Tonkin+Taylor

Job No: 1009613.000
28 June 2019

520 GSR Limited
c/- Barker and Associates
PO BOX 1986
Shortland Street
Auckland 1140

Attention: Ms M Wong

Dear Mary

520 Great South Road, Papakura
Stormwater Management and Flooding Assessment

1 Introduction

Tonkin + Taylor was engaged by 520 GSR Limited to provide a high-level assessment of flood and stormwater management for the proposed development at 520 Great South Road, Papakura.

We understand it is proposed to apply for plan change to re-zone the property in the Auckland Unitary Plan. We also understand that two adjoining properties (21 Gatland Road and 522 Great South Road) will be included in the proposed Plan Change Area (PCA). A location plan of the PCA is shown on Figure A1 in the Appendices.

This assessment includes technical information regarding stormwater management for the proposed new land use to support the Plan Change application.

We have received the following information in relation to the proposed development:

- Preliminary Engineering Feasibility Assessment for a 75 Lot Development at 520 Great South Road, Papakura for Newhaven, Airey Consultants, ref 12530-07, February 2018.
- 520 Great South Road, Phase One. Feasibility Study. Draft for Discussion. Isthmus, January 2018
- Proposed Masterplan, 520 Great South Road, Barker and Associates, ref 17104, dated 8 March 2019.

2 Site characteristics

The following subsections address specific characteristics of 520 Great South Road and the PCA insofar as they relate to the management of stormwater and flooding.

The property lies within the Papakura Local Board Area of Auckland Council, and is zoned for Future Urban land use in the Auckland Unitary Plan (AUP).

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2.1 Topography and catchment

The PCA is located in the Slippery Creek catchment, and has frontage to Gatland Road to the north and Great South Road to the west. The PCA comprises three separate titles, namely 520 Great South Road, 21 Gatland Road and 522 Great South Road.

The topography of the site is generally characterised by broad slopes with elevations ranging from 9.4 m RL to 19.2 m RL.

The PCA is approximately 4.6 ha, and comprises two distinct subcatchments draining separately to the south and east, as shown on Figure A2. The contributing area is approximately 0.1% of the greater Slippery creek catchment.

The northern subcatchment drains to an unnamed stream along the north-eastern boundary of 520 Great South Road, which flows to Slippery Creek. Runoff from the southern subcatchment flows overland towards and along State Highway 1 to discharge into the lower reaches of Drury Creek.

2.2 Existing land use

The proposed PCA is located on the edge of a predominantly rural area and is zoned for future urban land use. The 520 Great South Road property comprises empty open greenspace with one commercial building. The neighbouring properties hold residential buildings. The Land Cover Database Version 4.1 (LCDB v4.1) classifies most of the site area as high producing exotic grassland, with the south-western corner classified as built-up area.

2.3 Geology

The GNS Auckland geological map classifies the geology of the PCA as part of the Puketoka formation. This is described as consisting of pumiceous mud, sand and gravel with muddy peat and lignite. S-MAP Landcare Research describes the soil as primarily well-drained clay and loam. This suggests the soil drainage may be receptive of infiltration, however, site-specific soakage tests are required to confirm this.

2.4 Existing drainage system

There is no public stormwater infrastructure within the properties. However, Auckland Council piped systems run along Gatland and Great South Roads. The Gatland Road system discharges into the open channel along the north-eastern boundary of the properties. This channel is classified as a permanent stream by Auckland Council, however, it was noted by T+T staff during a site visit that the stream was dry, as shown on Figure 1. The unnamed stream features an embankment approximately 60 m upstream of the south eastern property boundary. It is considered that this may have been constructed to detain upstream runoff on the neighbouring cemetery property. The locations of these features are shown on Figure A3.

2.5 Receiving environment

The unnamed open watercourse within the site drains to the Slippery Creek, which flows into Drury Creek. The ultimate receiving environment is the Manukau Harbour. The properties are not located above any high-use aquifers, and are not in any designated management areas in the Auckland Unitary Plan (AUP).

Figure 1 Unnamed stream on the north-eastern boundary of the 520 Great South Road property.

3 Proposed development

The proposed development for 520 Great South Road is presented in the masterplan[1] prepared by Barker and Associates. The development will create 83 individual lots, comprising variously terrace, duplex, stand-alone, and zero-lotted house types. The impervious cover of the site will thus increase, with greater runoff volumes and higher flows as a result.

It is expected that following the Plan Change, the re-zoned properties at 522 Great South Road and 21 Gatland Road will also ultimately be developed for residential purposes, creating another 30 lots.

4 Previous investigations

Two earlier investigations for development of the property were carried out for Newhaven Property Limited. Report for these have been provided to T+T, as noted in Section 1.

The Isthmus report included a site analysis, development layout options testing, and presented a structure plan and indicative development details.

The Airey report considered infrastructure requirements and civil engineering aspects for the 75 lot development. With regard to stormwater, Airey proposed a new stormwater network as part of the development, with stormwater mitigation on each of the individual sites. The overall stormwater management concept included for a stormwater pond to provide detention and mitigation for roading and accessways. The report includes runoff calculations for the 2 year ARI and 10 year ARI storm events, and water quality and extended detention storms.

5 Auckland Council flood hazard mapping

5.1 Existing flood risk

Auckland Council has mapped the 100 year average recurrence internal (ARI) flood plain, including for climate change and maximum probable development in the catchment (MPD). The floodplain

[1] Proposed Masterplan, 520 Great South Road, Barker & Associates, ref 17104, 8 March 2019.

currently extends generally along the open channel into the 520 Great South Road property and partially onto the 21 Gatland Road property. A major overland flow path is also mapped along the north-eastern boundary of 520 Great South Road, representing the stream on the property.

5.2 Auckland Council flood model

Auckland Council has developed a Rapid Flood Hazard Assessment (RFHA) model for the Slippery Creek catchment from which T+T has obtained result data for the following scenarios:

- Existing Development (ED) Climate Change (CC) 100 year ARI scenario
- Maximum Probable Development (MPD) CC 100 year ARI scenario.

The model does not represent Auckland Council's stormwater pipe network within the catchment. It assumes all water flows overland, excluding that which flows through modelled stream structures. The Slippery Creek flood model includes nine bridges within the catchment, including the Great South Road bridge located downstream of the PCA.

The MPD scenario does not represent any specific development on the PCA, however, it incorporates the general nature of future development in the Slippery Creek catchment including the site. It is assumed in the MPD scenario that the impervious coverage in the rural areas increases by 20% compared to the ED scenario. Both models have incorporated a 16.8% increase in 24-hour Design Rainfall Depth for the 1 in 100 year ARI to represent future climate change.

5.3 Model results

The comparison of 100 year ARI flood extents in the vicinity of the PCA properties for the ED and MPD scenarios is shown on Figure A4. The MPD flood extent is not significantly greater than the ED flood extent, with no previously unaffected areas flooding for the MPD scenario.

The differences in 100 year ARI flood levels for the ED and MPD scenarios are shown on Figure A5. The modelling results show that the MPD flood levels within the PCA are higher than the ED flood levels by 10 mm to 30 mm.

Peak flows and flood levels have also been extracted at the following locations downstream of the PCA (refer Figure A6):

- Location A – PCA downstream property boundary
- Location B – 1st point along Slippery Creek tributary
- Location C – 2nd point along Slippery Creek tributary
- Location D – 3rd point along Slippery Creek tributary
- Location E – at Great South Road bridge.

