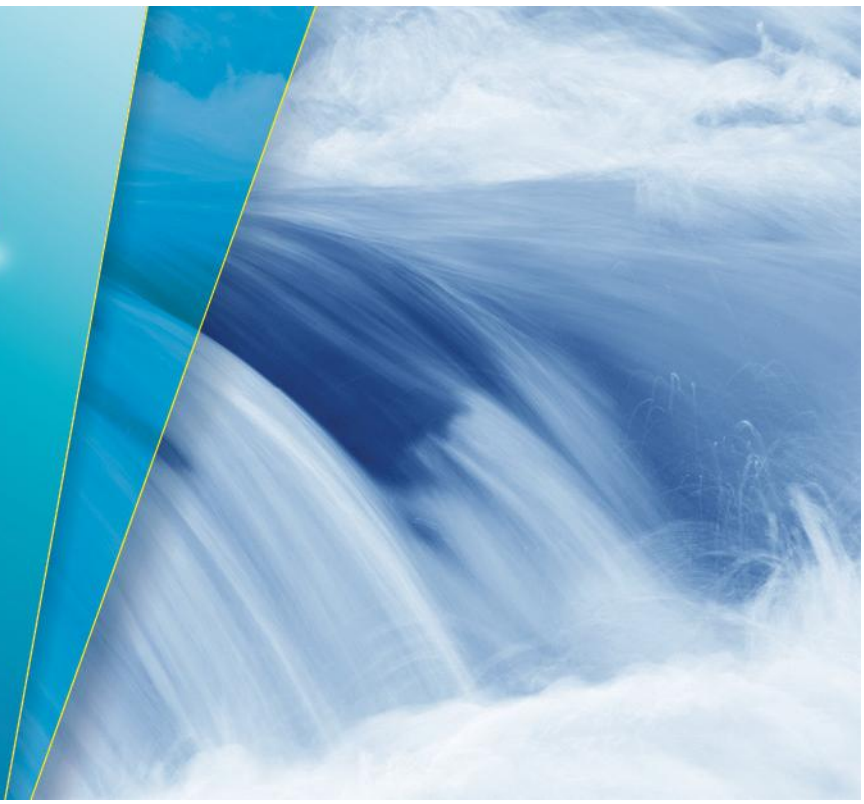
REPORT

Tonkin+Taylor

Stormwater Management Plan

For Plan Change Area: 520, 522 Great South Road and 21 Gatland Road

Prepared for
520 GSR Limited
Prepared by
Tonkin & Taylor Ltd
Date
May 2020
Job Number
1009613.1000.vC



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520 GSR Limited	1 electronic copy
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Executive summary

520 GSR Limited has lodged a private Plan Change application to rezone the Plan Change Area (PCA) from Future Urban Zone (FUZ) for Mixed Urban Housing (MUH). The properties which form the PCA are 520 and 522 Great South Road and 21 Gatland Road (Refer to Figure 1.1).

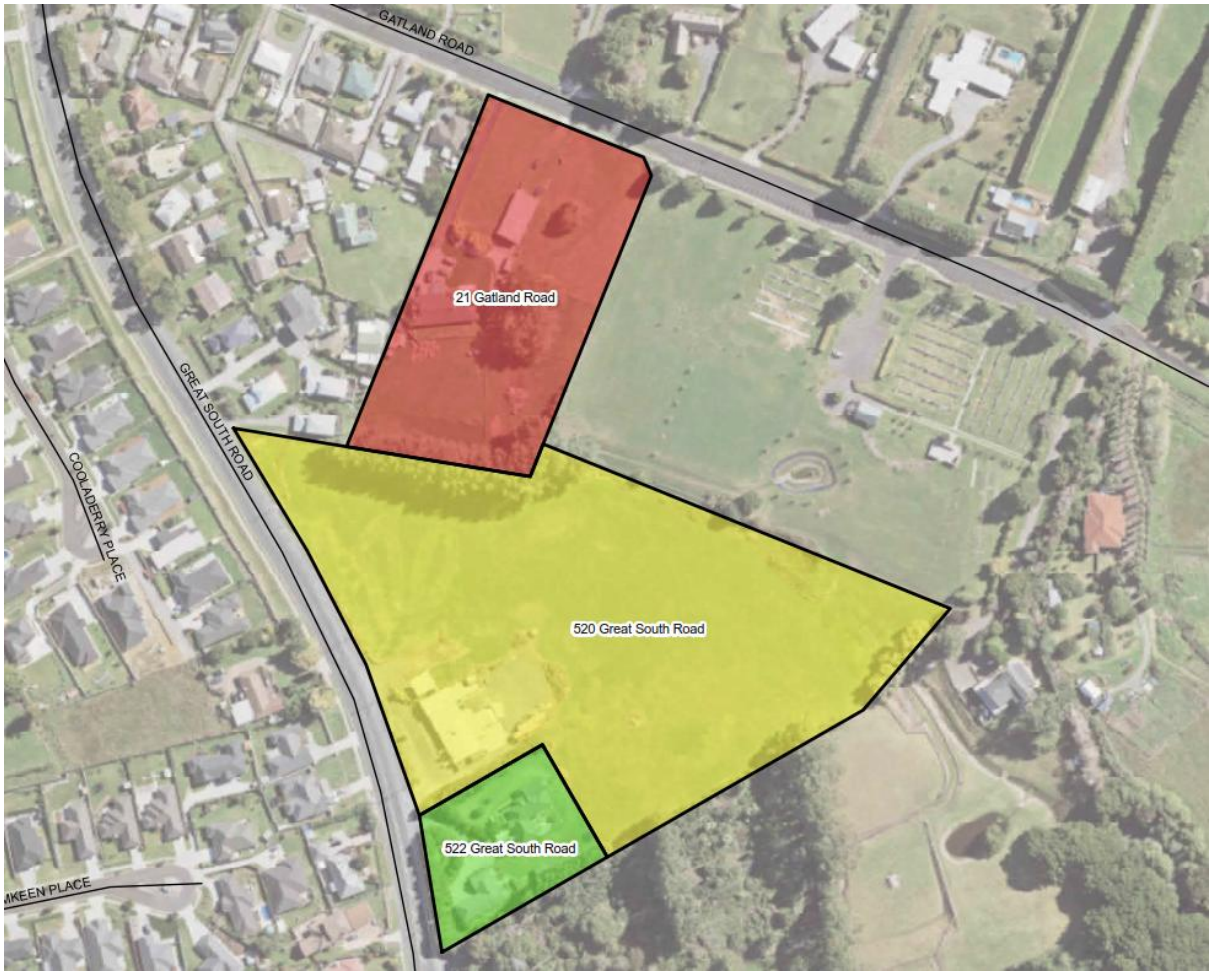

Figure 1.1: Properties which comprise the PCA

Tonkin + Taylor (T+T) previously prepared a high-level assessment of stormwater and flooding issues[1] for the development of 520 Great South Road and this SMP builds on that assessment and addresses stormwater management requirements for future development of all three properties in the PCA.

The purpose of the SMP is to provide guidance to the applicant and Auckland Council on how stormwater will be managed at the PCA. It demonstrates that the proposed stormwater management is the best practicable option, taking into consideration the existing site features and the future land use. This guidance is consistent with regulatory and stormwater-specific guidelines and based on conventional stormwater management techniques to meet Auckland Unitary Plan, Operative in Part (AUP), provisions. The Draft Drury-Opāheke Future Urban Zone Stormwater

[1] Tonkin + Taylor, 28 June 2019, *520 Great South Road, Papakura – Stormwater Management and Flooding Assessment* (Job number: 1009613.000)

Management Plan[2] (FUZ SMP) has been referred to ensure to the stormwater management approach integrates with existing and future stormwater systems in the Slippery Creek catchment.

The SMP, as it stands, is intended to be adopted within Auckland Council's Network Discharge Consent (NDC) and provides an assessment to support the Plan Change application. The applicant is concurrently preparing a Resource Consent application to develop 520 Great South Road with 102 terraced dwellings in accordance with the MUH zone. The property at 21 Gatland Road currently has a Resource Consent lodged with Auckland Council for a subdivision to create 20 lots, which this SMP has taken into account. The property at 522 Great South Road does not have plans for redevelopment at this stage. The SMP may need to be developed in further detail at future stages to address outcomes of Resource Consents and Engineering Plan Approvals for the proposed developments.

The overarching principles of the SMP are to:

- Recognise the key constraints and opportunities on site and in the greater Slippery Creek catchment
- Devise an integrated stormwater management approach to facilitate urban development.
- Develop a set of Best Practicable Options (BPO) for stormwater management that can be incorporated into the development
- Emphasise a water-sensitive design approach that manages the impact of land use change from rural to urban, and which protects and enhances stream systems and natural hydrology while mitigating hydrological changes and managing flooding effects
- Minimise the generation and discharge of contaminants/sediments into the sensitive receiving environment of the Manukau Harbour
- Protect key infrastructure, people and the environment from significant flood events.

To achieve these outcomes, the proposed stormwater management approach is to:

- Provide a minimum of Stormwater Management Area – Flow (SMAF) 1 hydrological mitigation for all impervious surfaces within the PCA. Any additional mitigation for stream erosion can be developed as the SMP progresses based on site observations of erosion and/or improved erosion modelling
- Limit the generation of contaminants through selection of green building materials and providing green infrastructure to treat runoff at-source or as close to the source as practicable
- Protect, restore and enhance the onsite intermittent stream
- Pass forward flows, i.e. flows from the PCA will be discharged directly into Watercourse A and Slippery Creek without onsite flood attenuation so that they arrive before peak flooding from the upper reaches of the Slippery Creek catchment.

To meet the stormwater management approach set out above, a treatment train strategy is adopted for the PCA. A toolbox of BPO (refer to Table 1.1) has been prepared to assist in selecting appropriate stormwater management devices to achieve water quality, hydrological mitigation and water-sensitive design outcomes for corresponding land-use.

[2] Mott McDonald, 12 April 2019, *Drury-Opāheke Structure Plan Future Urban Zone – Draft Stormwater Management Plan.* Prepared for Auckland Council in support of the Drury-Opāheke Structure Plan.

Table 1.1: Stormwater management requirements and toolbox of BPO for stormwater management within the PCA

Activity	Component	Minimum requirements	Recommended approaches	Guidelines
Residential lots – Roof Area	Hydrological mitigation only	Retention of at least 5 mm of runoff depth from impervious surfaces. Detention and a drain down period of 24 hours for the difference between the pre-development and post-development runoff volumes from a 95th percentile, 24-hour rainfall event minus the achieved retention volume, over the impervious area for which hydrology mitigation is required.	· Infiltration through trench drains · Above ground rainwater storage/re-use tanks · Permeable pavement and porous concrete · Raingardens/planter boxed · Underground storage tanks	· Auckland Council GD01
Residential lots – Hardstand and jointly owned access lanes Roads, Carparking and HCGA Carriageway	Water quality Hydrological mitigation	Stormwater management of runoff from all impervious surfaces before discharging into the receiving environment. Minimise the generation of contaminants as much as possible. Where contaminants are generated, the preferred approach is to use green infrastructure to treat runoff at-source or as close to the source as practicable. Retention of at least 5 mm of runoff depth from impervious surfaces. Detention and a drain down period of 24 hours for the difference between the pre-development and post-development runoff volumes from a 95th percentile, 24-hour rainfall event minus the achieved retention volume, over the impervious area for which hydrology mitigation is required.	· Pre-treatment Devices - Gross Pollutant Trap - Proprietary Device · Infiltration through trench drains · Bioretention devices - Raingardens - Tree Pits - Filter strips/ swales - Wetlands · Permeable pavement and porous concrete	· Auckland Council GD01 · Auckland Council GD04 · Auckland Council Unitary Plan stormwater management provisions TR2013/35
Public spaces only i.e. Roads, Carparking, HCGA Carriageway, Open Spaces and Riparian Margins	Stormwater conveyance	Convey runoff generated from the 10 year ARI through a public piped stormwater network. Allowance for runoff flows greater than the 10 year ARI should be made in overland flow paths. Existing overland flow paths should be protected.	Primary Conveyance · Retain and enhance intermittent streams · Swales · Pipe network Secondary Conveyance · Retain and enhance intermittent streams	· Auckland Council GD01 · Auckland Council GD04 · Auckland Council Stormwater Code of Practice

Activity	Component	Minimum requirements	Recommended approaches	Guidelines
			· Swales and open channels · Road corridor	
Open Spaces and Riparian Margins	Stream hydrology and erosion protection	Enhance water quality, flows, stream channels and their margins and other freshwater values where the current condition is below the relevant thresholds.	· Green outfall (where practicable) · Riparian margin enhancement and planting, where necessary to mitigate identified adverse effects · With reference to the Assessment of Ecological Effects (by Freshwater Solutions)	· Auckland Council GD01 · Auckland Council TR2013/018

Watercourse A (refer to Figure 1.2) is a highly modified and intermittent tributary of the Slippery Creek Stream which will remain the primary conveyance route for runoff from the PCA. There is opportunity to improve stream ecological values and function through the restoration, protection and enhancement of Watercourse A. This is being assessed in detail as part of the Resource Consent application for 520 Great South Road within the context of a particular development scheme.

Figure 1.2: Existing private stormwater drainage within the PCA (Freshwater Solutions, 2020)

Based on the investigations already completed, it is expected that stormwater effects from the PCA can be appropriately and adequately managed consistent with the requirements of the Auckland Unitary Plan.

1 Introduction

This Stormwater Management Plan (SMP) has been prepared by Tonkin + Taylor (T+T) to support a private Plan Change application, by 520 GSR Limited, to rezone three properties in Papakura from Future Urban Zone (FUZ) for Mixed Urban Housing (MUH). The properties which form the Plan Change Area (PCA) are 520 and 522 Great South Road and 21 Gatland Road.

The purpose of the SMP is to provide guidance to the applicant and Auckland Council on how stormwater will be managed at the PCA. It demonstrates that the proposed stormwater management is the Best Practicable Option (BPO), taking into consideration the existing site features and the future land use master plan.

The SMP, as it stands, informs the Plan Change application and is intended at this stage to be adopted within Auckland Council's Network Discharge Consent (NDC). The applicant is preparing a concurrent Resource Consent application for 520 Great South Road to develop this site with terraced dwellings in accordance with the Mixed Housing Urban zone. This SMP informs the stormwater management approach in that Resource Consent and may need to be developed in further detail at future stages to support other applications for Resource Consents and Engineering Plan Approvals for development in the PCA.

T+T previously prepared a high-level assessment of stormwater management and flooding issues[3] for the development of 520 Great South Road, included in Appendix A2. This SMP builds on that assessment and addresses stormwater management requirements for future development of all three properties in the PCA.

This SMP has been prepared using the Auckland Council SMP template. The text '***Not applicable within this SMP***' indicates sections that are not relevant to this PCA.

[3] Tonkin + Taylor, 28 June 2019, *520 Great South Road, Papakura – Stormwater Management and Flooding Assessment* (Job number: 1009613.000)

2 Existing site appraisal

This section of the report summarises the existing site characteristics and conditions within the PCA, as they relate to stormwater management.

2.1 Summary of data sources and dates

This section provides a summary of key datasets used in the preparation of this SMP, including those that have been used to generate supporting figures. The supporting figures are provided in Appendix A1.

Table 2.1: Data Sources

Existing site appraisal item	Source and date of data used
Topography	· Auckland Council GeoMaps - AUP management layers: Contours (2020) · Topographic survey by Yeomans Survey Solutions (September 2019)
Geotechnical / soil conditions	· GNS Auckland geological map (2019) · S-MAP Landcare Research (2019)
Existing stormwater network	· Auckland Council GeoMaps - AUP management layers: Underground services - Stormwater (2020) · Topographic survey by Yeomans Survey Solutions (September 2019) · Site visit by T+T (April 2019) · 520 Great South Road Assessment of Ecological Effects prepared by Freshwater Solutions (April 2020) · Infrastructure Report – Proposed development 520 Great South Road prepared by Maven Associates, (April 2020)
Existing hydrological features	· Topographic survey by Yeomans Survey Solutions (September 2019) · Site visit by T+T (10 April 2019) · 520 Great South Road Assessment of Ecological Effect prepared by Freshwater Solutions (April 2020)
Stream, river, coastal erosion	· Auckland Council GeoMaps - AUP management layers: Catchments and Hydrology - River names (2020)
Flooding and flow paths	· Auckland Council GeoMaps - AUP management layers: Catchments and Hydrology - Overland Flow Paths, Flood Prone Areas, Flood Sensitive Areas and Flood Plains (2020)
Coastal Inundation	· Auckland Council GeoMaps - AUP management layers: Emergency Management - Coastal inundation (2020)
Ecological / environmental areas	· Auckland Council GeoMaps - AUP management layers: Significant Ecological Areas (2020) · 520 Great South Road Assessment of Ecological Effect prepared by Freshwater Solutions (April 2020)
Cultural and heritage sites	· Auckland Council GeoMaps - AUP management layers: Cultural Heritage Inventory (2020)
Contaminated land	· N/A

2.2 Location and general information

The PCA is located on the edge of a predominantly rural area within the Papakura Local Board Area of Auckland Council, and within the Drury-Opāheke FUZ as zoned in the Auckland Unitary Plan, Operative in Part (AUP). It comprises three properties covering a combined area of 46,268 m^2 and bounded by Gatland Road and Papakura South Cemetery to the north, Great South Road to the south-west, residential housing to the west and an unnamed paper road to the east. The PCA is surrounded by a mixture of established residential properties, public open spaces and rural land.

Table 2.2 provides key property details of the PCA and Figure 2.1 and Figure 2.2 show the location and extent.

Table 2.2: Property Information

Existing site element	
Site address	The PCA comprises three separate titles: · 520 Great South Road, Papakura · 522 Great South Road, Papakura · 21 Gatland Road, Papakura.
Legal description and property area	520 Great South Road: Lot 2 DP 172553, 30,198 m^2 522 Great South Road: Lot 1 DP 172553, 4,000 m^2 21 Gatland Road: Lot 16 DP 43579, 12,070 m^2
Current Land Use	520 Great South Road comprises open greenspace and one commercial building. The other two properties hold residential buildings.
Current building coverage	Approximately 2,900 m^2 (8 %) of the PCA comprises buildings or other impervious surfaces.
Historical Land Use	Rural

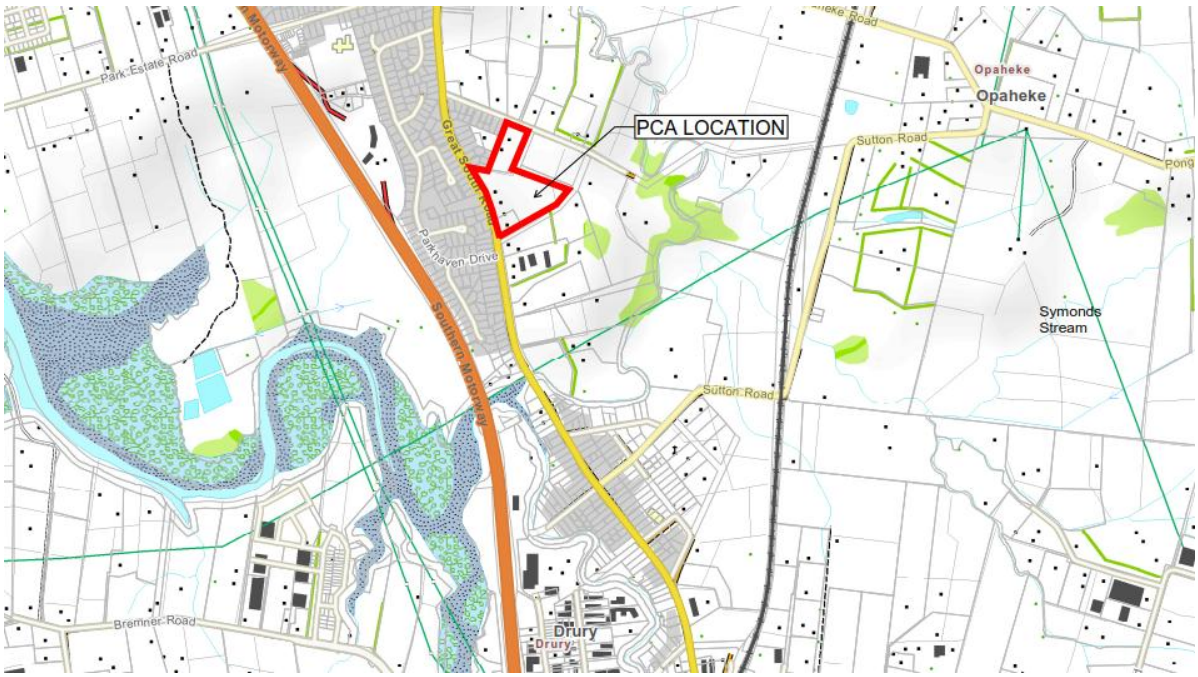

Figure 2.1: Map showing PCA location

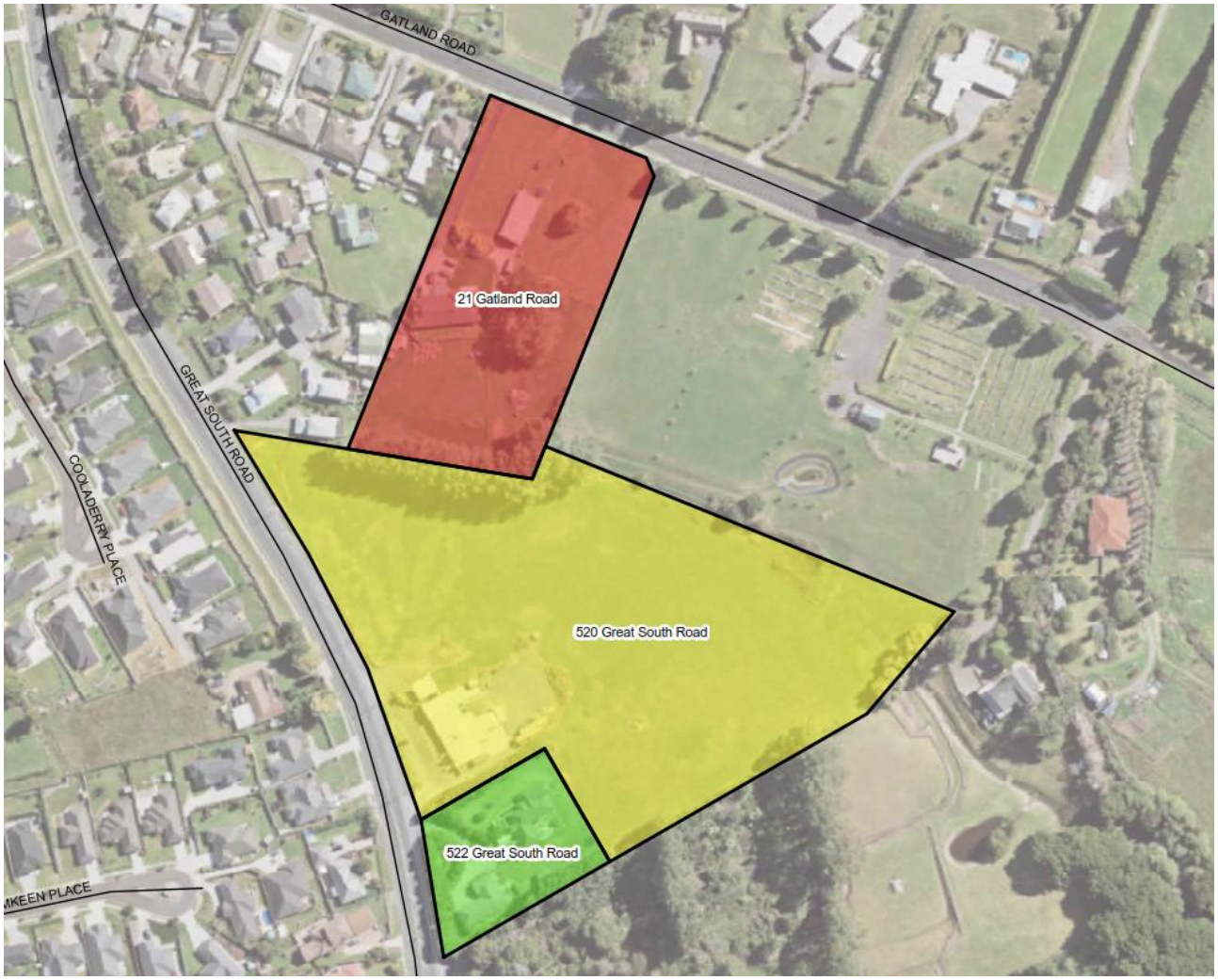

Figure 2.2: Properties which comprise the PCA

2.3 Topography and catchment

The PCA is located within the lower Slippery Creek catchment (refer to

Figure 2.3) which is part of the greater Drury-Opāheke catchment. The Draft Drury-Opāheke Future Urban Zone Stormwater Management Plan[4] (FUZ SMP) notes that the topography across the majority of the Drury-Opāheke catchment is characterised by low elevation gently undulating land. The Slippery Creek catchment is approximately 46.3 km^2 and predominantly rural with 50% in pasture and 25% in indigenous forest. The PCA comprises approximately 0.1% of the greater Slippery Creek catchment.

