Amberfield Development, Peacocke Structure Plan Area, Hamilton

Sub-catchment Integrated Management Plan

2 July 2018

AWA
ENVIRONMENTAL

Prepared by Awa Environmental Limited

for Weston Lea Ltd

Amberfield Development, Peacocke Structure Plan Area, Hamilton

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ABBREVIATIONS

CSDC	HCC Comprehensive Stormwater Discharge Consent
GRMP	HCC Gully Reserves Management Plan
HCC	Hamilton City Council
ICMP	Integrated Catchment Management Plan
ITS	HCC ITS
LOS	Levels of service
ODP	HCC Operative District Plan
PDP	HCC Proposed District Plan
Proj Water Watershed)	Waikato River Catchment Services – Level of Service and Funding Policy (Project
PRPS	WRC Proposed Regional Policy Statement
RPS	WRC Regional Policy Statement
RRMP	HCC Riverside Reserves Management Plan
SP	Structure Plan
Sust Strat	HCC Environmental Sustainability Strategy
SWMP	HCC Stormwater Management Plan
WDC	Waikato District Council
WRA	Waikato-Tainui Raupatu Claims (Waikato River) Settlement Act
WRC	Waikato Regional Council
WRP	Waikato Regional Plan

Executive Summary

This document is the sub-catchment Integrated Catchment Management Plan (ICMP) for the Amberfield development, which covers an area of approximately 105 hectares, being undertaken by Weston Lea Ltd, in the Peacocke Structure Plan Area (SPA). The catchment area falls under the Hamilton City Council territorial authority in the Waikato Region, for which Best Practicable Options (BPOs) have been developed in compliance with relevant HCC policy documents. The sub-catchment boundary extent has been defined in consultation with Hamilton City Council representing a hydrologically discrete catchment within Stage 2 of the wider Peacocke SPA extent. This sub-catchment ICMP will eventually be incorporated into a full Peacocke ICMP document.

This ICMP focuses on an integrated approach to three waters management, incorporating stormwater, wastewater and watersupply systems in a way that minimises the impact of development and enhances the surrounding natural environment.

General objectives for three waters management in the Waikato region include;

- Environmental: groundwater recharge through soakage, groundwater protection from contamination, stream water quality enhancement, ecological enhancement, minimisation of natural flow alteration, consistent water sensitive practices incorporation, water demand reduction and re-use;
- Economic: regard of economic affordability, cost-efficiency, minimisation of future maintenance;
- Cultural: protection and promotion of cultural values; and
- Social: flood protection, public safety management.

The Peacocke Structure Plan (SP) and Hamilton City Council (HCC) Operative District Plan (ODP) are two key planning documents referred to during the development of catchment-specific strategic objectives and opportunities for the Amberfield site.

Site investigations have been undertaken by a range of technical experts and compiled into a series of technical reports. The results of these reports have enabled the consideration of options for implementation of solutions in an urban planning context. Geotechnical analysis has shown the soil across the site to have consistently good soakage potential, which lead to the preliminary proposal of soakage as an efficient and sustainable stormwater solution.

This sub-catchment ICMP summarises all report findings that are relevant to catchment management and draws these together, with master planning for the development, to resolve any identified issues in sustainable management of the site. Freshwater ecology, terrestrial ecology, water quality and archaeological investigations have identified areas to be addressed to mitigate development impact, and these findings have been incorporated into the best practicable outcomes for this management plan.

Preliminary three water management solutions were presented at a best practicable options workshop with relevant stakeholder attendees, where a number of issues were raised regarding mitigation of environmental effects and roading. As a result, the solution presented in this sub-catchment ICMP proposes appropriate mitigation measures for the identified environmental impacts of development and outlines a revised approach to road cross sections in the context of stormwater design.

The catchment has a unique topography and location in the future urban development zone of Hamilton City, which informed the development's masterplan under the Peacocke SP. Being a greenfield site, infrastructure options have been assessed based on existing infrastructure in the area and by taking the HCC Long Term Infrastructure Strategy and Waikato Regional Council's (WRC) long term plans into account. The current rural nature of the site offers opportunities for three waters infrastructure to be developed sustainably and managed in integrated ways by following HCC's established hierarchy of options. All infrastructure BPO's achieve compliance by responding directly to requirements within the Hamilton City Council Infrastructure Technical Specifications (HCC ITS).

The final best practicable options detailed in this report (Section 14) synthesise the process of engagement and consultation into several mitigation actions to achieve desirable outcomes for the Amberfield development. Implementation of this sub-catchment ICMP will occur throughout the construction of the residential development, where all stages of design, construction, operation and maintenance will be compliant with the resource consents granted for the development and the conditions of the consent are expected to reflect the BPO's and mitigation measures detailed in this report. The desired outcomes and any additional considerations generated during the resource consent approval process will be incorporated into the resource consent conditions and the subsequent detailed design and on-site construction.

It is expected that this sub-catchment ICMP will undergo periodic review to maintain relevance to national, regional and local policy. It is also recognised that monitoring of possible changes within the sub-catchment will be required as the development progresses.

1 Framework

1.1 Purpose

This document is a sub-catchment Integrated Catchment Management Plan (ICMP) focused on the Amberfield development of approximately 105 hectares within the Peacocke SPA. The great majority of the sub-catchment area, defined in Figure 1, falls within a single land holding owned by The Adare Company Ltd. Weston Lea Ltd is the development company and is progressing the Amberfield development.

The Amberfield sub-catchment ICMP is part of the wider Peacocke ICMP catchment. This area has long been identified as an urban growth zone for Hamilton City, so growth associated with the Amberfield development has been considered in future development planning by Hamilton City Council (HCC).

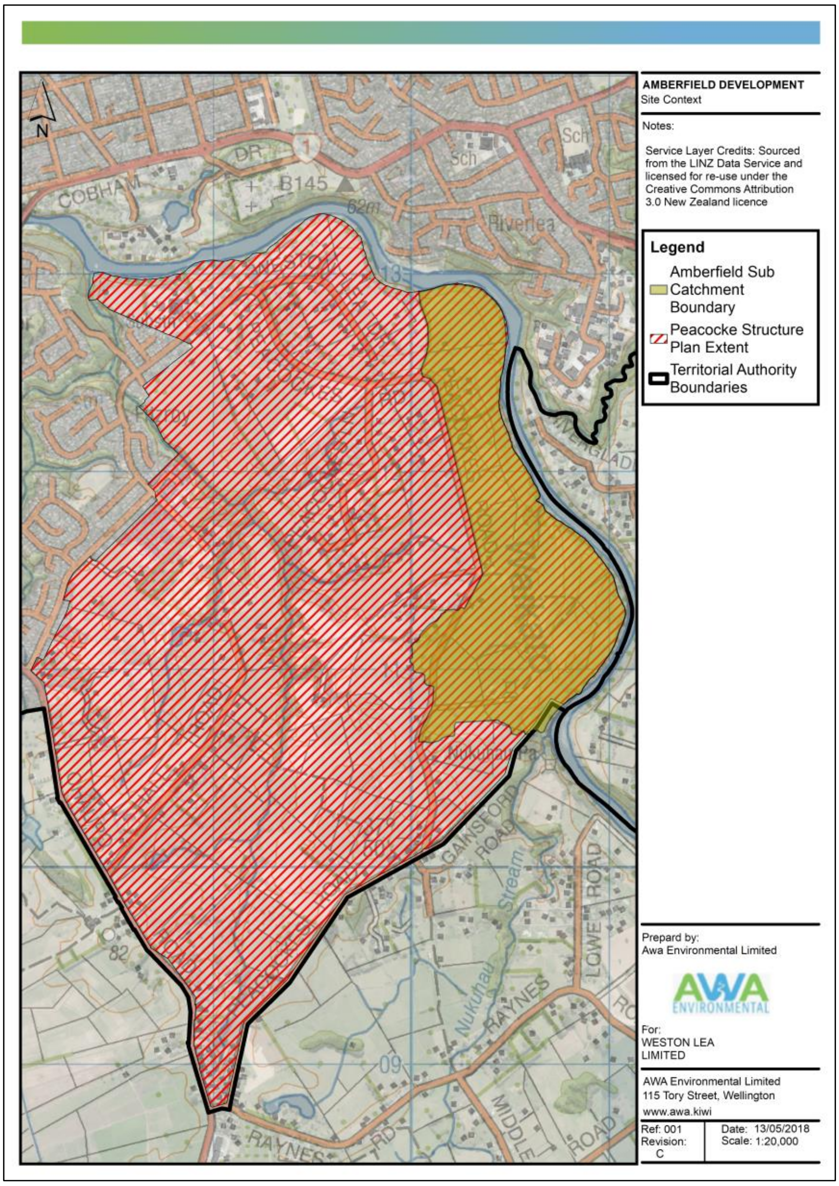


Figure 1 Amberfield sub-catchment overview

The sub-catchment ICMP has been developed for the following purposes;

a) To allow for the Amberfield development, comprising approximately 105-hectare land holding shown in Figure 1, for approximately 1000 residential lots, a future neighbourhood centre and associated reserves and roading on the site within the Peacocke SPA ahead of the development of a full catchment ICMP;

b) To provide an integrated management approach based upon the best practicable option to avoid as far as practicable and otherwise minimise the cumulative adverse effects of all new stormwater diversion and discharge activities in developing catchments;

c) To meet conditions of the Comprehensive Stormwater Discharge Consent (CSDC) number 105279 issued by Environment Waikato (now called Waikato Regional Council (WRC)). Specifically, this includes meeting requirements of conditions 3(a) which requires new stormwater activities to be consistent with all conditions of the CSDC;

d) To describe the proposed approach for how watersupply, wastewater and stormwater management in the catchment can accommodate growth in a staged and integrated manner in accordance with proposed land-uses;

e) To ensure that the Level of Service (LOS) of the existing three waters networks are not compromised; and

f) To provide a platform for considering the implementation of water sensitive devices to reduce demand for water, minimise wastewater generation and minimise the need for three waters infrastructure where appropriate.

This sub-catchment ICMP will eventually be incorporated into a full Peacocke ICMP document, and on-going decision making will be required for integrated management of the three waters infrastructure in the wider catchment.

This sub-catchment ICMP will undergo periodic review, by Weston Lea Ltd, to maintain relevance to national, regional and local policy. It is also recognised that monitoring of possible changes within the sub-catchment will be required as the development progresses.

1.1.1 Key Infrastructure Projects

Roading

Arterial roads in the Peacocke SPA have been incorporated into the future Southern Links projects, which will improve links to SH1 and SH3 and increase connectivity between the Peacocke SPA and the wider Hamilton region.

Wastewater

The HCC long-term infrastructure strategy 2015-2045 defines the future direction of the bulk wastewater network within the city. This document illustrates the council's intention to extend the Far eastern Interceptor south to service the Peacocke SPA, which would require a transfer pump station and reticulation infrastructure.

Watersupply

The HCC long-term infrastructure strategy 2015-2045 defines the future direction of the bulk water supply network within the city. This document illustrates the council's intention to accommodate future growth by extending new bulk mains from the existing water treatment plant south to the Peacocke SPA, connecting to the Hamilton South Reservoir. The HCC reticulation network will be extended progressively to service growth within the sub-catchment and the wider Peacocke SPA.

1.2 Report Structure

This report is structured into four specific sections;

Section 1 – Chapter 1 provides the policy and planning context for the sub-catchment ICMP document and defines the objectives of the plan;

Section 2 – Chapters 2 – 13 provide a summary of the initial technical assessments for the property;

Section 3 – Chapter 14 describes the development of the best practicable option to meet the objectives of the sub-catchment ICMP document and assesses the effects and mitigation requirements for this option; and

Section 4 – Chapter 15 provides the structure for the implementation of the sub-catchment ICMP plan.

1.3 Strategic Context

The key planning documents relevant to catchment management planning in the Waikato Region are discussed in this section. Their hierarchy is demonstrated in Figure 2. This sub-catchment falls under the Peacocke SP and is part of an area that has been planned and zoned for Hamilton's future urban growth. It is influenced by plans and policies at national, regional and local levels.

This sub-catchment ICMP and its prescribed best practicable options (BPOs) predominately focuses on mitigation of the adverse effects associated with the proposed land-use changes due to development. It includes best practicable options for watersupply, wastewater and stormwater infrastructure, management of receiving environments and connectivity across the wider Peacocke SPA.

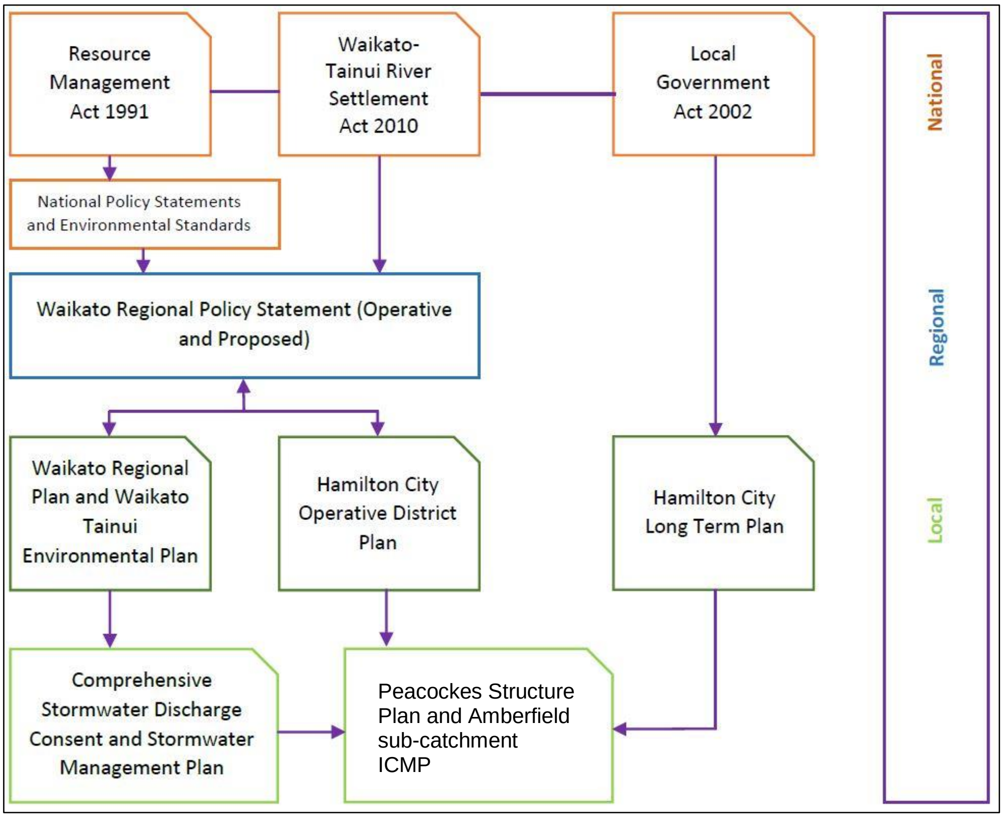


Figure 2 Planning document hierarchy and linkages

1.3.1 National Legislation

Resource Management Act 1991

The Resource Management Act is the primary reference for environmental management in New Zealand. It promotes sustainable management as a framework to prioritise ecological considerations and integrate the management of air, land, freshwater and marine environments. Public participation in decision-making is also a key priority. Communities are encouraged to provide for their social, economic and cultural well-being while sustaining natural and physical resources, safe-guarding the life-supporting capacity of air, water and soil ecosystems and avoiding, remedying or mitigating any adverse effects of activities on the environment.

Regarding stormwater, the act states that no person may discharge any contaminant or water into water or onto land unless the discharge is expressly allowed by a national environmental standard, a regional plan rule or a resource consent. It also stipulates that activities regarding water must not have an adverse effect on the environment.

Waikato-Tainui Raupatu Claims (Waikato River) Settlement Act 2010

The Waikato-Tainui Raupatu Claims (Waikato River) Settlement Act 2010 recognises the significance of the Waikato River to Waikato-Tainui and sets up arrangements for co-management of the river. The Act sets up Te Ture Whaimana o Te Awa, a Vision and Strategy relevant to all activities within its catchment with the purpose of "restoring and protecting the health and well-being of the Waikato River for future generations". It also provides for the preparation of an Integrated River Management Plan for the Waikato River and Waikato Tainui Environmental Plan. These documents are key policy documents for any development in the Waikato Region and aim to enhance Waikato-Tanui's role in environmental management.

1.3.2 Regional Policy

Waikato Regional Policy Statement

The Waikato Regional Policy Statement (RPS) is a long-term tool to outline the resource management issues of the region. It sets an overarching direction for the management and protection of Waikato's resources as well as objectives and policies for how these issues will be addressed. The RPS recognises the Waikato River's Te Tura Whaimana o Te Awa as the primary document for management of the Waikato River and promotes catchment-based approaches to water quality and freshwater biodiversity. In 2016 the second generation of the RPS became operative. It stipulates the importance of classifying waterways and assessing their ecological value to protect and restore the Waikato River and its tributaries. Any activities which could result in destabilisation of beds/banks of waterbodies, contaminant discharge, adverse effects on flora and fauna, loss of public access or adverse effect on cultural association of Waikato-Tainui with the Waikato River must be controlled. The RPS specifies the policy direction for the Hamilton District Plan.

Waikato Regional Plan

The Waikato Regional Plan (WRP) outlines issues, objectives, policies and implementation methods relevant to the sustainable management of resources in the Waikato Region. Water management is a key issue in the Waikato Region, the WRP includes requirements for efficient use of water, stormwater discharges and changes or disturbances to watercourses.

1.3.3 Local Policy

The Amberfield sub-catchment is situated in the Waikato Region to the south of Hamilton City and is entirely within the HCC territorial authority boundary.

Hamilton City District Plan

The Hamilton City District Plan became operative on 18 October 2017. It offers a framework for integrated resource management regarding the use, development or protection of land and associated natural and physical resources.

The District Plan provisions include requirements for the preparation of Integrated Catchment Management Plans, sub-catchment Integrated Catchment Management Plans and Water Impact Assessments. There are also provisions which set standards such as water efficiency, surface permeability, and building coverage. Together with the HCC Infrastructure Technical Specifications (ITS), the Hamilton District Plan is a key tool for on-going management within the Amberfield sub-catchment.

Peacocke Structure Plan

To cater for future urban growth, the currently rural Peacocke area was included in Hamilton City from the Waipa District Council in 1989. The Peacocke SP is included in the Hamilton City District Plan and prioritises ecological integrity, economic vitality, resource efficiency, accessibility, connectivity, legibility, identity and innovation.

Defining an overarching structure of new development in the area, the Peacocke SP has articulated staging requirements for a Stage 1 growth area which is now substantially developed but has not yet included Stage 2.

1.4 Key Stakeholder List

Key stakeholders for this sub-catchment ICMP include;

- The Adare Company Ltd (& Weston Lea Ltd)
- Hamilton City Council
- Waikato Regional Council
- Waikato-Tainui
- Te Haa o te whenua o Kirikiriroa (THaWK)
- Nga Mana Toopu o Kirikiriroa (NAMTOK)
- Department of Conservation
- Landowners

A detailed description of the consultation carried out for this sub-catchment ICMP, and for the resource consent application, is set out in Section 6 of the Application. However, an important element of the consultation with respect to this sub-catchment ICMP is the interaction and liaison with Waikato Regional Council, details of which are set out below.

Consultation has been undertaken with various departments within the WRC including the ecological, infrastructure, flood hazard and flood modelling teams. This consultation has taken the form of face to face meetings, phone presentations/conversations, site walkover and ongoing email conversations on various topics including proposed development approach, best practicable options assessment, freshwater ecology and flood hazard assessment associated with the Waikato River. The civil design team for the Amberfield development have also met with WRC to discuss design aspects of the proposed stormwater solutions.

Further consultation has been undertaken with affected landowners within the sub-catchment ICMP boundary as required by the District Plan. The District Plan requires, "*A list of the key stakeholders associated with the catchment (or sub-catchment), details of the consultation undertaken, and details of their respective views on providing for new stormwater diversion and discharge activities with the catchment (or sub-catchment)".*

Efforts have been made to consult all owners of land within the sub-catchment boundary as they have been identified as key stakeholders in the sub-catchment ICMP.

The majority of land within the sub-catchment ICMP boundary is owned by Adare. There are six titles which are all partially located within the sub-catchment area, all of which are located west of Peacockes Road to the south-west of the proposed development site. The six titles are owned by four different landowners. Despite best efforts, contact was unable to be made with one absentee landowner. However, all other landowners were successfully contacted and consultation meetings with them were held. A summary of responses provided at the consultation meetings are as follows;

- All of the landowners were generally supportive of development occurring and noted that it had been in the planning for Peacocke for a long time;
- All of the landowners were interested in the expected timeframes for the Adare development, particularly with respect to the extension of utility services and road upgrades along Peacockes Road;
- A landowner advised that some of the lower lying area of the northern part of her property on Peacockes Road floods. The area that she identified as being flood prone is in the Mangakotukutuku Catchment. She thinks the flooding is due to previous filling of a gully on the land holding to the north of her property which she considers has prevented natural drainage flows from her land to the gully. She also identified that stormwater from the Adare property backs up and floods through a culvert into her property following heavy rain;
- A landowner noted there have been traffic accidents along Peacockes Road in the vicinity of their property, including a fatality. They consider road improvements to be important as part of

the development to ensure safety, including addressing the existing substandard vertical geometry;

- A landowner is concerned at the potential for Peacockes Road to become a 'race track' for boy racers. She thinks that providing access to lots directly off Peacockes Road is likely to be unsafe;
- Two landowners consider that the development will worsen congestion at the intersections of Bader Street and Normandy Ave and Normandy Ave and Lorne Street. They both noted congestion is already bad at those intersections at peak periods. One said congestion at the intersection of Bader Street, Norrie Street and Peacockes Road is also bad at peak periods and they considers it is likely to get worse with the traffic from the proposed development added;
- A landowner thinks that lots down to 400m^2 are very small for single detached dwellings. They would prefer to see larger lots created as part of the subdivision.

The matters raised above are addressed within the resource consent application and within the supporting technical assessments.

1.5 Resource Consent Compliance

The Comprehensive Stormwater Discharge Consent (105279) issued and administered by Waikato Regional Council (WRC) for the urban catchments within Hamilton City authorises the discharge of stormwater from 'existing' developed areas subject to meeting resource consent conditions and for new developments in growth areas, meeting the requirements of any approved ICMP. HCC's water take consent has requirements for water demand management and HCC's wastewater discharge consent requires network management to avoid events such as wastewater overflows.

Section 2 of the application for resource consents for the Amberfield development sets out the specific consents required, including those relating to the discharge of stormwater from the site. This sub-catchment ICMP has been developed to satisfy condition 30 of the CSDC 105279. In accordance with condition 30, Table 1 shows where each requirement is addressed within this document.

a) Maps /drawings identifying for the relevant hydrological catchment (or sub-catchment):	Section
i. The catchment boundary; (Note: In the case of a full ICMP, this will be used in relation to determining future compliance with Rule 25.13.4.1(b));	1.1
ii. Natural features, surface water bodies, existing drainage systems and infrastructure;	4,7
iii. Existing development and land-uses (see f) vi below);	2.1
iv. Proposed future development and land-uses (see d) below); and	2.1
v. The extent of the infrastructure networks that have been assessed and the location of any network constraints (see f) vii below).	7.1,8.1,9.1
b) Classification of the surface water bodies within the catchment (or sub-catchment) as detailed in the Waikato Regional Plan.	4.1
c) A description of proposed urban growth, development and land-use intensification within the catchment (or sub-catchment).	2.1,11
d) A list of the key stakeholders associated with the catchment (or sub-catchment), details of the consultation undertaken, and details of their respective views on providing for new stormwater diversion and discharge activities with the catchment (or sub-catchment).	1.4
e) An assessment of the current state of the catchment (or sub-catchment) and	

stormwater receiving environment/s, and the provision of catchment baseline information (including maps/drawings) on:	
i. Topography;	6
ii. Soils and geology;	6
iii. Receiving environment	
a) Erosion;	6.3
b) Ecology, including ecological sensitivity;	4,5
c) Water quality (including contaminant load);	4.1
d) Sediment quality; and	4.1
e) Hydrology;	Appendix I
iv. Hydrogeology;	6.2
v. Flooding (including overland flow paths);	7.1
vi. Existing development and land-uses	2.1
vii. Existing three waters infrastructure and water source(s), including their capacity to appropriately service the proposed urban growth, development and land-use intensification within the catchment (or sub-catchment); and	14.5, 14.6
viii. All relevant existing resource use authorisations (including, for example, consents issued by the Waikato Regional Council for water take, wastewater and stormwater diversion and discharge activities).	
f) The effects of climate change.	7.1.2
g) An assessment of the environmental effects, including cumulative effects over time, of all proposed water take, wastewater management and stormwater diversion, and discharge activities on the catchment (or sub-catchment) and stormwater receiving environment/s. The assessment shall include maps/drawings and be in such detail as corresponds with the scale and significance of the effects on the catchment (or sub-catchment) including, but not limited to, effects on the following, taking into account the effects of climate change:	
i. Natural features, surface water bodies and aquifers, including water sources;	12
ii. Sites of cultural and/or historical significance;	12
iii. Public health;	12
iv. Flooding hazards, including overland flow;	12
v. Receiving water hydrology, including base flows and peak flows in rivers and streams and long-term aquifer levels;	4
vi. Receiving water sediment and water quality;	4
vii. Receiving water habitat, ecology and ecosystem health, including an explanation of how they will be maintained and enhanced;	4
viii. Receiving water riparian vegetation;	5
ix. The extent and quality of open stream channels, including erosion and sedimentation;	4

x. Fish passage for indigenous and trout fisheries (refer to the Waikato Regional Plan Water Management Classes for applicability); xi. The natural and amenity values of stormwater receiving waters, including the management of litter than becomes entrained in stormwater; xii. Existing infrastructure; and xiii. Existing resource use activities.	4 4
h) In response to the environmental effects assessment, a description and assessment of the available options for managing the effects of all proposed water take, wastewater management and stormwater diversion and discharge activities within the catchment (or sub-catchment).	14
i) Identification of a recommended integrated catchment management approach that is based on the Best Practicable Option to avoid as far as practicable and otherwise minimise or offset actual and potential adverse effects of all proposed water take, wastewater management and stormwater diversion, and discharge activities on the catchment (or sub-catchment) and its infrastructure, while ensuring the proposed urban growth, development and land-use intensification has an appropriate and sustainable water source and receives appropriate three-water services.	14
j) Maps/drawings, a description, and a prioritised schedule of the infrastructure works to be carried out to implement the integrated catchment management approach recommended in the ICMP.	14
k) Identification of the water sensitive techniques that are appropriate, and those that are unsuitable, within the catchment or any sub-catchment.	14
l) All ICMPs shall be of sufficient scope and detail to inform development of Water Impact Assessments.	

Table 1 Requirements

1.6 Three Waters Master Planning, Integration and Hierarchy

The term "three waters" refers to the 3 areas of strategic water management and their associated infrastructure, comprising;

a) Stormwater – rainwater that runs off a surface into streams, waterways, underground aquifers, rivers and eventually, far beyond Hamilton's boundaries, ends up in the sea;

b) Wastewater – liquid waste (including liquids containing waste solids) from domestic, industrial and commercial premises including toilet wastes, grey water and trade wastes; and

c) Watersupply – including drinking water and other water abstracted from the Waikato River, treated and used within the city, and water for firefighting purposes.

Three waters integration recognises that there is significant interaction between the three types of waters, surrounding natural water systems and land, and that it is beneficial to consider their interconnectedness. To ensure protection of the environment and the ongoing availability of services to growth areas, they need to be managed in integrated ways. The HCC ITS and ODP offer detailed information on the range of water sensitive techniques which are available for greenfield developments such as the Amberfield sub-catchment, to minimise the impact of development.

In the ODP, HCC has adopted a best-practice hierarchy for three waters management based on principles for sustainable resource management, environmental protection and efficiency. The development and implementation of BPO's should refer to the following hierarchy, which is also reflected in the ITS:

Minimise Demand (Water, wastewater) → Reuse (stormwater) → Treat & Dispose to Ground (stormwater) → Treatment & Detention (stormwater) → Reticulation (stormwater, wastewater)

Stormwater management in the Amberfield sub-catchment will be the primary focus of this report. The ideal stormwater system in a developed site is one that replicates the undeveloped scenario and mimics natural water flow and conditions as closely as possible.

1.7 Strategic Objectives

Policies and plans overseen by HCC influence any development within the Amberfield sub-catchment extent, as well as policies, plans and resource consent at central and regional government levels. As outlined in Section 1.2, the Waikato Regional Policy Statement ultimately defines policy requirements, iwi aspirations for the region and key issues to address regarding sustainable resource management. They are then put into practice and monitored by the Hamilton District Plan and Waikato Regional Plan.

The HCC's ODP has relevant rules regarding decisions and investigations in this sub-catchment ICMP in the following chapters;

- **Chapter 2** Strategic Framework (2.2.7, 2.2.8, 2.2.9)
- **Chapter 3** SPs (3.3.3, 3.3.6, 3.3.7)
- **Chapter 20** Natural Environments
- **Chapter 21** Waikato River Corridor and Gully Systems
- **Chapter 22** Natural Hazards
- **Chapter 23** Subdivision
- **Chapter 25.2** Earthworks and Vegetation Removal
- **Chapter 25.15** Three Waters

In particular, the entire **Chapter 3.4** of the Peacocke SP should be the primary reference document for zone-specific objectives and policies.

A review of several other ICMP documents informed the following issues as common areas of focus for catchment management in the Waikato region;

1. Erosion and instability of waterways
2. Water quality
3. Quality of riparian areas
4. Flooding and natural flow regime
5. Drainage in rural areas
6. Mauri of waterways
7. Water sensitivity
8. Ad hoc planning and development
9. Indigenous biodiversity

1.7.1 Generic Strategic Objectives

The following key strategic objectives for this sub-catchment ICMP have been derived from these national and regional planning policies and set the framework for urban development in the Amberfield sub-catchment area.

Strategic Objective 1

Where technically possible, development should incorporate a **natural environment-based system**. On-site management and disposal of stormwater is preferred. Key elements of this approach include avoiding or minimising impervious surfaces, minimising earthworks during construction, and utilising vegetation to assist in trapping sediments and pollutants. The focus of stormwater mitigation will be on rainfall retention, reuse, soakage and treatment ahead of detention and traditional piped systems.