The peak flow and peak flood level results at these locations for the two models are shown in Tables 5.1 and 5.2 respectively.

Table 5.1 Slippery Creek model 100 year ARI peak flows

Location	Modelled Peak Flow (m³/s)	
	ED	MPD
A	4.9	5.3
B	6.5	7.2
C	6.1	6.7
D	336	361
E	332	350

Table 5.2 Slippery Creek model 100 year ARI peak flood levels

Location	Modelled Peak Flood Levels (mRL)	
	ED	MPD
Location A	10.39	10.41
Location B	9.49	9.63
Location C	7.11	7.17
Location D	6.46	6.63
Location E	5.66	5.91

5.4 Impact of future urbanisation of upstream catchments

The 100 year ARI peak flow from the modelled 24 hour storm occurs at approximately 12 hours for Location A (PCA downstream property boundary) and 14.5 hours for Location E (Great South Road Bridge). This indicates that the flow response of the PCA catchment peaks approximately 2.5 hours the peak of the main catchment, refer Figure 1 and Figure 2. This indicates that flows from the PCA should be passed forward rather than detained, as detention to delay runoff could lead to coincidence of peaks and worsen downstream flooding.

Furthermore, the 100 year ARI MPD peak flow from the PCA at Location A is 5.3 m³/s compared to 350 m³/s at the Great South Road bridge (Location E). The additional runoff volume from the future development of the PCA is negligible compared to the greater catchment volumes.

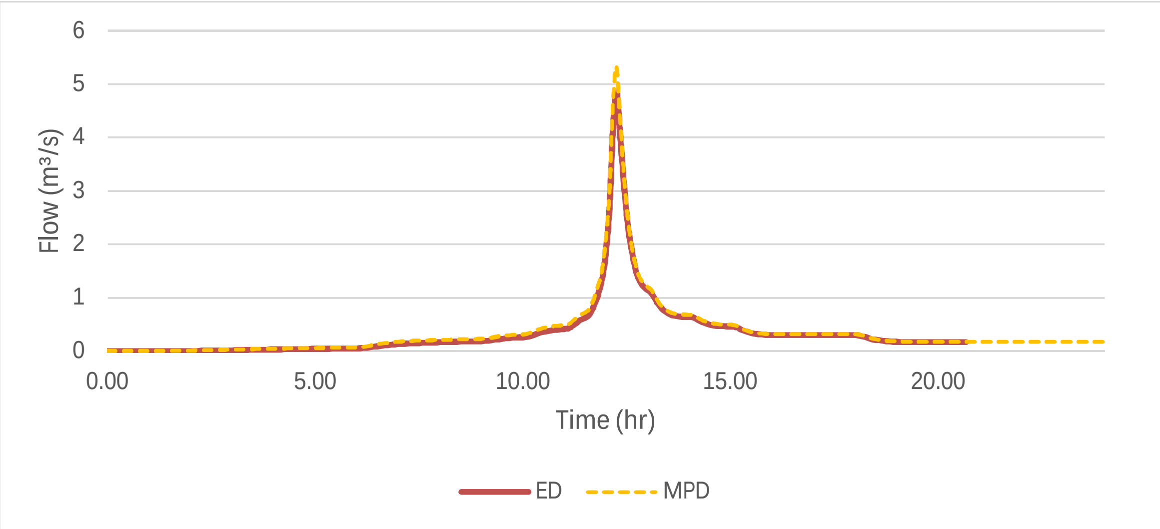

Figure 1 Modelled flow hydrograph at Location A (PCA downstream property boundary)

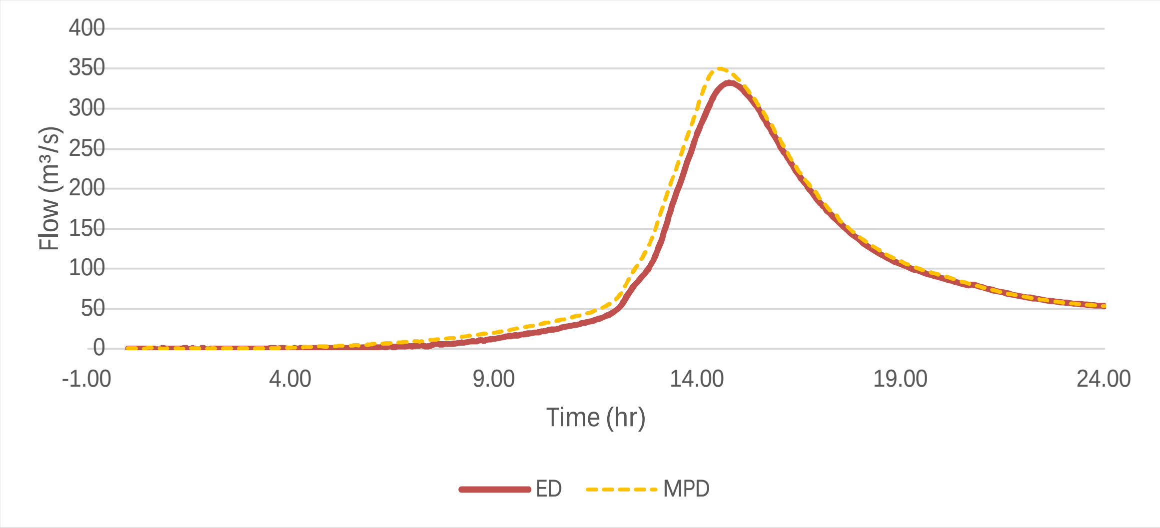

Figure 2 Modelled flow hydrograph at Location E (Great South Road Bridge)

6 Hydrological assessment

The hydrological assessment of the existing and proposed development is provided below. The proposed development is based on the masterplan prepared by Barker and Associates.

6.1.1 TP108 Hydrological Assessment

The hydrology of two subcatchment areas has been assessed, based on the topography of the PCA. The catchment area draining to Location A includes all of the 21 Gatland Road property and part of the 520 Great South Road property, and the natural catchment upstream of the properties. The balance of the PCA drains downstream of the Great South Road Bridge (refer Figure A7).

The catchment runoff for various storms has been calculated using the Auckland Council TP108 guidelines. Peak flows have been determined for the following scenarios:

- Existing development – Catchment A
- Proposed development – Catchment A
- Existing development – Catchment B
- Proposed development – Catchment B.

The calculations are included in Appendix B.

6.1.2 Assumptions

The hydrological assessment assumes the general drainage patterns will remain largely unchanged in the proposed development, i.e. that following development the two existing discharge points from the PCA identified on Figure A2 will be maintained.

Design rainfall has been obtained from NIWA HIRDS v4.1 database. A Representative Concentration Pathway (RCP) of 8.5 has been applied to represent climate change as this corresponds to a 2.1 °C increase in temperature, as specified in Auckland Council's guidelines.

A curve number (CN) of 98 was adopted for impervious surfaces such as roofs and paved areas. The pervious areas within the site were assumed to be pasture cover in good hydrologic condition. A curve number of 80 has been used, as the site soil has been classified as hydrologic soil group D. A minimum time of concentration of ten minutes was adopted given the relatively short drainage paths and probable piped drainage system for the development.

6.1.2.1 Results

The peak runoff results from the TP108 calculations are summarised in Table 6.1.