[4] Mott McDonald, 12 April 2019, *Drury-Opāheke Structure Plan Future Urban Zone – Draft Stormwater Management Plan.* Prepared for Auckland Council in support of the Drury-Opāheke Structure Plan.

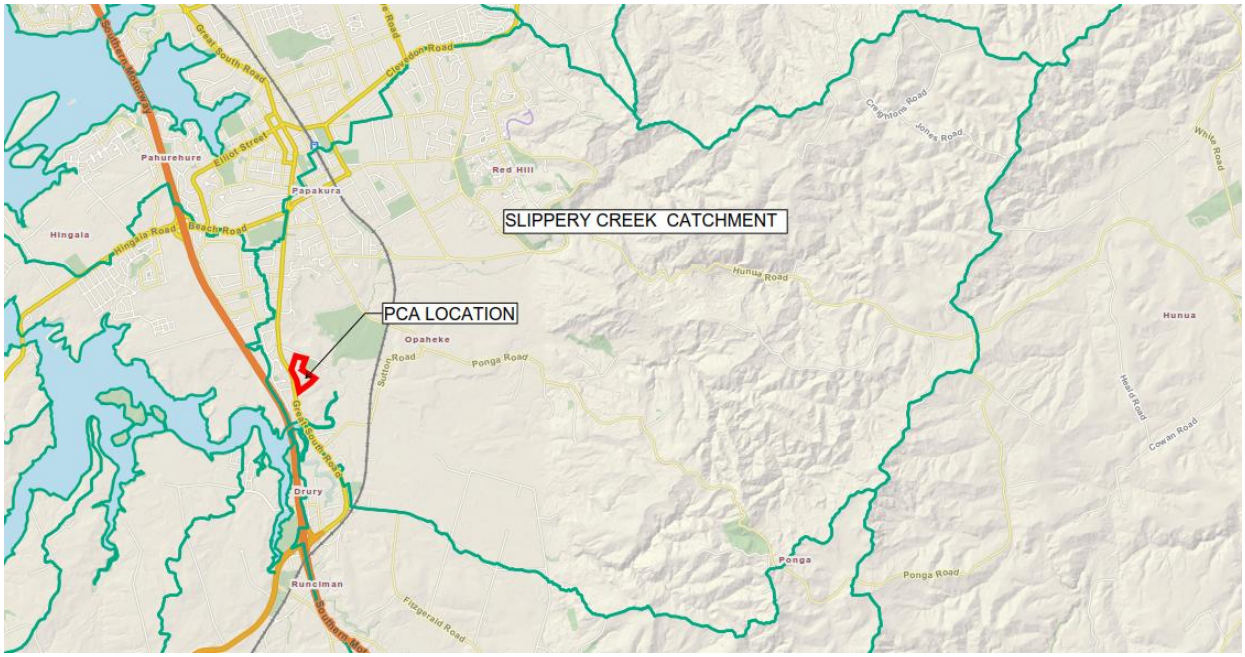

Figure 2.3: Location of PCA within the Slippery Creek catchment

Elevations within the PCA range from approximately 10 m RL to 20 m RL, as shown on Figure 2.4. There is elevated terrain in the southern corner of 520 Great South Road, effectively the boundary between two PCA sub-catchments:

- The majority of the PCA slopes towards an open channel (Watercourse A) which runs generally along the boundary between the PCA and Papakura South Cemetery.
- Part of the southern corner of 520 Great South Road and all of 522 Great South Road slope south.

Figure 2.4: PCA topography (Auckland Council Geomaps, 2020)

The PCA northern sub-catchment is part of a wider contributing catchment to Watercourse A. The PCA southern sub-catchment is at the top of the catchment and receives no runoff from outside the PCA boundary. These two sub-catchments are shown in Figure 2.5 and summarised below:

- Sub-catchment A includes all of 21 Gatland Road and the majority of 520 Great South Road, in addition to the upstream developed residential area to the west and Papakura South Cemetery to the north.
- Sub-catchment B includes all of 522 Great South Road and the southern corner of 520 Great South Road.

Figure 2.5: PCA sub-catchments

2.4 Geotechnical

The GNS Auckland geological map classifies the underlying geology of the PCA as part of the Puketoka formation. Puketoka Formation comprises alluvial and estuarine deposits of sand, silt, clay and occasionally peak and organic topsoils.

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.

2.5 Existing public stormwater infrastructure

Auckland Council GeoMaps indicates public stormwater infrastructure along the western side of Great South Road and the southern side of Gatland Road, as shown in Figure 2.6. There is no public stormwater infrastructure mapped within the PCA, however, the Gatland Road branch is piped along the paper road along the western boundary of the Papakura South Cemetery and discharges into Watercourse A. There is also a public connection between the pond at the Papakura South Cemetery and a private pipe in 520 Great South Road.

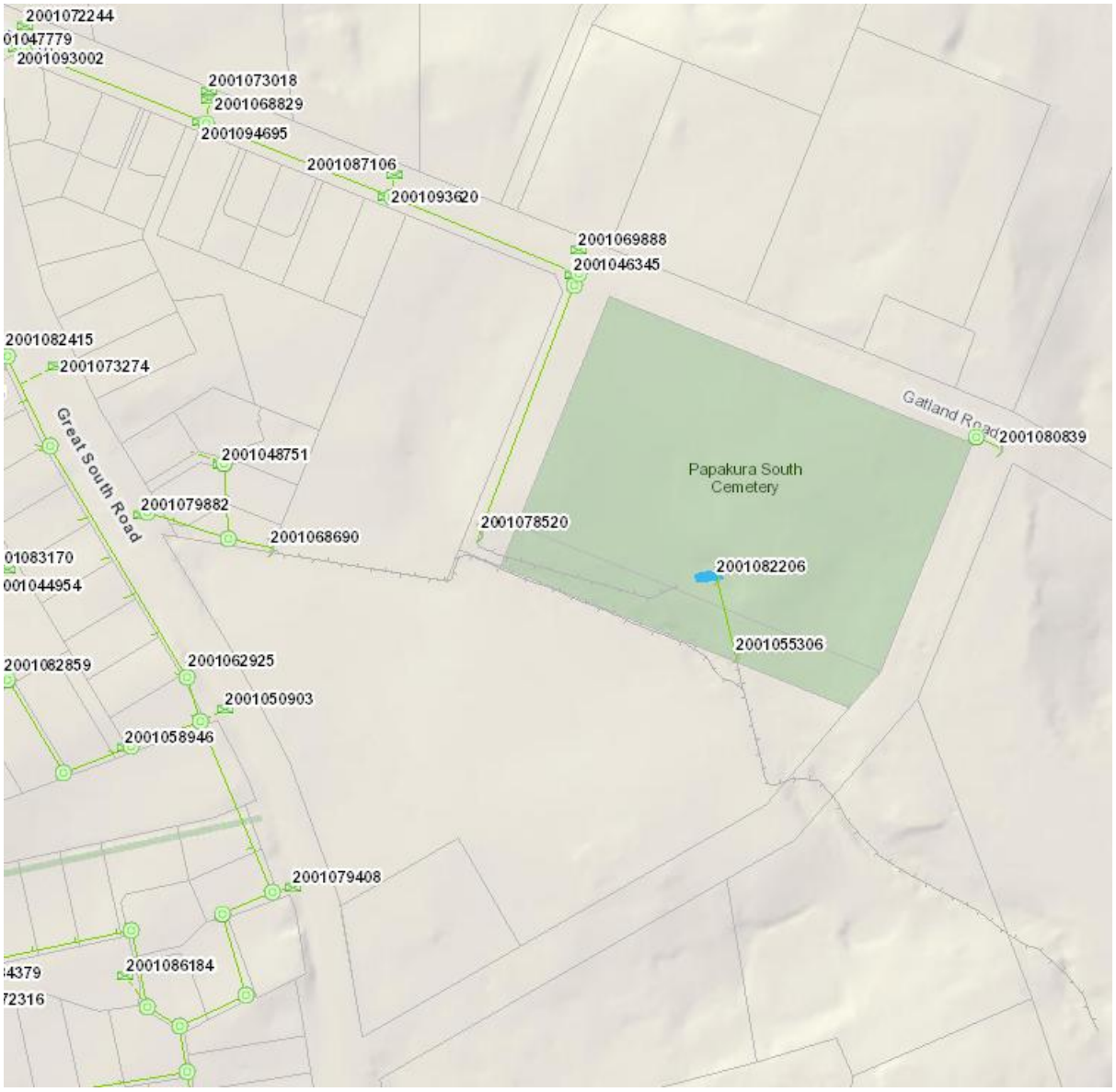

Figure 2.6: PCA existing public stormwater infrastructure (Auckland Council Geomaps, 2020)

2.6 Existing private stormwater drainage and hydrological features

Existing drainage in the PCA includes two open drains:

- Watercourse A
- An open drain which flows from north to south within 21 Gatland Road and discharges into Watercourse A at its origin.

Watercourse A discharges to a small pond in 520 Great South Road. Outflows from the pond are conveyed by a private stormwater pipe to discharge at the south-eastern boundary. These features are shown on Figure 2.7.

Downstream of the PCA, Auckland Council GeoMaps maps a stormwater channel (identified as a private swale) through the property at 91 Gatland Road and partially through the property at 95 Gatland Road. No stormwater asset or channel is mapped from the end of the swale to Slippery Creek. It has been suggested by others that this section may be piped, however, Geomaps does not

indicate any private or public stormwater asset. The downstream conveyance route should be investigated at the future resource consent process to confirm the flow path configuration.

Figure 2.7: PCA existing private stormwater drainage (Freshwater Solutions, 2020)

The key findings of the Freshwater Solutions Assessment of Ecological Effects[5] in support of the application for Resource Consent at 520 Great South Road, as they relate to the on-site stormwater drainage and hydrological features, are summarised below:

- The open drain within 21 Gatland Road is "*an ephemeral reach in pasture*."
- Watercourse A is classified as an intermittent tributary of Slippery Creek as discussed below:
  - "*Historical aerial imagery shows that Watercourse A was likely to have formerly been an ephemeral flow path which transitioned into a short section of intermittent stream near to (the eastern corner of 520 Great South Road). Modification during the 1980's has redirected runoff from the road into the upper reaches, resulting in the intermittent stream seen today.*"
- Watercourse A "*comprises a uniform straight channel with slow flowing run habitat*." It has been "*influenced and modified by a long history of rural land use practices including grazing, piping stormwater inputs, clearance of riparian vegetation and channelisation, which has resulted in a stream containing very limited natural character*." It has a low overall SEV score (0.284) which is indicative of very low ecological values and function.
- "*The artificial pond along the watercourse is an entirely unnatural feature that provides poor quality habitat for fish and invertebrates … and is choked with green algae growth. The pond was likely to be negatively influencing water quality downstream through elevated summer temperatures and low dissolved oxygen*."

[5] Freshwater Solutions, April 2020, *520 Great South Road Assessment of Ecological Effects.* Submitted to Barker and Associates Ltd.

2.7 Flooding and flow paths

Flooding is a major issue for the wider Drury-Opāheke and Slippery Creek catchments. Large runoff volumes, flat terrain, and road and rail crossings within the Slippery Creek catchment, in particular, result in an extensive flooded area. According to the Drury Stormwater Management Plan[6], this includes 2.9 km^2 of the 7.35 km^2 of the Slippery Creek catchment that is within the Drury-Opāheke Structure Plan area.

The flood plain and overland flow paths mapped by Auckland Council within and in the vicinity of the PCA are shown in Figure 2.8.

Figure 2.8: Overland flow paths, flood plains and flood prone areas

An overland flow path is mapped generally along Watercourse A, noting that it is not precisely aligned with the surveyed channel. It is fed by contributions from the open drain on 21 Gatland Road, and overland flow paths from the upstream developed residential area to the west, the Papakura South Cemetery to the north and from within 520 Great South Road. In larger storm events, the pond at 520 Great South Road will be over-topped. An overland flow path that discharges to Slippery Creek is mapped through the properties at 91 and 95 Gatland Road.

As noted above, downstream of the PCA Auckland Council Geomaps indicates a stormwater channel (identified as a swale) through the property at 91 Gatland Road and partially into the property at 95 Gatland Road. This generally aligns with the mapped overland flow path. At the end of this swale no stormwater asset is indicated, however, the overland flow path extends to Slippery Creek.

There is also an overland flow path mapped along the southern boundary of 522 Great South Road.

Auckland Council has mapped the 100 year average recurrence internal (ARI) flood plain, including for climate change and MPD in the catchment. The flood plain currently extends generally along Watercourse A and partially onto the 21 Gatland Road property. No flood prone or flood sensitive areas are mapped within the PCA, though a flood prone area is indicated at 91 Gatland Road.

[6] AECOM, 2017, *Drury Stormwater Management Plan for Auckland Council.* Prepared for Auckland Council in support of the Drury-Opāheke Structure Plan.

2.8 Receiving environment

As noted above, the northern sub-catchment flows via Watercourse A, a privately-owned pipe, landscaped swale and overland flow paths to discharge into the Slippery Creek just upstream of its confluence with Waihoihoi Stream.

Slippery Creek is considered to be the greatest contributor of sediment and the second greatest contributor of heavy metals to the Pāhurehure Inlet due to the existing rural land use in the catchment.[7] It is likely that this will continue if treatment measures are not incorporated in new stormwater systems, especially as contaminant levels typically increase with development. E.coli levels are also elevated and attributed to the grazing of stock within the catchment, though are expected to decrease as the land available for grazing is reduced with future urban development.

The Slippery Creek Watercourse assessment[8] found the condition of the Slippery Creek stream banks in the general vicinity of the PCA overland flow discharge point to have less than 20% erosion scars and fair bank stability. The riparian overhead cover was assessed to be between 30% and 70%. The PCA overland flow discharge point is located within Management Zone 1 – Future Urban, Erosion Risk. Suggested goals and objectives for this zone in the Slippery Creek Watercourse assessment include to:

- *Futureproof channels through erosion susceptibility mitigation works*
- *Investigate lower reaches of the main channel of Slippery Creek for potential inanga spawning habitat and potential for enhancement*
- *Upgrade and install all required inlets and outlets to appropriate inlet outlet standards including:*
  - *Auckland Council Technical Report 2013/18 - Hydraulic Energy Management Inlet Outlet Design for Treatment devices (TR18)*
  - *Auckland Council Guidance Document 2015/004 - Water Sensitive Design for Stormwater (GD04)*
  - *Auckland Council Stormwater Code of Practice for Land Development and Subdivision 2015 (SWCoP)*
- *Retain existing stream meander patterns and avoid any further channel straightening.*
- *Engage landowners to fence watercourses where moderate to severe stock damage has occurred to reduce further damage and ongoing sediment and faecal pollution downstream.*

Further downstream, Slippery Creek eventually flows into Drury Creek, which is the receiving watercourse of all streams within the Drury-Opāheke FUZ. Stormwater runoff from the sub-catchment B flows overland towards and along State Highway 1 and also discharges into Hingaia Stream at the confluence with Slippery Creek.

The upper tidal reaches of Drury Creek are classified as a Significant Ecological Area (SEA) – Marine 1 (M1) in the AUP due to the presence of a variety of marshes.[9] The M1 subtype covers highly significant areas that, due to their physical form, are considered to be the most vulnerable to any adverse effects of inappropriate subdivision, use and development.[10] This same area is a migration path between the marine and freshwater habitats for various native freshwater fish species.

The lower reaches of Drury Creek are classified as SEA – Marine 2 (M2) in the AUP, and comprise various intertidal habitats, ranging from sandy mud intertidal flats, currently exposed rocky reef

[7] Green M, 2008, *South-eastern Manukau Harbour / Pāhurehure Inlet Contaminant study. Predictions of Sediment, Zinc and Copper Accumulation under Future Development Scenario 1*. Prepared by NIWA for Auckland Regional Council.
[8] Morphum Environmental Ltd, 2015, *Watercourse Assessment Report: Slippery Creek*
[9] Auckland Council, 30 August 2017, *Ecology Assessment – Drury Structure Plan*
[10] Auckland Unitary Plan Operative in Part, 15 November 2016, Chapter L Schedule 4

habitats, and a variety of saline vegetation.[9] The M2 subtype covers similarly significant areas which do not warrant an SEA-M1 identification as they are generally considered to be more robust.[10]

There are no significant ecological areas identified within the PCA.

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

The PCA is not located above any high-use aquifers.

2.9 Coastal inundation

Based on the AUP management layers on Auckland Council GeoMaps, Coastal inundation is not identified as a risk to the PCA.

2.10 Biodiversity

Freshwater Solutions prepared an Assessment of Ecological Effects[5] in support of the concurrent Resource Consent application for residential development of 520 Great South Road . Reference can be made to this report for further details on biodiversity within the PCA, however, the key findings of the report related to the on-site hydrological features are:

- The onsite open drains comprise poor habitat and no freshwater fish were identified during the ecological assessment. It is possible that shortfin eels may use these channels and the small online pond as habitat, though the downstream piped network is likely to limit fish passage.
- It has a very low SEV score (0.17) for biodiversity.

2.11 Cultural and heritage sites

Based on the information provided on the AUP management layers in Auckland Council Geomaps, there are no known natural heritage, historic heritage or places of significance to Mana Whenua within the PCA.

2.12 Contaminated land

Resource Consent is required under the provisions of the National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health (NESCS), as described in the report by Williamson Water & Land Advisory Ltd and as summarised below:

- Regulation 9 – Controlled activity consent for the disturbance of soil containing contamination below the standards for residential and high-density residential use whereby the permitted standards for soil disturbance cannot be met because the volume of disturbance will be more than 25 m^3 per 500 m^2, and the duration of the activity is likely to be longer than two months.

3 Development summary and planning context

The relevant planning and regulatory requirements for future stormwater management within the PCA have been informed by the initial site appraisal (summarised in Section 2 of this report) along with the requirements of the AUP and are discussed in detail in the following sub-sections.

3.1 Regulatory and design requirements

A review of Auckland Council's regulatory and stormwater-specific guidelines has determined the stormwater management requirements. The relevant regulatory guidelines are listed in Table 3.1 and a summary on each of the listed requirements is presented in the sections that follow.

Table 3.1: Regulatory requirements and design guidelines relevant to the SMP

Requirement	Relevant regulatory / design to follow
Significant ecological areas	· AUP Chapter D9
Water quality and integrated management	· AUP Chapter E1
Stormwater management devices design	· GD01
Application of principles of water sensitive design	· GD04
Discharge and diversion	· AUP Chapter E8
High contaminant generating areas	· AUP Chapter E9
Hydrological mitigation	· AUP Chapter E10
Natural hazards and flooding	· AUP Chapter E36
Auckland Council regionwide network discharge consent	· NDC Schedule 4
Structure Plan	· Drury- Opāheke Structure Plan (Auckland Council, 2019)
Catchment management plan	· Drury-Opāheke FUZ SMP (Mott MacDonald, DRAFT 2019)

3.1.1 Significant ecological areas

Chapter D6 of the AUP sets out policies regarding the management of stormwater runoff to receiving environments within a SEA overlay. The relevant stormwater policy is summarised below:

3.1.1.1 Policy 2 (D9.3.2)

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

3.1.2 Water quality and integrated management requirements

Chapter E1 of the AUP contains the following relevant stormwater management policies:

3.1.2.1 Policy 2a and 2b (E1.3.2a and E1.3.2b)

Manage discharges, subdivision, use and development that affect freshwater systems to:

- *Maintain or enhance water quality, flows, stream channels and their margins and other freshwater values where the current condition is above the relevant thresholds (refer Table E1.3.1 of the AUP).*

  OR

- *Enhance water quality, flows, stream channels and their margins and other freshwater values where the current condition is below the relevant thresholds (refer Table E1.3.1 of the AUP).*

3.1.2.2 Policy 3 (E1.3.3)

Require freshwater systems to be enhanced unless existing intensive land use and development has irreversibly modified them such that it practicably precludes enhancement.

3.1.2.3 Policy 4 (E1.3.4)

Discharges must *avoid contamination that will have an adverse effect on the life supporting capacity of freshwater.*

3.1.2.4 Policy 5 (E1.3.5)

Discharges must *avoid contamination that will have an adverse effect on health of people and communities.*

3.1.2.5 Policy 8 (E1.3.8)

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

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

3.1.2.6 Policy 10 (E1.3.10)

An integrated stormwater management approach must have regard to all of the following:

- The nature and scale of the development and practical and cost considerations
- The location and design of site and infrastructure to protect significant site features and minimise effects on receiving environments
- The nature and sensitivity of receiving environments
- Reducing stormwater flows and contaminants at source
- The use and enhancement of natural hydrological features and green infrastructure where practicable.

3.1.2.7 Policy 11 (E1.3.11)

Avoid, minimise or mitigate adverse effects of stormwater diversions and discharges.

3.1.2.8 Policy 12 (E1.3.12)

Manage contaminants in stormwater runoff from high contaminant generating car parks (> 50 cars*) and high use roads* (>5000 vehicles per day) *to minimise new adverse effects and progressively reduce existing adverse effects on water and sediment quality in freshwater systems and coastal waters.*

3.1.2.9 Policy 13 (E1.3.13)

Require Stormwater quality or flow management to be achieved on-site unless there is a downstream communal device.

3.1.2.10 Policy 14 (E1.3.14)

Adopt the best practicable option to minimise the adverse effects of stormwater discharges.

3.1.2.11 Policy 15 (E1.3.15)

Utilise stormwater discharge to ground soakage where it is possible to do so in a safe and effective manner.

3.1.3 Water sensitive design

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

"An approach to freshwater management, it is applied to land use planning and development at complementary scales including region, catchment, development and site. Water sensitive design seeks to protect and enhance natural freshwater systems, sustainably manage water resources, and mimic natural processes to achieve enhanced outcomes for ecosystems and our communities."[11]

Water-sensitive design principles are further detailed in GD04. The key principles for water sensitive design are summarised 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.

3.1.4 Discharge and diversion

Chapter E8 of the AUP sets out policies which regulate the diversion and discharge of stormwater runoff from impervious areas into or onto land, or into water, or into the coastal marine area. The objectives are consistent with Chapter E1 and E2 of the AUP. The general standards (E8.6.1) are summarised below:

- The design of the proposed stormwater management device(s) must have consistent with any relevant precinct plan that addresses or addressed stormwater matters.

