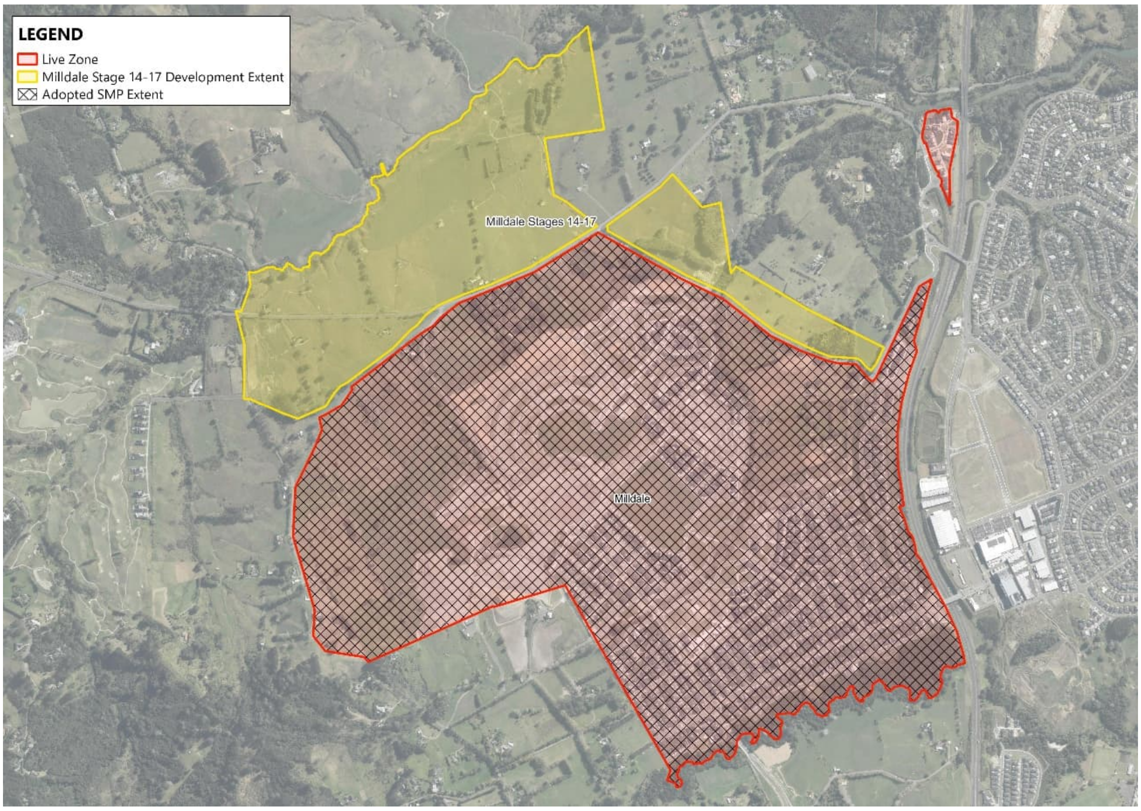

Figure 2: The Wainui Precinct and Proposed Milldale Stages 14-17 development extents

3. Flood Management

As per the Milldale Stage 14-17 Fast-track Stormwater Assessment Report, the stormwater management measures have been divided into five stormwater management zones (Zones A-E, as shown in Figure 3). These zones detail both the stormwater and flood management approach to be incorporated based on various factoring including location and discharge environment. This is discussed in detail in the Stormwater Assessment Report.

The flood modelling scenarios undertaken for the proposed Milldale Stages 14-17 development flood assessment are summarised as follows:

- Pre-Development – Existing Development (ED) - land use as per:
    - 5% for Stages 14-17
    - 65% for Current Live Zone Wainui/ Milldale Precinct
    - Impervious coverage for all other zones as per AUP

- Post-Development – MPD land use as per:
    - 70% for Stages 14-17
    - 80% for proposed road catchments
    - 65% for Current Live Zone Wainui/ Milldale Precinct
    - Impervious coverage for all other zones as per AUP

Catchment impervious percentages were derived from post-development MPD land use calculations for the 10-year and 100-year events. Refer to Appendix A for impervious calculations.

Model scenarios were simulated for the 2-year, 10-year and 100-year ARI storm events with allowance for 3.8 °C temperature increase by 2110 as per the Milldale Stages 14-17 Fast-track Stormwater Assessment Report and Stormwater Code of Practice, Version 4, March 2026 (SWCoP).

The following sensitivity scenarios are also assessed:

- The proposed infrastructure performance with allowance for blockage and overtopping risk/hazard that may be posed to the surrounding areas (if any); and
- Sensitivity to tidal boundary conditions.

Further details on flood modelling in Section 5.

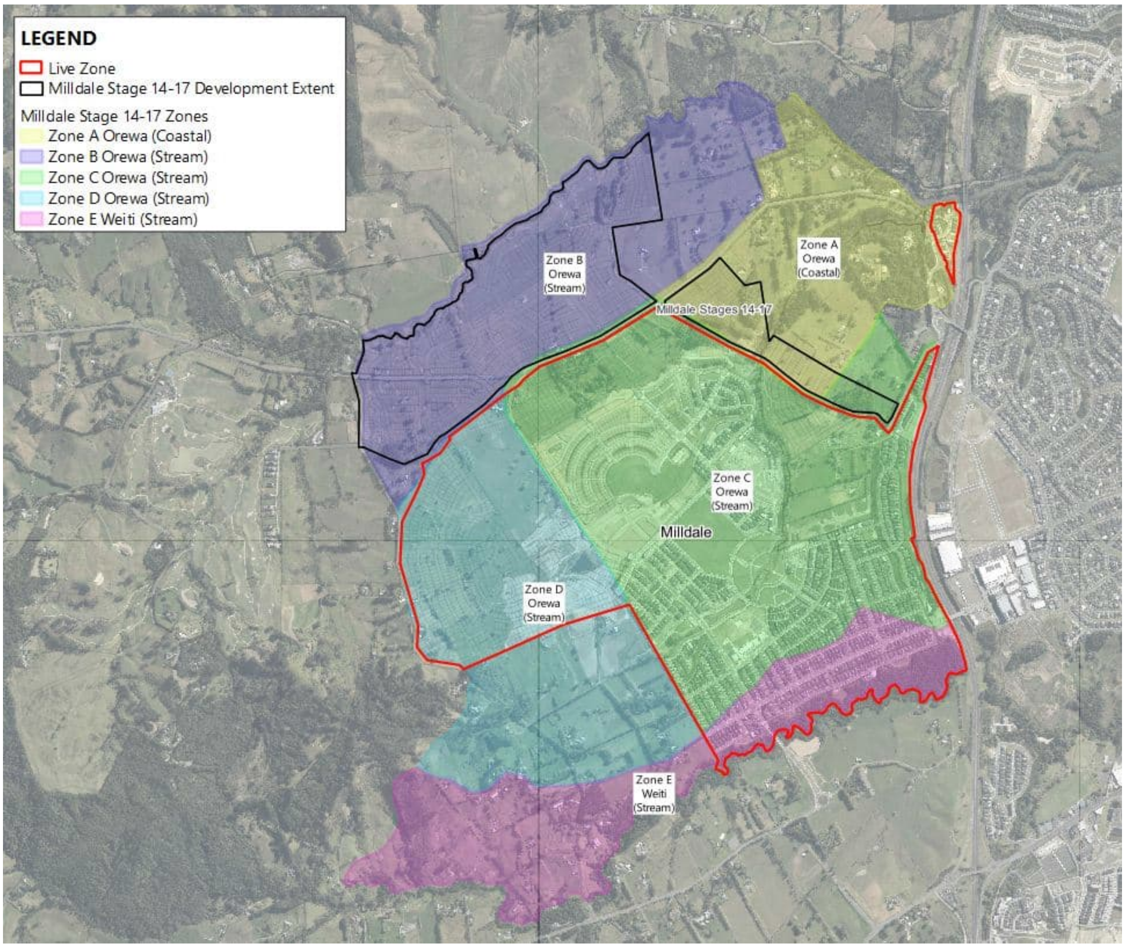

Figure 3: Stormwater Management Zones

4. Site Description

This section describes the physical setting relevant to the flood model, including the location of the Development Area, surrounding land uses, topography, watercourses and existing stormwater infrastructure. It also provides context for the wider modelled catchment, which extends beyond the Project site to assess potential upstream and downstream flood effects.

A full description of the Site and surroundings is provided in Stormwater Assessment Report.

4.1. Location

The Project site is located north of the existing Milldale development, west of Silverdale and Orewa, and near the State Highway 1 Wainui Road interchange. The flood model extends beyond the Project site to represent the wider upstream and downstream catchments and receiving watercourses. This allows potential flood effects to be assessed both within the Development Area and at relevant locations beyond its boundaries.

The Project site, Development Area and wider flood-model extent are shown in Figure 4.

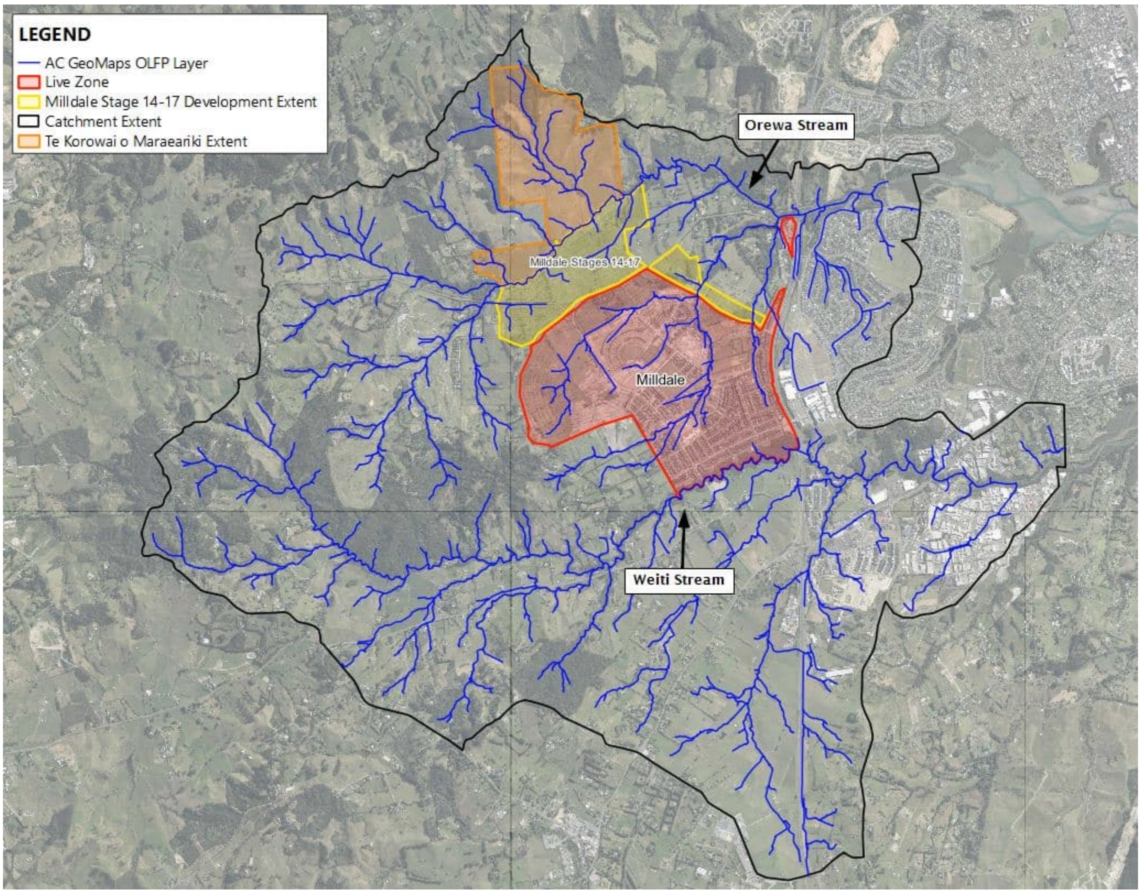

Figure 4. Milldale Stages 14-17 site locations

4.2. Existing Land Uses

The proposed Milldale Stages 14-17 development area is currently utilised for agricultural purposes, primarily grazing. There are various residential and commercial (linked to agriculture) structures located within the area. Additionally, along Wainui Road, there is a golf course and the Northridge Country Lodge, that serves as a function centre.

4.3. Watercourses

An ecological assessment has been undertaken by Virdis Environmental Consultants, which identified the intermittent and permanent streams within the proposed Milldale Stages 14-17 development area that are to be retained as part of the proposed development. Three permanent streams have been identified:

- Orewa River (P1)
- Waterloo Creek (P2)
- Waterloo Creek tributary (P3)

The freshwater features within Milldale Stages 14-17 are shown in Figure 5 and further information on the assessment can be found in the ecological reporting provided by Virdis in support of this application.