Table 6.1 Peak flows from the 520 Great South Road Plan Change Area

Catchment	Scenario	Peak flow (m^3/s)		
		2 year ARI	10 year ARI	100 year ARI
Catchment A	Existing development	0.67	1.27	2.33
	Proposed development	0.79	1.41	2.48
Catchment B	Existing development	0.07	0.13	0.24
	Proposed development	0.09	0.15	0.26

The difference between the calculated runoff and the Auckland Council modelled flows in the 100 year ARI event is due to the flood model setup, where no conveyance network has been modelled. That is, the model neglects the conveyance contribution of the stormwater infrastructure in the upstream catchment.

6.1.3 Impact of proposed development

The proposed development will increase the impervious area within the catchments. As a result, there is an increase in the magnitude and volume of the peak runoff generated from the PCA. The TP108 assessment indicates that the 100 year ARI peak flows will increase by 0.15 m^3/s and 0.02 m^3/s for Catchments A and B respectively. These are significantly smaller than the 18 m^3/s increase in 100 year ARI peak flow at Great South Road Bridge, refer Table 6.1. Therefore the impact of the proposed development at the PCA should be minor in comparison to the impact of the zoned future urbanisation of the greater Slippery Creek catchment.

It is proposed that the peak flows generated by the proposed development in the PCA can be passed forward without attenuation. Given the longer response time of the greater catchment, the PCA peak flows will discharge into the catchment streams before the peak flows from the greater catchment arrive. Thus, there will be no increase in peak flows downstream or significant adverse impact on downstream flood risk, noting that the increased peak flow from the PCA is anyway negligible compared to the greater catchment peak. It is also noted that the Drury-Opāheke Structure Plan Summary Report (Auckland Council, April 2019) suggests that "*the best way to manage flooding in the future urban areas is to pass flows forward or get the water to the Manukau as quickly as possible*", notwithstanding AUP requirements for stormwater detention.

An integrated stormwater management approach is proposed to provide water quality treatment and mitigation for hydrological volume. This is discussed further in Sections 6 and 7.

7 Stormwater management approach

7.1 Auckland Unitary Plan (AUP)

The AUP includes objectives and policies that relate to stormwater management. These are generally found in the following chapters:

- E.1 Water quality and integrated management
- E.8 Stormwater – discharge and diversion

- E.9 Stormwater quality – High contaminant generating car parks and high use roads
- E.36 Natural hazards and flooding.

In general, the objectives and policies seek to ensure that stormwater management for greenfield sites should avoid and/or minimise effects on the environment (especially for sensitive receiving environments) as far as is practicable.

The integrated stormwater management approach adopted for the proposed PCA has been aligned with the objectives and policies set out in the AUP, and are summarised in the following sections.

7.2 Water-Sensitive Design

Water-Sensitive Design (WSD) philosophies should be integrated within the proposed stormwater management approach to ensure that the AUP objectives are met. Water-sensitive design can be defined as an

> "*approach to freshwater management, it is applied to land use planning and development at complementary scales including region, catchment, development and site. Water sensitive design seeks to protect and enhance natural freshwater systems, sustainably manage water resources, and mimic natural processes to achieve enhanced outcomes for ecosystems and our communities"* (GD04, Auckland Council, 2015).

WSD principles are further detailed in the Water Sensitive Design for Stormwater (GD04) guideline document produced by Auckland Council. A summary of key principles for water sensitive design are as follows:

- Promoting inter-disciplinary planning and design
- Protecting and enhancing the values and functions of natural ecosystems
- Addressing stormwater effects as close to source as possible
- Mimicking natural systems and processes for stormwater management.

7.3 Water quality

The general approach to water quality management is summarised below:

- Provide near-source water quality treatment of runoff for all roads and High Contaminant Generated Carparks. Water quality treatment to target sediment, metals and gross pollutants
- Use "inert" building materials to prevent generation of contaminant-laden runoff, or otherwise provide site-specific treatment
- Minimise or mitigate the effects on freshwater systems arising from changes in water temperature caused by stormwater discharges
- Provide erosion protection in the stormwater systems including discharges to streams. Consider green outfalls for discharges to streams.

7.4 Hydrological mitigation

The general approach to water quantity management as outlined in the AUP is summarised below:

- Utilise stormwater infiltration for retention where it is possible to do so in a safe and effective manner. Where infiltration is not feasible, retention and detention volumes can be combined to provide hydrological mitigation.
- Utilise rainfall harvesting for retention for residential buildings where there is re-use demand

7.5 Flood management

The general approach to flood risk management within the PCA is summarised below:

- Avoid locating buildings or infrastructure within the 100 year ARI modified floodplain unless it can be design to be resilient to flood related 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
- Identify overland flow paths and ensure that they remain unobstructed to convey runoff safely.

8 Stormwater management options

The following options for stormwater management have been identified, in line with the AUP principles stated in Section 6 above.

8.1 Water quality

Water quality requirements as stated in the AUP and outlined within Section 3.1.1 of this report can be met through the following stormwater management devices:

- Treatment of runoff from roads and high contaminant generating car parks (over 30 spaces) using vegetated bio-retention devices such as swales, rain gardens and tree pits. Vegetated devices provide benefits of green infrastructure along road corridors as well as proximity to source.
- Bio-retention devices also can provide hydrological mitigation as well as water quality treatment.
- Within residential lots, it is proposed that inert building materials are used (e.g. not copper or zinc), and therefore no contaminants will be generated within the lots. If building materials that generate contaminants are used, site-specific water quality treatment will be required.

Multi-disciplinary engagement is recommended to ensure that road corridors are designed with landscaping provisions to incorporate vegetated bio-retention devices.

8.2 Hydrological mitigation

To meet the AUP water quantity hydrological mitigation requirements, the following stormwater management devices can be considered:

- Rainwater tanks for roof runoff. Rainwater tanks promote recycling and reuse of rainwater, while mitigating stormwater runoff at source.
- Pervious pavements can be included as part of the driveway / lot access, and can be designed to minimise land take and reduce runoff.
- Raingardens and swales designed to provide hydrological mitigation along road corridors and within public impervious spaces, while adding to the landscape value of the PCA.

Soakage tests for the PCA soils are recommended site, to confirm the effectiveness of infiltration devices. The Barker masterplan indicates stormwater treatment and amenity planting spaces. These are generally aligned with the existing stream.

8.3 Conveyance

The following measures are proposed to convey stormwater runoff within the PCA:

- Primary flows generated by all storm events up to a 1 in 10 year ARI storm to be conveyed through a new piped network to follow the proposed road network, and to discharge into the stream. If southern subcatchment is not reshaped to drain towards the stream, flows from this will to discharge into the existing Great South Road stormwater infrastructure.
- Runoff in excess of the 1 in 10 year ARI flows to be conveyed overland along the road carriageways towards the existing stream along the northern boundary of the site.
- Green outfalls and energy dissipation structures for outlets to the existing stream, to minimise stream disturbance and minimise outfall velocities.

9 Recommendations

Based on the regulatory requirements of the AUP and the Barker masterplan, a summary of the proposed integrated stormwater management approach is provided below. This should be confirmed and incorporated as the masterplan is developed further.

A more detailed design of the proposed stormwater management approach, including device sizing will be addressed as part of subdivision design once a site layout has been finalised.