[11] Auckland Council, December 2017, Guidance Document 2017/001 (GD01) – Stormwater Management Devices in the Auckland Region

- The diversion and discharge must not cause or increase scouring or erosion at the point if discharge or downstream.
- The diversion and discharge must not result in or increase the following:
  - Flooding of other properties in rainfall events up to the 10 Year ARI; or
  - Inundation of buildings on other properties in events up to the 100 Year ARI.
- The diversion and discharge must not cause or increase nuisance or damage to other properties
- The diversion and discharge of stormwater runoff must not give rise to the following in any surface water:
  - The production of conspicuous oil or grease films, scums or foams, or floatable or suspended materials
  - Any conspicuous change in colour or visual clarity
  - Any emissions of objectionable odour
  - The rendering of fresh water unsuitable for consumption by farm animals; or
  - Any significant adverse effects on aquatic life
- Any existing requirements for ground soakage, including devices to manage discharges and soakage, must be complied with.

For diversion and discharge of stormwater runoff from lawfully established impervious areas as at 30 September 2013 not directed to a stormwater network or combined sewer network (E8.6.2.2) the following policies also apply:

- As a result of a new land activity, a change in land use or the removal of existing stormwater management measures, stormwater flows and volumes and the concentration and load of contaminants in stormwater flows from the existing impervious areas must not be increased above those that would result from lawfully established impervious areas existing as of 30 September 2013
- Any existing stormwater management devices must not be reduced, and the location of discharge must not change.

3.1.5 High contaminant generating areas

Chapter E9 of the AUP outlines the regional land use rules for managing stormwater runoff quality from high contaminant generating areas (HCGAs). Treatment of runoff is required for HCGAs (as defined in the AUP) including:

- High use roads (with greater than 5,000 vehicle movements per day)
- Car park areas with greater than 50 vehicles per day
- High contaminant yielding building and roofing materials
- Industrial/Trade sites listed as high risk in Schedule 3 will require assessment under the ITA rules which may result in treatment being provided
- Treatment of discharges to the CMA will be required due to the receiving environment being identified as a SEA.

Stormwater runoff from the HCGAs is to be treated by stormwater management device(s) which is sized and design in accordance with Guidance Document 2017/001 - Stormwater Management Devices in the Auckland Region (GD01) or where alternative devices are proposed, the device must demonstrate it is designed to achieve an equivalent level of contaminant or sediment removal performance to that in GD01.

3.1.6 Hydrological mitigation

Hydrological mitigation seeks to minimise the change in hydrology, namely runoff volumes and flow rate, as a result of development. Chapter E10 of the AUP sets out a hydrological mitigation framework for brownfield sites which discharge to sensitive or high-value stream environments that have been identified as particularly susceptible to the effects of development. This framework must be applied to developments within the AUP management Stormwater Management Area Control – Flow 1 and Flow 2 (SMAF) overlay.

The PCA is a greenfield development and therefore does not fall within the AUP SMAF overlay. The general approach of this SMP is to provide a minimum of the SMAF 1 framework to provide hydrological mitigation for all impervious surfaces within the PCA. The SMAF 1 hydrological mitigation requirements in the AUP are:

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

The retention volume may be taken up by detention if:

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

3.1.7 Natural Hazards and flooding

Chapter E36 of the AUP sets out the policies relating to the management of natural hazards and flooding. Flooding is a major natural hazard that could impact the PCA based on the assessment in Section 2 of this report. The relevant policies are summarised briefly below.

3.1.7.1 Policy 1 (E36.3.1)

Identify land subject to natural hazards, taking into account the likely effects of climate change.

3.1.7.2 Policy 17 (E36.3.17)

Avoid locating buildings in the 100 year ARI flood plain unless it can be designed to be resilient to flood related damage.

3.1.7.3 Policy 20 (E36.3.20)

Earthworks within the 100 year ARI flood plain should not permanently reduce floodplain conveyance or exacerbate flooding experienced by other sites upstream or downstream.

3.1.7.4 Policy 21 (E36.3.21)

Ensure all development in the 100 year flood plain does not increase adverse effects or increased flood depths or velocities to other properties upstream or downstream of the site.

3.1.7.5 Policy 29 and 30 (E36.3.29 and E36.3.30)

Maintain the function and capacity of overland flow paths to convey stormwater runoff safely and without damage to the receiving environment.

3.1.8 Network Discharge Consent

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

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

- Treatment of 100% of impervious areas by a water quality device designed in accordance with GD01/TP10 for the relevant contaminants
- Achieve equivalent hydrology (infiltration, runoff volume, peak flow) to pre-development (grassed state) levels. A method of achieving equivalent hydrology to pre-development (grassed state) is to provide retention (volume reduction) and detention (temporary storage) for all impervious areas equivalent to SMAF 1
- Ensure that there is sufficient capacity within the pipe network downstream of the connection point to cater for the stormwater associated with the development in the 10 year ARI event, including incorporating flows from contributing catchment at MPD
- Buildings must not be flooded in the 100 year ARI event.

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

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

3.1.9 Structure Plan

The Drury-Opāheke Structure Plan[12] sets out key stormwater opportunities and constraints relating to development of the structure plan area, including:

- Flooding
  - There is existing flooding of parts of the structure plan area, and it is particularly extensive in the Slippery Creek catchment.
  - The flood plain extent is primarily determined by the large catchment upstream of the FUZ area rather than the effect of additional impervious area created by anticipated urban development
  - The best way to manage flooding in the future urban areas is to pass flows forward or get the water to the Manukau Harbour as quickly as possible
  - There is opportunity to provide flood mitigation to reduce hazards and unlock development.

[12] Auckland Council, 2019, Drury-Opāheke Structure Plan

- Water sensitive design
  - A decrease in water quality, aquifer recharge and instream ecological values has been identified as a result of changes in land-use and land development
  - Increased erosion (and associated sedimentation) due to increased impervious areas is of particular concern due to the highly sensitive, low energy receiving environment of the Pāhurehure Inlet
  - There is opportunity to:
    - restore and enhance existing watercourses
    - retain existing and increasing where appropriate the vegetation buffering to natural watercourses to improve water quality and increase numbers and diversity of instream biota
    - improve the water quality of stormwater reaching the Pāhurehure Inlet through reduced contaminant loads (sediment, metals and nutrients)
    - improve ecological functionality in currently degraded areas, along with the ability to set aside areas for public amenity value and stormwater attenuation.

These stormwater opportunities and constraints are discussed further in the FUZ SMP[4].

3.1.10 Future Urban Zone Stormwater Management Plan

The underlying principles of stormwater management for the Drury-Opāheke catchment are summarised in the FUZ SMP, prepared by Mott MacDonald in 2019 to support the Auckland Council Structure Plan for the area.[13] The FUZ SMP recognises the key constraints and opportunities in the catchments and reflects the requirements of the AUP and region-wide NDC. The FUZ SMP seeks to achieve the following outcomes:

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

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

- General
  - Development to be carried out using an integrated stormwater management approach (in accordance with E1.3.8 and E1.3.10 of the AUP).
- Water quality
  - Treatment of all impervious areas (excluding non-contaminant generating areas) to be provided at or near source using devices such as swales, rain gardens and tree pits

[13] Drury-Opaheke Structure Plan Future Urban Zone – Stormwater Management Plan' prepared by Mott McDonald for Auckland Council. Version 04C Dated 12 April 2019.

- Use inert building materials
- Exemplary sediment and erosion control measures are to be provided during earthworks and construction
- Integrated green outfalls to be used when discharging to streams.

· Flooding
- Due to the significant flood plain within Slippery Creek, development should be limited to land outside the flood plain. The flooding issues within this catchment require development of a comprehensive solution to avoid effects of cumulative development
- All buildings to be outside the 100 year ARI flood plain in accordance with E36.3.17 of the AUP. Avoid locating infrastructure in the 100 year ARI flood plain unless it can be designed to be resilient to flood damage
- Avoid increasing flood risk and flood extent upstream and downstream for all flood events up to the 100 year ARI
- Identify overland flow paths and ensure that they remain unobstructed and able to safely convey runoff
- Use capacity available in riparian margins as part of the water conveyance system and enhance intermittent streams to provide capacity and conveyance as a means to manage flood waters.

· Hydrological mitigation
- Changes in hydrology are avoided as far as practicable and any changes in hydrology are minimised or mitigated (in accordance with E1.3.8 of the AUP)
- The minimum requirement when hydrological mitigation is necessary is SMAF 1 in accordance with Table E10.6.3.1.1 of the AUP. An erosion assessment is to be carried out by Auckland Council14 to determine if additional measures (such as additional detention requirements) are required to mitigate the hydrological impacts of development.

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

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

4 Mana whenua matters

Notwithstanding that the PCA is not identified as a site or place of significance to mana whenua on the planning maps, the applicant has consulted with Iwi to obtain their views on the Plan Change and the Resource Consent application for 520 Great South Road.

While we understand that Iwi are supportive of the proposed rezoning, further consultation is required with Iwi on the Resource Consent application.

Consultation has been carried out with mana whenua on the Auckland Council's Iwi groups list that have a registered interest in the area. Refer to the Barker and Associates Section 32 Plan Change report for details on Iwi consultation. We understand that consultation and engagement with mana whenua is on-going.

5 Stakeholder engagement and consultation

Table 5.1 below identifies the parties deemed to be potentially affected by or interested in the outcomes of the SMP. As the application for adoption of this SMP under the NDC progresses, it is expected that this list will be populated with more stakeholder consultations.

Table 5.1: Stakeholder engagement and consultation register

Stakeholders	What is the reason for interest?	What engagement has been completed?	Feedback and response
520 GSR Limited	Client Applicant	Project commencement meetings and ongoing planning discussions	
Owner of 522 Great South Road	Neighbour included within PCA		Currently in support of the Plan Change.
Owner of 21 Gatland Road	Neighbour included within PCA		Currently in support of the Plan Change.
Auckland Council – Healthy Waters	The SMP will be adopted within Auckland Council's NDC. The public reticulated stormwater network and any communal bioretention devices or similar are intended to be vested to Auckland Council upon completion of construction.	Healthy Waters have has reviewed a high-level assessment of stormwater management and flooding issues prepared by T+T in June 2019 for the development of 520 Great South Road.	Feedback provided in Clause 23 RMA Further Information – 520 Great South Road Private Plan Change Request dated 6 April 2020 and latterly in a meeting with representatives of the Applicant, Healthy Waters, T+T and Barker and Associates representatives on 3 April 2020. Refer to Appendix A3 for queries raised by Auckland Council in the Plan Change process and how each of these Items (HW1 – HW15) have been addressed in this SMP.
Papakura South Cemetery	Private drainage currently connects to private drainage on 520 Great South Road.	None	N/A
91 and 95 Gatland Road	Downstream receiving environment	None	N/A

Refer to the Barker and Associates Section 32 Plan Change report for further details on Stakeholder engagement and consultation.

6 Proposed development

This section of the report summarises the current understanding for future development in the PCA, particularly as they relate to stormwater management.

6.1 General development information

The current development status of each property within the PCA is as follows:

- 520 Great South Road: Resource Consent sought for a 102 residential lot development, being a mixture of Terrace, duplex, zero lot and apartments (refer to Section 6.2)
- There are currently no development plans for 522 Great South Road, though the owner is in support of the Plan Change application
- 21 Gatland Road: Resource Consent sought for 20 residential lots and is support of the Plan Change application.

It is expected that following the Plan Change, the re-zoned property at 522 Great South Road will also ultimately be developed as residential lots.

6.2 Proposed Land Use

The draft Master plan for 520 Great South Road, prepared by Avery Associated Team Architects, is shown in Figure 6.1. As part of the Master Plan for 520 Great South Road, the existing commercial building will be removed. The proposed development comprises a network of public collector roads and local streets to provide access from Great South Road to the 102 residential lots. It allows for future connection to the developments on 522 Great South Road and 21 Gatland Road.

The subdivision plan for 21 Gatland Road, prepared by Hall Surveying Limited, is shown in Figure 6.2. The development at 21 Gatland Road will create 20 residential lots accessed from two new public roads.[15]

The property at 522 Great South Road does not have plans or proposed layouts at this stage. Based on the Master Plan for 520 Great South Road and discussions regarding the other two developments, we do not anticipate any HCGAs in the PCA.

[15] Enable, March 2019, Engineering Infrastructure Report: 21 Gatland Road, Drury prepared for Wainono Investments Limited

Figure 6.1: 520 Great South Road Master Plan (DRAFT, dated 3 April 2020)

Figure 6.2: Subdivision Plan for 21 Gatland Road (dated November 2018

6.3 Proposed stormwater drainage and hydrological features

Watercourse A will remain the primary conveyance route for runoff from sub-catchment A of the PCA. Lots 10, 12, 14 16 and 18 at 21 Gatland Road will discharge into the existing Gatland Road public stormwater system before discharging into Watercourse A. Lots 7, 8 and 9 will discharge directly into the open drain on 21 Gatland Road. The lots on the western side of the 21 Gatland Road will discharge via the existing buried outlet directly to Watercourse A.[13]

A new public stormwater network (to service the development all of 520 Great South Road and the remainder of 21 Gatland Road, and intended to be vested to Auckland Council) and the private stormwater pipes that currently convey flows from the Papakura South Cemetery pond will discharge into an extension to Watercourse A (discussed below). Overland runoff generated within the PCA will be conveyed along road reserves to flow into Watercourse A.

To enable development of the proposed roads and building platforms, sections of stream will be lost (21 m within the site and 27 m within 21 Gatland Road) at the upstream end. The open drain within 21 Gatland Road will be piped under the proposed public collector road on 520 Great South Road to discharge into Watercourse A. The remaining length of Watercourse A within the PCA will not be affected by works for the development, and furthermore will be extended approximately 55 m and restored with riparian planting.

The pond and private pipe within the PCA downstream of Watercourse A will be removed and rehabilitated into a natural stream channel, i.e. become an extension of Watercourse A. Figure 6.3 shows the proposed stormwater drainage plan included in the Assessment of Ecological Effects and reference should be made to the Infrastructure Report[16] for further details of the proposed drainage to service the development at 520 Great South Road.

As part of a future Resource Consent application, the current discharge point for primary flows (i.e. up to a 1 in 10 year ARI frequency) for the property at 522 Great Sound Road should be confirmed. Future primary flows from the development at 522 Great South Road could either:

- Discharge into the existing public stormwater network located under Great South Road; or
- Be collected by the new private stormwater network on 520 Great South Road.

If stormwater from 522 Great South Road currently discharges into the public stormwater network on Great South Road, a capacity assessment should be completed to assess if there is sufficient capacity in the existing public infrastructure to accept the development flows. In the second case, the new private stormwater network on 520 Great South Road should be designed to include primary flow contributions from the development at 522 Great South Road. Secondary flows (i.e. greater than 1 in 10 year ARI frequency and up to a 1 in 100 year ARI frequency) will continue to flow overland to Hingaia Stream at the confluence with Slippery Creek.

Figure 6.3: Proposed stormwater drainage (Freshwater Solutions, 2020)

6.4 Impervious Coverages

Development of the PCA will result in an increase in impervious area, which will generate more stormwater runoff (peak magnitude and volume). The percentage of impervious cover within the PCA will increase from approximately 13% to 67%. The change in coverage for the two sub-catchments is presented in Table 6.1

Table 6.1: Existing and proposed coverage within sub-catchments A and B

Sub-catchment		Existing area (m^3)		Proposed area (m^3)	
		Pervious	Impervious	Pervious	Impervious
Sub-catchment A	Within PCA	34,715	2,869	14,440	27,865
	Outside PCA	33,457	27,085	33,457	27,085
Sub-catchment B	Within PCA	5,633	3,088	1,360	2,640
	Outside PCA	-	-	-	-
Total area (m^3)		73,805	33,042	49,258	57,589

The existing coverage both within and outside of the PCA has been derived from aerial photography. Proposed coverage within 520 Great South Road was determined from the Master Plan. For the purposes of this report, the overall impervious percentage for the proposed development at 520 Great South Road was assumed for future coverage of 22 Gatland Rd and 522 Great South Road.

It is assumed all runoff within 520 Great South road will discharge to Watercourse A in the post-development case. This means an additional 4,721 m^2 of 520 Great South Road will be catered for in sub-catchment A. Sub-catchment B comprises the entirety of 522 Great South Road.

6.5 Earthworks

Maven Associates has prepared an initial infrastructure assessment report to support the application for Resource Consent for 520 Great South Road[16], which includes an assessment of earthworks required for the development. It states:

> *" Earthworks are proposed over the majority of the site* (with the exception of the section of Watercourse A which is proposed to be retained*) and include removal of existing trees, formation of building platforms, construction of retaining walls, and installation of drainage, and accessways.*
>
> *Earthworks will involve ground disturbance of 30,198 m^2. It is expected that the maximum cut and fill will be approximately 3.2 m and 3.8 m in height respectively. Temporary batter slopes not exceeding 1:3 will be created during construction. Retaining wall details will be finalised during building consent stage.*
>
> *The following is a summary of the proposed works:*
>
> - *Total area of ground disturbance = 30,191 m^2*
> - *Maximum cut and fill depth = 3.8 m Fill 3.2 m Cut*
> - *Total volume of cut to waste off site 12,000 m^3*
> - *Total volume of cut to fill = 12,400 m^3*
> - *Net Volume (import fill) = 9,400 m^3 "*

Enable has prepared an Engineering Infrastructure report for the Resource Consent application at 21 Gatland Road[15], which includes an assessment of earthworks required for the development. It states:

> *"The volume of bulk cut (1,858 m^3) will be used where bulk filling (6,325 m^3) is required. The remaining (4,467 m^3) material required to complete the bulk fill operation will be imported to site."*

522 Great South Road does not have a proposed layout at this point, and therefore has no earthworks plans.

[16] Maven Associates, 6 March 2020, *Infrastructure Report – Proposed development 520 Great South Road* (Job number: 135014)

7 Stormwater management

This section presents guidance on how stormwater will be managed in the future within the PCA. This guidance is consistent with regulatory and stormwater-specific guidelines and based on conventional stormwater management techniques to meet AUP provisions and to integrate with existing and future stormwater systems in the Slippery Creek catchment. It provides a framework for stormwater management which should be considered as part of an interdisciplinary planning process to enable implementation of an integrated stormwater management approach.

7.1 Principles of stormwater management

The stormwater management principles described below have been conceptualised to be in line with the site-specific constraints and opportunities identified and presented in Section 2, and the AUP policies on integrated stormwater management, the region-wide NDC, and the draft FUZ SMP as outlined in Section 3.

The stormwater management approach seeks to:

- Recognise the key constraints and opportunities on site and in the Slippery Creek catchment
- Devise an integrated stormwater management approach to facilitate urban development
- Develop a set of BPO for stormwater that can be incorporated into the development
- Emphasise a water-sensitive design approach that:
  - manages the impact of land use change from rural to urban
  - protect and enhance stream systems and natural hydrology
  - mitigates for hydrological changes and manages flooding effects
- Minimise the generation and discharge of contaminants/sediments into sensitive receiving environment of the Manukau Harbour
- Protect key infrastructure, people and the environment from significant flooding events

To achieve these outcomes, the proposed stormwater management approach identifies various requirements for management of stormwater within the PCA.

7.1.1 Updated principles

Not applicable within this SMP

7.2 Proposed stormwater management

This section of the SMP presents the detail of the proposed stormwater management approach. The approach generally meets the NDC requirements, and where it does not, this section demonstrates why the preferred option is the BPO for the development.

7.2.1 General

The proposed stormwater strategy to achieve water quality, hydrological mitigation and water sensitive design outcomes for the PCA is to use a treatment train approach. A treatment train toolbox of BPO (in order of preference) for corresponding land-use is presented in Figure 7.1. Flood attenuation is not required within the PCA (refer to Section 7.2.6).

The toolbox has been prepared to assist in selecting appropriate devices during design for the development of the PCA. All devices should be designed in accordance with the guidelines in GD01.

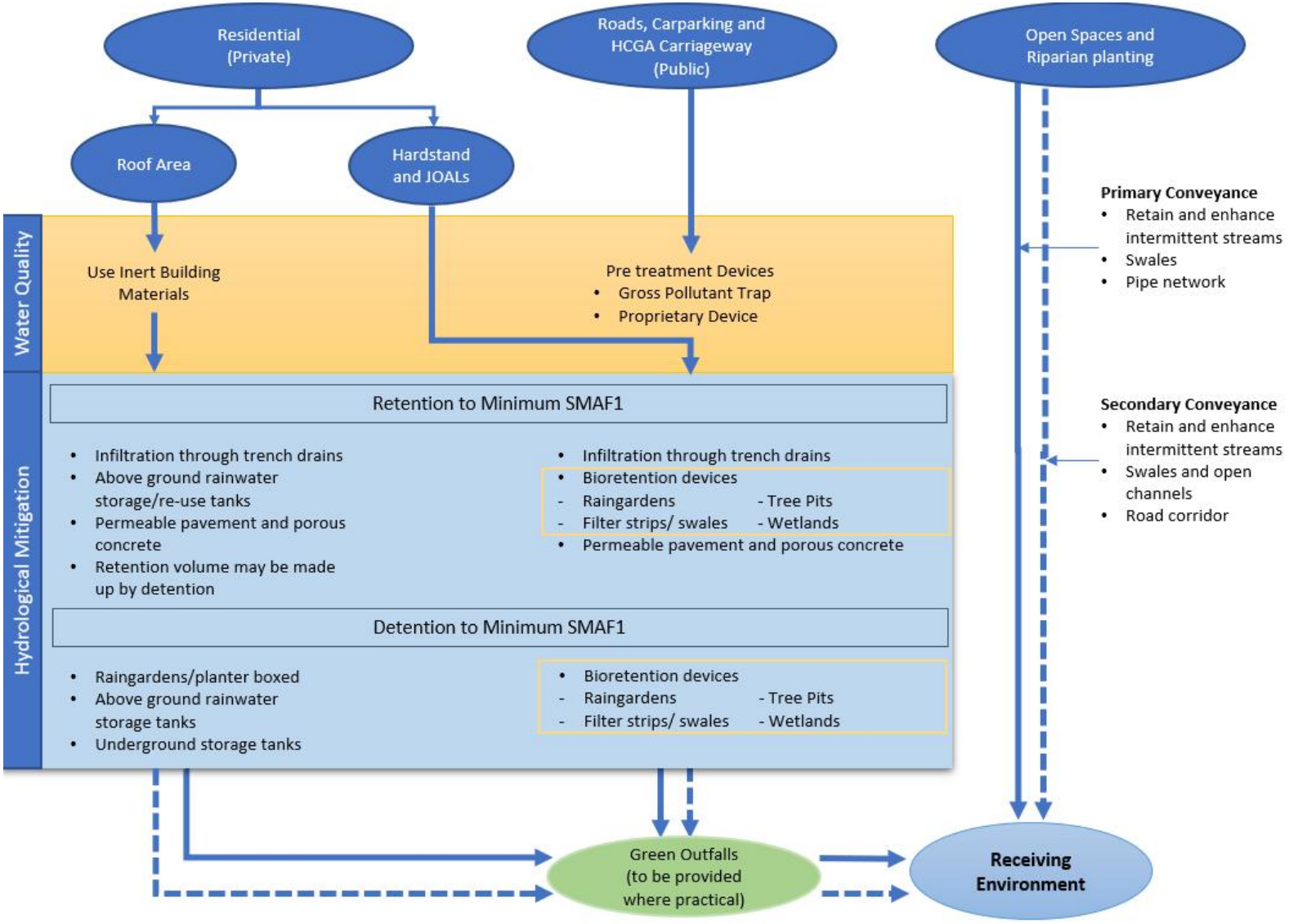

Figure 7.1: Stormwater Management Strategy

The proposed stormwater management approach and performance outcomes for this strategy are discussed further in the following sections.

