Appendix C1

Tonkin+Taylor

Memo

To:	**Carmel O'Sullivan**	**Job No:**	**1003297.1**
From:	**Sindiya Vaakesan**	**Date:**	**17 June 2019**
cc:	**Tim Fisher, Pranil Wadan (Woods) and Ajay Desai (Woods)**		
Subject:	**Drury Town Centre - Kiwi Property - Model Build Memo**		

1 Introduction

Tonkin & Taylor Ltd. (T+T) have been engaged by Kiwi Property to prepare a Stormwater Management Plan (SMP) for 120 and 133 Flanagan Road, Drury to support the proposed Drury Metropolitan Centre Plan Change. The proposed Drury Metropolitan Centre will occupy a total area of 52 hectares and is located within the wider area that is the subject of the proposed plan change which occupies a total area of 88 hectares. The two site boundaries are indicated on Figure 1.1.

The entire area that is the subject of the proposed plan change will be referred to herein as the 'Plan Change Area' for the purposes of clarity.

A flood risk assessment was carried out to assess the effects of the proposed developments on the existing flood plain extents along the Hingaia Stream for the 1 in 100yr Average Recurrence Interval rainfall events with climate change for maximum probable development landuse scenario (100yrCC).

The objective of this memo is to:

1 Summarise the methodology used to develop the Drury Town centre baseline flood model, and

2 Summarise scenarios modelled to assess the flood effects from proposed development within the Plan Change Area.

This memo should be read in conjunction with the June 2019 T+T report "Drury Metropolitan Centre Stormwater Management Plan" and is subject to the assumptions and limitations stated in the document. The outcomes of the flood modelling are discussed in the T+T report.

Figure 1.1: Location plan

2 Model development methodology

2.1 Source model

The Hingaia Stream Flood Model is an integrated one-dimensional (1D) and two-dimensional (2D) hydraulic model created using the Mike Software Suite developed by DHI (Version 2017, Service Pack 2).

The catchment topography has been developed using 2013 Auckland Council LiDAR data for the 2D model and a number of surveyed stream cross-sections form the 1D river channel.

For more details regarding the Hingaia Stream Flood Model set up the reader is referred to the following reports and technical memos:

- Model Build Report for Hingaia Stream Catchment (Draft). Prepared by Auckland Council. Dated June 2017.
- Drury South Structure Plan – Updates to flood modelling for detailed design case to support addendum to SMP – 8th October 2018. Memo prepared by Tonkin + Taylor, addressed to Carmel O'Sullivan and Jahangir Islam (Auckland Council)
- Drury South Structure Plan – Updates to flood modelling to support Stormwater Management Plan – 31st July 2017. Memo prepared by Tonkin + Taylor, addressed to Lisa Dowson and Nick Brown (Auckland Council)
- Drury South Structure Plan – Updates to flood modelling to support Stormwater Management Plan – 13th September 2017. Memo prepared by Tonkin + Taylor, addressed to Lisa Dowson (Auckland Council)
- Drury South Structure Plan – Updates to flood modelling to support Stormwater Management Plan – 8th November 2017. Memo prepared by Tonkin + Taylor, addressed to Lisa Dowson (Auckland Council)

2.2 Baseline model setup

The Drury Town Centre baseline model has been developed using T+T Drury South design model version 203 (Auckland Council reviewed), and incorporates changes from the Jan 2019 Auckland Council SMP model, which consists of:

- Full MPD Probable hydrology and
- Updates to the hydraulic model for the culverts under Flanagan Road/Southern Main Railway Line/Great South Road based on latest CCTV survey completed by Auckland Council.

2.3 Modelled scenarios

Three main development scenarios have been modelled to inform the flood risk assessment. These are listed below:

- Pre-development Scenario, which represents the land activity in the Hingaia Catchment prior to development of the Plan Change Area. This includes assuming 10% imperviousness for all Future Urban Zone within the catchment and full development of the Drury South Development Upstream.
- Post-development Iteration 01 Scenario, which represents the proposed landuse changes within the proposed Plan Change Area and adjacent developments. This includes the following land use assumptions that have been allowed for within the Future Urban Zone in the catchment:
  - Imperviousness within Kiwi Property Metropolitan Centre = 100%

  - Imperviousness within remainder of Kiwi Property owned land within Plan Change Area = 70%
  - Imperviousness within Fulton Hogan owned land = 65%
  - Imperviousness within remainder of the catchment outside of the Plan Change Area = 60%
- Post-development Iteration 04 Scenario, which includes the following:
  - Landuse changes as per Post-development Iteration 01
  - Kiwi Property modifications. Terrain within the Plan Change Area raised beyond predicted flooding levels based on developed land as per the April 2019 masterplan. Creek reserves, the proposed aquatic centre and residential R1 building have been excluded from the terrain adjustment. The extent of the terrain that has been raised in the model is shaded in red in Table 2.1.
  - Fulton Hogan modifications. Woods have incorporated the following changes to the model as part of their plan change application for Fulton Hogan site. Modified design terrain, re-loading of catchment inflows, and removal of all structures upstream of the Flanagan Road culvert, in the Fitzgerald Stream. It has been assumed that all structures in the Fitzgerald Stream will be designed to fit the 100yr flood levels.
  - Great South Road culvert upgrade by Woods designed to convey the 100yrCC flows, which consists of two new culverts (2m by 2.5m) in parallel with the existing culverts.

The assessments have been carried out for three storm events:

- 100 year without climate change (100yr);
- 100 year with climate change (100yrCC); and
- 10 year with climate change (10yrCC).

Table 2.2 below provides the detailed list of scenarios modelled as part of the assessment.

Table 2.1: Topography used in different development scenarios

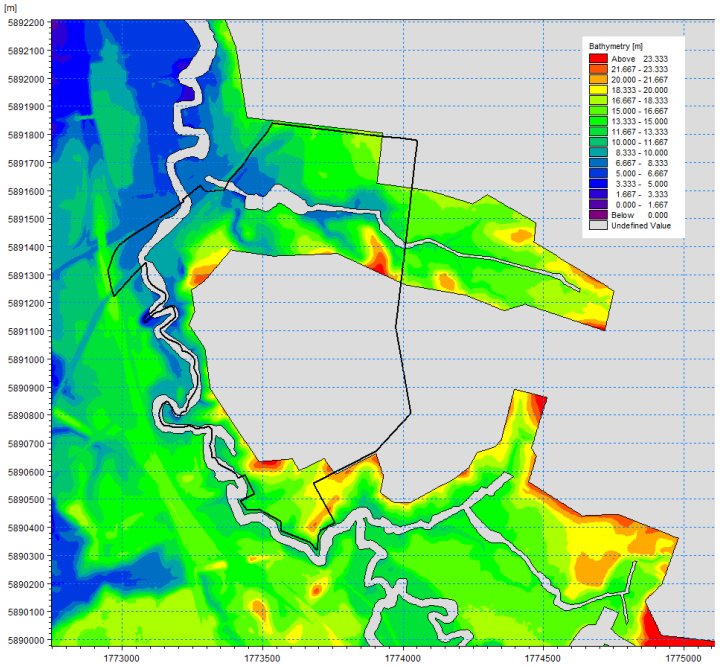
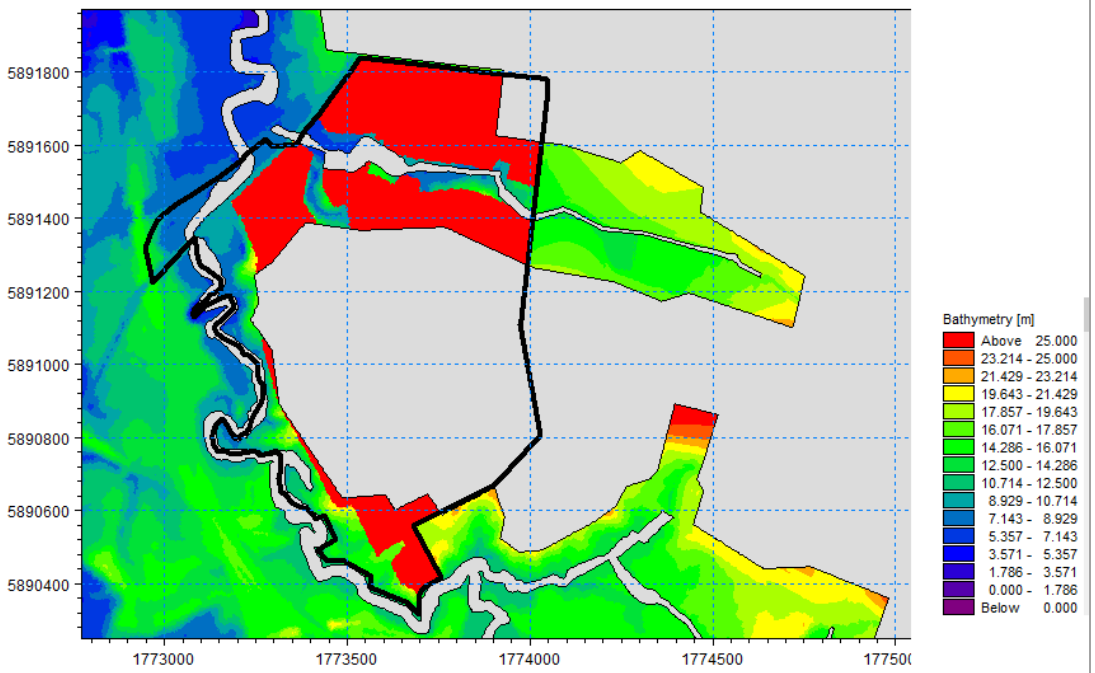
Pre-development Terrain	Post-development Iteration 004 Terrain
	

Table 2.2: Model scenarios

No	Scenario Name	Description	Landuse assumptions	Storm event (CC – climate change)	Terrain modification in Plan Change Area
0	Baseline model	Baseline model has been developed using T+T Drury South design model version 203 (Auckland Council reviewed), and incorporates changes from the Jan 2019 Auckland Council SMP model (full MPD Probable and updates to the hydraulic model for the culverts under Flanagan Road/Southern Main Railway Line/Great South Road).	MPD landuse in entire Hingaia Catchment	100yr ARI with CC	None
1	Post-development Iter01 - 100yrCC	Post-development Iter01 model (landuse changes only) for 100yr storm event with climate change	Post-development: • Imperviousness for Metropolitan Centre = 100% • Imperviousness for Kiwi Property land = 70% • Imperviousness for Fulton Hogan land = 65% • Future Urban Zone outside of Plan Change Area = 60%	100yr ARI with CC	None
2	Pre-development - 100yrCC	Pre-development model for 100yr storm event with climate change	Pre-development: • Imperviousness of Future Urban Zone set to 10% • Drury South development completed	100yr ARI with CC	None
3	Pre-development - 10yrCC	Pre-development model for 10yr storm event with climate change	Pre-development, as described above	10yr ARI with CC	None
4	Pre-development - 100yr	Pre-development model for 100yr storm event with present day climate	Pre-development, as described above	100yr ARI	None

No	Scenario Name	Description	Landuse assumptions	Storm event (CC – climate change)	Terrain modification in Plan Change Area
5	Post-development Iter04 – 100yrCC (received from Woods)	Post-development Iter04 model (landuse changes, Kiwi property terrain modifications, Fulton Hogan modifications and Great South Road culvert upgrade) for 100yr storm event with climate change.	Post-development, as described above	100yr ARI with CC	Yes, refer Table 2.1
6	Post-development Iter04 – 10yrCC	Post-development Iter04 model (landuse changes, Kiwi property terrain modifications, Fulton Hogan modifications and Great South Road culvert upgrade) for 10yr storm event with climate change.	Post-development, as described above	10yr ARI with CC	Yes, refer Table 2.1
7	Post-development Iter04 – 100yr	Post-development Iter04 model (landuse changes, Kiwi property terrain modifications, Fulton Hogan modifications and Great South Road culvert upgrade) for 100yr storm event.	Post-development, as described above	100yr ARI	Yes, refer Table 2.1

3 Applicability

This memo and enclosed GIS files have been prepared for the exclusive use of our client, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

17-Jun-19
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Tonkin+Taylor

Memo

To:	**Pranil Wadan (Woods) and Rachel Morgan (B&A)**	**Job No:**	**1003297.1000**
From:	**Tim Fisher and Sindiya Vaakesan (T+T)**	**Date:**	**9 July 2019**
Subject:	**Drury Flood Modelling - Effects of Proposed Development**		

1 Introduction

Tonkin & Taylor Ltd. (T+T) have been engaged by Kiwi Property to prepare a Stormwater Management Plan (SMP) for 120 and 133 Flanagan Road, Drury to support Kiwi Property's proposed Drury Metropolitan Centre Plan Change (refer Figure 1.1). A flood risk assessment was carried out to assess the effects of the proposed developments on the existing flood plain extents along the Hingaia Stream for the 1 in 100yr and 1 in 10yr Average Recurrence Interval (ARI) rainfall events with climate change (CC) for maximum probable development landuse scenario (referred to as the 100yrCC and 10yrCC storm events, respectively).

The purpose of this memo is to summarise the flood changes from the proposed development within the Kiwi Property Plan Change Area and the Fulton Hogan Plan Change area for the 100yrCC and 10yrCC storm events. The memo focuses on some differences that need to discussed with the Kiwi Property and Fulton Hogan project teams.

Figure 1.1: Location plan showing Kiwi Property Plan Change Area

2 Flood changes

This section provides an overview of the flood changes observed from the following model scenarios:

- Pre-development scenario, where imperviousness of Future Urban Zones are set to 10%.
- Post-development Iteration 02 scenario which consists of:
  - Landuse changes including;
    - Imperviousness for Metropolitan Centre = 100%
    - Imperviousness for Kiwi Property land = 70%
    - Imperviousness for Fulton Hogan land = 65%
    - Future Urban Zone outside of Plan Change Area = 60%; and
  - Terrain modifications within the Kiwi Property Plan Change Area.
- Post-development Iteration 04 scenario which consists of the above landuse changes and Kiwi property terrain modifications as well as terrain modifications within the Fulton Hogan site and the proposed Great South Road culvert upgrade (straight alignment – twin culverts).

Table 2.1, Table 2.2 and Table 2.3 below provide maximum predicted flood levels, stream discharge and flows for eight selected analysis locations around the Kiwi Property Plan Change Area and Fulton Hogan site. The analysis locations and maximum predicted flood depth for the 100yrCC post-development (Iteration 04) scenario are shown in Figure 2.1 below. Point 3 and Point 7 are within the Kiwi Property Plan Change Area and Fulton Hogan site while the rest of the analysis locations are within or adjacent to neighbouring land that is owned by others.

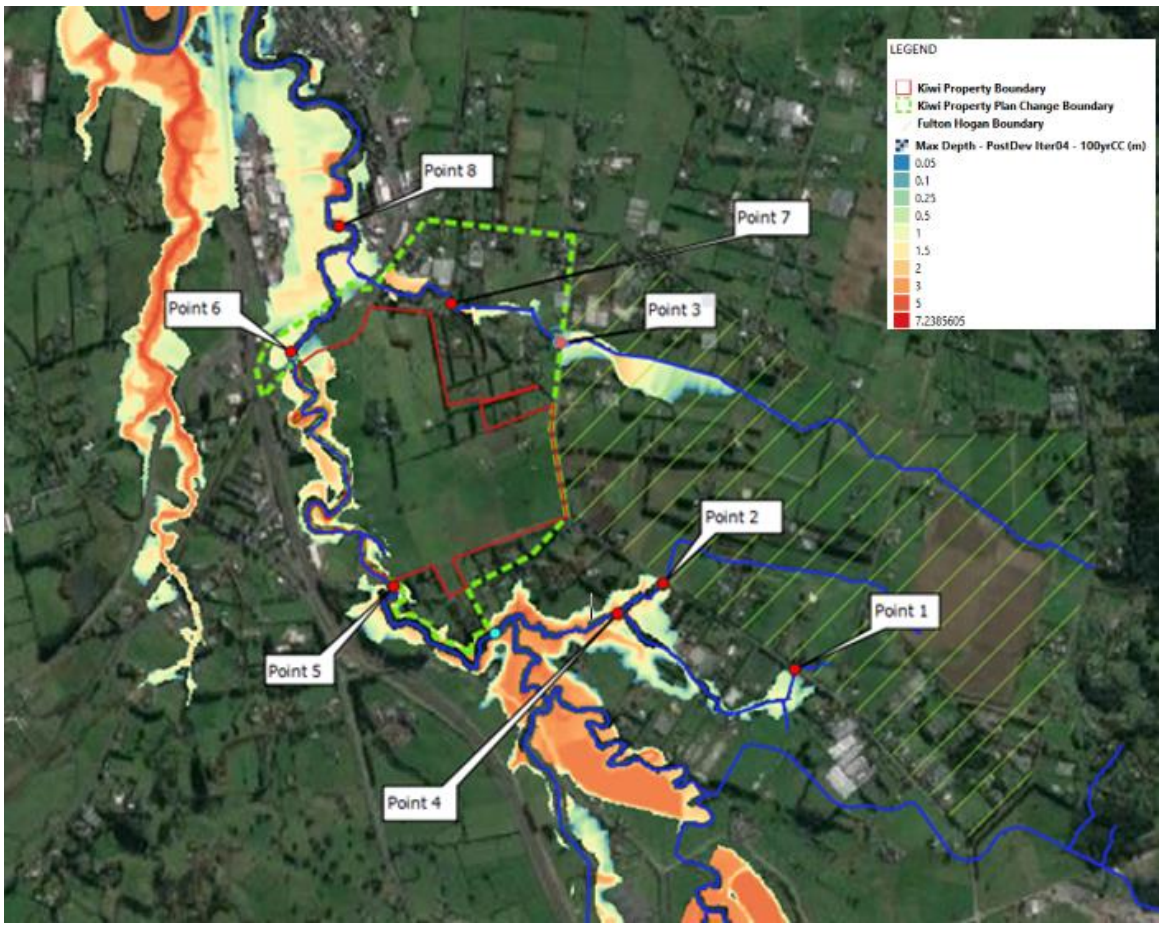

Figure 2.1: Location of analysis points

Table 2.1: Maximum water level at analysis locations (increase in levels highlighted)

ID	100yrCC Peak Flood Level (m)			10yrCC Peak Flood Level (m)		
	Pre-Dev	Post-Dev Iter02	Post-Dev Iter04	Pre-Dev	Post-Dev Iter02	Post-Dev Iter04
Point 1	16.1	16.2	16.2	16.1	16.0	16.0
Point 2	15.3	15.4	15.4	13.7	13.8	14.1
Point 3	12.5	12.6	13.8	11.8	12.0	13.2
Point 4	15.3	15.4	15.4	13.7	13.7	13.8
Point 5	12.9	12.9	12.9	11.4	11.4	11.4
Point 6	8.8	8.8	8.8	7.6	7.6	7.7
Point 7	8.6	9.0	8.3	7.2	7.3	7.8
Point 8	7.9	7.9	7.9	6.1	6.1	6.1

Table 2.2: Maximum 1D flow at analysis locations

ID	100yrCC Peak Flow (m^3/s)			10yrCC Peak Flow (m^3/s)		
	Pre-Dev	Post-Dev Iter02	Post-Dev Iter04	Pre-Dev	Post-Dev Iter02	Post-Dev Iter04
Point 1	10.0	11.5	11.6	4.7	6.3	6.3
Point 2	7.2	9.2	13.9	1.2	2.8	7.2
Point 3	24.1	28.2	31.7	9.5	11.2	15.8
Point 4	15.8	18.9	24.9	4.8	8.4	13.5
Point 5	270.1	268.9	274.7	137.4	137.3	140.0
Point 6	302.8	304.9	303.7	137.7	136.2	140.2
Point 7	24.4	27.8	33.3	10.2	12.0	16.7
Point 8	176.8	176.9	177.7	138.5	137.5	139.6

Table 2.3: Combined flow (1D and 2D) through flood plain at Point 8

Flows at Point 8	100yrCC Peak Flow (m^3/s)			10yrCC Peak Flow (m^3/s)		
	Pre-Dev	Post-Dev Iter02	Post-Dev Iter04	Pre-Dev	Post-Dev Iter02	Post-Dev Iter04
2D	186.4	193.0	194.4	1.1	1.1	2.3
1D	176.8	176.9	177.7	138.5	137.5	139.6
Total flow	363.2	369.9	372.1	139.6	138.6	141.9

The flood modelling results have also been mapped and are shown in Figures 2.2, 2.3 and 2.4. Figure 2.2 provides the maximum predicted flood depth for the 100yrCC event post-development scenario (Iteration 04). Figure 2.3 and Figure 2.4 provide the flood level difference between post-development (Iteration 04) and pre-development scenario for the 100yrCC and 10yrCC storm events, respectively.

3 Flood effect observations

For the area south of the Kiwi Property plan change area and west of the Fulton Hogan plan change area, represented by points 1, 2 and 4, the peak flows and maximum water levels increase. These increases in flood depths impact a wider spatial area, refer Figure 2.3 and 2.4. These changes may be an issue during plan change hearings as they are outside of the plan change area. These changes appear for Post-Development Iteration 04, which has the Fulton Hogan terrain changes in it.

The flows and water level changes are minor after the tributary stream reaches the main Hingaia Stream and flows pass the Kiwi Property Plan Change area (points 5 and 6).

Flows increase through the Fitzgerald Stream (points 3 and 7) as has been the intention of the design. These are within the combined Plan Change areas, but some are outside of Kiwi and Fulton Hogan land ownership (e.g. between Fitzgerald and Flanagan Road), so land owner approval will eventually be needed to implement these aspects of the design.

Downstream of the plan change areas (at point 8) there is a slight increase in flows for Post Development Iteration 4 (with Fulton Hogan terrain changes)

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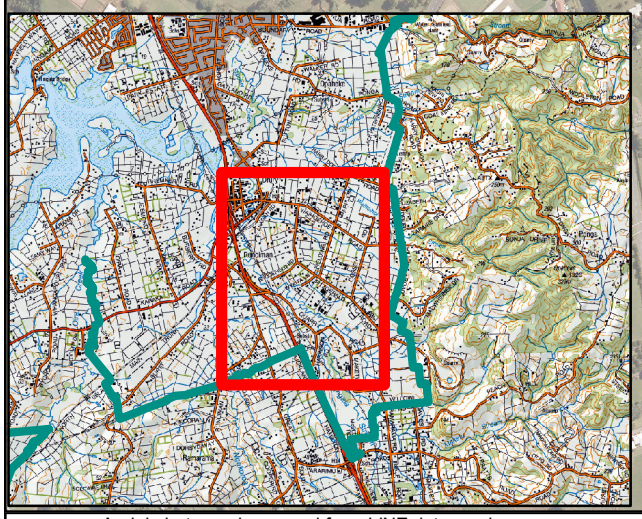
Applicability:
This figure has been prepared with respect to the particular brief given to Tonkin + Taylor for the assessment of effects for the proposed Drury Metropolitan Centre Plan Change. The supporting information methodology and assumptions adopted in the development of the figures can be found in the June 2019 Stormwater Management Plan report. Tonkin + Taylor does not accept responsibility for any loss or damage resulting from the use of the information and any person relying on the information does so at their own risk. Tonkin + Taylor strongly recommend that any person intending to rely on the information discuss the matter further with Tonkin + Taylor or Auckland Council.

FITZGERALD ROAD

SOUTHERN MOTORWAY

BROOKFIELD ROAD



LEGEND

- 1D river network
- Drury Metropolitan Centre Plan Change Area
- Kiwi Drury Property Boundary
- Fulton Hogan Boundary
- Kiwi Property Masterplan (April 2019)

Maximum Flood Depth (m)

- 0 - 0.05
- 0.05 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1
- 1 - 2
- 2 - 3
- >3

Notes:
Aerial photograph sourced from LINZ data service.
All reported levels are in Auckland Vertical Datum 1946.
Modelling results have been excluded where depth is below 0.05m.
Results shown from 2D extent only. 1D results from Hingaia stream not shown.

N

0 50 100 150 200 250 300 Meters

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APPROVED	TSRF	Jul.19
ARCFILE		
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PROJECT No.	1003297.1000	

Drury Town Centre
Maximum Flood Depth – 100yrCC
Post-development Iteration 04
with Gt South Rd straight alignment

FIGURE No. Figure 2.2

Rev.

Applicability:
This figure has been prepared with respect to the particular brief given to Tonkin + Taylor for the assessment of effects for the proposed Drury Metropolitan Centre Plan Change. The supporting information methodology and assumptions adopted in the development of the figures can be found in the June 2019 Stormwater Management Plan report. Tonkin + Taylor does not accept responsibility for any loss or damage resulting from the use of the information and any person relying on the information does so at their own risk. Tonkin + Taylor strongly recommend that any person intending to rely on the information discuss the matter further with Tonkin + Taylor or Auckland Council.

Flood level increase
= 230 mm

Flood level increase
= 50 mm

Flood level increase
= 80 mm

FITZGERALD ROAD

SOUTHERN MOTORWAY

BROOKFIELD ROAD

LEGEND

- 1D river network
- Drury Metropolitan Centre Plan Change Area
- Kiwi Drury Property Boundary
- Fulton Hogan Boundary
- Kiwi Property Masterplan (April 2019)

Level Difference (m)

- <-0.5 (Design flood level lower)
- -0.5 - -0.3
- -0.3 - -0.2
- -0.2 - -0.1
- -0.1 - -0.05
- -0.05 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- >0.5 (Design flood level higher)

Notes:
Aerial photograph sourced from LINZ data service.
All reported levels are in Auckland Vertical Datum 1946.
Modelling results have been excluded where depth is below 0.05m.
Results shown from 2D extent only. 1D results from Hingaia stream not shown.

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Drury Town Centre

Flood Level Difference – 100yrCC
Post-development Iteration 04 minus Pre-development

FIGURE No. Figure 2.3

Rev.

Applicability:
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Flood level increase = 80 mm

Flood level increase = 300 mm

Flood level increase = 200 mm

Flood level increase = 60 mm

Flood level increase = 150 mm

Flood level increase = 50 mm

Flood level increase = 50 mm

FITZGERALD ROAD

SOUTHERN MOTORWAY

BROOKFIELD ROAD

LEGEND

- 1D river network
- Drury Metropolitan Centre Plan Change Area
- Kiwi Drury Property Boundary
- Fulton Hogan Boundary
- Kiwi Property Masterplan (April 2019)

Level Difference (m)

- <-0.5 (Design flood level lower)
- -0.5 - -0.3
- -0.3 - -0.2
- -0.2 - -0.1
- -0.1 - -0.05
- -0.05 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- >0.5 (Design flood level higher)

Notes:
Aerial photograph sourced from LINZ data service.
All reported levels are in Auckland Vertical Datum 1946.
Modelling results have been excluded where depth is below 0.05m.
Results shown from 2D extent only. 1D results from Hingaia stream not shown.

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0 50 100 150 200 250 300 Meters

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Drury Town Centre

Flood Level Difference – 10yrCC

Post-development Iteration 04 minus Pre-development

FIGURE No. Figure 2.4

Rev.

Tonkin+Taylor

Memo

To:	**David Schwartfeger (Kiwi Property), Greg (Fulton Hogan), Nick Roberts (Barkers)**	**Job No:**	**1003297**
From:	**Tim Fisher (T+T) and Pranil Waden (Woods)**	**Date:**	**31 January 2020**
Subject:	**Drury East flood modelling - response to Auckland Council modelling requests**		

Auckland Council through their memo 21 January and at the meetings of 21 January and 24 January have asked for additional/revised modelling to cover more scenarios and to change assumptions (e.g. imperviousness).

Remodelling to the scale desired by Auckland Council would take months to do and are un-warranted for the plan change to assess the viability of the landuse change. The requested changes are also unreasonable as model versions and modelling scenarios and assumptions were agreed in January 2019.

However, some movement to address Auckland Council concerns are still necessary because issues are identified in the SMPs (Kiwi and FH) such as minor flooding. It was always the strategy (client/consultants agree) to talk with Auckland Council about the SMP and flood modelling completed to date, and there was an expectation (client/consultants) that additional modelling would be needed to address these issues. We expected that the 2-year events would need to be done for stream erosion in particular, as Council have been developing their assessments over the last year and are these are in place they expect them to be used.

Our approach is to:

- Back the flood assessments done to-date, which demonstrate that the plan changes are viable and without significant flood effects. There is no questions in the Auckland Council memo regarding the flood assessment work done to-date.
- Develop conditions that require negligible effects on upstream/downstream flooding due to the developments to give Auckland Council more certainty on the outcomes.
- For notification, stay with current model versions and assumptions (as agreed with Council) as it is major effort to redo all the assessment scenarios for new models, assumptions.
- Stage the additional modelling as required for the project stage/detail:
    - For notification, add the 2-year pre and post effects assessment, as well as the 100-year MPD climate change hazard assessment flood model runs.
    - For hearing align modelling to Council current models and assumptions.
    - For resource consents add more runs to provide a more complete assessment of effects.

When	What	Why	Runs	Cost

Mid March	• 2 year pre, 2 year post (1-3%) impervious	Demonstrate the viability of the plan change with supporting effects assessment: • Nuisance flooding • With 2, 10, 100yr we can bracket and eliminate the need for the 5, 20, 50 yr events • 2 year is input to stream erosion assessment		
	• 100 year CC, MPD, +400mm for Drury South difference	Hazard assessment for worst case to establish maximum extent of floodplain		
Pre-hearing ***Risk that Council want earlier***	• Redo 2, 10, 100 with Council updated model, existing impervious at 1-3%), design changes to tidy up minor effects	• Extra certainty for Council/ commissioners		
Pre-hearing	•> Status > Pass flow structures - open/closed + GSR WLU scenario			
Resource Consents	• 5, 20, 50 year • ED vs Proposed • Hazard 10,100 CC, MPD, RCP 8.5	• Assess effects • Design of structures • Hazard assessment		

Costs are for direct modelling time only. T+T/Kiwi have a contract with budget for support for the plan change for December to March 2020 in place. Woods/FH will work out their arrangements.