Table 9.1 Proposed stormwater treatment and flood mitigation options

Activity	Proposed device	Comment
Residential lots (hydrological mitigation only)	· Raingardens · Rainwater tanks for roof runoff · Permeable pavements · Infiltration (where feasible)	· Raingardens provide flood mitigation and natural aesthetics. · Permeable pavements can be included as part of the site impervious area. · Rainwater tanks promote recycle and re-use of water.
Roads and high contaminant generating car parks (water quality and hydrological mitigation)	· Vegetated bio-retention devices: · Raingardens · Tree pits · Vegetated swales (where feasible)	· Vegetated swales provide conveyance, natural aesthetics and treatment close to source. · Raingardens and tree pits provide at-source treatment.
Public open spaces and amenity areas	· Riparian buffer planting and re-vegetation · Green outfalls	· Green outfalls provide erosion protection at downstream environments. · Buffer planting and re-vegetation increase ecological amenity within the PCA.

10 Applicability

This report has been prepared for the exclusive use of our client, 520 GSR Limited, 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.

Tonkin & Taylor Ltd

Environmental and Engineering Consultants

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Authorised for Tonkin & Taylor Ltd by:

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Dr Tim Fisher
PROJECT DIRECTOR

Report reviewed by:

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Tom Bassett
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Appendix A: Site maps

- Figure A1 – Location Plan
- Figure A2 – Catchment setting
- Figure A3 – Existing stormwater infrastructure and flood risk
- Figure A4 – Flood extent comparison
- Figure A5 – Flood level difference
- Figure A6 – Flood model results locations
- Figure A7 – TP108 catchments

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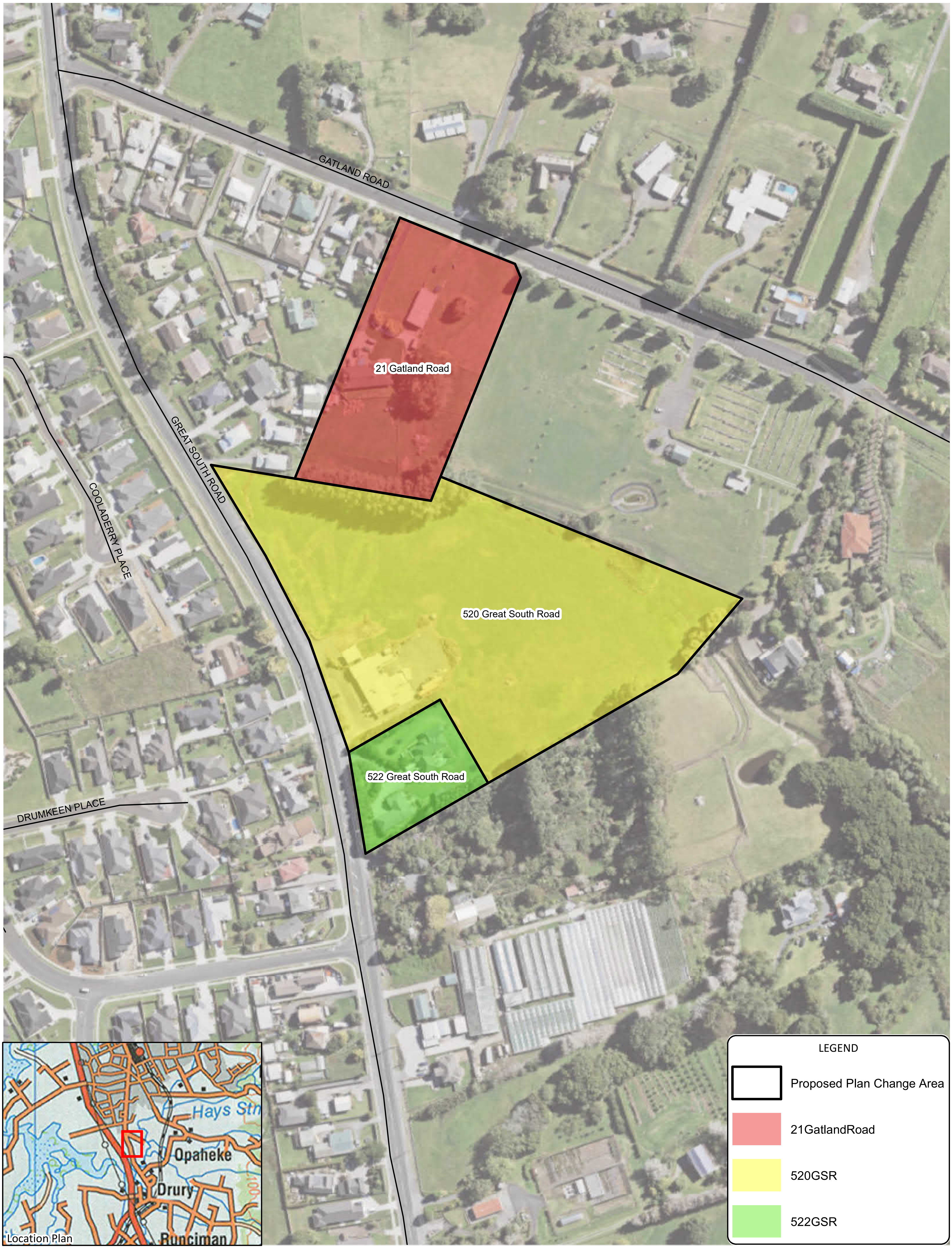

Notes: Aerials sourced from Auckland Council.

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520 Great South Road, Papakura
Location plan

FIGURE No. Figure A1

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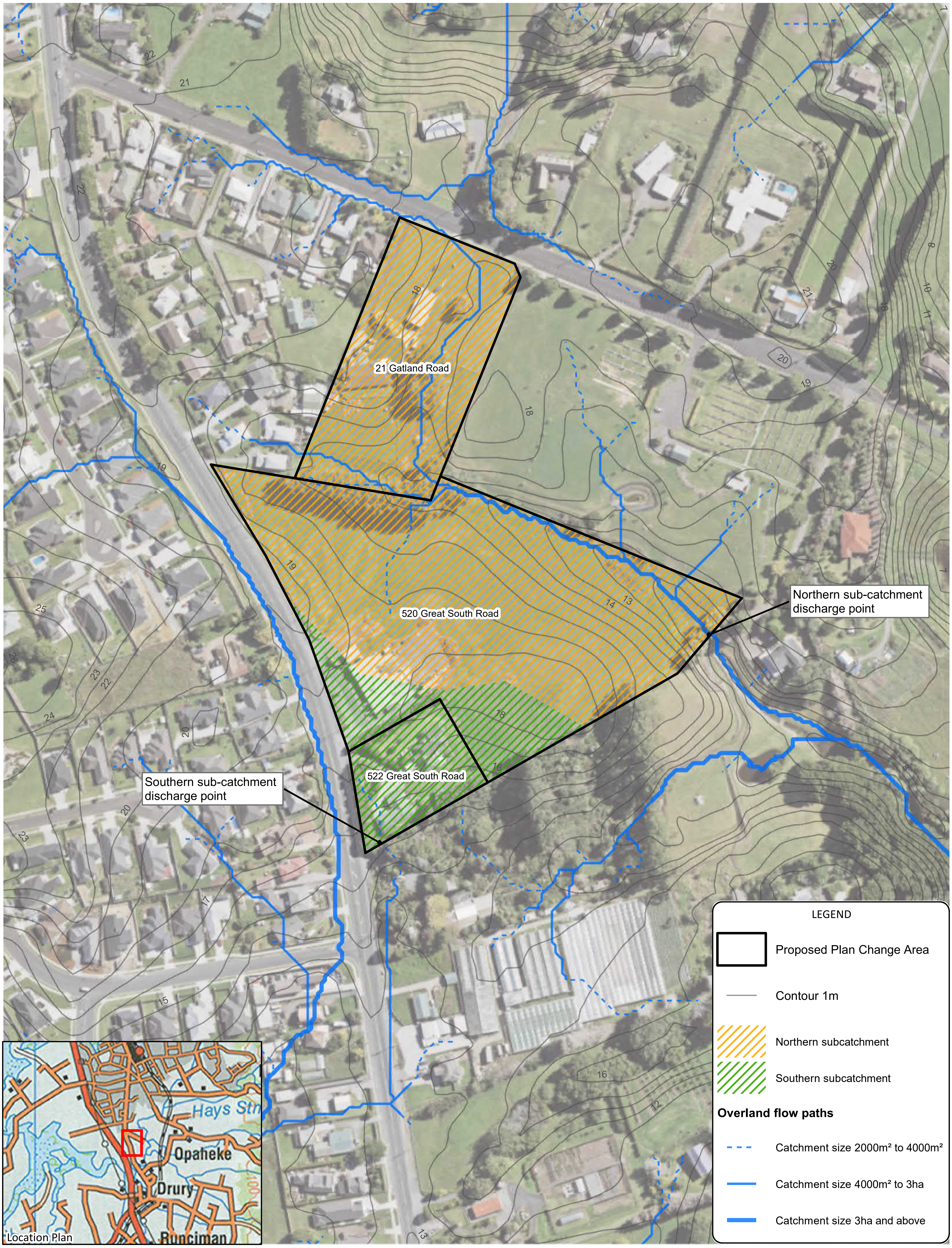