7.2.2 Water sensitive design

The key water sensitive design principles and how they are incorporated in the stormwater management approach for the PCA are summarised in Table 7.1.

Table 7.1: Application of water sensitive design principles within the PCA

Water sensitive design principles	Application within PCA
Promote interdisciplinary planning and design	· The Stormwater Management and Flooding Assessment report for 520 Great South Road was prepared by Tonkin + Taylor in 28 June 2019 to enable early multi-disciplinary engagement and to ensure an integrated stormwater management approach. · The Assessment of Ecological Effects for 520 Great South Road was prepared by Freshwater Solutions in April 2020 (issued in draft in March 2020) and provided specialist Ecological input to development of the stormwater management approach. · The Infrastructure Report prepared by Maven Associates for the proposed development at 520 Great South Road (issued 6 March 2020) and the Engineering Infrastructure Report prepared by Enable for 21 Gatland Road (issued March 2019) provided insight to the design solutions being considered. · The Infrastructure Report prepared by Maven Associates for the proposed development at 520 Great South Road (issued 6 March 2020) and the Engineering Infrastructure Report prepared by Enable for 21 Gatland Road (issued March 2019) provided insight to the design solutions being considered.
Protect and enhance the values and functions of natural ecosystem	· Through the Resource Consent at 520 Great South Road, riparian margins are proposed that will provide protection and enhancement of intermittent streams (i.e. Watercourse A) · "Overall, with the proposed planting, pond removal and daylighting of the piped section of Watercourse A, there will be a positive increase in both freshwater and terrestrial values within the site post the proposed development from that seen currently."
Address stormwater effects as close to source as possible	· Generation of contaminants will be prevented through the use of inert building materials, and where contaminants are generated, green infrastructure will be used to treat runoff as close to the source as practicable.
Mimic natural systems and processes for stormwater management	· The use and enhancement of natural hydrological features (i.e. Watercourse A) and green infrastructure where practicable.

7.2.3 Water quantity

Development of the PCA will result in an increase in impervious area, which in turn will generate more stormwater runoff (peak magnitude and volume). This section considers the smaller but more frequent storm events. Larger storm events are discussed in Section 0. The hydrological mitigation measures identified here, to offset the effects of development, will have the most effect during smaller events but will mitigate (to some extent) runoff in all storm events.

Retention is the act of storing and using stormwater runoff onsite, reducing the volume of stormwater runoff discharging to the receiving environment. Detention is the temporary storage and slow release of stormwater runoff, which effectively reduces peak runoff discharging from the site.

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

- Retention of at least 5 mm of runoff depth from impervious surfaces where possible with limitations set out in Table E10.6.3.1.1 (refer Section 3.1.6)
- Detention and a drain-down period of 24 hours for the difference between the pre-development and post-development runoff volumes from a 95th percentile, 24-hour rainfall event minus the achieved retention volume, over the impervious area for which hydrology mitigation is required.

To meet the water quality objectives set out above, the following management options are suitable:

For retention:

- By infiltration, where feasible (subject to soil infiltration testing) and possible in a safe, and effective manner. This may be provided in soakage pits, trench drains, or through appropriately designed bio-retention devices. Pervious pavements or porous concrete can be included as part of the driveways / access to the dwellings within the PCA. It is recommended that soakage tests are carried out for the site if infiltration features are to be considered
- At source for residential and buildings, through the use of rainwater tanks for collection of roof runoff where there is re-use demand.

The hydrological mitigation outcome is not fully achieved unless both retention and detention can be provided. However, exceptions for providing retention can be made in cases where soil infiltration rates preclude disposal to ground and rainwater re-use is not possible, in which case the retention volume can be made up by detention. Providing more detention volume to offset retention requirements may be the BPO approach if onsite infiltration is not feasible and noting that there is only so much application for water re-use.

For detention:

- Raingardens, planter boxes, swales and tree pits are bio-retention devices which can be designed to provide also hydrological mitigation within private residential property or along road corridors and within public impervious spaces, while adding to the landscape value of the PCA
- Above-ground rainwater storage tanks or underground attenuation tanks can be used within residential lots to provide detention volumes, with the latter devices minimising land take.

The Infrastructure report for the Resource Consent for 520 Great South Road[16] specifies onsite rainwater storage tanks (on lots) and raingardens (on roads and right of ways) will provide at source retention and detention devices to mitigate flow effects resulting from increased imperviousness. The Engineering Infrastructure Report for the Resource Consent for 21 Gatland Road[15] also specifies raingardens for hydrological mitigation to meet SMAF1 requirements.

7.2.4 Water quality

The development of the PCA into a MUH zone could result in increased contamination of stormwater runoff due to the land-use changes and increased impervious area. The stormwater quality will, therefore, be adversely affected and may negatively impact the sensitive receiving environments if unmitigated.

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

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

These water quality objectives could be met through the following measures and stormwater management devices:

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

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

  If building materials that generate contaminants are used, site-specific water quality treatment will be required.
- Use of grated catchpits and inlets to the stormwater network for capturing of gross contaminants, solids, sediment, and gravels
- Use of pre-treatment devices, (i.e. gross pollutant traps) for runoff from communal waste storage areas in apartments or multi-unit developments prior to discharging to communal bio-retention devices
- Based on the Traffic Impact Assessment[17] for 520 Great South Road and discussions regarding the other two properties within the PCA, we do not anticipate any HCGAs in the PCA. However, the public roads and carparks should still be treated using vegetated bio-retention devices such as swales, rain gardens and tree pits. Vegetated devices provide the multiple benefits of green infrastructure along road corridors as well as water quality treatment close to the runoff source. Bio-retention devices can also be designed to provide hydrological mitigation alongside water quality treatment
- Riparian margins that provide protection and enhancement to Watercourse A and act as a secondary benefit to stormwater management through the disconnection of impervious areas

[17] TPC Ltd, May 2020, *Proposed Residential Development - 520 Great South Road Papakura Traffic Impact Assessment.* Submitted to Barker and Associates Ltd.

from the receiving environment. The Assessment of Ecological Effects[5] in support of the Resource Consent application for 520 Great South Road propose the following riparian planting, noting that this is proposed in the context of a particular development proposal:

- The section of Watercourse that will be maintained upstream of the existing onsite pond will include a 6 m wide riparian margin (average) on the true right stream bank only
- The new section of Watercourse (downstream of the existing onsite pond) will include a 10 m wide riparian margin.

The Infrastructure report prepared to support the Resource Consent application for 520 Great South Road[16] adopts the following water quality treatment approach:

- *"Consented dwellings to be roofed with inert roofing materials (e.g. Colorsteel roofs) which will not generate contaminants and therefore will not require quality treatment."*
- *"All future trafficable surfaces including roading networks, accessways, manoeuvring and carparking areas proposed as part of the development entail stormwater quality treatment via the utilisation of raingardens to achieve the best practical stormwater management outcome."*

7.2.5 Receiving streams

Unless carefully managed, urbanisation can significantly exacerbate stream bank erosion due to the increased runoff rates and volume. This section considers the sensitivity of both the immediate receiving environment (between Watercourse A and Slippery Creek) and the discharge point into Slippery Creek to the changes in runoff attributed to development of the PCA.

7.2.5.1 Immediate receiving environment

In its current condition, Watercourse A is described in the Assessment of Ecological Effects[5] as a highly modified intermittent tributary of the Slippery Creek Stream. It manifests very little natural character due to clearance of riparian vegetation, grazing, realignment and artificial straightening and channelisation, as shown in Figure 7.2.

Figure 7.2: Watercourse A (Freshwater Solutions, 2020

The Resource Consent application for 520 Great South Road seeks consent for a development layout that will require the reclamation of an intermittent section of Watercourse A to facilitate efficient urban development. There is opportunity, however, to ensure 'no-net loss' of stream ecological values and function through the restoration, protection and enhancement, and extension of the remaining section of Watercourse A. The following stream protection works and onsite measures are recommended as part of the Resource Consent application to enable the rehabilitation and enhancement of Watercourse A:

- Minimise the generation and discharge of contaminants into the receiving environment using measures outlined in Section 7.2.4
- Use of retention and detention devices upstream to meet the minimum hydrological mitigation requirements outlined in Section 7.2.3
- Riparian planting of riparian margins
- The Assessment of Ecological Effects[5], in support of the Resource Consent application, proposes the following riparian planting:
  - The section of Watercourse A that will be maintained upstream of the existing onsite pond will include a 6 m wide riparian margin (average) on the true right stream bank only
  - The new section of Watercourse A (downstream of the existing onsite pond) will include a 10 m wide riparian margin.
- Provision of riparian margins will provide protection and enhancement of Watercourse A:
  - By minimising or mitigating the effects on freshwater systems arising from changes in water temperature caused by stormwater discharges
  - Through the disconnection of impervious areas from the receiving environment

- By providing additional erosion protection.

· Provide erosion protection at stormwater outfalls into streams in accordance with Auckland Council Technical Report 2018/35 – Auckland Unitary Plan stormwater management provisions: Technical basis of contaminant and volume management requirements (TR35). Consider using multiple stormwater outfalls into Watercourse A to minimise the peak flows at the discharge points and therefore disturbance to the stream.

Further downstream, Watercourse A discharges into a stormwater channel on 91 Gatland Road which becomes a wide, flat, and grassed swale-like feature across the paddock at 95 Gatland Road. It is also noted that the properties and 91 and 95 Gatland Road are also in the FUZ and are likely to be developed, which may provide opportunity to reinstate the stream to convey upstream runoff safely to Slippery Creek.

Considering the existing features, i.e. a highly modified open channel (Watercourse A) with very limited natural character becoming a wide, flat grassed swale, and proposed enhancement and mitigation measures (i.e. green outfalls or energy dissipation structures at all discharge points to provide erosion protection), there is a very small erosion risk to the immediate receiving environment.

7.2.5.2 Slippery Creek erosion risk

The increase in flows due to the PCA development flows could have the following effects on Slippery Creek:

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

· Change in stream morphology caused by changes to overland flow paths and increased peak flows within streams

· Change in stream ecology due to erosion and also protection at stormwater outfalls.

In order to assess the potential impact of the PCA development on Slippery Creek, the risk of erosion at the discharge point into Slippery Creek has been assessed by comparing the estimated shear stresses in the stream channel from pre- and post-development flows from the PCA only (without any hydrological mitigation). The assessment has compared flows in the 2, 10 and 100 year ARI, 24 hour duration design storms. A number of parameters were not available at the time of the assessment (i.e. stream cross section, bed slope and effective critical shear stress, inter alia) so some input parameters have been determined based on available contour information and aerial photography, and from values typical for similar streams. The erosion risk assessment calculations and assumptions are included in Appendix C1.

The erosion threshold bands in the Auckland Council Stream Erosion Risk Tool for the magnitude of predicted erosion (and used in this analysis) are shown in Table 7.2. Each threshold is based on the excess shear, which is the ratio of the hydraulic shear stress exerted by the driving force of water in the stream channel to critical shear stress. Potential erosion occurs when the excess shear is greater than unity and erosion is theoretically initiated in the channel. When excess shear is more than 2, there is potential for active erosion and for the channel to mobilise. Anything greater than 10 indicates a very rapid rate of erosion.

Table 7.2: Erosion threshold bands

Threshold	Excess Shear	Description
Green	<1.0	Indicates no erosion predicted to occur
Yellow	>1.0 <2.0	Indicates the potential for some erosion of the channel
Orange	>2.0 <10.0	Indicates the potential for channel to be mobile, (likely active erosion)
Red	>10.0	Indicates potential rapid rates of erosion and incision of channel

The excess shear for each of the design storm events is presented in normalised bar chart form in Figure 7.3. This shows that erosion potential (duration of excess shear greater than 1) is only triggered in the post-development 100 year scenario. The analysis indicates that:

- The existing PCA flow regime presents low or no erosion risk at the discharge point into Slippery Creek
- There will only be a small increase in erosion risk due to development of the PCA during low frequency storm events.

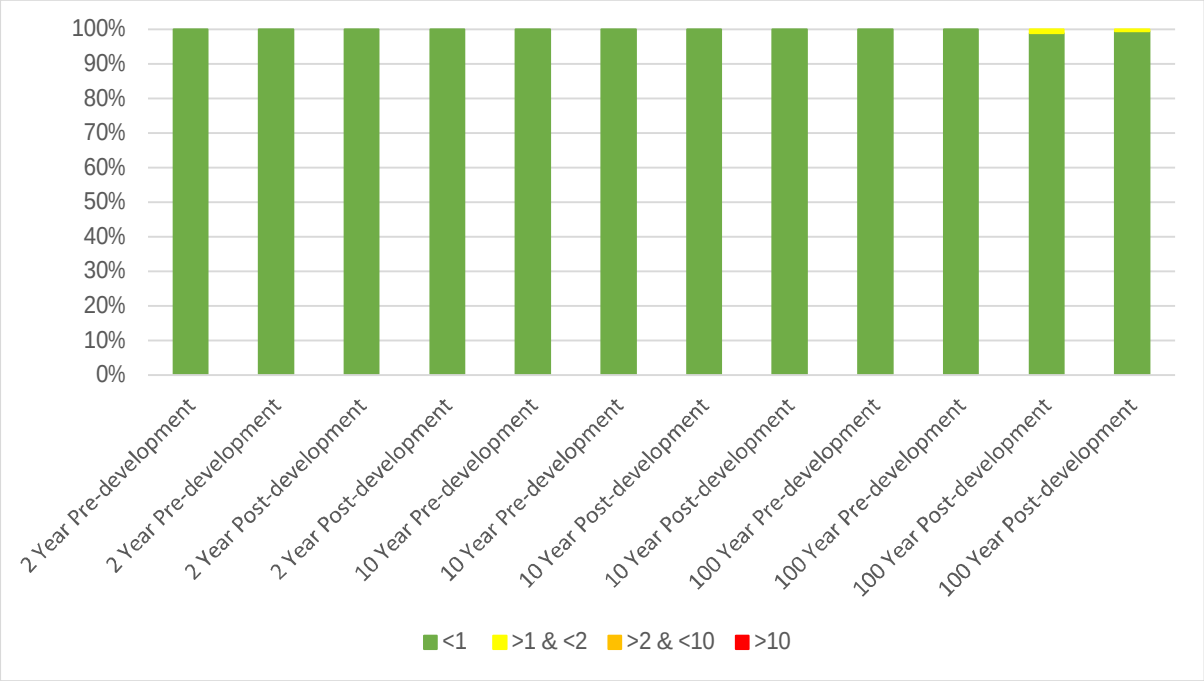

Figure 7.3: Excess shear at the discharge point into Slippery Creek

Furthermore, application of SMAF 1 hydrological mitigation will reduce flows and thus result in an even smaller increase to the erosion risk.

7.2.6 Flooding and flood plain management

The Drury- Opāheke Draft SMP identifies existing extensive flooding downstream in the Slippery Creek catchment. This attributes the large flood plain extent primarily to the large catchment upstream of the FUZ area, rather than the effect of additional impervious area created by anticipated urban development. Although the FUZ SMP identifies that urbanisation of the FUZ is expected to have minimal effects on existing flood hazards, flooding was assessed by T+T in June 2019[3] (refer to Appendix A2) to confirm the impact of development within the FUZ on the Slippery Creek flood plain.

The T+T assessment compared results from the Auckland Council Slippery Creek Rapid Flood Hazard Assessment (RFHA) model, which includes effective rainfall and major inflows from Slippery Creek, Hingaia Creek, Waihoihoi Stream, Symonds Creek, Whangapouri Creek, Ngakaroa Creek and Oira Creek, and associated tributaries compiled in Infoworks ICM software[18], for the following scenarios:

- 100 year ARI with existing development (ED) conditions with climate change
- 100 year ARI with MPD conditions, with future development modelled within the upstream FUZ and with climate change.

Neither model includes any specific development of the PCA, however, they incorporate the general nature of future urban development in the Slippery Creek catchment, including the PCA. The ED scenario is based on existing impervious coverage and the MPD scenario assumes an impervious coverage assumption of 60% within the FUZ and an additional 20% impervious coverage in the upper eastern catchment rural areas in the Hunua ranges.

The flooding issues in Slippery Creek catchment require development of a comprehensive total-catchment solution to avoid effects of cumulative development, and so use of the Auckland Council-owned catchment-wide RFHA model was deemed the most appropriate for this assessment, particularly because:

- It is known that this model was built using the latest Auckland Council specification for Rapid Flood Hazard Assessment (RFHA) modelling methodology (2012)
- The model includes survey information for key hydraulic structures in the catchment and utilises inflow boundary conditions from the Auckland Council Hingaia model
- The model showed an acceptable volume balance with a mass balance error of only -0.01% and no instabilities or abnormalities in the result outputs provided.

The assessment demonstrated that the flood extent is not significantly greater than the ED flood extent, with no previously unaffected areas of flooding for the MPD scenario. A comparison in flood extent for the ED and MPD scenarios is presented in Figure 7.4.

[18] Infoworks Integrated all source Catchment Modelling software

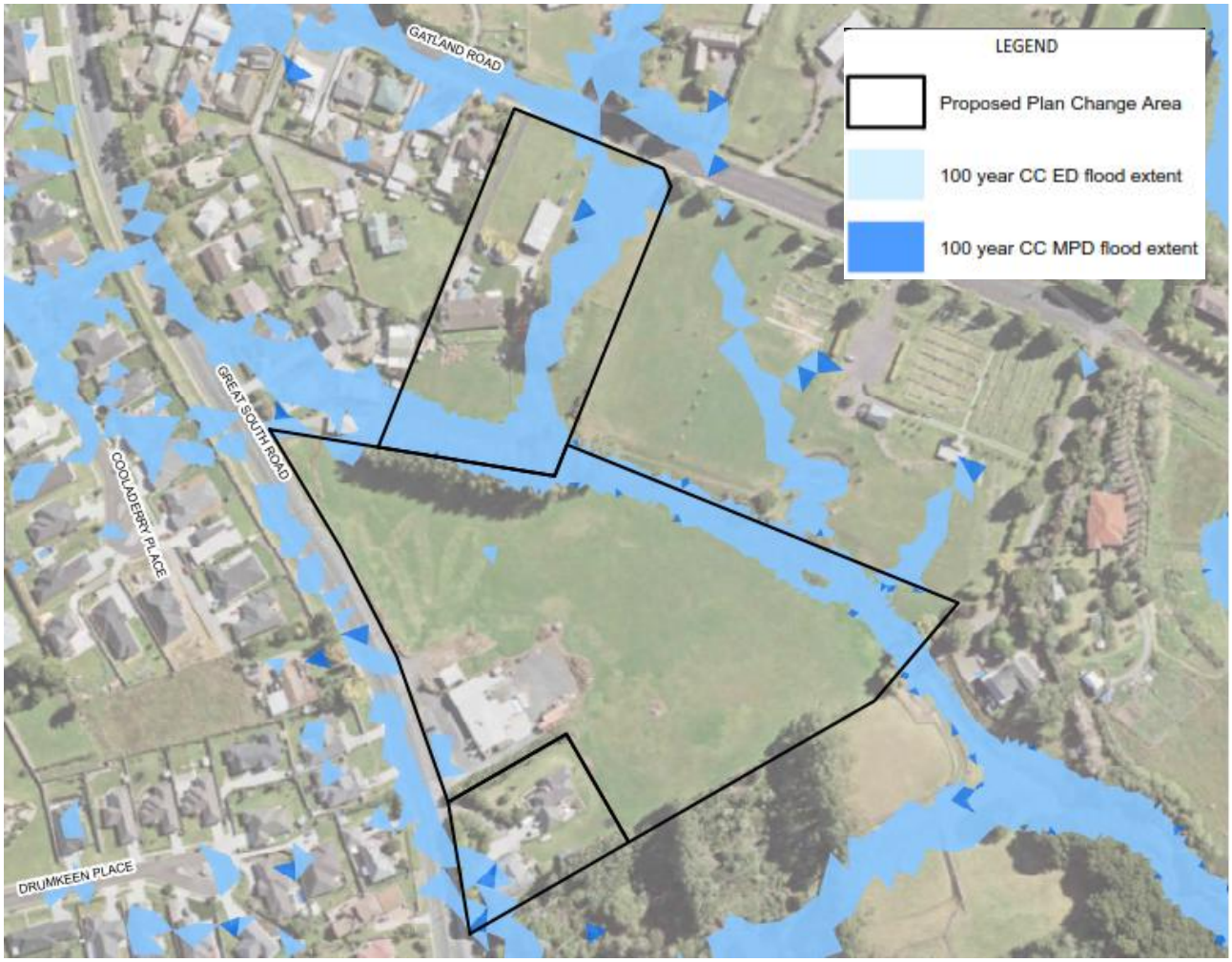

Figure 7.4: Comparison between 100 year ARI CC ED and 100 year ARI CC MPD flood extent

The assessment also demonstrated the peak flows generated as a result of the development at 520 Great South Road only will be negligible in comparison to, and occur earlier than, the peak flows from the upstream catchment, so it would be appropriate to discharge the stormwater from the PCA in advance of the catchment flood peak so as not to worsen flooding in the Slippery Creek flood plain.

The earlier T+T hydrological assessment has been modified to account for flow routing. The modified assessment seeks to ascertain whether the additional runoff from sub-catchment A exacerbates the existing flood hazard in the Slippery Creek flood plain downstream, and to identify any significant effects of the "pass flows forward" flood management approach for the catchment. The following methodology was used:

- Estimate 24 hour rainfall depths for the 2, 10 and 100 year ARI design storms from the TP108 isopleths and use these to prepare hyetographs using TP108 temporal distribution
- Build a HEC-HMS19 hydrological model for the pre- and post-development 2, 10 and 100 year ARI rainfall events for sub-catchment A and generate flows
- Compare post-development flows to:
  - Pre-development flows from the site

[19] Hydrologic Engineering Center – Hydrologic Modelling System software designed to simulate the complete hydrologic processes of dendritic watershed systems.

- Slippery Creek 100 year ARI ED model flows at the Great South Road Bridge (Location E in the June 2019 assessment included in Figure 7.5 below)
- Compare the increase in flood volume (and timing) to size/volume of the receiving flood plain.