Risk are:
Council may want more than we are proposing and re-work to our modelling based on their new models and position on assumptions.

Resolving minor effects may take time.
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Why use the Drury South model as the baseline model?

1 Council's concern is the current Drury South floodplain modification actually improves the downstream 100 year flood level to 11.3 mRL compared to existing (allowable) of 11.67 mRL, so that a baseline with Drury South will set the floodwater levels too low compared to what is allowed. Council would like us to use the pre-Drury South model.
2 T+T consider that Drury South should be in the baseline for the following reasons:
    a) It was agreed with Council Jan/February that "***For the purposes of a comparative analysis to assess effects from the development then the Drury South model will suitable***" Carmel O'Sullivan email

12 February 2019. If this agreement is breached then considerable rework and delays will occur to the project.

b) We accept that for design development e.g. resource consents, designing bridges and setting floor levels, and when more is known (development form, Mill Road, final Drury South), that the model will change and will need to be rerun.

c) We will add a flood hazard run with higher MPD to assess the flood plain conservatively as part of the plan change process. We can add 0.4m for Drury South to the maximum flood levels from this run to assess a maximum flood hazard extent.

d) The baseline model is for comparison purposes to see what the changes are when the plan change is included (landuse and landform changes). So it doesn't matter too much what baseline is used, but we like to have it as representative as possible.

e) For a plan change it is best to have the baseline model as representative as possible as to what will be in place when the plan change occurs. We think Drury South will be complete when Drury East occurs (circa 10 years). Drury South (industrial/commercial/housing) and modifications to the flood plain are all permitted by resource consents and Council's NDC.

f) The majority of the Drury South floodplain modification will be complete at the end of the 2019/2020 earthworks season. The existing (pre-development) situation does not exist anymore.

g) An existing model that re-produces the pre-development situation doesn't exist anymore or is out of date. Drury South are using a local TUFLOW model. Auckland Councils latest model is for MPD scenarios only.

•

Tonkin+Taylor

Memo

To:	Mark Iszard (Auckland Council)	Job No:	1003297
From:	Tim Fisher (T+T)	Date:	10 February 2020
cc:	David Schwartfeger (Kiwi Property), Greg Dewe (Fulton Hogan), Nick Roberts (Barkers), Pranil Waden (Woods)		
Subject:	Drury East (Kiwi and Fulton Hogan) flood modelling - response to Auckland Council modelling requests		

1 Introduction

Auckland Council (memo 21 January and meetings of 21 January and 24 January) has asked for additional/revised modelling to cover more scenarios and to change assumptions (e.g. imperviousness, exclude Drury South). This memo sets out the response from the developer team for Kiwi and Fulton Hogan, which both use the Hingaia flood models.

Stormwater Management Plans (SMPs) for Kiwi and Fulton Hogan plan change area are supported by flood modelling and assessments, which demonstrate the suitability of pass-forward flood management approaches and thus the viability of the land for development. The suitability of pass-forward flood management is also established in Auckland Council SMP *Drury-Opaheke Structure Plan, Future Urban Zone, Draft Stormwater Management Plan, 12 April 2019*, refer Section 4. The modelled scenarios are also consistent with the Auckland Council SMP with all based on the 10 and 100 year MPD (although defined differently).

The flood modelling approaches (scenarios and parameters/ imperviousness) for the Kiwi and Fulton Hogan SMPs were agreed with Auckland Council in January/February 2019 and the modelling undertaken in February to April 2019. The purpose of the modelling was to show the effects from the proposed landuse change to flooding for the 10 and 100 year events with (and without) the Drury East developments. These SMPs/modelling show negligible changes to maximum flood levels outside the future urban area, which confirmed the viability of pass-forward flood management approaches, as already established by Auckland Council SMP (refer Section 4). Some minor local flood changes were identified, which can be mitigated through staging and design refinement and managed through plan change and/or consent conditions.

Re-modelling to align current modelling approaches (model versions, impervious assumptions and excluding Drury South) will delay the plan change acceptance without adding value to the assessment. Some further detail on why inclusion the baseline model should include Drury South is provided at the end of this memo.

The project team wants to work with Auckland Council to provide additional assessments where they add value by assessing important issues. We will do these now where these are necessary to support the viability of the plan change for acceptance of the plan change application. However, we request that more extensive modelling for the notification SMP and for future different purposes (such as resource consents and design) can be staged as set out below in Table 1.

2 Proposed approach

The proposed approach is to supply information in two tranches, to give Auckland Council more information to make recommendations to its Planning Committee, while maintaining programme:

1) mid-March to support Healthy Waters recommendation to Planning Committee; and
2) mid-May to support the notification documentation we will updated modelling to align to Auckland Council new requirements.

For mid-March, we propose we will supply the below information to support Healthy Water's recommendation to Planning Committee (refer to Table 1 for details):

- Use current assessments based on the 10 and 100 year events as they demonstrate the viability of pass-forward flood management approaches and confirm the Auckland Council SMP. Changes to the models (model versions, impervious assumptions, Drury South) will not change this assessment, which is based on the comparison of with/without Drury East developments.
- Add the 2-year event (ED) to assess low level flooding and to support stream erosion assessments. Council has been developing assessments methods for stream erosion over the last year and we understand the 2-year event is necessary for this.
- Add the 100-year MPD/CC event to ascertain a maximum floodplain to fully understand the future hazard. Add 400mm to the maximum flood levels to allow for the benefits from Drury South not being realised.
- Develop draft conditions that require negligible flooding effects on upstream/downstream properties due to the developments to give Auckland Council more certainty on the outcomes and incorporate these into the plan changes prior to the Council plan change acceptance decision.

For mid-May to support the notification documentation we will updated modelling to align to Auckland Council new requirements. Refer to table 1 below. We will also update SMPs for notification.

For resource consents add more runs to provide a more complete assessment of effects. At this stage any floodplain modifications, such as bridges for access, will be understood.

Table 1: proposed model runs summary

When	What	Why
mid-March to support Council recommendation to Planning Committee	2yr pre, 2yr post, ED (1-3%) impervious for undeveloped catchments. No CC. Baseline (pre) with Drury South.	Demonstrate the viability of the plan change with supporting effects assessment: - Assess low-level, nuisance flooding - 2yr is input to stream erosion assessment - With new 2 and pervious 10 and 100yr we can bracket and eliminate the need for modelling the 5yr, 20yr, 50yr events

	100year +/- CC, MPD, Baseline (pre) with Drury South, add 400mm to max water levels for Drury South benefits.	Hazard assessment for worst case to establish maximum extent of floodplain
Prior to notification (mid May)	Re-simulate 2yr, 10r, 100yr, pre and post, ED (1-3%) impervious for undeveloped catchments, Baseline (pre) with Drury South. Include design changes to tidy up minor effects, staging, pass flow structures (Great South Road) (open/closed)	Provides extra certainty for effects assessment as discussed with Council 24 January
Resource Consents	Simulate -, 20, 50 year (if required); Existing Development vs Proposed 100yr CC, MPD, RCP 8.5	Assess effects Design of structures Hazard assessment

3 Why the current baseline (pre-development) model is appropriate

1) Council's concern is the current Drury South floodplain modification actually improves the downstream 100 year flood level to 11.3 mRL compared to existing (allowable) of 11.67 mRL, so that a baseline with Drury South will result in floodwater levels that are too low compared to what Drury South are allowed to achieve. Council would like T+T/Woods to use the existing (pre-Drury South) model.
2) T+T consider that Drury South should be in the baseline for the following reasons:
    a) It was agreed with Council Jan/February that "*For the purposes of a comparative analysis to assess effects from the development then the Drury South model will suitable*" Carmel O'Sullivan email 12 February 2019. If this agreement is breached then considerable rework and delays will occur to the project.
    b) We accept that for design development e.g. resource consents, designing bridges and setting floor levels, and when more is known (development form, Mill Road, final Drury South), that the model will change and will need to be rerun.
    c) The baseline model is for comparison purposes, to see what the changes are when the plan change is included (landuse and landform changes). So it doesn't matter too much what baseline is used, but we do like to have it as representative as possible.
    d) For a plan change it is best to have the baseline model as representative as possible to what will be in place when the plan change occurs. We think Drury South will be complete when Drury East occurs (circa 10 years). Drury South (industrial/commercial/housing) and modifications to the flood plain are all permitted by resource consents and Council's NDC. Each year as a condition of the earthworks consent, Drury South need to demonstrate to Council that flooding conditions are met for that stage of development.
    e) The majority of the Drury South floodplain modification will be complete at the end of the 2019/2020 earthworks season. The existing (pre-Drury South) situation does not exist anymore.

f) An existing model that re-produces the pre-development situation doesn't exist anymore or is out of date. Drury South are using a local TUFLOW model. Auckland Councils latest model is for MPD scenarios only (i.e. includes Drury South as being developed, however with no floodplain modifications?).

3) We will add a flood hazard run with higher MPD to assess the flood plain conservatively as part of the plan change process. We can add 0.4m for potential change Drury South to the maximum flood levels from the flood hazard run to assess a maximum flood hazard extent.
4) We can change the approach if directed by Auckland Council to not using the Drury South floodplain modifications, but we do not think it is the correct representation for the baseline, nor are there available models to do it, so it will take a lot more time.

4 Auckland Council SMP

The proposed flood management approaches in the Kiwi and Fulton Hogan SMPs are aligned with the Auckland Council's SMP, which gives general guidance and for the Hingaia says the flood management approach will be to pass flows forward.

The relevant extracts from the Auckland Council SMP *Drury-Opaheke Structure Plan, Future Urban Zone, Draft Stormwater Management Plan, 12 April 2019* are:

4.5.1 General

- Modelling has identified that a number of structures will be inundated during a 10 year and or 100 year ARI MPD CC event. Signage is to be provided at these structures indicating that the road is flood prone. Potentially a warning light when flood waters exceed a certain water level (or some other warning method) could also be implemented.
- Avoid locating buildings within the 100 year ARI floodplain.
- Avoid locating infrastructure in the 100 year ARI floodplain unless it can be designed to be resilient to flood damage.
- Ensure all development and changes within the 100 year floodplain do not increase adverse effects or increased flood depths or velocities to other properties upstream or downstream of the site.
- Avoid increasing flood risk and flood extent upstream and downstream for all flood events.
- Identify overland flowpaths and ensure that they remain unobstructed and able to safely convey runoff.
- Use capacity available in riparian margins as part of the water conveyance system and enhance intermittent streams to provide capacity and conveyance as a means to manage flood waters.

4.5.3 Hingaia Stream Catchment

The general management approach will be to pass flows forward.

However, existing culverts along the northern Hingaia Stream tributary will need to be upgraded to enable this management approach.

Further investigations are underway to determine the extent and timing of the required upgrades.

Tonkin+Taylor

Memo

To:	**Mark Iszard (Auckland Council)**	**Job No:**	**1003297**
From:	**Tim Fisher (T+T)**	**Date:**	**19 February 2020**
cc:	**David Schwartfeger (Kiwi Property), Greg Dewe (Fulton Hogan), Andrew McCarthy (Oyster), Nick Roberts (Barkers), Pranil Waden (Woods)**		
Subject:	**Drury East (Kiwi and Fulton Hogan) flood modelling - response to Auckland Council modelling requests**		

1 Introduction

This memo summarises our understanding of the agreements regarding the Further Information Request (FIR) expected from Auckland Council in response to lodged plan changes for Drury East by Kiwi Property and Fulton Hogan. It builds on the T+T Drury East flood modelling memo of 10 February 2020, based on additional meetings with Auckland Council on 11 and 14 February regarding flood modelling and 14 February regarding stream erosion.

Auckland Council (memo 21 January and meetings of 21 January and 24 January) has provided feedback on matters and especially requested additional/revised modelling to cover more scenarios and to change assumptions (e.g. imperviousness, exclude Drury South).

In the subsequent discussions, we have narrowed the focus to what should be in the FIR to enable Auckland Council to recommend to the Planning Committee that the plan changes be accepted for notification. This is the first tranch of information referred to in our memo 10 February. In three key issues that the Auckland Council want more information on (at this time) are:

1 Flooding effects downstream of the plan change areas from development
2 Stream erosion effects that can now be assessed as Auckland Council research and tools have been developed
3 Summary of water quality treatment across the three plan changes.

This memo focusses on the plan changes for Kiwi Property Town Centre and Fulton Hogan residential development. The approaches for the Oyster Capital plan change still need to be considered and may need to be different for 1 and 2 because the modelling tools and issues are different. We will confirm our approach separately for the Oyster Capital plan change.

2 Flooding effects

We understand that Council want additional assessments of the potential flooding caused by a "**development only flood scenario**". This scenario assumes extreme rainfall (2, 10, 100 year ARI rainfall) in the lower catchment only (over existing and plan change areas). The purpose of this assessment is to ascertain whether the development with its additional runoff causes a new flooding mechanism and effects. For example, does a 100-year ARI rainfall over the lower catchment with the proposed plan change result in flood levels comparable to flooding for a 2 year or 10 year "**full catchment flood scenario**" (ie from rainfall over the whole catchment).

The proposed steps are:

1 For 10 and 100 year ARI model runs (pre-development and post development) **full catchment flood scenario**, map the buildings with floors at risk from flooding. The Shape file with building extents and floor levels will be supplied by Auckland Council. Use T+T/Woods current models as they are (model version, Drury South included and impervious assumptions).
2 Simulate the potential flooding caused by the **development only flood scenario**. Reconfigure the post development models to:
   - Apply 10 and 100 year ARI rainfall to the lower catchment including existing Drury Township and the plan change areas
   - Allow for nominal "fresh" flow of 50 m^3/s from the upper catchment
   - Map the buildings that flood.
3 Compare the flood extents and buildings that flood for development only flood scenario to full catchment flood scenario (pre and post).
4 Assess the impacts on existing Drury flooding due to the plan change.

3 Stream erosion

We understand that Council want additional assessments to better understand the stream erosion risks. The current Kiwi/Fulton Hogan SMPs identity the erosion risk, but do not assess the impacts on development on this risk as techniques have not been available to do this. Council presented their technical work and tools to assess risks associated with stream erosion on Friday 14 February. Council has supplied additional information and briefed T+T on the Erosion Screening Tool. We suggested in the meeting 14 February that T+T/Woods could apply the Erosion Screening Tool to streams in the plan change area.

Prior to the Planning Committee Meeting in May (ie pre notification) the proposed steps are:

1 Setup 2 year ARI event in the flood model as an input to the Erosion Screening Tool. Pre and post development, 1-3% impervious for undeveloped catchments. No climate change. Use our baseline (pre-development) model that includes Drury South.
2 Select locations for the Erosion Screening Tool. Five locations are proposed. Extract typical cross sections from the flood models.
   - Tributary Stream to the Hingaia (downstream of Fulton Hogan PC)
   - Hingaia Stream upstream of Flanagan Road Bridge (adjacent to Kiwi PC)
   - Hingaia Stream downstream of GSR culvert and upstream of Norrie Bridge (downstream of Kiwi and Fulton Hogan PCs)
   - Hingaia Stream upstream of confluence with Slippery Creek
   - Fitzgerald Stream upstream of Flanagan Road.
3 Run pre and post development flood models for 2, 10 and 100 year ARI floods and extract flow hydrographs at the five locations.
4 Apply erosion effects using the Erosion Screening Tool
   - Assume geotechnical parameters informed by geotechnical specialists
   - Use locations and cross-sections as described above
   - Use 2, 10 and 100 year ARI flow hydrographs as described about.

Post Notification of the plan changes we will assess the erosion risks and approaches to mitigate effects after discussion with iwi.

4 Water quality treatment

We understand that Council want a clear integrated picture of water quality treatment. We will summarise the proposed treatment approaches across the three plan changes in a clearer way – table/matrix. We will say what treatment applies to what landuse. We will summarise hydrological mitigation as well. We will explain any differences of approach.

Stormwater Culvert Assessment

Drury East - Great South Road Culvert

Drury
Fulton Hogan Land Development Ltd
6/06/2019
For Information

Document Control

Project Number	P19-068
Project Name	Drury East - Great South Road Culvert
Client	Fulton Hogan Land Development Ltd
Date	6/06/2019
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Contents

1. Executive Summary

This report summarises the potential servicing strategies for stormwater flows passing forward from the proposed Fulton Hogan Land Development Ltd Drury East and Kiwi Property developments proposed in the Plan Change for the Drury-Opaheke Structure Plan Future Urban Zone area.

Two servicing strategies have been explored in this report with 3 alignment options for each investigated.

The two potential strategies that have been explored are:

- Strategy 1 – Connect to Hingaia Stream Utilising Maketu Stream Alignment and Outfall
  - Option 1A – Parallel Culverts
  - Option 1B – 1 Parallel, 1 Realigned
  - Option 1C – Single Culvert New Alignment
- Strategy 2 – Connect to Hingaia Stream Upstream of Existing Outfall
  - Option 2A – Piped to Flanagan Road Crossing
  - Option 2B – Open Channel to Flanagan Road Crossing
  - Option 2C – Culvert then KiwiRail Tunnel

Other options have been explored and discounted.

All the options explored utilise the existing culvert's capacity as well as new capacity provided by the option to meet the flow and headwater level requirements.

2. Introduction

Fulton Hogan Land Development Ltd (FHLDL) has engaged Wood and Partners Consultants Ltd (Woods) to prepare a Stormwater Assessment for the Maketu Stream (a tributary of the Hingaia Stream) Culverts across Flanagan Road, KiwiRail and Great South Road.

This assessment outlines potential solutions to allow development flows from the proposed FHLDL and Kiwi Property Ltd (Kiwi) developments in Drury East to pass forward.

2.1. Proposed Development

The proposed Plan Change for the Drury-Opaheke Structure Plan Future Urban Zone includes FHLDL Drury East Development to the south east and Kiwi Property south of the existing Drury township.

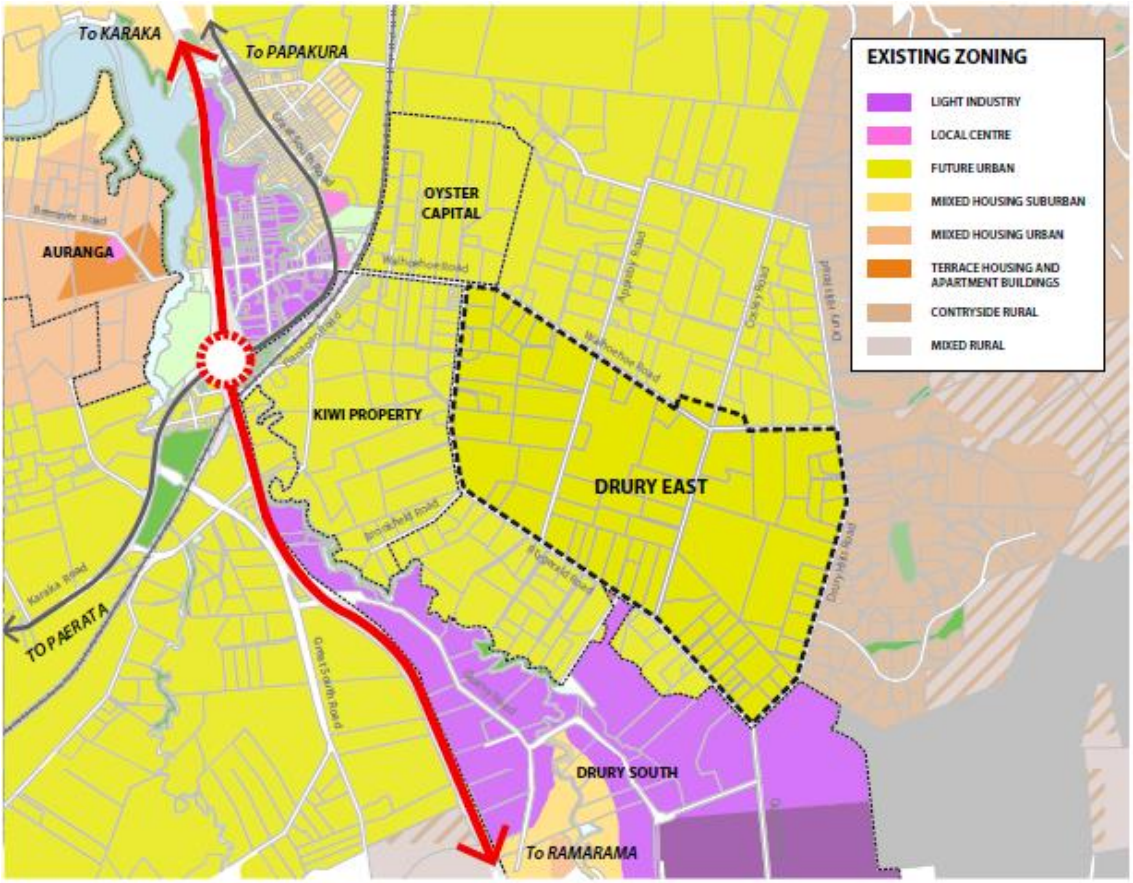


Figure 1: Existing Zoning

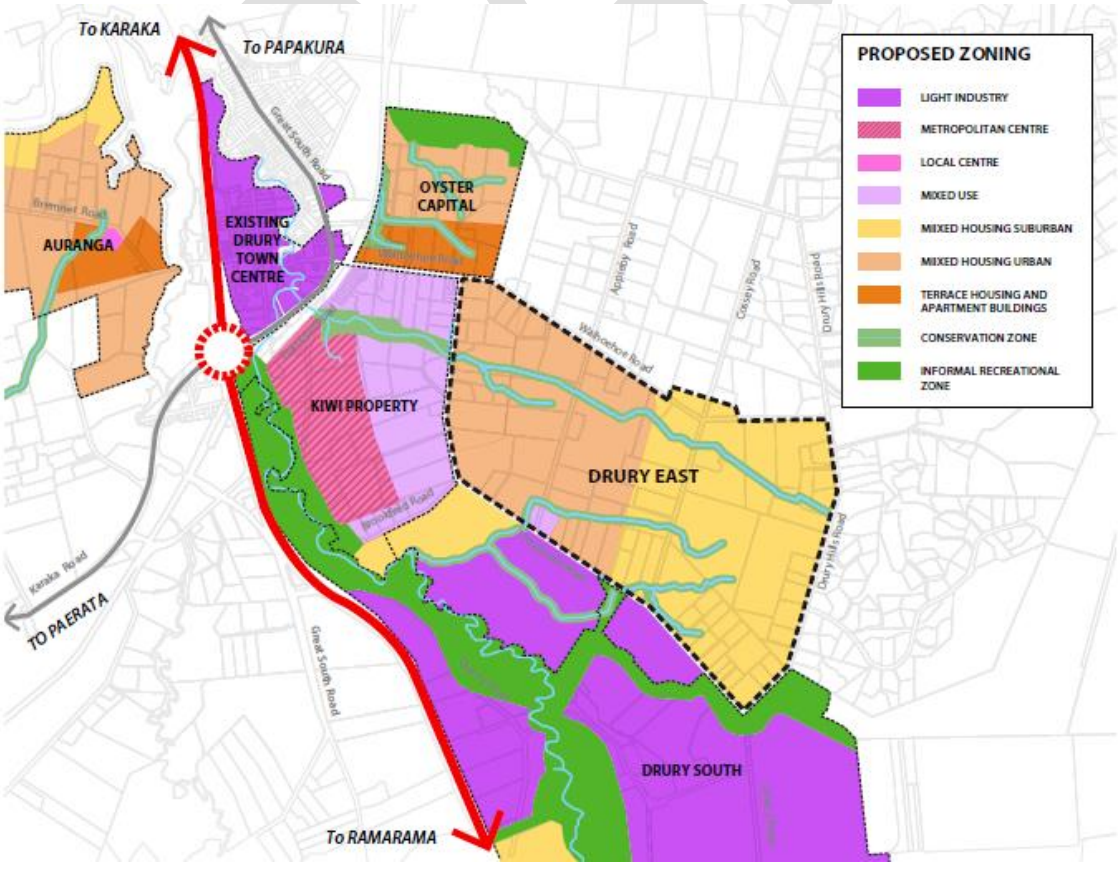


Figure 2: Proposed Future Zoning

2.2. Purpose

The general management approach for the Hingaia Stream catchment as per the Drury-Opaheke Structure Plan Future Urban Zone – Draft Stormwater Management Plan (12 April 2019) is to pass flows forward.

The existing structures in this stream tributary need to be upgraded to enable this management approach. The purpose of this exercise is to determine options to enable passing forward of flows upstream of the Great South Road and Flanagan Road culverts.

2.3. Existing Site

2.3.1. Description

The existing area surrounding the existing culverts is low density industrial and commercial within the Great South Road area and farming and residential in the Flanagan Road area.

2.3.1.1. Existing Businesses within Proposed Works Alignment

The existing private lots which the existing culverts are in or adjacent are:

- 54 Flanagan Road (Lot 1 DP 144988) – contains the upstream section of the Maketu Stream
- 64 Flanagan Road (Lot 1 DP 56120, Lot 7 DP 102224) – adjacent to the stream
- North Auckland Line, Auckland Region
- 2/260 Great South Road (ALLOT 394 Parish OPAHEKE) – contains section of Maketu Stream between culverts
    - Carters Yard
- 263-275 Great South Road (Lot 1 DP 62849) – contains culvert, split into several unit titles
    - 263 GSR – Wheels 4 U Limited
    - 267 GSR – Stihl Shop
    - 271 GSR – Active Electrical Supplies Ltd
    - 275 GSR – Chesters Plumbing & Bathroom

  Culvert sits in driveway between 263 & 267 and partially under structure of 263.
- 257-261 Great South Road (Lot 1 DP 148749) – contains culvert outlet to Hingaia Stream, split into several unit titles
    - 1/257 GSR – A2Z Engineering & Drury Motorcycle
    - 257 GSR – Drury Car Parts
    - 257-261 GSR – Town and Country Veterinary Services

2.3.2. Existing Structures

The following existing structures are present within the existing culvert alignment:

- Stockpiles within timber yard
- Inlet & outlet head walls
- Roads & driveways
- Blockwork buildings
- Precast panel buildings

2.3.3. Existing Services

GIS and B4UDig records have been checked for potential service clashes and implications in the area. Plans have been provided in Appendix D.

There is a Watercare water facility located to the south west of the Flanagan Road intake which has truck water reticulation from it.

Normal underground services are located within the Great South Road Corridor and within lots on that road.

2.3.4. Existing Culverts

Figure 3: Culvert Locations

2.3.4.1. Flannigan Road

The culvert conveys flows from the Maketu Stream within 54 Flanagan Road to 2/260 Great South Road, under Flanagan Road and the Kiwirail rail line.

This culvert is an arch culvert (2.2m high and 2.4m wide) with a capacity of 16.2m^3/s

2.3.4.2. Great South Road

The culvert conveys flows from 2/260 Great South Road under Great South Road to the Hingaia Stream outfall at 257-261 Great South Road, through the driveway and under the building of 263-275 Great South Road.

The culvert arrangement under Great South Road includes an arch culvert (2.2m high and 2.4m wide) with a capacity of 16.2m^3/s with a 1m circular culvert with diameter of 2.1m at the downstream end.

As per Auckland Council CCTV survey this culvert has a Level of Failure of 3 which means that collapse is unlikely in the near future and that the remaining life is 5-10 years.

A functionally sound pipe but with heavy wear and tear and deterioration is beginning to affect structural integrity and performance.

2.3.4.3. Existing Capacity

Both culverts have a capacity of 16.2m^3/s.

The existing capacity of these culverts is restricted by high downstream tailwater levels within the Hingaia Stream along Great South Road and Norrie Road bridges.

2.4. Flood Mitigation

There is a condition of existing flooding which occurs at the Flanagan Road intake, which has been observed by the design team.

It is proposed that any solution sought should mitigate this flooding so that the water level is less than the top of the existing culvert (RL 9.19).

3. Design Flows

3.1. Design Assumptions

The following design assumptions have been made:

- Discharge into the Hingaia Stream occurs ahead of flows from its upper catchment
- Existing Culvert is Retained – Auckland Council to replace culvert if failure occurs
- Headwater restricted to RL 9.19 at Flanagan Road

3.2. Design Flows

3.2.1. Stormwater Modelling

Stormwater modelling was undertaken to support the different design scenarios identified to achieve stormwater neutrality in terms of maximum water levels at downstream end of the Great South Road tributary within Hingaia Stream (upstream of Norrie Road bridge).

Auckland Council's Hingaia Stream Catchment Stormwater model (built in MIKE by DHI) was used to run the 100yr Maximum Probable Development (MPD) with Climate Change scenarios to assess the results in terms of maximum water levels. This model is also being used for completing the effects assessment of the Kiwi Property and Drury East/Fulton Hogan developments within the Future Urban Zone in Drury-Opaheke.

The proposed culvert arrangement was modelled within the MIKE 11 component of the 1D-2D coupled model wide dummy cross sections at upstream and downstream ends to control the flows using the culvert only. This arrangement is considered suitable to assess the appropriate culvert dimensions and the cross sections can be updated once the culvert dimensions are finalised.

A full copy of the modelling undertaken has been included in Appendix B.

3.2.2. Stormwater Flows

A total of 11 culvert options were tested to ascertain the most appropriate dimensions and inverts as tabulated below.

Table 1: Flow Transfer Testing

Scenario	No of Culverts	WIDTH	HEIGHT	Upstream Invert	Downstream Invert	Max Water Level	WL Difference	Flows diverted
MPD with CC	0	-	-	-	-	9.189	-	-
Option1	0	-	-	-	-	10.621	1.432	-
Option2	1	2.1	2	6.5	6.4	10.116	0.927	11.2m³/s
Option3	2	2.1	2	6.5	6.4	9.483	0.294	19.5m³/s
Option4	1	2.1	2	5.5	5.4	9.826	0.637	13m³/s
Option5	2	2.1	2	5.5	5.4	9.053	-0.136	22.5m³/s
Option6	1	2.1	3	5.5	5.4	9.568	0.379	17m³/s
Option7	1	2.1	2	4.5	4.4	9.572	0.383	14.5m³/s
Option8	1	2.1	2	3.5	3.4	9.399	0.21	15m³/s
Option9	1	2.1	3	3.5	3.4	8.9	-0.289	22m³/s
Option10	1	2.1	2.5	3.5	3.4	9.105	-0.084	19m³/s
Option11	1	2	2.5	3.5	3.4	9.186	-0.003	18m³/s

The selected option is:

- 2.5m high by 2.0m wide box culvert
- Grade = 0%
- Headwater Level RL 9.19
- Flow = 18 m^3/s

3.3. Typical Selections

3.3.1.1. Selection Requirements

Culvert selections have been made to ensure upstream flooding does not impact on new lots or overtop the road at Flanagan Road.