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520 Great South Road, Papakura
Catchment setting

FIGURE No. Figure A2

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520 Great South Road, Papakura

Existing stormwater infrastructure

FIGURE No. Figure A2

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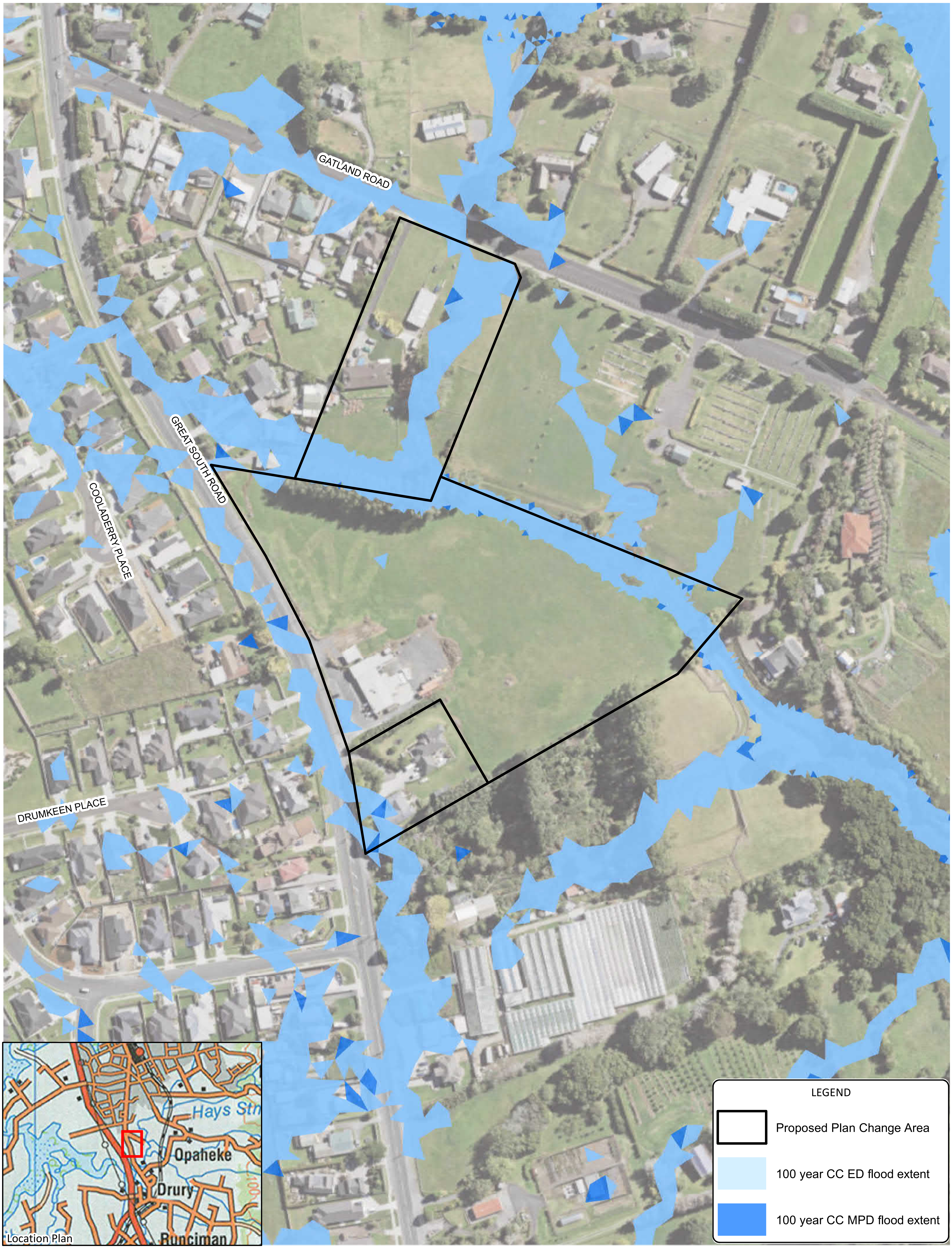

Notes: Aerials sourced from Auckland Council.
Flood depths less than 0.05m removed.

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520 Great South Road, Papakura
Flood extent comparison
100 year CC ED and 100 year CC MPD