Strategic Objective 2

Stormwater should as far as practicable be used to sustain groundwater levels and base flows in freshwater receiving environments and stormwater infrastructure should result in a hydrological cycle as close to the **pre-development hydrological cycle** as possible. The stormwater system shall utilise low impact design solutions and water sensitive techniques to replicate the pre-development hydrological regime.

Strategic Objective 3

The **quality of stormwater discharges** to the existing stormwater network should not pose a risk to human or ecosystem health and will assist with enhancement of the water quality in the receiving environment.

Strategic Objective 4

Stormwater is minimised, and stormwater discharges managed so as to avoid adverse effects on channel stability, rural drainage, and aquatic life supporting capacity, to protect and enhance natural flow regimes in waterways, and to maintain and enhance the values of ecologically significant freshwater habitats.

Strategic Objective 5

Manage stormwater discharges to **mitigate the effects of flooding** on both existing and new urban areas, while avoiding and remedying the adverse effects of channelisation and channel deepening on ecologically significant freshwater habitats.

Strategic Objective 6

Restore and protect the health and **mauri of the catchment waterways** and the relationship of Tangata whenua as Kaitiaki of waterways.

Strategic Objective 7

Wastewater generation is minimised, and **wastewater discharges are managed** such that there are no adverse effects on HCC's existing infrastructure network or natural environment.

Strategic Objective 8

Infrastructure needs (e.g. pump stations and stormwater treatment and detention devices) are minimised.

Strategic Objective 9

Water networks accommodate growth in accordance with **water conservation and demand management** objectives and potable water consumption is managed to minimise peak and total demand.

Strategic Objective 10

Resource **consent compliance** for three waters.

Strategic Objective 11

Network capacity planned and provided for, and **resilience to planned and unplanned events** ensured for the three waters.

The documents listed in Table 2 have relevance to the generic strategic objectives for all ICMPs and can provide further background information or detail if required. HCC documents such as the Three Water Management Practice Notes offer detail and guidance on what to consider during ICMP preparation.

Document Title	Date/Version
Waikato River Authority Vision & Strategy	July 2011
National Policy Statement for Freshwater Management	August 2014
WRC Waikato Regional Policy Statement	May 2016
WRC Waikato Regional Plan	April 2012
Sub-regional Three Waters Strategy	September 2012
HCC Operative District Plan	October 2017
Waikato Tainui Environmental Plan	Online website
Peacocke SP	August 2007
Southern Growth Corridor Strategic Land-use and Infra SP	October 2015
HCC Long-term Infrastructure Strategy 2015-2045	2015
HCC Comprehensive Stormwater Discharge Consent (#105279)	June 2011
HCC Water Take Consent (#113941)	March 2009
HCC Wastewater Discharge Consent (#114674)	September 2007

Table 2 Source documents

1.7.2 Catchment-specific Strategic Objectives

The following strategic objectives have been identified from the ODP and Peacocke SP that are specific to the Amberfield sub-catchment.

Strategic Objective 1

Development is designed, constructed, operated and maintained to **align with the Peacocke SP**.

Strategic Objective 2

Protection and enhancement of the Waikato River ecology and banks.

Strategic Objective 3

Improvement of **water quality** of on-site watercourses.

Strategic Objective 4

Consistency in three waters management throughout extent of development.

Strategic Objective 5

Provide a **public edge** to the gully and the Waikato River.

Strategic Objective 6

Future-proof the Peacocke SPA.

Strategic Objective 7

Protect **historic and culturally significant** sites or features.

Strategic Objective 8

Protection of low impact devices through construction to ensure bio-retention devices are not negatively impacted by sediment laden discharges.

Strategic Objective 9

Geotechnical investigation and design will **avoid erosion and piping** from low impact devices.

1.8 Levels of Service

Levels of Service are documented in different levels of detail in various key documents.

These currently include;

- Stormwater – management of 2, 5 and 10-year storm events (in accordance with land-use type);
- Wastewater - no additional overflows due to development (volume and frequency); and
- Water pressure – 10m of head at the boundary

Table 3 outlines documents to review for further levels of service and design standards information.

Document Title	Date/Version
HCC Operative District Plan	October 2017
HCC ITS	December 2016
HCC Three Water Management Practice Notes	September 2016
HCC 2015-2025 10 Year Plan	June 2015
WRC 2015-2025 Long Term Plan	June 2015
HCC Bylaws (including Water bylaw and Stormwater bylaw)	
HCC Water Master Plan	June 2015
HCC Wastewater Master Plan	June 2015

Table 3 Technical source documents

2 Catchment Description

The Amberfield sub-catchment is located within the territorial boundary of HCC as shown in Figure 1. The sub-catchment ICMP forms the eastern portion of the Peacocke SPA as defined by HCC's ODP.

Historically, the sub-catchment area was covered in forest, predominantly Kahikatea on the lower lying areas, with a mix of species on the elevated areas, including Kauri, Rimu, and Totara.

Archaeological evidence of 8 discrete Maori horticultural sites exists within the site, where the well-drained soils were modified by mixing soil profiles and adding charcoal, sand and gravel. This is now classified as Tamahere loam. There are 9 known Paa sites within 1.5km of the development area, distributed along the footprint of the Waikato River, being a primary communications artery, and its tributaries. While the Paa sites surround the development area at a relatively high density none are within the Amberfield site and none are directly affected by the development.

The Amberfield sub-catchment area is largely confined by Peacockes Road to the west and the Waikato River to the east. Existing land-use is predominately dairy farming with isolated areas of native bush in the gully and flanking the Western bank of the Waikato River.

Topographically the site generally grades from West to East over broad river terraces intersected with steep transition slopes terminating with large, steep free face slopes adjacent to the Waikato River. An incised gully dissects the Southern extent of the sub-catchment, as shown in Figure 3.

Soils within the sub-catchment are typical of those found in the wider Waikato area and are predominately sand, silty sand, clayey silt, river gravel and pumice. Drainage is via numerous farm drains, roadside drains, ephemeral, intermittent and permanent water courses. These are typically highly modified with numerous dissecting culverts.

Figure 3 Photo of site topography

2.1 Land-use

2.1.1 Current Land-use

Current land-use has been determined from site visits and 2017 aerial photography. At present the Amberfield sub-catchment area is mostly greenfields and dairy farming pastures with associated infrastructure (milking shed, implement sheds, effluent treatment installation, races, drains, rural-residential dwellings), as shown in Figure 4.

2.1.2 Proposed Land-use Changes

Most of the Peacocke SPA, within the Amberfield sub-catchment, is zoned for mixed residential density and typology. A neighbourhood centre is proposed for the development off Peacockes Road and is expected to provide for retail and commercial activities.

As the current land-use is predominately agricultural the site development will increase the percentage of connected impervious area across the site resulting in a change to the existing runoff profile. The treatment methodology recommended to mitigate the change in runoff profile is discussed later in this document.

The assessment of Landscape and Visual Effects is included in the Amberfield Subdivision Application for Resource Consents and Assessment of Environmental Effects May 2018 and appended to this report as Appendix A.

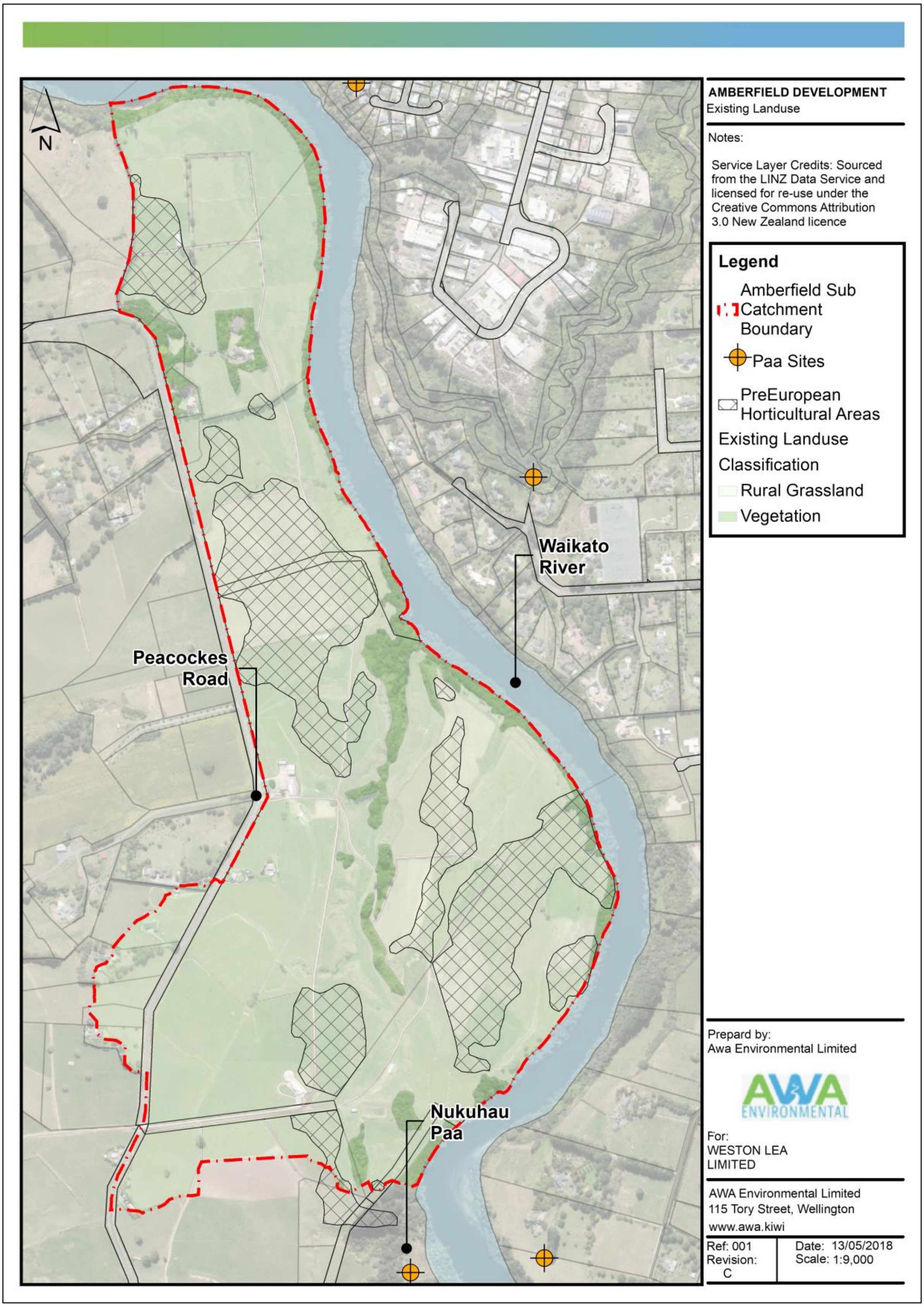


Figure 4 Amberfield sub-catchment existing land-use and historic / cultural features

3 Cultural Value to Iwi and Archeological Significance

3.1 Cultural and Historical Value

The Peacocke area is of historic, cultural and spiritual significance to tangata whenua and is considered a wāhi taonga area. This connection reaffirms the identity, whakapapa and enduring relationship tangata whenua has with the land and waterways in the project area. The protection of heritage, cultural and traditions is vital to their continued well-being.

The Waikato River is a culturally significant site in this area. It is one of New Zealand's major watercourses, is flanked by good soils and has been the primary focus of Maori activity in the region.

It has been recommended that an area of the sub-catchment is retained from construction to preserve some of the Maori horticultural sites, due to their cultural and archaeological significance to the wider Waikato region. The largest concentration of Maori-made soils in the country is found in inland Waikato.

The full Cultural and Historical Values Report has been appended to the Amberfield Subdivision Application for Resource Consents and Assessment of Environmental Effects May 2018 and appended to this report as Appendix B.

3.2 Archaeological Findings

An assessment of archaeological values was undertaken across the site identifying Maori-made agricultural soils totalling 19 hectares. Archaeological evidence has been found of 8 discrete Maori horticultural sites, where the well-drained soils were modified by mixing soil profiles and adding charcoal, sand and gravel. This is now classified as Tamahere loam. The sites form typical elements of the Waikato Horticultural Complex, where Maori were cultivating taro, bottle gourd and most predominantly kumara.

Paa form the other mainstay of this archaeological landscape, and while there are a number surrounding the development area at a relatively high density none are directly affected by the development. It is suspected that the Waikato river, with its value as a communications artery and rich soils, was the earliest focus for permanent settlement, which is supported by the number of paa found along the Waikato River footprint. The paa are generally located on headlands or above waterway escarpments and include features such as ditch and bank systems, terraces, borrow pits and made soils, for example.

Development in Hamilton City has significantly damaged many of these historical sites, and they are better preserved to the south of the CBD and outside the suburbs. Many of the paa in the surrounding area have suffered substantial damage from urban development.

Nukuhau Paa, one of the best preserved paa along the Waikato River, borders the southern boundary of the development area, approximately 500m north-west from the end of Gainsford Road (refer to Figure 4). Its features are particularly well preserved; two ditches, pits and terraces are visible within the fortification. Further borrow pits and made soils have been recorded nearby to the north (i.e. within the development area). The first documentation of the site came from the Waikato Historical Society in the 1960s, who recorded visible features associated with the paa, along with several burials in proximity to the paa. The paa is defended by an 80 m long straight ditch and bank with an additional outer ditch and bank measuring 150 m in length.

Several oral histories provide differing accounts of the paa's origins. Owen Wilkes notes in the records that unverified sources place early occupation at Nukuhau Paa between 1700-1750, and that there are at least two slightly different accounts of the paa's construction. While the exact chronology is vague, the oral histories do imply that Nukuhau Paa was occupied by separate hapu/iwi at different points in time. The site is reported to have been abandoned from approximately 1830 onwards.

A Map of historic and cultural features is shown in Figure 4.

The full Archaeological Assessment Report has been appended to the Amberfield Subdivision Application for Resource Consents and Assessment of Environmental Effects May 2018 and appended to this report as Appendix C.

4 Freshwater Ecology and Water Quality

Two freshwater ecology assessments have been carried out as part of progressing planning approvals for the Amberfield development. The first was an assessment by Argo Environmental Ltd (Argo), for preparation of this sub-catchment ICMP, appended to this report as Appendix D. This was followed by an assessment by Boffa Miskell Ltd. The Boffa Miskell assessment was for the application for resource consents for the development and has been integrated into this sub-catchment ICMP. The key findings of these assessments are summarised below and in the Boffa Miskell report, which incorporates the findings of the Argo report.

Argo carried out a freshwater ecological assessment over 3 days, 8th, 9th and 20th of November 2017 and 15th February 2018 to determine the surface watercourse classifications. There was 16 mm and 34 mm respectively of rainfall two days prior to the 8th and 9th November 2017 and 15 February 2018 surveys (based on the WRC's Te Awamutu monitoring station). Stream classifications were therefore carried out during wet conditions. An additional site visit was made on 19th February with WRC to get agreement on the approach taken and the definitions used. Of the 12 watercourses identified during the site visit, 6 key watercourses were identified for further investigation.

Boffa Miskell carried out a site visit on 11th April 2018. At the time of the site visit, weather conditions were overcast and approximately 12mm of rain had fallen in the preceding 24 hours of the site visit. Boffa Miskell identified the same 6 key watercourses (as the Argo assessment) as being the focus of ecological assessment of the site, in terms of the Amberfield development. Boffa Miskell found the 6 watercourses to vary in size and complexity. Figure 5 provides an overview of the 6 watercourses, including the ephemeral, intermittent and perennial reaches.

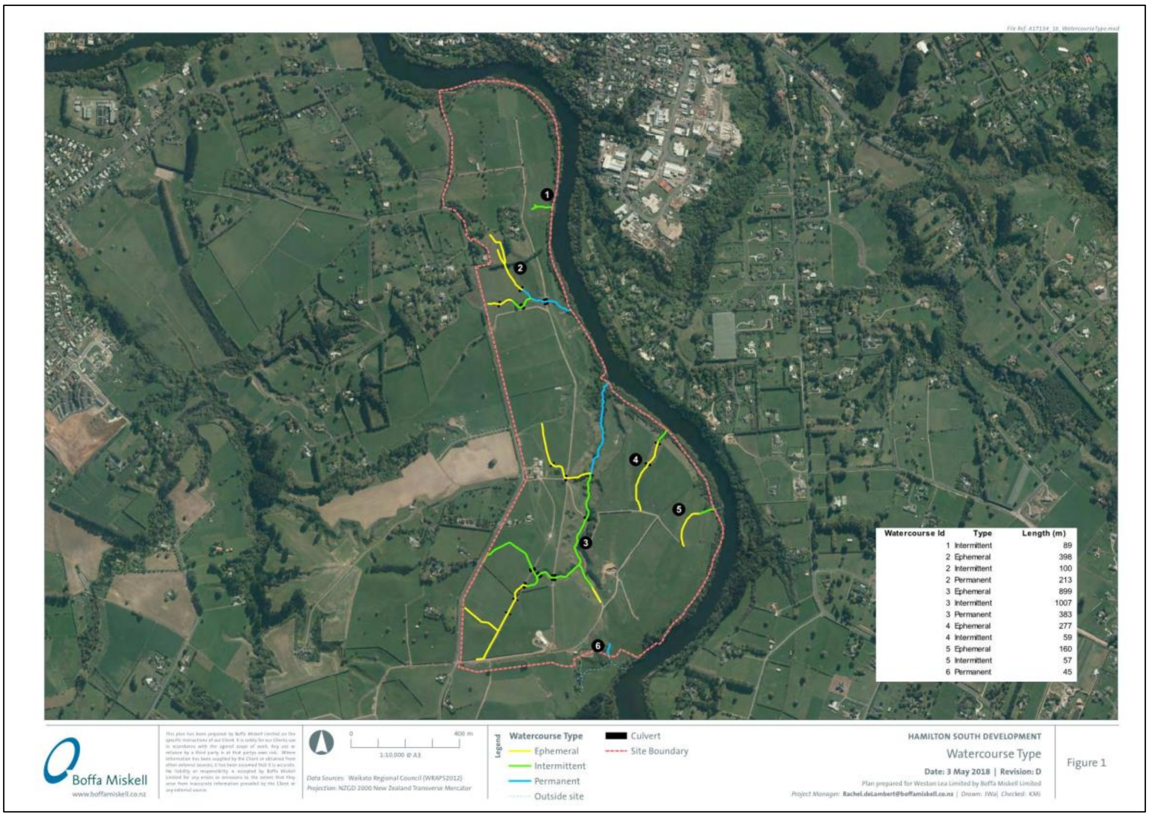


Figure 5 Surface water classification

Typically, the upper reaches of the 6 key watercourses are degraded and offer poor riparian habitat and poor to marginal aquatic habitat values. In reaches directly adjacent to the Waikato River and within the gully, an increase in the riparian habitat and better benthic habitat for invertebrates is typically present with an increase in particle size and woody debris, shallow runs and pools.

The Freshwater Ecological Impact Assessment report is appended to the Amberfield Subdivision Application for Resource Consents and Assessment of Environmental Effects May 2018 and appended to this report as Appendix E.

4.1 Water Quality Assessment

Field measurements for water quality were collected using an Aqua DO2 (dissolved oxygen, temperature) and TPS WP-81 (pH, conductivity, salinity) water quality meters. Laboratory analysis was undertaken for a range of parameters including total suspended solids (TSS), turbidity, Total Nitrogen, Nitrate, Nitrite, TKN, Ammoniacal Nitrogen, Total Phosphorus (TP) and dissolved reactive phosphorus (DRP).

Water samples were collected midstream where possible. All water samples were retained in ice in a chilli bin and delivered to Watercare laboratory, Auckland, New Zealand, within the required timeframes and using standard analytical procedures as described in APHA (1995).

Field measurements were collected at 4 sites (3 from farm site watercourses and 1 from Waikato River). Results from the three analysed waterways within the Amberfield site show moderate to good dissolved oxygen concentrations and water temperature, neutral pH levels and low turbidity. These parameters are likely to fluctuate daily and with seasons, but in general provide favourable conditions for stream biota.

The nutrient profile results show elevated concentrations across the three waterways. Total nitrogen, total organic nitrogen, dissolved reactive phosphorus and total phosphorus were all above applicable guidelines across the three waterways. Total ammonia was also recorded above the associated guideline in watercourse 3 and 6. These results indicate that there is some current potential for biological harm to stream biota.

4.2 Freshwater Ecological Assessment

The Boffa Miskell freshwater ecological assessment did not use the Waikato Regional Plans definitions for waterways as they do not include intermittent systems. The assessment instead defined ephemeral, intermittent and perennial streams using definitions from the Auckland Unitary Plan (Auckland Council 2016), as Boffa Miskell considered these to be more suitable for the site.

Aquatic ecological values were assessed across the waterways present within the site by recording the riparian vegetation, stream channel morphology and habitat diversity. Values were assessed following the methods described in (Harding et al. 2009), which were modified to suit the current assessment.

The assessment was based on the following definitions for the watercourses;

- Ephemeral stream: Stream reaches with a bed above the water table at all times, with water only flowing during and after rain events. This category is defined as those stream reaches that do not meet the definition of permanent river or stream or intermittent stream.
- Intermittent stream: Stream reaches that cease to flow for periods of the year because the bed is periodically above the water table. This category is defined by those stream reaches that do not meet the definition of permanent river or stream and meet at least three criteria of the following criteria;

(a) It has natural pools;

(b) It has a well-defined channel, such that the bed and banks can be distinguished;

(c) It contains surface water more than 48 hours after a rain event which results in stream flow;

(d) Rooted terrestrial vegetation is not established across the entire cross-sectional width of the channel;

(e) Organic debris resulting from flood can be seen on the floodplain; or

(f) There is evidence of substrate sorting process, including scour and deposition.

- Permanent river or stream: The continually flowing reaches of any river or stream.

The watercourse type, based on the above definitions for the 6 watercourses, is shown in Figure 5. The assessments of wetlands on the site is discussed in the Terrestrial Assessment report.

The assessment of ecological effects carried out by Boffa Miskell follows the method adapted from Regini (2002) and the Ecological Impact Assessment Guidelines (EIANZ, 2015). The method involves assessing the magnitude of the projects adverse effects on the site’s ecological values, before using a matrix to assess the level of different effects. The categories for the possible effect magnitudes and the matrix in which to determine the level of the effect on the ecological values are set out in their report. The level of effect for this assessment is based on site scale.

While it is becoming common to use the Stream Ecological Valuation (SEV) process (see Story et al. 2011) to measure relative stream function and use this as a currency to formulate a compensation ratio for adverse stream effects; that process and method is not applicable to all sites and effects and is not a mandatory method. In this instance the sites condition, values and effects are better reflected and managed using ecological principals and the EIANZ processes.

4.2.1 Fish Fauna

The assessment of fish is based on information collected during electric fishing survey using a 12-volt electro-fishing, and a fyke and Gee minnow net survey, by Argo, on 8-9 November 2017. All fish were released after identification.

The only species identified in the site survey was short finned eel, a single individual being observed in the pool below the waterfall on watercourse 2 and a single individual captured in a fyke net in the pond on Watercourse 3. Overall, it appears fish use of the key watercourses on-site is limited. This is likely due to a combination of the perched nature of the numerous culverts present and several watercourses dropping steeply into the Waikato River which are likely forming a natural barrier to fish migration.

4.2.2 Macroinvertebrate Communities

The assessment of macroinvertebrates is based on samples collected from key watercourses draining the site. Samples were collected using a kick-net (mesh 0.5 mm) and following the semi-quantitative Protocol C2 (Stark et al. 2001). Samples were preserved in 70% ethanol and processed by a taxonomist using Protocol P3 (full count with sub-sampling) (Stark et al. 2001). Invertebrate indices and metrics were calculated from community data (e.g., composition, taxa number, MCI-sb and EPT taxa number).

Macroinvertebrate Community Index (MCI) scores were variable across the seven samples. The two samples taken from two first order intermittent streams within watercourse 3 were indicative of poor water and/or habitat quality and probable severe pollution. Sample results from watercourse 1 and 2 (intermittent and permanent reaches) and the permanent stream reach of watercourse 3 were indicative of fair water and/or habitat quality and probable moderate pollution. The second order intermittent stream of watercourse 3 was the only sample which had an MCI index suggesting good water and/or habitat quality and possible moderate pollution.

4.2.3 Ecological Values

The 6 watercourses are the only freshwater features across the site which provide some degree of ecological value. Table 4 lists the different watercourses and flow types along with the associated ecological values (negligible, low, moderate, high).

Watercourse	Flow type	Ecological value	Explanation
1	Intermittent	Negligible	Limited habitat available, degraded habitat, poor connectivity.
2	Ephemeral	Negligible	Limited habitat available, degraded habitat, poor connectivity.
	Intermittent	Low	Marginal habitat, poor connectivity.
	Permanent	Low	Sub-optimal habitat, poor connectivity, high nutrient concentrations.
3	Ephemeral	Negligible	Limited habitat available, degraded habitat, poor connectivity.
	Intermittent (farm drain)	Negligible	Limited habitat available, degraded habitat, poor connectivity.
	Intermittent	Low	Marginal habitat, poor connectivity, moderate MCI index.
	Permanent	Moderate	Sub-optimal habitat with connectivity. One common fish species present, moderate MCI index, high nutrient concentrations.
4	Ephemeral	Negligible	Limited habitat available, degraded habitat, poor connectivity.
	Intermittent	Low	Sub-optimal habitat, poor connectivity.
5	Ephemeral	Negligible	Limited habitat available, degraded habitat, poor connectivity.
	Intermittent	Low	Sub-optimal habitat, poor connectivity.
6	Ephemeral	Negligible	Limited habitat available, degraded habitat, poor connectivity.
	Intermittent	Negligible	Limited habitat available, degraded habitat, poor connectivity.
	Permanent	Low	Sub-optimal habitat, poor connectivity, high nutrient concentrations.

Table 4 Freshwater features and associated ecological value

Freshwater ecological values are variable across the watercourses. All ephemeral water flows consist of negligible ecological value due to limited habitat available, habitat that is available is degraded and there is often poor connectivity within the reach and to downstream reaches. Intermittent stream reaches within watercourses 2, 3 (excluding the farm drain), 4 and 5 have low ecological value with marginal / sub-optimal habitat but poor connectivity within the reach and to downstream waterways. Permanent stream reaches within watercourses 2 and 6 also have low ecological value characterised by sub-optimal habitat, poor connectivity to downstream waterways and high nutrient concentrations. The permanent stream reach within watercourse 3 was the only section to provide moderate ecological value with sub-optimal habitat, connectivity to downstream waterways, moderate MCI index and the presence of a common fish species.

5 Terrestrial and Riparian Ecology

5.1 Terrestrial Ecology

5.1.1 Vegetation

Survey of the on-site vegetation was undertaken on 5 & 6 October 2017. The site was walked using geo-referenced aerial maps on a tablet to navigate to areas that appeared to have vegetation other than pasture (based on aerial maps). One ecologist searched for and recorded the plant species in all areas surveyed. Potential locations of rare taxa and areas previously identified as significant ecological areas were targeted. No quantitative vegetation studies were undertaken (i.e. transects or quadrats) as the vegetation found was low in species diversity, dominated by exotic pest plants, and the assessment did not require such data.

Survey results show the site to be dominated by exotic pasture grassland with the majority of the non-pasture vegetation features occurring along the Waikato River banks and gully escarpments.

As described in the initial assessments for the significant natural areas present on-site (Cornes et al., 2012b), kanuka forest is under-represented in the Hamilton City area. The kanuka dominated vegetation (3.37ha) and the area of planted native vegetation and kanuka (1.89ha) along the Waikato River has been assessed as having **High ecological value** regarding vegetation. All other areas, which include small areas of planted native trees (including the small kahikatea patch) and areas of predominately non-native vegetation, are of **Low ecological value**.

5.1.2 Bats

Bat surveys were undertaken using automatic bat monitors (ABM's) which passively record both long-tailed bat (40 kHz) and lesser short-tailed bat (28 kHz) echolocation calls on two concurrently operating frequency channels. They operate remotely by recording and storing each echolocation call (bat pass), along with the date and time of occurrence. Multiple versions of ABM's, all produced by the Department of Conservation, were used.

The project site is located in the last remaining habitat for long-tailed bats in Hamilton City. Although the levels of bat activity recorded in this study were not as high as other habitats in the Hamilton South area, bats were recorded commuting and foraging across the majority of the site. Furthermore, the patterns of activity indicate that the site provides connectivity between the Hammonds Bush - Mangaonua gully area and the Mangakotukutuku gully, both of which are key remaining habitat features for long-tailed bats.

Given the Threatened – Nationally Vulnerable threat status of long-tailed bats, and the above findings on their use of the habitats available on-site, the ecological value of the site for long-tailed bats has been assessed as **Very High** following the EIANZ guidance criteria.

5.1.3 Herpetofauna

A qualitative assessment of habitat values for native herpetofauna (such as geckos and skinks) was undertaken during the site walk over on 5 & 6 October 2017. The survey focused on identifying complex ground cover that would provide suitable habitat for copper skinks (Oligosoma aeneum) such as dense vegetation, rotting logs, leaf litter, and any other natural or artificial debris that may provide refugia (Peace, 2004).

Direct surveys for lizards were not undertaken because;

- Detection rates for New Zealand herpetofauna during surveys are generally poor (Anderson, Bell, Chapman, & Corbett, 2012);
- Most of the direct impacts of this development are limited to highly modified farmland, where (in the Hamilton area) populations are likely restricted to occasional copper skinks; and
- Surveys were likely to only confirm the presence of lizards, but not provide useful quantitative information on their numbers.

Instead, an assessment of the habitat availability was taken, with the assumption that copper skinks were likely to be present where there was suitable habitat.

There are many areas of potential habitat for copper skink throughout the site. Micro-habitat features preferred by copper skink including leaf litter, natural and artificial debris, areas of long grass, and areas of dense vegetation vary in abundance across the site. Much of the undergrowth within vegetated areas contains only sparse vegetation but may still provide habitat values for copper skink.

Copper skinks are not threatened, widespread (Peace, 2004), and in previous experience they have been found to be relatively common in low numbers throughout the wider Hamilton area. For these reasons, the ecological value for herpetofauna has been assessed as **Low**.