Due to different construction requirements, alternative arrangements need to be considered.

3.3.1.2. Flow Requirements

Cross Sectional Area = 2.5 * 2.0 = 5.0 m2

Obvert of Culvert RL = 9.19

3.3.1.3. Box Culvert Selection

Hynds confirmed they have a 2.5 x 2.0 box culvert available which meets requirements.

3.3.1.4. Circular Culvert Selection

A circular culvert min ID is 2523 mm, based on Hynds stocklists, the following pipes would be acceptable:

2550JACZSRJ – Hynds Skid Ring Joint Jacking Pipe

3.3.1.5. Culvert Strength

The required strength of the culverts depend on the installation methodology, cover to existing ground levels and use of the land above the culvert. This will be confirmed during design of the selected option.

4. Servicing Strategies and Options

Both servicing strategies involve utilising the existing culvert and providing additional capacity from the Maketu Stream south of Flanagan Road to the Hingaia Stream.

Two main strategies have been explored as part of this assessment, with several options considered for each strategy.

Preliminary costings have been undertaken for the main components of the works. Other components are likely to be similar across all options including: Preliminary & General Items, Erosion & Sed Control, etc.

4.1. Strategy 1 – Connect to Hingaia Stream via Maketu Stream

This strategy involves installation of new culverts and discharging to a similar location on the Hingaia Stream – ie the current Maketu Stream outfall. Utilising a similar outfall

Three different options have been explored for this strategy.

Plans for these options have been included in Appendix A.

4.1.1. Option 1A – Install Parallel Culvert

4.1.1.1. Description

To add to the capacity of the culvert, it is proposed that a second culvert is installed parallel to the existing culvert utilising a tunnelling methodology. Five pits will be set up at Flanagan Road, 2/260 Great South Road, 263-267 Great South and the outfall location in order to install this line.

Figure 4: Option 1A Layout

4.1.1.2. Preliminary Costings

Table 2: Option 1A Costing

Item	Total
Preliminary & General	$2,638,168.91
Groundworks	$2,725,000.00
Drainage	$3,526,355.14
Landscaping	$74,750
Total	**$8,964,274.05**

Full costings have been included in Appendix C.

4.1.1.3. Advantages

- Likely to only affect neighbours within 263-275 Great South Road, potential strategy to purchase lot to ensure works can be carried out effectively.

4.1.1.4. Disadvantages

- Multiple pits adjacent to existing waterway – environmental and flooding risk
- Multiple set ups for tunnelling machine
- Potential settlement issues for adjacent buildings
- High risk in unforeseen ground conditions during tunnelling
- Tunnelling – Complex operation, higher health & safety risk
- Monitoring of KiwiRail during installation
- Higher Geotech investigation requirement for tunnelling
- Settlement monitoring under existing structures
- High traffic management costs for working adjacent to existing major and minor roads

4.1.2. Option 1B – Duplicate Flanagan Road/Kiwi Rail Crossing & Install Culvert North of 263 Great South Road

4.1.2.1. Description

To add to the capacity of the culvert, it is proposed that a second culvert is installed parallel to the existing culvert from Flanagan Road to 2/260 Great South Road, then on an alternative alignment from 2/260 Great South Road to the outfall location utilising a tunnelling methodology. Four pits will be set up at Flanagan Road, 2/260 Great South Road and the outfall location in order to install this line.

Figure 5: Option 1B Layout

4.1.2.2. Preliminary Costings

Table 3: Option 1B Costing

Item	Total
Preliminary & General	$2,325,281.47
Groundworks	$2,725,000.00
Drainage	$3,006,161.55
Landscaping	$74,750.00
Total	**$7,681,193.02**

Full costings have been included in Appendix C.

4.1.2.3. Advantages

- No deep manhole install next to existing structure
- Likely to only affect properties in 257-261 Great South Road, potential strategy to purchase lot to ensure works can be carried out effectively.

4.1.2.4. Disadvantages

- Multiple pits adjacent to existing waterway – environmental and flooding risk
- Multiple set ups for tunnelling machine
- Potential settlement issues for adjacent buildings
- Tunnelling – Complex operation, higher health & safety risk
- Monitoring of KiwiRail during installation
- Higher Geotech investigation requirement for tunnelling
- Settlement monitoring under existing structures
- High traffic management costs for working adjacent to existing major and minor roads
- High risk in unforeseen ground conditions during tunnelling

4.1.3. Option 1C – Install Culvert North of 263 Great South Road

4.1.3.1. Description

To add to the capacity of the culvert, it is proposed that a second culvert is installed from Flanagan Road to the outfall location utilising a tunnelling methodology. Two pits will be set up at Flanagan Road and the outfall location in order to install this line.

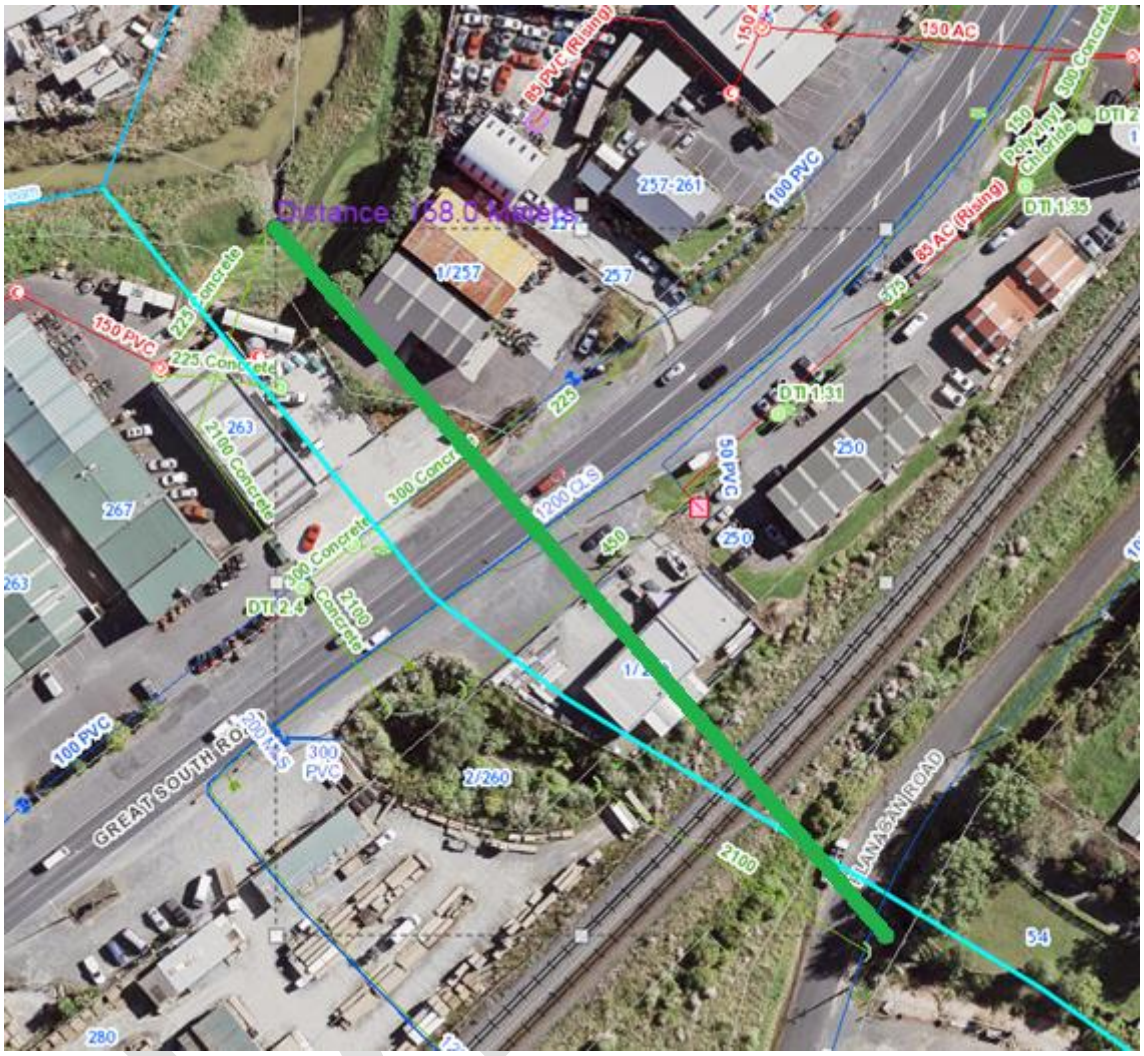


Figure 6: Option 1C Layout

4.1.3.2. Preliminary Costings

Table 4: Option 1C Costing

Item	Total
Preliminary & General	$1,957,938.64
Groundworks	$1,175,000.00
Drainage	$3,003,238.99
Landscaping	$38,625.00
Total	**$6.174.802.62**

Full costings have been included in Appendix C.

4.1.3.3. Advantages

- Direct route, no impact on existing roads
- Low impact, only 2 shafts

4.1.3.4. Disadvantages

- Tunnelling – Complex operation, higher health & safety risk
- Monitoring of KiwiRail during installation
- Higher Geotech investigation requirement for tunnelling
- Settlement monitoring under existing structures
- High risk in unforeseen ground conditions during tunnelling

4.2. Strategy 2 – Connect Upstream to Hingaia Stream

This strategy involves relocating the outfall to a new position higher upstream than the current Maketu Stream outfall. This isn't an issue in terms of flooding as the Maketu Stream flooding occurs well in advance of the Hingaia Stream flooding and therefore will not have any adverse effects on upstream infrastructure. This strategy looks to reduce the technical construction items in favour of simpler and potentially less expensive infrastructure.

New intake and outfall structures would be required and consideration of staged inflows is required.

Plans for these options have been included in Appendix A.

4.2.1. Option 2A – Install Pipeline Along Flanagan Road to Hingaia Stream South of Bridge

4.2.1.1. Description

This option would involve the installation of a stormwater line from the Maketu Stream to the Hingaia Stream along the existing Flanagan Road alignment. A circular or box culvert pipeline could be used for this installation.

Figure 7: Option 2A Layout

4.2.1.2. Preliminary Costings

Table 5: Option 2A Costing

Item	Total
Preliminary & General	$1,781,725.40
Groundworks	$125,000.00
Drainage	$4,877,868.50
Landscaping	$76,125.00
Total	**$6,860,718.90**

Full costings have been included in Appendix C.

4.2.1.3. Advantages

- No impact on major roads
- Minor road upgraded for development, incorporate into development
- Easy to maintain and access
- Conventional installation – wider range of contractors can install

4.2.1.4. Disadvantages

- Trafffic management required on minor road
- Upgrade costs of minor road

4.2.2. Option 2B – Install Open Channel Adjacent Flanagan Road to Hingaia Stream South of Bridge

4.2.2.1. Description

This option creates an open channel from the Maketu Stream to the Hingaia Stream adjacent to Flanagan Road. The location of this channel could entirely be within the adjacent lots or partially within the road reserve or Watercare Lot.

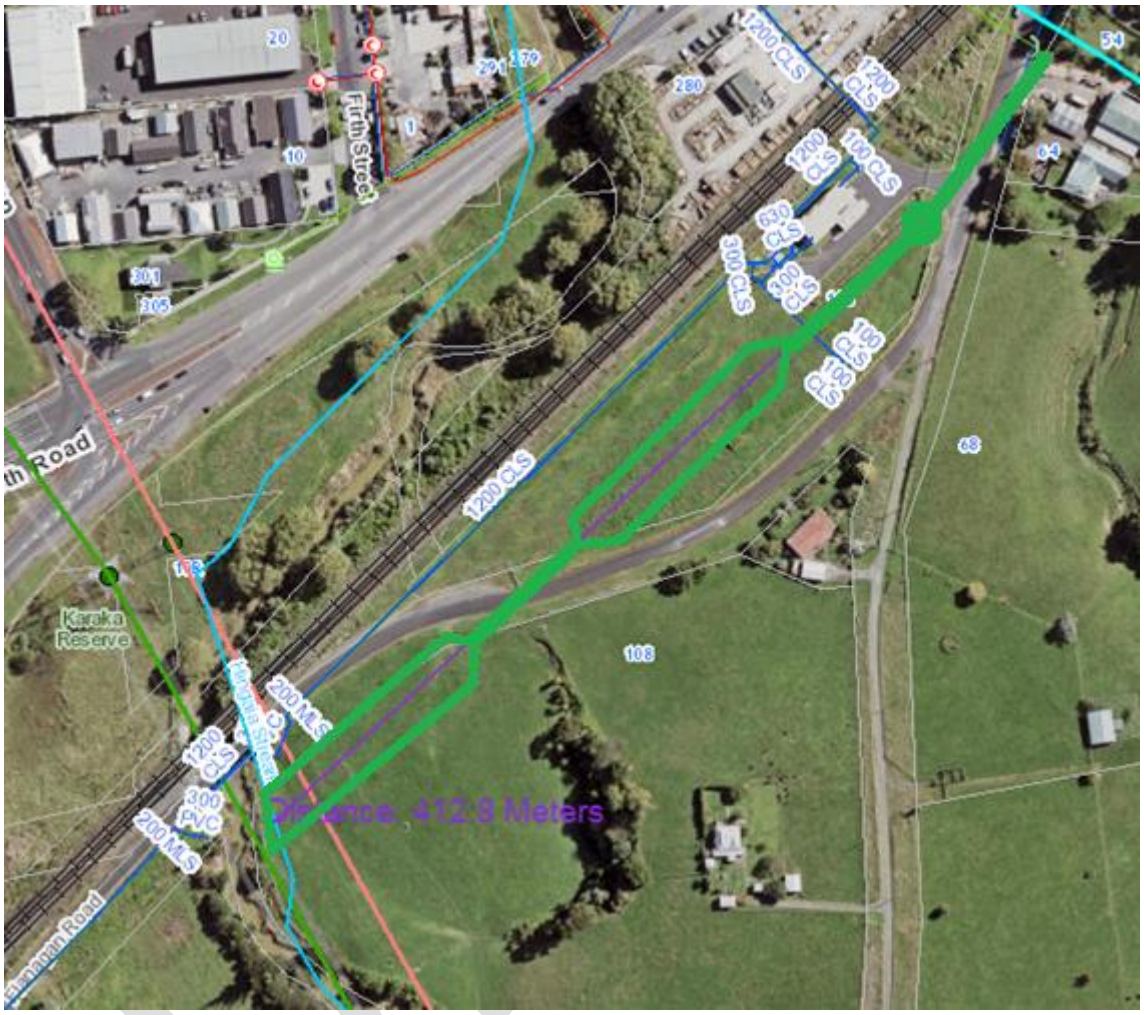


Figure 8: Option 2B Layout

Some culverts may be required where crossing Flanagan Road and allowing access for the existing lots. Alternative alignments could be considered if these lots were purchased and an earthworks operation was undertaken in order to regrade the land so that it is more suitable to this option.

4.2.2.2. Preliminary Costings

Table 6: Option 2B Costing

Item	Total
Preliminary & General	$847,015.25
Groundworks	$125,000.00
Drainage	$1,890,395.17
Landscaping	$76,125.00
Total	**$2,938,535.42**

Additional costs may be incurred due to the alignment, however this is not quantifiable until the route is selected. These include land costs, access requirements, service realignment, etc.

Full costings have been included in Appendix C.

4.2.2.3. Advantages

- Reduction in cost due to less precast elements.
- Easy to maintain and access
- Environmentally friendly
- Low impact on minor roads – very low traffic management costs
- No impact on major roads

4.2.2.4. Disadvantages

- Hard to provide accurate costings without understanding the route.
- Utilise land area ie reduces developable land
- Maintenance for landscaping area

4.2.3. Option 2C – Install Pipeline Along Flanagan Road to Hingaia Stream Under Rail

4.2.3.1. Description

This option would involve the installation of a stormwater line from the Maketu Stream to the Hingaia Stream along the existing Flanagan Road alignment passed the Watercare Water Facility then a tunnelled section under the rail to Hingaia Stream. A circular or box culvert pipeline could be used for the trenching installation and a circular pipeline would be required for the tunnelled section.

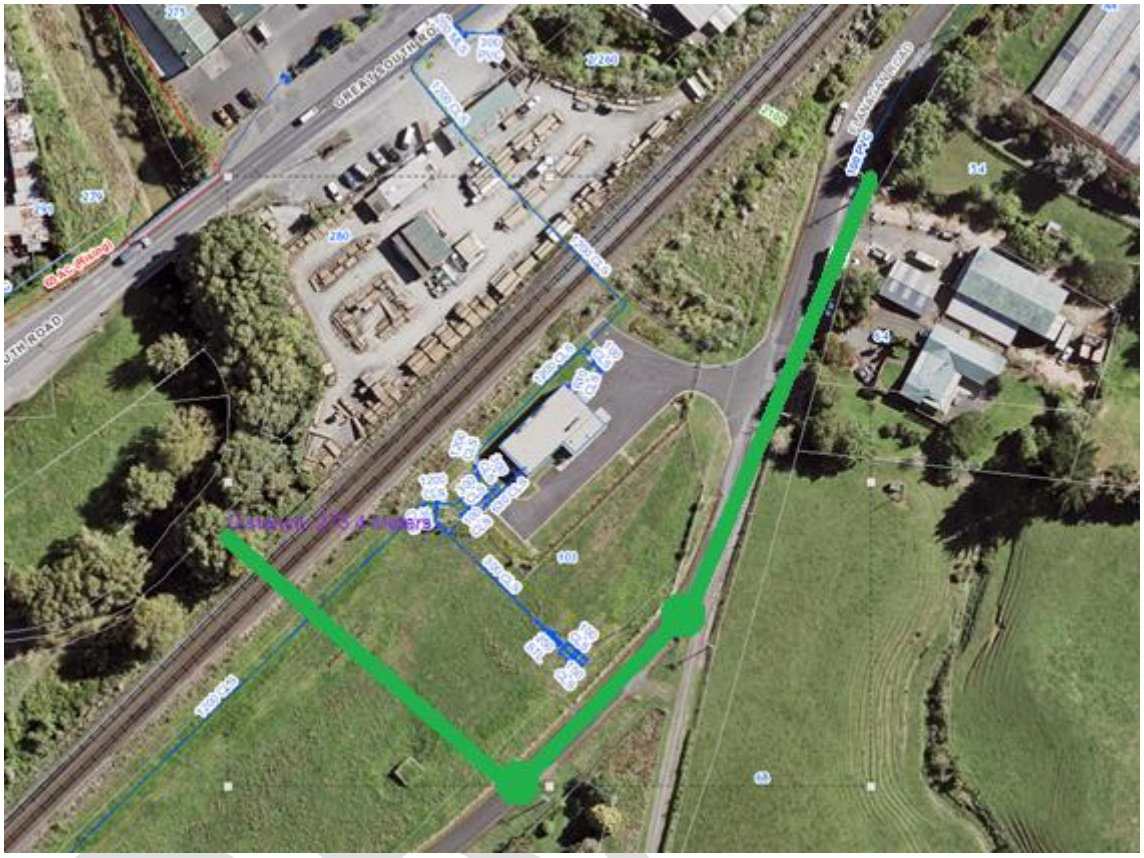


Figure 9: Option 2C Layout

4.2.3.2. Preliminary Costings

Table 7: Option 2C Costing

Item	Total
Preliminary & General	$1,813,759.63
Groundworks	$1,175,000.00
Drainage	$3,445,474.64
Landscaping	$58,625.00
Total	**$6,492,859.27**

Full costings have been included in Appendix C.

4.2.3.3. Advantages

- Away from major roads
- Away from existing buildings
- Low Maintenance

- Lower traffic management requirements

4.2.3.4. Disadvantages

- Impact on Minor Road
- Working within WSL Lot
- Tunnelling – Complex operation, higher health & safety risk
- Monitoring of KiwiRail during installation
- Higher Geotech investigation requirement for tunnelling
- High risk in unforeseen ground conditions during tunnelling, however less risk that option 1 for access.

4.3. Other Options Considered

4.3.1. Overland Flow Path Options

Reduction in the sizing of the new culverts would create flooding issues at Flanagan Road and an overland flow path would need to be created to ensure the flooding issue did not create problems to existing infrastructure (such as properties and rail).

This overland flow path could allow some flooding of Flanagan Road during higher rainfall events. This would involve a combination of the two strategies and will likely incur higher costs as well as provide a less suitable solution

4.3.2. Divert the Maketu Stream Upstream

A diversion of the Maketu Stream could be made further upstream where flows sent to the Hingaia Stream before they reach the Flanagan Road Culvert. Due to the distance of this diversion >1km this is not seen as a viable option unless major recontouring as part of the development is proposed.

4.3.3. Culvert Replacement – Install Dual Culverts

As there is a risk that the existing culvert could need replacement within the next 5-10 years, a cost sharing agreement could be put into place for Auckland Council to fund the replacement of the existing culvert.

The best option for undertaking this is to duplicate the option utilised above. The costs will increase significantly however will not be double the figures above as there are efficiencies in undertaking the works as a single contract.

5. Options Summary & Conclusions

5.1. Cost Comparison

Table 8: Cost comparison summary

Option	Description	Cost
1A	Parallel Culvert – Alignment Duplication	$8,964,274.05
1B	Parallel Culvert from Maketu inlet to 2/260 Great South Road, new alignment from 2/260 Great South Road to outfall	$7,681,193.02
1C	New alignment from Maketu inlet to outfall	$6,174,802.62
2A	Pipeline on Flanagan Road	$6,860,718.90
2B	Open Channel on Flanagan Road	$2,938,535.42
2C	Pipeline on Flanagan Road, Pipeline within Watercare Lot and Tunnel under KiwiRail	$6,492,859.27

5.2. Option Summary

Table 9: Options Summary

Option	Complexity	Safety Risk	Consenting Risk	Environment Risk	Capital Cost	Operation Cost
1A	High	High	High	Medium	High	Low
1B	High	High	High	Medium	High	Low
1C	High	High	High	Medium	Medium	Low
2A	Medium	Medium	Medium	Medium	Medium	Low
2B	Low	Low	Low	Medium	Low	Medium
2C	High	Medium	Medium	Medium	Medium	Low

5.3. Summary

FHLDL have engaged Woods to prepare a Stormwater Assessment for the Flanagan Road, KiwiRail and Great South Road Culverts as part of the larger Kiwi and FHLDL developments within Drury East.

This reports summaries 6 main options for upgrading stormwater infrastructure to allow development flows to be passed forward utilising 2 strategies.

The two potential strategies that have been explored are:

- Strategy 1 – Connect to Hingaia Stream Utilising Maketu Stream Alignment and Outfall
    - Option 1A – Parallel Culverts
    - Option 1B – 1 Parallel, 1 Realigned
    - Option 1C – Single Culvert New Alignment

- Strategy 2 – Connect to Hingaia Stream Upstream of Existing Outfall
    - Option 2A – Piped to Flanagan Road Crossing
    - Option 2B – Open Channel to Flanagan Road Crossing
    - Option 2C – Culvert then KiwiRail Tunnel

Other options have been explored and discounted.

All the options explored utilise the existing culvert's capacity as well as new capacity provided by the option to meet the flow and headwater level requirements.

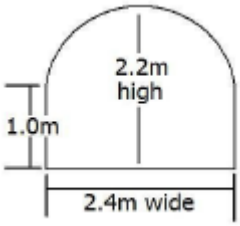
6. Appendix A – Concept Design Plans

7. Appendix B – Stormwater Modelling / Reporting

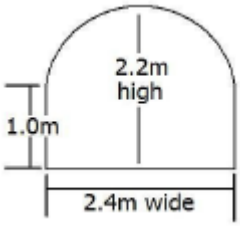
7.1. Modelling Input Information

Existing culverts

1. Name: C8 Flanagan Rd Culvert
   - Upstream invert: 2.903mRL
   - Downstream invert: 2.707mRL
   - Length: 50m
   - Arch culvert



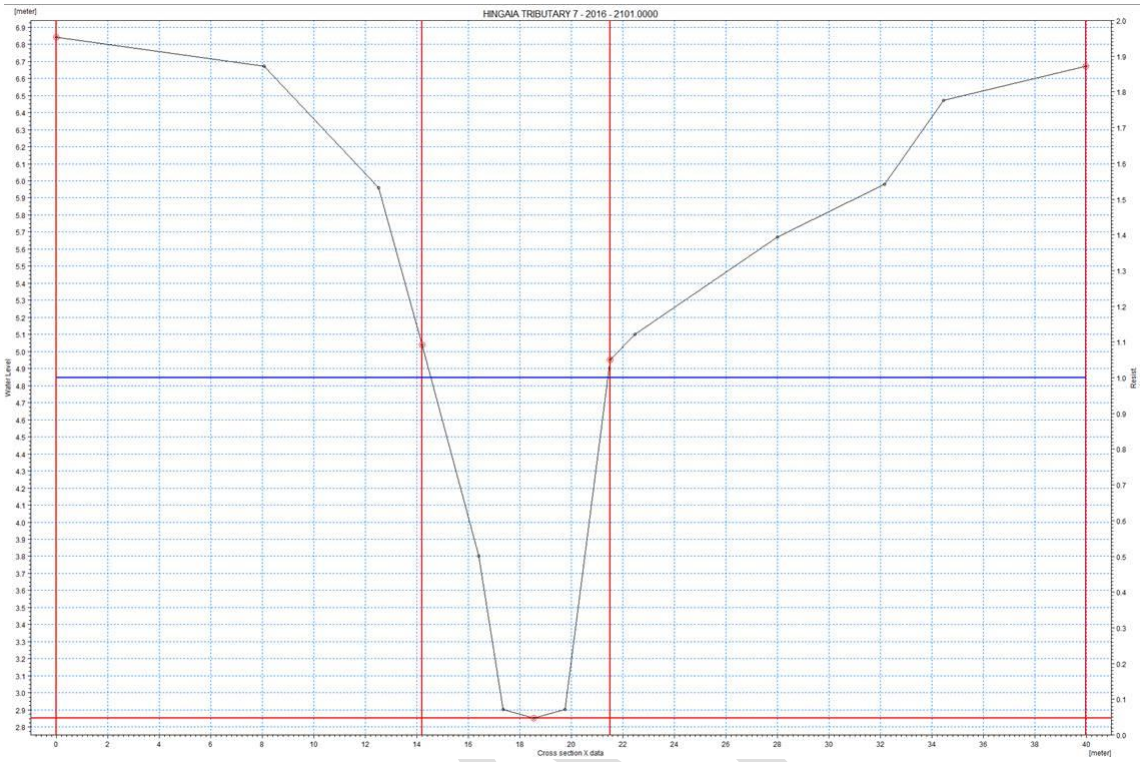
2. Name: Great South Road Culvert
   - Upstream invert: 2.17mRL
   - Downstream invert: 1.925mRL
   - Length: 28m
   - Arch culvert



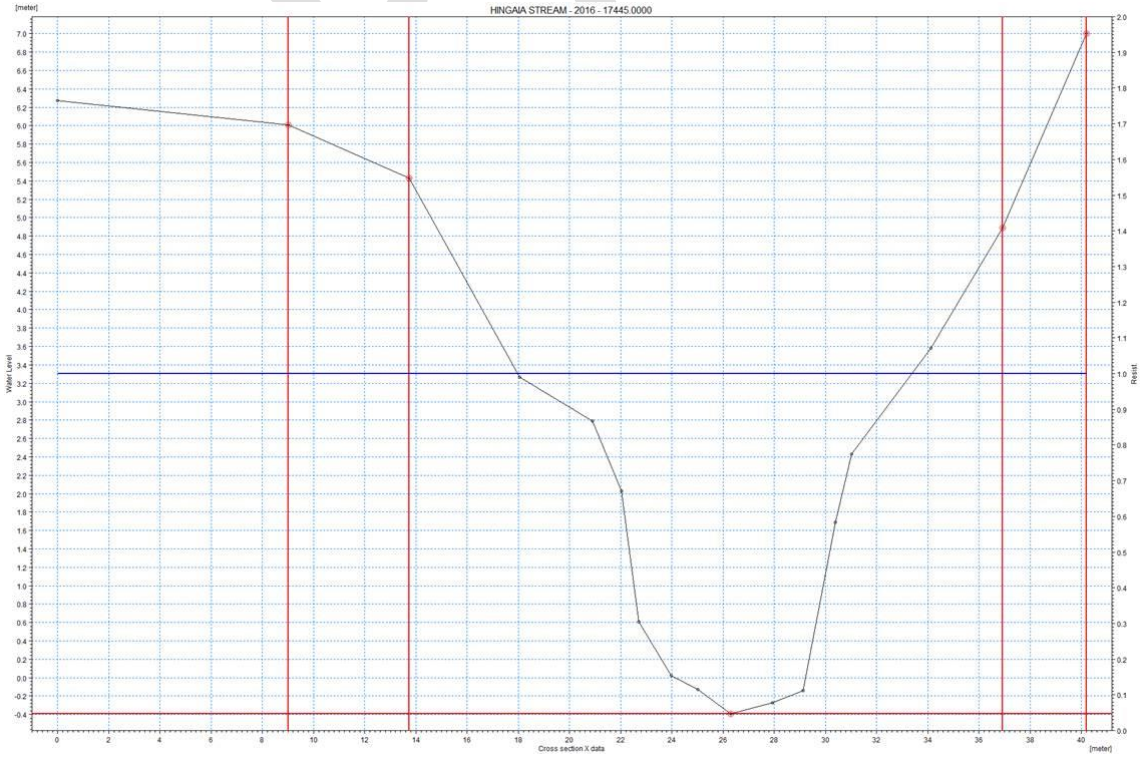
3. Name: Great South Road Culvert (downstream end)
   - Upstream invert: 1.925mRL
   - Downstream invert: 1.34mRL
   - Length: 62m
   - Diameter: 1.2m circular