FIGURE No.: Figure A4

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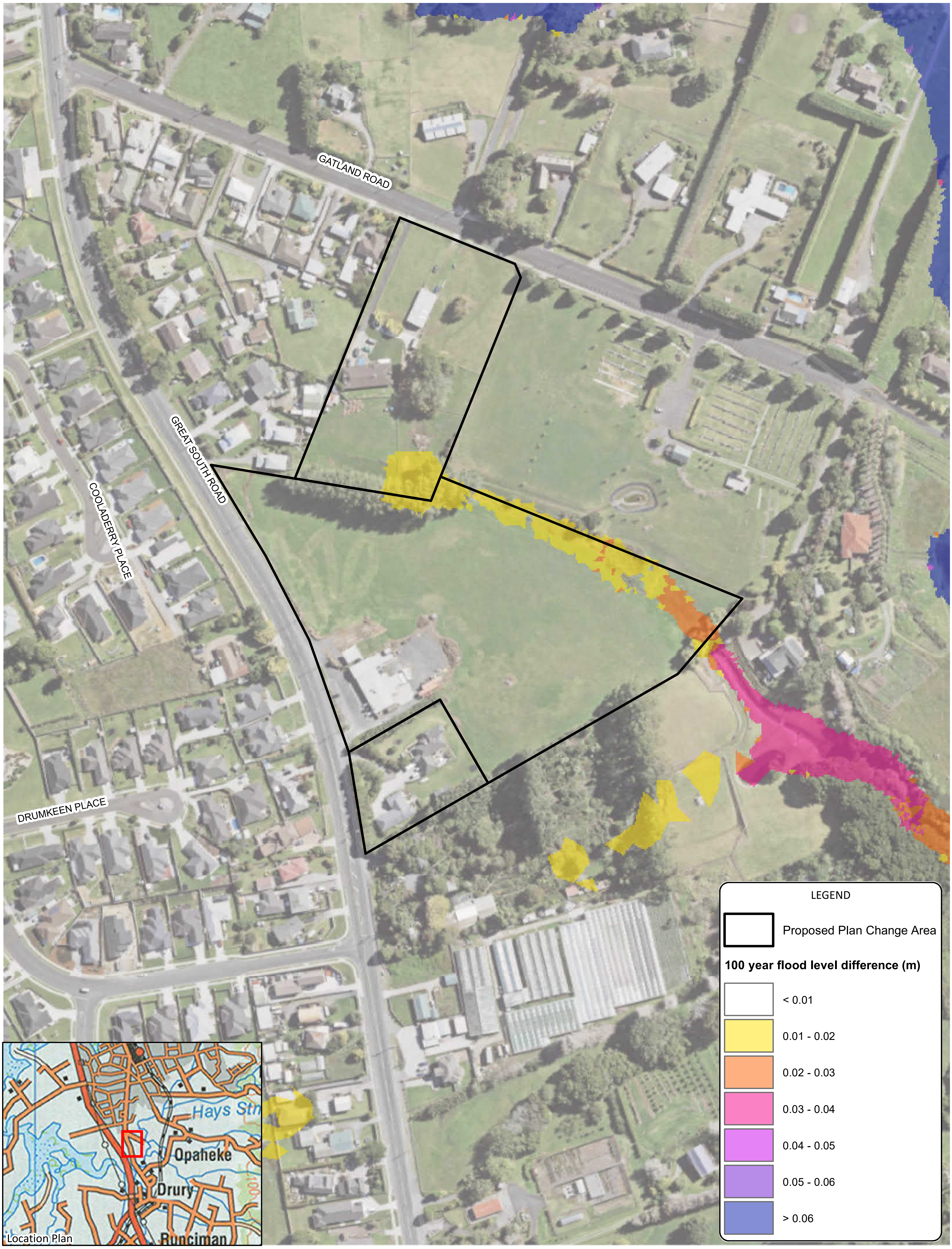

Notes: Aerials sourced from Auckland Council.

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520 Great South Road, Papakura

Flood level difference

100 year CC MPD MINUS 100 year CC ED

FIGURE No.: Figure A5

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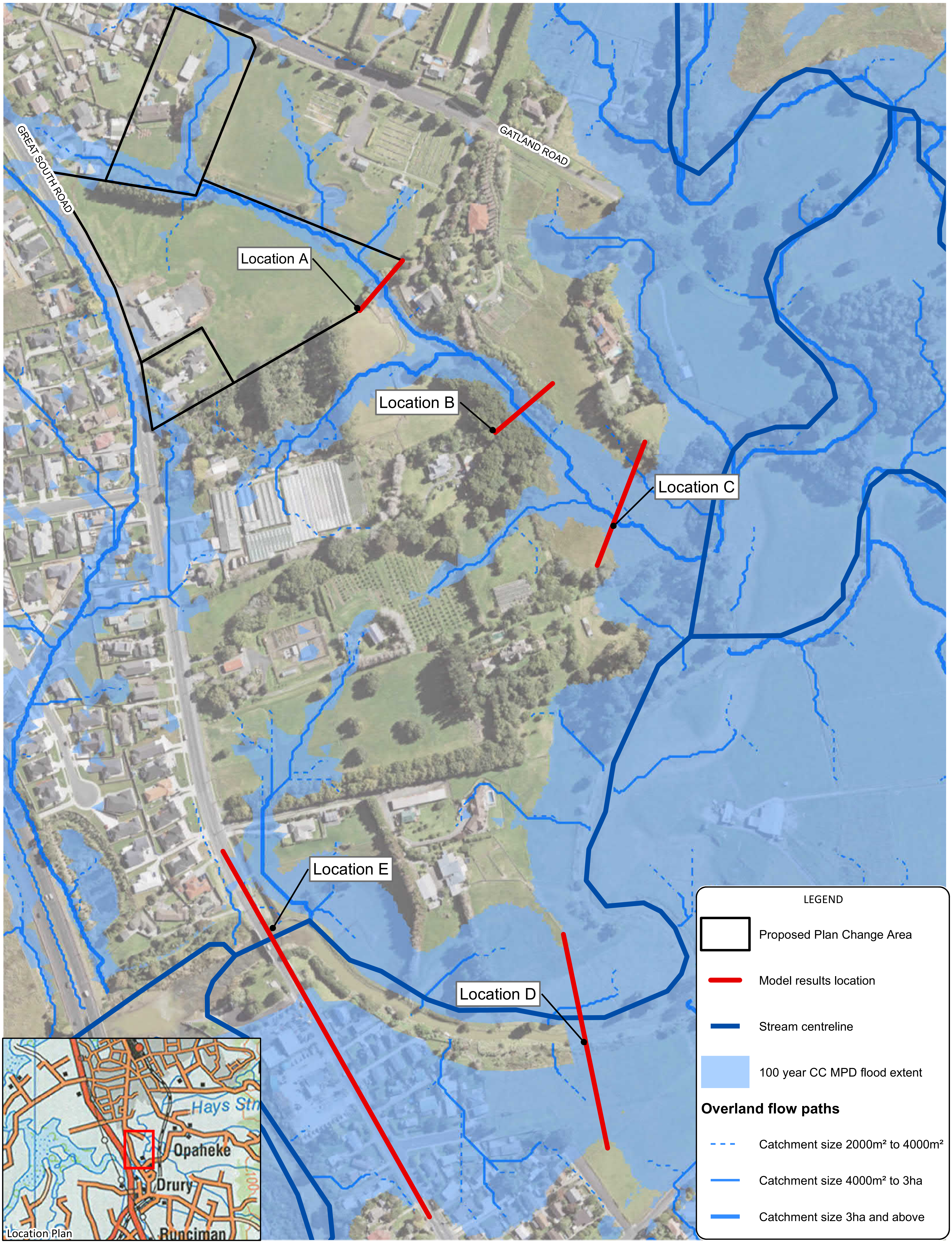

Notes: Aerials sourced from Auckland Council.

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520 Great South Road, Papakura
Flood model result locations