5.1.4 Avifauna

The primary source of avifauna data was gathered via casual visual and call observations when on-site. These were taken in conjunction with the 5 & 6 October 2017 site walk-over, 20 November 2017 ABM set-out, 5 December 2017 ABM collection, and 20 December 2017 ABM collection.

In addition to the casual surveys, birds were surveyed using five-minute bird counts following Department of Conservation best practice (Hartley & Greene, 2012) which largely follows Dawson & Bull's (1975) methodology. The survey at this site was unbounded (no cut off distance) and included birds seen flying overhead. Five surveys were carried out across the site and these were located on the farm edge of the riparian vegetation to maximise the range of habitat types surveyed and potential species detected. In combination with the large amount of time spent on-site making casual observation this is considered to be sufficient to provide an understanding of the utilisation of habits by birds within this pasture dominated site.

The Amberfield development site has a diverse avifauna (23 species) comprised of 13 native species and 10 exotic species which include both terrestrial species, and species associated with wetland/water habitats. This reflects its location directly adjacent to the Waikato River. In terms of abundance, the avifauna assemblage is dominated by naturalised introduced species which are common in the agricultural landscape surrounding Hamilton such as common starling and European goldfinch. The native species present are all widespread and common species such as silvereye and pukeko. No threatened or at-risk species where detected in any surveys.

At risk species that were not detected in the surveys at this site, but have been found in previous Hamilton surveys, could utilise the site, but are likely to be relatively rare visitors and are primarily associated with the Waikato River. As such, the riparian vegetation in this area is considered to be of higher ecological value than the remainder of the site.

Recognising the above, the riparian habitats along the Waikato River within the site have been assessed as having **Medium-High ecological** value for avifauna, with the remainder of the site having **Low ecological value** for avifauna following the EIANZ guidance criteria, as shown in the Terrestrial and Riparian Ecology Assessment Report appended to the Amberfield Subdivision Application for Resource

Consents and Assessment of Environmental Effects May 2018 and appended to this report as Appendix F.

5.2 Riparian Ecology

The Waikato River riparian area within the site is vegetated for its entire length and consists of several different vegetation types with the dominant canopy trees changing between kanuka, Chinese privet, tree privet and mahoe along the river. The majority of the vegetation types are dominated by pest plant species, contain little sub-canopy vegetation and support few or no native plants to provide succession to established native canopy trees such as kanuka. Around the confluence of the Waikato River and the small stream associated with the minor gully in the south of the site there is an area of planted native species and naturally occurring kanuka and silver fern vegetation.

Figure 6 shows a typical view from the site looking across the Waikato River.

Figure 6 Photo of Waikato River on-site

6 Ground Investigation

Early indications for this site were that ground conditions may lend themselves favourably to low impact stormwater solutions due to the owner's experience of the farms soil properties. It was important for the proposed sub-catchment ICMP that these soil properties were understood and that, if soakage-based solutions were to be focussed on, geotechnical risks would need to be adequately considered. A number of geotechnical observations and investigations were undertaken to gain a detailed understanding of the geotechnical constraints of the site as summarised below. The location of each investigation, and underlying soils are shown in Figure 7.

6.1 Fieldwork

Preliminary fieldwork comprising twenty hand auger boreholes (HAs) and twenty cone penetration tests (CPTs) was undertaken in August 2017.

This initial investigation was supplemented by a further nineteen HAs, thirteen rotary core machine boreholes (MBHs), nine geotechnical test pits (TPs) and six seismic CPT tests. This additional testing was undertaken during November and December 2017.

A further twenty-two TPs were also excavated and logged by ENGEO on behalf of AWA Environmental Limited to determine the drainage characteristics of the site subsoils.

Machine boreholes were advanced with a Sonic rig supplied by Pro Drill Limited and test pits were advanced using a 12T hydraulic excavator.

6.1.1 Hand Auger Boreholes

Thirty-nine hand auger boreholes were undertaken across the site with associated in situ testing - Scala penetrometer and shear vanes tests to a maximum depth of 5.0 m. These logs were prepared in general accordance with the New Zealand Geotechnical Society field classification guidelines (NZGS, 2005).

6.1.2 Cone Penetrometer Testing

Twenty-nine CPTs were undertaken within the site. These tests extended to depths of between 6.3 m and 24.0 m.

In addition to the twenty-nine CPT tests, a further six seismic CPT tests were undertaken within areas previously identified as having a high risk of liquefaction.

Based on investigations, site soils are consistent with published geological maps and can be broadly classified into the following soil units;

- SAND – fine to coarse sand, found to be very loose to very dense. This is predominantly high pumice content sand though some layers of non-pumiceous sands were also encountered;
- SILT and CLAY – cohesive soils generally silt and clay rich with variable sand content, found to be soft to hard; and
- Very Dense Soils – inferred from Cone Penetrometer results, anticipated to be very dense gravel.

Investigations show that while soil types are commonly interbedded with one another, sandy soils are commonly found in greater thicknesses and frequency in the eastern portion of the site, and cohesive (silt and clay) soils are more prominent in the western potions of the site.

The outcomes from the site investigations are discussed in the report, Geotechnical Investigation Report, March 2018, appended to the Amberfield Subdivision Application for Resource Consents and Assessment of Environmental Effects May 2018 and appended to this report as Appendix G.

6.2 Groundwater

Groundwater levels were recorded at a number of locations across the site, (refer to page 19 of the Geotechnical Assessment Report). Groundwater levels measured in the machine boreholes indicate that standing groundwater levels across the site are typically significantly below developed ground levels at depths ranging from 6.88 to 19.88 m below ground level.

However, water levels recorded in the hand auger boreholes suggest that perched and transitory water levels do occur across the site.

For low impact stormwater disposal solutions to be effective groundwater levels do need to be managed to allow free soakage with each device. Underlying groundwater levels appear ideal, but in some parts of the site moderate soakage is evident. These moderate soakage levels are associated with interbedded clays that have created the aforementioned perched water tables. Of interest is that these clays appear to be largely allophanic. After being worked one could expect these clays to have much higher soakage rates.

It is expected that these perched groundwater levels can be managed during the construction phase in most instances.

6.3 Erosion and Scour

Varying degrees of active bank erosion/failure were observed in several locations along the surface watercourses. Observations indicate this failure is likely a result of channel modification, livestock treading and slumping of over-steep poorly vegetated channel banks. Although some surface watercourses have riparian vegetation consisting of exotic trees or native species, particularly adjacent the Waikato River, riparian vegetation typically consists of grass and weed species, and is insufficient to prevent slumping.

6.4 Soils

Generally, the Geotechnical Investigation Report shows that while soil types are commonly interbedded, sandy soils are commonly found in greater thicknesses and frequency in the eastern portion of the site, and cohesive (silt and clay) soils are more prominent in the western potions of the site.

Soakage rates are expected to be moderate to high across the site with the majority of the site comprising surficial deposits of highly permeable sand. Areas of more plastic clay (identified within the western portion of the site) are likely to have more moderate soakage rates as indicated by the preliminary soakage testing undertaken to date.

Given the high sand content of the insitu soils piping erosion is unlikely, however some deposits of pumiceous sandy silt may be susceptible to this phenomenon. In the context of a full soakage solution as the primary form of stormwater disposal dialogue around the key risk of piping has been specifically considered in this investigation.

6.5 Beneficial Geotechnical conditions

In terms of implementing the strategic objectives for stormwater, the site's geotechnical conditions are primary in determining the ability of the site to manage low impact "at source" solutions. In the case of Amberfield;

- Soakage rates are expected to be moderate to high across the site with the majority of the site comprising surficial deposits of highly permeable sand. Areas of more plastic clay (identified within the western portion of the site) are likely to have more moderate soakage rates as indicated by the preliminary soakage testing undertaken to date;
- Where these plastic clays are utilised as fill it is likely that they will be mixed with other materials to form a composite fill. This mixing and compacting process will likely release water from allophanic clays and result in a breakdown of their initial structure. The blended compacted fill is therefore likely to have better soakage rates than the initial clay materials; and
- Given the high sand content of the insitu soils piping erosion is considered unlikely, however some deposits of pumiceous sandy silt may be susceptible to this phenomenon. Inspection of the earthworks construction will be required to ensure earthworks soils are not prone to piping erosion.

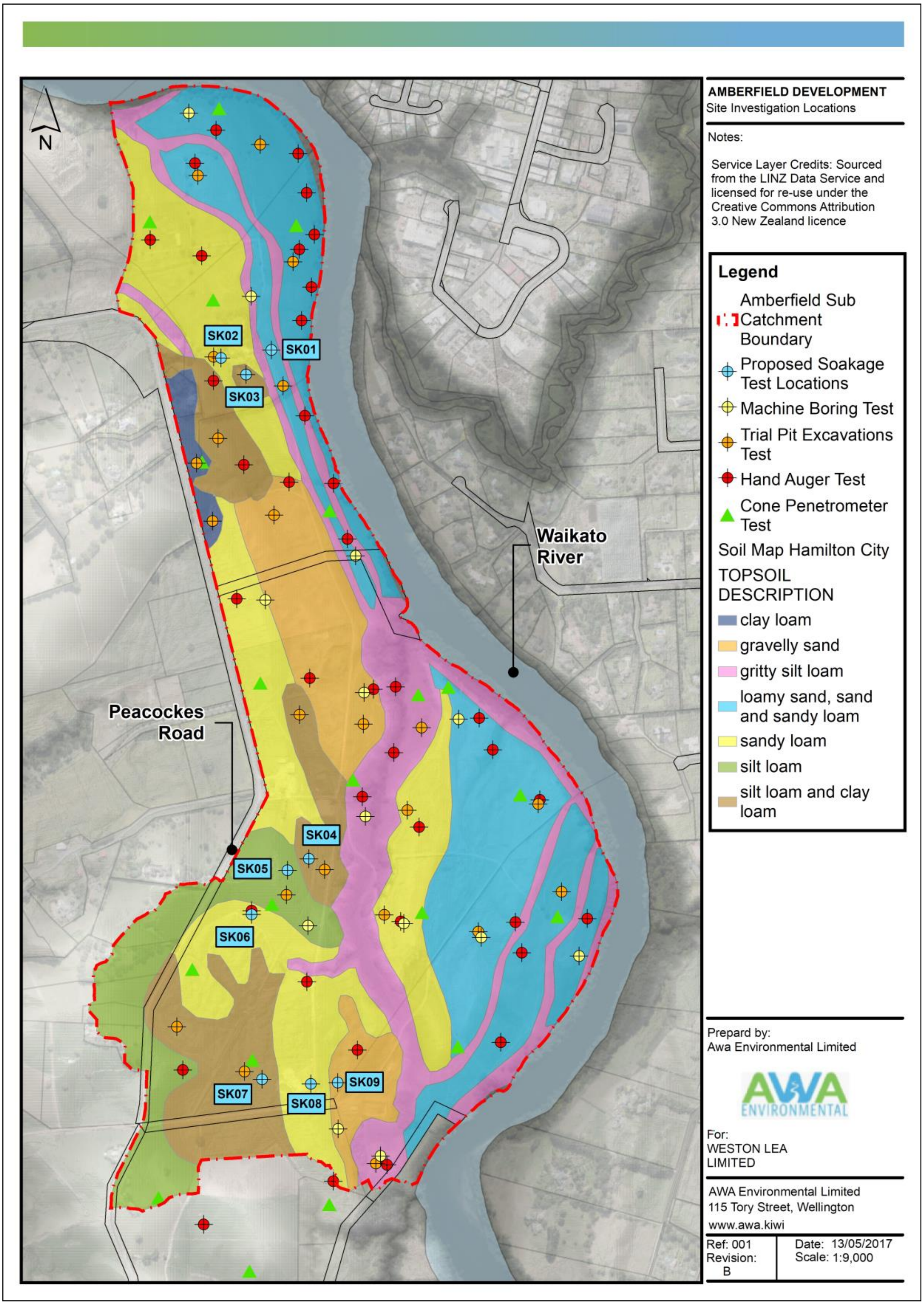


Figure 7 Geotechnical investigation-sites overlain LRIS soil classification

7 Stormwater

7.1 Existing Flood Hazard

There are two sources of flood hazard associated with the Amberfield sub-catchment area;

- Flood hazard associated with flows from the Waikato River; and
- Localised flood hazard associated with stormwater run-off from within the sub-catchment extent.

7.1.1 Waikato River Flood Hazard

Flood hazard information for the Waikato River has been provided by the WRC in the form of reduced levels (RL's). The level of flooding differs based on location as the river falls towards the sea.

Within the Amberfield sub-catchment ICMP extent the Waikato River RL locations are in the South (adjacent the island) and in the North. The higher RL relates to the southern location, the lower RL the northern location. The RL's provided correspond to a 1% AEP flood event in the Waikato River excluding the effects of Climate Change and a Karapiro dam break scenario, levels for each event are shown in Table 5. The RL's effectively grade down from South to North between these two locations.

Scenario	Southern (RL)	Northern (RL)
1% AEP flood event (excl CC)	19.1m	18.5m
Dam break scenario	27.0m	26.3m

Table 5 Reduced levels

The flood extents for these events are shown in Figure 8 and Figure 9.

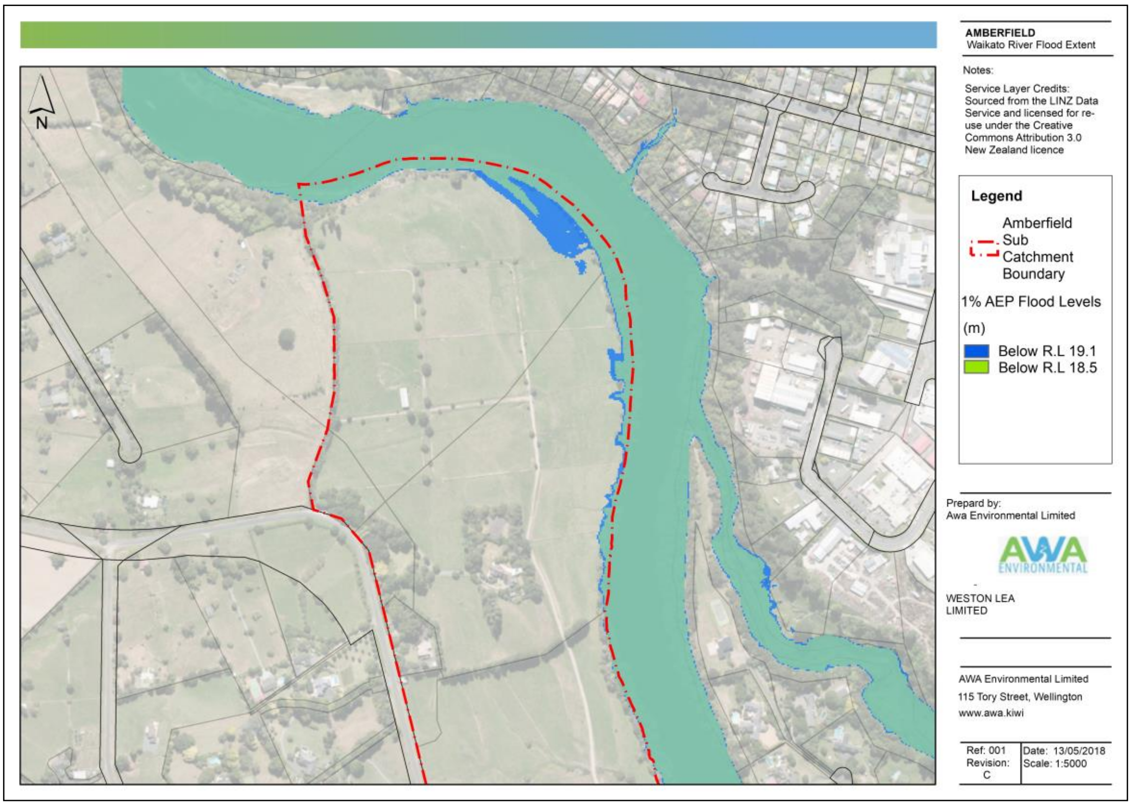


Figure 8 Waikato River 1% AEP flood event extents

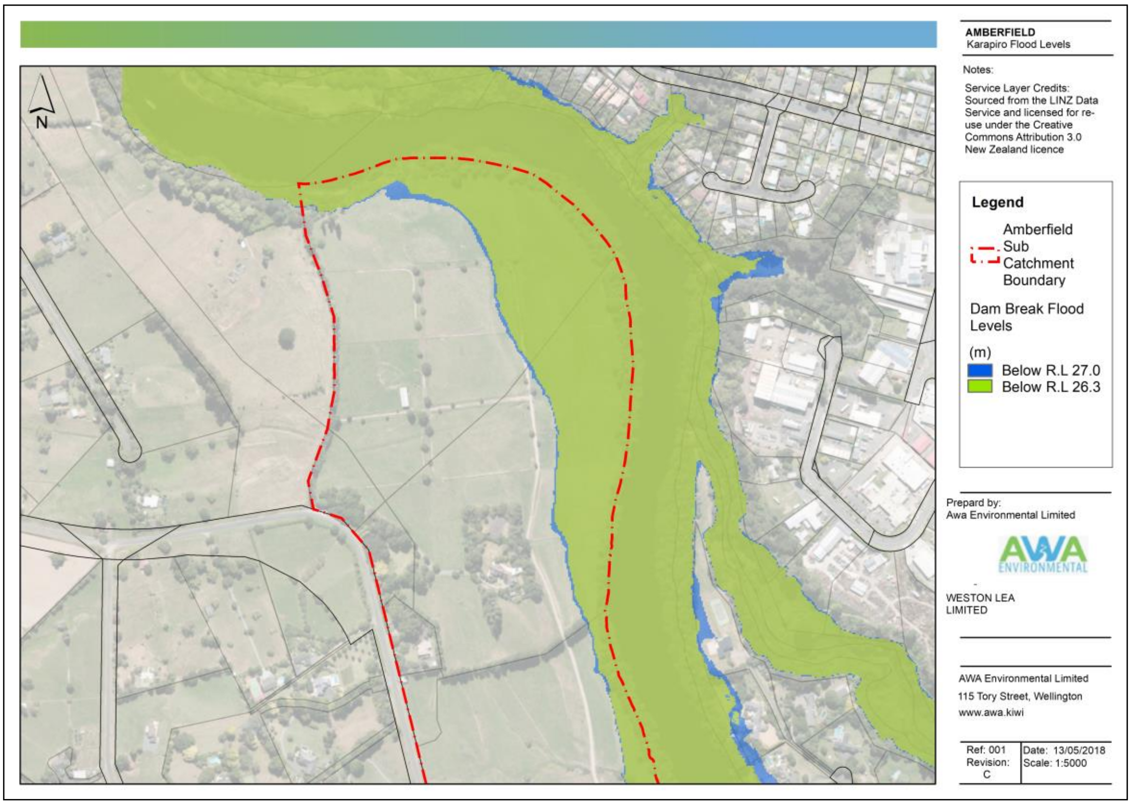


Figure 9 Waikato River dam break event flood extents

7.1.2 Climate Change Conditions

The effects of climate change on flood levels and extents within the Waikato River needs to be taken into consideration. In the report titled *Waikato River Adare Flood Hazard Report, 10 November 2017* (contained in Appendix H), AWA recommended, in the absence of a model with climate change, that an allowance of 1 metre be added to the flood hazard depths to provide some consideration of climate change and freeboard. With this additional freeboard, for the purposes of forward planning, a representative 1% AEP design level between RL 20.1m to 19.5m has been assumed. The recommended design level of RL19.5 applies to the northern end of the site and the level of RL20.1 applies to the southern area of the site. The effects of this allowance, on existing ground levels, are shown in Figure 10.

Information provided by WRC on the possible effects of climate change state that the IPCC forth assessment report suggests that the average annual temperature rise in the Waikato area is predicted to cause an increase in sea level of up to 1.0m and an increase in rainfall intensity of 4% to 8% by 2115. The effect of sea level rise would apply at the mouth of the Waikato River and for some distance up the river due to backwater effects. WRC has not remodelled the predicted flood water levels in the Hamilton City area or the Amberfield development area. However, the effect of climate change on river flood levels in the Hamilton area is likely to be influenced by the effect of increased rainfall intensity, rather than sea level rise due to the distance from the coast. As a precautionary approach, the design surface level for roads in the Amberfield development has been based on the 1% AEP predicted flood water level with an additional 1m for combined climate change and freeboard. Minimum house floor levels would be above this level.

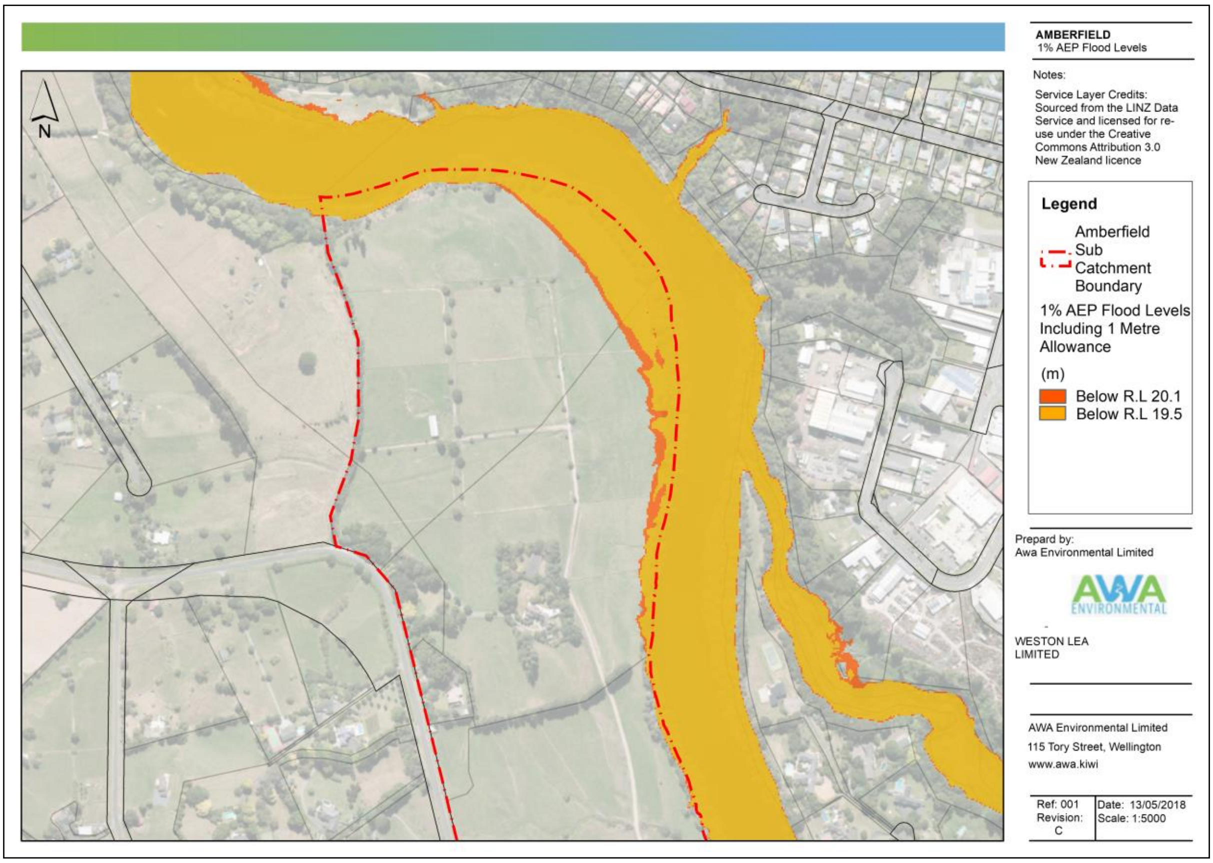


Figure 10 Waikato River climate change allowance flood extent

7.1.3 Existing Stormwater Infrastructure

A review of HCC's City Waters Viewer shows the site is not serviced by reticulated storm water network infrastructure. The nearest infrastructure is located to the west with a 300mm pipe terminating at the intersection of Waiora Terrace and Peacockes Road.

Stormwater discharge from the site is currently managed through a network of open water courses draining either directly to the Waikato River or via the Central Gully. Numerous culverts throttle the drainage of the watercourses with a pond located behind a culvert restriction within the central gully, as shown in Figure 11.

The remainder of Peacockes Road is drained via numerous open road side drains connected via side culverts under driveway access points. The road-side drains are typical of rural roads in that they are predominately grassed with bordering hedge rows. Maintenance of the drains is likely intermittent.

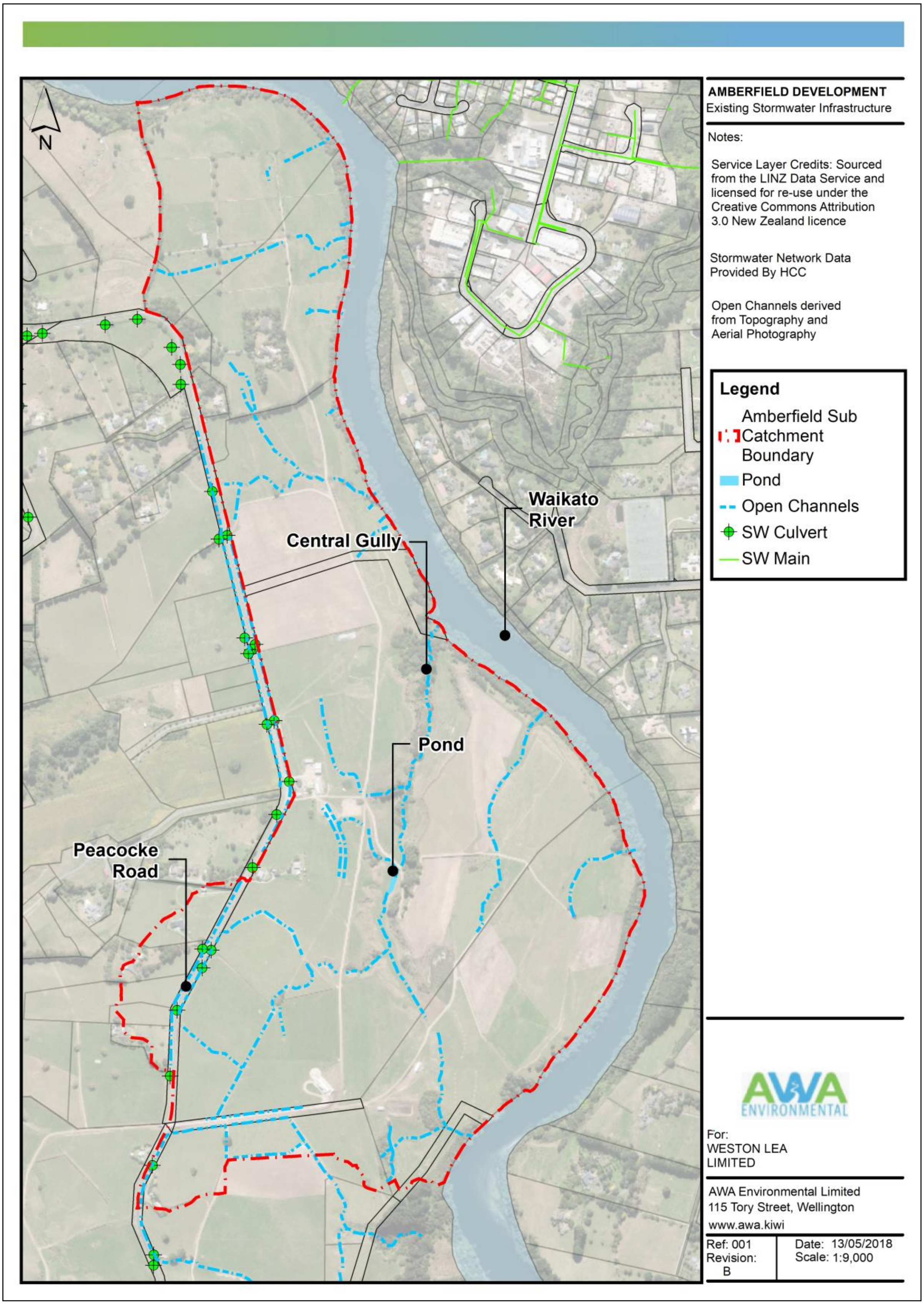


Figure 11 Map of existing stormwater infrastructure

7.1.4 Local Flood Hazard

Hydrologic and hydraulic modelling has been undertaken to determine the existing flood hazard within the Amberfield sub-catchment extent and to inform future development. Hydrological modelling has been undertaken using the Rational Method in accordance with *Hamilton City Council's ITS (ITS) for Stormwater* and *Acceptable Solutions and Verification Methods for New Zealand Building Code Clause E1 Surface Water.*

The hydraulic model has been developed using MIKEFLOOD software by DHI. Overland flow has been modelled using MIKE21 Classic Grid with a 2-metre grid sizing. The stormwater pipe and open channel networks have been modelled using MIKEURBAN and MIKE11.

Modelling results show the site is affected by flooding in the existing scenario, as shown in Figure 12. Flooding is largely contained within the watercourses, with the exception of the area adjacent to Peacockes Road where flooding is a function of localised low topography, localised catchment discharges, upstream catchment overflows and restrictions within the open channel network.

The full Flood Risk Report has been appended to the Amberfield Subdivision Application for Resource Consents and Assessment of Environmental Effects May 2018 and appended to this report as Appendix I.