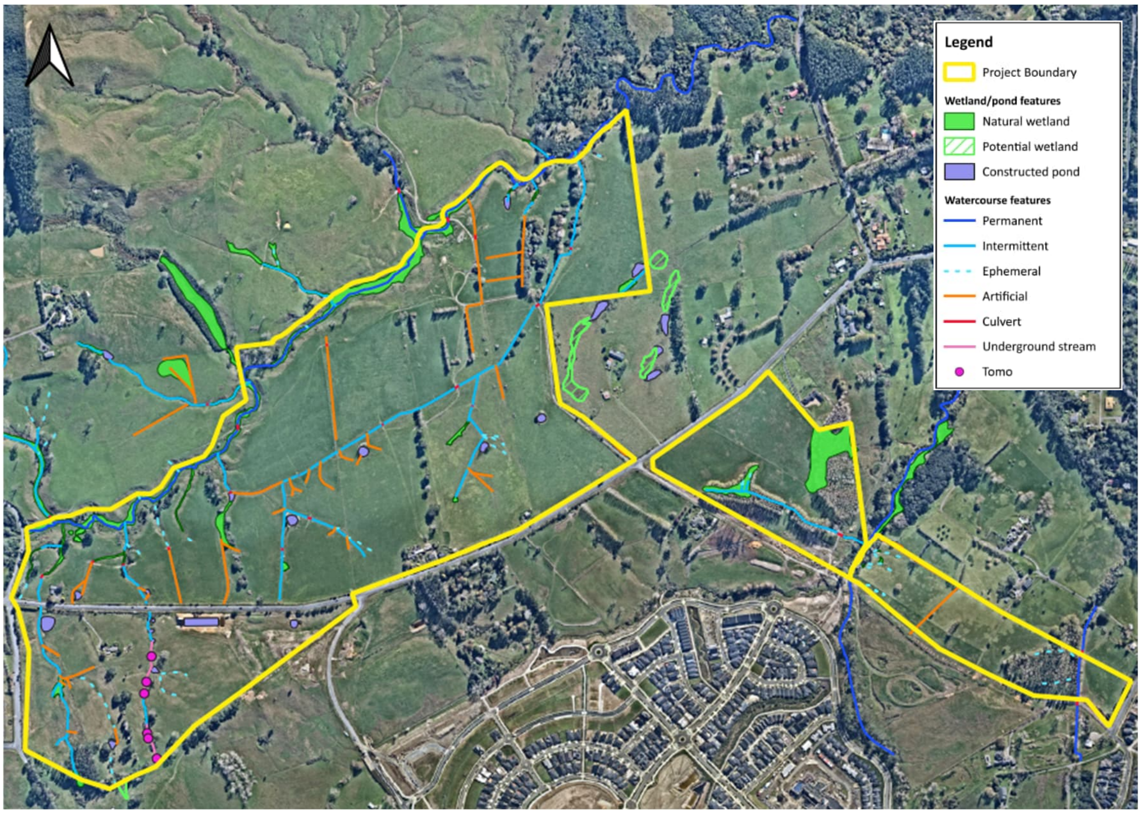

Figure 5: Freshwater features within Milldale Stages 14-17 Development Area (Source: Virdis, March 2026)

4.4. Existing Stormwater Infrastructure

Auckland Council GeoMaps indicates the presence of numerous existing stormwater assets along Wainui Road, Gervin Road and near Cemetery Road. These assets predominantly appear to comprise culverts associated with the road drainage network, and they can be seen in Figure 6.

Figure 6: Existing Stormwater assets along Wainui Road, Gervin Road, and Lysnar Road

Asset data was collected during the topographical survey of the proposed Milldale Stags 14-17 development area, and they can be seen in the survey plans provided in the Milldale Stage 14-17 FT Infrastructure Design Report. The surveyed culvert data is summarised in Table 1.

Table 1: Existing culvert data summary

ID	Shape	Length (m)	Size (m)	US Invert Level (m RL)	DS Invert Level (m RL)
Link363	Circular	30.16	4.5	17.27	16.57
Link362	Circular	12.34	2.05	14.82	14.58
Link211	Circular	18.96	0.3	24.53	24.08
Link212	Circular	17.11	0.3	24.23	23.42
Link221	Circular	14.62	0.3	24.84	24.52
Link334	Circular	17.12	0.45	28.16	27.43
Link213	Circular	6.21	0.3	22.20	21.90
Link220	Circular	6.19	0.3	21.56	21.53
Link224	Circular	6.03	0.375	20.93	20.79
Link324	Circular	4.24	0.3	32.54	31.82
Link325	Circular	6.13	0.3	28.37	27.96
Link237	Circular	5.88	0.375	19.72	19.46
Link227	Circular	6.11	0.375	21.61	21.53
Link354	Circular	6.04	0.45	13.62	13.41
Link231	Circular	2.48	0.525	20.01	20.06
Link228	Circular	3.3	0.3	22.87	22.79
Link233	Circular	2.74	0.225	19.57	19.67
Link229	Circular	6.13	0.3	19.08	19.98
Link230	Circular	6.09	0.3	19.09	18.96

Link234	Circular	5.81	0.3	18.48	18.21
Link236	Circular	6.06	0.3	17.98	17.96
Link235	Circular	4.28	0.3	17.98	18.00
Link232	Circular	4.2	0.6	16.83	16.90

Key assets outside the proposed Milldale Stages 14-17 development area were identified along the Orewa River and Waterloo Creek, including:

- Wainui Bridge
- Kowhai Bridge
- Upper Orewa Bridge

These structures have been surveyed as part of previous assessments, with their details summarised in Table 2 and their location shown in
Figure 7.

Table 2: Modelled Bridges

Bridge Name	US IL (m RL)	DS IL (m RL)	Length (m)	Max WSEL (m RL)	High chord elevation (m RL)	Low chord elevation (m RL)	Skew angle (degrees)	Survey
Kowhai	2.64	2.62	16.33	12	9.28	7.95	N/A	Yes
Wainui	-0.34	-0.47	18.50	10	5.44	4.79	28	Yes
Upper Orewa	5.57	5.31	30.42	22.75	12.75	12.25	19	Yes

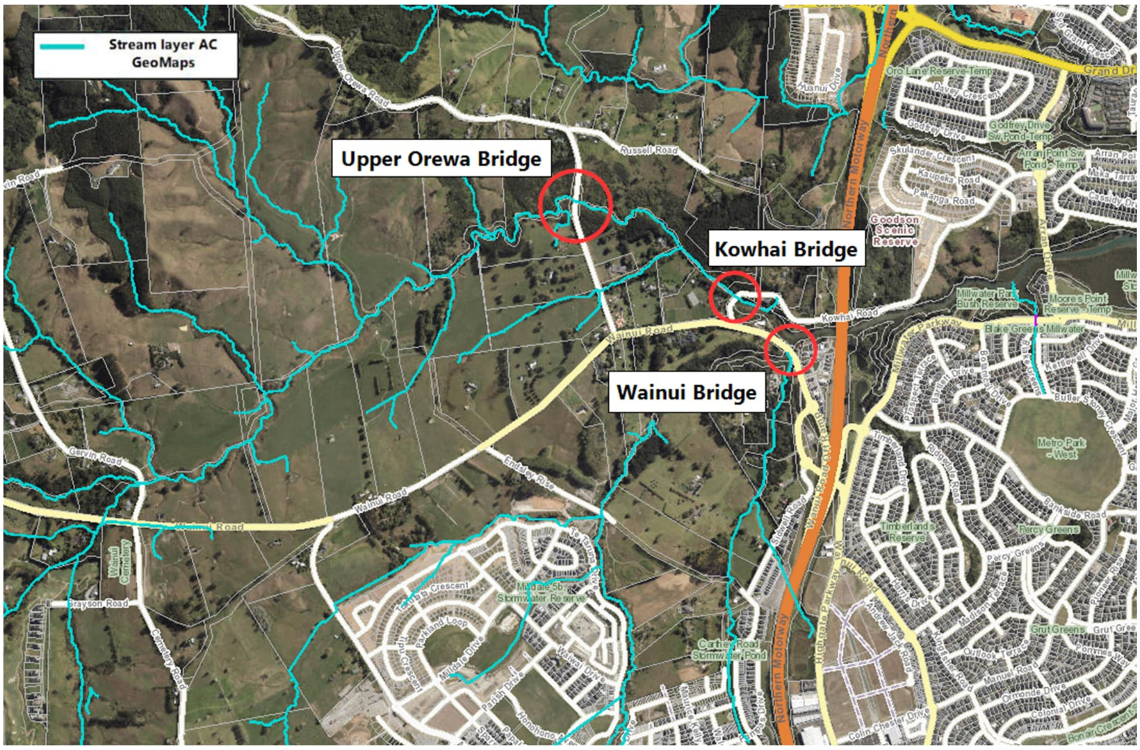

Figure 7: Locations of modelled bridges

5. Flood Model Build

The flood modelling undertaken for this flood assessment is not only an update to the previously issued Wainui East Flood Model Build Report V1 as part of Wainui East SMP (V4 - Woods, Sept 2016), but also it builds on from the Milldale Stages 10-13 Fast Track models.

5.1. Modelling software

XPSWMM 2024.2 by Innovyze was used to model the scenarios presented in this document.

5.2. Model Extent

The catchment extent has a total area of approximately 3336 ha and it has the following two final discharge locations (as also shown on Figure 8):

- Orewa Estuary
- Weiti Stream

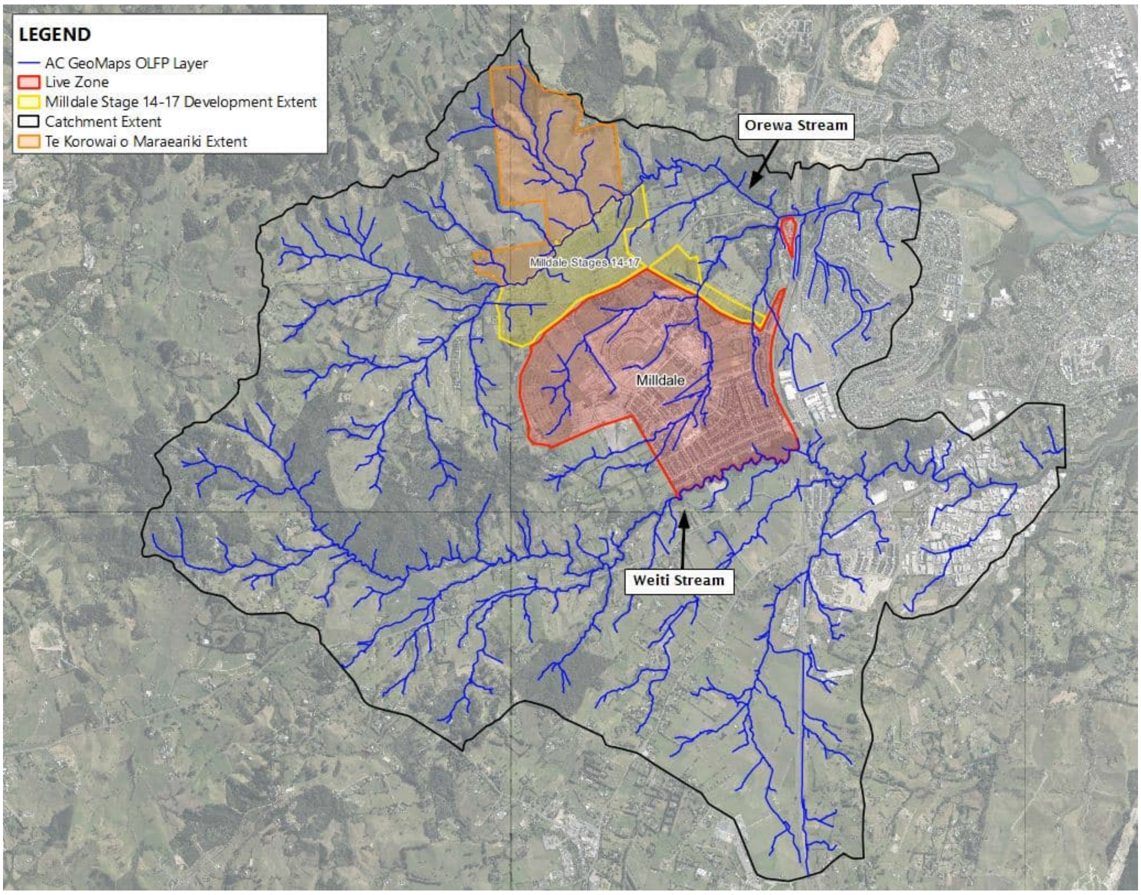

Figure 8: Model catchment extent

5.3. Model Terrain

This section refers to the topographical data and assumptions used to represent the surface in the modelled scenarios discussed in the following sub-sections.

5.3.1. Landform Data

Woods used raw ground classified point cloud data from the Auckland Council LiDAR Dataset 2024 and topographical data to represent the existing surface for flood modelling. It is noted that the modelled surface within the Milldale development area has been represented as follow:

- As-built surface where available
- Consented design surface for stages yet to be completed
- Existing landform for 147 Argent Lane (an undeveloped block within the development that is not owned by FHLD)

The modelled surface for the pre-development model scenarios is shown in Figure 9.

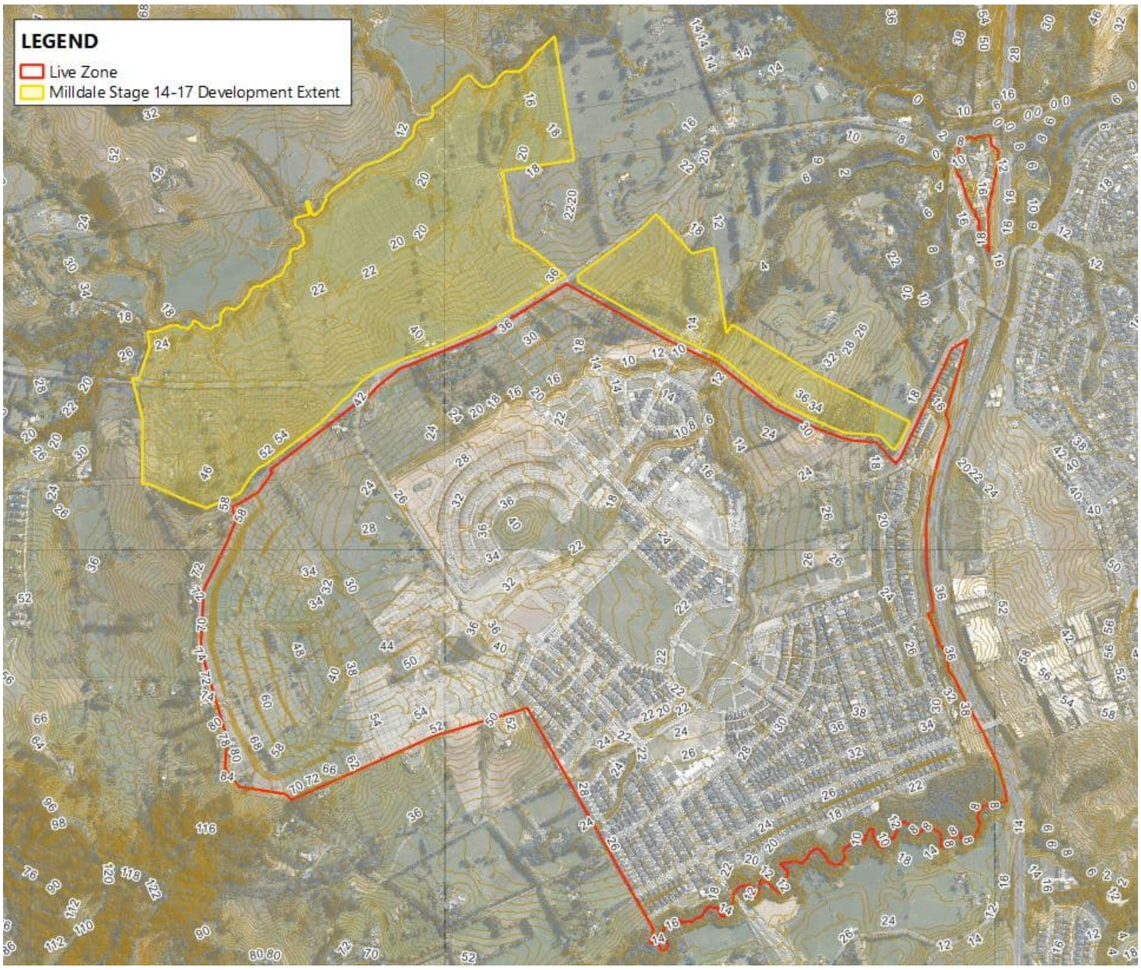

Figure 9: Predevelopment model scenario surface topography

The modelled surface for the post-development model scenarios has been updated to include the proposed design contours for the proposed Milldale Stages 14-17 development area as shown in Figure 10.