FIGURE No. Figure A6

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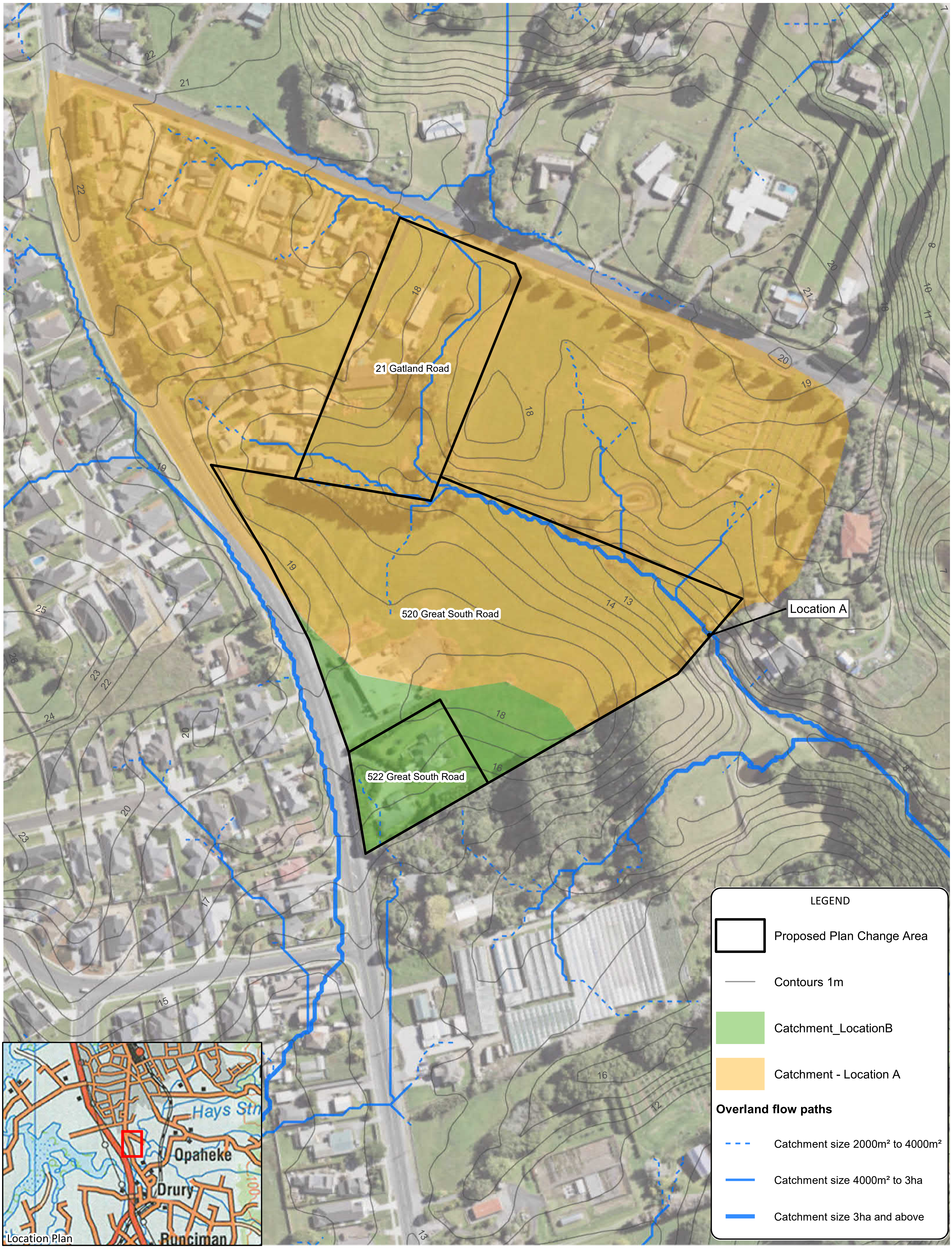

Notes: Aerials sourced from Auckland Council.

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520 Great South Road, Papakura

TP108 catchments

FIGURE No. Figure A7

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Appendix B: TP108 Calculations

- Figure B1 – Catchment A existing development
- Figure B2 – Catchment A proposed development
- Figure B3 – Catchment B existing development
- Figure B4 – Catchment B proposed development

TP108 - Runoff Analysis - Peak Discharge

Project: *520 GSR* By: JOPA Date: 12/04/2019

Location: *Catchment B* Checked: BRNA Date: 12/04/2019

1. Runoff Curve Number (CN) and Initial Abstraction (Ia)

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)	Curve Number CN*	Area (hectares)	Product of CN x Area
	Bush	70	0.00	0
	Grass	80	0.68	54
	Subtotal for Pervious Areas		0.68	54
	Roads / paved / roof	98	0.19	19
	Subtotal for Impervious Areas		0.19	19
		Totals	0.87	73

* from Table 3.3

CN (weighted) : $\frac{\text{total product}}{\text{total area}} = \frac{73}{0.8721} = 84$

Ia (weighted) : $\frac{5 \times \text{pervious area}}{\text{total area}} = \frac{6797254098\text{6}}{0.8721} = 3.90$ mm

2. Time of Concentration

Channelisation Factor : C = 0.8 (from Table 4.2)

Catchment Length : L = 0.145 km (along drainage path)

Catchment Slope : Sc = 0.032 m/m (by equal area method)

Runoff Factor R : $\frac{CN}{200 - CN}$ = 0.72

Time of Concentration : $t_c = 0.14\ C\ L^{0.66}\ R^{-0.55}\ Sc^{-0.30}$ = 0.17 hrs

SCS Lag for HEC-HMS : $t_p = 2/3\ t_c$ = 0.11 hrs

3. Soil Storage Parameter : S = ((1000/CN)-10)*25.4

Total = 48.5 mm
Pervious = 63.5 mm
Impervious = 5.2 mm

		Storm #1	Storm #2	Storm #3	Storm #4	Storm #5	Storm #6
4. Average Recurrence Interval, ARI (yr) :		2yr	5yr	10yr	20yr	50yr	100yr
5. 24 hour Rainfall Depth, P_{24} (mm), (from Appendix A)		**72**	**96**	**114**	**136**	**165**	**187**
6. Runoff Index, c* : $= \frac{P_{24} - 2Ia}{P_{24} - 2Ia + 2S}$		0.40	0.48	0.52	0.57	0.62	0.65
7. Specific Peak Flow Rate, q*, (from Figure 5.1)		0.107	0.121	0.129	0.136	0.143	0.147
8. Peak Flow Rate, q_p : $= q^*\ A\ P_{24}$ (m^3/s)		0.067	0.101	0.128	0.161	0.206	0.239
9. Runoff Depth, Q_{24} : $= \frac{(P_{24} - Ia)2}{(P_{24} - Ia) + S}$ (mm)	Pervious	34.4	53.6	68.9	88.2	114.5	134.9
	Impervious	67.2	91.1	109.0	131.0	160.0	182.0
10. Runoff Volume, V_{24} : $= 1000 \times Q_{24}\ A$ (m^3)	Pervious	234	364	468	600	779	917
	Impervious	129	175	210	252	308	350
	Total	363	540	678	852	1,086	1,267

TP108 - Runoff Analysis - Peak Discharge

Project: *520 GSR* By: JOPA Date: 12/04/2019

Location: *Catchment B* Checked: BRNA Date: 12/04/2019

1. Runoff Curve Number (CN) and Initial Abstraction (Ia)

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)	Curve Number CN*	Area (hectares)	Product of CN x Area
	Bush	70	0.00	0
	Grass	80	0.30	24
	Subtotal for Pervious Areas		0.30	24
	Roads / paved / roof	98	0.58	56
	Subtotal for Impervious Areas		0.58	56
		Totals	0.87	80

* from Table 3.3

CN (weighted) : $\frac{\text{total product}}{\text{total area}} = \frac{80}{0.8721} = 92$

Ia (weighted) : $\frac{5 \times \text{pervious area}}{\text{total area}} = \frac{5 \times 0.296514}{0.8721} = 1.70$ mm

2. Time of Concentration

Channelisation Factor : C = 0.8 (from Table 4.2)

Catchment Length : L = 0.145 km (along drainage path)

Catchment Slope : Sc = 0.032 m/m (by equal area method)

Runoff Factor R : $\frac{CN}{200 - CN}$ = 0.85

Time of Concentration : $t_c = 0.14\, C\, L^{0.66}\, R^{-0.55}\, Sc^{-0.30}$ = 0.17 hrs