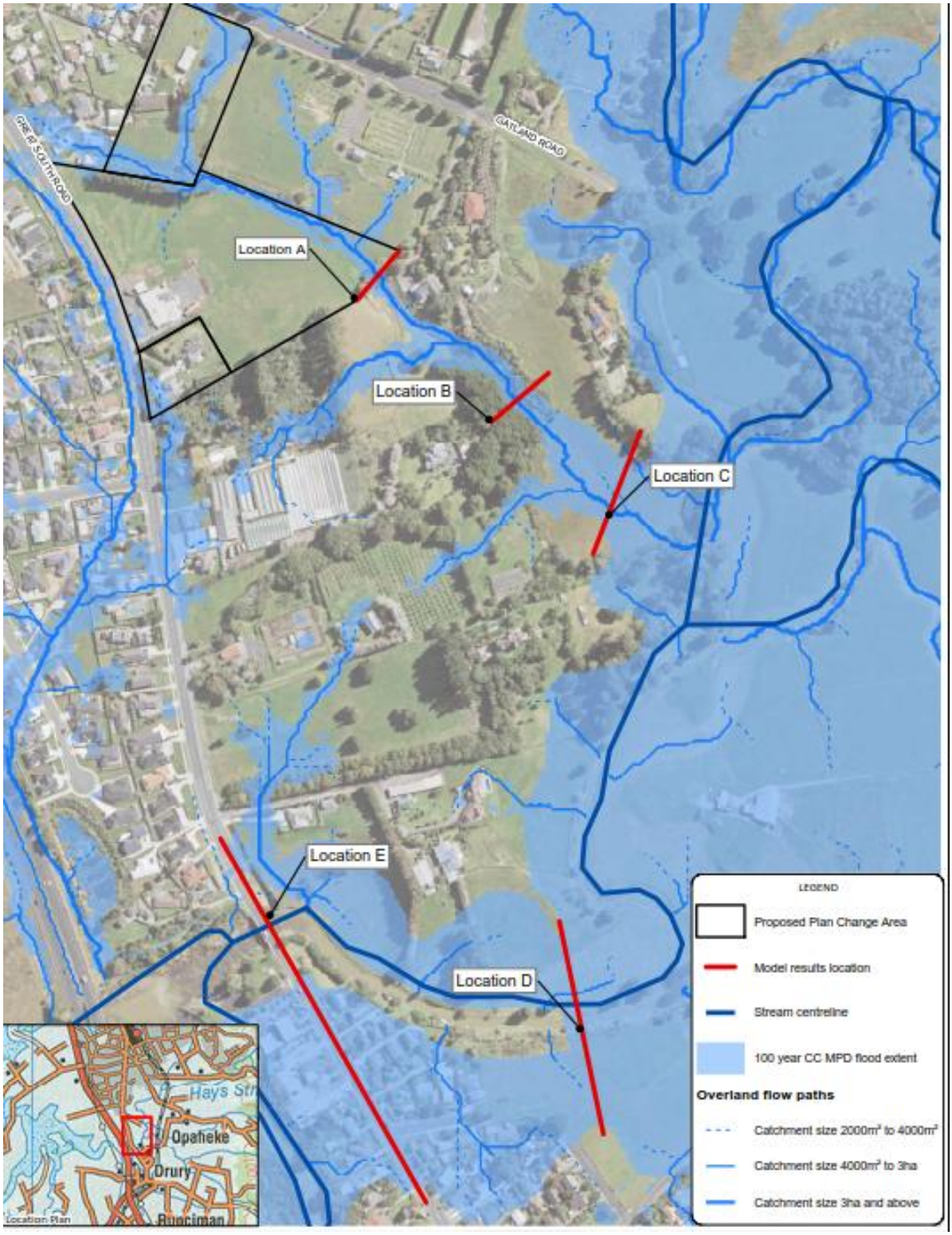

Figure 7.5: Flood model result locations

Figure 7.6 shows the sub-catchment A hydrographs generated in HEC-HMS and Table 7.3 shows the peak flow rates for the pre- and post-development 2, 10 and 100 year ARI rainfall events. The results show that in all rainfall events the post-development flows will be almost twice the pre-development flows.

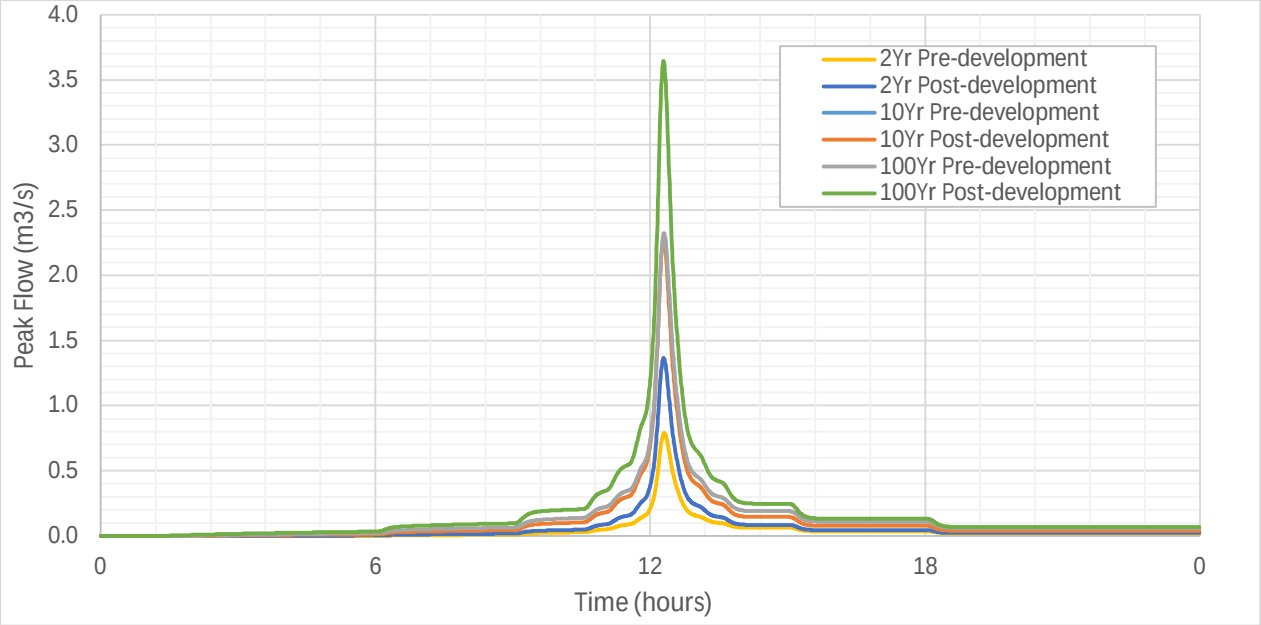

Figure 7.6: Runoff hydrographs from sub-catchment A for the pre- and post-development 2, 10 and 100 year ARI rainfall events

Table 7.3: Peak flow rates from sub-catchment A for the pre- and post-development 2, 10 and 100 year ARI rainfall events

ARI rainfall event	2 Year	10 Year	100 Year
Pre-development (m^3/s)	0.8	1.4	2.3
Post-development (m^3/s)	1.4	2.3	3.6
Difference (m^3/s)	**0.6**	**0.9**	**1.3**

Total catchment flow hydrographs at the Great South Road Bridge are shown in Figure 7.7. The "Pre-development" flow is the output from the Slippery Creek rapid flood hazard assessment model ED scenario. The "Post-development" flow is based on addition of the "extra flow" resulting from development of the PCA (i.e. PCA post-development less the PCA pre-development flows from sub-catchment A) to the "Pre-development" hydrograph. Only "extra flow" from the development has been added because the "Pre-development" case already accounts for the greenfield runoff from sub-catchment A.

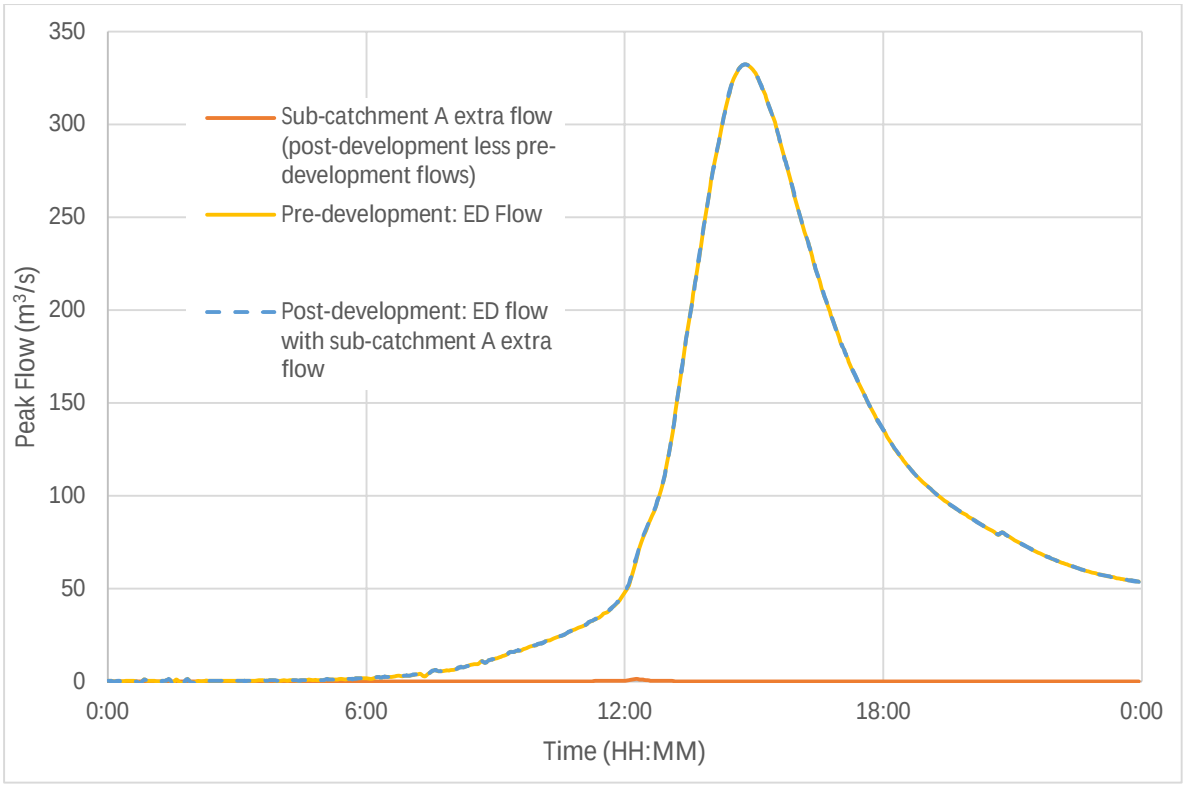

Figure 7.7: Slippery Creek flood plain 100 year flood hydrographs at the Great South Road Bridge

At the Great South Road Bridge, the extra flow from development within sub-catchment A is negligible in comparison to the large volume of flow from Slippery Creek's upstream catchment, thus, the "Pre-development" and "Post-development" hydrographs look identical. The PCA peak flow occurs at approximate model time 12:20 pm, more than two hours prior to the catchment peak at 2:45 pm.

Acknowledging this is a simplistic analysis of a dynamic system, the volume of additional flow from sub-catchment A of the development is 5,177 m^3 and surface area of the Slippery Creek 100 year flood plain between the development and the flow constraint at Great South Road Bridge is approximately 209,000 m^2. This suggests that the theoretical maximum effect that the development extra flow could have on the 100 year flood level is 25 mm if the peaks coincided, which is best mitigated if the proposed pass forward flow approach is adopted.

As discussed in section 3.1.10, the FUZ SMP recommends development outside of the Slippery Creek flood plain. The PCA does not lie within the main catchment flood plain and all building platforms within the PCA are to be located outside of and set above the 100 year ARI MPD flood plain.

Given the small contribution to Slippery Creek from the development of the PCA, although one of the many as the FUZ of the catchment is developed, it is proposed to pass forward flows without attenuation. Flows from the site will be discharged directly into Watercourse A and Slippery Creek as quickly as possible in order to pass them through to the Harbour before the peak flows from the upper reaches of the catchment reach the area. This is to avoid coincidence of flood peaks that would worsen the downstream flooding and increase flood risk upstream of the Great South Road Bridge. This is consistent with the general recommendation of the FUZ SMP for the four Drury Opāheke sub-catchments.

As a result of development, all runoff within 520 Great South road will be directed to sub-catchment A so that sub-catchment B comprises only the overland flow from the entirety of 522 Great South Road. This means the land discharging to sub-catchment B is reduced in the post-

development scenario and, as shown in Table 7.4, the peak flow rates and volumes conveyed down Great South Road will be less too. Stormwater runoff from sub-catchment B can also be discharged without flood attenuation.

Table 7.4: Peak flow rates and volumes from sub-catchment B for the pre- and post-development 2, 10 and 100 year ARI rainfall events

ARI rainfall event	2 Year	10 Year	100 Year
Pre-development Peak flow m^3/s (volume m^3)	0.069 (446)	0.127 (797)	0.220 (1,389)
Post-development Peak flow m^3/s (volume m^3)	0.039 (246)	0.066 (416)	0.110 (695)

To ensure that there are no adverse flooding impacts within the PCA, the following approaches are proposed to manage flood risk:

- Adopt a "passing flows forward" approach which means flows from the site will be discharged without attenuation into Watercourse A (for sub-catchment A) then into Slippery Creek along Great South Road (for sub-catchment B) to Drury Creek as quickly as possible to pass them through before the peak flows from the upper catchment.
- Ensure all building platforms are located outside of and set above the 100 year ARI MPD flood plain, with a suitable allowance for freeboard. It is also recommended that infrastructure is located outside this extent, unless it can be designed to be resilient to flood damage. The flooding assessment[3] by T+T in 2019 developed the MPD 100 year ARI flood plain (refer to Figure 7.4).
- 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.
- Ensure development within the PCA does not increase flood risk to buildings or infrastructure on properties upstream or downstream of the site.

7.2.7 Overland flow path

Watercourse A is mapped as an overland flow path, and the proposed development within 520 Great South Road seeks to maintain it as a primary and secondary conveyance means for the northern sub-catchment of the PCA. In fact, the stormwater management approach is proposing to maintain all existing entry and exit points for overland flow paths within the PCA.

Flows up to a 1 in 10 year ARI frequency will be conveyed through a piped network within the development. The piped network will follow the road network and discharge at two locations to Watercourse A. Secondary flows (i.e. from storms greater than 1 in 10 year ARI frequency and up to a 1 in 100 year ARI frequency) will be conveyed along road corridors, existing overland flow paths where they are maintained, or along dedicated overland flow channels to Watercourse A. All secondary flow paths will be located within public areas (roads and parks) and not on private properties.

The overland flow path from the north-western corner of the site will create adverse flooding on the road corridor. It is proposed to be piped from the proposed road berm, traverse under Lot 9 and discharge into Watercourse A.

There is also a mapped overland flow path along the southern boundary of 522 Great South Road which will convey less flows from the PCA, as in the development runoff from the 520 Great South Road property will be diverted to Watercourse A.

7.2.8 Development staging

Not applicable within this SMP

7.3 Hydraulic connectivity

Not applicable within this SMP

7.4 Asset ownership

All public stormwater infrastructure within the PCA, including the reticulated stormwater network, and any communal bioretention devices, are intended to be vested to Auckland Council upon completion of construction.

7.5 Ongoing maintenance requirements

Not applicable within this SMP

7.6 Implementation of stormwater network

Not applicable within this SMP

7.7 Dependencies

Not applicable within this SMP

7.8 Risks

Table 7.5 presents the identified risks to the proposed stormwater management within the PCA and addresses how these risks might be mitigated or managed. As the application for adoption of this SMP under the NDC progresses, it is expected that this list will be further populated as more risks are identified.

Table 7.5: Risk Register

What is the risk to the proposed stormwater management?	How can this be mitigated / managed?	What other management / mitigation could be used?	When does this risk need to be addressed?	What is the resultant level of risk?
Unknown In-situ soil infiltration rates	Percolation testing required	Retention through re-use	During the Resource Consent phase	Low
No verification of SMAF 1 hydrological mitigation approach	Appropriately scaled erosion stream risk assessment		During the Resource Consent phase	Moderate
Sub-catchment A - Unknown downstream network for discharge of primary flows	The downstream conveyance route should be investigated further to ensure there are no capacity constraints (i.e. undersized pipe network) between the PCA and Slippery Creek to cater for the stormwater associated with the development in the 10 Year ARI event, including incorporating flows from contributing catchment at MPD.		During the Resource Consent phase	Moderate
Sub-catchment B - Unknown downstream network for discharge of primary flows	Survey to determine existing connection point which may require further investigation of the downstream capacity in Great South Road public stormwater network to decide which option to pursue.		During the Resource Consent phase	Moderate
Auckland Council Overland flow mapping doesn't align with natural drainage features on the properties	Confirmed through survey	N/A	During the Resource Consent phase	Low

8 Departures from regulatory or design codes

The stormwater management approach for development with the PCA meets the minimum regulatory or design codes standards and is considered the BPO approach.

9 Conclusions and recommendations from future work

Guidance on how stormwater will be managed at the PCA is summarised in this section, along with recommendations for further investigation to support of the next phases of development within the PCA.

9.1 Conclusions

This SMP for the PCA comprising 520 and 522 Great South Road and 21 Gatland Road has been developed based on AUP regulatory policies, Auckland Council stormwater-specific guidelines and NDC requirements and the FUZ SMP.

The overarching principles of the SMP are to:

- Recognise the key constraints and opportunities on site and in the Slippery Creek catchment.
- Devise an integrated stormwater management approach to facilitate urban development.
- Develop a set of BPO for stormwater that can be incorporated into the development.
- Emphasise a water sensitive design approach that manages the impact of land use change from rural to urban and protects and enhances stream systems and natural hydrology, while mitigating for hydrological changes and managing flooding effects.
- Minimise the generation and discharge of contaminants/sediments into sensitive receiving environment of the Manukau Harbour.
- Protect key infrastructure, people, and the environment from significant flooding events.

Stormwater management for the development has been divided in to two management zones based on the natural topography and existing sub-catchments.

The general approach for hydrological mitigation and water quality treatment is the same for each sub-catchment, and consists of:

- Providing a minimum of SMAF 1 hydrological mitigation for all impervious surfaces within the PCA. Any additional mitigation for stream erosion can be developed as the SMP progresses based on site observations of erosion and/or improved erosion modelling.
- Minimising the generation of contaminants as much as possible. Where contaminants are generated, the preferred approach is to use green infrastructure to treat runoff at-source or as close to the source as practicable.

The general approach for flood mitigation is to “pass forward flows”. This means flows from sub-catchment A of the PCA should be discharged directly into Watercourse A and Slippery Creek without onsite flood attenuation, in order to pass them through before peak flooding from the upper reaches of the Slippery Creek catchment arrives. Flows from sub-catchment B will be reduced as runoff from within 520 Great South Road will be directed to sub-catchment A, so stormwater runoff from sub-catchment B can also be passed forward without flood attenuation.

Stormwater management specific to sub-catchment A:

- To protect, restore and enhance the onsite intermittent stream referred to as Watercourse A.

The stormwater management requirements for development within the PCA are summarised in Table 9.1. A toolbox of BPO has been prepared to assist in selecting appropriate stormwater management devices to achieve at-source water quality, hydrological mitigation and water sensitive design outcomes for corresponding land-use.

Table 9.1: Stormwater management requirements and toolbox of BPO for stormwater management within the PCA

Activity	Component	Minimum requirements	Recommended approaches	Guidelines
Residential lots – Roof Area	Hydrological mitigation only	Retention of at least 5 mm of runoff depth from impervious surfaces. Detention and a drain down period of 24 hours for the difference between the pre-development and post-development runoff volumes from a 95th percentile, 24-hour rainfall event minus the achieved retention volume, over the impervious area for which hydrology mitigation is required.	· Infiltration through trench drains · Above ground rainwater storage/re-use tanks · Permeable pavement and porous concrete · Raingardens/planter boxed · Underground storage tanks	· Auckland Council GD01
Residential lots – Hardstand and jointly owned access lanes Roads, Carparking and HCGA Carriageway	Water quality Hydrological mitigation	Stormwater management of runoff from all impervious surfaces before discharging into the receiving environment. Minimise the generation of contaminants as much as possible. Where contaminants are generated, the preferred approach is to use green infrastructure to treat runoff at-source or as close to the source as practicable. Retention of at least 5 mm of runoff depth from impervious surfaces. Detention and a drain down period of 24 hours for the difference between the pre-development and post-development runoff volumes from a 95th percentile, 24-hour rainfall event minus the achieved retention volume, over the impervious area for which hydrology mitigation is required.	· Pre-treatment Devices - Gross Pollutant Trap - Proprietary Device · Infiltration through trench drains · Bioretention devices - Raingardens - Tree Pits - Filter strips/ swales - Wetlands · Permeable pavement and porous concrete	· Auckland Council GD01 · Auckland Council GD04 · Auckland Council Unitary Plan stormwater management provisions TR2013/35
Public spaces only i.e. Roads, Carparking, HCGA Carriageway, Open Spaces and Riparians	Stormwater conveyance	Convey runoff generated from the 10 year ARI through a public piped stormwater network. Allowance for runoff flows greater than the 10 year ARI should be made in overland flow paths. Existing overland flow paths should be protected.	Primary Conveyance · Retain and enhance intermittent streams · Swales · Pipe network Secondary Conveyance · Retain and enhance intermittent streams	· Auckland Council GD01 · Auckland Council GD04 · Auckland Council Stormwater Code of Practice

Activity	Component	Minimum requirements	Recommended approaches	Guidelines
			· Swales and open channels · Road corridor	
Open Spaces and Riparians	Stream hydrology and erosion protection	Enhance water quality, flows, stream channels and their margins and other freshwater values where the current condition is below the relevant thresholds.	· Green outfall (where practicable) · Riparian margin enhancement and planting, where necessary to mitigate identified adverse effects	· Auckland Council GD01 · Auckland Council TR2013/018 · Assessment of Ecological Effects

More detailed design of the proposed stormwater management approach, including device selection, sizing and location will be addressed at later stages of development.

Based on the investigations that have been completed at this stage, it is expected that stormwater effects from the PCA can be managed safely and without damage to the receiving environment. The plan change can, therefore, proceed without any major concerns relating to stormwater management. It is noted that this SMP will evolve and be developed in more detail as the application proceeds through further stages of the NDC process.

9.2 Recommendations

Recommendations for further investigation to support of the next phases of development within the PCA are listed below:

- It is recommended the conveyance route downstream of Watercourse A is investigated further to ensure there are no capacity constraints.
- Site-specific soakage/percolation testing is recommended to confirm if infiltration is viable and inform conceptual or detailed design of soak pits.
- Advance design of the proposed stormwater infrastructure, including device selection, sizing and location, to meet the requirements set out in this SMP for the Plan Change application.

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.

We understand and agree that our client will submit this report as part of an application for Plan Change and that Auckland Council as the consenting authority will use this report for the purpose of assessing that application.

Tonkin & Taylor Ltd

Report prepared by:	Authorised for Tonkin & Taylor Ltd by:
	
.....	.....
Charlotte Peyroux	Tom Bassett
WATER ENGINEER / PROJECT MANAGER	PROJECT DIRECTOR

CEMP
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Appendix A1: Plans of existing site features

- 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.

A3 SCALE 1:2,000

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520 GSR

520 Great South Road, Papakura
Location plan

FIGURE No.: Figure A1

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21 Gatland Road

520 Great South Road

522 Great South Road

Northern sub-catchment discharge point

Southern sub-catchment discharge point

Location Plan

Hays Stn

Opaheke

Drury

Runciman

LEGEND

Proposed Plan Change Area

Contour 1m

Northern subcatchment

Southern subcatchment

Overland flow paths

Catchment size 2000m² to 4000m²

Catchment size 4000m² to 3ha

Catchment size 3ha and above

Notes: Aerials sourced from Auckland Council.

A3 SCALE 1:2,000

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520 GSR

520 Great South Road, Papakura

Catchment setting

FIGURE No. Figure A2

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GATLAND ROAD

GREAT SOUTH ROAD

COOLADERRY PLACE

DRUMKEEN PLACE

Embankment

1.5m diameter riser

LEGEND

Proposed Plan Change Area

Stormwater manholes

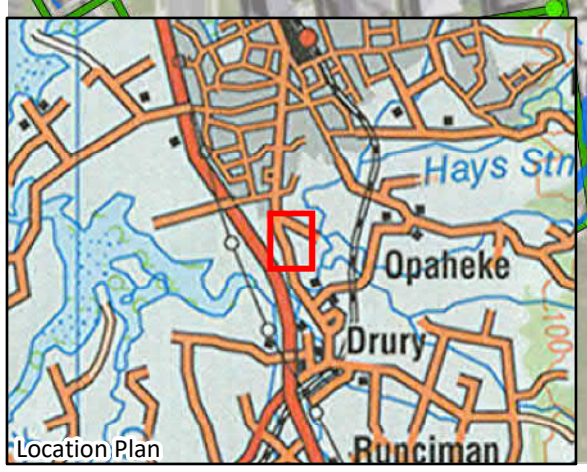
Stormwater pipes

Overland flow paths

Catchment size 2000m² to 4000m²

Catchment size 4000m² to 3ha

Catchment size 3ha and above



Notes: Aerials sourced from Auckland Council.