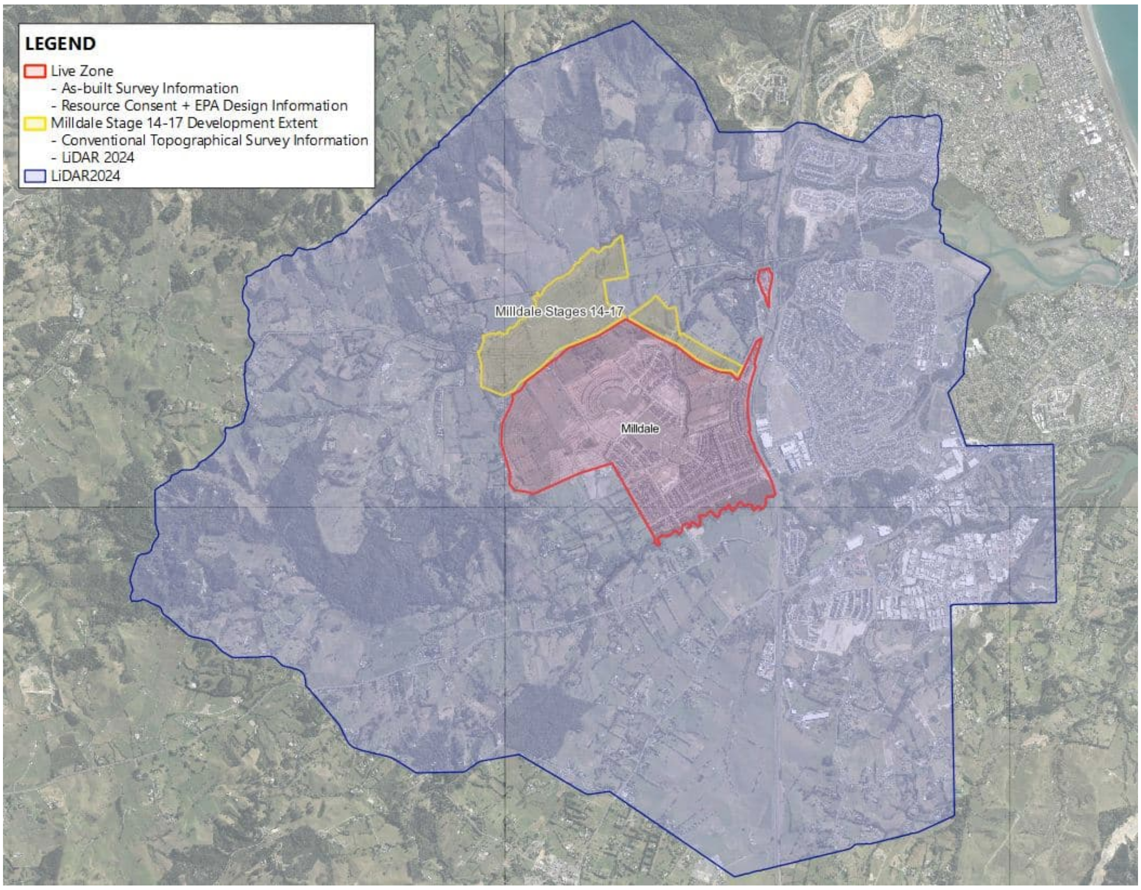

Figure 10: Post-development model scenario surface topography

5.3.2. Model Grids

A total of three 2D grid resolutions were used to represent the terrain in the flood model as follow:

- 0.75m resolution: Represent intermittent and permanent streams identified in the Structure Plan extent as well as few other streams
- 1.5m resolution – Allow for a smooth transition and stability matters between the 0.75m and 3m grids
- 3m resolution - Represent runoff and wider floodplains

Figure 11 shows the different model grid extents.

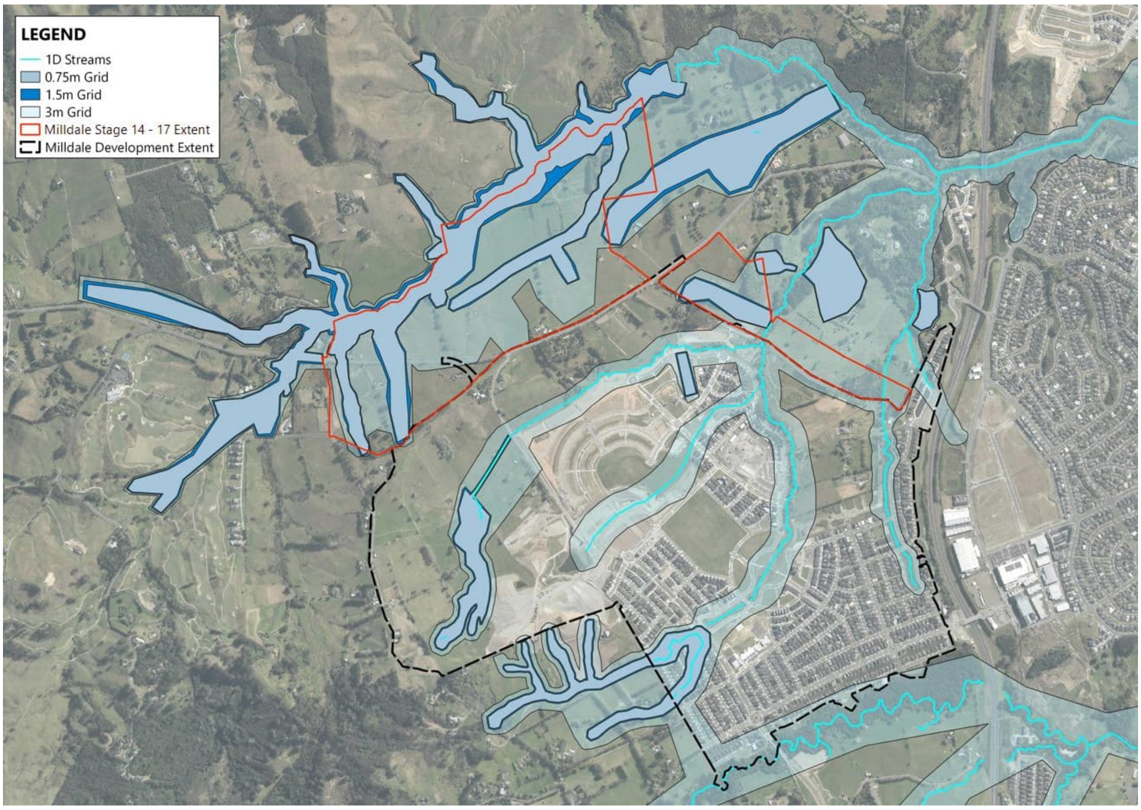

Figure 11: Model grid extents

5.3.3. Watercourses

Watercourses within the flood models have been represented based on ecological assessments, survey data, GIS analysis, and previously modelled information.

Initial surveys for the Milldale development (from 2016) included full topographic and cross-section surveys of watercourses downstream of Argent Lane discharging to the Orewa River. Hydrographic surveys were also undertaken in the Orewa Estuary where traditional methods were not feasible, and this survey data has been incorporated into the current flood models.

Major watercourses within the flood model that were originally represented in 1D i.e., Weiti stream and Waterloo Stream, have kept this representation in all scenarios for consistency the previous flood models that were developed for Milldale Stages 10-13 Fast Track models. The 1D cross-sections were limited to the stream bank extents and any overflow from this, traverses over to the modelled terrain.

The Orewa Stream, the primary watercourse within Milldale Stages 14-17, has been updated from a 1D to a 2D representation. The reach from upstream of the Orewa Stream to immediately upstream of the Upper Orewa Bridge is modelled in 2D, while the Upper Orewa Bridge structure remains represented in 1D.

All the streams identified in the proposed Milldale Stages 14-17 development area extent have been modelled with 2D grids in all scenarios. These streams are considered pre-liminary and subject to further detail design completed during future development stages. The extents of the streams modelled in 1D and 2D are shown in Figure 13 for the pre-development scenario and in Figure 13 for the post-development scenario.