SCS Lag for HEC-HMS : $t_p = 2/3\, t_c$ = 0.11 hrs

3. Soil Storage Parameter : $S = ((1000/CN)-10)*25.4$

Total = 22.4 mm
Pervious = 63.5 mm
Impervious = 5.2 mm

		Storm #1	Storm #2	Storm #3	Storm #4	Storm #5	Storm #6
4. Average Recurrence Interval, ARI (yr) :		2yr	5yr	10yr	20yr	50	100yr
5. 24 hour Rainfall Depth, P_{24} (mm), (from Appendix A)		**72**	**96**	**114**	**136**	**165**	**187**
6. Runoff Index, c* : $= \frac{P_{24} - 2Ia}{P_{24} - 2Ia + 2S}$		0.60	0.67	0.71	0.75	0.78	0.80
7. Specific Peak Flow Rate, q*, (from Figure 5.1)		0.141	0.150	0.154	0.157	0.160	0.161
8. Peak Flow Rate, q_p : $= q^* A P_{24}$ (m^3/s)		0.089	0.125	0.153	0.186	0.230	0.263
9. Runoff Depth, Q_{24} : $= \frac{(P_{24} - Ia)2}{(P_{24} - Ia) + S}$ (mm)	Pervious	34.4	53.6	68.9	88.2	114.5	134.9
	Impervious	67.2	91.1	109.0	131.0	160.0	182.0
10. Runoff Volume, V_{24} : $= 1000 \times Q_{24} A$ (m^3)	Pervious	102	159	204	262	340	400
	Impervious	387	524	628	754	921	1,047
	Total	489	683	832	1,016	1,260	1,447

TP108 - Runoff Analysis - Peak Discharge

Project: *520 GSR* By: JACH/JOPA Date: 10/04/2019

Location: *Catchment A - Existing* Checked: BRNA Date: 12/04/2019

1. Runoff Curve Number (CN) and Initial Abstraction (Ia)

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)	Curve Number CN*	Area (hectares)	Product of CN x Area
	Bush	70	0.00	0
	Grass	80	6.82	545
	Subtotal for Pervious Areas		6.82	545
	Roads / paved / roof	98	3.00	294
	Subtotal for Impervious Areas		3.00	294
		Totals	9.81	839

* from Table 3.3

CN (weighted) : $\frac{\text{total product}}{\text{total area}} = \frac{839}{9.8126} = 85$

Ia (weighted) : $\frac{5 \times \text{pervious area}}{\text{total area}} = \frac{5 \times 6.817225}{9.8126} = 3.47$ mm

2. Time of Concentration

Channelisation Factor : C = 0.8 (from Table 4.2)

Catchment Length : L = 0.595 km (along drainage path)

Catchment Slope : Sc = 0.019 m/m (by equal area method)

Runoff Factor R : $\frac{CN}{200 - CN}$ = 0.75

Time of Concentration : $t_c = 0.14\,C\,L^{0.66}\,R^{-0.55}\,Sc^{-0.30}$ = 0.31 hrs

SCS Lag for HEC-HMS : $t_p = 2/3\ t_c$ = 0.20 hrs

3. Soil Storage Parameter : S = ((1000/CN)-10)*25.4

Total = 43.1 mm
Pervious = 63.5 mm
Impervious = 5.2 mm

		Storm #1	Storm #2	Storm #3	Storm #4	Storm #5	Storm #6
4. Average Recurrence Interval, ARI (yr) :		2yr	5yr	10yr	20yr	50	100yr
5. 24 hour Rainfall Depth, P_{24} (mm), (from Appendix A)		**72**	**96**	**114**	**136**	**165**	**187**
6. Runoff Index, c* : = $\frac{P_{24} - 2Ia}{P_{24} - 2Ia + 2S}$		0.43	0.51	0.55	0.60	0.65	0.68
7. Specific Peak Flow Rate, q*, (from Figure 5.1)		0.095	0.107	0.113	0.119	0.124	0.127
8. Peak Flow Rate, q_p : = $q^*\,A\,P_{24}$ (m^3/s)		0.672	1.011	1.267	1.590	2.008	2.330
9. Runoff Depth, Q_{24} : = $\frac{(P_{24} - Ia)2}{(P_{24} - Ia) + S}$ (mm)	Pervious	34.4	53.6	68.9	88.2	114.5	134.9
	Impervious	67.2	91.1	109.0	131.0	160.0	182.0
10. Runoff Volume, V_{24} : = $1000 \times Q_{24}\,A$ (m^3)	Pervious	2,345	3,654	4,695	6,015	7,809	9,198
	Impervious	2,012	2,728	3,266	3,924	4,792	5,450
	Total	4,357	6,382	7,962	9,939	12,600	14,648

TP108 - Runoff Analysis - Peak Discharge

Project: *520 GSR* By: JACH/JOPA Date: 10/04/2019

Location: *Catchment A - Proposed* Checked: BRNA Date: 12/04/2019

1. Runoff Curve Number (CN) and Initial Abstraction (Ia)

Soil name and classification	Cover description (cover type, treatment, and hydrologic condition)	Curve Number CN*	Area (hectares)	Product of CN x Area
	Bush	70	0.00	0
	Grass	80	4.58	366
	Subtotal for Pervious Areas		4.58	366
	Roads / paved / roof	98	5.24	513
	Subtotal for Impervious Areas		5.24	513
		Totals	9.81	879

* from Table 3.3

CN (weighted) : $\frac{\text{total product}}{\text{total area}} = \frac{879}{9.8126} = 90$

Ia (weighted) : $\frac{5 \times \text{pervious area}}{\text{total area}} = \frac{5 \times 4.577035}{9.8126} = 2.33$ mm

2. Time of Concentration

Channelisation Factor : C = 0.8 (from Table 4.2)

Catchment Length : L = 0.595 km (along drainage path)

Catchment Slope : Sc = 0.019 m/m (by equal area method)

Runoff Factor R : $\frac{CN}{200 - CN}$ = 0.81

Time of Concentration : $t_c = 0.14\ C\ L^{0.66}\ R^{-0.55}\ Sc^{-0.30}$ = 0.29 hrs

SCS Lag for HEC-HMS : $t_p = 2/3\ t_c$ = 0.20 hrs

3. Soil Storage Parameter : S = ((1000/CN)-10)*25.4

Total = 29.5 mm
Pervious = 63.5 mm
Impervious = 5.2 mm

		Storm #1	Storm #2	Storm #3	Storm #4	Storm #5	Storm #6
4. Average Recurrence Interval, ARI (yr) :		2yr	5yr	10yr	20yr	50	100yr
5. 24 hour Rainfall Depth, P_{24} (mm), (from Appendix A)		**72**	**96**	**114**	**136**	**165**	**187**
6. Runoff Index, c* : = $\frac{P_{24} - 2Ia}{P_{24} - 2Ia + 2S}$		0.53	0.61	0.65	0.69	0.73	0.76
7. Specific Peak Flow Rate, q*, (from Figure 5.1)		0.112	0.121	0.126	0.130	0.133	0.135
8. Peak Flow Rate, q_p : = $q^*\ A\ P_{24}$ (m^3/s)		0.791	1.143	1.406	1.732	2.158	2.481
9. Runoff Depth, Q_{24} : = $\frac{(P_{24} - Ia)2}{(P_{24} - Ia) + S}$ (mm)	Pervious	34.4	53.6	68.9	88.2	114.5	134.9
	Impervious	67.2	91.1	109.0	131.0	160.0	182.0
10. Runoff Volume, V_{24} : = $1000 \times Q_{24}\ A$ (m^3)	Pervious	1,574	2,453	3,152	4,038	5,243	6,176
	Impervious	3,516	4,769	5,709	6,859	8,376	9,526
	Total	5,091	7,222	8,861	10,897	13,618	15,702