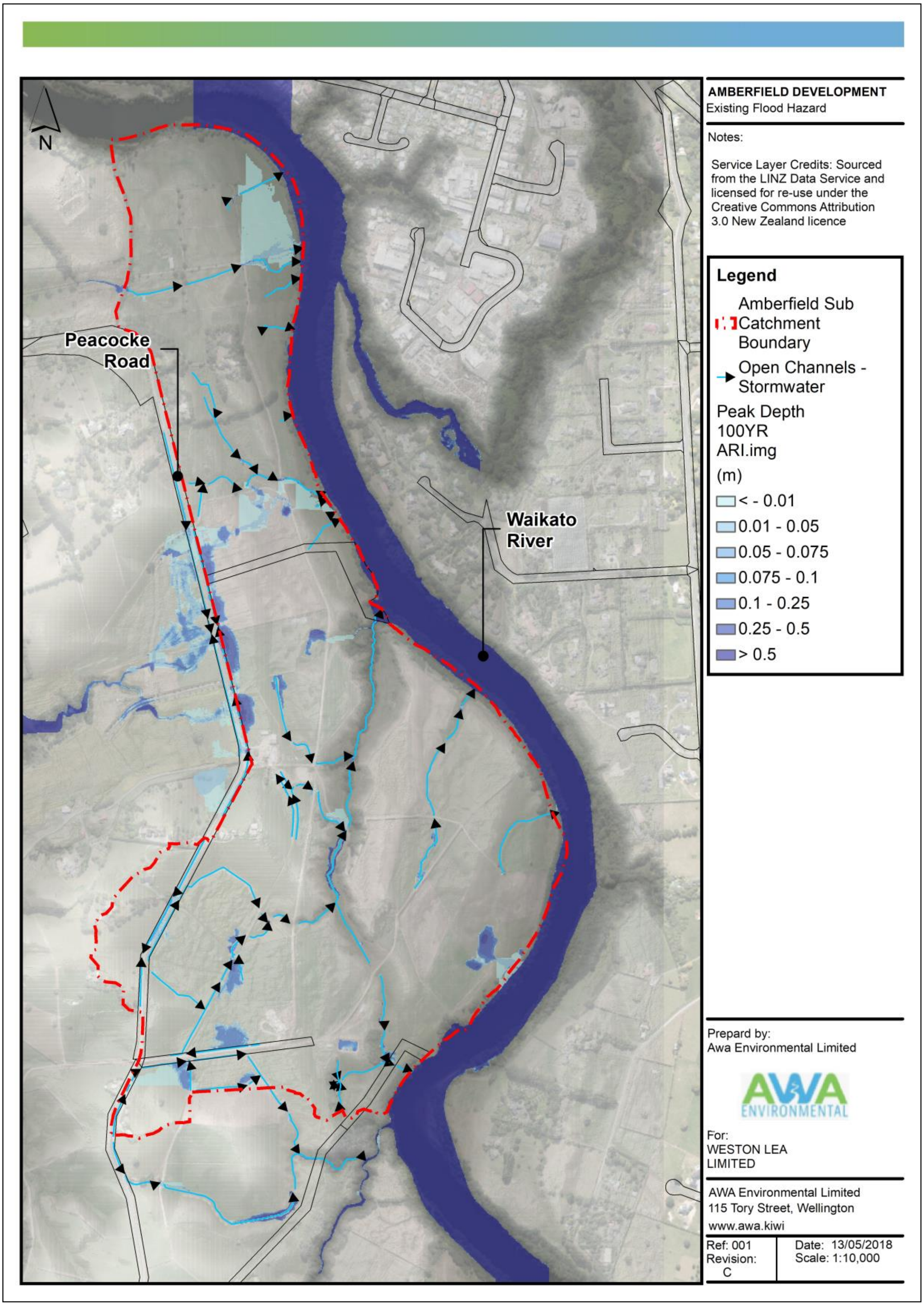


Figure 12 Local flood hazards extents

7.2 Soakage Methodology

To determine the soakage potential of on-site soils 9 soakage tests have been undertaken. The LRIS soil classification layer was used to inform the locations of the soakage tests. A summary of the soakage results is shown in Table 6 with the locations shown in Figure 7. It should be noted that these tests were undertaken near the end of a particularly wet year, which could lead to underestimation of soakage potential for a normal year.

Test Site	Test mm/hr	Reduction Factor @ 25% mm/hr	Comments
SKT 1	2320	500	Loamy Sand
SKT 2	330	83	Sandy Loam
SKT 3	533	133	Silt Loam & Clay Loam
SKT 4	146	37	Silt Loam & Clay Loam
SKT 5	102	26	Silt Loam
SKT 6	234	60	Sandy Loam
SKT 7	205	50	Silt Loam & Clay Loam
SKT 8	372	93	Sandy Loam
SKT 9	537	134	Gravelly Sands

Table 6 Soakage testing results

Soakage results were cross-referenced against adjacent soil profile logs to provide a detailed picture of soil soakage potential. All the geotechnical investigation sites were then reviewed, and their profiles assessed to build a detailed wider picture of soil soakage potential.

While the risk of piping was a concern in the well-drained soils across the site, it has been established that pumice quantities in the soil are low and adverse effects on soakage should be negligible. It is however suspected that perched water tables in some places may have affected groundwater table measurements and underestimated soakage capacity. This will be considered in more detail during detailed design and again after earthworks have been completed.

7.3 Stormwater Design Parameters

This section summarises the key design requirements contained within Hamilton City Council's ITS for stormwater and the District Plan's information requirements for a sub-catchment ICMP. It is not exhaustive, but instead covers all those issues considered core requirements in the approach to managing stormwater within the sub-catchment.

Hamilton City Council's published ITS for stormwater sets out the requirements for the design and construction of stormwater systems for land development and subdivision in the following specification documents;

- ITS – Section 4 – Stormwater – DEC 2016;
- Section 4 – Stormwater – Drawings; and
- Section 4 – Stormwater – Forms and Checklists

The key design and construction requirements from these documents have been used to create a methodology used to calculate the required length of bio-infiltration devices for managing water quality, and the under-drain soakage component for managing primary stormwater disposal as shown in Appendix J. The detailed design phase, for Engineering Approval, will include a re-calculation of the final lengths required as it is expected that the minisub-catchments will change slightly with final road grading/surface grading. However, any further refined re-calculation will be based on the design parameters set out in this sub-catchment ICMP.

7.4 Proposed Stormwater Design Statement

The proposed primary form of stormwater disposal and treatment from the sub-catchment is described in detail in Section 5 of the Civil Infrastructure Report, dated 2nd May 2018, prepared by Harrison Grierson Ltd, which is contained in the resource consent application document. Extracts of that report are included in the discussion below.

The proposed solution for managing stormwater within the full Amberfield sub-catchment, as described in the Civil Infrastructure report, has been developed by detailed modelling of the stormwater, during various design events. The full Amberfield development, which comprises virtually all of the sub-catchment ICMP catchment, has been separated into several dozen mini catchments, defined by road grades, lot layout, proposed ground surface profile, secondary flow paths and road intersections. The 50%, 10% and 1% AEP flows from these have been calculated using run-off coefficients, assuming normal development (i.e. land-use as residential development) on each lot (and the neighbourhood centre area) complying with the District Plan standards (i.e. no restrictions to development on private land that is additional or more restrictive in terms of stormwater runoff to that required by the District Plan), and the resulting design flows managed by the proposed combination of “private on-lot” and public stormwater infrastructure. Specific solutions for managing secondary flow from one private lot onto/through a neighbouring downslope private lot have not been presented in this sub-catchment ICMP. It is noted that the ITS requires consideration of managing secondary flow from private property and this will be assessed at detailed engineering design stage, when final surface gradients have been designed and the potential scale of the secondary flow from an individual lot assessed.

The engineering design solutions proposed for the Amberfield sub-catchment have been developed to provide appropriate mitigation measures to address the environmental impacts of the proposed development. They have been incorporated into the design as shown within the resource consent application document and associated detailed drawings. These documents are far more detailed than concept design and more detailed than what would normally be required for an ICMP process. However, in this case, this sub-catchment ICMP process is running in parallel with a very detailed resource consent process and so this sub-catchment ICMP has incorporated much of the detail developed for the Amberfield resource consent process. Additional information can be found in the resource consent application on stormwater matters.

In addition, following the granting of the resource consents, final detailed design would be carried out as part of the implementation of the development and that detailed design will refine the catchment flows to a higher degree of accuracy once the final earthworks surface is confirmed. Notwithstanding this, the preliminary earthworks design surface presented in the resource consent application is not expected to change by more than 1m vertically over most of the Amberfield development and so the actual stormwater assessment carried out for the application will is not expected to vary significantly.

There are some very small areas, within the catchment of this sub-catchment ICMP, that fall outside the specific Amberfield development footprint, as shown in Figure 1. These include the section of Peacockes Road along the ridge and a small area on the western side of Peacockes Road in the southern area of the Amberfield development. The stormwater solutions within the Amberfield development have been designed on the assumption that the stormwater runoff from these areas will include some elements of low impact stormwater design and the secondary flow system through the Amberfield development incorporates allowance for secondary flow from these areas.

For the purposes of this sub-catchment ICMP, the proposed solution for the management of stormwater on the Amberfield sub-catchment, which is reflected in the various stormwater elements in detail on the resource consent application drawings, are summarised as;

1. Following the best practice stormwater hierarchy outlined in the Hamilton ITS (now mostly incorporated into the Draft Regional ITS) and the Draft Waikato Stormwater Management Guidelines (intended to replace TP 10);

2. Stormwater controlled at source on private lots using on site water efficiency measures to firstly minimise demand (water, wastewater), then re-use for gardens and emergencies (stormwater), then treat and dispose to ground (soakage devices);

3. Runoff from the roof will be directed to a rain tank connected via an overflow to on-lot soakage devices. Where technically feasible, runoff from driveways and other hardstand areas will be directed to soakage devices;

4. Water quality treatment using bio-retention devices within the road reserve;

5. Primary flows up to the 10% AEP event managed within soakage trench devices and disposed to ground within the road reserve. In doing so providing additional level of water quality treatment;

6. Secondary flows up to the 1% AEP managed within the road reserve. Depths and velocities will be managed in accordance with the flood hazard matrix and flood risk objectives outlined in the ITS, as well as Waikato Stormwater Management Guidance and the Regional Flood Modelling Specification;

7. 50% AEP ‘interim’ pipe reticulation to manage flows during the construction phase to safeguard the soakage trench devices prior to bringing them online. Long term this reticulation network will only ‘kick in’ when the capacity of the primary soakage system is exceeded (see Section 7.4.2 “System Protection”) for further details; and

8. A limited 10% AEP reticulated network linking with the 50% AEP network (sized accordingly) to service steeper road areas (following treatment within modular raingardens within those steeper areas) where a soakage trench system is not feasible.

This system will firstly capture (via drop kerb and channel), treat and then dispose of the majority of stormwater that is generated within the proposed development (up to the ‘primary’ 10% AEP flow). The excess water (‘secondary’ flow up to the 1% AEP) will be conveyed via the road network to the most appropriate low point before spilling across the riparian margin (within an appropriately shaped berm/swale with flat side slopes) to the Waikato River. All of the stormwater from privately owned lots (roof, driveways and hardstand) will be collected within a rain tank and then overflow, treated and disposed at source, via soakage devices located within each lot. As noted above, the details of any secondary flow from this concentrated on-lot source will be dealt with at detailed design. In the case of the Amberfield development, there is mostly no more than one lot above the lower lot, beside the road, and hence secondary flow volumes from one lot onto a downslope lot will be very small.

Through the use of bio-retention devices, the stormwater will be treated effectively before soaking to the ground to continue to recharge groundwater. This solution is therefore likely to provide a level of treatment above that specified in the guidance because following bio-retention and/or pre-treatment, soakage, in itself, provides a high level of treatment (noting the groundwater levels are likely to remain well below the base of the trench).

The groundwater catchment within the Amberfield sub-catchment is obviously very small in relation to the overall Waikato River recharge zone. Notwithstanding, the objective to maintain recharge and groundwater levels is considered best practice and most importantly results in a runoff volume loss discharged to the Waikato River. Returning runoff to ground aligns strongly with the cultural and spiritual aspects of managing rainwater runoff close to where it falls at source.

It is proposed to use rainwater retention (rainwater tanks) incorporated with the soakage solution as preferred in HCC’s stormwater management disposal hierarchy. Run-off from the roof will be directed to a rain-tank connected via an overflow into a lot soakage device. Sizing of the rainwater tanks will meet the requirements of Three Waters Management Practice Note HCC 06: Detention Tanks.

Run-off from the impervious lot area will also be directed into the lot soakage device where feasible. Sizing of the soakage device will meet the requirements of Three Water Management Practice Note HCC 03: Soakage.

Run-off from the lot pervious area, and a section of the driveway, due to location, will be directed into the primary stormwater management system located within the road reserve.

This solution will manage stormwater as close to the point of origin as possible, reducing the need for collection and conveyance infrastructure.

7.4.1 Design Life

The proposed stormwater management solution will have a design life of less than 100 years and will require maintenance or replacement to ensure it maintains its long term operational efficiency.

The proposed protection of the under-drain soakage system during the first 2 – 3 years of house construction, by the blocking off the soakage systems, will provide protection from sediment ingress during the initial house construction phase when sediment discharge from house excavations can be problematic to soakage systems.

It is envisaged that the stormwater system will be managed by Weston Lea Ltd for a 3-year maintenance period for each stage of construction, so they can be protected, managed and maintained immediately after completion of each stage. At the end of a 3-year maintenance period the system for that stage would be inspected by Council, any remedial work undertaken, and the system would then revert to HCC control.

An operations and maintenance schedule detailing the proposed ongoing asset management for these devices is attached for consideration in Appendix K.

7.4.2 System Design

Commissioned System – Water Quality

The proposed stormwater management solution has been designed to serve both a water quality and quantity purpose. For water quality the bio-infiltration component of the devices and rain gardens will be sized to accept discharge from 1/3 of the 50% AEP event including climate change allowing road run-off and pollutants to be captured and treated.

Bio-retention will generally be located in the berm for roads with gradients less than 5%. Precast rain garden units will be used to manage surface water within road reserves with gradients greater than 5%.

Precast units (HYNDS or similar) will have an open base in order to allow disposal to ground with an overflow pipe to an adjacent sump. This pipe will be connected to the 10% AEP piped system.

Soak holes – all lots will have a soak hole (sized to accommodate the 10% AEP critical duration event) which will discharge directly to the ground.

The outfall structures for the 50% AEP interim network will be a low-profile design with suitable erosion control at the outlet. Visual impacts will be reduced, and discharge velocities will be minimised to protect against erosion or damage to the Waikato River bank.

Runoff from Peacockes Road will be managed using the same guiding principles outlined in this sub-catchment ICMP and within the resource consent application ie. bio-retention treatment followed by primary soakage disposal.

<u>Commissioned System – Water Quantity</u>

For water quantity the under-drain soakage system component of the devices will be sized to accept discharge from the 10% AEP event including climate change. Discharge will enter the under-drain soakage system via inlets in the bio-infiltration component of the devices where it will enter the perforated nova coil pipe.

<u>System Protection</u>

To protect the under-drain soakage system, (during the first 2 – 3 years of house construction within a stage/phase of the Amberfield development), from excess construction sediment, the under-drain soakage system will be temporarily controlled, using geotextile fabric or similar flow control devices, from any direct surface water entry. This will reduce device capacity during the construction phase. The under-drain soakage system will still receive some flow from seepage from the bio-infiltration device above, but this will not contain any notable sediment load.

To manage stormwater during the first 2 – 3-year “house construction” phase, during which time the under-drain soakage system is unavailable for operation, flows exceeding the capacity of the bio-infiltration devices will overflow to a piped system, which will discharge to existing gully/stream/drain systems.

After the initial 2 – 3-year “house construction” phase, when the under-drain soakage system is commissioned, the piped system will revert to a “first stage” secondary flow system.

During construction, events that exceed the capacity of the bio-infiltration devices and rain gardens will trigger overflow to the piped system. The piped system will be sized to cope with a 50% AEP design event for the bio-infiltration devices as this pipe is only intended to provide a short term (2 – 3 year) bypass system while the under-drain soakage systems are blocked off to avoid sediment ingress during the main house construction phase.

The pipe system connected to the rain gardens on steep streets will be designed to cater for a 10-year event on that catchment as the soakage capacity of the rain gardens is limited due to the slope of the ground where these are used. The two piped systems will be connected to form one stormwater piped network. The piped system will discharge the flows exceeding the capacity of the under-drain soakage systems to existing adjacent gullies and drainage systems.

The Applicant for the resource consent for the Amberfield development is proposing to offer a condition of consent that will require the consent holder to manage the stormwater treatment and disposal devices on public land for a period of 2 -3 years after they have been constructed and commissioned, before handing over to HCC as public infrastructure. This is to ensure that the stormwater elements are protected from excessive sediment loading/clogging and that the vegetation establishes to the desired standard in the early period so that they are fully functional when they do transfer to public operation.

Secondary Overflow

In events greater than the 10% AEP event it is expected that secondary flow will occur down some of the roads and will be directed to adjacent gullies to avoid nuisance or damage to private property. The discharge points will be formed with erosion and scour protection to avoid damage from secondary flow.

The resource consent application documentation includes detailed drawings, prepared by Harrison Grierson Ltd, including drawings showing overland flow paths, outlets and secondary flow control. This is also described in their Civil Infrastructure report. The design of the secondary flow paths and piped outlets has been based around avoiding significant natural areas adjacent to the river edge.

The overarching solution is to manage overland flows by containment within the road reserves, with "spills" down into the lower gullies where appropriate, and in an engineered manner that will minimise damage to the environment.

Flows up to the 1% AEP (including allowance for climate change) event will be managed in accordance with the relevant guidance in terms of the maximum depth and velocity to ensure adequate freeboard levels are maintained to property and to ensure safety of roads users (pedestrians and cars).

Secondary overland flow from lot soakage devices will occur during exceedance events. Flow paths will either spread locally within each lot and eventually infiltrate back to ground or during more intense events, discharge to roadside conveyance network. Soak holes will be positioned in accordance with NZBS E1 and set away from the building foundation on the downslope of each lot.

7.4.3 Proposed ITS Levels of Service

The relatively high on-site soakage characteristics of the site have allowed the adoption of quite specific low impact stormwater solutions for the Amberfield development, which covers the majority of this sub-catchment ICMP. The solutions incorporate water re-use on private lots, treatment of all stormwater runoff up to the design event, disposal to ground, a preliminary development period "by-pass" piped system to protect the subsurface disposal trenches, a piped system for flows that cannot be discharged to ground and overland secondary flow paths along road corridors. These elements have a specific level of service as summarised below;

- The proposed primary Stormwater treatment system will include initial collection of rainfall in a raintank at the house lot for reuse. Overflows from the raintank system, and other impervious areas, where feasible, would be directed to soakage on-site. These will be sized to ITS and NZBC E1 requirements;
- The proposed primary stormwater management solution is a gravity-based disposal system;
- The proposed treatment elements of the system will be bio-infiltration devices in the berm of streets with gradients less than 5% and rain gardens in the berm of streets with grades steeper than 5%, within the road reserve. These devices will be designed the cope with the runoff from the road corridor and the areas of the "up-slope" private lots within the mini catchment of the devices that cannot be collected within the private lot by their stormwater system. These devices will be designed to meet the full requirements of TP10 for treatment;
- The stormwater passing through the bio-infiltration devices, and the additional flow overflowing them through the scruffy dome inlets, will be directed to the under-drain soakage trenches constructed in the berm of the roads, as shown by the resource consent drawings. These have been sized to accept flows for the 10% AEP event including climate change;
- An "initial overflow" system, comprising a piped system, will be used to manage flows in the initial 2 - 3 years of house construction, during which time the under-drain soakage systems will be blocked off to avoid overloading/clogging from excess sediment runoff from house construction activity. This piped system will revert to a "first phase secondary flow" system once the under-drain soakage systems are commissioned. This piped system will provide protection

for a 50% AEP design event for the catchments serviced by bio-infiltration devices and a 10% AEP design event for the rain garden catchments;

- Where possible, this piped system will incorporate connections to additional soakage systems to reduce the volume discharged to the surface; and
- Secondary flow, occurring in extreme events, will utilise the road corridor to convey flows greater than the 10% AEP storm flows within a defined path to dedicated overflow locations. The secondary flow paths have been designed for a 1% AEP event.
- All outlets from the piped system will be designed, constructed and managed to avoid scour from the discharge.

The HG plans are appended to the Amberfield Subdivision Application for Resource Consents and Assessment of Environmental Effects May 2018 and appended to this report as Appendix L.

8 Wastewater Management

8.1 Existing Infrastructure

A review of HCC's City Waters Viewer shows the sub-catchment is not serviced by reticulated waste water infrastructure and the small number of rural dwellings are likely serviced by private septic tanks.

The nearest infrastructure is located to the west with a 150mm pipe terminating at the intersection of Waiora Terrace and Peacockes Road. Currently there is insufficient capacity to service flows from the proposed development through a connection directly into that pipe with no other improvements.

Hamilton City Council has a wastewater treatment plant in the north of Hamilton, where all wastewater from the Amberfield development will eventually be treated and discharged.

8.2 Operational Issues

The primary operational issue in the existing wastewater network is the lack of infrastructure leading to the Amberfield sub-catchment site. While there are opportunities to connect to existing HCC infrastructure, their planed timeframe to extend reticulation to the Amberfield site is too far off to suit an early commencement of the Amberfield development. This necessitates Weston Lea Ltd progressing a solution for wastewater connection to the Council network ahead of wider wastewater infrastructure extensions to the Peacocke SPA.

Due to the slope and long, narrow shape of the site, it is not feasible to drain the entire Amberfield development area to a single collection point with gravity reticulation. The existing gully through the Amberfield development area creates a separate wastewater sub-catchment on the island area to the east, requiring the construction of pump stations.

Wastewater collected from the Amberfield site can be pumped to the Council's bulk interceptor system (see Figure 13). There are 3 possible HCC interceptors within the general area of the sub catchment and the connection points to these are;

- The Western Interceptor, potential connection at Lorne Street Pump Station;
- The Eastern Interceptor, potential connection at Clyde Street; and
- The Far Eastern Interceptor, potential connection near Crosby Road

There are currently capacity issues with the Western and Eastern Interceptors. The Western Interceptor has had notable new development connections to it, and despite some duplication in recent years it is known to be susceptible to overflows during wet weather, due to excess inflow and infiltration into the system. Numerous manhole surcharges are known to be likely in heavy weather. It therefore does not have the capacity to cope with additional flow from the full Peacocke Zone and connecting to it would require additional investment in further duplication of large sections of the interceptor and on-site storage facilities for poor weather conditions.

8.3 Operational Objectives

Beyond minimising wastewater generation as far as possible, strategic objectives for wastewater focus on managing discharges to avoid adverse effects on existing infrastructure and the natural environment.

HCC ITS document states, new wastewater systems shall achieve the following minimum standards;

- Pipelines shall not surcharge at the peak design wet weather flow;

- The system shall not be designed to overflow under any conditions;
- Storage shall not be used for flow buffering purposes unless approved by Council for the purpose of protecting the existing network; and
- The system shall be self-cleaning.

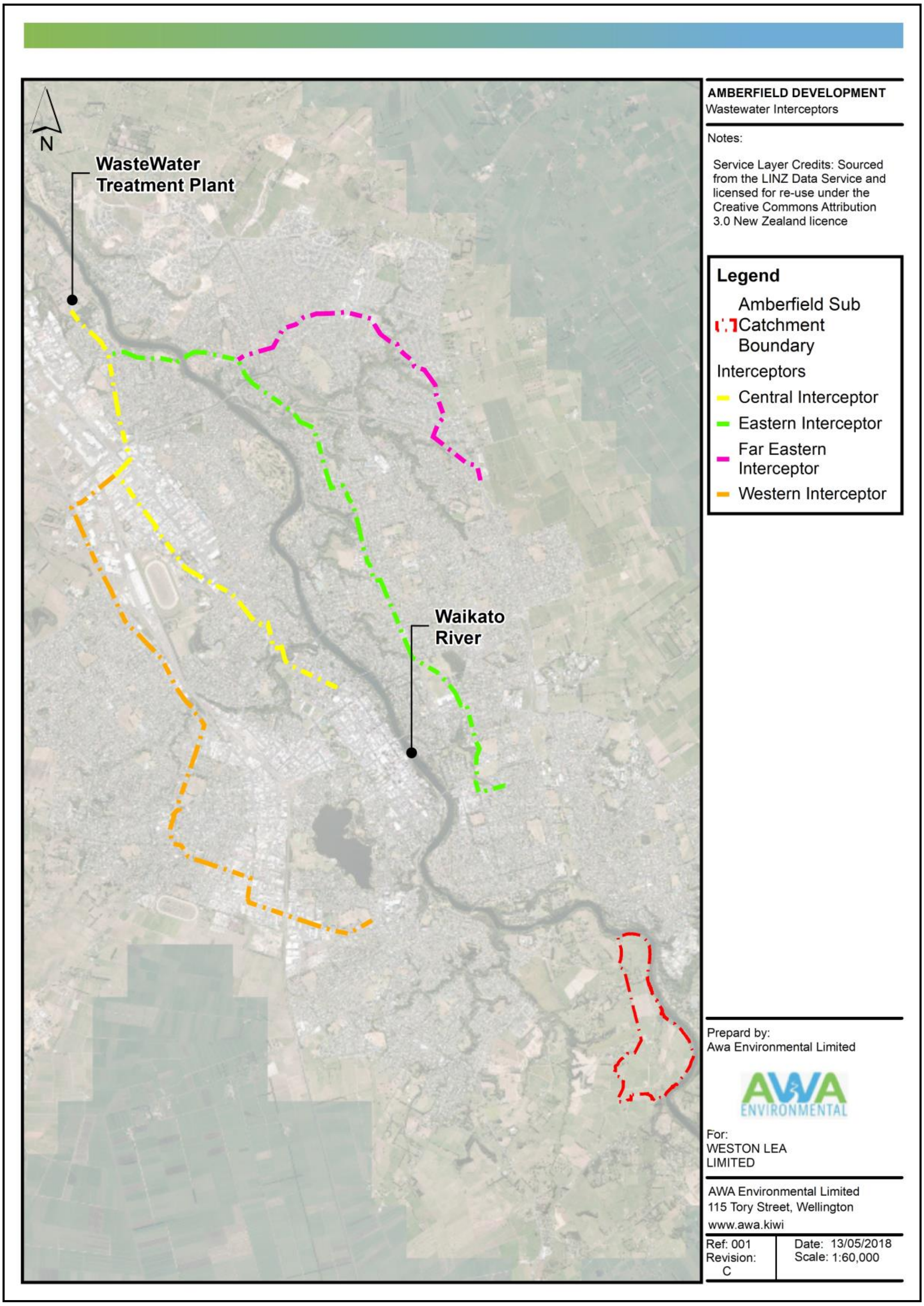


Figure 13 Overview of wastewater interceptors

8.4 Opportunities and Options Considered

A detailed assessment of the options to discharge wastewater from the Amberfield sub-catchment area has been carried out and is described in the bulk wastewater report titled "Report on Wastewater Disposal at Amberfield Development", dated 12th May 2018, prepared by O'Callaghan Design Ltd. This report addresses the options for connection to the Council's network.

Harrison Grierson have completed a detailed assessment of the proposed wastewater reticulation within the Amberfield development footprint and have set out details of the proposed internal wastewater system in their Civil Infrastructure report, dated 2nd May 2018. The Harrison Grierson report is supported by a large number of drawings, including several drawings showing details of the pump stations, rising mains and gravity mains. Both reports and the drawings form part of the resource consent application.

As described in the Harrison Grierson Civil Infrastructure report the wastewater generated within the Amberfield development will be collected by a conventional gravity reticulation system. Considering the site's topography and the existing gully, it is proposed to construct three smaller local wastewater pump stations that will convey the wastewater toward a single collection point in the northern area of the site. The larger northern pump station would pump the wastewater from the Amberfield development to the Councils network.

The wastewater reticulation will be sized to cater for the wastewater requirements on the western side of Peacockes road that is within this sub-catchment ICMP.

As described in the Wastewater Report, Councils strategic solution for conveyance of wastewater from the Peacockes SPA is to pump it to the Far Eastern Interceptor. This requires a large Transfer Pump Station in the lower part of the Peacockes SPA, near the water treatment plant. The Far Eastern option is Council's preferred option, but their expected construction/implementation timeframe does not suit the planned early start on the Amberfield development by Weston Lea Ltd. An interim option would be to discharge to the Western Interceptor, though this solution would require storage at the main Amberfield pump station to enable the pumps to be turned off during wet weather, to avoid overflows. This Western Option requires wet weather storage of approximately 3,000m^3 to avoid an increase in overflows in the downstream section of the Western interceptor. Whilst a Western Option, with large storage is technically feasible, the operational issues associated with managing such large storage are undesirable to Council. In addition, this option is only an interim option and some infrastructure would become redundant once the Council implemented their Peacocke SPA Far Eastern Interceptor solution.

The Wastewater Report describes the Eastern Option for the Amberfield development and provides broad details of the pipe connection to Crosby Road. The pipeline would require a 280mm diameter pumping main from the Amberfield development to the Waikato River and an interim 280mm diameter pipe beneath the River to near Cobham Drive. The 6km pipeline from Cobham Drive to the Far Eastern Interceptor is expected to be constructed in partnership with Council, as HCC sees this as an opportunity to construct their Stage 1 Peacocke SPA pumping main immediately. It is also possible that the section of pipe beneath the river could be upsized to be a joint section of pipe. However, Councils network will eventually include the main delivery pipe across the river as a pumping main attached to the new Southern Links bridge, once it is constructed. The pipe beneath the river would then be decommissioned but maintained in a state of readiness if a problem occurred with the pipe on the bridge (or if it was required to be taken out of service for maintenance).

Whilst the investigations for a preferred solution for wastewater have confirmed that a solution to the Western Interceptor could be achieved without increases in existing overflows during wet weather, the reliance on large storage with prolonged shutdown of the pumps is undesirable and should be avoided if feasible to do so.

As described in the Wastewater Report, the preferred solution is to discharge the flows from the Amberfield development to the Far Eastern interceptor near Crosby Road. The report has identified this option as the preferred option because;

- It does not require the use of large storage infrastructure during wet weather;
- It creates the least risk of overflows during wet weather in the downstream interceptor system;
- It fits the best with Council's long-term strategy for the Peacocke SPA;
- It provides a long-term solution where-as connection to the Western option was only an interim solution until Council progressed their solution for the Peacocke SPA;
- It allows Council to progress their solution for the Peacocke SPA more efficiently if the two parties progress the solution together; and
- It results in the least amount of potential redundant infrastructure.

The Amberfield development is therefore being progressed through the planning process on the basis of the Eastern Option being implemented by Weston Lea Ltd, in co-operation with Council.

The strategic wastewater network and treatment plant will be under pressure in the future, so volume minimisation will also be beneficial. Options such as wide scale wastewater disposal or grey water re-use at source to manage wastewater volumes in existing interceptor pipelines and the treatment plant may be considered in future, however, due to their complexity, environmental and health concerns, these options are not currently being investigated by Council.

The full Wastewater Management Report has been appended to the Amberfield Subdivision Application for Resource Consents and Assessment of Environmental Effects May 2018 and appended to this report as Appendix M.