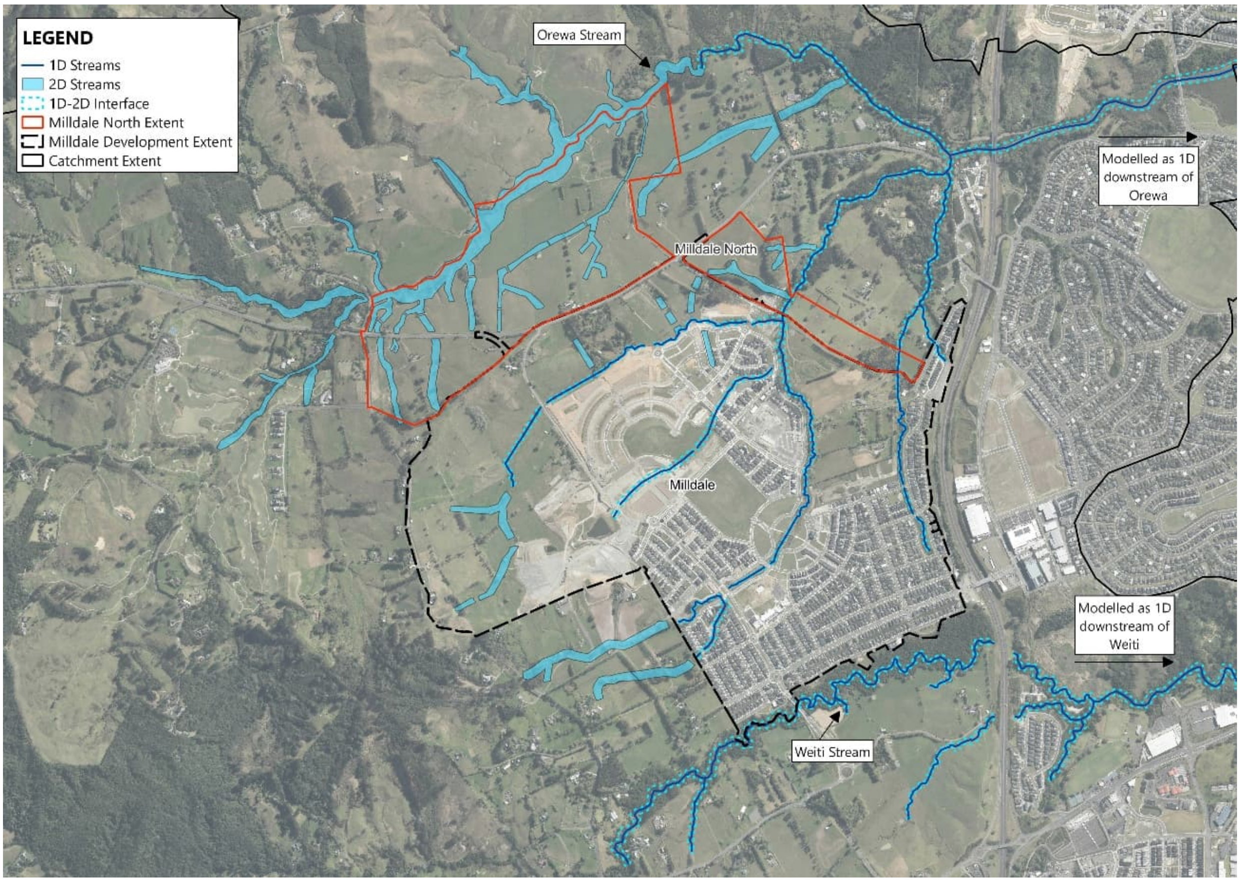

Figure 12: Modelled stream extents pre-development scenario

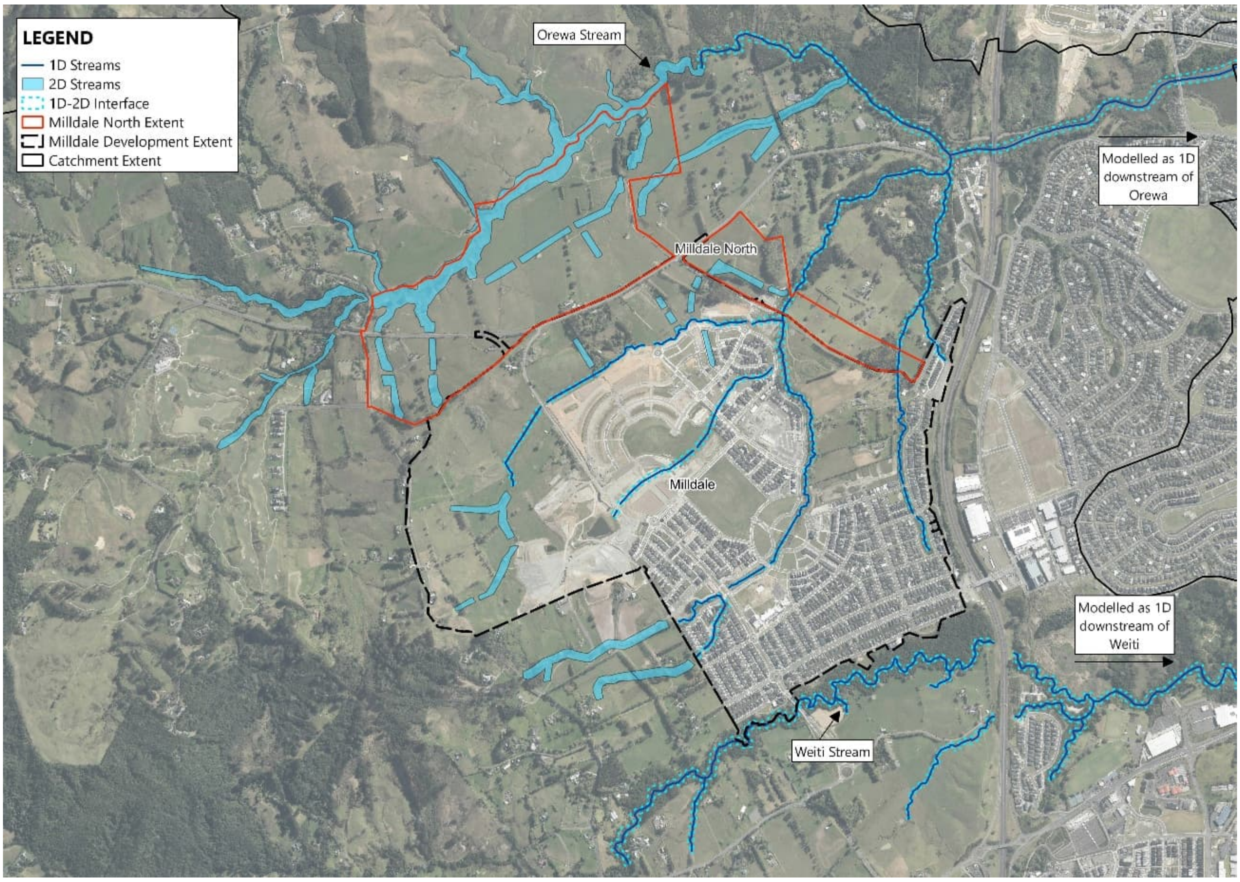

Figure 13: Modelled stream extents post-development scenario

5.3.4. Manning's Roughness Coefficients (2D)

The manning's roughness coefficient used in the flood modelling are as follows:

- 0.06 for bed level for select streams based on aerials and site visits, otherwise 0.03
- 0.08 for overbank, floodway, floodplain and vegetated areas
- 0.02 for roads

5.4. Hydrology

5.4.1. Rainfall-Runoff methodology

The flood models use the Soil Conservation Services (SCS) Unit Hydrograph method used to transform rainfall into runoff as specified in the former Auckland Regional Councils Technical Publication 108 (TP108). Normalized 24-hour temporal rainfall profiles (existing and with future climate change allowances), as specified in TP108, has been adopted for the flood modelling. The normalised rainfall profiles adopted are based on SWCoP, Version 4, March 2026 for future temperature increase of 3.8°C by 2110 and the profiles are shown in Table 3.

Table 3: TP108 normalised 24-hour temporal rainfall profile

Time [hrs:min]	Time interval [min]	TP-108 (normalised rainfall intensity [I/I24])	
		Existing condition	3.8°C Climate Change
0:00 –	360	0.34	0.27
6:00 –	180	0.74	0.66
9:00 –	60	0.96	0.85
10:00 –	60	1.4	1.40
11:00 –	30	2.2	2.36
11:30 –	10	3.8	4.35
11:40 –	10	4.8	5.5
11:50 –	10	8.7	9.97
12:00 –	10	16.2	18.56
12:10 –	10	5.9	6.76
12:20 –	10	4.2	4.81
12:30 –	30	2.9	3.2
13:00 –	60	1.7	1.77
14:00 –	60	1.2	1.14
15:00 –	180	0.75	0.7
18:00 – 24:00	360	0.4	0.34

5.4.2. Rainfall

The 24-hour rainfall depths for the 2-year, 10-year and 100-year ARI design storms were obtained from the currently operative TP108's rainfall design isohyets graphs, based on the centroid of the catchment. To incorporate 3.8°C future climate change, the rainfall depth was then increased by respective percentages based on the SWCP(V4).

An additional scenario was included to incorporate the revised rainfall depths based on a draft TP108 guidance document. More information is available on the revised TP108 rainfall depths in the stormwater assessment report, Section 8.3.2.

The rainfall data is summarised in Table 4.

Table 4: TP108 rainfall depths

Event	TP108 rainfall depth (mm)	% Increase due to 3.8 °C Climate Change	Rainfall depth + allowance for 3.8°C Climate Change (mm)
2 Year ARI (50% AEP)	88	27.4%	112.1
10 Year ARI (10% AEP)	145	30.8%	189.6
100 Year ARI (1% AEP)	225	32.7%	298.6
100 Year ARI (1% AEP) Revised TP108	260	32.7%	345.0

5.4.3. Sub-catchment Delineation

The hydrological model is linked by having sub-catchments draining directly to loading nodes.

The sub-catchments delineation has been updated using the topographical data covered in Section 5.3, while also considering landform changes undertaken to date and anticipated as part of the consented Milldale Stages 10-13.

The sub-catchments summary is shown in Table 5.

Table 5: Subcatchment Summary

Hydrological model components	ED	MPD (10-year)	MPD (100-year)
Number of sub-catchments	157	164	181
Range of sub-catchment size	0.42 - 714 ha	0.19 - 714 ha	0.20 - 714 ha

Figure 14 shows a schematic of the pre-development model scenario sub-catchments. The 10yr, and 100yr post-development model scenario sub-catchments delineation includes the design surface for the proposed Milldale Stages 14-17 development area and are respectively shown in Figure 15 and Figure 16.

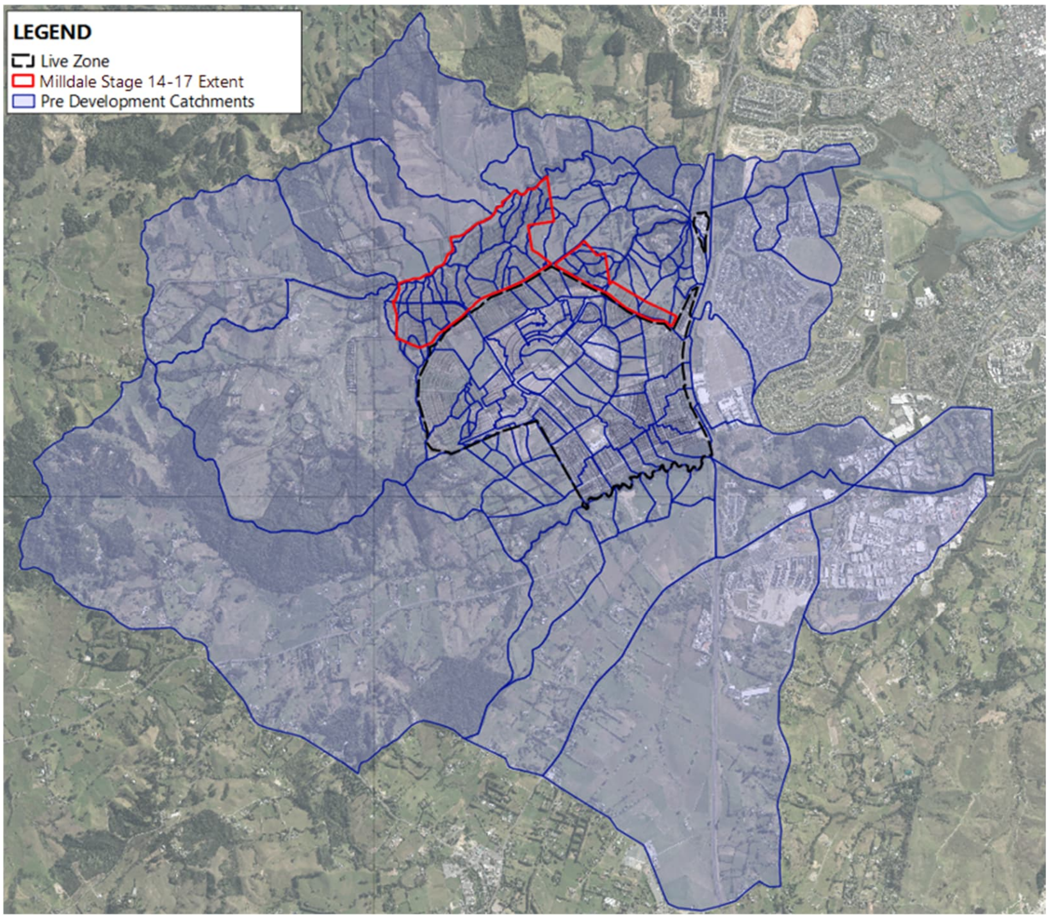

Figure 14: Pre-development subcatchment delineation for Milldale Stages 14-17

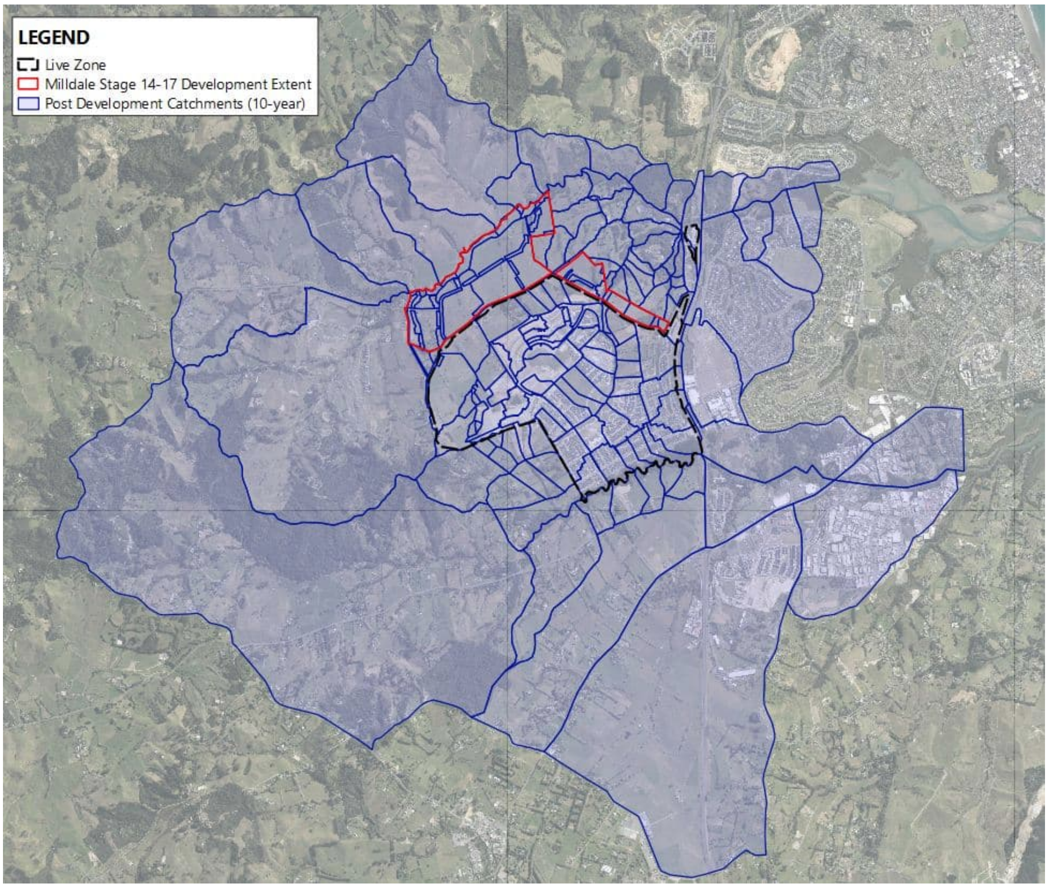

Figure 15: Post-development 10-year subcatchment delineation for Milldale Stages 14-17

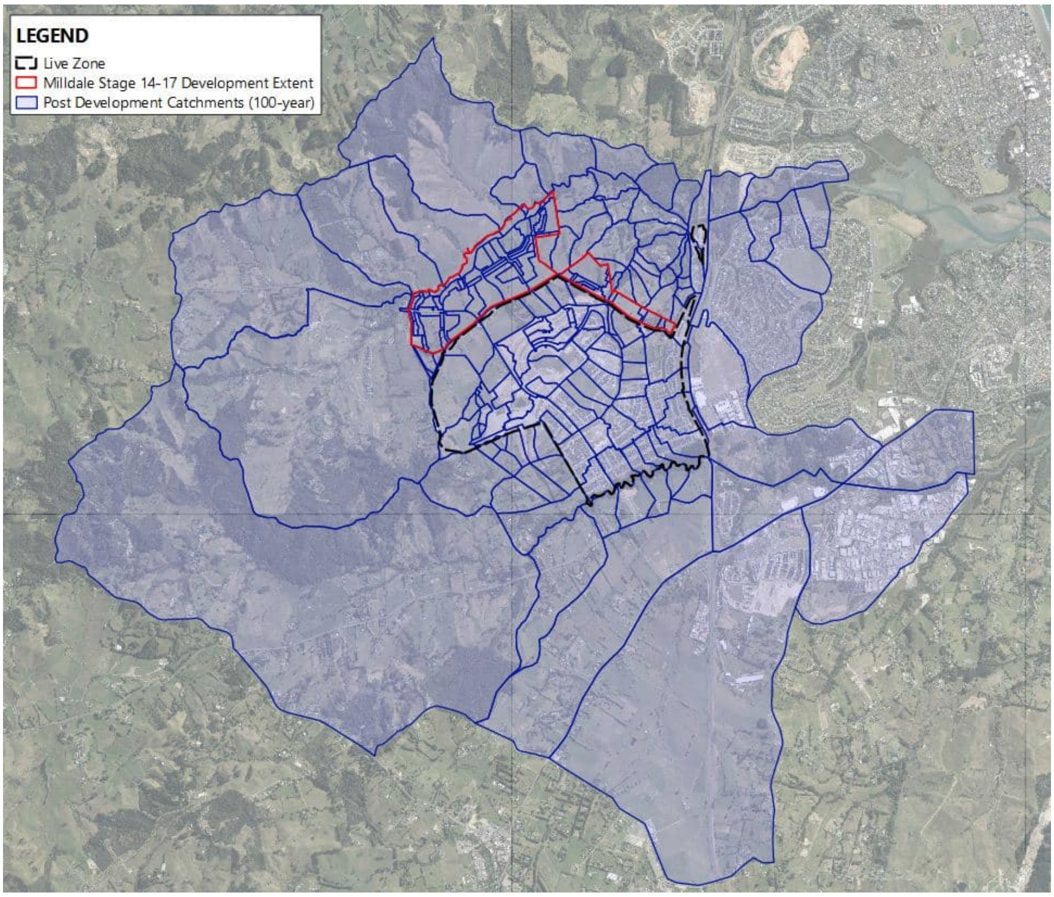

Figure 16: Post-development 100-year subcatchment delineation for Milldale Stages 14-17

5.4.4. Impervious Coverage

Impervious coverages have been used varyingly based on the purpose of each modelled scenario and this is further discussed in Section 3. Impervious coverage for sub-catchments is modelled as either with Existing Development (ED) coverage or Maximum Probable Development (MPD) coverage.