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PROJECT No. 1009613.000

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520 Great South Road, Papakura

Existing stormwater infrastructure

FIGURE No. Figure A2

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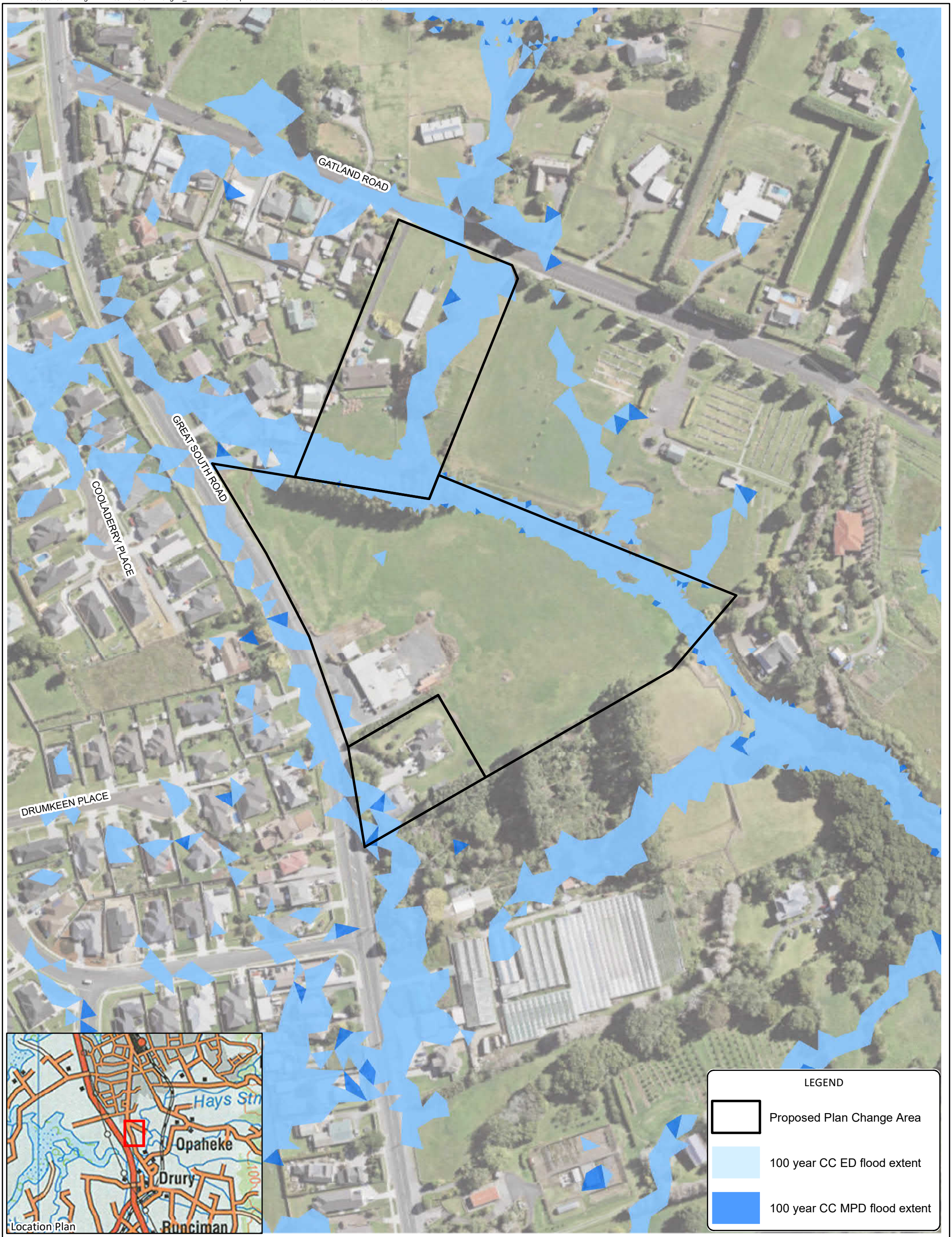

Notes: Aerials sourced from Auckland Council.
Flood depths less than 0.05m removed.

A3 SCALE 1:2,000

0 20 40 60 80 100 Meters

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PROJECT No. 1009613.000		

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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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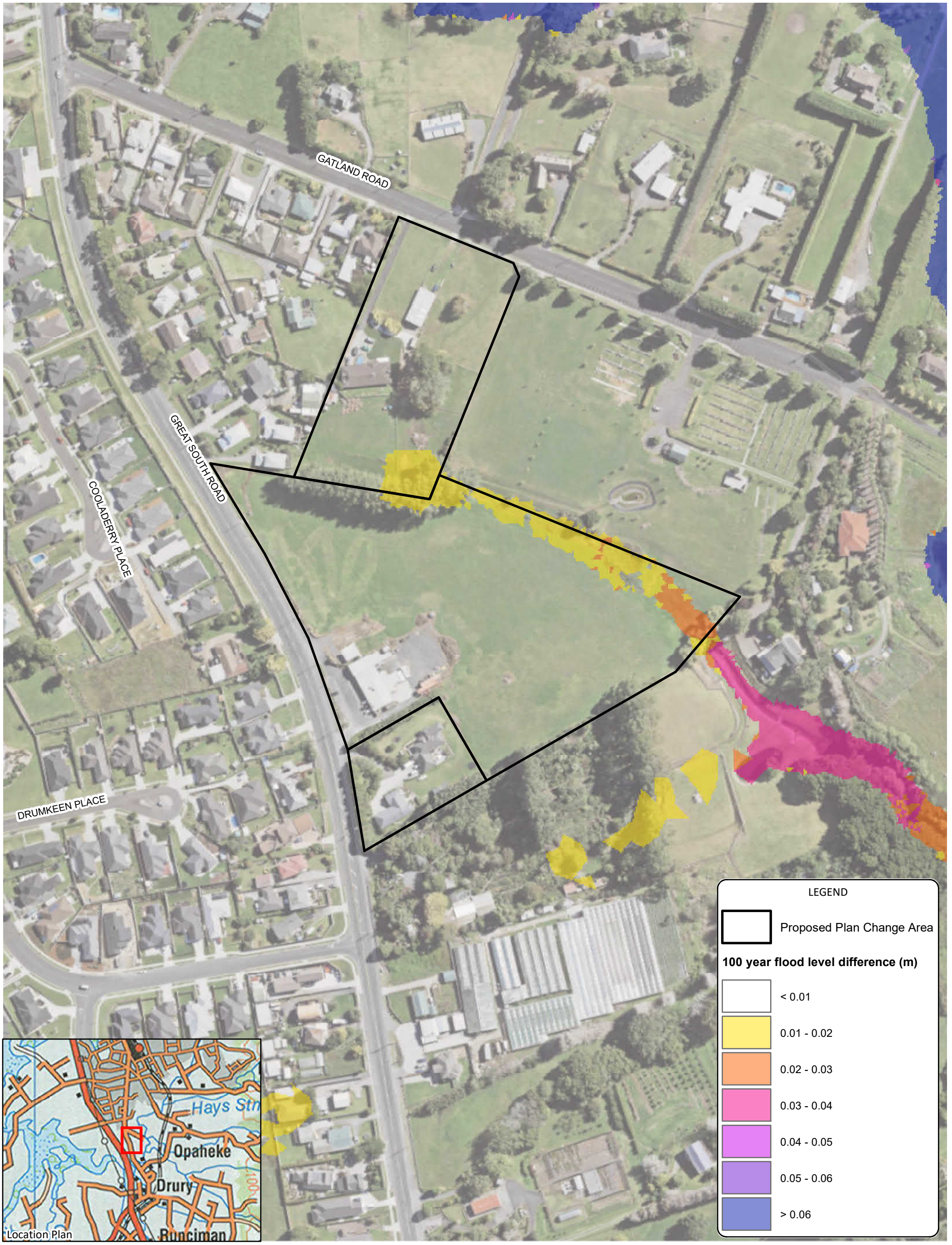

Notes: Aerials sourced from Auckland Council.

A3 SCALE 1:2,000

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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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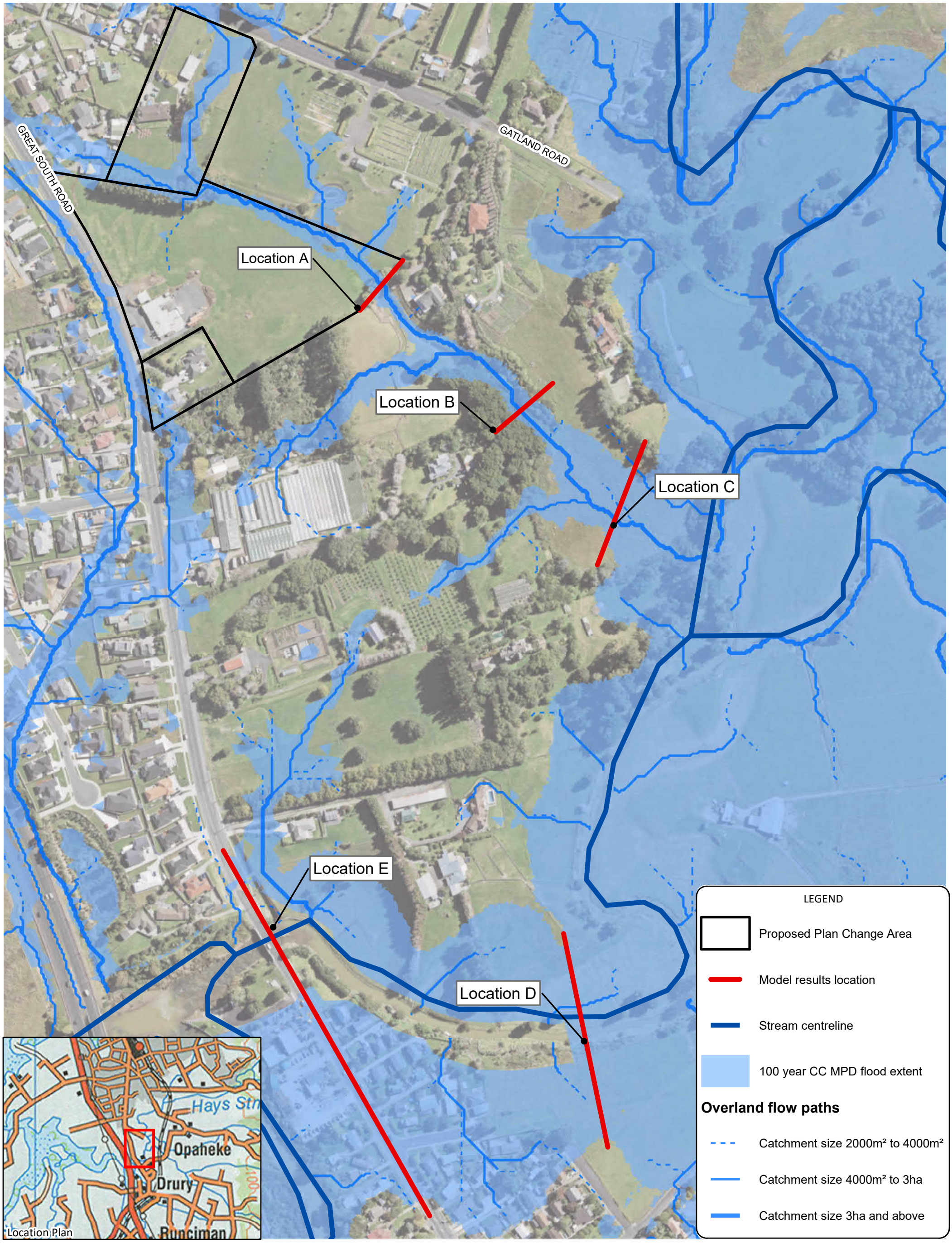

Notes: Aerials sourced from Auckland Council.

A3 SCALE 1:3,000

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SCALE (AT A3 SIZE) 1:3,000

PROJECT No. 1009613.000

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520 Great South Road, Papakura
Flood model result locations

FIGURE No. Figure A6

Rev. 0

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21 Gatland Road

520 Great South Road

522 Great South Road

Location A

LEGEND

- Proposed Plan Change Area
- Contours 1m
- Catchment_LocationB
- Catchment - Location A

Overland flow paths

- Catchment size 2000m² to 4000m²
- Catchment size 4000m² to 3ha
- Catchment size 3ha and above

Location Plan

Hays Stn

Opaheke

Drury

Runciman

Notes: Aerials sourced from Auckland Council.

A3 SCALE 1:2,000

0 20 40 60 80 100 Meters

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ARCFILE FigA7_TP108Catchment.mxd

SCALE (AT A3 SIZE) 1:2,000

PROJECT No. 1009613.000

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520 Great South Road, Papakura
TP108 catchments

FIGURE No. Figure A7

Rev. 0

Appendix A2: T+T Stormwater Management and Flooding Assessment

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 (m^3/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 m^3/s compared to 350 m^3/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.

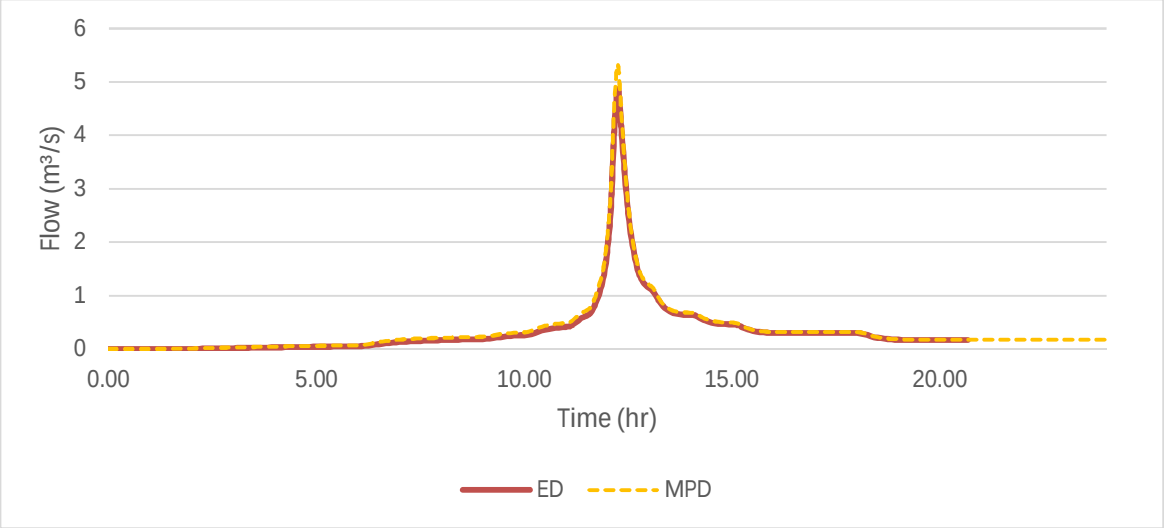

Figure 1 Modelled flow hydrograph at Location A (PCA downstream property boundary)

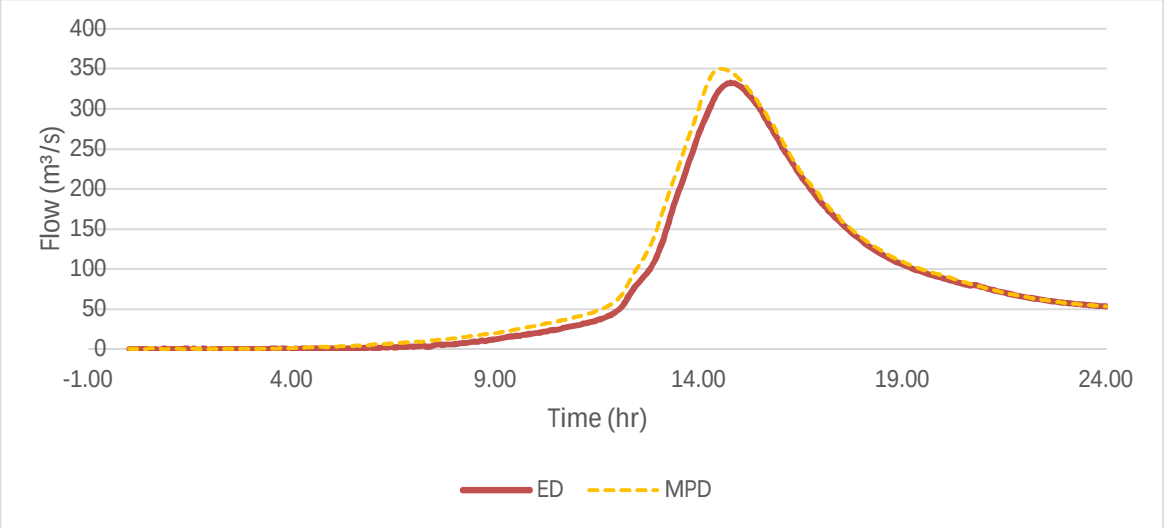

Figure 2 Modelled flow hydrograph at Location E (Great South Road Bridge)

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

Report prepared by:

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Joanna Park
WATER RESOURCES ENGINEER

Authorised for Tonkin & Taylor Ltd by:

.....

Dr Tim Fisher
PROJECT DIRECTOR

Report reviewed by:

.....

Tom Bassett
PROJECT MANAGER

JOPA
\\ttgroup.local\files\aklprojects\1009613\workingmaterial\letter report\for review\1009613.520 great south road.stormwater.28062019.ltr.docx

Appendix A3: Clause 23 RMA Further Information Request

Stormwater and flooding matters – Chloe Trenouth, Healthy Waters Consultant				
#	Category of Information	Specific Request	Reason for request	Addressed
HW1	Stormwater Management Plan (SMP)	Please provide a Stormwater Management Plan to support the plan change. Note: It is recommended that a meeting between the applicant and Healthy Waters be arranged to discuss the requirements of the SMP.	The plan change land is in the Future Urban zone and seeks to apply live zonings. An assessment of effects and proposed mitigations should be included in a SMP as part of the AEE and Section 32 Assessment to demonstrate how the Regional Policy Statement and regional plan provisions in Chapter E1 will be met, in particular policies E.1.3(3), E1.3(8) and E1.3(10). The SMP should: • address the Drury-Opaheke SMP and also discuss downstream effects; and • Assess why the proposed stormwater treatment and flood mitigation is the Best Practicable Option.	A meeting with representatives from Healthy Waters and T+T was held on 3 April 2020. This SMP has been prepared in support of the Plan Change for all three developments.
HW2	Network Discharge Consent (NDC)	Please confirm whether it is intended that the plan change come under the Council's Global NDC for stormwater discharges.	It is unclear from the plan change documents whether it is intended for the stormwater discharges from the site to come under the Council's global NDC. This should be clearly identified in the SMP. The Stormwater Assessment supplied does not constitute a SMP in accordance with the Council's NDC. A clear statement on the methods that are intended to be used to meet Schedule 4 NDC performance requirements is needed in the SMP and these should be tied to the proposed land use. It is recommended that a meeting between the applicant and Healthy Waters be arranged to discuss what is required to come under the NDC.	A meeting with representatives from Healthy Waters and T+T was held on 3 April 2020. Refer to: - Executive summary - Introduction - Section 3.1.8 - Stakeholder Engagement
HW3	Precinct	Please explain why precinct provisions have not been proposed to achieve the outcomes of the proposed stormwater management approach.	Section 8 of the stormwater assessment identifies options, including use of inert building materials, green outfalls, and quality treatment of all roads. These are not currently requirements of the AUP and therefore would may not be implemented without precinct provisions. Further	

			discussions regarding appropriate precinct provisions will be required once an SMP is provided.	
HW4	SMAF Control	Please confirm whether Stormwater Management Area (SMAF) - Flow Control is to apply to the site.	The stormwater assessment appears to require hydrological mitigation but it is unclear whether the plan change proposes to apply the SMAF Control to the site. Further assessment of the erosion risks should be undertaken to understand whether the SMAF Control will adequately mitigate potential effects. Additional mitigation may be required. The SMP should identify whether this is the best practicable option. Advice note (non-Clause 23): If hydrological mitigation is proposed then it is recommended that the SMAF Control be applied to the land through this PPC.	Refer to: - Section 7.2.3 - Section 7.2.5
HW5 Stormwater	Modelling	Please provide further information is on the modelling to be included within the SMP including: • more description on the modelling undertaken to support the development, in particular where there are discrepancies between the Council model and the TP108 graphical assessment. • demonstrate that the Council Rapid Model is suitable for undertaking the assessment of impacts from a specific site. • confirmation that Tonkin & Taylor have not amended the HW model as part of this work. • provide clarification of the MPD imperviousness used for the rural areas.	Modelling information is required to understand the effects of the plan change in terms of increased stormwater runoff, peak flows and effects on the flood plain both upstream and downstream. It appears that the HW model has been used to assess flows within the watercourse through 520 Great South Road and TP108 graphical has been used to assess the local discharge from 520 Great South Road. However, there does not appear to be any commentary around how the development would impact the catchment flows. Even if this is negligible then this should still be worked through. Section 5.2 states that '…rural areas increases by 20% compared to the ED scenario…' Is this correct, or has the rural imperviousness increased to 20%? This clarification is required to confirm the model that is being used and the accuracy of flow volumes assumed through the site.	Refer to Section 7.2.6

HW6	New asset ownership	Please provide discussion on the future ownership of the proposed stormwater devices.	It is unclear whether the proposed stormwater management approach will result public assets to be vested in Healthy Waters, or whether they would remain private assets The vesting of stormwater devices in Healthy Waters has implications for the design of these assets and future maintenance costs for Council.	Refer to: - Stakeholder engagement - Section 6.3 - Section 7.4
HW7	Proposed stormwater management	Please clarify the proposed stormwater management principles that have been adopted and explain what stormwater management is considered to be the Best Practicable Option.	It is unclear what the actual principles for this development are. Greater discussion needs to be provided in relation to what could be considered and why the proposed stormwater management is considered to be the Best Practicable Option. Swales are mentioned as being possible (Section 8.1 and 8.2); however, it is then proposed to convey runoff in a new pipe network (Section 8.3).	Refer to Stormwater management
HW8	SMP	Please provide a location plan of the plan change area to demonstrate how it fits in with the local Slippery Creek catchment.	Section 2.1 of the Stormwater Assessment discusses the catchment. However, it does not consider the site location in the context of the wider catchment. The site is located upstream of a very large floodplain associated with flows from the urban Papakura catchment. It is important to understand the effects of the plan change on the wider catchment.	Refer Figure 5 in Section 2.3
HW9	SMP	Please address the impact of the embankment approximately 60m upstream of the south eastern property boundary.	It is unclear from Section 2.4 of the Stormwater Assessment what the impact of the identified embankment would have on the environment. Does it create ponding water above the embankment, or does it impact the floodplain? This issue needs to be identified in order to determine the extent of effects and potential mitigation required.	This embankment is a pond feature to be removed as part of the landscaping to rehabilitate the watercourse. Refer to Section 2.6 and 6.3
HW10	SMP	Please include further discussion about the receiving environment identified as a Significant Ecological	Section 2.5 of the Stormwater Assessment discusses the receiving environment but does not identify the importance of it as a Significant Ecological Area. This is a	Refer to Section 2.8