9 Water Supply Management

9.1 Existing Infrastructure

A review of Hamilton City Council's City Waters Viewer shows the sub-catchment site is not serviced by water supply infrastructure and is likely serviced by private rainwater tanks.

Currently, the main water treatment plant for Hamilton is situated to the north west of the Peacocke area and produces water at an average head of 70m for transmission around Hamilton. The existing treatment works provide enough water and head to supply the first 1,000 lots of the Amberfield Development, but there is no pipeline to transfer the required flow to the area proposed for the first development.

The nearest infrastructure supplying rural properties in the wider Peacocke SPA is located to the west with a 25mm rider main running the length of Weston Lea Drive and a 63mm rider main servicing the northern extent of Peacockes Road and Peacockes Lane. These mains only provide trickle feed supply and are not sufficient to supply the proposed development, as the head loss to supply the design flows for even a few hundred lots would be too high.

9.2 Operational Issues

The nearby water treatment plant currently has no water reticulation to connect to the Amberfield development site, and the closest water supply infrastructure servicing rural properties is unfeasible to connect to. It is also not possible to provide for firefighting water supply through these mains as again the head loss would be too high to achieve the flow rates required.

Aside from lacking existing infrastructure to service the sub-catchment, there are no other constraints regarding water supply.

9.3 Operational Objectives

The objectives of the water supply solution for the Amberfield development are to manage potable water consumption to minimise peak and total demand, while ensuring water networks can accommodate growth. Technical aspects have been identified that may influence staging of the urban development of the Amberfield site, including;

- Consideration of existing capacity without upgrades to provide for substages of development;
- Possible temporary staging solutions for substages of development; and
- Long term solutions which will provide for not just the development within the Amberfield site but the future growth zone.

According to the Hamilton City Council's ITS, the water supply network shall achieve the following minimum standards;

- The minimum pressure and flow at point of supply to residential lots shall be 100 kPa (10m) and 25 L/min;
- The minimum fire supply service level shall be FW2 for residential areas and FW3 for all other areas; and
- To protect level of service of new subdivisions, no more than 150 residential Lots shall be serviced, at any point from a single ended 150mm watermain. Connectivity of the water network is to be established prior to further lots being brought forward for 224(c) release.

9.4 Opportunities and Options Considered

The primary opportunity in designing the water supply network for the Amberfield development is the nearby water treatment plant, which currently has the capacity to serve the proposed urban development of the Amberfield site.

To accommodate future growth, HCC is proposing a network of pipes for the south of Hamilton. This includes a 250mm diameter pipe from the water treatment plant to the Peacocke area on the 2040 design horizon, however, HCC have indicated their intention to complete these additions far sooner than 2040. Timelines will be confirmed in June 2018.

Hamilton City Council are also constructing a dedicated filling line from the existing water treatment works to Hamilton South Reservoir for additional water supply, due to be completed on 30th June 2018.

Water conservation techniques considered for the development include;

- Rainwater harvesting;
- Greywater recycling technologies; and
- Low-flow plumbing fittings

The full Water Supply Management Report has been appended to the Amberfield Subdivision Application for Resource Consents and Assessment of Environmental Effects May 2018 and appended to this report as Appendix N

10 Roading

10.1 Major transport links

10.1.1 Current Links

Peacockes Road forms the existing transport link running along the western edge of the development connecting Hamilton City to the North. Classified as a local road, this section of Peacockes Road runs North-South with a 6m wide sealed carriageway, 20m wide road reserve, 80km/h speed limit and approximately 1500 vehicles per day.

10.1.2 Proposed Links

Following the identification of the Amberfield development as having the potential to significantly affect traffic on the local road network, an Integrated Transport Assessment was conducted by TDG using the 2006 Waikato Regional Transport Model. In response to the development there are several proposed upgrades being considered along Peacockes Road, which are discussed in the Amberfield resource consent application.

The proposed roading layout for the Amberfield development is shown on the Harrison Grierson drawings attached to the resource consent application. They show several road access points connecting into the development off Peacockes Road to ensure efficient movement. These connect with the proposed spine road within the development running parallel to Peacockes Road, to facilitate movement onto residential streets.

The various road typologies are in response to the built form within the development and have been designed to ensure they support public transport services, cycle and pedestrian facilities. In addition to this, off-road cycle and pedestrian facilities will be integral to the development and connectivity to the Waikato River.

Arterial roads in the Peacocke SP have been incorporated into the future Southern Links projects, which will improve links to SH1 and SH3 and increase connectivity between the Peacocke block and wider Hamilton region. There is also possible funding through the Housing Infrastructure Fund (HIF) for a new river bridge across the Waikato River, which would connect Peacockes Road to the Waihere Link on SH1. This would greatly improve the sub-catchment’s accessibility and minimise its traffic effects.

An overview of the proposed major transport links encompassing State Highway routes and local arterial road network is shown in Figure 14.

The Integrated Transport Assessment Report been appended to the Amberfield Subdivision Application for Resource Consents and Assessment of Environmental Effects May 2018 and appended to this report as Appendix O.

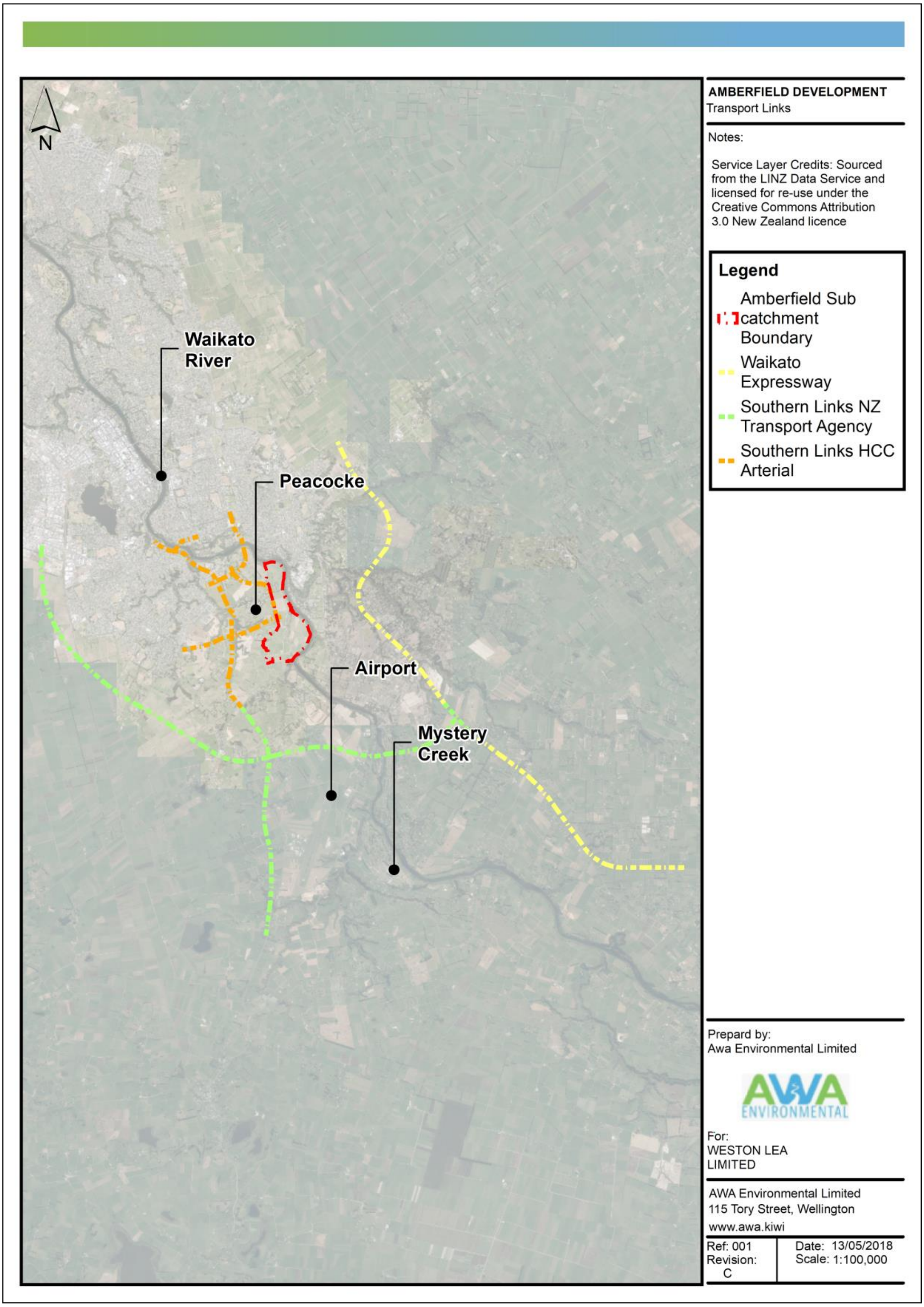


Figure 14 Transport links overview

11 Urban Design Context

The primary objective of the Amberfield sub-catchment ICMP has been to prepare for an initial development comprising approximately 1000 residential lots within the subject site. In this context the opportunity to develop solutions across such a large area, with a single integrated development vision, is a significant opportunity. Weston lea Ltd have had the opportunity to take all of the technical analysis provided for the site and synthesise a plan that incorporates all of this understanding.

Urbanism Plus have produced a masterplan for the Amberfield development and a series of urban design responses to the site. The proposed urban form is cognisant of and responsive to the direction set through the Peacocke SP and its intended land-use, transport networks, open space and neighbourhoods. Urban design decisions have focused on diversity, legibility, connectedness, uniqueness, and a sinuous reflection of the Waikato River in layout geometry. Primarily low-density housing will be offered across the Amberfield sub-catchment, as per the Peacocke SP.

11.1 Conceptual Framework

The conceptual framework seeks to reconcile two fundamental dynamics. The first dynamic is that of nature, the river, the land and the history of all who have inhabited this place, represented by the street alignments. They are sinuous and flow with the contours and echo the flow of the river. The second dynamic is that of human intervention and urbanism. These purposefully connect the user across the site toward the river and the cultural reserve. Together these alignments, where they intersect, form a network which binds the entire community.

Networks are important, they offer freedom of choice and efficiency of movement. They stimulate more pedestrian and cycle use which in turn stimulates more community interaction, safety conditions are improved, and social conditions enriched. In combination they are unequivocally public, enabling all to engage with the salient features of the site such as the river, the gully, the homestead gardens and the elevated knoll. The conceptual framework is robust and can evolve over time as all cities do. It can absorb a range of uses and development densities that respond to user preferences and locational attributes.

11.2 Base Masterplan

The proposed Masterplan leverages the presence and amenity of the adjacent Waikato River drawing this feature back into the site and seeking to maximise the public presence and democratic access to the river corridor. This contrasts the historical development of Hamilton which has tended to either privatise the river frontage or have the ‘rear’ of development adjoining the river esplanade corridor.

The base masterplan showing the proposed arrangement of urban development around the Waikato River and topography is contained within the resource consent application and shown in Figure 15. The masterplan sets up a broadly gridded, well connected, structure of streets with short east/west connections extending from Peacockes Road. Where the interval between vehicular intersections with Peacockes Road becomes too close, the vehicular connection is dropped retaining only the cycle and pedestrian connectivity.

The neighbourhood centre development intention will be informed by the master plan to provide a mixture of retail, employment, community and medium density residential use. Development will be defined over time as occupation of Amberfield is taken up. The masterplan sets aside land for future commercial development to support the local residential community both within and immediately beyond the subject site within the Peacocke SPA.

11.3 Road connections and cycling

Figure 15 shows a primary street running parallel to Peacockes Road through the loose grid, and east of this a series of loop road alignments access the deeper parts of the site toward the river. Along the river corridor the majority of streets are 'single sided' with urban development fronting the west side of the street and addressing the open space of the river corridor to the east.

A shared path walk/cycleway will be accommodated within the esplanade and contiguous open space reserve areas set aside along the western river corridor with the potential to connect with the wider regional 'Te Awa River Ride' connecting Ngaruawahia in the north to Karapiro in the south. Cycle infrastructure is designed into the movement network of the masterplan, providing recreational cycle access along the river corridor and connecting back to the dedicated cycle lanes along the upgraded corridor of Peacockes Road.

For the majority of the development area adjacent to the river corridor the esplanade reserve will adjoin the eastern side of the street giving a public street frontage to the open space along the river. The river corridor Esplanade Reserve will also provide substantial recreational amenity particularly as a linear walking, running and cycling recreational corridor.

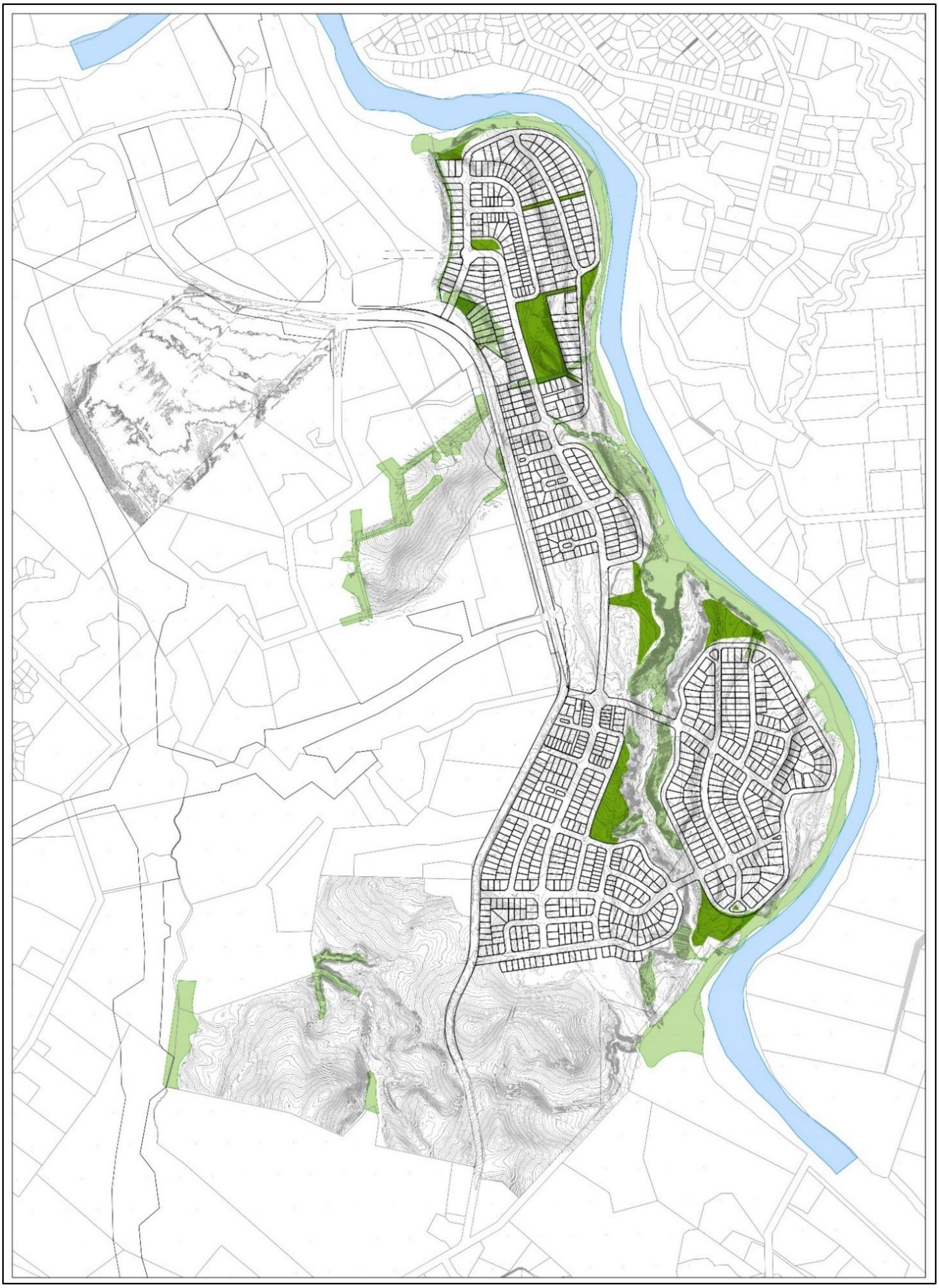


Figure 15 Urban design base map showing lot locations and road connections

The full Urban Design Report has been included in the Amberfield Subdivision Application for Resource Consents and Assessment of Environmental Effects May 2018 and appended to this report as Appendix P.

The development of this suburban form is based on suggested initial options from the technical team and has formed the basis of the initial presentation back to Council on recommended BPO's for the development of the site. The proposed development form has then informed technical assessments and enabled these to consider a wider range of issues that had not previously been detailed.

Particularly regarding stormwater soakage, this built form enabled understanding of likely development contours, allowing consideration of what soakage could be achieved post-earthworks over the site. Figure 16 identifies the likely soakage capacity of the soils across the site at soakage device depth. This analysis considers the cut and fill across the site, and the beneficial impact of mixing and working the allophanic clays.

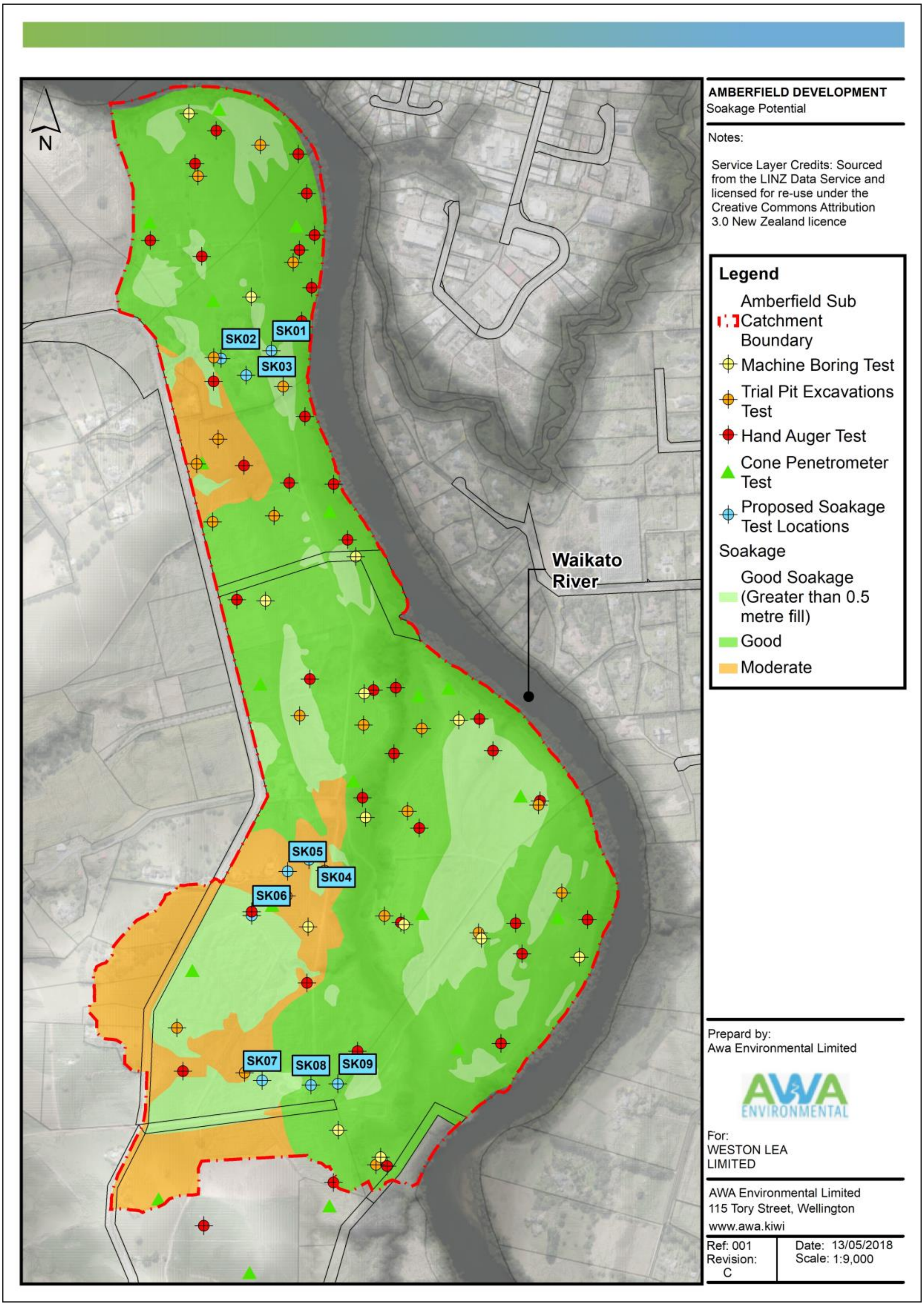


Figure 16 Geotechnical investigation-sites overlain soakage classification

12 Assessment of Potential Environmental Effects

12.1 Archaeological and Cultural Effects

As discussed in the archaeological report earthworks and construction associated with development tends to destroy archaeological and historical sites. The Amberfield development and its associated infrastructure will have an intensive and extensive effect on the archaeological deposits and landscape. The identified Maori horticultural sites will therefore be destroyed throughout the sub-catchment outside the allocated reserve area.

12.2 Freshwater Ecology and Water Quality Impact

The Freshwater Ecological Assessment conducted by Boffa Miskell has established that the Amberfield development will involve the development of existing rural land into an urban area comprising residential and town centre land-use as well as associated roading and other infrastructure. Activities and effects associated with the construction and operation of the subdivision related to freshwater ecological issues within or adjacent to the site includes;

- earthworks and sediment related discharges to water;
- watercourse modification / removal; and
- discharge of stormwater

The proposed development will result in the removal of ephemeral, intermittent and permanent waterways across the site as shown in Figure 17 which shows the development extent over the site in relation to the waterways present, while Table 7 provides an overview of the flow types and lengths of waterway loss across the 6 watercourses.

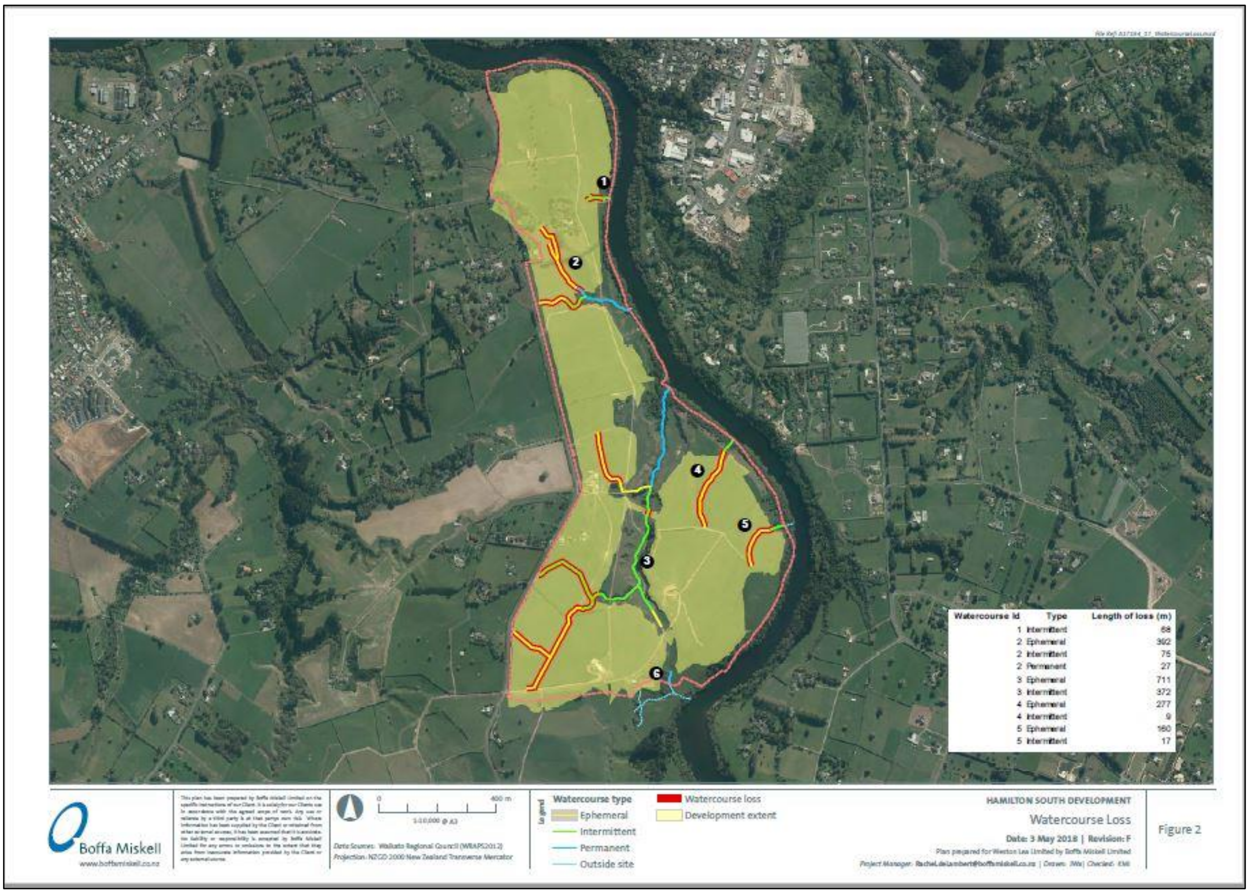


Figure 17 Watercourse loss

Watercourse	Flow type	Impacted length (m)
1	Intermittent	68
2	Ephemeral	392
	Intermittent	75
	Permanent	27
3	Ephemeral	711
	Intermittent (farm drain)	265
	Intermittent	107
4	Ephemeral	277
	Intermittent	9
5	Ephemeral	160
	Intermittent	17

Table 7 Overview of flow types and lengths of waterway loss across the six watercourses

Overall, the development will result in the loss of approximately;

- 1,540m of ephemeral waterway categorised as negligible ecological value;
- 333m of intermittent waterway categorised as negligible ecological value;
- 208m of intermittent waterway categorised as low ecological value; and
- 27m of permanent waterway categorised as low ecological value.

The affected waterways will be lost entirely, as well as associated freshwater ecological values, as part of the earthworks and proposed Amberfield development. The magnitude of effect, on watercourses with at least low ecological values and that are affected by habitat loss (i.e. watercourses 2, 3, 4 and 5), will be moderate. This is because at the site level the loss of waterways will result in the alteration to one or more key elements/features (headwaters) of the baseline conditions such that post development character/composition/attributes of baseline will be partially changed.

The Boffa Miskell Freshwater Ecological Impact Assessment concluded that the significance of the adverse effects on the ecological values present on site, from the proposed Amberfield development, are variable. The adverse effects on freshwater ecological values includes the loss of intermittent and permanent waterways that consist of low ecological values, erosion and sedimentation and the discharge of stormwater to the receiving environment. They concluded that there would be minimal direct ecological effects where habitat is lost within watercourses that have negligible ecological value. Table 8 provides an overview of the effects and the magnitude of those effects on the freshwater ecological values present on site.

Feature	Ecological value	Effect	Magnitude of effect	Significance of ecological effect
Watercourses 2, 3, 4 & 5 (intermittent)	Low	Habitat loss	Moderate	Very low
Watercourse 2 (permanent)	Low	Habitat loss	Moderate	Very low
All watercourses	Med – Low	Erosion and sedimentation	Negligible	Very low
All watercourses	Med – Low	Stormwater discharge	Negligible	Very low

Table 8 Overview of the significance of adverse effects on the site's freshwater ecological values

12.3 Terrestrial Ecology Effects

The entire Waikato River's riparian vegetation is ecologically significant as this area protects and buffers the Waikato River (which is an important bat commuting corridor). The buffering role of the high value bat corridor will become even more important as the development of the Peacocke SPA progresses. The Amberfield development will require the conversion of what is currently a rural/pastoral dominated landscape to an urban/residential dominated landscape. The development will result in the loss of vegetation and therefore some loss of habitat for fauna, as well as increases in anthropogenic disturbance associated with lighting (street lights etc.), roading, and noise.

12.3.1 Vegetation

The proposed development will not directly impact any of the vegetation of high ecological value and maintains a set-back from both the Waikato River riparian strip and the minor gully to the south to preserve the native vegetation currently on-site. Impacts on the low ecological value vegetation will be restricted to the loss of non-native vegetation such as barberry hedges and isolated trees within the farmland and small areas of native plantings. There is also a proposal to thin an area of vegetation on the South of the site to allow for views over the Waikato River. This thinning is restricted to a small area of low value privet-alder vegetation.

12.3.2 Bats

The relative levels of activity recorded do not indicate that bats are likely to be regularly roosting within the development footprint, rather, they are commuting and foraging within it. However, development will permanently increase anthropogenic disturbance in the form of increases in lighting, roading, noise, and housing densities. This is a potentially significant impact; as suitable long-tailed bat habitat is now highly restricted in Hamilton City. Furthermore, as long-tailed bats are known to be sensitive to anthropogenic disturbance such as lighting and noise, a residential development of the density proposed is likely to make the site effectively permanently impermeable to bats meaning they will no longer be able to continue to forage or disperse across or within the site at all.

12.3.3 Herpetofauna and Avifauna

The development will have potential impacts on copper skinks, including direct injury, mortality, and loss of habitat. It is also likely to cause only a minor, short-term disturbance to the bird species present within the site. The vegetation proposed for removal is all classified as providing low value habitat for avifauna.

12.4 Landscape and Visual Effects

An assessment of Landscape and Visual Affect has been undertaken by Boffa Miskell, who have outlined possible changes to visual amenity in the Amberfield sub-catchment. In areas of anticipated landscape change, such as in the case of the Peacocke SP, the prospect of a change to the character of the landscape, in this case the shift from rural to urban, has already been signalled with the area being deemed appropriate, at least at a general level, for such change. This change has been put through a public planning process and the community's views taken into consideration at the time of the decisions on the Plan.

The change from a largely open, pastoral, rural landscape to an urbanised low and medium density, predominantly residential urban area will be transformational and initially dramatic both within the series of phases of physical construction and in respect of the changed landscape, its visual characteristics and amenity.

12.5 Public Health

An important consideration in the recommendation of rainwater tanks as a water storage solution, is to ensure water treatment procedures are well understood should rain tank water be used as potable water in emergency situations.

Levels of contaminates entering waterways may result in health risks associated with contact recreational activities such as swimming.

A move away from traditional kerb and channel and piped stormwater infrastructure into low impact devices such as bio-infiltration devices and rain gardens can lead to a perceived increase in the 'risk' to pedestrians and cyclists falling into these devices. Any change in form from traditional practices will require time to become accepted. Any perceived risk can be mitigated through thoughtful design, landscaping, signage or strategic tree planting.