5.4.4.1. Existing Development (ED) Impervious Coverage

In the pre-development models, an impervious coverage of 5% is adopted for the areas which are currently zoned as Future Urban Zone (FUZ) based on Auckland Unitary Plan (AUP). This is consistent with the Wainui East Flood Model Build Report V1.

5.4.4.2. Maximum Probable Development (MPD) impervious coverage

Sub-catchment areas which fall under live zones as per Auckland Unitary Plan Viewer have been modelled with the recommended MPD impervious coverage shown in the 'Land Use Zone Imperviousness for Hydraulic Modelling based on the Auckland Unitary Plan Operative in Part (AUP OiP)'.

Catchments within Milldale Stages 14-17 were assessed using refined post-development impervious percentages to provide a more reliable estimate. A high-level assessment of the development catchments was undertaken to establish specific impervious rates with the average calculated impervious percentage taken for each area.

Milldale Stage 14-17 Development Area catchments are modelled at 70% imperviousness, while Development Area Road-Only catchments are modelled at 80%.

Catchments outside the development area retain their existing impervious percentages. These parameters are consistent with the approach outlined in the Wainui East Flood Model Build Report V1. A summary of the applicable underlying zones and MPD impervious coverages are included in Table 6. The AUP zones within the catchment extent are shown in Figure 17.

Table 6: Summary of zones and MPD Impervious coverages

Zone type	Impervious %
Millwater (Single House)	65
Milldale (Single House)	65
Single House	60
Large Lot	10
Milldale Stages 14-17	70*
Road Catchments	80
Mixed Rural	10
Rural Production	10
Countryside Living	10
Heavy Industry	80
Light Industry	80
General Business	80
Town Centre	100
Public Open Space (Conservation/ Community/ Information Recreation)	Lesser of 10% or 5000m^2

*Future urban coverage based on Wainui East Precinct zoning plan

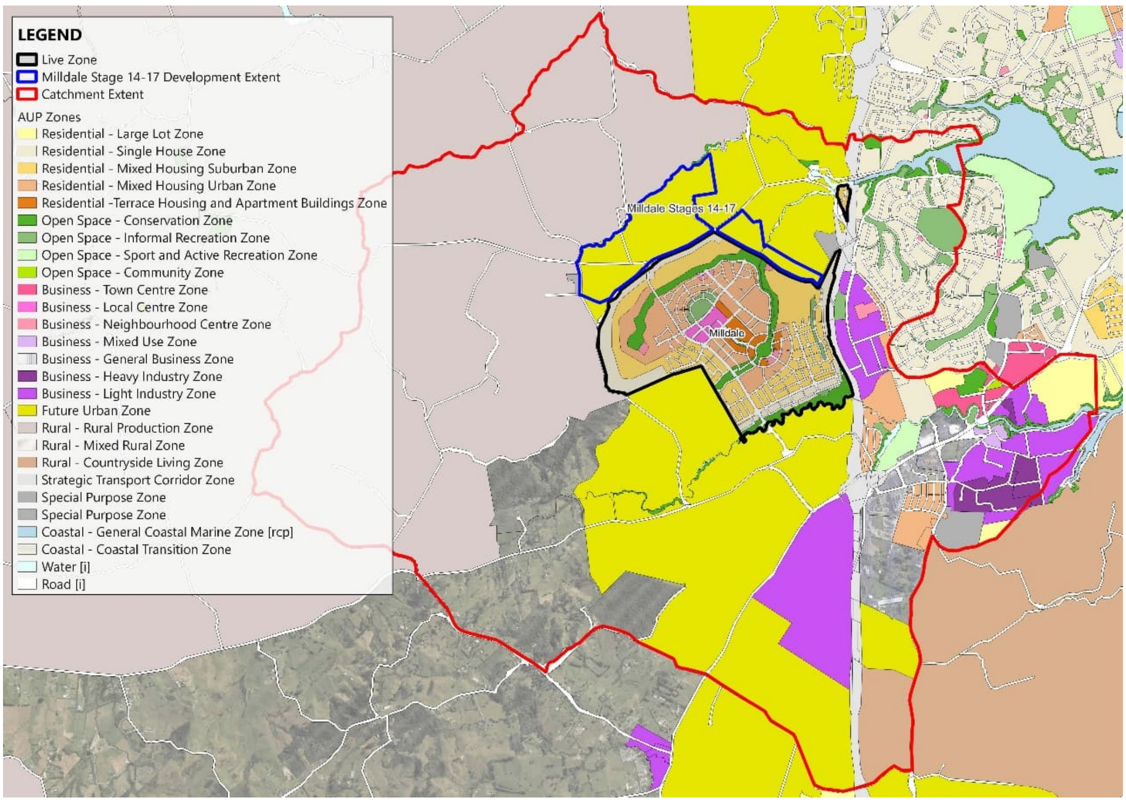

Figure 17: AUP zoning for Milldale Stages 14-17 catchment

5.4.5. Curve Number (CN)

The curve number has been determined using the SCS Hydrology Method as set out in TP108. The catchment has been modelled as hydrological soil group C following which the pervious part of the sub-catchments has been modelled with a CN of 74 as the existing land is predominantly pasture for grazing and in 'good' hydrological condition while, for future development, the pervious area can be considered to be urban lawns.

5.4.6. Initial Abstraction

Initial abstraction accounts for losses that occur before runoff begins as a result of depression storage, interception by vegetation, evaporation and infiltration. The stormwater modelling has been undertaken using the initial abstraction depths of 5mm for pervious surfaces and 1mm (1mm is due to a limitation in XPSWMM that doesn't allow 0 values) for impervious, as stated in TP108.

5.4.7. Channelization Factors

A channelization factor of 0.6 and 1.0 was used for impervious and pervious areas respectively.

5.4.8. Areal Reduction Factors

There are no areal reduction factors applied in the model.

5.4.9. Time of concentration

The time of concentration was determined based on TP108 methodology. Catchment length and landform profile were calculated for identified longest flow path based on the topographical data. Equal area method was used to calculate slope for each sub-catchment. The time for concentration was then calculated as per TP108 guidelines with a minimum value of 10 minutes.

5.5. Hydraulics

A 1D/2D hydraulic model was developed using XPSWMM version 2024.2 which dynamically couples the two elements to enable flow to interface between them. It is noted that the modelling undertaken does not include the primary network. The entire proposed Milldale Stages 14-17 development will include a reticulated primary stormwater network which will be designed for up to the 10-year ARI event (inclusive of climate change). The flood modelling loads stormwater sub-catchments to the streams and open channels, this is suitable for events greater than the 10-year ARI event, with smaller events being contained within the primary network, therefore surface flooding along the road should be discounted in these smaller events.

5.5.1. Mannings Roughness Coefficients (1D)

The manning's roughness coefficient used in the flood modelling are as follows:

- 0.06 for bed levels channels represented in 1D or 0.03 for bed level in channels sections near the Orewa estuary and the Weiti stream outlet as well as for other select stream extents represented in 1D as previously agreed with Healthy Waters.
- 0.014 for concrete pipes

5.5.2. Losses

Culverts and bridges have been modelled with the following losses:

- Entrance loss: 0.50
- Exit loss: 1.0

5.5.3. Bridges

Bridges have been modelled as a "bridge link" (including high cord and low cord elevations representing the top of deck and underside of the bridge) or a multilink with a "natural channel link" with weirs represented at the high cord elevation.

5.5.4. Boundary Conditions

5.5.4.1. Tidal

The tidal boundary conditions applied in the stormwater model for the Orewa River and Weiti Creek are summarised in Table 7 and shown in Figure 18. It is noted that the boundary conditions applied in the Wainui East SMP (Woods, Sept 2016) were lower as the allowance for sea level rise was only +0.50 m.

The adopted sea level rise assumptions were determined using the MfE publication – Coastal Hazards and Climate Change Guidance (2024). The tidal boundary conditions use a timeframe out to 2130 while applying the medium confidence SSP5-8-5 H+ based relative sea level rise (RSLR) projection. This projection includes the relevant vertical land movement for the local area and approximately 1.6 metre rise in mean sea level.

Table 7: Boundary conditions based on MHWS 10%ile allowing for +1m sea level rise

	Tidal Boundary Condition
Orewa River	3.72 m RL
Weiti Creek	3.79 m RL

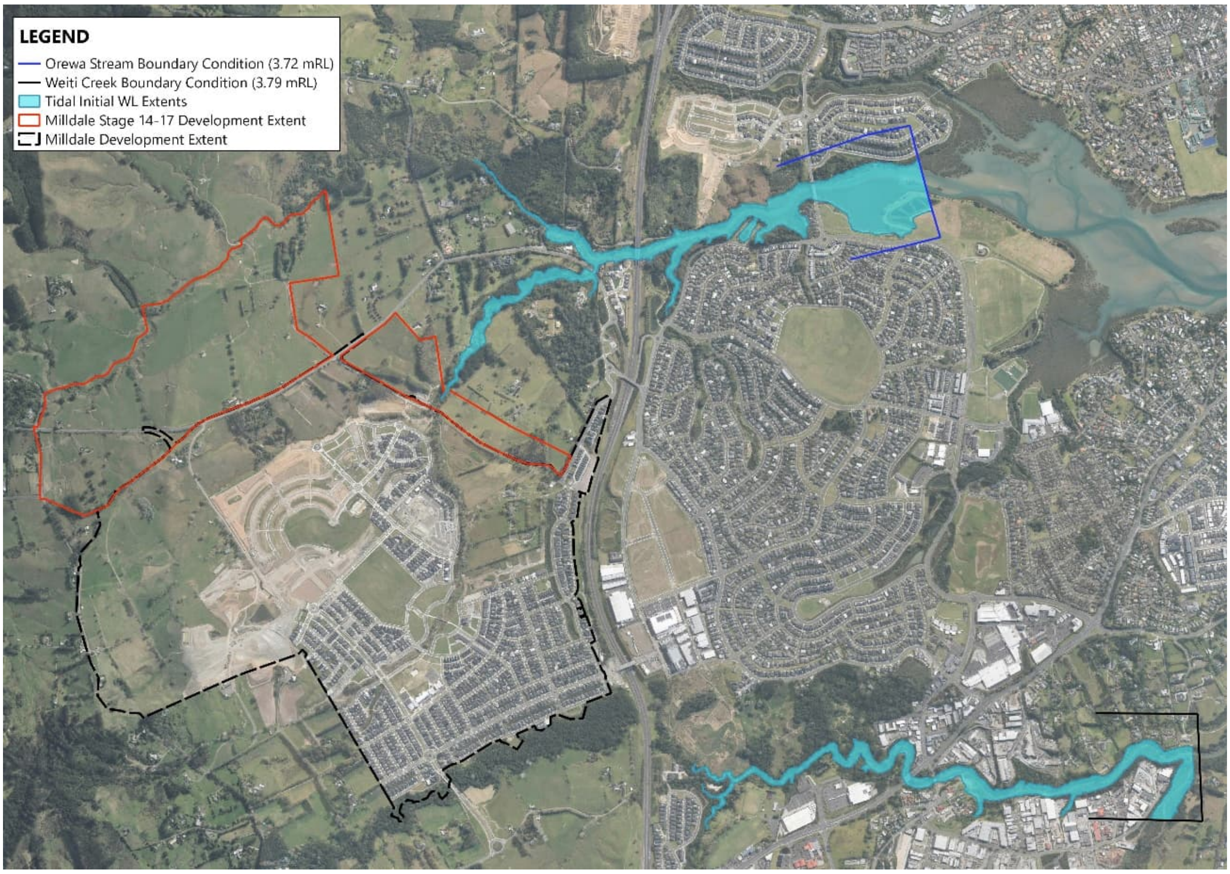

Figure 18: Tidal Boundary Conditions included in the Milldale Stage 14-17 model

5.5.4.2. Highgate Stormwater Pond

The Highgate stormwater pond has been modelled based on the information outlined in the Highgate Stormwater Pond Design report (Highgate catchment One - Stormwater Design Report, December 2014) along with updated design information provided by the project engineers who undertook the design. The Highgate development included the construction of a stormwater pond that discharges flow via a 1600 mm culvert (surveyed and located under the Northern Motorway) into a watercourse within the Wainui East Precinct.

User inflows hydrographs from the neighbouring Highgate stormwater pond for the 2-year, 10-year and 100-year assuming 2.1 °C future climate change were included in the flood model for all scenarios accordingly.