Stream Cross Sections

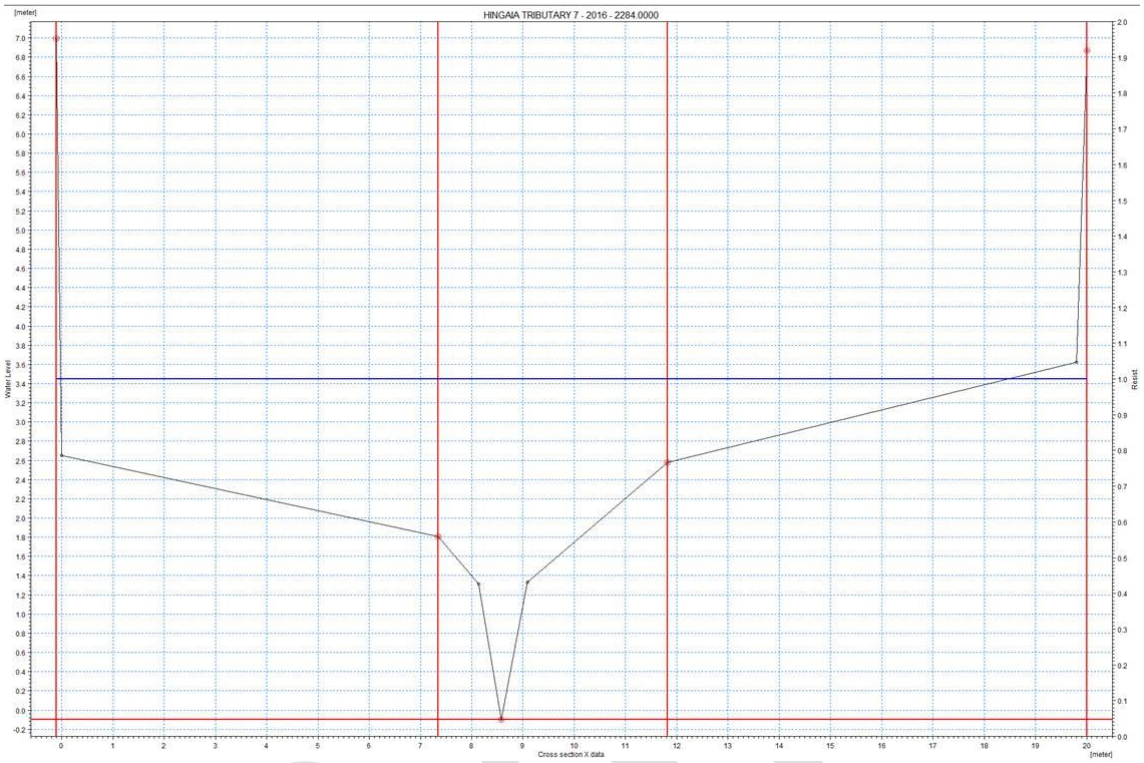
1. Upstream cross section (upstream of Flanagan Road)



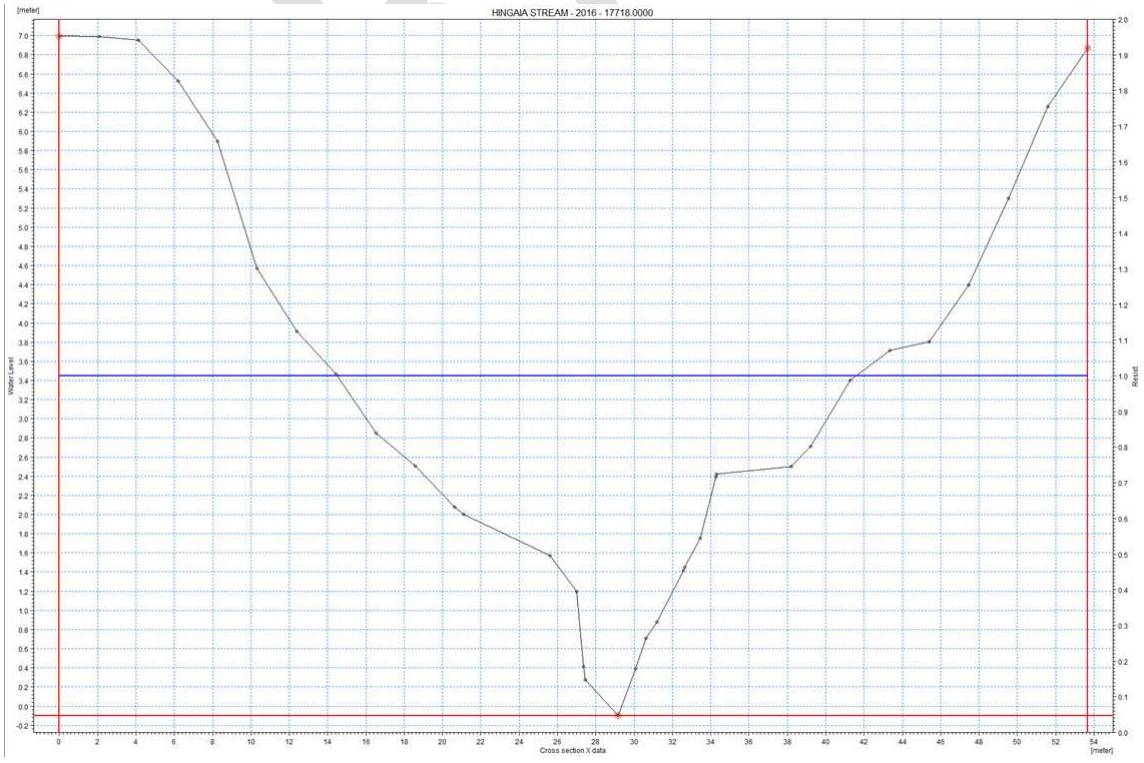
2. Downstream cross section (upstream of Flanagan Road – when proposed culvert goes west to Hingaia Stream)



3. Downstream cross section at tributary (upstream of Norrie Road bridge – when proposed culvert goes along existing culverts)



4. Downstream cross section at Hingaia Stream (upstream of Norrie Road bridge– when proposed culvert goes along existing culverts)



7.2. Model Build Memo

8. Appendix C – Engineer's Estimate's

9. Appendix D - Existing Services Information

9.1. GIS Plans

9.2. B4UDig Plans

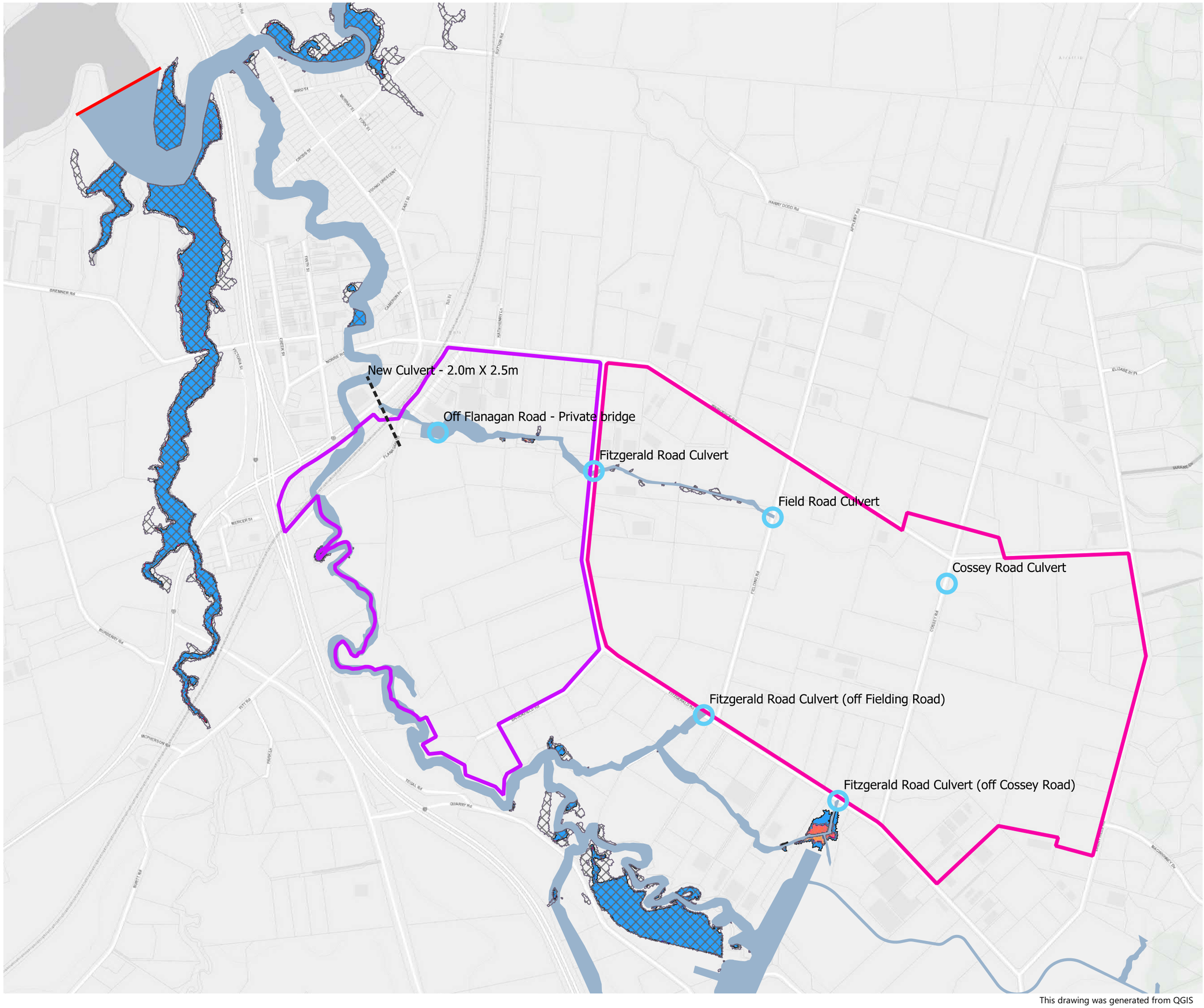
9.2.1. Watercare

9.2.2. Chorus

9.2.3. Vector Gas

9.2.4. Transpower

9.2.5. LINZ



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WOODS EST.1970

LEGEND

- 1D River Extent
- Flood Model Boundary
- Fulton Hogan Development
- Kiwi Property Plan Change (Feb 2019)

Peak Water Level Difference (m)

- <0.05
- 0.05-0.1
- 0.1-0.15
- 0.15-0.2
- 0.2-0.25
- 0.25-0.6
- 0.6-1
- 1-2
- 2-3
- 3-6
- Post Development Flood Extent

Existing Flood Extent

REVISION DETAILS		BY	DATE
1.0	Issued for Information	PW	5/06/2020

SURVEYED	AC	
DESIGNED	PW/AD	
DRAWN	SH	
CHECKED	PW	
APPROVED	PW	WOODS.CO.NZ

N

2 Year ED Flood Assessment
Catchment Model
Climate Change - NO

STATUS	ISSUED FOR INFORMATION	REV
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COUNCIL	AUCKLAND COUNCIL	
DWG NO	P16-335-SKT-0001	

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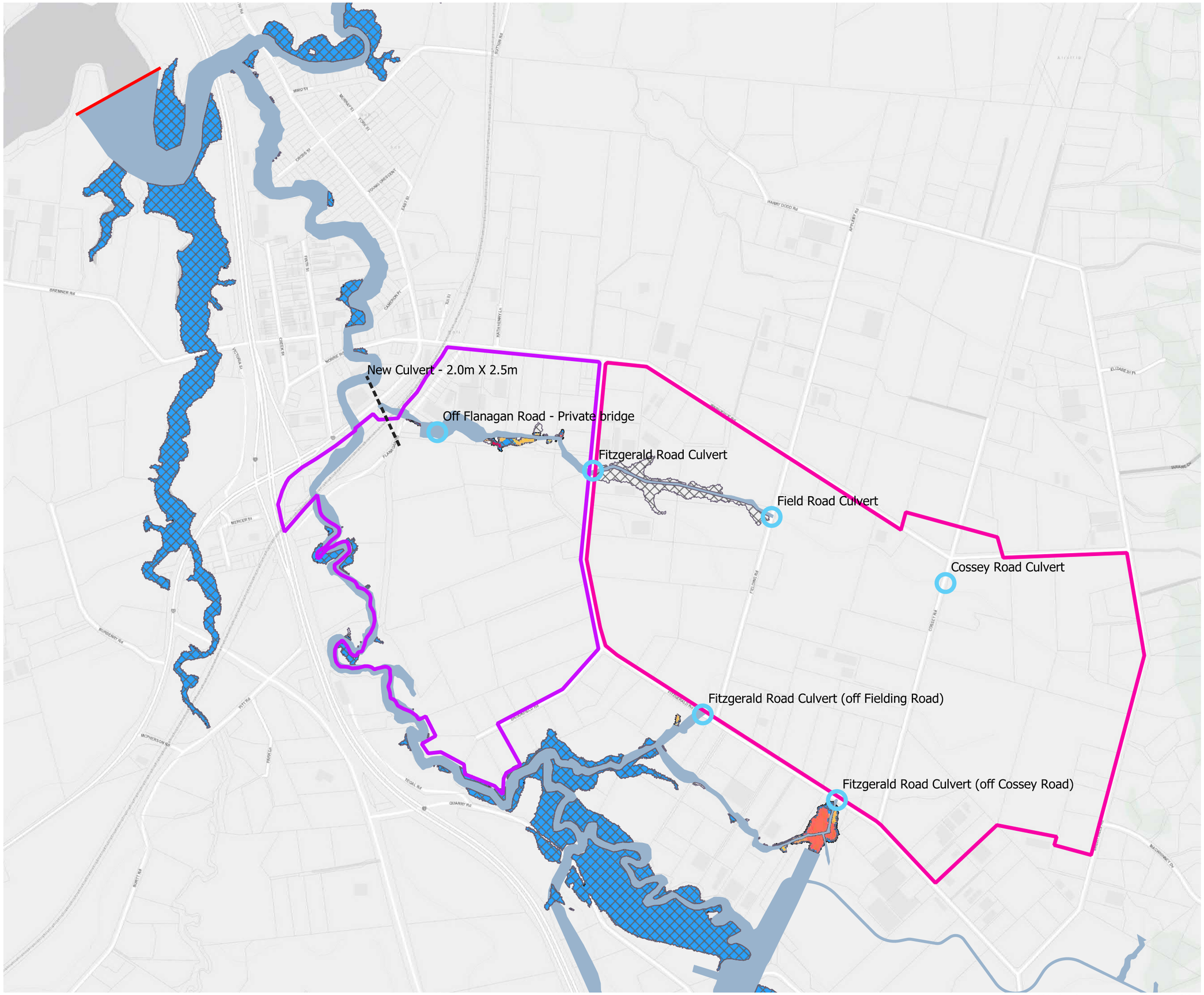

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WOODS EST.1970

LEGEND

- 1D River Extent
- Flood Model Boundary
- Fulton Hogan Development
- Kiwi Property Plan Change (Feb 2019)

Peak Water Level Difference (m)

- <0.05
- 0.05-0.1
- 0.1-0.15
- 0.15-0.2
- 0.2-0.25
- 0.25-0.6
- 0.6-1
- 1-2
- 2-3
- 3-6
- Post Development Flood Extent
- Existing Flood Extent

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10 Year ED Flood Assessment
Catchment Model
Climate Change - NO

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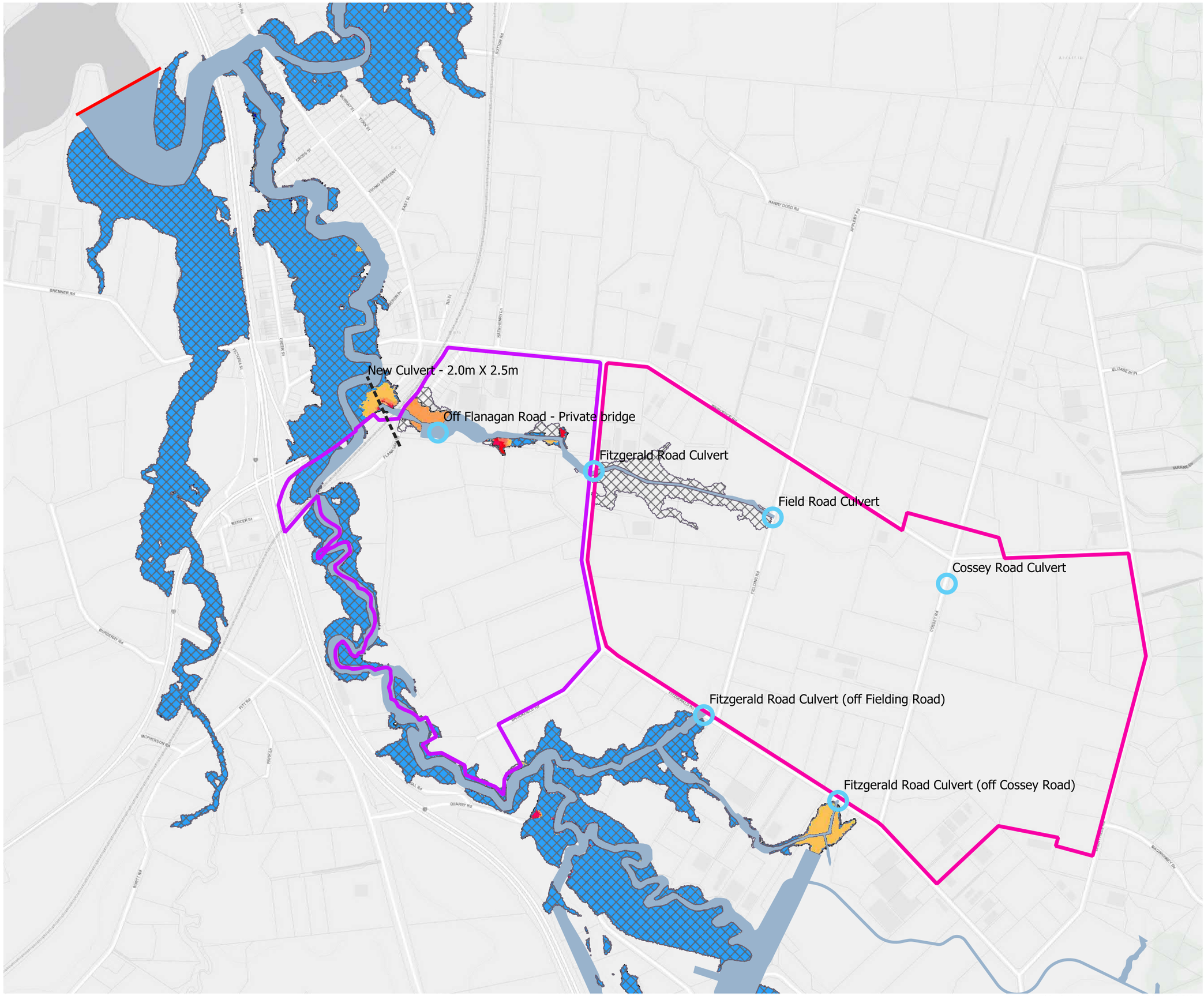

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WOODS EST.1970

LEGEND

- 1D River Extent
- Flood Model Boundary
- Fulton Hogan Development
- Kiwi Property Plan Change (Feb 2019)

Peak Water Level Difference (m)

- <0.05
- 0.05-0.1
- 0.1-0.15
- 0.15-0.2
- 0.2-0.25
- 0.25-0.6
- 0.6-1
- 1-2
- 2-3
- 3-6
- Post Development Flood Extent
- Existing Flood Extent

REVISION DETAILS		BY	DATE
1.0	Issued for Information	PW	5/06/2020

SURVEYED	AC	
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DRAWN	SH	
CHECKED	PW	
APPROVED	PW	WOODS.CO.NZ

N

100 Year ED Flood Assessment
Catchment Model
Climate Change - NO

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DWG NO	P16-335-SKT-0003	

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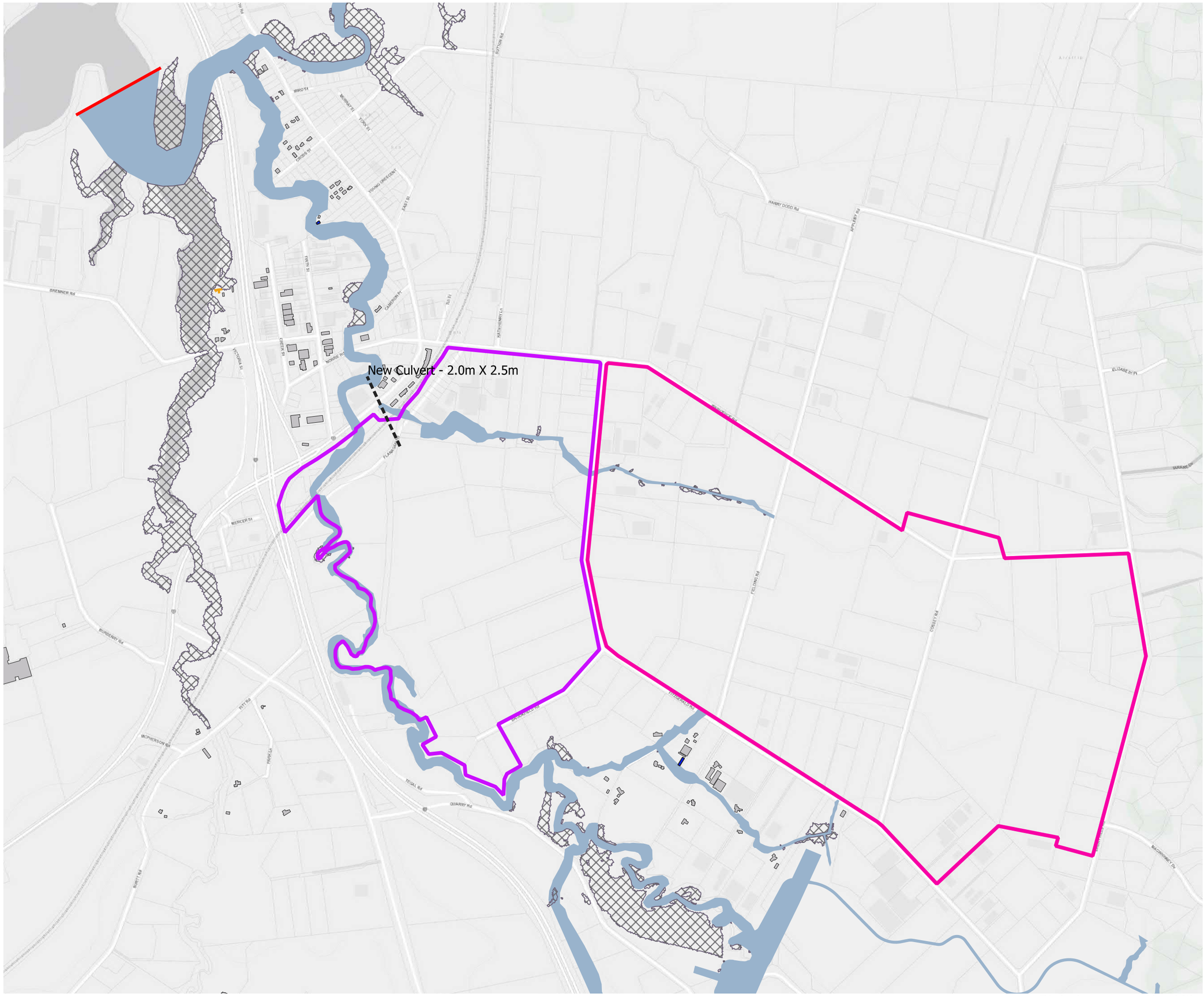

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WOODS Est.1970

LEGEND

- 1D River Extent
- Flood Model Boundary
- Fulton Hogan Development
- Kiwi Property Plan Change (Feb 2019)
- Flood Extent

Buildings

- Flood depth <0.15m
- No flooding
- Flood level < Building level
- Flood level > Building level
- Flood level > 0.15m

REVISION DETAILS		BY	DATE
1.0	Issued for Information	PW	5/06/2020

SURVEYED	AC	
DESIGNED	PW/AD	
DRAWN	SH	
CHECKED	PW	
APPROVED	PW	WOODS.CO.NZ

N

2 Year ED Pre Development Flood Assessment
Catchment Model
Climate Change - NO
Building Assesment

STATUS	ISSUED FOR INFORMATION	REV
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DWG NO	P16-335-SKT-0004	

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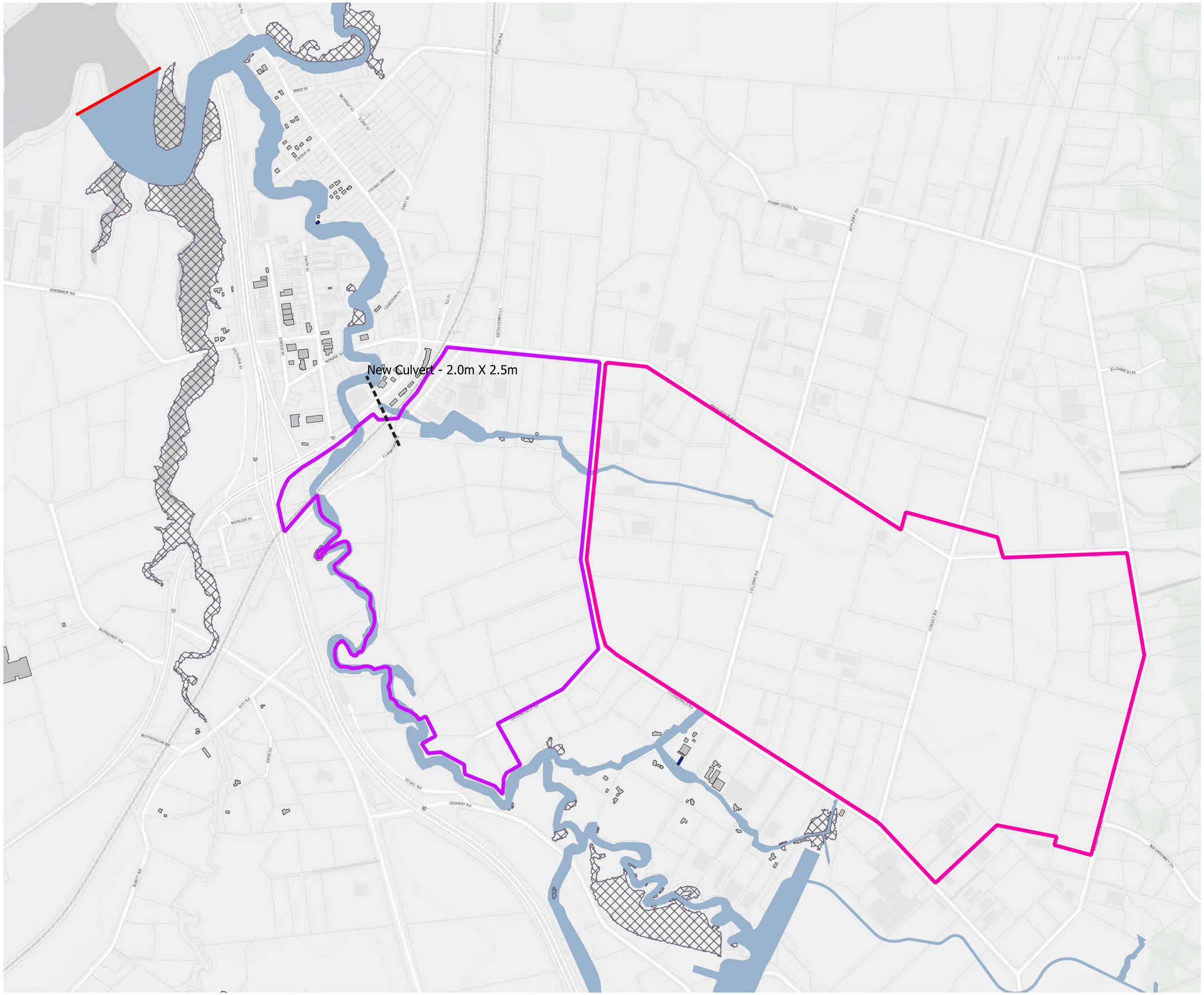

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WOODS Est.1970

LEGEND

- 1D River Extent
- Flood Model Boundary
- Fulton Hogan Development
- Kiwi Property Plan Change (Feb 2019)
- Flood Extent

Buildings

- Flood depth <0.15m
- No flooding
- Flood level < Building level
- Flood level > Building level
- Flood level > 0.15m