12.6 Flooding Hazards

Events greater than the capacity of the stormwater management solution will result in overland flow. Overland flow can, if poorly managed, result in damage to land, property and potentially lives. Sediment laden overland flow entering watercourses can have detrimental effects on in stream fish habitat and communities. Uncontrolled overland flow discharge can also result in scour and erosion of open channels if protection is not adequate.

12.7 Receiving Water Hydrology

The change in land-use across the site will result in an increase in connected impervious area which will have an impact on run-off, not only on the profile but also the distribution. A change to existing ground levels and connected impervious area will result in alteration to the overland flow regime entering the watercourses. It will also result in changes to groundwater recharge and distribution. While the mechanism of watercourse recharge will change from pre-development conditions the proposed soakage solution returns flow to ground as close to the source as possible. This, as close as possible, replicates the pre-development mechanisms of recharge.

12.8 Receiving Water Sediment and Water Quality

During construction there is a risk of uncontrolled sediment laden discharges entering the watercourses and the Waikato River. While this is primarily due to uncontrolled run-off it can also be due to high winds mobilising dust particles.

13 Environmental Effect Mitigation

13.1 Cultural and Archaeological Effects Mitigation

The primary form of mitigation suggested is to prioritise archaeological investigation throughout the development phase, to allow for the discovery and documentation of any additional sub-surface sites in the project area. A reserve area will also protect some representative Maori horticultural landscape, with a conservation plan developed with Mana whenua. Cultural recognition will be expressed in the place, trail and street names.

The proposed archaeological reserve, located adjoining the Waikato River Esplanade Reserve, will maintain an area of unmodified topography which also expresses the cultural history of the site as an agricultural landscape.

This reserve area set aside for cultural / archaeological purposes will establish a significant open space and recreational amenity along the river corridor with high levels of public access provided through the location of public roads at the interface between the reserve and adjacent residential development, and the provision of cycleways, shared paths (including potentially a section of Te Awa River Ride) and walkways linking the urban development to the river corridor. Earthworks and other construction within the archaeological reserve area will be minimised to ensure the associated values are preserved.

13.2 Freshwater Ecology Effects Mitigation

The following mitigation was proposed by Boffa Miskell and the Amberfield development has incorporated all of these mitigation measures into their resource consent process;

- Best practice erosion and sediment controls are implemented to avoid any sediment discharge into the freshwater receiving environments;
- Stormwater treatment systems are designed to treat stormwater to the permitted standards outlined in the Waikato Regional Plan, before being discharged into any watercourses present within or adjacent to the site;
- Intermittent and permanent stream reaches within watercourse 3, that are not directly affected by the development, are enhanced to improve freshwater ecological values. These mitigation areas are shown in Figure 18. Enhancement of watercourse 3 is proposed to mitigate for the loss of 208m of intermittent and 27m of permanent waterway across the site (all are categorised as low ecological value). The proposed enhancements to watercourse 3 will include approximately 543m of intermittent and 154m of permanent waterway. We recommend the preparation and implementation of an enhancement plan that includes the following aspects;
  - Creating a channel in the intermittent stream reach, where there is no defined channel, to improve connectivity within the waterway. This provides the opportunity to create a variety of hydrologic conditions (i.e. pools, riffles, run) and instream habitats.
  - Removal of the two existing culverts (or replacement which allows for fish access) which are likely to be restricting fish passage.
  - Riparian planting along both intermittent and permanent stream reaches.
- Stock will also be excluded from watercourse 3 (as well as the other watercourses present on site) as part of the proposed development, which will assist in enhancing freshwater ecological values; and

- Although fish are unlikely to be present within waterways that will be lost, native fish relocation practices will be implemented, and any native fish are relocated to suitable habitat downstream before construction.

In summary, potential and likely effects from the proposed development on freshwater ecological values include waterway and habitat loss, erosion and sedimentation into waterways and the discharge of stormwater. The proposed development will mitigate for the loss of freshwater ecological values through enhancing existing habitat on site (watercourse 3) as well as implementing erosion and sediment control practices and treating stormwater. Provided all recommendations are adhered to, adverse ecological effects from the proposed development will be managed to very low or low levels.

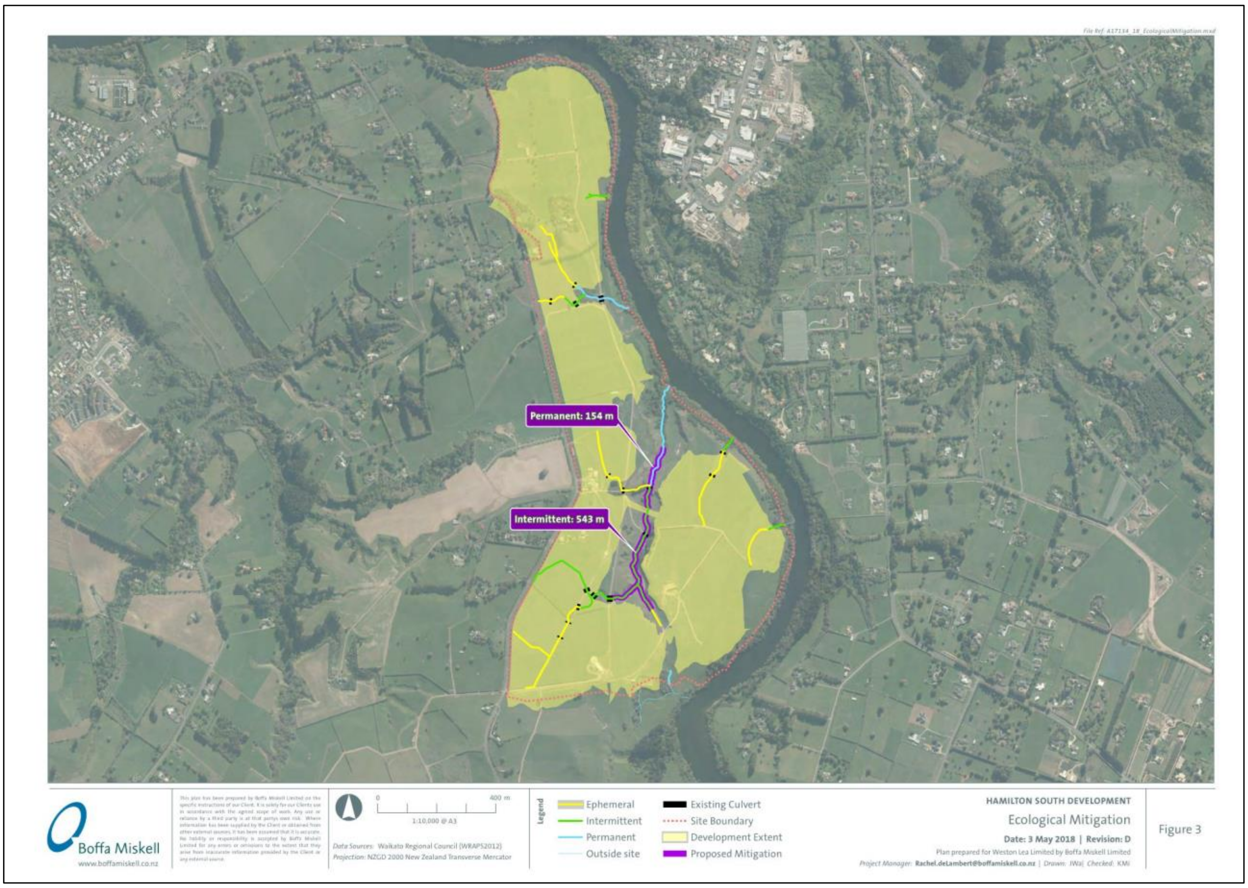


Figure 18 Mitigation planting areas

13.3 Terrestrial Ecology Effects Mitigation

13.3.1 Vegetation

Potential effects on vegetation at this site are very low, but there is a significant opportunity to enhance the ecological value of the area. As much of the area to be planted is currently pasture grassland, or low stature pest plant shrubs, it is recommended to plant early successional species as they grow well in the open and grow rapidly allowing them to suppress pest plant growth. Recommended species for plantings on well drained soils (most of the site including all but the low riparian areas) are; kanuka, lacebark, totara, matai, wineberry, lancewood, and kowhai. In wet soils recommended early succession species are; karamu, manuka, swamp sedge, wheki, and ribbonwood. Once established, these early successional species can then be under-planted with a range of middle and late stage successional species.

13.3.2 Bats

To avoid indirect effects on bats, bat sensitive design should be used across the site. Such initiatives could include, a vegetated setback from key habitat features planted to maximise screening from anthropogenic disturbance, bat sensitive lighting, revegetation of the upper reaches of the southern gully with tall trees and a continuous vegetated corridor from the Waikato River to the Mangakotukutuku gully.

The mitigation and offsetting required to address the effects of the development on the long-tailed bats is being finalised and is dependent on some additional work currently being carried out. In addition to the mitigation initiatives listed above, offsetting is likely to be required. Offsetting can include creation of new habitat, development or enhancement of existing habitats, and legal or physical protection of existing habitat.

13.3.3 Herpetofauna and Avifauna

A Lizard Management Plan will be required to support a Wildlife Act Authority application and should include the proposed methodology to manage impacts on native lizards. It is recommended that lizard management should focus on incidental capture protocol and, although not required to mitigate effects, the creation of high value lizard habitats as this will likely have a greater net benefit for copper skink populations in the area.

The proposed replanting areas should include plantings and habitat elements which maximise the copper skink’s preferred habitat attributes such as; dense vegetation, rotting logs, leaf litter, and any other natural cover. Additionally, the large amounts of additional riparian and gully plantings proposed will provide suitable copper skink habitat in the medium to long-term as natural debris and vegetation cover builds.

This increase in available habitat and additional buffering of the existing habitat would also likely result in a net benefit to avifauna ecological values on-site.

13.4 Landscape Effects Mitigation

The proposed development will retain important components of the existing landform and vegetation within the Waikato River Esplanade Reserve. The presence of the river will be celebrated in the development’s urban form with the primary north-south streets running parallel to the river and the series of short east-west streets oriented to visually and physically connect to the river corridor.

In addition to the important landscape and cultural feature of the Waikato River the retention of the main gully system separating ‘the Island’ from the land to the west and north as an open space, ecological and recreational corridor will maintain this unique landscape feature.

The lack of significant vegetation generally across the site, and the retention of key native and exotic vegetation within the site, including all the vegetation along the river corridor, will avoid landscape effects due to loss of important vegetation. Initially the change in the landscape is likely to generate moderate to low adverse landscape effects, however this will reduce to low and transition to positive as the urban area becomes established and the quality amenity of the form of the masterplan and its response to the features of the landscape is realised.

The landscape impact resulting from the physical works involved in urbanising the area will comprise a moderate level of adverse landscape effects, due to the extent and timeframe of the earthworks. These effects, as well as the related up to moderate adverse visual effects, are however temporary in nature and can be expected (cannot be avoided) as a result of development.

14 Best Practicable Options

14.1 Framework

Integrated three waters approaches work to find efficient and sustainable solutions to the three water networks. It is important to acknowledge the strong interconnection between each of the water networks, the local environment and the larger catchment area.

The three waters strategy aims to promote the sustainable and economic use and delivery of three waters resources and services and to ensure the efficient utilisation of existing assets. This needs to be balanced with managing adverse effects on existing infrastructure and the natural environment by avoiding overflows and exceeding capacities. A general strategic objective is to minimise infrastructure needs across the three waters with water conservation, water sensitive practices and waste reduction.

General objectives for three waters management in the Waikato region include;

- Environmental: groundwater recharge through soakage, groundwater protection from contamination, stream water quality enhancement, ecological enhancement, minimisation of natural flow alteration, consistent water sensitive practices incorporation, water demand reduction and re-use;
- Economic: regard of economic affordability, cost-efficiency, minimisation of future maintenance;
- Cultural: protection and promotion of cultural values; and
- Social: flood protection, public safety management.

To achieve truly integrated catchment management, a holistic approach toward land-use and fresh water decision making is necessary. Across the three waters, indigenous species, ecosystem processes and water's life-supporting capacity must be protected. In the Amberfield development, there is an opportunity to improve the fresh water ecosystem conditions and cultural recognition of waterways, using sustainable three waters management.

The Waikato River is a particularly culturally and ecologically important part of the Amberfield sub-catchment and represents an opportunity to achieve cultural objectives through enhancement and protection of its banks and tributaries. The location of the Amberfield sub-catchment offers a chance to connect the Hamilton urban area with the Waikato River.

14.2 BPO Workshop

Initial findings from the geotechnical and freshwater ecology assessments were presented at the BPO workshop on 30th January 2018, along with the proposed primary stormwater solution of soakage and how this could be incorporated into road cross sections. The proposed soakage solution was explained to the attendees, and questions were raised about secondary flow, maintenance and safety, water quality and contaminant loads.

Freshwater ecological impact mitigation activities were discussed at a later meeting with WRC.

These issues have been picked up from the workshop and meeting and worked through directly with the various sectors of HCC and WRC. Some changes have been made to the best practicable option based on the outcomes from these discussions and have been covered further in the following section on effects.

14.3 BPO Summary and Means of Compliance

The proposed BPO's are intended to directly address the catchment-specific issues identified in previous sections, while simultaneously responding to the wider objectives for the area surrounding the Amberfield sub-catchment. Mitigation activities for environmental impacts of development, three waters infrastructure solutions and broader strategic outcomes have been compiled to produce a list of key preferred options that should be implemented in accordance with this sub-catchment ICMP. Table 9 summarises the key BPO's identified for the Amberfield sub-catchment, links these to the strategic objective they each respond to and identifies the technical and strategic documents relevant to each objective and solution. The assessment of options that have led to the adoption of the BPO for the 3 waters is set out in Sections 14.4 – 14.6.

	Strategic Objectives	Best Practicable Options	Means of Compliance	Relevant Section
	General Objectives			
1	Where technically possible, development should incorporate a **natural environment-based system**. On-site management and disposal of stormwater is preferred.	Stormwater discharge by soakage, using rain garden and bio-infiltration devices (compliant with ITS). Rainwater storage tanks for use in gardens and emergencies.	HCC ITS 4.2.15 (pg 4-35), 4.2.18 (pg 4-56)	7
2	Stormwater should as far as practicable be used to sustain groundwater levels and base flows in freshwater receiving environments and stormwater infrastructure should result in a hydrological cycle as close to the **pre-development hydrological cycle** as possible.	Low-flow plumbing fittings. Rainwater storage tanks for use in gardens and emergencies. Low impact design solutions	Operative District Plan (ODP) 25.13.4.5 a) and c), 25.13.4.2 b) HCC ITS	4, 7, 14
3	The **quality of stormwater discharges** to the existing stormwater network should not pose a risk to human or ecosystem health and will assist with enhancement of the water quality in the receiving environment.	Bio-infiltration devices to manage contaminant loads. Secondary flow directed along roads to specific discharge points.	CDSC Conditions 14 (pg 7), 15 (pg 7), 16 (pg 7)	4, 7, 14
4	**Stormwater is minimised,** and stormwater discharges managed to avoid adverse effects on channel stability, rural drainage, and aquatic life supporting capacity, to protect and enhance natural flow regimes in waterways, and to maintain and enhance the	Stormwater discharge by soakage, using rain garden and bio-infiltration devices (compliant with ITS). Secondary flow directed along roads to specific discharge points.	ODP 25.13.4.5 a CDSC Conditions 7 (pg 5), 9a (pg 5), 9c (pg 5), 11 (pg 6), 18 (pg 7)	4, 7, 14

	values of ecologically significant freshwater habitats.	Mitigative planting to improve terrestrial and freshwater habitats and removal of perched culverts to improve fish passage. Rainwater storage tanks for use in gardens and emergencies.	HCC ITS 4.2.12.3 (pg 4-34), Table 4-3	5, 13
5	Manage stormwater discharges to **mitigate the effects of flooding** on both existing and new urban areas, while avoiding and remedying the adverse effects of channelisation and channel deepening on ecologically significant freshwater habitats.	Secondary flow directed along roads to specific discharge points. Stormwater discharge by soakage, using rain garden and bio-infiltration devices (compliant with ITS).	ODP 25.13.4.2 CDSC Condition 9b (pg 5)	6, 7
6	Restore and protect the health and **mauri of the catchment waterways** and the relationship of tangata whenua as Kaitiaki of waterways.	Mitigative planting to improve terrestrial and freshwater habitats. Archaeological reserve to protect representative Maori horticultural sites and respect nearby paa sites.	CDSC Condition 11 (pg 6) Waikato Regional Plan 2.3 Waikato Regional Policy Statement ODP 21.2.1 d)	3, 4, 5, 7, 13
7	Wastewater generation is minimised, and **wastewater discharges are managed** such that no adverse effects are encountered on Hamilton City Council's existing infrastructure network or natural environment.	Connection of gravity reticulation wastewater system to existing Far Eastern Interceptor for further reticulation to existing wastewater treatment plant.	ODP 25.13.4.3 Waikato Regional Plan 3.5.7 HCC ITS 5.2.9, 5.2.5, 5.2.11,	8, 14
8	**Infrastructure** needs (e.g. pump stations and stormwater treatment and detention devices) are minimised.	Connection to existing water and wastewater infrastructure nearby. Consideration of Council long-term plans to avoid unnecessary expenditure and infrastructure.	HCC Long term Strategy 2015-2025	1, 8, 9, 14

9	Water networks accommodate growth in accordance with **water conservation and demand management** objectives and potable water consumption is managed to minimise peak and total demand.	Connection to water treatment plant and Hamilton South Reservoir to allow for future growth. Low-flow plumbing fittings. Rainwater storage tanks for use in gardens and emergencies.	ODP 25.13.4.4 HCC ITS 6.2.3	9, 14
10	Resource **consent compliance** for three waters.		CDSC Condition 1 (pg 3) ODP 25.13.1 d)	1
11	Network capacity planned and provided for, and **resilience to planned and unplanned events** ensured for the three waters.	Connection to existing water and wastewater infrastructure nearby. Consideration of Council long-term plans to avoid unnecessary expenditure and infrastructure.	HCC Long term Strategy 2015-2025 HCC ITS 4.2.4	14, 15
	Catchment-specific Objectives			
1	Development is designed, constructed, operated and maintained to **align with the Peacocke SP.**		ODP 3.3, 3.4.1	1
2	**Protection and enhancement** of the Waikato River ecology and banks.	Mitigative planting to improve terrestrial and freshwater habitats.	ODP 3.4.1.1, 20.2.1, 21.2.1	4, 5, 13, 14
3	Improvement of **water quality** of on-site watercourses.	Reduction in farm based nutrient contamination through redevelopment Treatment of all road runoff to meet TP10 standards.	ODP 21.2.4	4, 13
4	**Consistency** in three waters management throughout extent of development.	On-going monitoring and reference back to ICMP recommended.	ODP 25.13.2	1, 15

5	Provide a **public edge** to the gully and the Waikato River.	Masterplan proposes shared walk/cycleway along river esplanade.	ODP 3.4.1.7, 21.2.2	11
6	**Future-proof** the Peacocke SP area.	Connection to water treatment plant and Hamilton South Reservoir to allow for future growth.	Southern Growth Corridor 4.1.2 (pg 7) HCC Long term Strategy 2015-2025 (pg 22)	9
7	Protect **historic and culturally significant** sites or features.	Archaeological reserve to protect representative Maori horticultural sites and respect nearby paa sites.	ODP 3.4.1.15 and numerous other documents	3, 13
8	**Protection of low impact devices** through construction to ensure bio-retention devices are not negatively impacted by sediment laden discharges.	Sediment and erosion control through construction phase including home build phase. Staging for bringing disposal units into full operation.	HCC ITS 4.3.10 CDSC Condition 13 (pg 6)	7, 15
9	Geotechnical investigation and design will **avoid erosion and piping** from low impact devices.	Specific testing at each site.	HCC ITS 4.2.18 (pg 4-56)	6, 7, 14

Table 9 Strategic objectives, BPOs and means of compliance

14.4 Stormwater

Section 1.7 sets out the following objectives for stormwater management:

- development should incorporate a natural environment-based system.
- utilise low impact design solutions and should result in a hydrological cycle as close to the pre-development hydrological cycle as possible.
- achieve appropriate quality of stormwater discharges.
- minimise stormwater discharges so as to avoid adverse effects
- manage stormwater discharges to mitigate the effects of flooding.
- restore and protect the health and mauri of the catchment waterways and the relationship of Tangata whenua as kaitiaki of waterways.
- infrastructure needs are minimised.

- network capacity planned and provided for, and resilience to planned and unplanned events ensured for the three waters.

The options for dealing with the primary stormwater flows (10% ARI) from the Amberfield development include:

Option 1 Collection at source, piping and discharge to water courses (i.e. no pre-treatment);

Option 2 Collection at source, piping to large open areas for pre-treatment and discharge to water courses. Pre-treatment could be by large swales, rain-gardens and/or bio-infiltration devices with some soakage to ground through topsoil layer but excess flow discharged to open water courses. The need for large open areas for treatment would impact on developable areas in parts of the site;

Option 3 Collection at source, piping to large open areas for detention and treatment and discharge to large subsurface soakage trenches. Treatment achieved by pre-treatment in devices and further treatment via filtration in subsurface disposal. Geotechnical constraints in some areas near the river terrace would preclude disposal to subsurface trenches in these areas due to increased risks of instability from high flow discharge – direct discharge to water courses required in these areas;

Option 4 Collection and pre-treatment at source and piping for disposal to large subsurface soakage areas/trenches in lower part of site, near river terraces. Could include some additional detention in front of sub-surface disposal system to optimise storage/soakage system and additional treatment achieved through soakage disposal. Geotechnical constraints in some areas near the river terrace would preclude disposal to subsurface trenches in these areas due to increased risks of instability from high flow discharge – direct discharge to water courses required in these areas;

Option 5 Collection, treatment and disposal to subsurface soakage systems at source (predominantly in road reserve). Some flows from steeper streets not able to be discharged to on-site sub-surface soakage systems due to grade challenges. The excess flows from these areas (small proportion of total development flow) could be discharged to a few subsurface disposal systems site clear of the geotechnically constrained areas of the site to avoid discharge of 10-year ARI flows to water courses.

Option 1, involving no treatment and direct discharge to water courses, is contrary to all of the sub-catchment ICMP objectives and is therefore dismissed. The assessment of the four remaining options for managing stormwater from the Amberfield development is set out in Table 10 below.

Objective	**Option 2** Pipe to large open areas near rive terrace for pre-treatment, discharge to water courses	**Option 3** Pipe to large open areas for detention, treatment and discharge to large sub-surface soakage systems, where feasible, but some site constraints due to geotechnical issues	**Option 4** Collection and pre-treatment at source and piping to further treatment and disposal in large subsurface soakage systems (where feasible but some site constraints due to geotechnical issues)	**Option 5** Collection, treatment and disposal at source. Disposal to subsurface soakage systems in road reserve. Can have occasional additional larger system near river terrace where feasible (if desired).
incorporate a natural environment-based system	This option incorporates the least natural environment-based elements Score: 2	Incorporates natural systems. Some areas cannot have sub-surface disposal due to geotechnical constraints. Score: 6	Incorporates natural systems. Some areas cannot have sub-surface disposal due to geotechnical constraints. Score: 8	Incorporates natural systems the best as treatment and disposal at source, all flows (10% ARI) discharged to ground. Score: 10

utilise low impact design solutions	Minor compliance in terms of pre-treatment but minimum low impact solution elements utilised Score: 2	Uses wide range of low impact solutions. Sub-surface disposal systems near river terrace edge to be avoided in places due to geotechnical constraints – direct discharge to water courses (after treatment) required in these areas. Additional land requirements that would reduce available developable land area. Score: 6	Uses wide range of low impact solutions. Sub-surface disposal areas near river terrace edge in parts of the site to be avoided in places due to geotechnical constraints – direct discharge to water courses (after treatment) required in these areas. Additional land requirements that would reduce available developable land area. Score: 8	Uses wide range of low impact solutions for all elements. No limitations or adverse impacts on land requirements etc. Proposed use of piped system for 2 year ARI during "house building phase" provides reasonable protection from clogging during construction phase. Score: 10
achieve appropriate stormwater quality	Minor improvement from pre-treatment only Score: 2	Good water quality where soakage is achievable, moderate improvement where soakage near river terrace edge is not achievable. Score: 6	Good water quality where soakage is achievable, moderate improvement where soakage is not achievable. Score: 8	Good water quality achieved as all flows are able to be discharged to ground for further treatment and minimal flows discharged to water courses. Score: 10
minimise stormwater discharges	Minor benefit from flow buffering through pre-treatment devices and some minor reduction in discharge from soakage Score: 2	Minimal discharge volume where soakage is achievable, moderate flow management where soakage is not achievable. Score: 5	Minimal discharge volume where soakage is achievable, moderate flow management where soakage is not achievable. Score: 6	Minimal discharge volume – soakage achievable in all areas. Excess flows from the steeper streets can be discharged to moderate soakage systems near river terrace in areas where there are no geotechnical constraints Score: 8
minimise flooding	Minor benefit, all flow must be piped from source. Score: 4	Minor benefit, all flow must be piped from source. Score: 4	Modest benefit, but still requires almost all flow must be piped from source. Score: 5	Maximum benefit as almost all flow is discharged at source, only secondary flow to be conveyed. Score: 8
restore and protect the health and mauri of the catchment waterways	Minimal benefit as only part of the flow is pre-treated and solution results in direct discharge to water ways. Score: 2	Achieves objective where soakage is achievable, only partial achievement where soakage is not achievable. Score: 6	Achieves objective where soakage is achievable, only partial achievement where soakage is not achievable. Score: 8	Achieves objective the best - all primary flows are treated and discharged at source- no discharge to water courses. Score: 10

Table 10 Best Practicable Option for Stormwater

From this assessment, Option 5, involving collection, treatment and disposal to sub-surface trenches at source (i.e. in road reserve for each small mini-catchment) is the best practical option. This option best meets the objectives and avoids the risk of large concentrated discharge to ground in the lower areas of the site near the river terrace as these areas have geotechnical constraints due to the nature of the subsurface soils. This option is described in more detail below.

Soakage testing has shown the Amberfield development site to have generally good soakage potential across the site once earthworks have been conducted. As a result, the primary management solution of stormwater discharge associated with the BPO will be soakage.

This solution has been selected with consideration of the HCC stormwater management hierarchy, where the stormwater system should replicate the natural system as closely as possible.

Houses in the development will have on-lot rainwater tanks with overflow directed to soak pits. Stormwater generated within the development, not collected by the on-lot stormwater collection devices will be collected and disposed of via a combination of bio-infiltration devices and rain garden devices, with disposal as described above.

To be effective, the bio-infiltration devices require a shallow gradient to allow soakage. The placement of bio-infiltration devices in relation to steep, linear transition slopes has been avoided by placing devices along the contour in a North/South direction, within the road corridor, following a gentler gradient.

Run-off from the roads on steeper slopes will generally be directed into smaller rain gardens, with an overflow to a piped system. Where gradient and cover allow, some of the flow from the steeper streets can be conveyed to adjacent bio-infiltration devices. However, preliminary design indicates that this is not feasible in most intersections due to the desire to avoid inverted syphons on a piped connection between the sumps in the sag of the road on the steep street and the associated bubble-up sump in the adjacent bio-infiltration device on the flatter street if this solution were adopted.

It is therefore preferred to collect the excess flow from the smaller rain garden devices and pipe it to a bio-infiltration device further down that catchment.

Secondary flow for rain events over the 10-year event will be directed along roads to specific designed discharge points.

14.5 Wastewater

As described in Section 1.7 of this sub-catchment ICMP, the objectives, with respect to wastewater, are:

- The development should incorporate a natural environment-based system.
- Restore and protect the health and mauri of the catchment waterways and the relationship of Tangata whenua as Kaitiaki of waterways.
- Wastewater generation is minimised, and wastewater discharges are managed such that there are no adverse effects on HCC's existing infrastructure network or natural environment.
- Infrastructure needs (e.g. pump stations and detention devices) are minimised.
- Resource consent compliance for three waters.
- Network capacity planned and provided for, and resilience to planned and unplanned events ensured for the three waters.

The options for dealing with wastewater, including both within the development and connection to the existing HCC reticulation include:

Option 1 Individual on-site discharge for each lot.

Option 2 Collection on site via either a pressurised system or a gravity reticulation system, discharging to a communal on-site treatment and disposal system.

Option 3 Collection on site via a conventional gravity-based reticulation system, discharging to the Council's Western Interceptor, near Lorne Street.

Option 4 Collection on site via a conventional gravity-based reticulation system, discharging to the Council's Far Eastern Interceptor, near Crosby Road.

Option 1, involving individual on-site treatment and disposal on each lot is not viable as it is contrary to the objectives, would create cumulative adverse effects on the environment and potential health risks from intense discharge of partially treated effluent. This option is therefore rejected.

Option 2, involving treatment and disposal to a site specific wastewater treatment plant and an associated disposal system is also not viable as it would involve an additional wastewater treatment plant to be operated and maintained, would have considerable cost, would require a disposal system that could create potential adverse effects on the receiving environment (groundwater and Waikato River), is in conflict with the objective of restoring the mauri of the catchment waterways and would require a large area of the site. This option is therefore also rejected.

The remaining two viable options, involving connection to Council's reticulation system both meet the objectives set out above. The two options were assessed in Section 5 of the Report on Wastewater Disposal, attached to the Application. That assessment concluded that connection to the Far Eastern Interceptor, near Crosby Road, was the best practical option.

All interceptors discharge to Council's wastewater treatment plant at the northern side of Hamilton. Therefore, all wastewater from the Amberfield development, and Peacocke SPA will be treated at the wastewater treatment plant and discharged to the consented outfall.

The smaller, internal pump stations will have emergency storage tanks to manage wastewater flows at times of power failure, stand-by pumps in case of pump failure and telemetry to ensure automated operation and monitoring. The large main Amberfield pump station at the northern end will also have a stand-by emergency electrical generator to ensure the pumps can operate in a prolonged power failure.

The pump station facilities will include an odour treatment bio-filter at each station to avoid nuisance to neighbours from offensive odour. All pumps will be submersible pumps and thus there is not expected to be noticeable noise emitted from the pump stations. The pump stations will form part of the Hamilton City Councils public infrastructure once they become operational, as part of the development of each stage.