It is noted that Highgate stormwater pond design was not undertaken for 3.8 °C future climate change allowance and so modelled scenarios for the 3.8°C climate change event includes the 2.1°C climate change storm event inflow hydrograph.

Figure 19 shows the location of the stormwater pond.

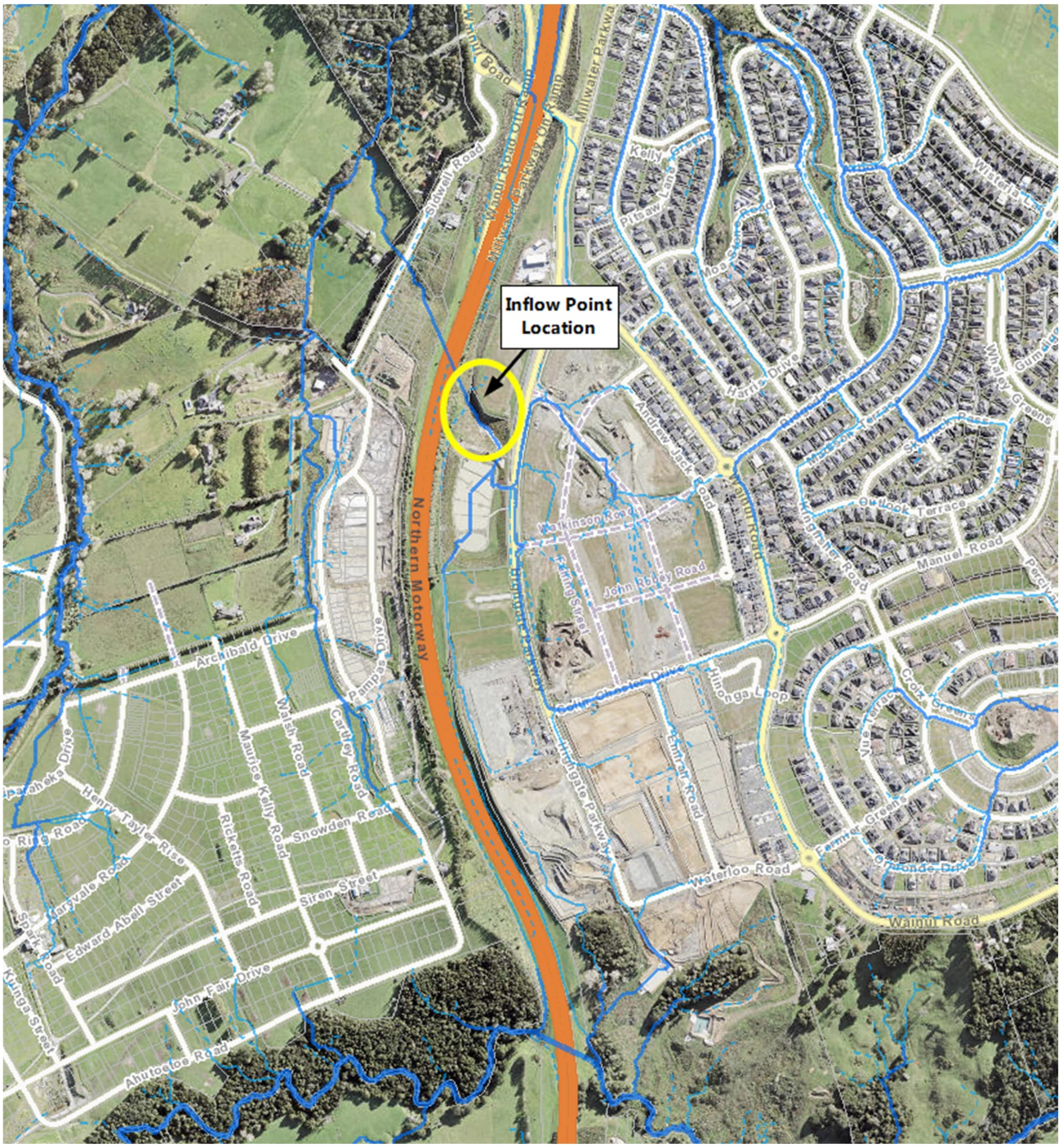

Figure 19: Highgate stormwater pond location

6. Flood Model Results

Flood modelling has been undertaken to assess any flood effects from the proposed Milldale Stages 14-17 development to the upstream or downstream areas. Modelling has been undertaken in line with recommended flood management strategy i.e. pass flow forward, as per the Milldale Stages 14-17 FT Stormwater Assessment Report. Water levels and flood depth results were extracted from the simulated model scenarios and used to assess flood effects for the 2-year, 10-year and 100-year ARI events with allowance for 3.8°C climate change (as per the SWCP V4).

The assessment also covers an analysis of the minimum freeboard requirements and blockage for culvert structures in accordance with the Stormwater Code of Practice (V4). The culverts' freeboard requirements are covered in more detail in the Stormwater Assessment Report.

6.1. Modelled Scenarios

There was a total of eight modelled scenarios and they are summarised in Table 8.

Table 8: Modelled scenarios summary

#	Model Scenario	Rainfall Event	Land Use	Landform	Hydraulic Conveyance	Tidal Boundary Condition	Purpose
1	Pre-Development (ED)	2-Year ARI + 3.8°C future climate change	5% Existing development for Future Urban Zone areas 65% Wainuia/Milldale Precinct Impervious coverage for all other zones as per AUP	Topographical Survey LiDAR 2024 Full buildout for Milldale development area + existing landform for 147 Argent Lane and rest of the model extent	No primary network within the proposed Milldale Stages 14-17 development All consented structures within the Milldale development area + Existing Structures within Milldale Stages 14-17 and remaining model extent	3.72 m RL (MfE publication – Coastal Hazards and Climate Change Guidance (2024) + SLR and VLM)	To provide a baseline reference model which is used to compare the effects from the proposed Milldale Stages 14-17 development
2		10-Year ARI + 3.8°C future climate change					
3		100-Year ARI + 3.8°C future climate change					
	Post-Development (MPD)	2-Year ARI + 3.8°C future climate change	70% impervious for Milldale Stages 14-17 80% Road-Only catchments 65% Wainui/Milldale Precinct Impervious coverage for all other zones as per AUP	Milldale Stages 14-17 Design Surface Topographical Survey LiDAR 2024 Full buildout for Milldale	No primary network within the proposed Milldale Stages 14-17 development All consented structures within the Milldale development area +	3.72 m RL (MfE publication – Coastal Hazards and Climate Change Guidance (2024) + SLR and VLM)	To assess flood effects (if any) resulting from the Milldale Stages 14-17 development. To assess the culverts performance as per the SWCOP(V4)
5		10-Year ARI + 3.8°C future climate change					

6		100-Year ARI + 3.8°C future climate change	70% impervious for Milldale Stages 14-17 65% Wainui/Milldale Precinct Impervious coverage for all other zones as per AUP	development area + existing landform for 147 Argent Lane and rest of the model extent	Proposed structures within Milldale Stages 14-17 + Existing structures in the remaining model extent		
Additional Scenarios							
7	Post-Development (MPD) assuming culverts blockage	100-Year ARI + 3.8°C future climate change	70% impervious for Milldale Stages 14-17 65% Wainui/Milldale Precinct Impervious coverage for all other zones as per AUP	Milldale Stages 14-17 Design Surface Topographical Survey LiDAR 2024 Full buildout for Milldale development area + existing landform for 147 Argent Lane and rest of the model extent	No primary network within the proposed Milldale Stages 14-17 development Includes proposed culverts/structures proposed for Milldale Stages 14-17 development and allows for blockage as per SWCOP V4	3.72 m RL (MfE publication – Coastal Hazards and Climate Change Guidance (2024) + SLR and VLM)	To assess the proposed infrastructure performance with allowance for blockage and overtopping risk/hazard that may be posed to the surrounding areas (if any).
8	Post-Development (MPD)	100-Year ARI + 3.8°C future climate change. With revised TP108 Rainfall distribution	70% impervious for Milldale Stages 14-17 65% Wainui/Milldale Precinct Impervious coverage for all other zones as per AUP	Milldale Stages 14-17 Design Surface Topographical Survey LiDAR 2024 Full buildout for Milldale development area + existing landform for 147 Argent Lane and rest of the model extent	No primary network within the proposed Milldale Stages 14-17 development Includes proposed culverts/structures proposed for Milldale Stages 14-17 development and allows for blockage as per SWCOP V4	3.72 m RL (MfE publication – Coastal Hazards and Climate Change Guidance (2024) + SLR and VLM)	To assess the resilience of the development under the revised TP108 rainfall distribution (draft guidance, currently out for consultation and not operative)

6.2. Pre-Development Model Results

The pre-development scenario flood depth results for the 2-year, 10-year and 100-year ARI events (including 3.8 °C climate change) are shown in Figure 20, Figure 21 and Figure 22 respectively. It is noted that the flood depth model results are filtered by 50 mm (consistent with the Wainui East SMP, Woods, 2016).

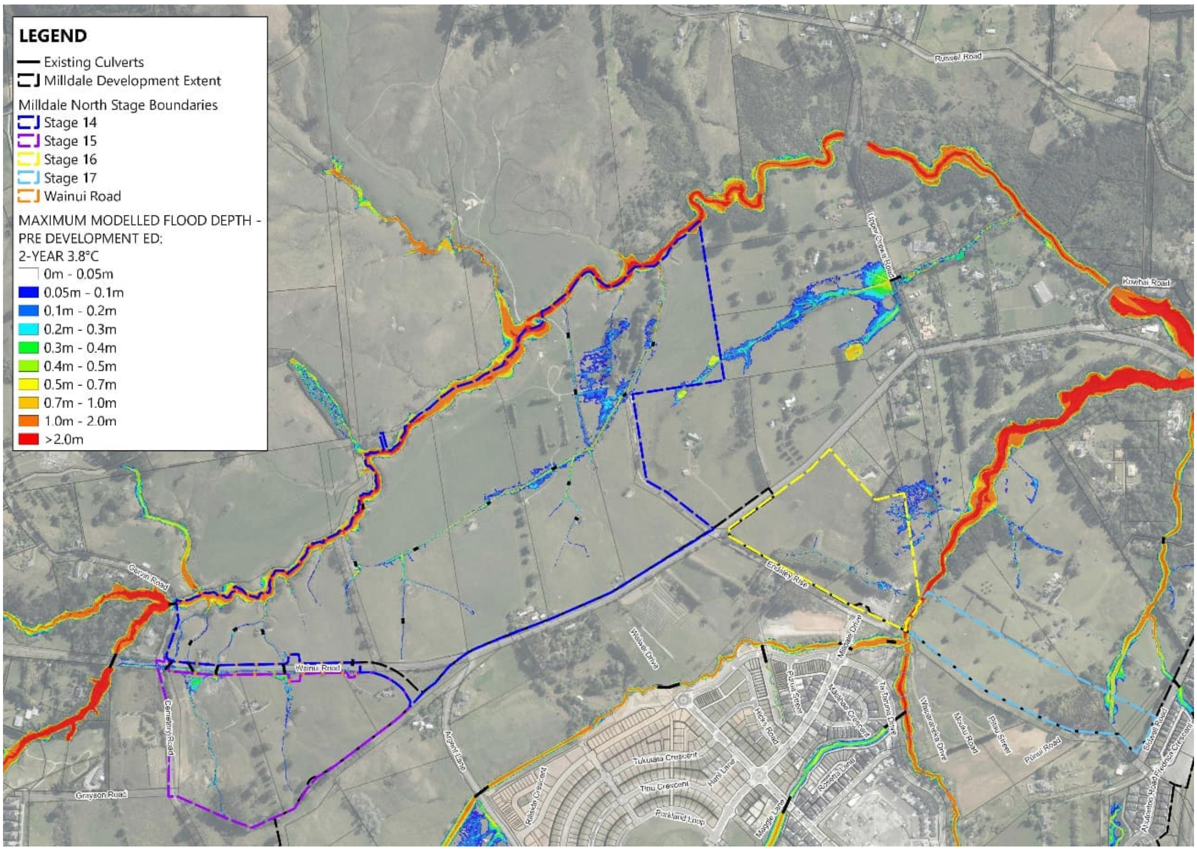

Figure 20: Pre-development scenario model flood depth results (2-year ARI event including 3.8 °C climate change)

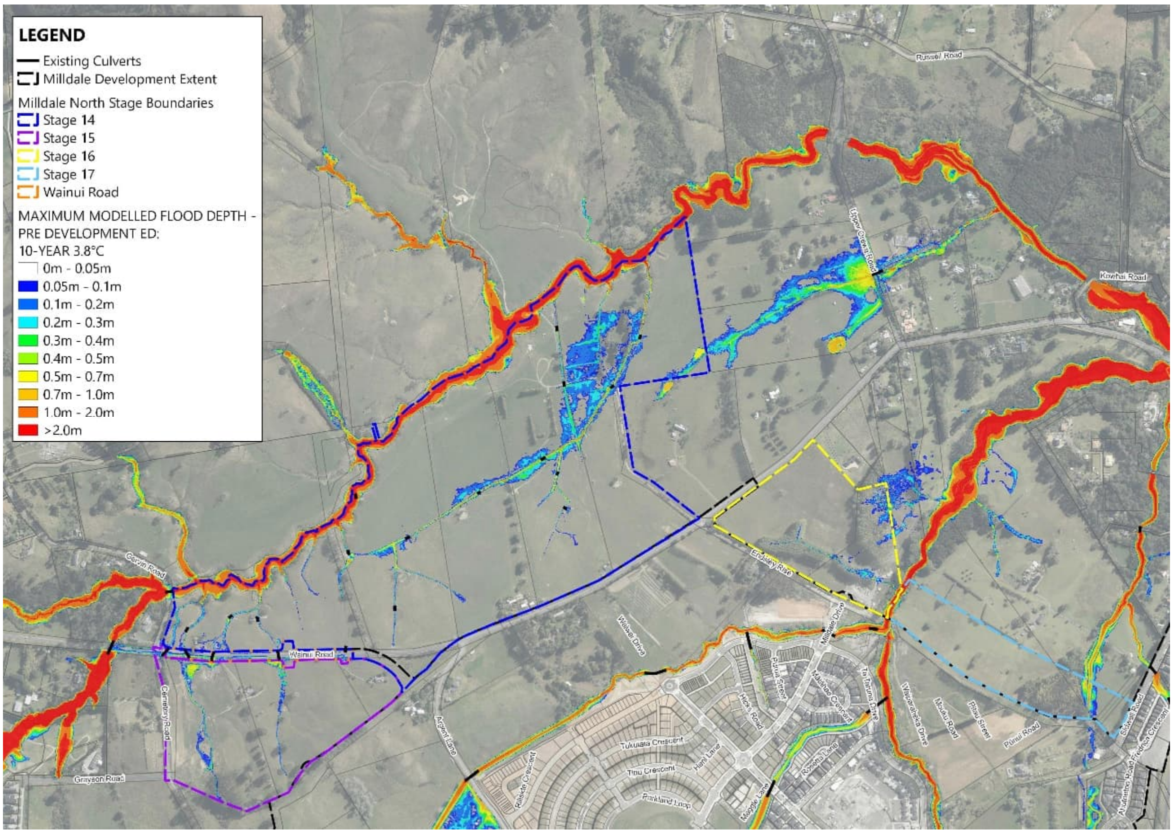

Figure 21: Pre-development scenario model flood depth results (10-year ARI event including 3.8 °C climate change)