REVISION DETAILS		BY	DATE
1.0	Issued for Information	PW	5/06/2020

SURVEYED	AC	
DESIGNED	PW/AD	
DRAWN	SH	
CHECKED	PW	
APPROVED	PW	WOODS.CO.NZ

N

2 Year ED Post Development Flood Assessment
Catchment Model
Climate Change - NO
Building Assesment

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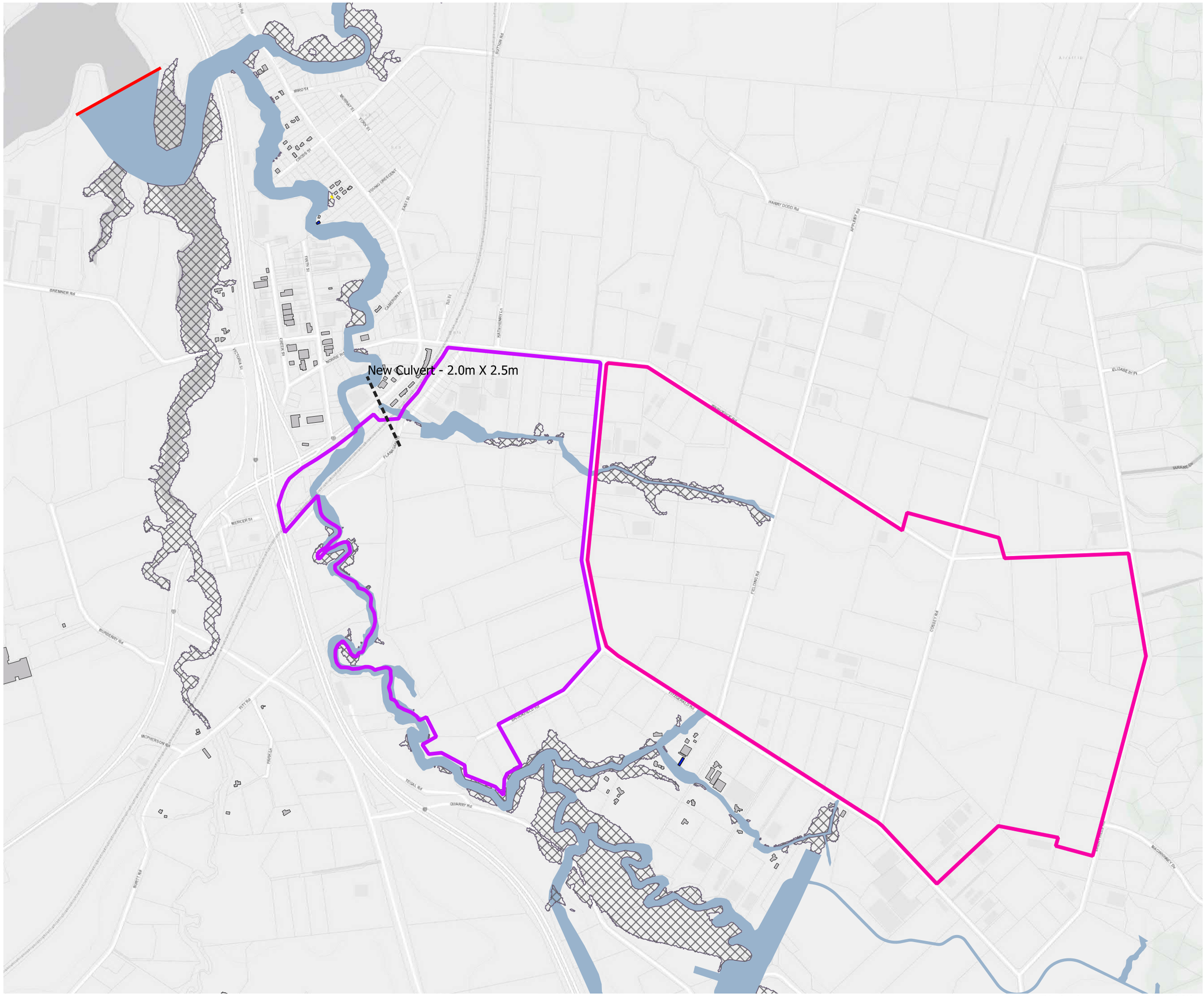

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WOODS Est.1970

LEGEND

- 1D River Extent
- Flood Model Boundary
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- Kiwi Property Plan Change (Feb 2019)
- Flood Extent

Buildings

- Flood depth <0.15m
- No flooding
- Flood level < Building level
- Flood level > Building level
- Flood level > 0.15m

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10 Year ED Pre Development Flood Assessment
Catchment Model
Climate Change - NO
Building Assesment

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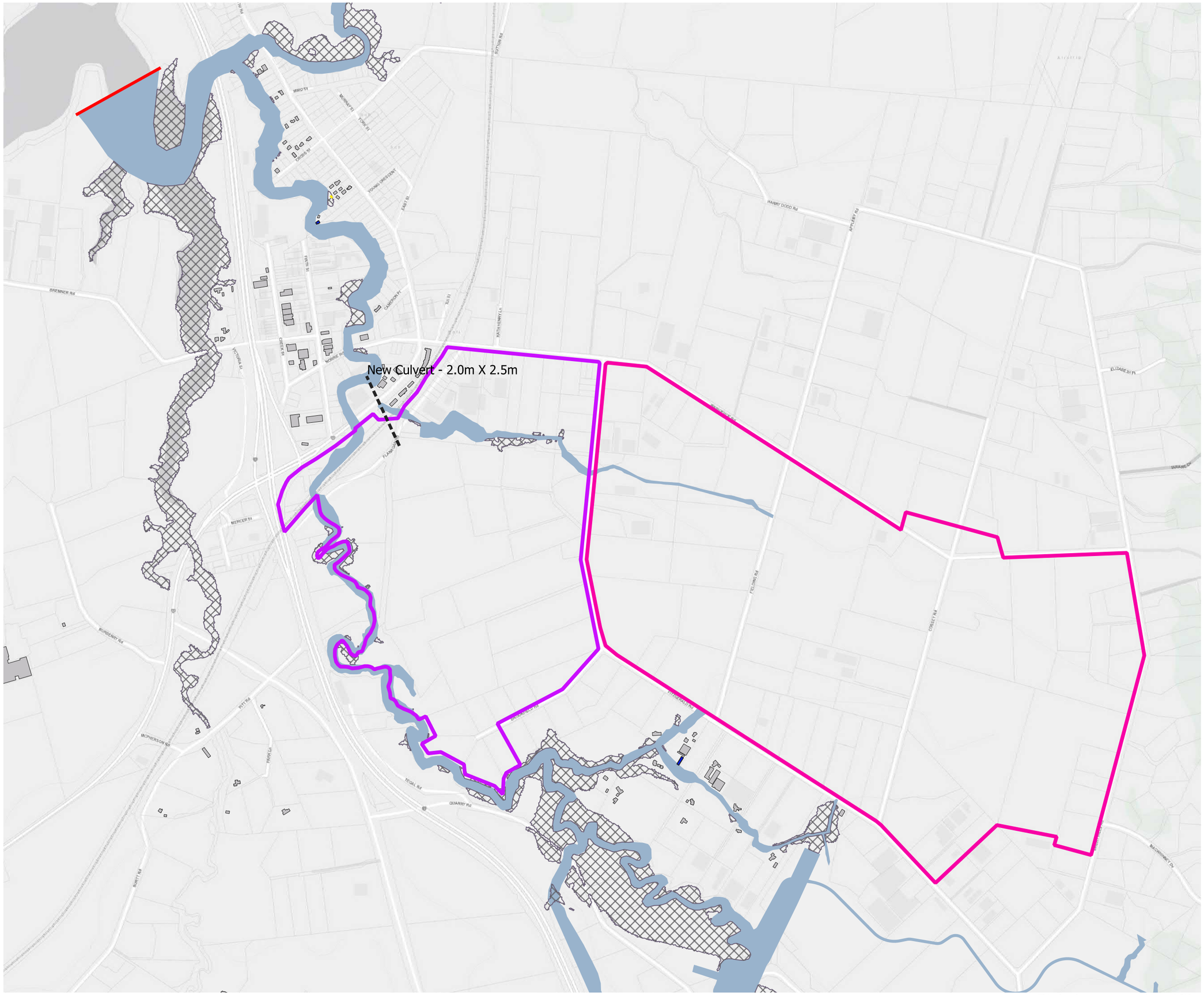

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WOODS Est.1970

LEGEND

- 1D River Extent
- Flood Model Boundary
- Fulton Hogan Development
- Kiwi Property Plan Change (Feb 2019)
- Flood Extent

Buildings

- Flood depth <0.15m
- No flooding
- Flood level < Building level
- Flood level > Building level
- Flood level > 0.15m

REVISION DETAILS		BY	DATE
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CHECKED	PW	
APPROVED	PW	WOODS.CO.NZ

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10 Year ED Post Development Flood Assessment
Catchment Model
Climate Change - NO
Building Assesment

STATUS	ISSUED FOR INFORMATION	REV
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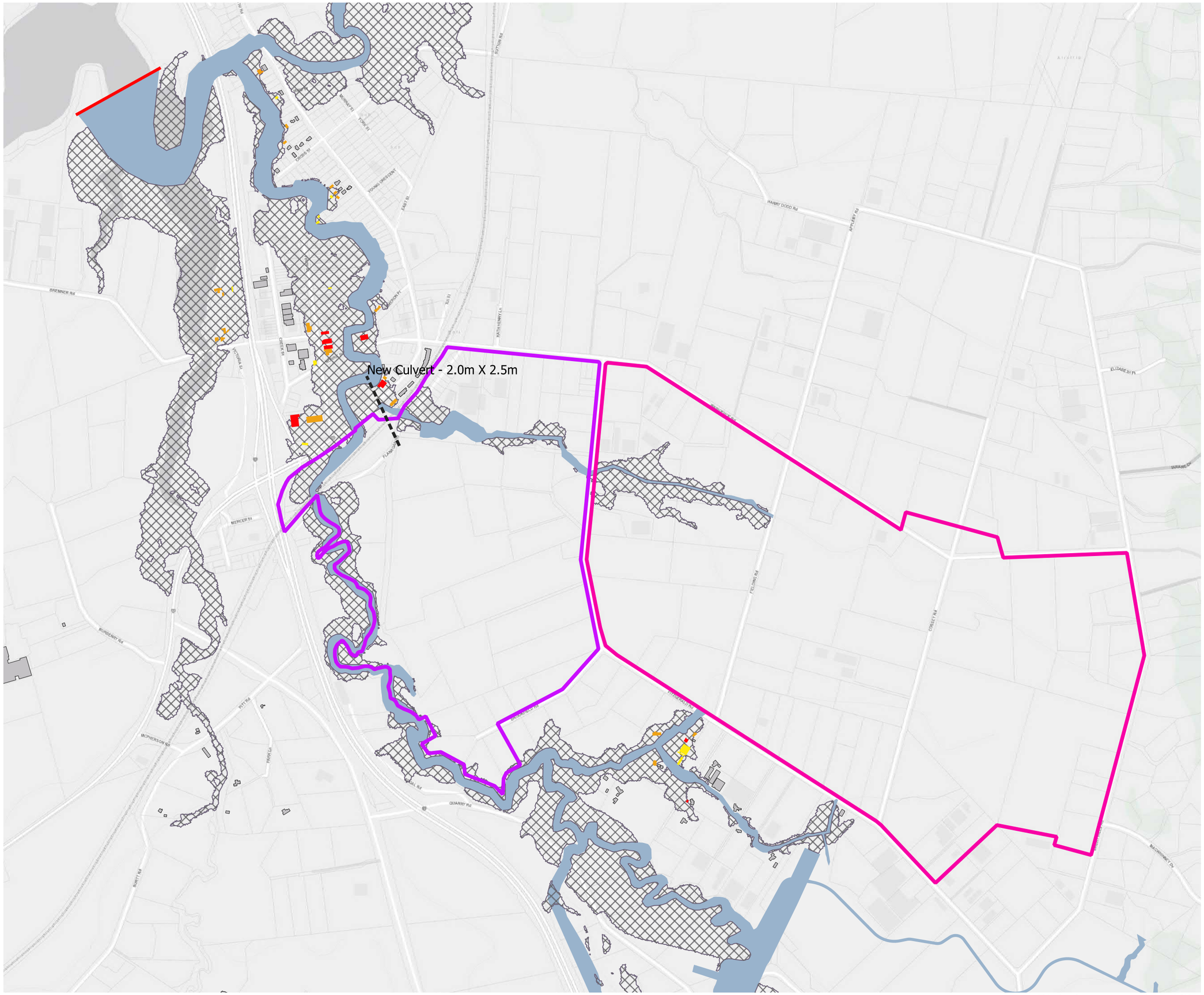

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WOODS
Est.1970

LEGEND

- 1D River Extent
- Flood Model Boundary
- Fulton Hogan Development
- Kiwi Property Plan Change (Feb 2019)
- Flood Extent

Buildings

- Flood depth <0.15m
- No flooding
- Flood level < Building level
- Flood level > Building level
- Flood level > 0.15m

REVISION DETAILS		BY	DATE
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SURVEYED	AC	
DESIGNED	PW/AD	
DRAWN	SH	
CHECKED	PW	
APPROVED	PW	WOODS.CO.NZ

N

100 Year ED Pre Development Flood Assessment
Catchment Model
Climate Change - NO
Building Assesment

STATUS	ISSUED FOR INFORMATION	REV
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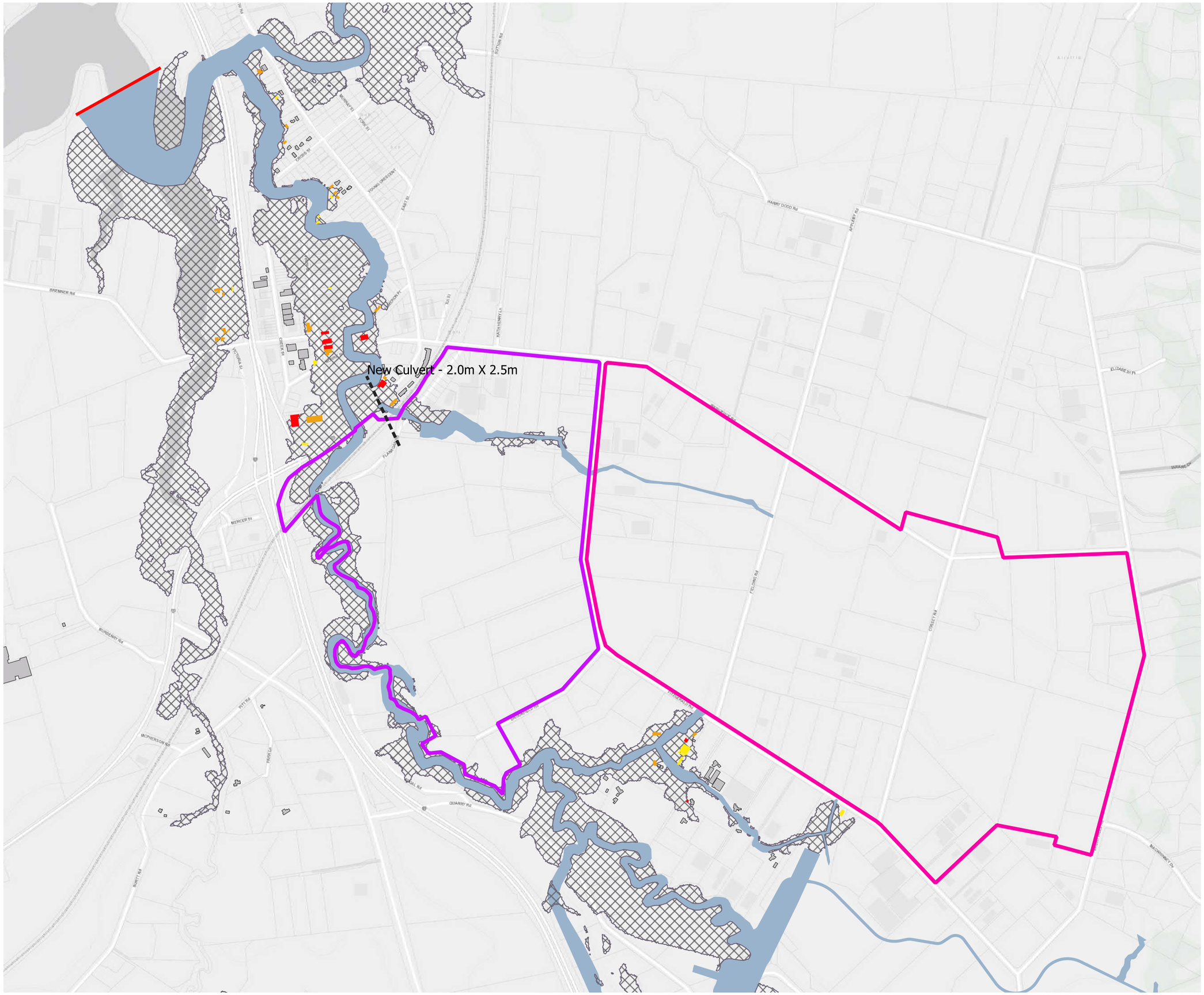

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WOODS
Est.1970

LEGEND

- 1D River Extent
- Flood Model Boundary
- Fulton Hogan Development
- Kiwi Property Plan Change (Feb 2019)
- Flood Extent

Buildings

- Flood depth <0.15m
- No flooding
- Flood level < Building level
- Flood level > Building level
- Flood level > 0.15m

REVISION DETAILS		BY	DATE
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DESIGNED	PW/AD	
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CHECKED	PW	
APPROVED	PW	WOODS.CO.NZ

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100 Year ED Post Development Flood Assessment
Catchment Model
Climate Change - NO
Building Assesment

STATUS	ISSUED FOR INFORMATION	REV
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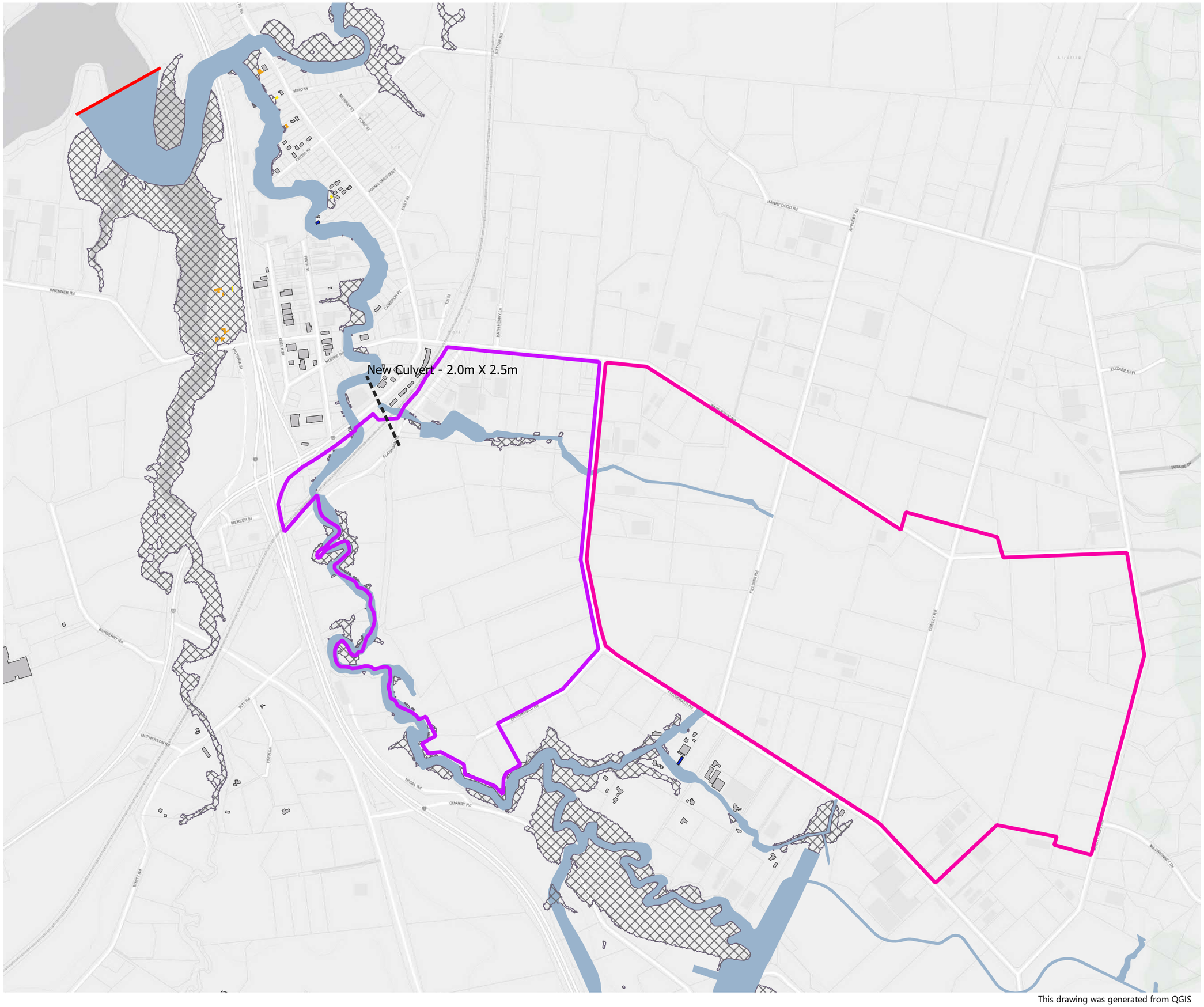

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WOODS Est.1970

LEGEND

- 1D River Extent
- Flood Model Boundary
- Fulton Hogan Development
- Kiwi Property Plan Change (Feb 2019)
- Flood Extent

Buildings

- Flood depth <0.15m
- No flooding
- Flood level < Building level
- Flood level > Building level
- Flood level > 0.15m

REVISION DETAILS		BY	DATE
1.0	Issued for Information	PW	5/06/2020

SURVEYED	AC	
DESIGNED	PW/AD	
DRAWN	SH	
CHECKED	PW	
APPROVED	PW	WOODS.CO.NZ

N

10 Year MPD Post Development Flood Assessment
Catchment Model
Climate Change - YES
Building Assesment

STATUS	ISSUED FOR INFORMATION	REV
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COUNCIL	AUCKLAND COUNCIL	
DWG NO	P16-335-SKT-0010	

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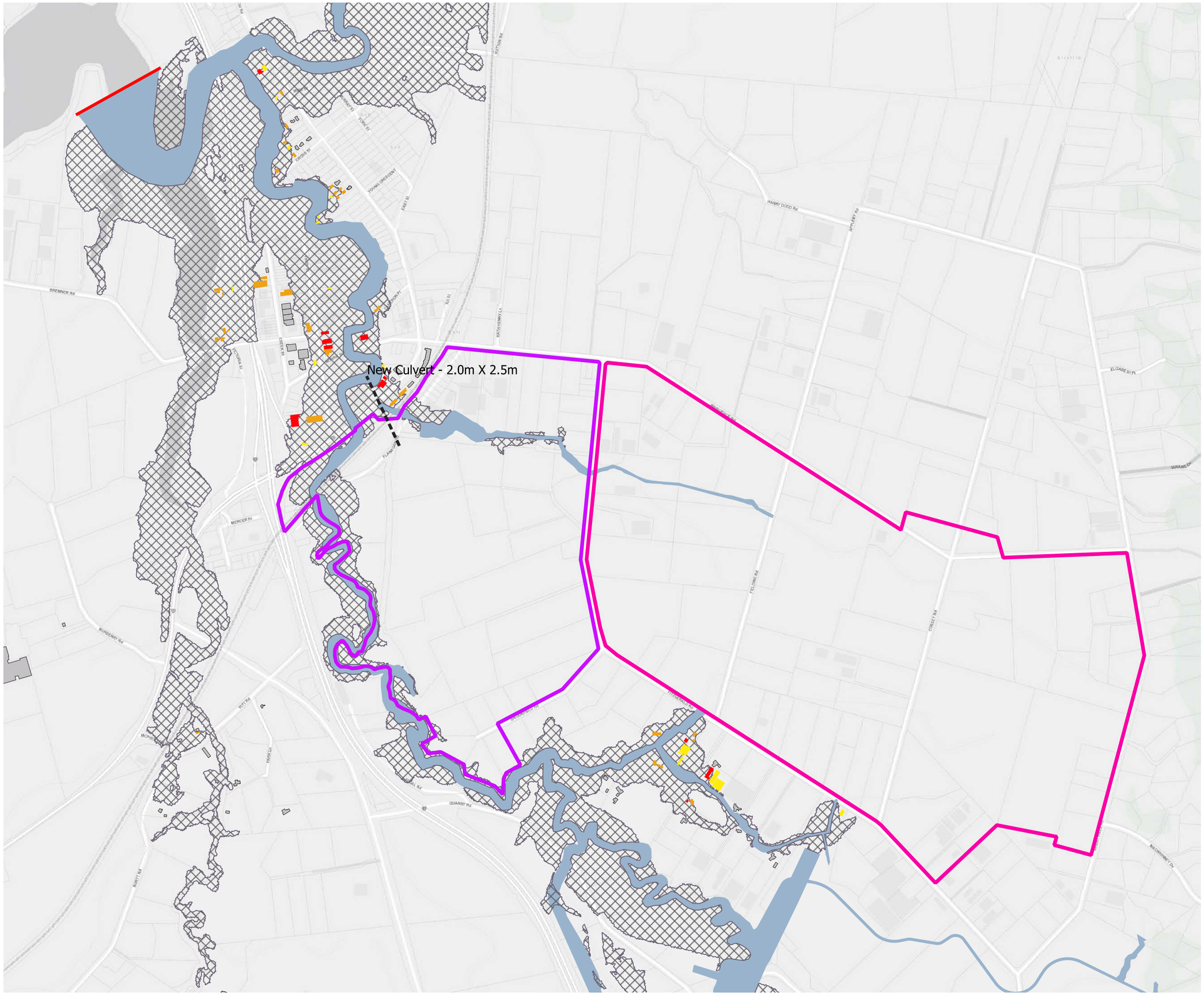

Tonkin+Taylor

WOODS Est.1970

LEGEND

- 1D River Extent
- Flood Model Boundary
- Fulton Hogan Development
- Kiwi Property Plan Change (Feb 2019)
- Flood Extent

Buildings

- Flood depth <0.15m
- No flooding
- Flood level < Building level
- Flood level > Building level
- Flood level > 0.15m

REVISION DETAILS		BY	DATE
1.0	Issued for Information	PW	5/06/2020

SURVEYED	AC	
DESIGNED	PW/AD	
DRAWN	SH	
CHECKED	PW	
APPROVED	PW	WOODS.CO.NZ

N

100 Year MPD Post Development
Flood Assessment
Catchment Model
Climate Change - YES
Building Assesment

STATUS	ISSUED FOR INFORMATION	REV
SCALE	1:12000 @ A3	1.0
COUNCIL	AUCKLAND COUNCIL	
DWG NO	P16-335-SKT-0011	

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To

Sindiya Vaakesan
Tonkin & Taylor

From

Woods
Pranil Wadan – Senior Associate
Ajay Desai – Stormwater Modeller

W-REF: P16-335
17 May 2019

Drury East – Fulton Hogan - Model Build Memo

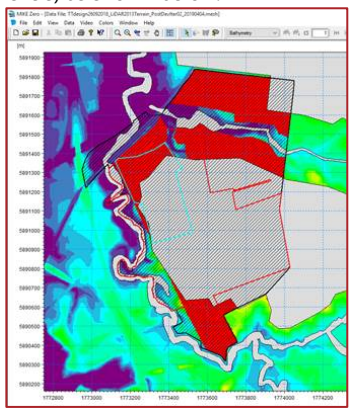
1. Objective

The objective of this memo is to document the updates within the Drury East/ Fulton Hogan Development to the pre and post development scenarios of the Drury Town flood model (referred as Models 01 and 02 respectively in Table 1) provided by Tonkin + Taylor (T+T).

These models were used to incorporate the topographical and landform changes to reflect the post development scenario for the Drury East development as documented in the next section of this memo.

The associated supporting information will be supplied along with this memo. The outcomes of the modelling (consideration of effects) will be completed at a later stage based on the modelling outputs provided.

Table 1: MPD with Climate Change Models provided by T+T

Model Reference	Scenario	Model scenarios	Model Name (Mike Flood couple file name)	Key Assumptions/Information
01	**Pre Development Scenario (Pre Kiwi Pre FH)** – *Pre Kiwi Property and Fulton Hogan/Drury East Developments*	10yr MPD with CC 100yr MPD with CC 100yr MPD without CC	20190407_Run007_MPD10yrCC _DruryTown_PreDevIter001 1_20190331_Run005_MPD100yrCC _DruryTown_PreDevIter001 1_20190408_Run010_MPD100 _DruryTown_PreDevIter001	1. Baseline model has been developed using T+T Drury South design model version 203 (Auckland Council reviewed) and incorporates changes from the Jan 2019 Auckland Council SMP model (full MPD Probable and upgrades to the hydraulic model for the culverts under Flanagan Road/Southern Main Railway Line/Great South Road). 2. Impervious assumptions modified within Future urban zones (i.e. All future urban imperviousness set to 10%).
02	**Post Development Scenario** (Post Kiwi Post FH) – *Post Kiwi Property and Fulton Hogan/Drury East Developments*	10yr MPD with CC 100yr MPD with CC 100yr MPD without CC	20190407_Run008_MPD10yrCC _DruryTown_PostDevIter002 20190331_Run004_MPD100yrCC _DruryTown_PostDevIter001FH 20190430_Run012_MPD100yr _DruryTown_PostDevIter002	1. Kiwi Property Post Development terrain (raise development extent above 100yr water levels) as shown below:  2. Future urban imperviousness assumptions as listed below: - Within Kiwi Property Town Centre = 100% - Within remainder of Kiwi Property boundary = 70% - Within Fulton Hogan boundary = 65% - Remainder of the catchment = 60%

These models were used to incorporate the topographical and landform changes to reflect the post development scenario for the Drury East development as documented in the next section of this memo.

The associated supporting information will be supplied along with this memo. The outcomes of the modelling (consideration of effects) will be completed at a later stage based on the modelling outputs provided.

2. Hydrology Updates

The contributing areas to 2 modelled streams within Fulton Hogan site (Hingaia Tributary 6 and Hingaia Tributary 7) were revised based on the topography of the latest design surface for Drury East development site. These changes were modelled by changing the contributing areas (% contribution of the total pervious and impervious area) within the .nwk file of Mike 11 model. The affected subcatchments were:

Table 2: Updated sub-catchment loading in .nwk file

Catchment ID	Area	Branch	StartC	End C
HING_101Imp	0.01190215	HINGAIA TRIBUTARY 6	500	500
HING_21Imp	0.0027131	HINGAIA TRIBUTARY 6	400	400
HING_352Imp	0.0145652	Tributary_6A	60	60
HING_353Imp	0.04407325	Tributary_6A	50	50
HING_357Imp	0.00656045	Tributary_6A	70	70
HING_383Imp	0.0419315	HINGAIA TRIBUTARY 6	850	850
HING_101Per	0.00640885	HINGAIA TRIBUTARY 6	500	500
HING_21Per	0.0014609	HINGAIA TRIBUTARY 6	400	400
HING_352Per	0.0078428	Tributary_6A	60	60
HING_353Per	0.02373175	Tributary_6A	50	50
HING_357Per	0.00353255	Tributary_6A	70	70
HING_383Per	0.0225785	HINGAIA TRIBUTARY 6	850	850

All supporting data (GIS and spreadsheets) are included in Appendix A.