The preferred longer-term infrastructure solution is to connect the Peacocke SPA to the Far Eastern Interceptor in time. As Weston Lea Ltd wish to construct their development ahead of HCC's plans to construct a transfer pump station and pumping main on the proposed new Southern Links bridge, Weston Lea Ltd will implement a connection to the Far Eastern Interceptor at Crosby Road as part of the BPO for the Amberfield development. It is expected that the construction of the network from the eastern side of the river to the Far Eastern Interceptor would be in partnership with the HCC.

HCC and Weston Lea Ltd are aligned in principle with preferred infrastructure options as set out in this document, and they are currently actively working to agree these.

14.6 Watersupply

As described in Section 1.7 of the sub-catchment ICMP, the objectives, with respect to water supply, are:

- The development should incorporate a natural environment-based system.
- Restore and protect the health and mauri of the catchment waterways and the relationship of Tangata whenua as Kaitiaki of waterways.
- Water networks accommodate growth in accordance with water conservation and demand management objectives and potable water consumption is managed to minimise peak and total demand.
- Infrastructure needs (e.g. additional pump stations and reservoirs) are minimised.
- Resource consent compliance for three waters.
- Network capacity planned and provided for, and resilience to planned and unplanned events ensured for the three waters.

The feasibly of connecting to the Council's reticulation network, near the water treatment plant and conveying potable water to the development in a new piped network to the site was assessed and concluded to be feasible. The proposed solution was modelled and reported on and is included in the

Application. The proposed network has been designed to facilitate the further expansion of the Peacock Structure Plan Area and is in accordance with Council's ITS.

Therefore, the best practical option for dealing with water supply, in this case, is connection to Council's water reticulation system. This is because the reticulation system has the capacity to supply the area, the system has been designed and constructed to facilitate expansion to this development area and it best meets the objectives set out above. The only other technical solution would be to develop a separate water extraction, treatment, storage and conveyance system for this development, which is not practical, is contrary to the objectives above, is contrary to Council's proposed water supply solution to the Peacock Structure Plan Area and would be uneconomic.

The proposed BPO solution is to install a 2.24km long, 250mm diameter pipe with a 1.5km long, 150mm diameter pipe rider main also installed. The HCC reticulation network will be progressively extended to service growth within the sub-catchment and the wider Peacocks SPA. In accordance with the technical specifications of HCC a rider main is included in the planning for this development to provide resilience and some level of service should one of the mains be damaged. The length of main pipeline required to supply water to the Amberfield site is 2.24km. A rider pipeline would be placed on the opposite side of the road from the main pipeline that is 1.5km in length. Once the main supply pipeline and the resilience rider pipeline reach the development, it is expected that the larger water mains within the development that run parallel with Peacockes Road will provide the resilience for the overall network.

Considering the existing network operations, the Amberfield development is predicted to have a positive impact on the system performance due to the recommended connection to the Peacockes Lane watermain. The firefighting water supply requirements for classification FW2 are exceeded by the peak design flow above for all pipeline combinations considered.

Low-flow plumbing fittings and rainwater harvesting are recommended for water conservation in the Amberfield development site, to supplement water resources. Generally, the existing city water source and network will be adequate to meet future demand; however, climate change predictions indicate that Hamilton will become drier for extended periods. It was decided that greywater technologies were not a viable option for the nature of this development.

Once the dedicated filling line is built by HCC from the water treatment works to the Hamilton South Reservoir, the water main supplying the proposed Peacocke development should be connected to the 750mm diameter main at the intersection between Wairoa Terrace and Peacockes Road. This move of connection point has the effect of increasing the head available to supply the Peacocke development. Once the bulk mains across the Peacocke SPA, from the reservoir to Peacockes Road, have been installed, development can take place up to the 62/60m contour. This would need to be confirmed by further modelling.

Knowing that Hamilton's climate is likely to dry out for longer periods in the future due to climate change makes the integration of stormwater and watersupply an important initiative. Rainwater tanks are recommended to alleviate pressure on watersupply during dry periods while also reducing volumes in the storm water system.

Measures that help supplement water sources such as rain tanks are beneficial tools to manage water resources. Other benefits include;

- Reduced peak flow impacts due to fast response runoff from impermeable areas;
- Less water taken from the water source;
- Lower treatment and network operational costs;
- Maximum use of the existing Water Treatment Plant, but with the potential to delay future; and upgrades

- Emergency supply

Proposed water reticulation is shown in Figure 19.

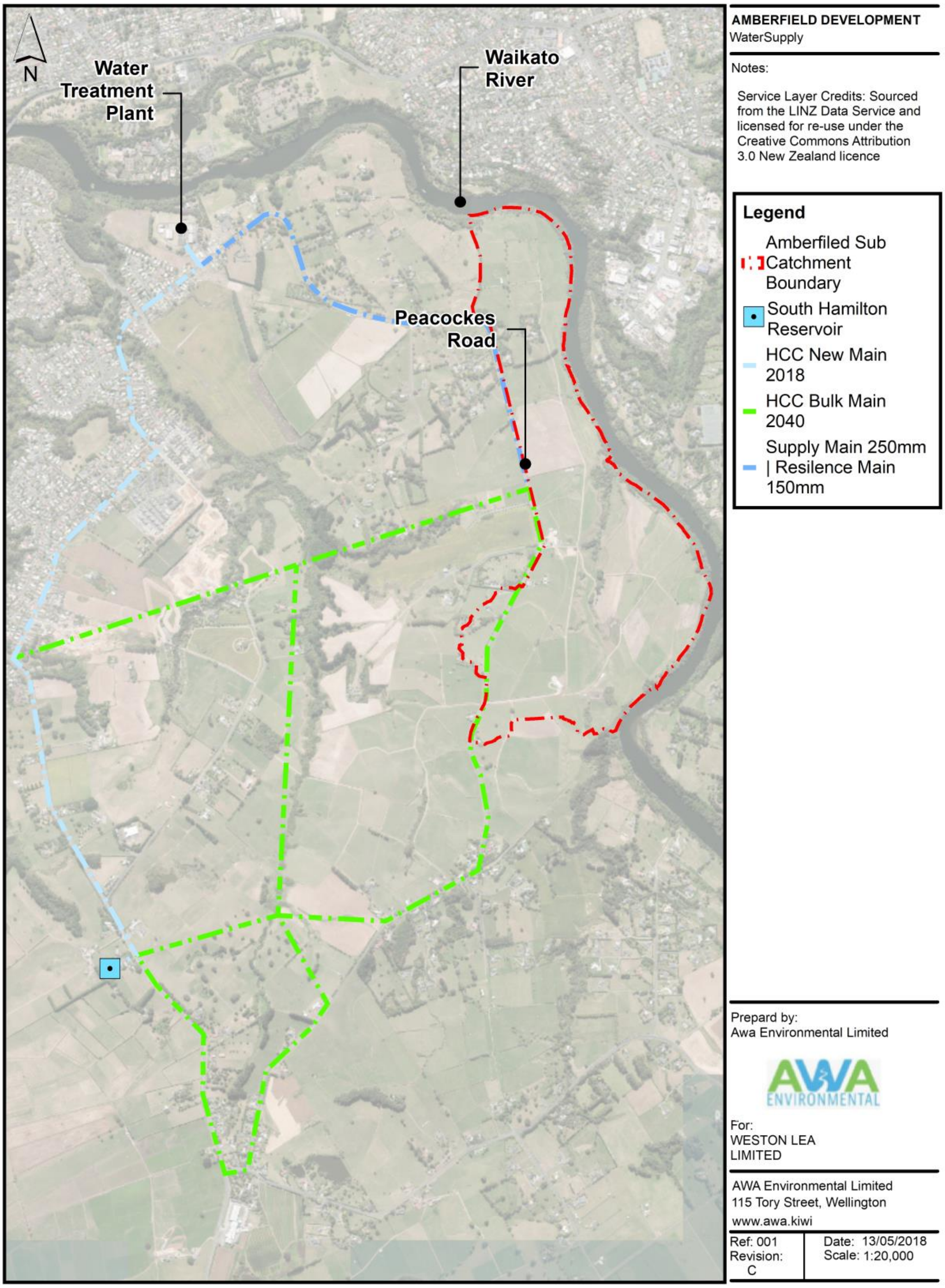


Figure 19 Proposed water supply infrastructure

15 ICMP Implementation

This sub-catchment ICMP will be implemented through the construction of the Amberfield residential development, where all stages of design, construction, operation and maintenance will be compliant with the BPO's and mitigation measures detailed in this report. The desired outcomes and any additional considerations generated during the preparation of this report will be applied on-site. It is recommended that all stormwater management devices are constructed and operational prior to the start of construction leading to an increase in impervious surfaces, as per Condition 31 in the CDSC.

15.1 Means of Compliance

Table 9 in the Best Practicable Options section (14.3) outlines how each Best Practicable Option in this ICMP meets the requirements of the respective planning documents introduced in Section 1.

15.2 Mitigation Measures Implementation

Most of the mitigation measures set out in this sub-catchment ICMP and selected in the planning and design process will be required to be implemented as subdivision proceeds and as individual lot development progresses.

It will be the responsibility of the Hamilton City Council to ensure that any building and subdivision consent information for the sub-catchment area is compliant with BPO measures outlined in this document. Additionally, any provision of infrastructure undertaken by Weston Lea Ltd will be in accordance with resource and/or building consent.

15.3 Hamilton City Council Preferred Options Hierarchy

Table 11 shows the hierarchy of stormwater solutions acceptable to Hamilton City Council to capture the ITS and Operative District Plan hierarchies of reuse, soak, detain. This should be referred to at the time of building consents, where the solutions most suitable to the Amberfield sub-catchment have been illustrated.

Option Hierarchy	Primary driver
On lot (refer to Hamilton City Council's Three Waters Practice Notes)	
	The preferred-on lot stormwater efficiency measure for this catchment: Rainwater reuse tanks (garden use). Overflow and hardstand areas to be directed to soakage where soakage is suitable. Other equivalent features suitable for this catchment: 1. Soakage 2. Bio-retention 3. Detention 4. Other on lot practices that are encouraged 5. Proper building and landscape design
Centralised devices and practices	

Option Hierarchy	Primary driver
On lot (refer to Hamilton City Council's Three Waters Practice Notes)	
All contributing area (including on lot, new roads and reserves)	1. Soakage 2. Bio-retention 3. Subdivision overland flow paths with erosion control 4. Swales 5. Rain gardens on steeper streets 6. Riparian Planting

Table 11 Options for Amberfield sub-catchment development

15.4 Operations and Maintenance

The tables in Appendix K outline the maintenance associated with bio-infiltration devices and rain gardens, in accordance with CDSC Condition 21.

The sumps associated with these devices will need to be protected with filter cloth until the construction phase is complete. As described above, bio-infiltration devices are designed as an internal system and these will be blocked off during the first 2 – 3 years during the house construction phase to avoid excess sediment from house construction activity. Once they are commissioned the maintenance requirements for them will be very low if the amount of fine sediment entering them is kept to a minimum.

16 Glossary and References

16.1 Glossary

Average Recurrence Interval (ARI): A statistical estimate of the average period in years between the occurrences of an event of a given size or larger.

ARC TP10: A design guideline document that outlines and demonstrates the (ex) ARC"s preferred design approach for stormwater management devices. Specifically, this includes design guidance for water quality and water quantity. This document is under review by Auckland Council and the new documents will automatically apply as the new guide to support this CMP.

Best Practicable Option: The best method for preventing or minimising adverse effects on the environment, having regarded to:

- The nature of the discharge or emission and the sensitivity of the receiving environment to adverse effects; and
- The financial implications, and the effects on the environment, of that option when compared with other options; and
- The current state of technical knowledge and the likelihood that the option can be successfully applied.

Base Flow: The flow in a stream between storm events. This flow is supplied by groundwater.

Buffer: A vegetated strip immediately adjacent to a water body. The primary function of buffers is to protect the receiving water from sediment and pollutants derived from upstream areas. Ancillary benefits may include infiltration of rainfall and habitat enhancement.

Catchment: The area of land drained by a stream or river system, or the boundary of an area where all surface water drains to a common point.

Catchment Management Plan: A management plan devised to manage land, its environmental and social resources on a catchment basis.

Extended Detention Pond: A stormwater facility that temporarily detains part of stormwater runoff for up to 24 hours after a storm by using a fixed orifice.

Flood Hazard Mapping: Defines flood hazard areas using flood levels established as part of flood hazard studies.

Flow Attenuation: The process of reducing the peak flow rate by redistributing the same volume of flow over a longer period of time, i.e. by using detention structures.

Green roof (or eco-roof or living roof): A roof of a building that is partially or completely covered with vegetation and planted over a waterproofing membrane. The sustainable design method treats storm water runoff, reduces heat transfer and energy consumption.

Groundwater Recharge: Increasing the amount of groundwater in storage via percolating rainwater.

Hydraulic Model: A computer model of a watercourse used to evaluate the hydraulic conditions of water flow through natural rivers and other channels.

Impervious surface: Those surfaces in the landscape that cannot infiltrate rainfall, such as rooftops, road pavements, footpaths, driveways and compacted earth.

Infiltration: The downward movement of water from the surface of the land to subsoil.

Integrated Catchment Management Plan: A management plan devised to manage natural resources on catchment basis to achieve sustainable use which provides for social and economic benefit.

Linear under-drain bio-infiltration devices: A drainage depression along which stormwater flows. It is usually grassed and regularly mowed. It collects and treats water by slowing the flow and allowing solids to drop out of the water prior to discharging via a cesspit to a piped network.

Perennial stream: A stream that has water flow all year.

Rain garden: A planted depression or raised enclosed bed that is designed to absorb contaminants in stormwater runoff which are generated from impervious areas such as roofs, roads, paving, and lawn areas. The water will percolate through the rain garden prior to discharge, which is either through natural soakage, to low velocity overland flow or a piped network.

Riparian Corridor: Generally, the vegetated land adjacent to a watercourse.

Treatment Train: A “Treatment Train” approach to stormwater management consists of sequential components that contribute to the treatment of stormwater before it discharges to natural watercourses.

Water-sensitive techniques: include a variety of methods that aim to achieve better outcomes for water related issues. They include many techniques referred to under other names e.g. Low Impact Design (LID), Water Sensitive Urban Design (WSUD), Low Impact Urban Design and Development (LIUDD), Sustainable Urban Drainage Systems (SUDS) “natural”, “green” and “sustainable” A primary aim of water-sensitive techniques is to maximise the achievement of multiple benefits rather than a single engineering technical efficiency measure. Recognised water-sensitive techniques include:

Appendices

Appendix A: Landscape and Visual Effects Assessment Report

Appendix B: Cultural and Historical Values Report

Appendix C: Archaeological Assessment Report

Appendix D: Freshwater Ecological Resource Assessment Report

Appendix E: Freshwater Ecological Impact Assessment Report

Appendix F: Terrestrial and Riparian Ecology Assessment Report

Appendix G: Geotechnical Investigation Report

Appendix H: Waikato River Adare Flood Hazard Report

Appendix I: Flood Model Build Report

Appendix J: Key Design and Construction Requirements

Memo

To:

From: Awa Environmental

CC:

Date: 13 March 2018

Re: Bioretention: Swale and Linear Infiltration Trench Design Detail

This memo summaries the methodology used to calculate the required length of Swale for managing water quality, and linear infiltration trenches for managing primary stormwater disposal. It details the inputs used in HEC for the swale and Linear Infiltration Trench devices as below;

HEC Flow Analysis

The flows from the catchment were calculated in HEC.

Each catchment was divided into three areas:

- Residential Areas
- Pervious Road Areas
- Impervious Road Areas

Residential Areas-Impervious

The impervious component of the residential area will be disposed of via a lot soakage device – therefore this component does NOT need to be calculated as part of the swale Linear Infiltration Trench device sizing.

Residential Areas - Pervious

The residential areas were assessed using the plan see Figure 1.

50% of the area is assumed to go to the swale and the Linear Infiltration Trench devices.

For the residential areas the following HEC inputs were used:

Storage Ratio Residential	0.107
Initial Abstraction Residential (mm)	5
Time of Concentration Residential (hr)	0.25

Road - Pervious Area

Using schematic road plans, pervious road areas were calculated for short sections of road. This produced an average pervious area per length of road. For each sub-catchment, the average pervious area was multiplied by the road length to give a pervious road area. See Figure 2.

For the road – pervious areas the following HEC inputs were used:

Storage Ratio Pervious	0.07
Initial Abstraction Pervious (mm)	5
Time of Concentration Pervious (hr)	0.166

<u>Road - Impervious Area</u>

Using schematic road plans, impervious road areas were calculated for short sections of road. This produced an average impervious area per length of road. For each sub-catchment, the average pervious area was multiplied by the road length to give a pervious road area for each sub-catchment. See Figure 2.

For the road – impervious areas the following HEC inputs were used:

Storage Ratio Impervious	0.055
Initial Abstraction Impervious (mm)	0
Time of Concentration Impervious (hr)	0.166

<u>HEC Output</u>

Outputs from the HEC model of the 2yrCC peak flow and the 10yr CC volume where then input into the swales and Linear Infiltration Trench devices.

Sub-catchments E_152 & C_2 are combined as the road in C_2 is very steep. The sub-catchments were combined after the HEC analysis.

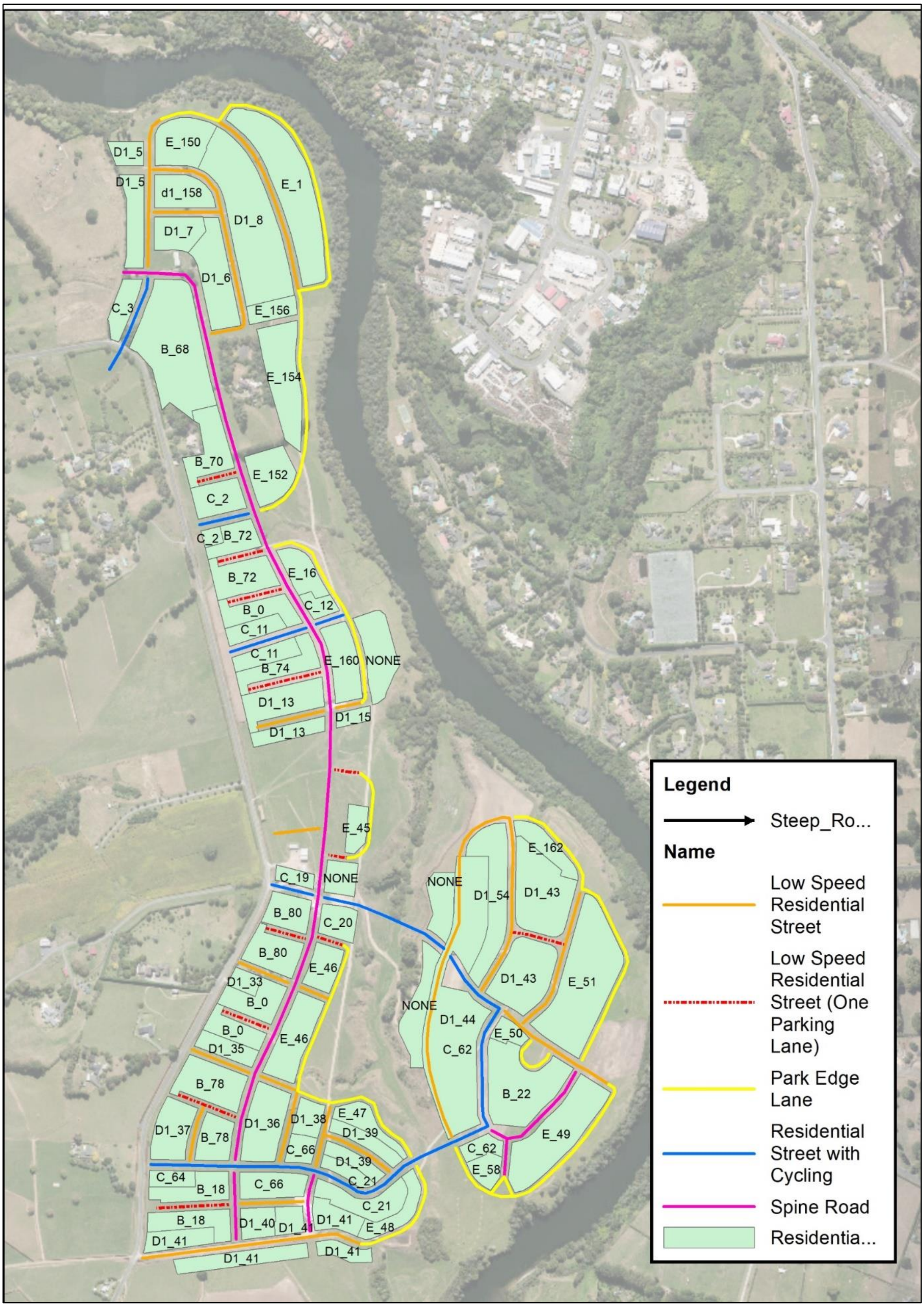


Figure 1 Residential Areas

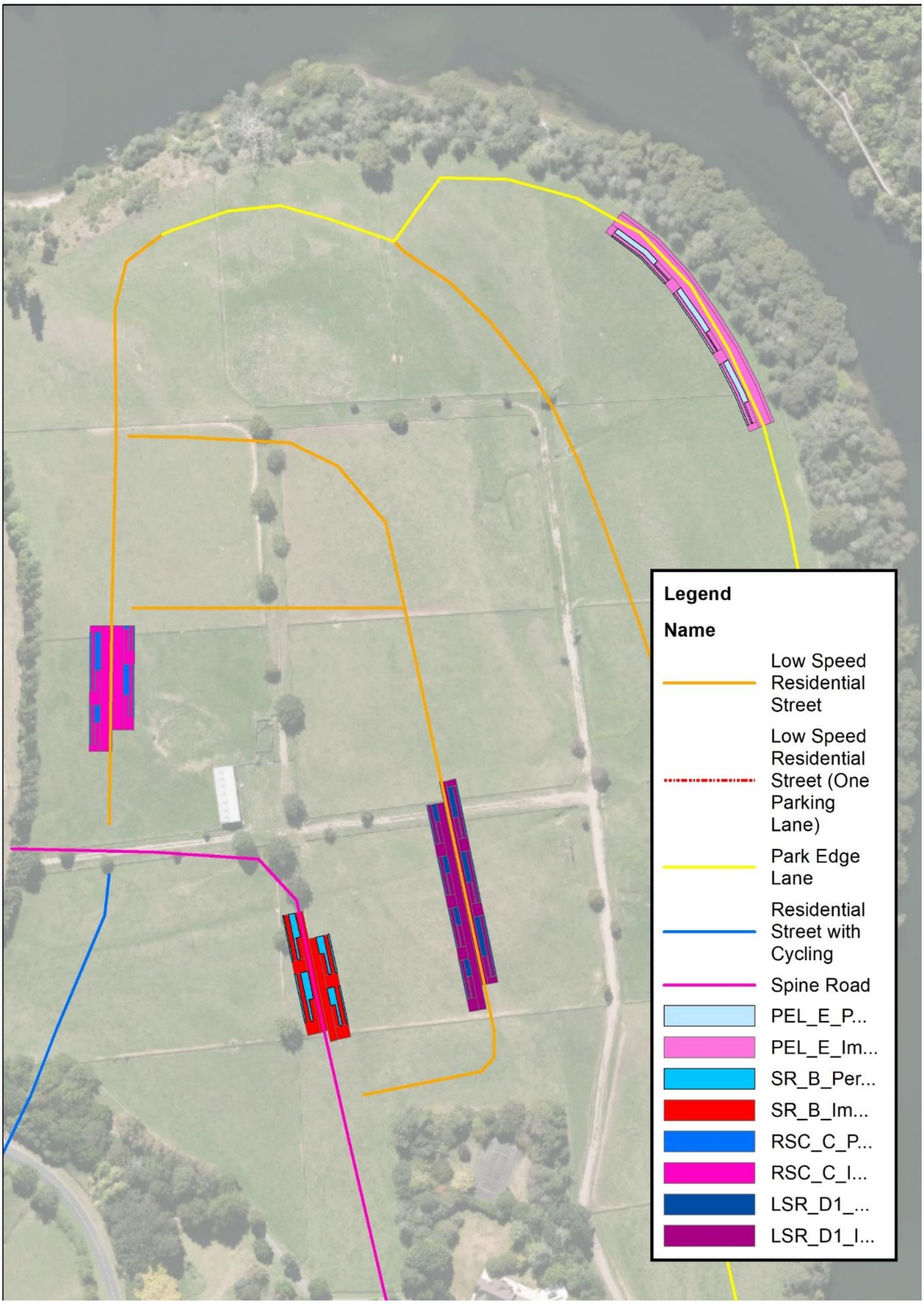


Figure 2 Sample impervious and pervious areas

Swale Calculation

An AWA tool was used to calculate the swale dimensions. The calculation is based on the TP 10 manual,(http://www.aucklandcity.govt.nz/council/documents/technicalpublications/TP10%20Design%20guideline%20manual%20stormwater%20treatment%20devices%20Chapter%209%20-%202003.pdf).

The following assumptions were made:

Slope (m/m)	0.01
Bank Slope (m/m)	4.5
Hydraulic Residence Time (mins)	9

These assumptions have not been changed from TP10.

Mannings

The roughness is calculated based on the depth, and grass height.

Grass Height

The calculation gives two options for grass height, 50mm or 150mm. Both were calculated but generally 50mm grass was found to be marginally more conservative (between 0-20% longer). For simplicity results with grass length of 50mm were shared. Table 1 shows the difference in length between a swale with 50mm grass and 150mm grass.

Swale Output

The output from the swale is the swale width, the swale length and the flow velocity for the peak flow during a two-year event.

Table 1 difference between 50mm grass and 150mm grass

	Grass Height = 150mm		Grass Height =50mm			
Road Name	Depth of Flow	Length	Depth of Flow	Length	Difference	% Change
D1_13	0.13	91.5	0.11	96.7	5.2	6
D1_15	0.075	32.7	0.07	37.2	4.5	14
D1_158	0.12	78.8	0.11	96.7	17.9	23
D1_32	0.085	41.3	0.075	50.4	9.1	22
D1_33	0.09	46.0	0.08	53.3	7.3	16
D1_34	0.07	28.8	0.067	32.1	3.3	12
D1_35	0.11	67.0	0.09	66.5	-0.5	-1
D1_36	0.14	105.1	0.12	113.8	8.7	8
D1_37	0.11	67.0	0.09	66.5	-0.5	-1
D1_38	0.1	56.0	0.09	66.5	10.4	19
D1_39	0.12	78.8	0.1	80.9	2.1	3
D1_40	0.1	56.0	0.09	66.5	10.4	19
D1_41	0.17	151.1	0.15	172.8	21.6	14
D1_42	0.13	91.5	0.11	96.7	5.2	6
D1_43	0.18	168.2	0.15	172.8	4.6	3
D1_44	0.18	168.2	0.15	172.8	4.6	3
D1_5	0.14	105.1	0.12	113.8	8.7	8
D1_54	0.17	151.1	0.14	151.8	0.7	0
D1_56	0.1	56.0	0.09	66.5	10.4	19
D1_6	0.15	119.6	0.13	132.2	12.6	11
D1_7	0.11	67.0	0.1	80.9	14.0	21
D1_8	0.18	168.2	0.16	194.9	26.7	16
B_0	0.14	105.1	0.12	113.8	8.7	8
B_17	0.095	50.9	0.08	53.3	2.4	5
B_18	0.085	41.3	0.076	48.4	7.1	17
B_22	0.14	105.1	0.12	113.8	8.7	8
B_23	0.08	36.9	0.072	41.6	4.7	13
B_68	0.16	134.9	0.14	151.8	16.9	13
B_70	0.14	105.1	0.12	113.8	8.7	8
B_72	0.15	119.6	0.13	132.2	12.6	11
B_74	0.13	91.5	0.12	113.8	22.3	24
B_76	0.15	119.6	0.13	132.2	12.6	11
B_78	0.14	105.1	0.12	113.8	8.7	8
B_80	0.13	91.5	0.12	113.8	22.3	24
E_1	0.2	204.8	0.18	242.9	38.1	19
E_150	0.12	78.8	0.1	80.9	2.1	3
E_152	0.11	67.0	0.1	80.9	14.0	21
E_154	0.15	119.6	0.13	132.2	12.6	11
E_156	0.085	41.3	0.075	50.4	9.1	22
E_16	0.13	91.5	0.11	96.7	5.2	6

E_160	0.13	91.5	0.11	96.7	5.2	6
E_162	0.13	91.5	0.11	96.7	5.2	6
E_45	0.13	91.5	0.11	96.7	5.2	6
E_46	0.16	134.9	0.14	151.8	16.9	13
E_47	0.14	105.1	0.12	113.8	8.7	8
E_48	0.13	91.5	0.11	96.7	5.2	6
E_49	0.16	134.9	0.14	151.8	16.9	13
E_50	0.1	56.0	0.09	66.5	10.4	19
E_51	0.17	151.1	0.15	172.8	21.6	14
E_52	0.065	25.0	0.06	24.2	-0.8	-3
E_53	0.065	25.0	0.062	26.0	1.0	4
E_58	0.1	56.0	0.09	66.5	10.4	19
E_60	0.07	28.8	0.065	29.4	0.6	2
C_11	0.14	105.1	0.12	113.8	8.7	8
C_12	0.09	46.0	0.08	53.3	7.3	16
C_19	0.1	56.0	0.09	66.5	10.4	19
C_2	0.12	78.8	0.1	80.9	2.1	3
C_20	0.15	119.6	0.13	132.2	12.6	11
C_21	0.17	151.1	0.15	172.8	21.6	14
C_3	0.14	105.1	0.12	113.8	8.7	8
C_62	0.2	204.8	0.17	218.3	13.5	7
C_64	0.13	91.5	0.11	96.7	5.2	6
C_66	0.14	105.1	0.12	113.8	8.7	8

Infiltration Device

A soakage spreadsheet was used to calculate the Linear Infiltration Trench device dimensions. The discharge hydrograph for the 10YR CC event was input into the spreadsheet. The soakage rate, depth, porosity and width soakage inputs remained constant. The length of the device was then adjusted until soakage of the hydrograph was achieved.