		Area (SEA) and implications to stormwater management because it is identified as a SEA.	relevant consideration in terms of effects on the environment and in determining the Best Practicable Option for stormwater management, particularly quality.	
HW11	SMP	Please clarify the extent of impervious coverage anticipated by the plan change.	Section 3 of the Stormwater Assessment identifies that the impervious coverage will increase, with greater runoff volumes and higher flows. However, the document is confusing with regard to what area it actually covers. This needs to be clarified.	Refer to Section 6.4
HW12	SMP	Clarify that Table 5.2 identifies 100-year ARI peak flow levels rather than flood levels.	Table 5.2 indicates flood levels but they are not necessarily flood levels. This appears to be an error.	N/A
HW13	SMP	Confirm whether the 24hour rainfall depth was used for the TP108 graphical assessment.	Section 6.2.1 discusses the assumption for runoff. Although HW assumes that the 24hr rainfall depths was used this is not explicitly identified in the document.	N/A
HW14	Flooding	Clarify how it is proposed to manage discharges from each sub-catchment when flows will be passed forward into a floodplain.	Discharges to the south currently enter a floodplain area across 530 GSR. Will unattenuated flows increase the extent, depth or frequency of this flooding? Will it be affected by the Slippery Creek Catchment? Further information is required to determine the proposal not to require attenuation is the Best Practicable Option.	Refer to Section 7.2.6
HW15	Flooding	Confirm how Subcatchment B will work in relation to passing forward flows. This would need to rely on overland flow paths because there no pipe network	Section 6.1.3 discusses the proposal to pass forward flows without attenuation. Depending on what development area you consider, No. 522 GSR could be significantly affected with flows passed to the property every time there is rainfall. Insufficient information is provided to understand the downstream effects of passing flows forward without attenuation.	Refer to: - Section 7.2.6 - Section 7.2.7

Appendix A4: Proposed development plans

Typology Key

	Type	Beds	Parking	Count
A1	Zero-lot	4	1 Ext / 1 Gge	4
A2	Zero-lot	4	1 Ext / 1 Gge	5
B1	Zero-lot	3	1 Ext / 1 Gge	4
C1	Zero-lot	3	1 Ext / 1 Gge	8
D	Duplex	3	1 Ext / 1 Gge	8
E1/E2	Duplex	3	1 Ext / 1 Gge	6
E3/E4	Duplex	3	1 Ext / 1 Gge	6
E5	Zero-lot	3	1 Ext / 1 Gge	1
F1	Zero-lot	3	1 Ext / 1 Gge	1
G1	Terrace	3	2 Ext	6
G2	Duplex	3	1 Ext or 2 Ext	2
G3	Terrace	3	2 Ext	3
G4	Terrace	3	2 Ext	2

	Type	Beds	Parking	Count
H1	Terrace	2	1 Ext	6
H2	Duplex	2	1 Ext	2
H3	Terrace	2	1 Ext	3
I1	Terrace	3	2 Ext	2
I2	Terrace	3	2 Ext	2
J1	Terrace	2	1 Ext	1
K	Terrace	3+1	1 Ext / 1 Gge	1
Lot 16	Apartments	2	1 Ext	6
Lot 42	Apartments	1/2	1 Ext	9
Lot 61	Apartments	2	1 Ext / 1 Gge	6
Lot 66	Apartments	2	1 Ext / 1 Gge	8
			Total:	**102**

Notes Types - Walk-Up, common stair / breezeway

1 **Typology Plan**
1 : 1000

DRAFT

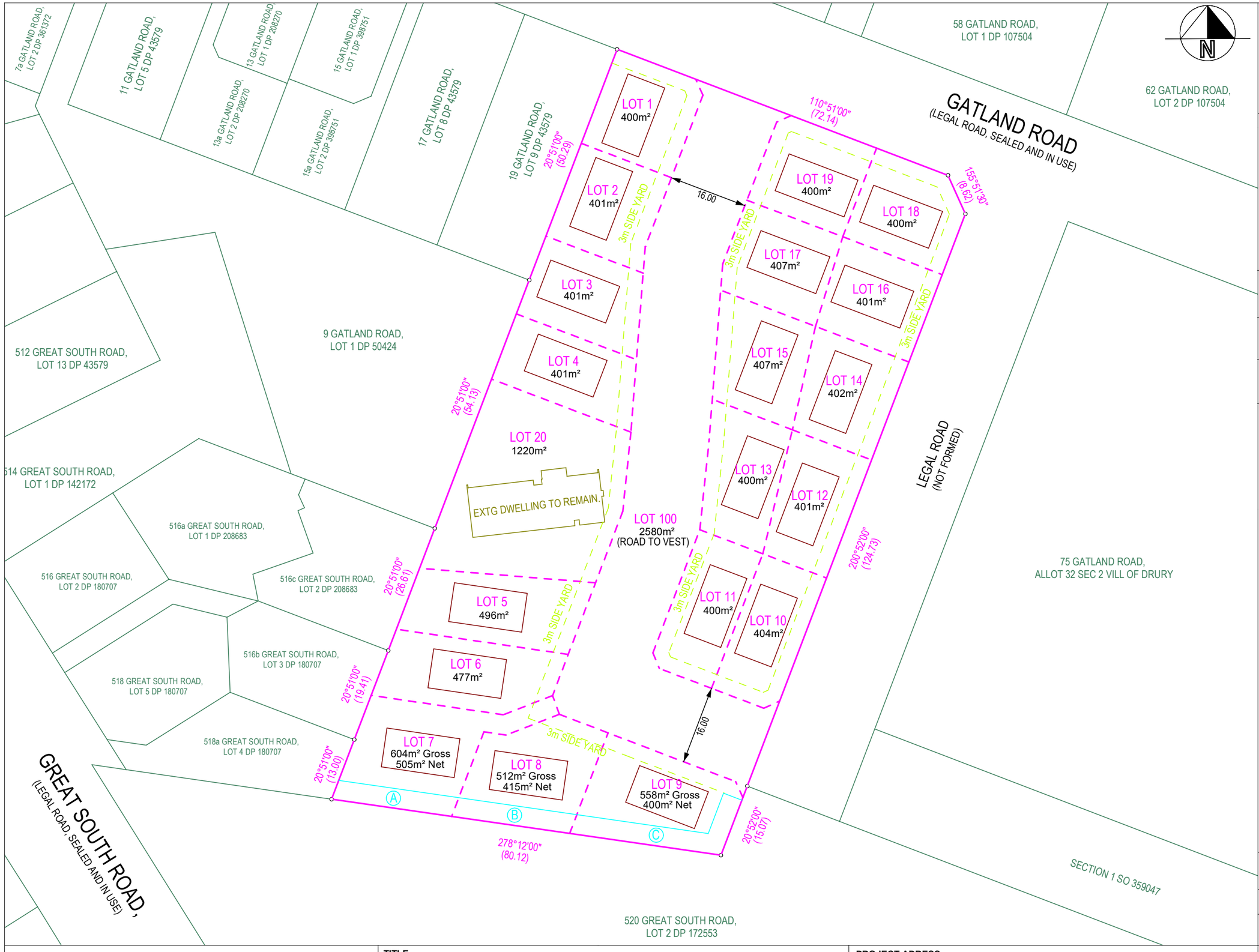
520 GSR
520 Great South Road, Papakura

Avery Associates Team Architects Ltd PO Box 37701, Parnell, Auckland 1151, New Zealand **t** 09 6384449 **e** www.averyarchitects.co.nz

N

Job No.	Scale (A3):	Sheet no.		DATE
4167	1 : 1000	**2.04**	Typology Plan	03/04/20

avery associates **team**architects
auckland | hamilton | napier | new plymouth palmerston north | wellington | christchurch greymouth | wanaka | dunedin



NOTES

- HORIZONTAL DATUM IS NZ GEODETIC DATUM 2000.
- AREAS AND DIMENSIONS ON THIS PLAN ARE SUBJECT TO FINAL SURVEY
- THIS PLAN IS PREPARED FOR RESOURCE CONSENT APPLICATION AND SHOULD NOT BE RELIED ON ON FOR ANY OTHER PURPOSE.

LEGEND:

- SITE BOUNDARY
- ADJACENT BOUNDARY
- PROPOSED BOUNDARY
- PROPOSED COVENANT
- 3M SIDE YARD
- 15m x 8m SHAPE FACTOR AREA

LEGAL DESCRIPTION:

LOT 16 DP 43579 = NA12D/1482

TOTAL AREA

1.2072 Ha

LOCAL AUTHORITY

AUCKLAND COUNCIL

AREAS A - C ARE SUBJECT TO AN OVERLAND FLOWPATH COVENANT.

HALL SURVEYING

Hall Surveying Limited
p: 09 428 1359
m: 021 262 6367
w: www.hallsurveying.co.nz
e: tom@hallsurveying.co.nz

TITLE

LOTS 1 - 20 & 100
BEING A SUBDIVISION OF LOT 16 DP 43579.

PROJECT ADRESS

21 GATLAND ROAD,
DRURY.
LOT 16 DP 43579

CLIENT
WAINONO INVESTMENTS LTD

DRAWING # C150	REV 4
Scale:	1 : 750 (A3)
Job #	2018-140

Surveyed	TH	Date 20/10/2018
Drawn	TH	Date 27/11/2018

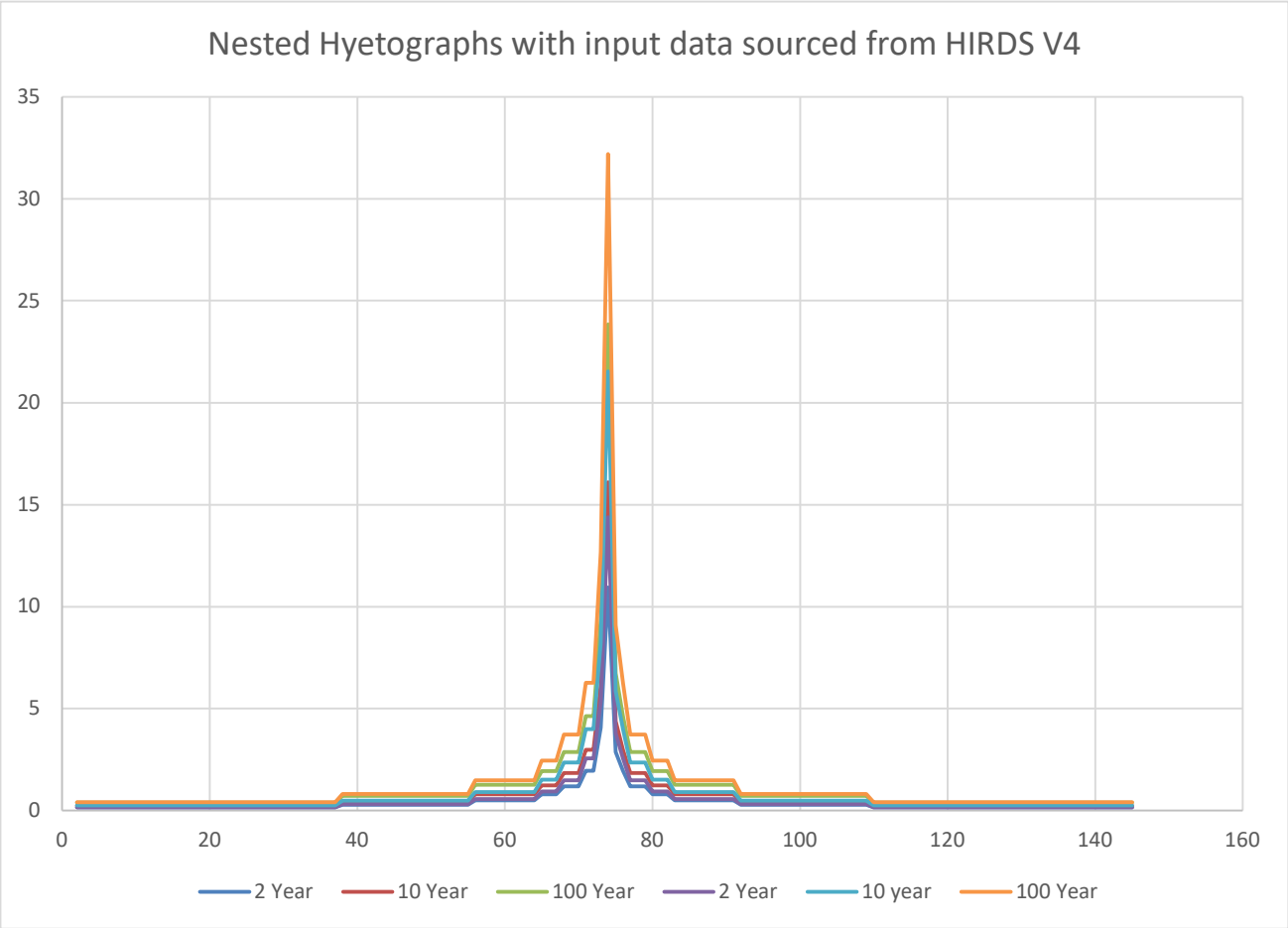
Appendix B1: Calculations

HEC HMS Inputs

CEMP 23/04/2020

Generated from HIRDS V4 hyetograph Generation (april 2020)

		Nested Hyetograph					
		Historical Data			RCP8.5 for the period 2081-2100		
Check - total depth		65.555	101.422	159.715	77.732	122.617	195.153
Check - peak		10.936	16.102	23.840	14.378	21.545	32.205
Time (10 minute intervals)		2 Year	10 Year	100 Year	2 Year	10 year	100 Year
01Jan2000, 00:00	0						
01Jan2000, 00:10	0.17	0.151	0.241	0.396	0.153	0.250	0.413
01Jan2000, 00:20	0.33	0.151	0.241	0.396	0.153	0.250	0.413
01Jan2000, 00:30	0.50	0.151	0.241	0.396	0.153	0.250	0.413
01Jan2000, 00:40	0.67	0.151	0.241	0.396	0.153	0.250	0.413
01Jan2000, 00:50	0.83	0.151	0.241	0.396	0.153	0.250	0.413
01Jan2000, 01:00	1.00	0.151	0.241	0.396	0.153	0.250	0.413
01Jan2000, 01:10	1.17	0.151	0.241	0.396	0.153	0.250	0.413
01Jan2000, 01:20	1.33	0.151	0.241	0.396	0.153	0.250	0.413
01Jan2000, 01:30	1.50	0.151	0.241	0.396	0.153	0.250	0.413
01Jan2000, 01:40	1.67	0.151	0.241	0.396	0.153	0.250	0.413
01Jan2000, 01:50	1.83	0.151	0.241	0.396	0.153	0.250	0.413
01Jan2000, 02:00	2.00	0.151	0.241	0.396	0.153	0.250	0.413
01Jan2000, 02:10	2.17	0.151	0.241	0.396	0.153	0.250	0.413
01Jan2000, 02:20	2.33	0.151	0.241	0.396	0.153	0.250	0.413
01Jan2000, 02:30	2.50	0.151	0.241	0.396	0.153	0.250	0.413
01Jan2000, 02:40	2.67	0.151	0.241	0.396	0.153	0.250	0.413
01Jan2000, 02:50	2.83	0.151	0.241	0.396	0.153	0.250	0.413



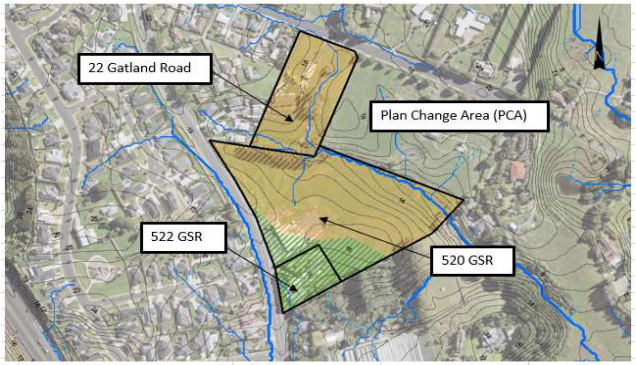
Northern sub-catchment (A)

	Total area m²	Pervious area m²	Impervious area m²	% Impervious	Weighted curve number	Weighted Ia
Sub-catchment A Total Existing	98,126	68,172	29,954	30.5	85.49	
Sub-catchment A Total Proposed	102,847	47,898	54,949	53.4	89.62	
Existing						
Cemetery ED & MPD	23,535	22,420	1,115	4.7	80.85	
Residential 1 ED & MPD	19,850	7,940	11,910	60.0	90.80	
Residential 2 ED & MPD	3,250	3,097	153	4.7	80.85	
Road & footpath (outside PCA)	13,907	-	13,907	100.0	98.00	
	60,542	**33,457**	**27,085**		**88.05**	2.76
21 Gatland Road existing	12,115	10,615	1,500	12.4	82.23	
520 Great South Road existing (partial)	24,100	24,100	-	0.0	80.00	
Road & footpath (inside PCA)	1,369	-	1,369	100.0	98.00	
	37,584	**34,715**	**2,869**	**112**	**81.37**	4.62
Proposed						
Cemetery ED & MPD	23,535	22,420	1,115	4.7	80.85	
Residential 1 ED & MPD	19,850	7,940	11,910	60.0	90.80	
Residential 2 ED & MPD	3,250	3,097	153	4.7	80.85	
Road & footpath (outside PCA)	13,907	-	13,907	100.0	98.00	
	60,542	**33,457**	**27,085**		**88.05**	2.76
21 Gatland Road	12,115	4,135	7,980	65.9	91.86	
520 GSR (Lots)	15,452	3,863	11,589	75.0	93.50	
520 GSR (pervious areas)	6,442	6,442	-	0.0	80.00	
520 GSR (paved footpath/road)	8,296	-	8,296	100.0	98.00	
	42,305	**14,440**	**27,865**		**91.86**	1.71

Southern sub-catchment (B)

	Total area m²	Pervious area m²	Impervious area m²	% Impervious	Weighted curve number	Weighted Ia
Sub-catchment B Total Existing	8,721	5,633	3,088	35	86.37	
Sub-catchment B Total Proposed	4,000	1,360	2,640	-	91.88	
Existing						
520 GSR + 522 GSR	8,721	5,633	3,088	35.4	86.37	
	8,721	**5,633**	**3,088**	**35**	**86.37**	3.23
Proposed						
522 GSR	4,000	1,360	2,640	66.0	91.88	
	4,000	**1,360**	**2,640**		**91.88**	1.70

Total imperviousness of 520 GSR = 66%



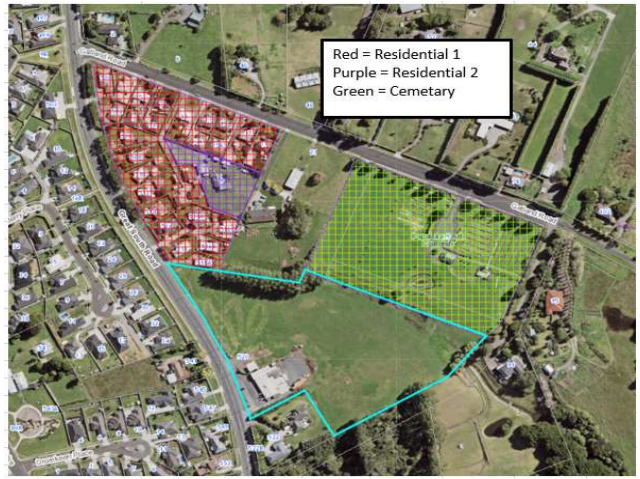
	Pervious area m²	Impervious area m²	Total area m²	
Existing	73,805	33,042	106,847	**31%**
Proposed	49,258	57,589	106,847	**54%**

Latest masterplan recieved from client saved here:
1009613.1000 GSR Master Plan dated 03042020

Note 1:
Based on the latest proposed development masterplan, the impervious coverage within in a given Lot ranges from 60% for spacious end sections to 85% for narrow terrace sections. For this calculation, the average lot impervious is assumed to be 75%.

Note 2:
For properties within the PCA but not included in the proposed development masterplan, an average imperviousness of 66% has been used. This is based on the total imperviousness % of the 520 GSR property

Note 3:
It is assumed all runoff within 520 Great South road will discharge to Watercourse A in the post-development case. This means an additional 4,721 m2 of 520 Great South Road will be catered for in sub-catchment A.



Runoff Hydrographs from the Northern Catchment extracted from HEC HMS model

Design Storm		2 Year		10 Year		100 Year	
Peak flow		0.791	1.368	1.390	2.283	2.326	3.649
Volume		3626	5587	6696	9948	12029	17206
Date	Time	Pre-development	Post-development	Pre-development	Post-development	Pre-development	Post-development
1-Jan-00	0:00	0.000	0.000	0.000	0.000	0.000	0.000
1-Jan-00	0:01	0.000	0.000	0.000	0.000	0.000	0.000
1-Jan-00	0:02	0.000	0.000	0.000	0.000	0.000	0.000
1-Jan-00	0:03	0.000	0.000	0.000	0.000	0.000	0.000
1-Jan-00	0:04	0.000	0.000	0.000	0.000	0.000	0.000
1-Jan-00	0:05	0.000	0.000	0.000	0.000	0.000	0.000
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1-Jan-00	0:08	0.000	0.000	0.000	0.000	0.000	0.000
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1-Jan-00	0:26	0.000	0.000	0.000	0.000	0.000	0.000
1-Jan-00	0:27	0.000	0.000	0.000	0.000	0.000	0.000
1-Jan-00	0:28	0.000	0.000	0.000	0.000	0.000	0.000
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1-Jan-00	0:30	0.000	0.000	0.000	0.000	0.000	0.000
1-Jan-00	0:31	0.000	0.000	0.000	0.000	0.000	0.000
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1-Jan-00	0:46	0.000	0.000	0.000	0.000	0.000	0.000
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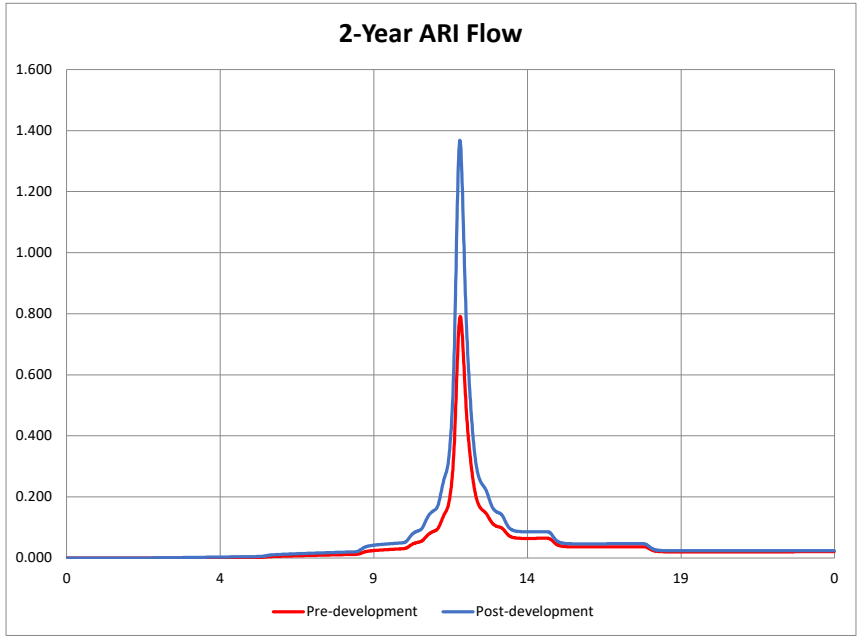
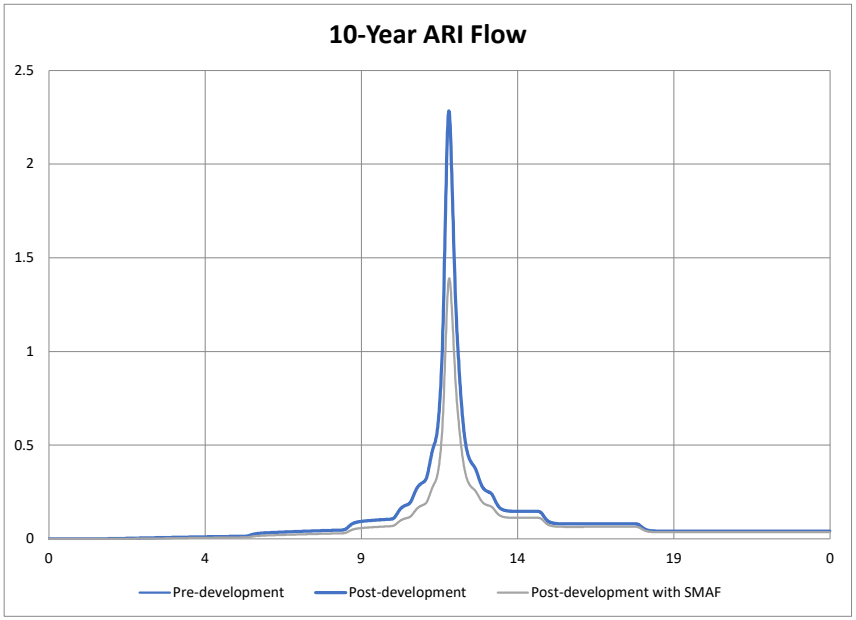
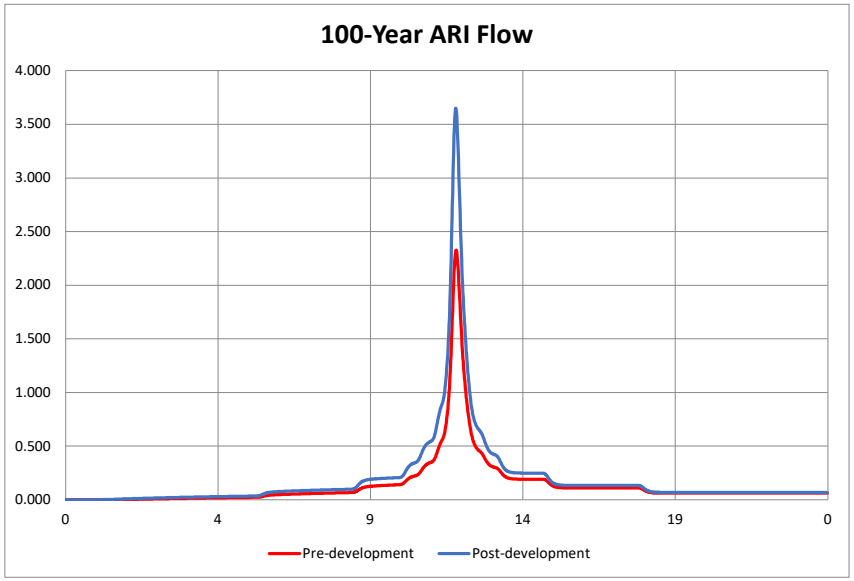