3. Model updates

Changes were made to the pre-development (Model 01) and post-development (Model 02) scenarios to include the post development terrain and landform/land use changes for Drury East Development only to assess the increases in water levels at upstream and downstream boundaries of the site. The changes are listed in Table 3.

Table 3: Updates to MPD with CC models

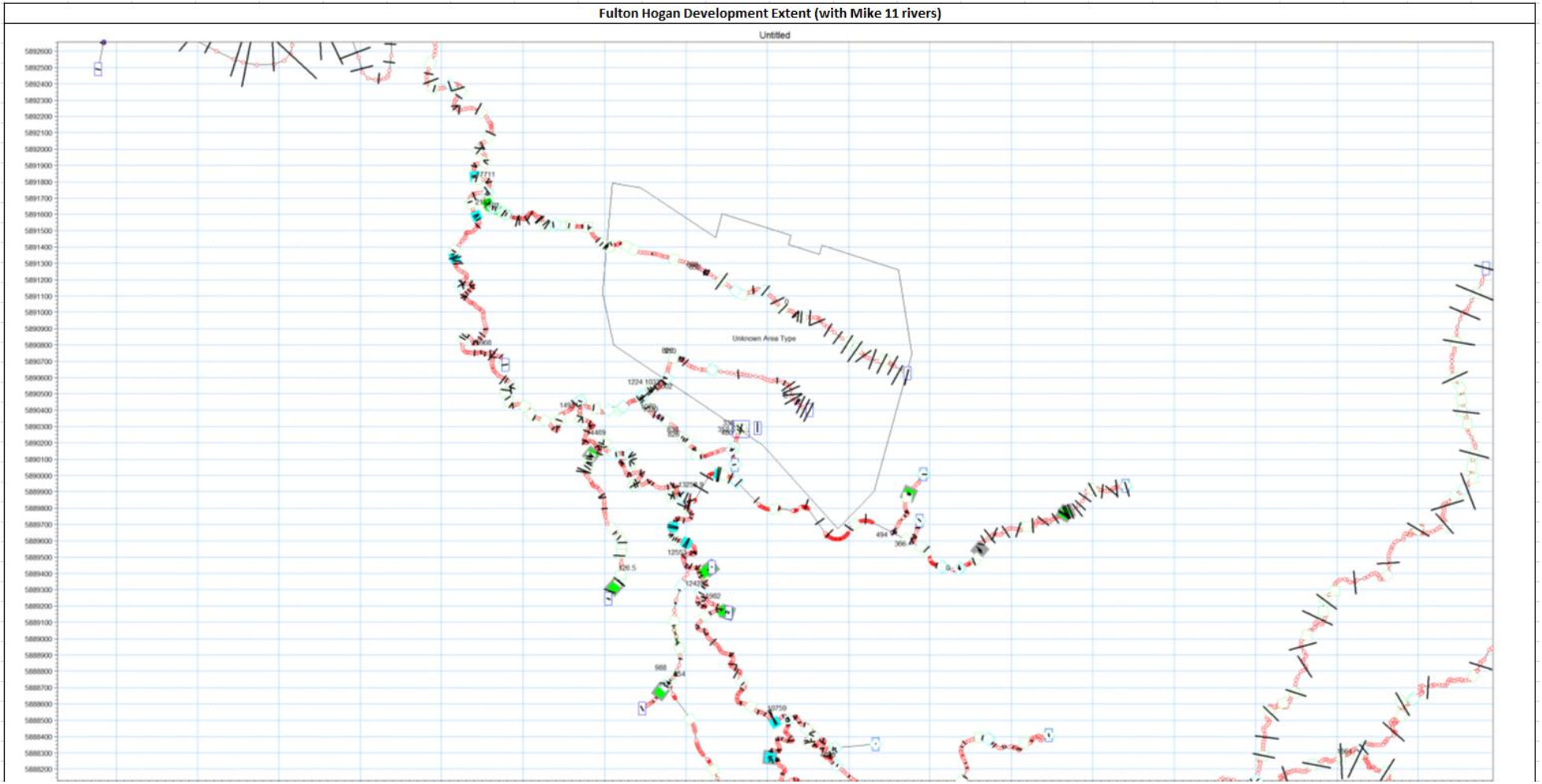
Model Reference	Scenario	Model scenarios	Model Folder Name	Key Assumptions/Information
05	**Post Kiwi Pre FH** *Post Kiwi Property development and Pre Fulton Hogan/Drury East Development*	100yr MPD with CC	5_20190331_Run005_MPD100yrCC _DruryTown_PreDevIter001FH2 (Updated by Woods from Model 02)	1. Kiwi Property Post Development terrain used as per Model 02 2. Future urban imperviousness assumptions as listed below: - Within Kiwi Property Town Centre = 100% - Within remainder of Kiwi Property boundary = 70% - Within Fulton Hogan boundary reverted to pre-development impervious based on model 01 - Remainder of the catchment = 60%
08	**Pre Kiwi Post FH3** *Pre Kiwi Property development and Post Fulton Hogan/Drury East Development*	100yr MPD with CC	8_20190331_Run005_MPD100yrCC _DruryTown_PreDevIter001FH2 (Updated by Woods from Model 01)	1. Model 01 terrain updated with Fulton Hogan design surface (new mesh file created using v203 .mdf file provided by T+T) included in Appendix B 2. Future urban imperviousness assumptions were retained as Model 01. Only changes included were: - Imperviousness within Fulton Hogan boundary = 65% 3. Hydrological loading updates as described in Section 2 in the Mike 11 .nwk file 4. All structures within Fulton Hogan site (i.e. not including Fitzgerald Road culvert) were removed from the model assuming these will be designed and upgraded to convey the 100yr MPD flows.
09	**Post Kiwi Post FH3** *Post Kiwi Property development and Pre Fulton Hogan/Drury East Development*	10yr MPD with CC 100yr MPD with CC 100yr MPD without CC	20190407_Run008_MPD10yrCC _DruryTown_PostDevIter002FH 20190430_Run012_MPD100yr _DruryTown_PostDevIter002 9_20190331_Run004_MPD100yrCC _DruryTown_PostDevIter001FH2 (Updated by Woods from Model 02)	1. Model 01 terrain updated with Fulton Hogan design surface (new mesh file created using v203 .mdf file provided by T+T) and manually raised within Kiwi Property to a high level (200m) based on Model 02 2. Future urban imperviousness assumptions as per Model 02 3. Hydrological loading updates as described in Section 2 in the Mike 11 .nwk file 4. All structures within Fulton Hogan site (i.e. not including Fitzgerald Road culvert) were removed from the model assuming these will be designed and upgraded to convey the 100yr MPD flows.

4. Results Analysis

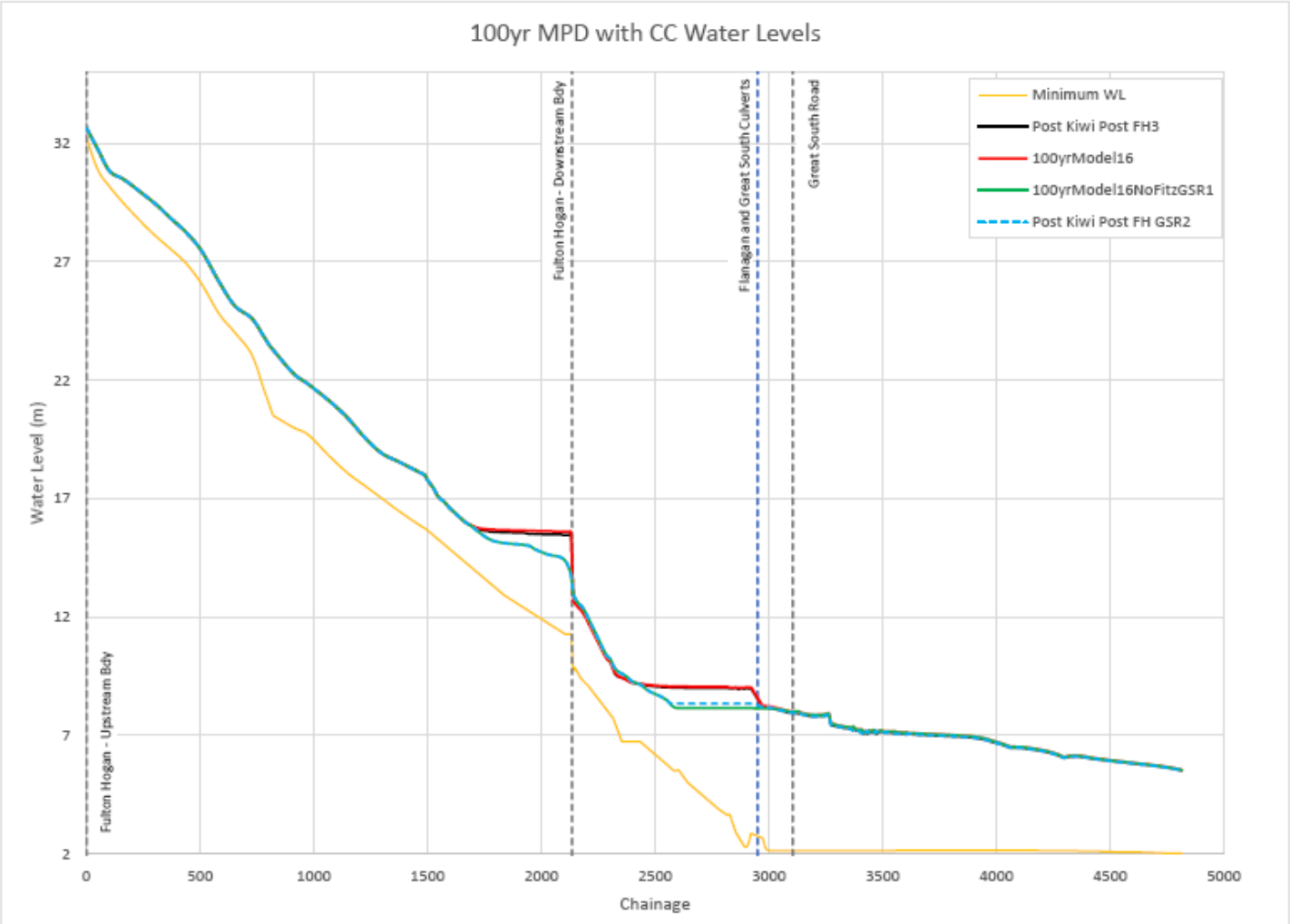
A summary of the model runs that were completed and analysed are as follows:

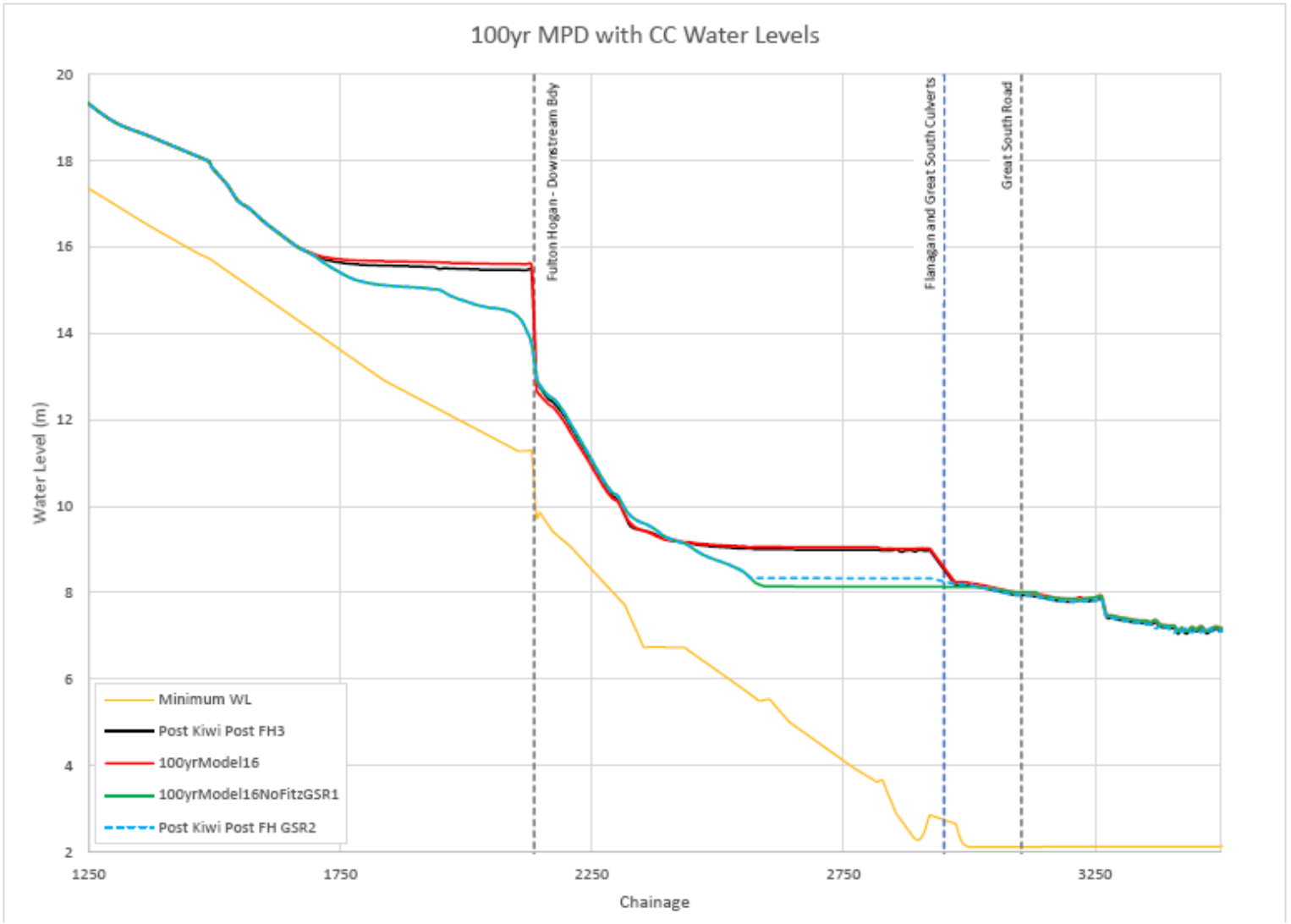
Scenario	Development State	Reason
100yr MPD with Climate Change	Pre Kiwi Pre FH	Define pre development scenario (Baseline)
	Post Kiwi Pre FH	Understand increases in water levels due to Kiwi Property development only at downstream end of Fulton Hogan Development
	Pre Kiwi Post FH	Understand increases in water levels due to Fulton Hogan development only at upstream and downstream end of Fulton Hogan Development
	Post Kiwi Post FH	Understand increases in water levels due to Fulton Hogan and Kiwi Property developments together at upstream and downstream end
10yr MPD with Climate Change	Pre Kiwi Pre FH	Define pre development scenario (Baseline)
	Post Kiwi Post FH	Understand increases in water levels due to Fulton Hogan and Kiwi Property developments together at upstream and downstream end
100yr MPD without Climate Change	Pre Kiwi Pre FH	Define pre development scenario (Baseline)
	Post Kiwi Post FH	Understand increases in water levels due to Fulton Hogan and Kiwi Property developments together at upstream and downstream end