Soakage Rate (mm/hr)	75.0
Depth (m)	0.8
Porosity (n)	0.2
Width (m)	3.5

The soakage rate of 75mm/hr is considered conservative.

Calculations

Catchment Areas							Hec Inputs									
								Residential			Pervious			Impervious		
Road Name	Total Subcatch Area (km2)	Road Length (m)	Pervious Area (km2)	Impervious Area (km2)	Residential Area (km2)	50% Residential Area (km2)	Curve Number	Storage Ratio Residential	Initial Abstraction Residential	Time of Concentration Residential (hr)	Storage Ratio Pervious	Initial Abstraction Pervious	Time of Concentration Pervious (hr)	Storage Ratio Impervi	Initial Abstraction Impervious	Time of Concentration Impervious (hr)
D1_13	0.014137	125.5	0.00042	0.00116	0.003713	0.00596	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166
D1_15	0.002609	48.8	0.00016	0.00045	0.001703	0.000851	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166
D1_158	0.008705	171.6	0.00058	0.00158	0.005854	0.002927	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166
D1_32	0.001425	82.3	0.00028	0.00076	No Res	No Res	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166
D1_33	0.003714	97.1	0.00033	0.00090	0.001995	0.000998	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166
D1_34	0.000921	55.1	0.00019	0.00051	No Res	No Res	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166
D1_35	0.005746	113.6	0.00038	0.00105	0.003736	0.001868	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166
D1_36	0.012873	205.3	0.00069	0.00189	0.009237	0.004618	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166
D1_37	0.008677	100.4	0.00034	0.00093	0.007017	0.003508	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166
D1_38	0.005036	111.2	0.00038	0.00103	0.003142	0.001571	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166
D1_39	0.008914	134.4	0.00045	0.00124	0.002967	0.00332	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166
D1_40	0.005396	115.2	0.00039	0.00106	0.003425	0.001713	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166
D1_41	0.028925	407.0	0.00137	0.00376	0.002735	0.010189	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166
D1_42	0.004659	234.0	0.00079	0.00216	No Res	No Res	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166
D1_43	0.031399	268.5	0.00091	0.00248	0.014243	0.013054	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166
D1_44	0.036888	525.2	0.00177	0.00485	0.008977	0.004489	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166
D1_5	0.014672	278.1	0.00094	0.00257	0.002604	0.00421	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166
D1_54	0.017486	330.1	0.00111	0.00305	0.011677	0.005838	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166
D1_56	0.001839	131.7	0.00044	0.00122	No Res	No Res	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166
D1_6	0.015013	273.0	0.00092	0.00252	0.010458	0.005229	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166
D1_7	0.007112	124.3	0.00042	0.00115	0.005143	0.002571	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166
D1_8	0.032623	353.0	0.00119	0.00326	0.026561	0.01328	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166
B_0	0.01532	179.5	0.00082	0.00264	0.004217	0.007718	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166
B_17	0.001777	103.5	0.00047	0.00152	No Res	No Res	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166
B_18	0.016601	121.8	0.00056	0.00179	0.005835	0.005697	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166
B_22	0.019824	212.9	0.00098	0.00313	0.01568	0.00784	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166
B_23	0.001017	70.3	0.00032	0.00103	No Res	No Res	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166
B_68	0.034287	349.6	0.00160	0.00515	0.024172	0.012086	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166
B_70	0.01277	214.5	0.00098	0.00316	0.007356	0.003678	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166
B_72	0.02412	237.7	0.00109	0.00350	0.006931	0.005571	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166
B_74	0.011528	156.6	0.00072	0.00231	0.005723	0.002861	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166
B_76	0.007742	344.1	0.00158	0.00506	No Res	No Res	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166

	Hec Output			Swale Calculation Inputs						Swale Calculation Outputs			Infiltration Inputs				Infiltration Output
Road Name	HEC Peak 2yr Flow (m3/s)	HEC 10yr Flow Volume (m3)	HEC Peak 10yr Flow (m3/s)	Grass Height (mm)	Slope (m/m)	Bank Slope (m/m)	Hydraulic Residence Time (mins)	Depth of Flow (m)	Mannings Calculated (n)	Swale Width (m)	Swale Length (m)	Velocity (m/s)	Soakage Rate (mm/hr)	Depth (m)	Porosity (n)	Width (m)	Length (m)
D1_13	0.0324	304.44	0.0594	50	0.01	4.5	9	0.11	0.127	2.1	96.7	0.179	75.0	0.8	0.2	3.5	150
D1_15	0.0089	78.19	0.0149	50	0.01	4.5	9	0.07	0.244	2.2	37.2	0.069	75.0	0.8	0.2	3.5	40
D1_158	0.0310	273.28	0.0521	50	0.01	4.5	9	0.11	0.127	2.1	96.7	0.179	75.0	0.8	0.2	3.5	130
D1_32	0.0119	92.62	0.0180	50	0.01	4.5	9	0.075	0.189	2.0	50.4	0.093	75.0	0.8	0.2	3.5	50
D1_33	0.0159	136.65	0.0258	50	0.01	4.5	9	0.08	0.186	2.4	53.3	0.099	75.0	0.8	0.2	3.5	70
D1_34	0.0080	62.10	0.0121	50	0.01	4.5	9	0.067	0.275	2.3	32.1	0.059	75.0	0.8	0.2	3.5	30
D1_35	0.0209	183.03	0.0349	50	0.01	4.5	9	0.09	0.162	2.3	66.5	0.123	75.0	0.8	0.2	3.5	90
D1_36	0.0400	357.50	0.0686	50	0.01	4.5	9	0.12	0.115	2.1	113.8	0.211	75.0	0.8	0.2	3.5	170
D1_37	0.0227	209.00	0.0405	50	0.01	4.5	9	0.09	0.162	2.5	66.5	0.123	75.0	0.8	0.2	3.5	100
D1_38	0.0193	168.19	0.0320	50	0.01	4.5	9	0.09	0.162	2.1	66.5	0.123	75.0	0.8	0.2	3.5	80
D1_39	0.0269	242.17	0.0466	50	0.01	4.5	9	0.1	0.143	2.2	80.9	0.150	75.0	0.8	0.2	3.5	120
D1_40	0.0202	176.46	0.0336	50	0.01	4.5	9	0.09	0.162	2.2	66.5	0.123	75.0	0.8	0.2	3.5	90
D1_41	0.0818	737.06	0.1417	50	0.01	4.5	9	0.15	0.088	2.4	172.8	0.320	75.0	0.8	0.2	3.5	350
D1_42	0.0339	263.41	0.0512	50	0.01	4.5	9	0.11	0.127	2.2	96.7	0.179	75.0	0.8	0.2	3.5	130
D1_43	0.0833	768.04	0.1489	50	0.01	4.5	9	0.15	0.088	2.4	172.8	0.320	75.0	0.8	0.2	3.5	370
D1_44	0.0845	714.02	0.1346	50	0.01	4.5	9	0.15	0.088	2.4	172.8	0.320	75.0	0.8	0.2	3.5	340
D1_5	0.0489	428.21	0.0815	50	0.01	4.5	9	0.12	0.115	2.5	113.8	0.211	75.0	0.8	0.2	3.5	210
D1_54	0.0735	639.80	0.1215	50	0.01	4.5	9	0.14	0.095	2.5	151.8	0.281	75.0	0.8	0.2	3.5	300
D1_56	0.0190	148.23	0.0288	50	0.01	4.5	9	0.09	0.162	2.1	66.5	0.123	75.0	0.8	0.2	3.5	70
D1_6	0.0508	450.49	0.0861	50	0.01	4.5	9	0.13	0.104	2.2	132.2	0.245	75.0	0.8	0.2	3.5	220
D1_7	0.0236	210.32	0.0403	50	0.01	4.5	9	0.1	0.143	2.0	80.9	0.150	75.0	0.8	0.2	3.5	100
D1_8	0.0822	760.81	0.1477	50	0.01	4.5	9	0.16	0.081	2.1	194.9	0.361	75.0	0.8	0.2	3.5	370
B_0	0.0715	635.36	0.1215	50	0.01	4.5	9	0.12	0.115	3.4	113.8	0.211	75.0	0.8	0.2	3.5	300
B_17	0.0237	183.55	0.0357	50	0.01	4.5	9	0.08	0.186	3.4	53.3	0.099	75.0	0.8	0.2	3.5	90
B_18	0.0175	252.91	0.0381	50	0.01	4.5	9	0.076	0.198	2.9	48.4	0.090	75.0	0.8	0.2	3.5	100
B_22	0.0662	592.21	0.1136	50	0.01	4.5	9	0.12	0.115	3.2	113.8	0.211	75.0	0.8	0.2	3.5	280
B_23	0.0161	124.62	0.0242	50	0.01	4.5	9	0.072	0.223	3.2	41.6	0.077	75.0	0.8	0.2	3.5	60
B_68	0.1066	950.93	0.1821	50	0.01	4.5	9	0.14	0.095	3.3	151.8	0.281	75.0	0.8	0.2	3.5	450
B_70	0.0639	562.70	0.0996	50	0.01	4.5	9	0.12	0.115	3.1	113.8	0.211	75.0	0.8	0.2	3.5	250
B_72	0.0775	669.98	0.1268	50	0.01	4.5	9	0.13	0.104	3.0	132.2	0.245	75.0	0.8	0.2	3.5	320
B_74	0.0611	510.69	0.0963	50	0.01	4.5	9	0.12	0.115	3.0	113.8	0.211	75.0	0.8	0.2	3.5	240
B_76	0.0787	610.19	0.1187	50	0.01	4.5	9	0.13	0.104	3.1	132.2	0.245	75.0	0.8	0.2	3.5	290

B_78	0.018684	161.1	0.00074	0.00237	0.004912	0.006741	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166	0.0678	598.66	0.1142	50	0.01	4.5	9	0.12	0.115	3.2	113.8	0.211	75.0	0.8	0.2	3.5	290
B_80	0.015957	169.6	0.00078	0.00250	0.006406	0.005618	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166	0.0615	539.41	0.1027	50	0.01	4.5	9	0.12	0.115	3.0	113.8	0.211	75.0	0.8	0.2	3.5	260
E_1	0.027847	511.4	0.00109	0.00506	0.021079	0.010539	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166	0.1001	884.58	0.1687	50	0.01	4.5	9	0.18	0.070	2.0	242.9	0.450	75.0	0.8	0.2	3.5	420
E_150	0.010152	110.4	0.00023	0.00109	0.008088	0.004044	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166	0.5432	239.41	0.0463	50	0.01	4.5	9	0.1	0.143	2.2	80.9	0.150	75.0	0.8	0.2	3.5	120
E_154	0.015667	284.0	0.00060	0.00281	0.011914	0.005957	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166	0.0559	494.18	0.0943	50	0.01	4.5	9	0.13	0.104	2.3	132.2	0.245	75.0	0.8	0.2	3.5	240
E_156	0.004036	54.3	0.00012	0.00054	0.003172	0.001586	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166	0.0118	106.71	0.0205	50	0.01	4.5	9	0.075	0.189	2.0	50.4	0.093	75.0	0.8	0.2	3.5	60
E_16	0.007856	204.0	0.00043	0.00202	0.004661	0.002331	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166	0.0353	301.56	0.0568	50	0.01	4.5	9	0.11	0.127	2.3	96.7	0.179	75.0	0.8	0.2	3.5	150
E_160	0.009645	170.2	0.00036	0.00168	0.007154	0.003577	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166	0.0335	296.29	0.0565	50	0.01	4.5	9	0.11	0.127	2.2	96.7	0.179	75.0	0.8	0.2	3.5	140
E_162	0.008224	200.0	0.00042	0.00198	0.004341	0.00217	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166	0.0344	292.54	0.0551	50	0.01	4.5	9	0.11	0.127	2.2	96.7	0.179	75.0	0.8	0.2	3.5	140
E_45	0.007706	188.4	0.00040	0.00186	0.003013	0.001506	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166	0.0364	300.23	0.0568	50	0.01	4.5	9	0.11	0.127	2.3	96.7	0.179	75.0	0.8	0.2	3.5	140
E_46	0.018145	287.6	0.00061	0.00284	0.008942	0.006653	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166	0.0652	574.69	0.1095	50	0.01	4.5	9	0.14	0.095	2.3	151.8	0.281	75.0	0.8	0.2	3.5	270
E_47	0.007857	269.5	0.00057	0.00267	0.004168	0.002084	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166	0.0447	371.17	0.0700	50	0.01	4.5	9	0.12	0.115	2.3	113.8	0.211	75.0	0.8	0.2	3.5	180
E_48	0.007878	216.4	0.00046	0.00214	0.004505	0.002253	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166	0.0370	313.91	0.0591	50	0.01	4.5	9	0.11	0.127	2.4	96.7	0.179	75.0	0.8	0.2	3.5	150
E_49	0.02019	284.7	0.00060	0.00282	0.016042	0.008021	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166	0.0612	551.39	0.1059	50	0.01	4.5	9	0.14	0.095	2.2	151.8	0.281	75.0	0.8	0.2	3.5	260
E_50	0.004553	106.2	0.00023	0.00105	0.002177	0.001088	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166	0.0181	153.54	0.0289	50	0.01	4.5	9	0.09	0.162	2.0	66.5	0.123	75.0	0.8	0.2	3.5	80
E_51	0.03029	363.2	0.00077	0.00359	0.023841	0.011921	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166	0.0824	749.74	0.1445	50	0.01	4.5	9	0.15	0.088	2.4	172.8	0.320	75.0	0.8	0.2	3.5	360
E_52	0.000365	38.8	0.00008	0.00038	No Res	No Res	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166	0.0059	45.25	0.0088	50	0.01	4.5	9	0.06	0.339	2.5	24.2	0.045	75.0	0.8	0.2	3.5	30
E_53	0.000416	39.9	0.00009	0.00039	No Res	No Res	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166	0.0060	46.45	0.0090	50	0.01	4.5	9	0.062	0.322	2.3	26.0	0.048	75.0	0.8	0.2	3.5	30
E_58	0.004125	109.6	0.00023	0.00108	0.002899	0.001449	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166	0.0194	167.45	0.0316	50	0.01	4.5	9	0.09	0.162	2.2	66.5	0.123	75.0	0.8	0.2	3.5	80
E_60	0.000758	49.5	0.00011	0.00049	No Res	No Res	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166	0.0075	57.64	0.0112	50	0.01	4.5	9	0.065	0.294	2.4	29.4	0.054	75.0	0.8	0.2	3.5	30
C_11	0.010239	145.8	0.00052	0.00246	0.003892	0.003654	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166	0.0450	389.86	0.0738	50	0.01	4.5	9	0.12	0.115	2.3	113.8	0.211	75.0	0.8	0.2	3.5	190
C_12	0.003158	52.4	0.00019	0.00088	0.002163	0.001081	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166	0.0156	133.63	0.0252	50	0.01	4.5	9	0.08	0.186	2.3	53.3	0.099	75.0	0.8	0.2	3.5	70
C_19	0.003419	77.2	0.00028	0.00130	0.001918	0.000959	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166	0.0217	179.65	0.0339	50	0.01	4.5	9	0.09	0.162	2.4	66.5	0.123	75.0	0.8	0.2	3.5	90
C_20	0.00915	240.6	0.00086	0.00406	0.003906	0.001953	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166	0.0658	531.56	0.1013	50	0.01	4.5	9	0.13	0.104	2.7	132.2	0.245	75.0	0.8	0.2	3.5	250
C_21	0.015666	296.8	0.00106	0.00501	0.006828	0.004614	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166	0.0853	715.97	0.1345	50	0.01	4.5	9	0.15	0.088	2.5	172.8	0.320	75.0	0.8	0.2	3.5	340
C_3	0.007745	181.3	0.00065	0.00306	0.003875	0.001937	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166	0.0505	413.30	0.0783	50	0.01	4.5	9	0.12	0.115	2.5	113.8	0.211	75.0	0.8	0.2	3.5	200
C_62	0.01267	431.9	0.00155	0.00728	0.018956	0.010735	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166	0.1329	1152.02	0.2181	50	0.01	4.5	9	0.17	0.075	2.7	218.3	0.404	75.0	0.8	0.2	3.5	540
C_64	0.005375	142.9	0.00051	0.00241	0.002524	0.001262	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166	0.0393	318.58	0.0606	50	0.01	4.5	9	0.11	0.127	2.5	96.7	0.179	75.0	0.8	0.2	3.5	150
C_66	0.011084	148.8	0.00053	0.00251	0.005587	0.004046	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166	0.0467	406.49	0.0771	50	0.01	4.5	9	0.12	0.115	2.4	113.8	0.211	75.0	0.8	0.2	3.5	200
E_152	0.019274	194.9	0.00053	0.00257	0.013419	0.0067095	45	0.107	5	0.25	0.07	5	0.166	0.055	0	0.166	0.0543	486.64	0.0933	50	0.01	4.5	9	0.11	0.127	3.3	96.7	0.179	75.0	0.8	0.2	3.5	230

Swale Calculations

From TP10
http://www.aucklandcity.govt.nz/council/documents/technicalpublications/TP10%20Design%20guideline%20manual%20stormwater%20treatment%20devices%20Chapter%209%20-%202003.pdf

2. Select a value of Manning's n (equations developed from swale study project, 2003)

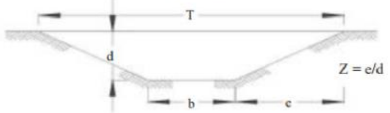
   For 150 mm grass and $d < 60$ mm $n = 0.153\, d^{-0.33} / (0.75 + 25s)$
   $d > 60$ mm $n = 0.013\, d^{-1.2} / (0.75 + 25s)$

   For 50 mm grass and $d < 75$ mm $n = (0.54\text{-}228\, d^{2.5}) / (0.75 + 25s)$
   $d > 75$ mm $n = 0.009 d^{-1.2} / (0.75 + 25s)$

   Where:
   d = depth of flow (m) for water quality storm
   s = longitudinal slope as a ratio of vertical rise/horizontal run (m/m)

4. Use Manning's equation and first approximations relating hydraulic radius and dimensions for the selected shape (use a trapezoidal shape for a swale or a rectangular shape for a filter strip) to obtain a working value of a swale or filter strip width dimension

Figure 9-3
Channel geometry



Cross sectional area (A) = $bd + Zd^2$
Top width (W) = $b + 2dZ$

Hydraulic radius (R) $= \dfrac{bd + Zd^2}{b + 2d\,(Z + 1)^{1/2}}$

$Q = AR^{0.67}s^{0.5}/n$ (1)

$A_{rectangle} = Td$ (2)

$R_{rectangle} = Td/(T+2d)$ (3)

Where:
Q = design runoff flow rate (m^3/s, cms)
n = Manning's n (dimensionless)
s = longitudinal slope as a ratio of vertical rise/horizontal run (m/m so dimensionless)
A = cross-sectional area (m^2)
R = hydraulic radius (m)
T = top width of trapezoid/parabolic shape or width of a rectangle
d = depth of flow (m) for water quality storm
b = bottom width of trapezoid (m)

If equations (2) and (3) are substituted into equation 1 and solved for T, complex equations result that are difficult to solve manually. However, approximate solutions can be found by recognising that T>>d and z^2>>1, and that certain terms are nearly negligible. The approximation solutions for rectangular and trapezoidal shapes are:

Rrectangle = d Rtrapezoid = d Rparabolic = 0.67 d Rv = 0.5d

Substituting Rtrapezoid and Atrapezoid = $bd+Zd^2$ into equation (1), and solve for the bottom width b (trapezoidal swale)

$b = (Qn / d^{1.67} s^{0.5}) - Zd$

For a trapezoid, select a side slope Z of at least 3. Compute b and then top width T, where T = b + 2dZ.

b for a filter strip can be as great as uniform flow distribution can be assured. For a parabolic swale configuration, refer to figure 9-3.

5. Calculate A:

   $A_{rectangle} = Td$ or $A_{trapezoid} = bd + Zd^2$

   $A_{filter\ strip} = Td$

6. Calculate the flow velocity at design flow rate:

   $V = Q/A$

   If V > 0.8 m/sec (or V > 0.4 m/sec. for filter strip), repeat steps 1 - 6 until the condition is met. A greater velocity will flatten grasses and reduce filtration. A velocity lower than this maximum value will allow a 9 minute hydraulic residence time. If the value of V suggests that a longer swale or filter strip will be needed than space permits, investigate how Q can be reduced, or increase d and/or T and repeat analysis.

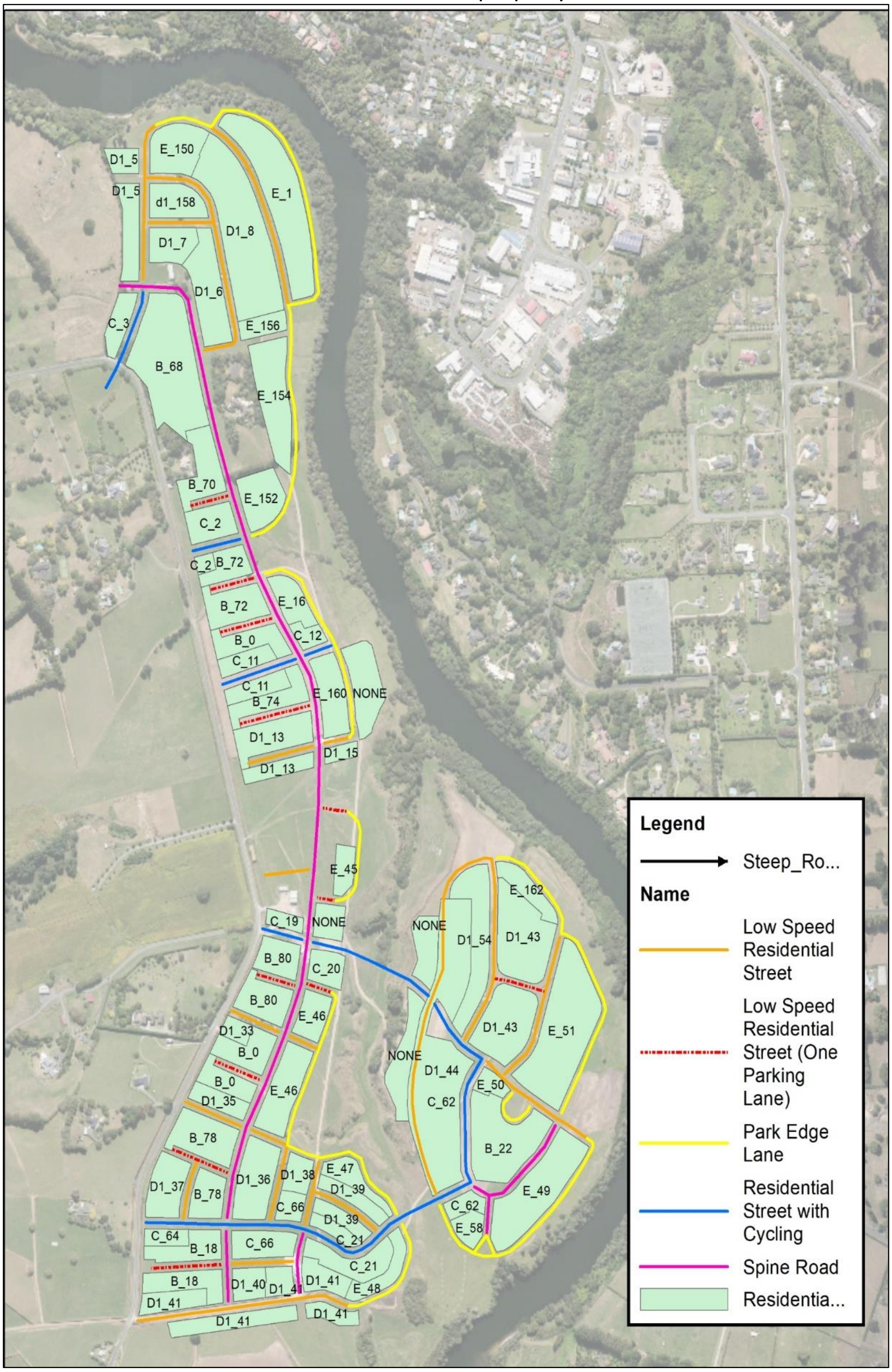
7. Calculate the swale length (L, metres)

   $L = Vt$ (60 sec/min)

   Where t = hydraulic residence time (min)

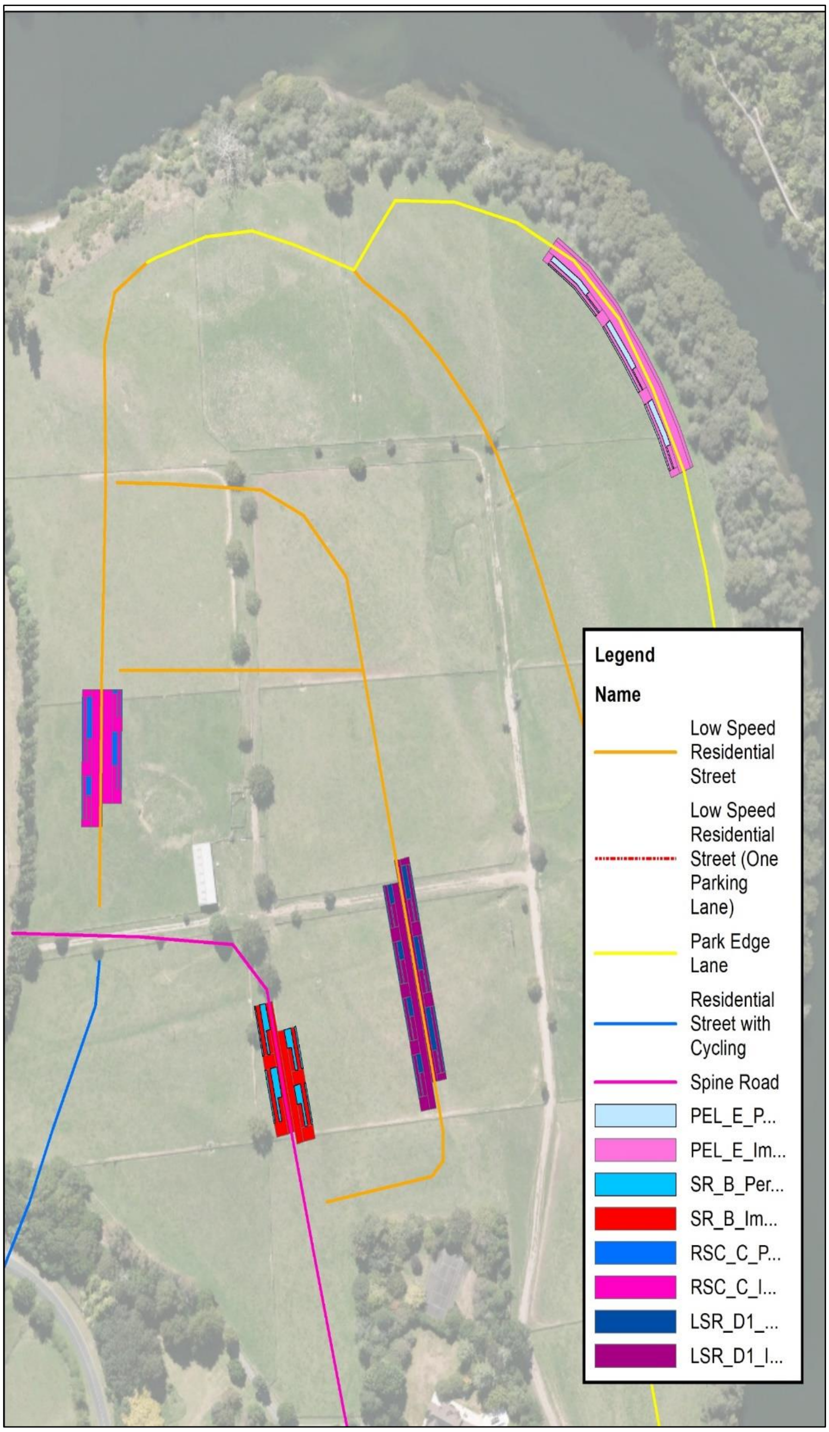
Residential Sub-catchments

Residential sub-catchments are based on the property units. It does not include roads or grassed areas.



Impervious / pervious Areas

Using schematic road plans, pervious and impervious road areas were calculated for short sections of road the pervious and impervious areas of road were calculated using the length of road in other sub-catchments multiplied by the average pervious and impervious area from the plans.



Appendix K: Maintenance Schedule

Frequency:							Action:
After Major Storm	**monthly**	**3 monthly**	**6 monthly**	**Annually**	**5 years**	**10 years**	
Y							Check inflow points, side slopes and channel base for scouring, channelling and erosion, repair as necessary
	Y						Check outlet for scouring or erosion and repair
	Y						Remove rubbish and debris on the inflow points
	Y						Mow grassed channel no shorter that 50mm in length. Re-seed bare patches of grass and water to establish
	Y						Remove weeds
Y				Y			Remove accumulated sediment within the device and grass re-established to ensure the device performs as originally designed
Y				Y			Check stormwater is filtering through soil, by either monitoring after storm runoff or by running water across swale
					Y		CCTV Nexus drains
			Y				Clean Sump chamber
						Y	Test soakage rate by overwhelming system from watermain
		Y					Clean or replace sump liners for a period of 18 months

Linear Under-Drained Bio-Infiltration Device Maintenance

Frequency:						Action:
After Major Storm	**monthly**	**3 monthly**	**Annually**	**5 years**	**10 years**	
Y						Check inflow points, side slopes and channel base for scouring, channelling and erosion, and repair as necessary
	Y					Check outlet for scouring or erosion and repair
	Y					Remove rubbish and debris on the inflow points
	Y					Check plants are healthy and growth dense. Remove dead plants. Replant any gaps and water new plants until established *
	Y					Remove weeds *
Y			Y			Remove accumulated sediment within the device and grass re-established to ensure the device performs as originally designed
Y	Y					Check stormwater is filtering through soil, by either monitoring after storm runoff or by running water across swale
				Y		CCTV Nexus drains
			Y			Clean Sump chamber
					Y	Test soakage rate by overwhelming system from watermain
		Y				Clean or replace sump liners for a period of 18 months

Raingardens Maintenance

Appendix L: HG Plans and Secondary Flow Paths

Appendix M: Wastewater Management Report

Appendix N: Water Supply Management Report

Appendix O: Integrated Transport Assessment Report

Appendix P: Urban Design Report