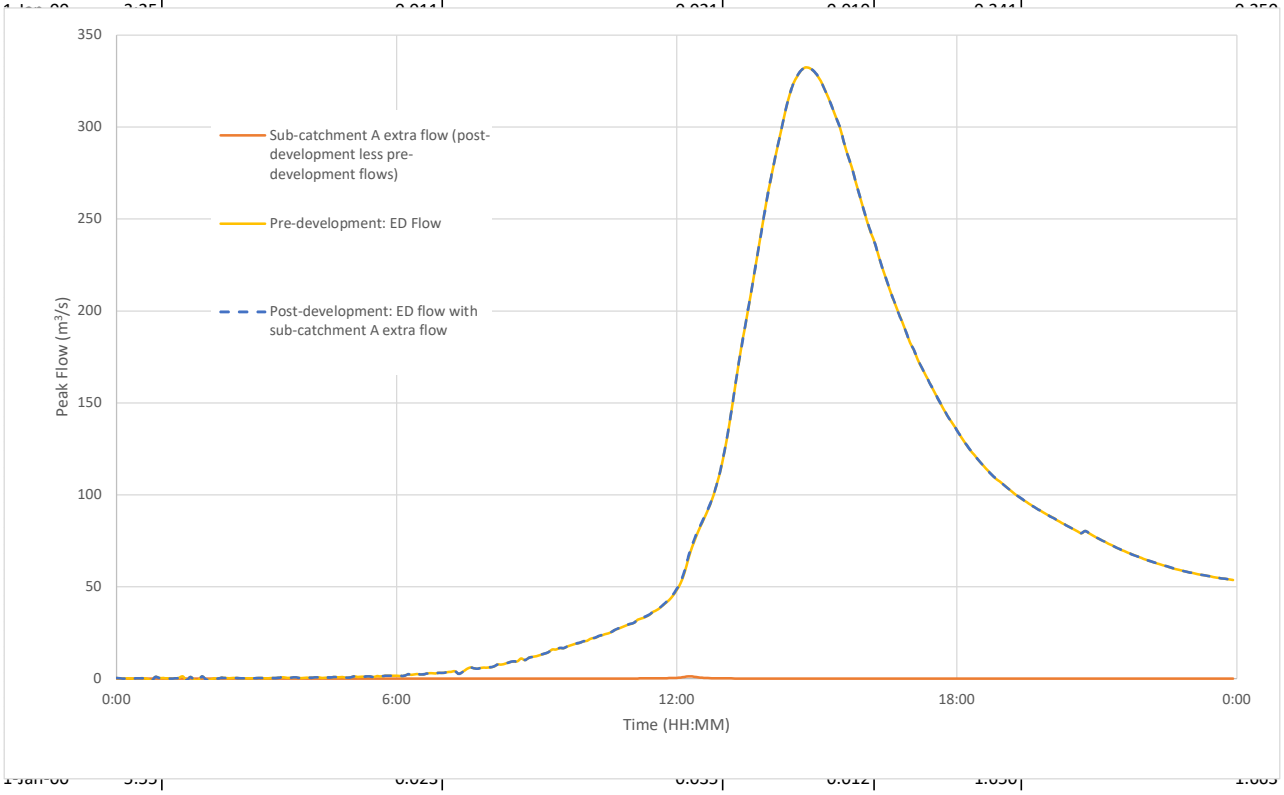


1-Jan-00	0:50	0.000	0.000	0.000	0.000	0.000	0.000
1-Jan-00	0:51	0.000	0.000	0.000	0.000	0.000	0.000
1-Jan-00	0:52	0.000	0.000	0.000	0.000	0.000	0.000
1-Jan-00	0:53	0.000	0.000	0.000	0.000	0.000	0.000
1-Jan-00	0:54	0.000	0.000	0.000	0.000	0.000	0.000
1-Jan-00	0:55	0.000	0.000	0.000	0.000	0.000	0.000
1-Jan-00	0:56	0.000	0.000	0.000	0.000	0.000	0.000
1-Jan-00	0:57	0.000	0.000	0.000	0.000	0.000	0.000
1-Jan-00	0:58	0.000	0.000	0.000	0.000	0.000	0.000
1-Jan-00	0:59	0.000	0.000	0.000	0.000	0.000	0.000
1-Jan-00	1:00	0.000	0.000	0.000	0.000	0.000	0.001
1-Jan-00	1:01	0.000	0.000	0.000	0.000	0.000	0.001
1-Jan-00	1:02	0.000	0.000	0.000	0.000	0.000	0.001
1-Jan-00	1:03	0.000	0.000	0.000	0.000	0.000	0.001
1-Jan-00	1:04	0.000	0.000	0.000	0.000	0.000	0.001
1-Jan-00	1:05	0.000	0.000	0.000	0.000	0.000	0.001
1-Jan-00	1:06	0.000	0.000	0.000	0.000	0.000	0.001
1-Jan-00	1:07	0.000	0.000	0.000	0.000	0.000	0.001
1-Jan-00	1:08	0.000	0.000	0.000	0.000	0.000	0.001
1-Jan-00	1:09	0.000	0.000	0.000	0.000	0.000	0.001
1-Jan-00	1:10	0.000	0.000	0.000	0.000	0.000	0.001
1-Jan-00	1:11	0.000	0.000	0.000	0.000	0.000	0.002
1-Jan-00	1:12	0.000	0.000	0.000	0.000	0.000	0.002
1-Jan-00	1:13	0.000	0.000	0.000	0.000	0.000	0.002
1-Jan-00	1:14	0.000	0.000	0.000	0.000	0.000	0.002
1-Jan-00	1:15	0.000	0.000	0.000	0.000	0.000	0.002



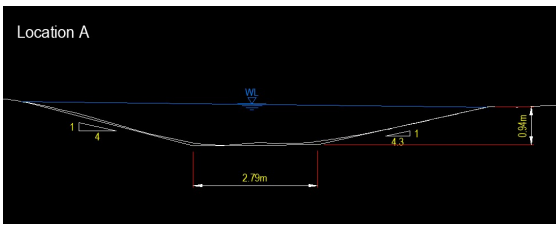
100 Year runoff at Great South Road Bridge

		HEC HMS outputs			From AC models	
Date	Time	Pre-development	Post-development	Extra flow	ED at GSR Bridge	ED at GSR Bridge + Extra Flow
1-Jan-00	0:00	0.000	0.000	0.000	0.377	0.377
1-Jan-00	0:05	0.000	0.000	0.000	0.219	0.219
1-Jan-00	0:10	0.000	0.000	0.000	0.079	0.079
1-Jan-00	0:15	0.000	0.000	0.000	0.287	0.287
1-Jan-00	0:20	0.000	0.000	0.000	0.027	0.027
1-Jan-00	0:25	0.000	0.000	0.000	0.232	0.232
1-Jan-00	0:30	0.000	0.000	0.000	0.270	0.270
1-Jan-00	0:35	0.000	0.000	0.000	0.276	0.276
1-Jan-00	0:40	0.000	0.000	0.000	-0.119	-0.119
1-Jan-00	0:45	0.000	0.000	0.000	-1.011	-1.011
1-Jan-00	0:50	0.000	0.000	0.000	0.985	0.985
1-Jan-00	0:55	0.000	0.000	0.000	0.405	0.405
1-Jan-00	1:00	0.000	0.001	0.001	0.330	0.331
1-Jan-00	1:05	0.000	0.001	0.001	0.219	0.220
1-Jan-00	1:10	0.000	0.001	0.001	0.020	0.022
1-Jan-00	1:15	0.000	0.002	0.002	0.191	0.193
1-Jan-00	1:20	0.000	0.003	0.002	0.393	0.395
1-Jan-00	1:25	0.000	0.003	0.003	1.207	1.210
1-Jan-00	1:30	0.001	0.004	0.004	-0.818	-0.814
1-Jan-00	1:35	0.001	0.005	0.004	0.916	0.921
1-Jan-00	1:40	0.001	0.006	0.005	-0.686	-0.681
1-Jan-00	1:45	0.002	0.007	0.005	-0.856	-0.851
1-Jan-00	1:50	0.002	0.008	0.005	1.234	1.239
1-Jan-00	1:55	0.003	0.008	0.006	-0.362	-0.356
1-Jan-00	2:00	0.003	0.009	0.006	-0.598	-0.591
1-Jan-00	2:05	0.003	0.010	0.007	0.196	0.202
1-Jan-00	2:10	0.004	0.011	0.007	0.060	0.067
1-Jan-00	2:15	0.004	0.012	0.007	0.507	0.514
1-Jan-00	2:20	0.005	0.012	0.008	0.375	0.382
1-Jan-00	2:25	0.005	0.013	0.008	0.261	0.269
1-Jan-00	2:30	0.006	0.014	0.008	0.473	0.481
1-Jan-00	2:35	0.006	0.015	0.008	0.327	0.336
1-Jan-00	2:40	0.007	0.015	0.008	0.218	0.226
1-Jan-00	2:45	0.007	0.016	0.009	0.266	0.274
1-Jan-00	2:50	0.008	0.017	0.009	0.285	0.294
1-Jan-00	2:55	0.008	0.017	0.009	0.203	0.212
1-Jan-00	3:00	0.009	0.018	0.009	0.319	0.329
1-Jan-00	3:05	0.009	0.019	0.009	0.455	0.464
1-Jan-00	3:10	0.010	0.019	0.009	0.213	0.222
1-Jan-00	3:15	0.010	0.020	0.010	0.247	0.257
1-Jan-00	3:20	0.011	0.021	0.010	0.342	0.352



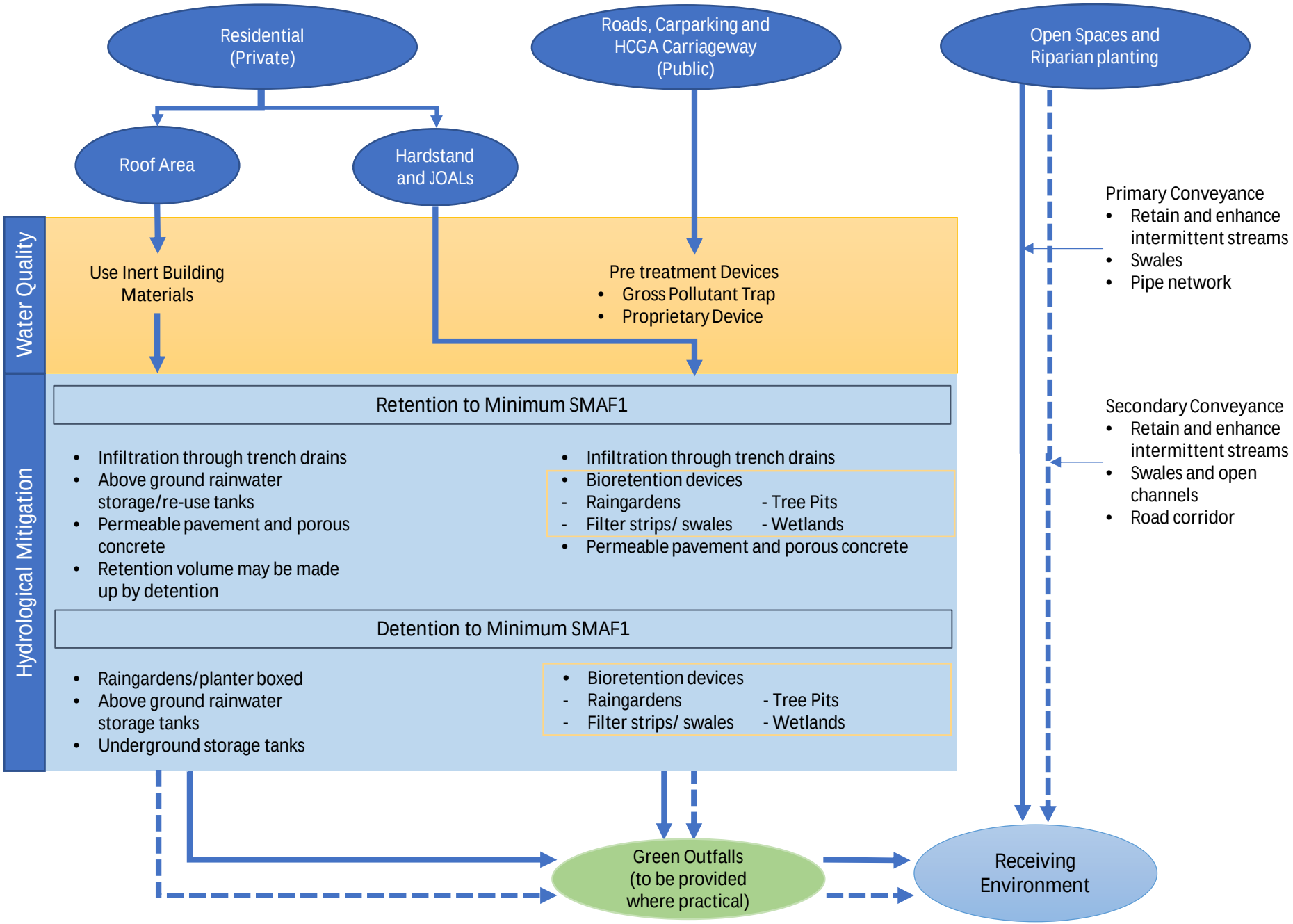
Slippery Creek Discharge point

	Input parameters	
	Pre-development	Post-development
Longitudinal slope S	0.01	
Mannings roughness n	0.04	
Side slope 1:X_1	1.5	
Side slope 1:X_2	1.5	
Bottom Width B	6	
Critical shear stress Ts	32.6	



	2 Year Pre-development					
TIME	CHANNEL FLOW	NORMAL DEPTH	BOUNDARY SHEAR (ds)	BOUNDARY SHEAR (R)	EXCESS SHEAR (dS)	EXCESS SHEAR (RS)
t	Q	d	t_o	t_o	t_e	t_e
minutes	m^3/s	m	Pa	Pa	gamma DS	gamma RS
Peak shear stress	0.79	0.17	16.47	15.59	0.51	0.48
<1					1440	1440
>1 & <2					0	0
>2 & <10					0	0
>10					0	0
0:00	0.00	0.000	0.00	0.00	0.00	0.00
0:01	0.00	0.000	0.00	0.00	0.00	0.00
0:02	0.00	0.000	0.00	0.00	0.00	0.00
0:03	0.00	0.000	0.00	0.00	0.00	0.00
0:04	0.00	0.000	0.00	0.00	0.00	0.00
0:05	0.00	0.000	0.00	0.00	0.00	0.00
0:06	0.00	0.000	0.00	0.00	0.00	0.00
0:07	0.00	0.000	0.00	0.00	0.00	0.00
0:08	0.00	0.000	0.00	0.00	0.00	0.00
0:09	0.00	0.000	0.00	0.00	0.00	0.00
0:10	0.00	0.000	0.00	0.00	0.00	0.00
0:11	0.00	0.000	0.00	0.00	0.00	0.00
0:12	0.00	0.000	0.00	0.00	0.00	0.00
0:13	0.00	0.000	0.00	0.00	0.00	0.00
0:14	0.00	0.000	0.00	0.00	0.00	0.00
0:15	0.00	0.000	0.00	0.00	0.00	0.00
0:16	0.00	0.000	0.00	0.00	0.00	0.00
0:17	0.00	0.000	0.00	0.00	0.00	0.00
0:18	0.00	0.000	0.00	0.00	0.00	0.00
0:19	0.00	0.000	0.00	0.00	0.00	0.00
0:20	0.00	0.000	0.00	0.00	0.00	0.00
0:21	0.00	0.000	0.00	0.00	0.00	0.00
0:22	0.00	0.000	0.00	0.00	0.00	0.00
0:23	0.00	0.000	0.00	0.00	0.00	0.00
0:24	0.00	0.000	0.00	0.00	0.00	0.00
0:25	0.00	0.000	0.00	0.00	0.00	0.00
0:26	0.00	0.000	0.00	0.00	0.00	0.00
0:27	0.00	0.000	0.00	0.00	0.00	0.00
0:28	0.00	0.000	0.00	0.00	0.00	0.00
0:29	0.00	0.000	0.00	0.00	0.00	0.00
0:30	0.00	0.000	0.00	0.00	0.00	0.00
0:31	0.00	0.000	0.00	0.00	0.00	0.00
0:32	0.00	0.000	0.00	0.00	0.00	0.00
0:33	0.00	0.000	0.00	0.00	0.00	0.00
0:34	0.00	0.000	0.00	0.00	0.00	0.00
0:35	0.00	0.000	0.00	0.00	0.00	0.00
0:36	0.00	0.000	0.00	0.00	0.00	0.00
0:37	0.00	0.000	0.00	0.00	0.00	0.00
0:38	0.00	0.000	0.00	0.00	0.00	0.00
0:39	0.00	0.000	0.00	0.00	0.00	0.00
0:40	0.00	0.000	0.00	0.00	0.00	0.00
0:41	0.00	0.000	0.00	0.00	0.00	0.00
0:42	0.00	0.000	0.00	0.00	0.00	0.00
0:43	0.00	0.000	0.00	0.00	0.00	0.00
0:44	0.00	0.000	0.00	0.00	0.00	0.00
0:45	0.00	0.000	0.00	0.00	0.00	0.00
0:46	0.00	0.000	0.00	0.00	0.00	0.00
0:47	0.00	0.000	0.00	0.00	0.00	0.00
0:48	0.00	0.000	0.00	0.00	0.00	0.00
0:49	0.00	0.000	0.00	0.00	0.00	0.00
0:50	0.00	0.000	0.00	0.00	0.00	0.00
0:51	0.00	0.000	0.00	0.00	0.00	0.00
0:52	0.00	0.000	0.00	0.00	0.00	0.00
0:53	0.00	0.000	0.00	0.00	0.00	0.00

Appendix C1: Proposed stormwater management


Residential (Private)
Roads, Carparking and HCGA Carriageway (Public)
Open Spaces and Riparian planting
Roof Area
Hardstand and JOALs
Water Quality
Use Inert Building Materials
Pre treatment Devices
• Gross Pollutant Trap
• Proprietary Device
Primary Conveyance
• Retain and enhance intermittent streams
• Swales
• Pipe network
Hydrological Mitigation
Retention to Minimum SMAF1
• Infiltration through trench drains
• Above ground rainwater storage/re-use tanks
• Permeable pavement and porous concrete
• Retention volume may be made up by detention
• Infiltration through trench drains
• Bioretention devices
- Raingardens - Tree Pits
- Filter strips/ swales - Wetlands
• Permeable pavement and porous concrete
Secondary Conveyance
• Retain and enhance intermittent streams
• Swales and open channels
• Road corridor
Detention to Minimum SMAF1
• Raingardens/planter boxed
• Above ground rainwater storage tanks
• Underground storage tanks
• Bioretention devices
- Raingardens - Tree Pits
- Filter strips/ swales - Wetlands
Green Outfalls (to be provided where practical)
Receiving Environment

Activity	Component	Minimum requirements	Recommended approaches	Guidelines
Residential lots – Roof Area	Hydrological mitigation only	Retention of at least 5 mm of runoff depth from impervious surfaces. Detention and a drain down period of 24 hours for the difference between the pre-development and post-development runoff volumes from a 95th percentile, 24-hour rainfall event minus the achieved retention volume, over the impervious area for which hydrology mitigation is required.	• Infiltration through trench drains • Above ground rainwater storage/re-use tanks • Permeable pavement and porous concrete • Raingardens/planter boxed • Underground storage tanks	• Auckland Council GD01
Residential lots – Hardstand and jointly owned access lanes Roads, Carparking and HCGA Carriageway	Water quality Hydrological mitigation	Stormwater management of runoff from all impervious surfaces before discharging into the receiving environment. Minimise the generation of contaminants as much as possible. Where contaminants are generated, the preferred approach is to use green infrastructure to treat runoff at-source or as close to the source as practicable. Retention of at least 5 mm of runoff depth from impervious surfaces. Detention and a drain down period of 24 hours for the difference between the pre-development and post-development runoff volumes from a 95th percentile, 24-hour rainfall event minus the achieved retention volume, over the impervious area for which hydrology mitigation is required.	• Pre-treatment Devices - Gross Pollutant Trap - Proprietary Device • Infiltration through trench drains • Bioretention devices - Raingardens - Tree Pits - Filter strips/ swales - Wetlands • Permeable pavement and porous concrete	• Auckland Council GD01 • Auckland Council GD04 • Auckland Council Unitary Plan stormwater management provisions TR2013/35
Public spaces only i.e. Roads, Carparking, HCGA Carriageway, Open Spaces and Riparians	Stormwater conveyance	Convey runoff generated from the 10 year ARI through a public piped stormwater network. Allowance for runoff flows greater than the 10 year ARI should be made in overland flow paths. Existing overland flow paths should be protected.	**Primary Conveyance** • Retain and enhance intermittent streams • Swales • Pipe network **Secondary Conveyance** • Retain and enhancestreams • Swales and open channels • Road corridor	• Auckland Council GD01 • Auckland Council GD04 • Auckland Council Stormwater Code of Practice
Open Spaces and Riparians	Stream hydrology and erosion protection	Enhance water quality, flows, stream channels and their margins and other freshwater values where the current condition is below the relevant thresholds.	• Green outfall (where practicable) • Riparian margin enhancement and planting	• Auckland Council GD01 • Auckland Council TR2013/018 • Assessment of Ecological Effects

Appendix C2: Stormwater management selection process

Not applicable within this SMP

Appendix D1: Draft operation and maintenance

Not applicable within this SMP

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