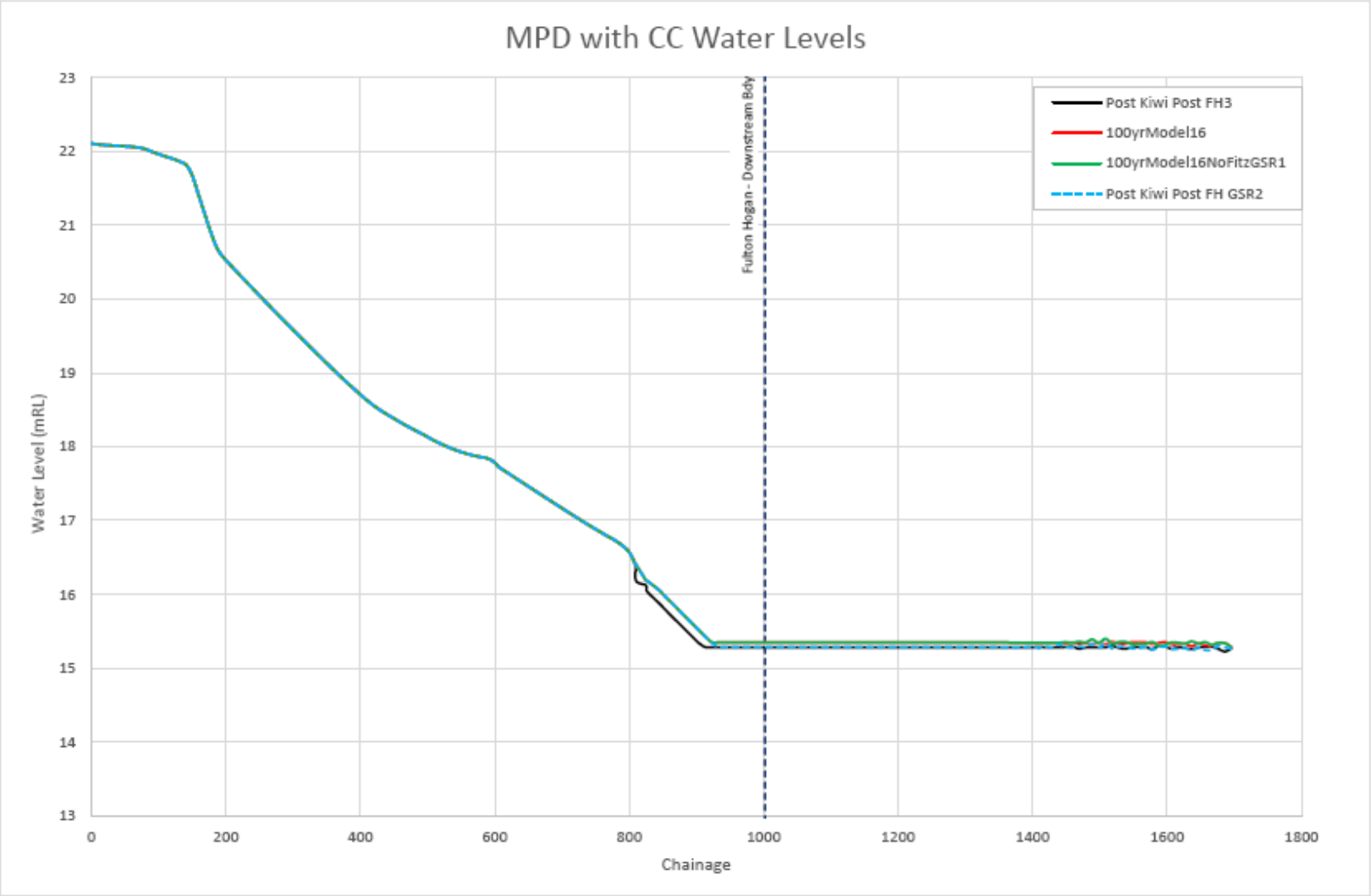
Location Plan

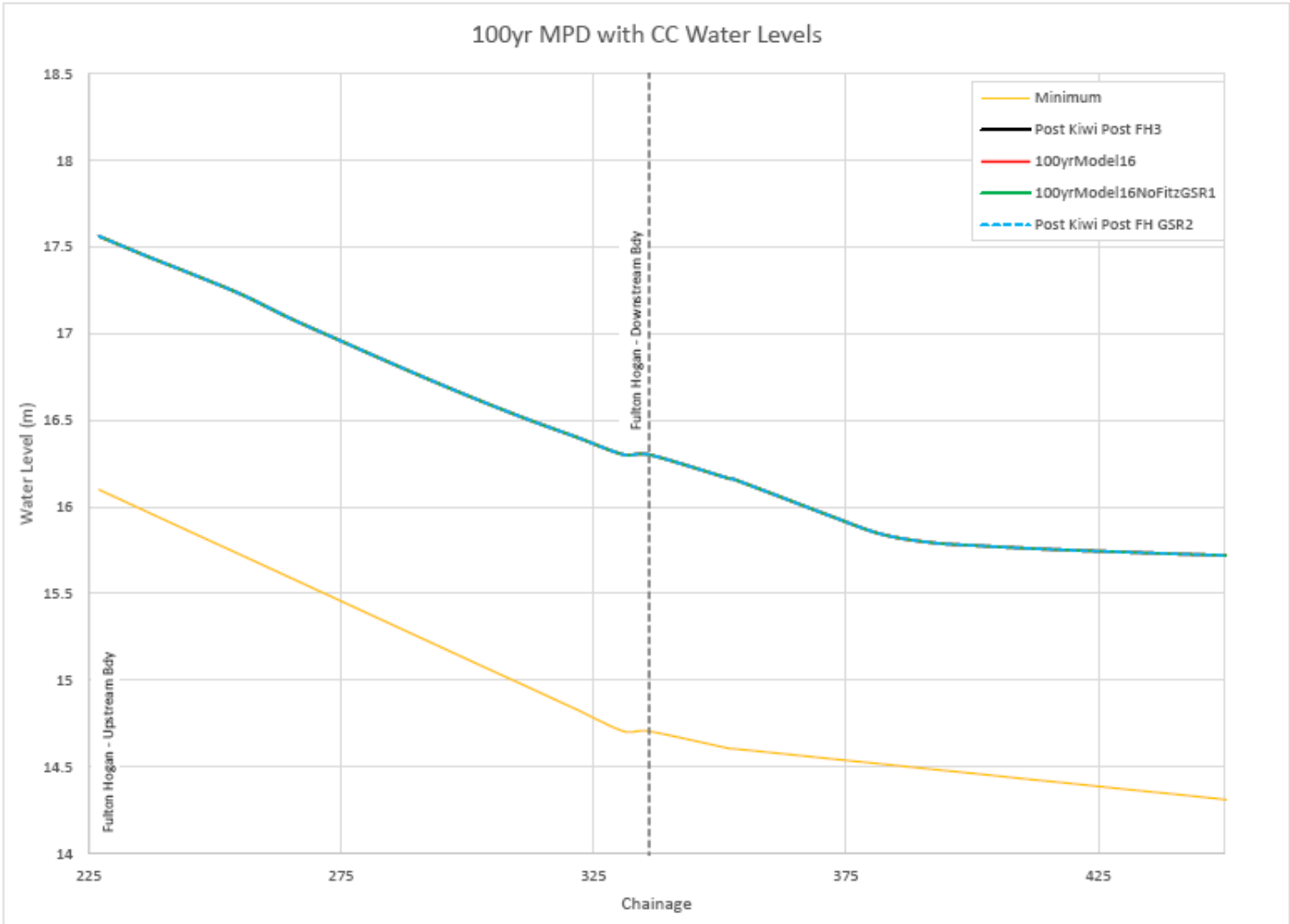


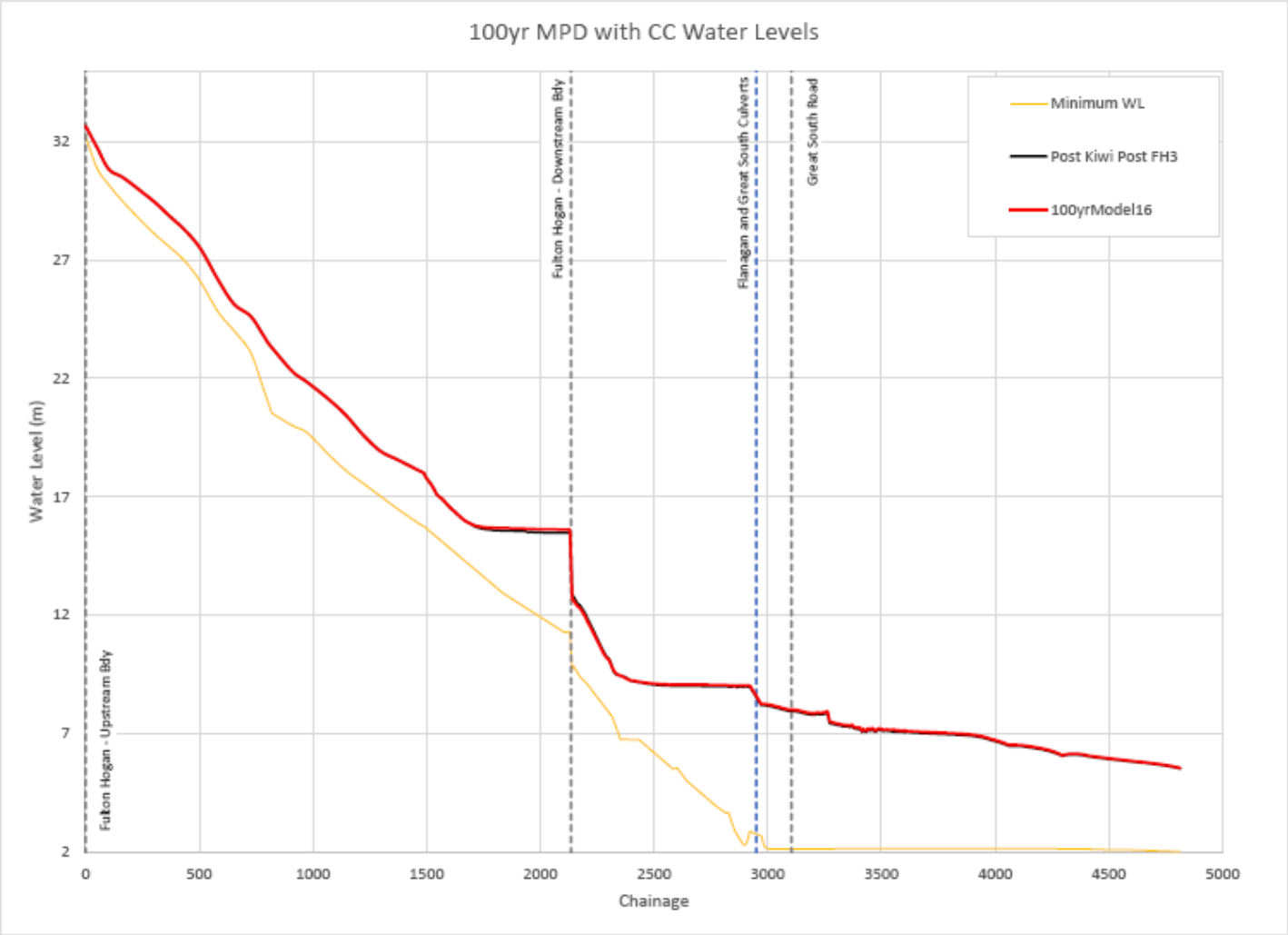
Great South Road Culverts

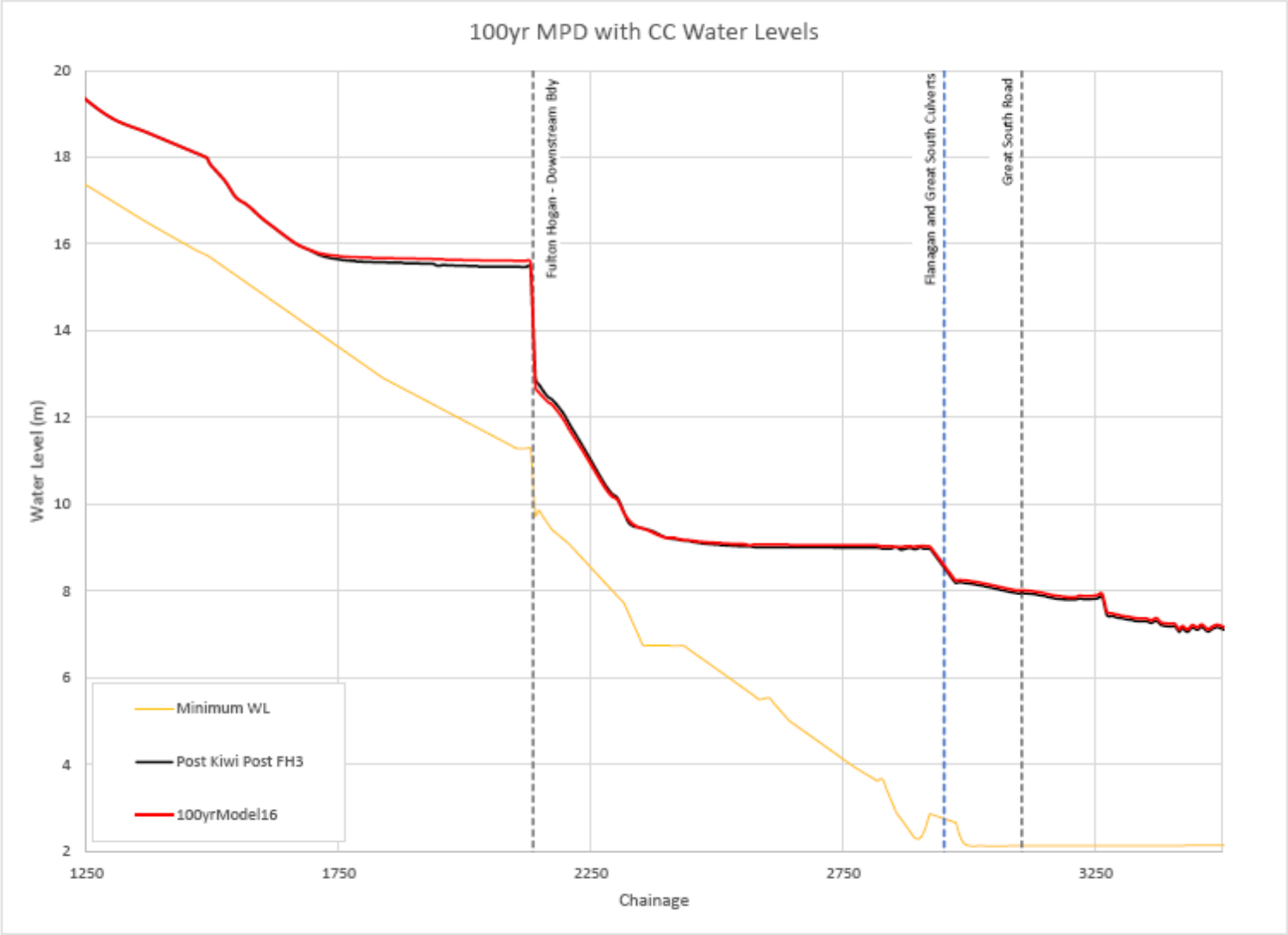


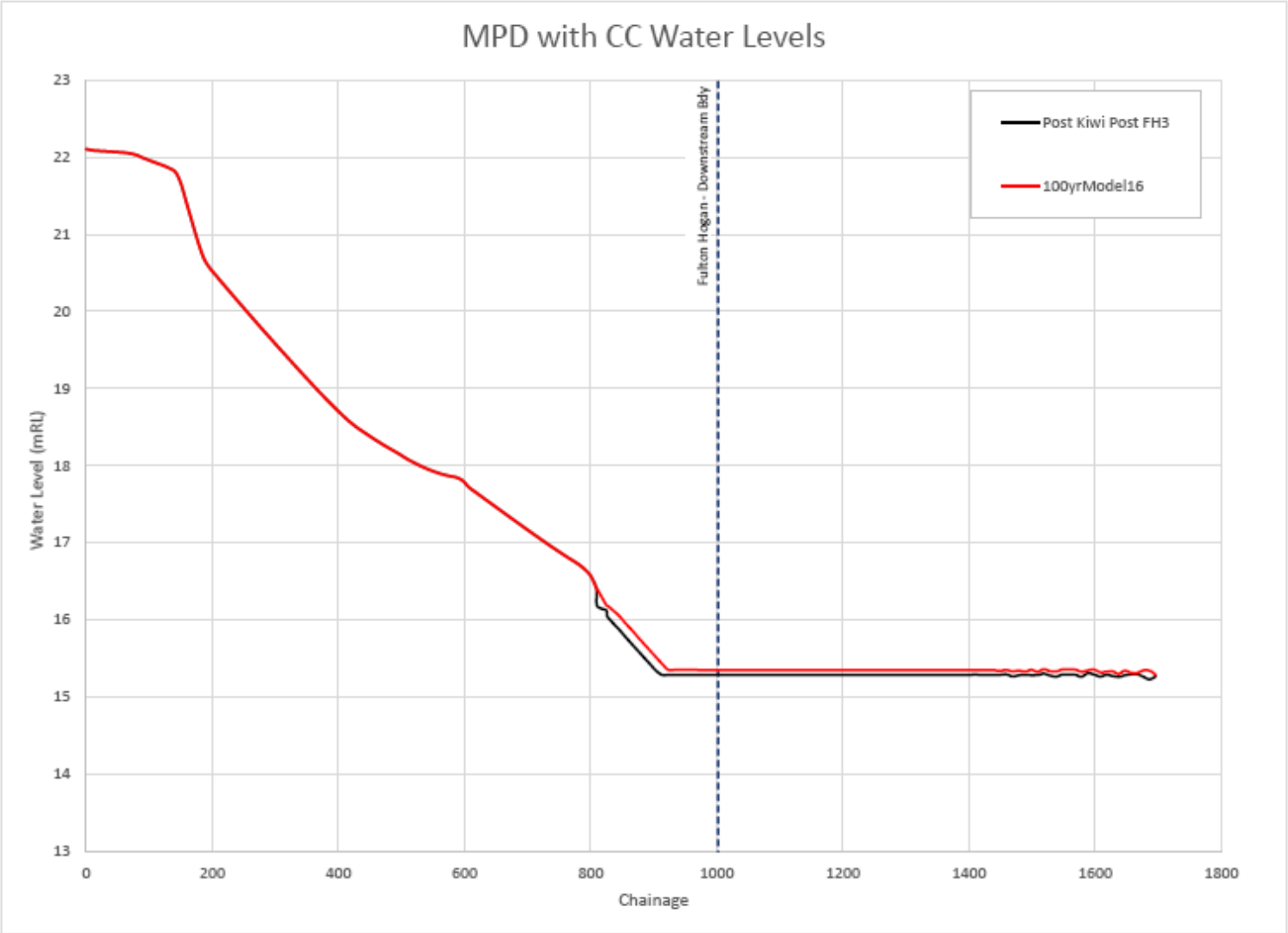

100yr MPD with CC Water Levels
Water Level (m)
Chainage
20
18
16
14
12
10
8
6
4
2
1250
1750
2250
2750
3250
Fulton Hogan - Downstream Bdy
Flanagan and Great South Culverts
Great South Road
Minimum WL
Post Kiwi Post FH3
100yrModel16
100yrModel16NoFitzGSR1
Post Kiwi Post FH GSR2

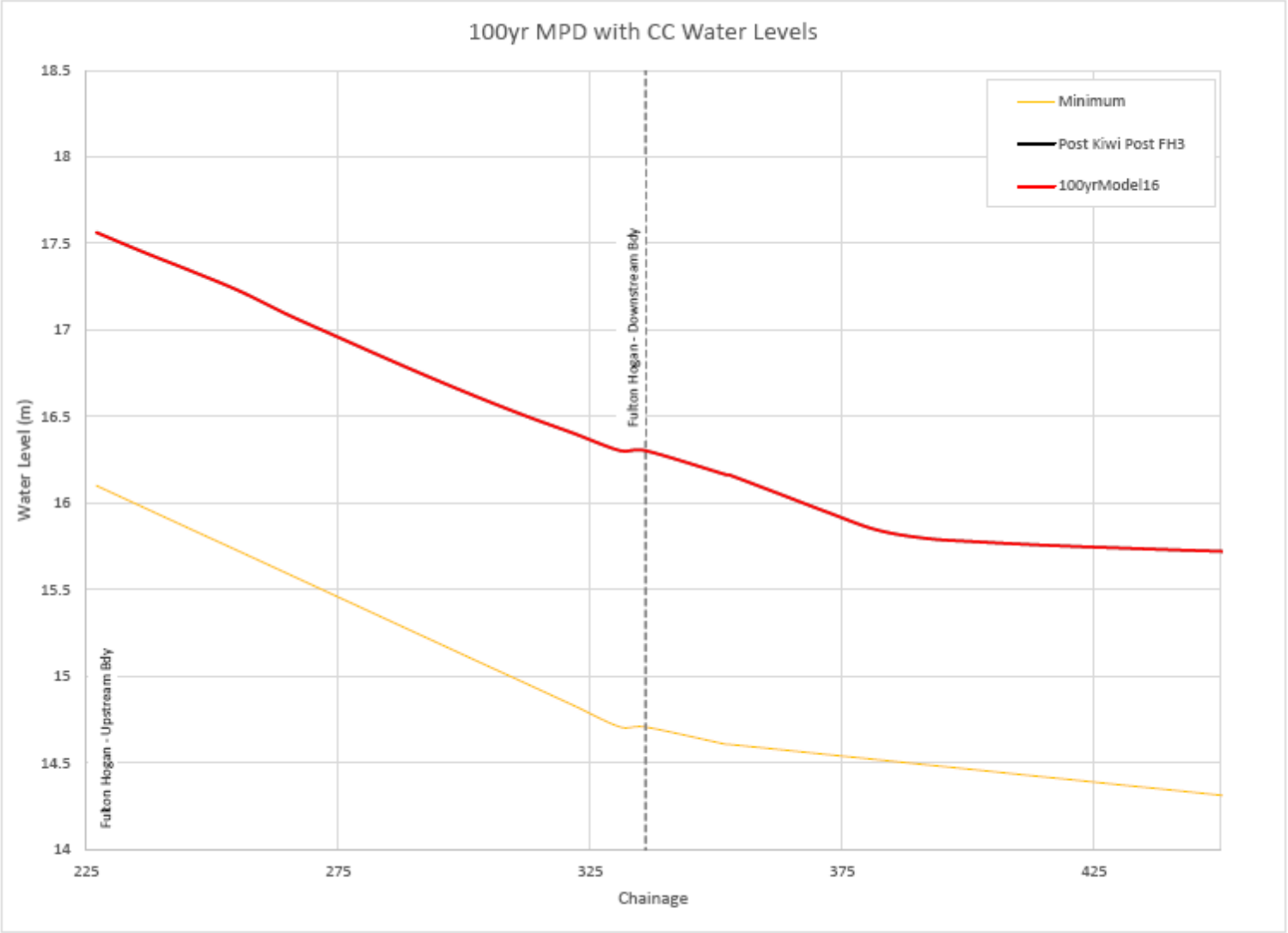

MPD with CC Water Levels
Water Level (mRL)
Chainage
Fulton Hogan - Downstream Bdy
Post Kiwi Post FH3
100yrModel16
100yrModel16NoFitzGSR1
Post Kiwi Post FH GSR2
23
22
21
20
19
18
17
16
15
14
13
0
200
400
600
800
1000
1200
1400
1600
1800


100yr MPD with CC Water Levels
Water Level (m)
18.5
18
17.5
17
16.5
16
15.5
15
14.5
14
225
275
325
375
425
Chainage
Minimum
Post Kiwi Post FH3
100yrModel16
100yrModel16NoFitzGSR1
Post Kiwi Post FH GSR2
Fulton Hogan - Downstream Bdy
Fulton Hogan - Upstream Bdy


100yr MPD with CC Water Levels
Minimum WL
Post Kiwi Post FH3
100yrModel16
Fulton Hogan - Upstream Bdy
Fulton Hogan - Downstream Bdy
Flanagan and Great South Culverts
Great South Road
Water Level (m)
32
27
22
17
12
7
2
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
Chainage


100yr MPD with CC Water Levels
Water Level (m)
20
18
16
14
12
10
8
6
4
2
1250
1750
2250
2750
3250
Chainage
Fulton Hogan - Downstream Bdy
Flanagan and Great South Culverts
Great South Road
Minimum WL
Post Kiwi Post FH3
100yrModel16


MPD with CC Water Levels
Water Level (mRL)
Chainage
Fulton Hogan - Downstream Bdy
Post Kiwi Post FH3
100yrModel16
23
22
21
20
19
18
17
16
15
14
13
0
200
400
600
800
1000
1200
1400
1600
1800


100yr MPD with CC Water Levels
Minimum
Post Kiwi Post FH3
100yrModel16
Fulton Hogan - Downstream Bdy
Fulton Hogan - Upstream Bdy
Water Level (m)
Chainage
18.5
18
17.5
17
16.5
16
15.5
15
14.5
14
225
275
325
375
425

Applicability:
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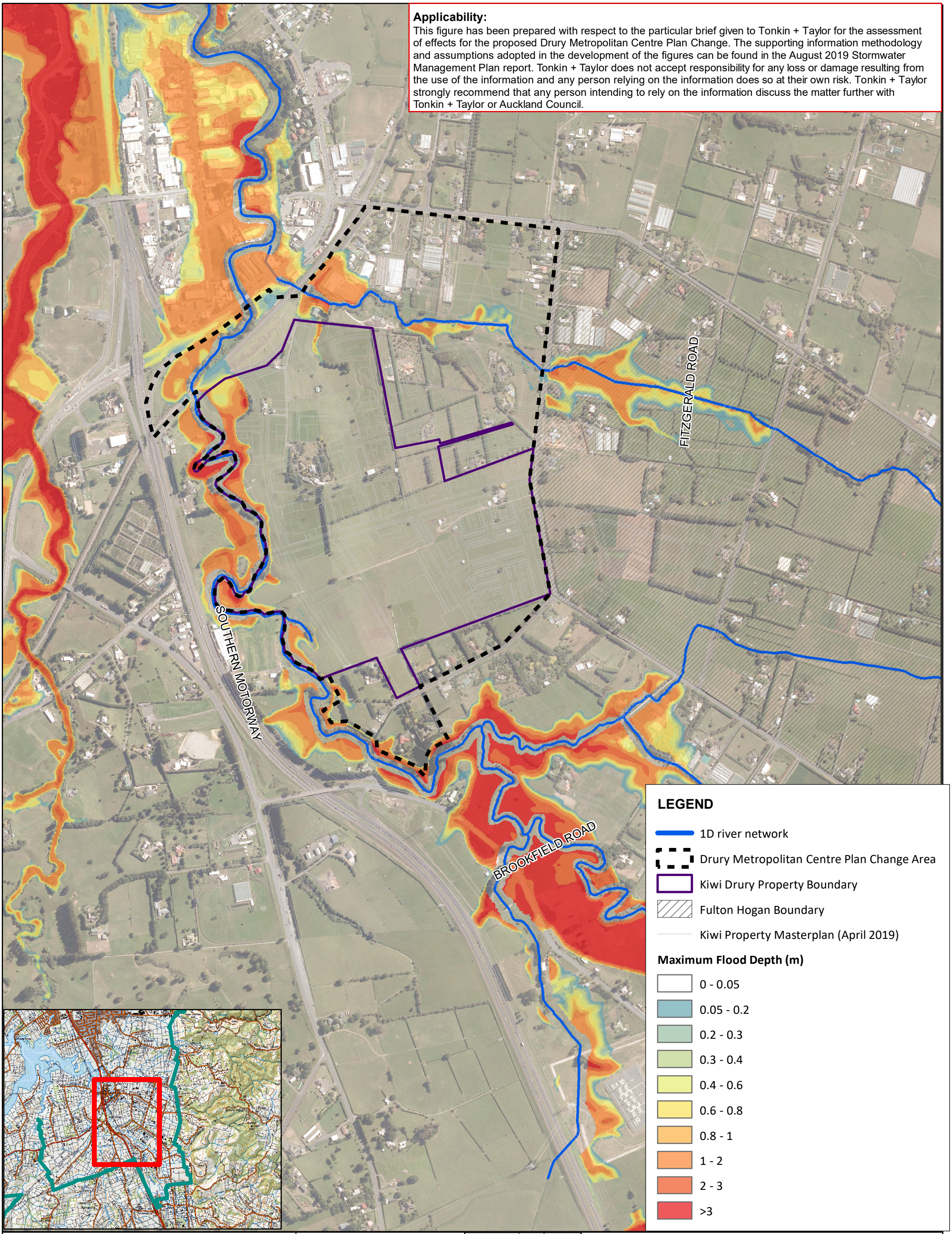

Notes:
Aerial photograph sourced from LINZ data service.
All reported levels are in Auckland Vertical Datum 1946.
Modelling results have been excluded where depth is below 0.05m.
Results shown from 2D extent only. 1D results from Hingaia stream not shown.

N

0 50 100 150 200 250 300 Meters

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CHECKED	SGV	Jun.19
APPROVED	TSRF	Jun.19
ARCFILE		
SCALE (AT A3 SIZE)	1:9,000	
PROJECT No.	1003297.1000	

Drury Town Centre
Maximum Flood Depth - 100yrCC
Pre-development

FIGURE No. Figure D1

Rev.

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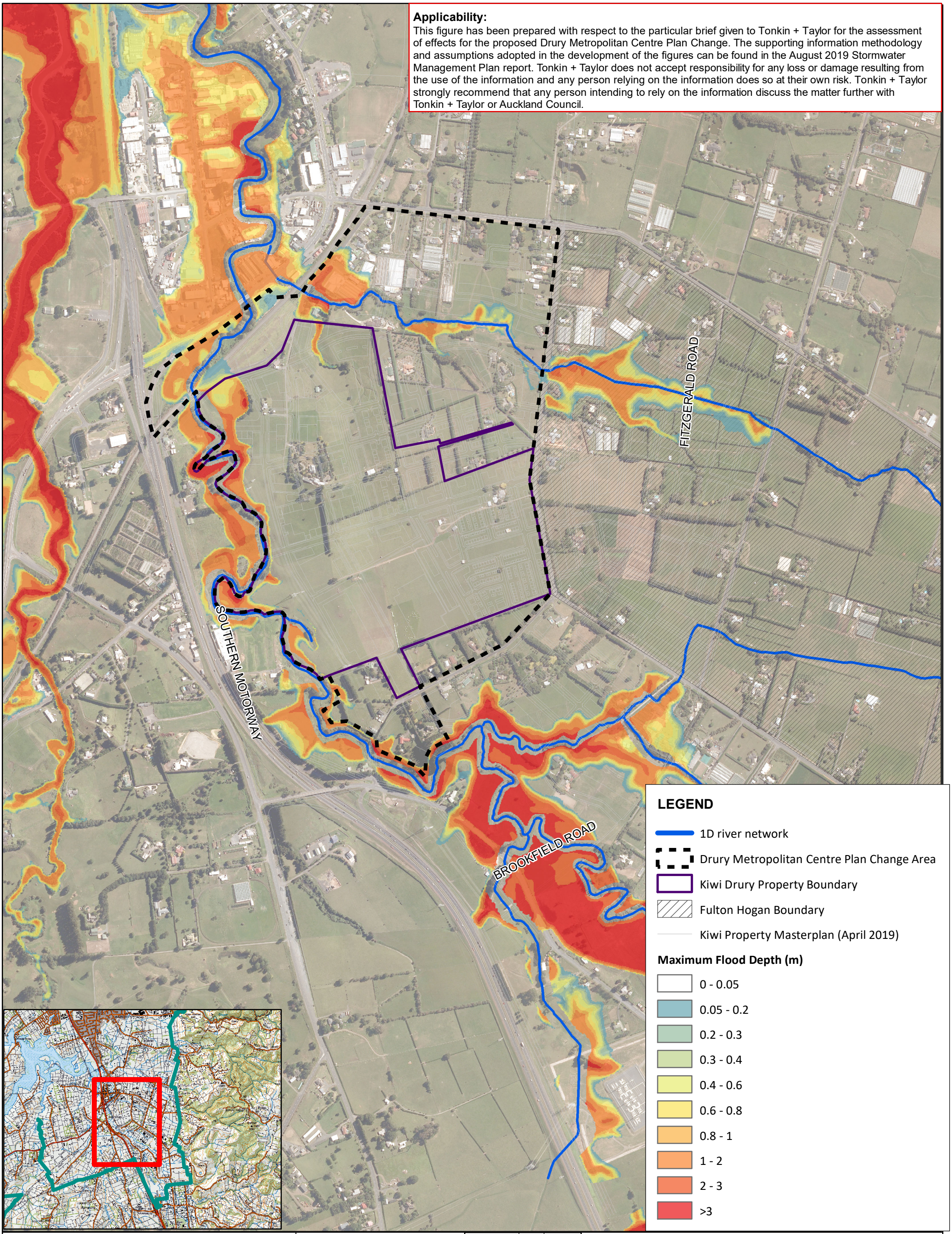

Notes:
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Drury Town Centre
Maximum Flood Depth - 100yrCC
Post-development Iteration 01

FIGURE No. Figure D2

Rev.

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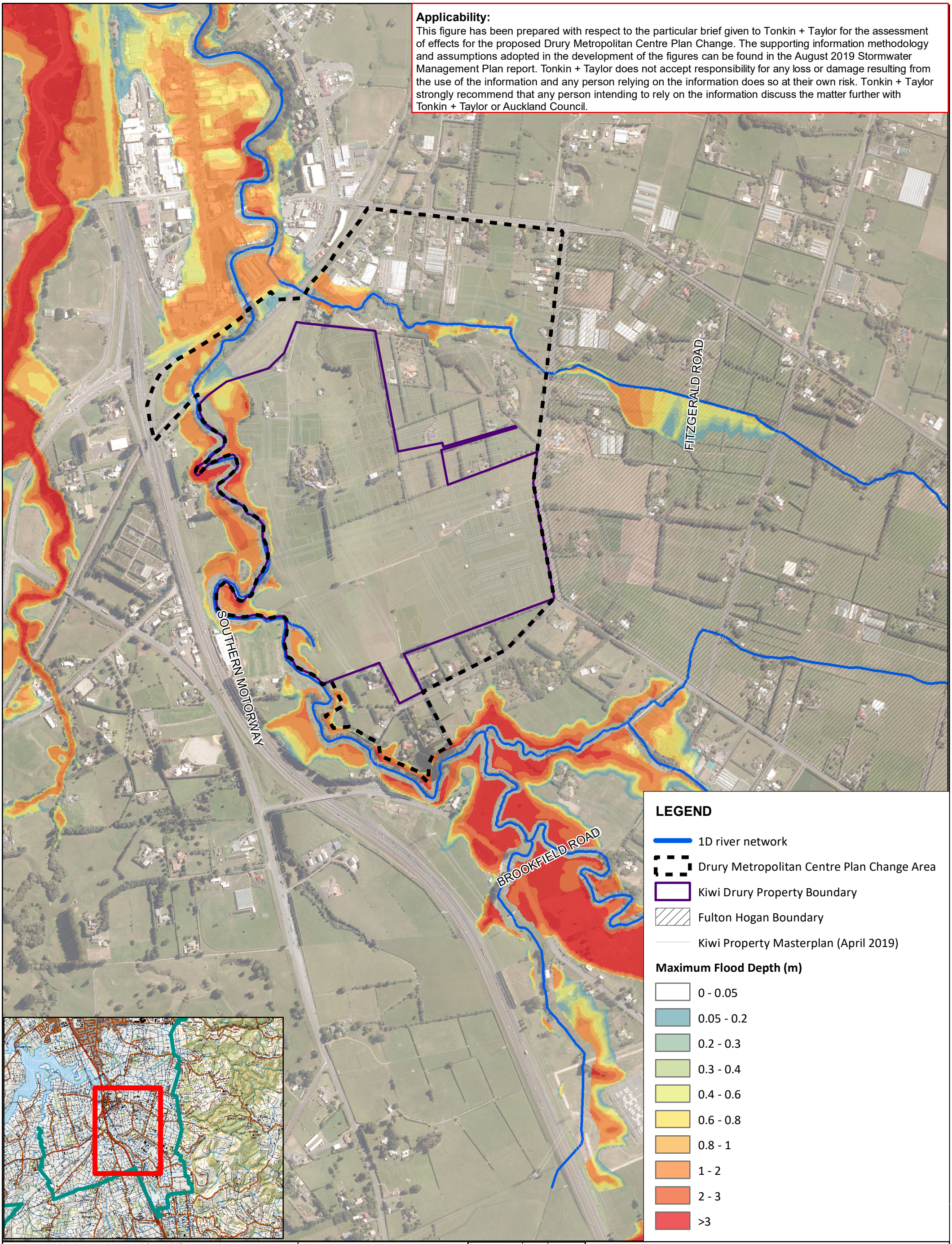

Notes:
Aerial photograph sourced from LINZ data service.
All reported levels are in Auckland Vertical Datum 1946.
Modelling results have been excluded where depth is below 0.05m.
Results shown from 2D extent only. 1D results from Hingaia stream not shown.

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APPROVED	TSRF	Aug.19
ARCFILE		
SCALE (AT A3 SIZE)	1:9,000	
PROJECT No.	1003297.1000	

Drury Town Centre
Maximum Flood Depth – 100yrCC
Post-development Iteration 04
with Gt South Rd Culvert straight alignment

FIGURE No. Figure D3

Rev.

Applicability:
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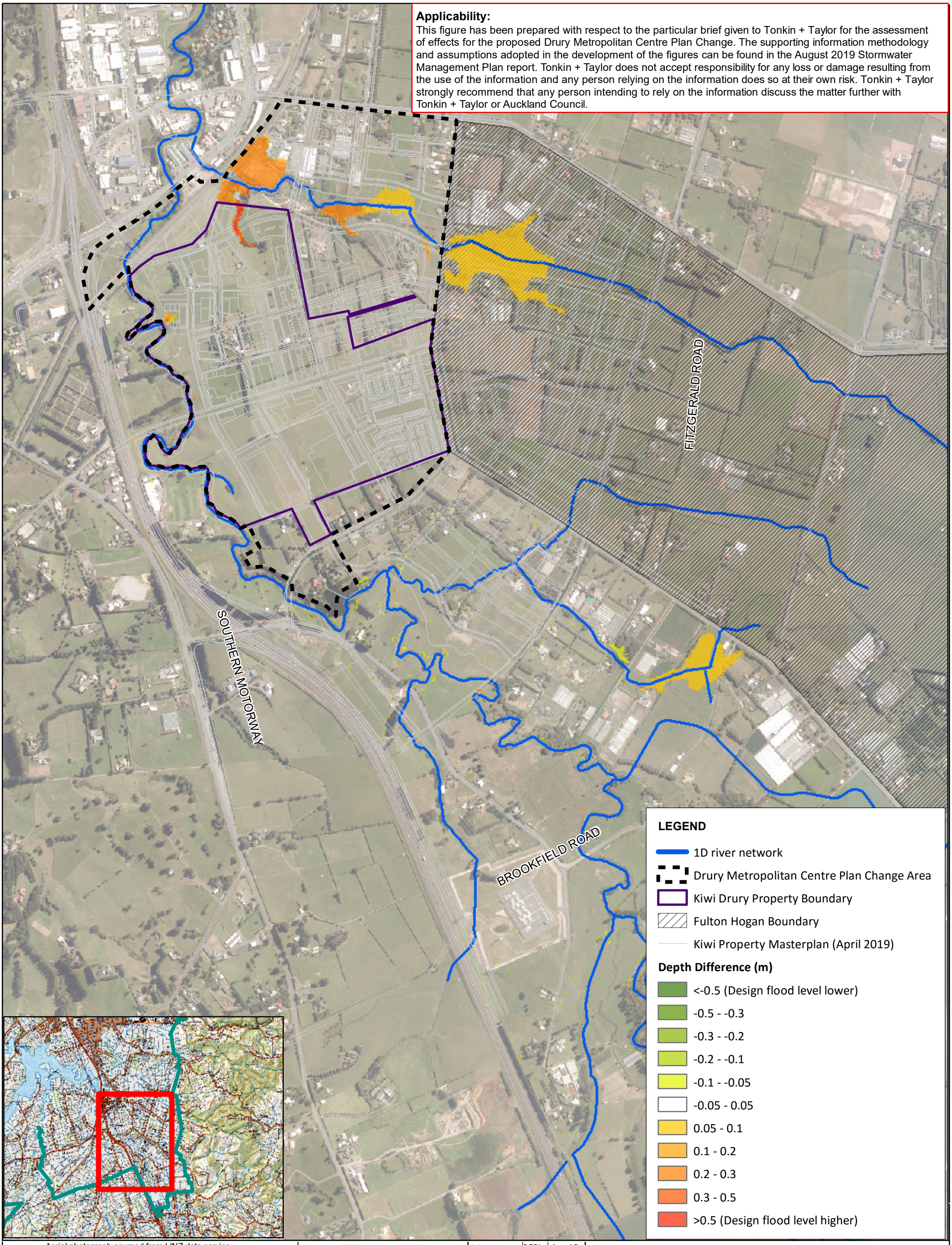

Notes:
Aerial photograph sourced from LINZ data service.
All reported levels are in Auckland Vertical Datum 1946.
Modelling results have been excluded where depth is below 0.05m.
Results shown from 2D extent only. 1D results from Hingaia stream not shown.

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ARCFILE		
SCALE (AT A3 SIZE)	1:10,000	
PROJECT No.	1003297.1000	

Drury Town Centre
Flood Depth Difference - 100yrCC
Post-development Iteration 01 minus Pre-development

FIGURE No. Figure D4

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Applicability:
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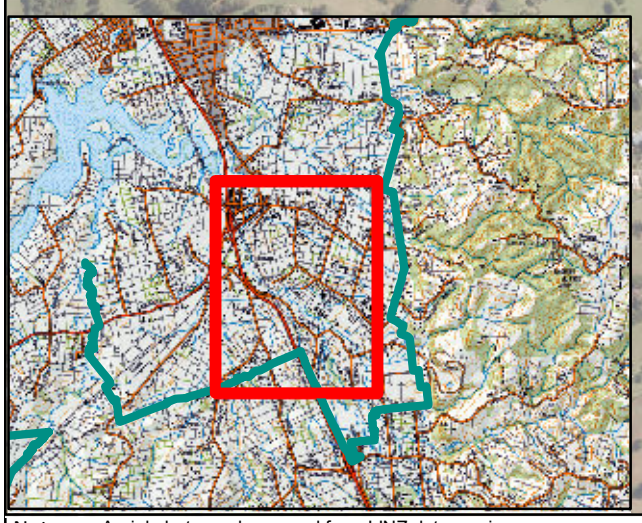
FITZGERALD ROAD

SOUTHERN MOTORWAY

BROOKFIELD ROAD



LEGEND

- 1D river network
- Drury Metropolitan Centre Plan Change Area
- Kiwi Drury Property Boundary
- Fulton Hogan Boundary
- Kiwi Property Masterplan (April 2019)

Level Difference (m)

- <-0.5 (Design flood level lower)
- -0.5 - -0.3
- -0.3 - -0.2
- -0.2 - -0.1
- -0.1 - -0.05
- -0.05 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- >0.5 (Design flood level higher)

Notes:
Aerial photograph sourced from LINZ data service.
All reported levels are in Auckland Vertical Datum 1946.
Modelling results have been excluded where depth is below 0.05m.
Results shown from 2D extent only. 1D results from Hingaia stream not shown.

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ARCFILE		
SCALE (AT A3 SIZE)	1:10,000	
PROJECT No.	1003297.1000	

Drury Town Centre

Flood Level Difference – 100yrCC

Post-development Iteration 04 minus Pre-development

FIGURE No. Figure D5

Rev.