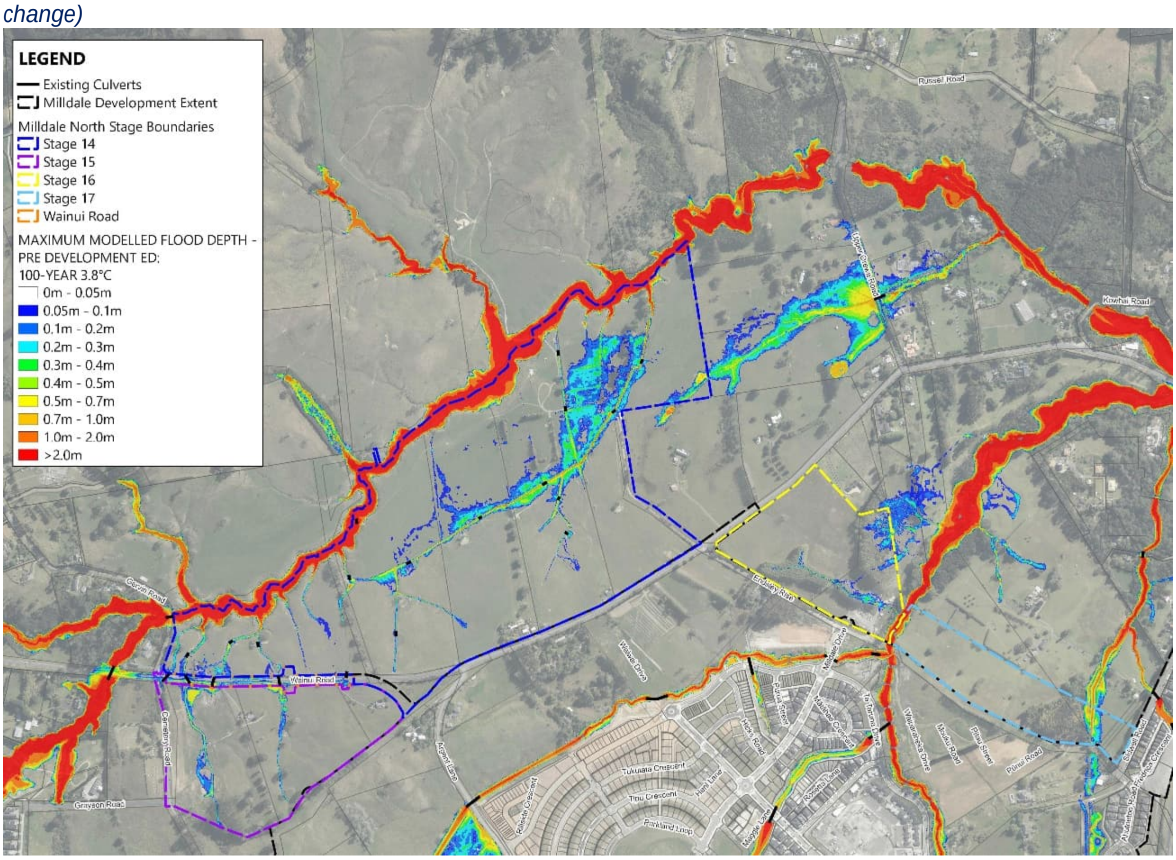

Figure 22: Pre-development scenario model flood depth results (100-year ARI event including 3.8 °C climate change)

6.3. Post-Development Model Results

The post-development scenario flood depth results for the 2-year,10-year and 100-year ARI events (including 3.8 °C climate change) are shown in Figure 23, Figure 24 and Figure 25 respectively. It is noted that the flood depth model results are filtered by 50 mm (consistent with the Wainui East SMP, Woods, 2016).

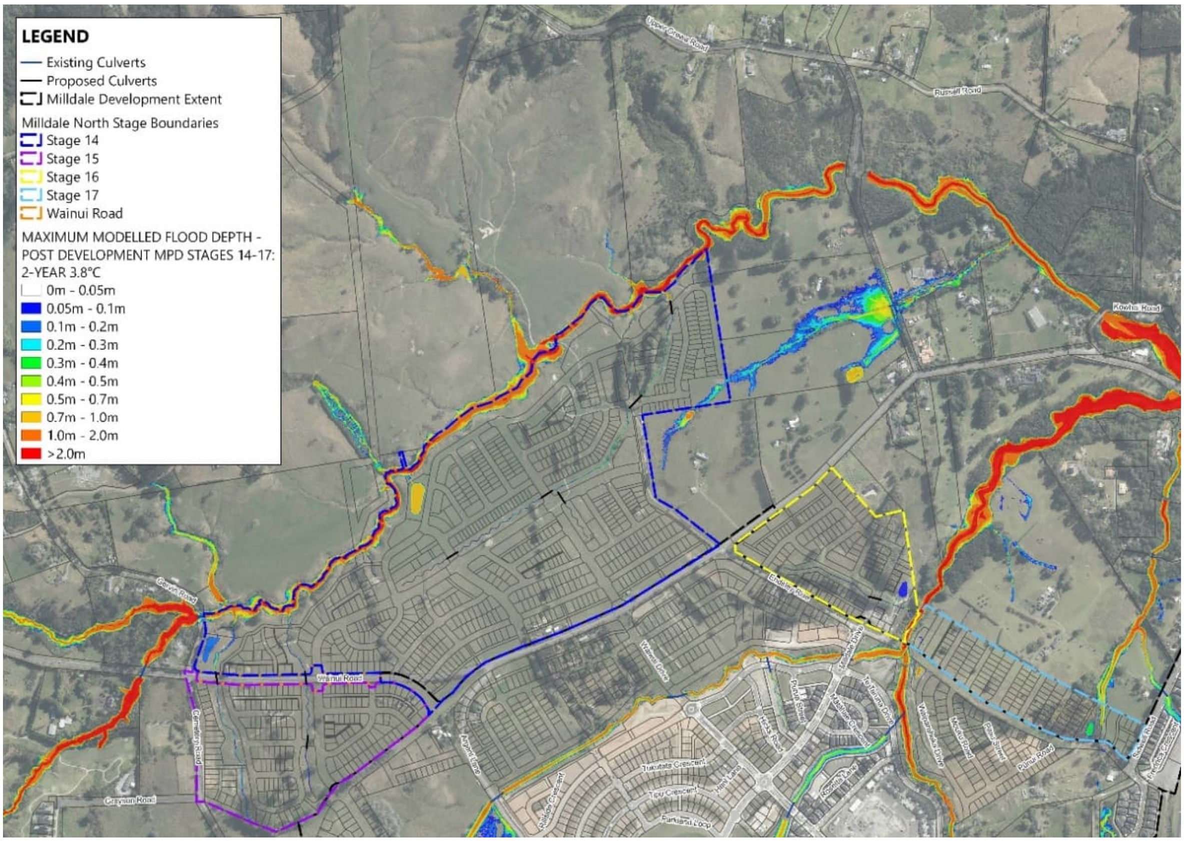

Figure 23: Post-development scenario model flood depth results (2-year ARI event including 3.8 °C climate change)

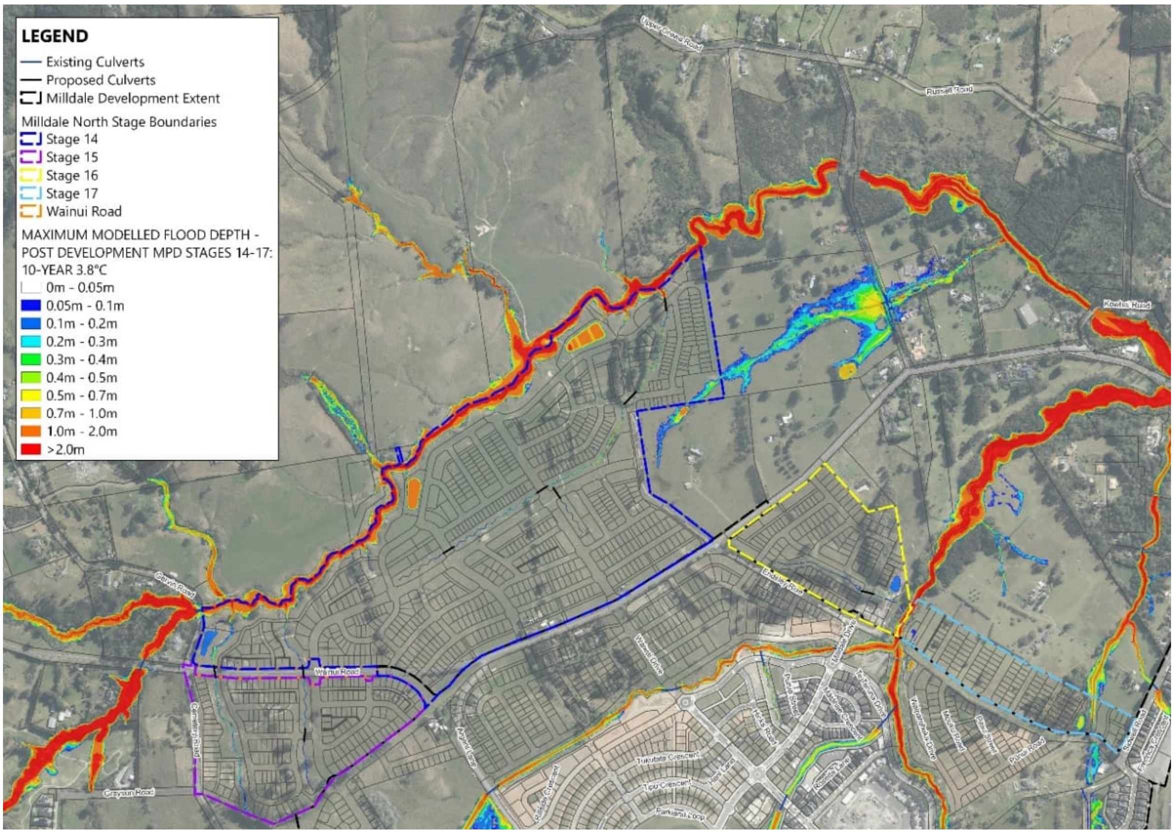

Figure 24: Post-development scenario model flood depth results (10-year ARI event including 3.8 °C climate change)

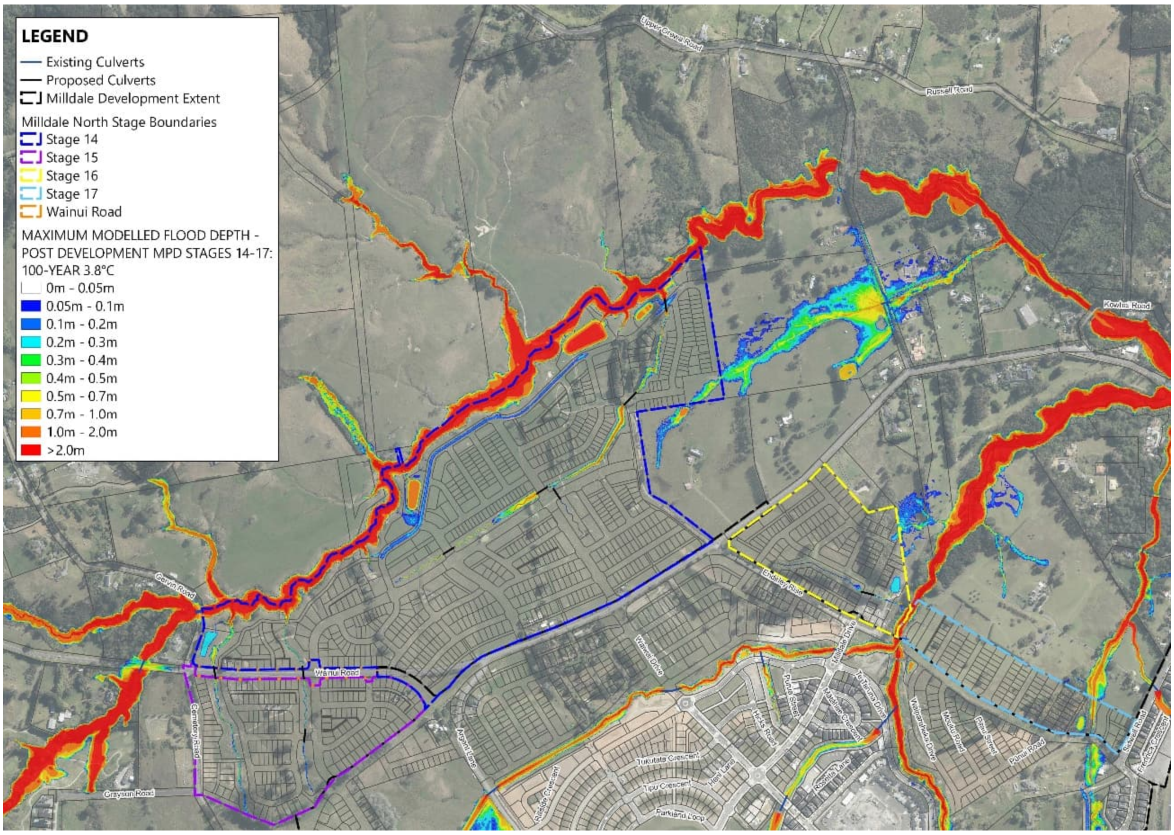

Figure 25: Post-development scenario model flood depth results (100-year ARI event including 3.8 °C climate change)

7. Pre vs Post Development Comparison

A comparison of the pre- and post-development flood depths was made to understand the potential impacts of the development in the areas. Results for these are presented for the 2-year, 10-year and 100-year in Appendix B and discussed in Section 8 of the stormwater assessment report.