Applicability:
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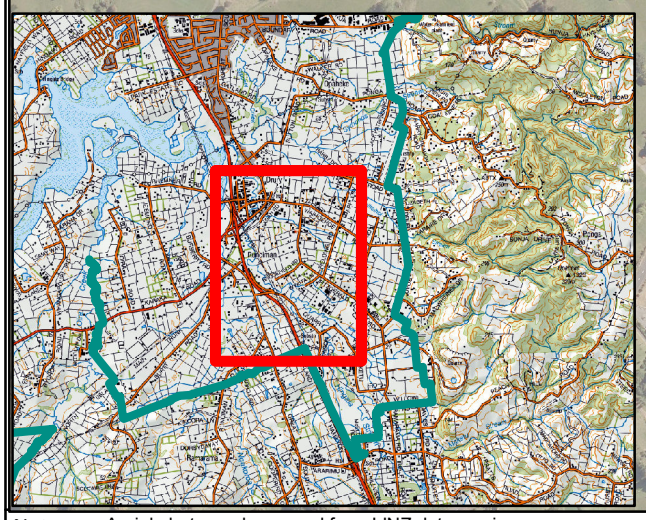
FITZGERALD ROAD

SOUTHERN MOTORWAY

BROOKFIELD ROAD



LEGEND

- 1D river network
- Drury Metropolitan Centre Plan Change Area
- Kiwi Drury Property Boundary
- Fulton Hogan Boundary
- Kiwi Property Masterplan (April 2019)

Pre-Development and Post-Development Overlap

Pre-Development

Post-Development Iteration 04

Notes:
Aerial photograph sourced from LINZ data service.
All reported levels are in Auckland Vertical Datum 1946.
Modelling results have been excluded where depth is below 0.05m.
Results shown from 2D extent only. 1D results from Hingaia stream not shown.

N

0 50 100 150 200 250 300 Meters

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APPROVED	TSRF	Aug.19
ARCFILE		
SCALE (AT A3 SIZE)	1:9,000	
PROJECT No.	1003297.1000	

Drury Town Centre
Flood Extent Comparison - 100yrCC
Pre-Development vs Post-Development Iteration 04

FIGURE No. Figure D6

Rev.

Applicability:
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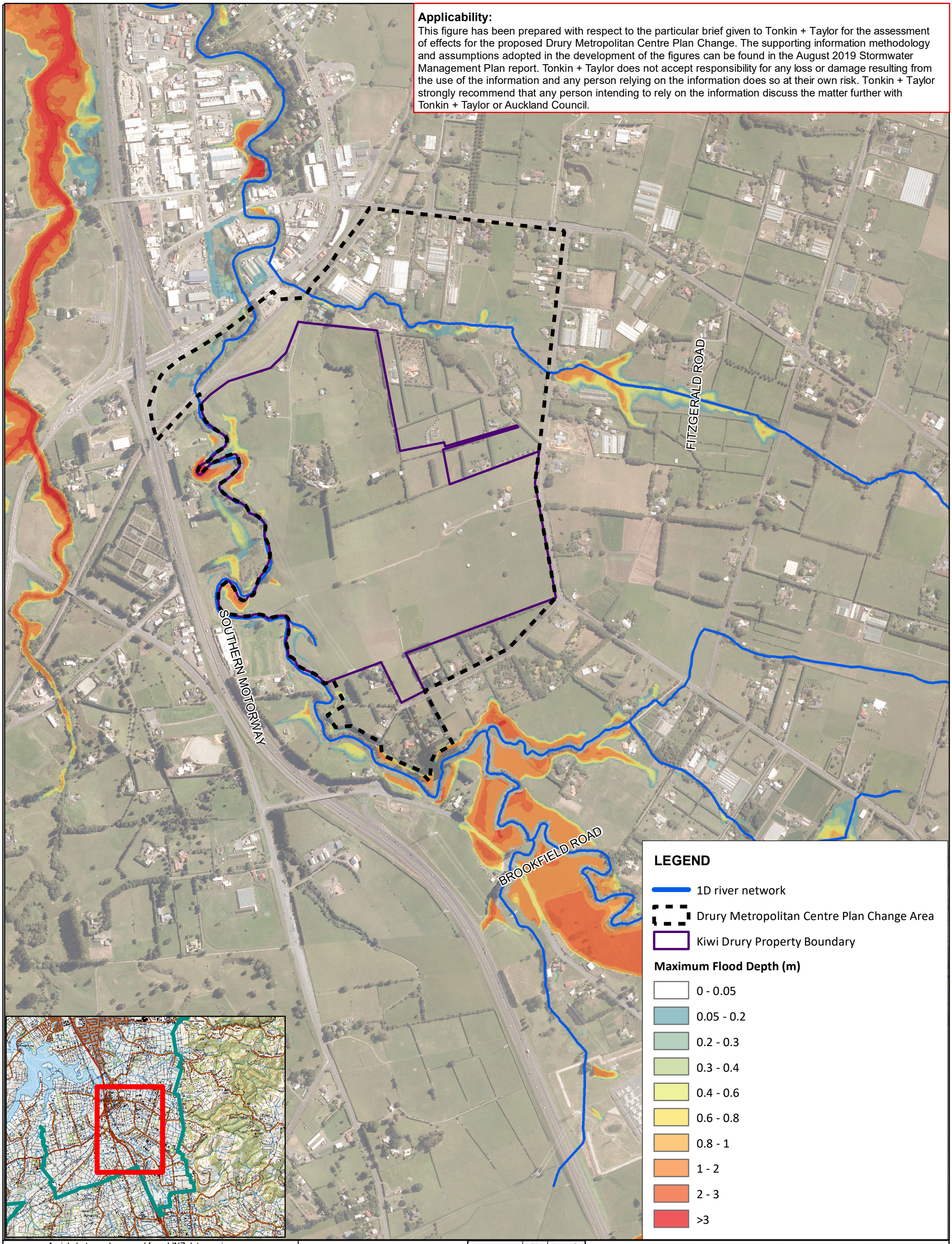

Notes:
Aerial photograph sourced from LINZ data service.
All reported levels are in Auckland Vertical Datum 1946.
Modelling results have been excluded where depth is below 0.05m.
Results shown from 2D extent only. 1D results from Hingaia stream not shown.

N

0 50 100 150 200 250 300 Meters

Tonkin+Taylor
105, Carlton Gore Rd, Newmarket, Auckland
www.tonkintaylor.co.nz

DRAWN	DERI	Jun.19
CHECKED	SGV	Jun.19
APPROVED	TSRF	Jun.19
ARCFILE		
SCALE (AT A3 SIZE)	1:9,000	
PROJECT No.	1003297.1000	

Drury Town Centre
Maximum Flood Depth – 10yrCC
Pre-development

FIGURE No. Figure D7

Rev.

Applicability:
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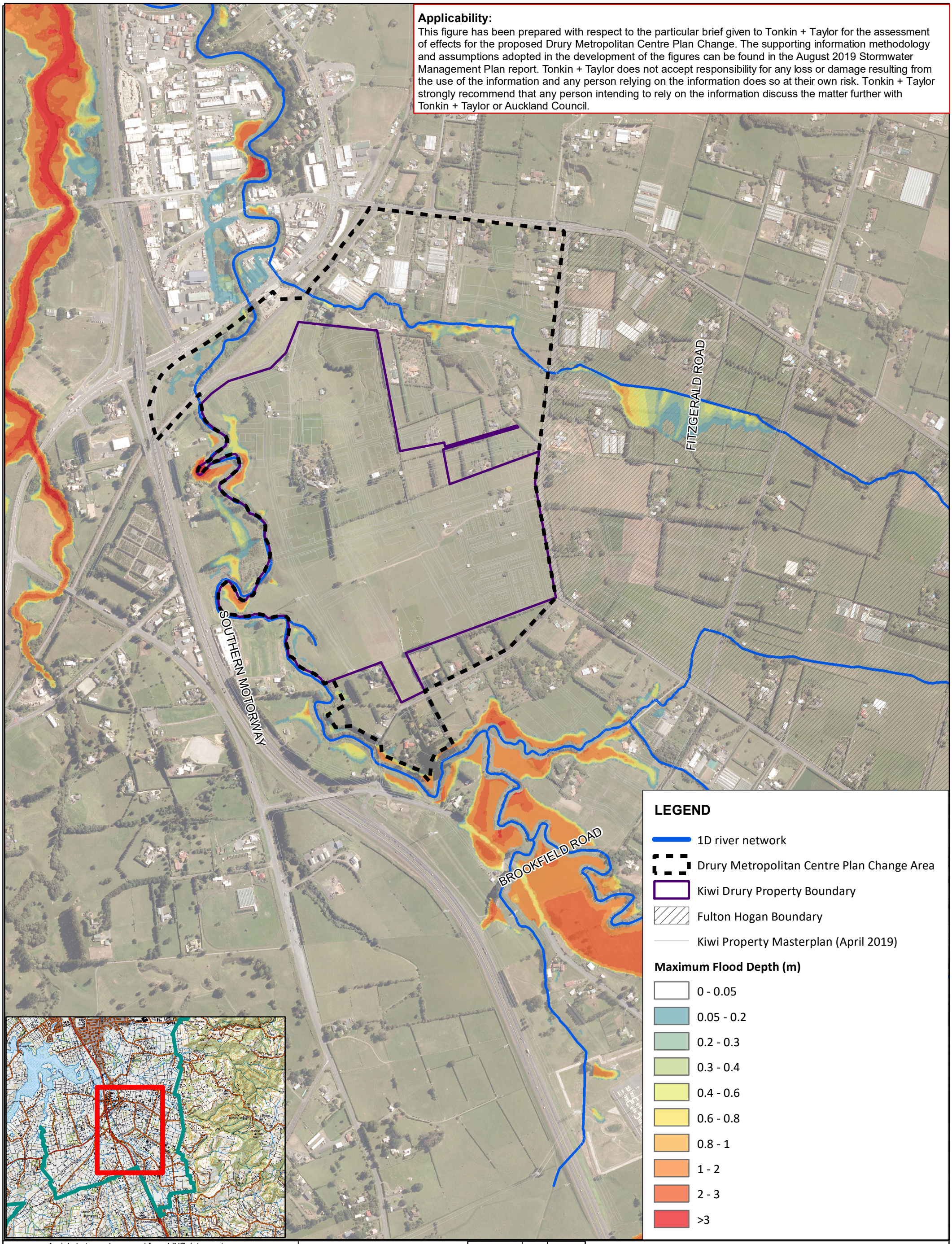

Notes:
Aerial photograph sourced from LINZ data service.
All reported levels are in Auckland Vertical Datum 1946.
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Results shown from 2D extent only. 1D results from Hingaia stream not shown.

N

0 50 100 150 200 250 300 Meters

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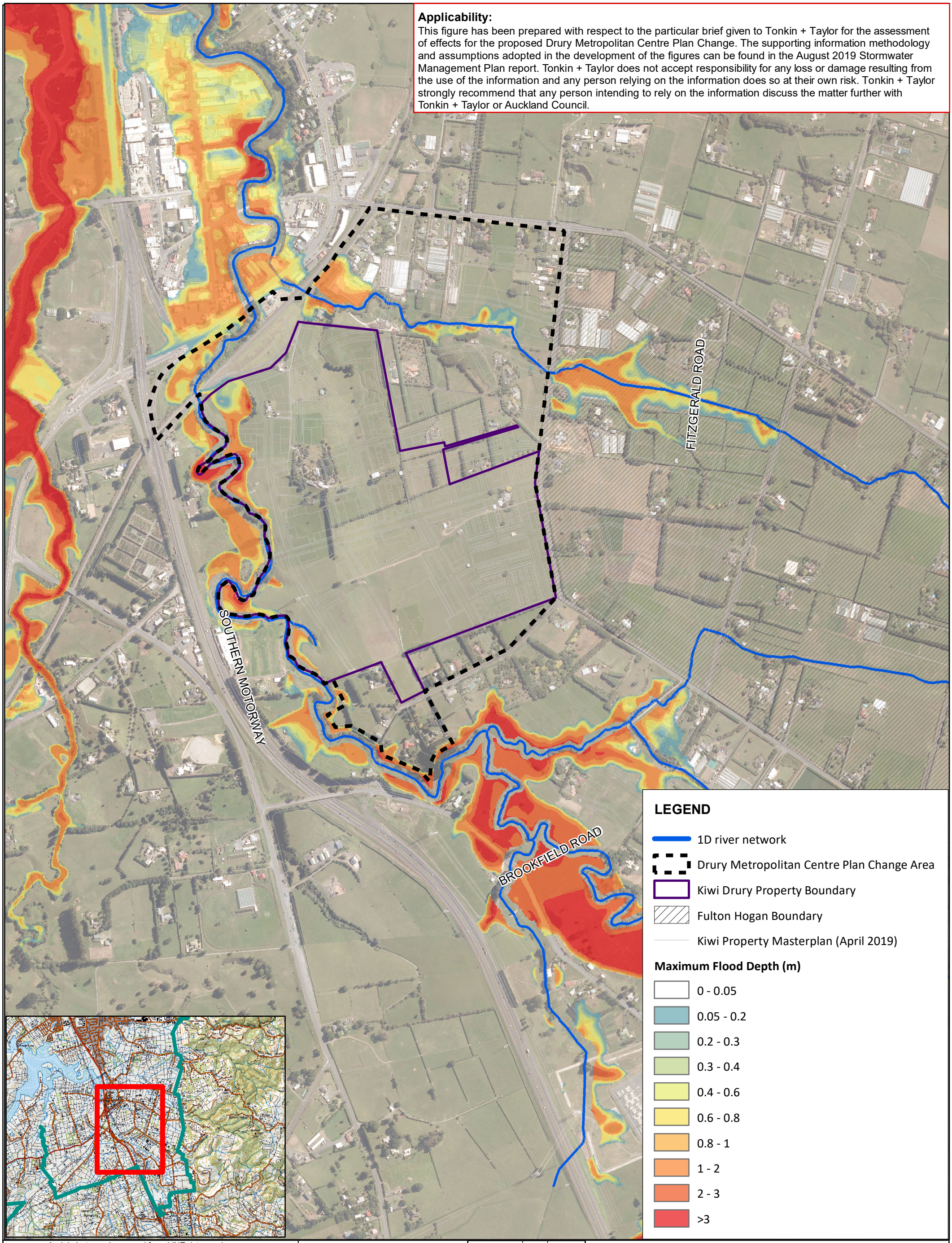
DRAWN	DERI	Aug.19
CHECKED	SGV	Aug.19
APPROVED	TSRF	Aug.19
ARCFILE		
SCALE (AT A3 SIZE)	1:9,000	
PROJECT No.	1003297.1000	

Drury Town Centre
Maximum Flood Depth – 10yrCC
Post-development Iteration 04
with Gt South Rd Culvert straight alignment

FIGURE No. Figure D8

Rev.

Applicability:
This figure has been prepared with respect to the particular brief given to Tonkin + Taylor for the assessment of effects for the proposed Drury Metropolitan Centre Plan Change. The supporting information methodology and assumptions adopted in the development of the figures can be found in the August 2019 Stormwater Management Plan report. Tonkin + Taylor does not accept responsibility for any loss or damage resulting from the use of the information and any person relying on the information does so at their own risk. Tonkin + Taylor strongly recommend that any person intending to rely on the information discuss the matter further with Tonkin + Taylor or Auckland Council.



Notes:
Aerial photograph sourced from LINZ data service.
All reported levels are in Auckland Vertical Datum 1946.
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N

0 50 100 150 200 250 300 Meters

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DRAWN	DERI	Jun.19
CHECKED	SGV	Jun.19
APPROVED	TSRF	Jun.19
ARCFILE		
SCALE (AT A3 SIZE)	1:9,000	
PROJECT No.	1003297.1000	

Drury Town Centre
Maximum Flood Depth – 100yr
Pre-development

FIGURE No. Figure D9

Rev.

Applicability:
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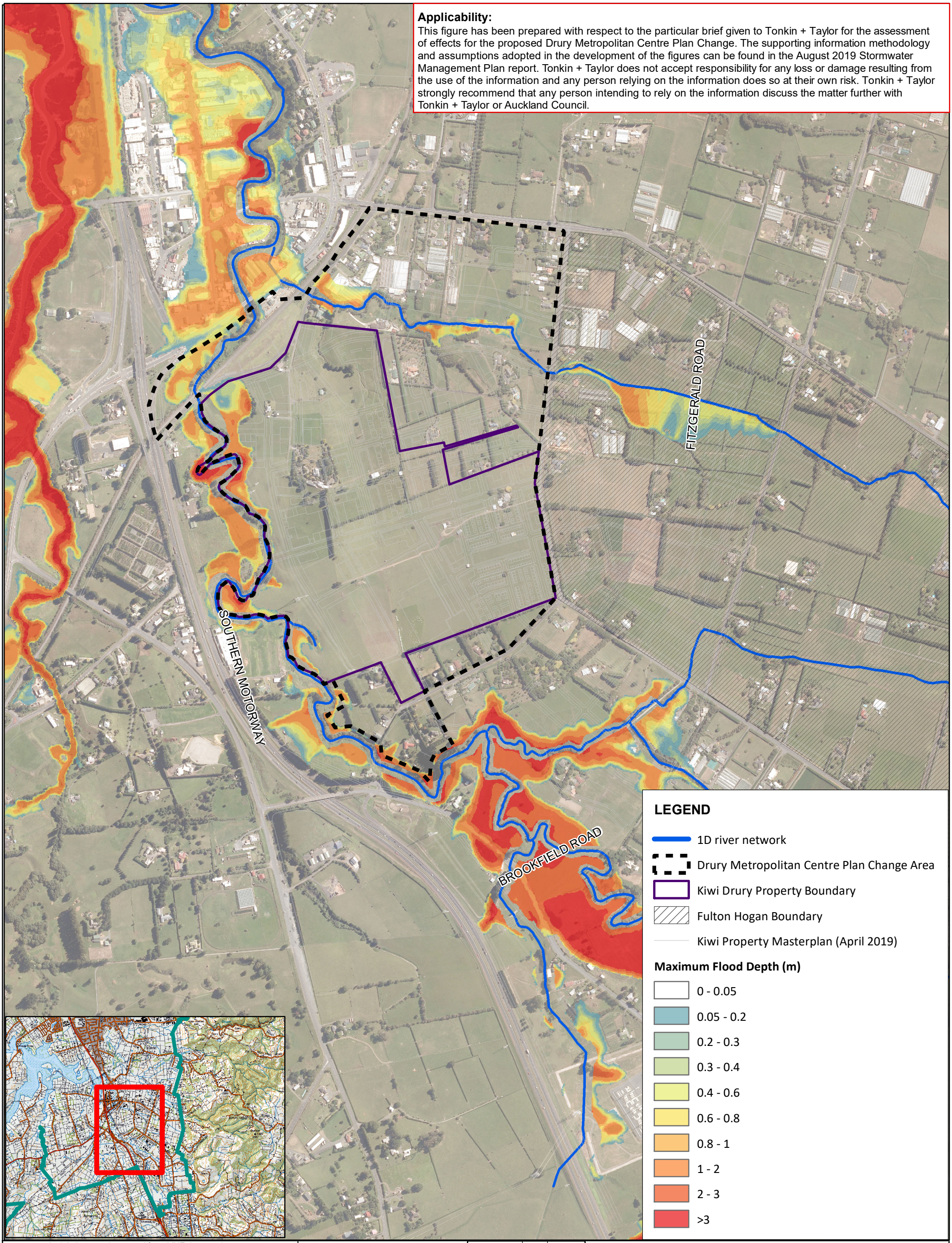

Notes:
Aerial photograph sourced from LINZ data service.
All reported levels are in Auckland Vertical Datum 1946.
Modelling results have been excluded where depth is below 0.05m.
Results shown from 2D extent only. 1D results from Hingaia stream not shown.

N

0 50 100 150 200 250 300 Meters

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DRAWN	DERI	Aug.19
CHECKED	SGV	Aug.19
APPROVED	TSRF	Aug.19
ARCFILE		
SCALE (AT A3 SIZE)	1:9,000	
PROJECT No.	1003297.1000	

Drury Town Centre
Maximum Flood Depth – 100yr
Post-development Iteration 04
with Gt South Rd Culvert straight alignment

FIGURE No. Figure D10

Rev.

Applicability:
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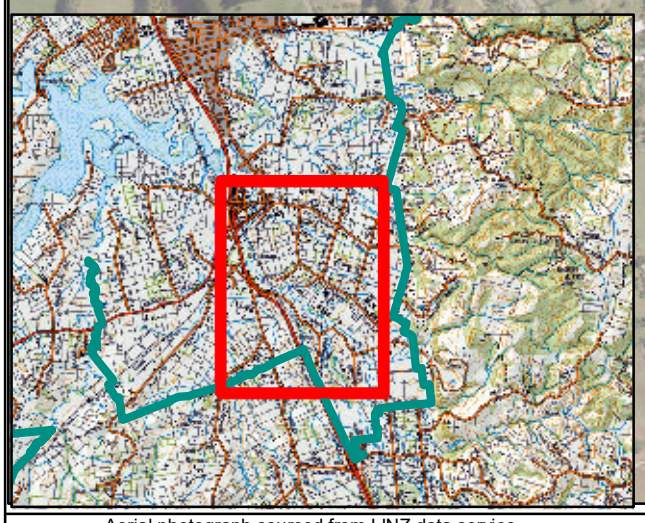
FITZGERALD ROAD

SOUTHERN MOTORWAY

BROOKFIELD ROAD



LEGEND

- 1D river network
- Drury Metropolitan Centre Plan Change Area
- Kiwi Drury Property Boundary
- Fulton Hogan Boundary
- Kiwi Property Masterplan (April 2019)

Level Difference (m)

- <-0.5 (Design flood level lower)
- -0.5 - -0.3
- -0.3 - -0.2
- -0.2 - -0.1
- -0.1 - -0.05
- -0.05 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- >0.5 (Design flood level higher)

Notes:
Aerial photograph sourced from LINZ data service.
All reported levels are in Auckland Vertical Datum 1946.
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N

0 50 100 150 200 250 300 Meters

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DRAWN	DERI	Aug.19
CHECKED	SGV	Aug.19
APPROVED	TSRF	Aug.19
ARCFILE		
SCALE (AT A3 SIZE)	1:10,000	
PROJECT No.	1003297.1000	

Drury Town Centre
Flood Level Difference – 10yrCC
Post-development Iteration 04 minus Pre-development

FIGURE No. Figure D11

Rev.

Applicability:
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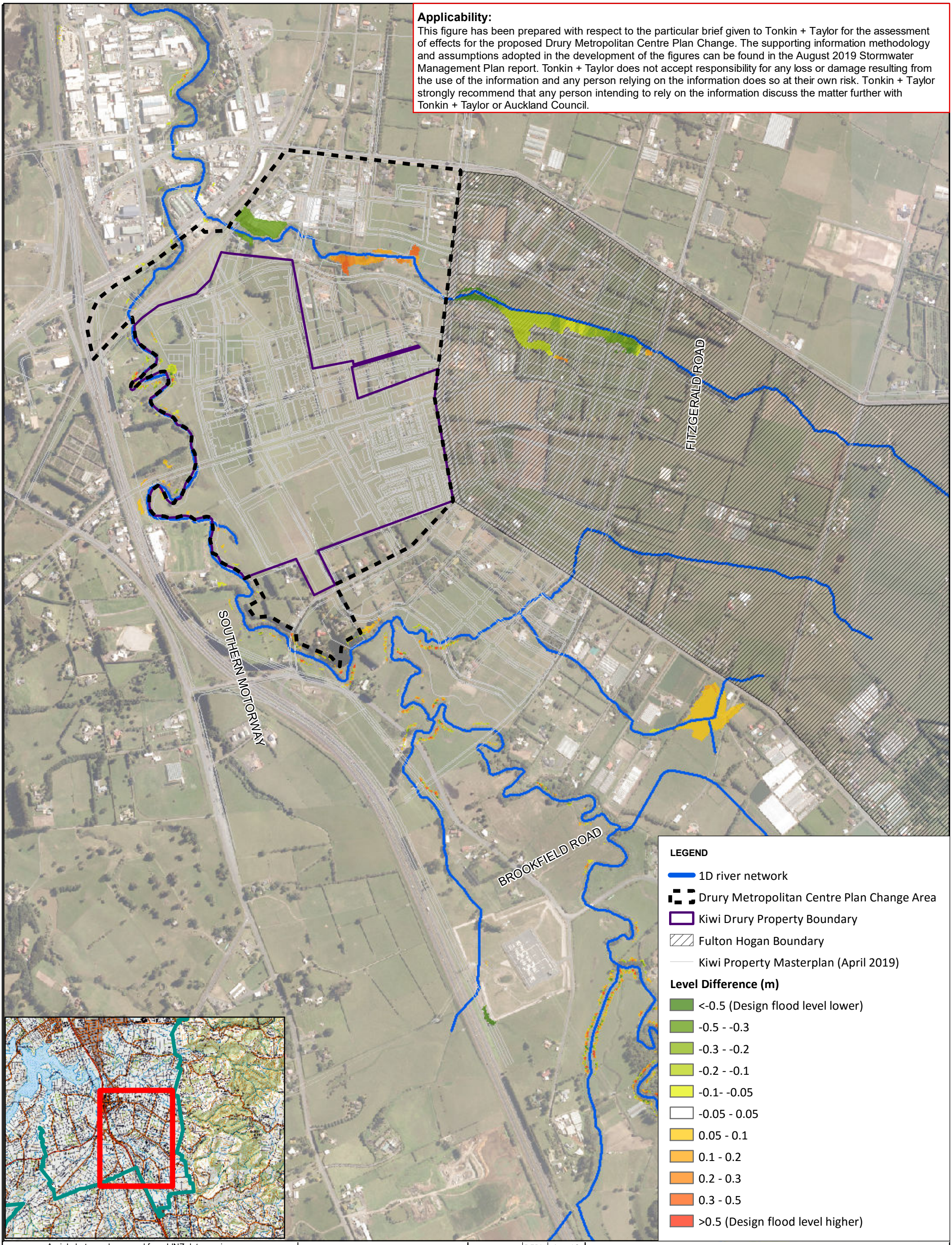

Notes:
Aerial photograph sourced from LINZ data service.
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N

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DRAWN	DERI	Aug.19
CHECKED	SGV	Aug.19
APPROVED	TSRF	Aug.19
ARCFILE		
SCALE (AT A3 SIZE)	1:10,000	
PROJECT No.	1003297.1000	

Drury Town Centre
Flood Level Difference – 100yr
Post-development Iteration 04 minus Pre-development

FIGURE No. Figure D12

Rev.

Applicability:
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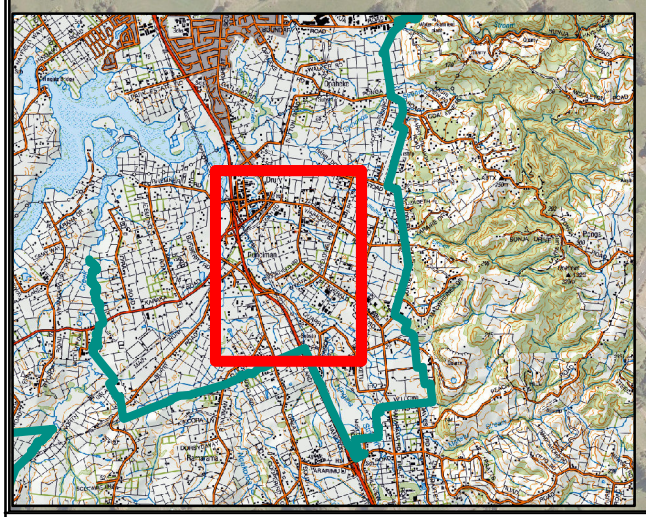
FITZGERALD ROAD

SOUTHERN MOTORWAY

BROOKFIELD ROAD



LEGEND

- 1D river network
- Kiwi Property Masterplan (April 2019)
- Drury Metropolitan Centre Plan Change Area
- Kiwi Drury Property Boundary
- Fulton Hogan Boundary

Pre-Development and Post Development Overlap

Pre-Development

Post-Development Iteration 04

Notes:
Aerial photograph sourced from LINZ data service.
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N

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DRAWN	DERI	Aug.19
CHECKED	SGV	Aug.19
APPROVED	TSRF	Aug.19
ARCFILE		
SCALE (AT A3 SIZE)	1:9,000	
PROJECT No.	1003297.1000	

Drury Town Centre
Flood Extent Comparison – 10yrCC
Pre-Development vs Post-Development Iteration 04

FIGURE No. Figure D13

Rev.

Applicability:
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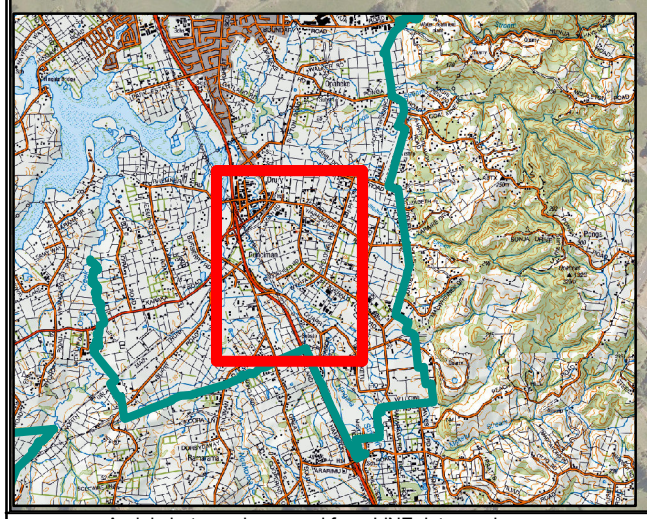
FITZGERALD ROAD

SOUTHERN MOTORWAY

BROOKFIELD ROAD



LEGEND

- 1D river network
- Drury Metropolitan Centre Plan Change Area
- Kiwi Drury Property Boundary
- Fulton Hogan Boundary
- Kiwi Property Masterplan (April 2019)

Pre-Development and Post-Development Overlap

Pre-Development

Post-Development Iteration 04

Notes:
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N

0 50 100 150 200 250 300 Meters

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DRAWN	DERI	Aug.19
CHECKED	SGV	Aug.19
APPROVED	TSRF	Aug.19
ARCFILE		
SCALE (AT A3 SIZE)	1:9,000	
PROJECT No.	1003297.1000	

Drury Town Centre
Flood Extent Comparison – 100yr
Pre-Development vs Post-Development Iteration 04

FIGURE No. Figure D14

Rev.