8. Model Validation

The validation of the flood model has been undertaken using two different approaches. The validation methods and outcomes are presented in the sections below.

8.1. TP108 Validation

Manual checks were done to validate runoff generated from the hydrological model. A TP108 assessment of peak flows for all sub catchments was carried out for Post Development model scenario simulated for 100-year ARI storm event with existing rainfall. TP108 validation was only done for the scenario with existing rainfall as TP108 document does not provide c* and q* values for 3.8°C future climate change.

The TP108 validation assessment shows that the sum of the peak flows from the TP108 graphical method is 535.30m^3/s whilst the sum of peak flows from XPSWMM model is 533.55m^3/s. This results in an overall variance of 0.3%.

Overall, the assessment shows that the hydrological model is in line with the TP108 methodology, and the variances lie within acceptable tolerances.

8.2. Reporting Locations

The peak flows generated from the post-development model scenario were compared with the flood models results issued to Healthy Waters as part of the Milldale Fast Track application at 6 reporting locations for the 100-year storm event with allowance for 3.8°C future climate change. The reporting locations are shown in Figure 26.

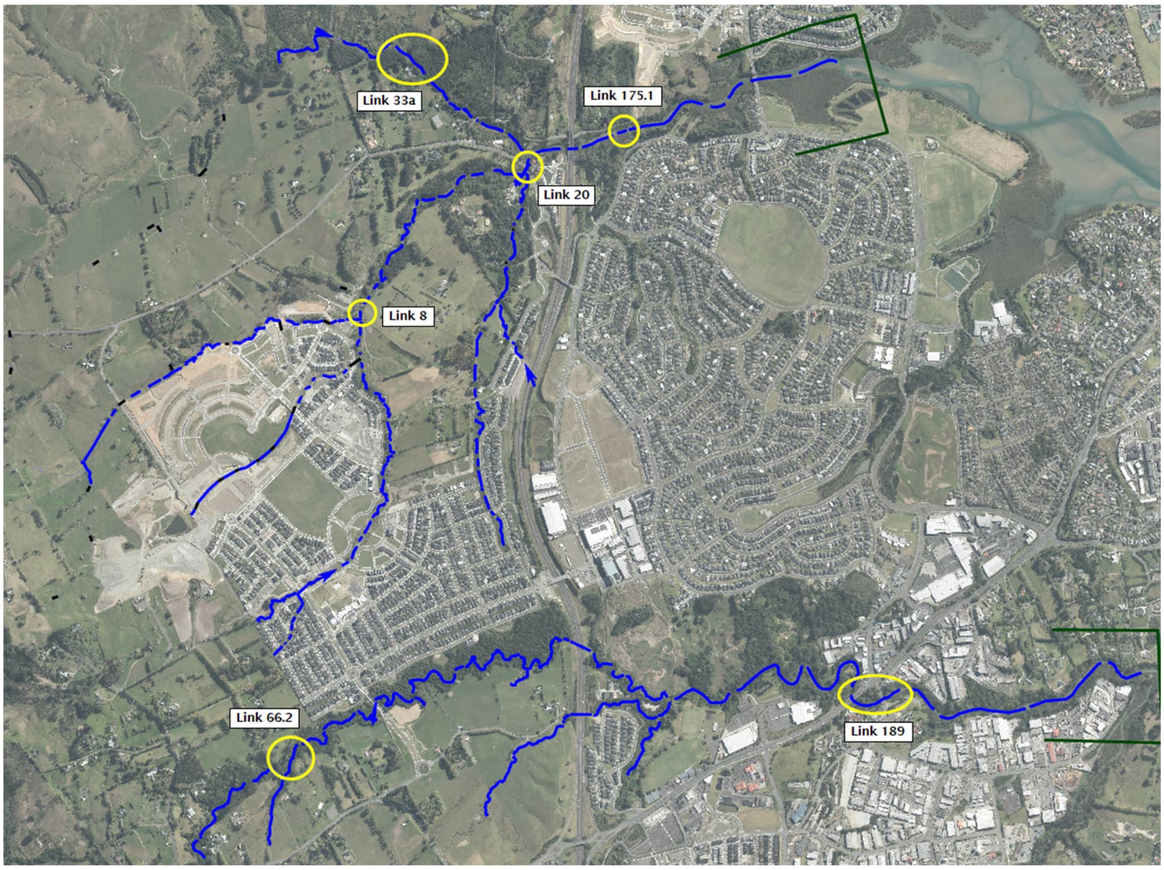

Figure 26: Map of reporting locations

The peak flow comparisons are summarised in Table 9 with a variance of ±5% which is considered an acceptable range. Instances where the variance is slightly higher than ±5% has been attributed to updates in sub-catchment delineation and updates to the tidal boundary condition.

Table 9: Peak flow comparison table (100-year 3.8°C ARI storm event)

Reporting location	Milldale Stages 10-13 Fast Track Model	Post Development model	Variance (m^3/s)	Variance percentage
	Total flow (m^3/s)	Total flow (m^3/s)		
Link 175.1*	222.77	200.33	22.44	10.61%
Link20*	116.17	123.22	7.05	5.89%
Link33a*	163.25	150.70	12.55	7.99%
Link 66.2	124.99	124.21	0.78	0.63%
Link 8	106.30	102.05	4.25	4.08%
Link 189	164.34	163.04	1.26	0.77%

**Links 175.1, 20, and 33a have higher variance due to change in subcatchment delineation, and tidal boundary conditions within Milldale and Wainui West area.*

9. Model Limitations and Assumptions

The flood modelling undertaken represents the flood risk within the modelled extent and are subject to assumptions and limitations outlined below:

- The design storms are in accordance with the former Auckland Regional Councils (ARC) Technical Publication 108 (TP108). The TP108 model has a reported 90% confidence of flow results being within ± 25% of the system being modelled (ARC, 1999)
- The runoff flows calculated by the hydrological model are loaded in the hydraulic model at specified nodes inside the two-dimensional model extents (structured mesh). Inside the two-dimensional model extents, water can flow in all directions from the loading node. The extents of the flow paths may vary according to the location of the loading node, the elevation of the two-dimensional grid cells (from LiDAR data) and other model assumptions. The location of the loading determines the origin of the overland flow path
- The footbridge by Upper Orewa Road has not been represented in the model as it has been inoperative since 2010 or sooner (as per Auckland Council GeoMaps Aerials) and there is no data currently available for this asset. The footbridge could be included in future modelling stages
- The potential for change in asset condition over time is not represented
- This model has been prepared to provide guidance on flood levels and depths within the modelled catchment area for the modelled scenario. The modelling process relies on a range of assumptions and simplifications and is subject to errors and inaccuracies. The compounding effects of the uncertainties in the TP108 rainfall model (ARC, 1999), the uncertainties in the contour model and the uncertainties in hydraulic parameters such as roughness could result in the water level varying from the mapped levels
- The stormwater model has been developed using topographical data from various sources. The accuracy of different sources of information is as follows:
    - Conventional survey – Vertical accuracy of ± 0.05m at 68% confidence interval
    - LiDAR 2024 - Vertical accuracy of ± 0.05m at 68% confidence interval

  This relates to the spheroid height; additional error is introduced when the geodic height model is applied. As a result of the water level variability the lateral extent of flood extent may vary significantly from that shown on the plans. This can have a compounding effect with other uncertainties such as the TP108 rainfall model and other causes for uncertainty.

10. Conclusion

The flood assessment report for Milldale Stages 14-17 (referred to as the Site) supports the resource consent application by Fulton Hogan Land Development (FHLD) to the Environmental Protection Authority (EPA) under the Fast-Track Approvals Act 2024. The flood assessment has been performed in consistency with the recommended flood management strategy to pass flow forward of the adopted Wainui East Stormwater Management Plan (SMP), Version 4, September 2016. The recommended flood management strategy for the Site also ensures there are no flood effects upstream or downstream of the Site while the downstream stormwater infrastructure, both proposed and already constructed, have sufficient capacity to convey upstream flows for MPD development conditions.

The flood assessment involved stormwater modelling, and eight model scenarios were developed, including pre-development and post-development scenarios. The flood modelling undertaken in this flood assessment builds on the Wainui East flood models originally developed while creating the Wainui East Model Build Report (Woods, July 2016). Since the adoption of the Wainui East SMP, the flood model has undergone various updates and high-level reviews with Healthy Waters, the most recent being in May 2022.

The flood model scenarios have been simulated for the 2-year, 10-year and 100-year ARI storm events including climate change including 3.8°C temperature increase by 2110. An additional model scenario has been developed which allows for blockage of the proposed culverts within the Site extent.

The flood assessment findings are as follow:

- Flood results summary

  Flood depths comparison between the pre-development and post-development scenario for the 2-year, 10-year and 100-year ARI events including 3.8°C climate change shows that any flood depth increases are limited to the stream corridor and does not increase pre-development flood extents, this is consistent with the adopted SMP. There are no upstream or downstream flood effects resulting from developing the Site.

- Culverts freeboard assessment

  The post-development model results also show that all proposed culvert structures within the Site comply with the freeboard requirements stated in the Stormwater Code of Practice (V4, Mar 2026) for both 10 and 100-year ARI storm events including 3.8°C climate change.

- Blockage assessment

  The culvert blockage assessment shows that there is road overtopping where the proposed culverts within the Site are assumed to be fully blocked, and in most instances, the runoff overtopping the culverts immediately returns to the stream. Instances where flows overtop and do not immediately return to the stream, then flows are fully contained within the roads and do not enter the proposed lots.

- Wainui Bridge Assessment

  Previous modelling and flood assessments showed that there is an overtopping risk at the Wainui Road Bridge as a result of the climate change adjustments, the modelling undertaken as part of this package of works continues to show the bridge being overtopped in the 1% AEP 3.8°C climate change event.

Appendices

Appendix A - Impervious catchment calculations

10YR ARI EVENT CATCHMENT ASSESSMENT

Catchment	Road Catchment (Ha)	Lot Catchment (Ha)	Impervious Catchment (Ha)	Pervious Catchment (Ha)	Total Catchment A	Impervious %
Wetland A	3.61	4.89	5.82	2.68	8.50	68%
Wetland B	4.61	10.67	10.09	5.19	15.28	66%
Wetland C	13.74	18.79	22.27	10.26	32.53	68%
Wetland D	1.89	2.88	3.24	1.53	4.77	68%
Wetland E	2.24	4.77	4.65	2.36	7.01	66%
Wetland F	0.33	1.11	0.93	0.51	1.44	65%
Wetland G	0.59	1.74	1.52	0.81	2.33	65%
Wetland H	0.92	3.13	2.61	1.44	4.05	65%
Stream 2	0	1.62	0.97	0.65	1.62	60%
Stream 3	0.95	0.31	0.95	0.31	1.26	75%
Stream 4	1.47	0	1.18	0.29	1.47	80%
Stream 8	0.28	0	0.22	0.06	0.28	80%
Stream 10	0.61	0	0.49	0.12	0.61	80%
				Average		70%

70%

80%

100YR ARI EVENT CATCHMENT ASSESSMENT

Catchment	Road Catchment (Ha)	Lot Catchment (Ha)	Impervious Catchment (Ha)	Pervious Catchment (Ha)	Total Catchment A	Impervious %
OLFP Catchment A	1.42	1.02	1.75	0.69	2.44	72%
OLFP Catchment B	1.89	3.01	3.32	1.58	4.90	68%
OLFP Catchment C	1.34	1.01	1.68	0.67	2.35	71%
OLFP Catchment D	2.44	3.66	4.15	1.95	6.10	68%
OLFP Catchment E	1.74	2.64	2.98	1.40	4.38	68%
OLFP Catchment F	1.04	1.71	1.86	0.89	2.75	68%
OLFP Catchment W	3	3.16	4.30	1.86	6.16	70%
OLFP Catchment J	2.27	3.33	3.81	1.79	5.60	68%
OLFP Catchment Z	1.89	2.09	2.77	1.21	3.98	69%
OLFP Catchment L	1.12	1.67	1.90	0.89	2.79	68%
OLFP Catchment N	2.13	2.32	3.10	1.35	4.45	70%
OLFP Catchment O	1.44	1.63	2.13	0.94	3.07	69%
OLFP Catchment AC	0.68	0.42	0.80	0.30	1.10	72%
OLFP Catchment AB	1.07	0.96	1.43	0.60	2.03	71%
OLFP Catchment AA	1.07	2.26	2.21	1.12	3.33	66%
OLFP Catchment Y	0.57	0.76	0.91	0.42	1.33	69%
OLFP Catchment X	1.14	1.14	1.60	0.68	2.28	70%
OLFP Catchment AE	1.9	3.45	3.59	1.76	5.35	67%
OLFP Catchment AF	1.45	1.07	1.80	0.72	2.52	72%
OLFP Catchment AG	2.68	2.68	3.75	1.61	5.36	70%
OLFP Catchment AH	1.27	2.42	2.47	1.22	3.69	67%
OLFP Catchment AI	1.21	1.6	1.93	0.88	2.81	69%
OLFP Catchment AJ	0.28	1.45	1.09	0.64	1.73	63%
				Average		69%

70%